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A Library of Standards for Rock Names, Rock Modifiers and Terms Related to Structure, Alteration, Mineralization and Minerals for Precambrian Rocks in Ontario

by T.L. Muir, S. Buse, N.F. Trowell and M. Duguet

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35B and 35D	191	Reineck, H.-E. and Singh, I.B. 1975. Depositional sedimentary environments: with reference to terrigenous clastics; Springer-Verlag, Berlin Heidelberg New York (soft cover), 439p. ISBN 3-540-07377-9 (Corrected Reprint of the First Edition)	138 and 141, respectively	85 and 86, respectively
38	194	Passchier, C.W. and Trouw, R.A.J. 1998. Microtectonics; Springer-Verlag, Berlin, 289p. ISBN 3-540-58713-6	5.18	116
43	198	Passchier, C.W. and Trouw, R.A.J. 2005. Microtectonics; 2nd, Revised and Enlarged Edition, Springer Berlin, Heidelberg New York, 366p. ISBN-10 3-540-64003-7, ISBN-13 978-3-540-64003-5	5.14	128

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Abstract

This library of rock names and rock modifiers is a contribution toward establishing a variety of standards for digital applications as used by the Ontario Geological Survey. There are 2 functions for this publication. The first is to establish a set of lists of rock names and rock modifiers that are recommended for use by the Ontario Geological Survey: a) with hand-held computers during field work; and b) in publications, such as maps, geological reports and miscellaneous data releases. The second is to provide functional guidance and definitions for these terms in the form of a manual for geologists. The terms have been chosen to comply, as much as possible, with published international, national and/or provincial standards. The lists are designed to be apropos to Ontario geology.

The manual is divided into 2 parts. Part 1 consists of recommended rock nomenclature, definitions and heirarchical pick lists. Part 2 provides definitions for modifiers used to describe pertinent rock features and corresponding hierarchical pick lists. Rock names are divided into igneous (intrusive and volcanic), sedimentary, metamorphic, and "other", which includes products of deformational processes and extraterrestrial impacts. Rock modifiers are divided into the same categories, with additional categories for structural, alteration, mineralization and mineralogy. Accompanying tables and figures serve to summarize and/or explain salient terminology.

A Library of Standards for Rock Names, Rock Modifiers and Terms Related to Structure, Alteration, Mineralization and Minerals for Precambrian Rocks in Ontario

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Ontario Geological Survey
Open File Report 6289

2016

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Introduction

The Earth Resources and Geoscience Mapping Section (ERGMS) of the Ontario Geological Survey (OGS) has, for some time, considered capturing data digitally during field mapping. In order to properly accomplish this, it was realized that a common set of terms and principles had to be assembled or developed. Ideally, the parameters collected must use preferred geological terminology and must be incorporated into the programming of any computing devices used (e.g., desktop computers, laptop computers and hand-held computers). Hence, what we term "libraries" of different attributes needed to be developed. Each "library" would consist of as many terms as practical to cover as many possible situations as could be foreseen, with respect to Precambrian bedrock geology in Ontario. Precambrian rocks constitute the majority of exposed bedrock by area in the province and range in age from Mesoarchean to Neoproterozoic (Figure 1).

The OGS has previously developed guidelines for standardized Precambrian rock nomenclature. In the late 1970s, the OGS adopted the International Union of Geological Sciences (IUGS) terminology for plutonic rocks proposed in Streckeisen (1976) for use in its publications, and developed internal standards for nomenclature of volcanic rocks (Trowell, Pirie and Jensen 1978) and sedimentary rocks (Blackburn, Wood and Wallace 1978). Several years ago, initial steps were taken to produce sets of terms and symbols that geologists could use with computers. This effort to develop what ultimately became known as a "Common Legend" has taken several stages and is still in progress. The first stage was to develop a library of digital bedrock mapping symbols (Jackson, Muir and Romkey 1995; Muir 1995). The second stage consisted of a library of digital line standards for contacts, faults and fold traces (Muir, Watkins and Berdusco 2000). The third stage resulted in a proposed system of hierarchical codes to be applied to rock names and modifiers for OGS Precambrian map legends (Easton et al. 2008). The current stage (i.e., this Open File Report) has focussed on setting out nomenclature and definitions (as detailed below) to be used in field data acquisition and in OGS Precambrian products (maps, reports, data releases, etc.).

The most recent approach of the OGS, with the intent of digital acquisition of field data, was to re-examine the nomenclature of rocks and to develop library lists for rock names and rock modifiers as well as attributes for structural terms, alteration, mineralization and minerals. The ultimate goal was to allow geologists to collect information digitally, while on outcrops, with the aid of hand-held devices; facilitate digital transfer of the data to a base-camp or office computer; and utilize appropriate computer software to produce maps, reports and geodatabases of the field data for publication. For field work, the OGS currently uses Trimble Juno SB handheld computers, with built-in GPS, and customized Esri® ArcPad® v.10 software (as of December 2014).

There were several goals behind the development of the library lists: a) the terms must avoid redundancy, be technically sound, be preferably current and, where possible, be based on available organized attempts to set standards; b) the terms must be referenceable and/or justifiable; c) the terms must cover the vast majority of expected situations to be found in Archean and Proterozoic geology in Ontario; d) a manual would accompany the lists of terms and set forth guidelines for proper implementation by OGS geologists; e) the libraries of terms should be, directly or with some modification, suitable for use with current and foreseeable OGS equipment; and f) the structured lists would be published so that clients would have access to this approach taken by the OGS. The OGS manual would also set out the organization of the pick lists, which would be used largely with the hand-held computers. The emphasis with this manual is for field use, but clearly also covers the end goal of applying proper terminology for reports, maps and miscellaneous releases of data.

The lists of rock types and modifiers are designed to be logical and hierarchical, recognizing that there is not always a unique solution. Parallelism in list hierarchy among the major classes of rocks was not everywhere achieved because some design requirements would not have been met. Various "levels" of terms have been implemented, each one successively applying a more detailed degree of subdivision. Parts of this hierarchical structure proved rather complex to implement with the ArcPad® software and have been modified in the device programming to make it more compatible. The original pick list structure, though, is provided here. The term "unsubdivided" in the pick lists is used to indicate that a more detailed degree of subdivision was not appropriate or achievable. In setting out the appropriate terms for use in areas in Ontario underlain by Precambrian rocks, we noted several cases of unintended inconsistency and/or contradiction in the stated use of various published terms or definitions. We have made "executive" decisions to rectify these cases for our purposes.

Some fundamental definitions, derived from the American Geosciences Institute's (AGI) Glossary of Geology (Neuendorf, Mehl and Jackson 2005), follow:

- *Lithology*: the description of rocks, especially in hand specimen and in outcrop, on the basis of such characteristics as colour, mineralogic composition, and grain size. As originally used, *lithology* was essentially synonymous with *petrography* as currently defined. Adjective: lithologic.
- *Nomenclature* (as applied to rocks): The practice of naming rocks according to a hierarchical system and formal procedure prescribed by accepted authoritative codes, e.g., the International Stratigraphic Guide or the North American Stratigraphic Code.
- *Petrography*: that branch of geology dealing with the description and systematic classification of rocks, especially igneous and metamorphic rocks and especially by means of microscopic examination of thin sections. *Petrography* is more restricted in scope than *petrology.*
- *Petrology*: that branch of geology dealing with the origin, occurrence, structure, and history of rocks. Petrology is broader in scope than *petrography.*
- *Rock*: An aggregate of one or more minerals, e.g., granite, sandstone, marble; or a body of amorphous matter, e.g., obsidian; or a lithified organic material, e.g., coal.

Note that the term "lithologies" should not be used as it is neither a correct word nor a proper substitute for "rocks" or "rock types".

This manual is intended as a reference guide for Precambrian rocks for use within the ERGMS of the OGS. However, expressions of interest from geologists outside of the OGS have been conveyed. Publication of this manual with its attendant figures and tables not only contributes toward establishing a more consistent use of geological terms within the OGS but also allows all users of the survey's products to be aware of the terminology being used for maps, reports and databases.

Each figure has been designed to fit within the limits of a single page. To facilitate referral to the figures, they are grouped together at the end of this report. Tables that can fit legibly on a page are included in the main body of text, whereas more comprehensive, oversize tables have been placed in the back pocket. In Part 1, the paired tables for rock type classification and pick lists are colour co-ordinated. In Part 2, pairs of colours in each table are unique to each table and are used for visual separation of columns only.

The layout of the manual is as follows:

Part 1 includes nomenclature and definitions for the following major classes of rocks:

- Igneous (Intrusive and Volcanic subclasses);
- Sedimentary (Terrigenous-clastic and Chemical subclasses);
- Metamorphic (Structural basis, Compositional basis, Migmatites, and Metasomatic rocks subclasses); and
- Other (Fault rocks and Impactite rocks subclasses)

Part 2 includes modifiers and definitions for the above rock classes and all corresponding subdivisions as well as for structural features, alteration, mineralization and mineralogy.

This manual is not intended as a guide for the construction of map legends or the creation and use of formal and informal stratigraphic (*sensu lato*) units. These activities currently remain the purview of the individual mapper, although it is possible that such guidelines may be forthcoming.

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Part 1: Rock Nomenclature

Consistency in rock nomenclature has been a key issue to geologists for hundreds of years. In the last one or two decades, major international and intracontinental efforts have been made to address long-standing and new issues, such as melding nomenclature schemes with systematic design of digital geologic databases. Several committees assigned to develop nomenclature schemes have presented their principles of nomenclature as noted below. The nomenclature scheme now used by the OGS, outlined in this manual, is largely derived from these various schemes.

SOURCES OF INFORMATION

The following are the main sources of information for various rock classes used by the OGS-ERGMS Rock Committee in developing the standards outlined in this manual.

- Igneous rocks (intrusive and volcanic): International Union of Geological Sciences (IUGS) subcommission on the systematics of igneous rocks (Le Maitre 2002) and American Geological Institute (AGI) glossary of geology (Neuendorf, Mehl and Jackson 2005, and on-line version).
- Sedimentary rocks (terrigenous-clastic and chemical): Science Language Technical Team (SLTT) (Soller 2004a) and AGI glossary of geology (Neuendorf, Mehl and Jackson 2005, and on-line version).
- Metamorphic rocks: IUGS subcommission on the systematics of metamorphic rocks (Fettes and Desmons 2007), SLTT (Soller 2004b), AGI glossary of geology (Neuendorf, Mehl and Jackson 2005, and on-line version) and Sawyer (2008).
- Other rock categories (fault rocks and impactites): IUGS subcommission on the systematics of metamorphic rocks (Fettes and Desmons 2007) and AGI glossary of geology (Neuendorf, Mehl and Jackson 2005, and on-line version). Note that the IUGS subcommission on the systematics of metamorphic rocks includes fault rocks and impactites as metamorphic rocks.
- Other sources and modifications for OGS purposes are noted in the text.

The following main points for systematic rock nomenclature have been culled from the major sources cited above. The OGS differs with some points for rocks of low to medium metamorphic grade, whereby the interpreted protolith rock name is given priority where possible (*see* section on “Igneous Rocks”, Part 1).

Igneous Rocks (IUGS: Le Maitre 2002)

- The primary classification should be based on the mineral content or mode. For fine-grained rocks or those consisting wholly or partly of glass, other criteria may be used (e.g., chemical composition).
- Rocks should be named according to what they are, and not according to what they might have been.
- Natural relationships should be taken into account in a classification scheme.
- The classification should take into account well-established historical terms so that drastic redefinitions are not required.
- The classification should be simple and easy to use.

Sedimentary Rocks (SLTT: Soller 2004a)

- The classification should provide a logical, consistent, hierarchical framework for naming and classifying rocks.
- The system must also be robust and flexible.
- The scheme should be clearly understandable, internally consistent, and usable by both data user and data producer.
- Names should be adopted that express a singular science concept (e.g., grain size), be narrowly defined, relatively simple and explicit, and reflect only those attributes essential for the identification and naming of an object or concept.

Metamorphic Rocks ([1]IUGS: Fettes and Desmons 2007; [2]SLTT: Soller 2004b; [3]Sawyer 2008)

- [1]The scheme must provide a consistent set of names to cover the spectrum of rock types and their characteristics without any terminology gaps.
- [1]The scheme must ensure that all users can apply the same criteria to give any rock or its characteristic features the same name. These names should be understood uniquely and without ambiguity.
- [2]The system should be as descriptive as possible, not genetic, and be complete (must cover all metamorphic rocks).
- [2]The system should be hierarchical (e.g., superclasses, classes, subclasses) and may use more than one concept (e.g., rock fabric or composition (modal mineralogy)), but a classification must be unique.
- [2]The protolith of a rock must not determine the classification, but may be part of it.
- [2]The classification must be useful, simple and flexible.
- [2]Properties used for field classification include modal mineralogy, grain size, grain shape, rock fabric (arrangement of grains) and structures (e.g., bedding, layering).
- [3]The term migmatite refers to a rock that, in part, has formed by partial melting of an existing rock that also contains the partial melts.

GOALS AND MODIFICATIONS

The principal component of legends for ERGMS Precambrian geology maps is rock type. Centuries of rock nomenclature have led to a plethora of rock names in the literature, many of which over time have a) become in or out of fashion; b) been deemed technically incorrect; or c) evolved into numerous modified definitions leading to ambiguity as to the intended meaning. Local variations in usage have often developed based on geography and/or country. Various attempts, particularly since the mid-1960s (e.g., Streckeisen 1967, 1976), have been made to condense and clarify the terminology, with the intention of working toward a worldwide common nomenclature. To that end, progress has been made but consensus has not always been possible and variations in usage still occur.

To date, all of the groups involved in these national and international efforts toward achieving a standard nomenclature have focussed their efforts on individual rock classes (e.g., igneous). In contrast, this study examined all 4 main rock classes and, wherever possible, tried to find commonalities in nomenclature among the different rock classes, especially in the use of modifiers.

In our endeavours to choose a rock nomenclature scheme that would be supported, as much as possible, by acknowledged current recommended usage, we recognized that the preferred terminology did not always adequately address some specific rock types that occur in Ontario. These situations can largely be ascribed to a) the effects of metamorphism and/or deformation superposed on Precambrian rocks; or b) the occurrence of rocks that are much more common in Precambrian terranes than in Phanerozoic terranes. In many cases, ERGMS Precambrian geologists attempt to infer protoliths for what are commonly variably deformed, low- to medium-grade metamorphosed rocks. In other cases, highly deformed rocks and/or rocks metamorphosed under high-grade conditions are encountered and must be interpreted appropriately. The spectrum of strain and metamorphism observed in Ontario's Precambrian rocks requires use of a robust, comprehensive nomenclature based on original protolith, metamorphism and deformation. Notwithstanding preferred definitions, we have chosen to modify the definition and/or the use of some rock names in specific cases, which are noted and explained in this manual.

USE OF A "NOTES" FIELD IN THE ROCK NAME PICK LISTS WITHIN ARCPAD®

Under each rock class, the provision exists in the customized ArcPad® pick lists for the inclusion of free-form notes. This Notes field can be used to provide additional information on the rock unit that is not conferred in the standardized pick lists. For example, the Notes field could be used to indicate if the rock was part of a defined stratigraphic unit (e.g., a sandstone present in the Huronian Supergroup), or if the geoscientist wanted to assign rocks to a field legend at the time the data were first collected in the field.

IGNEOUS ROCKS

The igneous rocks category is subdivided into 2 classes, based on method of emplacement, namely "Intrusive" and "Volcanic". An explanation for the use of these terms is in order. Although the term "plutonic" is used by the International Union of Geological Sciences (IUGS) to define such terms as "gabbro" and "granite", the term is implicitly defined as "an igneous rock or intrusive body formed at great depth" (AGI: Neuendorf, Mehl and Jackson 2005). The use of depth of emplacement in the definition could be considered unnecessarily restrictive and may not be appropriate for our mapping purposes. Hence, in our rock lists, we have chosen to use the broader term "intrusive" to include "plutonic", "hypabyssal" and all other igneous rocks intruded at intermediate depths. We are invoking, however, the plutonic terminology of the IUGS for the classic common phaneritic rocks. Aphanitic rocks are placed in the "Miscellaneous Cases" category and are based on inferred colour index.

All references to colour index in this manual are based on volume per cent mafic minerals and are subdivided into the following ranges: felsic <15; intermediate 15 to 35; mafic 35 to 90; and ultramafic >90. Mineral abundances can be estimated in the field (Figure 2) and, along with mineral ratios, can be more precisely applied later in the laboratory or office settings.

Although one might expect that the term "Extrusive" would be the logical counterpart to "Intrusive", the OGS has traditionally used the term "Volcanic" (and "Intrusive", for that matter) in its legends. Hence, we have chosen to retain the terms "Intrusive" and "Volcanic".

In practice, the application of the terms "Intrusive" and "Volcanic" is fraught with several difficulties, most notably the lack of complete exposure. Contact relationships in the field, which could unequivocally demonstrate an intrusive relationship, are commonly not observed. Coarse-grained centres of flows may appear similar to "plutonic" textures. Differentiation in some flows, particularly those of komatiitic composition, may lead to cumulate rocks that appear similar to fine- to medium-grained intrusive rocks. Moreover, a rock may be a contemporaneous hypabyssal or subvolcanic intrusion (e.g., dike) within volcanic flows, in which case, some geologists have used arguably contradictory terms such as "basalt dike". As such, the rock name applied in the field often applies a degree of interpretation, not implicit in a definition. The definitions are expected to take priority. The above situations can be appropriately accommodated in the design of a map legend.

The IUGS system for naming igneous rocks followed several principles. We are in accord with most of those principles, including the use of rock root names, accompanied by appropriate modifiers (e.g., hornblende granodiorite). However, we differ on one particular principle. That is, for our purposes, given that most of the Precambrian rocks in Ontario are deformed and/or metamorphosed to some degree, we attempt, where practical, to name a rock based on what it was, not what it is. This is contrary to the stated IUGS principle. The OGS has an established culture of producing maps that attempt to depict the distribution of rocks which are named with respect to their original mode of deposition or emplacement, be they intrusive, volcanic, sedimentary, or to some extent, mineralization. However, there are areas of notable deformation and/or metamorphism (e.g., Grenville Province) whereby the most appropriate terminology is that based on a metamorphic system. We think that this approach, perhaps imperfect, still serves our purposes and our clients better.

The IUGS treatise on igneous rocks recognizes that no single method of classification can apply to all igneous rocks. As such, the IUGS recommends a hierarchy of classifications so that geologists can consistently choose the best one. Geologists should choose the appropriate section in this OGS manual after determining the applicable type of igneous rock from the following hierarchical sequence: 1) pyroclastic origin; 2) carbonatite (>50% primary modal carbonate); 3) melilite-bearing rock (>10% modal melilite); 4) kalsilite-bearing rock (modal); 5) kimberlite; 6) lamproite; 7) leucite-bearing rock (modal); 8) lamprophyre; 9) charnockite; 10) plutonic; 11) volcanic. Note that, in this manual, the section "Volcanic Rocks" includes pyroclastic rocks.

Intrusive Rocks

The intrusive rocks are subdivided into 17 categories, 9 of which can be graphically represented in one diagram. The “rules of engagement” for use of plutonic or phaneritic intrusive rock names are given in Le Maitre (2002). The classification is based on certain modal primary mineral criteria, which are defined as follows for rocks with a value of M <90:

- M = volume percent of mafic and so-called “related” minerals: mica, amphibole, pyroxene, olivine, opaque minerals, accessory minerals (such as zircon, apatite, titanite), epidote, allanite, garnet, melilite, monticellite, primary carbonate
- M′ = colour index = volume percent of dark-coloured ferromagnesian minerals = M minus muscovite, apatite, primary carbonates, epidote, garnet, melilite, monticellite, and opaque and accessory minerals
- Q = quartz
- A = alkali feldspar, including orthoclase, microcline, perthite, anorthoclase, sanidine, albitic plagioclase (An_0 to An_5)
- P = plagioclase (An_5 to An_{100}) and scapolite
- F = feldspathoid (also known as foid), including nepheline, leucite, kalsilite, analcime, sodalite, nosean, haüyne, cancrinite and pseudoleucite
- Q + A + P + F + M = 100%, and components of QAP or FAP are recalculated to total 100% for use in a double triangle figure (e.g., Figure 3)
- Primary Q and F cannot co-exist in an igneous rock

Details of intrusive rock types for this manual are provided as follows:

- The general outline for the Intrusive Rock Classification (4 levels) is given in Table 1.
- The specific outline with rationale is in Table 2 (back pocket).
- The hierarchical organization of the pick lists for field data input is given in Table 3 (back pocket).
- For field use, a provisional graphical representation of the first 9 subdivisions of Level 2 is shown in Figure 3.
- A detailed graphical representation of the first 9 subdivisions is shown in Figure 4.
- Subdivisions of gabbro (Level 4) are depicted in Figure 5 and subdivisions of peridotites, pyroxenites and hornblendites (Level 4) are shown in Figure 6.
- Prefixation to the root intrusive rock names (e.g., “leuco”, “mela”) based on colour index (M′) is provided in Figures 7 and 8.
- Definitions for the rock types are provided in Table 4.
- Definitions for additional intrusive rock terms are in Table 5.
- Both Figures 3 and 4 should be used in conjunction with the definitions.

Table 1. Intrusive rocks: overview.

Level 1	Intrusive Rock Classification
Level 2 (Rock class)	Granitoid
	Syenitoid
	Dioritoid
	Gabbroid
	Anorthosoid
	Foid Syenitoid
	Foid Dioritoid
	Foid Gabbroid
	Foidolite
	Ultramafic rock
	Miscellaneous cases
	Carbonatite
	Melilitolite
	Kalsilite-bearing rock
	Kimberlite
	Lamproite
	Lamprophyre
Level 3 (Rock name)	Additional subdivisions of almost all Level 2 subdivisions
Level 4 (Rock name)	Additional subdivisions of some rocks at Level 3, particularly gabbro-norite rocks, peridotite-pyroxenite-hornblendite rocks and foidolite rocks

DEFINITIONS

Table 4 provides the essential components for the definitions of intrusive rock names. Relatively uncommon rocks such as carbonatites, melilite-bearing rocks, kalsilite-bearing rocks, kimberlites, lamproites and lamprophyres generally have the most complicated classifications. Key points regarding all rock types are found in Table 4. Table 5 outlines additional terminology for selected intrusive rock topics, including unusual rocks. Features summarized in Table 2 outline major aspects of rock naming, but geologists faced with unusual or uncommon rock types (*see* Table 5) would benefit from additional information on nomenclature in Le Maitre (2002). For feldspathoid-bearing rocks, the predominant feldspathoid mineral name should replace the word “foid” in a rock name (e.g., leucite-bearing monzonite (leucite <10% of FAP ratios) or nepheline syenite (nepheline >10% of FAP ratios)).

An “essential” mineral, in the petrological sense, is a mineral component of a rock that is necessary to its classification and nomenclature, but not necessarily present in large amounts. An “accessory” mineral is one that is not essential to the proper classification of the rock and generally occurs in minor amounts.

Note that the rock name “pyroxenite” can be applied in 2 ways or at 2 levels (*see* Table 3). As a Level 3 designation, it refers to a group of rocks consisting of significant amounts of pyroxene. As a Level 4 designation, it refers specifically to a rock with >90% pyroxene relative to olivine – pyroxene – hornblende. If the general definition is desired, then one would choose “pyroxenite” Level 3 and then “unsubdivided” at Level 4. If the specific definition is desired, then one would choose “pyroxenite” at Level 3 followed by “pyroxenite” at Level 4.

Table 4. Intrusive rocks: definitions, based on the schemes shown in Figures 3 to 6 and 9.

Rock Class	Rock Name[A]	Definition[B,C]	Figure	Field[D]
Granitoid		Collective term for rocks consisting mostly of quartz, alkali feldspar and plagioclase A tentative field term for unsubdivided rocks of the granitoid group (quartz 20 to 60% of QAP minerals)	3	–
	Alkali-feldspar granite	Variety of *granite* with relatively little plagioclase (quartz 20 to 60% of QAP minerals; plagioclase <10% of total feldspar)	4	2
	Granite	Consists mostly of various amounts of quartz, alkali feldspar and sodic plagioclase, with biotite and/or hornblende Collective term for monzogranite and syenogranite (quartz 20 to 60% of QAP minerals)	4	3a + 3b
	Granodiorite	Consists mostly of quartz, sodic plagioclase and lesser amounts of alkali feldspar, with minor hornblende and/or biotite (quartz 20 to 60% of QAP minerals)	4	4
	Monzogranite	Variety of *granite* with subequal amounts of alkali feldspar and plagioclase (considered an optional term) (quartz 20 to 60% of QAP minerals)	4	3b
	Syenogranite	Variety of *granite* with alkali feldspar and subordinate plagioclase (considered an optional term) (quartz 20 to 60% of QAP minerals)	4	3a
	Tonalite	Consists mostly of quartz and intermediate plagioclase, usually with biotite and/or amphibole (quartz 20 to 60% of QAP minerals; alkali feldspar <10% of total feldspar)	4	5
	Quartzolite	Quartz >90% of QAP minerals	4	1a
	Quartz-rich granitoid	Consists chiefly of quartz along with alkali feldspar and plagioclase (quartz 60 to 90% of QAP minerals)	4	1b
Syenitoid		Collective term for rocks consisting mostly of alkali feldspar, plagioclase and subordinate quartz or minor feldspathoids A tentative field term for unsubdivided syenitic rocks (either quartz <20% of QAP minerals, or feldspathoid <10% of FAP minerals)	3	–
	Alkali-feldspar syenite	Variety of *syenite* with a small amount of plagioclase (quartz <5% of QAP minerals; plagioclase <10% of total feldspar)	4	6
	Foid-bearing alkali-feldspar syenite	Variety of undersaturated *syenite* with a small amount of feldspathoid and plagioclase (feldspathoid <10% of FAP minerals; plagioclase <10% of total feldspar)	4	6′
	Foid-bearing monzonite	Variety of undersaturated *monzonite* with a small amount of feldspathoid (feldspathoid <10% of FAP minerals)	4	8′
	Foid-bearing syenite	Variety of undersaturated *syenite* with a small amount of feldspathoid (feldspathoid <10% of FAP minerals)	4	7′
	Monzonite	Consists mostly of subequal amounts of alkali feldspar and plagioclase, with minor quartz and some amphibole and/or pyroxene (quartz <5% of QAP minerals)	4	8
	Quartz alkali-feldspar syenite	Variety of *syenite* consisting mostly of alkali feldspar, essential quartz, and mafic minerals (quartz 5 to 20% of QAP minerals; plagioclase <10% of total feldspar)	4	6*
	Quartz monzonite	Variety of *monzonite* consisting mostly of subequal amounts of alkali feldspar and plagioclase, with essential quartz (quartz 5 to 20% of QAP minerals)	4	8*
	Quartz syenite	Variety of *syenite* consisting mostly of alkali feldspar, essential quartz and some mafic minerals (quartz 5 to 20% of QAP minerals)	4	7*
	Syenite	Consists mostly of alkali feldspar with subordinate sodic plagioclase, minor quartz, and biotite, pyroxene, amphibole, (rarely fayalite) (quartz <5% of QAP minerals)	4	7
Dioritoid		Collective term for rocks consisting mostly of plagioclase ($An_{<50}$) with subordinate alkali feldspar and quartz or feldspathoid, as well as some amphibole and biotite A tentative field term for unsubdivided dioritic rocks (quartz <20% of QAP minerals or feldspathoid <10% of FAP minerals)	3	–

Table 4. *continued*

Rock Class	Rock Name[A]	Definition[B,C]	Figure	Field[D]
	Diorite	Consists mostly of plagioclase ($An_{<50}$) with hornblende, minor quartz, and commonly biotite or augite (quartz <5% of QAP minerals; alkali feldspar <10% of total feldspar; M′ >10)	4	10
	Foid-bearing diorite	Variety of undersaturated *diorite* with a small amount of feldspathoid (feldspathoid <10% of FAP minerals; alkali feldspar <10% of total feldspar)	4	10′
	Foid-bearing monzodiorite	Variety of undersaturated *monzodiorite* with a small amount of feldspathoid (feldspathoid <10% of FAP minerals)	4	9′
	Monzodiorite	Variety of diorite intermediate between *monzonite* and *diorite*, consisting mostly of plagioclase ($An_{<50}$), lesser alkali feldspar and minor quartz (quartz <5% of QAP minerals)	4	9
	Quartz diorite	Variety of *diorite* consisting mostly of plagioclase, essential quartz, and mafic minerals (quartz 5 to 20% of QAP minerals; alkali feldspar <10% of total feldspar)	4	10*
	Quartz monzodiorite	Variety of *monzodiorite* consisting mostly of plagioclase, alkali feldspar and essential quartz, with some mafic minerals (quartz 5 to 20% of QAP minerals)	4	9*
Gabbroid		Collective term for rocks consisting mostly of plagioclase ($An_{>50}$), with subordinate alkali feldspar and quartz or feldspathoid, as well as some pyroxene and hornblende A tentative field term for unsubdivided gabbroic rocks (quartz <20% of QAP minerals or feldspathoid <10% of FAP minerals)	3	–
	Clinopyroxene norite	Variety of *norite* consisting mostly of orthopyroxene, lesser clinopyroxene, and plagioclase (plagioclase 10 to 90%)	5D	2
	Foid-bearing gabbro	Variety of undersaturated *gabbro* with a small amount of feldspathoid (feldspathoid <10% of FAP minerals; alkali feldspar <10% of total feldspar)	4	10′
	Foid-bearing monzogabbro	Variety of undersaturated *monzogabbro* with a small amount of feldspathoid (feldspathoid <10% of FAP minerals)	4	9′
	Gabbro	Consists mostly of calcic plagioclase ($An_{>50}$), clinopyroxene, minor quartz, iron oxide minerals and <5% each of olivine, hornblende and orthopyroxene (quartz <5% of QAP minerals; alkali feldspar <10% of total feldspar; plagioclase 10 to 90% for Figure 5; M′ >10)	4, 5A, 5B, 5D	10, 2, 2, 4
	Gabbronorite	Variety of *gabbro* with >5% each of orthopyroxene and clinopyroxene and <5% each of olivine or hornblende (plagioclase 10 to 90%)	5A, 5B, 5D	2, 2, 2 + 3
	Hornblende gabbro	Variety of *gabbro* with primary hornblende and <5% pyroxene (hornblende 5 to 85%; plagioclase 10 to 90%)	5B	4
	Monzogabbro	Variety of *gabbro* intermediate between monzonite and gabbro, consisting mostly of plagioclase ($An_{>50}$), alkali feldspar and minor quartz (quartz <5% of QAP minerals)	4	9
	Norite	Variety of *gabbro* consisting mostly of plagioclase (bytownite, labradorite or andesine) and orthopyroxene with <5% each of olivine, hornblende and clinopyroxene (plagioclase 10 to 90%)	5A, 5B, 5D	2, 2, 1
	Olivine gabbro	Variety of *gabbro* with essential olivine (olivine and pyroxene each 5 to 85%; plagioclase 10 to 90%)	5A	3
	Olivine gabbronorite	Variety of *gabbronorite* with essential olivine (olivine and pyroxene each 5 to 85%; plagioclase 10 to 90%)	5A	3
	Olivine norite	Variety of *norite* with essential olivine (olivine and pyroxene each 5 to 85%; plagioclase 10 to 90%)	5A	3
	Orthopyroxene gabbro	Variety of *gabbro* consisting mostly of clinopyroxene, lesser orthopyroxene, and plagioclase (plagioclase 10 to 90%)	5D	3
	Pyroxene hornblende gabbro	Variety of *gabbro* with hornblende and pyroxene, each 5 to 85% (plagioclase 10 to 90%)	5B	3

Table 4. *continued*

Rock Class	Rock Name[A]	Definition[B,C]	Figure	Field[D]
	Pyroxene hornblende gabbronorite	Variety of *gabbronorite* with hornblende and pyroxene each 5 to 85% (plagioclase 10 to 90%)	5B	3
	Pyroxene hornblende norite	Variety of *norite* with hornblende and pyroxene each 5 to 85% (plagioclase 10 to 90%)	5B	3
	Quartz gabbro	Variety of *gabbro* consisting mostly of plagioclase, essential quartz, and mafic minerals (quartz 5 to 20% of QAP minerals; alkali feldspar <10% of total feldspar)	4	10*
	Quartz monzogabbro	Variety of *monzogabbro* consisting mostly of plagioclase, alkali feldspar, and essential quartz, with some mafic minerals (quartz 5 to 20% of QAP minerals)	4	9*
	Troctolite	Variety of *gabbro* consisting mostly of plagioclase and olivine (plagioclase 10 to 90%; olivine 5 to 85%; pyroxene <5%)	5A	4
Anorthosoid[E]		Collective term for rocks consisting almost entirely of plagioclase with minor quartz or feldspathoid A tentative field term for unsubdivided anorthositic rocks (quartz <5% of QAP minerals or feldspathoid <10% of FAP minerals)	3	–
	Anorthosite	Hololeucocratic rock (M′ <10) consisting almost entirely of plagioclase (plagioclase >90%; quartz <5% of QAP minerals; alkali feldspar <10% of total feldspar)	4, 5A, 5B	10, 1, 1
	Foid-bearing anorthosite	Variety of *anorthosite* with a small amount of feldspathoid (feldspathoid <10% of FAP minerals; alkali feldspar <10% of total feldspar)	4	10′
	Quartz anorthosite	Variety of *anorthosite* with essential quartz (quartz 5 to 20% of QAP minerals; alkali feldspar <10% of total feldspar)	4	10*
Foid syenitoid		Collective term for rocks consisting mostly of feldspathoid, alkali feldspar and lesser plagioclase A tentative field term for unsubdivided foid syenitic rocks (feldspathoids 10 to 60% of FAP minerals)	3	–
	Foid monzosyenite	Consists mostly of alkali feldspar, feldspathoid and subordinate plagioclase, with some mafic minerals (feldspathoid 10 to 60% of FAP minerals; plagioclase <50% of total feldspar)	4	12
	Foid syenite	Variety of undersaturated *syenite* consisting mostly of feldspathoid, alkali feldspar and mafic minerals (feldspathoid 10 to 60% of FAP minerals; plagioclase <10% of total feldspar)	4	11
Foid dioritoid		Collective term for rocks consisting mostly of feldspathoid, plagioclase ($An_{<50}$) and lesser alkali feldspar A tentative field term for unsubdivided foid dioritic rocks (feldspathoids 10 to 60% of FAP minerals)	3	–
	Foid diorite	Variety of undersaturated *diorite* consisting mostly of feldspathoid, plagioclase and generally notable amounts of mafic minerals (feldspathoid 10 to 60% of FAP minerals; alkali feldspar <10% of total feldspar)	4	14
	Foid monzodiorite	Variety of undersaturated *monzodiorite* consisting mostly of intermediate plagioclase and feldspathoid, with subordinate alkali feldspar and generally notable amounts of mafic minerals (feldspathoid 10 to 60% of FAP minerals; plagioclase >50% of total feldspar)	4	13
Foid gabbroid		Collective term for rocks consisting mostly of feldspathoid, plagioclase ($An_{>50}$) and lesser alkali feldspar A tentative field term for unsubdivided foid gabbroic rocks (feldspathoid 10 to 60% of FAP minerals)	3	–
	Foid gabbro	Variety of undersaturated *gabbro* consisting mostly of feldspathoid, plagioclase and generally notable amounts of mafic minerals (feldspathoid 10 to 60% of FAP minerals; alkali feldspar <10% of total feldspar)	4	14

Table 4. *continued*

Rock Class	Rock Name[A]	Definition[B,C]	Figure	Field[D]
	Foid monzogabbro	Variety of undersaturated *monzogabbro* consisting mostly of plagioclase and feldspathoid, with subordinate alkali feldspar, and generally notable amounts of mafic minerals (feldspathoid 10 to 60% of FAP minerals; plagioclase >50% of total feldspar)	4	13
Foidolite[F]		*See* footnote "F" and "Foidolite" below	3	–
	Foidolite	Collective term for rocks consisting mostly of feldspathoid and lesser feldspars (feldspathoid 60 to 100% of FAP minerals)	3, 4	–, 15
	Leucitolite[G]	Variety of *foidolite* with leucite as the most abundant feldspathoid	–	–
	Nephelinolite	Variety of *foidolite* with nepheline as the most abundant feldspathoid	–	–
Ultramafic rock		A rock with M′ >90	6	–
	Clinopyroxenite	Variety of *pyroxenite* consisting almost entirely of clinopyroxene (clinopyroxene >90%)	6A	10
	Dunite	Variety of *peridotite* consisting almost entirely of olivine (olivine >90%)	6A, 6B	1, 1
	Harzburgite	Variety of *peridotite* consisting mostly of olivine and orthopyroxene (olivine 40 to 90%; clinopyroxene <5%)	6A	2
	Hornblende peridotite	Variety of *peridotite* consisting mostly of olivine and hornblende (olivine 40 to 90%; pyroxene <5%)	6B	4
	Hornblende pyroxenite	Variety of *pyroxenite* consisting mostly of pyroxene and hornblende (olivine <5%)	6B	10
	Hornblendite	Consists almost entirely of hornblende (hornblende >90%)	6B	12
	Lherzolite	Variety of *peridotite* consisting of olivine, orthopyroxene and clinopyroxene (olivine 40 to 90%)	6A	3
	Olivine clinopyroxenite	Variety of *pyroxenite* consisting mostly of clinopyroxene and subordinate olivine (olivine 5 to 40%; orthopyroxene <5%)	6A	7
	Olivine hornblende pyroxenite	Variety of *pyroxenite* with 30 to 90% pyroxene and various amounts of hornblende and olivine (olivine 5 to 40%; hornblende <46%)	6B	6
	Olivine hornblendite	Variety of *hornblendite* consisting mostly of hornblende and subordinate olivine (olivine 5 to 40%; pyroxene <5%)	6B	8
	Olivine orthopyroxenite	Variety of *pyroxenite* consisting mostly of orthopyroxene and subordinate olivine (olivine 5 to 40%; clinopyroxene <5%)	6A	5
	Olivine pyroxene hornblendite	Variety of *hornblendite* with 30 to 90% hornblende and various amounts of pyroxene and olivine (olivine 5 to 40%; pyroxene <46%)	6B	7
	Olivine pyroxenite	Variety of *pyroxenite* consisting mostly of pyroxene and subordinate olivine (olivine 5 to 40%; hornblende <5%)	6B	5
	Olivine websterite	Variety of *pyroxenite* consisting mostly of orthopyroxene and clinopyroxene, with subordinate olivine (olivine 5 to 40%)	6A	6
	Orthopyroxenite	Variety of *pyroxenite* consisting almost entirely of orthopyroxene (orthopyroxene >90%)	6A	8
	Peridotite	A collective term for ultramafic rocks consisting mostly of olivine and pyroxene and/or hornblende (olivine 40 to 100%)	6A, 6B	–
	Plagioclase-bearing hornblendite	Variety of *hornblendite* consisting mostly of hornblende with essential plagioclase (hornblende >90%; plagioclase <10%)	5B	8
	Plagioclase-bearing hornblende pyroxenite	Variety of *pyroxenite* consisting mostly of pyroxene and hornblende with essential plagioclase (pyroxene 45 to 90%, hornblende <50%, plagioclase <10%)	5B	6

Table 4. *continued*

Rock Class	Rock Name[A]	Definition[B,C]	Figure	Field[D]
	Plagioclase-bearing pyroxene hornblendite	Variety of *hornblendite* consisting mostly of hornblende and pyroxene with essential plagioclase (hornblende 45 to 90%; pyroxene <50%, plagioclase <10%)	5B	7
	Plagioclase-bearing pyroxenite	Variety of *pyroxenite* consisting mostly of pyroxene with essential plagioclase (pyroxene >90%; plagioclase <10%)	5B	5
	Pyroxene hornblende peridotite	A variety of *peridotite* consisting of olivine, pyroxene and hornblende (olivine 40 to 90%)	6B	3
	Pyroxene hornblendite	Variety of *hornblendite* consisting mostly of hornblende and pyroxene (olivine <5%)	6B	11
	Pyroxene peridotite	Variety of *peridotite* consisting mostly of olivine and pyroxene (olivine 40 to 90%; hornblende <5%)	6B	2
	Pyroxenite	This term can be used in 2 ways – see text for use with pick lists: a) *Sensu lato*: Corresponds to Level 3 – a collective term for ultramafic rocks consisting mostly of pyroxene and subordinate olivine and/or hornblende (olivine <40%) b) *Sensu stricto*: Corresponds to Level 4 – a specific term for a rock consisting almost entirely of pyroxene (pyroxene >90%)	6A, 6B 6B	- 9
	Websterite	Variety of *pyroxenite* consisting mostly of orthopyroxene and clinopyroxene (olivine <5%)	6A	9
	Wehrlite	Variety of *peridotite* consisting almost entirely of olivine and clinopyroxene, often with minor brown biotite (olivine 40 to 90%; orthopyroxene <5%)	6A	4
Carbonatite		A collective term for igneous (i.e., intrusive and volcanic) rocks consisting of >50% modal primary carbonate	–	–
	Calciocarbonatite	A chemically defined variety of *carbonatite* in which $CaO/(CaO+MgO+FeO+Fe_2O_3+MnO)$ [wt %] >0.8	9	–
	Calcite-carbonatite	A variety of *carbonatite* with calcite as the main carbonate mineral	–	–
	Dolomite-carbonatite	A variety of *carbonatite* with dolomite as the main carbonate mineral	–	–
	Ferrocarbonatite	Can be used in 2 ways: a) a modally defined variety of *carbonatite* in which the main carbonate mineral is iron rich; or b) a chemically defined variety of carbonatite in which $CaO/(CaO+MgO+FeO+Fe_2O_3+MnO)$ [wt %] <0.8 and $MgO < (FeO+Fe_2O_3+MnO)$ [wt %]	– 9	– –
	Magnesiocarbonatite	A chemically defined variety of *carbonatite* in which $CaO/(CaO+MgO+FeO+Fe_2O_3+MnO)$ [wt %] <0.8 and $MgO > (FeO+Fe_2O_3+MnO)$ [wt %]	9	–
	Silicocarbonatite	A variety of *carbonatite* which is chemically defined, with SiO_2 >20%; silicate minerals may be in excess of carbonate minerals; silicates may be sodic pyroxenes and amphiboles, biotite, phlogopite, olivine or feldspars	–	–
Melilitolite		A general term for melilite-bearing intrusive rocks (modally: melilite >10%; melilite > feldspathoid (if present); generally M >90) (IUGS refers, in one place, to melilitolite as an ultramafic rock; not corroborated)	–	–
	Olivine melilitolite	A *melilitolite* with at least 10% olivine, and less than 10% clinopyroxene (AGI)	–	–
	Olivine pyroxene melilitolite	A *melilitolite* consisting mostly of melilite, olivine, and clinopyroxene, with clinopyroxene > olivine (AGI)	–	–
	Pyroxene melilitolite	A *melilitolite* consisting mostly of melilite and clinopyroxene, with less than 10% olivine (AGI)	–	–
	Pyroxene olivine melilitolite	A *melilitolite* consisting mostly of melilite, olivine, and clinopyroxene, with olivine>clinopyroxene (AGI)	–	–
Kalsilite-bearing rock		Principal minerals include clinopyroxene, kalsilite, leucite, melilite, olivine and phlogopite	–	–
	Kalsilitite	A *kalsilite-bearing rock* with neither leucite or melilite.	–	–

Table 4. *continued*

Rock Class	Rock Name[A]	Definition[B,C]	Figure	Field[D]
Kimberlite		An ultramafic rock that cannot be defined but is characterized by mineralogical criteria and subdivided into "Group 1" and "Group II" (*see* text); consists of major amounts of serpentinized olivine with various amounts of phlogopite, orthopyroxene, clinopyroxene, carbonate and chromite	–	–
Lamproite		A comprehensive term that cannot be defined but is characterized by mineralogical and chemical criteria (*see* text); a rock type no longer considered a lamprophyre	–	–
Lamprophyre		A distinctive diverse class of rocks that cannot be chemically separated easily from "normal" igneous rocks (*see* text for more specific attributes) Below are generalized names developed by the OGS for field mapping purposes	–	–
	Mesocratic lamprophyre	*Lamprophyre* with M′ from 35 to 65	–	–
	Melanocratic lamprophyre	*Lamprophyre* with M′ from 65 to 90	–	–
	Holomelanocratic lamprophyre	*Lamprophyre* with M′ from 90 to 100	–	–
Miscellaneous cases	Aphanitic ultramafic	An aphanitic intrusive rock with M′ >90	–	–
	Aphanitic mafic	An aphanitic intrusive rock with M′ 35 to 65	–	–
	Aphanitic intermediate	An aphanitic intrusive rock with M′ 15 to 35	–	–
	Aphanitic felsic	An aphanitic intrusive rock with M′ <15	–	–
	Aplite	A fine-grained to aphanitic hololeucocratic dike (consists mostly of feldspar and quartz); M′ <10	–	–
	Pegmatite	A general term for a very coarse- to extremely coarse-grained intrusive rock Preferred use now is in adjectival form (*see* Part 2, "Rock Modifiers": e.g., pegmatitic granite, pegmatitic gabbro)	–	–
	Chromitite	A rock consisting of >90% chromite	–	–
	Ilmenitite	A rock consisting of >90% ilmenite	–	–
	Magnetitite	A rock consisting of >90% magnetite	–	–

[A] *Rock names are derived from Le Maitre (2002), except as noted, and listed alphabetically within classes.*
[B] *Where a mineral is referred to as essential, it means that it is necessary to its classification and nomenclature but not necessarily present in large amounts.*
[C] *AGI = Neuendorf, Mehl and Jackson (2005); IUGS = Le Maitre (2002).*
[D] *Field designations are shown in corresponding figures.*
[E] *The term "Anorthosoid" has been invoked for parallelism with other rock classification names.*
[F] *The term "Foiditoid", which would parallel other rock class names with the suffix "oid", has been reserved for volcanic rocks of similar composition and hence is not used here.*
[G] *The term "Leucitolite" (along with Nephelinolite) is provided as a specific example of a foidolite in the IUGS glossary, but is no where recognized or defined as an official rock name (IUGS, AGI, etc.); likely an oversight.*

SPECIAL CASES

Carbonatites

Carbonatites can be either intrusive or volcanic. No volcanic equivalents have yet been described in Ontario, thus these rocks are not listed under "Volcanic" rocks. Additional points relative to the properties listed in Table 4 are as follows:

- Primary modal carbonate minerals are >50%.
- Contrary to the IUGS, the OGS recommends that grain size not be used to define a rock name. For example, use "coarse-grained calcite-carbonatite" and not "sövite"; medium- to fine-grained calcite-carbonatite" and not "alvikite".

- If the carbonate minerals are <10% modally, then the specific mineral(s) can be used as a modifier: e.g., calcite-bearing dolomite-carbonatite; dolomite-bearing peridotite.
- If the carbonate minerals are from 10 to 50% modally, then the rocks can be modified with adjectives: e.g., carbonatitic ijolite; calcitic ijolite (*see* Table 5).

If the carbonatite is too fine grained for modal identification or contains Ca-Mg-Fe solid solution carbonate minerals, then a chemical classification can be used for carbonatites with <20% SiO_2, (Figure 9). Varieties of carbonatite in this classification are calciocarbonatite, magnesiocarbonatite and ferrocarbonatite. If the carbonatite has >20% SiO_2, then the rock is a silicocarbonatite.

Melilitolites

Intrusive melilite-bearing rocks with >10% modal melilite (a sorosilicate) are termed melilitolites (volcanic equivalents are called melilitites). Parameters include the following:

- Melilite >10% modally
- Melilite > feldspathoid (feldspathoid may be absent)
- Most melilitolites have M >90 and may be named according to their mineral content: e.g., pyroxene melilitolite
- Other principal minerals include perovskite, olivine, haüyne, nepheline and pyroxene.

For rocks with melilite < feldspathoid and feldspathoid >10%, use the FAP part of the double triangle (Figure 4). Example rock names are melilite nepheline syenite and melilite nephelinolite (*see* Table 4). Rocks containing melilite+kalsilite are classified as “kalsilite-bearing rocks”.

Kalsilite-bearing Rocks

Intrusive kalsilite-bearing rocks are particularly uncommon and may not occur in Ontario. These rocks may be more appropriately referred to using other root names (e.g., kalsilite pyroxenite). Kalsilite is a feldspathoid (tectosilicate).

Kimberlites

Kimberlites are complex, hybrid, ultramafic rocks which are based on mineralogical criteria and divided into 2 classes: named Group I and Group II. However, there is only partial consensus regarding more detailed nomenclature. The presence of leucite is precluded. Essential characteristics follow, but more detailed descriptions and caveats are provided in Le Maitre (2002):

Group I – volatile-rich (dominantly CO_2), potassic, ultrabasic rocks with distinctive inequigranular texture:

- Macrocrysts (0.5 to 10 mm): include forsteritic olivine (very common), Cr-pyrope, almandine-pyrope, Cr-diopside, magnesian ilmenite, phlogopite, Ti-poor chromite; (may include xenocrysts)
- Megacrysts (1 to 2 mm): include low-Cr varieties of magnesian ilmenite, Ti-pyrope, diopside, olivine, enstatite and Ti-poor chromite; (may include xenocrysts)
- Groundmass: olivine with one or more of monticellite, phlogopite, perovskite, spinel (Mg-ulvospinel – Mg-chromite – ulvospinel – magnetite solid solutions), apatite, carbonate, serpentine; Ni-sulphides and rutile as common accessory minerals
- May be diamondiferous

Group II – volatile-rich (dominantly H_2O), ultrapotassic, peralkaline rocks (also known as orangeites), which have a mineralogical affinity to lamproites, but are considered a separate rock type:

- Macrocrysts: phlogopite (characteristic); may include olivine
- "Microphenocrysts" (~0.5 to 1 mm): phlogopite (characteristic)
- Groundmass: includes micas (ranging from phlogopite to "tetraferriphlogopite) and a mixture of up to many other minerals including the following, noted by specific trace elements: diopside zoned to and mantled by aegirine (Ti), chromite (Mg), magnetite (Ti), perovskite (Sr, REE), apatite (Sr), phosphates (REE), titanates (K, Ba), triskaidecatitanates (K), rutile (Nb) and ilmenite (Mn), with possible sanidine, K-richterite and Zr-silicates

Lamproites

Lamproites typically occur as dikes or small extrusive bodies (the latter are not known to occur in Ontario) that are noted for potassium and magnesium contents and are based on mineralogical and chemical criteria. The unusual characteristics reflect diverse conditions involved in their genesis. Intrusive lamproites may occur in Ontario. Essential characteristics follow, but more detailed descriptions and caveats are provided in Le Maitre (2002):

MINERALOGICAL CRITERIA

- Primary mineral phases present include at least one that is dominant and 2 to 3 that are subordinate (specified ranges for indicated elements and oxides in Le Maitre (2002)): Al-poor, Ti-phlogopite phenocrysts; poikilitic, groundmass Ti-"tetraferriphlogopite; Ti-K-richterite; forsteritic olivine; Al- and Na-poor diopside; Fe-leucite; Fe-sanidine
- Accessory minerals (minor and common): priderite, wadeite, apatite, perovskite, Mg-chromite, Ti-Mg-chromite, Mg-Ti-magnetite
- Accessory minerals (less common): jeppeite, armalcolite, shcherbakovite, ilmenite, enstatite
- Precluded minerals: plagioclase (primary), melilite, monticellite, kalsilite, certain feldspathoids (nepheline, sodalite, nosean, haüyne), Na-rich alkali feldspar, melanite, schorlomite, kimzeyite

CHEMICAL CRITERIA

- Ultrapotassic: molecular K_2O/Na_2O >3; molecular K_2O/Al_2O_3 >0.8 (commonly >1)
- Peralkaline: molecular $(K_2O+Na_2O)/Al_2O_3$ >1
- FeO and CaO each generally <10%; TiO_2 1 to <7%; Ba >2000 ppm; Sr >1000 ppm; Zr >500 ppm; La >200 ppm

Lamprophyres

Lamprophyres comprise a diverse class of mafic to ultramafic rocks which typically exhibit the following characteristics:

- They commonly occur as dikes or small intrusions but are not typical textural varieties of intrusive or volcanic rocks.
- Porphyritic, with colour indexes ranging from 35 to (rarely) >90.
- Phenocryst phases are mafic minerals, typically biotite, amphiboles, pyroxenes.
- Groundmass commonly contains biotite and/or amphibole, sometimes clinopyroxene.
- Feldspars and feldspathoids (if present) are restricted to the groundmass.
- Alteration (hydrothermal, deuteric) of olivine, pyroxene, biotite and plagioclase is common.

- Primary mineral phases may include calcite, zeolites and other hydrothermal minerals.
- Compared to rocks of similar composition, lamprophyres are relatively high in K_2O and/or Na_2O, H_2O, CO_2, S, P_2O_5, and Ba.

There are at least 7 uncommon rock names for types of lamprophyre based on the type of feldspar, the ratio of feldspar to feldspathoid, and types and relative abundances of various mafic minerals. For the purpose of mapping lamprophyres in the OGS, we recommend classifying the lamprophyre based on colour index and noting the phenocryst phase(s) with modifiers. Detailed petrographic work may permit use of more explicit terminology which can be found in Le Maitre (2002) and outlined in Table 5.

Miscellaneous Cases

This category is reserved for rocks that are not explicitly covered in the IUGS classification and may be apropos to OGS mapping. Fine-grained intrusive rocks (dikes, sills, or otherwise) for which mineral modes cannot be determined in the field, may be assigned a rock name on the basis of an estimated colour index, such as “aphanitic mafic” dike (*see* Tables 2 and 3).

The term “aplite” is included as it commonly occurs as small dikes within or adjacent to some granitoid intrusions. The term “pegmatite” refers to a particularly coarse-grained facies of any igneous rock (i.e., not just granitoids). If the modal composition is evident, the preferred procedure is to select the appropriate rock name, based on mineralogy, and use the modifier “pegmatitic” to describe it (e.g., pegmatitic gabbro).

For layered intrusions in particular, the rock types “chromitite”, “ilmenitite” and “magnetitite” are included for use where appropriate.

Charnockitic Rocks

Because the definition of charnockitic rocks is in part based on the origin of the rock, which itself is controversial, i.e., either igneous and/or metamorphic, these rocks have not been included as a separate rock type in any of the figures or tables in this manual. Charnockitic rocks occur in some terranes that have undergone granulite-facies metamorphism, hence deformation and recrystallization are commonly evident.

The rocks represent orthopyroxene- (or fayalite-) bearing equivalents of several intrusive rocks, with charnockite (*sensu stricto*) being an orthopyroxene granite. Many of these rocks display perthite, mesoperthite or antiperthite textures and, as such, a relatively precise in-field use of the QAP triangle is rendered difficult. A procedure for handling these textures within the QAP scheme is covered in Le Maitre (2002).

The OGS recommends for general purposes that the prefix “orthopyroxene” or “fayalite” be used for a charnockitic rock that is otherwise comparable to alkali-feldspar granite, granite, granodiorite, tonalite, alkali-feldspar syenite, syenite, monzonite, norite, diorite, monzodiorite or anorthosite (e.g., orthopyroxene monzonite) (*see* Table 5 for details).

Table 5. Intrusive rocks: supplemental terms (recommended and nonrecommended).[1]

Additional Topics	Additional Terms	Definition and/or Comment
Carbonatites		
	Alvikite	Unnecessary name for a medium- to fine-grained calcite carbonatite (use modifiers instead)
	Beforsite	Unnecessary name for a fine- to medium-grained dolomite carbonatite (use modifiers instead)
	Sövite	Unnecessary name for a coarse-grained calcite carbonatite (use modifiers instead)
Charnockitic rocks		Orthopyroxene-bearing rocks commonly associated with other members of an orthopyroxene-bearing series, from granite and intermediate members to noritic and ultramafic rocks Preferably the charnockitic names should be replaced by appending “orthopyroxene” as a prefix to the appropriate rock name (e.g., orthopyroxene granite) May be confused with charnockites generated by metamorphism

Table 5. *continued*

Additional Topics	Additional Terms	Definition and/or Comment
	Charnockite	Charnockitic term synonymous with preferred term "orthopyroxene granite"
	Charno-enderbite	*See* "opdalite" below
	Enderbite	Charnockitic term synonymous with preferred term "orthopyroxene tonalite"
	Jotunite	Charnockitic term synonymous with preferred term "orthopyroxene monzonorite" (*see* "Miscellaneous Rocks", this table)
	Mangerite	Charnockitic term synonymous with preferred term "orthopyroxene monzonite", commonly with mesoperthite
	Opdalite	Charnockitic term synonymous with "orthopyroxene granodiorite" (and "charno-enderbite"); consists of zoned plagioclase, microcline, quartz, biotite, enstatite and diopside
Granitoids		
	Adakite	Used for a series of andesites, dacites and sodic rhyolites of unusual chemical composition in some continent-based and island arc settings. Characterized by high values of Sr, high Sr/Y, high La/Yb, and negative Nb, Ti and Zr anomalies. More mafic rocks in the series may contain high values of Cr and Ni. Usually contain phenocrysts of plagioclase, amphibole, mica, rarely orthopyroxene, no clinopyroxene; titanomagnetite, apatite, zircon and titanite are common accessory minerals. Applied by some geologists to certain Archean intrusive rocks (i.e., tonalite, trondhjemite, granodiorite).
	Alaskite	Unnecessary synonym for leucocratic alkali-feldspar granite (use modifiers)
	Alkali granite	Not a synonym for alkali-feldspar granite and not recommended as a synonym for peralkaline granite *See* "Alkali" under "Miscellaneous terms"
	A-type granite	General term for anorogenic granites. Mildly alkaline granites with low CaO and Al_2O_3, high Fe/(Fe+Mg), high K_2O/Na_2O, high K_2O
	C-type granite	General term for charnockitic granites. Contain orthopyroxene (inverted pigeonite), highly calcic alkali-feldspar and potassic plagioclase; high K_2O, TiO_2, P_2O_5 and LILE; low CaO relative to SiO_2 compared to metamorphic charnockites, I-, S-, and A-type granites
	Felsite	A microcrystalline, light-coloured rock of "granitic" composition (either hypabyssal or extrusive)
	Granitic	Although considered by some to be synonymous with "granitoid", the OGS preferred use is a general term for rocks of the "granite" clan (*see* Figure 4)
	Granophyre	A textural term for a porphyritic rock of granite composition in which the groundmass alkali feldspar and quartz are in micrographic intergrowth
	Graphic granite	A textural term for a variety of pegmatitic granite in which the quartz and feldspar are intergrown with the appearance of cuneiform or runic writing
	I-type granite	General term for igneous-sourced, metaluminous, calc-alkali granitoids; mainly tonalites, granodiorites and granites lacking muscovite.
	M-type granite	General term for mantle-sourced (partial melting), continental margin granitoids; with chemical and isotopic compositions of island arc volcanic rocks
	Peralkaline granite	Variety of alkali-feldspar granite with alkali pyroxene and/or amphibole
	S-type granite	General term for sedimentary-sourced ("pelitic") granitoids, mainly peraluminous granodiorites and granites, with muscovite, aluminosilicates, garnet and/or cordierite (rarely hornblende)
	Sanukitoid	Now commonly used for Archean, high-Mg quartz monzodiorite and granodiorite with relatively high Ni and Cr; also as an intrusive equivalent of sanukite (*see* "Volcanic Rocks")
	Trondhjemite	Leucocratic variety of tonalite consisting mostly of sodic plagioclase and quartz with minor biotite; essentially synonymous with leucotonalite (*see* Figure 7)
Foidalites		
	Fergusite	A mesocratic foidolite with leucite as the predominant feldspathoid (*see* Figure 8)
	Ijolite	A mesocratic foidolite with nepheline as the predominant feldspathoid (*see* Figure 8)
	Italite	A leucocratic foidolite with leucite as the predominant feldspathoid (*see* Figure 8)
	Urtite	A leucocratic foidolite with nepheline as the predominant feldspathoid (*see* Figure 8)
	Missourite	A melanocratic foidolite with leucite as the predominant feldspathoid (*see* Figure 8)
	Melteigite	A melanocratic foidolite with nepheline as the predominant feldspathoid (*see* Figure 8)
Lamprophyres		Terms are likely appropriate only after petrographic studies
	Minette	A lamprophyre with biotite > hornblende, ± diopsidic augite, (± olivine); alkali feldspar > plagioclase
	Kersantite	A lamprophyre with biotite > hornblende, ± diopsidic augite, (± olivine); plagioclase > alkali feldspar
	Vogesite	A lamprophyre with hornblende, diopsidic augite, ± olivine; alkali feldspar > plagioclase
	Spessartite	A lamprophyre with hornblende, diopsidic augite, ± olivine; plagioclase > alkali feldspar
	Sannaite	A lamprophyre with brown amphibole, Ti-augite, olivine, biotite; alkali feldspar > plagioclase, feldspar > feldspathoid

Table 5. *continued*

Additional Topics	Additional Terms	Definition and/or Comment
	Camptonite	A lamprophyre with brown amphibole, Ti-augite, olivine, biotite; plagioclase > alkali feldspar, feldspar > feldspathoid
	Monchiquite	A lamprophyre with brown amphibole, Ti-augite, olivine, biotite; glass or feldspathoid, no feldspar
Melilitolites		Principal minerals include melilite, perovskite, olivine, haüyne, nepheline and pyroxene
	Afrikandite	Synonym for preferred term "perovskite melilitolite" Principal minerals combined >10%, melilite <65%, perovskite >10%
	Kugdite	Synonym for preferred term "olivine melilitolite" Principal minerals combined >10%, melilite <65%, olivine >10%
	Okaite	Synonym for preferred term "haüyne melilitolite" Principal minerals combined >10%, melilite <65%, haüyne >10% and melilite > haüyne
	Turjaite	Synonym for preferred term "nepheline melilitolite" Principal minerals combined >10%, melilite <65%, nepheline >10% and melilite > nepheline
	Uncompahgrite	Synonym for preferred term "pyroxene melilitolite" Principal minerals combined >10%, melilite <65%, pyroxene >10%
Syenitoids		
	Albitite	A variety of alkali-feldspar syenite consisting almost entirely of albite
	Alkali syenite	Not a synonym for alkali-feldspar syenite and not recommended as a synonym for peralkaline syenite *See* "alkali" under Miscellaneous terms"
	Malignite	A mesocratic foid syenite (*see* Figure 8)
	Shonkinite	A melanocratic foid syenite (*see* Figure 8)
Miscellaneous rocks		
	Biotitite	A rock consisting of >75% biotite.
	Diabase	The AGI glossary notes a number of differing uses in various countries, with U.S. and Canada (including OGS) usage being similar: namely, a [mafic] dike-rock with ophitic texture. Current approved IUGS usage considers "diabase" as synonymous with "dolerite" and a synonym of "microgabbro", neither of which has been used by the OGS. As such, the term "diabase" should be avoided and replaced by "gabbro" with modifiers such as "dike" and "ophitic texture" noted where appropriate.
	Dolerite	Now regarded by IUGS as synonymous with "Diabase" (*see* above)
	Essexite	Synonym for preferred terms "nepheline monzogabbro" or "nepheline monzodiorite"
	Monzonorite	A variety of norite in which plagioclase accounts for 65 to 90% of feldspars
	Porphyry	A general term for any igneous rock (intrusive or volcanic) that contains phenocrysts in a finer-grained groundmass
	Serpentinite	Considered a metamorphic rock: *see* section on "Metamorphic Rocks"
Miscellaneous terms		
	Alkali	Modifier for a rock with either of the following: a) modal feldspathoid and/or alkali amphiboles or pyroxenes; or b) normative feldspathoid or acmite
	Hypabyssal	An igneous or intrusive body formed at a shallow depth. Term is not used by many petrologists.
	Metaluminous	A chemical term for rocks with molecular ($Na_2O + K_2O$) < Al_2O_3 < ($CaO + Na_2O + K_2O$) Produces anorthite in the norm (CIPW), and typically Al-bearing minerals such as hornblende, biotite and melilite in the mode
	Oversaturated	Refers to igneous rocks with SiO_2 (or occasionally alumina) in excess of the amount required to form saturated minerals from the bases present, leading to quartz in the mode or in the norm
	Peralkaline	A chemical term for rocks with molecular Al_2O_3 < ($Na_2O + K_2O$). Typical modal minerals include the sodium pyroxene aegirine (acmite) and the sodium amphibole riebeckite.
	Peraluminous	A chemical term for rocks with molecular Al_2O_3 > ($CaO + Na_2O + K_2O$) Produces corundum in the norm (CIPW), and typically minerals such as muscovite, corundum, tourmaline, topaz and almandine-spessartine in the mode
	Saturated	Refers to igneous rocks that are neither oversaturated or undersaturated with respect to silica (SiO_2), i.e., no quartz or feldspathoid in the norm or mode
	Subalkali	Modifier for a rock that is not alkalic in character (*see* "Alkali")
	Subaluminous	A chemical term for rocks with molecular Al_2O_3 = ($Na_2O + K_2O$) (±0.5).
	Undersaturated	Refers to igneous rocks which are undersaturated with respect to SiO_2, leading to feldspathoid or Mg-olivine in the mode or norm (i.e., no quartz)

[1]*Rock names are derived from Le Maitre (2002) and Neuendorf, Mehl and Jackson (2005); listed alphabetically within topics.*
Abbreviations: CIPW, Cross, Iddings, Pirsson and Washington norm.

Volcanic Rocks

Volcanic rocks present challenges to the ability of geologists to apply a rigorous classification scheme to Precambrian rocks in the field, as most schemes use a combination of features such as texture (especially for flow rocks) or grain size (especially for pyroclastic rocks). An additional complication is that in Precambrian terranes, the original, generally fine-grained and glassy character of the rocks has been converted to fine-grained minerals and/or devitrified glass because of post-volcanic alteration and/or metamorphism. Furthermore, many modern classification schemes are based solely or largely on geochemistry, which cannot yet be reliably determined in the field.

There are 3 different criteria or methods outlined in this manual for identifying Precambrian volcanic rocks in Ontario. They are based on colour index, mineral mode and geochemistry. These methods are discussed separately below. All have particular limitations, particularly for rocks of Archean age.

COLOUR INDEX METHOD

As there are considerable limitations in the application of the 2 other criteria for mapping Precambrian volcanic rocks, it is anticipated that the colour index method will be used most commonly. In most cases, this method has been used traditionally by OGS Precambrian geologists by estimating the present or inferred colour index of the volcanic rocks being mapped, in conjunction with observable primary features and textures, if present, such as those generalized in Table 6. The method has particular utility (e.g., Jensen (1976), which has been historically used in the OGS by some geologists) in areas where the metamorphic grade is relatively low and/or where deformation is minimal, such as in parts of the Abitibi greenstone belt or the Abram Lake–Minnitaki Lake greenstone belt in Ontario.

Colour index refers to the volume percentage of mafic (i.e., dark-coloured, ferromagnesian) minerals in a rock. The standard terms based on colour index are ultramafic (colour index >90), mafic (colour index 35 to 90), intermediate (colour index 15 to 35) and felsic (colour index <15). To facilitate situations in which variations in rocks from outcrop to outcrop lead to ambiguity in consistently estimating the colour index, additional terms are provided, namely “mafic to ultramafic”, “intermediate to mafic” and “felsic to intermediate”, for use on a tentative, in-field basis.

The original colour index is unknown, of course, so a geologist considers, in part, the current colour index, which largely reflects the current metamorphic mineralogy, and the inferred chemistry of the mineralogy. For example, magnesite and light-coloured tremolite, are magnesian-rich minerals, which may reflect products of alteration and/or metamorphism of an originally magnesian-rich protolith.

There are cases where a rock may display evidence of primary features and textures that reveals the original nature of the rock as opposed to the current colour index. Two examples are 1) preserved spinifex texture in a rock that has been partly to completely serpentinized or carbonatized, in which case “ultramafic” would be selected from the pick list, despite the rock not being ultramafic in its present form; and 2) a hard, felsic, silicified rock displaying pillow selvages would not be considered “felsic” but rather intermediate or mafic, depending on other features, such as thickness of the selvages (*see* Table 6).

As such, the colour index method is a compromise that presents difficulty in applying it in a consistent, reliable fashion. However, experienced mappers can produce a reasonably good first approach, particularly during mapping, especially coupled with pre-existing petrographic or geochemical information for a given area, if available. If neither one of these is available, the colour index method, applied judiciously, is the best method.

MINERAL MODE METHOD

This method, as outlined by the IUGS (Le Maitre 2002), provides a procedure for classifying volcanic rocks using mineral modes (Figures 10 and 11). This method takes priority over the geochemistry method, if mineral modes can be determined. As Precambrian volcanic rocks are commonly too fine grained to determine mineral modes, this method will not likely be used much by the OGS. The provisional IUGS classification (*see* Figure 10) can be used with tentative modal ratios estimated in the field. If more detailed modal information can be determined, then Figure 11 can be used. Additional information about various volcanic rock types is provided in Table 10, including the corresponding comparable mineralogical equivalents for intrusive rocks.

GEOCHEMISTRY METHOD

The most serious limitation for the use of this method in the field stems from the inability of geologists to determine the geochemistry during the course of normal mapping. Geochemistry may be applicable if one has access to previous laboratory results for rocks in the immediate area and the commensurate experience in relating characteristics of the rocks to the geochemistry. Research and development in portable instruments for measuring mineralogical and/or chemical composition may make field use of this method appropriate in the future.

Notwithstanding the above limitations, the structure of the geochemically based nomenclature is presented in this manual, based on Le Maitre (2002). The general procedure follows:

a) Check whether the volcanic rock is a “High-Mg” rock by using the Total Alkali – Magnesium (TAM) system shown in Figure 12. If so, the rock name is determined at this stage.

b) Check whether the alkalis, and modal and normative mineralogy applies to determine if “melilitite” or “nephelinite” terminology is apropos (Table 10), in which case, the rock name is determined at this stage. In that regard, use CIPW normative nepheline (i.e., *ne*) and albite (i.e., *ab*) results, to account for nepheline normative rocks. In the latter case, if *ne* >20%, the rock is a nephelinite, or if *ne* <20% and *ab* (if present) <5%, the rock is a melanephelinite.

c) If neither of the above criteria is met, then the Total Alkali – Silica (TAS) system (Figure 13) is to be used.

The TAS system has terminology that can be applied at a general level (e.g., andesites), at an intermediate level (e.g., trachyandesite), or at a detailed level (e.g., benmoreite), each level requiring more specific geochemical criteria.

Note that the more “precise” the subdivision of rock names based on geochemistry (e.g., trachybasalt → hawaiite, potassic trachybasalt), the greater the degree of uncertainty in applying the name in typical metamorphosed and/or altered rocks of the Superior and Southern provinces of Ontario. Care should be used to avoid applying terms that are too precise for the Precambrian rocks at hand.

The TAS scheme (*see* Figure 13) is based on geochemical results from “fresh” rocks (H_2O^+ <2%, CO_2 <0.5%), with results recalculated to 100% on a H_2O- and CO_2-free basis. The scheme implies no genetic significance, i.e., it is descriptive only. Technically, using the TAS scheme for rocks with H_2O^+ >2% and/or CO_2 >0.5% is not advised. In the case of Ontario Precambrian rocks, this would commonly make the use of TAS largely impractical. Nevertheless, cautious and judicious use of the TAS scheme for rocks with volatiles above these limits may be considered. In any case, proper use of the TAS scheme requires recalculating geochemical results to 100% volatile free.

Note that the TAS scheme is recommended only for the purpose of primary rock classification. Subsequently, the geoscientist is free to use any of the numerous geochemical classification and/or tectonic discrimination schemes that exist in order to further classify, subdivide and/or interpret the origin of the volcanic rocks that are being studied. When publishing their data, however, the geoscientists should ensure that the various schemes utilized are fully referenced.

The IUGS volcanic rock nomenclature systems do not take into account the original geotectonic setting of the volcanic rocks (e.g., mid-ocean ridge, island arc, orogenic belt) nor do they consider volcanic "suites" (e.g., tholeiitic, calc-alkalic, komatiitic). There have been various systems proposed, including the cation system, which was developed in-house and was reasonably applicable to the Abitibi greenstone belt (Jensen 1976). However, this manual also does not provide input into the use of said terminology as it is beyond its scope.

Table 6. Volcanic rocks and aphanitic to fine-grained dikes: general characteristics.[1]

Criteria	Ultramafic	Mafic	Intermediate	Felsic	Comment
Common Name(s)	komatiite, picrite	basalt	andesite	rhyolite, dacite	
Colour Index (M′)	>90	typically >35 to 90	typically 15 to 35	typically <15	-M′ defined by typically dark coloured iron-magnesium silicates; -alteration and metamorphism may change primary colour index
Weathered surface	tend to have more rounded edges and pieces			may have sharper, more angular edges and pieces	
Colour: weathered	very dark grey to black to very dark green; can be medium grey to greenish grey or orange brown	medium to dark green	medium grey to medium green	white, cream, light grey	-highly dependent on alteration and/or metamorphic grade and length of time of exposure; -alkalic rocks may have a purplish to pinkish hue overall
Colour: fresh	very dark grey to black to very dark green; can be medium grey to greenish grey	medium to dark green	medium grey to medium green	white, cream, light grey; can be dark green to black	-highly dependent on alteration and/or metamorphic grade -alkalic rocks may have a purplish to pinkish hue overall
Breakage by hammer: fracture pattern				may have subconchoidal fracture (especially if aphanitic)	
Breakage by hammer: sound	may be thud or punky sound if altered (talc, carbonate, serpentine)	may have more typical clunk		may have a sharp, high pitch, almost a ring, with chips of rock flying off with a whistling sound	
Specific gravity	tends to be highest			tends to be lowest	
Flow thickness	typically thinnest			typically thickest	ponding of lava excluded; ultramafic flows likely to display differentiation characteristics

Table 6. *continued*

Criteria	Ultramafic	Mafic	Intermediate	Felsic	Comment
Pillows, tubes, lobes, polyhedral joints	may have pillows, tubes; polyhedral joints common	pillows common, may have tubes, lobes	may have pillows, tubes, lobes	may have lobes	
Selvage thickness	thin	medium to thin	thickest	not applicable	
Vesicles and/or amygdules	yes	yes	yes	yes	
Varioles and/or spherules (may not be distinguishable in field)	varioles	varioles	spherules	spherules	some geologists consider these features to be of controversial origin
Phenocrysts: quartz ± plagioclase ± alkali feldspar	absent	may contain Ca-rich plagioclase	may contain plagioclase	-rhyolite: may contain alkali feldspar ± quartz (± Ca-poor plagioclase) -dacite: may contain plagioclase ± quartz (± alkali feldspar)	
Phenocrysts: olivine ± pyroxene ± hornblende ± biotite	typically olivine (forsterite) if present, possible pyroxene	may contain pyroxene ± olivine	may contain biotite, amphibole, pyroxene (± olivine)	-rhyolite: may contain biotite, amphibole, pyroxene, olivine (fayalite) -dacite: may contain biotite, amphibole, pyroxene	
Pyroclastic rocks	less common			more common	
Dikes: "designation" to be used for aphanitic to very fine-grained dikes	similar characteristics as above, except for volcanic features	similar characteristics as above, except for volcanic features	similar characteristics as above, except for volcanic features	similar characteristics as above, except for volcanic features	

[1]*Features typical of Superior and Southern Province rocks in Ontario; features such as "flow thickness", "pillows, tubes, lobes", "selvage thickness" are not applicable to dikes.*

There are 2 major subdivisions of volcanic rocks, namely lavas and pyroclastic rocks, with attendant additional subdivisions up to a seventh level for work based on geochemical results (Table 8). The colour index and geochemistry are most applicable to flows and relatively monolithic pyroclastic deposits. In the case of relatively heterolithic pyroclastic deposits, the scheme is more difficult to apply, and arguably becomes rather moot in highly heterogeneous rocks. An approximation of matrix colour index may suffice in providing the greatest "comfort" level with in-field interpretation of rock nomenclature, although alteration can change the original appearance considerably.

Details of volcanic rock types for this manual are provided as follows:

- The general outline for the Volcanic Rock Classification (seven levels) is given in Table 7.
- The specific outline with rationale is in Table 8.
- A provisional triangular graphical representation, for field-use, of the common volcanic rock names based on mineral modes is displayed in Figure 10.
- A detailed triangular modal classification of major volcanic rock types based on mineral modes is shown in Figure 11.
- Chemical classification schemes are based on a) total alkalis–MgO–TiO_2–SiO_2 (Figure 12); and b) total alkali–silica (TAS) (Figure 13).
- The hierarchical organization of the pick lists for field data input is shown in Table 9.
- Definitions for the rock types are provided in Table 10, parts a), b) and c).

The triangular classification applies to rocks with a value of M <90 and is based on the same criteria as for intrusive rocks, namely:

- M = volume percent of mafic and so-called “related” minerals: mica, amphibole, pyroxene, olivine, opaque minerals, accessory minerals (such as zircon, apatite, titanite), epidote, allanite, garnet, melilite, monticellite, primary carbonate
- M′ = colour index = volume percent of dark-coloured ferromagnesian minerals = M minus muscovite, apatite, primary carbonates, epidote, garnet, melilite, monticellite, and opaque and accessory minerals
- Q = quartz
- A = alkali feldspar, including orthoclase, microcline, perthite, anorthoclase, sanidine, albitic plagioclase (An_0 to An_5)
- P = plagioclase (An_5 to An_{100}) and scapolite
- F = feldspathoid (also known as foids), including nepheline, leucite, kalsilite, analcime, sodalite, nosean, haüyne, cancrinite and pseudoleucite
- Q + A + P + F + M = 100% and components of QAP or FAP are recalculated to total 100% for use in the double triangle figure
- Primary Q and F cannot co-exist in an igneous rock.

Table 7. Volcanic rocks: overview.

Level 1	Volcanic Rock Classification
Level 2 (Rock class)	Lavas
	Pyroclastic deposits
Level 3 (Rock class)	For lavas, there are no Level 3 subdivisions
	Tuff
	Lithic tuff
	Crystal tuff
	Vitric tuff
	Lapilli-tuff
	Lapillistone
	Tuff breccia
	Pyroclastic breccia
	Agglomerate
Level 4	Colour Index Method
	Mineral Mode Method
	Geochemistry Method
Level 5	First-order subdivisions based on colour index
	First-order subdivisions based on modal mineralogy
	First-order subdivisions based on geochemistry
Level 6	Second-order subdivisions based on modal mineralogy
	Second-order subdivisions based on geochemistry
Level 7	Third-order subdivisions based on geochemistry

DEFINITIONS

Table 10 provides essential components for the definitions of volcanic rock names. Key points regarding uncommon rock types follow Table 10 (*see* "Lavas" under "Special Cases"). Table 11 outlines additional terminology for selected topics, including miscellaneous circumstances. Features summarized in Table 8 outline major aspects, but geologists faced with some of these rock types would benefit from additional information in Le Maitre (2002). For feldspathoid-bearing rocks, the predominant feldspathoid should replace the word "foid" in a rock name (e.g., leucite-bearing latite (leucite <10% of FAP ratios) or nepheline phonolite (nepheline 10 to 60% of FAP ratios)).

An "essential" mineral, in the petrological sense, is a mineral component of a rock that is necessary to its classification and nomenclature, but not necessarily present in large amounts. An "accessory" mineral is one that is not essential to the proper classification of the rock and generally occurs in minor amounts.

Table 10. Volcanic rocks: definitions, based on the schemes shown in Figures 10 to 14.

Rock Class a) Mineralogical (modal)	Rock Name[A]	Definition	Figure	Field[B]
Rhyolitoid		Collective term for rocks tentatively identified as rhyolitic rocks (quartz 20 to 60% of QAP minerals)	10	–
	Alkali-feldspar rhyolite	Variety of *rhyolite* that is plagioclase poor (quartz 20 to 60% of QAP minerals; plagioclase <10% total feldspar) Volcanic equivalent of alkali-feldspar granite	11	2
	Rhyolite	A silicic rock typically with quartz and alkali-feldspar phenocrysts, often with minor plagioclase and biotite, in a microcrystalline or glassy groundmass (quartz 20 to 60% of QAP minerals) Volcanic equivalent of granite	11	3a + 3b
Dacitoid		Collective term for rocks tentatively identified as dacitic rocks (quartz 20 to 60% of QAP minerals)	10	
	Dacite	Composed of quartz and sodic plagioclase with minor amounts of biotite and/or hornblende and/or pyroxene (quartz 20 to 60% of QAP minerals) Volcanic equivalent of granodiorite and tonalite	11	4, 5
Trachytoid		Collective term for rocks tentatively identified as trachytic and latitic rocks	10	–
	Quartz alkali-feldspar trachyte	A variety of *trachyte* consisting mostly of alkali feldspar, quartz and mafic minerals (quartz 5 to 20% of QAP minerals; plagioclase <10% total feldspar) Volcanic equivalent of quartz alkali-feldspar syenite	11	6*
	Quartz trachyte	A variety of *trachyte* consisting mostly of alkali feldspar and quartz phenocrysts in a cryptocrystalline or glassy matrix (quartz 5 to 20% of QAP minerals) Volcanic equivalent of quartz syenite	11	7*
	Quartz latite	Variety of *latite* consisting mostly of subequal amounts of alkali feldspar and plagioclase, as well as quartz and mafic minerals (quartz 5 to 20% of QAP minerals) Volcanic equivalent of quartz monzonite	11	8*
	Alkali-feldspar trachyte	A variety of *trachyte* that is plagioclase poor (quartz <5% of QAP minerals; plagioclase <10% of total feldspar) Volcanic equivalent of alkali-feldspar syenite	11	6
	Trachyte	Consists mostly of alkali feldspar and some plagioclase (quartz <5% of QAP minerals) Volcanic equivalent of syenite	11	7

Table 10. *continued*

Rock Class a) Mineralogical (modal) *cont'd*	**Rock Name[A]**	**Definition**	**Figure**	**Field[B]**
	Latite	Consists of subequal amounts of alkali feldspar and sodic plagioclase (quartz <5% of QAP minerals) Volcanic equivalent of monzonite	11	8
	Foid-bearing alkali-feldspar trachyte	Variety of undersaturated *trachyte* with a small amount of feldspathoid and plagioclase (feldspathoid <10% of FAP minerals; plagioclase <10% total feldspar) Volcanic equivalent of foid-bearing alkali-feldspar syenite	11	6′
	Foid-bearing trachyte	Variety of undersaturated *trachyte* with a small amount of feldspathoid (feldspathoid <10% of FAP minerals) Volcanic equivalent of foid-bearing syenite	11	7′
	Foid-bearing latite	Variety of undersaturated *latite* with a small amount of feldspathoid (feldspathoid <10% of FAP minerals) Volcanic equivalent of foid-bearing monzonite	11	8′
Andesitoid		Collective term for rocks tentatively identified as andesitic rocks	10	–
	Andesite	A commonly porphyritic, intermediate rock with plagioclase (zoned labradorite to oligoclase), pyroxene, hornblende and/or biotite May or may not contain feldspathoid (quartz <20% of QAP minerals, or feldspathoid <10% of FAP minerals) Approximate volcanic equivalent of oversaturated and slightly undersaturated dioritic rocks	11	9
Basaltoid		Collective term for rocks tentatively identified as basaltic rocks	10	–
	Basalt	Commonly consists of calcic plagioclase and pyroxene, possibly with olivine, minor foids, or interstitial quartz (quartz <20% of QAP minerals, or feldspathoid <10% of FAP minerals) Approximate volcanic equivalent of oversaturated and slightly undersaturated gabbroic rocks	11	10
Phonolitoid		Collective term for rocks tentatively identified as phonolitic rocks	10	–
	Phonolite	A plagioclase-poor rock with notable feldspathoid; the predominant foid should be used as a modifier (e.g., nepheline phonolite; leucite phonolite) (feldspathoid 10 to 60% of FAP minerals; plagioclase <10% of total feldspars) Volcanic equivalent of foid syenite	11	11
	Tephriphonolite	Synonym for preferred term "*tephritic phonolite*"		
	Tephritic phonolite	An alkalic rock consisting of alkali feldspar, sodic plagioclase, feldspathoid and various mafic minerals; more alkali feldspar than plagioclase (feldspathoid 10 to 60% of FAP minerals; plagioclase 10 to 50% of total feldspars) Volcanic equivalent of foid monzosyenite Synonym: tephriphonolite. The inferred IUGS preference is tephritic phonolite.	11	12
Tephritoid		Collective term for rocks tentatively identified as tephritic and basanitic rocks	10	–
	Tephrite	An alkali-feldspar-poor, alkalic rock consisting of calcic plagioclase, clinopyroxene and feldspathoid, and commonly minor olivine (feldspathoid 10 to 60% of FAP minerals, alkali feldspar <10% of total feldspars; olivine <10%) Volcanic equivalent of foid diorite	11	14

Table 10. *continued*

Rock Class a) Mineralogical (modal) *cont'd*	**Rock Name[A]**	**Definition**	**Figure**	**Field[B]**
	Phonolitic tephrite	An alkalic rock consisting of plagioclase, feldspathoid, augite, and commonly minor olivine and sanidine; more plagioclase than alkali feldspar (feldspathoid 10 to 60% of FAP minerals; alkali feldspar 10 to 50% of total feldspars; olivine <10%) Volcanic equivalent of foid monzodiorite Synonym: Phonotephrite. The inferred IUGS preference is phonolitic tephrite.	11	13
	Basanite	A rock composed of clinopyroxene, plagioclase, notable feldspathoid and olivine (feldspathoid 10 to 60%, alkali feldspar <10% total feldspars; olivine >10%) Volcanic equivalent of foid gabbro	11	14
	Phonolitic basanite	An alkalic rock consisting of plagioclase, feldspathoid, olivine, augite and commonly minor sanidine; more plagioclase than alkali feldspar (feldspathoid 10 to 60% of FAP minerals; alkali feldspar 10 to 50% of total feldspars; olivine >10%) Volcanic equivalent of foid monzogabbro	11	13
	Phonotephrite	Synonym for preferred term "*phonolitic tephrite*"		
Foiditoid		Collective term for alkalic rocks tentatively identified as foidites	10	–
	Phonolitic foidite	Variety of *foiditoid* consisting mostly of feldspathoid with some alkali feldspar and lesser plagioclase; the most abundant feldspathoid should be used in the name (e.g., phonolitic nephelinite, phonolitic leucitite) (feldspathoid 60 to 90% of FAP minerals)	11	15a
	Tephritic foidite	Variety of *foiditoid* consisting mostly of feldspathoid with some plagioclase, lesser alkali feldspar and minor olivine; the most abundant feldspathoid should be used in the name (e.g., tephritic nephelinite, tephritic leucitite) (feldspathoid 60 to 90% of FAP minerals; olivine <10%)	11	15b
	Basanitic foidite	Variety of *foiditoid* consisting mostly of feldspathoid with some plagioclase, lesser alkali feldspar and olivine (feldspathoid 60 to 90% of FAP minerals; olivine >10%)	11	15b
	Foidite[C]	A rock consisting almost entirely of feldspathoid; the most abundant feldspathoid should be used in the name (e.g., nephelinite, leucitite, analcimite) (feldspathoid 90 to 100% of FAP minerals)	11	15c
Melilitites		Contains >10% melilite and melilite > feldspathoid (melilite is a sorosilicate; feldspathoid is a tectosilicate) If a rock falls within the foidite field of QAPF (Fig. 11), "melilite" should precede the appropriate foidite name (e.g., melilite nephelinite)	11	–
	Melilite-bearing volcanic rock	Melilite <10% of Mel + Ol + Cpx (e.g., melilite-bearing phonolite)	14	–
	Melilitite	Generally olivine <10% of Mel + Ol + Cpx	14	–
	Olivine melilitite	Melilite 10 to 90%; olivine 10 to 90%; clinopyroxene <80% for Mel + Ol + Cpx	14	–
Rock Class b) Geochemical (high-magnesium rocks)	**Rock Name[A]**	**Definition[F]**	**Figure**	**Field**
	Boninite	SiO_2 52 to 63%; MgO >8%; TiO_2 <0.5% (An andesitic rock with high magnesium and low alkalis, consisting of phenocrysts of enstatite (protoenstatite reverting to clinoenstatite), orthopyroxene, clinopyroxene, olivine in a glassy groundmass full of crystallites)	12	–
	Komatiite	SiO_2 30 to <52%; MgO 18 to 32%; (Na_2O + K_2O) <2%; TiO_2 <1% A variety of high-magnesium ultramafic extrusive rocks; commonly displays flow-tops, pillow forms and spinifex texture with intergrown skeletal and bladed olivine and pyroxene crystals in a glassy matrix	12	–

Table 10. *continued*

Rock Class b) Geochemical (high-magnesium rocks) *cont'd*	**Rock Name[A]**	**Definition[F]**	**Figure**	**Field**
	Meimechite	SiO_2 30 to <52%; MgO 18 to 32%; ($Na_2O + K_2O$) <2%; TiO_2 >1% A variety of high-magnesium ultramafic extrusive rocks; composed of olivine phenocrysts in a groundmass of olivine, clinopyroxene, magnetite and glass (more TiO_2 than komatiite)	12	–
	Picrite	MgO from 12 to 18% and ($Na_2O + K_2O$) <3% A mafic (basaltic) rock consisting largely of olivine and pyroxene	12	–
Rock Class c) Geochemical (TAS classification[D])	**Rock Name[A,E]**	**Definition[F]**	**Figure**	**Field[G]**
	Andesite	SiO_2 from 57 to 63% $Na_2O + K_2O$ from 0 to 7% (depends on silica)	13A	O2
	Basaltic andesite	SiO_2 from 52 to 57% $Na_2O + K_2O$ from 0 to 5.9% (depends on silica)	13A	O1
	Basaltic trachyandesite	SiO_2 from 49.4 to 57% (depends on alkalis) $Na_2O + K_2O$ from 5 to 9.3% (depends on silica)	13A	S2
	Mugearite	Subtype of *basaltic trachyandesite* with $Na_2O - 2.0 \geq K_2O$	13B	–
	Shoshonite	Subtype of *basaltic trachyandesite* with $Na_2O - 2.0 < K_2O$	13B	–
	Trachyandesite	SiO_2 from 53 to 63% (depends on alkalis) $Na_2O + K_2O$ from 5.9 to 11.7% (depends on silica)	13A	S3
	Benmoreite	Subtype of *trachyandesite* with $Na_2O - 2.0 \geq K_2O$	13B	–
	Latite	Subtype of *trachyandesite* with $Na_2O - 2.0 < K_2O$	13B	–
	Basalt	SiO_2 from 45 to 52% $Na_2O + K_2O$ from 0 to 5%	13A, 13C	B, –
	Alkali basalt	A chemically defined variety of *basalt* with normative nepheline SiO_2 from 45 to 48.5% (depends on alkalis) $Na_2O + K_2O$ from 2.2 to 5% (depends on silica)	13C	
	Picrobasalt	SiO_2 from 41 to 45% $Na_2O + K_2O$ from 0 to 3%	13A	Pc
	Subalkali basalt	A chemically defined variety of *basalt* with normative nepheline SiO_2 from 45 to 52% (depends on alkalis) $Na_2O + K_2O$ from 1.4 to 5% (depends on silica)	13C	
	Trachybasalt	SiO_2 from 45 to 52% $Na_2O + K_2O$ from 5 to 7.3% (depends on silica)	13A	S1
	Hawaiite	Subtype of *trachybasalt* with $Na_2O - 2.0 \geq K_2O$	13B	–
	Potassic trachybasalt	Subtype of *trachybasalt* with $Na_2O - 2.0 < K_2O$	13B	–
	Basanite	Normative olivine >10% SiO_2 from 41 to 49.4% (depends on alkalis) $Na_2O + K_2O$ from 3 to 9.4% (depends on silica)	13A	U1
	Phonoliltic basanite	SiO_2 45 to 53% (depends on alkalis) $Na_2O + K_2O$ from 7.3 to 11.5% (depends on silica)	13A	U2
	Dacite	SiO_2 from 63 to 77% (depends on alkalis) $Na_2O + K_2O$ <8% (depends on silica)	13A	O3
	Trachydacite	Normative quartz >20% SiO_2 from 57.6 to 69% (depends on alkalis) $Na_2O + K_2O$ from 7 to 13% (depends on silica)	13	T
	Foidite	SiO_2 from 35 to 52.5% (depends on alkalis) $Na_2O + K_2O$ <15% (depends on silica)	13A	F
	Phonolite	SiO_2 from <49 to >61% (depends on alkalis) $Na_2O + K_2O$ from >11.7% (depends on silica)	13A	Ph

Table 10. *continued*

Rock Class c) Geochemical (TAS classification[D]) *cont'd*	Rock Name[A,E]	Definition[F]	Figure	Field[G]
	Tephritic phonolite	SiO_2 from 48.4 to 57.6% (depends on alkalis) $Na_2O + K_2O$ from 9.3 to 14% (depends on silica)	13A	U3
	Rhyolite	SiO_2 from 69 to >77% (depends on alkalis) $Na_2O + K_2O$ <13% (depends on silica)	13A	R
	Tephrite	Normative olivine <10% SiO_2 from 41 to 49.4% (depends on alkalis) $Na_2O + K_2O$ from 3 to 9.4% (depends on silica)	13A	U1
	Phonolitic tephrite	Normative quartz <20% SiO_2 from 45 to 53% (depends on alkalis) $Na_2O + K_2O$ from 7.3 to 11.5% (depends on silica)	13A	U2
	Trachyte	SiO_2 from 57.6 to 69% (depends on alkalis) $Na_2O + K_2O$ from 7 to 13% (depends on silica)	13A	T

[A] Rock names are derived from Le Maitre (2002) and listed alphabetically within classes.
[B] Field designations are shown in Figure 11.
[C] The IUGS defines "foidite" (see Table 10(a)) the same as "foidolite" (Table 4); likely an oversight. The OGS has distinguished the 2 definitions, likely as originally intended.
[D] TAS = Total Alkali – Silica.
[E] Rock names within subtypes are listed alphabetically.
[F] Values are in weight % unless otherwise indicated.
[G] Field designations are shown in Figure 13.

Table 11. Volcanic rocks: supplemental terms (recommended and nonrecommended).[1]

Additional Topics	Additional Terms	Definition and/or Comment
Rhyolitoid		
	Alkali rhyolite	Not a synonym for alkali feldspar rhyolite and not recommended as a synonym for peralkaline rhyolite *See* "alkali" under "Miscellaneous Terms"
	Comendite	Synonymous with the preferred term "*comenditic rhyolite*"
	Comenditic rhyolite	A rhyolite with Al_2O_3 >1.33 FeO + 4.4
	Pantellerite	Synonymous with the preferred term "*pantelleritic rhyolite*"
	Pantelleritic rhyolite	A rhyolite with Al_2O_3 <1.33 FeO + 4.4
	Peralkaline rhyolite	A variety of rhyolite with $Al_2O_3 < (Na_2O + K_2O)$ or a variety of rhyolite with alkali pyroxene and/or amphibole
	Rhyodacite	A term for a rock intermediate between rhyolite and dacite (Fields 3b and 4 of Figure 11) commonly having phenocrysts of quartz, plagioclase and some ferromagnesian minerals in a microcrystalline groundmass This term is vague and its use is discouraged
Trachytoid		
	Alkali trachyte	Not a synonym for alkali feldspar trachyte and not recommended as a synonym for peralkaline trachyte *See* "alkali" under Miscellaneous Terms"
	Basalt trachyte	Obsolete
	Comenditic trachyte	A trachyte with Al_2O_3 >1.33 FeO + 4.4
	Pantelleritic trachyte	A trachyte with Al_2O_3 <1.33 FeO + 4.4
	Peralkaline trachyte	A variety of trachyte with $Al_2O_3 < (Na_2O + K_2O)$ or a variety of alkali-feldspar trachyte containing sodic pyroxene and/or sodic amphibole
Andesitoid		
	Dacite-andesite	Obsolete term for an andesitic rock containing olivine and quartz
	Icelandite	A chemically intermediate rock with phenocrysts of andesine, clinopyroxene and/or orthopyroxene and/or pigeonite and less commonly olivine in a groundmass of the same minerals; it is poorer in alumina and richer in iron than typical "orogenic" andesite
	Mela-andesite	An andesite with colour index >35 and SiO_2 >52%
	Sanukite	An orthopyroxene-bearing andesite, somewhat similar to boninite, except that TiO_2 >0.5%

Table 11. *continued*

Additional Topics	Additional Terms	Definition and/or Comment
Basaltoid		
	Calc-alkali basalt	Basalt associated with basalt-andesite-dacite suite of the orogenic belts and island arcs
	Komatiitic basalt	The preferred term is "*basaltic komatiite*"
	Leuco-basalt	A basalt with colour index <35 and SiO_2 <52%
	Tachylyte	Basaltic glass typically found in chilled margins of dikes, sills and flows Commonly contains magnetite microlites
Komatioid		
	Basaltic komatiite	A variety of komatiite typically displaying spinifex texture and with MgO from 5 to 15% Intermediate between tholeiitic basalt and boninite; thought to be komatiitic magmas contaminated by crustal material
	Peridotitic komatiite	More highly magnesian variety of komatiite
	Serpentinite	*See* section on "Metamorphic rocks"
Phonolitoid		
	Peralkaline phonolite	A variety of phonolite with $Al_2O_3 < (Na_2O + K_2O)$ or a phonolite containing sodic pyroxene and/or sodic amphibole
Miscellaneous Terms		
	Alkali	Modifier for a rock with either: a) modal feldspathoid and/or alkali amphibole or pyroxene; or b) normative feldspathoid or acmite
	Kalsilitite	A kalsilite-bearing rock with no melilite or leucite
	Oversaturated	Refers to igneous rocks with an excess of SiO_2 over other oxides, leading to quartz in the mode or in the norm
	Peralkaline	A chemical term for rocks with molecular $Al_2O_3 < (Na_2O + K_2O)$
	Porphyry	A general term for any igneous rock (intrusive or volcanic) that contains phenocrysts in a finer grained groundmass
	Saturated	Refers to igneous rocks that are neither oversaturated or undersaturated with respect to silica (SiO_2), i.e., no quartz or feldspathoid in the mode or norm
	Undersaturated	Refers to igneous rocks which are undersaturated with respect to SiO_2, leading to feldspathoid or Mg-olivine in the mode or norm (i.e., no quartz)

[1] *Rock names are derived from Le Maitre (2002) and Neuendorf, Mehl and Jackson (2005); listed alphabetically within topics.*

LAVAS

Lavas (including domes) may comprise the majority of volcanic material that can provide relatively reliable geochemical results. The major styles of lavas, such as massive flows, pillowed flows, flow-top breccias, etc., are considered, for our purposes, variants on a theme rather than rock types: all these features and more may be displayed by an individual flow. These features are relegated to "rock modifiers" and are dealt with in Part 2. Special and uncommon lava compositions that must be considered before applying common classification schemes are discussed below.

SPECIAL CASES

Carbonatites

There are no known volcanic carbonatites in Ontario of any age.

Melilite-bearing Rocks

Volcanic melilite-bearing rocks (rare or non-existent in Ontario) with >10% modal melilite (a sorosilicate) are termed melilitites (intrusive equivalents are called melilitolites). The classification of melilitites is shown in Figure 14. Parameters for melilitites include:

- Melilite >10% modally
- Melilite > feldspathoid (feldspathoid may be absent)
- Other principal minerals include perovskite, olivine, haüyne, nepheline and pyroxene.

For rocks with melilite < feldspathoid and feldspathoid >10%, use the FAP part of the double triangle (Figure 11). Example rock names are melilite phonolite and melilite nephelinite. Rocks containing melilite and kalsilite are classified as "kalsilite-bearing rocks".

Kalsilite-bearing Rocks

Volcanic kalsilite-bearing rocks are particularly uncommon world wide, and along with kalsilite+leucite-bearing rocks, which form a suite of rocks referred to as kamafugites, likely do not occur in Ontario. Principal minerals, aside from kalsilite (a feldspathoid), include various combinations of phlogopite, clinopyroxene, leucite, melilite and olivine. Rocks should be named by using 1 to 4 of the most abundant principle minerals, in increasing order of abundance (e.g., kalsilite-phlogopite melilitite).

Lamproites

Lamproites typically occur as dikes or small extrusive bodies that are noted for potassium and magnesium contents and are based on mineralogical and chemical criteria. The unusual characteristics reflect diverse conditions involved in their genesis. Lamproites likely do not occur in Ontario. Essential mineralogical and geochemical characteristics are given in the "Lamproites" subsection under "Intrusive Rocks". More detailed descriptions and caveats for usage are provided in Le Maitre (2002).

Leucite-bearing Rocks

Leucite pseudomorphs have been reported in the alkalic volcanic rocks in the Kirkland Lake area. Recommendations for applying rock nomenclature for leucite-bearing rocks are included in Le Maitre (2002).

PYROCLASTIC ROCKS

Deposits formed largely (>75%) from tephra are considered pyroclastic deposits (Table 12). These deposits are subdivided into 5 rock types based on the proportions of various sizes of particles (Figure 15A). The particle sizes are subdivided into 3 ranges, termed ash, lapilli, and blocks and bombs, and the classification of pyroclastic rocks is given in Tables 8 and 13. Additional subdivisions for tuff, based on the main constituents (i.e., crystals, vitric particles and lithic particles), are shown in Figure 15B.

Notwithstanding issues related to "synvolcanic" hydrothermal alteration in subaqueous and subaerial environments, pyroclastic deposits of Precambrian age are truly difficult to confidently distinguish between "pure" pyroclastic deposits and mixed pyroclastic-epiclastic deposits. The original geochemical composition in the latter case is variably compromised.

To reduce the tendency to over-interpret in the field, we have not included in the pick lists genetic types of pyroclastic and related deposits within the rock nomenclature (e.g., ignimbrite), although the terms are included and flagged in Table 12 as a reference. We recommend use of such genetic terms, if appropriate, after a post-mapping interpretation of mode of deposition and/or facies, based on the map distribution of rock features and results from petrography. If the geoscientist needs to record such genetic information in the field, he/she can do so using the free-form Notes field provided in the customized ArcPad® pick lists.

Table 12. Pyroclastic and related rocks and processes: definitions.[A]

Essential terms	Definition and/or Comment
Volcanic	Igneous processes that occur on or very close to the surface of the Earth; pertaining to activities, structures or rock types of a *volcano*.
Volcano	The form or structure that is produced by the material passed through a *volcanic* vent(s).
Pyroclastic	Clastic fragmental rock material produced by *volcanic* explosion or expulsion from a volcanic vent.
Pyroclastic rock	Consolidated *pyroclastic* material which forms >75% of the rock.
Tuffite	General term for a rock formed from mixed *pyroclastic–epiclastic* deposits of which 25 to 75% is pyroclastic material.
Volcaniclastic	All clastic volcanic material formed, fragmented, transported and deposited by any processes. See *volcaniclastic rock*.
Volcaniclastic rock	A sedimentary rock in which the *volcaniclastic* material constitutes a significant [unspecified] proportion relative to nonvolcanic material. *See* section on "Sedimentary Rocks".
Epiclastic	Material derived by weathering and/or erosion of pre-existing rocks.
Epiclastic rock	A sedimentary rock composed mostly of *epiclastic* material (<25% *pyroclastic* material is permitted).
Reworked	Refers to sediment, rock fragments or other geologic material that have been moved from the place of origin and incorporated elsewhere in recognizable form in a younger deposit (e.g., reworked tuff).
Interpretive genetic terms[C]	
Agglutinate	Not recommended: the term "agglutinated" is now used as a modifier instead of a rock name.
Ash-cloud surge	Deposit from a dilute *pyroclastic flow*. A type of *pyroclastic surge*.
Ash fall	Airborne ash that falls from an eruption cloud, and the resulting deposit.[B]
Ash flow	A density current, generally a hot mixture of *volcanic* gases and tephra that travels across the ground surface; produced by the explosive disintegration of viscous lava in a volcanic crater, or from a fissure or group of fissures. The solid materials contained in a typical ash flow are generally unsorted and ordinarily include volcanic ash, pumice, scoria and blocks.[B]
Ash-flow tuff	A tuff deposited by an *ash flow*; a type of *ignimbrite.* It is a consolidated but not necessarily *welded* deposit.[B]
Ash tuff	The preferred term is "tuff".
Base surge deposit	Deposit from a ring-shaped cloud of gas and suspended solid debris that moves radially outward at high velocity as a density flow from the base of a [collapsing] vertical explosion column. It accompanies a *volcanic* eruption or crater formation by a hydrovolcanic explosion (resulting from the interaction of magma and/or lava with water) or hypervelocity impact.[B]

Table 12. *continued*

Essential terms	Definition and/or Comment
Block-and-ash flow deposit	A small-volume *pyroclastic flow* deposit characterized by a large fraction of dense to moderately vesicular juvenile blocks in a medium to coarse ash matrix of the same composition.[B]
Compound cooling unit	An ash-flow unit or series of such units that record breaks in the history of cooling, compaction, and welding.
Cooling unit	An ash-flow unit or series of such units that were deposited rapidly enough to share a common history of cooling, compaction, and welding.[B]
Debris flow	A moving mass of rock fragments, soil and mud, more than half of the particles being larger than sand size (0.0625 to 2 mm). Slow debris flows may move less that 1m per year; rapid ones reach 160 km per hour. Might not be related to *volcanic* rocks.[B]
Glowing avalanche	*Ash flow*.
Ground surge deposit	Thin, fairly well-sorted *pyroclastic flow* deposits that occur immediately beneath *ignimbrite* deposits and are intimately associated with the overlying ignimbrite; possibly derived from flow processes within the head of the pyroclastic flow that deposited the ignimbrite.[B]
Ignimbrite	The deposit of a *pyroclastic flow*, typically an indurated felsic to intermediate deposit consisting of crystal and rock fragments in a matrix of glass shards. The term originally implied dense welding but there is no longer such a restriction, so that the term includes rock types such as *welded tuff* and nonwelded *sillar*.[B]
Incandescent tuff flow	A term essentially synonymous with *ash flow* or *pyroclastic flow*.[B]
Lahar	A *mudflow* composed chiefly of *volcaniclastic* materials on the flank of a *volcano*. The debris carried in the flow includes pyroclasts, blocks from primary lava flows, and *epiclastic* material.[B]
Mudflow	A general term for a mass-movement landform and a process characterized by a flowing mass of predominantly fine-grained earth material possessing a high degree of fluidity during movement. The degree of fluidity is revealed by the distribution and morphology of the resulting deposit. If more than half of the solid fraction of such a mass consists of material larger than sand size (0.0625 to 2 mm), the term *debris flow* is preferable.[B] May be associated with *volcanic* activity (*see* lahar).
Pumice fall	The descent of pumice from an eruption cloud; pumice fallout.[B]
Pumice flow	A type of *pyroclastic flow* in which a large proportion of the fragments are pumice.[B]
Pyroclastic density current	A gravity-controlled, laterally moving mixture of pyroclasts and gas. It is a more general term that includes *pyroclastic flow* and *pyroclastic surge*.[B]
Pyroclastic flow	A density current of pyroclastic material, usually very hot and composed of a mixture of gases and particles. A synonym of *ash flow* used in a more general sense in that an ash flow is composed of ash-sized pyroclasts.[B]
Pyroclastic surge deposit	Deposit from a low-density, dilute, turbulent *pyroclastic flow*. Types of pyroclastic surges include *base surges*, *ash-cloud surges*, and *ground-surges*.[B]
Sillar	(a) The deposit from a *pyroclastic flow* (*ignimbrite*) that became indurated by recrystallization due to escaping gases rather than by welding, as is the case with *welded tuff*; it is a type of *ignimbrite*. (b) A nonwelded *ash-flow tuff*.[B]
Welded tuff	A glass-rich *pyroclastic rock* that has been indurated by the welding together of its glass shards under the combined action of the heat retained by particles, the weight of overlying material, and hot gases. It is generally composed of silicic pyroclasts and appears banded or streaky.[B]

[A] *Definitions are derived mainly from Le Maitre (2002) except where followed by [B].*
[B] *Definition derived mainly from Neuendorf, Mehl and Jackson (2005).*
[C] *These terms carry a significant degree of genetic interpretation, best obtained from mapping many outcrops over a sizeable area. As such, they are included here as a reference, but are not included in pick lists designed for individual outcrop observations.*

Deposits that consist of 25 to 75% pyroclastic material are designated “tuffites” (*see* Table 12). For our purposes, we consider these as sedimentary deposits because the recommended nomenclature uses sedimentary rock names as the root (e.g., tuffaceous sandstone, tuffaceous conglomerate). The sedimentary designation would appear contrary to the somewhat vague treatment of terms in the IUGS recommended scheme and the AGI definition of tuffite, but is similar to the approach taken by the British Geological Survey (Gillespie and Styles 1999). However, as root rock names are considered paramount in intrusive (plutonic) and volcanic (i.e., lava) terminology, and because of the possibility that epiclastic material may indicate a degree of reworking and/or weathering of the original pyroclastic material, we consider it more appropriate to apply a sedimentary designation (*see* section on “Sedimentary Rocks”).

In the field, consistently distinguishing true pyroclastic rocks from collapse of volcanic structures, such as domes or advancing flow fronts or from reworked volcaniclastic rocks (e.g., White and Houghton, 2006) or tuffites, particularly in Precambrian settings, is problematic and is best inferred from map distribution of rock features, associated rock units and petrographic results.

Table 13. Pyroclastic rocks and component particles: definitions, based on the scheme shown in Figure 15.

Tephra	All unconsolidated pyroclastic material (regardless of size, shape or origin) ejected during an explosive volcanic eruption		
Pyroclast	A particle ejected during a volcanic eruption (classified by size and/or shape)		
Pyroclasts	Ash	Any shape	Mean diameter <2 mm
	Lapilli	Any shape	Mean diameter 2 to 64 mm
	Blocks	Angular to subangular: solid when erupted	Mean diameter >64 mm
	Bombs	Shape indicates wholly or partly molten when erupted; shaped while in flight; subtypes based on shape	Mean diameter >64 mm
Pyroclastic Rock	Consolidated deposit of pyroclasts		
	Tuff	*Ash* >75%	
	Lithic *tuff*	*Ash* >75%, of which rock fragments are dominant	
	Crystal *tuff*	*Ash* >75%, of which crystals and crystal fragments are dominant	
	Vitric *tuff*	*Ash* >75%, of which pumice and glass fragments are dominant	
	Lapilli-tuff	*Blocks* and/or *bombs* <25%, and *lapilli* and *ash* each <75%	
	Lapillistone	*Lapilli* >75%	
	Tuff breccia	*Blocks* and/or *bombs* from 25 to 75%	
	Pyroclastic breccia	*Blocks* >75%	
	Agglomerate	*Bombs* >75%	

Deposits consisting of <25% pyroclastic material are considered here as epiclastic. Note that the AGI definition uses the term epiclastic only as “epiclastic rock” (*see* Neuendorf, Mehl and Jackson 2005). In the OGS vernacular, the terms “epiclastic” and “volcaniclastic” may have been used loosely (*see* Table 12).

Note that Figure 15A is technically flawed. There are 2 components represented by blocks and bombs at 1 vertex and 2 names assigned to the same polygon in the triangular diagram. But it is possible to have vertex components (recalculated to 100%) that cannot have an appropriate associated rock name, as defined. For instance, a rock with 45% blocks and 35% bombs (i.e., blocks + bombs = 80%) could not be classified according to the diagram, because it would not meet the requirements of tuff breccia (blocks and bombs would be too abundant (i.e., >75%)), pyroclastic breccia (blocks are not >75%) or agglomerate (bombs are not >75%). In terms of the significance of the problem, it is anticipated that equivalent scenarios may be relatively uncommon in most map areas. More specifically, the occurrence of a high proportion of both blocks and bombs may generally be mutually exclusive.

Depositional processes in pyroclastic rocks may lead to grading by particle size and/or density. Varieties or normal and/or reverse grading may occur, either symmetrically or asymmetrically, as shown in Figure 16.

SEDIMENTARY ROCKS

Sedimentary rocks constitute one of the 3 principal rock classes (in addition to igneous and metamorphic). They are somewhat akin to volcanic rocks in that they are deposited at the surface of the Earth, but overall, they form through a plethora of mechanisms, from mixtures of original rock sources, processes of degradation of the source rock(s), various mediums for transporting detritus, variation in depositional environments, and a host of processes superposed before final induration and lithification.

The permutation of the sedimentary processes has led to a variety of nomenclature schemes to the point that there is no singular scheme for classification that clearly stands out as being the most appropriate. The Science Language Technical Team (SLTT) has issued a report (Soller 2004a) with recommendations for naming sedimentary rocks and it includes a summary of the history of various nomenclature schemes; the problems that the various schemes have solved or created; and an explanation of the team's rationale for naming rocks.

A primary goal in recommending a sedimentary rock nomenclature is that the rock name is based on a single "science concept", such as grain size or chemical composition. Grain size can be estimated in the field with the aid of Figure 17. The SLTT system was designed as primarily field based and, as such, we have chosen to follow their system for the most part, with exceptions as noted.

The 2 main, or parent, first-order subdivisions for sedimentary rocks are terrigenous-clastic and chemical. In the SLTT rock nomenclature scheme, terrigenous-clastic material is governed by grain size and consists of material originating largely, but not solely, from continental sources. Chemical or chemogenic material is derived from the *in situ* chemical "precipitation" of material and is governed by composition. Biogenic material, derived from accumulation of biologically produced matter is instrumental in so few Precambrian rocks in Ontario that we have included such material and the resulting rocks produced under the "chemical" subdivision.

Details of sedimentary rock types for this manual are provided as follows:

- The general outline for the Sedimentary Rock Classification (5 levels) is given in Table 14.
- The specific outline with rationale is in Table 15.
- A provisional graphical representation of the 3 parent subdivisions of terrigenous-clastic rocks (Level 3) is shown in Figure 18.
- A field-based graphical representation of the basic terrigenous-clastic rock subdivisions (Level 4) is shown in Figure 19.
- The organization of the pick lists for field data input is given in Table 16.
- Level 5 subdivisions of mudrock, sandy rock and conglomeratic rock are shown in Figures 20, 21 and 22, respectively.
- Size ranges for sedimentary particles are provided in Table 17.
- Definitions for the sedimentary rock types are provided in Tables 18, 19, 20 and 21.
- Test reactions of carbonate rocks with hydrochloric (HCl) acid are summarized in Table 20. These test reactions are also applicable to the metamorphic equivalents of these rocks (pure and impure marbles).
- Distinction between iron-rich and iron-bearing rocks is shown in Table 21.
- Figures 19 to 22 inclusive should be used in conjunction with the definitions.
- Figures 23 and 24 outline the various rock types for sedimentary carbonate rocks (Levels 4 and 5).

Table 14. Sedimentary rocks: overview.

Level 1	Sedimentary Rock Classification
Level 2	Terrigenous-clastic
	Chemical
Level 3	Mudrock
	Sandy rock
	Conglomeratic rock
	Carbonate rock
	Siliceous rock
	Ironstone
	Barite rock
Level 4	Additional subdivisions of most Level 3 rock types
Level 5	Additional subdivisions of some rocks at Level 4, particularly for cases involving detailed petrographic work

Terrigenous-Clastic Rocks

Terrigenous-clastic rocks are fairly abundant worldwide and it is not surprising that several methods of classifying them have been proposed. The broad term “terrigenous-clastic” refers to rocks formed from >50% clastic material, of whatever composition, predominantly derived from a previous rock or sediment, accumulating in place or being transported from the place of origin. The more restrictive term “siliciclastic” is avoided by the SLTT and for our Level 2 terminology because it denotes a compositional limitation. However, the term siliciclastic may be appropriate for other uses when a deliberate composition restriction is intended, such as the exclusion of clastic carbonate rocks.

The 3 principal subdivisions of terrigenous-clastic rocks are mudrock, sandy rock and conglomeratic rock, which are primarily defined on the basis of grain sizes, outlined in Table 17, and secondarily on size ratios, shown in Figures 18 to 22. A preferred rock name such as “muddy sandstone”, for instance, derives its full name from the size and proportion of the particles, whereas a term such as “feldspathic sandstone” refers to “sandstone” with the somewhat ill-constrained compositional modifier “feldspathic”.

Deposits that consist of 25 to 75% pyroclastic material are designated “tuffites” (*see* Table 12). For our purposes, we consider these as sedimentary deposits because the recommended nomenclature uses sedimentary rock names as the root (i.e., tuffaceous mudstone, tuffaceous sandstone, tuffaceous conglomerate, tuffaceous breccia). The sedimentary designation is similar to the approach taken by the British Geological Survey (Gillespie and Styles 1999). However, as root rock names are considered paramount in intrusive (plutonic) and volcanic (i.e., lava) terminology, and because of the possibility that epiclastic material may indicate a degree of reworking and/or weathering of the original pyroclastic material, we consider it more appropriate to apply a sedimentary designation (*see* section on Pyroclastic Rocks). This approach is not taken without reservation but rather is a compromise with respect to uncertainties in mapping deformed and metamorphosed rocks of Precambrian age (*see* section on Metamorphic Rocks).

Table 17. Sedimentary rocks: particle size ranges.

Particle name	Size range
Mud	**<0.0625 mm (1/16 mm)**
Clay	<0.004 mm
Silt	0.004 to <0.0625 mm
Sand	**0.0625 to 2.0 mm**
Very fine sand	0.0625 to 0.125 mm
Fine sand	0.125 to 0.25 mm
Medium sand	0.25 to 0.5 mm
Coarse sand	0.5 to 1.0 mm
Very coarse sand	1.0 to 2.0 mm
Gravel	**>2.0 mm**
Granule	2 to 4 mm
Pebble	4 to 64 mm
Cobble	64 to 256 mm
Boulder	>256 mm

MUDROCK

Mudrock (Figure 18) is an inclusive term for mudstone and its 4 siblings (Figure 19), siltstone and claystone and their 4 siblings (Figure 20) and, indirectly, shale and argillite. Mudstone, *sensu stricto*, is a rock well constrained by particle size ratios, namely at least 90% mud-size material and less than 0.01% gravel-size material (by volume). In essence, mudstone and sandy mudstone are virtually free of gravel-size material. The size proportion limits are chosen, in part, to reflect typical, relatively low-energy environments of deposition and possibly source derivation. Variants of mudstone, *sensu lato* (other than sandy mudstone), can contain up to 30% gravel-size material with a ratio of sand size to mud size less than 1.0 (*see* Figure 19).

It is unlikely in most Archean and possibly Proterozoic cases that a realistic distinction between what were originally clay- and silt-size particles can be made, as is required in Figure 20. The nomenclature defined in Figure 20 is generally impractical for our purposes, save for the term "orthosandstone", an uncommon term defined in the SLTT report. The classification scheme shown in Figure 20 is provided here for general reference.

Terms such as "shale" and "argillite" have been used in a variety of ways, some of which are ambiguous or contradictory. Based on the historical use of the term "shale", as outlined in the SLTT report, it is clear that the term is of limited practical use. As pointed out in the SLTT report, "shale" as a rock name is based on compound (not singular) concepts, namely grain size (mud), depositional fabric (fissile lamination) and mineralogy (clay, the orientation of which imparts fissility). Given this, and the fact that geologists have historically used the term in a variety of ways, SLTT does not recommend use of the term and the OGS concurs. If it is to be used, the term refers to a "clay-bearing mudstone" in which a) the amount of clay is specified; and b) the rock must have a fissile *depositional* (i.e., primary) fabric. As determining or inferring the amount of "clay" and establishing the original mineralogical influence on the fabric in Archean mudstones is very imprecise, the term "shale" is not really apropos to our use, particularly as an initial rock name used during field mapping.

Similarly, based on the historical use of the term "argillite", as pointed out in the SLTT report, the term is not based on a single preferred science concept, but rather on both grain size and degree of induration. Argillite is defined as a mudstone that is well indurated, less clearly laminated than shale, without the fissility of shale and the distinctive cleavage of slate, but may have been derived from shale. As a form of negative definition, with ambiguity, the term "argillite" is also not recommended for use by the OGS, particularly as an initial rock name used during field mapping.

Another historical term is "pelite", which is a general term for a sedimentary rock composed mainly of mud-size (mostly clay-size) particles (e.g., mudstone, claystone). The term has also been used for the metamorphosed equivalent of mudstone and claystone, i.e., a metamorphic rock with a high modal ratio of mica to quartz+feldspar. The preferred term for these "metamorphosed equivalents" is *metapelite* (*see* section on Schist). Note that the terms *pelite* and *metapelite* are not considered bona fide rock names in this OGS manual, but are used as general terms. The preferred rock terms are *mudstone* (or *claystone* if appropriate) and *metamudstone*, respectively. The adjectival term for pelite is pelitic.

SANDY ROCK

Sandy rock (*see* Figure 18) is an inclusive term for sandstone and its 5 siblings (*see* Figure 19). Sandstone, *sensu stricto*, is a rock well constrained by particle size ratios, namely at least 90% sand-size material and less than 0.01% gravel-size material (by volume). In essence, sandstone and muddy sandstone are virtually free of gravel-size material. The size proportion limits have been chosen, in part, to reflect the more typical type of moderate-energy environments of deposition and possibly source derivation. Variants of sandstone, *sensu lato* (other than muddy sandstone), can contain up to 30% gravel-size material with a ratio of sand size to mud size greater than 1.0 (*see* Figure 19). The more specific sand-size ranges (e.g., fine, medium, etc.; Table 17) can be used as modifiers in the field or in cases when detailed petrographic work has been undertaken and where recrystallization is not a factor.

Various historical schemes of classification for sandy rocks have been proposed, especially from the 1940s to the 1970s. Terms such as arenite, wacke, arkose and quartzite, among many others, each have more than one definition and various issues of ambiguity related to their usage. As such, the SLTT system prefers to restrict classification of sandy rock beyond Level 4 (*see* Figure 19) to situations where one has more detailed petrographic information garnered after field mapping. In keeping with using a single science concept for naming rocks, namely grain size, we are recommending a minimum of rock names, no matter what "level" of nomenclature is being used. To the extent possible, we have attempted to maintain the fundamental goals of the SLTT study, including the point that rock names carry no implied depositional method of transport or origin of matrix. Mineralogy or composition of cement does not enter into the classification. Cement type, if known, can be used as a modifier of the rock name, (e.g., calcareous subfeldspathic arenite). Similarly, if an arenite has a lot of olivine, then it may be called olivine arenite. The SLTT report considers that epiclastic lithic grains of limestone or dolostone are considered "terrigenous-clastic" material and not "chemical". Presumably, examples of such cases would be called "calcite arenite", or "dolomite wacke", depending on the nature of the carbonate and other grains.

In order to maintain consistency of nomenclature amongst various levels, we have recast Level 5 nomenclature, as shown in Figure 21, relative to earlier work. The main points of distinction and rationale include the following:

- The discrimination between mudrock and sandy rock has been retained using a mud to sand ratio of 1, which is in keeping with the scheme shown in Figure 19. Previously sandstone has been defined as >25% sand-size grains (Gilbert in Williams, Turner and Gilbert 1954; Dott 1964; Pettijohn, Potter and Siever 1972), and >50% sand-size grains (Gilbert in Williams, Turner and Gilbert 1982).
- The size range of mud material is retained as <0.0625 mm (see Figure 19). The previous upper size limit, when specified, has been 0.030 mm (Gilbert in Williams, Turner and Gilbert 1954; Dott 1964; Pettijohn, Potter and Siever 1972), which corresponds neither to the SLTT recommended size nor to the size distinction between silt and clay (*see* Table 17).
- The distinction between "clean" sandstones, or arenites, and "dirty" sandstones, or wackes, is placed at 10% mud-size material, consistent with Figures 19 and 20. Other classification schemes have set the limit at 5% (Gilbert in Williams, Turner and Gilbert 1982), 10% (Gilbert *in* Williams, Turner and Gilbert 1954; Dott 1964) or 15% (Pettijohn, Potter and Siever 1972).
- Quartz-rich sandstones are recognized in Figure 21 by a simple fixed lower limit of 90% quartz sand-size grains (as with Gilbert in Williams, Turner and Gilbert 1982). Previously used more complex limits include those ranging from 80 to 90% quartz (Gilbert in Williams, Turner and Gilbert 1954; Dott 1964) and 90 to 95% quartz (Pettijohn, Potter and Siever 1972). The range depended on the abundance of sand-size feldspar crystals and/or rock fragments. "Quartz arenite" is more or less equivalent to "orthoquartzite", depending on definitions, but the former term is less ambiguous and preferred.
- We have simplified the Level 5 types of arenite by eliminating the term "arkosic arenite", which is variably defined in the literature, and replacing it with the term "feldspathic arenite", a term logically consistent with another subdivision of arenite, namely "subfeldspathic arenite". Note though, that the term "feldspathic arenite" has been used in the past with a definition more akin to the present use of the term "subfeldspathic arenite" (*see* Williams, Turner and Gilbert 1954).

A comparison between Figures 19 and 21 shows that "sandstone", *sensu stricto*, is equivalent to "arenite", and "muddy sandstone" is equivalent to "wacke". However, we recommend the use of Figure 19 terminology except in special cases. It is possible to make some relatively simple Level 5 distinctions in the field with Figure 21, based on visual modal estimates, namely 1) between arenite and wacke, based on the percentage of mud-size material (10%); and subsequently 2) between quartz arenite and quartz wacke (quartz sand-size grains >90%). The distinctions between feldspathic and lithic arenite, subfeldspathic arenite and sublithic arenite, and feldspathic and lithic wacke are based on the ratio of feldspar to rock fragment sand-size grains. A reasonably reliable estimate of sand-size rock fragments is unlikely to be achieved in the field, even with a hand lens. By and large, the use of Figure 21 in the field can be restricted to quartz-rich sandy rocks.

The use of the term "pebbly" in a rock name is discouraged. Terms such as "pebbly mudstone" and "pebbly sandstone" could be applicable when a visual estimate of pebbles can be made, and the modifier "pebbly" could be used to replace the term "conglomeratic" for 2 subtypes of mudrock and 4 subtypes of sandy rock (Figure 19). However, the SLTT report points out that there is no defined abundance of pebbles relative to granules (or coarser gravel-size material) for the term to be used, nor is there a term to be used for granule-rich rocks.

The classification schemes shown in Figures 19 and 21 do not recognize the terms "arkose", "subarkose", "arkosic", "quartzite" and "greywacke" or "graywacke". "Arkose" has been variably and not always precisely defined. "Arkosic" refers variably to relatively feldspathic sandstone and is not applied to sandstone, arenite or wacke in this report. "Quartzite" is commonly used to denote both metamorphosed, clean, quartz-rich sandstone, as well as clean, quartz-rich sandstone cemented with silica, which has grown in optical continuity around quartz grains. Geologists who apply the former definition prefer the term "metaquartzite" (or paraquartzite) to denote truly metamorphic, clean, quartz-rich sandstone. Departures from the original specific definition of graywacke (greywacke) have resulted in favouring the term "wacke" at least in North American usage.

CONGLOMERATIC ROCK

Conglomeratic rock (*see* Figure 18) is an inclusive term for conglomerate and its 3 siblings (*see* Figure 19). Variants of conglomerate, *sensu lato*, contain from 30 to 80% gravel-size material by volume (e.g., muddy conglomerate, muddy sandy conglomerate and sandy conglomerate; *see* Figure 19). Conglomerate, *sensu stricto*, consists of over 80% gravel-size material by volume, regardless of the sand:mud ratio, and itself can be subdivided into 4 subtypes (e.g., granule-rich, pebbly, cobbly and bouldery; *see* Figure 22). The proportions of the specific gravel-size ranges (e.g., granule, pebble, etc.; *see* Table 17) can be estimated in the field and incorporated into a more specific name for the conglomerate, according to the graphical scheme shown in Figure 22 (e.g., pebbly conglomerate). The OGS has opted, for the time being, not to incorporate an additional 24 subtypes of conglomerate defined by SLTT, which are based on more specific ratios of the 4 size ranges of gravel-size material.

The text definitions for conglomerate in the SLTT report conflict with the scheme shown in Figure 22 and are ambiguous or untenable. The OGS has opted to use Figure 22 notwithstanding its 2 technical flaws as outlined below.

1) The SLTT report defines bouldery conglomerate and granule-rich conglomerate as having no granule-size or boulder-size material, respectively, yet defines pebbly conglomerate and cobbly conglomerate as being capable of having all sizes of gravel material (granule, pebble, cobble, boulder). These restrictions are not necessary. Consider a hypothetical tetrahedron consisting of 4 sides (2 of which are essentially shown in Figure 22), labelled granule-size/pebble-size/cobble-size; boulder-size/pebble-size/cobble-size; boulder-size/pebble-size/granule-size; and boulder-

size/cobble-size/granule-size. Of all the SLTT subtypes of conglomerate (total 28) only "pebble conglomerate" and "cobble conglomerate" (not incorporated into the OGS lexicon), which are strictly defined as consisting of >90% pebbles or cobbles, respectively, could actually plot within the volume of the tetrahedron. All other subtypes of conglomerate (both the terms selected by the OGS and the multiple other subtypes of SLTT) would plot only on the granule-size/pebble-size/cobble-size or boulder-size/ pebble-size/cobble-size sides of the tetrahedron, and nowhere within it. Moreover, other stated restrictions in the SLTT report preclude conglomerates from plotting in specific parts of those sides of the tetrahedron. Hence, the OGS has adjusted the definitions of the 4 subtypes of conglomerate (*see* Table 18, Figure 22) to include all possible proportions and all ranges in gravel size for all conglomerate definitions (*see* Table 17).

2) There are cases where proportions of granule, pebble, cobble and boulder clasts will result in 2 different rock names being applicable to the same rock. Consider 2 hypothetical examples. Firstly, a rock that consists, in terms of its gravel-size material, of 0% boulders, 20% cobbles, 30% pebbles and 50% granules, will be classified as a granule-rich conglomerate, in terms of granule-cobble-pebble components, and a pebbly conglomerate in terms of boulder-cobble-pebble components. Secondly, a rock that consists, in terms of its gravel-size material, of 10% boulders, 20% cobbles, 30% pebbles and 40% granules, will be classified as a granule-rich conglomerate in the granule-cobble-pebble triangle, and a pebbly conglomerate in terms of boulder-cobble-pebble components.

Because of the technical flaws noted above, when using Figure 22, we recommend that if more than one rock name results from using this figure, then one should choose the name that reflects the greater abundance in the particle size category. In the second example above, the particle composition consists of a greater proportion of granules (40%) than pebbles (30%), and hence the name granule-rich conglomerate would be chosen.

Table 18. Terrigenous-clastic sedimentary rocks: definitions, based on the schemes shown in Figures 18 to 22.[1]

Major class	Subclass	Definition	Figure
Mudrock		A general term for terrigenous-clastic sedimentary rock having: a) ≤30% gravel-size particles; and b) a sand:mud ratio <1:1	18
	Mudstone	A *mudrock* having: a) less than a trace (0.01%) of gravel-size particles; and b) a modal sand:mud ratio <1:9	19
	Sandy mudstone	A *mudrock* having: a) less than a trace (0.01%) of gravel-size particles; and b) a modal sand:mud ratio between 1:9 and 1:1	19
	Slightly conglomeratic mudstone	A *mudrock* having: a) between a trace (0.01%) and 5% gravel-size particles; and b) a modal sand:mud ratio <1:9	19
	Slightly conglomeratic sandy mudstone	A *mudrock* having: a) between a trace (0.01%) and 5% gravel-size particles; and b) a modal sand:mud ratio between 1:9 and 1:1	19
	Conglomeratic mudstone	A *mudrock* having: a) between 5 and 30% gravel-size particles; and b) a modal sand:mud ratio <1:1	19
	Claystone[A]	A *mudstone* having: a) no gravel-size component; b) <10% sand-size components; and c) a modal silt:clay ratio <1:2	20

Table 18. *continued*

Major class	Subclass	Definition	Figure
	Sandy claystone[A]	A *mudstone* having: a) no gravel-size component; b) between 10 and 50% sand-size particles; and c) a modal silt:clay ratio <1:2	20
	Siltstone[A]	A *mudstone* having: a) no gravel-size components; b) <10% sand-size material; and c) a modal silt:clay ratio >2:1	20
	Clayey siltstone[A]	A *mudstone* having: a) no gravel-size components; b) <10% sand-size material; and c) a modal silt:clay ratio between 1:2 and 2:1	20
	Clayey sandy siltstone[A]	A *mudstone* having: a) no gravel-size components; b) between 10 and 50% sand-size particles; and c) a modal silt:clay ratio between 1:2 and 2:1	20
	Sandy siltstone[A]	A *mudstone* having: a) no gravel-size components; b) between 10 and 50% sand-size particles; and c) a modal silt:clay grain-size ratio >2:1	20
	Marlstone	Variably defined in the literature: term not to be used. Preferred term here is calcareous *claystone*.	
	Pelite	A general term for a sedimentary rock composed mainly of mud-size (mostly clay size) particles (e.g., mudstone, claystone). The term has also been used for the metamorphosed equivalent of mudstone and claystone, i.e., a metamorphic rock with a high modal ratio of mica to quartz + feldspar. Note that the terms *pelite* and *metapelite* are not considered bona fide rock names in this OGS manual. The preferred term is *mudstone* (or *claystone* if appropriate). *See* section on Mudstone.	
Sandy rock		A general term for terrigenous-clastic sedimentary rock having: a) <30% gravel-size particles; and b) a modal sand:mud ratio >1:1	18
	Sandstone	A *sandy rock* having: a) less than a trace (0.01%) gravel-size particles; and b) a modal sand:mud ratio >9:1 [Synonym: arenite]	19
	Muddy sandstone	A *sandy rock* having: a) less than a trace (0.01%) gravel-size particles; and b) a modal sand:mud ratio between 1:1 and 9:1	19
	Slightly conglomeratic sandstone	A *sandy rock* having: a) between a trace (0.01%) and 5% gravel-size particles; and b) a modal sand:mud ratio >9:1	19
	Slightly conglomeratic muddy sandstone	A *sandy rock* having: a) between a trace (0.01%) and 5% gravel-size particles; and b) a modal sand:mud ratio between 1:1 and 9:1	19
	Conglomeratic sandstone	A *sandy rock* having: a) between 5 and 30% gravel-size particles; and b) a modal sand:mud ratio >9:1	19
	Conglomeratic muddy sandstone	A *sandy rock* having: a) between 5 and 30% gravel-size particles; and b) a modal sand:mud ratio between 1:1 and 9:1	19
	Clayey sandstone	A *muddy sandstone* having: a) no gravel-size components; b) between 50 and 90% sand-size particles; and c) a modal silt:clay ratio <1:2	20

Table 18. *continued*

Major class	Subclass	Definition	Figure
	Clayey silty sandstone	A *muddy sandstone* having: a) no gravel-size components; b) between 50 and 90% sand-size particles; and c) a modal silt:clay ratio between 1:2 and 2:1	20
	Silty sandstone	A *muddy sandstone* having: a) no gravel-size components; b) between 50 and 90% sand-size particles; and c) a modal silt:clay ratio >2:1	20
	Orthosandstone	A *sandstone* having: a) no gravel-size component; b) >90% sand-size material; c) any modal silt:clay ratio; and d) the amount of both clay-sized and silt-sized particles has been determined	20
	Arenite[B]	A synonym of *sandstone*: a "clean" sandstone that is well sorted (<0.01% gravel-size material), contains little or no matrix material, and has a relatively simple mineralogic composition; specifically a pure or nearly pure, chemically cemented sandstone containing <10% muddy matrix (sand:mud ratio >9:1)(cf. wacke)	21A
	Feldspathic arenite[B,C,D]	An *arenite* having: a) a modal rock fragment:feldspar ratio <1; b) >25% feldspar; and c) <75% quartz	21B
	Subfeldspathic arenite[B,C]	An *arenite* having: a) a modal rock fragment:feldspar ratio <1; b) 5 to 25% feldspar; and c) 50 to 90% quartz	21B
	Lithic arenite[B,C]	An *arenite* having: a) a modal rock fragment:feldspar ratio >1; b) >25% rock fragments; and c) <75% quartz	21B
	Sublithic arenite[B,C]	An *arenite* having: a) a modal rock fragment:feldspar ratio >1; b) 5 to 25% rock fragments; and c) 50 to 90% quartz	21B
	Quartz arenite[B,C]	An *arenite* having: a) any modal rock fragment:feldspar ratio; and b) >90% quartz	21B
	Wacke[B,C]	A type of *muddy sandstone*: a "dirty" *sandstone* that consists of a mixed variety of unsorted or poorly sorted mineral and rock fragments and of an abundant matrix of mud (clay and fine silt) (sand:mud ratio between 1:1 and 9:1); specifically an impure sandstone containing 10 to 50% muddy matrix (cf. arenite)	21A
	Feldspathic wacke[B,C]	A *wacke* having: a) a modal rock fragment:feldspar ratio <1; and b) <90% quartz	21C
	Lithic wacke[B,C]	A *wacke* having: a) a modal rock fragment:feldspar ratio >1; and b) <90% quartz	21C
	Quartz wacke[B,C]	A *wacke* having: a) any modal rock fragment:feldspar ratio; and b) >90% quartz	21C
Conglomeratic rock		A general term for terrigenous-clastic sedimentary rock having >30% gravel-size particles	18
	Conglomerate	A *conglomeratic rock* having ≥80% gravel-size particles. Where appropriate and desirable, the conglomerate can be named based on the boulder:cobble:pebble:granule ratio (*see* Figure 22).	19
	Muddy conglomerate	A *conglomeratic rock* having: a) between 30 and 80% gravel-size particles; and b) a modal sand:mud ratio <1:1	19

Table 18. *continued*

Major class	Subclass	Definition	Figure
	Muddy sandy conglomerate	A *conglomeratic rock* having: a) between 30 and 80% gravel-size particles; and b) a modal sand:mud ratio between 1:1 and 9:1	19
	Sandy conglomerate	A *conglomeratic rock* having: a) between 30 and 80% gravel-size particles; and b) a modal sand:mud ratio >9:1	19
	Granule-rich conglomerate	A type of *conglomerate* having: a) granule-size clasts >33%; and b) granule-size:pebble-size and granule-size:cobble-size ratios each >1:1 for granule-pebble-cobble material.	22
	Pebbly conglomerate	A type of *conglomerate* having: a) pebble-size clasts >33% and pebble-size:granule-size and pebble-size:cobble-size ratios each >1:1 for granule-pebble-cobble material; or b) pebble-size clasts >33% and pebble-size:cobble-size and pebble-size:boulder-size ratios each >1:1 for pebble-cobble-boulder material.	22
	Cobbly conglomerate	A type of *conglomerate* having: a) cobble-size clasts >33% and cobble-size:granule-size and cobble-size:pebble-size ratios each >1:1 for granule-pebble-cobble material; or b) cobble-size clasts >33% and cobble-size:pebble-size and cobble-size:boulder-size ratios each >1:1 for pebble-cobble-boulder material.	22
	Bouldery conglomerate	A type of *conglomerate* having: a) boulder-size clasts >33%; and b) boulder-size:pebble-size and boulder-size:cobble-size ratios each >1:1 for pebble-cobble-boulder material.	22

[1] *Definitions are based on Soller (2004a), except where noted, and as shown in related figures (right-most column).*
[A] *Term should be applied if the ratio of clay and silt size particles can be determined.*
[B] *Term should be applied if the ratios of quartz, feldspar and rock fragments can be determined.*
[C] *Term not defined by SLTT (Soller 2004a) but applied by OGS.*
[D] *This term has been modified for use by OGS to create parallelism with terms such as subfeldspathic arenite, lithic arenite, sublithic arenite and feldspathic wacke. It has been previously termed "arkosic arenite" (Pettijohn, Potter and Siever 1972).*

Chemical Rocks

Chemical rocks are those formed largely by chemical processes such as precipitation in the form of calcium carbonate, silica, iron or sulphates (e.g., barite). Carbonate rocks are those which consist of ≥50% primary and/or recrystallized carbonate constituents (e.g., calcite, dolomite); these constituents are, by definition, intrabasinal in origin (i.e., not transported into the final depositional environment from other sediment sources). Siliceous rocks are dominated by ≥50% nonclastic siliceous sedimentary material of chemical or biogenic origin. Iron-rich rock, or ironstone, consists of ≥50% iron-bearing minerals, which generally corresponds to >15% iron by weight. It is possible that barite-rich sedimentary rocks occur in the Superior Province of Ontario, as proposed for one area. There is no proposed limit for the proportion of barite for a rock to be considered "barite-rich"; we tentatively propose a limit of ≥20%. Definitions for chemical sedimentary rocks are provided in Table 19, which is followed by specific comments based on various rock subheadings.

Table 19. Chemical sedimentary rocks: definitions, based on the schemes shown in Figures 23 and 24.[1]

Major class	Subclass	Definition	Figure
Noncarbonate rock		A carbonate-bearing sedimentary rock with >50% impurities in a 3-component system of calcite-dolomite-impurities	23
Carbonate rock		A rock with ≥50% primary carbonate minerals (calcite, dolomite) or recrystallized constituents.	23
	Calcitic rock	A *carbonate rock* with modal dolomite:calcite ratio <1:1	23
	Limestone	A *calcitic rock* with: a) >90% carbonate minerals; and b) <10% dolomite	24
	Dolomitic limestone	A *calcitic rock* with: a) >90% carbonate minerals; and b) a modal dolomite:calcite ratio from 1:9 to 1:1	24
	Impure limestone	A *calcitic rock* with: a) 50 to 90% carbonate minerals; and b) <10% dolomite	24
	Impure dolomitic limestone	A *calcitic rock* with: a) 50 to 90% carbonate minerals; and b) a modal dolomite:calcite ratio from 1:9 to 1:1	24
	Dolomitic rock	A *carbonate rock* with modal dolomite:calcite ratio > 1:1	23
	Dolostone	A *dolomitic rock* with: a) >90% carbonate minerals; and b) <10% calcite	24
	Calcareous dolostone	A *dolomitic rock* with: a) >90% carbonate minerals; and b) a modal dolomite:calcite ratio from 1:1 to 9:1	24
	Impure dolostone	A *dolomitic rock* with: a) 50 to 90% carbonate minerals; and b) <10% calcite	24
	Impure calcareous dolostone	A *dolomitic rock* with: a) 50 to 90% carbonate minerals; and b) a modal dolomite:calcite ratio from 1:1 to 9:1	24
Siliceous rock		A sedimentary rock composed of siliceous materials that may be fragmental, concretionary, or precipitated, and of either organic or inorganic origin; e.g., chert, novaculite, geyserite, or diatomite. Siliceous sediments may be formed by primary deposition of silica or by secondary silicification and replacement.[2]	

Table 19. *continued*

Major class	Subclass	Definition	Figure
	Chert[2]	A hard, extremely dense or compact, dull to semi-vitreous, microcrystalline or cryptocrystalline *siliceous rock*, consisting dominantly of interlocking crystals of quartz less than about 30 µm in diameter; it may contain amorphous silica (opal). It has a tough, splintery to conchoidal fracture, and may be white or variously coloured grey, green, blue, pink, red, yellow, brown and black. Chert can occur as areally extensive layered deposits (bedded chert); it may be an original organic or inorganic precipitate or a replacement product.	
	Jasper[2]	A variety of *chert* that may or may not be associated with iron ores and contains iron-oxide impurities that give it various colours, characteristically reddish.	
	Siliceous sinter[2]	A chemical sedimentary *siliceous rock* deposited as a hard incrustation on rocks or on the ground by precipitation from hot or cold mineral waters of springs, lakes or streams.	
Ironstone		An iron-rich sedimentary rock (iron minerals ≥50%), either deposited directly as a ferruginous sediment or resulting from chemical replacement. The term is customarily applied to a hard, coarsely banded or non-banded, and non-cherty sedimentary rock. The iron minerals may be an oxide, carbonate, silicate or sulphide. If iron minerals are from 10 to 50%, the term ferruginous can be applied to the appropriate modified sedimentary rock name (e.g., ferruginous *sandstone*).	
	Carbonate ironstone[3]	An *ironstone* in which the principal iron mineral is a carbonate (e.g., siderite)	
	Silicate ironstone[3]	An *ironstone* in which the principal iron mineral is a silicate (e.g., amphibole, chlorite, greenalite, minnesotaite)	
	Oxide ironstone[3]	An *ironstone* in which the principal iron mineral is an oxide (e.g., magnetite, hematite)	
	Sulphide ironstone[3]	An *ironstone* in which the principal iron mineral is a sulphide (e.g., pyrite, pyrrhotite)	
Sulphate rock		A type of noncarbonate salt sedimentary material having primary constituents consisting of chloride, sulphate, or borate minerals, formed as an exhalite or through evaporative precipitation. (Exhalite: a chemical sediment, usually containing oxide, carbonate or sulphide as anions, and iron, manganese, base metals and gold as cations; formed by the issuance of volcanically-derived fluids onto the sea floor or into the sea.)	
	Barite rock[3]	A *sulphate rock* in which the notable constituent is barite (>20%) (*See* text for rationale).	

[1] *Definitions are largely based on Soller (2004a), except where noted (e.g., [2], [3]), and as shown in related figures (see right-most column).*
[2] *Definition derived mainly from Neuendorf, Mehl and Jackson (2005).*
[3] *Name and definition derived for use within OGS.*

CARBONATE ROCK

Carbonate rocks (consisting of ≥50% carbonate material) are subdivided into 2 classes for our purposes: calcitic rock, with ≥50% of the carbonate material being calcite; and dolomitic rock, with ≥50% of the carbonate material being dolomite (Figure 23). Each of these 2 classes has 4 subdivisions (Figure 24). Table 19 provides definitions of rock names. Technically, the percentages of carbonate minerals are based on weight, but for practical field purposes and petrographic studies, the reaction of the rock to the application of 10% HCl may be the best tool to use (Table 20). Table 20 is roughly correlative to the corresponding metamorphosed equivalents of carbonate rocks (i.e., marbles; *see* Table 28, Part 1).

Limestone, *sensu stricto*, consists of >80% calcite, with <10% dolomite and <10% impurities (*see* Figure 24). Similarly, dolostone, *sensu stricto*, consists of >80% dolomite, with <10% calcite and <10% impurities. Limestone, *sensu lato*, comprises rocks with a dolomite to calcite ratio of <1 and impurities <50% (*see* Figure 24). Dolostone, *sensu lato*, comprises rocks with a dolomite to calcite ratio of >1 and impurities <50%.

Table 20. Reaction of calcitic and dolomitic rocks to dilute (10%) HCl.[1,2]

Material	Rock	Reactivity to 10% dilute HCl solutions
Calcitic material	Limestone	Fizzes aggressively
	Dolomitic limestone	Fizzes moderately
	Impure limestone	Fizzes aggressively to moderately, depending on amount of impurities
	Impure dolomitic limestone	Fizzes moderately to slightly
Dolomitic material	Dolostone	Does not fizz
	Calcareous dolostone	Fizzes slightly
	Impure dolostone	Does not fizz
	Impure calcareous dolostone	Fizzes slightly or not at all, depending on amount of impurities

[1] *Modified after Soller (2004a).*
[2] *These reactions also apply generally to pure and impure marbles.*

The above nomenclature system of carbonate rocks does not take into account the presence of siderite (iron carbonate), a mineral found in abundance in some ironstone units. For iron-bearing rocks, see the section on Ironstone. Calcareous sinter has not been recognized in Ontario and is not included in our list for carbonate rocks.

SILICEOUS ROCK

Siliceous chemical rocks (>50% nonclastic siliceous sedimentary material), essentially consist of chert in the case for Archean terranes in Ontario. We have subdivided siliceous rock into chert, jasper and siliceous sinter. Recognizing true chert (i.e., chemical sediment) in Archean terranes is difficult to do reliably, particularly in the more deformed and metamorphosed rocks. It has in some, possibly many, cases been mistaken for finely recrystallized quartz and possibly silica-flooded zones in mylonite. Jasper is essentially chert with some iron impurities that produce a ruddy colour. The term may be useful in some cases (e.g., in association with some ironstone, or pebbles in some Neoarchean (“Temiskaming-type”) and Proterozoic (“Huronian”) conglomerates). The term siliceous sinter relies on considerable interpretation of the depositional environment (e.g., hot or cold springs) and should be used with caution, if at all.

IRONSTONE

For years, there has been debate over the use of the terms “iron formation” and “ironstone”. The 2 terms have been defined in large part on aspects such as age (Archean vs. Proterozoic), thickness, extent, physical character, mineralogy, associated rocks and relative abundance of iron species. The term “iron formation” has been used commonly within the OGS and elsewhere to describe specific units in Ontario, within both mapping and lithological contexts. However, as elucidated in the SLTT report, there are reasonable technical arguments that can be used to treat the 2 terms in a manner more consistent with the SLTT rules for optimum nomenclature:

- Definitions of rocks versus formations ought to be adhered to.
- Ironstone is a rock name, referring to a rock with >50% iron minerals or components, as distinct from rocks with 10 to 50% iron minerals or components (Table 21).
- Iron formation should refer to a rock stratigraphic unit composed, in general, of a notable proportion of ironstone.
- Rock names should not be based on age.

Table 21. Distinction between rocks with iron-rich versus iron-bearing sedimentary material.[1]

Iron-bearing sedimentary material	Iron minerals or components between 10 to <50%	Examples: Ferruginous limestone Ferruginous sandstone Ferruginous mudstone
Iron-rich sedimentary material	Iron minerals or components ≥50%	Examples:[2] Oxide ironstone Carbonate ironstone Sulphide ironstone

[1] *Modified after Soller (2004a).*
[2] *These examples are invoked for OGS use. See text below.*

The issue of nomenclature of iron-rich rocks is not dealt with sufficiently in the SLTT report, in our view, for application to the Precambrian Shield of Ontario. Hence, we have modified the SLTT terminology somewhat (*see* Table 19) and are providing guidelines as to usage of terms (*see* Table 15, back pocket). The primary purpose is to elucidate the general type of iron-bearing mineral(s) in the ironstone. Hence we prefer terms such as "oxide ironstone" (i.e., magnetite) and "carbonate ironstone" (i.e., siderite) to terms such as "arenaceous ironstone", "muddy ironstone" or "calcareous ironstone". The latter could be taken to signify an association of material with ironstone but with no indication as to what the ironstone consists of. Therefore, we recommend, for mapping purposes, the use of the terms provided in Table 21. Once the ironstone and associated rocks have been named and described, then a map unit name can be assigned, for example, "arenite-magnetite ironstone" or "chert-magnetite ironstone" or "banded chert-magnetite ironstone". In general parlance and in specific context, the terms "iron formation" or "banded iron formation" may suffice when referring to a stratigraphic unit, even if it is an informal unit. Nomenclature for metamorphosed ironstones is described under the section on Metamorphic Rocks.

SULPHATE ROCK

The only likely type of sulphate rock in Archean rocks in Ontario would be a barite-rich rock, hence the inclusion of the term "barite rock" as a possible sedimentary rock name. In the SLTT report, barite rocks are referred to under "sedimentary material dominated by noncarbonate salts (sulphate-salt sediment)". Barite can be deposited in an evaporitic environment and in deep oceanic environments as pelagic crystals and possibly as precipitates from hydrothermal fluids as an exhalite. Archean sedimentary barite deposits are rare and have been described in a few Paleo- to Mesoarchean terranes. The difficulty in establishing the sedimentary nature of a barite-rich sedimentary rock in the field (and laboratory) cannot be understated as not all barite-rich rocks in Ontario, if any, are sedimentary in origin. It is not expected that this rock type will be confidently recognized in the field in Ontario. As a provisional guide, we are assigning a limit of ≥20% barite to define a sedimentary "barite rock".

METAMORPHIC ROCKS

The third major rock class is Metamorphic Rocks, which is arguably the most difficult to address. One must infer the original properties of the rock to some degree and contend with additional metamorphic changes such as those imposed by heat, pressure, related fluids and often deformation. A fundamental issue in mapping rocks in the Precambrian Shield is the basis on which one chooses to name rocks. Some geologists prefer to name a rock based on what it is, not what it may have been, as expressed by the IUGS (Le Maitre 2002) for igneous rocks. However, for metamorphic rocks, the IUGS (Fettes and Desmons 2007) acknowledges that metamorphic rocks may have up to 3 names: a systematic name (e.g., carbonate granofels), a specific name (e.g., marble) and a protolith-based name (e.g., metalimestone). The SLTT has proffered that appending the prefix “meta” to an inferred protolith name is common practice in the Canadian Shield and utilized by mineral explorationists, academics and resource appraisers because of its utility (Soller 2004b: Appendix B, “Classification by Protolith”). Nevertheless, the contributors to that tome argue that this genetic approach is not preferable in a database system, in part because fabric and composition are key attributes of the rock, and thus, at least technically, the form “meta(*some rock name*)” as a primary field name is not a preferred practice.

The term “metamorphic rock” in current usage refers to “any rock derived from pre-existing rocks by mineralogical [generally minor], chemical, or structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment, generally at depth in the Earth's crust” (Neuendorf, Mehl and Jackson 2005). This definition would include virtually all Precambrian rocks in Ontario, from those that preserve delicate primary features to those in which no primary features are recognizable. It would also include impact rocks, impact melts, fault-related rocks and other brecciated rocks. The OGS has opted to place Fault Rocks and Impactites in another class termed, simply, “Other Rocks”.

The OGS has traditionally produced maps, particularly for greenstone belt areas, that infer what the protolith was and appended the prefix “meta” to the rock name to indicate what it was before metamorphism. For the moment, the OGS prefers to retain its traditional approach, with caveats. During mapping, geological context is important. Hence, in typical volcano-sedimentary “greenstone” belts, the common mapping approach is to determine the protolith of the rock being mapped, and use the prefix “meta” and appropriate modifiers for elaboration (*see* Part 2). However, for mapping relatively thin greenstone belts or slivers, which are typically more extensively metamorphosed and deformed, our tactic is to use Metamorphic Rock nomenclature (this section). This latter approach is also applicable to high-grade terranes, such as the English River Subprovince or parts of the Grenville Province (Figure 1), which consist predominantly of gneiss, migmatite, amphibolite and other rock units such as marbles.

The recommended approach in the previous paragraph is problematic, however, when metamorphic grade differs considerably across the map area. For example, under greenschist-facies conditions with minimal deformation, textural features may be sufficiently well-preserved to allow for unequivocal determination of the original rock (e.g., a pillowed basalt flow). However, where the same parent rock was subjected to upper amphibolite conditions, it may not be possible to unequivocally determine the protolith (e.g., the pillowed basalt flow is more appropriately described as an amphibolite). Under these circumstances, the individual geoscientist will need to determine the approach that works best for their particular project. For example, in a situation where higher metamorphic grade increases toward the margins of a greenstone belt, it might be fruitful to use primary rock names at lower metamorphic grades, but to switch to the metamorphic class terminology for the higher-grade rocks. This would allow for the change in grade to be readily portrayed on the map; but this approach only works if the mapper is consistent as to the transition from one terminology to the other. In other situations, if there is no discernable pattern in distribution of metamorphic grade, then the sole use of the metamorphic class terminology might be preferable.

As individual metamorphic terranes may have considerably different general characteristics, we have found that some of the decisions used in the metamorphic classification schemes are not apropos to our needs. The differences between the IUGS and the SLTT systems are numerous and it is commonly impractical to invoke both systems to any significant degree. Some of the more salient differences are as follows:

- Both the SLTT and IUGS classification schemes are designed for hand specimen scale (1 to 30 cm), which is commonly not sufficient to capture key or salient outcrop features (e.g., describing migmatites).
- Neither the SLTT nor IUGS classification schemes are truly hierarchical, which poses problems for database and pick list construction. We have used the 4 groupings in Level 2 (Table 22) in an attempt to address this problem; however, our proposed approach is not a unique solution.
- The IUGS does not recommend the use of "colour terms" for metamorphic rocks, such as melanocratic. But we have opted to use colour index as subdivisions for some rocks that are defined on the basis of structure, owing to the potential for a wide variety of rocks throughout Ontario.
- Because of the general abundance of high-grade metamorphic rocks in the Grenville Province, many of which are derived by partial melting, the IUGS system for migmatites was considered inadequate. Consequently, we have favoured the terminology proposed by Sawyer (2008).
- Breccias in metamorphic terranes present the problem of establishing with certainty the timing of the brecciation, that is, before, during or after metamorphism and deformation. As such, features representing a variety of types of breccia, particularly in the Grenville Subprovince, are dealt with in a fashion modified from the IUGS and SLTT systems.
- Reflecting the geology of Ontario, we have 1) expanded the nomenclature proposed by IUGS for metacarbonate and related rocks to make the classification more complete; 2) simplified the metasomatic rock and contact metamorphism classifications proposed by IUGS, in part because these categories violate the general principle that terminology should be nongenetic; and 3) omitted terms related to combustion, lightning and hot-slab metamorphism (*see* Fettes and Desmons 2007).
- For rocks that have been subjected to changes due solely to fault action, nomenclature is contained in the "Other Rocks—Fault Rocks" subsection. Rocks subjected to fault action, and subsequently metamorphosed, are treated as metamorphic rocks.
- For rocks that were either formed or modified by impact processes, notwithstanding the term "shock metamorphism", nomenclature is contained in the "Other Rocks—Impactites" subsection.

In order to develop a systematic approach to naming a metamorphic rock, the IUGS has proposed a flow chart for focussing on an appropriate rock name (Figure 25). This chart represents a reasonable approach to naming a metamorphic rock when mapping. Also provided, as general references, are the various metamorphic facies with indicator minerals for rocks of basaltic composition (Figure 26).

The 4 main, or parent, first-order subdivisions for metamorphic rocks are "Fabric basis", "Compositional basis", "Migmatites" and "Metasomatic rocks". All subdivisions are further subdivided into additional levels.

Details of metamorphic rock types for this manual are provided as follows:

- The general outline for the Metamorphic Rock Classification (5 levels) is given in Table 22.
- The specific outline with rationale is in Table 23.
- The organization of the pick lists for field data input is provided in Table 24.
- Metamorphic facies and grades of metamorphism are in Table 25.
- Key definitions of metamorphic rock terms are given in Table 26.
- Definitions for the metamorphic rock names are provided in Table 27.
- Mineral abundances can be estimated with the aid of Figure 2.

Table 22. Metamorphic rocks: overview.

Level 1	Metamorphic Rock Classification
Level 2	Structural basis
	Compositional basis
	Migmatites
	Metasomatic rocks
Level 3	Schist
	Gneiss
	Granofels
	Hornfels
	Metabreccia
	Mafic/ultramafic
	Metacarbonate rocks
	Meta-ironstone rocks
	Metatexite
	Diatexite
	Boundary
	Contact
	Non-contact
Level 4	Additional subdivisions of most Level 3 rock names
Level 5	Additional subdivisions of some rocks at Level 4

Table 25. Metamorphic rocks: facies and grades.

Metamorphic Facies (Pressure, Temperature)[A,B]
Zeolite
Subgreenschist
Greenschist
Epidote-amphibolite
Amphibolite
Hornfels
Sanidinite
Glaucophane-schist (or blueschist)
Eclogite
Granulite
Metamorphic Grade (Temperature, Pressure)[A]
Very low
Low
Medium
High
Very high

[A] *Modified from Fettes and Desmons (2007).*
[B] *See Figure 26.*

Key Definitions

Table 26. Metamorphic rocks: key terms.[1]

Main Term	Sub-term	Definition
Structure		Arrangement of parts of a rock mass irrespective of scale, including spatial relationships between the parts, their relative size and shape and the internal features of the parts. Hence, *microstructure*, *mesostructure*, *megastructure*.
	Gneissose structure	Type of *structure* characterized by a *schistosity* that is either poorly developed throughout the rock or, if well developed, occurs in broadly spaced zones, such that the rock will split on a scale of >1 cm. Mineralogical or lithological layering, streaks and/or lenses are commonly present. Replaces the term *gneissosity*.
	Granoblastic structure	Type of *structure* in which the constituent grains are equidimensional and of equal size and have well-sutured or irregular boundaries.
	Granoblastic-polygonal structure	Type of *structure* in which the constituent grains are equidimensional and of equal size (hence granoblastic) and have straight or smoothly curved boundaries (polygonal) such that they meet at triple junctions (i.e., 120° angles).
	Granofelsic structure	Type of *structure* resulting from the absence of *schistosity* such that the mineral grains are equant (e.g., quartz, feldspar, garnet, pyroxene), or if inequant have a random orientation. Mineralogical or lithological layering may be present.
	Megastructure	*Structure* at the regional or mappable scale.
	Mesostructure	*Structure* at the hand-specimen scale.
	Microstructure	*Structure* at the microscope scale.
	Schistose structure	Type of *structure* characterized by a *schistosity* that is well developed, either uniformly throughout the rock or in narrowly spaced repetitive zones such that the rock will split on a scale of ≤1 cm.
Fabric		Relative orientation of parts of a rock mass (complete spatial and geometrical configuration), which commonly refers to crystallographic and/or shape orientation of mineral grains or groups of grains, but can also be used on a larger scale. Hence *microfabric*, *mesofabric*, *megafabric*. *Preferred orientation* of minerals can be characterized as *linear fabric* and *planar fabric*. Cf. *random fabric*.
	Linear fabric	The *fabric* of a rock with a *preferred orientation* of linear or elongate minerals (e.g., amphiboles).
	Megafabric	The *fabric* of a rock as seen in an outcrop.
	Mesofabric	The *fabric* of a rock as seen in hand specimen, with or without the aid of a hand lens.
	Microfabric	The *fabric* of a rock as seen under the microscope.
	Penetrative fabric	Said of features that contribute to a rock *fabric* if all subdivisions of the rock at some scale possess those features (e.g., *microfabric*, *mesofabric*, *megafabric*). These features may be penetrative at one scale, but may be nonpenetrative at a different scale.
	Planar fabric	The *fabric* of a rock with a *preferred orientation* of planar minerals (e.g., micas).
	Preferred orientation	Non-random orientation of *planar* or *linear fabric* elements, including crystallographic directions (lattice-preferred orientation) or elongation/flattening axes of crystals (shape-preferred orientation). May result from primary processes (e.g., magmatic settling or flow) or secondary processes (e.g., deformation). See *foliation*.
	Random fabric	The *fabric* of a rock lacking a *preferred orientation* of minerals.
Texture		Currently used in 2 ways: the intended use should be defined (IUGS does not recommend how it should be used). a) Term defining the relative size, shape and spatial interrelationship between grains, and internal features of grains. Synonymous with some aspects of the preferred term *microstructure*. b) Term denoting the presence of *preferred orientation* on the microscopic scale. Synonymous in the sense of preferred orientation with the preferred term *microfabric*.
Foliation		A general term for any repetitively occurring or *penetrative* planar feature in a rock body. Examples include layering on a scale of a centimetre or less, and the preferred planar orientation of inequant mineral grains or grain aggregates. Includes *schistosity*, *gneissose structure*, *cleavage*.
	Cleavage	Property of a rock to split along a regular set of parallel or subparallel closely spaced surfaces. Subdivided into *continuous cleavage* and *spaced cleavage*.
	Continuous cleavage	*Cleavage* present throughout the rock at the grain-size scale. Equivalent to well-developed *schistosity* and *slaty cleavage*.
	Fine continuous cleavage	*Continuous cleavage* as found in fine-grained rocks.

Table 26. *continued*

Main Term	Sub-term	Definition
	Coarse continuous cleavage	*Continuous cleavage* as found in coarse-grained rocks.
	Slaty cleavage	Type of *continuous cleavage* in which individual grains are too small to be seen with the unaided eye.
	Microlithon	Tabular to lenticular domain lying between surfaces in a *spaced cleavage* (e.g., *crenulation cleavage*, *disjunctive cleavage*).
	Spaced cleavage	*Cleavage*, visible to the unaided eye, that is not *continuous* or completely *penetrative* in a rock, such that the cleavage planes are spaced at regular intervals and separated by zones known as *microlithons*. Also known as "domainal cleavage" where there are "M-domains" or mica-rich domains, i.e., that part occupied by the cleavage plane, and "Q-domains" or quartz-rich domains, i.e., that part in between the "M-domains".
	Crenulation cleavage	Type of *spaced cleavage* developed during crenulation of a pre-existing foliation, and oriented parallel to the axial plane of the crenulation. (Also called "crenulation schistosity").
	Disjunctive cleavage	Type of *spaced cleavage* developed independently of any pre-existing mineral orientation in the rock (e.g., *fracture cleavage*, *pressure solution cleavage*).
	Fracture cleavage	Type of *disjunctive cleavage* comprising a regular set of closely spaced parallel or subparallel fractures along which the rock will preferentially split.
	Pressure solution cleavage	Type of *disjunctive cleavage* resulting from the preferential movement of material, usually quartz, from the cleavage domains into the intercleavage domains or *microlithons*, creating phyllosilicate-rich and quartz-rich zones, which impart a striped appearance.
	Spaced schistosity	Type of *spaced cleavage* characterized by regularly spaced zones, with *schistose structure*, that are structurally distinct and separate from rock layers called *microlithons*.
	Gneissosity	Replaced by the synonymous term *gneissose structure*.
	Schistosity	*Preferred orientation* of inequant mineral grains or grain aggregates produced by metamorphic processes. *Schistosity* is present in most cleavage types with the exception of some *disjunctive cleavages* (e.g., *fracture cleavage*). If "well developed", there is a high degree of preferred orientation of a large amount of inequant mineral grains or grain aggregates either throughout the rock or in narrowly spaced repetitive zones such that the rock tends to split on a scale of ≤1 cm. If "poorly developed", there is either a low degree of preferred orientation of a small amount of inequant mineral grains or grain aggregates; or a high degree of preferred orientation such that the rock tends to split on a scale of >1cm.
Migmatization		The process, involving partial melting, that leads to the formation of migmatite.
Metasomatism		The process whereby a chemical composition of a rock or rock portion is pervasively altered, in a solid state, through the introduction and/or removal of chemical components as a result of the interaction of the rock with aqueous fluids or solutions.
	Boundary metasomatism	*Metasomatism* that occurs at the contact of 2 rock types, with replacement of both rock types (e.g., carbonate and shale).
	Contact metasomatism	*Metasomatism* that occurs at or near the contact between a magmatic rock and another rock, at various stages in the magmatic evolution.
	Diffusional metasomatism	*Metasomatism* that takes place by the diffusion of a solute through a stagnant solution, driven by chemical potential or chemical activity gradients in the rock-pore solution. The resulting rocks form rather thinly zoned bodies (rims) along cracks, veins and contact surfaces, and the composition of minerals may vary gradually across metasomatic zones.
	Infiltrational metasomatism	*Metasomatism* that takes place by the transfer of material in solution, infiltrating through the host rocks, driven by pressure and concentration gradients between the infiltrating and rock-pore solutions. The resulting rocks generally occupy much greater volumes than diffusional metasomatic rocks and the composition of minerals is constant across metasomatic zones.
	Non-contact metasomatism	An unofficial term referring to *metasomatism* that occurs distal to a contact between rocks or country rock and crystallized magma.

[1]*Definitions modified from Fettes and Desmons (2007).*

Table 27. Metamorphic rocks: definitions.[1]

Rock Class	Rock Name	Definition
Structural Basis		
Schist		A rock displaying a schistose structure (well-developed schistosity). The term includes the specific varieties of *phyllite* and *slate*.
	Ultramafic schist[D]	A *schist* with an overall M′ >90 [A]
	Mafic schist[D]	A *schist* with an overall M′ from 35 to 90 [A]
	Intermediate schist[D]	A *schist* with an overall M′ from 15 to 35 [A]
	Felsic schist[D]	A *schist* with an overall M′ from 0 to 15 [A]
	Phyllite	A variety of *schist* that is fine to medium grained, having a lustrous sheen due to the parallel arrangement of phyllosilicate minerals. Typically occurs at low metamorphic grade.
	Slate	A variety of *schist* that is ultra fine to very fine grained, having a slaty cleavage. Typically occurs at very low metamorphic grade.
Gneiss		A generally medium- to coarse-grained rock, displaying a planar gneissose structure (poorly developed schistosity) or a dominant linear fabric, which will split on a scale of >1 cm. In the latter case, the rock is termed *lineated gneiss*.
	Ultramafic gneiss[D]	A *gneiss* with an overall M′ >90 [A]
	Mafic gneiss[D]	A *gneiss* with an overall M′ from 35 to 90 [A]
	Intermediate gneiss[D]	A *gneiss* with an overall M′ from 15 to 35 [A]
	Felsic gneiss[D]	A *gneiss* with an overall M′ from 0 to 15 [A]
	Granular gneiss[D]	A feldspar-dominated *gneiss* that exhibits a protomylonitic texture, but lacks the fine-grained matrix present in *porphyroclastic gneisses*. Texturally, it is similar to the early stages of development of a protomylonite, but has a coarser grain size due to subsequent recrystallization. A field-based descriptive term that has been used in the Grenville Province.
	Irregular-layered gneiss[D]	A fine-grained, well-layered *gneiss* with non-rectilinear layering and discordance between layers. May occur interlayered with *straight gneiss* and *porphyroclastic gneiss*. A field-based descriptive term that has been used in the Grenville Province.
	Lineated gneiss	A *gneiss* with a dominant linear fabric as opposed to the more common dominant planar fabric.
	Orthogneiss	A *gneiss* that is derived from an igneous rock. May be used with other terms such as “felsic orthogneiss".
	Paragneiss	A *gneiss* that is derived from a sedimentary rock. May be used with other terms such as “intermediate paragneiss".
	Porphyroclastic gneiss[D]	A fine-grained *gneiss* with isolated large crystals (porphyroblasts or porphryoclasts). The larger crystals are typically alkali feldspar, garnet and/or amphibole, but specific mineralogy is not part of the definition. Origin of the crystals (*in-situ* growth, or the result of mechanical and/or diffusional grain-size reduction) is not part of the definition. May occur interlayered with *irregular-layered gneiss*. Texturally, it is similar to the late stages of development of a protomylonite, but the groundmass is coarser grained. A field-based descriptive term that has been used in the Grenville Province.
	Straight gneiss[D]	A fine-grained, well-layered *gneiss* with rectilinear layering that is continuous on the metre scale and which exhibits minimal discordance between layers. May occur interlayered with *irregular-layered gneiss*. Texturally, it is similar to a layered ultramylonite, but the rock is coarser grained than an ultramylonite. A field-based descriptive term that has been used in the Grenville Province.
Granofels		A generally medium- to coarse-grained rock displaying a granofelsic structure, with the absence or near absence of schistosity or lineation. A granoblastic structure may be present.
	Ultramafic granofels[D]	A *granofels* with an overall M′ >90 [A]
	Mafic granofels[D]	A *granofels* with an overall M′ from 35 to 90 [A]
	Intermediate granofels[D]	A *granofels* with an overall M′ from 15 to 35 [A]
	Felsic granofels[D]	A *granofels* with an overall M′ from 0 to 15 [A]

Table 27. *continued*

Rock Class	Rock Name	Definition
Structural Basis *cont'd*		
Hornfels		A typically aphanitic metamorphic rock that has little or no foliation or lineation. Inherited protolith characteristics may be preserved (e.g., sedimentary laminations, metamorphic layering). Although hornfels is typically a product of contact metamorphism, that genesis is not a requirement of this descriptive definition. Hornfels, in this sense, is the aphanitic equivalent of *granofels*.
	Ultramafic hornfels[D]	A *hornfels* with an overall M′ >90 [A]
	Mafic hornfels[D]	A *hornfels* with an overall M′ from 35 to 90 [A]
	Intermediate hornfels[D]	A *hornfels* with an overall M′ from 15 to 35 [A]
	Felsic hornfels[D]	A *hornfels* with an overall M′ from 0 to 15 [A]
Metabreccia		Normally, a rock composed of angular to subrounded broken rock fragments surrounded by a matrix that may be fine grained, but is generally medium or coarse grained. The origin of the rock may be the result of igneous, volcanic, sedimentary, and/or tectonic and metamorphic processes.
	Block gneiss[D]	A *metabreccia* that consists of angular to subrounded broken rock fragments surrounded by a medium- to coarse-grained matrix, with the matrix exhibiting gneissose structure.
	Marble breccia[D]	A *metabreccia* that consists of fragments, typically of silicate rock, surrounded by a matrix composed of carbonate minerals (typically calcite and/or dolomite in varied proportions). Fragments may be monolithic or heterolithic. Sometimes referred to as marble tectonic breccia.
Compositional Basis		
Mafic and ultramafic rocks		
	Amphibolite	A mafic, gneissose or granofelsic metamorphic rock consisting mainly of green, brown or black amphibole and plagioclase (including albite). Amphibole + plagioclase ≥75% (each a major constituent); amphibole ≥30% of the rock, and amphibole ≥50% of total mafic minerals; plagioclase >5%. *See* Figure 27.
	Ortho-amphibolite	*Amphibolite* derived from an igneous rock
	Para-amphibolite	*Amphibolite* derived from a sedimentary rock
	Feather amphibolite	Variety of *amphibolite* or amphibole-rich rock wherein acicular amphibole crystals lie within the main foliation of the rock and intersect each other to produce a mat of crystals, which commonly show stellate grouping.
	Eclogitoid	Collective term for metamorphic rocks containing omphacite and garnet
	Eclogite	A plagioclase-free metamorphic rock composed of ≥75% (volume) omphacite and garnet (typically almandine-pyrope); each is a major constituent Omphacite ≤75%; garnet ≤75%; rutile, kyanite and quartz may be present.
	Garnet omphacitite	An *eclogite*-like rock except omphacite ≥75%
	Omphacite garnetite	An *eclogite*-like rock except garnet ≥75%
	Serpentinite	A rock composed of >75% minerals of the serpentine group, from the (metamorphic) hydration of ferromagnesian silicate minerals, most commonly olivine and pyroxene.
Metacarbonate rocks		A general term which includes carbonate and carbonate-bearing metamorphic rocks and all calc-silicate and related rocks, some of which may be free of carbonate minerals.
	Marble	A metamorphic rock containing >50% (volume) carbonate minerals (calcite, dolomite, siderite). *See* Figure 28.
	Pure Marble[D]	A *marble* that contains >90% (vol.) carbonate minerals with the remainder as silicate and other minerals. *See* Figure 28.
	Calcite marble[D]	A *pure marble* in which calcite accounts for >67% of the carbonate minerals.
	Meso-carbonate marble[D]	A *pure marble* in which calcite accounts for 33 to 67% of the carbonate minerals.
	Dolomite marble[D]	A *pure marble* in which dolomite accounts for >67% of the carbonate minerals.
	Impure marble[D]	A *marble* that contains from 50 to 90% (vol.) carbonate minerals with the remainder as silicate and other minerals. *See* Figure 28.

Table 27. *continued*

Rock Class	Rock Name	Definition
Compositional Basis *cont'd*		
	Impure calcite marble[D]	An *impure marble* in which calcite accounts for >67% of the carbonate minerals.
	Impure meso-carbonate marble[D]	An *impure marble* in which calcite accounts for 33 to 67% of the carbonate minerals.
	Impure dolomite marble[D]	An *impure marble* in which dolomite accounts for >67% of the carbonate minerals.
	Carbonate-silicate rock[D]	A rock that contains 10 to 50% carbonate minerals, with the remainder as silicate and other minerals. *See* Figure 28.
	Calcitic carbonate-silicate rock[D]	A *carbonate-silicate rock* in which calcite accounts for >67% of the carbonate minerals.
	Meso-carbonate-silicate rock[D]	A *carbonate-silicate rock* in which calcite accounts for 33 to 67% of the carbonate minerals.
	Dolomitic carbonate-silicate rock[D]	A *carbonate-silicate rock* in which dolomite accounts for >67% of the carbonate minerals.
	Carbonate-bearing silicate rock[D]	A rock that contains <10% carbonate minerals, >45% impurities, and the remainder as calc-silicate minerals. *See* Figure 28.
	Calcitic carbonate-bearing silicate rock[D]	A *carbonate-bearing silicate rock* in which calcite accounts for >67% of the carbonate minerals.
	Meso-carbonate-bearing silicate rock[D]	A *carbonate-bearing silicate rock* in which calcite accounts for 33 to 67% of the carbonate minerals.
	Dolomitic carbonate-bearing silicate rock[D]	A *carbonate-bearing silicate rock* in which dolomite accounts for >67% of the carbonate minerals.
	Calc-silicate rock[D]	A rock that contains <10% carbonate minerals, >45% calc-silicate minerals, and the remainder as impurities. *See* Figure 28.
	Calcitic calc-silicate rock[D]	A *calc-silicate rock* in which calcite accounts for >67% of the carbonate minerals.
	Meso-calc-silicate rock[D]	A *calc-silicate rock* in which calcite accounts for 33 to 67% of the carbonate minerals.
	Dolomitic calc-silicate rock[D]	A *calc-silicate rock* in which dolomite accounts for >67% of the carbonate minerals.
Meta-ironstone		A metamorphosed iron-rich sedimentary rock (iron minerals ≥ 50%). The iron minerals may be an oxide, carbonate, silicate or sulphide, and may be associated with metamorphic minerals such as garnet and ferrosilite. If iron minerals are from 10 to <50%, the term ferruginous can be applied to the appropriate metamorphic rock name.
	Oxide meta-ironstone[D]	A *meta-ironstone* in which the principal iron mineral is an oxide (magnetite)
	Pyroxene meta-ironstone[D]	A *meta-ironstone* in which the principal iron mineral was carbonate, which has now, through metamorphism, been replaced by pyroxene minerals, typically ferrosilite (e.g., originally siderite)
	Silicate meta-ironstone[D]	A *meta-ironstone* in which the principal iron mineral is a silicate (amphibole, garnet)
	Sulphide meta-ironstone[D]	A *meta-ironstone* in which the principal iron mineral is a sulphide (pyrite, pyrrhotite)
Migmatites		
Migmatite[B, C]		A mesoscopically to megascopically heterogeneous, composite rock found in medium- and high-grade metamorphic areas, consisting of 2 or more petrographically different parts (*see* Table 29), one of which has formed by partial anatexis of a pre-existing rock.
	Metatexite	A type of *migmatite* with the following characteristics: – paleosome: - widely preserved, coherent pre-melting structures - microstructure appears unchanged – neosome: - generally segregated into leucosome and melanosome (but not necessarily) – melanosome: - may have preserved pre-melting structures (as the fraction of melt is low) (Leucosome <20%) *See* Figure 29.
	Patch metatexite	A type of *metatexite* in which the neosome occurs *in situ* as small, discrete patches. (Leucosome <20%)

Table 27. *continued*

Rock Class	Rock Name	Definition
Migmatites ***cont'd***		
	Dilation-structured metatexite	A type of *metatexite* in which the location of the domains of leucosome or neosome is controlled by the distribution of dilational structures that develop in the competent layers as the migmatite is deformed. (Leucosome <20%)
	Net-structured metatexite	A type of *metatexite* in which the neosome, or more commonly the leucosome, or leucocratic veins, form a net-like pattern enclosing paleosome or residuum. (Leucosome <20%)
	Stromatic metatexite	A type of *metatexite* in which the neosome (leucosome and melanosome), or just the leucosome, occurs as laterally continuous, parallel layers oriented along the compositional layering (e.g., bedding) or foliation. (Leucosome <20%)
	Diatexite	A type of *migmatite* with the following characteristics: – paleosome: - if present, occurs as rafts, schollen and xenoliths – neosome: - dominant and diverse in appearance reflecting a large range in anatectic melt, which is dispersed throughout - pre-partial melting structures are absent; commonly replaced by low synanatectic strain structures (e.g., magmatic/submagmatic foliation, schlieren), or by isotropic neosome - ranges from dominantly leucocratic to dominantly mesocratic (e.g., unsegregated melt and residuum) to dominantly melanocratic (Leucosome >20%) *See* Figure 29.
	Nebulite diatexite	A type of *diatexite* in which the neosome is diffuse and difficult to differentiate from the paleosome. (Leucosome >20%)
	Schollen diatexite	A type of *diatexite* that contains schollen or rafts of paleosome or more rarely residuum. Schollen may show a progression from blocky to rounded or elongate shapes and a progressively better alignment in the direction of a higher fraction of melt and synanatectic strain. (Leucosome >20%)
	Schlieric diatexite	A type of *diatexite* characterized by the presence of schlieren, but few schollen or rafts of paleosome material. (Leucosome >20%)
	Diatexite migmatite	A type of *diatexite* in which the neosome is dominant and melt is pervasively distributed throughout.
Metasomatic Rocks		
Metasomatic rock		A metamorphic rock in which the mineral and chemical bulk compositions have been substantially changed by metasomatism (*see* Table 51).
Boundary		*Metasomatic rock* that occurs at the contact of any 2 rock types.
	Bimetasomatic rock	*Boundary metasomatic rock* formed by replacement of (reaction between) both rocks from two-way diffusion of different components by migration of stationary pore fluids.
	Fenite	A high-temperature *boundary metasomatic rock* characterized by the presence of alkali feldspar, sodic amphibole and sodic pyroxene. May also contain nepheline, calcite and biotite/phlogopite. Common accessory minerals are titanite and apatite. Typically forms zoned aureoles around alkalic complexes on a metre to kilometre scale; may also occur at the intrusive contact.
	Rodingite	A *boundary metasomatic rock*, typically involving the replacement of dikes or inclusions of basic rocks within serpentinized ultramafic bodies. May also replace mafic/basic rocks associated with ultramafic rocks. Composed primarily of grossular-andradite garnet and calcic pyroxene, with vesuvianite, epidote, scapolite and iron oxides as characteristic accessories. May host Fe and Au mineralization.
Contact		*Metasomatic rock* formed at or near the contact between a magmatic rock and another rock (country rock).
	Endocontact zone	*Contact metasomatic rock* derived from replacement of the magmatic rock.
	Exocontact zone	*Contact metasomatic rock* derived from replacement of the country rock.

Table 27. *continued*

Rock Class	Rock Name	Definition
Metasomatic Rocks *cont'd*		
	Greisen	A medium-temperature *contact metasomatic rock* characterized by the presence of quartz and white mica, commonly with topaz, fluorite, tourmaline and locally with amazonite, orthoclase, andalusite and diaspore. Associated with high-level, late-orogenic leucogranitoids; forms as replacements either in the granitoid body and/or in a wide range of country rocks; may be mineralogically zoned. May host Be, W, Mo, Sn and Ta mineralization.
	Endogreisen	*Greisen* that replaces the granitoid rock.
	Exogreisen	*Greisen* that replaces the country rock.
	Skarn	*Metasomatic rock* that forms at the contact between a magmatic rock (or other silicate rock) and typically a carbonate rock. Consists mainly of Ca-, Mg-, Fe-, Mn-silicates, which are free from or low in H_2O. May host economic mineralization as a "skarn deposit".
	Endoskarn	*Skarn* that forms at the contact, within the magmatic rock (or other silicate rock).
	Exoskarn	*Skarn* that forms at or near the contact, within the country rock.
	Calc-skarn	High- to medium-temperature *skarn* that forms at the contact typically in calcium carbonate rocks. Consists mainly of granditic garnet, diopside, wollastonite, Mn-rich pyroxenoids. May host Fe, base metal, Cu, W, Mo, Be, B, U, REE mineralization.
	Magnesian skarn	High-temperature *skarn* that forms at the contact typically in magnesian or calc-magnesian carbonate rocks. Typically contains forsterite, diopside, spinel, periclase, clinohumite, phlogopite, pargasite. May host Fe, base metal, Cu, Au, Fe-Mg-borates, phlogopite mineralization.

[1] *Definitions derived from Fettes and Desmons (2007) except as noted.*
[A] *M′ = Colour index.*
[B] *Migmatite terms largely from Sawyer (2008).*
[C] *Definitions for principal parts of migmatites are given in Table 29.*
[D] *Definition used by OGS; see text for explanation.*

Structural Basis

The term "structural basis" is used in the sense that the primary distinguishing feature of the rock is based on structure at any scale (*see* Table 26) although it normally refers to the crystallographic or mineral aggregate scale (*see* Fettes and Desmons 2007). The SLTT uses the term "rock fabric" (Soller 2004b). The structural basis categories are schist, gneiss, granofels, hornfels and metabreccia. Additional subdivision is based on overall composition, as estimated by colour index, followed by specific types of schists and gneisses, based on textures or mineralogy.

The terms "schist" and "gneiss" are replete with historical diversity and both the IUGS and SLTT present summaries. According to the IUGS system, schistosity may be: well developed (throughout the rock or in zones <1 cm apart), in which case the rock has a schistose structure and is termed schist; or poorly developed (or well developed but spaced in zones >1 cm apart), in which case the rock has a gneissose structure and is termed gneiss. If the schist is fine grained it may be called phyllitic schist, and if it is very fine grained, it may be called a slate if it has a slaty cleavage. A metamorphic rock with no schistosity (i.e., grains are equant or randomly oriented) is a granofels, with or without mineralogical or lithological layering. Note that in the IUGS system, a hornfels is a subsidiary name of granofels, which is not reflected in our layout (Tables 22, 23, 24, 27).

The breccia category is designed to incorporate a variety of styles of breccia that occur locally, particularly in the Grenville Province (*see* Figure 1). This subdivision is not included in the IUGS or SLTT systems.

SCHIST

Historically, the term schist has been applied in various ways. In modern usage, as set forth by the IUGS, the term schist is used as a root name referring to a rock that displays a well-developed schistosity (schistose structure). The term is most appropriate for medium- to coarse-grained phyllosilicate-rich rocks. Fine-grained schists can be named more specifically as slate or phyllite. Note that well-developed schistosity, characteristic of continuous cleavage, is independent of grain size.

In OGS use, schist that does not have a readily discernible protolith, but rather a bulk composition that can be estimated by colour index, can be designated by a first-order prefix such as "ultramafic", "mafic", "intermediate" or "felsic", to construct a rock name. More detailed modifiers may be utilized for elaboration, such as "biotite-hornblende mafic schist".

GNEISS

Historically, the term gneiss has also been applied in various ways. In modern usage, as set forth in part by the IUGS and in common British and North American usage, the term gneiss is used here as a root name referring to a rock that displays a poorly developed schistosity, is typically medium to coarse grained, and commonly displays a banded fabric reflecting variations in composition or fabric.

In OGS use, gneiss that does not have a readily discernible protolith, but rather a bulk composition that can be estimated by colour index, can be designated by a first-order prefix such as "ultramafic", "mafic", "intermediate" or "felsic", to construct a rock name. More detailed modifiers may be utilized for elaboration, such as "biotite-hornblende intermediate gneiss".

Within the Grenville Province of Ontario, a field-based descriptive terminology has been developed that describes the nature of the compositional variation in the gneissose structure (e.g., intermediate straight gneiss) (Davidson 1984; Easton 1992; Davidson, Culshaw and Nadeau 1982; Culshaw, Davidson and Nadeau 1983; Hanmer and Ciesielski 1984). These terms are not present in the AGI Glossary of Geology (Neuendorf, Mehl and Jackson 2005) nor in the IUGS or SLTT systems, but definitions based on the aforementioned sources are provided in Table 27. The compositional layering present in these gneisses reflects a number of origins, including migmatization and deformation. These compositionally layered gneisses commonly occur at or near terrane and domain boundaries in the Grenville Province, where they truncate pre-existing structures and rock units between terranes. They can also occur internally within domains where they mark high-strain zones.

When using the terms gneiss and gneissic, the following usage is recommended. A *gneissic granite* is a meta-igneous rock of granitic composition with gneissic structure. A *granitic gneiss*, a *granite gneiss*, or a *gneiss of granitic composition* may be either a meta-igneous or a metasedimentary rock. Similarly, a *tonalitic gneiss* or a *tonalite gneiss* is a gneiss of tonalite modal composition, but may be of either meta-igneous or metasedimentary origin.

GRANOFELS

Our application of the term "granofels", particularly with respect to the term "granulite", differs from the IUGS recommendations. We have chosen not to use "granulite" as a field mapping rock term.

- The IUGS considers granofels to refer to medium- to coarse-grained rocks (>3 mm) that are otherwise similar in composition and origin to granulite (i.e., fine- to medium-grained (<3 mm) rocks). We choose not to make grain size a part of our terminology, but rather use the term granofels to include fine- to coarse-grained rocks that have granofelsic structure.
- The IUGS defines a granulite as being a high-grade metamorphic rock, while acknowledging that granulites may belong to the amphibolite facies or granulite facies. Determining metamorphic grade in the field can be difficult (particularly in the absence of orthopyroxene). Many granofels rocks may be of high-grade metamorphic rank, but we opt to use granofelsic structure as the defining parameter in the field.
- The IUGS recommends that the term granulite not be used for ultramafic rocks. Again, our use of the term granofels is not restricted to composition, although ultramafic granofels may be rare.

In OGS use, granofels that does not have a readily discernible protolith, but rather a bulk composition that can be estimated by colour index, can be designated by a first-order prefix such as "ultramafic", "mafic", "intermediate" or "felsic", to construct a rock name. More detailed modifiers may be utilized for elaboration, such as "biotite-garnet-plagioclase granofels".

HORNFELS

Our application of the term "hornfels" follows the SLTT (Soller 2004b) recommendations rather than those of the IUGS. In this classification, hornfels is a nonfoliated, typically aphanitic rock having granoblastic fabric in thin section. The term hornfels does not necessarily denote a contact metamorphic origin, although that is most commonly the case. Our choice is consistent with the goal of keeping terminology as descriptive as possible. Hornfels, in this sense, is the aphanitic equivalent of granofels.

Hornfels may or may not have a readily discernible protolith, but a bulk composition can be estimated using colour index to designate a first-order prefix, such as "ultramafic", "mafic", "intermediate" or "felsic", to construct a rock name. More detailed modifiers may be utilized for elaboration, such as "spotted cordierite-sillimanite-spinel hornfels". Some features may be retained in hornfels, such as pillow selvages, bedding and metamorphic layering. In the example listed above, it would be important to ascertain whether the "spotted" feature was a result of contact metamorphism (resulting in hornfels) versus earlier or later regional metamorphism. The term hornfels incorporates no connotation of grain size or metamorphic facies.

In contact metamorphic situations, gradations in rock characteristics may occur between the outer and inner parts of a contact aureole and rock nomenclature may capitalize on the different characteristics. For instance, one may map, toward an intrusive contact, schist, hornfelsed schist, schistose hornfels, and hornfels. A term such as “schistose hornfels”, by itself, could be construed as ambiguous in terms of the timing of contact metamorphism relative to the development of schistosity. However, in the context used above, there may be no ambiguity.

METABRECCIA

Breccias that formed as a result of the processes of metamorphism and deformation comprise this category and are subdivided on the basis of the main type of rock that forms the matrix. In the case of marble breccia, for instance, blocks of more competent silicate rocks may be entrained within a carbonate matrix, and are likely produced through a high degree of boudinage. The use of breccia as a rock name in these contexts is not intended to apply to brecciated rocks that have been metamorphosed, in which case the term “breccia” or “brecciated” should be applied as a modifier to the root rock type (e.g., brecciated granofels, metamorphosed intrusion breccia, metamorphosed pyroclastic breccia).

Compositional Basis

Several metamorphic rock names that are primarily based on composition have been used historically, are now widely adapted and are here retained for practical reasons. Two major subdivisions are “mafic–ultramafic rocks” and “metacarbonate rocks”. Also included is a section on meta-ironstone.

MAFIC TO ULTRAMAFIC ROCKS

Amphibolite

Variations in historical definition aside, metamorphosed mafic rocks with gneissose or granofelsic structure and consisting primarily of amphibole and plagioclase are referred to as amphibolite. The definition of an amphibolite requires that amphibole and plagioclase constitute ≥75% of the rock. Amphibole must be ≥30% of the rock, and ≥50% of total mafic minerals. The type of amphibole (blue, green, black, clino- or ortho-) and the composition of plagioclase (ranging from labradorite to albite) are not part of the definition. Most amphibolites are metamorphosed mafic igneous rocks, which can be termed ortho-amphibolites. Some amphibolite may be metamorphosed calcareous sediments, or multi-metamorphosed mafic igneous rocks that contain atypical mineral phases such as biotite; either can be termed para-amphibolite. An amphibolite with a particular texture involving amphibole that resembles a stellate or feather-like pattern on some foliation planes is termed “feather amphibolite”.

Eclogitoids

The eclogitoid class consists of omphacite- and garnet-bearing metamorphic rocks in general, and eclogite in particular, including garnet omphacitite and omphacite garnetite. Eclogite is rare in the Superior and Southern provinces in Ontario, perhaps occurring only as xenoliths in some kimberlites. Although no plagioclase is permitted in the definition of eclogite, alkali-feldspar is. Other minerals, if totalling >5% modally, may be listed in the expanded rock name, such as “kyanite-paragonite eclogite", or if <5%, may be used with “-bearing”, such as “rutile-bearing eclogite”. A retrogressively metamorphosed eclogite may be referred to as “amphibolitized eclogite” if it consists of omphacite and garnet relics in an amphibolite groundmass. If the rock contains ≥75% omphacite or ≥75% garnet, then the appropriate rock name is garnet omphacitite or omphacite garnetite, respectively.

Within the Grenville Province, eclogitic rocks occur locally in the Central Gneiss Belt, typically on the hanging-wall side of the Allochthon Boundary Thrust. Eclogite-facies mineral assemblages have only been documented in mafic rocks present as large blocks surrounded by quartzofeldspathic gneisses. If the surrounding quartzofeldspathic gneisses ever achieved eclogite-facies conditions, then the record of this history has been destroyed by subsequent metamorphic events. The eclogitic rocks within the Grenville Province are typically massive, relatively fine-grained, dark green granofels or amphibolite studded with red garnets. Corona textures are common in the eclogitic and associated mafic rocks within the Central Gneiss Belt. Although they have the appearance of eclogite, these rocks typically do not contain the mineral assemblage omphacite plus garnet without plagioclase because of the breakdown of omphacite during retrogression or subsequent metamorphism, which results in the re-formation of plagioclase. To note this mineralogical difference, Davidson (1991) has referred to these rocks as pseudo-eclogites. Because these are texturally and mineralogically distinctive rocks that can be identified in the field, use of the eclogitoid terminology is still permissible, with the proviso that in any publication, any differences from the ideal mineralogical composition must be clearly specified.

Serpentinite

Serpentinite consists of >75% minerals of the serpentine group and is considered a derivative of an ultramafic protolith. Depending on the reference used for rock definition, the process of serpentinization is either hydrothermal (e.g., AGI), or metamorphic or metasomatic (e.g., IUGS). In this report, we do not make a distinction as to the genesis of serpentinite formation, as either mechanism or multiple mechanisms (i.e., hydrothermal alteration followed by metamorphism) may have been responsible for its development.

METACARBONATE ROCKS

The subclass "metacarbonate rocks" includes marble, carbonate-silicate rock, calc-silicate rock and carbonate-bearing silicate rock, some of which may no longer actually contain carbonate minerals as a result of metamorphism. The nomenclature proposed herein is weighted toward a field-based system and is based on modal mineralogy. We have also attempted to retain parallelism, where feasible, with the terminology applied in this report to chemical sedimentary rocks (*see* Tables 28, 19, 20). In principle, in most metamorphic environments, marble is derived from limestone and dolostone; and carbonate-silicate and calc-silicate rocks are derived from carbonate-bearing mudstones, sandstones, tuffaceous and evaporitic sedimentary rocks and calcareous mudstones. For practical field purposes, the reaction of the metacarbonate rock to the application of 10% HCl is an effective tool in determining the relative proportion of carbonate and noncarbonate mineralogy present (*see* Tables 28, 20).

The classification scheme proposed is similar to that set forth by the IUGS, and is shown in Figure 28 as a triangular diagram with apexes represented by carbonate, calc-silicate minerals and impurities. A major difference proposed herein is that the boundary between pure and impure marble be defined as 90% carbonate minerals, as opposed to the 95% limit of the IUGS. The reasons for this change are as follows:

- 10% impurities is the boundary defined by SLTT (Soller 2004a) between pure and impure limestone or dolostone for chemical sedimentary rocks. For simplicity alone, it makes sense to use the same boundary for metamorphic rocks.
- At higher metamorphic grade, metamorphosed carbonate rocks may include a variety of non-silicate mineral impurities, such as graphite, oxide minerals, and/or apatite. Using a boundary based on 10% impurities eliminates the need to make precise distinctions between silicate and non-silicate mineralogy in the field.
- In lower grade marbles, which are typically fine to medium grained, it is commonly difficult to precisely determine the proportion of silicate minerals in the rock. This problem is compounded by the fact that many of the silicate and non-silicate minerals that form are elongate or platy in habit. We believe that using a 10% impurities boundary is more practical for field-based estimates for a wide range of metamorphic grade conditions than is the 5% boundary.
- In researching the primary sources used by IUGS in proposing the 95% boundary, we found that the original boundary was based on geochemical limits, which were subsequently converted to calculated normative modal percentages (Rosen, Fettes and Desmons 2005). The geochemical boundary was based on 5 weight % SiO_2, which is not exactly equivalent to 5 volume % silicate minerals (Rosen, Fettes and Desmons 2005). We would argue that any geochemically based boundary should include both SiO_2 and Al_2O_3 in order to adequately account for all the potential silicate phases that could result during metamorphism. Within Ontario, Al_2O_3 contents in marbles are typically 15% of the reported SiO_2 content (Grant, Papertzian and Kingston 1989), which would suggest a minimum boundary of at least 6 weight %, not 5%. Again, use of a 10% impurities boundary accounts both for alumina content and non-silicate phases in the rock.

- Finally, the geochemical database for marbles in the Grenville Province in Ontario (Grant, Papertzian and Kingston 1989) is roughly 4.5 times the size of the database examined by Rosen, Fettes and Desmons (2005) and used by IUGS. The Ontario database does not show a natural break at 5% SiO_2. If the Ontario data are examined on a domain basis, however, several different breaks are observed. For example, there is a gap between 6.1 and 6.8 weight % SiO_2 for marbles in Sharbot Lake domain, which has a minimum of volcanic rocks; but between 6.9 and 7.6 weight % SiO_2 in Mazinaw domain, where marble deposition was locally coincident with volcanism. Again, we believe that a 10% boundary is more practical for field-based estimates across the variety of carbonate depositional basins present within the Grenville Province in Ontario.

Additionally, we have changed the boundary between "carbonate-silicate rock" and "calc-silicate rock", and "carbonate-bearing silicate rock" from 5% carbonate minerals to 10%. This also is intended to facilitate estimating mineral abundances in the field.

We have also expanded the full range of rock names to produce a more complete range of names based on the relative proportion of calcite versus dolomite for cases where the mineralogy can be determined (see Table 23). This expansion in the range of rock names is based on parallelism with the SLTT nomenclature for Sedimentary carbonate rocks (Soller 2004a). The main calc-silicate minerals (IUGS) include calcic garnet (ugrandite), calcic plagioclase, calcic scapolite, diopside-hedenbergite, epidote group minerals, grossular, johannsenite, prehnite, pumpellyite, titanite, vesuvianite and wollastonite (*see* Table 23).

The system for classifying metacarbonate rocks does not take into account the structure of a rock. It is possible that in some cases, alternative uses of structural-based rock names modified by various minerals may be more appropriate. Examples would be "quartz-mica-carbonate schist" (for lower grade rocks) and "calc-silicate granofels" (for higher grade rocks). In this light, the IUGS recommends that metamorphosed siderite- and magnesite-bearing rocks be named using structural root terms and appropriate mineral prefixes (e.g., biotite-siderite gneiss).

Table 28. Classification of rocks containing abundant carbonate minerals.[1]

Based on Carbonate Content				
Dolomite content	0 to 10%	10 to 50%	50 to 90%	90 to 100%
Metamorphosed (Precambrian strata in map area)	Calcite marble	Dolomitic calcite marble	Calcitic dolomite marble	Dolomite marble
Unmetamorphosed (Paleozoic strata in map area)	Limestone	Dolomitic limestone	Calcitic dolostone	Dolostone
Reaction to HCl	Fizzes aggressively	Fizzes moderately	Fizzes slightly	Does not fizz; may fizz slightly when powdered
MgO Content (approximate)	0.0 to 2.2 wt %	2.2 to 10.9 wt %	10.9 to 19.7 wt %	19.7 to 21.8 wt %
Geochemical division based on CaO/MgO ratio	>24.4	24.4 to 3.95	3.95 to 1.67	1.67 to 1.4
Based on Silicate Content				
Silica content	0 to 5%	5 to 30%	30 to 65%	>65%
Name (metamorphosed)	Marble (*see* Part 2)	Siliceous marble	Calc-silicate rock	Silicate rock
Name (unmetamorphosed)	Limestone or dolostone	Siliceous limestone	Calc-silicate rock	Silicate rock
Reaction to HCl	Fizzes aggressively if calcitic, decreasing reactivity with increasing dolomite content	Fizzes slightly to moderately	Typically does not fizz	Does not fizz

[1]*Modified after Easton (2012).*

META-IRONSTONE

The classification scheme proposed herein (*see* Tables 22, 27) is similar to that for Sedimentary Rocks (*see* Tables 19, 15), slightly modified to take into account the main mineralogical changes that occur with increasing metamorphic grade. These changes most directly affect carbonate-ironstone, where decarbonation reactions result in the replacement of siderite by pyroxene phases such as ferrosilite, resulting in pyroxene meta-ironstone. In the case of silicate ironstone, with increasing metamorphic grade, a wide range of amphibolite phases, along with garnet, may develop, resulting in silicate meta-ironstone.

The decision to create a meta-ironstone classification was in part based on practical considerations, in that in higher grade terranes, it allows for all rock units present to be classified as Metamorphic Rocks. The alternative would have been to describe the ironstones, metamorphosed or otherwise, as (Meta)Sedimentary Rocks, even though all adjacent rock units utilized Metamorphic Rock terminology.

Migmatites

Migmatites are complex composite rocks that render efforts to define the rock, the rock components and the rock processes difficult. In OGS deliberations, we found more comfort, for the most part, in using the terminology of Sawyer (2008) as opposed to that of the IUGS (Fettes and Desmons 2007) and the SLTT (Soller 2004b). These differences focus on whether the term migmatite should refer to a class of rocks, or whether the term is a specific rock name. For example, the SLTT (Soller 2004b) and the British Geological Survey (Robertson 1999) regard migmatite as a specific rock name, and therefore prefer to use the term "migmatitic" as a modifier, and not "migmatite" as a root rock name. We have chosen to use the term "migmatite" as a rock class. A simplified definition of migmatite is a mesoscopically to megascopically heterogeneous, composite rock found in medium- and high-grade metamorphic areas, and formed by partial anatexis of an existing rock. A more detailed definition is given in Table 27.

Migmatites collectively display a wide variety of features depending on the degree of partial melting and deformation during development. The first-order division of migmatites, based on morphology and proportion of leucosome, results in 2 types, metatexite and diatexite. Each type is subdivided into 4 categories based on the predominant features present which, in part, reflect the relative degree of strain (*see* Table 27, Table 23). Table 29 provides definitions for the principal collective parts of migmatites. A generalized classification scheme for migmatites (metatexite and diatexite) is illustrated in Figure 29. A variety of structural sites for leucosome are illustrated in Figure 30.

The division between metatexite and diatexite is based on the relative amount of melt (leucosome) in the rock. There is no single agreed upon definition of this boundary, although Sawyer (2008) notes that at least 16% leucosome needs to be present to call the rock a diatexite. We have chosen a boundary of 20% leucosome between metatexite and diatexite for field use, as it is near the minimum value suggested by Sawyer (2008) and does not require the same precision in estimating leucosome content as would the use of 16%. The 20% boundary, rather than say 25%, also accounts for the fact that initial bulk-rock composition of the protolith is a factor in the amount of partial melt that can be produced, and thus the lower limit is better suited for a wide range of bulk-rock compositions.

In many high-grade terranes, migmatites may have undergone more than 1 phase of high-grade metamorphism, which can result in the presence of different generations of leucosome. Mapping these generations may be important in understanding the regional geological history of the area.

Migmatites are complex rocks that require considerable experience to map and interpret adequately. The work by Sawyer provides an extensive colour atlas of examples of migmatites and is a useful guide (Sawyer 2008; Sawyer and Brown 2008; and references therein).

Table 29. Migmatites: principal parts.[1]

Neosome		The relatively new products of partial melting of an existing rock, with or without segregation from the unmelted solid fraction. Neosome is typically coarser grained than the rest of the migmatite.
	Leucosome[2]	The light-coloured, generally quartzo-feldspathic, part of a *neosome* which may have undergone fractional crystallization and/or separation from the *paleosome*.
	Melanosome[2]	The darker coloured, residual part of a *neosome* (typically consisting of minerals such as biotite, garnet, pyroxene, amphibole, cordierite, olivine), which remains after some or all of the melt fraction has been extracted.
	Residuum[2]	The part of the *neosome* that is predominantly the solid fraction left after partial melting and extraction of some or all the melt fraction.
Paleosome		The unmelted part of a partially melted rock that preserves pre-melting features such as layering, folding, foliation
	Resister	A type of *paleosome* that resists partial melting even in the highest-grade parts of a migmatite.
Mesosome		Descriptive term only: intermediate between *leucosome* and *melanosome*; occurs in *neosome* or *paleosome*.
Miscellaneous	Selvage	A narrow, leucocratic, mesocratic or melanocratic rim that is 1) compositionally, mineralogically and microstructurally different from the host; 2) a product of reaction or diffusional exchange, rather than the residuum from partial melting; and 3) found in migmatites and nonmigmatite rocks.

[1] *Definitions derived from Sawyer (2008).*
[2] *The size, physical form, orientation and grain size of this component are not factors in the type of neosome, but all parameters should be recorded.*

Metasomatic Rocks

Metasomatism is the isovolumetric process by which aqueous fluids (solutions) alter the chemical composition of a rock in the solid state through introduction and/or removal of chemical components. The process results in fine- to coarse-grained rocks with hornfelsic or granofelsic structure and sometimes banding or layering. The process can result in complete replacement of rock in one or more zones, or a more selective process such as the pseudomorphic replacement of crystals by one or more minerals.

Determining when to use Metasomatic rock names is similar to the situation faced when determining whether to switch from Intrusive, Volcanic and/or Sedimentary rock names to the use of Metamorphic rock names. Key factors in making that determination will be the nature of the mapping program and the degree to which the metasomatic process has changed the original character of the rock. For example, the more intensely the rock has been metasomatized, as well as the general character of the surrounding rock units (i.e., Metamorphic), would be reasons for using Metasomatic rock names. If the original rock is still recognizable, even if metamorphic, then the use of Metasomatic rock names is not recommended. The key is whether or not there has been introduction or removal of chemical components. If the latter can not be determined, the default is to use the applicable Metamorphic nomenclature (with any necessary modifiers).

Although there are 2 main types of metasomatism, namely diffusional and infiltrational (*see* Table 26), field use necessitates that more appropriate terms be used. Terms recommended here relate to contacts and rock types. Boundary metasomatism occurs between any 2 rock types, otherwise unspecified. It produces bimetasomatic rocks, some types of fenites, and rodingites. Some fenites may be associated with an intrusive contact (*see* Table 23).

Contact metasomatism is a subset of boundary metasomatism that typically occurs at or near a contact between an existing rock of any type and a now crystallized magma body and may involve replacement of the magmatic rock (endocontact zone), the country rock (exocontact zone), or both. An extensive body of terms, many of them confusing, has developed for situations where the country rock involves a carbonate rock, in part because of the ease in recognizing that chemical components have been introduced and/or removed. In these situations, the resultant metasomatic product is referred to as a skarn and, relative to the siting of the metasomatism, the terms endoskarn (intrusion) and exoskarn (country rock) may be used (*see* Table 23). Where the emphasis needs to be placed on skarn composition rather than on spatial distribution to the intrusion, the terms calc-skarn and magnesian-skarn can be used for calcium carbonate rocks and magnesian carbonate rocks, respectively (*see* Table 27). It should be noted that contact metasomatism is not synonymous with contact metamorphism, as the former involves the transfer of chemical components, whereas the latter may occur simply though the transfer of heat into the surrounding rocks.

In areas rich in carbonate rock, the mineralogy present in skarns developed in carbonate rocks (i.e., exoskarn) is similar to that found in metamorphosed silicate-rocks containing varied amounts of carbonate (i.e., carbonate-silicate rocks, calc-silicate rocks, carbonate-bearing silicate rocks). In these situations, it may not always be easy to determine if Metamorphic or Metasomatic terminology is more appropriate, and this is one of the reasons why the SLTT (Soller 2004b) did not recommend the use of the term skarn. Spatial relationships may provide a clue. For example, in a situation where the carbonate-silicate and calc-silicate rocks are only located proximal to an intrusive body, one can probably interpret the rocks as being metasomatic. Grain size may also be an indication. In the aforementioned example, if the grain size of either or both of the carbonate and silicate minerals were observed to change with distance from the intrusion, that grain size change could be interpreted as evidence of a metasomatic origin. In situations where the carbonate-silicate and calc-silicate rocks have a more regional distribution, it may be difficult or impossible to unequivocally determine their origin (examples occur in Bancroft terrane in the Grenville Province).

Although fraught with difficulty, one of the reasons for retaining the use of the term skarn and its variants (*see* Table 27) is that many skarns are mineralized, containing sulphide or oxide minerals, or both. Where mineralization is present, we recommend the use of the term “skarn deposit” rather than “skarn”, in order to distinguish between mineralized and unmineralized systems. Where possible, the key commodity can also be noted, as in zinc skarn deposit or iron skarn deposit. The source of the mineralization is commonly directly related to the character of the metasomatic fluids, and numerous ore deposit models are available for various types of skarn deposits, some of which may be distal to the original source magma body (cf. Einaudi, Meinert and Newberry 1981; Meinert 1993).

OTHER ROCKS

Rocks other than the 3 main traditional types (i.e., igneous, sedimentary and metamorphic) have been grouped in this manual into the “Other Rocks” category, which consists of Fault Rocks and Impactites. The IUGS (Fettes and Desmons 2007) considers fault-related rocks, quenched rocks (e.g., impact melts, fulgarites and pseudotachylites) and hydrothermally altered rocks as metamorphic. The IUGS also places impact-related rocks in the “Metamorphic” category, in part because these rocks have undergone what is termed “shock metamorphism”. The SLTT (Soller 2004b) utilize the term “Composite-genesis” rocks to include conventional metamorphic rocks (in which they also include hydrothermally altered rocks and mylonitic rocks), cataclastic rocks and impactites (excluding impact melts). However, the OGS has decided to use the term “Other Rocks” to include “Fault Rocks” and all “Impactites” (including impact melts). This manual discusses hydrothermally altered rocks under “Alteration Terms” in Part 2.

Details of “Other Rocks” for this manual are provided as follows:

- The general outline for the Other Rock classification (5 levels) is given in Table 30.
- The specific outline with rationale is in Table 31 (back pocket).
- The organization of the pick lists for field data input is shown in Table 32 (back pocket).
- A flow chart for classifying fault rocks is shown in Figure 31.
- Definitions for Fault Rocks are provided in Table 33.
- Key definitions for Impactites are given in Table 34.
- General definitions for Impactites are provided in Table 35.
- A schematic diagram showing the distribution of different types of impactites for impact craters of various sizes is presented in Figure 32.
- A proposed classification scheme for impactites containing particulates, based on particle size, is shown in Figure 33.

Table 30. Other rocks—fault rocks and impactite rocks: overview.

Level 1	Other Rocks Classification
Level 2	Fault rocks
	Impactite rocks
Level 3	Additional subdivisions of Level 2 subdivisions
Level 4	Additional subdivisions of Level 3 rock types
Level 5	Additional subdivisions of Level 4 impactites

Fault Rocks

In the broadest of terms, fault rocks are rocks that occur in faults and fault zones and are associated with fault surfaces and fault movement. A fault is a fracture surface along which rocks have moved relative to each other. A fault zone is a zone of sheared, crushed or foliated rock, in which numerous small dislocations have occurred, adding up to an appreciable total offset of the undeformed walls. All gradations may occur between multiple fault planes and single shear zones. The boundaries of shear zones are typically abruptly to broadly gradational.

Deformation in faults and shear zones occurs in a continuum of environmental conditions from near the Earth's surface, where discrete, brittle processes dominate, to higher temperature conditions deeper in the Earth where continuous deformation and crystal-plastic processes dominate. First-order divisions of Fault Rocks are based on whether brittle processes dominate (cataclastic rocks, *see* Table 33) or ductile processes dominate (mylonitic rocks, *see* Table 33). It should be noted, however, that there may be a continuum between brittle and ductile processes within a fault system, and that fault systems may exhibit complex histories, evolving from brittle to ductile to brittle processes.

In more detail, distinctions can be made as to the cohesiveness of the rock and the relative conditions under which faulting took place. The first stage in the flow chart for fault rock classification is whether a rock is cohesive or incohesive (Figure 31). In addition to temperature and pressure, rate of strain is a major factor in governing the type of fault rock produced. Cataclasites are formed by grain size reduction due to fragmentation and grinding, usually under relatively lower temperature and pressure conditions. Mylonites are formed by grain size reduction due to dynamic recrystallization, usually under elevated temperature and pressure conditions. Fault pseudotachylite is formed by extreme cataclasis and/or melting of rocks largely due to friction. Fault pseudotachylite may be autochthonous (within a fault plane or zone) or slightly allochthonous (intruded outside of the fault plane proper). It may be cryptocrystalline, glassy or devitrified. The OGS includes the word "fault" as part of the rock name (i.e., fault pseudotachylite) to distinguish the term from "impact pseudotachylite". In reality, the two are not mutually exclusive as some fault-zone-generated pseudotachylite may have been initiated as a result of crustal adjustments caused by an impact event. For most field situations, field geologists will be dealing with fault pseudotachylite. In cases where they are mapping an area where impactites occur, they will need to determine the appropriate terminology to use in their project (i.e., impact pseudotachylite, fault pseudotachylite, or both).

Fault rocks can be metamorphosed to high grade, and where this has occurred, they should be described according to the section on Metamorphic Rocks. In many cases, with metamorphism, there may be textural preservation of many key features of cataclasites or mylonites, but this is accompanied by an increase in grain size, especially of groundmass material, as a result of recrystallization. Some of the specialized terminology of gneissic rocks discussed in the section on Metamorphic Rocks (*see* Table 27) was developed for describing rocks that are interpreted to represent metamorphosed cataclasites and/or mylonites.

Characteristics of fault rocks such as cohesiveness and the presence of a foliation are included in the list of modifiers (Part 2) and not in the definition of the rock itself.

DEFINITIONS

Table 33. Fault rocks: definitions.[1,2]

Rock Class	Rock Name	Definition
Cataclasite		A general term for a fault rock, which is either cohesive, with a weakly developed or absent foliation, or incohesive and characterized by generally angular porphyroclasts and lithic fragments in a finer grained matrix of similar composition.
	Fault breccia	A *cataclasite* that is medium to coarse grained and contains ≥30% visible fragments. May be cohesive or incohesive
	Fault gouge	A *cataclasite* that is fine to ultra fine grained, contains <30% visible fragments, is typically clay rich and incohesive, and may have a foliation.
	Fault pseudotachylite	Ultra fine-grained, vitreous-looking cohesive material, commonly black or dark grey (may be white to light grey depending on host rock) and flinty in appearance, occurring as thin planar veins or injection veins, infilling dilation fractures in the host rock along or adjacent to a fault.
	Protocataclasite	A *cataclasite* in which the matrix forms <50% of the rock volume; cohesive or incohesive.
	Mesocataclasite	A *cataclasite* in which the matrix forms from 50 to 90% of the rock volume; cohesive or incohesive.
	Ultracataclasite	A *cataclasite* in which the matrix forms >90% of the rock volume; cohesive or incohesive.
Mylonite		A general term for a fault rock which is cohesive and characterized by a strongly developed planar fabric resulting from tectonic reduction of grain size (involving recrystallization), and commonly containing rounded porphyroclasts and lithic fragments of similar composition to minerals in the matrix. Fine-scale layering and an associated mineral or stretching lineation are commonly present. Brittle deformation of some minerals may be present, but deformation occurs commonly by crystal plasticity.
	Protomylonite	A *mylonite* in which <50% of the rock volume has undergone grain size reduction.
	Mesomylonite	A *mylonite* in which 50 to 90% of the rock volume has undergone grain size reduction.
	Ultramylonite	A *mylonite* in which >90% of the rock volume has undergone grain size reduction.
	Augen mylonite	A *mylonite* containing distinctive large crystals or lithic fragments around which the foliated fine-grained matrix is wrapped, often forming symmetric or asymmetric tails.
	Blastomylonite	A *mylonite* that displays a significant degree of grain growth (recrystallization) related to or following mylonitization.
	Phyllonite	A *mylonite* that is phyllosilicate rich (phyllosilicate minerals >40%) and has the lustrous sheen of a phyllite.

[1] *Definitions derived largely from Fettes and Desmons (2007).*
[2] *Refer to Figure 31.*

Impactite Rocks

Preserved (and recognized) rocks produced from collision of the Earth with asteroids, comets and other extraterrestrial entities are relatively rare. In Ontario, there are only 5 recognized impact structures, and these lie between Terrace Bay and Kingston: Slate Islands (30 km diameter; 450 Ma), Sudbury (250 km diameter; 1850 Ma), Wanapitei (7.5 km diameter; 37.2 Ma), Brent (3.8 km diameter; 396 Ma) and Holleford (2.35 km diameter; 550 Ma) (Grieve 2006). Of these features, the Brent crater is mostly covered by post-impact Ordovician sedimentary rocks and glacial drift, the Holleford crater is covered by post-impact Ordovician sedimentary rocks, and the Wanapitei crater lies within Lake Wanapitei (with clasts of suevite and melt rock (up to boulder size) observed in glacial deposits to the south). The Slate Islands impact structure lies within Lake Superior, with the Precambrian target rocks partly exposed only on a set of 15 islands (<40 km^2) in what has been interpreted as the central uplift (i.e., most of the structure lies underwater). The Sudbury Structure is relatively well exposed in terms of Archean and Proterozoic target rocks and resulting products. The Sudbury Structure is the only impact structure of its size on Earth to have a complete section of preserved crater-fill impact deposits and impact melt rocks as well as a host of economic mineral deposits (e.g., Ames et al. 2005).

Recent attempts to standardize impactite and impact metamorphism terminology have been proffered by the IUGS (*see* Fettes and Desmons 2007) with some modifications to the SLTT (Soller 2004b). Figure 32 shows a schematic of impact craters of different size and the distribution of the general types of associated impact products. The major terminology proposed in Fettes and Desmons (2007) is outlined in Table 34.

Table 34. Impactite rocks: key terms.[1,2]

Rock Class	Rock Name	Definition
Impactite		Rock material naturally produced by hypervelocity impact (see *impact metamorphism*). Rock products include *shocked rocks*, *impact breccias*, *impact melt rocks*, *tektites*, *impactoclastic deposits* and *impactoclastic airfall beds*. Processes include shock compression of the target rocks (compression stage), decompression and material transport (excavation stage) and deposition upon ballistic transport and collapse of the central ejecta plume, which takes place during or after the collapse of the transient crater cavity (modification stage).
	Allochthonous breccia	*Impact breccia* in which the component materials have been displaced from their point of origin. It includes *polymict breccias* and *impact melt rocks* of *proximal impactites*. The magnitude of displacement is not specified. Cf. *autochthonous*; *parautochthonous*.
	Autochthonous breccia	*Monomict breccia* in which the component materials have not been displaced any distance from their point of origin (i.e., fragments occur in the original location with only minor rotation and translation[3]). Cf. *parauthochthonous*; *allochthonous*.
	Breccia dike	Dike formed in the (par)authochthonous basement or in displaced megablocks of impact craters. The dikes consist of *polymict breccia* or more rarely *monomict breccia*. These dikes are related to all stages of crater formation (see *impactite*) and may display 2 or more generations of dikes associated with a single impact structure. Compression stage: *shock veins* ("previously termed 'pseudotachylite'") and *shock vein* networks; Compression and excavation stages: *polymict breccia* dikes; Modification stage: final generation as *polymict breccia* and/or *monomict breccia* dikes.
	Distal impactite	*Impactite* occurring outside the outer limit of the continuous *ejecta blanket*. The term includes *tektite* and *impactoclastic airfall bed*. Cf. *proximal impactite*.
	Ejecta	Solid, liquid and vaporized rock ejected ballistically from an impact crater.
	Ejecta blanket	Continuous *ejecta* deposit around an impact crater.
	Impactoclast	Rock fragment resulting from impact-induced comminution of rocks; may display various degrees of *shock metamorphism*.
	Impact breccia	*Monomict breccia* or *polymict breccia* that occurs around, inside and below impact craters.

Table 34. *continued*

Rock Class	Rock Name	Definition
	Impact melt rock	Crystalline, semi-glassy or glassy rock solidified from impact melt and containing various amounts of clastic debris of different degrees of *shock metamorphism*. Impact melt products include a) allochthonous coherent melt sheets; b) inclusions in *suevite*; c) dikes and veins in autochthonous crater basement, in displaced *shocked rock* fragments and in displaced (unshocked) megablocks; d) melt particles on top of the *ejecta blanket* and glassy or crystallized spheres in global *impactoclastic airfall beds*; and e) *tektites*.
	Impact metamorphism	*Shock metamorphism* restricted to hypervelocity impact of a solar system body (impactor) with another solar system body (target). Includes solid state deformation, melting and vaporization of the target rocks and impactor. Cf. *shock metamorphism*.
	Impactoclastic airfall bed	A *distal impactite* forming a bedded sedimentary layer containing shock-metamorphosed material (e.g., shock minerals and melt particles), which has been ejected from an impact crater and deposited by interaction with the atmosphere over large regions or globally.
	Impactoclastic deposit	A deposit of *distal impactite* consisting of consolidated (or unconsolidated) sediment resulting from ballistic excavation, transport, and deposition of rocks at impact craters (with or without impact melt particles).
	Impact pseudotachylite	Pseudotachylite produced by *impact metamorphism*. Occurs as dike-like breccia bodies formed by frictional melting in the basement of impact craters, often resulting in irregular vein- or vein-like networks. Contains unshocked and shocked mineral and lithic clasts in a fine-grained aphanitic matrix.
	Lithic breccia	*Polymict breccia* that lacks cogenetic impact melt particles.
	Melt vein	Irregular vein of quenched melt material produced by shock-induced localized melting in moderately to strongly shocked rocks. Commonly observed in (par)autochthonous basement of impact craters and in allochthonous clasts of *shocked rocks*.
	Monomict breccia	*Impact breccia* consisting of cataclasite produced by impact and displaying weak or no *shock metamorphism*. Occurs a) in the (par)autochthonous impact crater floor; or b) as fragments within *polymict breccia*. Displaced blocks and megablocks within *allochthonous polymict breccias* forming the continuous *ejecta blanket* are usually monomictly brecciated. Cf. *polymict breccia.*
	Parautochthonous breccia	*Monomict impact breccia* in which the component materials have not been displaced any significant distance from their point of origin (i.e., intermediate between autochthonous and allochthonous[3]) or relative to the immediately adjacent material in which they are contained (e.g., breccia within a displaced block or megablock). "Significant" in this case is not defined. Cf. *authochthonous*; *allochthonous*.
	Polymict breccia	*Impact breccia* with clastic or crystalline (from crystallization of *impact melt*) matrix containing unshocked and shocked (various degrees of *shock metamorphism*) lithic clasts, mineral clasts, +/- impact melt clasts, excavated by an impact from different regions of the target rock, mixed, transported and deposited inside or around an impact crater or injected into the target rocks as *breccia dikes*. Comprises *lithic breccia* and *suevite*. Cf. *monomict breccia*.
	Proximal impactite	*Impactite* occurring in the immediate vicinity of the impact crater, i.e., inside the outer limit of the continuous *ejecta blanket*. The term includes all types of *impact breccias*, *impact melt rocks*, and *shocked rocks*. Cf. *distal impactite*.
	Shocked rock	Rock affected by impact shock metamorphism, specifically nonbrecciated rocks showing unequivocal *shock metamorphism* exclusive of whole rock melting. Can be subdivided with reference to progressive stages of *shock metamorphism*.
	Shock metamorphism	Type of metamorphism of local extent caused by shock wave compression due to the hypervelocity impact of a solid body or due to the detonation of high-energy chemical or nuclear explosives. Cf. *impact metamorphism*.
	Shock vein	Thin vein of quenched melt produced by shock-induced, localized, frictional melting in moderately *shocked rocks*.
	Suevite	*Polymict breccia* that includes cogenetic melt particles, which are in a glassy or crystallized state.
	Tektite	A *distal impactite* consisting of glassy *impact melt rock* formed from melt ejected ballistically and deposited as aerodynamically shaped bodies in a strewn field outside the continuous *ejecta blanket*. Size ranges from submillimetre (i.e., microtektite), rarely up to decimetres.

[1] *Definitions derived largely from Fettes and Desmons (2007).*
[2] *Refer to Figure 32.*
[3] *Definition derived in part from Neuendorf, Mehl and Jackson (2005).*

For rock nomenclature, the OGS has adopted some of the IUGS terminology with reservations and modifications, particularly as they pertain to the Sudbury Structure, as outlined below.

- The IUGS terminology is based on a relatively small, highly diverse population of world-wide impacts situated in unique geological settings, many of which have not undergone post-impact metamorphism and deformation. Many of the features observed with respect to the Sudbury Structure are unique and not adequately covered by the IUGS system, in part because of self-contained ambiguities.
- Some of the impact products are, in part, defined genetically and in terms of process, such as timing relative to cratering stages; magnitude of material displacement; degree(s) of shock metamorphism; and method of matrix formation. With the exception of shatter cones, shock (impact) metamorphic features are generally limited to petrographic, not field, observations.
- In many cases, it is not possible to evaluate whether particles are allochthonous, autochthonous or parautochthonous. Proximal versus distal is less of a problem, as erosion has removed much of the original distal material. There has been recent recognition of preserved distal deposits related to the Sudbury Structure (Addison et al. 2005).
- Field evidence indicates that post-cratering processes, likely directly related to crustal adjustments, have modified the original impact products and introduced features in the rocks that complicate interpretation of syn-cratering to post-cratering processes. It is not clear in all cases which particular IUGS rock name is apropos to some impact rocks found within or outside of the Sudbury Structure.
- Some IUGS terms specify whether the matrix material is (impact) cataclasite, impact-generated frictional melt, or impact-generated shock metamorphic melt. These distinctions are often not evident given recrystallization from residual impact heat, regional metamorphism and deformation.
- Some IUGS terms are problematic, such as “monomict breccia” and “polymict breccia”, as parts of the definition are vague when compared to one another, and the terms are defined quite differently by the SLTT (Soller 2004b) and the AGI (Neuendorf, Mehl and Jackson 2005).

With respect to the above points and in light of the geologic and economic significance of the Sudbury Structure, particular attention was paid to the following nomenclature issues.

- The rock nomenclature for the OGS needs to be integrated into an extensive system of rock modifiers (*see* Part 2) to account for the descriptive features found specifically in Ontario, most notably the Sudbury Structure. Provision is incorporated into the modifiers a) to assign a term with specific reference to traditional geological units of the Sudbury Structure; and b) to ascribe genetic or process implications through the rock names listed in Table 34.
- Impact melt rock: The OGS system specifies, in a 3-fold subdivision, the proportion of clasts within a melt matrix, followed by a rock name based on an equivalent intrusive igneous mineralogical composition when determinable (cf. Figures 3, 4 and 5; Table 31).
- Impact pseudotachylite: The OGS system parallels that for impact melt rock in specifying, in a 3-fold subdivision, the proportion of clasts within the matrix. For our purposes, the term impact pseudotachylite has been broadened to include matrixes consisting of melt and/or extremely comminuted cataclastic material. This was done to accommodate the broad spectrum of characteristics in pseudotachylite-like material related to the Sudbury Structure, collectively known locally as “Sudbury breccia” (*also see* Neuendorf, Mehl and Jackson 2005). It is not always possible, considering post-impact crustal adjustments, metamorphism and deformation, to determine whether the initial product was 1) a true impact-generated melt or a post-impact-related

melt; and 2) a frictional melt and/or ultra-fine, comminuted material, both of which may look similar after recrystallization and both of which may exhibit flow banding. An example of post-impact crustal adjustment, or unrelated faulting, is the occcurrence of Sudbury-breccia-like pseudotachylite in granite (“granophyre”) of the Sudbury Igneous Complex impact melt sheet.

- Impact breccia: The formidable complexity and diversity of characteristics of both the crater floor and crater-fill breccias of the Sudbury Structure require a more detailed subdivision to facilitate mapping of important variations. This is particularly apropos to the suevite breccias, which correspond to the crater-fill material constituting the Onaping Formation. To assist in this goal, the terminology has been modelled on that of pyroclastic rocks by referring to proportions and size ranges of fragments (Figure 33; cf. Figure 15A and Table 31). In addition, some impact breccias in the footwall of the Sudbury Structure appear, for the most part, to be lithic (polymictic) breccia, yet there are occurrences of rounded clasts (up to cobble size) with crystalline textures consistent with other rocks in the structure which have been ascribed to crystallized impact melt. This could require assigning the term suevite (polymictic breccia) to the hosting breccias which are profoundly different from suevite of the Onaping Formation. Hence, rock names tentatively proposed in Table 35 are more descriptive, rather than genetic.

Table 35 provides the tentative rock nomenclature scheme proposed herein, particularly as it pertains to the Sudbury Structure.

Table 35. Impactite rocks: definitions for Ontario[1,2], based largely on features related to the Sudbury Structure[3].

Rock Class	Rock Name	Definition
Impact-related pseudotachylite[1]		Ultra fine-grained (comminuted), in some cases vitreous-looking material, commonly black or dark grey (may be white to light grey depending on host rock), with widely diverse contents of visible clasts, and occurring as widely diverse bodies ranging from thin vein- and dike-like bodies to large irregularly shaped bodies. Clasts typically appear to be relatively locally derived but may have no obvious source. May be monomict breccia[2]. [Corresponds to Sudbury breccia[3] and similar features.]
	Clast-free impact pseudotachylite[1]	*Impact-related pseudotachylite* with essentially no macroscopic clasts[A].
	Clast-poor impact pseudotachylite[1]	*Impact-related pseudotachylite* with <25% macroscopic clasts[A].
	Clast-rich impact pseudotachylite[1]	*Impact-related pseudotachylite* with >25% macroscopic clasts[A].
Impact breccia[2]		Impact-generated, *monolithic* to *heterolithic breccias*, with or without *impact melt* particles, spatially associated with an impact structure.
	Lithic impact breccia[2]	*Impact breccia* with a clastic matrix containing shocked and/or unshocked mineral and lithic clasts, without impact melt particles. Occurs as dikes, lenses or irregularly shaped bodies. May be polymict breccia[2]. [Corresponds to Footwall breccias[3].]
	Monolithic impact breccia[1]	A *lithic impact breccia* largely containing clasts of virtually 1 rock type. Occurs as stand-alone bodies or as clasts or lenses in *heterolithic impact breccia*.
	Heterolithic impact breccia[1]	A *lithic impact breccia* containing clasts of many rock types. May contain clasts of monolithic and/or heterolithic impact breccia. Generally is polymict breccia[2].
	Suevite[2]	A heterolithic, polymict breccia[2] with a particulate matrix containing shocked and unshocked mineral and lithic clasts along with impact melt particles, all exhibiting a complex variety of features, presumably as a result of complex formation and depositional processes. Lithic and melted particles may be very small to very large. [Corresponds to breccias of Onaping Formation[3].]
	Tuff-like suevite[1]	*Suevite* with ash-size[B] particles >75%[A] (*see* Figure 33).
	Lithic tuff-like suevite[1]	*Tuff-like suevite* in which lithic rock fragments are dominant (cf. Figure 15B).
	Crystal tuff-like suevite[1]	*Tuff-like suevite* in which crystal fragments are dominant (cf. Figure 15B).
	Vitric-tuff-like suevite[1]	*Tuff-like suevite* in which pumiceous and glassy fragments are dominant (cf. Figure 15B).
	Lapilli tuff-like suevite[1]	*Suevite* with block- and/or bomb-size clasts <25%, and lapilli- and ash-size particles[B] each <75%[A] (*see* Figure 33).
	Lapillistone-like suevite[1]	*Suevite* with lapilli-size[B] particles >75%[A] (*see* Figure 33).

Table 35. *continued*

Rock Class	Rock Name	Definition
	Tuff-breccia-like suevite[1]	*Suevite* with block- and/or bomb-size clasts[B] from 25 to 75%[A] (*see* Figure 33).
	Pyroclastic breccia-like suevite[1]	*Suevite* with block-size[B] clasts >75%[A] (*see* Figure 33).
	Agglomerate-like suevite[1]	*Suevite* with bomb-size[B] clasts >75%[A] (*see* Figure 33).
Impact melt rock[2]		Crystalline, semi-glassy or glassy rock solidified from impact-generated melt and containing various amounts of clastic debris with different degrees of shock metamorphism. Impact melt products include a) melt sheets; b) fragments in *suevite*; and c) dike- and vein-like bodies. [Corresponds to Sudbury Igneous Complex, Offset dikes, Onaping intrusions and some components of Onaping Formation[3].]
	Clast-free impact melt rock[1]	*Impact melt rock* with essentially no macroscopic clasts[A].
	Clast-poor impact melt rock[1]	*Impact melt rock* with <25% macroscopic clasts[A].
	Clast-rich impact melt rock[1]	*Impact melt rock* with >25% macroscopic clasts[A].

[1] *Definition derived for use within OGS.*
[2] *Definition derived largely from Fettes and Desmons (2007); see Table 34.*
[3] *See Table 60 for definition.*
[A] *Amounts or percentages shown here have been specified by the OGS; (see Figure 33).*
[B] *Although ash, lapilli, block and bomb are defined in volcanic terms as pyroclasts (Fisher 1966), the terms are used here strictly as a useful size classification that has functioned well, in mapping pyroclastic rocks. Suevite shares some characteristics with pyroclastic rocks except that suevite is formed by hypervelocity impact processes.*

Part 2: Rock Modifier Definitions

Naming a rock, be it at an outcrop or with a hand specimen or diamond-drill core, is a crucial step in the process of data collection, particularly for field mapping. However, the process of determining a rock name is the end result of observing and recording characteristics about a rock to arrive at an appropriate name and to provide additional data for the mapping geologist and end user. To that end, Part 2 of this manual includes lists of rock modifiers for the various rock types. The Earth Resources and Geoscience Mapping Section (ERGMS) of the Ontario Geological Survey (OGS) has endeavoured to conceive of complete lists of rock modifiers pertinent to Ontario Precambrian geology.

The tables in Part 2 list, alphabetically, the modifiers for each of the major rock types. The modifiers have been arranged in hierarchical form as a proposed form of pick lists for use with hand-held devices in the field. Definitions supplied are presented in the context of the specific lists of modifiers. In cases where definitions may be used in more than one context, the context is indicated in parentheses after the modifier. Words within definitions that are in *italics* are also defined elsewhere in the same table.

Mineralogical modifiers for igneous and metamorphic rocks are to be applied in a specified order. The current rules for both igneous (Le Maitre 2002) and metamorphic rocks (Fettes and Desmons 2007) are to list the mineral modifiers in *increasing* order of abundance. For example, with hornblende-biotite granodiorite, biotite is more abundant, and with staurolite-garnet schist, garnet is more abundant. Previously, for igneous rocks, the order was reversed, at least with OGS policy. The current rules are designed to increase consistency and ease of use.

The following list of tables facilitates a relatively quick reference for an appropriate rock type or topic. Pick list tables can be found in the back pocket.

IGNEOUS ROCKS

Intrusive Rocks

The pick list of modifiers for Intrusive Rocks (Table 36, back pocket) is structured so that major headings consist of features related to the following:

- colour index (relative to the “normal” range for the rock type chosen);
- colour (fresh and weathered surfaces);
- form of intrusive body (e.g., dike, pluton);
- contact relationships (e.g., concordant, discordant);
- rock fabric (e.g., massive, foliated);
- rock structure (e.g., layering, flow alignment; intrusion breccia, inclusions);
- rock texture (e.g., features of crystals – groundmass, phenocrysts);
- secondary features (e.g., cavities); and
- miscellaneous (e.g., group, formation).

MODIFIERS

Modifiers and ancillary terms for intrusive rocks are listed alphabetically. Words within definitions that are in *italics* are also defined elsewhere in the same table. A word in square [brackets] following a modifier indicates the appropriate geologic theme or topic to which the modifier refers, as the modifier can apply to more than one theme. A word in (parentheses) following a modifier refers to the general topic as laid out in the hierarchical design of the appropriate pick list.

Table 37. Intrusive rocks: modifier definitions.

Modifier	Definition[A]	Source[B]
Acicular (crystal habit)	Said of a crystal that is needle-like in form. Cf. *equant*; *prismatic*; *sheet*; *tabular*.	1
Acicular pyroxene spinifex (texture)	Pyroxene *spinifex texture* with coarse-grained *acicular* pyroxene crystals arranged in sheaths, perpendicular to flow margins or randomly oriented, in an *aphanitic* to *glassy* matrix with fine-grained quench olivine ±pyroxene ±sulphides.	3
Adcumulate (texture)	Texture consisting of early formed accumulated crystals, enlarged by overgrowths of the same mineral (and same composition) such that interstices (<5% of the rock) are almost totally filled. Cf. *mesocumulate*; *orthocumulate*.	1
Angular (roundness class)	Having sharp angles or borders; specifically said of a *particle* showing very little or no evidence of abrasion, with all of its edges and corners sharp. A subdivision of the *roundness class*; used here in the context of fragments in an intrusion breccia. Cf. *well rounded*; *rounded*; *subrounded*; *subangular*; *very angular*.	(1)
Anhedral	Said of a crystal lacking well-developed crystal faces. Cf. *subhedral*, *euhedral*. [Synonym: allotriomorphic].	1
Antiperthite	A variety of alkali feldspar consisting of parallel or subparallel intergrowths in which the sodium-rich phase (albite, oligoclase or andesine) appears to be the host from which the potassium-rich phase (usually orthoclase) exsolved. Cf. *perthite*, *mesoperthite*.	1
Aphanitic	Any fine-grained igneous rock with crystalline components that are not distinguishable with the unaided eye (approximately <0.1 mm). See *microcrystalline*; *cryptocrystalline*. Cf. *phaneritic*.	1,2
Aphyric	Said of the texture of a fine-grained or *aphanitic* igneous rock that lacks *phenocryst*s.	1
Autolith	An *inclusion* in an igneous rock to which it is genetically related. Cf. *xenolith*. [Synonym: cognate inclusion; cognate xenolith].	1
Batholith	A large, generally discordant plutonic body having an aerial extent of ~100 km^2 or more and no known floor. Batholiths may consist, in part, of aggregates of plutons. Cf. *stock; pluton.*	1
Bilithic	In OGS usage, refers to the presence of 2 types of rock fragments (e.g., in an *intrusion breccia*). Cf. *monolithic*; *heterolithic*.	

Table 37. *continued*

Modifier	Definition[A]	Source[B]
Cavity	A hollow, empty space in solid rock. See *druse*; *miarolitic*, *vug*.	
Chilled (margin)	The border or outer zone of an igneous intrusion that is finer grained, due to more rapid cooling, than the interior.	1
Colour index	The volume percentage of mafic (dark-coloured) minerals in a rock (commonly igneous) (denoted as M′ in QAPF terminology).	2
Comb texture	A row of mineral grains oriented with their long axes perpendicular to a surface.	1
Compositional layering	Layers of different minerals (in some cases alternating) in igneous and metamorphic rocks. Cf. *cryptic layering*; *phase layering*; *rhythmic layering*.	1
Concordant [intrusive]	Said of a *contact* between an igneous intrusion and the country rock that parallels the bedding or foliation planes of the latter. Cf. *discordant* [*intrusive*].	(1)
Conformable [intrusive]	An intrusive igneous contact that has the same attitude as that of the intrusion's internal structures. Cf. *disconformable* [*intrusive*].	1
Contact	In intrusive terms, a plane or irregular surface between an intrusion and the country rock.	(1)
Contact breccia	Breccia at the contact of an igneous intrusion, resulting from country-rock fragmentation, and consisting of both intrusive material and country rock. Cf. *intrusion breccia*.	1
Crescumulate	Texture in which large, elongated crystals are oriented roughly normal to cumulate layering in the rock. Cf. *adcumulate; mesocumulate.*	1
Cross-bedding	*Cross-stratification* in which the cross-strata are thicker than 1 cm. Cf. *cross-lamination*.	(1)
Cross-lamination	*Cross-stratification* in which the cross-strata are thinner than 1 cm. Cf. *cross-bedding*.	(1)
Cross-stratification	A general term for an arrangement of strata inclined at an angle to the main stratification (see *cross-bedding*; *cross-lamination*). Rare in intrusive rocks.	1
Cryptic layering	Invisible layering, within and commonly parallel to the sides and bottom of igneous intrusions, identified by a regular vertical change in chemical composition of the minerals; so named because it is less obvious than *rhythmic layering*. (Typical element ratios defining cryptic layering are Fe/Mg in mafic minerals and Ca/Na in plagioclase). Cf. *compositional layering*; *phase layering*; *rhythmic layering*.	1
Cryptocrystalline	Said of the texture of an igneous rock consisting of crystals that are too small to be recognized and separately distinguished even under the ordinary microscope. Crystal size <<0.1 mm in size. Cf. *microcrystalline.*	1
Cumulate (texture)	Texture formed by the accumulation of crystals that settle out from a *magma* by the action of gravity.	(1)
Dendritic	Said of a mineral that has crystallized in a branching pattern.	1
Diatreme	A funnel-shaped, breccia-filled [volcanic] pipe or dike-like body that likely resulted in a gaseous explosion, commonly by hydrovolcanic fragmentation and wall-rock collapse. In OGS usage, an *intrusion breccia* with or without a magmatic matrix, which may or may not be lamprophyric, and with or without exotic inclusions.	1
Dike	A tabular igneous intrusion that cuts across the bedding or foliation of the country rock. Cf. *sheet*; *sill*.	1
Disconformable [intrusive]	An intrusive igneous contact that does not have the same attitude as that of the intrusion's internal structures. Cf. *conformable* [*intrusive*].	1
Discordant [intrusive]	Said of a contact between an igneous intrusion and the country rock that is not parallel to the bedding or foliation planes of the latter. Cf. *concordant* [*intrusive*].	1
Druse	An irregular *cavity* or opening in a vein or rock, having its interior surface or walls lined (encrusted) with small projecting crystals usually of the same minerals as those of the enclosing rock, and sometimes filled with water. Definition does not specify type of host rock. Cf. *miarolitic*; *vug*.	1
Enclave [magmatic]	*Not recommended: not recognized by IUGS, AGI and not well defined or consistently used in the literature*. A volume of rock surrounded by emplaced host rock of related but distinct composition and of separate genesis (e.g., incomplete magmatic mixing). Better to use terms such as *xenolith*, *autolith*, *schlieren* and so on where the nature of the included material can be determined.	
Equant (crystal habit)	Said of a crystal having the same or nearly the same diameter in all directions. Cf. *acicular*; *prismatic*; *sheet*, *tabular*. [Synonym: equidimensional].	1
Equigranular	Texture consisting of grains roughly equal in size; term used primarily for igneous and metamorphic rocks. Cf. *inequigranular*.	1
Euhedral	Said of a crystal bounded by "perfect" crystal faces; well-formed. Cf. *anhedral*; *subhedral*. [Synonym: idiomorphic].	1
Felsic (colour index)	In OGS usage, an adjective for a fine-grained intrusive (or volcanic) rock with a *colour index* <15.	
Flow alignment	In OGS usage, an alignment of crystals (commonly plagioclase) inferred as being due to primary *magma* flow.	
Flow layering	The structure of an igneous rock, characterized by layering defined by color, mineralogic composition, and/or texture, formed as a result of the flow of *magma*. [Synonym: flow banding].	
Fragment	A rock or mineral *particle* larger than a grain (i.e., larger than a few millimetres). Cf. *grain*.	(1)
Fresh surface	Refers to a surface that exposes rock that has not undergone weathering. Cf. *weathered surface*.	

Table 37. *continued*

Modifier	Definition[A]	Source[B]
Glassy	Said of the texture of certain extrusive igneous rocks, which is similar to that of broken glass or quartz and developed as a result of rapid cooling of the lava, without distinct crystallization. [Synonym: hyaline].	1
Glomerocryst	An aggregate of crystals, usually *phenocryst*s, of the same mineral.	(1)
Graded bedding	A type of bedding in which each layer displays a gradual and progressive change in particle size, usually from coarse at the base of the bed to fine at the top (rare in intrusive rocks).	1
Grain [petrology]	In an igneous sense, commonly refers to crystals (e.g., grain size). Also can refer to a rock *particle*, smaller than a fragment (i.e., less than a few millimetres). Cf. *fragment*.	1
Graphic	Said of the texture of an igneous rock characterized by regular *poikilitic* intergrowth of triangular or linear-angular quartz grains within larger alkali feldspar grains. Similar intergrowths of other minerals, e.g., ilmenite-pyroxene, are less common.	1
Groundmass [igneous]	The finer grained and/or glassy material between the phenocrysts in a *porphyritic* igneous rock.	1
Habit	The characteristic crystal form or combination of forms of a mineral, including characteristic irregularities.	1
Heterolithic	In OGS usage, refers to the presence of multiple (generally 3 or more) types of rock fragments (e.g., in an *intrusion breccia*). Cf. *monolithic*; *bilithic*.	
Hololeucocratic	A *colour index* term for a rock with M′ <10. Cf. *leucocratic*; *mesocratic*; *melanocratic*; *holomelanocratic*.	2
Holomelanocratic	A *colour index* term for a rock with M′ >90. Cf. *hololeucocratic*; *leucocratic*; *mesocratic*; *melanocratic*.	2
Hypidiomorphic-granular	A *phaneritic* igneous texture dominated by *subhedral*, *equant* grains. Cf. *idiomorphic-granular*; *xenomorphic-granular*.	1
Idiomorphic-granular	A *phaneritic* igneous texture dominated by *euhedral*, *equant* grains. Cf. *hypidiomorphic-granular*; *xenomorphic-granular*.	1
Igneous lamination	In intrusive rocks, the arrangement of tabular crystals parallel to each other and to any layering the rocks may have.	(1)
Inclusion	A general term for a *fragment* of older rock within an igneous rock to which it may or may not be genetically related. See *autolith*; *xenolith*.	1
Inequigranular	Texture consisting of grains exhibiting a range in grain (crystal) size; term used primarily for igneous and metamorphic rocks. Cf. *equigranular*.	1
Intermediate (colour index)	In OGS usage, an adjective for a fine-grained intrusive (or volcanic) rock having a *colour index* from 15 to 35.	
Intrusion breccia	In OGS usage, a breccia that is composed of numerous *fragments* of rock within an igneous matrix. May occur at the intrusion contact with country rock fragments (i.e., *contact breccia*) and/or within the intrusion.	
Layering [petrology]	A succession of tabular units exhibiting distinct variation in mineralogic, textural or structural characteristics within an igneous body, such as the phenomenon in plutonic rocks resulting from crystal settling in *magma*.	(1)
Leuco-	Used as a prefix, and hence modifier, for a rock that has considerably more felsic minerals than would be regarded as normal for that rock type (limits specified in Figures 7 and 8). Cf. *mela-*.	(2)
Leucocratic	A *colour index* term for a rock with M′ from 10 to 35. Cf. *hololeucocratic*; *mesocratic*; *melanocratic*; *holomelanocratic*.	2
Mafic (colour index)	In OGS usage, an adjective for a fine-grained intrusive (or volcanic) rock having a *colour index* from >35 to 90.	
Magma	Naturally occurring molten or partially molten rock material, generated within the Earth and capable of intrusion and extrusion, from which igneous rocks are derived through solidification and related processes. It may or may not contain suspended solids (such as crystals and rock fragments) and/or gas phases.	1
Massive [igneous]	Igneous rocks possessing a more or less homogeneous *texture* (fabric) over wide areas and lacking *layering*, foliation, cleavage or similar features. Sometimes used, somewhat inappropriately, for an igneous rock with no layering, *fragments*, etc., even though the rock may have a foliation.	1
Megacryst	A non-genetic term introduced for “any crystal or grain” in an igneous or metamorphic rock that is “significantly larger” than the surrounding groundmass or matrix; e.g., a large microcline crystal in *porphyritic* granite. It may be a *phenocryst*, *xenocryst*, porphyroblast or porphyroclast.	1
Mela-	Used as a prefix, and hence modifier, for a rock that has considerably more mafic minerals than would be regarded as normal for that rock type (limits specified in Figures 7 and 8). Cf. *leuco-*.	(1)
Melanocratic	A *colour index* term for a rock with M′ from 65 to 90. Cf. *hololeucocratic*; *leucocratic*; *mesocratic*; *holomelanocratic*.	2
Mesocratic	A *colour index* term for a rock with M′ from 35 to 65. Cf. *hololeucocratic*; *leucocratic*; *melanocratic*; *holomelanocratic*.	2
Mesocumulate (texture)	A cumulate containing a small amount of intercumulus material; intermediate between an *orthocumulate* and an *adcumulate* texture.	1

Table 37. *continued*

Modifier	Definition[A]	Source[B]
Mesoperthite	A variety of perthitic feldspar consisting of an intimate mixture of about equal amounts of alkali feldspar and plagioclase (usually albite, sometimes oligoclase). It is intermediate in composition between *perthite* and *antiperthite*.	1
Miarolitic	Small irregular *cavities* in *phaneritic* igneous rocks, especially "granites", into which small crystals of the rock-forming minerals protrude. Cf. *druse*; *vug*.	1
Microcrystalline	Said of the texture of a rock consisting of or having crystals that are small enough to be visible only under the microscope. Crystal size <0.1 mm in size. Cf. *cryptocrystalline*.	1
Mineral assemblage (igneous)	The minerals that compose a rock, including the different kinds and relative abundances, but excluding *texture* and fabric.	1
Monolithic	In OGS usage, refers to the presence of only 1 type of rock fragment (e.g., in an *intrusion breccia*). Cf. *heterolithic*, *bilithic*.	
Ocellar	An igneous rock texture, especially one with nepheline, in which aggregates of smaller crystals (e.g., of biotite or acmite) a) are arranged radially or tangentially around larger, *euhedral* crystals (e.g. of leucite or nepheline) or b) form rounded eye-like branching forms.	1
Oikocryst	In *poikilitic* fabric, the enclosing crystal.	1
Ophitic	Igneous *texture* characterized by plagioclase laths largely or entirely enclosed by pyroxene grains. Cf. *poikilitic*.	1
Orbicular	Igneous *texture* characterized by numerous *orbicules*.	1
Orbicule	A more or less spherical body, from microscopic size to several centimetres or more in diameter, commonly composed of concentric "shells" of alternating light and dark minerals. Their centres may or may not exhibit *xenolithic* nuclei.	1
Orthocumulate (texture)	Texture consisting of early formed, accumulated crystals and relatively large amounts of interstitial minerals formed later by crystallization of *magma* trapped between the early crystals. Cf. *mesocumulate*; *adcumulate*.	1
Particle	A general term, used without restriction as to shape, composition or internal structure, for a separable or distinct component in a rock, e.g., a fragment or a grain, usually consisting of a mineral. See *fragment*; *grain*.	1
Pegmatitic	Said of the texture of very coarse- to extremely coarse-grained (crystal diameter greater than 3 cm) igneous rocks.	
Perthite	A variety of alkali feldspar consisting of parallel or subparallel intergrowths in which the potassium-rich phase (usually microcline) appears to be the host from which the sodium-rich phase (usually albite) exsolved. The exsolved parts are visible to the naked eye, and typically form strings, lamellae, blebs, films, or irregular, thin vein-like features. Cf. *antiperthite*, *mesoperthite*.	1
Phaneritic	Said of the *texture* of an igneous rock in which the *grains* are large enough to be distinguished with the unaided eye, i.e., megascopically crystalline. Cf. *aphanitic*.	1
Phase layering	The mineralogical layering of plutonic rocks caused by the generally sudden appearance and progressive disappearance (from bottom to top) of some mineral phase. Cf. *compositional layering*; *cryptic layering*; *rhythmic layering*.	1
Phenocryst	A term widely used for a relatively large, conspicuous crystal in a *porphyritic* rock. Phenocrysts are commonly *euhedral* (to *subhedral*) because of early growth within *magma* or by crystallization after emplacement. Cf. *xenocryst*.	1
Platy flow structure	An igneous rock structure of tabular sheets suggesting stratification. It is formed by contraction during cooling; the structure is parallel to the surface of cooling, and is commonly accentuated by weathering.	1
Platy olivine spinifex (texture)	Olivine *spinifex texture* in which olivine has a plate or lattice habit and forms complex *grains* made up of many individual plates arranged roughly parallel to one another, sometimes in sets, and oriented approximately perpendicular to flow or intrusive margins. Cf. *random olivine spinifex*.	3
Pluton	A deep-seated igneous intrusion. OGS usage tends to favour a size connotation, with pluton being intermediate between *stock* (smaller) and *batholith* (larger).	(1)
Poikilitic	Said of an igneous *texture* in which small *grains* of one mineral (e.g., plagioclase) are irregularly scattered within a typically larger, *anhedral* crystal of another mineral (e.g., pyroxene). The enclosing crystal is an *oikocryst*.	1
Porphyritic	Said of the *texture* of an igneous rock in which *phenocrysts* (larger crystals) are set in a finer grained groundmass, which may be crystalline or *glassy* or both.	1
Prismatic (crystal habit)	Said of a crystal that shows one dimension markedly longer than the other two. Cf. *acicular*; *equant*; *sheet*; *tabular*.	1
Quartzose	For use in the sense of fragment rock type under *intrusion breccia*. A general term for a rock with quartz as the principal constituent, especially a quartz-rich sedimentary rock (i.e., quartz arenite, quartz wacke).	
Random olivine spinifex (texture)	Olivine *spinifex texture* in which, compared to *platy olivine spinifex*, the olivine crystals are smaller, less elongate, randomly oriented plates.	3

Table 37. *continued*

Modifier	Definition[A]	Source[B]
Rapakivi texture	A texture of igneous (intrusive and volcanic) and metamorphic rocks in which relatively large crystals of alkali feldspar are surrounded by a rim of sodic plagioclase, set in a finer grained matrix.	1
Reaction rims	A general term for minerals that have grown around an object, such as a *fragment* or crystal, as a result of a reaction between *magma* or related fluids and the object.	
Rheomorphic intrusion	A body of country rock rheomorphically injected into the igneous intrusion that caused the *rheomorphism*.	1
Rheomorphism	The process by which a rock becomes mobile as a result of at least partial fusion, commonly accompanied by, if not promoted by, addition of new material by diffusion.	1
Rhythmic layering	Readily observable structure in an igneous intrusion involving the repetition of gravity-stratified layers (typically more mafic minerals along the bottom, more plagioclase along the top), resulting from periodic crystallization and accumulation (settling) of crystals. Cf. *compositional layering*; *cryptic layering*; *phase layering*.	1
Rounded (roundness class)	Round or curving in shape; specifically said of a *particle* with original edges and corners that have been smoothed off to rather broad curves and with original faces that are almost completely removed by abrasion (although some comparatively flat surfaces may be present). The original shape is still readily apparent. A subdivision of the *roundness class*; used here in the context of fragments in an intrusion breccia. Cf. *well rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Roundness class	An arbitrarily defined range of roundness values, originally for the classification of sedimentary particles, but utilized here in a modified version for convenience in describing fragments/xenoliths in an intrusive rock. See *well rounded*; *rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Schliere (igneous)	Tabular or disc-like concentrations of minerals (flow layers) within an igneous intrusion. They have the same general mineralogy as the plutonic rocks, but because of differences in mineral ratios they are darker or lighter; the boundaries with the rock tend to be transitional. Some schliere are modified inclusions, others may be segregations of minerals. Plural: schlieren.	1
Scour channel (igneous)	A large groove-like erosional feature on the floor of a *magma* chamber resulting from magma flow.	
Seriate	Said of the texture of an igneous rock, typically *porphyritic*, in which the sizes of the larger *grains* range continuously to the size of groundmass grains.	1
Sheet [intrusive]	A general term for a tabular igneous intrusion, especially those that are concordant or only slightly discordant. In this general sense, the term *dike* is used for a vertical or steeply dipping tabular body, and the term *sill* for a horizontal or gently dipping one. Cf. *dike*; *sill*.	1
Sheet (crystal habit)	Said of a mineral that forms flat sheets or flakes, such as phyllosilicates. Cf. *acicular*; *equant*; *prismatic*; *tabular*.	
Sill	A tabular igneous intrusion that parallels the planar structure of the surrounding rock. Cf. *dike*; *sheet*.	1
Spinifex texture	Texture characterized by the presence of large skeletal platy blades of olivine or dendritic crystals of pyroxene found in the upper parts of komatiitic flows or less commonly at the margins of some sills and dikes of komatiitic composition. Generally considered the result of rapid quenching of magnesium-rich *magma* from unusually high temperatures. See *platy olivine spinifex*; *random olivine spinifex*; *acicular pyroxene spinifex*.	3
Stellate	Said of an aggregate of crystals in a star-like arrangement.	1
Stock	A relatively small, concordant and/or discordant plutonic body having an aerial extent less than 100 km^2 and no known floor. Cf. *pluton; batholith.*	1
Subangular (roundness class)	Somewhat angular, free from sharp angles but not smoothly rounded; specifically said of a sedimentary *particle* showing definite effects of slight abrasion, retaining its original general form, and having faces that are virtually untouched and edges and corners that are rounded off to some extent. A subdivision of the *roundness class*; used here in the context of fragments in an intrusion breccia. Cf. *well rounded*; *rounded*; *subrounded*; *angular*; *very angular*.	(1)
Subequant	Said of a crystal having roughly the same or nearly the same diameter in all directions, but not as much as *equant* crystals.	
Subhedral	A *grain* (crystal) partly bounded by crystal faces; intermediate between *euhedral* and *anhedral*. [Synonym: hypidiomorphic].	1
Subrounded (roundness class)	Partially rounded; specifically said of a *particle* showing considerable but incomplete abrasion and an original general form that is still discernible, and having many of its edges and corners noticeably rounded off to smooth curves. A subdivision of the *roundness class*; used here in the context of fragments in an intrusion breccia. Cf. *well rounded*; *rounded*; *subangular*; *angular*; *very angular*.	(1)
Symplectic	An intimate intergrowth of 2 different minerals; sometimes restricted to those of secondary origin.	1
Tabular (crystal habit)	Said of a crystal form that shows one dimension markedly smaller than the other two. Cf. *acicular*; *equant*; *prismatic*; *sheet*.	1
Texture	The general physical appearance or character of a rock; the crystallinity, granularity and fabric of the constituent elements of an igneous rock. (The term "texture" is applied to the smaller (mesoscopic or microscopic) features whereas the term "structure" is generally used for the larger features of a rock. The two terms should not be used synonymously, although certain textural features may parallel major structural features.)	

Table 37. *continued*

Modifier	Definition[A]	Source[B]
Trough banding	*Rhythmic layering* or alignment of minerals confined to trough-like depressions within an intrusion.	1
Ultramafic (colour index)	In OGS usage, an adjective for a fine-grained intrusive (or volcanic) rock having a *colour index* >90.	
Unchilled (margin)	The border or outer zone of an igneous intrusion that is not finer grained than the interior because there was insufficient thermal contrast with the country rock during emplacement and cooling.	
Unzoned (contact)	No systematic variation in the composition of an intrusive body (mineralogical, grain size, etc.) in relation to its contact with the country rock.	
Vein	An epigenetic mineral filling of a fault or other fracture in a host rock, in tabular or sheet-like form, often with associated replacement of the host rock; may be mineralized. Not recommended usage as an igneous intrusive term for a thin dike.	1
Very angular (roundness class)	A term used to describe a particle with considerable angularity. A subdivision of the *roundness class*; used here in the context of fragments in an intrusion breccia. Cf. *well rounded*; *rounded*; *subrounded*; *subangular*; *angular*.	(1)
Vug	A small *cavity* in a *vein* or in rock, usually lined with crystals of a different mineral composition from the enclosing rock. Definition does not specify rock type. Cf. *druse*, *miarolitic*.	1
Weathered surface	Used to refer to the surface rind of a rock that has undergone weathering, as evident by colour, mineralogy, hardness, porosity, etc. Typically <1 cm thick, the weathered rock may be <1 mm thick to tens of centimetres thick. Cf. *fresh surface*.	
Well rounded (roundness class)	Said of a *particle* with original faces, edges and corners that have been destroyed by abrasion and in which the entire surface consists of broad curves without any flat areas; specifically said of a particle with no secondary corners. The original shape may be suggested by the present form of the particle. A subdivision of the *roundness class*; used here in the context of fragments in an intrusion breccia. Cf. *rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Xenocryst	A crystal that resembles a phenocryst in an igneous rock but is foreign to the body of rock in which it occurs. Cf. *phenocryst*.	1
Xenocrystic	Said of the texture of an igneous rock in which *xenocryst*s are set in a finer grained groundmass, which may be crystalline or *glassy* or both.	
Xenolith	A foreign *inclusion* of country rock within an intrusive or volcanic rock. Cf. *autolith*.	
Xenomorphic-granular	A *phaneritic* igneous texture dominated by *anhedral*, *equant* grains. Cf. *hypidiomorphic-granular*, *idiomorphic-granular*.	1
Zoned (contact)	Systematic variation in the composition of an intrusive body (mineralogical, grain size, etc.) in relation to its contact with the country rock.	

[A] *Preferred terms are defined: synonyms are in square brackets for reference only.*
[B] *Indicates source of definition: primary sources are indicated by a number; secondary sources are indicated by numbers in parentheses.*
1 = Neuendorf, Mehl and Jackson (2005); 2 = Le Maitre (2002); 3 = Arndt (2008).
Where no source(s) is indicated, definitions are derived from or modified for use by the OGS.

SIZE RANGES

Table 38. Intrusive rocks: size ranges for various parameters.[A]

Crystals	Aphanitic	Cryptocrystalline	<<0.1 mm
		Microcrystalline	<0.1 mm
	Phaneritic	Very fine grained	0.1 to 0.5 mm
		Fine grained	0.5 to 1 mm
		Medium grained	1 to 5 mm
		Coarse grained	5 to 30 mm
		Very coarse grained	3 to 10 cm
		Extremely coarse grained	>10 cm
Breccia	Fragments	Small	<1 cm
		Medium	1 to 30 cm
		Large	30 to 100 cm
		Very large	1 to 10 m
		Extremely large	>10 m

[A]*Adapted from a variety of sources and modified for OGS usage.*

Volcanic Rocks—Lavas

The pick list of modifiers for lavas (Table 39, back pocket) is structured so that major headings consist of features related to the following:

- colour (fresh and weathered surfaces);
- form (e.g., massive or pillowed flow, subvolcanic dike or sill);
- flow thickness;
- contact relationships (e.g., concordant, gradational);
- rock fabric (e.g., megascale, mesoscale);
- structure (flow alignment, layering, spherules, inclusions);
- rock texture (e.g., features of crystals – groundmass, phenocrysts); and
- secondary features (e.g., cavities).

MODIFIERS

Modifiers and ancillary terms for lava rocks are listed alphabetically. Words within definitions that are in *italics* are also defined elsewhere in the same table. A word in square [brackets] following a modifier indicates the appropriate geologic theme or topic to which the modifier refers, as the modifier can apply to more than one theme. A word in (parentheses) following a modifier refers to the general topic as laid out in the hierarchical design of the appropriate pick list.

Table 40. Volcanic rocks—lava: modifier definitions.

Modifier	Definition[A]	Source[B]
Aa	A Hawaiian [and commonly adopted] term for a type of lava flow typified by a rough, jagged, spinose, clinkery surface. Cf. *pahoehoe*; *block lava*.	1
Accretionary lava ball	A rounded mass, ranging in diameter from a few centimetres to several metres, formed on the surface of a lava flow such as *aa,* or on cinder cone slopes, by the moulding of viscous lava around a core of already solidified lava.	1
Acicular (crystal habit)	Said of a crystal that is needle shaped in form. Cf. *equant*; *prismatic*; *sheet*; *tabular*.	1
Acicular pyroxene spinifex (texture)	Pyroxene *spinifex texture* with coarse-grained acicular pyroxene crystals arranged in sheaths, perpendicular to flow margins or randomly oriented, in an *aphanitic* to *glassy* matrix with fine-grained quench olivine ±pyroxene ±sulphides.	3
Acidic [geochemical]	A chemical term now defined in the TAS classification for volcanic rocks with SiO_2 >63%. Cf. *intermediate*; *basic*; *ultrabasic*. The IUGS uses the term “acid”, but the OGS prefers the adjectival form “acidic”, which is also in keeping with the other chemical terms listed above. Not equivalent to “felsic” or “oversaturated”.	(2)
Adcumulate (texture)	Texture consisting of early formed accumulated crystals, enlarged by overgrowths of the same mineral (and same composition) such that interstices (<5% of the rock) are almost totally filled. Cf. *mesocumulate*; *orthocumulate*.	1
Amoeboid (pillow)	A non-official term for a nonspecific shape that consists of rounded protrusions and embayments, like that of some amoeba.	
Amygdule	A gas *cavity* or *vesicle* in an igneous rock that is filled with secondary minerals. [Adjective: amygdaloidal].	1
Anastomosing (fractures)	As used with fractures, reminiscent of the pattern of a braided stream (i.e., branching and reconnecting).	(1)
Anhedral	Said of a crystal lacking well-developed crystal faces. Cf. *subhedral*; *euhedral*. [Synonym: allotriomorphic].	1
Angular (roundness class)	Having sharp angles or borders; specifically said of a *particle* showing very little or no evidence of abrasion, with all of its edges and corners sharp. A subdivision of the *roundness class*; used here in the context of fragments in a *lava flow*. Cf. *well rounded*; *rounded*; *subrounded*; *subangular*; *very angular*.	(1)

Table 40. *continued*

Modifier	Definition[A]	Source[B]
Aphanitic	Any fine-grained igneous rock with crystalline components that are not distinguishable with the unaided eye (approximately <0.1 mm). See *microcrystalline*; *cryptocrystalline*. Cf. *phaneritic*.	1,2
Aphyric	Said of the texture of a fine-grained or *aphanitic* igneous rock that lacks *phenocrysts*.	1
Autobreccia	A general term for a breccia formed by some process that is contemporaneous with the formation or consolidation of the rock unit from which the fragments are derived. See *flow breccia*.	1
Autolith	An *inclusion* in an igneous rock to which it is genetically related. Cf. *xenolith*. [Synonym: cognate *inclusion*; cognate *xenolith*].	1
Basal clinker	The zone of *autobreccia* that forms the base of an *aa* flow.	1
Basic [geochemical]	A chemical term now defined in the TAS classification for volcanic rocks with SiO_2 between 45 and 52%. Cf. *acidic*; *intermediate*; *ultrabasic*.	2
Block lava	Lava having a surface of angular blocks; it is similar to *aa* but the fragments are more regular in shape, somewhat smoother, and less vesicular. Cf. *aa*; *pahoehoe*.	
Breccia	A coarse-grained clastic rock composed of angular broken rock fragments held together by mineral cement or in a fine-grained matrix; it differs from conglomerate in that the fragments have sharp edges and unworn corners. Breccia may originate as a result of sedimentary processes (sedimentary breccia); igneous processes (intrusion breccia, volcanic breccia); disturbance during sedimentation (intraclastic breccia); collapse of rock material (solution breccia, collapse breccia); or tectonic processes (fault breccia). This definition is exclusive of impact breccias (*See* section on Impactites).	1
Bun-shaped (pillow)	A non-official shape term for a rounded *pillow*, resembling that of a bun.	
Cavity	A hollow space in solid rock. See *druse*; *miarolitic*; *vug*.	
Chilled (margin)	The border or outer zone of a lava flow that is finer grained, due to more rapid cooling, than the interior.	1
Clinker	A rough, jagged pyroclastic or *autobrecciated* fragment, such as *aa* that resembles the clinker or slag of a furnace. Cf. *basal clinker*.	1
Colour index	The volume percentage of mafic (dark-coloured) minerals in an igneous (commonly volcanic) rock (denoted as M′ in QAPF terminology).	2
Concordant	Said of an igneous contact that is parallel to foliation or bedding in the country rock. Cf. *discordant*.	(1)
Corded	The typical kind of *pahoehoe,* having a surface resembling coils of rope or cord. Cf. *elephant-hide*; *entrail*; *festooned*; *filamented*; *sharkskin*; *shelly*; *slab*.	1
Crescumulate	Texture in which large, elongated crystals are oriented roughly normal to *cumulate* layering in the rock.	1
Cryptocrystalline	Said of the texture of an *aphanitic* rock consisting of crystals that are too small to be recognized and separately distinguished even under the ordinary microscope. Crystals <<0.1 mm in size. Cf. *microcrystalline*.	1
Cumulate (texture)	Texture formed by the accumulation of crystals that settle out from a *magma* by the action of gravity.	(1)
Cumulate layer (komatiite)	Lower part of a *differentiated* komatiite flow which includes olivine cumulates ranging from 40 to 50% olivine in poorly differentiated flows to 80 to 98% olivine in thicker, more differentiated flows.	3
Dendritic	Said of a mineral that has crystallized in a branching pattern.	1
Differentiated (komatiite)	Refers to the separation of crystal and liquid phases of komatiite flows to form mineralogically and texturally distinctive zones within single solidified flows. See *cumulate layer*; *knobby texture*; *spinifex texture*.	
Discordant	Said of an igneous contact that is not parallel to foliation or bedding in the country rock. Cf. *concordant*.	(1)
Druse	An irregular *cavity* or opening in a vein or rock, having its interior surface or walls lined (encrusted) with small projecting crystals usually of the same minerals as those of the enclosing rock, and sometimes filled with water. Definition does not specify type of host rock. Cf. *miarolitic*; *vug*.	1
Elephant-hide	A type of *pahoehoe* having a wrinkled and draped surface. Cf. *corded*; *entrail*; *festooned*; *filamented*; *sharkskin*; *shelly*; *slab*.	1
Entrail	A type of *pahoehoe* that has a surface resembling an intertwined mass of entrails, formed on steep slopes as dribbles around and through cracks in the flow crust. Cf. *corded*; *elephant-hide*; *festooned*; *filamented*; *sharkskin*; *shelly*; *slab*.	1
Equant (crystal habit)	Said of a crystal having the same or nearly the same diameter in all directions. Cf. *acicular*; *prismatic*; *sheet*; *tabular*. [Synonym: equidimensional].	1
Equigranular	Texture consisting of grains roughly equal in size; term used primarily for igneous and metamorphic rocks. Cf. *inequigranular*.	1
Euhedral	Said of a crystal bounded by "perfect" crystal faces; well-formed. Cf. *anhedral*; *subhedral*. [Synonym: *idiomorphic*].	1
Felsic (colour index)	In OGS usage, an adjective for a volcanic (or fine-grained intrusive) rock with a *colour index* <15.	

Table 40. *continued*

Modifier	Definition[A]	Source[B]
Festooned	A type of *pahoehoe,* the ropy surface of which has been dragged by flow of underlying molten lava into festoon patterns. Cf. *corded*; *elephant-hide*; *entrail*; *filamented*; *sharkskin*; *shelly*; *slab*.	1
Filamented	A type of *pahoehoe,* the surface of which displays thread-like strands that are formed by escaping gas bubbles and are recumbent and aligned with the direction of flow. It is a common type and is often found superimposed on other forms. Cf. *corded*; *elephant-hide*; *entrail*; *festooned*; *sharkskin*; *shelly*; *slab*.	1
Flow alignment	In OGS usage, an alignment of crystals (commonly plagioclase) inferred as being due to primary flow of lava.	
Flow breccia	A *breccia* that is formed contemporaneously with the movement of a lava flow; the cooling crust becomes fragmented while the flow is still in motion. It is a type of *autobreccia*. [N.B., "flow top breccia" is an unnecessary term].	1
Flow layering	The structure of an igneous rock, characterized by alternating layers of color, mineralogic composition, and/or texture, formed as a result of the flow of lava. [Synonym: flow banding].	1
Flow lobe	A solid or partly hollow (drained) globular extrusion of fluid basalt, generally ~2 m thick and 5 to 10 m in diameter; a protrusion from an extrusive body. Cross-sections of some lobes are pillow-like. "Skins" of adjacent flow lobes may melt and disappear, resulting in amalgamated lava bodies.	1
Fresh surface (rock)	Refers to a surface that exposes rock that has not undergone weathering. Cf. *weathered surface*.	
Glassy	Said of the texture of certain extrusive igneous rocks that is similar to that of broken glass or quartz and developed as a result of rapid cooling of the lava, without distinct crystallization. [Synonym: hyaline; Adjectival prefix: "hyalo"].	1
Glomerocryst	An aggregate of crystals, usually *phenocryst*s, of the same mineral.	(1)
Granular	Particular size range for *hyaloclastite*; 2 to 4 mm (mean diameter).	
Hyaloclastite	A deposit formed by the flow or intrusion of lava or *magma* into water, ice or water-saturated sediment, and its consequent granulation or shattering into small angular fragments. Also includes vitric tuff from shallow-water explosive volcanism or explosive interaction of magma and groundwater. [Synonym: aquagene tuff].	1
Hypidiomorphic-granular	A *phaneritic* igneous texture dominated by *subhedral*, *equant* grains. Cf. *idiomorphic-granular*; *xenomorphic-granular*.	1
Idiomorphic-granular	A *phaneritic* igneous texture dominated by *euhedral*, *equant* grains. Cf. *hypidiomorphic-granular*; *xenomorphic-granular*.	1
Inclusion	A general term for a fragment of older rock within an igneous rock to which it may or may not be genetically related. See *autolith*; *xenolith.*	1
Inequigranular	Texture consisting of grains exhibiting a range in grain (crystal) size; term used primarily for igneous and metamorphic rocks. Cf. *equigranular.*	1
Intermediate (colour index)	In OGS usage, an adjective for a fine-grained volcanic (or intrusive) rock having a *colour index* from 15 to 35.	
Intermediate [geochemical]	A chemical term now defined in the TAS classification for volcanic rocks with SiO_2 between 52 and 63%. Cf. *acidic*; *basic*; *ultrabasic*.	2
Knobby texture (komatiite)	A rarely noted feature evident by weathering-resistant knobs or patches of pyroxene-glass material (~ 1 cm across) occurring in some *differentiated komatiites*.	(3)
Lava	A general term for molten extrusive magma and for the rock that has solidified from it.	1
Lava ball	A globular mass of lava that is scoriaceous inside and compact on the outside; it is formed by the coating of a fragment of scoria by fluid lava.	1
Lava dome	A steep-sided, rounded accumulation of lava extruded from a volcano to form a dome-shaped or bulbous mass of congealed lava above and around a *vent*. Commonly parasitic on the flanks of, or within the crater of, larger edifices. May be hundreds of metres across and high. [Synonym: volcanic dome].	1
Lava flow	A lateral, surficial outpouring of molten lava, from a *vent* or a fissure; also, the solidified body of rock that is so formed.	1
Lava toe	One of a series of small, bulbous projections that develop at the front of a moving *pahoehoe* flow, formed by the breaking-open of the crust and the emergence of fluid lava.	1
Lava tube	A roofed conduit of molten lava flowing from an eruptive *vent* or locus of subcrustal injection of lava to a depositional site, formed by one or more of the following processes: (1) growth of flat, rooted crusts across lava streams within confined channels; (2) overflow and accretion of spatter to levees, producing a roof arched across a lava stream; (3) coalescence of plates of solidified crust floating downstream, forming a roof over a lava stream; (4) extension of *pahoehoe* lobes through injection of lava beneath a solidified crust. Typically hollow after lava withdrawal.	1

Table 40. *continued*

Modifier	Definition[A]	Source[B]
Lithophysa	A hollow, bubble-like to irregularly rounded structure, formed by expanding gases before complete lithification, commonly composed of concentric shells of finely crystalline alkali feldspar, quartz, and other minerals; found in some acidic volcanic flows and ignimbrites. May have a later-formed lens- or star-shaped mineral(s) infilling. Plural: lithophysae.	1,4
Mafic (colour index)	In OGS usage, an adjective for a volcanic (or fine-grained intrusive) rock with a colour index from >35 to 90.	
Magma	Naturally occurring molten or partially molten rock material, generated within the Earth and capable of intrusion and extrusion, from which igneous rocks are derived through solidification and related processes. It may or may not contain suspended solids (such as crystals and rock fragments) and/or gas phases.	1
Massive	Igneous rocks possessing a more or less homogeneous texture (fabric) over wide areas and lacking layering, foliation, cleavage or similar features. Sometimes used, somewhat inappropriately, for an igneous rock with no layering, fragments, etc., even though the rock may have a foliation.	1
Mattress (pillow)	A non-official shape term for a large, naturally flattened pillow, resembling that of a mattress.	
Mesocumulate (texture)	A cumulate containing a small amount of intercumulus material; intermediate between an *orthocumulate* and an *adcumulate* texture.	1
Miarolitic	Small irregular *cavities* in *phaneritic* igneous rocks (more commonly in "granites"), into which small crystals of the rock-forming minerals protrude. Cf. *druse*; *vug*.	1
Microcrystalline	Said of the texture of an *aphanitic* rock consisting of or having crystals that are small enough to be visible only under the microscope. Crystals <0.1 mm in size. Cf. *cryptocrystalline*.	1
Nodule (igneous)	A rounded fragment of a coarse-grained igneous rock, apparently crystallized at depth, occurring as an *inclusion* in an extrusive rock.	1
Oikocryst	In *poikilitic* fabric, the enclosing crystal.	1
Orthocumulate (texture)	Texture consisting of early formed, accumulated crystals and relatively large amounts of interstitial minerals formed later by crystallization of *magma* trapped between the early crystals. See *mesocumulate*; *adcumulate*.	1
Pahoehoe	A Hawaiian [and commonly adopted] term for a type of basaltic lava flow typified by a smooth, billowy or ropy surface. See *corded*; *elephant-hide*; *entrail*; *festooned*; *filamented*; *sharkskin*; *shelly*; and *slab* pahoehoe. Cf. *aa*; *block lava*.	1
Particle	A general term used without restriction as to shape, composition or internal structure, for a separable or distinct component in a rock, e.g., a fragment or a grain, usually consisting of a mineral.	1
Peperite	A *breccia*-like material in marine sedimentary rock, interpreted by some as a mixture of lava with sediment, and by others as shallow intrusions of *magma* into wet sediment. Note: this term is often used rather loosely.	1
Phaneritic	Said of the texture of an igneous rock in which the grains are large enough to be distinguished with the unaided eye, i.e., megascopically crystalline. Cf. *aphanitic*.	1
Phenocryst	A term widely used for a relatively large, conspicuous crystal in a *porphyritic* rock. Phenocrysts are commonly *euhedral* (to *subhedral*) because of early growth within *magma* or by crystallization after emplacement.	1
Pillow	The individual component that collectively forms *pillow structure*.	
Pillow breccia	A deposit of *pillows*, broken pillows and fragments of lava in a fine-grained matrix.	1
Pillow lava	A general term for those lavas displaying *pillow structure* and considered to have formed in a subaqueous environment; such lava is usually basaltic or andesitic, rarely dacitic. In general the more intermediate the composition, the larger the *pillows*, due to the increase in viscosity of the erupting lava.	1
Pillow structure [igneous]	A structure, observed in certain extrusive igneous rocks, that is characterized by discontinuous, typically *bun*-shaped masses ranging in size from a few centimetres to a metre or more in greatest dimension (commonly between 30 and 60 cm). The *pillows* are close-fitting, the concavities of one matching the convexities of another. Grain size within pillows tends to decrease toward the exterior. Pillow structures are considered the result of subaqueous extrusion.	1
Pillow voids / shelves	Gas *cavities*, which may be subsequently filled with minerals. A flat side to the cavity, with a convex opposing side, indicates a "way up" (i.e., convex side up).	
Pipe (amygdule)	A *pipe vesicle* filled with secondary minerals.	(1)
Pipe (vesicle)	Slender vertical *cavities* a few centimetres or tens of centimetres in length extending upward from the base of a lava flow. Most are formed by water vapour, derived from the underlying wet ground, which streamed upward into the lava.	1
Platy olivine spinifex (texture)	Olivine *spinifex texture* in which olivine has a plate or lattice habit and forms complex grains made up of many individual plates arranged roughly parallel to one another, sometimes in sets, oriented approximately perpendicular to flow or intrusive margins, in an *aphanitic* to *glassy* matrix with fine-grained quench olivine ±pyroxene ±sulphides. Cf. *random olivine spinifex*.	3

Table 40. *continued*

Modifier	Definition[A]	Source[B]
Poikilitic	Said of an igneous texture in which small grains of one mineral (e.g., plagioclase) are irregularly scattered within a typically larger, *anhedral* crystal of another mineral (e.g., pyroxene). The enclosing crystal is an *oikocryst*.	1
Polyhedral joints	Fracturing that occurs in the upper parts of some komatiitic flows, characterized by centimetre- to metre-scale polyhedrons with rounded corners, resembling tortoise shell joints in some basalt or andesite pillows and flows. Fractures terminate downward within the flow without forming polyhedra. Joint interstices are very fine grained and contain skeletal olivine crystals and *phenocrysts* in a very fine-grained or *glassy* groundmass. The features suggest early cooling cracks and interaction with water.	(3)
Porphyritic	Said of the texture of an igneous rock in which larger crystals (*phenocrysts*) are set in a finer grained groundmass, which may be crystalline or glassy or both.	1
Prismatic (crystal habit)	Said of a crystal that shows one dimension markedly longer than the other two. Cf. *acicular*; *equant*; *sheet*; *tabular*.	1
Random olivine spinifex (texture)	Olivine *spinifex texture* in which, compared to *platy olivine spinifex*, the olivine crystals are smaller, less elongate, randomly oriented plates, in an *aphanitic* to *glassy* matrix with fine-grained quench olivine ±pyroxene ±sulphides.	3
Re-entrant (pillow)	Refers to a *selvage* that appears to be a re-entrant, that is, intruding into the body of the *pillow*.	
Rounded (roundness class)	Round or curving in shape; specifically said of a *particle* with original edges and corners that have been smoothed off to rather broad curves and with original faces that are almost completely removed by abrasion (although some comparatively flat surfaces may be present). The original shape is still readily apparent. A subdivision of the *roundness class*; used here in the context of fragments in a *lava flow*. Cf. *well rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Roundness class	An arbitrarily defined range of roundness values, originally for the classification of sedimentary particles, but utilized here in a modified version for convenience in describing fragments/xenoliths in *lava*. See *well rounded*; *rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Selvage [igneous]	The chilled border of a pillow in pillow lava, usually characterized by a very fine grained or *glassy* texture.	(1)
Seriate	Said of the texture of an igneous rock, typically *porphyritic*, in which the sizes of the larger grains range continuously to the size of groundmass grains.	1
Sharkskin	A type of *pahoehoe* with surfaces that display innumerable tiny spicules or spines produced by escaping gas bubbles. Cf. *corded*; *elephant-hide*; *entrail*; *festooned*; *filamented*; *shelly*; *slab*.	1
Sheet (crystal habit)	Said of a mineral that forms flat sheets or flakes, such as phyllosilicates. Cf. *acicular*; *equant*; *prismatic*; *tabular*.	
Shelly	A type of *pahoehoe* with surfaces that contain large open tubes and blisters; its crust is 1 to 30 cm thick. Cf. *corded*; *elephant-hide*; *entrail*; *festooned*; *filamented*; *sharkskin*; *slab*.	1
Silicic	Essentially synonymous with *acidic*.	1
Slab	A type of *pahoehoe* with surfaces that consist of a jumbled arrangement of plates or slabs of flow crust, presumably so arranged as a result of the draining-away of the underlying molten lava. Cf. *corded*; *elephant-hide*; *entrail*; *festooned*; *filamented*; *sharkskin*; *shelly*.	1
Spherule	A little sphere or spherical body; e.g., a "magnetic spherule" in a deep-sea sediment, or an object that appears to be an *amygdule* or a *spherulite*.	1
Spherulite	A rounded or spherical mass of *acicular* crystals, commonly of feldspar, radiating from a central point. Spherulites may range in size from microscopic to several centimetres in diameter. Most commonly formed by the devitrification of volcanic glass.	1
Spinifex texture	Texture characterized by the presence of large skeletal platy blades of olivine or *dendritic* crystals of pyroxene found in the upper parts of komatiitic flows or less commonly at the margins of some sills and dikes of komatiitic composition. Generally considered the result of rapid quenching of magnesium-rich *magma* from unusually high temperatures. See *acicular pyroxene spinifex; platy olivine spinifex*; *random olivine spinifex*.	3
Steam hole	Opening through which water vapour and other gasses escaped through lava.	
Subangular (roundness class)	Somewhat angular, free from sharp angles but not smoothly rounded; specifically said of a sedimentary *particle* showing definite effects of slight abrasion, retaining its original general form, and having faces that are virtually untouched and edges and corners that are rounded off to some extent. A subdivision of the *roundness class*; used here in the context of fragments in a *lava flow*. Cf. *well rounded*; *rounded*; *subrounded*; *angular*; *very angular*.	(1)
Subequant	Said of a crystal having roughly the same or nearly the same diameter in all directions, but not as much as *equant* crystals.	
Subhedral	A grain (crystal) partly bounded by crystal faces; intermediate between *euhedral* and *anhedral*. [Synonym: *hypidiomorphic*].	1

Table 40. *continued*

Modifier	Definition[A]	Source[B]
Subrounded (roundness class)	Partially rounded; specifically said of a *particle* showing considerable but incomplete abrasion and an original general form that is still discernible, and having many of its edges and corners noticeably rounded off to smooth curves. A subdivision of the *roundness class*; used here in the context of fragments in a *lava flow*. Cf. *well rounded*; *rounded*; *subangular*; *angular*; *very angular*.	(1)
Subvolcanic dike	An unofficial term for a near-surface, vertical to subvertical intrusion of magma into unlithified to lithified country rock, including temporally related volcanic rocks, and typically displaying chilled margins, protrusions into the country rock or cooling joints perpendicular to contacts, as well as some features similar to overlying volcanic flows. Widths can be centimetres to many metres. May be a volcanic conduit or “feeder dike” for overlying effusive material.	
Subvolcanic sill	An unofficial term for a near-surface, horizontal to subhorizontal intrusion of magma into unlithified to lithified country rock, including temporally related volcanic rocks, and typically displaying chilled margins, protrusions into the country rock or cooling joints perpendicular to contacts, as well as some features similar to overlying volcanic flows. Widths can be centimetres to many metres. May be temporally related to volcanic dikes.	
Tabular (crystal habit)	Said of a crystal form that shows one dimension markedly smaller than the other two. Cf. *acicular*; *equant*; *prismatic*; *sheet*.	1
Trachytic	Volcanic groundmass texture in which tightly packed, strongly aligned feldspar microlites occur with interstitial *microcrystalline* or *cryptocrystalline* material.	1
Ultrabasic [geochemical]	A chemical term now defined in the TAS classification for volcanic rocks with SiO_2 <45%. See *acidic*; *intermediate*; *basic*.	2
Ultramafic (colour index)	In OGS usage, an adjective for a volcanic (or fine-grained intrusive) rock having a *colour index* >90.	
Unchilled	The border or outer zone of a lava flow that is not finer grained than the interior because there was insufficient thermal contrast with the country rock during emplacement and cooling.	
Variole	A pea-size *spherule*, usually composed of radiating crystals of plagioclase or pyroxene. This term is generally applied only to such spherical bodies in *basic* igneous rock.	1
Variolite	Obsolete term for a rock containing *varioles*.	1
Vari-textured	An unofficial term to indicate a range in crystal textures within the lava body.	
Vent	The opening at the Earth’s surface through which volcanic materials are extruded; also, the channel or conduit through which they pass.	1
Very angular (roundness class)	A term used to describe a particle with considerable angularity. A subdivision of the *roundness class*; used here in the context of fragments in a *lava flow*. Cf. *well rounded*; *rounded*; *subrounded*; *subangular*; *angular*.	(1)
Vesicle [igneous]	A relatively small *cavity* of variable shape in lava, formed by the entrapment of a gas bubble during solidification of the lava.	1
Vesicular [igneous]	Said of the texture of a volcanic rock characterized by abundant *vesicles* formed as a result of the expansion of gases during the fluid stage of the lava.	1
Vug	A small *cavity* in a vein or in rock, usually lined with crystals of a different mineral composition from the enclosing rock. Definition does not specify rock type. Cf. *druse*; *miarolitic*.	1
Weathered surface	Refers to the surface zone or rind of a rock that has undergone weathering, as evident by colour, mineralogy, hardness, porosity, etc. Typically <1 cm thick, the weathered rock may be <1 mm thick to tens of centimetres thick. Cf. *fresh surface*.	
Welded flow breccia	The lower part of the fragmented crust of *aa* and *block lava* flows, where the fragments are thoroughly welded together rather than being loose as in the upper crust of the flow.	1
Well rounded (roundness class)	Said of a *particle* with original faces, edges and corners that have been destroyed by abrasion and in which the entire surface consists of broad curves without any flat areas; specifically said of a particle with no secondary corners. The original shape may be suggested by the present form of the particle. A subdivision of the *roundness class*; used here in the context of fragments in a *lava flow*. Cf. *rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Xenocryst	A crystal that resembles a *phenocryst* in an igneous rock but is foreign to the body of rock in which it occurs. Cf. *phenocryst*.	1
Xenocrystic	Said of the texture of an igneous rock in which *xenocryst*s are set in a finer grained groundmass, which may be crystalline or *glassy* or both.	
Xenolith	A foreign *inclusion* of country rock within an intrusive or volcanic rock. Cf. *autolith*.	
Xenomorphic-granular	A *phaneritic* igneous texture dominated by *anhedral*, *equant* grains. Cf. *hypidiomorphic-granular*; *idiomorphic-granular*.	1

[A] *Preferred terms are defined: synonyms are in square brackets for reference only.*
[B] *Indicates source of definition: primary sources are indicated by a number; secondary sources are indicated by numbers in parentheses.*
1 = Neuendorf, Mehl and Jackson (2005); 2 = Le Maitre (2002); 3 = Arndt (2008); 4 = McPhie, Doyle and Allen (1993); 5 = Williams and McBirney (1979).
Where no source(s) is indicated, definitions are derived from or modified for use by the OGS.

SIZE RANGES

Table 41. Volcanic rocks—lava: size ranges for various parameters.[A]

Crystals	Aphanitic	Cryptocrystalline	<<0.1 mm
		Microcrystalline	<0.1 mm
	Phaneritic	Very fine grained	0.1 to 0.5 mm
		Fine grained	0.5 to 1 mm
		Medium grained	1 to 5 mm
		Coarse grained	5 to 30 mm
		Very coarse grained	3 to 10 cm
Lavas	Flow thickness	Very thin	<0.5 m
		Thin	0.5 to 1 m
		Medium	1 to 5 m
		Thick	5 to 10 m
		Very thick	>10 m
	Breccia particles	Fine	<2 mm
		Granular	2 to 4 mm
		Breccia	4 to 64 mm
		Coarse Breccia	>64 mm
	Pillow size	Very small	<10 cm
		Small	10 to 30 cm
		Medium	30 to 100 cm
		Large	1 to 3 m
		Very large	>3 m
	Pillow selvage	Thin	<1 cm
		Medium	1 to 3 cm
		Thick	>3 cm

[A]*Adapted from a variety of sources and modified for OGS usage.*

Volcanic Rocks—Pyroclastics

The pick list of modifiers for pyroclastic rocks (Table 42, back pocket) is structured so that major headings consist of features related to the following:

- colour (fresh and weathered surfaces);
- contact relationships (e.g., concordant, discordant);
- rock fabric (e.g., megascale, mesoscale);
- structure (e.g., bedform, bedding, internal);
- tephra (e.g., particle types);
- texture (e.g., particle characteristics);
- material source (e.g., proximal, distal).

MODIFIERS

Modifiers and ancillary terms for pyroclastic rocks are listed alphabetically. Words within definitions that are in *italics* are also defined elsewhere in the same table. A word in square [brackets] following a modifier indicates the appropriate geologic theme or topic to which the modifier refers, as the modifier can apply to more than one theme. A word in (parentheses) following a modifier refers to the general topic as laid out in the hierarchical design of the appropriate pick list.

Table 43. Volcanic rocks—pyroclastic: modifier definitions.

Modifier	Definition[A]	Source[B]
Accessory [pyroclast]	Said of *pyroclastic* materials that are formed from *fragments* of the volcanic cone or earlier *lavas*. Cf. *accidental*; *essential*.	1
Accidental	Said of *pyroclastic* materials that are formed from *fragments* of nonvolcanic rocks or from volcanic rocks not related to the erupting volcano. Cf. *accessory*; *essential*.	1
Accretionary (lapilli)	Spheroidal pellets, mostly between 1 mm and 1 cm diameter, of consolidated or cemented *ash*. Formed by accretion of *particles* around wet nuclei, e.g., raindrops falling through a cloud of ash or accretion in a wet surge cloud.	1
Acicular (crystal habit)	Said of a crystal that is needle shaped in form. Cf. *equant*; *prismatic*; *sheet*; *tabular*.	1
Acidic [geochemical]	A chemical term now defined in the TAS classification for volcanic rocks with SiO_2 >63%. See *intermediate*; *basic*; *ultrabasic*. The IUGS uses the term “acid”, but the OGS prefers the adjectival form “acidic”, which is also in keeping with the other chemical terms listed above. Not equivalent to “felsic” or “oversaturated”.	(2)
Agglutinated (volcanic)	Said of a *welded pyroclastic* deposit characterized by *vitric* material binding the *pyroclasts*, or “sintered” vitric pyroclasts. Commonly used to describe deposits of volcanic *bombs* and *spatter*, fused while hot and viscous.	1
Angular (roundness class)	Having sharp angles or borders; specifically said of a *particle* showing very little or no evidence of abrasion, with all of its edges and corners sharp. A subdivision of the *roundness class*. Cf. *well rounded*; *rounded*; *subrounded*; *subangular*; *very angular*.	(1)
Angular unconformity	An *unconformity* between 2 rock units where bedding planes are not parallel or in which the older, underlying rocks dip at a different angle (usually steeper) than the younger, overlying strata; specifically an unconformity in which younger sediments rest upon the eroded surface of tilted or folded older rocks.	1
Anhedral	Said of a crystal lacking well-developed crystal faces. Cf. *subhedral*; *euhedral*. [Synonym: allotriomorphic].	1
Armoured (lapilli)	A lapilli-size, crystal- pumice- or lithic-*fragment* nuclei, coated by fine to coarse ash.	4
Ash (volcanic)	Unconsolidated *pyroclastic particles* <2 mm diameter.	1
Basic [geochemical]	A chemical term now defined in the TAS classification for volcanic rocks with SiO_2 between 45 and 52%. See *acidic*; *intermediate*; *ultrabasic*.	2
Bedding-plane sag	Depressed and disturbed strata or laminae of tuff, or other deposit, resulting from the introduction of a volcanic *block* or *bomb*.	1

Table 43. *continued*

Modifier	Definition[A]	Source[B]
Bedform	A three-dimensional sediment shape that forms on top of a depositional surface in response to fluid flow. Classified into *dune bedforms* and *ripple bedforms*. Bedforms range from flat, almost featureless surfaces (e.g., upper plane bed) to complex forms spanning a wide range of sizes that are characterized by topographic highs and lows of varying morphology. The nature of the currents that produce bedforms range from simple unidirectional currents (e.g., directed blast) to complex, multidirectional currents.	7,1
Block [volcanic]	A *pyroclast* ejected in a solid state; having a diameter greater than 64 mm. It may be *essential*, *accessory*, or *accidental*.	1
Bomb [volcanic]	A *pyroclast* ejected while viscous and shaped while in flight and/or upon impact with the ground. It is larger than 64 mm in diameter, and may be *vesicular* to hollow inside. Actual shape or form varies greatly, and is used in descriptive classification. See *breadcrust*; *cored*; *cow-dung*; *fusiform*; *ribbon*; *rotational*; *spherical*; *spindle-shaped*.	1
Breadcrust (bomb)	A type of *bomb* characterized by a network of open cracks on its surface, due to continued expansion of the interior after solidification of the crust. Cf. *cored*; *cow-dung*; *fusiform*; *ribbon*; *rotational*; *spherical*; *spindle-shaped*.	1
Bubble wall (shard)	A *shard* with outlines demarking some of the bubble walls formed before fragmentation took place. Cf. *cuspate*; *platy*.	
Cinder	An *essential vitric vesicular pyroclastic fragment* that falls to the ground in an essentially solid condition. Cf. *scoria.*	1
Convolute lamination	Used here in the sense of similarly formed sedimentary layering, modified as follows: a descriptive term for the wavy, extremely disorganized, and markedly and intricately crumpled, twisted or folded laminae that are confined within a single, relatively thin, well-defined, undeformed layer; that die out both upward and downward; and that are overlain and underlain by parallel undisturbed layers.	(1)
Cored (lapillus)	A type of *lapillus* that has a core of nonvolcanic rock or already solidified *lava*, around which newer lava has moulded itself.	
Cored (bomb)	A type of *bomb* that has a core of nonvolcanic rock or already solidified *lava*, around which younger lava has moulded itself. Cf. *breadcrust*; *cow-dung*; *fusiform*; *ribbon*; *rotational*; *spherical*; *spindle-shaped*.	1
Cow-dung (bomb)	A type of *bomb* with a flattened shape (resembling a cow pie), which is due to its impact while still viscous. Its surface is somewhat scoriaceous. Cf. *breadcrust*; *cored*; *fusiform*; *ribbon*; *rotational*; *spherical*; *spindle-shaped*.	1
Cross-bedding	A type of *cross-stratification* consisting of inclined layers that are >1 cm thick. See *tabular cross-bedding*; *trough cross-bedding*. Cf. *cross-lamination*.	7,1
Cross-lamination	A type of *cross-stratification* consisting of inclined laminae <1 cm thick. See *tabular cross-lamination*; *trough cross-lamination*. Cf. *cross-bedding*.	7,1
Cross-stratification	A type of *internal depositional structure* that has laminae or beds oriented at an angle to the bounding surfaces of a bed. Use *cross-bedding* or *cross-lamination* depending on the thickness of individual cross-stratified layers. Classified into *2* main subdivisions: *cross-bedding* and *cross-lamination*. See also *dune cross-stratification*; *herringbone cross-stratification*; *hummocky cross-stratification*. Cf. *graded bedding*; *lamination*; *massive structure*.	7,1
Cuspate (shard)	A *shard* in which curvatures in the outline are due to relatively small parts of the walls of bubbles before fragmentation. Cf. *bubble wall*; *platy*.	
Degassing pipe	A type of *fumarole* formed by gasses escaping from a *pyroclastic* flow, particularly the upper unwelded parts, as indicated by fines-depleted (*ash*) (with corresponding "enrichment" in crystals and lithic fragments) and/or oxidized linear or curvilinear zones. The pipes may occur in single or in branching patterns and range from about 10 cm to 10 m long by 1 cm to 30 cm wide.	6
Density grading	A type of *particle* grading in which the density of particles plays a dominant role in the grading. *Pumice* is commonly involved because of its lower density relative to other particulate matter.	
Disconformity	An *unconformity* in which the bedding planes above and below the break are essentially parallel, indicating a significant interruption in the orderly sequence of sedimentary rocks, generally by a considerable interval of erosion (or sometimes of nondeposition), and usually marked by a visible and irregular or uneven erosion surface of appreciable relief; e.g., an unconformity in which the older rocks remained essentially horizontal during erosion or during simple vertical rising and sinking of the crust (without tilting or faulting).	1
Draped bedding	Bedding, formed by deposition from suspension, which blankets the underlying topography. Layer thickness may decrease over topographic highs.	
Dune (bedform)	A large-scale sedimentary *bedform* having height >5 cm above the bed surface.	7
Dune cross-stratification	Sets of cross-laminae or cross-layers >5 cm in height.	7
Equant (crystal habit)	Said of a crystal having the same or nearly the same diameter in all directions. Cf. *acicular*; *prismatic*; *sheet*; *tabular*. [Synonym: equidimensional].	1
Essential	Said of *pyroclastic* materials that are formed from magma. Cf. *accessory*; *accidental*. [Synonym: juvenile].	1
Euhedral	Said of a crystal bounded by "perfect" crystal faces; well formed. Cf. *anhedral*; *subhedral*. [Synonym: idiomorphic].	1

Table 43. *continued*

Modifier	Definition[A]	Source[B]
Eutaxitic	Said of the banded structure in certain extrusive rocks, resulting from the parallel arrangement and alteration of layers of different textures, mineral composition or color. Commonly applied to banded structures such as *fiamme* in *welded* tuff and defined by *pumice fragments* which have been compacted into parallel, disc-shaped lenses.	1
Felsic (colour index)	In OGS usage, an adjective for a volcanic (or fine-grained intrusive) rock with a *colour index* <15.	
Fiamme	Dark, *vitric* lenses in *welded* tuffs, averaging a few centimetres in length, perhaps formed by the collapse of *fragments* of *pumice.*	1
Fluid-escape structure (volcanic)	A general term for a feature produced by the escape of fluids (gas or liquid) from a volcanic unit after deposition.	(1)
Fold structure (prelithification)	Any fold that developed before lithification, as a result of a variety of processes, including slumping and syndepositional faulting.	
Fragment	A rock or mineral *particle* larger than a *grain* (i.e., a few millimetres); a piece of rock that has been detached or broken from a pre-existing mass.	(1)
Fusiform (bomb)	A type of *bomb* that tapers and slightly twists at both ends from an enlarged middle; it includes both *rotational bomb*s and *spindle-shaped bomb*s. Cf. *breadcrust*; *cored*; *cow-dung*; *ribbon*; *rotational*; *spherical*; *spindle-shaped.*	1
Fumarole	A *vent*, usually volcanic, from which gases and vapours are emitted; it is characteristic of a late stage of volcanic activity. It is sometimes described by the composition of its gases, e.g., chlorine fumarole. Fumaroles may occur along a fissure or in apparently chaotic clusters or fields. See *rootless (fumarole)*.	1
Graded bedding	A type of internal depositional structure in which each layer displays a gradual and progressive change in *particle* size. Although the grading is usually from coarse at the base of the bed to fine at the top, many variations can occur with *pyroclastic* rocks (*see* Figure 16). It may form under conditions in which the velocity of the prevailing current declined in a gradual manner, as by deposition from a single short-lived current. Cf. *lamination*; *massive structure*; *cross-stratification*.	1
Gradation	Refers to the number of gradations, from fine to coarse or coarse to fine, within a bed (choices are “single” or “multiple”).	
Grain [petrology]	A mineral or rock *particle,* smaller than a *fragment,* having a diameter of less than a few millimetres, such as a sand-size grain. [Also, a general term for volcanic *particles* of all sizes (from *ash* to *blocks* or *bombs*): this usage is discouraged].	1
Herringbone cross-stratification	A kind of *cross-stratification* that dips in different or opposite directions in alternating or superposed beds, forming a chevron or herringbone pattern.	7
Heterolithic	In OGS usage, refers to the presence of multiple (generally 3 or more) types of rock *fragment* compositon. Cf. *monolithic*.	
Hummocky cross-stratification	A type of *cross-stratification* in which lower bounding surfaces of sets are erosional and commonly slope at angles <10°, though dips can reach 15°. Laminae above these erosional set boundaries are parallel to that surface, or nearly so; the hummocks range in scale from 1 to 5 m in diameter.	7,1
Hydroclastic (volcanic)	A volcanic rock broken or fragmented during chilling under water or ice.	1
Intermediate (colour index)	In OGS usage, an adjective for a volcanic (or fine-grained intrusive) rock having a *colour index* from 15 to 35.	
Intermediate [geochemical]	A chemical term now defined in the TAS classification for volcanic rocks with SiO_2 between 52 and 63%. Cf. *acidic*; *basic*; *ultrabasic*.	2
Internal depositional structure	A syngenetic depositional structure occurring within a bed or lamina, originating from migration of a depositional bedform. Classified into *massive structure*, *graded bedding*, *cross-stratification*, and *lamination*.	7
Lamination	A type of internal depositional structure where the depositional fabric has diffuse to discrete planar structure created by layers and (or) grains that are oriented parallel to bedding planes. Cf. *graded bedding*; *massive structure*; *cross-stratification*.	7
Lapillus; Lapilli	*Pyroclastic particles* that may either be *essential, accessory*, or *accidental* in origin, of a size range from 2 to 64 mm (mean diameter). The fragments may be either solidified or still viscous when they land (though some classifications restrict the term to the former); thus there is no characteristic shape. Singular: lapillus; plural: lapilli.	(1)
Large-scale tabular cross-bedding	A type of *tabular cross-bedding* in which the cross-bedded sets are >5 cm in height.	7
Large-scale tabular cross-lamination	A type of *tabular cross-lamination* in which the cross-laminated sets are >5 cm in height.	7
Large-scale trough cross-lamination	A type of *trough cross-lamination* in which the cross-laminated sets are >5 cm in height.	7
Lava	A general term for molten extrusive magma and for the rock that has solidified from it.	1
Lava ball (accretionary)	A globular mass of *lava* that is scoriaceous inside and compact on the outside; it is formed by the coating of a *fragment* of *scoria* by fluid lava.	1

Table 43. *continued*

Modifier	Definition[A]	Source[B]
Mafic (colour index)	In OGS usage, an adjective for a volcanic (or fine-grained intrusive) rock with a *colour index* from 35 to 90.	
Magma	Naturally occurring molten or partially molten rock material, generated within the Earth and capable of intrusion and extrusion, from which igneous rocks are derived through solidification and related processes. It may or may not contain suspended solids (such as crystals and rock *fragments*) and/or gas phases.	1
Massive structure (modified sedimentary)	Said of a stratum or stratified rock that is obscurely bedded, or that is or appears to be without internal structure (such as a rock free from minor joints, fissility or *lamination*), regardless of thickness. Cf. *cross-stratification*; *graded bedding*; *lamination*.	1,(7)
Moderately sorted	Said of sorted *pyroclastic* material or pyroclastic rock that is intermediate between *poorly sorted* and *well sorted*.	1
Monolithic	In OGS usage, refers to the presence of mostly 1 type of rock *fragment*. Cf. *heterolithic*.	
Normal grading	A systematic *particle*-size gradation upward through a depositional layer in which the coarsest particles are at the base and the progressively finer ones, toward the top. Cf. *reverse grading*.	1
Particle	A general term, used without restriction as to shape, composition or internal structure, for a separable or distinct component in a rock. See *fragment*; *grain*.	1
Planar	Lying or arranged as a plane or in planes, usually implying more or less parallelism, as in bedding or cleavage. It is a two-dimensional property. Cf. *wavy*.	1
Plane bed	A flat, almost featureless surface that is produced by the interaction of a unidirectional current flowing over a mobile bed.	1
Platy (shard)	A *shard* that appears to be a relatively thin plate after fragmentation. Cf. *bubble wall*; *cuspate*.	
Poorly sorted	Said of *pyroclastic* material or pyroclastic rock that is not sorted or that shows a wide spread of sizes around the average size, or that consists of *particles* of many sizes mixed together in an unsystematic manner so that no one size class predominates. Cf. *moderately sorted*; *well sorted*.	1
Prismatic (crystal habit)	Said of a crystal that shows one dimension markedly longer than the other two. Cf. *acicular*; *equant*; *sheet*; *tabular*.	1
Pumice	Highly *vesicular* pyroclasts of volcanic glass (with or without crystals) with very low bulk density and thin vesicle walls. Typically of *felsic* composition. Cf. *scoria*.	1
Pyroclastic	Pertaining to clastic rock material formed by volcanic explosion or aerial expulsion from a volcanic *vent*; also, pertaining to rock texture of explosive origin. It is not synonymous with the adjective “volcanic”.	1
Reverse grading	A systematic *particle*-size gradation upward through a depositional layer in which the finest particles are at the base and the progressively coarser ones, toward the top. [Synonym: inverse grading.] Cf. *normal grading*.	1
Ribbon (bomb)	A type of *bomb* that is flat and elongate, some with a circular cross-section and typically fluted along the length; may have tabular *vesicle*s. Cf. *breadcrust*; *cored*; *cow-dung*; *fusiform*; *rotational*; *spherical*; *spindle-shaped*.	
Ripple (bedform)	A small-scale sedimentary *bedform* having height <5 cm above the bed surface.	7
Rootless (fumarole)	A *fumarole* emanating from within a degassing pyroclastic flow as opposed to being connected directly or indirectly to a subsurface magmatic source.	(6)
Rotational (bomb)	A type of *fusiform bomb* with a shape that is formed by spiral motion or rotation during flight; rotation produces such types as spheroidal, tear-shaped, and *spindle-shaped bombs*. Cf. *breadcrust*; *cored*; *cow-dung*; *fusiform*; *ribbon*; *spherical*; *spindle-shaped*.	1
Rounded (roundness class)	Round or curving in shape; specifically said of a *particle* with original edges and corners that have been smoothed off to rather broad curves and with original faces that are almost completely removed by abrasion (although some comparatively flat surfaces may be present). The original shape is still readily apparent. A subdivision of the *roundness class*. Cf. *well rounded*; *subrounded*; *subangular; angular*; *very angular*.	(1)
Roundness class	An arbitrarily defined range of roundness values, originally for the classification of sedimentary particles, but utilized here in a modified version for convenience in describing fragments in a pyroclastic rock. See *well rounded*; *rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Scoria	Highly *vesicular pyroclasts* of volcanic glass (with or without crystals), typically of *mafic* to *intermediate* composition. Also defined as a vesicular cindery crust on the surface of andesitic or basaltic *lava*. Cf. *pumice*. Adjective: scoriaceous.	4,(1)
Scour channel (modified sedimentary)	A large groove-like erosional feature produced in deposits by scour.	1
Shard	A *vitric fragment* formed by volcanic processes; some have a characteristically curved surface of fracture. Shards generally consist of *bubble-wall* fragments produced by disintegration of *pumice* during or after the eruption. See *bubble wall*; *cuspate*; *platy*.	1
Sheet (crystal habit)	Said of a mineral that forms flat sheets or flakes, such as phyllosilicates. Cf. *acicular*; *equant*; *prismatic*; *tabular*.	
Silicic	Essentially synonymous with *acidic*.	1

Table 43. *continued*

Modifier	Definition[A]	Source[B]
Slump structure (modified sedimentary)	A generic term for any structure produced by slumping, either subaqueous or subaerial.	1
Small-dune cross-stratification	A type of *dune cross-stratification* produced by the downstream migration of small-dune *bedform*s, where the tabular or trough geometry of the inclined layers is not known.	7
Small-scale tabular cross-bedding	A type of *tabular cross-bedding* in which the cross-bedded sets are <5 cm in height.	7
Small-scale tabular cross-lamination	A type of *tabular cross-lamination* in which the cross-laminated sets are <5 cm in height.	7
Small-scale trough cross-lamination	A type of *trough cross-lamination* in which the cross-laminated sets are <5 cm in height.	7
Sole mark (volcanic)	A general descriptive term applied to a directional structure or to a small, wavelike, mainly convex irregularity or penetration found on the underside of a bed of tuffaceous material along its contact with a finer grained layer such as *ash* or mud.	(1)
Sorting (particle)	The dynamic process by which *particle*s having some particular characteristic (such as similarity of size, as used in this manual) are naturally selected and separated from associated but dissimilar particles by the agents of transportation.	1
Spatter	An accumulation of initially very fluid *pyroclasts*, usually *agglutinated*, coating the surface around a *vent*.	1
Spherical (bomb)	Spherical-shaped *bomb*, formed from highly to moderately fluid magma with interaction from surface tension during flight. Cf. *breadcrust*; *cored*; *cow-dung*; *fusiform*; *ribbon*; *rotational*; *spindle-shaped*.	
Spindle-shaped (bomb)	A type of *fusiform bomb*, with earlike projections at its ends and longitudinal fluting with one side smoother than the other (aerodynamic effect). Cf. *breadcrust*; *cored*; *cow-dung*; *fusiform*; *ribbon*; *rotational*; *spherical*.	1
Subangular (roundness class)	Somewhat angular, free from sharp angles but not smoothly rounded; specifically said of a *particle* showing definite effects of slight abrasion, retaining its original general form, and having faces that are virtually untouched and edges and corners that are rounded off to some extent. A subdivision of the *roundness class*. Cf. *well rounded*; *rounded*; *subrounded*; *angular*; *very angular*.	(1)
Subequant	Said of a crystal having roughly the same or nearly the same diameter in all directions, but not as much as *equant* crystals.	
Subhedral	A *grain* partly bounded by crystal faces; intermediate between *euhedral* and *anhedral*. [Synonym: hypidiomorphic].	1
Subrounded (roundness class)	Partially rounded; specifically said of a *particle* showing considerable but incomplete abrasion and an original general form that is still discernible, and having many of its edges and corners noticeably rounded off to smooth curves. A subdivision of the *roundness class*. Cf. *well rounded*; *rounded*; *subangular*; *angular*; *very angular*.	(1)
Symmetrical grading	Refers to multiple grading with symmetry of style within a unit, such as normal–reverse–normal, or reverse–normal–reverse.	
Tabular (crystal habit)	Said of a crystal form that shows one dimension markedly smaller than the other two. Cf. *acicular*; *equant*; *prismatic*; *sheet*.	1
Tabular cross-bedding	A type of *cross-bedding* in which the cross-bedded units, or sets, are bounded by *planar*, essentially parallel surfaces, forming a tabular body. Classified into *small-scale tabular cross-bedding* and *large-scale tabular cross bedding*.	7
Tabular cross-lamination	A type of *cross-lamination* in which the cross-laminated units, or sets, are bounded by *planar*, essentially parallel surfaces, forming a tabular body. Classified into *small-scale tabular cross-lamination* and *large-scale tabular cross-lamination*.	7
Trough cross-bedding	A type of *cross-bedding* in which the lower bounding surfaces are curved surfaces of erosion; it results from local scour and subsequent deposition. Commonly formed by the migration of large-scale *dune bedforms*.	7
Trough cross-lamination	A type of *cross-lamination* in which the lower bounding surfaces are curved surfaces of erosion, resulting from local scour and subsequent deposition. Commonly formed by the migration of *ripple bedforms*. Classified into *small-scale trough cross-lamination* and *large-scale trough cross-lamination*.	7
Turbidite (Bouma cycle)	A sediment or rock deposited from a turbidity current. It is characterized by *graded bedding*, *moderate sorting*, and well-developed primary structures in the sequence noted in the Bouma cycle. (*See* Sedimentary Rock modifiers).	1
Ultrabasic [geochemical]	A chemical term now defined in the TAS classification for volcanic rocks with SiO_2 <45%. See *acidic*; *basic*; *intermediate*.	2
Ultramafic	In OGS usage, an adjective for a volcanic (or fine-grained intrusive) rock having a *colour index* >90.	
Unconformity	In the context of *pyroclastic* rocks, a break or gap in the geological record where a rock unit is overlain by another that is not next in depositional succession, such as an interruption in the continuity of deposition or a break between eroded igneous and/or sedimentary rocks.	1
Vent	The opening at the Earth's surface through which volcanic materials are extruded; also, the channel or conduit through which they pass.	1

Table 43. *continued*

Modifier	Definition[A]	Source[B]
Very angular (roundness class)	A term used to describe a particle with considerable angularity. A subdivision of the *roundness class*. Cf. *well rounded*; *rounded*; *subrounded*; *subangular; angular*.	
Vesicle [igneous]	A relatively small cavity of variable shape in *lava*, formed by the entrapment of a gas bubble during solidification of the lava.	1
Vesicular [igneous]	Said of the texture of a volcanic rock characterized by abundant *vesicles* formed as a result of the expansion of gases during the fluid stage of the *lava*.	1
Vitric	Said of *pyroclastic* material that is characteristically glassy, i.e., contains more than 75% glass.	1
Water-escape structure	A general term referring to any fluid-escape structure caused by water escaping upward under pressure, usually from the overlying material.	
Wavy	Bedding characterized by undulatory bounding surfaces. Cf. *planar*.	1
Welded (texture)	A texture of *pyroclastic* rocks, especially those derived from *ash* flows and nuées ardentes that is formed by the heat and pressure of still-plastic *particles* as they are deposited, and are fused together to various degrees.	1,(6)
Well rounded (roundness class)	Said of a *particle* with original faces, edges and corners that have been destroyed by abrasion and in which the entire surface consists of broad curves without any flat areas; specifically said of a particle with no secondary corners. The original shape may be suggested by the present form of the particle. A subdivision of the *roundness class*. Cf. *rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Well sorted	Said of sorted *pyroclastic* material or *pyroclastic* rock that consists of *particles* all having approximately the same size. Cf. *moderately sorted*; *poorly sorted*.	1

[A] *Preferred terms are defined: synonyms are in square brackets for reference only.*
[B] *Indicates source of definition: primary sources are indicated by a number; secondary sources are indicated by numbers in parentheses.*
1 = Neuendorf, Mehl and Jackson (2005); 2 = Le Maitre (2002); 4 = McPhie, Doyle and Allen (1993); 6 = Fisher and Schmincke (1984); 7 = Soller (2004a).
Where no source(s) is indicated, definitions are derived from or modified for use by the OGS.

SIZE RANGES

Table 44. Volcanic rocks—pyroclastic: size ranges for various parameters.[A]

Pyroclastic Rocks	Particles	Ash	<2 mm
		Fine ash	<0.0625 mm
		Coarse ash	0.0625 to 2 mm
		Lapilli	2 to 64 mm
		Blocks	>64 mm
		Bombs	>64 mm
	Crystals	Very fine grained	0.1 to 0.5 mm
		Fine grained	0.5 to 1.0 mm
		Medium grained	1 to 5 mm
		Coarse grained	5 to 30 mm
		Very coarse grained	3 to 10 cm
	Bedding	Very thinly laminted	<1 mm
		Thinly laminated	1 to 3 mm
		Thickly laminated	3 to 10 mm
		Very thinly bedded	1 to 3 cm
		Thinly bedded	3 to 10 cm
		Medium bedded	10 to 30 cm
		Thickly bedded	30 to 100 cm
		Very thickly bedded	1 to 3 m
		Extremely thickly bedded	>3 m

[A] *Adapted from a variety of sources and modified for OGS usage.*

SEDIMENTARY ROCKS

The pick list of modifiers for sedimentary rocks (Table 45, back pocket) is structured so that major headings consist of features related to:

- matrix colour (fresh and weathered surfaces);
- rock fabric (e.g., massive, foliated);
- primary structure (e.g., depositional, erosional);
- biogenic structures (e.g., stromatolite);
- secondary structure (e.g., pre-lithification, post-lithification);
- unclassified structure (e.g., bed surface, within bed);
- depositional fabric (e.g., matrix material);
- texture (e.g., particle size, sorting, shape); and
- miscellaneous (e.g., inferred provenance, unconformity).

Six classes of roundness can be used to describe sedimentary particles and are graphically represented in Figure 34. Types of bedding geometry and cross-stratification are graphically explained in Figure 35.

MODIFIERS

Modifiers and ancillary terms for sedimentary rocks are listed alphabetically. Words within definitions that are in *italics* are also defined elsewhere in the same table. A word in square [brackets] following a modifier indicates the appropriate geologic theme or topic to which the modifier refers, as the modifier can apply to more than one theme. A word in (parentheses) following a modifier refers to the general topic as laid out in the hierarchical design of the appropriate pick list.

Table 46. Sedimentary rocks: modifier definitions.

Modifier	Definition[A]	Source[B]
Alluvial	Pertaining to or composed of alluvium, or deposited by a stream or running water.	1
Alluvial fan	A low, outspread, relatively flat to gently sloping mass of loose rock material, shaped like an open fan or a segment of a cone, deposited by a stream (especially in a semiarid region) at the place where it issues from a narrow mountain valley upon a plain or broad valley, or where the gradient of a stream suddenly decreases. Cf. *delta*.	1
Amalgamated (bedding)	Merged, mixed or combined *beds*.	
Angular (roundness class)	Having sharp angles or borders; specifically said of a sedimentary *particle* showing very little or no evidence of abrasion, with all of its edges and corners sharp. *Roundness* value: between 0.05 and 0.15 (modified by OGS). A subdivision of the *roundness class*. Cf. *well rounded*; *rounded*; *subrounded*; *subangular*; *very angular*.	(1)
Angular unconformity	An *unconformity* between 2 rock units with *bedding planes* that are not parallel or in which the older, underlying rocks dip at a different angle (usually steeper) than the younger, overlying strata; specifically an unconformity in which younger sediments rest upon the eroded surface of tilted or folded older rocks. Cf. *disconformity*.	1
Argillaceous	Pertaining to, largely composed of, or containing clay-size *particles* or clay minerals; especially said of a sediment or a sedimentary rock containing an appreciable amount of clay.	1
Armoured mud ball	A large subspherical mass of silt or clay that becomes coated or studded with coarse sand and fine gravel as it rolls along downstream; it is generally 5-10 cm in diameter, although the size ranges between 1 and 50 cm.	1
Asymmetric ripple	A *ripple* having an asymmetric profile in cross-section, characterized by a short steep slope facing downcurrent (*lee* side) and a long gentle slope facing upcurrent (*stoss* side).	1

Table 46. *continued*

Modifier	Definition[A]	Source[B]
Ball and pillow	A primary sedimentary structure found in sandstone and some limestone, characterized by hemispherical or kidney-shaped masses resembling balls and pillows, and commonly attributed to foundering (due to density differences and water content).	1
Barchan	An isolated crescent-shaped sand *dune* lying transverse to the direction of the prevailing wind. [Synonym: barchan dune.]	1
Basal unconformity	An *unconformity* at the base of a thick rock sequence, generally used to refer to the lowest part of the sequence. To use properly, it requires a detailed knowledge of the overlying rock sequence and a knowledge of whether or not the base of the sequence is diachronous. This term is not recommended.	
Basal-surface mark	Any type of *syngenetic erosional structure* that occurs on the underside of a sedimentary *bed* or layer. Classified into *scour mark* and *tool mark*.	7
Beachrock	A type of *sedimentary hardground* consisting of a friable to well-cemented sedimentary rock, formed in the intertidal zone in a tropical or subtropical region, consisting of sand or gravel (detrital and/or skeletal) cemented with calcium carbonate, i.e., beach sediment cemented in situ. Cf. *submarine hardground*.	1,(7)
Bed [stratigraphy]	A layer of sediment or sedimentary rock, greater than 1 cm thick, bounded above and below by more or less well-defined *bedding surfaces*, and deposited under essentially consistent physical conditions. A bed is the smallest formal lithostratigraphic unit of sedimentary rocks. The composition and texture within a bed may be 1) uniform or heterogeneous; 2) rhythmically variable; or 3) systematically gradational.	1,7
Bedding	A *syngenetic depositional structure* consisting of layering that results from the successive stacking of sedimentation units (i.e., beds), each of which generally formed under uniform depositional conditions. Bedding may be conspicuous or inconspicuous. Cf. *bed*.	(7)
Bedding plane	A *planar* or nearly planar *bedding surface* that visibly separates each successive layer (*bed*) of stratified rock (of the same or different rock type) from the preceding or following layer (bed); a plane of deposition. It often marks a change in the circumstances of deposition, and may show a parting, a colour difference, or both. *See* Figure 35.	1
Bedding surface	A surface, usually conspicuous, within a mass of stratified rocks, representing an original surface of deposition; the surface of separation or interface between 2 adjacent *beds* of sedimentary rock. If the surface is more or less regular or nearly planar, it is called a *bedding plane*.	1
Bed-surface structure	A *syngenetic depositional structure* occurring on the upper surface of a *bed* or *lamina*, originating from fluid flow (streamflow, current flow, wind).	7
Bedform	A three-dimensional sediment shape that forms on top of a depositional surface in response to fluid flow. Classified into *dune bedforms* and *ripple bedforms*.	7
Bedset	A relatively conformable succession of genetically related *bed*s bounded by surfaces (called bedset surfaces) of erosion, nondeposition, or their correlative conformities.	1
Bioturbation	The reworking of a sediment by organisms.	1
Blade [sedimentology]	A bladed or triaxial shape of a sedimentary *particle* having width/length and thickness/width ratios less than 2/3.	1
Bladed (crystal habit)	Said of a mineral in the form of aggregates of flattened *blade*s or elongate crystals.	1
Blocky (parting)	A tendency to break into pieces, typically tabular, that are 10 to 100 cm thick. Cf. *papery; fissile; platy*; *flaggy*; *slabby*; *massive*.	7
Bottomset bed	One of the horizontal or gently inclined layers of sediment deposited in front of the advancing *foreset bed*s of a *delta* or *bedform*.	1
Bouma cycle	A fixed, characteristic succession, of a combination of up to 5 intervals, that makes up a complete sequence of a *turbidite*. One or more of the intervals may be missing. The intervals, from the top, with recognized letter designations are E - pelitic (for “pelite”, “pelitic”, *see* section on Mudrock); D - upper parallel laminations; C - current ripple laminations; B - lower parallel laminations; A - graded.	1
Bounce mark	A shallow *tool mark* oriented parallel to the current and produced by an object that struck or grazed against the bottom, rebounded, and was carried upward. The longitudinal profile is symmetrical. The mark is widest and deepest in the middle and fades out gradually in both directions. Cf. *chevron marks*; *grooves*; *prod marks*; *skip marks*.	1
Bounding surface	An erosional truncation surface that separates groups of *cross-bed*s on various scales.	1

Table 46. *continued*

Modifier	Definition[A]	Source[B]
Breccia	A coarse-grained clastic rock composed of *angular* broken rock fragments held together by mineral cement or in a fine-grained *matrix*; it differs from *conglomerate* in that the fragments have sharp edges and unworn corners. Breccia may originate as a result of sedimentary processes such as talus accumulation (sedimentary breccia); igneous processes, especially explosive (igneous breccia, volcanic breccia); disturbance during sedimentation (intraclastic breccia); collapse of rock material (*solution breccia*, *collapse breccia*); or tectonic processes (fault breccia). This definition is exclusive of impact breccias (*see* section on Impactites).	1
Calcrete	A general term for a type of calcareous *duricrust* consisting of calcium carbonate layers, crusts and nodules that form hard discontinuous to continuous masses in sedimentary materials. The calcium carbonate is precipitated from solution and re-deposited through the agency of infiltrating waters, or deposited by the escape of carbon dioxide from *vadose water*. Cf. *ferricrete*; *silcrete*.	7,(1)
Cast [sedimentology]	A sedimentary structure representing the infilling of an original mark or depression made on top of a soft *bed* and preserved as a solid form on the underside of the overlying and more durable stratum. See *channel cast*; *gutter cast*; *load cast*.	1
Catenary bedform	A *bedform* having a crestline shaped like a chain of catenary waves, such that the more pointed segments of the crestline face downcurrent.	7
Cavity filling structure	A type of *epigenetic-growth structure* consisting of mineral aggregates that fill or partly fill open spaces in sedimentary materials. The open spaces may be primary pores or may be *fenestrae* created by secondary processes. See: *geopetal structure*; *vugs*. Cf. *replacement-displacive structure*.	7
Channel [sedimentary structures]	A linear current mark larger than a *groove*, produced on a sedimentary surface, parallel to the current, and often preserved as a *channel cast*. Typically 0.5 to 2 m wide, 20 to 50 cm deep and up to 30 m long. Best developed in a *turbidite* sequence.	1
Channel cast	The cast of a *channel* that is generally cut in mudstone and filled with sand.	1
Chevron mark	A *tool mark* consisting of chevron-like depressions arranged in a row, the points of the chevrons generally but not always pointing downstream. Cf. *bounce marks*; *grooves*; *prod marks*; *skip marks*.	1
Clast (sedimentary)	An individual *particle* of a sediment or rock, >2 mm diameter, produced by the mechanical or chemical disintegration of a larger rock mass. Cf. *grain*.	(7)
Clast-supported fabric	A depositional fabric in which sand- and gravel-size particles touch at point contacts and form a supporting framework, with any fine matrix merely occupying interstices between the coarser grains.	7
Climbing ripple cross-lamination	A type of *ripple cross-lamination* with series of cross laminae produced by superimposed migrating ripples, in which the crests of vertically succeeding laminae appear to be advancing upslope.	(1),(7)
Collapse breccia	A type of *dissolution structure* consisting of a breccia formed by the collapse of rock overlying an opening, as by foundering of the roof of a cave. Cf. *solution breccia*; *stylolite*.	1,(7)
Columnar structure [sedimentology]	A *primary sedimentary structure* found in some calcareous shales or argillaceous limestones, consisting of columns (9-14 cm in diameter, and 1-1.4 m in length) perpendicular to *bedding* and oval to polygonal in section. See *pillar structure*.	1
Concretion	A type of *replacement-displacive epigenetic-growth structure* in which a hard, compact mass or aggregate of mineral matter, normally subspherical but commonly oblate, disk-shaped, or irregular with odd or fantastic outlines; formed by precipitation from aqueous solution about a nucleus or centre in the pores of a sedimentary or fragmental volcanic rock, and usually of a composition widely different from that of the rock in which it is found and from which it is rather sharply separated. It represents a concentration of some minor constituent of the enclosing rock or of cementing material, such as silica (chert), calcite, dolomite, iron oxide, pyrite or gypsum, and it ranges in size from a small pellet-like object to a great spheroidal body as much as 3 m in diameter. Most concretions were formed during *diagenesis*, and mainly (especially in limestone and shale) shortly after sediment deposition. Cf. *cone-in-cone structure*; *duricrust*; *nodule*.	1,(7)
Cone-in-cone structure [sedimentology]	A type of *replacement-displacive epigenetic-growth structure*: a minor sedimentary structure in thin, generally calcareous layers of some shales and in the outer parts of some large concretions, especially septaria; it resembles a set of concentric, right circular cones fitting one into another in inverted positions (base upward, apex downward), commonly separated by clay films, and consisting usually of fibrous calcite and rarely of siderite or gypsum. The apical angles are between 30 and 60 degrees and the cone axes are normal to the *bedding*; the height of the cones usually ranges from 10 mm to 10 cm, and their sides are often ribbed, fluted, or grooved, and marked by annular depressions and ridges that are more pronounced near the bases and finer and more obscure near the apices. The structure appears to be due to pressure aided by crystallization and weathering (solution) along intersecting conical shear zones. Cf. *concretion*; *duricrust*; *nodule*.	1,(7)
Convolute lamination	A descriptive term for the wavy, extremely disorganized, and markedly and intricately crumpled, twisted, or folded *laminae* that are confined within a single, relatively thin, well-defined, undeformed layer, that die out both upward and downward, and that are overlain and underlain by parallel undisturbed layers. The structure appears to result from deformation during deposition of sediments that become partially liquefied but still retain some cohesion. Convolutions may be truncated by erosion surfaces that are themselves convoluted, demonstrating the *penecontemporaneous* nature of the deformation. Axes of the convolutions generally have a preferred orientation normal to the paleocurrent.	1

Table 46. *continued*

Modifier	Definition[A]	Source[B]
Convolute stratification	A type of *secondary deformation structure* consisting of a structure showing marked crumpling or complicated folding of the *laminae* of a rather well-defined sedimentation unit.	7
Coset [stratigraphy]	A sedimentary unit composed of 2 or more *set*s, either of strata or of cross-strata, separated from other strata or cross-strata by original flat surfaces of erosion, non-deposition, or abrupt change in character. Cf. *set*.	1
Couplet	Genetically related paired sedimentary *laminae*, generally occurring in repeating series. Applies to *varve*s as well as laminated nonglacial mudstones, evaporates, and other sediments as well. Cf. *rhythmite*; *varve*.	1
Cross-bed	A single *bed*, greater than 1 cm thick, inclined at an angle to the main planes of stratification.	1
Cross-bedding	A type of *cross-stratification* consisting of inclined layers (*cross-beds*) >1 cm thick.	(1),(7)
Cross-lamina	A single layer, less than 1 cm thick, inclined at an angle to the main planes of stratification.	1
Cross-lamination	A type of *cross-stratification* consisting of inclined layers (laminae) <1 cm thick.	(1)
Cross-stratification	A type of *internal depositional structure* that has layers (*beds* or *laminae*) oriented at an angle to the *bounding surfaces* of a bed. There are 2 main subdivisions: *cross-bedding* and *cross-lamination*. See also *dune cross-stratification*; *herringbone cross-stratification*; *hummocky cross-stratification*. Cf. *massive structure; graded bedding; lamination*. See Figure 35.	1,7
Crystal cast	The filling of a crystal mould. See *ice-crystal cast*, *salt-crystal cast*.	1
Current mark	Any structure formed by the action of a current of water, either directly or indirectly, on a sedimentary surface. See *scour mark*s and *tool mark*s.	1
Cuspate (bedform)	One of a series of *linguoid bedform*s arranged in phase, in rows parallel to flow.	7
Deformed cross-stratification	A type of *within-bed penecontemporaneous* structure consisting of oversteepened or overturned *foreset bed*s that occur within single sets. The deformation ranges from *foreset bed*s that dip more steeply than the angle of rest in the upper parts of sets (oversteepened) to extensive overturning of foresets into recumbent folds. The overfolding is always in the direction of the original foreset dip. Oversteepening and overturning develop in response to a shear force acting on the upper surface of a *bedform*.	7
Delta	The low, nearly flat, *alluvial* tract of land at or near the mouth of a river, commonly forming a triangular or fan-shaped plain of considerable area, crossed by many distributaries of the main river, perhaps extending beyond the general trend of the coast, and resulting from the accumulation of sediment supplied by the river in such quantities that it is not removed by tides, waves and currents. Most deltas are partly subaerial and partly below water. Cf. *alluvial fan*.	1
Desiccation crack	A *penecontemporaneous, shrinkage crack* consisting of an irregular fracture in a crudely polygonal pattern, formed by the shrinkage of clay, silt or mud, generally in the course of drying under the influence of atmospheric conditions. Cf. *syneresis crack*.	1,7
Diagenesis	All the chemical, physical and biological changes undergone by sediment after its initial deposition, and during and after its lithification, exclusive of surficial alteration (weathering) and metamorphism. The term embraces compaction, cementation, reworking, replacement and recrystallization (authigenesis), leaching, hydration, bacterial action, and formation of concretions that occur under conditions of low pressure (up to 1 kb) and low temperature (variably considered to be up to 100 to 300°C). Some geologists consider the term to apply only to processes occurring before lithification ("early diagenesis"). There is no universally accepted definition.	1
Disconformity	An *unconformity* in which the *bedding planes* above and below the break are essentially parallel, indicating a significant interruption in the orderly sequence of sedimentary rocks, generally by a considerable interval of erosion (or sometimes of non-deposition), and usually marked by a visible and irregular or uneven erosion surface of appreciable relief; e.g. an unconformity in which the older rocks remained essentially horizontal during erosion or during simple vertical rising and sinking of the crust (without tilting or faulting). Cf. *unconformity*.	1
Dish structure	A type of *fluid-escape structure* that is a *primary sedimentary structure*, generally found in sandstone, consisting of small meniscus-shaped lenses (4-50 cm long and one to a few centimetres thick) that are oval in plan, oriented parallel to the *bedding*, and defined by slightly finer grained, concave-up bottoms each of which truncates the underlying lenses. It is thought to form as a result of *elutriation* of clay by pore water escaping soon after deposition of the sand. Cf. *mud volcano*; *pillar structure*; *sand volcano*; *sheet structure*.	1,(7)
Dissolution	The process of dissolving into a homogeneous solution, as when an acidic solution dissolves limestone. In *karst*, refers to the process of dissolving rock to produce landforms, in contrast to solution, the chemical product of dissolution. [Synonym: solution]	1
Dissolution structure	A type of *secondary sedimentary structure* formed where soluble material has been partly or wholly removed by *dissolution*, thereby creating a void space into which adjacent and superjacent (overlying) sedimentary material can collapse or subside by plastic failure. Includes *collapse breccias*, *solution breccias* and *stylolites*.	7
Downlap	A base-discordant relation in which initially inclined strata terminate downdip against an initially horizontal or inclined surface.	1

Table 46. *continued*

Modifier	Definition[A]	Source[B]
Dropstone	An oversized stone in laminated or bedded sediment that depresses the underlying *lamina*e or *beds* and may be covered by "draped" laminae. Most dropstones originate through ice-rafting.	1
Dune cross-stratification	Sets of *cross-laminae* or *cross-bed*s greater than ~5 cm in height.	7
Dune (bedform)	A large-scale sedimentary *bedform* having height >5 cm above the *bed* surface.	7
Duricrust	A type of *replacement-displacive epigenetic-growth structure*: a general term for a zone of chemical precipitation and hardening formed at or near the surface of sedimentary bodies through *pedogenic* and/or nonpedogenic processes. It is formed by the accumulation of soluble minerals deposited by mineral-bearing waters that move upward, downward or laterally by capillary action, commonly assisted in arid settings by evaporation. Classified into *calcrete*, *ferricrete*, *silcrete*. Cf. *concretion*; *cone-in-cone structure*; *nodule*.	7
Elutriation (sedimentary)	A process in which the finer and/or lightweight particles are separated from the coarser and/or heavy *particles* by means of a slowly rising current of water carrying the lighter particles upward and allowing the heavier ones to sink.	(1)
Eolian	Pertaining to the wind, especially said of such deposits as *loess* and *dune* sand, of sedimentary structures such as wind-formed *ripple* marks, or of erosion and deposition accomplished by the wind.	1
Epigenesis	As used here, the changes, transformations or processes, occurring at low temperatures and pressures that affect sedimentary rocks subsequent to their compaction, exclusive of surficial alteration (weathering) and metamorphism. Some geologists consider this to be "late diagenesis". Cf. *diagenesis*. Adjective: *epigenetic*.	1
Epigenetic [sedimentary]	Said of a sedimentary mineral, texture or structure formed after the deposition of the sediment.	1
Epigenetic growth structure	A type of *secondary sedimentary structure* formed during *epigenesis* by growth of minerals. They range in size from centimetres (*nodules* and *concretions*) to basin-wide dimensions (e.g., *duricrust*s). Classified into *cavity filling structure*s and *replacement-displacive structure*s.	7
Equant (sedimentary)	Said of a sedimentary *particle* with length that is less than 1.5 times its width.	1
Erosional	Pertaining to or produced by the wearing away of the land.	1
Fenestra [sedimentology]	A type of *within-bed penecontemporaneous structure* term for a shrinkage pore, or primary or *penecontemporaneous* gap in rock framework larger than the grain-supported interstices. It may be an open space in the rock, or be completely or partly filled with secondarily introduced sediment or cement. Plural: fenestrae. Adjective: fenestral.	1,(7)
Ferricrete	A general term for a *ferruginous duricrust* consisting of secondary *ferruginous* layers, crusts and *nodules* that form hard discontinuous to continuous masses in *terrigenous-clastic* sedimentary materials. Cf. *calcrete*; *silcrete*.	7,(1)
Ferruginous	A semi-quantitative compositional term for sedimentary material containing enough iron minerals (but <50%) to influence the geologist's description. Where appropriate, ferruginous sedimentary material can be described as goethitic, hematitic or pyritic.	7
Fissile lamination	A type of *lamination* consisting of diffuse to distinct planar fabric developed in mudstones and mud due to the alignment of clay minerals.	7
Fissile (parting)	A tendency to break into pieces, typically tabular, that are 1 to 3 mm thick. Cf. *papery*; *platy*; *flaggy*; *slabby*; *blocky; massive*.	7
Flaggy (parting)	A tendency to break into pieces, typically tabular, that are 1 to 3 cm thick; suitable for use as flagstone. Cf. *papery*; *fissile*; *platy*; *slabby*; *blocky*; *massive*.	7
Flame structure (sedimentary)	A sedimentary structure consisting of wave- or flame-shaped plumes of mud that have been squeezed irregularly upward into an overlying layer. It is probably formed by *load casting* accompanied by horizontal slip or drag.	1
Flaser cross-lamination	A type of *form-set cross-lamination* with *ripple bedding* in which mud streaks are preserved completely in the troughs and partly on the crests. Sand-size material dominates over mud-size material. Cf. *lenticular cross-lamination.*	7
Flat lamination	A type of *lamination* consisting of diffuse to conspicuous parallel lamination (plane-bed lamination) produced by current *traction* of silt- to gravel-size grains.	7
Fluid-escape structure	A type of secondary deformation structure that is a general category of sedimentary feature produced by the escape of fluids from a *bed* of sediment after deposition. See *dish structure*; *mud volcano*; *pillar structure*; *sand volcano*; *sheet structure*.	1,(7)
Flute [sedimentology]	A primary sedimentary structure, commonly seen as a *flute cast*, typically 2 to 10 cm long, usually formed by the scouring action of a turbulent, sediment-laden current of water flowing over a muddy bottom.	1
Flute cast	A spatulate or lingulate *sole mark* consisting of a raised, oblong and subconical bulge on the underside of a siltstone or sandstone *bed*, characterized by a steep or blunt bulbous or beaked upcurrent end from which the structure flattens or flares out in the downcurrent direction and merges with the bedding plane. It is formed by the filling of a flute. Cf. *groove cast*; *load cast*.	1

Table 46. *continued*

Modifier	Definition[A]	Source[B]
Flute mark	A type of *scour mark* consisting of an elongate depression scoured in cohesive sediment by random eddy scour or by current eddies produced behind an obstacle. The marks range in length from a few centimetres to as much as 50 cm. They are elongate parallel to current flow, have a bulbous depression at the upstream end, and shallow and flare out downcurrent. Usually expressed as *flute casts* on the base of overlying sand *beds*. Cf. *gutter cast*; *longitudinal ridges and furrows*; *obstacle scour*; *transverse scour*.	7
Foreset bed	One of the inclined, internal and systematically arranged layers of a cross-bedded unit; specifically one of the gently inclined layers of sandy material deposited upon or along an advancing and relatively steep frontal slope, such as the outer margin of a *delta* or the *lee* side of a *dune*, and progressively covering the *bottomset bed* and in turn being covered or truncated by the *topset bed*. Foreset beds represent the greater part of the deposits of a *delta*. [Synonym: foreset.]	1
Form-set cross-lamination	A type of *ripple cross-lamination* having a set of *cross-stratification* with an upper surface that preserves the shape of the original *bedform*.	7,1
Geopetal structure	A type of *cavity-filling epigenetic-growth structure*, a common structure in some limestones, where a cavity contains sediment in the lower part and cement (usually calcite) in the upper part. These structures are like spirit levels and can be used to deduce the way-up of the rocks and the horizontal at the time of deposition.	1,(7)
Graded bedding	A type of *internal depositional structure* in which each layer displays a gradual and progressive change in *particle* size, usually from coarse at the base of the *bed* to fine at the top. It may form under conditions in which the velocity of the prevailing current declined in a gradual manner, as by deposition from a single short-lived current. Classified into *normal graded bedding* and *reverse graded bedding*. Cf. *massive structure*; *cross-stratification*; *lamination*.	1
Grain [petrology]	An individual *particle* in a sedimentary rock, <2 mm diameter, produced by the mechanical or chemical disintegration of a larger rock mass; generally lacks well-developed crystal faces; especially a small, hard, more or less rounded mineral particle, such as a sand grain. Cf. *clast*.	(1),(7)
Grain overgrowths	Secondary material deposited in optical and crystallographic continuity around a crystal grain of the same composition, as in the *diagenetic* process of secondary enlargement. See *diagenesis*.	1
Groove [sedimentology]	A *tool mark* that is a long, straight narrow depression, with an almost uniform depth and cross-section, on a sedimentary surface (as of mud or mudstone). It is thought to have been produced by a simultaneous rectilinear advance of objects propelled by a continuous current. Filled grooves are often preserved as a *groove cast* in the overlying *bed*. Cf. *bounce marks*; *chevron marks*; *prod marks*; *skip marks*.	1
Groove cast	A rounded or sharp-crested rectilinear ridge, a few millimetres high and many centimetres long and wide, produced on the underside of a sandstone *bed* by the filling of a *groove* on the surface of an underlying mudstone. Cf. *flute cast*; *load cast*.	1
Groundmass [sedimentology]	A term sometimes used for the *matrix* of a sedimentary rock.	1
Gutter cast	A type of *scour mark* represented by a downward bulge on the bottom of a sedimentary *bed*, of great length (usually one metre or more) compared with its width and depth (a few centimetres to several decimetres). In cross-section it has the form of a small channel. Cf. *flute mark*; *longitudinal ridges and furrows*; *obstacle scour*; *transverse scour*.	1
Hail imprint	A small, shallow depression or crater-like pit formed by a hailstone falling on a soft sedimentary surface. It is generally larger, deeper and more irregular in shape than a *rain print*.	1
Herringbone cross-stratification	*Cross-stratification* that dips in different or opposite directions in alternating or superimposed *beds*, forming a herringbone or *chevron* pattern. [Synonym: chevron cross-bedding.]	(1)
Hummocky cross-stratification	A type of gently undulating *cross-stratification* in which lower *bounding surface*s of *sets* are erosional and commonly slope at angles from <10 up to 15°; *laminae* above these erosional set boundaries are parallel, or nearly so, to that surface, with convex upper parts forming a "hummock" and concave downward parts forming the "swale"; the hummocks have a domal shape in plan view and range from 1 to 5 m diameter. Laminae can systematically thicken laterally in a set so that their traces on a vertical surface are fan-like and dip diminishes regularly; and the dip directions of erosional set boundaries and of the overlying laminae are scattered.	1
Ice-crystal cast	A *crystal cast* formed by the filling of an ice-crystal mark with mud or sand; it commonly appears as a straight, slightly raised ridge on the underside of a sandstone *bed*.	1
Ice wedge	Wedge-shaped, foliated ground ice produced in permafrost, occurring as a vertical or inclined sheet, dike or vein tapering downward, and measuring from a few millimetres to as much as 6 m wide and from 1 m to as much as 30 m high. It originates by the growth of hoarfrost or by the freezing of water in a narrow crack or fissure produced by thermal contraction of the permafrost.	1
Ice-wedge cast	A *sedimentary structure* formed by the filling of the space formerly occupied by an *ice wedge* that had melted; the sediment fill may be wedge-shaped or very irregular.	1
Ice-wedge polygon	A large polygon characterized by borders of intersecting ice wedges, found only in permafrost regions and formed by contraction of frozen ground. The fissured borders delineating the polygon may be ridges (low-centred polygon in which sediments are being upturned) or shallow troughs (high-centred polygon in which erosion and thawing are prevalent), and are underlain by *ice wedge*s. Diameter: up to 150 m, averaging 10 to 40 m. In plan, the polygons tend to be three- to six-sided.	1

Table 46. *continued*

Modifier	Definition[A]	Source[B]
Imbricated	Overlapping, as with tiles on a roof or scales on a bud.	1
Internal depositional structure	A *syngenetic depositional structure* occurring within a *bed* or *lamina*, originating from migration of a sedimentary *bedform*. Classified into *massive structure*; *graded bedding*; *cross-stratification*; *lamination*.	7
Intraformational fold	A minor fold confined to a sedimentary layer lying between undeformed *beds*; it results from processes, such as sliding or slumping that took place prior to complete lithification.	1
Karst	A type of topography that is formed on limestone, gypsum and other rocks by *dissolution*, and that is characterized by sinkholes, caves and underground drainage.	1
Lag deposit	(a) A residual accumulation of coarse, usually hard rock fragments remaining on a surface after the finer material has been blown away by winds; (b) Coarse-grained material that is rolled or dragged along the bottom of a stream or sea floor at a slower rate than the finer material, or that is left behind after currents have winnowed or washed away the finer material.	1
Lamina	The thinnest recognizable unit layer of original deposition in a sediment or sedimentary rock, differing from other layers in colour, composition or particle size; specifically such a sedimentary layer less than 1 cm thick (commonly 0.05 to 1.00 mm thick). It may be parallel or oblique to the general stratification. Several laminae may constitute a *bed*. Plural: laminae.	1
Lamination	A type of *internal depositional structure* where the depositional fabric has diffuse to discrete planar structure created by layers and (or) grains that are oriented parallel to *bedding planes*. Cf. *massive structure*; *graded bedding*; *cross-stratification*.	7
Large-scale cross-bedding	Individual cross-bedded *set*s (units) are >5 cm high and may be *planar* or trough-shaped. Cf. *small-scale cross-bedding*.	(7)
Large-scale cross-lamination	Individual cross-laminated *set*s (units) are >5 cm high and may be *planar* or trough-shaped. Cf. *small-scale cross-lamination*.	(7)
Large-scale tabular cross-bedding	A type of *tabular cross-bedding* in which the cross-bedded sets are >5 cm in height. Cf. *small-scale tabular cross-bedding*.	7
Large-scale tabular cross-lamination	A type of *tabular cross-lamination* in which the cross-laminated sets are >5 cm in height. Cf. *small-scale tabular cross-lamination*.	7
Large-scale trough cross-lamination	A type of *trough cross-lamination* in which the cross-laminated sets are >5 cm in height. Cf. *small-scale trough cross-lamination*.	7
Lee	The term used for the relatively steep, downstream side of an asymmetrical *bedform* such as a *ripple* or *dune.* [Antonym: *stoss* (upstream side).]	1
Lenticular cross-lamination	A type of *form-set cross-lamination* where *ripple* forms are surrounded by layers of mud-sized sediment. The resulting association of mud- and sand-sized material yields a lenticular interlayering of ripple form sets and mud layers. Cf. *flaser cross-lamination*.	7
Linguoid (bedform)	A *bedform* having a tongue-shaped outline, with the bulbous end of the form oriented downcurrent; rows arranged parallel to flow are out-of-phase. Considered a result of aqueous flow, best developed on bottoms of shallow streams, with a highly irregular pattern and wide variety of forms. The form has an opposite orientation to that of a *lunate* bedform.	1,7
Load cast	A type of *sole mark,* usually measuring less than 1 m in any direction, consisting of a swelling in the shape of a slight bulge, a deep or shallow rounded sack, a highly irregular protuberance, or a bulbous, *mammillary*, or papilliform protrusion of sand or other coarse clastics, extending downward into finer grained, softer and originally hydroplastic underlying material, such as wet clay, mud or peat, that contained an initial depression. It is produced by the exaggeration of the depression as a result of unequal settling and compaction of the overlying material and by the partial sinking of such material into the depression, as during the onset of deposition of a *turbidite* on unconsolidated mud. A load cast is more irregular than a *flute cast* (it is usually not systematically elongated in the current direction), and is characterized by an absence of a distinction between the upcurrent and downcurrent ends. Cf. *flute cast*; *groove cast*.	1
Loess	A widespread, homogeneous, commonly nonstratified, porous, friable, slightly coherent, usually highly calcareous, fine-grained blanket deposit (generally <30 m thick), consisting predominantly of silt with subordinate *grain* sizes ranging from clay to fine sand.	1
Longitudinal ridges and furrows	A type of *scour mark*, these features consist of many closely spaced continuous ridges, elongated parallel to the current and developed rhythmically on all or part of a stream *bed*, separated by regularly spaced longitudinal furrows: the separation ranges from 3 mm to as much as 5 cm. Cf. *flute mark*; *gutter cast*; *obstacle scour*; *transverse scour*.	1
Lunate (bedform)	A *bedform* in which the crest lines are strongly curved and open out downcurrent: the form is similar to that of a *barchan* and has the opposite orientation to that of a *linguoid* bedform. Cf. *cuspate*.	1,7
Mammillary	Forming smoothly rounded masses resembling breasts or portions of spheres.	(1)
Massive (parting)	A tendency to break into pieces, typically tabular, that are >100 cm thick. Cf. *papery*; *fissile*; *platy*; *flaggy*; *slabby*; *blocky*.	7

Table 46. *continued*

Modifier	Definition[A]	Source[B]
Massive structure	A type of *internal depositional structure* in which the fabric is structureless, regardless of thickness—i.e., the fabric lacks any form of geometry or *particle* organization, such as *lamination*, *cross-lamination*, and size grading, as viewed by the unaided eye. The massive appearance may be deceptive, as many “massive” *beds* display *laminae* and other structures when X-rayed. Cf. *graded bedding*; *lamination*; *cross-stratification*.	7,1
Matrix	The finer grained material enclosing, or filling the interstices between, the larger *grain*s or *particle*s of a sediment or sedimentary rock; the natural material in which a sedimentary particle is embedded. The term refers to the relative size and disposition of the particles, and no particular particle size is implied. In carbonate sedimentary rocks, the matrix usually consists of clay minerals or *micritic* components surrounding coarser material; the term should be used in a descriptive, nongenetic and noncompositional manner. Cf. *groundmass*.	1
Matrix-supported fabric	A depositional fabric in which finer grained clastic *particles* support the sediment mass while coarser grained particles “float” in the *matrix* with minimal point contacts between them. The result is a distinctive bimodal or multi-modal *grain*-size distribution.	7
Micrite	A descriptive term for the semi-opaque crystalline matrix of limestone, consisting of carbonate mud with crystals less than 4 microns in diameter. Adjective: micritic.	1
Moderately sorted	Said of a sorted sediment or sedimentary rock that is intermediate between *poorly sorted* and *well sorted*.	1
Mud ball	A spherical mass of mud or mudstone in a sedimentary rock, developed by weathering and break-up of clay deposits. It may measure as much as 20 cm in diameter.	1
Mudcrack	See *shrinkage crack*. Also spelled “mud crack”.	1,(7)
Mud volcano	A type of *fluid-escape structure* consisting of an accumulation, usually conical, of mud and rock ejected by volcanic gases; also, a similar accumulation formed by escaping *petroliferous* gases. The term has also been used for a mud cone not of eruptive origin. Cf. *dish structure*; *pillar structure*; *sand volcano*; *sheet structure*.	1,(7)
Multi-bed penecontemporaneous structure	A type of *penecontemporaneous sedimentary structure* that affects more than one *bed* in a superpositional sequence of beds. Classified into *slump block*; *slump fold*; *slump scar*; *synsedimentary fault*.	7
Nodule [sedimentology]	A type of *replacement-displacive epigenetic growth structure* consisting of a small, irregularly rounded knot, mass, or lump of a mineral or mineral aggregate, normally having a warty or knobby surface and no internal structure, and usually exhibiting a contrasting composition from the enclosing sediment or rock *matrix* in which it is embedded; e.g., a nodule of pyrite in a coal *bed*, a chert nodule in limestone, or a phosphatic nodule in marine strata. Most nodules appear to be *secondary sedimentary structure*s: in sedimentary rocks they are primarily the result of postdepositional replacement of the host rock and are commonly elongated parallel to the *bedding*. Cf. *concretion*; *cone-in-cone structure*; *duricrust*.	1,(7)
Normal graded bedding	A type of *graded bedding* in which *grain* size decreases systematically toward the top of the *bed*.	7
Oblate (geometry)	In terms of *particle* shape, refers to a disk-like shape (ellipsoid flattened at the poles). Cf. *prolate*.	
Obstacle scour	A type of *scour mark* produced by the interaction of an obstacle on the *bed* and a current flowing around it. The mark typically consists of crescent- or horseshoe-shaped ridges around an object as a cast on the base of a bed, but may also form on the top of a bed. Cf. *flute mark*; *gutter cast*; *longitudinal ridges and furrows*; *transverse scour*.	1
Offlap	The progressive offshore regression of the updip terminations of the sedimentary units within a conformable sequence of rocks in which each successively younger unit leaves exposed a portion of the older unit on which it lies. Also, the successive contraction in the lateral extent of strata (as seen in an upward sequence) due to their being deposited in a shrinking sea (regression) or on the margin of a rising landmass. Cf. *onlap*.	1
Oligomictic [sedimentology]	Said of a clastic sedimentary rock composed of a single rock type, such as a quartz arenitic conglomerate; also, said of the clasts of such a rock. Cf. *polymictic*.	1
Olistostrome	A type of *within-bed penecontemporaneous structure* consisting of a chaotic mass of intimately mixed heterogeneous materials (such as blocks and mud) that accumulated by submarine gravity sliding or slumping of unconsolidated sediments (a debris-flow deposit). It is a mappable, lens-like stratigraphic unit lacking true *bedding* but intercalated among normally bedded sequences.	1,(7)
Onlap	An overlap characterized by the regular and progressive pinching out, toward the margins or shores of a depositional basin, of the sedimentary units within a conformable sequence of rocks in which the boundary of each unit is transgressed by the next overlying unit and each unit in turn terminates farther from the point of reference. Also, the successive extension in the lateral extent of strata (as seen in an upward sequence) due to their being deposited in an advancing sea (transgression) or on the margin of a subsiding landmass. Cf. *offlap*.	1

Table 46. *continued*

Modifier	Definition[A]	Source[B]
Oolith	A small, round or ovate accretionary body in a sedimentary rock, resembling the roe of fish, and having a diameter of 0.25 to 2 mm (commonly 0.5 to 1 mm). It is usually formed of calcium carbonate, but may be of dolomite, silica or other minerals, in successive concentric layers, commonly around a nucleus such as a shell fragment, an algal pellet, or a quartz sand *grain*, in shallow, wave-agitated water; it often shows an internal radiating fibrous structure indicating outward growth or enlargement at the site of deposition. Ooliths are frequently formed by inorganic precipitation, although many noncalcareous ooliths are produced by replacement, in which case they are less regular and spherical, and the concentric or radial internal structure is less well developed, than in accretionary ooliths. Cf. *pisoid.*	1
Overturned or over-steepened cross-bedding	A type of *penecontemporaneous sedimentary structure* consisting of oversteepened or overturned *foreset beds* that occur within single *sets*. The deformation ranges from foresets that dip more steeply than the angle of rest in the upper parts of sets (oversteepened) to extensive overturning of foresets into recumbent folds. The overfolding is always in the direction of the original foreset dip. Oversteepening and overturning develop in response to a shear force acting on the upper surface of a *bedform*, and in the same direction of the current that produced the bedform.	7
Papery (parting)	A tendency to break into pieces, typically tabular, that are <1 mm thick. Cf. *fissile*; *platy*; *flaggy*; *slabby*; *blocky*; *massive*.	7
Particle	A general term, used without restriction as to shape, composition or internal structure, for a separable or distinct constituent in a rock (e.g., a sediment particle). In common sedimentary parlance, a *clast* refers to a gravel-size particle (i.e., >2 mm diameter) whereas a *grain* refers to a particle that is sand size and smaller (i.e., <2 mm diameter).	(1),(7)
Parting	Layer-parallel textural or compositional anisotropies that lead to the splitting of a sedimentary interval into tabular pieces. Many splitting planes correspond to true *bedding* or *bounding surfaces*, but the term bedding or *bedding plane* should not be used for surfaces along which splitting takes place. See *papery*; *platy*; *flaggy*; *slabby*; *blocky*.	7
Parting lineation	A type of *syngenetic depositional structure*, formed on the upper surface of some *lamina* and *bed*s, parallel to the direction of current flow. It consists of faint irregularities or streaks, parallel ridges and grooves a few millimetres wide and many centimetres long, especially in thin-bedded sandstone. [Synonym: current lineation].	1,7
Pedogenic	Pertaining to soil formation.	1
Penecontemporaneous (structure)	Formed or existing at almost the same time; e.g., said of a structure or mineral that was formed immediately after deposition of a sediment but before its consolidation into rock.	1
Petroliferous	Bearing crude oil or natural gas. The term may be applied to a province, a geologic structure or a geologic formation or unit.	1
Pillar structure	A type of *fluid-escape structure* consisting of a *columnar structure*, normal or oblique to the *bedding*, consisting of massive or "swirled" sand that cuts across *lamina*e or other primary structures in a sand *bed*. It is thought to be formed by the escape of water after deposition of the *bed*. Cf. *dish structure*; *mud volcano*; *sand volcano*; *sheet structure*.	1,(7)
Pisoid	A round or ellipsoidal accretionary body commonly formed of calcium carbonate. A pisoid is larger and less regular in form than an *oolith,* although it may have the same concentric and/or radial internal structure. [Synonym: pisolith]. Cf. *oolith*.	1,7
Planar (bedding)	Lying or arranged as a plane or in planes, usually implying more or less parallelism, as in *bedding*. Cf. *wavy (bedding)*.	1
Platy (parting)	A tendency to break into pieces, typically tabular, that are 3 to 10 mm thick. Cf. *papery*; *fissile; flaggy*; *slabby*; *blocky; massive*.	7
Polymictic [sedimentology]	Said of a clastic sedimentary rock composed of many mineral or rock types, such as an arenite or wacke, or a conglomerate with more than one variety of pebble; also, said of the *clasts* of such a rock. Cf. *oligomictic*.	1
Poorly sorted	Said of a clastic sediment or of a cemented detrital rock that is not sorted or that shows a wide spread of sizes around the average size, or that consists of *particles* of many sizes mixed together in an unsystematic manner so that no one size class predominates. Cf. *moderately sorted*; *well sorted*.	1
Primary sedimentary structure	A *syngenetic sedimentary structure* determined by the conditions of deposition (mainly current velocity and rate of sedimentation) and developed before lithification of the rock in which it is found. It includes *bedding* in the broad sense (especially the external form of the *beds* and their continuity and uniformity of thickness), *bedding-plane* markings such as *ripple*s and *sole mark*s, and those deformational structures produced by preconsolidation movement due to unequal loading or to downslope sliding or slumping.	1
Prod mark (sedimentary)	A short *tool mark* oriented parallel to the current of a stream and produced by an object that plowed into and was then raised above the bottom. Its longitudinal profile is asymmetric. The mark deepens gradually downcurrent where it ends abruptly (unlike a *flute*). Cf. *bounce marks*; *chevron marks*; *grooves*; *skip marks*.	1
Prolate (geometry)	In terms of *particle* shape, refers to a rugby-ball-like shape (polar ellipsoidal axis greater than equatorial axis). Cf. *oblate*.	

Table 46. *continued*

Modifier	Definition[A]	Source[B]
Pull-apart	A precompaction *sedimentary structure* resembling boudinage, consisting of *beds* that have been stretched and torn apart into relatively short slabs, the intervening cracks being filled in from the top (or in some cases possibly from below); e.g., stiff clay embedded in more mobile, water-soaked sand, or compact sandstone embedded in hydroplastic clayey rock.	1
Rain print	A type of *penecontemporaneous bed-surface structure* that is a small, shallow, crater-like pit surrounded by a slightly raised rim, formed in soft fine sand, silt or clay, or in the mud of a tidal flat, by the impact of a falling raindrop, and sometimes preserved on the *bedding planes* of sedimentary rocks or as *casts* on the underside of overlying sandstone *beds*. It is generally smaller, shallower and more regular in shape than a *hail imprint.*	1
Recrystallization	The formation, essentially in the solid state, of new crystalline mineral *grains* in a rock. The new grains are generally larger than the original grains and may have the same or a different mineralogical composition.	1
Replacement-displacive structure	A type of *epigenetic growth structure* that forms by *epigenetic* growth, thereby replacing and (or) displacing pre-existing sedimentary particles. In the extreme, such growth may bind pre-existing sediment into hard, extensive concretionary aggregates. Classified into *concretion*; *cone-in-cone structure*; *duricrust*; *nodule*. Cf. *cavity filling structure*.	7
Reverse graded bedding	A type of *graded bedding* in which *grain* size increases systematically toward the top of the *bed*.	7
Rhomboid ripple	An aqueous current ripple characterized by diamond-shaped tongues of sand arranged in a reticular pattern resembling the scales of certain fish. Tongues range from 12 to 25 mm wide and 25 to 50 mm long; each has 1 acute angle (formed by 2 steep sides) pointing downcurrent, and another acute angle (formed by the gentle side extending into the re-entrant angle of the steep sides of 2 tongues of the following forms) pointing upcurrent; it is common on sand beaches where it forms during the final stages of backwash of each retreating wave. The sides are not more than 1 mm high. Arranged in rows parallel to flow, out-of-phase.	1,(7)
Rhythmite	An individual unit of a rhythmic succession or of *beds* developed by rhythmic sedimentation; a *couplet* of distinct types of sedimentary rock, or the graded sequence of sediments, that forms a unit in rhythmically *bedded* deposits. The term implies no limit as to thickness or complexity of *bedding* and it carries no time or seasonal connotation. Cf. *couplet*; *varve*.	1
Rill mark	A type of *syngenetic water-erosion structure* consisting of either: a) a small, dendritic channel, *groove*, or furrow formed on the surface of beach mud or sand by a wave-generated rill or by a retreating tide; especially one formed on the *lee* side of a half-buried pebble, shell or other obstruction, and usually branching upstream; or b) a dendritic channel formed by a small stream or spring debouching [to emerge from a narrow or confined place onto open ground] on a sand flat or a mud flat; it shows a downslope bifurcation. Cf. *scour mark*; *swash mark*.	1,(7)
Ripple (bedform)	A small-scale sedimentary *bedform*, having height < 5 cm above the *bed* surface. All ripples are roughly triangular in transverse cross-section and develop due to the interaction of a moving fluid (air or water) with a mobile substrate (most commonly sand-size sediment). The overall morphology of a ripple is determined by the nature of the fluid that acts to form it.	1,(7)
Ripple cross-lamination	A type of *small-scale cross-lamination* formed by the downstream migration of *ripple bedforms*. Can be either *tabular cross-lamination* or *trough cross-lamination*. Includes *climbing-ripple cross-lamination*, *form-set cross-lamination*, *flaser cross-lamination*, *lenticular cross-lamination*.	7
Ripple index	The ratio of *ripple* wavelength to ripple amplitude. The ratio usually ranges from 6 to 22 for ripples produced by water currents or waves and from 20 to 50 for ripples produced by wind.	1
Rip-up	Said of a clast, usually consisting of flat-shaped pieces of semi-consolidated mud, that have been “ripped up” by currents and transported to a new depositional site.	(1)
Rounded (roundness class)	Round or curving in shape; specifically said of a sedimentary *particle* with original edges and corners that have been smoothed off to rather broad curves and with original faces that are almost completely removed by abrasion (although some comparatively flat surfaces may be present). The original shape is still readily apparent. *Roundness* value: between 0.40 and 0.60. A subdivision of the *roundness class*. Cf. *well rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Roundness	The degree of abrasion of a clastic *particle* as shown by the sharpness of its edges and corners, expressed as the ratio of the average radius of curvature of the corners of the particle image to the radius of the maximum inscribed circle. A perfectly rounded particle (such as a sphere) has a *roundness* value of 1.0; less-rounded particles have values less than 1.0. Not to be confused with sphericity (a nearly spherical particle may have sharp corners and be angular, while a flat pebble, far from spherical in shape, may be well rounded). Cf. flatness.	1
Roundness class	An arbitrarily defined range of *roundness* values for sedimentary particles. See *well rounded*; *rounded*; *subrounded*; *subangular*; *angular*; *very angular*. See Figure 34.	1
Saltation [sedimentology]	A mode of sediment transport in which the *particle*s are moved progressively forward in a series of short intermittent leaps, jumps, hops or bounces from a bottom surface. There is insufficient energy to keep the particles in suspension. It is intermediate in character between *suspension* and *traction*.	1
Salt-crystal cast	A *crystal cast* formed by solution of a soluble salt crystal, followed by filling with mud or sand or by crystallization of a pseudomorph (such as calcite after halite).	1

Table 46. *continued*

Modifier	Definition[A]	Source[B]
Sand volcano	A type of *fluid-escape structure* resulting in an accumulation of sand resembling a miniature volcano or low volcanic mound (maximum diameter 15 m), produced by expulsion of liquefied sand to the sediment surface. Examples are found on top of *slump* sheets or on the upper surface of highly contorted layers of laminated sediments. Cf. *dish structure*; *mud volcano*; *pillar structure*; *sheet structure*.	1
Sand tail	A type of *syngenetic wind-erosion structure* on the *lee* side of a wind-obstructing object.	(7)
Sand wave	(a) A general term for a wavelike *bedform* in sand. (b) A generally large and asymmetrical bedform in sand, with a wavelike form but lacking the deep scour associated with *dunes* and megaripples. Large sand waves generally have a high *ripple index*, and *lee* slopes inclined at less than the angle of repose of sand.	1
Scour mark	A type of *syngenetic erosional structure* or *basal-surface mark* (more specifically a type of *current mark*) produced by the cutting or scouring action of a current of water flowing over the bottom. Classified into *flute mark*; *gutter cast*; *longitudinal ridges and furrows*; *obstacle scour*; *transverse scour*. Cf. *rill mark*; *swash mark*; *tool mark*.	1,(7)
Secondary sedimentary structure	A sedimentary structure that originated subsequent to the deposition or emplacement of the rock in which it is found, especially an *epigenetic growth structure*, such as a *concretion* or *nodule* produced by chemical action, or a *sedimentary dike* formed by infilling.	1
Sedimentary dike	A tabular mass of sedimentary material that cuts across the structure or *bedding* of pre-existing rock in the manner of an igneous dike. It is formed by the filling of a crack or fissure from below, above or laterally, by forcible injection or intrusion of sediments under abnormal pressure (as by gas pressure or by the weight of overlying rocks, or by earthquakes), or from above by simple infilling. It may be a sand dike if composed mostly of sand, or a pebble dike if composed mostly of pebbles.	1
Sedimentary hardground	A type of *secondary sedimentary structure* consisting of substrates that are hardened without undergoing burial *diagenesis* or subaerial exposure. Typically such hardgrounds develop in carbonate sediment to yield limestone hardgrounds, but they also can develop in clay-rich sediment that is calcareous. Classified into *beachrock* and *submarine hardground*.	7
Sedimentary structure	A structure in a sedimentary rock, formed either contemporaneously with deposition (a *primary sedimentary structure*) or by sedimentary processes subsequent to deposition (a *secondary sedimentary structure*).	1
Sequence	A succession of geologic events, processes or rocks, arranged in chronologic order to show their relative position and age with respect to geologic history as a whole.	1
Set [stratigraphy]	A group of essentially conformable strata or cross-strata, separated from other sedimentary units by surfaces of erosion, nondeposition, or abrupt change in character; composed of 2 or more consecutive *beds* of the same rock type; the smallest and most basic group unit. Cf. *coset*.	1
Sheet structure	A type of *fluid-escape structure* consisting of slightly sinuous, subparallel, mainly vertical streaks in a sedimentary rock, distinguished from the surrounding rock by their lighter colour and greater resistance to weathering. In plan view they show a straight or slightly wavy pattern of subparallel lines and thus have a sheet-like three-dimensional form. The structure is thought to be formed after deposition of a sand *bed* by escape of fluid, which washes out some of the finer *particles*. Cf. *dish structure*; *mud volcano*; *pillar structure*; *sand volcano*.	1,(7)
Shrinkage crack	A type of *bed-surface structure* consisting of a crack produced in fine-grained sediment or rock by the loss of contained water during drying, dehydration, or shrinkage of swelling-clay minerals. See *desiccation crack*; *syneresis crack*. [Synonym: *mudcrack*.]	7,1
Silcrete	A general term for a siliceous *duricrust* consisting of secondary siliceous layers, crusts, and *nodules* that form hard, discontinuous to continuous masses in *terrigenous-clastic* sedimentary materials. Cf. *calcrete*; *ferricrete*.	(1),(7)
Siliceous	Said of a rock containing abundant silica, especially free silica, rather than silicates.	1
Skip mark	A type of *tool mark* consisting of a linear series of regularly spaced, crescent-shaped tool marks produced by an object that intermittently impinged on or skipped along the bottom of a stream. Cf. *bounce marks*; *chevron marks*; *grooves*; *prod marks*.	1
Slabby (parting)	A tendency to break into pieces, typically tabular, that are 3 to 10 cm thick. Cf. *papery*; *fissile*; *platy*; *flaggy*; *blocky*; *massive*.	7
Slump	(a) A landslide characterized by a shearing and rotary movement of a generally independent mass of rock or earth along a curved slip surface (concave upward) and about an axis parallel to the slope from which it descends, and by backward tilting of the mass with respect to that slope so that the slump surface often exhibits a reversed slope facing uphill; (b) The sliding-down of a mass of sediment shortly after its deposition on an underwater slope; especially the downslope flowage of soft, unconsolidated marine sediments, as at the head, or along the side, of a submarine canyon; (c) The mass of material slipped down during, or produced by, a slump.	1
Slump block	A type of *multi-bed penecontemporaneous structure* consisting of the mass of material torn away as a coherent unit during slumping. It may be up to 2 km long and 300 m thick.	1,(7)
Slump fold	A type of *multi-bed penecontemporaneous structure* consisting of an *intraformational fold* produced by slumping of soft sediments.	1,(7)

Table 46. *continued*

Modifier	Definition[A]	Source[B]
Slump scar	A type of *multi-bed penecontemporaneous structure* consisting of a pull-away scarp from which a submarine slump has detached and across which younger sediment is draped.	7
Small-dune cross-stratification	A type of *cross-stratification* produced by the downstream migration of small-dune *bedforms*, where the tabular or trough geometry of the inclined layers is not known.	7
Small-scale cross-bedding	Individual cross-bedded *sets* (units) are <5 cm high and may be *planar* or trough-shaped. Cf. *large-scale cross-bedding*.	(7)
Small-scale cross-lamination	Individual cross-laminated *set*s (units) are <5 cm high and may be *planar* or trough-shaped. Cf. *large-scale cross-lamination*.	(7)
Small-scale tabular cross-bedding	A type of *tabular cross-bedding* in which the cross-bedded sets are <5 cm in height. Cf. *large-scale tabular cross-bedding*.	7
Small-scale tabular cross-lamination	A type of *tabular cross-lamination* in which the cross-laminated sets are <5 cm in height. Cf. *large-scale tabular cross-lamination*.	7
Small-scale trough cross-lamination	A type of *trough cross-lamination* in which the cross-laminated sets are <5 cm in height. Cf. *large-scale trough cross-lamination*.	7
Soft-sediment fold	Folding of unconsolidated sedimentary layering.	
Sole mark	A general descriptive term applied to a directional structure or to a small, wavelike, mainly convex irregularity or penetration found on the underside of a *bed* of sandstone or siltstone along its contact with a finer grained layer such as mudstone. The term usually refers to a filling of a *primary sedimentary structure*, e.g. a crack, track, *groove*, or other depression, formed on the surface of the underlying mud by such agents as currents, organisms and unequal loading, and preserved as a sole *cast* after the underlying material had consolidated and weathered away. See *flute cast*; *groove cast*; *load cast*.	1
Solution breccia	A type of *dissolution structure* consisting of a *collapse breccia* formed where soluble material has been partly or wholly removed by dissolution, thereby allowing the overlying rock to fall or settle and become fragmented; e.g., a *breccia* consisting of chert fragments gathered from a limestone in which the carbonate material has been dissolved away. Cf. *collapse breccia*; *stylolite*.	1,(7)
Sorting (particle)	The dynamic process by which sedimentary particles having some particular characteristic (such as similarity of size) are naturally selected and separated from associated but dissimilar particles by the agents of transportation.	1
Stromatactis	A *sedimentary structure* characterized by a horizontal or nearly flat bottom, up to about 10 cm in diameter, and an irregular or convex-upward upper surface, consisting of sparry-calcite cement, usually in the central part of a reef core; sometimes called reef tufa. They have been interpreted as infillings of original cavities caused by the burial and decay of soft-bodied but rigid frame-building organisms, although they may represent syngenetic voids in calcareous sediments; some examples represent recrystallized sheet-like bryozoan colonies.	1
Stromatolite	A type of microbial mat that is an organosedimentary structure produced by sediment trapping, binding, and/or precipitation as a result of the growth and metabolic activity of micro-organisms, principally cyanophytes (blue-green algae). It has a variety of gross forms (branching, columnar, conical, domal, flat), from nearly horizontal to markedly vertical.	1
Stoss	The term used for the relatively gentle, upstream-facing slope of an asymmetric *bedform* such as a *ripple* or *dune*.	1
Stylolite	A type of *dissolution structure* consisting of a surface or contact, usually occurring in homogeneous carbonate rocks and more rarely in sandstones, which is marked by an irregular and interlocking penetration of the 2 sides: the columns, pits, and teeth-like projections on one side fit into their counterparts on the other. As usually seen in cross-section, it resembles a suture or the tracing of a stylus. The seam is characterized by a concentration of insoluble constituents of the rock, e.g., clay, carbon or iron oxides, and is commonly parallel to the *bedding*. Stylolites are supposedly formed diagenetically by differential vertical movement under pressure, accompanied by solution. Cf. *collapse breccia*; *solution breccia*.	1,(7)
Subangular (roundness class)	Somewhat angular, free from sharp angles but not smoothly rounded; specifically said of a sedimentary *particle* showing definite effects of slight abrasion, retaining its original general form, and having faces that are virtually untouched and edges and corners that are rounded off to some extent. *Roundness* value: between 0.15 and 0.25. A subdivision of the *roundness class*. Cf. *well rounded*; *rounded; subrounded*; *angular*; *very angular*.	(1)
Submarine hardground	A type of *sedimentary hardground* consisting of limestone which has been cemented on the seafloor. The hardground surface may be encrusted, discoloured, case-hardened, bored or solution-ridden. It implies a gap in sedimentation and may be preserved stratigraphically as an *unconformity*. Cf. *beachrock*.	1,(7)
Subrounded (roundness class)	Partially rounded; specifically said of a sedimentary particle showing considerable but incomplete abrasion and an original general form that is still discernible, and having many of its edges and corners noticeably rounded off to smooth curves. *Roundness* value: between 0.25 and 0.40. A subdivision of the *roundness class*. Cf. *well rounded*; *rounded*; *subangular*; *angular*; *very angular*.	(1)
Supratenuous fold	A pattern of fold in which there is thickening at the synclinal troughs and thinning at the anticlinal crests. It is formed by differential compaction on an uneven basement surface.	1

Table 46. *continued*

Modifier	Definition[A]	Source[B]
Suspension	A mode of sediment transport in which the upward currents in eddies of turbulent flow are capable of supporting the weight of sediment particles and keeping them indefinitely held in the surrounding fluid (water, air). Cf. *saltation*; *traction*.	1
Swash mark	A type of *syngenetic water-erosion structure* consisting of a thin, delicate, wavy or arcuate line or very small ridge on a beach, marking the farthest advance of wave uprush. It is convex landward and consists of fine sand, mica flakes, bits of seaweed, and other debris. Cf. *obstacle scour*; *rill mark*.	1
Symmetric ripple	A *ripple* having a symmetric profile in cross-section, being similarly shaped on both sides of the crest, which in plan view is predominantly straight. Considered synonymous with “oscillation ripple”, but the latter carries with it an implicit genesis (i.e., wave action). Cf. *asymmetric ripple*.	(1)
Syneresis crack	A *secondary sedimentary structure* that is a subaqueous *shrinkage crack* formed by the loss of pore water from clays or shrinkage of swelling-clay mineral lattices due to changes in salinity of surrounding water. Cf. *desiccation crack*.	7,(1)
Syngenetic	Said of a *primary sedimentary structure*, such as a *ripple*, formed contemporaneously with the deposition of the sediment.	1
Syngenetic depositional structure	A *syngenetic sedimentary structure* produced by the movement and aggradation (i.e., vertical accretion) of sediment under the influence of wave action, currents and streamflows, or through the action of sediment-gravity flows. Classified into *bedding*, *bed-surface structures*; *internal depositional structures*.	7
Syngenetic erosional structure	A *syngenetic sedimentary structure* formed by the marking, scouring or impression of sediment by fluid flows or by objects during or shortly after its accumulation. Classified into *basal-surface marks*; *upper-surface marks*.	7
Syngenetic sedimentary structure	A nonbiogenic *sedimentary structure* formed during the genesis of sedimentation units and sedimentary *bedforms* or caused by the scouring action of fluids, and intrinsically reflecting conditions of the sedimentary environment. Classified into *syngenetic depositional structures*; *syngenetic erosional structures*.	7
Synsedimentary fault	A fault in sedimentary rock that forms contemporaneously and continuously with deposition, so that the stratigraphic throw of synfaulting sedimentary units increases dramatically with depth and the strata of the downthrown side are thicker than the correlative strata of the upthrown side. [Synonym: growth fault.]	1
Tabular cross-bedding	A type of *cross-bedding* in which the cross-bedded units, or *sets*, are bounded by *planar*, essentially parallel surfaces, forming a tabular body. Classified into *small-scale tabular cross-bedding* and *large-scale tabular cross-bedding*.	7,1
Tabular cross-lamination	A type of *cross-lamination* in which the cross-bedded units, or *sets*, are bounded by *planar*, essentially parallel surfaces, forming a tabular body. Classified into *small-scale tabular cross-lamination* and *large-scale tabular cross-lamination*.	7,1
Tabular cross-stratification	A type of *cross-stratification* in which the thickness of individual inclined layers is not known, although the sets can be described as bounded by *planar*, essentially parallel surfaces that form a tabular body. Cf. *trough cross-stratification*.	7,1
Terrigenous-clastic	Clastic sedimentary rock having ≥50% of its fragmental constituents composed of broken fragments derived from a previous rock or sediment. Classified into conglomeratic rock, sandy rock and mudrock.	7
Thread	a) A thin stream of water; b) The line along the surface of a stream connecting points of maximum current velocity.	1
Tool mark	A type of *syngenetic erosional structure* or *basal-surface mark* (more specifically a type of *current mark*) produced by the impact against a muddy bottom of a solid object swept along by the current, and generally preserved as a *cast* on the underside of the overlying *bed*. Classified into *bounce marks*; *chevron marks*; *grooves*; *prod marks*; *skip marks*. Cf. *scour mark*.	1,(7)
Topset bed	One of the nearly horizontal layers of sediments deposited by a river on the top surface of an advancing *delta* and continuous with the landward *alluvial* plain; it truncates or covers the edges of the seaward-lying *foreset beds*. Cf. *bottomset bed.*	1
Traction [sedimentology]	A mode of sediment transport, in water or air, in which the particles are swept along a bottom surface by rolling, sliding, dragging, pushing or *saltation*. Cf. *saltation*; *suspension*.	1
Transverse scour	A *scour mark* with a long axis that is transverse to the main direction of the current. The regular spacing of such marks may lead to confusion with ordinary transverse *ripple*s. Morphologically transitional with *flutes*. Cf. *flute mark*; *gutter cast*; *longitudinal ridges and furrows*; *obstacle scour*.	1,7
Trough cross-bedding	A type of *cross-bedding* in which the lower bounding surfaces are curved surfaces of erosion; it results from local scour and subsequent deposition. Commonly formed by the migration of large-scale *dune bedforms*. [Synonym: festoon cross-bedding.]	7,1
Trough cross-lamination	A type of *cross-lamination* in which the lower bounding surfaces are curved surfaces of erosion, resulting from local scour and subsequent deposition. Commonly formed by the migration of *ripple bedforms*. Classified into *small-scale trough cross-lamination* and *large-scale trough cross-lamination*.	7,1
Trough cross-stratification	A type of *cross-stratification* in which the thickness of individual inclined layers is not known, although the lower bounding surfaces of the sets can be described as curved surfaces of erosion resulting from local scour and subsequent deposition. Cf. *tabular cross-stratification*.	7,1

Table 46. *continued*

Modifier	Definition[A]	Source[B]
Turbidite (Bouma cycle)	A sediment or rock deposited from a *turbidity current.* It is characterized by *graded bedding*, moderate *sorting*, and well-developed primary structures in the sequence noted in the *Bouma cycle*.	1
Turbidity current	A type of sediment-gravity flow (fluidized sediment) in which sediment is supported by fluid turbulence. Typically, a bottom-flowing current laden with suspended sediment, moving swiftly (under the influence of gravity) down a subaqueous slope and spreading horizontally on the floor of the body of water, having been set and/or maintained in motion by locally churned- or stirred-up sediment that gives the water a density greater than that of the surrounding or overlying clear water. The depositional product is a *turbidite*.	1,7
Unclassified structure [sedimentary]	A general term for a structure formed during the lifecycle of sedimentary material but whose primary or secondary origin cannot be determined.	7
Unconformity	A notable break or gap in the geological record where a rock unit is overlain by another that is not next in depositional succession, such as an interruption in the continuity of deposition or a break between eroded igneous and/or sedimentary rocks.	1
Upper-surface mark	A type of *syngenetic erosional structure* that occurs on the top of a sedimentary *bed* or layer. Classified into *water-erosion structure*s and *wind-erosion structure*s.	7
Vadose water	Water within the *vadose zone*.	1
Vadose zone	The “unsaturated zone” or “zone of aeration” within soils and rocks where pore spaces usually contain air and water (hence *vadose water*). The vadose zone extends from the land surface to the water table.	
Varve	(a) Any cyclic sedimentary *couplet,* as in certain mudstones and evaporites. (b) A sedimentary *bed* or *lamina* or sequence of laminae deposited in a body of still water within 1 year’s time; specifically a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier. A glacial varve normally includes a lower “summer” layer consisting of relatively coarse-grained, light-coloured sediment (usually sand or silt) produced by rapid melting of ice in the warmer months, which grades upward into a thinner “winter” layer, consisting of very fine-grained (clayey), often organic, dark sediment slowly deposited from suspension in quiet water while the streams were ice-bound. Cf. *couplet*; *rhythmite*.	1
Very angular (roundness class)	A term used to describe a sedimentary *particle* with a *roundness* value between 0.0 and 0.05 (modified by OGS). A subdivision of the *roundness class*. Cf. *well rounded*; *rounded*; *subrounded*; *subangular*; *angular*.	
Vugs	A type of *epigenetic-growth*, *cavity-filling structure* that is a primary pore or secondary *dissolution* space, partly or wholly filled with sediment or *epigenetic* minerals. Typically developed in carbonate rocks, but may occur in any sedimentary material.	7
Water-erosion structure	A type of *syngenetic upper-surface mark* formed by the scouring action of aqueous-flow *threads*. Classified into *rill mark*; *scour mark*; *swash mark*.	7
Wavy (bedding)	a) *Bedding* characterized by undulatory *bounding surface*s. (b) A form of interbedded mud and *ripple-cross*-laminated sand, in which the mud layers overlie *ripple* crests and more or less fill the ripple troughs, so that the surface of the mud layer only slightly follows the concave or convex curvature of the underlying ripples. Cf. *planar* (bedding).	1
Well rounded (roundness class)	Said of a sedimentary *particle* with original faces, edges, and corners that have been destroyed by abrasion and with the entire surface consisting of broad curves without any flat areas; specifically said of a particle with no secondary corners. The original shape may be suggested by the present form of the particle. *Roundness* value: between 0.60 and 1.00. A subdivision of the *roundness class*. Cf. *rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Well sorted	Said of sorted sediment that consists of *particle*s all having approximately the same size. Cf. *moderately sorted*; *poorly sorted*.	1
Wind-erosion structure	A type of *syngenetic upper-surface mark* formed by the scouring action of *eolian* flow. See *sand tail*.	7
Within-bed (structure)	A type of *penecontemporaneous sedimentary structure* that occurs within a single *bed*.	7

[A] Preferred terms are defined: synonyms are in square brackets for reference only.
[B] Indicates source of definition: primary sources are indicated by a number; secondary sources are indicated by numbers in parentheses. 1 = Neuendorf, Mehl and Jackson (2005); 7 = Soller (2004a).
Where no source(s) is indicated, definitions are derived from or modified for use by the OGS.

SIZE RANGES

Table 47. Sedimentary rocks: size ranges for various parameters.[A]

Grains	≤2 mm			
		Clay		<0.004 mm
		Silt		0.004 to 0.0625 mm
		Sand	Very fine	0.0625 to 0.125 mm
			Fine	0.125 to 0.25 mm
			Medium	0.25 to 0.50 mm
			Coarse	0.5 to 1.0 mm
			Very coarse	1 to 2 mm
Clasts	>2 mm			
		Granule		2 to 4 mm
		Pebble		4 to 64 mm
			Fine	4 to 8 mm
			Medium	8 to 16 mm
			Coarse	16 to 32 mm
			Very coarse	32 to 64 mm
		Cobble		64 to 256 mm
			Small	64 to 128 mm
			Large	128 to 256 mm
		Boulder		>256 mm
			Small	256 to 512 mm
			Medium	512 to 1024 mm
			Large	1024 to 2048 mm
			Very large	2048 to 4096 mm
Layers		Laminae	Very thinly laminated	<1 mm
			Thinly laminated	1 to 3 mm
			Thickly laminated	3 to 10 mm
		Beds	Very thinly bedded	1 to 3 cm
			Thinly bedded	3 to 10 cm
			Medium bedded	10 to 30 cm
			Thickly bedded	30 to 100 cm
			Very thickly bedded	1 to 3 m
			Extremely thickly bedded	>3 m

[A] *Modified from Walker and Cohen (2009).*

METAMORPHIC ROCKS

The pick list of modifiers for metamorphic rocks (Tables 48, 49 and 50: back pocket) is structured so that major headings (collectively in this list) consist of features related to:

- colour index;
- uniformity (compositional and textural);
- bulk composition (e.g., mineralogical, textural);
- major components (e.g., rock types);
- major features (e.g., protolith, layering, grain characteristics);
- breccia features (fragments, matrix);
- migmatite features (neosome, paleosome); and
- metamorphism (facies, grade, phases)

MODIFIERS

Modifiers and ancillary terms for metamorphic rocks are listed alphabetically. Table 51 includes terms that apply to metamorphic rocks, based on structure and composition, as well as metasomatic rocks, metamorphic-related breccias and migmatites. However, it does not include migmatite terms such as leucosome, mesosome, melanosome, resister, residuum, selvage, etc. These definitions are in Table 29, “Principal parts of migmatites”. Words within definitions that are in *italics* are also defined elsewhere in the same table. A word in square [brackets] following a modifier indicates the appropriate geologic theme or topic to which the modifier refers, as the modifier can apply to more than one theme. A word in (parentheses) following a modifier refers to the general topic as laid out in the hierarchical design of the appropriate pick list.

Table 51. Metamorphic rocks: modifier definitions.

Modifier	Definition[A]	Source[B]
Acicular (crystal habit)	Said of a crystal that is needle shaped in form. Cf. *equant*; *prismatic*; *sheet*; *tabular*.	1
Amphibolite facies	Metamorphic *facies* corresponding to moderate pressure (>300 MPa) and temperature (450-700°C) conditions. It lies between the *epidote-amphibolite* and *granulite facies*. *Mafic* rocks (basaltic composition): typically characterized by hornblende-plagioclase (>An_{17}) assemblages, commonly with epidote, almandine and clinopyroxene “Pelitic” rocks: assemblages contain micas associated with almandine staurolite, kyanite or sillimanite, but not andalusite or cordierite. (For “pelite”, “pelitic”, *see* section on Mudrock.)	1,8
Anatexis	Refers to the melting or remelting of rocks and covers the entire range from incipient to complete melting.	9
Angular	Said of an object (e.g., crystal, fragment) having sharp angles or borders; most edges and corners sharp. Cf. *well rounded*; *rounded*; *subrounded*; *subangular*; *very angular*.	(1)
Aphanitic	Used here in the sense of a fine-grained rock in which the crystalline components are not distinguishable with the unaided eye (approximately <0.1 mm). Cf. *phaneritic*.	(1),(8)
Armoured relict	An unstable *relict* that is prevented from further reaction by a rim of reaction products.	1
Atoll structure	A type of structure characterized by a ring or shell of one mineral around a core of another mineral or other minerals, resembling an atoll. The ring may be complete or not. The core may consist of a single crystal or an aggregate of crystals and may be older or younger than the rim. Cf. *corona* (*structure*).	8
Augen	Lenticular grains or grain aggregates, having the shape of an eye in cross-section (in contrast to the shapes of other minerals in the rock), usually on the mesoscopic scale. Augen generally occur in gneissose or schistose rocks and the schistose planes bend around the augen. Augen are usually products of deformation (e.g., relict clasts in a mylonite). Hence *augen structure*. Cf. *Phacoidal structure*; *flaser structure*.	8
Augen structure	Type of structure characterized by the presence of *augen*. Cf. *flaser structure*; *phacoidal structure*.	8
Bilithic (fragment rock type)	An unofficial term referring to fragments in a rock consisting of 2 rock types. Cf. *monolithic*; *heterolithic*.	

Table 51. *continued*

Modifier	Definition[A]	Source[B]
Boudin	One of a series of elongate, sausage-shaped (in cross-section), competent segments occurring in *boudinage,* either separate or joined by pinched connections, and commonly having barrel-shaped cross-sections. Boudins result from the failure of the competent tabular body under compressional stress, whereas the enclosing incompetent material yields by shearing and/or flowing.	1,8
Boudinage	A structure common in strongly deformed rocks (particularly sedimentary and metamorphic), in which an original continuous competent tabular body (layer, bed, sheet, etc.) between less competent layers has been stretched, thinned and broken at regular intervals into bodies resembling *boudin*s or sausages (in cross-section).	1
Colour index	The volume percentage of mafic (dark-coloured) minerals in an igneous (commonly volcanic) rock (denoted as M′ in QAPF terminology of igneous rocks). See *M′*.	(2)
Concordant	As used here, said of a contact which is parallel to foliation or bedding in the country rock. Cf. *discordant*.	
Contact aureole	Zone around a magma body (plutonic, near-surface or volcanic) in which contact metamorphism, due to that body, can be recognized. The thickness ranges from centimetres to kilometres, depending on the dimensions and composition of the magma body, the physico-chemical properties of the surrounding rocks and the depth of the magma emplacement. The metamorphic effects are more pronounced close to the igneous mass, i.e., in the inner aureole, and tend to diminish away to the outer aureole.	8
Contorted	Notably bent, twisted or distorted out of normal shape	
Corona (structure) [petrology]	A type of structure characterized by a zone or zones of minerals arranged concentrically around a core mineral. The zoning minerals usually exhibit a radial arrangement. The zone or zones may be primary or result from secondary reactions. Can occur in both metamorphic and igneous rocks.	8
Crystalloblast	Mineral grain or crystal that has grown under metamorphic processes as opposed to crystallizing from a melt. See *hypidioblast*; *idioblast*; *xenoblast*.	8
Discordant	As used here, said of a contact which is not parallel to foliation or bedding in the country rock. Cf. *concordant*.	
Eclogite facies	Metamorphic *facies* corresponding to middle to high grade and middle to high P/T values. *Mafic* rocks: characterized by omphacitic pyroxene and almandine-pyrope garnet with an absence of plagioclase. Commonly associated with pyrope + olivine + diopside + enstatite.	1,8
Epidote-amphibolite facies	Metamorphic *facies* corresponding to low to moderate temperatures and pressures. It lies between the *greenschist* and the *amphibolite facies*. May be a high-grade subfacies of the *greenschist facies*. *Mafic* rocks: characterized by hornblende + albite (An $_{<17}$) + epidote ± chlorite.	8
Equant (crystal habit)	Said of a crystal having the same or nearly the same diameter in all directions. Cf. *acicular*; *prismatic*; *sheet*; *tabular*. [Synonym: equidimensional].	(1)
Fabric	Relative orientation (spatial and geometrical) of part of a rock mass. Hence *megafabric*, *mesofabric*, *microfabric*. The term is commonly used to refer to the crystallographic and/or shape orientation of mineral grains or groups of grains, but can also be used on a larger scale. Preferred linear orientation of the parts is termed “linear fabric”, preferred planar orientation is referred to as “planar fabric”, and the lack of a preferred orientation is referred to as “random fabric”.	8
Facies (metamorphic)	A set of metamorphic mineral *parageneses*, repeatedly associated in space and time, and showing a regular and predictable relationship between mineral composition and bulk chemical composition, such that different metamorphic facies appear to be related to different metamorphic conditions (*see* Figure 26A). It is generally assumed that the metamorphic facies represent the results of equilibrium crystallization (*paragenesis*) of rocks under a restricted range of externally imposed physical conditions, in particular temperature and pressure, although other variables, such as P_{H_2O}, may also be important. The modified recommended facies names are: *zeolite*, *subgreenschist*, *greenschist*, *epidote-amphibolite*, *amphibolite*, *hornfels*, *sanidinite*, *granulite*, *glaucophane-schist*, and *eclogite*.	8,(1)
Felsic	In OGS usage, an adjective for a fine-grained igneous or metamorphic rock with a *colour index* <15.	
Flaser structure [metamorphism]	Type of structure produced by dominantly mylonitic deformation and characterized by the presence of fissile zones or layers of highly sheared or finely crushed rocks separating lenticular relicts of relatively undeformed rock. Cf. *augen structure*; *phacoidal structure*.	8
Ghost stratigraphy	Stratigraphy and structure of a pre-existing rock sequence which can be identified in, or traced through, highly metamorphosed rocks or igneous bodies, by means of relict features.	8
Glaucophane-schist facies	Metamorphic *facies* corresponding to very low to low metamorphic grade and to high P/T values, and bounded in rocks of suitable composition, at low P-values, by the lawsonite-in reactions and, at higher P-values, by the stability limit of iron-poor Na-amphibole. It represents lower T and higher P than the *greenschist facies*. Typically found in subduction zones with their unusually low geothermal gradients. [Synonym: blueschist facies]. *Mafic* rocks: characterized by combinations of sodic amphibole (e.g., glaucophane, crossite), lawsonite, sodic pyroxene, aragonite, epidote and garnet. The mineral pair jadeite + quartz is also diagnostic. Not known to occur in Ontario.	1,8

Table 51. *continued*

Modifier	Definition[A]	Source[B]
Grade [metamorphism]	The intensity or rank of *metamorphism*, measured by the amount or degree of difference between the original parent rock and the metamorphic rock. It indicates in a general way the P-T environment, but terms are imprecisely defined. The recommended grade terms are: "very low", "low" (e.g., *greenschist*), "medium", "high" (e.g., *amphibolite*, *granulite*) and "very high" (*granulite*, *eclogite*).	1,(8)
Granoblastic structure	Type of metamorphic rock structure in which the constituent grains are *equant* and of equal size and have well-sutured or irregular boundaries. Cf. *granoblastic-polygonal structure*; *homeoblastic structure*; *lepidoblastic structure*; *nematoblastic structure*.	8
Granoblastic-polygonal structure	Type of metamorphic rock structure in which the constituent grains are *equant* and of equal size and have straight or smoothly curved crystal boundaries (polygonal) meeting at triple points with ~120° angles. (Generally a *microfabric*). Cf. *granoblastic structure*; *homeoblastic structure*; *lepidoblastic structure*; *nematoblastic structure*.	8
Granofels	A *phaneritic* metamorphic rock displaying a *granofelsic structure* (little or no foliation or lineation).	8,(1), (10)
Granofelsic structure	Type of metamorphic rock structure resulting from the absence of *schistosity* such that the mineral grains and aggregates of mineral grains are equant (e.g., quartz, feldspar, garnet, pyroxene) or, if inequant, have a random orientation. Mineralogical or lithological layering may be present.	8
Granulite facies	Metamorphic *facies* corresponding to the highest grades of *metamorphism* and to high temperature (>650°C) and medium to high pressures. Pressure-wise, it lies between the *eclogite*, *hornfels* and *sanidinite facies*. *Mafic* rocks: characterized by clinopyroxene-orthopyroxene-plagioclase assemblages; garnet (almandine) also characteristic; amphibole generally minor; olivine not stable with plagioclase or garnet. "Pelitic" rocks: association of sillimanite or kyanite with perthitic feldspar and almandine; cordierite commonly present; biotite minor, muscovite absent. (For "pelite", "pelitic" *see* section on Mudrock.)	1,8
Greenschist facies	Metamorphic *facies* corresponding to low grades of *metamorphism* and low to moderate temperatures (300 to 500°C) and pressures. It lies between the *epidote-amphibolite* and *subgreenschist facies*. *Mafic* rocks: characterized by actinolite-albite-epidote-chlorite assemblages. "Pelitic" rocks: chlorite, white mica, biotite and chloritoid are typical minerals. (For "pelite", "pelitic", *see* section on Mudrock.)	1,8
Groundmass [metamorphic]	The finer grained material relative to larger entities, such as *porphyroblasts*, *porphyroclasts* and *augens*.	
Heteroblastic structure	Type of metamorphic rock structure in which the constituent grains are of 2 or more different sizes. Antonym: *homeoblastic*.	8
Heterolithic (fragment rock type)	An unofficial term referring to fragments in a rock consisting of 3 or more rock types. Cf. *monolithic*; *bilithic*.	
Hololeucocratic	As used here, a colour index term for a rock with *M′* from 0 to 10. Cf. *leucocratic*; *mesocratic*; *melanocratic*; *holomelanocratic*.	2
Holomelanocratic	As used here, a colour index term for a rock with *M′* from 90 to 100. Cf. *hololeucocratic*; *leucocratic*; *mesocratic*; *melanocratic*.	2
Homeoblastic structure	Type of metamorphic rock structure in which the constituent grains are essentially of equal size. Antonym: *heteroblastic structure*. Cf. *granoblastic structure*; *granoblastic-polygonal structure*; *lepidoblastic structure*; *nematoblastic structure*.	8
Hornfels	Hard, compact metamorphic rock typically, but not necessarily, aphanitic, dominantly composed of silicate + oxide minerals in varying proportions, with a spiky aspect and a subconchoidal to jagged fracture. It may retain some structural features inherited from its *protolith* (e.g., bedding, lamination, metamorphic layering, *porphyroblasts*, *relict phenocrysts*). Preferred qualifiers refer to the nature of the hornfels, such as structural (e.g., fine-grained, spotted, layered), chemical (e.g., peraluminous) or mineralogical (e.g., *mafic*; *ultramafic*; cordierite-sillimanite-spinel). Hornfels occurs commonly, but not exclusively, in the innermost part of *contact aureoles*.	8,(1)
Hornfels facies	Metamorphic *facies* corresponding to low or very low pressures and low- to high-grade *metamorphism*. Temperature conditions are lower than in the *sanidinite facies* and the pressure lower than in the *granulite facies*. Subdivisions not recognized here (based on Neuendorf, Mehl and Jackson (2005)), are based on the presence of albite-epidote (~low *grade*), or hornblende (~medium grade), or pyroxene (~high grade). Fettes and Desmons (2007) recognize only pyroxene-hornfels facies (high-grade metamorphism with T >550°C). For pyroxene-hornfels facies: *Mafic* rocks: characterized by clinopyroxene-orthopyroxene-plagioclase assemblages; olivine stable with plagioclase; amphibole typically absent. "Pelitic" rocks: association of sillimanite (or andalusite) and cordierite with alkali feldspar; muscovite is absent. (For "pelite", "pelitic", *see* section on Mudrock.) Carbonate rocks: marbles contain wollastonite and calcite + forsterite + periclase.	8
Idioblast	A *crystalloblast* which is wholly bounded by its own crystal faces; hence *idioblastic structure*. Cf. *subidioblast*; *xenoblast*. Comparable to "euhedral" in igneous rocks.	8
Idioblastic structure	Said of a metamorphic structure in which the constituent grains are wholly bounded by the individual crystal faces. Cf. *subidioblastic structure*; *xenoblastic structure*.	(8)

Table 51. *continued*

Modifier	Definition[A]	Source[B]
Intermediate	In OGS usage, an adjective for a fine-grained igneous or metamorphic rock having a *colour index* from 15 to 35.	
Knotted (texture)	Type of schist or phyllite in which mineral clots or *porphyroblasts* give the rock a knotted or nodular appearance. It is common in the outer parts of metamorphic *contact aureoles*.	8
Lepidoblastic structure	Type of metamorphic rock structure in which the constituent grains are *homeoblastic*, have a flaky or platy habit and are arranged parallel to each other. Cf. *granoblastic structure*; *granoblastic-polygonal structure*; *homeoblastic structure*; *nematoblastic structure*.	8
Leucocratic	As used here, a *colour index* term for a rock with *M′* from 10 to 35. Cf. *hololeucocratic*; *mesocratic*; *melanocratic*; *holomelanocratic*.	2
M	Used in the same sense as with igneous rocks, "M" refers to the volume percentage of mafic and related minerals, which includes micas, amphibole, pyroxene, olivine, opaque minerals, accessory minerals (e.g., zircon, apatite, titanite), epidote, allanite, garnet, melilite, monticellite and primary carbonate. See *M′*.	2
M′	Used in the same sense as with igneous rocks, "M′", or *colour index*, refers to the volume percentage of the constituent minerals that are dark-coloured ferromagnesian minerals, which equals "M" minus muscovite, apatite, primary carbonates, epidote, garnet, melilite, monticellite and opaque and accessory minerals. See *M*.	2
Mafic	In OGS usage, an adjective for a fine-grained igneous or metamorphic rock having a *colour index* from >35 to 90.	
Massive [metamorphism]	Said of a metamorphic rock with constituents that are neither oriented in parallel position nor arranged in layers; that is, a rock that does not have schistosity, foliation or any similar structure.	1
Megafabric	The *fabric* of a rock as seen in an outcrop. Cf. *mesofabric*; *microfabric*.	(1)
Melanocratic	As used here, a *colour index* term for a rock with *M′* from 65 to 90. Cf. *hololeucocratic*; *leucocratic*; *mesocratic*; *holomelanocratic*.	2
Mesocratic	As used here, a *colour index* term for a rock with *M′* from 35 to 65. Cf. *hololeucocratic*; *leucocratic*; *melanocratic*; *holomelanocratic*.	2
Mesofabric	The *fabric* of a rock as seen in hand specimen, with or without the aid of a hand lens. Cf. *megafabric*; *microfabric*.	
Metamorphic event (metamorphism)	Coherent sequence of metamorphic conditions (temperature, pressure, deformation) under which metamorphic reconstitution commences and continues until it eventually ceases. Represented by an overall clockwise or anticlockwise loop on a P-T grid. May be *monophase* or *polyphase*.	8
Metamorphism	The mineralogical, chemical and structural adjustment of solid rocks to physical and chemical conditions, which have generally been imposed at depth below the surface zones of weathering and diagenesis, and which differ from the conditions under which the rocks originated. The process may coexist with partial melting and may also involve changes in the bulk chemical composition of the rock. See *prograde*; *retrograde*.	1,8
Metasomatism	Metamorphic process, in the solid state, by which the chemical composition of a rock or rock portion is altered in a pervasive manner and which involves the introduction and/or removal of chemical components as a result of the interaction of the rock with aqueous fluids (solutions).	8
Microfabric	The *fabric* of a rock as seen under the microscope. Cf. *megafabric*; *mesofabric*.	1
Mineral assemblage [metamorphism]	The minerals that compose a metamorphic rock or domain in a metamorphic rock. The minerals listed are not necessarily in equilibrium with each other nor result from one metamorphic phase. The list may include the relative abundances of the minerals, but excludes aspects related to texture and fabric. Also referred to as *mineral association*. See *paragenesis*; *paragenetic sequence*.	8,(1)
Mineral association [metamorphism]	A group of minerals found together in a rock. The minerals did not necessarily form in equilibrium. See *mineral assemblage*. Cf. *paragenesis*.	8
Monolithic (fragment rock type)	An unofficial term referring to fragments in a rock consisting of 1 rock type. Cf. *bilithic*; *heterolithic*.	
Monometamorphism	*Metamorphism* resulting from 1 *metamorphic event*; may be *monophase* or *polyphase*. Cf. *polymetamorphism*.	8
Monophase (metamorphism)	*Metamorphic event* with only 1 pressure and/or temperature peak. Cf. *polyphase*.	8
Nematoblastic structure	Type of metamorphic rock structure in which the constituent grains are *homeoblastic*, have an *acicular* or rod-like form, and are arranged parallel to each other. Cf. *granoblastic structure*; *granoblastic-polygonal structure; homeoblastic structure*; *lepidoblastic structure*.	8
Neoblast	A metamorphic crystal that is younger than the other mineral grains of the same or other mineral species in the rock. It may be of a composition different from or identical to the other grains. Antonym: *paleoblast*. [Synonym: holoblast].	8
Neosome	The parts of a migmatite newly formed by, or reconstituted by, partial melting. The neosome may, or may not, have undergone segregation in which the melt and solid fractions are separated.	9

Table 51. *continued*

Modifier	Definition[A]	Source[B]
Paleoblast	A metamorphic crystal that is older than the other mineral grains of the same or other mineral species in the rock. A paleoblast may be of a composition different from or identical to the other grains. Such relicts represent former conditions of equilibration of the rock. [Antonym: *neoblast*].	8,(1)
Paleosome	The non-neosome part of a migmatite that was not affected by partial melting and in which structures (such as foliations, folds, layering) older than the partial melting are preserved. The micostructure (size, form and orientation of grains) is either unchanged, or only slightly coarsened, compared to that in similar rocks just outside the regions affected by *anatexis*.	9
Paragenesis [metamorphism]	An association of minerals in a metamorphic rock considered to have developed under the same physico-chemical conditions. A paragenesis always comprises an equilibrium assemblage. Changing metamorphic conditions may result in new parageneses, resulting in a *paragenetic sequence*. Plural: parageneses. Cf. *mineral assemblage*; *mineral association*.	8
Paragenetic sequence [metamorphism]	The sequential (i.e., temporal) order of mineral formation, taking into account *paragenesis* (equilibrium assemblages). Also called "mineral sequence".	(1)
Penetrative (fabric)	Said of features that contribute to a rock fabric if all subdivisions of the rock at some scale possess those features (e.g., *microfabric*, *mesofabric*, *megafabric*, regional fabric). These features may be penetrative at one scale, but may be nonpenetrative at a different scale.	1, 15
Phacoidal structure	A type of structure characterized by the presence of lenticular *relict*s, up to the metre scale, in a deformed and characteristically finer grained matrix. Cf. *augen structure*; *flaser structure*.	8
Phaneritic	Used here in the sense of a rock in which the crystalline components are large enough to be distinguished with the unaided eye, i.e., megascopically crystalline. Cf. *aphanitic*.	(1)
Phenocryst	A term widely used for a relatively large, conspicuous crystal in a porphyritic rock. Phenocrysts are commonly *euhedral* (to *subhedral*) due to early growth within magma or by crystallization after emplacement. Phenocrysts and/or *porphyroblasts* may occur in a metamorphic rock. Cf. *porphyroblast*.	1
Polymetamorphism	*Metamorphism* resulting from 2 or more *metamorphic events*; each event may be *monophase* or *polyphase*. Recognized through relicts of metamorphic minerals or structures. Each successive event(s) may be of higher or lower *grade*. See *prograde*; *retrograde*.	8
Polyphase (metamorphism)	*Metamorphic event* with 2 or more temperature and/or pressure peaks. Cf. *monophase*.	8
Porphyroblast	A relatively large crystal produced by metamorphic recrystallization and set in a matrix of smaller grains. Cf. *phenocryst*.	1,8
Porphyroclast	A relatively large, recrystallized or brecciated, *relict* crystal in a metamorphic rock, set in a finer grained matrix that was produced by deformation. The crystals in the matrix may have undergone recrystallization.	8,(1)
Porphyroclastic structure	Type of structure characterized by the presence of *porphyroclasts*.	8
Prismatic (crystal habit)	Said of a crystal that shows one dimension markedly longer than the other two. Cf. *acicular*; *equant*; *sheet*; *tabular*.	1
Prograde (metamorphism)	Metamorphic changes in response to a higher pressure and/or temperature than that to which the rock last adjusted itself. Cf. *retrograde.*	1
Protolith	The precursor rock (igneous, sedimentary, or previously metamorphic) from which a given metamorphic rock is derived. [Synonym: parent rock].	8
Pseudomorph	Mineral (or mineral aggregate) in a metamorphic rock, with a shape that is of a pre-existing mineral which it has replaced. Hence pseudomorphous, pseudomorphic (pertaining to a pseudomorph).	8
Reaction rim	Peripheral zone around a mineral grain, composed of another mineral species and formed by reaction between the mineral and its surroundings. See *armoured relict*; *atoll structure*; *corona*.	
Relict	Adjective: pertaining to a mineral, structure or feature of an earlier rock that has persisted in a later rock in spite of processes tending to destroy it. Noun: such a mineral, structure or other feature.	1
Relict structure	Type of structure in a deformed rock characterized by the presence of remnants of the pre-existing undeformed rock. The structure usually takes the form of lenticular *relicts* in a finer grained matrix.	8
Retrograde (metamorphism)	A type of *polymetamorphism* by which metamorphic minerals of a lower *grade* are formed at the expense of minerals characteristic of a higher grade of metamorphism; it is a readjustment necessitated by a change in physical conditions, e.g., the lowering of temperature. Cf. *prograde.* [Synonym: retrogressive metamorphism].	1
Rounded	Said of an object (e.g., crystal, fragment) which is round or curving in shape; original edges and corners smoothed off to rather broad curves; the original shape is still readily apparent. Cf. *well rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Sanidinite facies	Metamorphic *facies* corresponding to extremely high temperatures and low or very low pressures. It lies below the *granulite facies*, in terms of pressure. It is characterized by the occurrence of especially high-temperature varieties and polymorphs of minerals (e.g., pigeonite, potassium-rich labradorite) and of sanidine-rich rocks derived from pelitic rocks (for "pelite", "pelitic", *see* section on Mudrock). Other minerals may include tridymite, mullite, monticellite, larnite. Some rocks show evidence of partial to complete fusion.	1,8

Table 51. *continued*

Modifier	Definition[A]	Source[B]
Schliere (metamorphic)	Streak or minor lenticular part of a rock that differs from the main body of the rock in the mineral content or the ratio of minerals, and which commonly has transitional boundaries. The term was originally used for magmatic rocks but is now also used for similar structures in migmatites: e.g., patches of non-leucosome within the leucosome. Plural: schlieren.	8
Scholle	In a migmatite, a block or raft of *paleosome* within the *neosome*; the neosome is sufficiently abundant that the disrupted blocks float like rafts. Plural: schollen.	8
Sheet (crystal habit)	Said of a mineral that forms flat sheets or flakes, such as phyllosilicates. Cf. *acicular*; *equant*; *prismatic*; *tabular*.	(1)
Spotted (texture)	Type of schist or slate characterized by the presence of concretions or clots representing incipient *porphyroblasts* that may range in size from minute spots to the size of beans. The rocks are characteristic of the outer part of metamorphic *contact aureoles*.	8
Subangular	Said of an object (e.g., crystal, fragment) which is somewhat *angular*, free from sharp angles but not smoothly *rounded*; retaining its original general form, and having faces that are virtually untouched and edges and corners that are rounded off to some extent. Cf. *well rounded*; *rounded*; *subrounded*; *angular*; *very angular*.	(1)
Subgreenschist facies	Metamorphic *facies* defining part of the very low-grade *metamorphism* that is characterized by pressures lower than those of the *glaucophane-schist facies*; the term refers to various metamorphic facies lower in *grade* than the *greenschist facies*, including the previously named prehnite-pumpellyite, prehnite-actinolite, and pumpellyite-actinolite facies and originally the *zeolite facies*.	8
Subidioblast	A *crystalloblast* that is only partly bound by it own crystal faces; hence *subidioblastic structure*. Cf. *idioblast*; *xenoblast*. Comparable to “subhedral” in igneous rocks.	8
Subidioblastic structure	Said of a metamorphic structure in which the constituent grains are partly bounded by the individual crystal faces. Cf. *idioblastic structure*; *xenoblastic structure*.	(8)
Subrounded	Said of an object (e.g., crystal, fragment) which is partially *rounded*; an original general form that is still discernible, many edges and corners noticeably rounded off to smooth curves. Cf. *well rounded*; *rounded*; *subangular*; *angular*; *very angular*.	(1)
Tabular (crystal habit)	Said of a crystal form that shows one dimension markedly smaller than the other two. Cf. *acicular*; *equant*; *prismatic*; *sheet*.	1
Ultramafic	In OGS usage, an adjective for a fine-grained igneous or metamorphic rock having a *colour index* >90.	
Very angular	Said of an object (e.g., crystal, fragment) having very sharp angles or borders; all edges and corners sharp. Cf. *well rounded*; *rounded*; *subrounded*; *subangular*; *angular*.	(1)
Well rounded	Said of an object (e.g., crystal, fragment) with original faces, edges and corners destroyed; entire surface consists of broad curves without any flat areas. Cf. *rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Xenoblast	A *crystalloblast* that is not bounded by any of its own crystal faces; hence *xenoblastic structure*. Cf. *idioblast*; *subidioblast*. Comparable to “anhedral” in igneous rocks.	8
Xenoblastic structure	Said of a metamorphic structure in which the constituent *xenoblasts* are not bounded by the individual crystal faces. Cf. *idioblastic structure; subidioblastic structure*.	(8)
Zeolite facies	Metamorphic *facies* corresponding to the lowest *grade* of *metamorphism*, transitional between diagenesis (or unmetamorphosed rock) and the *subgreenschist facies*. It is characterized by zeolite minerals (analcime, heulandite, stilbite, laumontite, wairakite) and quartz, irrespective of the mode of origin, whether metamorphic (including hydrothermal) or diagenetic. It is best developed in metawacke and metabasalt. Various zeolite assemblages can be correlated with depth of burial.	1,8

[A] *Preferred terms are defined: synonyms are in square brackets for reference only.*

[B] *Indicates source of definition: primary sources are indicated by a number; secondary sources are indicated by numbers in parentheses.*
1 = Neuendorf, Mehl and Jackson (2005); 2 = Le Maitre (2002); 8 = Fettes and Desmons (2007); 9 = Sawyer 2008; 10 = Soller (2004b); 15 = Hobbs, Means and Williams (1976).

Where no source(s) is indicated, definitions are derived from or modified for use by the OGS.

SIZE RANGES

Table 52. Metamorphic rocks: size ranges for various parameters.[A]

Layering thickness	Non-layered	-
	Poorly developed layering, thickness not specified	-
	Layered, thickness not specified	-
	Extremely thinly layered	<1 cm
	Very thinly layered	1 to 3 cm
	Thinly layered	3 to 10 cm
	Medium layered	10 to 30 cm
	Thickly layered	30 to 100 cm
	Very thickly layered	1 to 3 m
	Extremely thickly layered	>3 m
Grain Size (general/ groundmass)	Ultra fine grained	<0.1 mm
	Very fine grained	0.1 to 0.5 mm
	Fine grained	0.5 to 1 mm
	Medium grained	1 to 5 mm
	Coarse grained	5 to 10 mm
	Very coarse grained	10 to 50 mm
	Extremely coarse grained	>50 mm
Grain Size (porphyroblasts, porphyroclasts)	Fine grained	0.5 to 1 mm
	Medium grained	1 to 5 mm
	Coarse grained	5 to 10 mm
	Very coarse grained	10 to 50 mm
	Extremely coarse grained	>50 mm
Fragment Size (breccias)	Small	<1 cm
	Medium	1 to 30 cm
	Large	30 to 100 cm
	Very large	1 to 10 m
	Extremely large	>10 m

[A] *Source of size ranges: layering thickness, adapted from Walker and Cohen (2009); grain size, adapted from Neuendorf, Mehl and Jackson (2005); fragment size, OGS usage.*

OTHER ROCKS

Fault Rocks

The pick list of modifiers for fault rocks (Table 53, back pocket) is structured so that major headings consist of features related to the following:

- matrix (cohesiveness, material, colour, fabric);
- fragments (size, variety, roundness, abundance, composition); and
- structures (porphyroclasts and related systems, mica fish)

MODIFIERS

Modifiers and ancillary terms for fault rocks are listed alphabetically. Words within definitions that are in *italics* are also defined elsewhere in the same table. A word in square [brackets] following a modifier indicates the appropriate geologic theme or topic to which the modifier refers, as the modifier can apply to more than one theme. A word in (parentheses) following a modifier refers to the general topic as laid out in the hierarchical design of the appropriate pick list.

Table 54. Fault rocks: modifier definitions.

Modifier	Definition[A]	Source[B]
Angular	Having sharp angles or borders; most edges and corners sharp. Cf. *well rounded*; *rounded*; *subrounded*; *subangular*; *very angular*.	(1)
Cleavage	Property of a rock to split along a regular set of parallel or subparallel, closely spaced surfaces (*see* Table 26).	8
Cohesive	Refers to a particulate rock (i.e., consisting of particles) that tends to stick together or has a tendency to remain intact, especially when handled. Cf. *incohesive*.	
Fabric	Relative orientation of parts of a rock mass, which commonly refers to crystallographic and/or shape orientation of mineral grains or groups of grains, but can also be used on a larger scale. See *microfabric*; *mesofabric*; *megafabric*. Preferred linear or planar orientation of the parts is termed “linear fabric” and “planar fabric”, respectively, and lack of preferred orientation is referred to as “random fabric”.	8
Foliated	Said of a rock having *foliation*.	
Foliation	A general term for any repetitively occurring or *penetrative* planar feature in a rock body. Examples include layering on a scale of a centimetre or less, and the preferred planar orientation of inequant mineral grains or grain aggregates. Includes *schistose structure*, *gneissose structure*, *cleavage*.	8
Gneissosity	Replaced by the synonymous term *gneissose structure*.	8
Gneissose structure	Type of structure characterized by a planar *fabric* that is either poorly developed throughout the rock or, if well developed, occurs in broadly spaced zones, such that the rock will split on a scale of >1 cm. Mineralogical or lithological layering, streaks and/or lenticles are commonly present. Replaces the term “gneissosity”.	8
Incohesive	Refers to a particulate rock (i.e., consisting of particles) that does not tend to stick together or has a tendency to fall apart, especially when handled. Cf. *cohesive*.	
Mantled porphyroclast	Term covering the geometry of a *porphyroclast* and its tails, formed by dynamically recrystallized material. The asymmetry of the system indicates the sense of shear. (Cf. Fettes and Desmons (2007); *see* Structural Terms – Modifiers).	(8)
Massive	Said of a rock with constituents that are neither oriented in parallel position nor arranged in layers; that is, a rock that does not have *schistosity*, *foliation*, or any similar structure.	1
Megafabric	The *fabric* of a rock as seen in an outcrop. Cf. *microfabric*; *mesofabric*.	(1)
Mesofabric	The *fabric* of a rock as seen in hand specimen, with or without the aid of a hand lens. Cf. *microfabric*; *megafabric*.	
Mica fish	Asymmetric or lozenge-shaped mica *porphyroclast*s found in some mylonites. The asymmetry indicates the sense of shear.	8
Microfabric	The *fabric* of a rock as seen under the microscope. Cf. *mesofabric*; *megafabric*.	1

Table 54. *continued*

Modifier	Definition[A]	Source[B]
Penetrative (fabric)	Said of features that contribute to a rock *fabric* if all subdivisions of the rock at some scale possess those features (e.g., *microfabric*, *mesofabric*, *megafabric*, regional fabric). These features may be penetrative at one scale, but may be nonpenetrative at a different scale.	(1)
Porphyroclast	A relatively large relict crystal in a deformed metamorphic rock, set in a finer grained matrix that was produced by deformation. The crystals in the matrix may have undergone recrystallization. See *mantled porphyroclast*.	8,(1)
Rounded	Round or curving in shape; original edges and corners smoothed off to rather broad curves; the original shape is still readily apparent. Cf. *well rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Schistose	Said of a rock having *schistose structure*.	
Schistose structure	Type of structure characterized by a *schistosity* that is well developed, either uniformly throughout the rock or in narrowly spaced repetitive zones such that the rock will split on a scale of 1 cm or less.	8
Schistosity	Preferred orientation of inequant mineral grains or grain aggregates produced by metamorphic processes. Schistosity is present in most cleavage types with the exception of some disjunctive cleavages (e.g., fracture cleavage). If "well developed", there is a high degree of preferred orientation of a large amount of inequant mineral grains or grain aggregates either throughout the rock or in narrowly spaced repetitive zones such that the rock tends to split on a scale of ≤1 cm. If "poorly developed", there is either a low degree of preferred orientation of a small amount of inequant mineral grains or grain aggregates; or a high degree of preferred orientation of inequant grains occurring in broadly spaced zones such that the rock tends to split on a scale of >1 cm.	8
Subangular	Somewhat angular, free from sharp angles but not smoothly rounded; retaining its original general form, and having faces that are virtually untouched and edges and corners that are rounded off to some extent. Cf. *well rounded*; *rounded*; *subrounded*; *angular*; *very angular*.	(1)
Subrounded	Partially rounded; an original general form that is still discernible, many edges and corners noticeably rounded off to smooth curves. Cf. *well rounded*; *rounded*; *subangular*; *angular*; *very angular*.	(1)
Very angular	Having very sharp angles or borders; all edges and corners sharp. Cf. *well rounded*; *rounded*; *subrounded*; *subangular*; *angular*.	(1)
Well rounded	Original faces, edges and corners have been destroyed; entire surface consists of broad curves without any flat areas. Cf. *rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)

[A] Preferred terms are defined: synonyms are in square brackets for reference only.
[B] Indicates source of definition: primary sources are indicated by a number; secondary sources are indicated by numbers in parentheses.
1 = Neuendorf, Mehl and Jackson (2005); 8 = Fettes and Desmons (2007).
Where no source(s) is indicated, definitions are derived from or modified for use by the OGS.

SIZE RANGES

Table 55. Fault rocks: size ranges for various parameters.[A]

Fault Rocks	Fragment size (general, maximum)	Very small	<1 mm
		Small	1 to 10 mm
		Medium	1 to 30 cm
		Large	30 to 100 cm
		Very large	1 to 10 m
		Extremely large	>10 m
	Crystal size (e.g., augen)	Fine grained	0.5 to 1 mm
		Medium grained	1 to 5 mm
		Coarse grained	5 to 10 mm
		Very coarse grained	10 to 50 mm
		Extremely coarse grained	>50 mm

[A] Adapted from a variety of sources and modified for OGS usage.

Impactite Rocks

The pick lists of modifiers for impactites (Tables 56, 57, 58, 59: back pocket) are structured so that major headings consist of features related to the following:

- form (e.g., irregular body, dike);
- contact relationships (e.g., concordant, discordant);
- unit thickness;
- degree of heterogeneity;
- rock fabric (massive, foliated);
- bedding, internal sedimentary structures;
- matrix features; and
- fragment features.

MODIFIERS

Modifiers and ancillary terms for impactites are listed alphabetically. Some features have not been reported or interpreted in actual impact deposits, but are included here as a pre-emptory list of possibilities. Words within definitions that are in *italics* are also defined elsewhere in the same table. A word in square [brackets] following a modifier indicates the appropriate geologic theme or topic to which the modifier refers, as the modifier can apply to more than one theme. A word in (parentheses) following a modifier refers to the general topic as laid out in the hierarchical design of the appropriate pick list.

Table 60. Impactite rocks: modifier definitions.

Modifier	Definition[A]	Source[B]
Accretionary (lapilli size)	Spheroidal pellets, mostly between 1 mm and 1 cm in mean diameter, of consolidated or cemented ash-size material. Formed by accretion of *particles* around wet nuclei, e.g., raindrops falling through a cloud of ash-size material or accretion in a wet surge cloud.	1
Acicular (crystal habit)	Said of a crystal that is needle-like in form. Cf. *equant*; *prismatic*; *sheet*; *tabular*.	1
Acicular daisy	Used here to refer to *acicular* crystals arranged in radiating clusters resembling the petals (ray florets) of a daisy (flower) without the central disc (disc florets).	
Angular	Having sharp angles or borders; most edges and corners sharp. Cf. *well rounded*; *rounded*; *subrounded*; *subangular*; *very angular*.	(1)
Angular unconformity	An *unconformity* between 2 rock units with bedding planes that are not parallel or in which the older, underlying rocks dip at a different angle (usually steeper) than the younger, overlying strata; specifically an unconformity in which younger deposits rest upon the eroded surface of tilted or folded older rocks.	1
Anhedral	Said of a crystal lacking well-developed crystal faces. Cf. *subhedral*, *euhedral*.	1
Aphanitic	As used here, any fine-grained igneous-textured rock with components that are not distinguishable with the unaided eye (approximately <0.1 mm).	1,8
Armoured (lapilli size)	A lapilli-size crystal, pumice or lithic *fragment* nucleus, coated by fine to coarse ash-size material.	4
Basal Member	*Sudbury Structure* term. An older term for the lowermost member of the *Onaping Formation* and what now constitutes, collectively, the *Garson Member* and the *Onaping intrusion*. Previous Basal Member definition: a variety of monolithic or heterolithic *breccias* consisting of *fragments* of Archean and Proterozoic igneous, metamorphic or sedimentary rocks in a fine-grained recrystallized matrix. Cf. *Garson Member*. As there are significant differences in map or rock interpretations, the term Basal Member is retained here until a consensus is achieved.	12
Bedding-plane sag	Depressed and disturbed strata or laminae of suevite or other deposit into which a block or *bomb* has fallen.	
Bilithic (fragment rock type)	An unofficial term referring to *fragments* in an impact breccia consisting of 2 rock types. Cf. *monolithic*; *heterolithic*.	

Table 60. *continued*

Modifier	Definition[A]	Source[B]
Bomb (impact)	As used here, a *fragment* of impact *melt* ejected while viscous and shaped while in flight and/or upon impact with the ground. It is larger than 64 mm in diameter, and may be vesicular and/or flow layered. Actual shape or form varies greatly, and is used in descriptive classification. See *breadcrust*; *cored bomb*; *cow-dung*; *fusiform*; *ribbon*; *rotational*; *spherical*; *spindle-shaped*.	1
Breadcrust (bomb)	A type of *bomb* characterized by a network of open cracks on its surface, due to continued expansion of the interior after solidification of the crust. Cf. *cored bomb*; *cow-dung*; *fusiform*; *ribbon*; *rotational*; *spherical*; *spindle-shaped*.	1
Breccia (impactite)	Impact-related breccias include several varieties (*see* Tables 34, 35). They collectively may consist of any combination of broken country rock of any rock type (including pre-existing tectonic breccia), any shape and size of *fragment*, a variety of degrees of shock metamorphism, and with or without an impact-*melt*-related component, of any size, shape and composition. Many of these factors depend on the target rocks, the size of the meteorite and proximity to the initial impact site.	
Breccia in breccia (fragment)	An impactite *breccia fragment* containing a fragment (or fragments) of breccia that is pre-existing breccia or an impact breccia.	
Bubble wall (shard)	A *shard* with outlines demarking some of the thin walls of bubbles formed before fragmentation took place.	
Comminuted material	As used here, material reduced to very small *particle*s (microscopic size) through crushing, grinding or explosive forces.	
Complex "glasses" (fragment)	Informal: once glassy *fragments* currently displaying complex or complicated internal textures and currently consisting of felsic and mafic minerals. Cf. *simple "glasses"*.	11
Composite breccia (fragment)	Refers to a *fragment* of *breccia* within a breccia body or breccia fragment (breccia in breccia). The enclosed breccia may or may not be a pre-impact breccia.	
Composite (fragment)	Refers to a *fragment* with more than one textural or structural component or stage of development. See: *accretionary*; *armoured*; *composite breccia*; *cored*.	
Concordant	Used in this sense, a contact that is parallel to foliation or bedding in the country rock. Cf. *discordant*.	(1)
Contact sublayer	*Sudbury Structure* term. Inclusion- and sulphide-bearing gabbronoritic to noritic rock, generally occurring at or near the base of the *Sudbury Igneous Complex*.	13
Cored (fragment)	Refers to a *lapilli*- or *bomb*-size *fragment* of rock, around which unsolidified impact *melt* has moulded itself prior to solidification. Collectively, the roundness of the cores, of any type, ranges from *well rounded* to *very angular*. See *cored aphanitic melt*; *cored breccia*; *cored flow-layered; cored lithic*; *cored welded.*	
Cored (bomb)	As used here, a type of impact-related *bomb* that has a core consisting of intact pre-impact country rock or impact-generated rock (*breccia*, *melt*), which is completely or partly enveloped by impact *melt*. Cf. *breadcrust*; *cow-dung*; *fusiform*; *ribbon*; *rotational*; *spherical*; *spindle-shaped*.	
Cored aphanitic melt (fragment)	A cored lapillus or bomb consisting of a *fragment* of generally massive, *aphanitic* impact *melt* partly or completely enveloped by impact *melt* having a different texture and/or composition. Cf. *cored breccia*; *cored flow-layered; cored lithic*; *cored welded.*	
Cored breccia (fragment)	A cored lapillus or bomb consisting of a *fragment* of *breccia*, either a pre-existing breccia or an impact breccia, which is partly or completely enveloped by impact *melt*. Cf. *cored aphanitic melt*; *cored flow-layered; cored lithic*; *cored welded.*	
Cored breccia in breccia (fragment)	A cored lapillus or bomb consisting of a *breccia in breccia fragment* that is partly or completely enveloped by impact melt. Cf. *cored aphanitic melt*; *cored flow-layered*; *cored breccia*; *cored lithic*; *cored welded*.	
Cored flow-layered (fragment)	A cored lapillus or bomb consisting of a *fragment* of a type of impact *melt* with *flow layering*, which is partly or completely enveloped by impact melt (generally without flow layering). Cf. *cored aphanitic melt*; *cored breccia*; *cored lithic*; *cored welded.*	
Cored lithic (fragment)	A cored lapillus or bomb consisting of a *fragment* of country ("target") rock which is partly or completely enveloped by impact *melt*. Cf. *cored aphanitic melt*; *cored breccia*; *cored flow-layered; cored welded.*	
Cored welded (fragment)	A cored lapillus or bomb consisting of a *fragment* of slightly to highly *welded* material, which is partly or completely enveloped by impact *melt*. Cf. *cored aphanitic melt*; *cored breccia*; *cored flow-layered; cored lithic.*	
Cow-dung (bomb)	As used here, a type of impact-related *bomb* with a flattened shape (resembling a cow pie) that is due to its impact with the ground while still viscous. Its surface may be somewhat scoriaceous. Cf. *breadcrust*; *cored bomb*; *fusiform*; *ribbon*; *rotational*; *spherical*; *spindle-shaped*.	
Crystal particles	Refers to broken crystals of any size.	
Cuspate (shard)	A *shard* with curved outlines which are due to relatively small parts of the walls of bubbles before fragmentation.	

Table 60. *continued*

Modifier	Definition[A]	Source[B]
Degassing pipe	A type of fumarole formed by gasses escaping from a blanketing suevite unit, particularly the upper un*welded* parts, as indicated by fines (ash)-depleted (with corresponding "enrichment" in crystals and lithic *fragments*) and/or oxidized linear or curvilinear zones. Cf. *water-escape structure*.	(6)
Disconformity	An *unconformity* in which the bedding planes above and below the break are essentially parallel, indicating a significant interruption in the orderly sequence of ordinary sedimentary rocks, generally by a considerable interval of erosion (or sometimes of nondeposition), and usually marked by a visible and irregular or uneven erosion surface of appreciable relief; e.g., an unconformity in which the older rocks remained essentially horizontal during erosion or during simple vertical rising and sinking of the crust (without tilting or faulting).	1
Discordant	Used in this sense, a contact that is not parallel to foliation or bedding in the country rock. Cf. *concordant*.	1
Dowling Member	*Sudbury Structure* term. Uppermost member of the *Onaping Formation*: fragmental rocks composed of <30% altered lenticular vitric andesitic composition melt *fragments* and >50% matrix; dominantly tuff-like suevite with minor lapilli-tuff-like suevite. Middle and upper parts are block- and *bomb*-poor; chlorite-calcite alteration is locally common; matrix may contain carbon.	(13)
Draped bedding	Bedding, formed by deposition from suspension, and blanketing the underlying topography. Layer thickness may decrease over topographic highs.	
Equant	Said of a crystal having the same or nearly the same diameter in all directions. Cf. *acicular*; *prismatic*; *sheet*; *tabular*. [Synonym: equidimensional].	1
Equigranular	Texture consisting of grains roughly equal in size; term used primarily for igneous and metamorphic rocks but also here for impact *melt*.	1
Euhedral	Said of a crystal bounded by "perfect" crystal faces; well-formed. Cf. *anhedral*; *subhedral*. [Synonym: *idiomorphic*].	1
Felsic	As used here, an adjective for a fine-grained intrusive, volcanic or impact melt rock with a colour index <15.	
Felsic norite	*Sudbury Structure* term, previously used for a variety of "*norite*" found in the Lower zone of the *Sudbury Igneous Complex* (North Range). Cf. *mafic norite*, *quartz-rich norite*.	13
Flow layering	The structure of a once-molten rock, characterized by various layers of colour, mineralogic composition, and/or texture, formed as a result of the flow of inhomogeneous molten material. The flow layering may be straight, wavy or convolute (i.e., disorganized, intricately crumpled).	(1)
Fluid-escape structure	A general term for a feature produced by the escape of fluids (gas or liquid) from a unit after deposition. See *degassing pipe*; *water-escape structure*.	(1)
Footwall breccia	*Sudbury Structure* term. Generally, heterolithic breccia containing footwall rock *fragments* set in a contact metamorphic, granoblastic and, in places, *granophyre*-like matrix.	13
Fragment	A rock or mineral *particle* larger than a *grain*; a piece of rock that has been detached or broken from a pre-existing mass.	1
Fresh surface	Refers to a surface that exposes rock that has not undergone weathering. Cf. *weathered surface*.	
Fusiform (bomb)	As used here, a type of impact-related *bomb* that tapers and slightly twists at both ends from an enlarged middle; it includes both rotational bombs and spindle-shaped bombs. Cf. *breadcrust*; *cored bomb*; *cow-dung*; *ribbon*; *rotational*; *spherical*; *spindle-shaped*.	1
Garson Member	*Sudbury Structure* term. The lowermost member of the *Onaping Formation*: thick-bedded to massive fragmental rocks dominated by >20 to 85% Huronian "quartzite" *fragments* (<6 cm in diameter) and blocks (>6 cm to 50 m in diameter), and containing up to 15% vitric andesitic lapilli-size fragments, and <5% vitric andesitic composition bomb- and block-size fragments. Lapillistone-like suevite and coarse tuff breccia-like suevite units are most common, the latter with a lapillistone- to lapilli-tuff-like matrix. Depositional units are typically massive to reversely graded. Cf. *Basal Member*.	(13)
Glassy/microcrystalline	Used in a Precambrian context: having the appearance of originally being glass or currently being microcrystalline.	
Graded bedding	A type of internal depositional structure in which each layer displays a gradual and progressive change in *particle* size, usually from coarse at the base of the bed to fine at the top. Classified into *normal graded bedding*; *reverse graded bedding*.	1
Grain	A kind of *particle* that is a mineral or rock particle smaller than a *fragment*, having a diameter of less than a few millimetres and generally lacking well-developed crystal faces.	(1)
Granophyre	*Sudbury Structure* term, previously used for a variety of granite found in the Upper zone of the *Sudbury Igneous Complex*. Does not have plagioclase phenocrysts, implicit in the traditional definition of granophyre (*see* Table 5). Cf. plagioclase-rich granophyre.	13
Heterolithic (fragment rock type)	An unofficial term referring to *fragments* in an impact breccia consisting of 3 or more rock types. Cf. *monolithic*; *bilithic*.	

Table 60. *continued*

Modifier	Definition[A]	Source[B]
Holocrystalline	Used in the impact context, said of the texture of once molten material now composed entirely of crystals, i.e., having no *glassy* part. Cf. *hypocrystalline*.	(1)
Hypidiomorphic-granular	Used in the impact context, a phaneritic igneous-like texture dominated by *subhedral*, *equant* crystals. Cf. *idiomorphic-granular*; *xenomorphic-granular*.	(1)
Hypocrystalline	Used in the impact context, said of once molten material now composed of a mixture of crystals and *glassy* material.	1
Idiomorphic-granular	Used in the impact context. a phaneritic igneous-like texture dominated by *euhedral*, *equant* crystals. Cf. *hypidiomorphic-granular*; *xenomorphic-granular*.	(1)
Intermediate	As used here, an adjective for a fine-grained intrusive, volcanic or impact melt rock with a colour index from 15 to 35.	
Internal offset dike	*Sudbury Structure* term. Local, tabular, dike-like bodies, consisting of numerous *mafic* (± intermediate, ultramafic) igneous-textured fragments in an igneous-textured matrix, which intrude the lower zone of the *Sudbury Igneous Complex*.	
Lithic	Used in the sense of pertaining to consolidated rock material that does not consist of *glassy* or *melt* material.	
Load structure	Any structure formed from the weight of overlying material, such as a load cast, flame structure, or ball-and-pillow structure.	
Mafic	As used here, an adjective for a fine-grained intrusive, volcanic or impact melt rock with a colour index from 35 to 90.	
Mafic norite	*Sudbury Structure* term, previously used for a variety of "*norite*" found in the Lower zone of the *Sudbury Igneous Complex* (North Range). Cf. *felsic norite*, *quartz-rich norite*.	13
Main mass	*Sudbury Structure* term for the main part of the *Sudbury Igneous Complex* overlying the *contact sublayer*. Consists of the Lower zone (quartz monzogabbro, quartz gabbro); Middle zone (quartz monzogabbro, quartz gabbro); Upper zone (granite, granodiorite).	
Massive	Said of a rock with constituents that are neither oriented in parallel position nor arranged in layers; that is, a rock that does not have schistosity, foliation, or any similar structure.	1
Melt (impact)	Melt formed by *shock melting* of rocks in impact craters.	
Melt body	*Sudbury Structure* term. Irregularly shaped bodies, within or at the base of the *Onaping Formation*, with a fine-grained igneous-like-textured matrix and few to numerous inclusions.	
Melt dike	*Sudbury Structure* term. *Aphanitic* tabular bodies that intrude the *Onaping Formation* and may display *flow-layering* and/or *spherulitic* textures.	
Moderately sorted	As used here, said of sorted particulate material that is intermediate between *poorly sorted* and *well sorted*.	1
Monolithic (fragment rock type)	An unofficial term referring to *fragments* in an impact breccia consisting of essentially 1 rock type. Cf. *bilithic*; *heterolithic*.	
Norite	*Sudbury Structure* term, previously used for a variety of gabbro found in the Lower zone of the *Sudbury Igneous Complex* (South Range).	13
Normal graded bedding	A type of *graded bedding* in which *particle* size decreases systematically toward the top of the bed. Cf. *reverse graded bedding*.	7
Offset dike	*Sudbury Structure* term. Commonly referred to as quartz diorite; more precisely, it collectively includes granodiorite, quartz monzodiorite, quartz diorite. Generalized "phases" are a) marginal inclusion/sulphide-free phase; and b) central sulphide/inclusion-rich phase. Occurs as dike-like bodies structurally below the main part of the *Sudbury Igneous Complex*, within the "basement" or footwall rocks.	13
Onaping Formation	*Sudbury Structure* term. The lowermost of 3 formations of the *Whitewater Group* and immediately overlying the *Sudbury Igneous Complex*. The Onaping Formation represents a complex crater-fill sequence of vitric breccias and redeposited material, which have been subdivided into *Garson Member*, *Sandcherry Member* and *Dowling Member*.	(13)
Onaping intrusion	*Sudbury Structure* term. Xenolithic "*quartz diorite*" with abundant partially assimilated Archean and Proterozoic *fragments*.	13
Particle	A general term, used without restriction as to shape, composition or internal structure, for a separable or distinct unit in a rock, such as a *fragment* or a *grain*.	1
Plagioclase-rich granophyre	*Sudbury Structure* term, previously used for a variety of granodiorite found in the Upper zone of the *Sudbury Igneous Complex*. Does not have plagioclase phenocrysts, implicit in the traditional definition of granophyre (*see* Table 5). Cf. *granophyre*.	(13)
Platy (shard)	Refers to *shards* that appear to be relatively straight thin plates after fragmentation.	
Poorly sorted	As used here, said of particulate material that is not sorted or that shows a wide spread of sizes around the average size, or that consists of *particles* of many sizes mixed together in an unsystematic manner so that no one size class predominates. Cf. *moderately sorted*; *well sorted*.	1

Table 60. *continued*

Modifier	Definition[A]	Source[B]
Prismatic (crystal habit)	Said of a crystal that shows one dimension markedly longer than the other two. Cf. *acicular*; *equant*; *sheet*; *tabular*.	1
Quartz diorite	*Sudbury Structure* term, previously used for a variety of rock compositions, ranging from granodiorite to quartz monzodiorite to diorite, found in the *Offset dikes* of the *Sudbury Igneous Complex*.	13
Quartz gabbro	*Sudbury Structure* term, previously used for a variety of gabbro found in the Middle zone of the *Sudbury Igneous Complex*.	13
Quartz-rich norite	*Sudbury Structure* term, previously used for a variety of "*norite*" found in the Lower zone of the *Sudbury Igneous Complex* (South Range). Cf. *felsic norite*, *mafic norite*.	13
Reverse graded bedding	A type of *graded bedding* in which *particle* size increases systematically toward the top of the bed. Cf. *normal graded bedding*.	7
Ribbon (bomb)	As used here, a type of impact-related *bomb* which is flat and elongate, some with a circular cross-section and typically fluted along the length; may have tabular vesicles. Cf. *breadcrust*; *cored bomb*; *cow-dung*; *fusiform*; *rotational*; *spherical*; *spindle-shaped*.	
Rotational (bomb)	As used here, a type of impact-related fusiform *bomb* with a shape that is formed by spiral motion or rotation during flight; rotation produces such types as spherical, tear-shaped and spindle-shaped bombs. Cf. *breadcrust*; *cored bomb*; *cow-dung*; *fusiform*; *ribbon*; *spherical*; *spindle-shaped*.	(1)
Rounded	Round or curving in shape; original edges and corners smoothed off to rather broad curves; the original shape is still readily apparent. Cf. *well rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Sandcherry Member	*Sudbury Structure* term. Middle member of the *Onaping Formation*: fragmental rocks composed of >60% altered, blocky, vitric andesitic composition *fragments*, <35% matrix; locally block- and *bomb*-rich units; composed of melt fragments (with or without *flow layering*) units and *equant shard* units; dominantly lapilli-tuff-like suevite to lapillistone-like suevite; in part silicified and/or albitized; may contain carbon in the matrix.	(13)
Shard	A vitric *fragment* formed by quick cooling and shattering of once molten material; some shards have a characteristically curved surface of fracture. Shards generally consist of bubble-wall fragments produced by disintegration of pumiceous material. See *bubble wall*; *cuspate*; *platy*.	1
Shatter cone	A distinctively striated conical structure in rocks, ranging in length from less than a centimetre to several metres. It is generally found in nested or composite groups in the rocks of impact structures and formed by shock waves generated by impact. The cones are most common in fine-grained homogeneous rocks such as limestone and dolomite, but are also known in shale, sandstone, quartzite and granite. The striated surfaces radiate outward from the apex in horsetail fashion; the apical angle varies but is close to 90°. Shatter cones superficially resemble cone-in-cone structure in sedimentary rocks.	1
Sheet (crystal habit)	Said of a mineral that forms flat sheets or flakes, such as phyllosilicates. Cf. *acicular*; *equant*; *prismatic*; *tabular*.	
Shock melting	Melting of solid matter by shock wave compression resulting from high post-shock temperature after pressure release.	8
Shock metamorphism	The permanent physical, chemical, mineralogic and morphologic changes produced in rocks and minerals by the passage of high-pressure shock waves acting over time intervals ranging from a few microseconds to a fraction of a minute. The only known natural mechanism for producing shock-metamorphic effects is the hypervelocity impact of meteorites. Can also occur with man-made, small-scale laboratory experiments, nuclear explosions and chemical explosions.	1
Simple "glasses" (fragment)	Informal term: once *glassy* fragments currently displaying uncomplicated internal textures and currently consisting of essentially monomineralic felsic or mafic minerals. Cf. *complex "glasses"*.	11
Slump structure	(a) A landslide characterized by a shearing and rotary movement of a generally independent mass of rock or earth along a curved slip surface (concave upward) and about an axis parallel to the slope from which it descends, and by backward tilting of the mass with respect to that slope so that the slump surface often exhibits a reversed slope facing uphill; (b) The sliding-down of a mass of deposited material shortly after its deposition on an underwater slope; especially the downslope flowage of soft, unconsolidated marine sediments, as at the head or along the side of a submarine canyon; (c) The mass of material slipped down during, or produced by, a slump.	1
Spherical (bomb)	As used here, a spherical-shaped impact-related *bomb*, formed from highly to moderately fluid magma with interaction from surface tension during flight. Cf. *breadcrust*; *cored bomb*; *cow-dung*; *fusiform*; *ribbon*; *rotational*; *spindle-shaped*.	
Spherulite	A *rounded* or spherical mass of *acicular* crystals, commonly of feldspar, radiating from a central point. Spherulites may range in size from microscopic to several centimetres in diameter. Most commonly formed by the devitrification of volcanic or impact-generated glass.	(1)
Spherulitic	Having or containing *spherulites*.	

Table 60. *continued*

Modifier	Definition[A]	Source[B]
Spindle-shaped (bomb)	A used here, a type of impact-related *fusiform bomb*, with earlike projections at its ends and longitudinal fluting with one side smoother than the other (aerodynamic effect). Cf. *breadcrust*; *cored bomb*; *cow-dung*; *fusiform*; *ribbon*; *rotational*; *spherical*.	
Subangular	Somewhat angular, free from sharp angles but not smoothly *rounded*; retaining its original general form, and having faces that are virtually untouched and edges and corners that are rounded off to some extent. Cf. *well rounded*; *rounded*; *subrounded*; *angular*; *very angular*.	(1)
Subequant	Said of a crystal having roughly the same or nearly the same diameter in all directions, but not as much as *equant* crystals.	
Subhedral	Said of a crystal partly bounded by crystal faces; intermediate between *euhedral* and *anhedral*.	1
Subrounded	Partially *rounded*; an original general form that is still discernible, many edges and corners noticeably rounded off to smooth curves. Cf. *well rounded*; *rounded*; *subangular*; *angular*; *very angular*.	(1)
Sudbury breccia	*Sudbury Structure* term. *Breccia* bodies, collectively ranging from dike-like to irregularly shaped, with an overall wide range in characteristics: simplified as randomly oriented, *well-rounded* to *subangular* blocks and small *fragments* of largely locally derived country rock, in a very fine-grained pseudotachylitic and/or cataclastic matrix.	(13)
Sudbury Igneous Complex	*Sudbury Structure* term. Large, thick, impact-related melt sheet, consisting, from lower to upper: *Offset dikes*; *Contact sublayer*; *Main mass*.	13
Sudbury Structure	General term used for the structure created by an impact event ca. 1850 Ma. Approximately indicated currently as an oval-shaped "ring" (resulting from deformation) visible on satellite images, outlined as a topographic high largely by the *Sudbury Igneous Complex* and *Onaping Formation*.	
Tabular (crystal habit)	Said of a crystal form that shows one dimension markedly smaller than the other two. Cf. *acicular*; *equant*; *prismatic*; *sheet*.	1
Ultramafic	As used here, an adjective for a fine-grained intrusive, volcanic or impact melt rock with a colour index >90.	
Unconformity	A notable break or gap in the geological record where a rock unit is overlain by another that is not next in depositional succession, such as an interruption in the continuity of deposition or a break between eroded igneous and/or sedimentary rocks.	1
Unzoned (contact)	No variation in the composition of a once-molten body (mineralogical, grain size, etc.) in relation to its contact with the country rock.	
Very angular	Having very sharp angles or borders; all edges and corners sharp. Cf. *well rounded*; *rounded*; *subrounded*; *subangular*; *angular*.	
Water-escape structure	A general term referring to any fluid-escape structure caused by water escaping upward under pressure, usually from the overlying material. Cf. *degassing pipe*.	
Weathered surface	Used to refer to the surface rind of a rock that has undergone weathering, as evident by colour, mineralogy, hardness, porosity, etc. Typically <1 cm thick, the weathered rock may be <1 mm thick to tens of centimetres thick. Cf. *fresh surface*.	
Welded	A texture of once-hot rocks that is formed by the heat and pressure of still-plastic *particle*s as they are deposited and fuse together to various degrees.	(1)
Well rounded	Original faces, edges and corners have been destroyed; entire surface consists of broad curves without any flat areas. Cf. *rounded*; *subrounded*; *subangular*; *angular*; *very angular*.	(1)
Well sorted	As used here, said of sorted particulate material that consists of *particles* all having approximately the same size. Cf. *moderately sorted*; *poorly sorted*.	1
Whitewater Group	*Sudbury Structure* term. Basin (crater) infill material, subdivided into 3 formations, from lower to upper: *Onaping Formation* (impact-related *breccia*s and *melt*); Onwatin Formation (carbonaceous and pyritic mudstone and minor wacke); Chelmsford Formation (turbiditic wacke and siltstone).	13
Xenomorphic-granular	Used in the impact context, a phaneritic igneous-like texture dominated by *anhedral*, *equant* crystals. Cf. *hypidiomorphic-granular*, *idiomorphic-granular*.	1
Zoned (contact)	Systematic variation in the composition of a once-molten body (mineralogical, grain size, etc.) in relation to its contact with the country rock.	

[A] *Preferred terms are defined: synonyms are in square brackets for reference only.*
[B] *Indicates source of definition: primary sources are indicated by a number; secondary sources are indicated by numbers in parentheses.*
1 = Neuendorf, Mehl and Jackson (2005); 4 = McPhie, Doyle and Allen (1993); 6 = Fisher and Schmincke (1984); 7 = Soller (2004a); 8 = Fettes and Desmons (2007); 11 = Muir and Peredery (1984); 12 = Dressler (1984); 13 = Ames, Davidson and Wodicka (2008).
Where no source(s) is indicated, definitions are derived from or modified for use by the OGS.

SIZE RANGES

Table 61. Impactite rocks: size ranges for various parameters.[A]

Impact pseudotachylite	Thickness	Very thin	<1 mm
		Thin	1 to 10 mm
		Medium	1 to 30 cm
		Thick	30 to 100 cm
		Very thick	>1 m
	Fragment size: general, maximum	Very small	< 1 mm
		Small	1 to 10 mm
		Medium	1 to 30 cm
		Large	30 to 100 cm
		Very large	1 to 10 m
		Extremely large	> 10 m
Lithic impact breccia	Unit thickness	Thin	<1 cm
		Medium	1 to 30 cm
		Thick	30 to 100 cm
		Very thick	1 to 10 m
		Extremely thick	>10 m
	Fragment size: general, maximum	Very small	<1 mm
		Small	1 to 10 mm
		Medium	1 to 30 cm
		Large	30 to 100 cm
		Very large	1 to 10 m
		Extremely large	>10 m
Suevite	Unit thickness	Thin	<1 cm
		Medium	1 to 30 cm
		Thick	30 to 100 cm
		Very thick	1 to 10 m
		Extremely thick	>10 m
	Bedding thickness	Thinly laminated	<3 mm
		Thickly laminated	3 to 10 mm
		Very thinly bedded	1 to 3 cm
		Thinly bedded	3 to 10 cm
		Medium bedded	10 to 30 cm
		Thickly bedded	30 to 100 cm
		Very thickly bedded	1 to 3 m
		Extremely thickly bedded	>3 m
	Fragment size: ash size	Fine ash	<0.0625 mm
		Coarse ash	0.0625 to 2 mm
	Lapilli size	Fine	2 to 16 mm
		Medium	16 to 32 mm
		Coarse	32 to 64 mm
	Block size and bomb size	Small	64 to 100 mm
		Medium	10 to 30 cm
		Large	30 to 100 cm
		Very large	1 to 10 m
		Extremely large	>10 m
Impact melt rock	Unit thickness	Thin	<1 cm
		Medium	1 to 30 cm
		Thick	30 to 100 cm
		Very thick	1 to 10 m
		Extremely thick	>10 m

Table 61. *continued*

Impact melt rock, *cont'd*	Flow layering	Very thin	<1 mm
		Thin	1 to 5 mm
		Medium	5 to 10 mm
		Thick	1 to 5 cm
		Very thick	>5 cm
	Matrix (crystal size)	Aphanitic	<0.1 mm
		Very fine grained	0.1 to 0.5 mm
		Fine grained	0.5 to 1 mm
		Medium grained	1 to 5 mm
		Coarse grained	5 to 10 mm
		Very coarse grained	>10 mm
	Fragment size	Very small	<1 mm
		Small	1 to 10 mm
		Medium	1 to 30 cm
		Large	30 to 100 cm
		Very large	1 to 10 m
		Extremely large	>10 m

[A]*Adapted from a variety of sources and modified for OGS usage.*

STRUCTURAL TERMS

The structural terms, as laid out in the "structural" pick list (Table 62, back pocket), are intended to provide a way to record specific information about various structural features that go beyond strike/dip or trend/plunge measurements. The goal is to characterize or demonstrate spatial "domains" at a map scale or temporal events of commonality with respect to fabrics (planar or linear), fractures (e.g., joints), faults (sense of shear or movement), folds (asymmetry or vergence), winged objects (style), and other kinematic indicators.

The structural terms pick list is structured so that major headings consist of features related to:

- fabric (e.g., S-tectonite, linear elements);
- generation of feature (e.g., relative chronology);
- element (planar, linear)
- folds (e.g., morphology, classification, orientation);
- fractures (e.g., faults, joints);
- kinematic indicators (e.g., markers, rotation, pressure shadow, vergence)
- sense and direction of shear (e.g., three-dimensional geometry); and
- bedrock symbols

Graphic illustrations of some specific structural features are included as follows:

- Fold – facing (*see* "facing (fold)"); (Figure 36)
- Fold – superposed patterns, sheath fold (Figure 37)
- Kinematic indicators – foliation pairs as S-C-C′ fabrics (Figure 38)
- Kinematic indicators (selected) – rotated crystals, bookshelf sliding, displaced crystals (Figure 39)
- Riedel shears (Figure 40)
- Vergence related to folds, fold geometry and refolded folds (Figure41)
- Vergence related to cleavage and folds (Figure42)
- Mantled porphyroclast classification (Figure43)

MODIFIERS

Modifiers and ancillary terms for structural features are listed alphabetically. Words within definitions that are in *italics* are also defined elsewhere in the same table. A word in square [brackets] following a modifier indicates the appropriate geologic theme or topic to which the modifier refers, as the modifier can apply to more than one theme. A word in (parentheses) following a modifier refers to the general topic as laid out in the hierarchical design of the appropriate pick list.

Table 63. Structural terms: modifier definitions.

Modifier	Definition[A]	Source[B]
Anastomosing (crenulation)	As used with the *hinge*s of *crenulations* to describe the geometric relation displayed on the earlier *foliation* plane; reminiscent of the pattern of a braided stream (i.e., branching and reconnecting). Cf. *conjugate*; *parallel*.	(1),(14)
Anticline	A *fold*, generally convex upward, the core of which contains the stratigraphically older rocks. Antonym: *syncline*. See *antiform*. Cf. *synformal anticline*	1
Antiform	Any convex-upward, concave downward *fold*. The term is usually used when the folded layers do not possess a stratigraphic order (e.g., mylonite), when the stratigraphic order of the folded layers is not known (e.g., insufficient *facing* information), or when the fold core also contains the stratigraphically younger rock (e.g., refolded fold). See *anticline*. Cf. *antiformal syncline; synformal anticline*.	1
Antiformal syncline	A *syncline* the limbs of which close upward as in an *antiform* but with facing that is downward. Cf. *synformal anticline*.	1
Antithetic (fault)	Term used for minor *fault*s or *shear bands* with the opposite sense of *displacement* to the major structure in which they develop.	14
Antithetic (object rotation)	Term used for object rotation which is the opposite sense as the major structure in which they develop.	
Asymmetric fold (*see* Figure 41)	a) Said of *folds* with limbs of unequal length; b) Folds with *axial planes* that are not perpendicular to the *enveloping surface* drawn tangential to those folds. Examples include "s" and "z" folds. Fold asymmetry is to be determined, by convention, by viewing the *fold axis* down plunge.	15
Axial-plane cleavage	*Cleavage* that is in the *hinge* of a *fold*, parallel to the *hinge surface* of the fold and having an *intersection lineation* with bedding that is parallel to the fold hinge. Axial-plane cleavage may be everywhere parallel to the fold hinge surface, but normally cleavage fans or changes its orientation systematically with position about the fold.	1
Axial plane (fold)	An axial surface that is planar (i.e., straight). Cf. *axial surface*.	1
Axial surface (fold)	The curviplanar surface formed from joining the *hinge lines* in adjacent folded surfaces (e.g., beds). Cf. *axial plane*. [Synonym: *hinge surface*.]	15,(1)
Back thrust (fault)	Normally, a thrust *fault* in a fold-thrust belt that dips opposite to the general dip of faults and results in displacement back toward the hinterland of the fold-thrust belt. May be used here in an analogous situation with mesoscopic-scale (outcrop) structures of any orientation.	1
Bedding joint	*Joint* that is parallel to the plane of bedding in a fold.	16
Bookshelf (faulting)	A geometric model of crustal extension in which movement on a series of parallel normal faults is accompanied by rigid rotation of the fault-bounded blocks, as with vertically standing books on a shelf falling over. [Synonym: domino-style faulting.]	1
Bookshelf sliding (*see* Figure 39)	Broken crystals, subjected to shear, which are rotated in the direction of *shear*, setting up an *antithetic* shear motion between fragments.	16
Boudin	One of a series of commonly elongate, sausage-shaped (in profile) competent segments occurring in *boudinage,* either separate or joined by pinched connections, and commonly having barrel-shaped cross-sections. Boudins result from the failure of the competent tabular body under compressional stress, whereas the enclosing incompetent material yields by shearing and/or flowing.	1
Boudin / boudin neck (lineation)	A measure of the long axis of a boudin, often parallel to the necks of boudins (the volume between boudins). The long axes of boudins are commonly, but not always, aligned parallel to associated *fold axes*. With *chocolate tablet structure*, where boudins are more equant then linear, it may be possible to measure 2 directions of boudin necks.	
Boudinage	A structure common in strongly deformed rocks (particularly sedimentary and metamorphic), in which an original continuous competent tabular body (layer, bed, sheet, etc.) between less competent layers has been stretched, thinned and broken at regular intervals into linear bodies, or boudins, that resemble sausages (in profile). Boudins are commonly, but not always, aligned parallel to the axes of related *folds*.	1
Boulder of decomposition	A boulder produced by chemical weathering; e.g., a joint block of basalt, modified and rounded by *spheroidal weathering*, leaving a relatively fresh spherical core surrounded by shells of decayed rock.	1
Box fold	A special case of *conjugate fold*, having the approximate profile form of 3 sides of a rectangle	(1)
Chevron fold	A *symmetric fold* with straight planar limbs of nearly equal length and sharp, narrow *hinge* zones	16,(17)
Chocolate tablet structure	A type of *boudinage* where a relatively rigid layer is stretched in 2 orthogonal directions, resulting in crossing *boudin necks*. The surface of the layer resembles that of a sheet of chocolate tablets.	1
Cleavage	Property of a rock to split along a regular set of parallel or subparallel closely spaced surfaces. Subdivided into *continuous cleavage* and *spaced cleavage*. *See* Table 26.	(8)
Close (interlimb angle)	A fold with an *interlimb angle* between 30 and 70°. Cf. *gentle*; *open*; *tight*; *isoclinal*; *elastica*.	1

Table 63. *continued*

Modifier	Definition[A]	Source[B]
Colonnade	Thick, well-formed columnar jointing normal to the base of a lava flow. See *upper colonnade*; *lower colonnade; entablature*.	1
Columnar joint	Parallel, prismatic columns, polygonal in cross-section, in some basaltic and rhyolitic flows and sometimes in other extrusive and intrusive rocks (lava lakes, ignimbrite sheets, domes, sills, dikes). Column sections are typically hexagonal, but may have 3, 4, 5 or 7 sides, and column widths collectively range from a few centimetres to several metres. These joints form as the result of contraction during cooling. See *colonnade*.	1
Complex fold	Refers to a *fold* or fold pattern having some complexity in fold form parameters: e.g., *convolute*; *polyclinal*; *ptygmatic*; *superposed*; *sheath*. Cf. *simple fold*.	
Complex (object) (*see* Figure 43)	A *winged object*, specifically a *mantled porphyroclast,* having more than one set of tails with monoclinic symmetry. The wings adjacent to the porphyroclast are narrow with characteristic bends creating 2 narrow "embayments" of matrix material also adjacent to the porphyroclast. *Stair stepping* may be present or not. Sense of *shear* may be determined from the internal asymmetry of the object and/or stair stepping of the wings. Occurs mainly in high-strain mylonites.	(14)
Concentric fold	A type of *parallel fold* in which individual layers have almost constant curvature, i.e., they define circular arcs. Cf. *nonconcentric*.	15,16
Congruent	Said of a *parasitic fold*, the axis and *axial surface* of which are parallel to the axis (*hinge line*) and axial surface of the main fold to which it is related.	1
Conjugate (crenulation)	As used with the *hinge*s of *crenulations* to describe the geometric relation displayed on the earlier foliation plane; two crenulation surfaces, intersecting at angles generally between 60 and 90º, without signs of overprinting (i.e., contemporary). Tend to be locally distributed. Cf. *anastomosing*; *parallel*.	15,14
Conjugate fold	Term used to describe any pair of apparently related *folds* that have *axial surface*s inclined to one another at a high angle. Examples are *box fold*; associated pairs of *kink bands*.	15
Conjugate (joint set)	Nonperpendicular *joint sets*. [Synonym: diagonal].	(16)
Continuous (cleavage)	*Cleavage* present throughout the rock at the grain-size scale, characterized by the preferred orientation of all the inequant mineral constituents. Cf. *spaced cleavage*. Equivalent to well-developed *schistosity* and *slaty cleavage*.	8
Contractional kink band	A *kink band* which involves an overall shortening of the planar fabric. Likely more common than *extensional kink bands*.	16
Convolute fold	*Complex folds* which have markedly curviplanar *axial surface*s and are generally *disharmonic*; typical in high-grade metamorphic rocks.	15
Coplanar (vergence)	Refers to 2 fabrics that are parallel (in which case, vergence is not defined).	17
Crenulation (cleavage)	Type of *spaced cleavage* developed during crenulation of a pre-existing *foliation*, oriented parallel to the axial plane of the crenulation and typically with ≤1 cm spacing. [Synonym: crenulation schistosity].	8
Crenulation (lineation)	A *lineation* defined by the *hinges* of small *folds* (crenulations) associated with *crenulation cleavage*.	1
Cross joint	*Joint* that is perpendicular to a *hinge line* (*fold axis*).	16
C-type shear band (cleavage) (*see* Figure 38)	Specific type of *shear band cleavage* commonly developed in strongly foliated and mica-rich mylonites. The shear bands are relatively straight and parallel to the *shear zone* boundary: slip along the cleavage is *synthetic* to the shear zone sense.	18,(14)
C′-type shear band (cleavage) (*see* Figure 38)	Specific type of *shear band cleavage* commonly developed in strongly foliated and mica-rich mylonites. The shear bands are curved, possibly anastomosing, and inclined to the *shear zone* boundary: slip along the cleavage is *synthetic* to the shear zone sense. [Synonyms (usage varies): shear band foliation; extensional *shear bands*; extensional *crenulation cleavage*.]	18,(14)
Cuspate-lobate fold	*Folds* in which adjacent *hinges* are alternately rounded and pointed; thought to be formed by buckling layers with low competence relative to their matrix.	1
Cylindrical fold	A *fold* that can be generated or reproduced by movement of a line of fixed orientation through space.	1
Décollement (fault)	Normally, a large-displacement (kilometres to tens of kilometres) subhorizontal to horizontal *fault* or *shear zone* related to some special stratal control of the *sole fault* in a particularly soft or incompetent horizon. Typically, *faults* and *folds* in rocks above the décollement do not extend across it. Cf. *detachment fault*. May be used here in an analogous situation with mesoscopic-scale (outcrop) structures of any orientation.	1,16
Deflection (kinematic indicator)	A term for the bending (deflection) of a marker object (e.g., bed, dike, *vein*, inclusion) near a *shear zone*, due to a strain gradient. Cf. *displacement*. Care must be taken not to interpret the wrong sense of movement (i.e., apparent deflection) from the surface of observation: the sense must be determined in a section parallel to the movement direction.	14,(1)
Deformation	A change in position (rigid-body translation), orientation (rigid-body rotation), shape (distortion), and/or size (dilation). A change in shape and/or size is also known as *strain*.	1

Table 63. *continued*

Modifier	Definition[A]	Source[B]
Delta-type (δ) (object) (*see* Figure 43)	A *winged object* having tails with monoclinic symmetry. The wings adjacent to the *porphyroclast* are narrow with characteristic bends creating 2 "embayments" of matrix material also adjacent to the porphyroclast. *Stair stepping* may be present or not. *Sense of shear* may be determined from the internal asymmetry of the object and/or stair stepping of the wings. Occurs mainly in high-strain mylonites. Cf. *phi-type*; *sigma-type*; *theta-type*.	(14)
Detachment (fault)	A regionally extensive, gently dipping *fault* that is not necessarily parallel to any one incompetent horizon, even though the fault surface is controlled by the competencies and the overall orientation of the boundaries between the differing rock units. Commonly associated with extension in a metamorphic core complex. Cf. *décollement*. N.B., some consider detachment and *décollement* synonymous. May be used here in an analogous situation with mesoscopic-scale (outcrop) structures of any orientation.	1,16
Dextral (sense of movement)	Refers to cases where the material on the opposite side of a plane of *displacement* has been displaced (*strike-slip component*) to the right. [Synonym: right lateral.]	(1)
Dip-slip component	The component of the *net slip*, parallel to the dip of the *fault*. In a *dip-slip fault*, dip slip component = net slip.	15
Dip-slip fault	A *fault* on which the movement is parallel to the dip of the fault (strike-slip component = 0). Cf. *oblique-slip fault*; *strike-slip fault.*	1
Disharmonic fold	A *fold* that varies noticeably in *profile* form and wavelength in the various layers through which it passes (i.e., *axial surface*s are not continuous from one layer to the next) resulting from wide separation distance between adjacent competent layers. Antonym: *harmonic fold.* Cf. *polyharmonic fold.*	1,17,16
Disjunctive (cleavage)	A type of *spaced cleavage* that is independent of any pre-existing mineral orientation in the rock. It includes *fracture cleavage* and *pressure solution cleavage*.	8
Displaced crystal (*see* Figure 39)	A crystal, with a well-developed *cleavage* aligned close to the shear plane, that becomes internally detached by gliding on the *cleavage* planes. (See *mica fish*).	
Displacement (kinematic indicator)	A term for the shifting (displacement) of part of a marker object (e.g., bed, dike, *vein*, inclusion) by a *shear zone*. Cf. *deflection*. Care must be taken not to interpret the wrong sense of movement (i.e., apparent displacement) from the surface of observation: the sense must be determined in a section parallel to the movement direction.	14,(1)
Doubly plunging fold	A *fold* that reverses its direction of plunge within the observed area.	1
Drag fold	A minor *fold*, formed due to *shear* resulting from slip on a fault. Cf. *parasitic fold; intrafolial fold.*	1
Elastica (interlimb angle)	*Fold*s with a negative *interlimb angle* (i.e., a bulbous *hinge*). Cf. *gentle*; *open*; *close*; *tight*; *isoclinal*.	16
Elongation (lineation)	The long dimension of a deformed object, such as a clast, variole or pillow. The term stretching lineation is considered synonymous by some geologists. Others consider stretching lineations to apply only to linear features on pre-existing surfaces such as *foliations* within *shear zones*.	
En echelon	Said of geologic features (e.g., *faults*, *veins*) that are in an overlapping or staggered or step-like arrangement, like tiles on a roof. Each is relatively short but collectively they form a linear zone, in which the strike of the individual features is oblique to that of the zone as a whole.	1,(14)
Entablature	A "tier" of irregular, blocky, splintery and relatively thin columns, arranged in complex ways (fans, curved patterns, or tilted in the direction of lava flow) above the thicker, more regular *columnar joints* of the lower colonnade, in two- or three-tiered lava flows with columnar jointing. See *upper colonnade*; *lower colonnade*.	1,5
Enveloping surface	An imaginary surface tangent to *antiformal* and *synformal hinges* in a single folded surface.	1
Exfoliation (joint)	The process by which concentric scales, plates or shells of rock, from less than a centimetre to several metres thick, are successively spalled or stripped from the bare surface of a large rock mass. It is caused by physical or chemical forces producing differential stresses within the rock, such as by expansion of minerals as a result of near-surface chemical weathering. It often results in a rounded rock mass or dome-shaped hill.	1
Extensional kink band	A *kink band* which involves an overall extension of the planar fabric. Less common than *contractional kink bands*.	16
Fabric	Relative orientation of parts of a rock mass (complete spatial and geometrical configuration), which commonly refers to crystallographic and/or shape orientation of mineral grains or groups of grains, but can also be used on a larger scale. Hence "microfabric", "mesofabric" and "megafabric" (*see* Table 26). Preferred linear or planar orientation of the parts is termed "linear fabric" and "planar fabric", respectively, and lack of preferred orientation is referred to as "random fabric" (*see* Table 26).	1,(14)
Fabric element	A component or feature of a rock *fabric*, such as *fold* axes, *foliation*, *lineation*. May be specified as *linear element* or *planar element*.	1
Facing (bedding) (*see* Figure 36)	The direction toward which a rock unit or layer is younger or "youngs". Cf. *facing (fold)*.	(1)

Table 63. *continued*

Modifier	Definition[A]	Source[B]
Facing (fold) (*see* Figure 36)	The direction, normal to the *fold* axis and along the *axial surface*, toward younger beds. Fold facing is independent of *fold vergence*. Cf. *Facing (bedding)*. [Synonym: structural facing.] See *facing (structural)*.	19
Facing (structural)	Synonymous with fold facing. See *facing (fold)*.	
Fault	A planar discontinuity between blocks of rock that have been displaced past one another, in a direction parallel to the discontinuity. Also a discrete fracture surface along which rocks have moved relative to each other. Cf. *fault zone*; *shear zone*.	15,8
Fault array	A set or multiple sets of *faults* with regular orientations and interrelated kinematic character.	1
Fault zone	A tabular region containing many parallel or anastomosing faults with similar sense of displacement; a region of localized brittle deformation. Cf. *fault*; *shear zone*.	15
Fish-hook fold	A somewhat colloquial term for a style of *asymmetric fold* formed by partial transposition of layering in which the short limbs of folds in competent layers are dismembered, leaving a “fish-hook”-shaped segment of the competent layer.	
Flat style (fault)	That part of a step-shaped thrust *fault* or *normal fault* that is nearly parallel to the enveloping layering; *thrust fault* and (less ubiquitous) normal fault flats are also commonly nearly horizontal.	1
Flexure-slip fold	A flexural *fold* in which the mechanism of folding is slip along bedding planes or along surfaces of *foliation*, resulting in a *parallel fold*.	1
Fold	A curve or bend of a planar structure such as rock strata, bedding planes, *foliation*, or *cleavage*, resulting from *deformation*, although its definition is descriptive and not genetic and may include primary structures.	1
Fold association (joints)	Systematic *joints* that are geometrically associated with folded layers or strata. Can be subdivided according to their orientation with respect to the *fold hinge*, the *axial plane*, and a plane perpendicular to the axial plane and fold hinge. See *bedding joint*; *cross joint*; *longitudinal joint*; *0kl joint*; *h0l joint*; *hk0 joint*; *hkl joint*. Ramsay and Huber (1987) caution against assuming a fold association as opposed to establishing the association. Cf. *no fold association*.	16
0kl joint	*Joints* forming *conjugate joint sets* that intersect in a plane perpendicular to the *axial plane*. The intersection may fan about the *hinge line*.	16
h0l joint	*Joints* forming *conjugate joint sets* that intersect parallel to the *hinge line*. The intersection may fan about the hinge line.	16
hk0 joint	*Joints* forming *conjugate joint sets* that intersect parallel to the pole to bedding. The intersection may fan about the *hinge line*.	16
hkl joint	*Joints* forming *joint sets* that cross all intersections related to *0kl*, *h0l* and *hk0* joints.	16
Fold axis (lineation)	A *lineation* defined by the *hinge line* of a *cylindrical fold*. Note: common OGS usage is to use this term (and bedrock symbols) for all folds (cylindrical and noncylindrical) instead of the more inclusive term *hinge line*.	1,16
Fold vergence (*see* Figure 41)	The horizontal direction within the plane of the *fold profile* toward which the upper component of rotation is directed. The use of an azimuth to define vergence is clear and unique. Fold vergence is independent of fold plunge variations.	19
Foliation	A general term for any repetitively occurring or penetrative planar feature in a rock body. Examples include layering on a scale of a centimetre or less, and the preferred planar orientation of inequant mineral grains or grain aggregates. Includes *schistosity*; *gneissose structure*; *cleavage* (*see* Table 26).	
Footwall	The underlying side of a nonvertical *fault*, orebody or mine working; especially the wall rock beneath an inclined fault or *vein*. Cf. *hanging wall*.	1
Form (fold)	An informal general term to denote the style and type of a *fold*.	
Fracture	General term for any break in a rock mass, whether or not it causes *displacement*. Includes cracks, *joints*; *faults*.	1
Fracture cleavage	A type of *disjunctive cleavage* with a regular set of closely spaced parallel or subparallel *fractures* along which the rock will preferentially split. Cf. *pressure solution cleavage*.	8
Fringe material	The mineral(s) that make up a *pressure fringe*.	
Generation of feature	A means to denote the different sets of features or relative chronology of those features at an outcrop (e.g., *fabric*, *fold*, *fault*, *kinematic indicator*). The letters represent a case when more than one set of feature (e.g., cleavage) is observed, but no relative chronology can be established, hence “a” may represent one cleavage and “b” represents another cleavage in the outcrop. The numbers represent a case whereby relative chronology can be determined, hence “0” represents a primary feature, “1” represents a 1st generation feature, “2” represents a 2nd generation feature, which overprints the earlier generation(s), etc.	
Gentle (interlimb angle)	A fold with an *interlimb angle* between 120 and 180°. Cf. *open*; *close*; *tight*; *isoclinal*; *elastica*.	1

Table 63. *continued*

Modifier	Definition[A]	Source[B]
Gneissose structure	Type of structure characterized by a *schistosity* that is either poorly developed throughout the rock or, if well developed, occurs in broadly spaced zones, such that the rock will split on a scale of >1 cm. Mineralogical or lithological layering, streaks and/or lenticles are commonly present. Replaces the term "gneissosity".	8
Hanging wall	The overlying side of a nonvertical *fault*, orebody or mine working; especially the wall rock above an inclined fault or *vein*. Cf. *footwall*.	1
Harmonic fold	A *fold* with uniform wavelength and amplitude (i.e., *axial plane*s are continuous from one layer to the next) resulting from similar competent-incompetent layer ductility contrasts. Antonym: *disharmonic fold.* Cf. *polyharmonic fold.*	1,17,16
Hinge	The surface region of the *fold* around the fold *hinge line*. [Synonym: *hinge zone*.]	15,16
Hinge line	The axis along which the curvature of the *fold* is greatest (i.e., minimum radius of curvature). [Synonym: fold hinge.]	1
Hinge surface	*Axial surface*.	1,16
Imbricate (fault array)	A series of related, subparallel *dip-slip faults* with similar *displacements* that merge with a single *detachment* horizon at depth. Faults in an imbricate array do not link in an upper detachment. Rock slices between imbricates are arranged in an overlapping shingle-like pattern. Imbricate arrays can occur in thrust fault systems and in normal-fault systems.	1
Inclined fold	A *fold* with an *axial surface* that is inclined from the vertical, and in which one limb may be steeper than the other. The steeper of the 2 limbs may be overturned. See *overturned fold*.	1
Inclined horizontal fold	A *fold* with an *axial plane* inclined from the vertical and a horizontal *hinge line*.	
Inclined plunging fold	A *fold* with an *axial plane* inclined from the vertical and a nonvertically plunging *hinge line* (i.e., 0° < plunge < 90°).	
Interlimb angle	The angle between adjacent limbs of a *fold*, normally determined by drawing tangents to the fold limbs at the inflection points. See *gentle*; *open*; *close*; *tight*; *isoclinal*; *elastica*.	1
Intermediate types (superposed patterns)	*Superposed* (fold) *pattern*s that are intermediate between Types 0, 1, 2 and 3 based on a) the angle between the 1st *axial plane* and 2nd *displacement* direction; and b) the angle between the 1st and 2nd fold axes. Choices are "intermediate between types 0 and 1"; "intermediate between types 0 and 2"; "intermediate between types 0 and 3"; "intermediate between types 1 and 2"; and "intermediate between types 2 and 3".	16
Intersection (lineation)	A *lineation* produced by the intersection of 2 planar surfaces, at least one of which is penetrative. An intersection with a *foliation* and a plane of reference (e.g., *joint*) has little value in structural analysis.	1,15
Intrafolial fold	A small-scale, commonly tight to isoclinal, remnant *fold hinge* in a competent layer in otherwise less competent material that does not appear to be folded. Typically found in intensely folded rocks.	15,16
Isoclinal (interlimb angle)	A *fold* with limbs that are parallel (*interlimb angle* = 0°). Cf. *gentle*; *open*; *close*; *tight*, *elastica*.	1
Joint	A planar fracture, crack or parting in a rock, without *shear* displacement (at the time of fracture formation) on the fracture surface. The surface may be decorated with *plume structure*. Often occurs with numerous parallel joints to form a *joint set* or part of a *joint system*. Joints may form in tensile or compressive stress fields.	1
Joint set	A group of *joints* of common origin, typically more or less parallel (i.e., most *systematic joints*), but may fan about a fold *hinge* (axis) (e.g., *longitudinal joint*). See *joint system*.	(1)
Joint spacing	The interval between *joint*s of a particular *joint set*, measured on a line perpendicular to the joint planes.	1
Joint system	Two or more *joint sets* that intersect. They may be of the same age or of different ages.	1
Kinematic indicator	A feature in a deformed rock body that indicates the *shear* sense or movement direction during *deformation*. Kinematic indicators include *asymmetric folds*, asymmetric *porphyroclast systems*, *S-C-C′ fabric*s, and asymmetric inclusion trails.	1
Kink band	A component of *kink folds*, a kink band is a type of deformation band occurring in foliated and thin-bedded rocks, in which the orientation of the *foliation* is changed or deflected by gliding or slippage between 2 kink planes or kink band boundaries. Kink bands commonly occur as conjugate systems. See *contractional kink band*; *extensional kink band.*	1
Kink fold	Asymmetrical *fold* with straight planar limbs, angular *hinge* zones, and short limbs that make up tabular zones called *kink band*s, which are bounded by planar boundaries known as kink planes or kink band boundaries.	16,17,15
Linear element	A *fabric element* having one dimension that is much greater than the other two. Examples are *mineral lineation*s, *fold axes* and *rods*.	1
Lineation	A general, nongeneric term for a locally occurring or penetrative, straight or curved, linear structure or *fabric* in a rock. Examples include scratches, striae, or slickensides on a single surface; alignment of long axes of elongate mineral grains (*mineral lineation*); parallelism of small-scale *folds* (*crenulation lineation*); and intersection of 2 foliations (*intersection lineation*).	1,8

Table 63. *continued*

Modifier	Definition[A]	Source[B]
Longitudinal joint	*Joint* that is parallel to a *hinge line* (*fold axis*); associated longitudinal joints commonly fan about the hinge line. [Synonym: radial joint].	16
Lower colonnade	The lower tier, in a two- or three-fold division of flows with columnar *joints*, consisting of straight-sided, well-developed columns, which is overlain by either entablature, or a thicker upper colonnade of more slender and irregular columns. See *upper colonnade*; *entablature*. [Synonym: basal colonnade].	5
L-S-tectonite	A *tectonite* with a fabric that has both notable *planar elements* and *linear elements* caused by deformation. Cf. *L-tectonite; S-tectonite*.	14
L-tectonite	A *tectonite* with a *fabric* that is dominated by the presence of *linear elements,* such as in a deformed conglomerate with elongate clasts. There may be no planar elements. Cf. *S-tectonite*; *L-S tectonite*.	1,(14)
Mantled porphyroclast	A *porphyroclast system* with a *porphyroclast* characterized by a rim, with or without tapered wings or tails elongated along the foliation, in which the mantles and wings are composed of aggregates of the same material as the porphyroclast. The wings are derived from deformed mantles developed at the expense of the porphyroclast. Mantled porphyroclasts with wings are termed *phi-type*, *sigma-type*, *delta-type*, or *complex* objects. Mantled porphyroclasts without wings are termed *theta-type* objects. Sense of *shear* may be determined from the internal asymmetry of the object and/or *stair stepping* of the wings, providing the porphyroclast occurs isolated in a fine-grained mylonitic matrix.	(8)
Master joint	A persistent joint of greater-than-average extent. Many of the notable lineaments seen on aerial photographs are master joints, rather than major faults. Master joints often influence the geomorphological activity at the Earth's surface.	1,16
Mesomylonitic	Having the texture of a mesomylonite (*see* Part 1 – Other Rocks – Fault Rocks – Definitions).	
Mica fish (porphyroclast)	Asymmetric, lenticular mica *porphyroclast*s with long axes inclined to mylonitic *foliation*. The asymmetry can be used to determine sense of shear. A type of *displaced crystal*.	1,14,8
Mineral (lineation)	A *linear element* defined by the preferred orientation of inequant mineral grains (e.g., prismatic grains of hornblende) or elongated grain aggregates. Mineral lineations are not always parallel to the axes of related folds and may be oriented up to 90° to a related fold axis.	1
Monoclinal (kink fold)	A single *kink band* array. Cf. *conjugate*.	(16)
Morphology (fold)	The general features of a *fold*, such as the entity that is folded, asymmetry and interlimb angle.	
Mullion	A type of *lineation* in metamorphic rock formed where the interface between rocks with differing ductilities becomes corrugated into a surface of alternating pointed peaks (pointing into the stiffer layers) and intervening smoothly curving cusps as a consequence of deformation. In profile, mullion structure looks like waves or ripples. In three dimensions, mullions are linear, rod-like structures.	1
Mullion structure	A wavelike pattern of parallel, V-shaped grooves and rounded semi-cylindrical ridges. The distance between adjacent grooves or between adjacent ridges, which may be millimetres to several metres, is fairly consistent. Mullion structure typically forms as a consequence of layer-parallel shortening where there is significant ductility contrast between adjacent layers. The mullions are generally thought to be oriented parallel to related *fold axes*.	1,(15)
Net slip	The displacement vector connecting originally contiguous points in the *hanging wall* and *footwall*. The vector is resolved into *strike-slip* and *dip-slip* components. Most faults are *oblique-slip faults*.	15
No fold association (joints)	Systematic joints with no geometric association with folded layers or strata. Cf. *fold association*.	
Nonconcentric fold	A type of *parallel fold* in which individual layers do not form concentric arcs. Cf. *concentric*.	16
Nonsystematic joint	*Joints* that are not part of a *joint set* because they are irregular in form, spacing and orientation. They typically do not cross other joints, they often terminate at bedding surfaces, and their surfaces may be strongly curved. Cf. *systematic joint*.	(1)
Nonwinged object (*see* Figure 43)	A *mantled porphyroclast* in which the mantle has not been deformed into wings. Cf. *winged object*.	
Normal fault	A high-angle (generally >45°) *dip-slip fault* on which the *hanging wall* has moved down relative to the *footwall*. [Antonym: *reverse fault*.]	15
Oblique-slip fault	A *fault* on which the *net slip* has a *dip-slip component* and *strike-slip component*. Cf. *dip-slip fault*; *strike-slip fault*.	1
Offset (kinematic indicator)	An informal term for the separation of a marker (e.g., bed, dike) on a fault as observed in the plane of an outcrop or cross-section.	1
Open (interlimb angle)	A *fold* with an *interlimb angle* between 70 and 120°. Cf. *gentle*; *close*; *tight*; *isoclinal*; *elastica*.	1
Orthogonal (joint set)	Mutually perpendicular *joint sets*.	16

Table 63. *continued*

Modifier	Definition[A]	Source[B]
Overturned fold	A term used by some to indicate a *fold* in which one of the limbs is stratigraphically overturned (i.e., inverted). The OGS recommends this term not be used because the words could be logically construed to imply that both limbs are overturned (i.e., the entire fold). If a fold can be demonstrably shown to be entirely overturned, then *facing* is known and the hinge zone can be observed (for outcrop scale observations). In such cases, the terms *antiformal syncline* or *synformal anticline* should be used. As a result, we do not distinguish, by terminology, a fold that has only one limb overturned.	
P shear (*see* Figure 40)	See *Riedel shears*	
Parallel (crenulation)	As used with the *hinges* of *crenulations* to describe the geometric relation displayed on the earlier *foliation* plane; hinges form parallel ridges. Cf. *anastomosing*; *conjugate*.	(14)
Parallel fold	A *fold* in which the thickness of a layer measured orthogonally across the layer boundaries is constant throughout the fold. Cf. *similar fold*.	1,16
Parasitic fold	A smaller-scale *fold* on a limb or hinge of a larger-scale fold to which it is *congruent*. [Synonym: second-order fold].	1
Pencil structure	The structure produced by the intersection of *cleavage* planes with bedding planes in a fissile rock, causing it to break into long, slender (pencil-like) pieces. The structure may represent an intermediate stage in the development of *slaty cleavage*, and thus generally occurs only in weakly metamorphosed rocks. Some gneisses have a similar structure and have been termed pencil gneiss. [Synonym: pencil cleavage].	1
Phi-type (ϕ) (object) (*see* Figure 43)	A *winged object* having tails with orthorhombic symmetry and displaying no *stair stepping*. No *sense of shear* can be determined. Occurs mainly in high-grade mylonites. Cf. *delta-type*; *sigma-type*; *theta-type*.	(14)
Phyllitic fabric	An unofficial term for a type of *slaty cleavage* in which the individual phyllosilicate grains are large enough to be seen by the unaided eye and produce a lustrous sheen on the cleavage planes. Typically occurs in phyllites and reflects low grade metamorphism.	
Planar element	A *fabric element* having 2 dimensions that are much greater than the third. Examples are bedding, *cleavage*, and *schistosity*.	1
Plume structure	A surface feature of a joint forming a ridge-like tracing in a plume-like (feather-like) pattern, usually oriented parallel to the upper and lower surfaces of the containing rock unit. [Synonym: plumose structure].	1
Plunging fold	A *fold* of which the hinge line is inclined to the horizontal.	1
Polyclinal fold	One of a group of adjacent *folds*, the *axial surface*s of which have various orientations.	1
Polyharmonic fold	A *fold* train that contains shorter wavelength, usually lower amplitude, components and longer wavelength, usually higher amplitude, components, resulting from marked differences in thickness or ductility contrast among layers. The component with the longest wavelength is the first-order fold; components with successively shorter wavelengths are successively higher order folds.	1,16
Porphyroblast	A relatively large crystal formed in a metamorphic rock and set in a matrix of smaller grains. Cf. *porphyroclast*.	8
Porphyroclast	A relatively large relict (protolith) single crystal or rock fragment within a finer grained, often recrystallized matrix (in a metamorphic rock, e.g., mylonite, cataclasite) that was formed by diminution of grains. The relict crystal may have been a porphyroblast. Cf. *porphyroblast*.	14, 8
Porphyroclast system	Term covering the geometry of a *porphyroclast* and its associated tapering grain aggregates, or tails, formed of dynamically recrystallized material. The asymmetry of the system indicates the *sense of shear*. See *mantled porphyroclast*; *strain shadow*. The systems may result in *winged objects* or *nonwinged objects*.	(8)
Pressure shadow	Alternative, but genetic, term for *strain shadow*.	14
Pressure solution	Deformation process by which material under *stress* goes into solution and is then transported by flow or diffusion to areas of relatively low stress. The material may move around a mineral grain boundary (e.g., into a *strain shadow*) or be transported out of the system. See *pressure solution cleavage*.	8
Pressure solution cleavage	A type of *disjunctive cleavage* resulting from the preferential movement of material, usually quartz, from the cleavage domains into the intercleavage domains (microlithons), leaving the cleavage domains relatively enriched in phyllosilicates and giving the rock a striped appearance. Cf. *fracture cleavage*.	8
Profile (fold)	A section drawn perpendicular to the *fold axis* (viewed down plunge). Fold parameters such as symmetry or asymmetry and interlimb angle are determined using the fold profile.	15
Protomylonitic	Having the texture of a protomylonite (*see* Part 1 – Other Rocks – Fault rocks – Definitions).	
Ptygmatic fold	*Folds* with rounded *hinges*, fold amplitudes nearly equal to fold wavelength, commonly *concentric* or *polyclinal*, may have negative interlimb angles (*elastica*) and represent considerable shortening. They develop in relatively highly competent isolated layers, dikes or *veins*, usually in metamorphic rocks where the matrix has a low competence.	1,15, 16,17

Table 63. *continued*

Modifier	Definition[A]	Source[B]
R_1 and R_2 shears	See *Riedel shears*	
Ramp (fault)	A portion of a step or *thrust fault* that cuts across formational contacts in a short distance. Thrust fault and *normal fault* ramps commonly have dips of 30° and 60°, respectively. May be used here in an analogous situation with mesoscopic-scale (outcrop) structures of any orientation.	1
Reclined fold	A *fold* with a *hinge* that plunges parallel to the direction of dip of the *axial surface*.	1
Recumbent fold	A *fold* with a horizontal *axial plane* (and hence a horizontal *hinge*).	
Reverse fault	A high- to low-angle *dip-slip fault* on which the *hanging wall* has moved up relative to the *footwall*. [Antonym: *normal fault*.]	15
Ribbon structure	Strongly elongated single crystal or very fine-grained aggregates of quartz crystals resembling ribbons in a rock (termed quartz ribbons). The structure is commonly the product of intense deformation at high temperature. The crystal grains may show undulose extinction or be recrystallized into polycrystalline ribbons.	8,(14)
Riedel shears (*see* Figure 40)	Secondary shears that are associated with some *faults*, which may or may not be *strike-slip faults*. These shears consist of sets of shear fractures that develop as follows: *en echelon* conjugate sets of *synthetic* faults, designated as R_1 (or R) at 10 to 15° to the orientation of the main fault surface, and *antithetic* faults, designated as R_2 or (R′) at 75 to 80°; and, in some cases, synthetic P faults. The main through-going fault, designated Y, is oriented at 45° to the maximum compressive stress.	1
Rod	The linear entities produced by *rodding*.	
Rodding (structure)	In metamorphic rocks, a linear structure in which the stronger parts, such as *vein* quartz or quartz pebbles, have been shaped into parallel rods. Although generally thought to be elongate parallel to related *fold* axes, there is debate as to whether the structure is formed parallel to the direction of transport or parallel to the fold axes.	1,15
Rotated crystal (*see* Figure 39)	A crystal that shows evidence of having been rotated during shearing.	16
S-C fabric (*see* Figure 38)	Composite fabric produced by the intersection of 2 planar *fabrics* (S-plane and C-plane) in sheared rocks. The C-fabric forms broadly parallel to the margins of the shear zone and the S-fabric forms oblique to the margin, the angle between the two decreasing as shear intensity increases. The S-planes curve into the C-planes, the nature of the curvature reflecting the sense of shear on the C-planes. S-C fabrics are common in strongly foliated and mica-rich mylonites or granitoid mylonites. (Originally referred to as C-S fabric or C/S fabric).	8
Schistosity	Preferred orientation of inequant mineral grains or grain aggregates produced by metamorphic processes. Schistosity is present in most cleavage types with the exception of some *disjunctive cleavages* (e.g., *fracture cleavage*). (*See* Table 26.)	8
Shadow material	The material (minerals) comprising the *strain shadow*.	
Shear	A deformation resulting from stresses that cause or tend to cause contiguous parts of a body to slide relatively to each other in a direction parallel to their plane of contact. It is the mode of failure of a body or mass whereby the portion of the mass on one side of a plane or surface slides past the portion on the opposite side. In geological literature the term refers almost invariably to *strain* rather than to *stress*. It is also used to refer to surfaces and zones of failure by shear, and to surfaces along which differential movement has taken place.	1
Shear band	Loosely defined as a thin zone of very high shear strain occurring in rocks in a shear zone. Numerous parallel to subparallel shear bands define a *shear band cleavage*. See *C′-type shear band* for a specific definition.	1
Shear band cleavage (*see* Figure 38)	Fabric produced by a set of *shear bands*. May superficially resemble *crenulation cleavage.*	14
Shear zone	A zone across which blocks of rock have been displaced in a fault-like manner, but without prominent development of visible faults; a region of localized ductile deformation. Cf. *fault*; *fault zone*.	15
Sheath fold (*see* Figure 37)	A *fold* with a tight to isoclinal *profile* wherein the hinge line also curves through more than 90° of arc. Sheath folds may result from superposed folding, but are often inferred to result from the distortion of folds with mildly curved hinges due to localized shearing.	1
Sheet fracture	A type of *joint* produced by pressure release (i.e., offloading through erosion and/or uplift), or *exfoliation*. Sheet fractures separate large rock masses (e.g., of granite) into tabular bodies or lenses, roughly parallel to the general rock surface, that become thicker, flatter and more regular with depth. A set of sheet fractures forms *sheet structure*.	1
Sheet structure	A *joint set* of sheet fractures.	1

Table 63. *continued*

Modifier	Definition[A]	Source[B]
Sigma-type (σ) (object) (*see* Figure 43)	A *winged object* having tails with monoclinic symmetry and displaying *stair stepping*. The mantles are wide near the *porphyroclast* with 2 planar faces and 2 curved faces that define an internal asymmetry. *Sense of shear* may be determined from the internal asymmetry of the object and *stair stepping* of the wings. Occurs in high-strain and lower-strain mylonites. Sigma-type objects should not be confused with asymmetric *strain shadows* and *strain fringes*. Cf. *delta-type*; *phi-type*; *theta-type*.	(14)
Similar fold	A *fold* in which the orthogonal thickness of the folded strata is greater in the hinge than in the limbs, but the distance between any 2 folded surfaces is constant when measured parallel to the *axial surface*. Cf. *parallel fold*.	1
Simple fold	Refers to a *fold* or fold style having relatively simple fold *form* parameters: e.g., *box*, *chevron*, *cuspate-lobate*, *drag*, *fish-hook*, *intrafolial*, *kink*, *mullion structure*, *parasitic*. Cf. *complex fold*.	
Sinistral (sense of movement)	Refers to cases where the material on the opposite side of a plane of displacement has been displaced (*strike-slip component*) to the left. [Synonym: left lateral.]	(1)
Slaty cleavage	A type of *continuous cleavage* in which the individual grains are too small to be seen by the unaided eye. Typically occurs in slates and reflects very low to low grade metamorphism.	1
Slickenfibre	Fibrous grains along a fault surface, subparallel to the *fault* and usually parallel to the direction of latest movement along the fault.	14
Slickenside	Term used to denote any of several types of lineated *fault* surfaces. Slickensides commonly have groove lineations, or alternatively may have fibrous minerals (*slickenfibres*); in both cases, the *lineations* indicate the direction of slip on the fault. Slickensides may also form as striae in a simple *flexure-slip fold*, perpendicular to the *fold* axis. [Term originally used for a polished fault surface formed by frictional wear during sliding].	1,16
Slickenside steps	Slickensides with asymmetric “steps” from which one can determine the sense of movement on a fault. Slickensides without steps only provide a direction of movement.	
Sole fault	A low-angle *thrust fault* forming the base of a thrust sheet; also, the basal main fault of an imbrication. May be used here in an analogous situation with mesoscopic-scale (outcrop) structures of any orientation.	1
Spaced (cleavage)	Type of *cleavage* in which the cleavage planes or domains are spaced at regular intervals and separated by zones known as microlithons. The structure is visible to the unaided eye. Spaced cleavage encompasses *crenulation cleavage* and *disjunctive cleavage*. Cf. *continuous cleavage*.	8
Spheroidal weathering	A form of chemical weathering in which concentric or spherical shells of decayed rock (ranging in diameter from 2 cm to 2 m) are successively loosened and separated from a block of rock by water penetrating the bounding joints or other fractures and attacking the block from all sides. It commonly forms a rounded *boulder of decomposition*. It is similar to larger scale exfoliation produced usually by mechanical weathering. [Synonym: onion-skin weathering].	1
Stair stepping (*see* Figure 43)	The wings lie at different “elevations” or “levels” on both sides of the *porphyroclast* with respect to a *foliation* plane projected through the porphyroclast.	(14)
S-tectonite	A *tectonite* with a fabric that is dominated by *planar elements* caused by deformation, such as in a schist. There may be no linear elements. Cf. *L-tectonite*; *L-S tectonite*.	1,(14)
Strain	In structural geology, the change in shape and/or size of a body. Strain is the nonrigid component of *deformation*. Cf. *stress*.	1
Strain fringe	Type of *strain shadow* consisting of fibrous material.	14
Strain shadow	A cone-shaped domain adjacent to a rigid body (e.g., *porphyroblast*, *porphyroclast*), usually composed of a different mineral, and elongated in the direction of the foliation. May be massive or consist of equidimensional crystals (e.g., quartz, carbonate, chlorite) with few or no foliation-forming minerals (e.g., micas). Boundaries of the strain shadow and the matrix may be sharp or more commonly gradational. The strain shadow shape may be used, with care, as a tool to determine shear sense. See *strain fringe*.	14
Stress	In a solid, the force per unit area, acting on any surface within it, and variously expressed as dynes or kilograms per square centimetre or pounds or tons per square inch; also, by extension, the external pressure which creates the internal force. The stress at any point is mathematically defined by 9 values: 3 to specify the normal components and 6 to specify the shear components, relative to 3 mutually perpendicular reference axes. Cf. *strain*.	1
Strike slip component	The component of the *net slip*, parallel to the strike of the *fault*. In a *strike-slip fault*, strike slip component = net slip.	15
Strike-slip fault	A *fault* on which the movement is parallel to the strike of the fault (dip slip component = 0). Cf. *dip-slip fault; oblique-slip fault.*	
Superposed pattern (*see* Figure 37)	The three-dimensional *fold* forms (commonly viewed on a rock surface and referred to as fold interference patterns), by superposition of 2 (or more) generations of folds. Subdivided into 4 main types (*Type 0*, *Type 1*, *Type 2*, *Type 3*), with 5 additional *intermediate types*.	16

Table 63. *continued*

Modifier	Definition[A]	Source[B]
Symmetric fold	a) Said of *folds* with limbs of equal length. b) Folds with *axial planes* that are perpendicular to the *enveloping surface* drawn tangential to those folds. Examples include "n", "u", "m" and "w" folds. Fold symmetry is to be determined, by convention, by viewing the *fold axis* down plunge.	15
Syncline	A *fold*, generally concave upward, the core of which contains the stratigraphically younger rocks. Antonym: *anticline*. See *synform*. Cf. *antiformal syncline*.	1
Synform	Any concave upward, convex downward *fold*. The term is usually used when the folded layers do not possess a stratigraphic order (e.g., mylonite), when the stratigraphic order of the folded layers is not known (e.g., insufficient *facing* information), or when the fold core also contains the stratigraphically older rock (e.g., refolded fold). See *syncline*. Cf. *synformal anticline*; *antiformal syncline*.	1
Synformal anticline	An *anticline* the limbs of which close downward as in a *synform*. Cf. *antiformal syncline*.	1
Synthetic (fault)	Term used for minor *faults* or *shear bands* with the same sense of displacement to the major structure in which they develop.	14
Synthetic (object rotation)	Term used for object rotation which is the same sense as the major structure in which they develop.	
Systematic joint	Individual *joints* that collectively form a *joint set*. Their surfaces are planar or only broadly curved, they are oriented perpendicular to the boundaries of the enclosing rock unit, and the structures (e.g., *plume structure*) on their faces are oriented. Cf. *nonsystematic joint; joint system.*	(1)
Tectonite	A rock with a *fabric* that has been modified substantially by *deformation* processes. See *L-tectonite*, *S-tectonite*; *L-S tectonite*.	1
Theta-type (θ) (object) (*see* Figure 43)	A nonwinged, *mantled porphyroclast* with a slightly elongated mantle having orthorhombic symmetry extended in the direction of the plane of *foliation*. No *stair stepping* is present. No *sense of shear* can be determined. Cf. *delta-type*; *phi-type*; *sigma-type*.	(14)
Thrust fault	A low-angle (generally <45°) *reverse fault*. Horizontal compresson (shortening), rather than vertical displacement, is its characteristic feature.	1,15
Tight (interlimb angle)	A *fold* with an *interlimb angle* between 0 and 30°. Cf. *gentle*; *open*; *close; isoclinal*; *elastica*.	1
Type 0: Redundant (*see* Figure 37)	For 2nd-generation *fold* pattern: angle between 1st *axial plane* and 2nd *displacement* direction = low; angle between 1st and 2nd fold axes = low. Results in a pattern similar, and possibly practically identical, to a single phase of deformation.	16
Type 1: Dome-Basin (*see* Figure 37)	For 2nd-generation *fold* pattern: angle between 1st *axial plane* and 2nd *displacement* direction = low; angle between 1st and 2nd fold axes = high. Results in a dome and basin pattern, or one resembling that of an egg carton. Dome and basin patterns may be created by other than superposed folds.	16
Type 2: Dome-Crescent-Mushroom (*see* Figure 37)	For 2nd-generation *fold* pattern: angle between 1st *axial plane* and 2nd *displacement* direction = high; angle between 1st and 2nd fold axes = high. Results in a variety of patterns, as suggested by the name.	16
Type 3: Convergent-Divergent (*see* Figure 37)	For 2nd-generation *fold* pattern: angle between 1st *axial plane* and 2nd *displacement* direction = high; angle between 1st and 2nd fold axes = low. Results in an intuitive refolded fold pattern as seen in profile.	16
Ultramylonitic	Having the texture of an ultramylonite (*see* Part 1 – Other Rocks – Fault Rocks – Definitions).	
Upper colonnade	The upper tier in a two- or three-fold division of flows with *columnar joints*, oriented perpendicular to the upper contact, underlain by either *entablature* or a *lower colonnade* of wider, more regular columns.	5
Upright fold	A *fold* having a vertical *axial plane*.	1
Upright-horizontal fold	A *fold* with a vertical *axial plane* and a horizontal *hinge*.	
Upright-plunging fold	A *fold* with a vertical *axial plane* and a nonvertically plunging *hinge*.	
Vein	An *epigenetic* mineral filling of a fault or other fracture in a *host rock*, in tabular or sheet-like form, often with associated *replacement* of the *wall rock*; may be mineralized. Not recommended usage as an igneous intrusive term.	1
Vergence (*see* Figures 41, 42)	A term used to describe the direction of movement and rotation during deformation, as applied to *asymmetric folds* and *cleavage* relationships. It is not the same as *facing* or *fold facing*. See *vergence (asymmetric fold)*; *vergence (cleavage)*.	17
Vergence (asymmetric fold) (*see* Figure 41)	The horizontal direction (azimuth or approximation) within the *profile* plane of the *fold*, toward which the upper component of rotation is directed. It is independent of the fold plunge of *asymmetric folds*. Minor folds with "s" or "z" asymmetry may have the same sense of vergence, but "m" or "w" folds in the hinge region have "neutral vergence". Vertically plunging folds have either *dextral* or *sinistral* vergence. Fold vergence is useful in polyphase deformation terranes as changes in vergence may indicate larger scale or otherwise undetectable folds.	19

Table 63. *continued*

Modifier	Definition[A]	Source[B]
Vergence (cleavage) (*see* Figure 42)	The horizontal direction within the plane which is normal to the *fabric intersection lineation*, toward which a younger fabric needs to be rotated to become parallel to the older fabric. In all cases, the younger fabric must be rotated through the upper acute angle (i.e., defines the direction of vergence of the later fabric). *Cleavage* vergence is independent of *facing* of bedding on cleavage and facing direction cannot be used to define it. Where the normal lies parallel to the later fabric (e.g., in a *fold hinge*) the cleavage vergence is neutral. Where the normal lies at right angles to the later fabric, the fabrics are coplanar and cleavage vergence is not defined. Where the earlier fabric is vertical, the normal is horizontal and the cleavage vergence (through the acute angle) is either dextral or sinistral. Cleavage vergence is useful where fold closures are not found, minor folds are not present, or cleavage-cleavage relationships are found but no bedding is visible. The term can be applied to cases where the older fabric is bedding.	19
Vertical fold	A *fold* having a vertical axis (and hence a vertical *axial plane*).	1
Winged object (*see* Figure 43)	A *mantled porphyroclast* in which the mantle has been deformed into "wings" or "tails". Cf. *nonwinged object*. [Synonym: winged inclusion].	14
Younging	Considered by some as a colloquial synonym of *facing*, but could be used to refer solely to primary depositional features (e.g., bedding facing (see *facing (bedding)*) in sedimentary or volcanic deposits) without a structural involvement (e.g., fold facing (see *facing (fold)*).	
Y shear (*see* Figure 40)	See *Riedel shears*.	
Zipper (fracture)	An unofficial term for a fracture which has numerous, short, roughly equally spaced fractures orthogonal to the main fracture, resembling the teeth of a zipper along its length. Found locally in ultramafic rocks that have been serpentinized.	

[A] Preferred terms are defined: synonyms are in square brackets for reference only.
[B] Indicates source of definition: primary sources are indicated by a number; secondary sources are indicated by numbers in parentheses.
1 = Neuendorf, Mehl and Jackson (2005); 8 = Fettes and Desmons (2007); 14 = Passchier and Trouw (1998);
15 = Hobbs, Means and Williams (1976); 16 = Ramsay and Huber (1987); 17 = McClay (1984); 18 = Hanmer and Passchier (1991);
19 = Bell (1981); 20 = Spry (1969).
Where no source(s) is indicated, definitions are derived by or modified for use by the OGS.

ALTERATION TERMS

In setting up a systematic scheme for recording information with respect to alteration, we chose a few key goals:

1) the system should be descriptive rather than interpretive (e.g., the nature of the alteration fluid should not be part of the scheme);
2) the scheme should be "universal", based in part on recognizable mineralogy, rather than commodity or deposit type;
3) the system would include both pervasive alteration and infiltration types of alteration (e.g., fracture-controlled alteration, alteration adjacent to veins); and
4) the system would include the veins themselves as a separate part of the information collected (including generation, orientation, thickness, vein and "ore" mineralogy, and abundance).

Alteration is defined as any change in the mineralogical and/or chemical composition and texture of a rock, generally restricted to physical or chemical changes resulting from weathering and/or hydrothermal solutions (Neuendorf, Mehl and Jackson 2005; Fettes and Desmons 2007). In general, for Precambrian rocks in Ontario, hydrothermal alteration is likely to be the most common factor. The term "alteration" does not refer to the material that fills dilational structures, such as veins. For instance, a quartz vein may have developed during alteration in which the wall rock adjacent to the vein is altered, but the quartz vein itself is not altered and hence, in this case, is not considered to be "silicification". However, for the purposes of recording features in the field, veins are included under the category "Alteration" as they are commonly associated with it.

Some minerals in the pick lists are provided to reflect description of the current mineralogy in altered rocks, which may reflect metamorphic upgrading of the original alteration mineralogy. For instance, in terms of diagnostic alteration minerals in a volcanogenic massive sulphide deposit, advanced argillic alteration initially consisting of kaolinite, alunite, opal and smectite may be represented under greenschist facies metamorphism by kaolinite, pyrophyllite, andalusite, corundum and topaz or, under granulite facies metamorphism, by sillimanite, kyanite and quartz (e.g., Shanks 2012).

The primary subdivisions of alteration are "pervasive", in which the entire rock volume has been saturated or permeated with fluids resulting in extensive alteration, and "nonpervasive" in which only selected parts of the rock volume have been affected by fluids, such as with individual fractures, specific cleavages, separate layers, etc. Alteration may or may not be associated with mineralization. Currently, we separate alteration from mineralization (Tables 65 and 67, respectively) and associate them with individual pick lists (Table 64 (alteration) and Table 66 (mineralization), respectively).

MODIFIERS

Modifiers and ancillary terms for alteration are listed alphabetically. Words within definitions that are in *italics* are also defined elsewhere in the same table. A word in square [brackets] following a modifier indicates the appropriate geologic theme or topic to which the modifier refers, as the modifier can apply to more than one theme. A word in (parentheses) following a modifier refers to the general topic as laid out in the hierarchical design of the appropriate pick list.

Table 65. Alteration terms: modifier definitions.

Modifier	Definition[A]	Source[B]
Acicular (crystal habit)	Said of a *prismatic* crystal that is needle-like in form. Cf. *columnar*; *fibrous*.	1
Albitization	Alteration involving the introduction of, or *replacement* by, albite, usually replacing a more calcic plagioclase.	1
Alteration	See introductory paragraphs in "Alteration Terms" section.	
Alteration (pseudomorph)	A type of *substitution pseudomorph*, in which only partial replacement occurs through a mineral composition changing by chemical reaction to another mineral of similar composition, retaining the original crystalline shape (e.g., anglesite (lead sulphate) after galena (lead sulphide)). Cf. *encrustation*; *paramorphism*; *substitution*.	
Antitaxial growth	Said of a *vein* infilling in which fibres grow from the centre toward the walls. Vein minerals tend to be different from those found in the wall and commonly have a fibrous habit. The oldest part of the vein is along the median line. Cf. *syntaxial growth*; *ataxial growth*.	1,8
Argillization	Alteration involving the *replacement* or alteration of feldspars to form clay minerals, especially that occurring in *wall rock*s adjacent to mineral *veins*.	1
Ataxial growth	Fibres of minerals are in continuity with crystals in the wall rock, but lack a localized growth surface. Growth is by repetitive fracturing at different sites. Young and old parts of the fibres can be mixed throughout the *vein*. No median line is present. Cf. *syntaxial growth*; *antitaxial growth*.	14
Bladed (crystal habit)	Said of a tabular crystal in the form of aggregates of flattened blades or elongate crystals. Cf. *platy*; *sheet*.	1
Botryoidal	Having the form of a bunch of grapes, e.g., hematite, having a surface of spherical shapes; also said of a crystalline aggregate in which the spherical shapes are composed of radiating crystals. Cf. *colloform*; *mammillary*; *reniform*.	1
Boudin neck	Informally, the volume between boudins. The boudinage may range from complete, i.e., the boudins are completely separate, to incomplete, i.e., there is pinching of the more competent material, without actual separation. The relative dilatancy during boudinage enhances fluid flow, which may lead to alteration.	
Carbonatization	Alteration involving the introduction of, or *replacement* by, carbonate minerals.	1
Chloritization	Alteration involving the introduction of, or *replacement* by, chlorite minerals.	
Cleavage controlled	Refers to a case where cleavage has partly to largely controlled fluid flow and hence the distribution of alteration.	
Cockade	An open-space *vein* filling in which the minerals are deposited in successive comb-like crusts around rock fragments, e.g., around breccia fragments in *veins*. See *comb texture*.	1
Colloform	Said of the rounded, finely banded kidney-like mineral texture formed by ultra-fine-grained rhythmic precipitation once thought to denote deposition of colloids. Cf. *botryoidal; mammillary*; *reniform*.	1
Columnar (crystal habit)	Said of a *prismatic* crystal habit that is a subparallel arrangement of column-like crystals having essentially *equant* cross-sections. Cf. *acicular*; *fibrous*.	1
Comb texture	A row of mineral grains oriented with their long axes perpendicular to a surface, resembling teeth of a comb.	1
Composite growth	Involves mineral growth with a *syntaxial* and *antitaxial* component. Two growth surfaces are present at the contact between the *vein* segments where the youngest parts of the vein are situated.	14
Concordant	Used in the sense that the alteration is parallel to layering or contacts in the *host rock*. Cf. *paraconcordant*; *discordant*.	
Conjugate (fractures/faults)	Said of 2 fracture or *vein* sets formed under the same stress field and intersecting with an acute dihedral angle bisected by the maximum principal stress.	1
Core (structure)	The inner or central part of a fold, especially of a folded structure that includes some sort of structural break.	1
Country rock	The rock enclosing or traversed by a mineral deposit. It is somewhat less specific than *host rock* and much less specific than *wall rock*.	1
Crack-seal growth (vein)	Growth of minerals along a fracture, thought to result from periodic fracturing and sealing by growth from a fluid.	14
Crustified	Said of a *vein* in which the mineral filling is deposited in layers on the *wall rock*.	1
Dendrite	A mineral, e.g., a surficial deposit of an oxide of manganese, that has crystallized in a branching pattern.	1
Dendritic	Said of a mineral that has crystallized in a branching pattern (pertaining to a *dendrite*).	1
Deuteric	Referring to reactions between primary magmatic minerals and the water-rich solutions that separate from the same body of magma at a late stage in its cooling history	1
Diffuse (boundary)	Refers to a limit of alteration that is ill-defined, highly gradational, not concise.	
Discordant	Used in the sense that the alteration is not parallel to layering or contacts in the *host rock*. Cf. *concordant*; *paraconcordant*.	
Disseminated	Said of alteration that is scattered throughout a volume of rock, in sufficient quantity to be noted. There is no genetic connotation.	(1)
Domainal	Alteration that is concentrated within well- or ill-defined volumes or domains, with or without obvious connectivity.	

Table 65. *continued*

Modifier	Definition[A]	Source[B]
Encrustation (pseudomorph)	A type of *pseudomorph* whereby a mineral is coated by another mineral and the encased mineral subsequently dissolves leaving the encrustation intact, retaining the shape of the original mineral. Another mineral may fill the void left by the original mineral (e.g., quartz after calcite). Cf. *alteration*; *paramorphism*; *substitution*.	
En echelon	Said of geologic features (e.g., faults, fractures, *veins*) that are in an overlapping or staggered or step-like arrangement, like tiles on a roof. Each is relatively short but collectively they form a linear zone, in which the strike of the individual features is oblique to that of the zone as a whole.	1,(14)
Epidotization	The formation of epidote in rocks by hydrothermal alteration. Also the alteration of rocks in which plagioclase feldspar is albitized, whereby the anorthite molecule is freed for the formation of epidote and zoisite, often accompanied by *chloritization*.	1
Epigenetic	As used here, said of material of origin later than that of the enclosing rocks.	
Equant (crystal habit)	Said of a crystal having the same or nearly the same diameter in all directions. Cf. *prismatic*; *tabular*. [Synonym: equidimensional].	(1)
Fault controlled	Refers to a case where a fault(s) has partly to largely controlled fluid flow and hence the distribution of alteration.	
Feature (generation)	As used here, a means to denote different features to be described, either independently (i.e., chronology of development is undetermined) or based on relative chronology. The letters represent a case when more than one stage of alteration is observed, but no relative chronology can be established. For example, “a” may represent one type of *vein* and “b” may represent another type. The numbers represent a case whereby relative chronology can be determined, hence “1” represents an earlier vein, and “2” represents a later vein, as determined by crosscutting relationships.	
Feldspathization	Alteration involving the formation of feldspar in a rock, usually as a result of metamorphism or metasomatism. Material for the feldspar may come from the *country rock* or be introduced by magmatic or other solutions. If the composition of the feldspar is known, then more appropriate terms such as *albitization* (sodic), or potassic feldspathization or calcic feldspathization may be used.	1,(8)
Fibrous (crystal habit)	Said of a *prismatic* crystal habit that consists of fibres. Cf. *acicular*; *columnar*.	(1)
Fibrous (vein)	A *vein* consisting of *fibrous* minerals. Cf. *nonfibrous vein*.	14
Fracture controlled	Refers to a case where fractures have partly to largely controlled fluid flow and hence the distribution of alteration. No vein material is involved.	
Groundmass	As used here, refers to the matrix of a porphyritic igneous rock, a clastic sedimentary rock or a varitextured metamorphic rock.	(1)
Halo	A circular or subcircular distribution of alteration about an object such as an inclusion or clast.	
Hematization	Alteration involving the introduction of, or *replacement* by, hematite. The hematite may be very fine to extremely fine grained and result in a pinkish orange to ruddy *hue* in the rock.	
Host rock	A body of rock serving as a host for other rocks or for mineral deposits; e.g., a pluton containing xenoliths, or any rock in which ore deposits occur. It is a somewhat more specific term than *country rock* and less specific than *wall rock*.	1
Hue	Although highly technical definitions for hue exist, as used here, refers to the purity of the colour (without tint or shade), such as red, green, blue, yellow. More technically, the attribute of colour associated with wavelength or dominant spectral colour. The category hue/saturation is intended to be used to describe the colour in general, such as light green, bright green, pistachio green, etc. Cf. *saturation*.	(1)
Intrusion controlled	Refers to a case where an intrusion has partly to largely controlled fluid flow and hence the distribution of alteration.	
Ladder vein	One of a series of relatively short *vein*s in transverse, roughly parallel fractures that traverse dikes, perpendicularly from wall to wall, along foliation planes or cooling fractures. Cf. definition in section on Mineralization modifiers (*see* Table 68).	(1)
Layer controlled	Refers to the case where layering has partly to completely controlled fluid flow and hence the distribution of alteration.	
Mammillary (mineral)	Forming smoothly rounded masses resembling breasts or portions of spheres; said of the shape of some mineral aggregates, as with malachite or limonite. Cf. *botryoidal; colloform; reniform.*	1
Mantle (crystal)	As used here, an overgrowth of minerals forming a rim around a crystal.	
Massive (mineral)	Said of a mineral that is physically isotropic, e.g., lacking a *platy*, *fibrous*, or other structure.	1
Massive (vein)	A nonfibrous vein with no specific texture. Cf. *cockade*; *comb*; *crustified*; *zoned*.	(14)
Motley	Diversified in colour, as in mottled; having an irregular arrangement of spots or patches of colour.	
Nonfibrous (vein)	A vein consisting of nonfibrous minerals. See *cockade*; *comb*; *crustified*; *massive*; *zoned*. Cf. *fibrous vein*.	14
Paleosol	A buried soil horizon of the geologic past.	1
Paraconcordant	Used in the sense that the alteration is almost, but not quite, concordant. Cf. *concordant*; *discordant*.	1
Paramorph	A *pseudomorph* with the same composition as the original mineral (e.g., calcite after aragonite).	1
Paramorphism	The process of becoming, and the condition of being, a *paramorph*. Cf. *alteration*; *encrustation*; *substitution*.	1

Table 65. *continued*

Modifier	Definition[A]	Source[B]
Patchy	Alteration that forms mesoscopic, irregularly distributed masses. Cf. *spotty*.	
Plumose	Said of a mineral cluster with fine, feather-like "scales".	
Platy (crystal habit)	Said of a *tabular* crystal with 2 subequal dimensions and a much shorter (~<1/3) third dimension. Cf. *bladed*; *sheet*.	
Prismatic (crystal habit)	Said of a crystal habit that shows one dimension markedly longer than the other two. See *acicular*; *columnar*; *fibrous*.	1
Propylitization	The result of low-pressure-temperature alteration around many ore bodies. The propylitic assemblage consists of epidote, chlorite, Mg-Fe-Ca carbonates, and sometimes albite-orthoclase, all involved in partial *replacement* of *wall-rock* minerals.	1
Pseudobreccia	A form of alteration that may considerably affect the *host rock* in many parts but leave other parts unaltered or less altered resulting in the appearance of a breccia (i.e., unaltered apparent "fragments" in an altered "matrix"). The distribution of alteration may have been controlled by multiple crosscutting fractures.	
Pseudomorph	A mineral with an outward crystal form that is of another mineral species; it has developed by *alteration*, *encrustation*, *paramorphism* or *substitution*. A pseudomorph is described as being "after" the mineral whose outward form it has, e.g., quartz after fluorite. See *paramorph.*	1
Pseudomorphism	The process of becoming, and the condition of being, a *pseudomorph*.	1
Radiating (mineral)	Said of a mineral cluster that is radially arranged.	
Reniform	Crystal structure in which radiating crystals terminate in rounded, kidney-shaped masses.	1
Replacement	Change in a mineral, or composition of a mineral, or mineral aggregate, presumably by diffusion of new material in and old material out.	1
Reticulated	Said of a mineral cluster that forms net-like intergrowths.	
Saprolite	A soft, earthy, typically clay-rich, thoroughly decomposed rock, formed in place by chemical weathering of igneous, sedimentary and metamorphic rocks. It often forms a layer or cover (as much as 100 m thick, especially in humid and tropical or subtropical climates); the colour is commonly some shade of red or brown, but it may be white or grey. Saprolite is characterized by preservation of structures that were present in the unweathered rock.	1
Saturation	Although highly technical definitions for saturation exist, as used here, refers to the colourfulness of a colour relative to its own brightness. Reworded, a completely saturated colour would be one with a single wavelength at high intensity (e.g., laser light). The category hue/saturation is intended to be used to describe the colour in general, such as light green, bright green, pistachio green, etc. Cf. *hue*.	
Saturated	As used here, alteration that has affected the whole rock.	
Saussuritization	The *replacement*, especially of plagioclase in basalts and gabbros, by a fine-grained aggregate of zoisite, epidote, albite, calcite, sericite and zeolites. It is a metamorphic or deuteric process and is frequently accompanied by *chloritization* of the ferromagnesian minerals.	1
Selvage	A marginal zone of a rock mass, having some distinctive feature of fabric or composition; specifically the chilled border of an igneous mass (as with a dike or lava flow), usually characterized by a finer grain or in some cases glassy texture, such as the glassy inner margins on the pillows in pillow lava.	1
Sericitization	A hydrothermal, deuteric, or metamorphic process involving the introduction of, alteration to, or *replacement* by sericitic muscovite. Care should be taken in restricting the term to potassic micas and not sodic micas (i.e., paragonite).	1
Shear controlled	Refers to a case where shearing and related structures have partly to completely controlled fluid flow and hence the distribution of alteration.	
Sheet (crystal habit)	Said of a *tabular* crystal that separates into thin sheets or layers (i.e., micas). Cf. *bladed*; *platy*.	
Silication	The *replacement* or breakdown of silicate minerals by reaction with free silica. Cf. *silicification*.	1
Silicification	Hydrothermal alteration in which the quartz, opal, chalcedony, jasper or other form of amorphous silica content of the rock increases. The term often refers to cases where there is a net addition of silica in the altered rock, but silicification may also occur by decomposition reactions where quartz is a byproduct (desilication) or by cation leaching in silica-stable systems. Often confused with *silication*. Adjective: silicified.	1
Spotty	As used here, said of alteration which occurs in small, scattered masses or spots. Cf. *patchy*.	
Stockwork	As used here, a three-dimensional network of planar to irregular *veins* spaced closely enough that the whole mass could be mined, were it mineralized.	
Substitution (pseudomorph)	A type of *pseudomorph* in which one mineral (or other material) is replaced by another whereby the original shape is retained but the properties of colour, hardness, etc. are those of the replacing mineral. (e.g., pyrolusite after calcite). Cf. *alteration*; *encrustation*; *paramorphism*.	
Syntaxial growth	Said of a *vein* infilling in which fibres grow from the walls toward the centre. Vein minerals tend to be the same as those in the wall rock. The habit of the vein minerals is often fibrous. A median line marks the final position of the growth surface. Cf. *antitaxial growth*; *ataxial growth*.	14,8
Tabular (crystal habit)	Said of a crystal habit that shows one dimension markedly smaller than the other two. See *bladed*; *platy*; *sheet*.	1
Tourmalinization	Alteration involving the introduction of, or *replacement* by, tourmaline minerals.	

Table 65. *continued*

Modifier	Definition[A]	Source[B]
Uniform	In the sense of colour uniformity, refers to being evenly distributed.	
Varicoloured	Of various or different colours.	
Vein	Any dilational *fracture* that contains mineral material such as quartz and/or carbonate. Veins can display either crack-normal extension or shear displacement coupled with crack-normal extension. Veins may consist of nonfibrous minerals (*nonfibrous veins*) or fibrous minerals (*fibrous veins*). Veins may be associated with no wallrock alteration and have sharp boundaries, or be associated with wallrock alteration and have diffuse boundaries. For OGS purposes, fractures along which alteration alone has replaced the wall-rock constitute fracture-controlled alteration, not nondilational veins (cf. Hobbs, Means and Williams (1976)) or replacement veins (cf. Passchier and Trouw (1998)).	1,14
Vein controlled	Refers to a case where veins have partly to completely controlled fluid flow and hence the distribution of alteration.	
Wall rock	The rock adjacent to, enclosing, or including a *vein*, layer, or dissemination of ore minerals. It is commonly altered. The term implies more specific adjacency than the terms *host rock* or *country rock*.	1
Zonal	Systematic variation in alteration characteristics in zones about a particular feature, e.g., fracture, *vein*, fragment.	
Zoned (vein)	A *vein* which displays a zoning of minerals from the *wall rock* to the vein centre.	

[A] *Preferred terms are defined: synonyms are in square brackets for reference only.*
[B] *Indicates source of definition: primary sources are indicated by a number; secondary sources are indicated by numbers in parentheses.*
1 = Neuendorf, Mehl and Jackson (2005); 8 = Fettes and Desmons (2007); 14 = Passchier and Trouw (1998).
Where no source(s) is indicated, definitions are derived from or modified for use by the OGS.

SIZE RANGES

Table 66. Alteration terms: size ranges for wall rock and vein minerals.[A]

Crystals	Aphanitic	<0.1 mm
	Very fine grained	0.1 to 0.5 mm
	Fine grained	0.5 to 1 mm
	Medium grained	1 to 5 mm
	Coarse grained	5 to 30 mm
	Very coarse grained	3 to 10 cm
	Extremely coarse grained	>10 cm

[A] *Adapted from a variety of sources and modified for OGS usage.*

MINERALIZATION TERMS

Mineralization is a general term that can be defined as the process or processes by which one or more minerals are introduced into a rock in various styles, such as crystal settling, fissure filling, impregnation and replacement, resulting in a valuable or potentially valuable deposit. Note that the definition uses key words such as "value" and "introduced". With respect to field mapping in particular, we use the term "mineralization" in a slightly broader sense. Examples include: 1) minerals such as disseminated pyrite or pyrite veins are not valuable *per se*, but may reflect potential for economic mineralization elsewhere in the mineralizing system (e.g., gold); and 2) minerals such as beryl and spodumene in pegmatites are part of the original rock and have not been "introduced" *per se*.

Mineralization may be associated with macroscopically visible alteration (e.g., volcanogenic massive sulphide deposits); macroscopically undetectable alteration (e.g., sedimentary basin mineralization); or no alteration (e.g., gravity settling in some magmatic nickel-copper-platinum group element deposits).

The primary subdivisions of mineralization are "massive", that is the entire rock volume consists of minerals considered as mineralization, and "nonmassive", that is only selected parts of the rock volume constitute mineralization, such as that associated with disseminations or individual veins. We currently treat mineralization and alteration separately, with their respective individual pick lists (Table 67 (mineralization) and Table 64 (alteration), respectively), as either may occur without the other.

MODIFIERS

Modifiers and ancillary terms for mineralization are listed alphabetically. Words within definitions that are in *italics* are also defined elsewhere in the same table. A word in square [brackets] following a modifier indicates the appropriate geologic theme or topic to which the modifier refers, as the modifier can apply to more than one theme. A word in (parentheses) following a modifier refers to the general topic as laid out in the hierarchical design of the appropriate pick list.

Table 68. Mineralization terms: modifier definitions.

Modifier	Definition[A]	Source[B]
Acicular (crystal habit)	Said of a *prismatic* crystal that is needle-like in form. Cf. *columnar*; *fibrous*.	1
Alteration (pseudomorph)	A type of *substitution pseudomorph*, in which only partial replacement occurs through a mineral composition changing by chemical reaction to another mineral of similar composition, retaining the original crystalline shape (e.g., anglesite (lead sulphate) after galena (lead sulphide)). Cf. *encrustation*; *paramorphism*; *substitution*.	
Antitaxial growth	Said of a *vein* infilling in which fibres grow from the centre toward the walls. Vein minerals tend to be different from those found in the wall and commonly have a *fibrous* habit. The oldest part of the vein is along the median line. Cf. *syntaxial growth*; *ataxial growth*.	1,8
Ataxial growth	Fibres of minerals are in continuity with crystals in the *wall rock*, but lack a localized growth surface. Growth is by repetitive fracturing at different sites. Young and old parts of the fibres can be mixed throughout the *vein*. No median line is present. Cf. *syntaxial growth*; *antitaxial growth*.	14
Bladed (crystal habit)	Said of a *tabular* crystal in the form of aggregates of flattened blades or elongate crystals. Cf. *platy*; *sheet*.	1
Botryoidal	Having the form of a bunch of grapes, e.g. hematite, having a surface of spherical shapes; also said of a crystalline aggregate in which the spherical shapes are composed of radiating crystals. Cf. *colloform*; *mammillary*; *reniform*.	1
Boudin neck	Informally, the volume between boudins. The boudinage may range from complete, i.e., the boudins are completely separate, to incomplete, i.e., there is pinching of the more competent material, without actual separation. The relative dilatancy during boudinage enhances fluid flow, which may lead to mineralization.	
Cleavage controlled	Refers to a case where cleavage has partly to largely controlled fluid flow and hence the distribution of mineralization.	
Cockade	An open-space vein filling in which the minerals (gangue or mineralization) are deposited in successive comb-like crusts around rock fragments, e.g., around vein breccia fragments in *veins*. See *comb texture*.	1
Colloform	Said of the rounded, finely banded kidney-like mineral texture formed by ultra-fine-grained rhythmic precipitation once thought to denote deposition of colloids. Cf. *botryoidal*; *mammillary*; *reniform*.	1

Table 68. *continued*

Modifier	Definition[A]	Source[B]
Columnar (crystal habit)	Said of a *prismatic* crystal habit that is a subparallel arrangement of column-like crystals having essentially *equant* cross-sections. Cf. *acicular*; *fibrous*.	1
Comb texture	A row of mineral grains oriented with their long axis perpendicular to a surface, resembling teeth of a comb.	1
Composite growth	Involves mineral growth with a *syntaxial* and *antitaxial* component. Two growth surfaces are present at the contact between the *vein* segments where the youngest parts of the vein are situated.	14
Concordant	Used in the sense that the mineralization is parallel to layering or contacts in the *host rock*. Cf. *paraconcordant*; *discordant*.	
Conjugate	Said of 2 mineralized fracture or *vein* sets formed under the same stress field and intersecting with an acute dihedral angle bisected by the maximum principal stress.	1
Core (structure)	The inner or central part of a fold, especially of a folded structure that includes some sort of structural break.	1
Country rock	The rock enclosing or traversed by a mineral deposit. It is somewhat less specific than *host rock* and much less specific than *wall rock*.	1
Crack-seal growth (vein)	Growth of minerals along a fracture, thought to result from periodic fracturing and sealing by growth from a fluid.	14
Crustified	Said of a *vein* in which the mineral filling is deposited in layers on the *wall rock*.	1
Dendrite	A mineral, e.g., a surficial deposit of an oxide of manganese that has crystallized in a branching pattern.	1
Dendritic	Said of a mineral that has crystallized in a branching pattern (pertaining to a dendrite).	1
Diffuse (boundary)	Refers to a limit of mineralization that is ill defined, highly gradational, not concise.	
Discordant	Used in the sense that the mineralization is not parallel to layering or contacts in the *host rock*. Cf. *concordant*; *paraconcordant*.	
Disseminated	Said of a mineral deposit (especially of metals) in which the desired minerals occur as scattered particles in the rock, generally but not necessarily in sufficient quantity to make the deposit an ore. There is no genetic connotation.	(1)
Domainal	Mineralization that is concentrated within well- or ill-defined volumes or domains, with or without obvious connectivity.	
Encrustation (pseudomorph)	A type of *pseudomorph* whereby a mineral is coated by another mineral and the encased mineral subsequently dissolves leaving the encrustation intact, retaining the shape of the original mineral. Another mineral may fill the void left by the original mineral (e.g., quartz after calcite). Cf. *alteration*; *paramorphism*; *substitution*.	
En echelon	Said of geologic features (e.g., faults, fractures, *vein*s) that are in an overlapping or staggered or step-like arrangement, like tiles on a roof. Each is relatively short but collectively they form a linear zone, in which the strike of the individual features is oblique to that of the zone as a whole.	1,(14)
Epigenetic [economic geology]	Said of a mineral deposit of origin later than that of the enclosing rocks. Cf. *syngenetic*.	1
Equant (crystal habit)	Said of a crystal having the same or nearly the same diameter in all directions. Cf. *prismatic*; *tabular*. [Synonym: equidimensional].	(1)
Fault controlled	Refers to a case where a fault(s) has partly to largely controlled fluid flow and hence the distribution of mineralization.	
Feature generation	As used here, a means to denote different features to be described, either independently (i.e., chronology of development is undetermined) or based on relative chronology. The letters represent a case when more than one stage of mineralization is observed, but no relative chronology can be established. For example, “a” may represent one type of *vein* and “b” may represent another type. The numbers represent a case whereby relative chronology can be determined, hence “1” represents an earlier vein, and “2” represents a later vein, as determined by crosscutting relationships.	
Fibrous (crystal habit)	Said of a *prismatic* crystal habit that consists of fibres. Cf. *acicular*; *columnar*.	(1)
Fracture controlled	Refers to a case where fractures have partly to largely controlled fluid flow and hence the distribution of mineralization.	
Gangue	The valueless rock or mineral aggregates in an ore; that part of an ore that is not economically desirable but cannot be avoided in mining. It is separated from the *ore minerals* during concentration.	1
Groundmass	As used here, refers to the matrix of a porphyritic igneous rock, a clastic sedimentary rock or a varitextured metamorphic rock.	(1)
Halo	A circular or subcircular distribution of mineralization about an object such as an inclusion or clast.	
Host rock	A body of rock serving as a host for other rocks or for mineral deposits; e.g., a pluton containing xenoliths, or any rock in which ore deposits occur. It is a somewhat more specific term than *country rock* and less specific than *wall rock*.	1
Hue	Although highly technical definitions for hue exist, as used here, refers to the purity of the colour (without tint or shade), such as red, green, blue, yellow. More technically, the attribute of colour associated with wavelength or dominant spectral colour. The category hue/saturation is intended to be used to describe the colour in general, such as dull brass, bright brass, etc. Cf. *saturation*.	(1)

Table 68. *continued*

Modifier	Definition[A]	Source[B]
Intrusion controlled	Refers to a case where an intrusion has partly to largely controlled fluid flow and hence the distribution of mineralization.	
Ladder vein	One of a series of *mineral deposits* in transverse, roughly parallel fractures that have formed along foliation planes perpendicular to the walls of a dike during its cooling, or along shrinkage joints in basaltic rocks or dikes. Cf. definition in section on Alteration modifiers (Table 65).	1
Lustre	The appearance of a mineral in reflected light, described by its quality and intensity. Terms such as metallic or resinous refer to general appearance; terms such as bright or dull refer to intensity. See *metallic*; *submetallic*; *nonmetallic*.	
Mammillary (mineral)	Forming smoothly rounded masses resembling breasts or portions of spheres; said of the shape of some mineral aggregates, as with malachite or limonite. Cf. *botryoidal; colloform; reniform.*	1
Mantle (crystal)	As used here, an overgrowth of minerals forming a rim around a crystal.	
Massive (mineral)	Said of a mineral that is physically isotropic, e.g., lacking a *platy*, *fibrous*, or other structure.	1
Massive (mineralization)	Said of a *mineral deposit* (especially of sulphides) characterized by a mass of unusually abundant metallic minerals, e.g., massive sulphide deposit; massive chalcopyrite.	1
Metallic (lustre)	Pertaining to a metal or a type of *lustre* characteristic of metals. Cf. *submetallic*; *nonmetallic*.	1
Mineral deposit	A mass of naturally occurring mineral material, e.g., metal ores or nonmetallic minerals, usually of economic value, without regard to mode of origin. Accumulations of coal and petroleum may or may not be included; usage should be defined in context.	1
Mineralization [ore deposit]	The process or processes by which a mineral or minerals are introduced into a rock, resulting in a valuable or potentially valuable *mineral deposit*. It is a general term, incorporating various types, e.g., fissure filling, impregnation, replacement.	1
Mineral occurrence	Any *ore* or economic mineral in any concentration found in bedrock or as float; especially a valuable mineral in sufficient concentration to suggest further exploration.	1
Motley	Diversified in colour, as in mottled; having an irregular arrangement of spots or patches of colour.	
Nonmetallic (lustre)	Pertaining to a nonmetal or mineral *lustre* other than *metallic* or *submetallic* lustre.	1
Ore	The naturally occurring material from which a mineral or minerals of economic value can be extracted at a reasonable profit; also the minerals thus extracted. The term is generally but not always used to refer to metalliferous material, and is often modified by the name of the valuable constituent, e.g., “iron ore”. Cf. *mineral deposit*; *orebody*; *ore mineral*.	1
Orebody	A continuous, well-defined mass of material of sufficient *ore* content to make extraction economically feasible.	1
Ore mineral	The part of an *ore*, commonly *metallic*, which is economically desirable, as contrasted with *gangue*.	
Paleosol	A buried soil horizon of the geologic past.	1
Paraconcordant	Used in the sense that the mineralization is almost, but not quite, concordant. Cf. *concordant*; *discordant*.	1
Paramorph	A *psuedomorph* with the same compositon as the original mineral (e.g., calcite after aragonite).	1
Paramorphism	The process of becoming, and the condition of being, a *paramorph*. Cf.*alteration*; *encrustation*; *substitution*.	1
Patchy	Said of a *mineral deposit* or mineralized zone in which the valuable constituent occurs in mesoscopic, irregularly distributed masses. Cf. *spotty*.	
Platy (crystal habit)	Said of a *tabular* crystal with 2 subequal dimensions and a much shorter (~ <1/3) third dimension. Cf. *bladed; sheet*.	
Prismatic (crystal habit)	Said of a crystal habit that shows one dimension markedly longer than the other two. See *acicular*; *columnar*; *fibrous*.	1
Pseudobreccia	A form of *mineralization* that may considerably affect the *host rock* in many parts but leave other parts unmineralized or less mineralized resulting in the appearance of a breccia (i.e., unmineralized apparent “fragments” in a mineralized “matrix”). The distribution of mineralization may have been controlled by multiple crosscutting fractures.	
Pseudomorph	A mineral with an outward crystal form that is of another mineral species; it has developed by *alteration*, *encrustation*, *paramorphism*, or *substitution*. A pseudomorph is described as being "after" the mineral whose outward form it has, e.g. quartz after fluorite.	1
Pseudomorphism	The process of becoming, and the condition of being, a *pseudomorph*.	1
Reniform	Crystal structure in which radiating crystals terminate in rounded, kidney-shaped masses.	1
Replacement	Change in a mineral, or composition of a mineral, or mineral aggregate, presumably by diffusion of new material in and old material out.	1
Reticulated	Said of a mineral cluster that forms net-like intergrowths.	
Saturation	Although highly technical definitions for saturation exist, as used here, refers to the colourfulness of a colour relative to its own brightness. Reworded, a completely saturated colour would be one with a single wavelength at high intensity (e.g., laser light). The category hue/saturation is intended to be used to describe the colour in general, such as dull brass, bright brass, etc. Cf. *hue*.	

Table 68. *continued*

Modifier	Definition[A]	Source[B]
Selvage	A marginal zone of a rock mass, having some distinctive feature of fabric or composition; specifically the chilled border of an igneous mass (as with a dike or lava flow), usually characterized by a finer grain or in some cases glassy texture, such as the glassy inner margins on the pillows in pillow lava.	1
Shear controlled	Refers to a case where shearing and related structures have partly to completely controlled fluid flow and hence the distribution of mineralization.	
Sheet (crystal habit)	Said of a *tabular* crystal that separates into thin sheets or layers (i.e., micas). Cf. *bladed*; *platy*.	
Spotty	Said of a *mineral deposit* or mineralized zone in which the valuable constituent occurs in scattered masses or spots of high-grade material. Cf. *patchy*.	1
Stockwork	A *mineral deposit* consisting of a three-dimensional network of planar to irregular *veins* spaced closely enough that the whole mass can be mined.	1
Stringer [ore deposit]	A thin mineral *vein* or filament, usually one of a number, occurring in a discontinuous subparallel pattern in host rock.	1
Submetallic (lustre)	A mineral *lustre* between *metallic* and *nonmetallic*. Chromite, for example, has a metallic to submetallic lustre. Cf. *metallic*; *nonmetallic*.	1
Substitution (pseudomorph)	A type of *pseudomorph* in which one mineral (or other material) is replaced by another whereby the original shape is retained but the properties of colour, hardness, etc. are those of the replacing mineral. (e.g., native copper after aragonite). Cf. *alteration*; *encrustation*; *paramorphism*.	
Syngenetic [economic geology]	Said of a *mineral deposit* formed contemporaneously with, and by essentially the same processes as, the enclosing rocks. Cf. *epigenetic*.	1
Syntaxial growth	Said of a *vein* infilling in which fibres grow from the walls toward the centre. Vein minerals tend to be the same as those in the *wall rock*. The habit of the vein minerals is often *fibrous*. A median line marks the final position of the growth surface. Cf. *antitaxial growth*; *ataxial growth*.	14,8
Tabular (crystal habit)	Said of a crystal habit that shows one dimension markedly smaller than the other two. See *bladed*; *platy*; *sheet*.	1
Uniform	In the sense of colour uniformity, refers to being evenly distributed.	
Varicoloured	Of various or different colours.	
Vein	An *epigenetic* mineral filling of a fault or other fracture in a *host rock*, in tabular or sheet-like form, often with associated *replacement* of the *wall rock*; may be mineralized. Not recommended usage as an igneous intrusive term.	1
Vein controlled	Refers to a case where veins have partly to completely controlled fluid flow and hence the distribution of mineralization.	
Wall rock	The rock adjacent to, enclosing, or including a vein, layer, or dissemination of ore minerals. It is commonly altered. The term implies more adjacency than the terms *host rock* or *country rock*.	1
Zonal	As used here, a type of nonmassive mineralization with systematic variation in mineralization characteristics in zones about a particular feature, e.g., fracture, *vein*, fragment.	
Zoned (vein)	A *vein* which displays a zoning of minerals (*gangue* or *mineralization*) from the *wall rock* to the vein centre.	

[A] *Preferred terms are defined: synonyms are in square brackets for reference only.*
[B] *Indicates source of definition: primary sources are indicated by a number; secondary sources are indicated by numbers in parentheses.*
1 = Neuendorf, Mehl and Jackson (2005); 8 = Fettes and Desmons (2007); 14 = Passchier and Trouw (1998).
Where no source(s) is indicated, definitions are derived from or modified for use by the OGS.

SIZE RANGES

Table 69. Mineralization terms: size ranges for wall rock and vein minerals.[A]

Crystals	Aphanitic	<0.1 mm
	Very fine grained	0.1 to 0.5 mm
	Fine grained	0.5 to 1 mm
	Medium grained	1 to 5 mm
	Coarse grained	5 to 30 mm
	Very coarse grained	3 cm to 10 cm
	Extremely coarse grained	>10 cm

[A]*Adapted from a variety of sources and modified for OGS usage.*

MINERALOGIC TERMS

Minerals are divided into sets at different hierarchical levels (i.e., class, subclass, family, supergroup, group and subgroup or series) according to key parameters, namely chemical composition and crystal structure. Some of the terms are officially defined by various organizations (e.g., International Mineralogical Association), but different schemes and common usage have been less rigorous. In some cases, terms are used interchangeably, in part because words such as "group" can be used in normal sentence construction in a number of ways. Because of inconsistent, conflicting and confusing usage of some terms, the mineral classification presented here is a working compromise, but based largely on that of Mills et al. (2009).

Table 70 provides definitions for the most common terms related to fundamental mineralogy, particularly as it relates to typical use within the OGS. Words within definitions that are in *italics* are also defined elsewhere in the same table. A word in square [brackets] following a modifier indicates the appropriate geologic theme or topic to which the modifier refers, as the modifier can apply to more than one theme. A word in (parentheses) following a modifier refers to the general topic as laid out in the hierarchical design of the appropriate pick list.

Table 71 (back pocket) lists some of the chief characteristics of minerals included in the pick lists. Minerals belonging to the Mohs scale of hardness are listed in Table 72.

Table 70. Mineralogic terms: definitions.

Term	Definition[A]	Source[B]
Amorphous	Said of a *mineral* or other substance that lacks crystalline structure or whose internal arrangement is so irregular that there is no characteristic external form. The term does not preclude the existence of any degree of order. Antonym: *crystalline*.	1
Anion	A negatively charged *ion*; an ion that is attracted to the anode in electrolysis. Cf. *cation*.	
Arsenate	A *mineral* compound characterized by pentavalent arsenic and oxygen in the *anion*. An example is mimetite, $Pb_5(AsO_4)_3Cl$. The arsenate *ion* has the empirical formula AsO_4^{3-}. Arsenates are *salts* of arsenic acid and are moderate oxidizers.	(1)
Borate	A *mineral* characterized by the presence of BO_3^{3-} and/or BO_4^{5-} *oxyanions* in its chemical formula. An example of a borate is boracite, $Mg_3B_7O_{13}Cl$.	1
Carbonate (mineral)	A *mineral* compound characterized by a fundamental anionic structure of CO_3^{2-}. Calcite and aragonite, $CaCO_3$, are examples of carbonates. Carbonates are *salts* of carbonic acid.	(1)
Cation	A positively charged *ion*; an ion that is attracted to the cathode in electrolysis. Cf. *anion*.	
Chromate	A *mineral* containing the chromate *ion* CrO_4^{2-}. An example is crocoite, $PbCrO_4$.	1
Class (mineral)	*Minerals* and gemstones are classified according to the main *anion* (e.g., O^{2-}, anionic complex (e.g., OH^-), or lack of anion (e.g., native element). There are various classes, depending on different reference sources. The classes referred to here, with simplified names, are listed in approximate order of their abundance in the Earth's crust, namely silicate; carbonate (includes nitrate, borate minerals); sulphate (includes chromate, molybdate, tungstate, selenate, sulphate, tellurate minerals); halide; oxide (includes hydroxide minerals); sulphide (includes selenide, telluride, arsenide, antimonide, bismuthinide, sulphosalt minerals); phosphate (includes arsenate, vanadate, antimonite minerals); element (includes native metals, intermetallic elements, semi-metals and nonmetals, natural alloys); and organic (includes oxalates and others).	(20)
Clay minerals	Very fine-grained hydrous aluminum *phyllosilicates* with various amounts of iron, magnesium, alkali metals, alkaline earths and other *cations*. Generally formed by weathering or hydrothermal alteration, under acidic or alkaline conditions. Also said to be any *mineral* of the clay-sized fraction (i.e., <0.004 mm).	(1)
Cleavage (mineral)	The breaking of a *mineral* along its crystallographic planes owing to either paucity of, or systematically weak, atomic bonds, thus reflecting crystal structure. The types of cleavage are named according to the morphology, e.g., *prismatic* cleavage.	1
Crystalline [crystallography]	Pertaining to or having the nature of a crystal, or formed by crystallization; specifically having a *crystal structure* or a regular arrangement of atoms in a space lattice.	1
Crystal class	One of 32 possible crystallographic combinations of the nontranslational elements of symmetry. Crystal classes are divided among the 6 *crystal systems*, and deal with outward symmetry.	1

Table 70. *continued*

Term	Definition[A]	Source[B]
Crystal lattice	The three-dimensional regularly repeating set of points that represent the translational periodicity of a crystal structure. Each lattice point has identical surroundings. There are 14 possible (Bravais) lattice patterns.	1
Crystal structure	The regular, orderly and repeated arrangement of atoms in a crystal, the translational properties of which are described by the *crystal lattice* or space lattice, which can have various elements of symmetry. See *crystal systems*; *unit cell*.	1
Crystal system	One of 6 classifications (some systems consider 7) of crystals according to the symmetry of their crystal faces, and having characteristic dimensional equivalences in the lattices or axes of reference. The systems are: *hexagonal system, isometric system, monoclinic system, orthorhombic system, tetragonal system* and *triclinic system.* Within the 6 systems there are a total of 32 *crystal classes*. See also *rhombohedral system*; *trigonal system*.	1
Cyclosilicate	A structural subclass of *silicate* characterized by the linkage of the SiO_4 tetrahedra in rings, with a ratio of Si:O=1:3. An example of a cyclosilicate is benitoite, $BaTiSi_3O_9$. Cf. *inosilicate*; *nesosilicate*; *phyllosilicate*; *sorosilicate*; *tectosilicate.* [Synonym: ring silicate.]	1
Family (mineral)	Applies to *groups* and/or *supergroups* having similar structural and/or chemical features that make them unique. Structural examples: zeolite, feldspathoid, amphibole and pyroxene families. Chemical example: pyrite-marcasite family, consisting of pyrite and marcasite supergroups. *Minerals* with a similar structure are grouped in homeotype (*homeotypic*) families: e.g., amphibole and pyroxene families.	(20)
Group (mineral)	A group of *minerals* consisting of 2 or more minerals with the same (*isotypic*) or essentially the same (*homeotypic*) structure, composed of chemically similar elements, and not forming solid solutions. Examples are the feldspathoid and garnet groups. Cf. *series*.	(20)
Halide	A *mineral* compound characterized by a halogen such as fluorine, chlorine, iodine or bromine as the *anion*. Halite (NaCl) is an example.	1
Hexagonal system	One of the 6 *crystal systems*, characterized by 1 unique axis of three-fold or six-fold symmetry that is perpendicular and unequal in length to 3 identical axes that intersect at angles of 120°. This definition includes the *trigonal system* of three-fold symmetry; however, the 2 systems of three-fold and six-fold symmetries may be defined separately. Cf. *isometric system*; *monoclinic system*; *orthorhombic system*; *tetragonal system*; *triclinic system.* See *trigonal system*.	1
Homeotypic	*Minerals* exhibiting all essential features of topology preserved between them: e.g., aikinite-bismuthinite series.	
Hydroxide	A type of *oxide* characterized by the linkage of a metallic element or *radical* with the *ion* OH, such as brucite, $Mg(OH)_2$.	1
Inosilicate	A structural subclass of *silicate* characterized by the linkage of the SiO_4 tetrahedra into linear chains by the sharing of oxygens. In a simple chain, e.g., pyroxenes, 2 oxygens are shared; in a double chain or band, e.g., amphiboles, half the SiO_4 tetrahedra share three oxygens and the other half share two. The Si:O ratio of the former type is 1:3 and for the latter it is 4:11. Cf. *cyclosilicate*; *nesosilicate*; *phyllosilicate*; *sorosilicate*; *tectosilicate.* [Synonym: chain silicate.]	1
Ion	An atom or molecule that has lost one or more electrons (*cation*), or gained one or more electrons (*anion*).	
Isometric system	One of the 6 *crystal systems*, characterized by 4 three-fold axes of symmetry as body diagonals in a cubic *unit cell* of the lattice. It comprises 5 crystal *classes* or point groups. Cf. *hexagonal system*; *monoclinic system*; *orthorhombic system*; *tetragonal system*; *triclinic system.* [Synonym: cubic system.]	1
Isomorph [crystallography]	A mineral that shares the same crystal form and analogous chemical composition with one or more minerals. E.g., calcite group (with decreasing cation radius) calcite, rhodochrosite, siderite, smithsonite, magnesite; garnet series. Cf. *polymorph*.	(21)
Isomorphism	The characteristic of 2 or more *crystalline* substances having similar-size *cations*/*anions*, *crystal structure* and hence external form and *cleavage*, belonging to the same crystal *class*. Adjective: isomorphous. See *isomorph*.	1
Isostructural	Said of 2 or more minerals with similar crystal structures but with little tendency to show *isomorphism*.	1
Isotypic	Said of *minerals* with analogous crystal structures and chemical compositions (e.g., zircon and xenotime). Cf. *series*. [Synonym: *isomorph*.]	1
Mineral	(a) A naturally occurring inorganic element or compound having a periodically repeating arrangement of atoms and characteristic chemical composition, resulting in distinctive physical properties. (b) An element or chemical compound that is *crystalline* and that has formed as a result of geologic processes. Materials formed by geologic processes from artificial substances are no longer accepted (after 1995) as new minerals. Mercury, a liquid, is a traditional exception to the crystallinity rule. Water is not a mineral (although ice is), and crystalline biologic and artificial materials are not minerals. Cf. *mineraloid*.	1
Mineraloid	A naturally occurring, usually inorganic substance that is not considered to be a *mineral* because it is *amorphous* and thus lacks a periodically repeating arrangement of atoms; e.g. opal.	1
Molybdate	A *mineral* compound characterized by the *radical* MoO_4. An example of a molybdate is wulfenite, $PbMoO_4$.	1
Monoclinic system	One of the 6 *crystal system*s, characterized by either a single two-fold axis of symmetry, a single plane of symmetry, or a combination of the two. Of the 3 non-equivalent axes, one is perpendicular to the plane formed by the other two. Cf. *hexagonal system*; *isometric system*; *orthorhombic system*; *tetragonal system*; *triclinic system.*	1

Table 70. *continued*

Term	Definition[A]	Source[B]
Native element	Any element found uncombined in a nongaseous state in nature. Nonmetallic examples are carbon, sulphur, and selenium; semimetal examples are antimony, arsenic, bismuth and tellurium; native metals include silver, gold, copper, iron, mercury, iridium, lead, palladium and platinum.	1
Nesosilicate	A structural subclass of *silicate* characterized by isolated SiO_4 tetrahedra, rather than by linkage of tetrahedra by the sharing of common oxygens. An example of a nesosilicate is olivine, $(Mg, Fe)_2SiO_4$. Cf. *cyclosilicate*; *inosilicate*; *phyllosilicate*; *sorosilicate*; *tectosilicate.* [Synonym: orthosilicate.]	1
Nitrate	A *mineral* compound characterized by a fundamental anionic structure of NO_3^-. Soda niter, $NaNO_3$, and niter, KNO_3, are nitrates.	1
Orthorhombic system	One of the 6 *crystal systems*, characterized by 3 axes of symmetry that are mutually perpendicular and of unconstrained relative lengths. Cf. *hexagonal system*; *isometric system*; *monoclinic system*; *tetragonal system*; *triclinic system.* [Synonym: rhombic system.]	1
Oxide	A *mineral* compound characterized by the linkage of oxygen with one or more metallic elements, such as cuprite, Cu_2O; rutile, TiO_2; spinel, $MgAl_2O_4$. See also: *hydroxide.*	1
Oxyanion	An anion with the generic formula $A_xO_y^{Z-}$. E.g., chlorate, ClO_2^-; *sulphite*, SO_3^{2-}.	
Phosphate	[Inorganic] A *mineral* compound containing tetrahedral PO_4^{3-} groups. An example is fluorapatite, $Ca_5(PO_4)_3F$. Phosphates are *salts* of phosphoric acid.	1
Phyllosilicate	A structural subclass of *silicate* characterized by the sharing of 3 of the 4 oxygens in each tetrahedron with neighbouring tetrahedra, to form flat sheets; the Si:O ratio is 2:5. An example is the mica group. Cf. *cyclosilicate*; *inosilicate*; *nesosilicate*; *sorosilicate*; *tectosilicate.* [Synonym: sheet silicate.]	1
Polymorph [crystallography]	A crystal form of a substance that displays *polymorphism*. Examples: pyrite, marcasite (FeS_2); rutile, anatase, brookite (TiO_2). Cf. *isomorph*.	1
Polymorphism [crystallography]	The characteristic of a chemical substance to crystallize in more than one form, e.g. *orthorhombic* and *monoclinic* sulphur; *orthorhombic* and *trigonal* calcium carbonate. Such forms are called *polymorphs*.	1,21
Prismatic (crystal habit)	Said of a crystal habit that shows one dimension markedly longer than the other two. See *acicular*; *columnar*; *fibrous*.	1
Radical [chemistry]	An element or atom or a group of these normally forming part of a compound and remaining unaltered during the compound's ordinary chemical changes.	
Rhombohedral system	A division of the *trigonal system* in which the *unit cell* is a rhombohedron.	1
Salt(s) [chemistry]	A chemical compound formed from the reaction of an acid with a base, with all or part of the hydrogen of the acid replaced by a metal or metal-like *radical*.	
Series (mineral)	*Minerals* with the same structure and forming solid solutions are considered to have *isomorphism*, and form series. Examples: olivine series comprises forsterite and fayalite; plagioclase feldspars comprise a continuous series from albite to anorthite. Cf. *group*.	
Silicate	A compound with a crystal structure that contains SiO_4 tetrahedra, either isolated or joined through one or more of the oxygen atoms to form groups, chains, sheets or three-dimensional structures, with metallic elements. Other elements, especially Al, may substitute for some of the Si. Silicates are classified according to crystal structure. See *cyclosilicate, inosilicate, nesosilicate, phyllosilicate, sorosilicate, tectosilicate*.	1
Sorosilicate	A structural subclass of *silicate* characterized by the linkage of 2 SiO_4 tetrahedra by the sharing of 1 oxygen, with a Si:O ratio of 2:7. An example of a sorosilicate is hemimorphite, $Zn_4Si_2O_7(OH)_2{\cdot}H_2O$. Cf. *cyclosilicate*; *inosilicate*; *nesosilicate*; *phyllosilicate*; *tectosilicate.* [Synonym: disilicate.]	1
Subclass (mineral)	A subclass results from additional subdivision of the silicate and borate classes because of the configuration and bonding of tetrahedra. The subclass prefixes are: cyclo-, ino-, neso-, phyllo-, soro- and tecto.	20
Subgroup (mineral)	Reserved for sets of 2 or more *minerals* that do not meet the strict definition of a mineral *group*. At the same hierarchical level as mineral *series.*	20
Sulphate	A *mineral* compound characterized by the sulphate *radical* SO_4. Anhydrous sulphates, such as barite, $BaSO_4$, have divalent cations linked to the sulphate radical; hydrous and basic sulphates, such as gypsum, $CaSO_4{\cdot}2H_2O$, contain water molecules.	1
Sulphide	A *mineral* compound characterized by the linkage of sulphur with a metal or semimetal, such as galena, PbS, or pyrite, FeS_2.	1
Sulphite	A *mineral* compound containing the *oxyanion* SO_3^{2-}, such as potassium bisulphite, $KHSO_3$.	
Sulphosalt	A type of *sulphide* in which both a metal and a semimetal (Sb, As, or Bi) are present, forming a double sulphide, e.g., enargite, Cu_3AsS_4.	1
Supergroup (mineral)	A supergroup generally consists of 2 or more *groups* that have essentially the same structure and are composed of chemically similar elements, typically from the same *mineral class* (e.g., epidote supergroup), rarely from different classes (e.g., alunite supergroup).	20
Tectosilicates	A structural subclass of *silicate* characterized by the sharing of all 4 oxygens of the SiO_4 tetrahedra with neighbouring tetrahedra, and with a Si:O ratio of 1:2. Quartz, SiO_2, is an example. Cf. *cyclosilicate*; *inosilicate*; *nesosilicate*; *phyllosilicate*; *sorosilicate.* [Synonym: framework silicate.]	1

Table 70. *continued*

Term	Definition[A]	Source[B]
Tetragonal system	One of the 6 *crystal systems,* characterized by 3 mutually perpendicular axes, the vertical one of which is a four-fold rotation or symmetry axis; it is longer or shorter than the 2 horizontal axes, which are of equal length. Cf. *hexagonal system*; *isometric system*; *monoclinic system*; *orthorhombic system*; *triclinic system.*	1
Triclinic system	One of the 6 *crystal systems*, characterized by a one-fold axis of symmetry, and having 3 axes with lengths and angles of intersection that are unconstrained. Cf. *hexagonal system*; *isometric system*; *monoclinic system*; *orthorhombic system*; *tetragonal system.*	1
Trigonal system	A *crystal system* of three-fold symmetry that is often considered as part of the hexagonal system since the lattice may be either hexagonal or rhombohedral. See *hexagonal system*; *rhombohedral system*.	1
Twinning	The development of a twin crystal by growth, transformation, or gliding. See *cyclic*; *lamellar*; *polysynthetic*; *simple* (below).	1
cyclic	Repeated *twinning* of 3 or more individual crystals according to the same twin law but with the twin axes or twin planes not parallel. Cyclic twinning often results in three-fold, four-fold, five-fold, six-fold, or eight-fold twins, which, if equally developed, display geometrical symmetry not formed in single crystals. Cf. *polysynthetic twinning.*	1
lamellar	*Twinning* composed of or arranged in lamellae; disposed in layers like the leaves of a book.	1
polysynthetic	Repeated *twinning* of 3 or more individuals according to the same twin law and on parallel composition planes; e.g., albite twinning of plagioclase. It is often revealed megascopically by striated surfaces. Cf. *cyclic twinning.*	1
simple	*Twinning* with twinned crystal composed of only 2 individuals in twin relation.	1
Tungstate	A *mineral* compound characterized by the *radical* WO_4. An example of a tungstate is wolframite, $(Fe, Mn)WO_4$.	1
Unit cell	The smallest volume or parallelepiped within the three-dimensional repetitive pattern of a crystal that contains a complete sample of the atomic or molecular groups that compose this pattern. *Crystal structure* can be described in terms of the translatory repetition of this unit in space in accordance with one of the space lattices.	1
Vanadate	A *mineral* compound characterized by pentavalent vanadium coordinated by 4 oxygen atoms. An example is vanadinite, $Pb_5(VO_4)_3Cl$. The simplest vanadate *ion* is the VO_4^{3-} *anion*.	(1)

[A] *Preferred terms are defined: synonyms are in square brackets for reference only.*
[B] *Indicates source of definition: primary sources are indicated by a number; secondary sources are indicated by numbers in parentheses.*
1 = Neuendorf, Mehl and Jackson (2005); 20 = Mills et al. (2009); 21 = Berry and Mason (1959).
Where no source(s) is indicated, definitions are derived from or modified for use by the OGS.

MINERALS AND MINERAL CHARACTERISTICS

A master list of minerals is given in Table 71 (back pocket). Minerals chosen for this list are those thought likely of most relevance to Ontario geology (i.e., the list is not all inclusive) but all minerals in pick lists are included. The main mineral characteristics are provided to aid geologists in mineral identification. The information provided in the table is intended for geologists' use in the field and for some basic in-office mineralogy. It is not intended for mineralogists or others who may wish to consult more technical sources.

Several sources for the mineral properties listed in Table 71 were utilized. These include, in order of decreasing weight of influence 1) the Mindat.org online web site; 2) the Wikipedia online web site; 3) Neuendorf, Mehl and Jackson (2005) and the AGI online web site; 4) Berry and Mason (1959); and 5) Deer, Howie and Zussman (1966). The specific sources are included for each mineral: not every source provided all of the features for all minerals. Not all reported mineral properties from the sources listed above are consistent. Where there was inconsistency, the majority ruled in terms of specific reported features, unless there has been a change in convention that would not be reflected in the older sources, in which case newer terms generally superseded older ones.

Mineral abbreviations are largely based on Kretz (1983), as modified by Whitney and Evans (2012), and Fettes and Desmons (2007). If no abbreviation was provided in these sources, a tentative one has been suggested here in most cases. Note that some abbreviations deviate from those traditionally used by the OGS in the past. Mineral names are generally listed from a field-based perspective. Listings based on class, subclass, group and subgroup are somewhat generalized. Simplified mineral formulas are listed where feasible, such as Al_2SiO_5 instead of $Al_2(SiO_4)O$ for andalusite, and $Na(Fe^{2+})_3Al_6(Si_6O_{18})(BO_3)_3(OH)_4$

instead of $\{Ca_2\}\{Al_3\}(Si_2O_7)(SiO_4)O(OH)$ for schorl. Not all possible trace elements that may substitute in mineral lattices are included in the formulas. Terms for twinning are generalized and do not include crystal lattice stereographic index designations (e.g., 010, 110, etc.). "Key Features" are restricted to those most practical in terms of field applicability.

Individual lists for minerals in the rocks and related modifiers pick lists (listed under Part 2: Rock Modifier Definitions) include only those minerals relevant to each category. For example, for phenocrysts, only those minerals that occur as phenocryst phases in igneous rocks are included in the pick lists. The same applies with porphyroblasts, porphyroclasts, xenocrysts, etc. This permits manageable list lengths when using hand-held units in the field.

The Mohs scale of hardness for the specific mineral property "hardness" and common object hardnesses for comparison are given in Table 72. A periodic table of the elements is provided in Figure 44 as both a general reference and a specific reference for associations between minerals and elements.

Table 72. Mohs scale of hardness for minerals.[A]

Mohs Scale	Mineral	Common Object for Comparison
1	Talc	
2	Gypsum	
		Finger nail (2.2)
3	Calcite	
		Copper coin (3.5)
4	Fluorite	
		Wire nail (4.5)
5	Apatite	
		Geological hammer (5.1)
		Pocket knife (5.2)
		Window glass (5.5)
6	Feldspar	
		Steel file (6.5)
7	Quartz	
		Streak plate (7.5)
		Hardened steel file (7+)
8	Topaz	
9	Corundum	
10	Diamond	

[A] *From Walker and Cohen (© 2009 American Geological Institute www.agiweb.org/pubs, used with permission.)*

Acknowledgments

This report is the end result of many meetings, with different committee members over several years, in conjunction with literature investigation. The outcome would not have been possible without the help and guidance of several people, other than the authors, whose contributions are much appreciated.

Early versions of the working committee also included Tom Hart and Michel Houlé, who contributed mainly to the terminology for igneous rocks. Zoran Madon worked toward a database modelling scheme. Dave Rowell acted as facilitator for a period of time. Sara McIlraith provided liaison with respect to co-ordinating pick lists on hand-held computers. Steve Josey was instrumental in ArcPad® programming for the hand-held computers to facilitate the pick lists, in modified form, that the committee developed. Pat Gervais capably drafted the figures which are incorporated here. Marg Rutka, Publications Services Unit, displayed extraordinary diligence in ferreting out numerous editorial deficiencies, from blatant to obscure, in the original submitted manuscript and subsequent revisions.

R.M. Easton of the OGS served as a member of the committee since its inception, and made numerous contributions to the section on the terminology of metamorphic rocks. In particular, he developed the high-level hierarchical structure for the various types of metamorphic rocks described in this report. In addition, he played a key role in the writing of the section on carbonate metamorphic rocks.

We anticipate that there will be an ongoing effort to improve on this report and its contents. Some definitions will evolve and require adjustment over time. Pick lists will be appended or condensed as practical usage necessitates improvements. Changes in technology will inevitably require learning new tools and applying new techniques. This publication is a product of Project Number 12-14.

Figures

Figure 1. Generalized geology of Ontario showing geologic provinces and subprovinces.

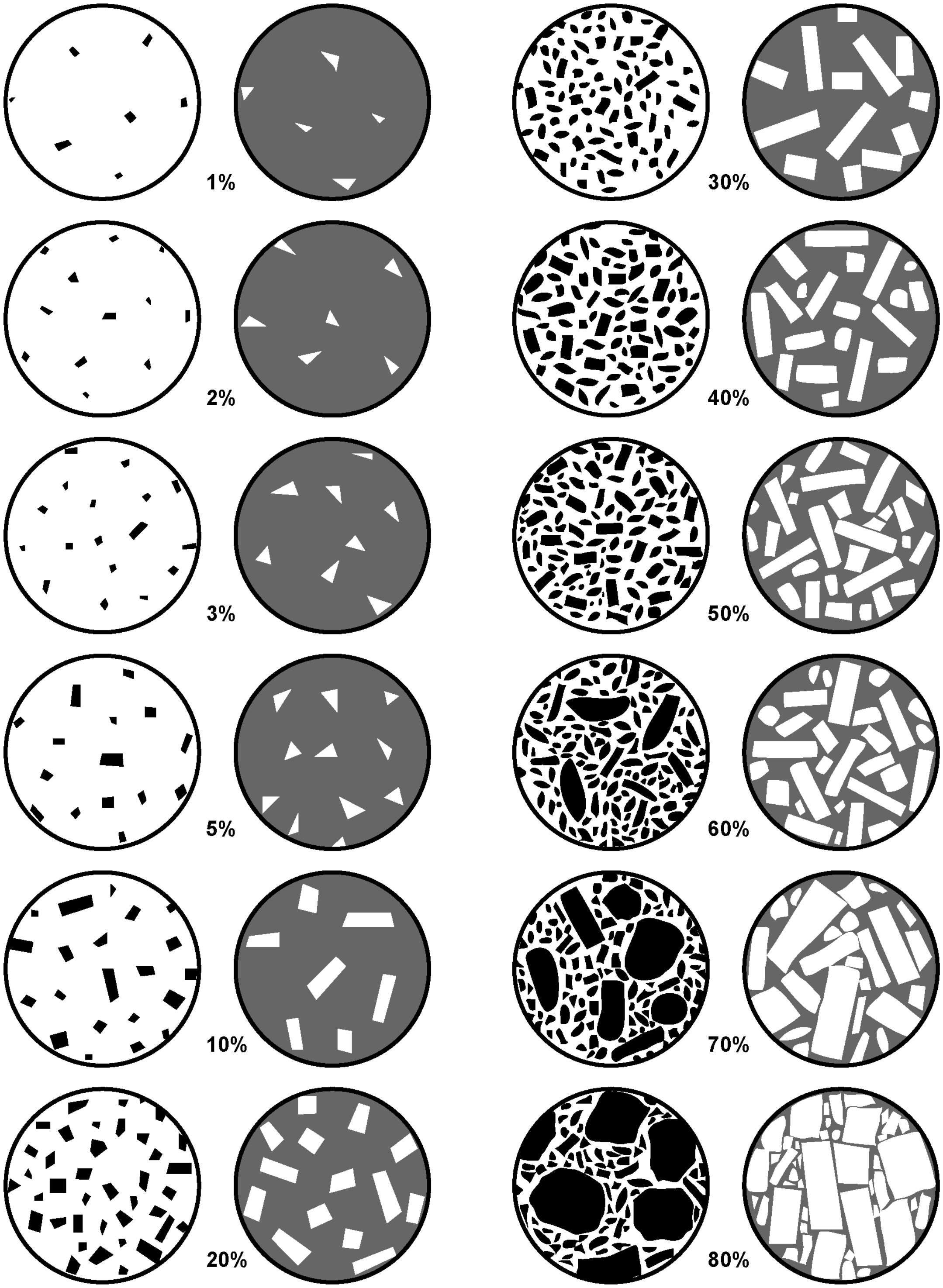

Figure 2. Estimating mineral percentages. Examples for specific percentages show dark minerals within a light matrix and light minerals within a dark matrix. *Modified from* Philpotts (2003).

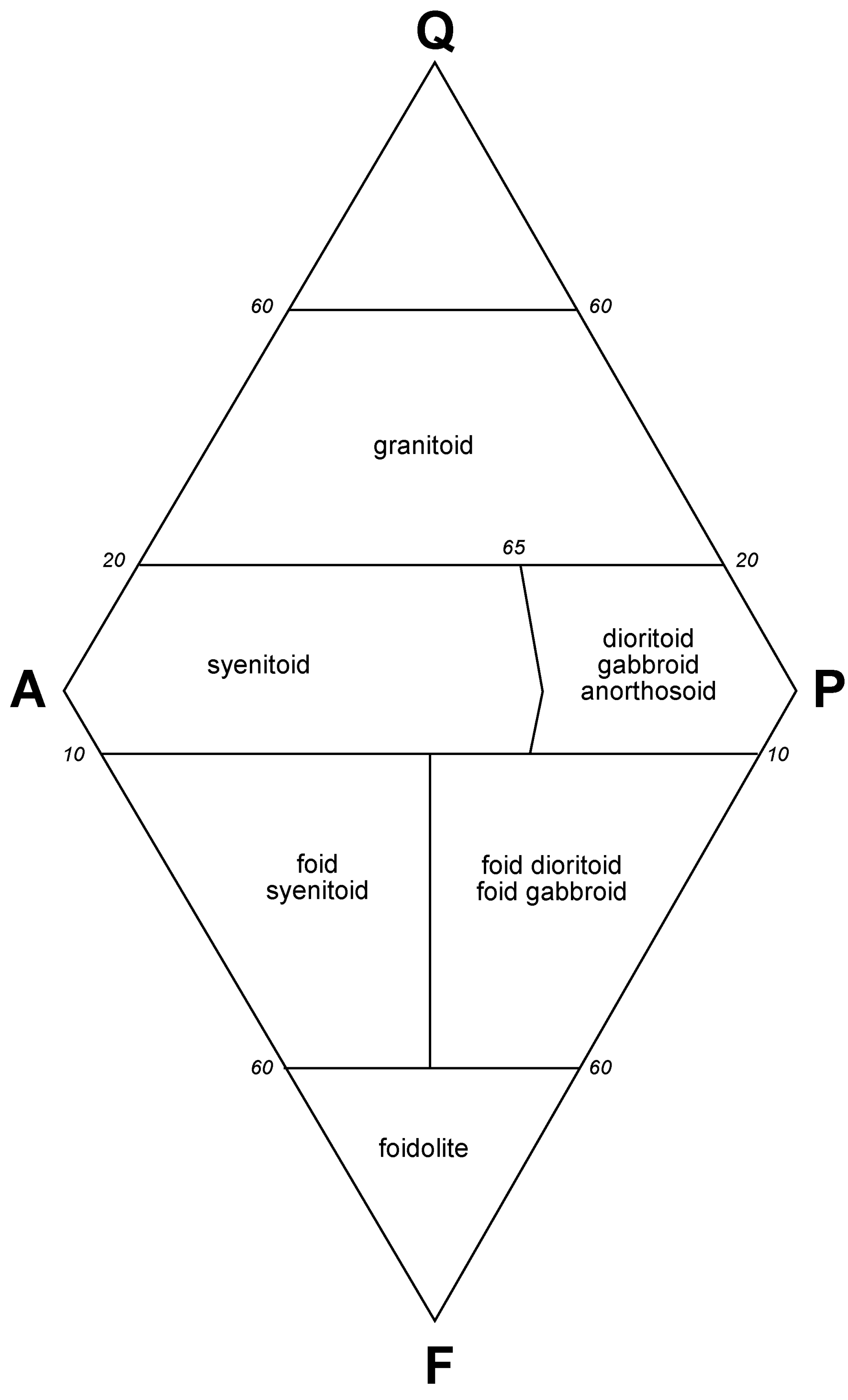

Figure 3. Simplified QAPF classification of intrusive rocks for preliminary field use. *Modified from* Streckeisen (1976). Abbreviations: Q = quartz; A = alkali feldspar; P = plagioclase; F = feldspathoid. © Elsevier, 1976. Reproduced with permission.

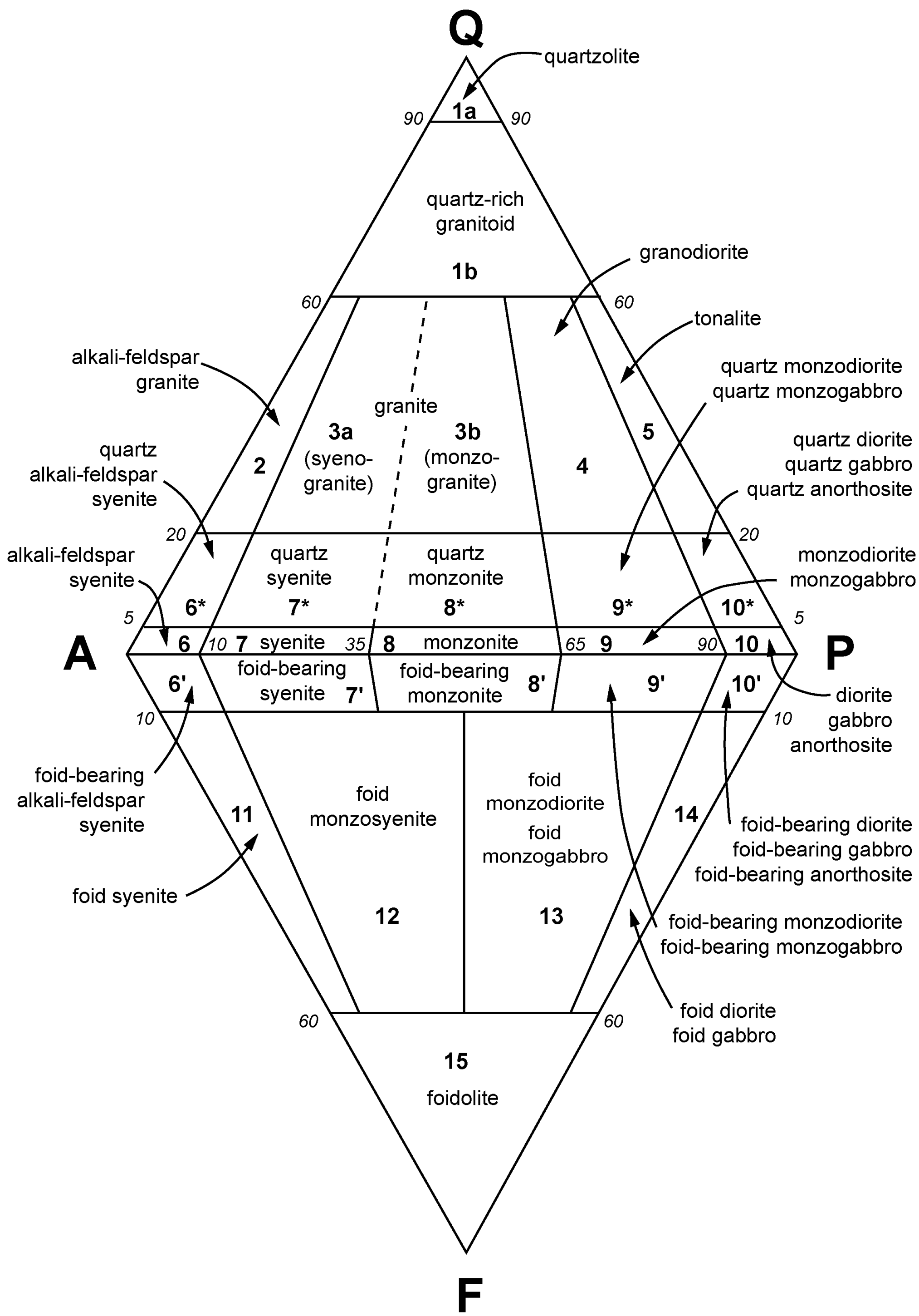

Figure 4. Detailed QAPF modal classification of intrusive rocks with mafic mineral content (M) ≤90. *Modified from* Streckeisen (1976). Abbreviations: Q = quartz; A = alkali feldspar; P = plagioclase; F = feldspathoid. Field numbers are keyed to Table 4. Field numbers marked 6* to 10* are slightly silica oversaturated variants of fields 6 to 10, whereas field numbers marked 6′ to 10′ are slightly silica undersaturated variants. © Elsevier, 1976. Reproduced with permission.

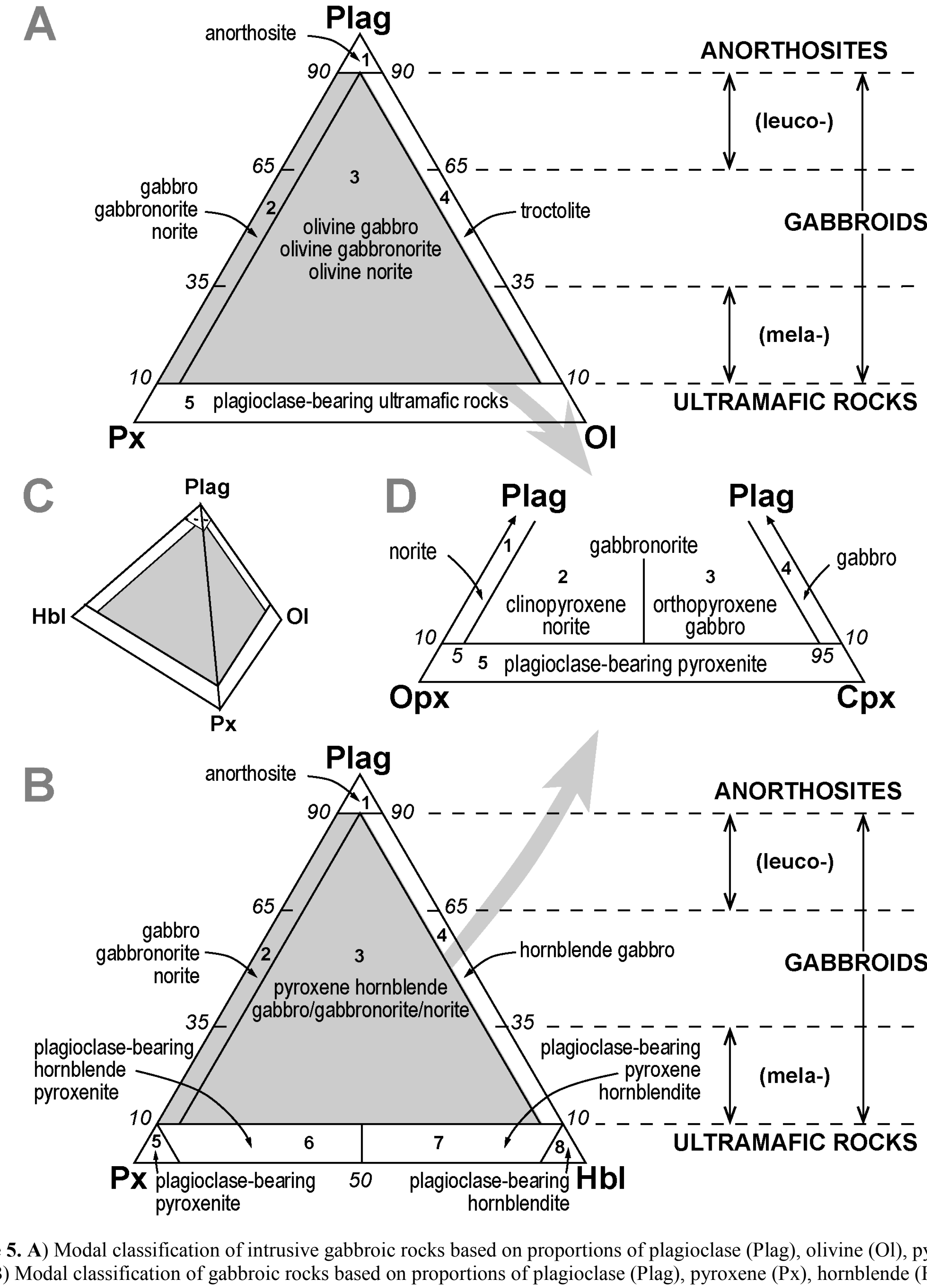

Figure 5. A) Modal classification of intrusive gabbroic rocks based on proportions of plagioclase (Plag), olivine (Ol), pyroxene (Px). **B**) Modal classification of gabbroic rocks based on proportions of plagioclase (Plag), pyroxene (Px), hornblende (Hbl). **C**) Inset tetrahedron shows the relative relationships of the components listed for figures A) and B). **D**) Shaded areas in A), B) and C) indicate rocks that may be subdivided based on proportions of plagioclase (Plag), orthopyroxene (Opx), clinopyroxene (Cpx). Field numbers in A), B) and D) are keyed to Table 4. A), B) and D) *after* Streckeisen (1976). © Elsevier, 1976. Reproduced with permission.

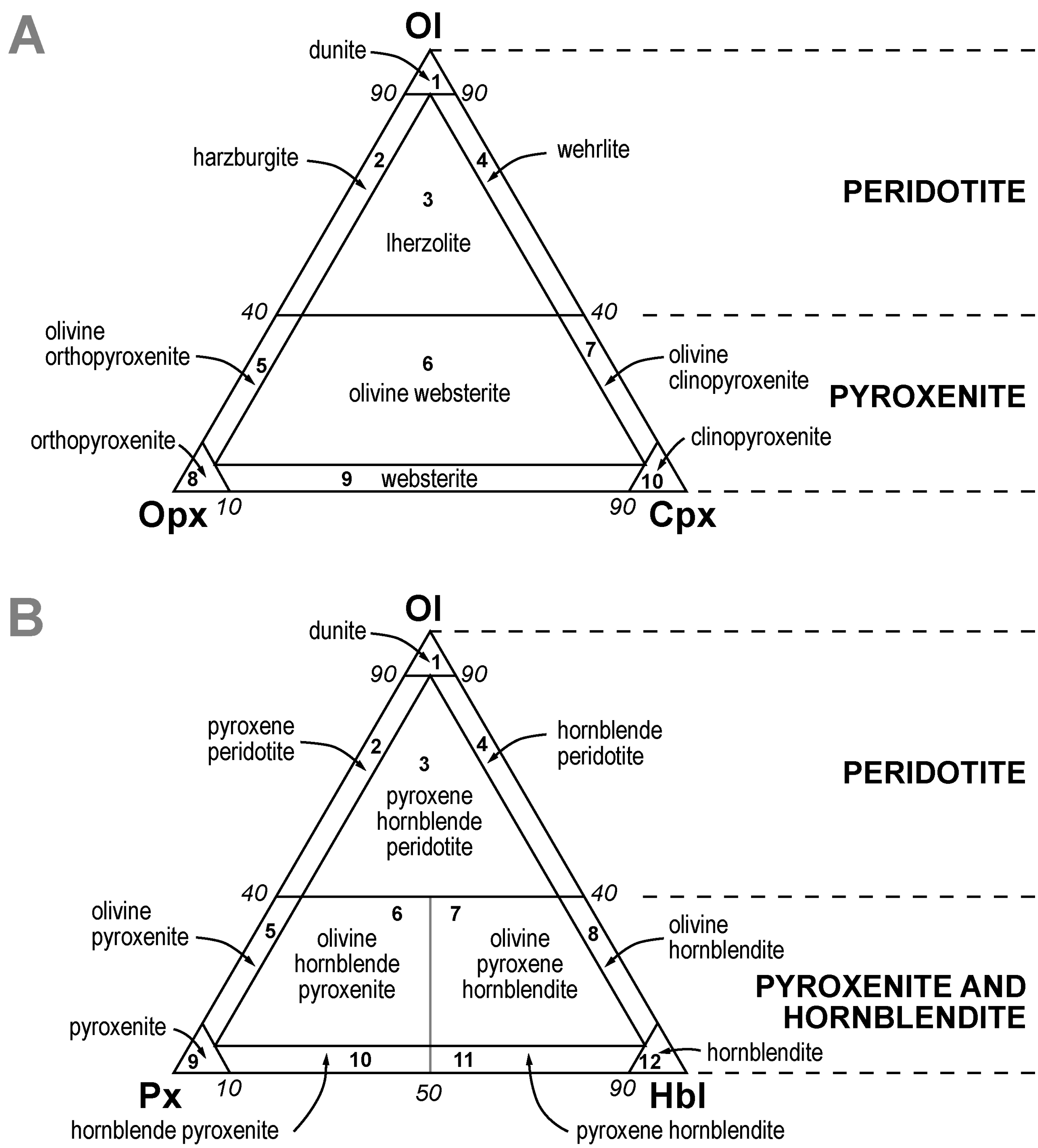

Figure 6. A) Modal classification of intrusive ultramafic rocks based on proportions of olivine (Ol), orthopyroxene (Opx), clinopyroxene (Cpx). **B**) Modal classification for ultramafic rocks based on proportions of olivine (Ol), pyroxene (Px), hornblende (Hbl). Field numbers in A) and B) are keyed to Table 4. A) and B) *modified from* Streckeisen (1976). © Elsevier, 1976. Reproduced with permission.

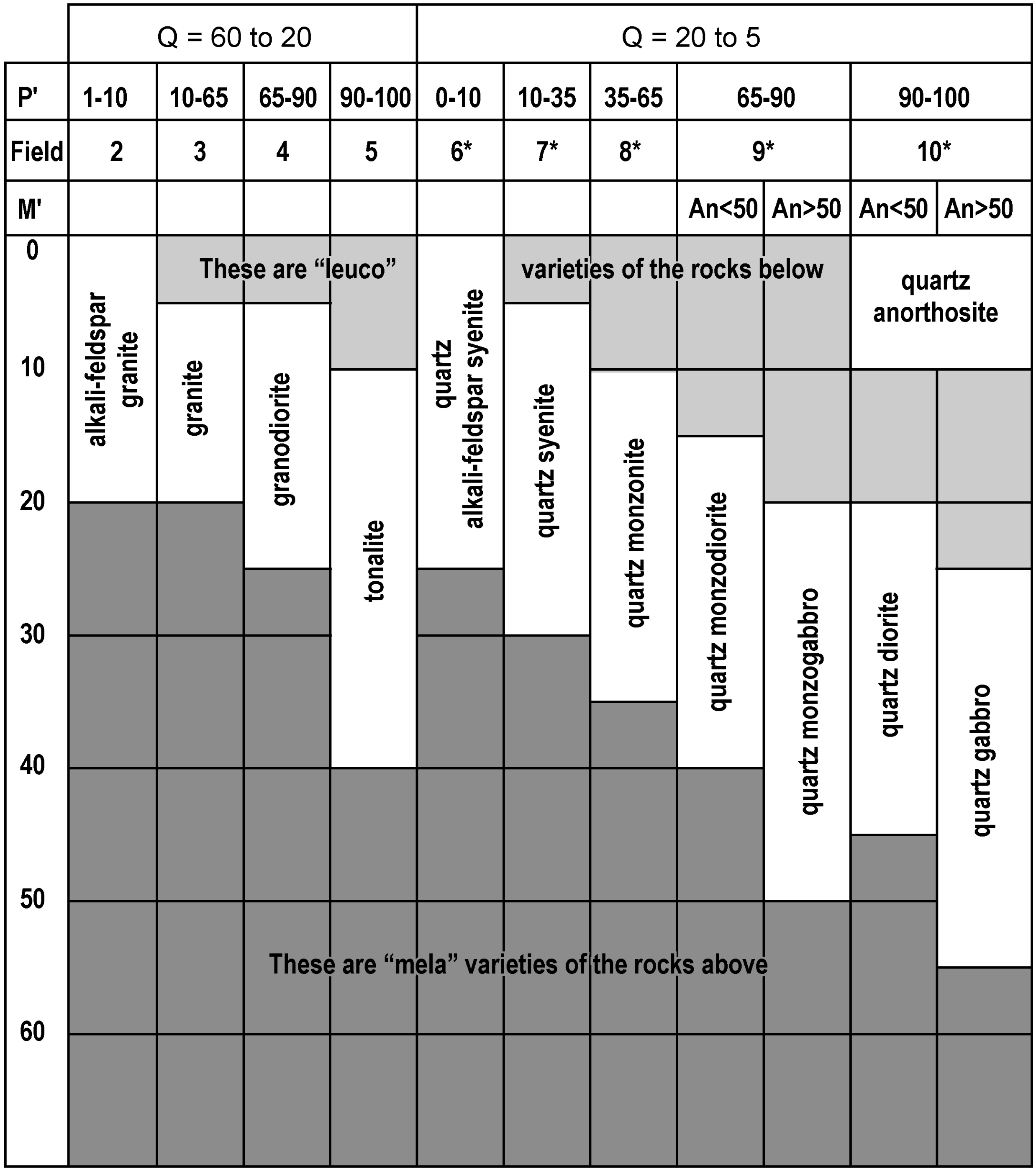

Figure 7. Use of "mela" and "leuco" prefixes for melanocratic and leucocratic variants (respectively) of QAPF intrusive rocks having modal Q > 5%. *After* Streckeisen (1976). Abbreviations: Q = quartz; P = plagioclase; A = alkali feldspar; P′ = 100 x P / (A + P); An = anorthite content of plagioclase; M′ = colour index. The prefixes should precede the root rock name; e.g., biotite leucotonalite.

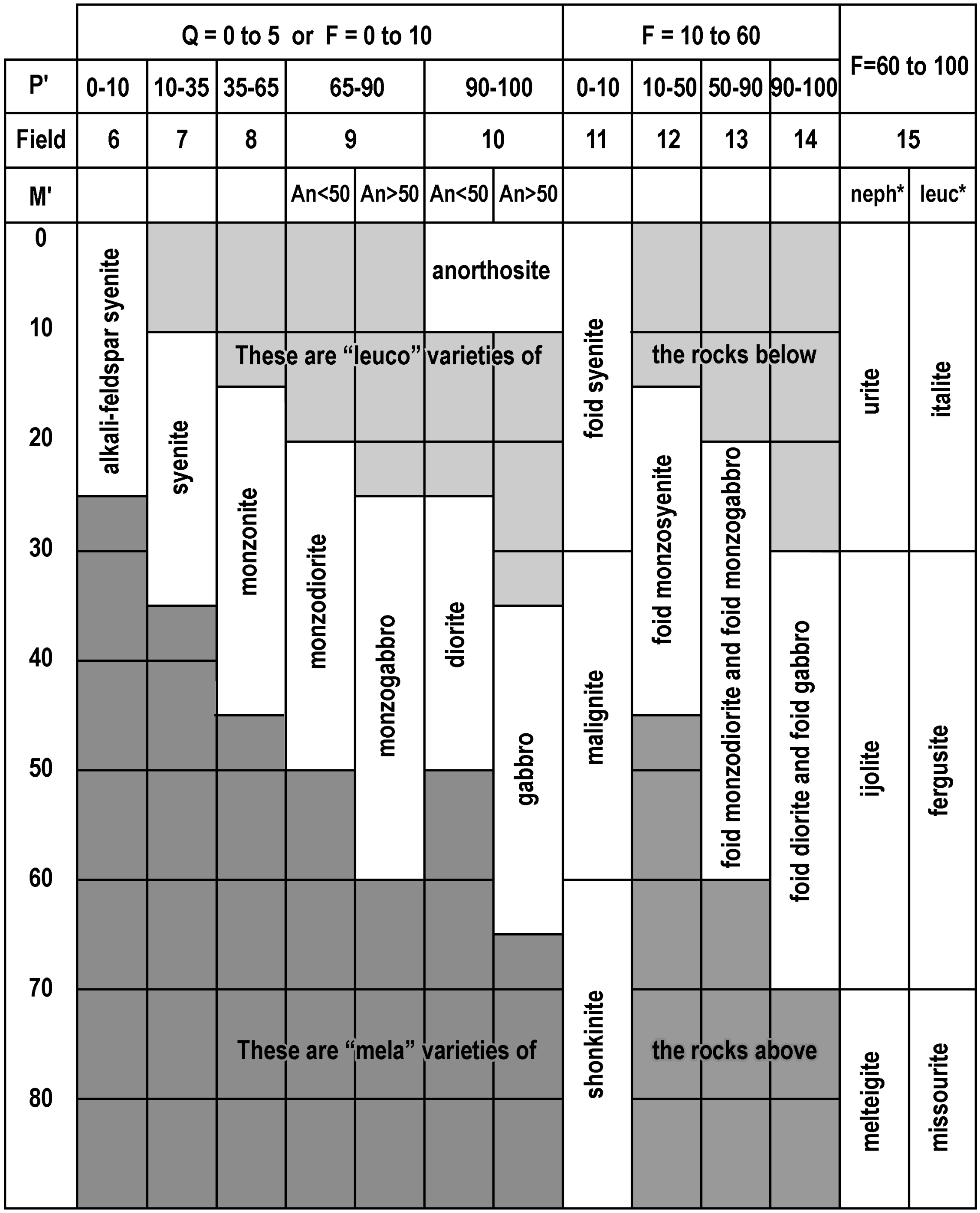

Figure 8. Use of “mela” and “leuco” prefixes for melanocratic and leucocratic variants (respectively) of QAPF intrusive rocks having modal Q < 5% or F > 0%. *After* Streckeisen (1976). Abbreviations: Q = quartz; F = feldspathoid; P = plagioclase; A = alkali feldspar; P′ = 100 x P / (A + P); An = anorthite content of plagioclase; M′ = colour index; neph* = nepheline is the predominant feldspathoid; leuc* = leucite is the predominant feldspathoid. The prefixes should precede the root rock name; e.g., hornblende melasyenite. © Elsevier, 1976. Reproduced with permission.

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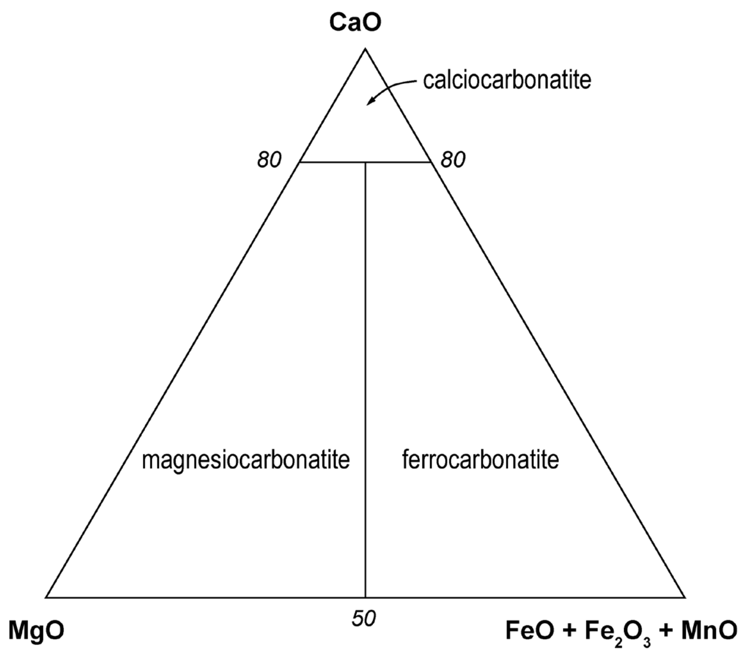


Figure 9. Chemical classification of carbonatites with SiO_2 <20% (wt % oxides). *From* Le Maitre (2002), based on Woolley and Kempe (1989). Carbonatites with SiO_2 >20% are termed silicocarbonatites. © R.W. Le Maitre and International Union of Geological Sciences. Reprinted with the permission of Cambridge University Press.

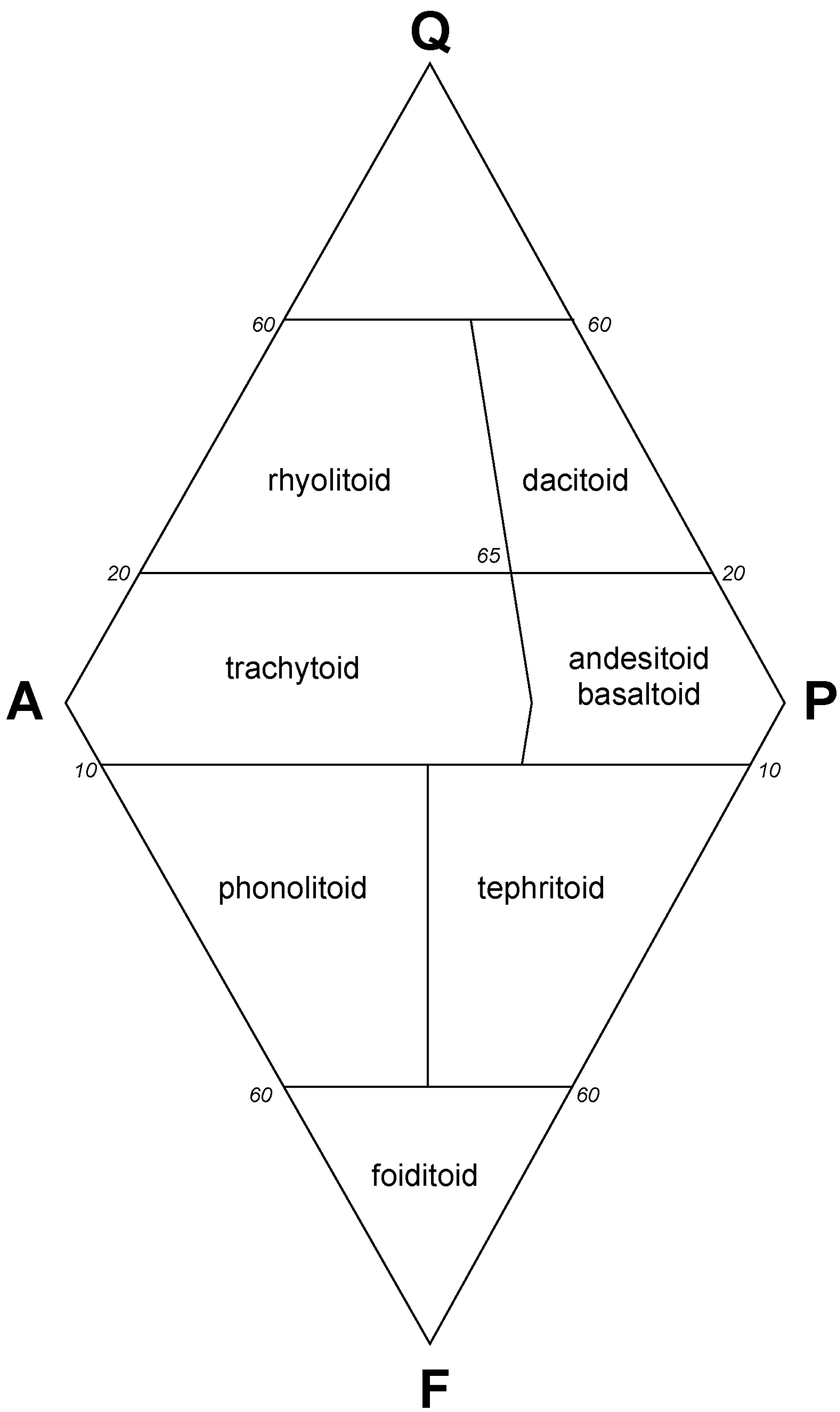


Figure 10. Simplified QAPF classification of volcanic rocks for preliminary field use. Abbreviations: Q = quartz; A = alkali feldspar; P = plagioclase; F = feldspathoid. *From* Streckeisen (1978). © Schweizerbart Science Publishers (www.schweizerbart.de), used with permission.

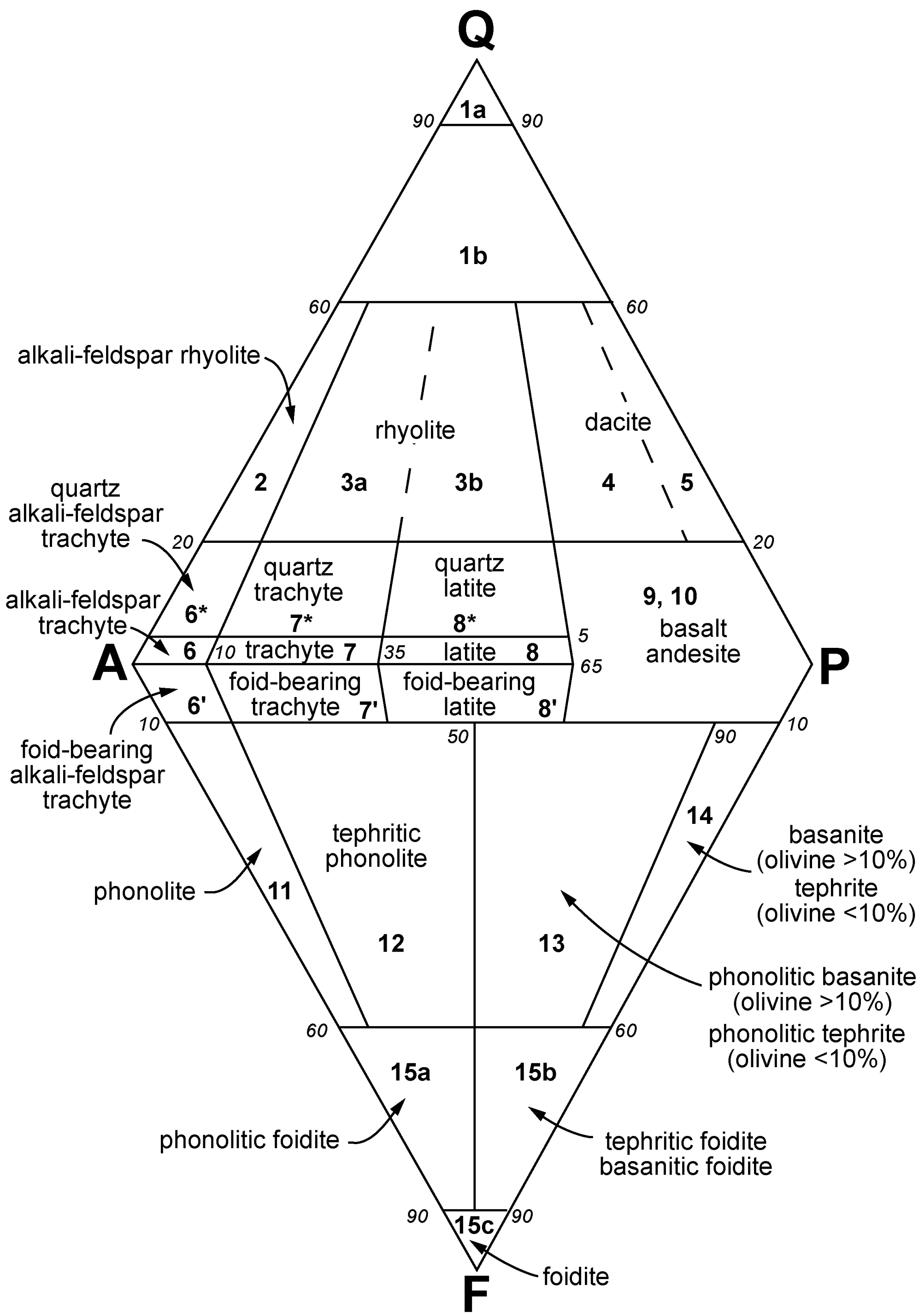


Figure 11. Detailed QAPF modal classification of volcanic rocks with mafic and related mineral content (M) ≤90. *Modified from* Le Maitre (2002) based on Streckeisen (1978). Abbreviations: Q = quartz; A = alkali feldspar; P = plagioclase; F = feldspathoid. Field numbers are keyed to Table 10. Field numbers marked 6* to 8* are slightly silica oversaturated variants of fields 6 to 8, whereas field numbers marked 6′ to 8′ are slightly silica undersaturated variants. © Schweizerbart Science Publishers (www.schweizerbart.de), used with permission.

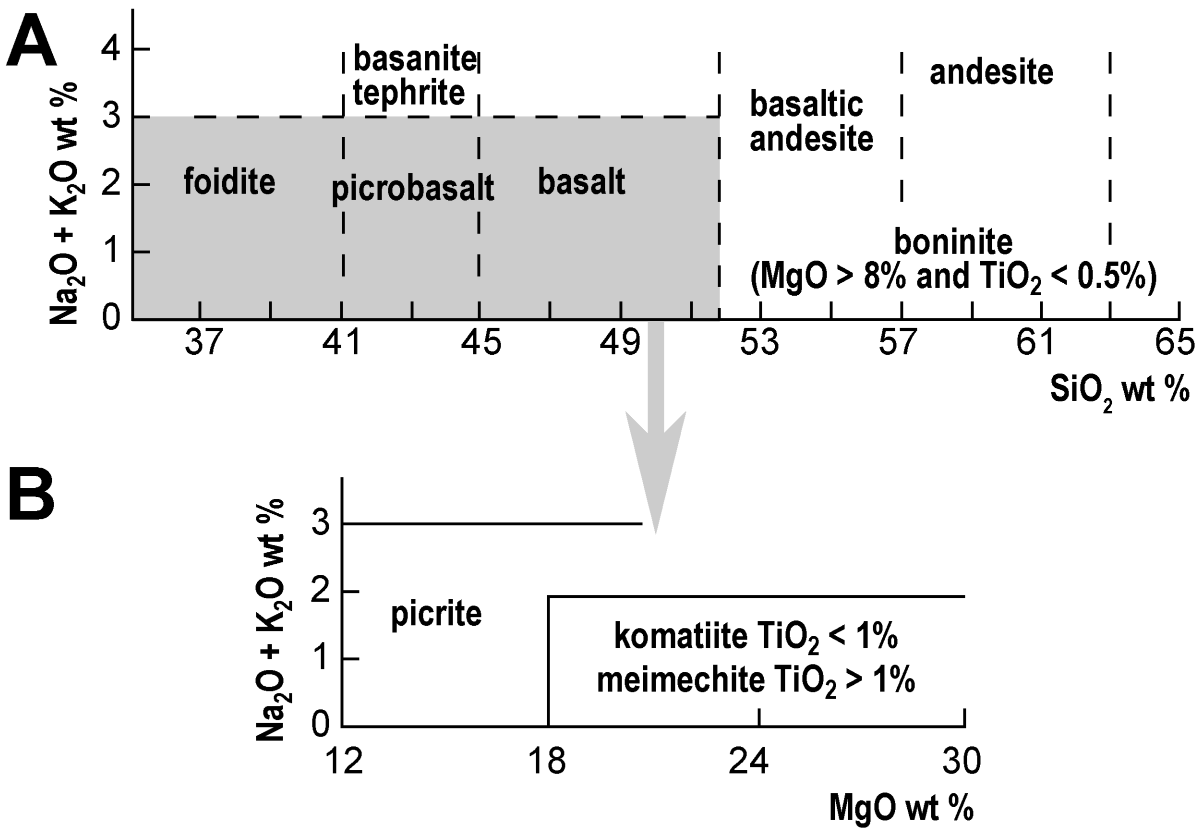
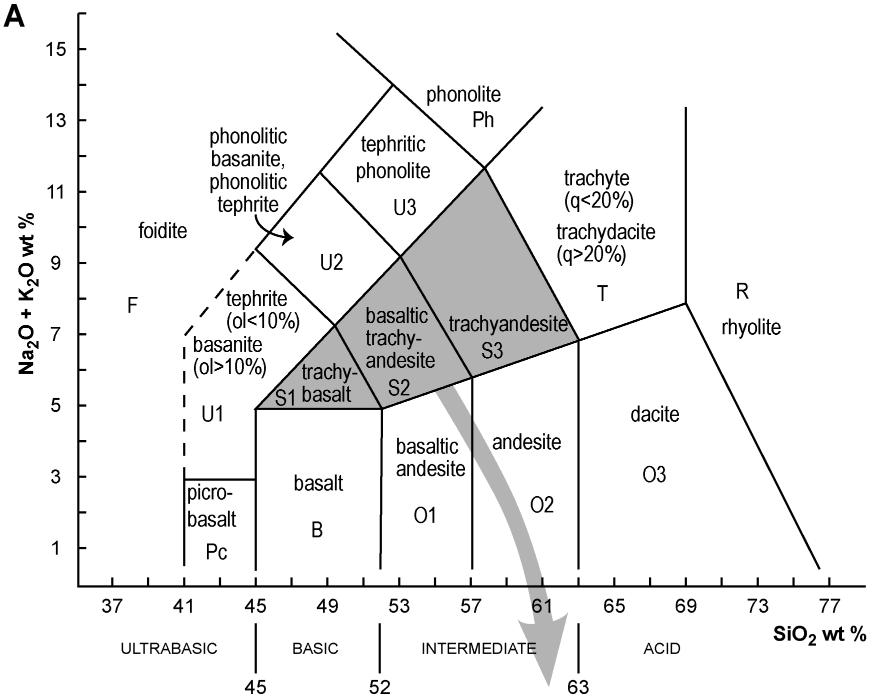


Figure 12. Chemical classification of "high-Mg" volcanic rocks boninite, komatiite, meimechite and picrite prior to using the Total Alkali–Silica (TAS) system. *From* Le Maitre (2002) based on Le Bas (2000). **A**) Step 1: use SiO_2 vs. $Na_2O + K_2O$ values (wt %) in A) to determine a preliminary rock name. Use MgO and TiO_2 values (wt %) in A) to determine if the rock is a boninite. Step 2: if a rock falls in the shaded area of A), use MgO vs. $Na_2O + K_2O$ values (wt %) in **B)**, if appropriate, to determine the final rock name. If the lower diagram (B) does not apply, then the final rock name is based on the shaded area and is either foidite, picrobasalt or basalt, as given in A). © R.W. Le Maitre and International Union of Geological Sciences. Reprinted with the permission of Cambridge University Press.

A



B

Further subdivisions of shaded fields	trachybasalt	basaltic trachyandesite	trachyandesite
$Na_2O - 2.0 \geq K_2O$	hawaiite	mugearite	benmoreite
$Na_2O - 2.0 < K_2O$	potassic trachybasalt	shoshonite	latite

C

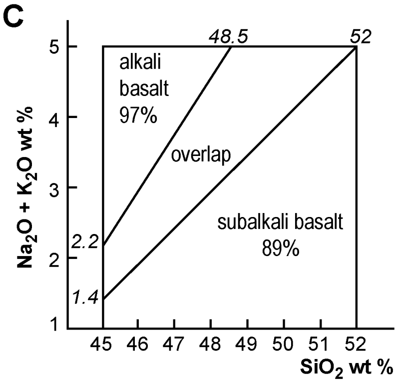


Figure 13. Chemical classification of volcanic rocks using the Total Alkali–Silica (TAS) system (after following the steps outlined in Figure 12). **A**) Step 1: use SiO_2 vs. $Na_2O + K_2O$ values (wt %) to determine a rock name. The dashed line between the foidite and basanite–tephrite fields indicates additional criteria must be applied to separate these types (*see* Le Maitre 2002). Abbreviations: *ol* = normative olivine; *ab* = normative albite; *an* = normative anorthite; *or* = normative orthoclase; *Q* = normative quartz; *q* = normative 100 x *Q* / (*Q* + *or* + *ab* + *an*). Field designations (keyed to Table 10): S = silica saturated; O = silica oversaturated; U = silica undersaturated. *Modified from* Le Maitre (2002), *after* Le Bas et al. (1986). **B**) Step 2: if the rock falls within the shaded area in A) (Step 1), use the relationship between Na_2O and K_2O (left side of diagram) to determine a more precise name. *From* Le Maitre (2002), based on Le Bas et al. (1986). **C**) Likelihood of correctly classifying alkali basalt and subalkali basalt using TAS, assuming equal chances of a basalt being alkali or subalkali. Oxide values recalculated to 100% on an H_2O- and CO_2-free basis. *From* Le Maitre (2002). A), B) and C) © R.W. Le Maitre and International Union of Geological Sciences. Reprinted with the permission of Cambridge University Press.

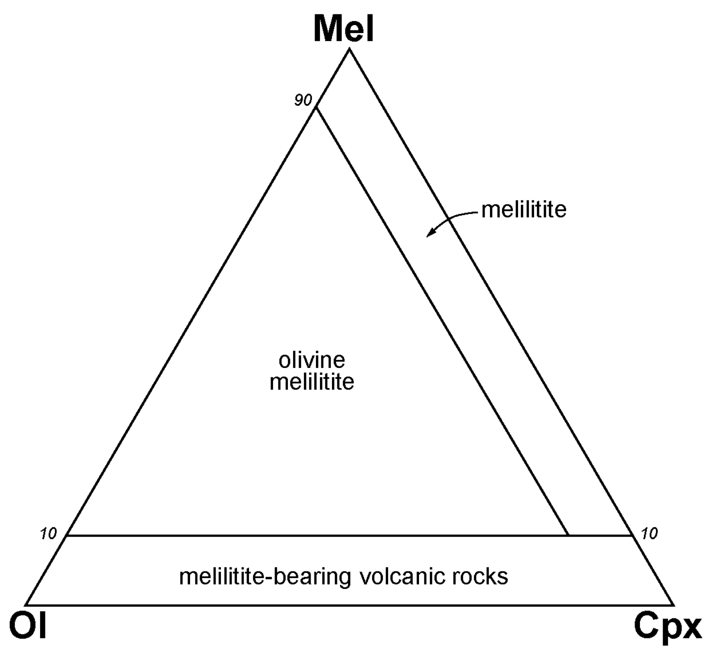


Figure 14. Modal classification of melilite-bearing volcanic rocks, based on proportions of melilite (Mel), olivine (Ol), clinopyroxene (Cpx). *From* Streckeisen (1978). © Schweizerbart Science Publishers (www.schweizerbart.ze), used with permission.

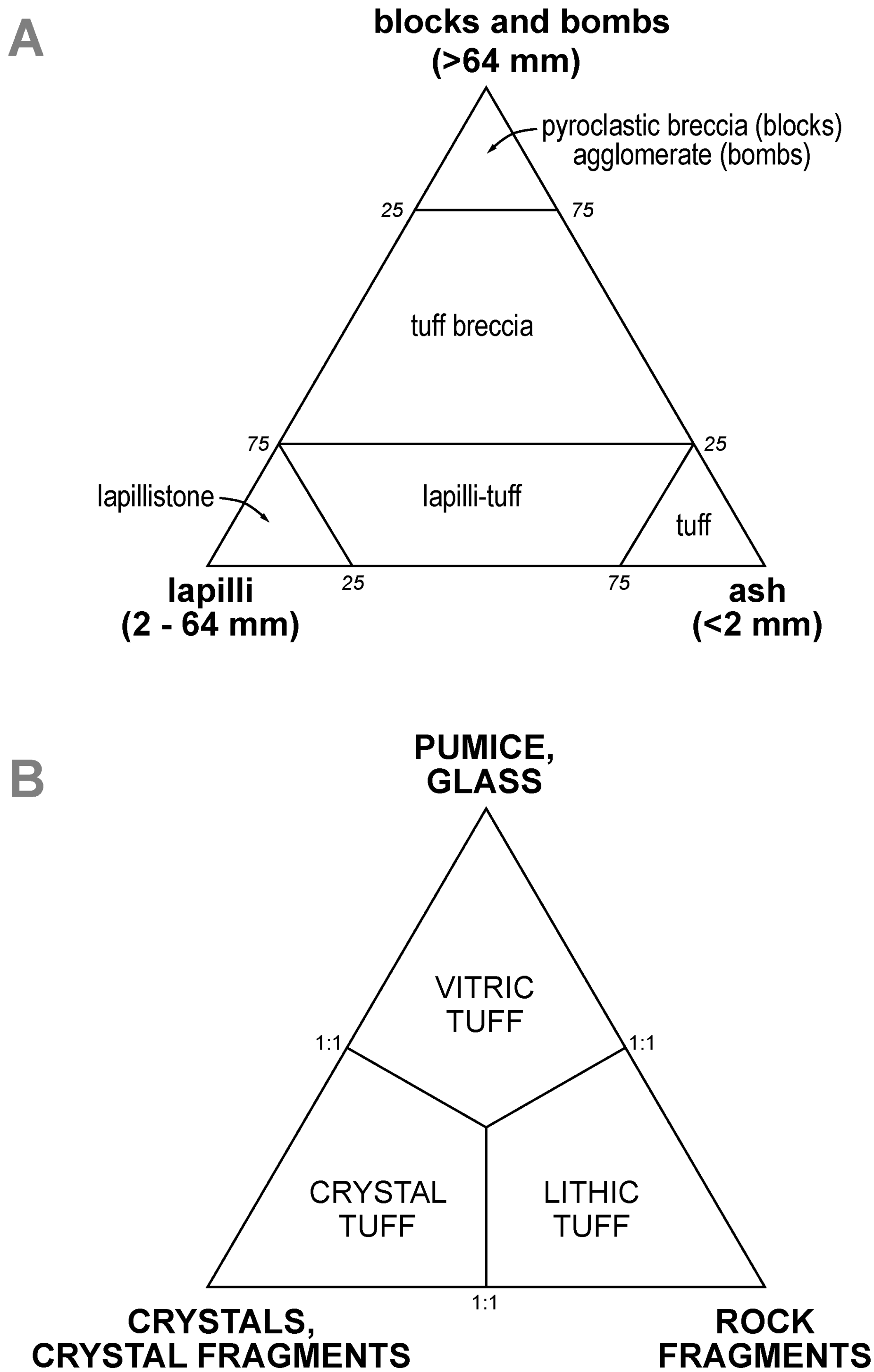


Figure 15. A) Classification of pyroclastic rocks based on particle-size proportions of blocks and bombs, lapilli and ash. *Modified from* Fisher (1966). **B**) Classification of tuff based on ash-size particle composition. *Modified from* Easton and Johns (1986). A) © Elsevier, 1966. Reproduced with permission.

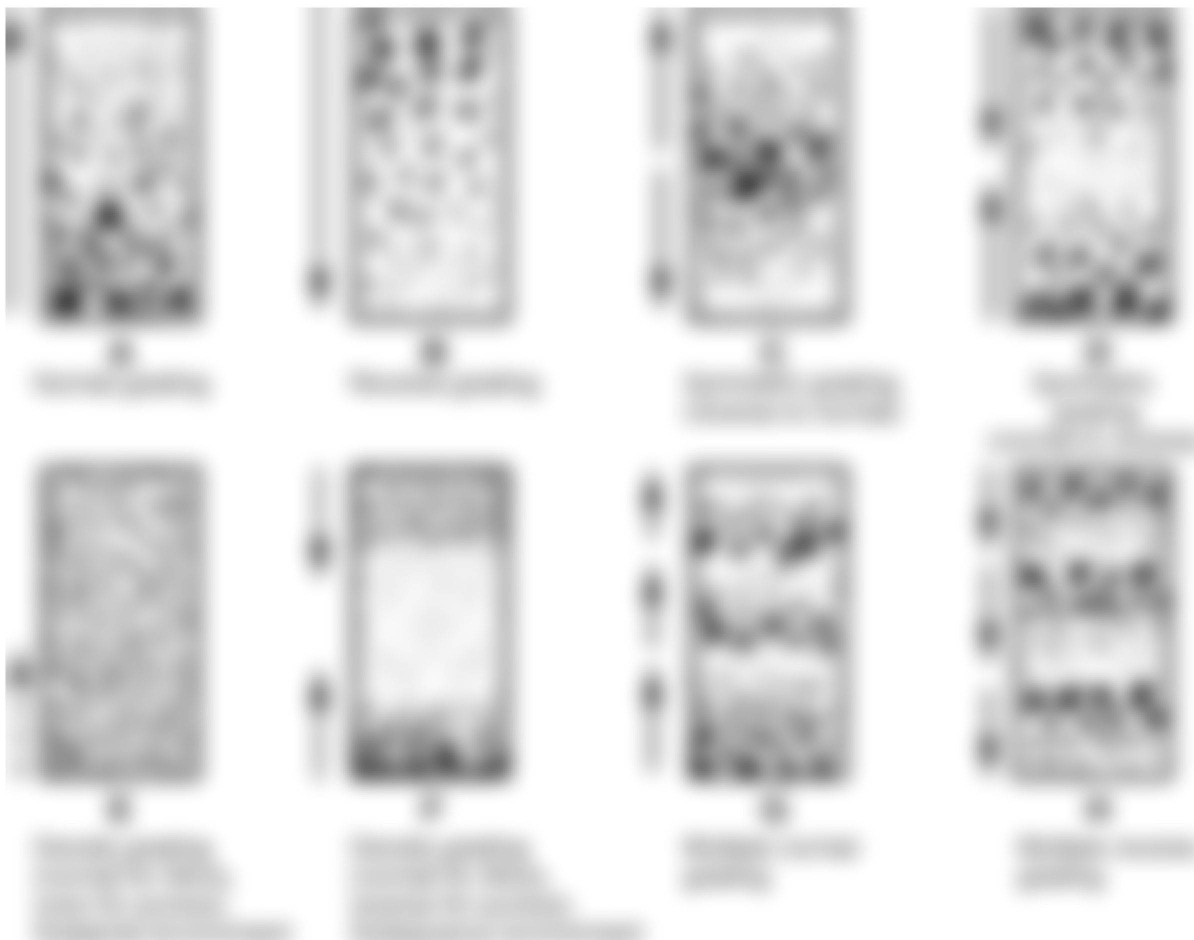


Figure 16. Diagrammatic examples of graded bedding in pyroclastic rocks. Solid arrows indicate direction toward finer grained sizes; dashed arrow indicates partial grading. Open circles = pumice; solid polygons = lithic fragments; dots = ash-sized material. *Modified from* Fisher and Schmincke (1984). © Springer, 1984. Reproduced with permission.

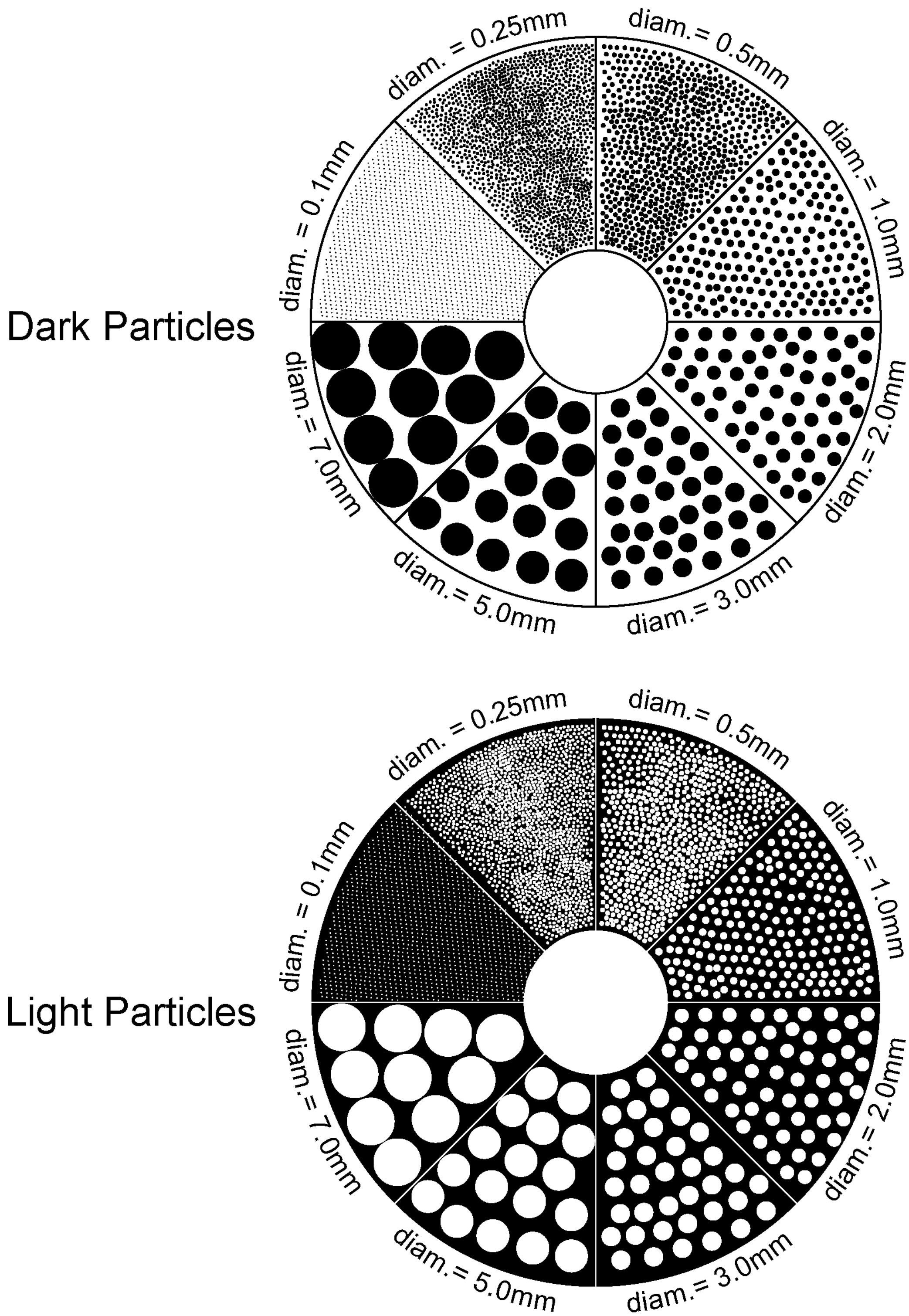


Figure 17. Estimating size of sedimentary particles. Pie diagrams show specific sizes for dark minerals within a light matrix and light minerals within a dark matrix. *Modified from* Walker and Cohen. © 2009 American Geological Institute www.agiweb.org/pubs (2009), used with permission.

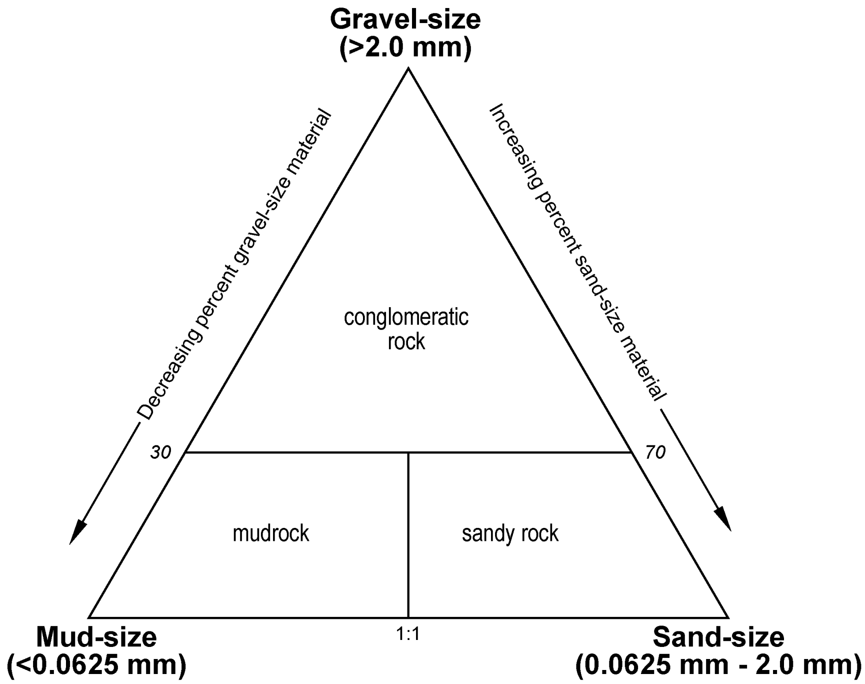


Figure 18. Level 3 classification of terrigenous-clastic sedimentary rocks. *Modified from* Soller (2004a).

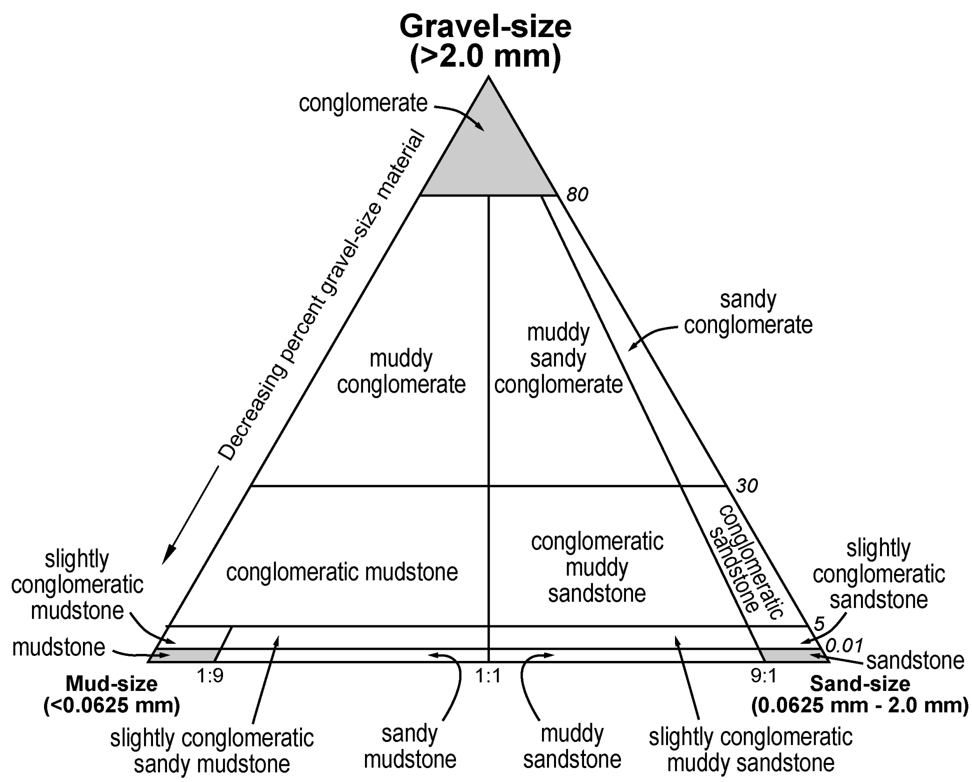


Figure 19. Level 4 classification of terrigenous-clastic sedimentary rocks. *Modified from* Soller (2004a). Ratios along bottom of triangle represent sand:mud. Note exaggerated limit of 0.01 gravel-size material for graphical purposes.

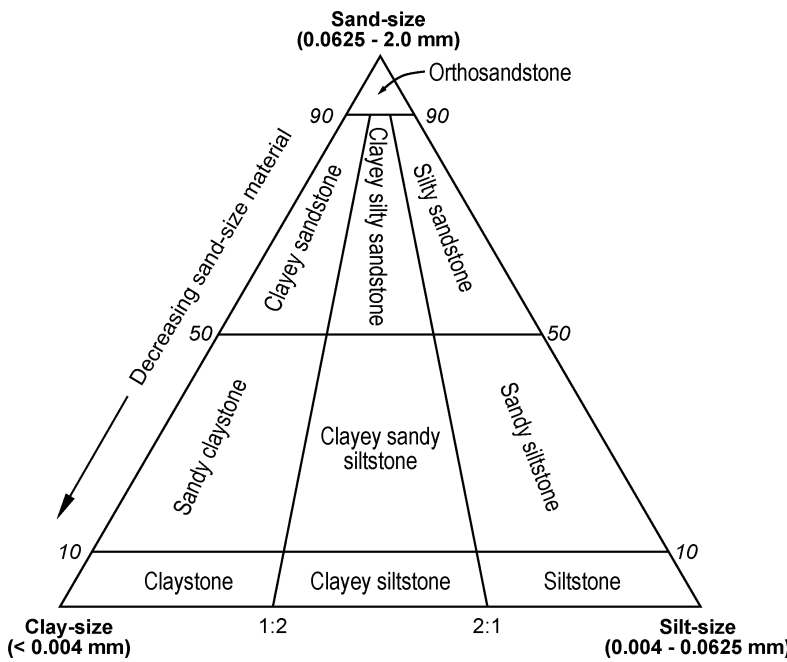


Figure 20. Level 5 classification of mudrock based on particle-size proportions of sand, silt and clay. Ratios along bottom of triangle represent silt:clay. *Modified from* Soller (2004a).

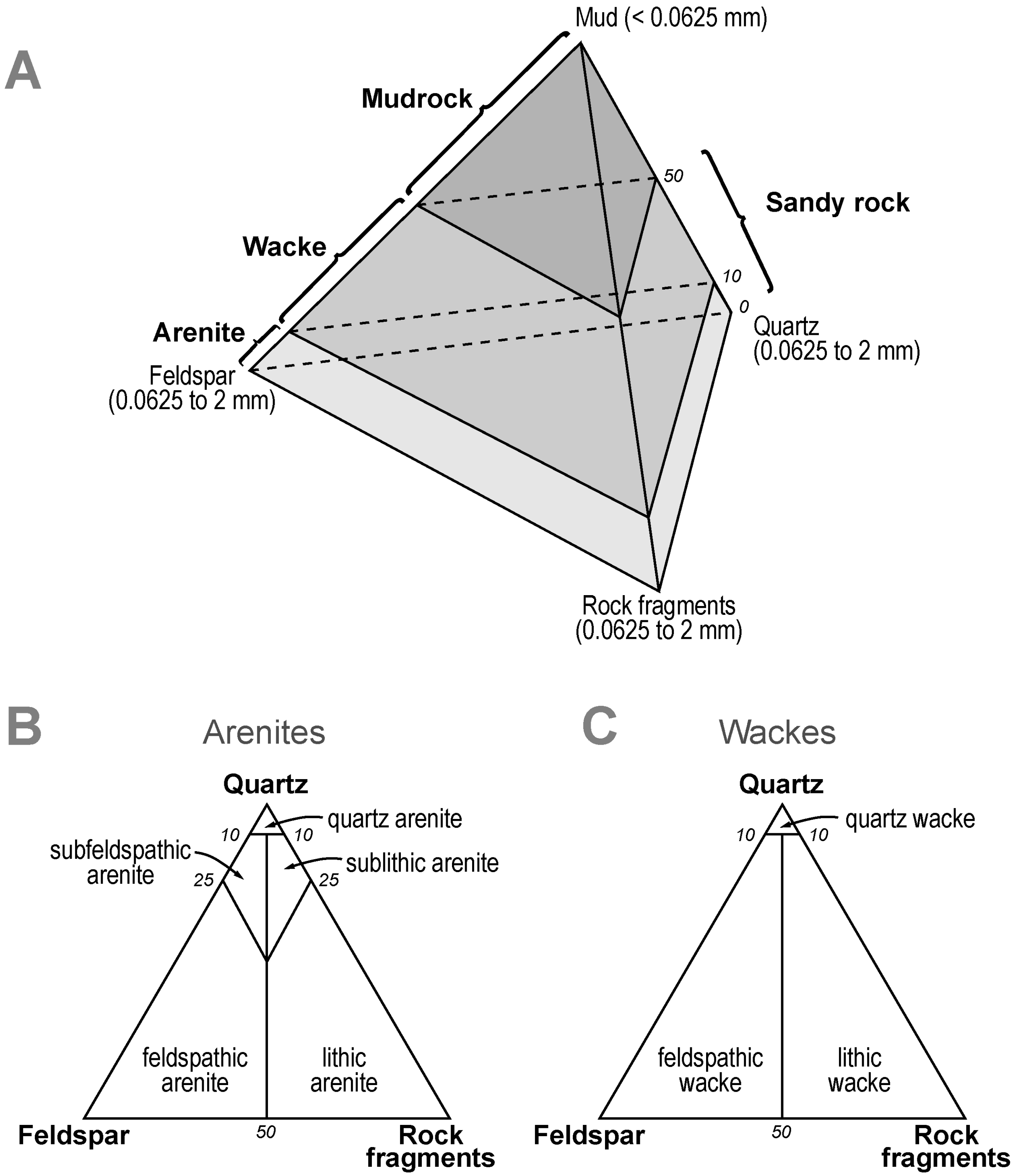


Figure 21. Level 5 classification of sandy rock. **A**) tetrahedron showing the relationship between mudrock, arenite and wacke based on the proportions of mud to sand-size quartz, feldspar and rock fragment grains. **B**) Classification of arenites based on proportions of quartz, feldspar and rock fragment particles. **C**) Classification of wackes based on proportions of quartz, feldspar and rock fragment particles. B) and C) are loosely based on classifications by Dott (1964) and Pettijohn et al. (1972).

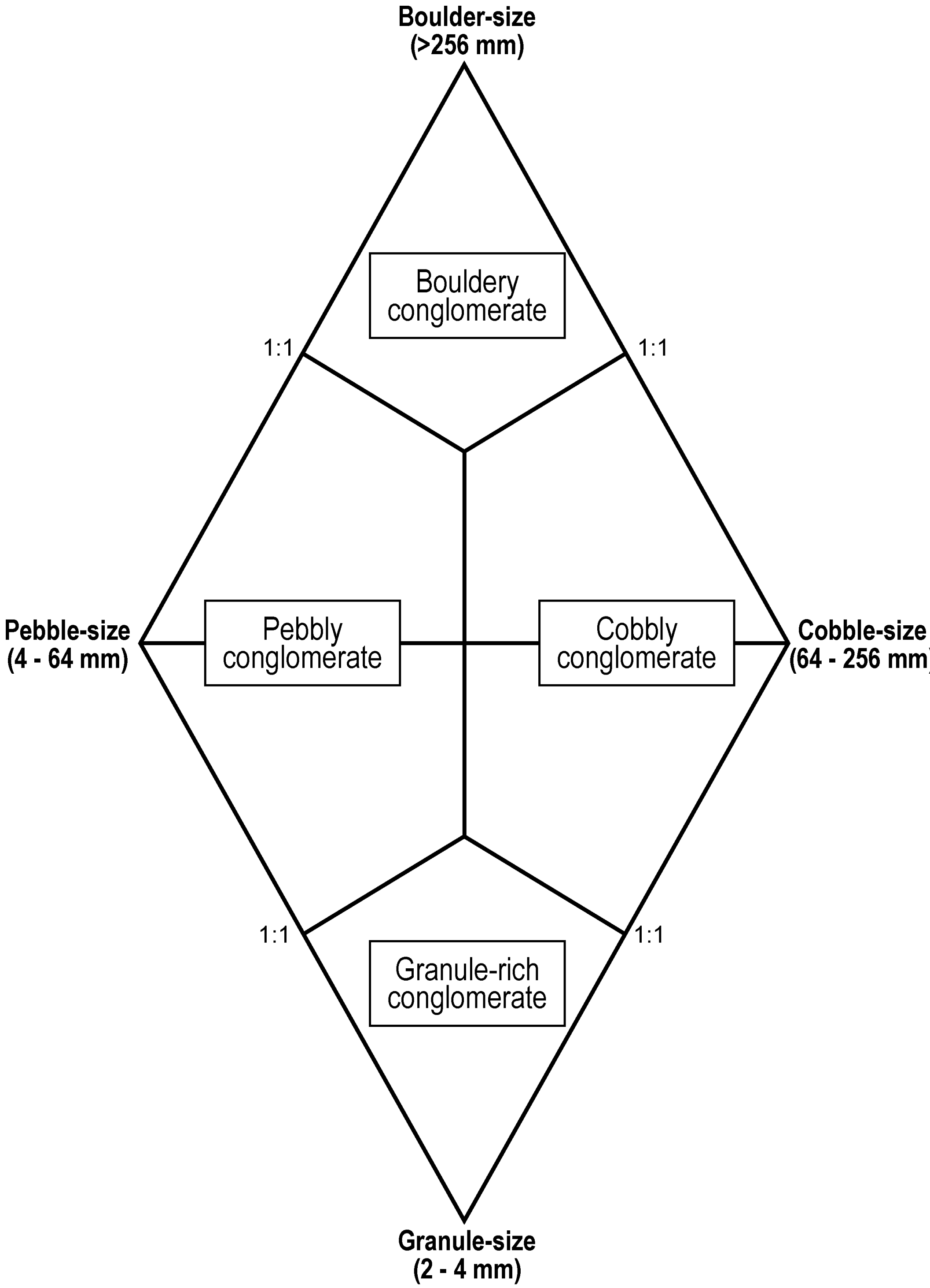


Figure 22. Level 5 classification of conglomeratic rock. *Modified from* Soller (2004a).

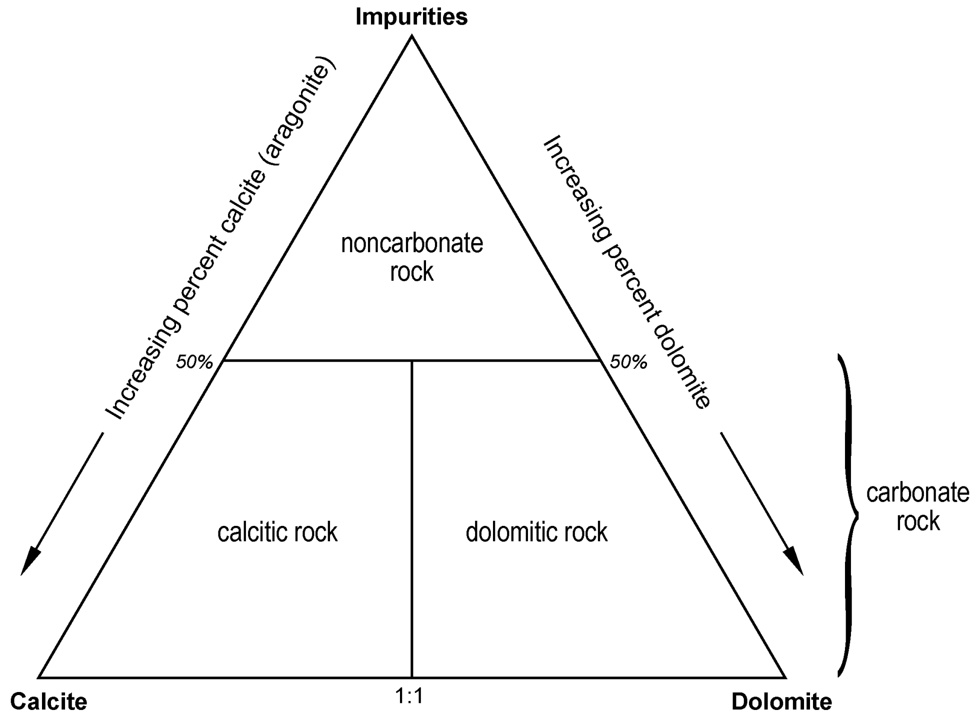


Figure 23. Level 4 classification of carbonate rocks based on proportions of calcite, dolomite and non-carbonate "impurities". *Modified from* Soller (2004a).

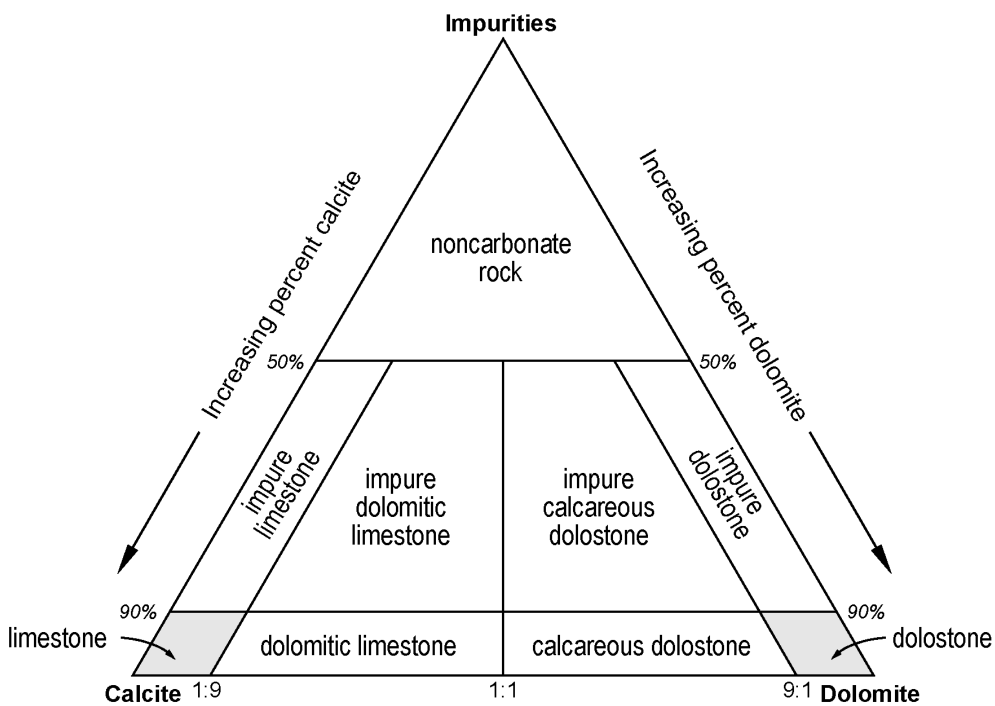


Figure 24. Level 5 classification of carbonate rocks based on proportions of calcite, dolomite and noncarbonate "impurities". *Modified from* Soller (2004a). Ratios along bottom of triangle represent dolomite:calcite.

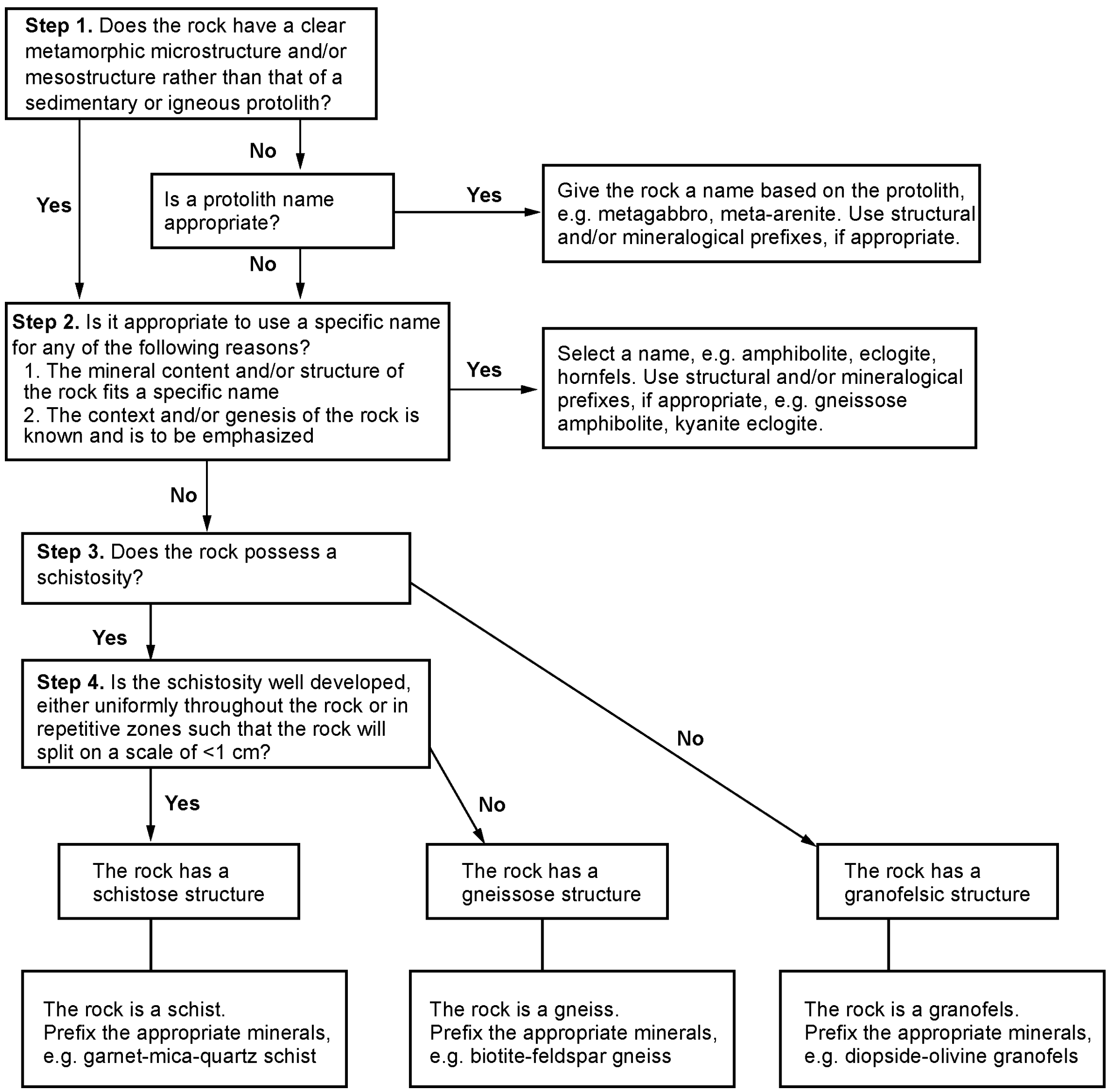
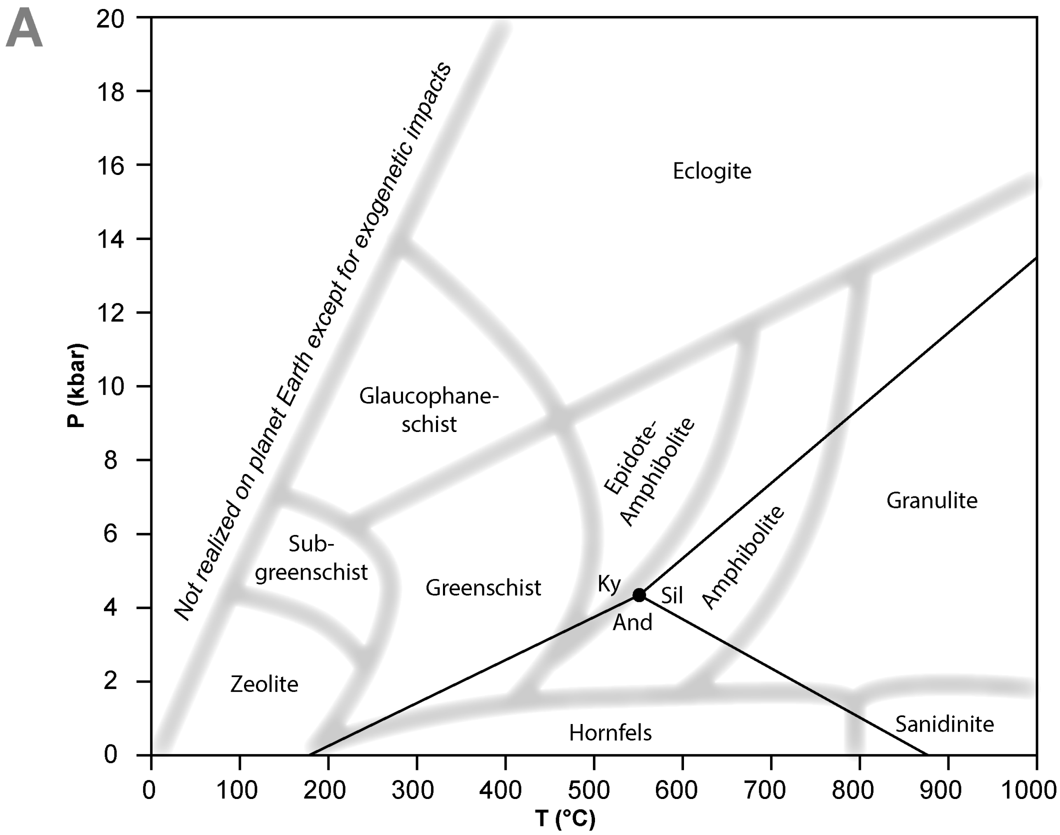


Figure 25. Flow chart outlining the process for determining a metamorphic rock name. Steps 1 and 2 outline the procedure for deriving a nonsystematic name. Steps 3 and 4 outline the procedure for deriving a systematic structural root name – only these steps should be used if going directly to a structural root name. *Modified from* Fettes and Desmons (2007). © Cambridge University Press, 2007. Reprinted with permission.



B

Facies	Minerals and mineral assemblages
Zeolite facies	Zeolites such as laumontite and heulandite, etc. (in place of other Ca-Al silicates such as prehnite, pumpellyite and epidote)
Subgreenschist facies	Prehnite-pumpellyite, pumpellyite-actinolite, prehnite-actinolite (prehnite and pumpellyite are the diagnostic Ca-Al silicates rather than minerals of the epidote or zeolite groups)
Greenschist facies	Actinolite-albite-epidote-chlorite (an epidote group mineral is the diagnostic Ca-Al silicate rather than prehnite or pumpellyite)
Epidote-amphibolite facies	Hornblende-albite-epidote(-chlorite)
Amphibolite facies	Hornblende-plagioclase (plagioclase more calcic than An_{17})
Hornfels facies	Albite epidote, hornblende, clinopyroxene, orthopyroxene, plagioclase (olivine stable with plagioclase) (encompasses albite-epidote-hornfels facies, hornblende-hornfels facies, and pyroxene-hornfels facies)
Sanidinite facies	Distinguished from the pyroxene-hornfels facies by the occurrence of especially high-temperature varieties and polymorphs of minerals (e.g. pigeonite, K-rich labradorite)
Glaucophane-schist (blueschist) facies	Glaucophane-epidote(-garnet), glaucophane-lawsonite, glaucophane-lawsonite-jadeite
Eclogite facies	Omphacite-garnet-quartz (no plagioclase, olivine stable with garnet)
Granulite facies	Clinopyroxene-orthopyroxene-plagioclase (olivine not stable with plagioclase or with garnet)

Figure 26. A) Schematic showing relative pressure–temperature conditions for the 10 metamorphic facies. And = andalusite; Ky = kyanite; Sil = sillimanite. *Modified from* Spear (1993) and Wikipedia (2012). Aluminosilicate triple point from Pattison (1992). **B**) Metamorphic facies and associated characteristic minerals and mineral parageneses in metamorphosed rocks of basaltic chemical composition. *Modified from* Fettes and Desmons (2007). © Cambridge University Press, 2007. Reprinted with permission.

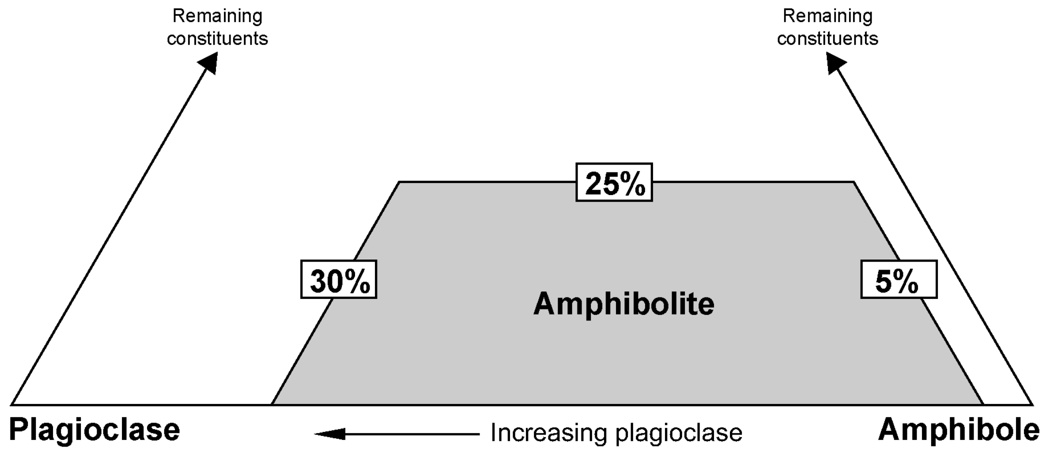


Figure 27. Amphibolite field based on proportions of plagioclase (≥5%), amphibole (≥30%) and all other (remaining) constituents (≤25%). *Modified from* Fettes and Desmons (2007). © Cambridge University Press, 2007. Reprinted with permission.

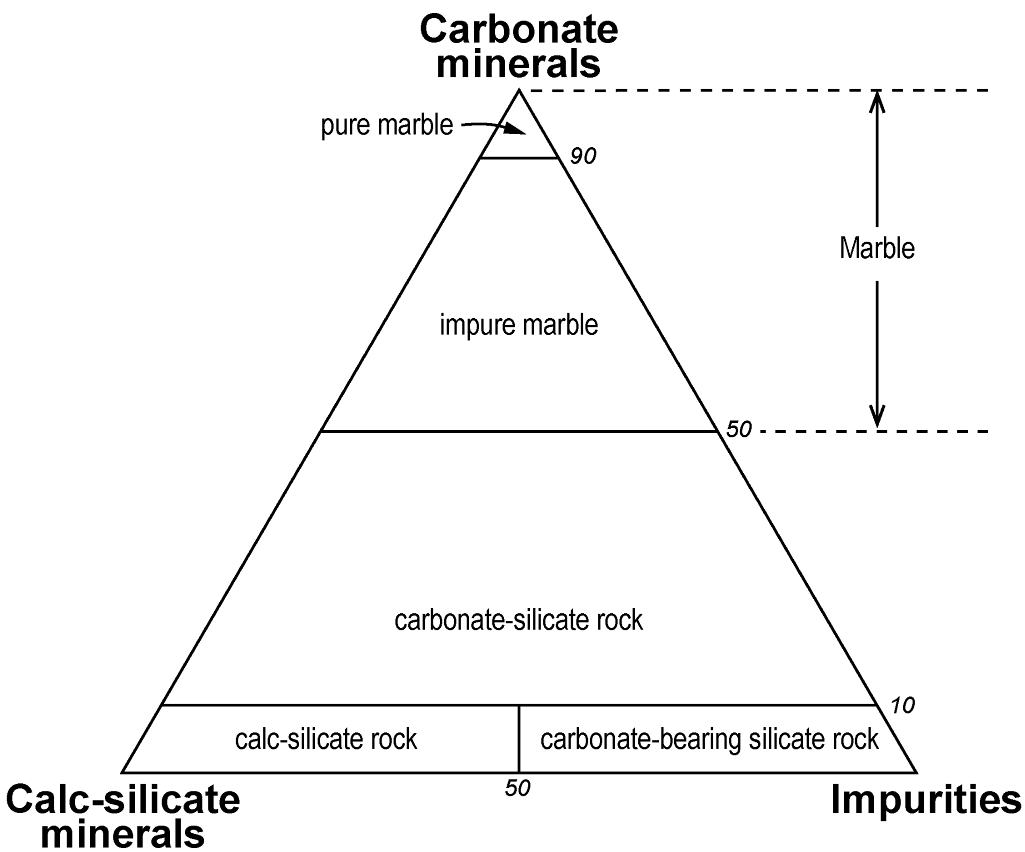


Figure 28. Classification of metacarbonate and related rocks based on proportions of carbonate minerals, calc-silicate minerals and impurities. Impurities includes non-calc-silicate silicate minerals and other minerals such as graphite, magnetite, apatite. *Modified from* Fettes and Desmons (2007). © Cambridge University Press, 2007. Reprinted with permission.

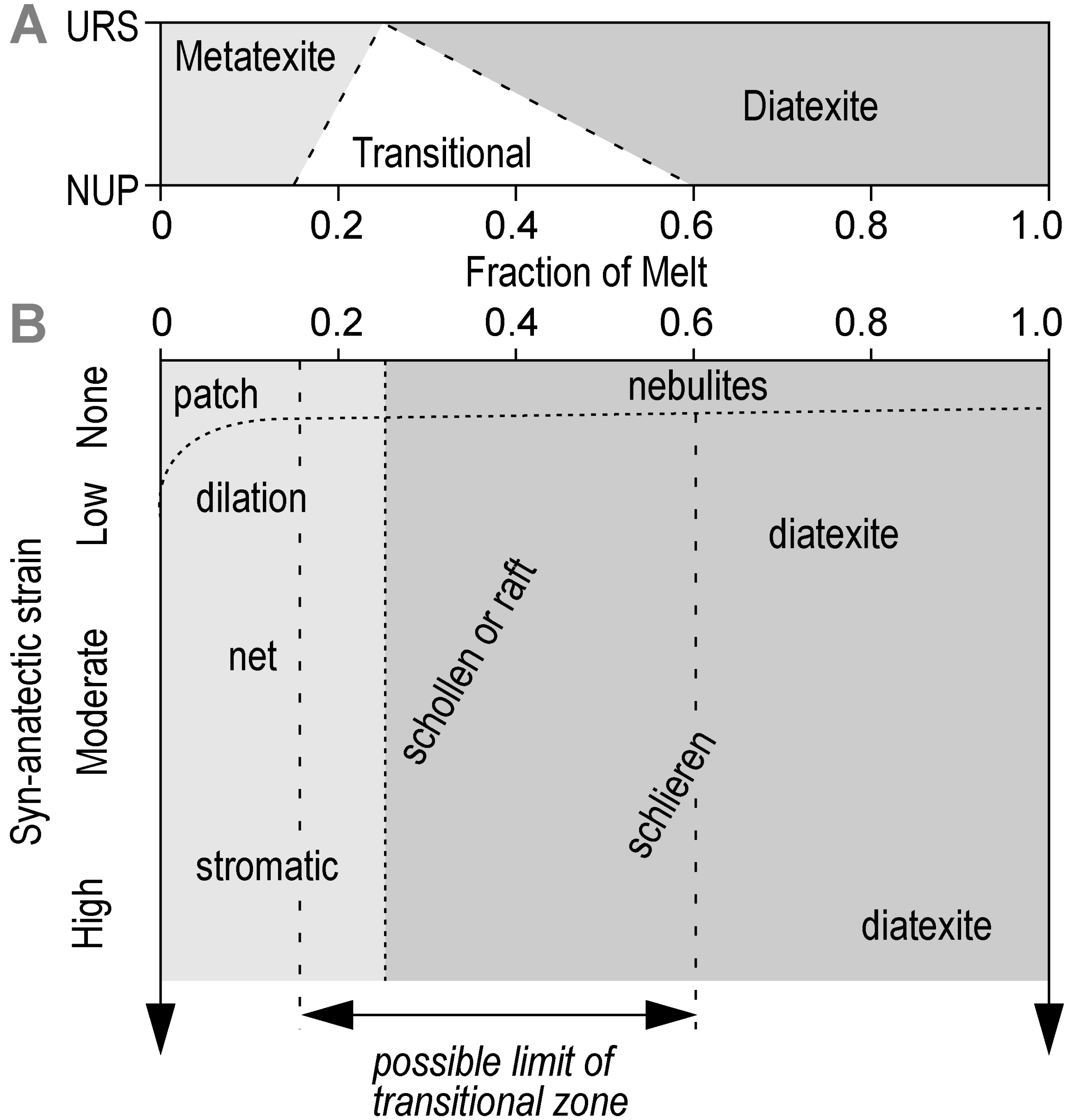


Figure 29. Classification of migmatites. *Modified from* Sawyer (2008). **A**) The first-order subdivision between metatexite and diatexite. The transitional field defining the boundary between the 2 types of migmatite ranges from a fraction of melt value of 0.26, using a uniform rigid sphere (URS) model, to values of fraction of melt ranging from 0.16 to 0.6, using a non-uniform particle (NUP) model. **B**) The second-order varieties of metatexite and diatexite relative to fraction of melt and degree of syn-anatectic strain. Shading is for the URS model conditions. Dashed lines are for the NUP model. Terms shown, except “diatexite”, should be used as prefixes to the type of migmatite (e.g., patch metatexite or schollen diatexite).

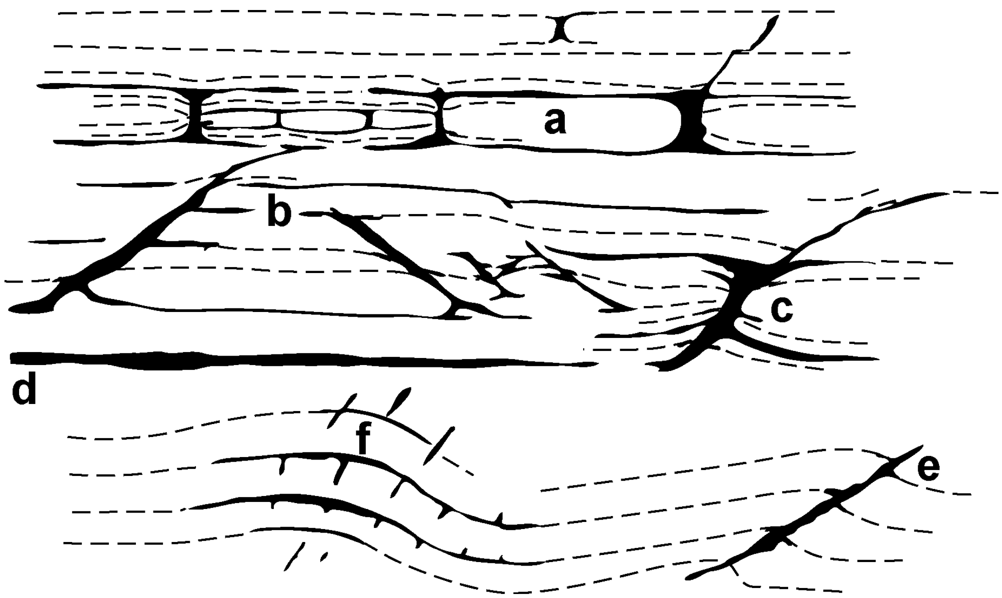
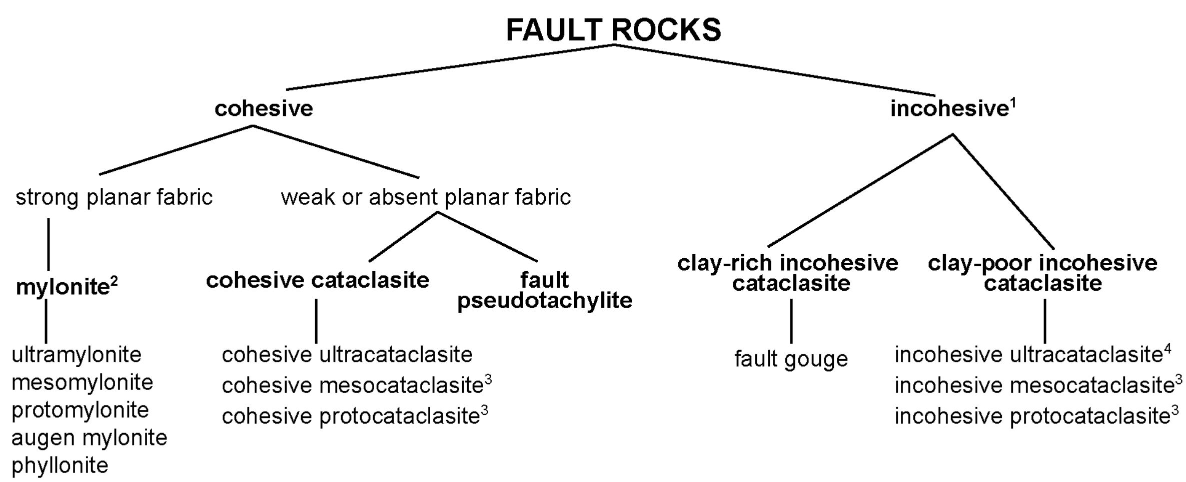


Figure 30. Schematic representation of some of the structural sites in which the leucosome in dilational metatexite can be expected to occur. *From* Sawyer (2008). Solid areas and lines represent leucosome, whereas the dashed black lines are the traces of bedding or foliation: a) leucosome in interboudin partitions; b) leucosome located in extensional shear bands; c) leucosome located in an asymmetrical foliation boudin; d) stromatic leucosome oriented parallel to the principal plane of anisotropy; e) leucosome located in a reverse shear, cutting the short limb of an asymmetrical fold ("flanking structures" of Grasemann and Stüwe 2001; Passchier 2001); f) leucosome associated with parallel folds, either parallel to layering, radially disposed outside of the folded competent layers, or axial planar in less competent layers.



1. incohesive (incoherent, friable, uncemented): capable of being broken into component granules with fingers or with the aid of a pen knife
2. cohesive and foliated cataclasite is indistinguishable in the field from a mylonite.
3. coarse-grained cataclasite may also be termed 'fault breccia' (with the prefix cohesive or incohesive).
4. incohesive very fine-grained ultracataclasite may also be termed 'fault gouge'.

Note: the incohesive rock names may be subdivided into foliated and nonfoliated varieties.

Figure 31. Classification of cohesive and incohesive fault rocks. *Modified from* Fettes and Desmons (2007). © Cambridge University Press, 2007. Reprinted with permission.

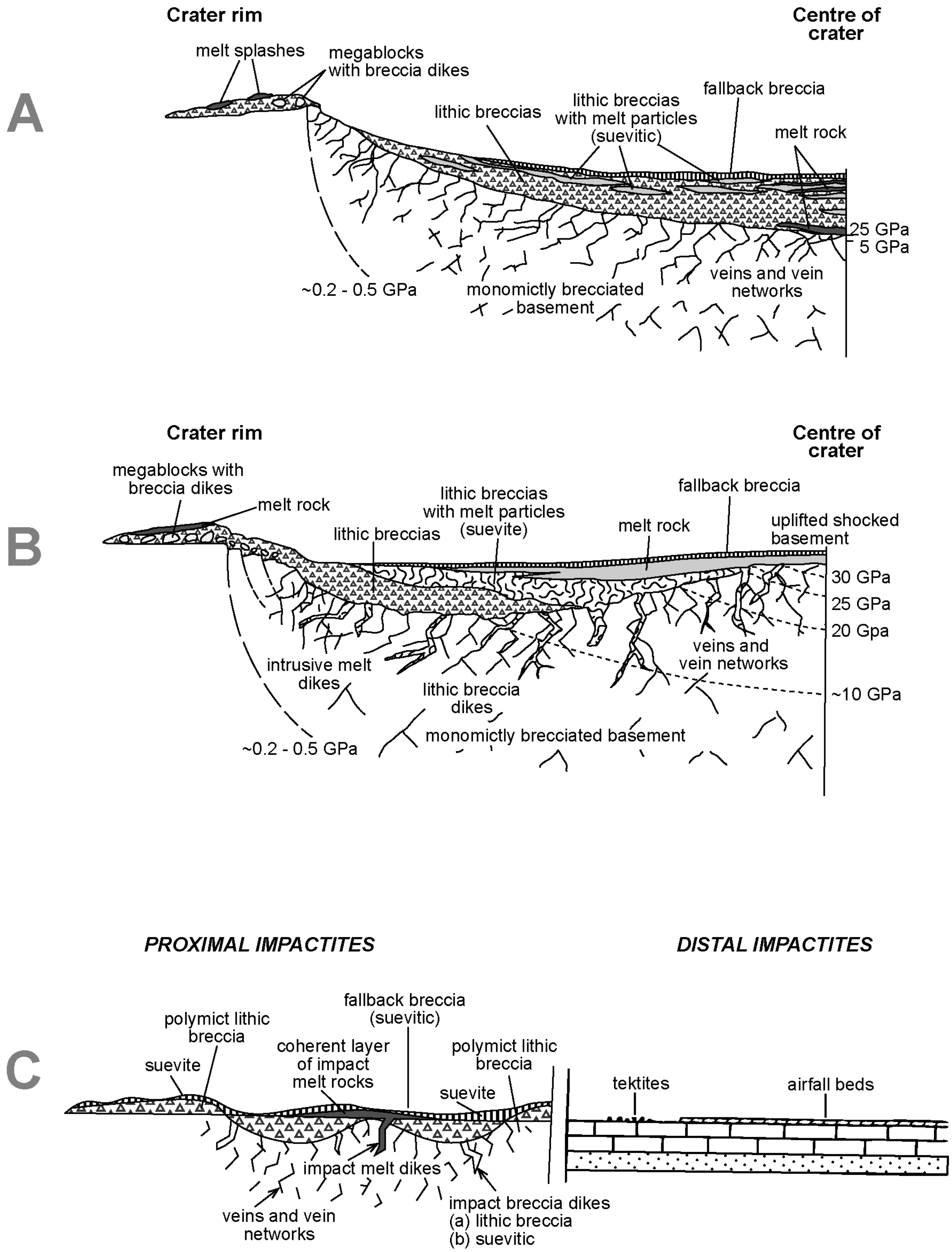


Figure 32. Diagram of impact craters and impactites on Earth: a) proximal impactites at a simple impact crater (diameter on Earth: ~30 m up to ~5 km); b) proximal impactites at a complex impact crater with central uplift (diameter range on Earth: ~5 km up to ~60 km); c) proximal and distal impactites. Shock pressure isobars are shown in the parautochthonous crater basement. *Modified from* Fettes and Desmons (2007). © Cambridge University Press, 2007. Reprinted with permission.

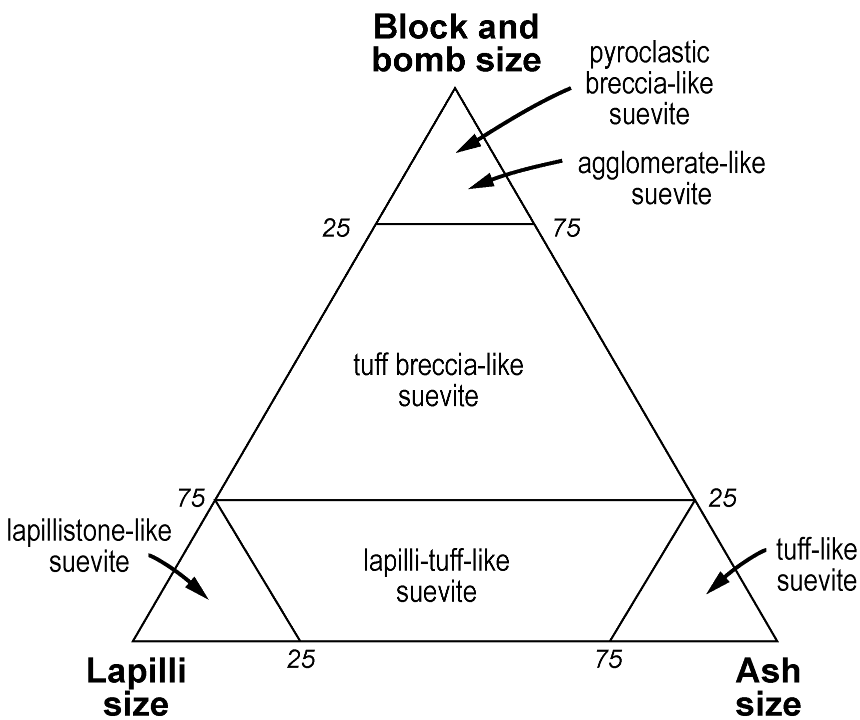


Figure 33. Classification of suevite rocks based on particle-size proportions as used with pyroclastic rocks, i.e., blocks and bombs, lapilli and ash. *Modelled after* Fisher (1966). © Elsevier, 1966. Reproduced with permission.

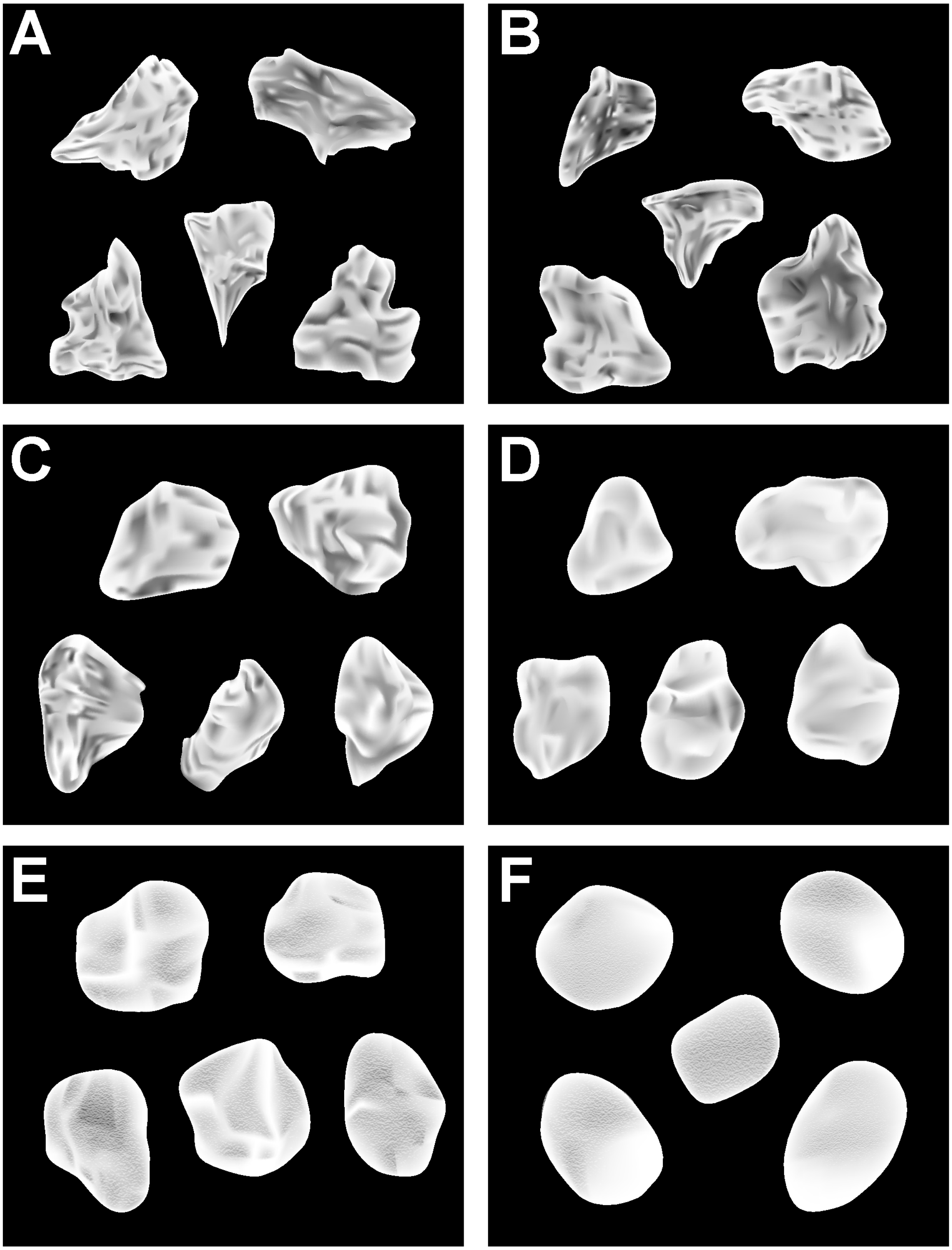


Figure 34. Estimating roundness classes of sand-size grains: A) very angular; B) angular; C) subangular; D) subrounded; E) rounded; F) well rounded. *Modified from* Shepard (1963), based on Powers (1953).

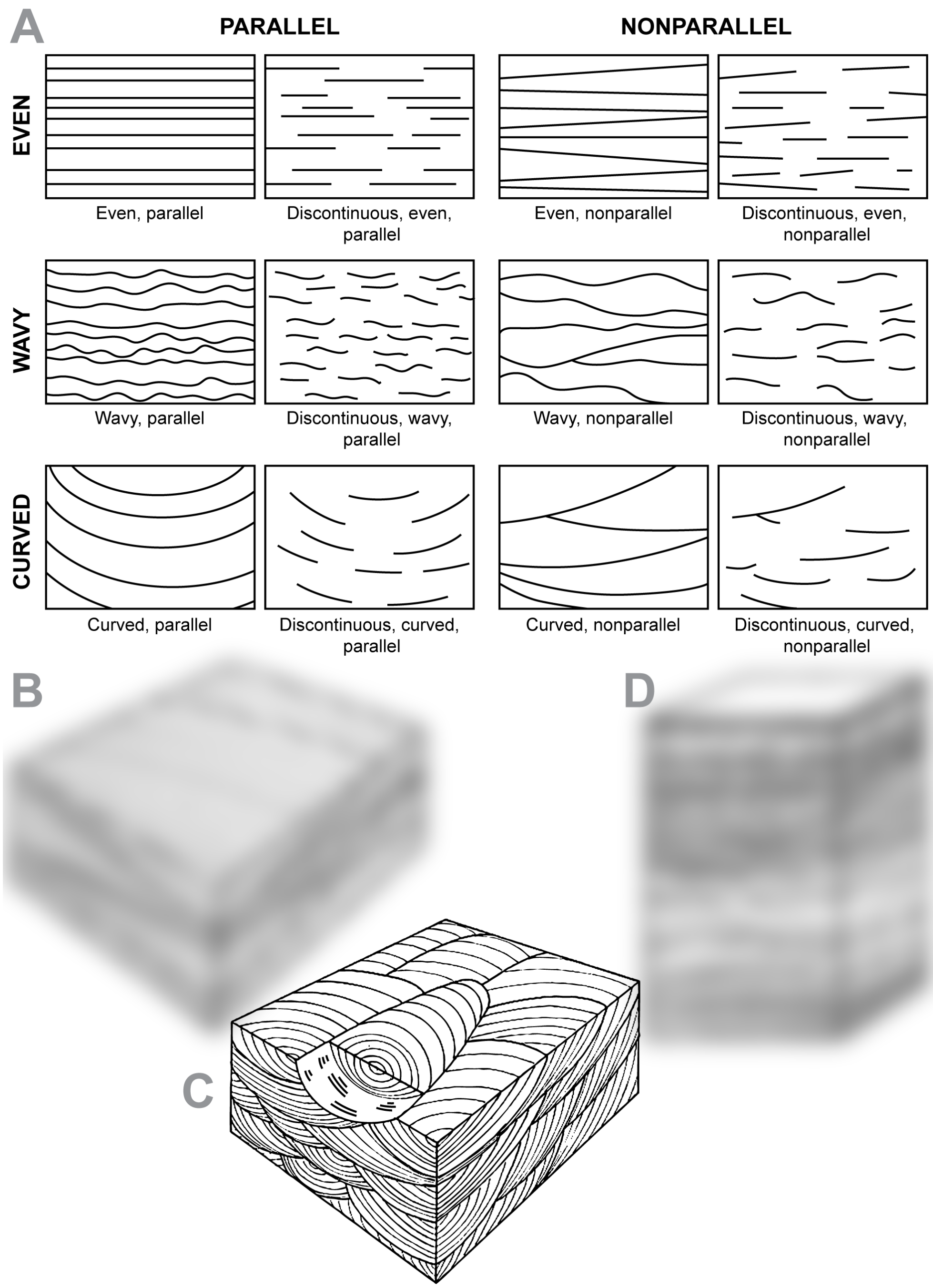


Figure 35. Bedding geometry and cross-stratification. **A**) Descriptive terms for shapes acquired by beds and laminae. *From* Campbell (1967). **B**) Block diagram showing planar cross-bedding as seen in horizontal, transverse and longitudinal sections. Units are tabular to wedge-shaped; bedding surfaces are planar. *From* Reineck and Singh (1975). **C**) Block diagram showing trough cross-bedding as seen in horizontal, transverse and longitudinal sections. Units are festoon-shaped. In transverse section, troughs are well developed with strongly curved bedding surfaces. All transition forms between planar and trough cross-bedding are known. *Modified from* Pettijohn (1975). **D**) Herringbone cross-stratification. Adjacent units of this bedding show foreset laminae dipping in opposite directions. *From* Reineck and Singh (1975). A) © John Wiley & Sons, 1967. Reproduced with permission. B) and D) © Springer, 1975. Reproduced with permission. C) ©1975. Printed and electronically reproduced by permission of Pearson Education, Inc., New York, New York.

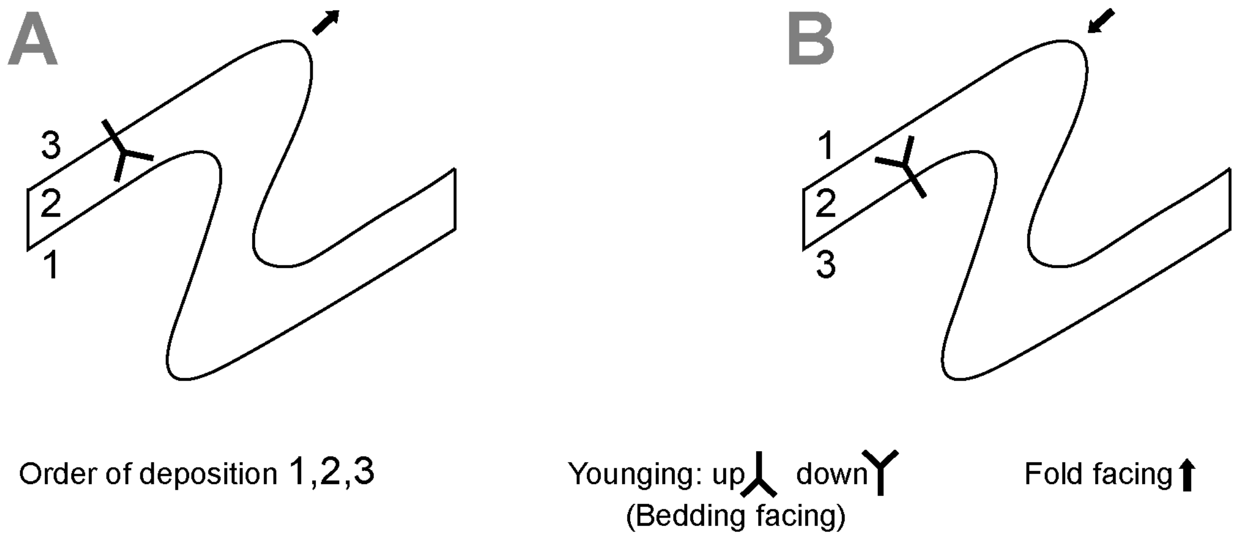


Figure 36. Distinction between fold asymmetry and fold facing. Both folds have the same sense of asymmetry, but **A**) faces upward / northeast, whereas **B**) faces downward / southwest. Orientation references are related to vertical profile view / plan view (with north toward top of page). *Modified from* Bell (1981). © Elsevier, 1981. Reproduced with permission.

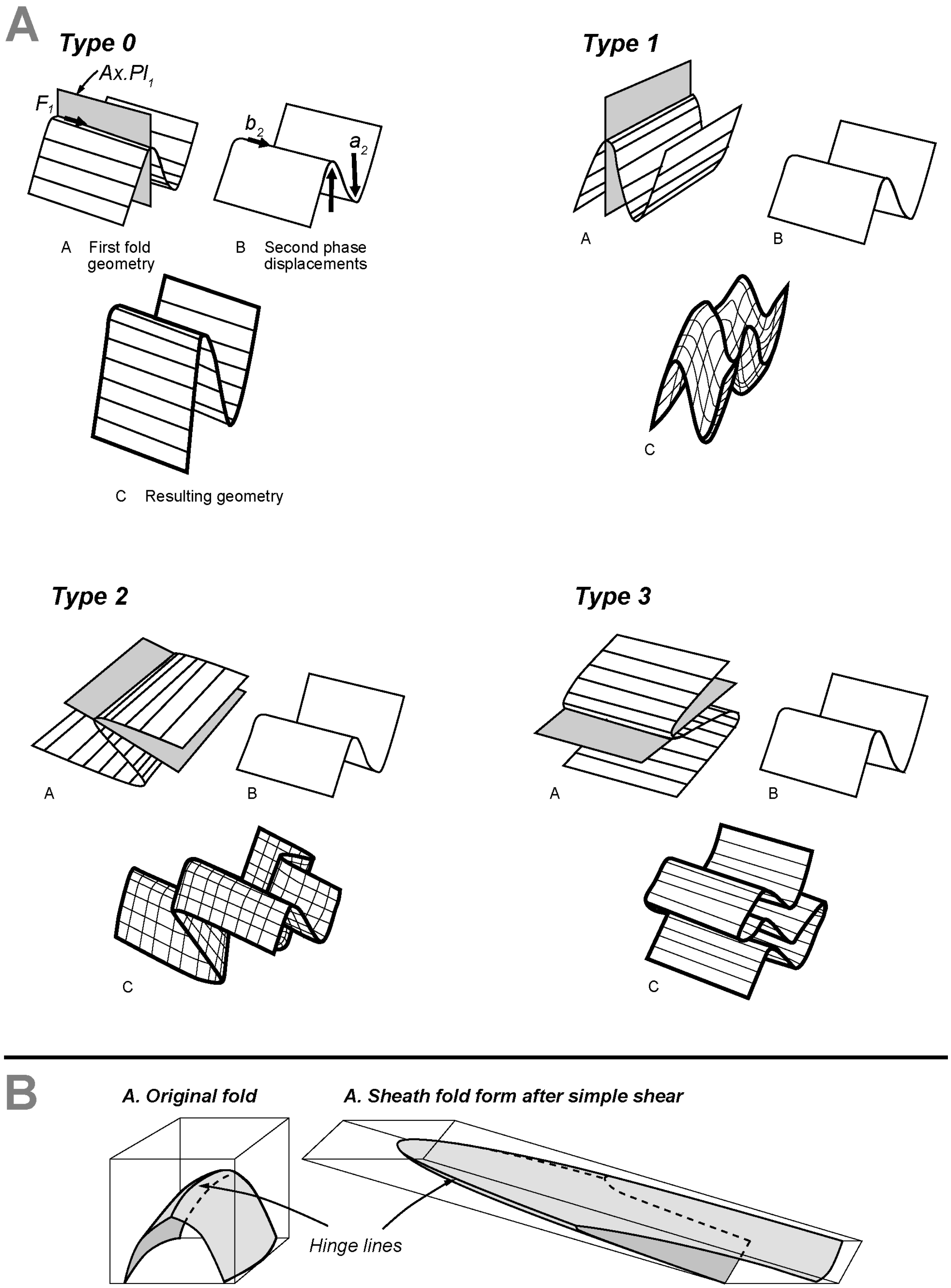


Figure 37. A) The 4 principal types of three-dimensional fold forms arising by the superposition of shear folds on pre-existing fold forms. *From* Ramsay and Huber (1987). **B**) The development of sheath folds by strong shearing of an initial fold form. *From* Ramsay (1980). © Elsevier, 1987 and 1980. Reproduced with permission.

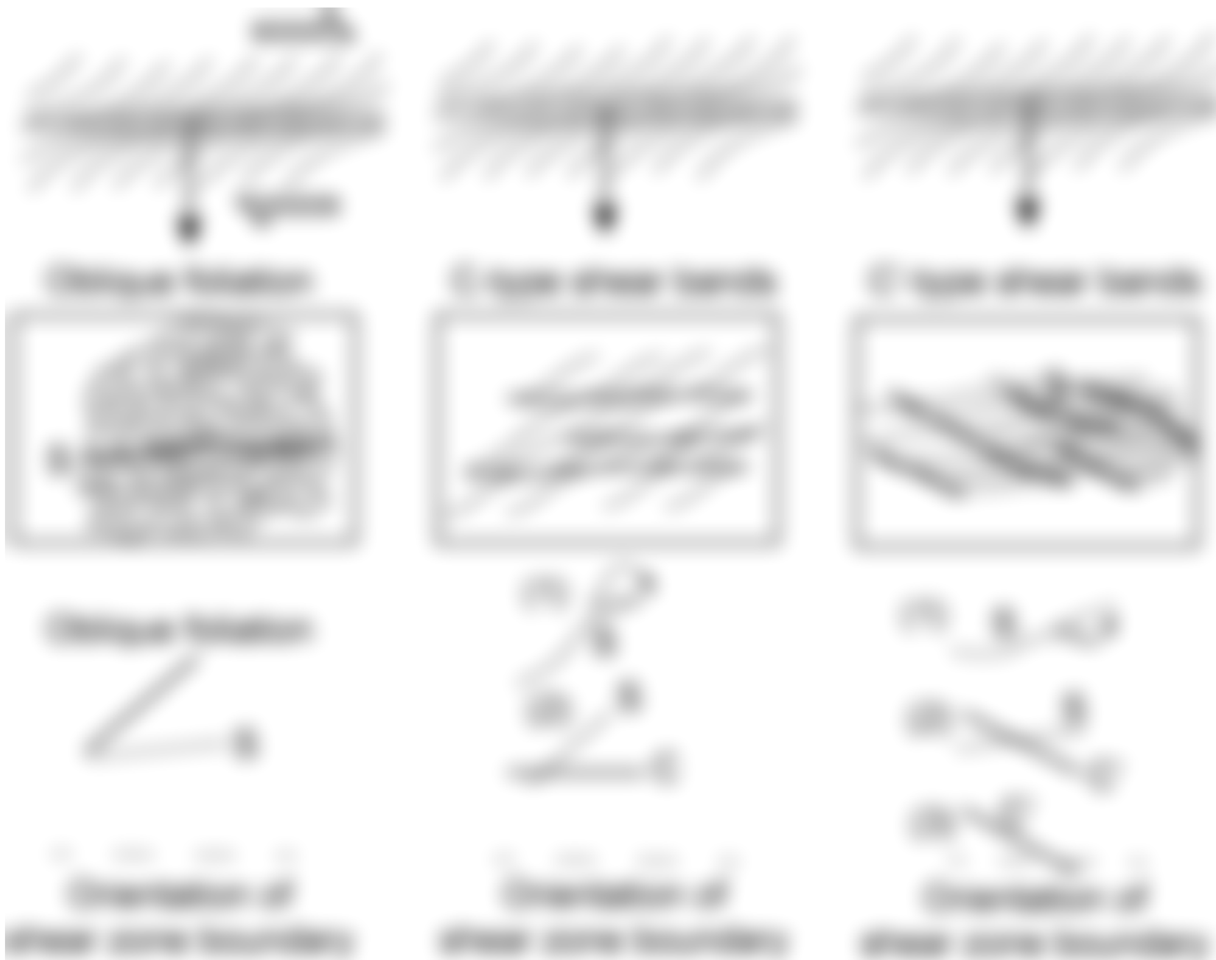


Figure 38. Common types of foliation pairs in ductile shear zones. Upper diagrams show a shear zone with typical foliation curvature. Middle diagrams show main differences in geometry between foliation pairs. Lower diagrams show planar elements used to determine sense of shear; arrows show sense of rotation of fabric during shear. Sets of C or C′ planes result in what is termed C-type and C′-type shear band cleavage, respectively. Shear band cleavage may superficially resemble crenulation cleavage. 1) Internal asymmetry is a sigmoidal shape of the older foliation between shear bands. 2) External asymmetry is the angle between the enveloping surface of the older foliation and the shear bands. 3) C′-type shear band cleavage has an additional external asymmetry element as the shear bands are inclined to the shear zone in a characteristic way. See Passchier and Trouw (2005), pages 122 and 128 to 132 for further explanation. *From* Passchier and Trouw (2005). © Springer, 2005. Reproduced with permission.

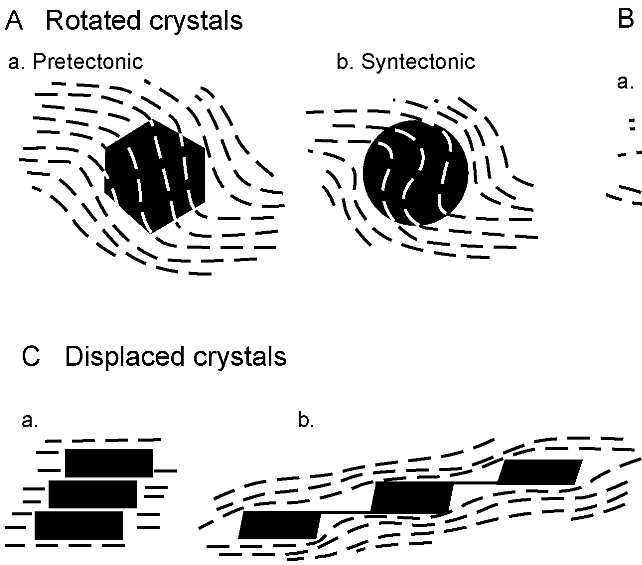


Figure 39. Examples of types of criteria used for the determination of shear sense in shear zones. All examples are with right-handed, or dextral, shear sense. *Modified from* Ramsay and Huber (1987). © Elsevier, 1987. Reproduced with permission.

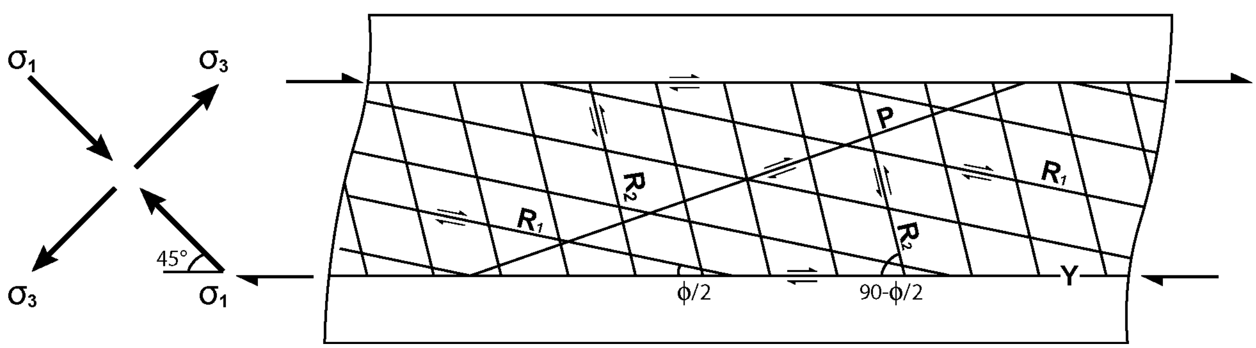


Figure 40. Conjugate Riedel shears R_1 and R_2 resulting from secondary fault development in a zone of right-handed (dextral) shear. The heavy arrows on the left show the principal axes of incremental strain (σ) developed as a result of simple shear in the zone. Note: Y = through-going fault, oriented 45° to maximum compressive stress; ϕ = 20° to 30°; R_1 = synthetic faults oriented 30° to σ_1, 10° to 15° to Y; R_2 = antithetic faults oriented 30° to σ_1, 75° to 80° to Y; P = synthetic faults (subordinate to absent); tension fractures and foliation (neither shown) may form parallel to σ_1 and σ_3, respectively. *Modified from* Ramsay and Huber (1987) and McClay (1984). © Elsevier, 1987. Reproduced with permission.

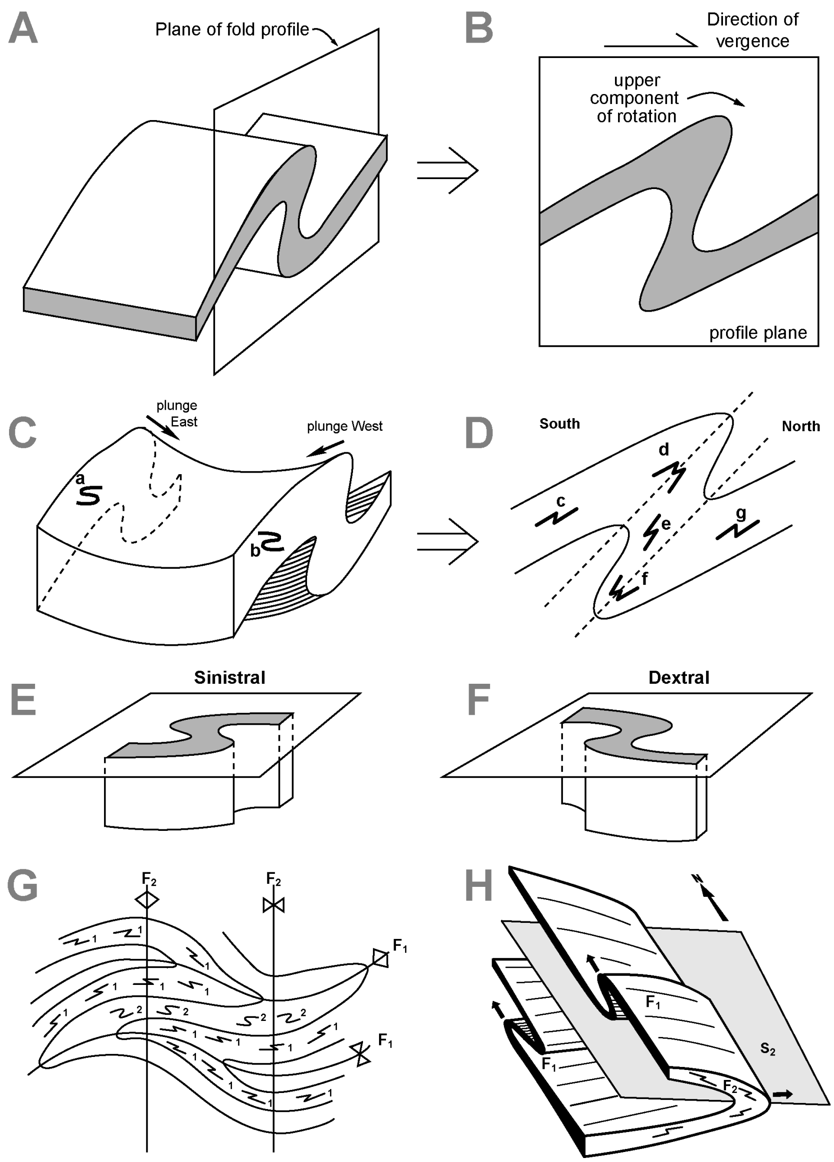


Figure 41. Fold vergence and fold facing. All figures *modified from* Bell (1981). © Elsevier, 1981. Reproduced with permission.

A) and **B**): Horizontal to subhorizontal fold axes: Graphical explanation of fold vergence relative to fold facing. Fold vergence is independent of fold plunge variations (cf. C).

C) and **D**): Nonvertical fold axes. C) Plunge reversals lead to reversals in sense of fold asymmetry (viewed down plunge) (cf. folds *a* and *b*) but not of fold vergence. D) Minor fold vergence can be used to locate axial surfaces of major folds. Change in vergence between *c* (north vergence), *e* (south vergence) and *g* (north vergence) indicate axial traces of a major fold pair have been crossed. *d* and *f* have neutral vergence.

E) and **F**): Vertical to subvertical fold axes. Folds have either sinistral (E) or dextral (F) vergence.

G) Vergence and facing with coaxial refolding (Type 3, *see* Figure 37). Minor (parasitic) F_1 folds (shown as “1”) do not change their vergence across F_2 axial surfaces, but do change their vergence across F_1 axial surfaces, hence locating the major F_1 folds. F_2 minor folds (shown as “2”) change their vergence across F_2 axial surfaces but not across F_1 axial surfaces. In strict terms, this may not apply to F_1 hinge zones. Changes of F_1 facing directions across F_2 axial surfaces may be used to define F_2 axial surfaces, even in the absence of minor F_2 folds.

H) Vergence and facing with orthogonal refolding (Type 2, *see* Figure 37). Both F_1 and F_2 minor (parasitic) folds change vergence but not facing direction across F_2 axial surfaces (arrows indicate facing direction). Hence, both vergence and facing are required to locate fold axes consistently.

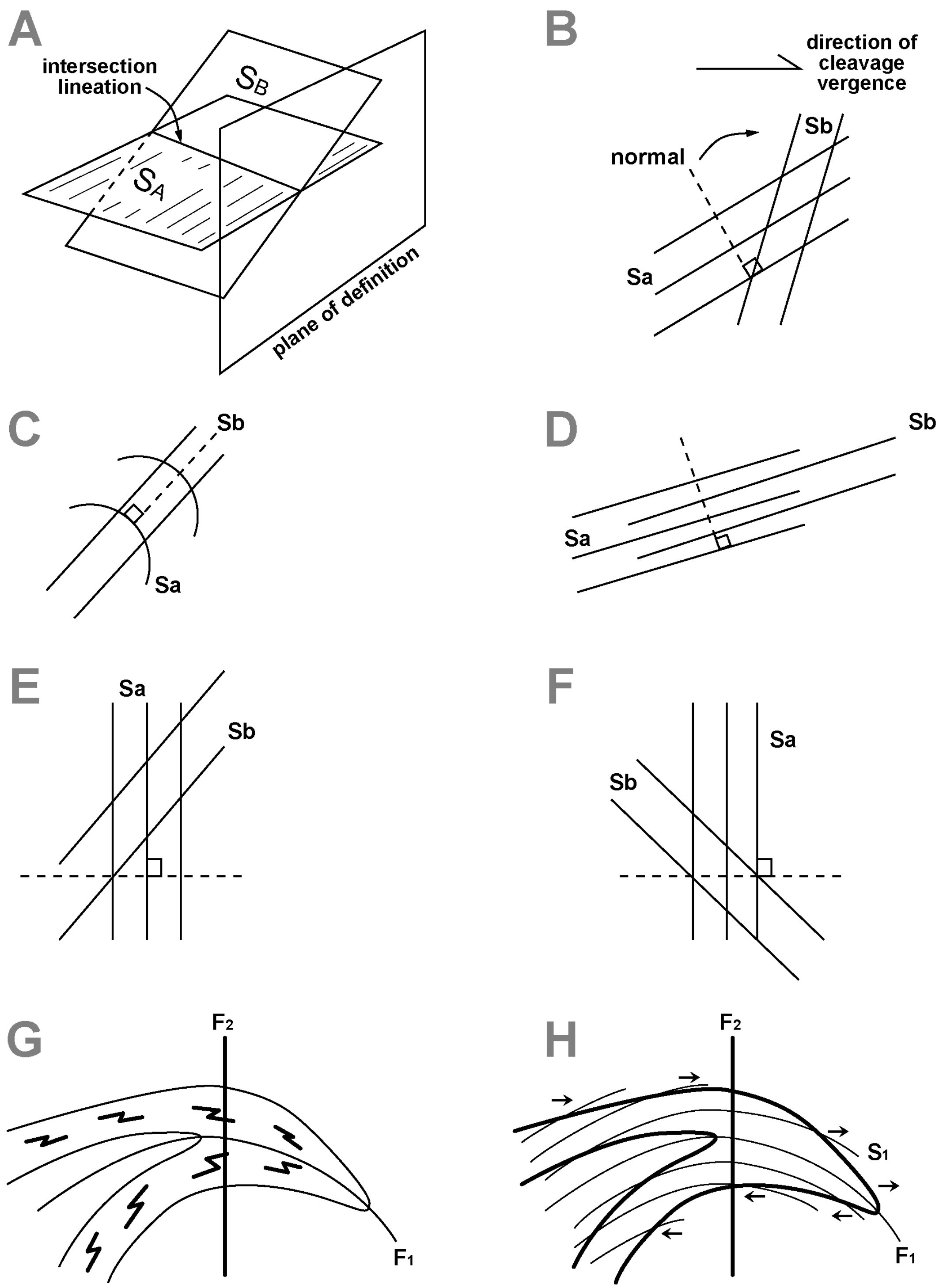


Figure 42. Cleavage vergence. **A**) Plane of definition of cleavage. **B**) Construction of normal to older fabric with direction of cleavage vergence indicated. **C**) Normal parallel to later fabric – cleavage vergence is neutral. **D**) Coplanar fabrics – cleavage vergence is not defined. **E**) and **F**) Vertical to subvertical earlier fabric – cleavage vergence is either sinistral (E) or dextral (F). **G**) and **H**) Supplementing fold vergence data (G) with cleavage vergence data (H). Note that F_1 cleavage vergence changes only across F_1 axial planes but not F_2 axial planes. Figures *from* or *modified from* Bell (1981). © Elsevier, 1981. Reproduced with permission.

Figure 43. Classification of mantled porphyroclasts. All examples are with right-handed, or dextral, shear sense, except for phi (ϕ) type which is for pure shear. *Modified from* Passchier and Trouw (1998). © Springer, 1998. Reproduced with permission.

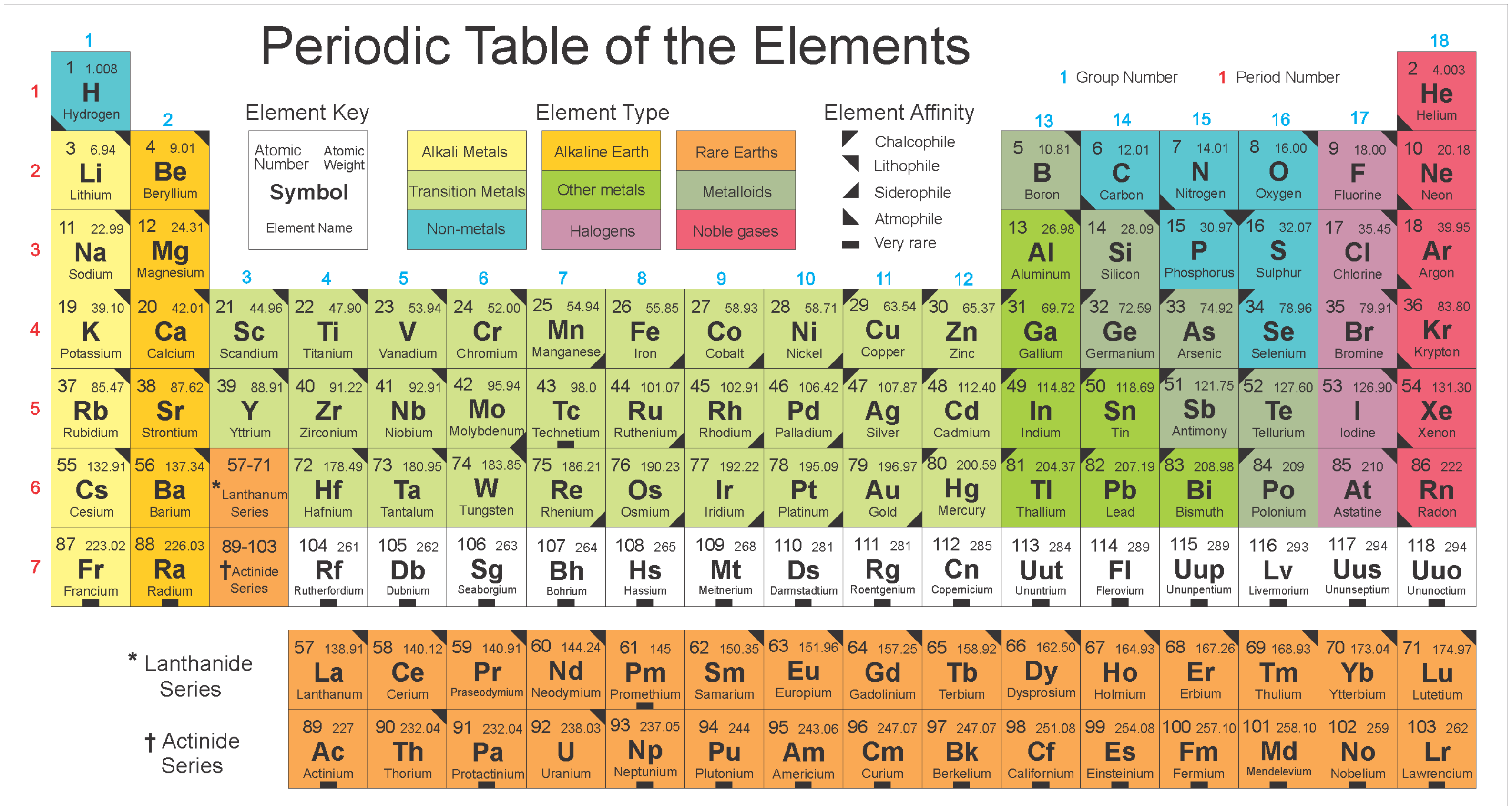


Figure 44. Periodic table of the elements showing element name, symbol, type, affinity, atomic number and atomic weight. Element type *from* Ontario Geo Labs Geoscience Laboratories brochure. Geochemical affinity *from* Goldschmidt (1937).

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Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm^3	0.061 023	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m^3
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton(short)	**907.184 74**	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 9**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy) / ton (short)	1 ounce (troy) / ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights / ton (short)	1 pennyweight / ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors in ***bold*** *type are exact. The conversion factors have been taken from or have been derived from factors given in the* Metric Practice Guide for the Canadian Mining and Metallurgical Industries*, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.*

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Table 2. Intrusive rocks: classification.

Intrusive Rocks Classification — Rationale / References

QAPF Classification: M <90 ^ ; Reference: Le Maitre (2002) and sources therein

Level 1							
Fig. 3	Fig. 4	Fig. 5D (for gabbros)	Fig. 5A (for gabbros)	Fig. 5B (for gabbros)	Fig. 5D (for gabbros)	Fig. 7, 8	
Level 2	**Level 3**	**Level 4**	**Level 4**	**Level 4**	**Level 4**	**Colour Index (M′) ^**	**Required Conditions and/or Variations ^**
Granitoid	granite →	syenogranite				5 - 20	Q 20 to 60%
		monzogranite				5 - 20	Q 20 to 60%
	alkali-feldspar granite →					0 - 20	-"alaskite" is a hololeucocratic alkali-feldspar granite (M′ <10); "peralkaline granite" is an alkali-pyroxene- and/or alkali-amphibole-bearing alkali-feldspar granite; Q 20 to 60%
	granodiorite					5 - 25	-average plagioclase An_0 - An_{50}; Q 20 to 60%
	tonalite					10 - 40	-"trondhjemite" is a leucotonalite: An_{10} to An_{50}; Q 20 to 60%
	quartz-rich granitoid						Q 60 to 90%
	quartzolite						Q >90%
Syenitoid	syenite					10 - 35	Q <5%
	quartz syenite					5 - 30	Q 5 to 20%
	alkali-feldspar syenite					0 - 25	Q <5%
	quartz alkali-feldspar syenite					0 - 25	Q 5 to 20%
	foid-bearing syenite					10 - 35	-foids <10%; substitute the feldspathoid mineral name for "foid" in the rock name
	foid-bearing alkali-feldspar syenite					10 - 35	-foids <10%; substitute the feldspathoid mineral name for "foid" in the rock name
	monzonite					15 - 45	Q <5%
	quartz monzonite					10 - 35	Q 5 to 20%
	foid-bearing monzonite					15 - 45	-foids <10%; substitute the feldspathoid mineral name for "foid" in the rock name
Dioritoid	diorite					25 - 50	-average plagioclase An_0 - An_{50}; M >10
	quartz diorite					20 - 45	-average plagioclase An_0 - An_{50}; M >10
	foid-bearing diorite					25 - 50 *	-average plagioclase An_0 - An_{50}; M >10; substitute the feldspathoid mineral name for "foid" in the rock name
	monzodiorite					20 - 50	-average plagioclase An_0 - An_{50}; M >10
	quartz monzodiorite					15 - 40	-average plagioclase An_0 - An_{50}; M >10
	foid-bearing monzodiorite					20 - 50 *	-average plagioclase An_0 - An_{50}; M >10; substitute the feldspathoid mineral name for "foid" in the rock name
Gabbroid			**Based on: Plag-Px-Ol**	**Based on: Plag-Px-Hbl**	**Based on: Plag-Opx-Cpx**		
	gabbro →	gabbro →	olivine gabbro	pyroxene hornblende gabbro	orthopyroxene gabbro	35 - 65	-average plagioclase An_{50} - An_{100}; M >10
			troctolite (Px <5%)	hornblende gabbro (Px <5%)		35 - 65	-average plagioclase An_{50} - An_{100}; M >10
		gabbronorite	olivine gabbronorite	pyroxene hornblende gabbronorite		35 - 65	-average plagioclase An_{50} - An_{100}; M >10
		norite	olivine norite	pyroxene hornblende norite	clinopyroxene norite	35 - 65	-average plagioclase An_{50} - An_{100}; M >10
	quartz gabbro					25 - 55	-average plagioclase An_{50} - An_{100}; M >10
	foid-bearing gabbro					35 - 65	-average plagioclase An_{50} - An_{100}; M >10; substitute the feldspathoid mineral name for "foid" in the rock name
	monzogabbro					25 - 60	-average plagioclase An_{50} - An_{100}; M >10
	quartz monzogabbro					20 - 50	-average plagioclase An_{50} - An_{100}; M >10
	foid-bearing monzogabbro					35 - 65	-average plagioclase An_{50} - An_{100}; M >10; substitute the feldspathoid mineral name for "foid" in the rock name
Anorthosite	anorthosite					0 - 10	-independent of plagioclase An
	quartz anorthosite					0 - 10	-independent of plagioclase An
	foid-bearing anorthosite					0 - 10 *	-independent of plagioclase An; substitute the feldspathoid mineral name for "foid" in the rock name
Foid Syenitoid	foid syenite					0 - 30	-substitute the feldspathoid mineral name for "foid" in the rock name; e.g., nepheline syenite
	foid monzosyenite					15 - 45	-substitute the feldspathoid mineral name for "foid" in the rock name; e.g., nepheline monzosyenite
Foid Dioritoid	foid diorite					30 - 70	-average plagioclase An_0 - An_{50}; substitute the feldspathoid mineral name for "foid" in the rock name
	foid monzodiorite					20 - 60	-average plagioclase An_0 - An_{50}; substitute the feldspathoid mineral name for "foid" in the rock name
Foid Gabbroid	foid gabbro					30 - 70	-average plagioclase An_{50} - An_{100}; e.g., nepheline gabbro
	foid monzogabbro					20 - 60	-average plagioclase An_{50} - An_{100}; e.g., nepheline monzogabbro
Foidolite	foidolite →						F 60 to 100%; e.g., cancrinite foidolite; -feldspathoids include: nepheline, leucite, sodalite, nosean, hauyne, lazurite, cancrinite, melilite (<10%) and analcime
	nephelinolite →					0 - 30	F 60 to 100%: nepheline dominant foid; "urtite" is a leuconephelinolite
						30 - 70	F 60 to 100%: nepheline dominant foid; "ijolite" is a mesonephelinolite
						70 - 90	F 60 to 100%: nepheline dominant foid; "melteigite" is a melanephelinolite
	"leucitolite" † →					0 - 30	F 60 to 100%: leucite dominant foid; "italite" is a leucoleucitolite
						30 - 70	F 60 to 100%: leucite dominant foid; "fergusite" is a mesoleucitolite
						70 - 90	F 60 to 100%: leucite dominant foid; "missourite" is a melaleucitolite

Ultramafic Classification: M >90 ^ ; Reference: Le Maitre (2002) and sources therein; Neuendorf, Mehl and Jackson (2005)

Fig. 6	Fig. 6	Fig. 6B	Fig. 6A	Fig. 5B	Fig. 5D		
Level 2	**Level 3**	**Level 4**				**Colour Index (M′) ^**	**Required Conditions and/or Variations**
		Based on Ol-Px-Hbl	**Based on Ol-Opx-Cpx**	**Based on Plag-Px-Hbl**	**Based on Plag-Opx-Cpx**		
Ultramafic rock	peridotite →	dunite	dunite			>90	-modal olivine >90%
		pyroxene peridotite	harzburgite			>90	-modal olivine 40 to 90%
		pyroxene hornblende peridotite	lherzolite			>90	-modal olivine 40 to 90%
		hornblende peridotite	wehrlite			>90	-modal olivine 40 to 90%
	pyroxenite →	pyroxenite				>90	-modal olivine <40%
		olivine pyroxenite	olivine orthopyroxenite	plagioclase-bearing pyroxenite	plagioclase-bearing pyroxenite	>90	-modal olivine 5 to 40%; or plag <10%
		olivine hornblende pyroxenite	olivine websterite	plagioclase-bearing hornblende pyroxenite		>90	-modal olivine 5 to 40%; or plag <10%
		hornblende pyroxenite	olivine clinopyroxenite			>90	-modal olivine <5%
			orthopyroxenite			>90	-modal olivine <10%
			websterite			>90	-modal olivine <5%
			clinopyroxenite			>90	-modal olivine <10%
	hornblendite →	olivine hornblendite		plagioclase-bearing hornblendite		>90	-modal olivine 5 to 40%; or plag <10%
		olivine pyroxene hornblendite		plagioclase-bearing pyroxene hornblendite		>90	-modal olivine 5 to 40%; or plag <10%
		pyroxene hornblendite				>90	-modal olivine <5%

Special Cases — Reference: condensed from Le Maitre (2002) and sources therein; Neuendorf, Mehl and Jackson (2005)

Level 2	**Level 3**		**Mafic and Related Minerals (M)^**	**Required Conditions / Variations**
Carbonatite (may be plutonic or volcanic)	calciocarbonatite		M >50	-modal primary carbonate indeterminate: use geochemistry (*see* Figure 9)
	calcite-carbonatite		M >50	-modal primary carbonate >50%: main one is calcite; SiO_2 <20%
	dolomite-carbonatite		M >50	-modal primary carbonate >50%: main one is dolomite; SiO_2 <20%
	ferrocarbonatite		M >50	-modal primary carbonate >50%: main one is iron-rich; SiO_2 <20%
			–	-modal primary carbonate indeterminate: use geochemistry (*see* Figure 9)
	magnesiocarbonatite		–	-modal primary carbonate indeterminate: use geochemistry (*see* Figure 9)
	silicocarbonatite		M >50	-SiO_2 >20%
Melilitolite	unsubdivided		M >90	-melilite >10%; melilite > feldspathoids; kalsilite is absent; -other principal minerals include: olivine, pyroxene, perovskite, haüyne, nepheline
	olivine melilitolite		M >90	-olivine >10%; clinopyroxene <10%
	pyroxene olivine melilitolite		M >90	-olivine > clinopyroxene
	olivine pyroxene melilitolite		M >90	-clinopyroxene > olivine
	pyroxene melilitolite		M >90	-olivine <10%
Kalsilite-bearing rock	unsubdivided	-the term pyroxenite may be more appropriately employed for a plutonic rock (e.g., kalsilite pyroxenite)		-principal minerals include: clinopyroxene, kalsilite, leucite, melilite, olivine, phlogopite
	kalsilitite	-the term pyroxenite may be more appropriately employed for a plutonic rock (e.g., kalsilite pyroxenite)		-kalsilitite has kalsilite present, but no melilite or leucite
Kimberlite		-porphyritic alkalic peridotite; some mineralogical affinity to lamproites, but mineral assemblages and compositions are sufficiently distinct to be grouped separately		
	Group I →	-volatile-rich (dominantly CO_2) potassic ultrabasic rocks -macrocrysts and megacrysts are generally, but not always, fundamental components -macrocrysts commonly include forsteritic olivine, magnesian ilmenite, Cr-pyrope, almandine pyrope, Cr-diopside, phlogopite, enstatite, and/or Ti-poor chromite -megacrysts commonly include Cr-poor varieties of magnesian ilmenite, Ti-pyrope, diopside, olivine and enstatite -matrix commonly includes olivine along with monticellite, phlogopite, perovskite, Mg-Cr-Fe spinels, apatite, carbonate, serpentine		
	Group II (orangeites) →	-volatile-rich (dominantly H_2O) ultrapotassic, peralkaline rocks -macrocrysts characteristically phlogopite, commonly olivine (not major) -matrix characteristically includes zoned diopside, Mg-Cr-Ti spinels, perovskite, Sr-apatite, REE-phosphates, K-Ba titanates, Nb-rutile, Mn-ilmenite in groundmass containing calcite, dolomite, ancylite, witherite, norsethite, serpentine		
Lamproite	Mineralogical criteria →	-generally occur as dikes or small extrusions; tend to be dark coloured and rich in potassium and magnesium -for rock names, use compound names with up to 4 mineral modifiers of the following: phlogopite, richterite, olivine, diopside, sanidine, leucite -may contain any one dominant and 2 to 3 subordinate minerals of the following: phlogopite phenocrysts (Ti-rich, Al-poor) and poikolitic phlogopite (Ti-rich), richterite (Ti-, K-rich), forsteritic olivine, diopside (Al-, Na-poor), leucite (Fe-rich), sanidine (Fe-rich) -numerous possible accessory minerals, many unusual except for apatite, perovskite, magnetite, specific chromites -cannot contain plagioclase, any feldspathoids, melilite, monticellite, kalsilite, Na-rich alkali feldspar, melanite, schorlomite, kimzeyite		
	Geochemical criteria →	-ultrapotassic, peralkaline, specific ratios and/or absolute amounts of K_2O, Na_2O, Al_2O_3, FeO, CaO, TiO_2, Ba, Sr, Zr, La		
Lamprophyre	typically distinguished on the following characteristics:	-for rock names, use colour index, phenocryst phases and foids if present (*see* pick list) → typically: mesocratic M′ 35 - 65 or melanocratic M′ 65 - 90; rarely: holomelanocratic M′ >90 -normally occur as dikes with textures not similar to common plutonic or volcanic rocks -feldspars and/or feldspathoids only in groundmass -typically contain biotite or Fe-phlogopite, and/or amphibole, sometimes clinopyroxene -hydrothermal alteration (olivine, pyroxene, biotite, plagioclase) is common -primary phases may include calcite, zeolites + hydrothermal minerals -tend to be high in K_2O, Na_2O, H_2O, CO_2, S, P_2O_5, Ba relative to rocks of similar composition		

Level 2	**Level 3**		**Colour Index (M′) ^**	**Comments**
Miscellaneous	aphanitic ultramafic		>90	-too fine grained for field use of IUGS classification
	aphanitic mafic		35 - 90	-too fine grained for field use of IUGS classification
	aphanitic intermediate		15 - 35	-too fine grained for field use of IUGS classification
	aphanitic felsic		<15	-too fine grained for field use of IUGS classification
	aplite		<10	-fine-grained, hololeucocratic "granitic" rock consisting mostly of feldspar and quartz
	pegmatite			-coarse-grained to extremely coarse-grained phase of any igneous rock type: use a rock name and choose "pegmatitic" as a textural modifier
	chromitite			-cumulate layers; >90% chromite
	ilmenitite			-cumulate layers; >90% ilmenite
	magnetitite			-cumulate layers; >90% magnetite

^ M = percentage of mafic and related minerals (e.g., olivine, pyroxene, amphibole, mica, opaque minerals, accessory minerals (e.g., zircon, apatite, titanite), epidote, allanite, garnet, melilite, monticellite, primary carbonate)) (volume percent)
M′ = colour index = percentage of mafic (dark coloured, ferromagnesian) minerals only (e.g., olivine, pyroxene, some amphiboles, etc.) (volume percent)
* = inferred from diagrams but not explicitly stated or defined
† = tentative name invented to be consistent with stated rules, which are not adhered to in the reference text

Table 3. Intrusive rocks: pick lists.

Level 1	Intrusive Rocks Pick Lists																
Level 2	Granitoid	Syenitoid	Dioritoid	Gabbroid	Anorthosite	Foid Syenitoid	Foid Dioritoid	Foid Gabbroid	Foidolite	Ultramafic Rock	Carbonatite	Melilitolite	Kalsilite-bearing Rock	Kimberlite	Lamproite	Lamprophyre	Miscellaneous
Level 3	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	aphanitic ultramafic
	granite	syenite	diorite	gabbro	anorthosite	foid syenite	foid diorite	foid gabbro	foidolite	peridotite	calciocarbonatite	olivine melilitolite	kasilitite	Group I		intermediate lamprophyre	aphanitic mafic
	alkali-feldspar granite	quartz syenite	quartz diorite	quartz gabbro	quartz anorthosite	foid monzosyenite	foid monzodiorite	foid monzogabbro	leucitolite	pyroxenite	calcite-carbonatite	pyroxene olivine melilitolite		Group II		mafic lamprophyre	aphanitic intermediate
	granodiorite	alkali-feldspar syenite	foid-bearing diorite	foid-bearing gabbro	foid-bearing anorthosite				nephelinolite	hornblendite	dolomite-carbonatite	olivine pyroxene melilitolite				ultramafic lamprophyre	aphanitic felsic
	tonalite	quartz alkali-feldspar syenite	monzodiorite	monzogabbro							ferrocarbonatite	pyroxene melilitolite					aplite
	quartz-rich granitoid	foid-bearing syenite	quartz monzodiorite	quartz monzogabbro							magnesiocarbonatite						pegmatite
	quartzolite	foid-bearing alkali-feldspar syenite	foid-bearing monzodiorite	foid-bearing monzogabbro							silicocarbonatite						chromitite
		monzonite															ilmenitite
		quartz monzonite															magnetitite
		foid-bearing monzonite															
Level 4	unsubdivided			unsubdivided						unsubdivided							
	syenogranite			olivine gabbro						dunite							
	monzogranite			troctolite						pyroxene peridotite							
				pyroxene hornblende gabbro						pyroxene hornblende peridotite							
				hornblende gabbro						hornblende peridotite							
				orthopyroxene gabbro						harzburgite							
				unsubdivided						lherzolite							
				gabbronorite						wehrlite							
				olivine gabbronorite						unsubdivided							
				pyroxene hornblende gabbronorite						pyroxenite							
				unsubdivided						olivine pyroxenite							
				norite						olivine hornblende pyroxenite							
				olivine norite						hornblende pyroxenite							
				pyroxene hornblende norite						olivine orthopyroxenite							
				clinopyroxene norite						olivine websterite							
										olivine clinopyroxenite							
										orthopyroxenite							
										websterite							
										clinopyroxenite							
										plagioclase-bearing pyroxenite							
										plagioclase-bearing hornblende pyroxenite							
										unsubdivided							
										olivine hornblendite							
										olivine pyroxene hornblendite							
										pyroxene hornblendite							
										plagioclase-bearing hornblendite							
										plagioclase-bearing pyroxene hornblendite							

Level 1	Volcanic Rocks Classification -- Rationale / References													
	Fig. 15		Table 6		Fig. 12		Fig. 13A; Table 10c	Fig. 10, 11, 14	Fig. 12	Fig. 14	Fig. 13A,C; Table 10c, 11	Fig. 13B; Table 10c		
Level 2	Level 3	Level 4	Level 5	Level 5	Level 5	Level 5	Level 5	Level 6	Level 6	Level 6	Level 6	Level 7		
		Basis of Primary Classification	OGS^ Field Classification	IUGS^ Provisional QAPF Classification	TAM^ Classification‡ (pre-TAS^)	pre-TAS‡^	TAS^ Classification	QAPF^ Classification	TAM^ Classification‡	pre-TAS‡^	TAS^ Classification	TAS^ Classification	Main Criteria*^	References
Lava Flows	unsubdivided													
Pyroclastic Flows+	tuff													
	lithic tuff													
	crystal tuff													
	vitric tuff													
	lapilli tuff													
	lapillistone													
	tuff-breccia													
	pyroclastic breccia													
	agglomerate													
		Colour Index*	Ultramafic										M' >90; typically includes komatiite	OGS useage
			Mafic to ultramafic										M' close to 90	OGS useage
			Mafic										M' 35 to 90; typically includes basalt	OGS useage
			Intermediate to mafic										M' close to 35	OGS useage
			Intermediate										M' 15 to 35; typically includes andesite	OGS useage
			Felsic to intermediate										M' close to 15; typically includes dacite	OGS useage
			Felsic										M' <15; typically includes rhyolite	OGS useage
		Mineral Mode		Rhyolitoid				rhyolite					Q 20 to 60%; P/(A+P) = 0.1 to 0.65; typically M' <15	Le Maitre (2002)
								alkali-feldspar rhyolite					Q 20 to 60%; P/(A+P) = 0 to 0.1; typically M' <15	Le Maitre (2002)
				Dacitoid				dacite					Q 20 to 60%; P/(A+P) = 0.65 to 1.0	Le Maitre (2002)
				Trachytoid				trachyte					Q <5%; P/(A+P) = 0.1 to 0.35	Le Maitre (2002)
								quartz trachyte					Q 5 to 20%; P/(A+P) = 0.1 to 0.35	Le Maitre (2002)
								alkali-feldspar trachyte					Q <5%; P/(A+P) = 0.0 to 0.1	Le Maitre (2002)
								quartz alkali-feldspar trachyte					Q 5 to 20%; P/(A+P) = 0.0 to 0.1	Le Maitre (2002)
								foid-bearing trachyte					F <10%; P/(A+P) = 0.1 to 0.35	Le Maitre (2002)
								foid-bearing alkali-feldspar trachyte					F <10%; P/(A+P) = 0.0 to 0.1	Le Maitre (2002)
								latite					Q <5%; P/(A+P) = 0.35 to 0.65	Le Maitre (2002)
								quartz latite					Q 5 to 20%; P/(A+P) = 0.35 to 0.65	Le Maitre (2002)
								foid-bearing latite					F <10%; P/(A+P) = 0.35 to 0.65	Le Maitre (2002)
				Andesitoid				andesite					Q <20% or F = <10%; P/(A+P) = 0.65 to 1.0; typically M' 15 to 35	Le Maitre (2002)
				Basaltoid				basalt					Q <20% or F = <10%; P/(A+P) = 0.65 to 1.0; typically M' >35	Le Maitre (2002)
				Phonolitoid				phonolite					F 10 to 60%; P/(A+P) = <0.0 to 0.1	Le Maitre (2002)
								tephritic phonolite					F 10 to 60%; P/(A+P) = 0.1 to 0.5	Le Maitre (2002)
				Tephritoid				tephrite					F 10 to 60%; P/(A+P) = 0.9 to 1.0; modal olivine <10%	Le Maitre (2002)
								phonolitic tephrite					F 10 to 60%; P/(A+P) = 0.5 to 0.9; modal olivine <10%	Le Maitre (2002)
								basanite					F 10 to 60%; P/(A+P) = 0.9 to 1.0; modal olivine >10%	Le Maitre (2002)
								phonolitic basanite					F 10 to 60%; P/(A+P) = 0.5 to 0.9; modal olivine >10%	Le Maitre (2002)
				Foiditoid				phonolitic foidite					F 60 to 90%; P/(A+P) = 0.0 to 0.5	Le Maitre (2002)
								tephritic foidite					F 60 to 90%; P/(A+P) = 0.5 to 1.0; modal olivine <10%	Le Maitre (2002)
								basanitic foidite					F 60 to 90%; P/(A+P) = 0.5 to 1.0; modal olivine >10%	Le Maitre (2002)
								foidite					F >90%	Le Maitre (2002)
				Komatitoid†				komatiite					Ultramafic (M' >90); typically associated with spinifex and related textures (olivine, pyroxene); Table 6	Le Maitre (2002); Arndt (2008)
				Melilitoid				melilitite					Mel >10%; Ol <10%; Cpx <90%	Le Maitre (2002)
								olivine melilitite					Mel 10 to 90%; Ol 10 to 90%; Cpx <80%	Le Maitre (2002)
								mellilite-bearing volcanic rock					Mel <10%; Ol 0 to 90%; Cpx 0 to 100%	Le Maitre (2002)
		Geochemical		TAM‡	boninite‡								High-Mg rocks: type of andesite: SiO_2 52 to 63%; MgO >8%; TiO_2 <0.5%; low alkalis	Le Maitre (2002)
					komatiites‡				komatiite				High-Mg rocks: SiO_2 30 to 52%; $Na_2O + K_2O$ <2; MgO 18 to 32%; TiO_2 <1%; typically associated with spinifex and related textures (olivine, pyroxene); Table 6	Le Maitre (2002)
									basaltic komatiite				High-Mg rocks: member of komatiitic series; MgO 5 to 15%; typically with spinifex and related textures	Le Maitre (2002)
					meimechite‡								High-Mg rocks: SiO_2 30 to 52%; $Na_2O + K_2O$ <2; MgO 18 to 32%; TiO_2 >1%	Le Maitre (2002)
					picrite‡								High-Mg rocks: SiO_2 30 to 52%; $Na_2O + K_2O$ <3%; MgO 12 to 18%	Le Maitre (2002)
					pre-TAS‡	melilitites‡				melilitite			$K_2O < Na_2O$; no kalsilite; *cs* > 10%; modal olivine <10%	Le Maitre (2002)
										olivine melilitite			$K_2O < Na_2O$; no kalsilite; *cs* > 10%; modal olivine >10%	Le Maitre (2002)
										potassic melilitite			$K_2O > Na_2O$; K_2O > 2%; *cs* > 10%; modal olivine <10%	Le Maitre (2002)
										potassic olivine melilitite			$K_2O > Na_2O$; K_2O > 2%; *cs* > 10%; modal olivine >10%	Le Maitre (2002)
						nephelinite‡							*ne* >20%	Le Maitre (2002)
						melanephelinite‡							*ne* <20% and *ab*, if present, is <5%	Le Maitre (2002)
						TAS‡	andesites				andesite		SiO_2 57 to 63%; $Na_2O + K_2O$ <7%	Le Maitre (2002)
											trachyandesites	trachyandesite	SiO_2 53 to 63%; $Na_2O + K_2O$ 5.9 to 11.7%	Le Maitre (2002)
												benmoreite	SiO_2 53 to 63%; $Na_2O + K_2O$ 5.9 to 11.7%; $Na_2O - 2.0 \geq K_2O$	Le Maitre (2002)
												latite	SiO_2 53 to 63%; $Na_2O + K_2O$ 5.9 to 11.7%; $Na_2O - 2.0 < K_2O$	Le Maitre (2002)
											basaltic andesite		SiO_2 52 to 57%; $Na_2O + K_2O$ <5.9%	Le Maitre (2002)
											basaltic trachyandesites	basaltic trachyandesite	SiO_2 49.4 to 57%; $Na_2O + K_2O$ 5.0 to 9.3%	Le Maitre (2002)
												mugearite	SiO_2 49.4 to 57%; $Na_2O + K_2O$ 5.0 to 9.3%; $Na_2O - 2.0 \geq K_2O$	Le Maitre (2002)
												shoshonite	SiO_2 49.4 to 57%; $Na_2O + K_2O$ 5.0 to 9.3%; $Na_2O - 2.0 < K_2O$	Le Maitre (2002)
							basalts				basalt		SiO_2 45 to 52%; $Na_2O + K_2O$ <5%	Le Maitre (2002)
											trachybasalts	trachybasalt	SiO_2 45 to 52%; $Na_2O + K_2O$ 5.0 to 7.3%	Le Maitre (2002)
												hawaiite	SiO_2 45 to 52%; $Na_2O + K_2O$ 5.0 to 7.3%; $Na_2O - 2.0 \geq K_2O$	Le Maitre (2002)
												potassic trachybasalt	SiO_2 45 to 52%; $Na_2O + K_2O$ 5.0 to 7.3%; $Na_2O - 2.0 < K_2O$	Le Maitre (2002)
											picrobasalt		SiO_2 41 to 45%; $Na_2O + K_2O$ <3%	Le Maitre (2002)
											alkali basalt		SiO_2 45 to 48.5%; $Na_2O + K_2O$ 2.2 to 5.0%; *ne* in CIPW norm	Le Maitre (2002)
											subalkali basalt		SiO_2 45 to 52%; $Na_2O + K_2O$ 1.4 to 5.0%; no *ne* in CIPW norm	Le Maitre (2002)
							basanites‡				basanite		SiO_2 41 to 49.4%; $Na_2O + K_2O$ 3.0 to 9.4%; *ol* >10%	Le Maitre (2002)
											phonolitic basanite		SiO_2 45 to 53%; $Na_2O + K_2O$ 7.3 to 11.5%; *ol* >10%	Le Maitre (2002)
							dacites				dacite		SiO_2 63 to 77%; $Na_2O + K_2O$ <8.0%	Le Maitre (2002)
											trachydacite		SiO_2 57.6 to 69%; $Na_2O + K_2O$ 7.0 to 13%; *q* >20%	Le Maitre (2002)
							foidite‡						SiO_2 35 to 52.5%; $Na_2O + K_2O$ <15%; -rock name utilizes main feldspathoid in lieu of "foid" (e.g., nephelinite)	Le Maitre (2002)
							phonolites				phonolite		SiO_2 ~49 to ~61%; $Na_2O + K_2O$ >11.7%	Le Maitre (2002)
											tephritic phonolite		SiO_2 48.4 to 57.6%; $Na_2O + K_2O$ 9.3 to 14.0%	Le Maitre (2002)
											peralkaline phonolite		SiO_2 ~49 to ~61%; $Na_2O + K_2O$ >11.7%; $Al_2O_3 < (Na_2O + K_2O)$	Le Maitre (2002)
							rhyolites				rhyolite		SiO_2 69.0 to >77%; $Na_2O + K_2O$ <13%	Le Maitre (2002)
											comenditic rhyolite		SiO_2 69.0 to >77%; $Na_2O + K_2O$ <13%; Al_2O_3 > 1.33 FeO + 4.4	Le Maitre (2002)
											pantelleritic rhyolite		SiO_2 69.0 to >77%; $Na_2O + K_2O$ <13%; Al_2O_3 < 1.33 FeO + 4.4	Le Maitre (2002)
											peralkaline rhyolite		SiO_2 69.0 to >77%; $Na_2O + K_2O$ <13%; $Al_2O_3 < (Na_2O + K_2O)$	Le Maitre (2002)
							tephrites‡				tephrite		SiO_2 41 to 49.4%; $Na_2O + K_2O$ 3.0 to 9.4%; *ol* <10%	Le Maitre (2002)
											phonolitic tephrite		SiO_2 45 to 53%; $Na_2O + K_2O$ 7.3 to 11.5%	Le Maitre (2002)
							trachytes				trachyte		SiO_2 57.6 to 69.0%; $Na_2O + K_2O$ 7.0 to 13%; *q* <20%;	Le Maitre (2002)
											comenditic trachyte		SiO_2 57.6 to 69.0%; $Na_2O + K_2O$ 7.0 to 13%; *q* <20%; Al_2O_3 > 1.33 FeO + 4.4	Le Maitre (2002)
											pantelleritic trachyte		SiO_2 57.6 to 69.0%; $Na_2O + K_2O$ 7.0 to 13%; *q* <20%; Al_2O_3 < 1.33 FeO + 4.4	Le Maitre (2002)
											peralkaline trachyte		SiO_2 57.6 to 69.0%; $Na_2O + K_2O$ 7.0 to 13%; *q* <20%; $Al_2O_3 < (Na_2O + K_2O)$	Le Maitre (2002)
+ Pyroclastic deposits	Particle size ranges	ash < 2 mm; lapilli 2 to 64 mm; blocks and bombs >64 mm												
	Deposit types	tuff											pyroclastic material >75%, of which ash is >75%	Le Maitre (2002); Fisher (1966)
		lapilli-tuff											pyroclastic material >75%, of which blocks + bombs are <25%, and ash and lapilli are each <75%	Le Maitre (2002); Fisher (1966)
		lapillistone											pyroclastic material >75%, of which lapilli are >75%	Le Maitre (2002); Fisher (1966)
		tuff-breccia											pyroclastic material >75%, of which blocks + bombs are 25 to 75%	Le Maitre (2002); Fisher (1966)
		pyroclastic breccia											pyroclastic material >75%, of which blocks are >75%	Le Maitre (2002); Fisher (1966)
		agglomerate											pyroclastic material >75%, of which bombs are >75%	Le Maitre (2002); Fisher (1966)

* Ultramafic: M' = >90; Mafic: M' = 35 to 90; Intermediate: M' = 15 to 35; Felsic: M' = <15
See also general field characteristics, Table 6.

† Term invoked to create parallelism with other rock classes in this column.

‡ Before using the TAS classification, check the following:
a) test the TAM classification – if applicable to the geochemical results, TAS is not used;
b) some rock types fall within fields F and U1, which explains the dashed line in Figure 13. TAS does not apply if *ne* >20% or if *ne* <20% and *ab*, if present, is <5%;
c) if the "Main Criteria" for melilitites are met, the TAS classification is inapplicable

^ Abbreviations:
M = percentage (by volume) of mafic & related minerals (e.g., olivine, pyroxene, amphibole, mica, opaque minerals, accessory minerals (e.g., zircon, apatite, titanite), epidote, allanite, garnet, melilite, monticellite, primary carbonate)
M' = colour index = percentage (by volume) of mafic (i.e., dark coloured, ferromagnesian) minerals only (e.g., olivine, pyroxene, some amphiboles, etc.)
QAPF: Q = quartz; A = alkali feldspar and albitic plagioclase (An_0 to An_5); P = plagioclase and scapolite; F = foids = feldspathoids
OGS = Ontario Geological Survey
IUGS = International Union of Geological Sciences
TAM = Total Alkali Magnesium (Le Bas 2000)
TAS = Total Alkali – Silica (Le Bas et al. 1986)
Mel = modal melilite
Ol = modal olivine
Cpx = modal clinopyroxene

CIPW = Cross, Iddings, Pirsson and Washington norm
ne = normative nepheline
ol = normative olivine
cs = normative dicalcium silicate (larnite)
$q = Q/(Q + or + ab + an) * 100$
Q = normative quartz
or = normative orthoclase
ab = normative albite

Table 9. Volcanic rocks: pick lists.

Level	Colour Index	Mineral Mode	TAM (pre-TAS)	pre-TAS	TAS
Level 1	Volcanic Rocks Pick Lists				
Level 2	Lava Flows				
Level 3	unsubdivided				
Level 4	Colour Index	Mineral Mode	Geochemistry		
			TAM (pre-TAS)	pre-TAS	TAS
Level 5	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided
	ultramafic	rhyolitoid	boninite	melilitites	andesites
	mafic to ultramafic	dacitoid	komatiites	nephelinite	basalts
	mafic	trachytoid	meimechite	melanephelinite	basanites
	intermediate to mafic	andesitoid	picrite		dacites
	intermediate	basaltoid			foidite
	felsic to intermediate	phonolitoid			phonolites
	felsic	tephritoid			rhyolites
		foiditoid			tephrites
		komatitoid			trachytes
		melilitoid			
Level 6		unsubdivided	unsubdivided	unsubdivided	unsubdivided
		rhyolite	komatiite	melilitite	andesite
		alkali-feldspar rhyolite	basaltic komatiite	olivine melilitite	trachyandesites
		dacite		potassic melilitite	basaltic andesite
		trachyte		potassic olivine melilitite	basaltic trachyandesites
		quartz trachyte			basalt
		alkali-feldspar trachyte			trachybasalts
		quartz alkali-feldspar trachyte			picrobasalt
		foid-bearing trachyte			alkali basalt
		foid-bearing alkali-feldspar trachyte			subalkali basalt
		latite			basanite
		quartz latite			phonolitic basanite
		foid-bearing latite			dacite
		andesite			trachydacite
		basalt			phonolite
		phonolite			tephritic phonolite
		tephritic phonolite			peralkaline phonolite
		tephrite			rhyolite
		phonolitic tephrite			comenditic rhyolite
		basanite			pantelleritic rhyolite
		phonolitic basanite			peralkaline rhyolite
		phonolitic foidite			tephrite
		tephritic foidite			phonolitic tephrite
		basanitic foidite			trachyte
		foidite			comenditic trachyte
		komatiite			pantelleritic trachyte
		melilitite			peralkaline trachyte
		olivine melilitite			
		melilite-bearing volcanic rock			
Level 7					unsubdivided
					trachyandesite
					benmoreite
					latite
					basaltic trachyandesite
					mugearite
					shoshonite
					trachybasalt
					hawaiite
					potassic trachybasalt

Level	Colour Index	Mineral Mode	TAM (pre-TAS)	pre-TAS	TAS
Level 2	Pyroclastic Deposits				
Level 3	unsubdivided				
	tuff				
	lithic tuff				
	crystal tuff				
	vitric tuff				
	lapilli-tuff				
	lapillistone				
	tuff-breccia				
	pyroclastic breccia				
	agglomerate				
Level 4	Colour Index	Mineral Mode	Geochemistry		
			TAM (pre-TAS)	pre-TAS	TAS
Level 5	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided
	ultramafic	rhyolitoid	boninite	melilitites	andesites
	mafic to ultramafic	dacitoid	komatiites	nephelinite	basalts
	mafic	trachytoid	meimechite	melanephelinite	basanites
	intermediate to mafic	andesitoid	picrite		dacites
	intermediate	basaltoid			foidite
	felsic to intermediate	phonolitoid			phonolites
	felsic	tephritoid			rhyolites
		foiditoid			tephrites
		komatitoid			trachytes
		melilitoid			
Level 6		unsubdivided	unsubdivided	unsubdivided	unsubdivided
		rhyolite	komatiite	melilitite	andesite
		alkali-feldspar rhyolite	basaltic komatiite	olivine melilitite	trachyandesites
		dacite		potassic melilitite	basaltic andesite
		trachyte		potassic olivine melilitite	basaltic trachyandesites
		quartz trachyte			basalt
		alkali-feldspar trachyte			trachybasalts
		quartz alkali-feldspar trachyte			picrobasalt
		foid-bearing trachyte			alkali basalt
		foid-bearing alkali-feldspar trachyte			subalkali basalt
		latite			basanite
		quartz latite			phonolitic basanite
		foid-bearing latite			dacite
		andesite			trachydacite
		basalt			phonolite
		phonolite			tephritic phonolite
		tephritic phonolite			peralkaline phonolite
		tephrite			rhyolite
		phonolitic tephrite			comenditic rhyolite
		basanite			pantelleritic rhyolite
		phonolitic basanite			peralkaline rhyolite
		phonolitic foidite			tephrite
		tephritic foidite			phonolitic tephrite
		basanitic foidite			trachyte
		foidite			comenditic trachyte
		komatiite			pantelleritic trachyte
		melilitite			peralkaline trachyte
		olivine melilitite			
		melilite-bearing volcanic rock			
Level 7					unsubdivided
					trachyandesite
					benmoreite
					latite
					basaltic trachyandesite
					mugearite
					shoshonite
					trachybasalt
					hawaiite
					potassic trachybasalt

Table 15. Sedimentary rocks: classification.

Level 1	Sedimentary Rocks Classification — Rationale / References			
Reference	Soller (2004a)	Soller (2004a); Volcaniclastic: Le Maitre (2002), Fisher (1966)	sandstone/claystone/siltstone: Soller (2004a); conglomerate: Soller (2004a)	sandstone: *modified after* Pettijohn, Potter and Siever (1972)† and Williams, Turner and Gilbert (1982); *modified after* Soller (2004a)
	Fig. 18	Fig. 19	Fig. 20	Fig. 21
Level 2	Level 3 *	Level 4	Level 5	
Terrigenous-clastic Sedimentary Rock	Mudrock	mudstone	claystone sandy claystone siltstone clayey siltstone clayey sandy siltstone sandy siltstone	
		sandy mudstone slightly conglomeratic sandy mudstone slightly conglomeratic mudstone conglomeratic mudstone tuffaceous mudstone ‡		
			Fig. 20	
	Sandy Rock	sandstone	clayey sandstone clayey silty sandstone silty sandstone orthosandstone	arenite feldspathic arenite subfeldspathic arenite lithic arenite sublithic arenite quartz arenite wacke feldspathic wacke lithic wacke quartz wacke
		muddy sandstone slightly conglomeratic sandstone slightly conglomeratic muddy sandstone conglomeratic muddy sandstone conglomeratic sandstone tuffaceous sandstone ‡		
			Fig. 22	
	Conglomeratic Rock	conglomerate	granule-rich conglomerate pebbly conglomerate cobbly conglomerate bouldery conglomerate	
		sandy conglomerate muddy sandy conglomerate muddy conglomerate tuffaceous conglomerate ‡ tuffaceous breccia ‡		

Reference	Soller (2004a)	Soller (2004a)	Soller (2004a)
		Fig. 23	Fig. 24
Level 2	Level 3 *	Level 4	Level 5
Chemical Sedimentary Rock	Carbonate Rock	calcitic rock	limestone impure limestone impure dolomitic limestone dolomitic limestone
		dolomitic rock	dolostone impure dolostone impure calcareous dolostone calcareous dolostone
	Siliceous Rock	chert jasper siliceous sinter	
	Ironstone^	carbonate ironstone silicate ironstone oxide ironstone sulphide ironstone	
	Sulphate rock	barite rock	

* Particle sizes: **mud** <0.0625 mm (clay <0.004 mm; silt 0.004 to 0.0625 mm)
sand 0.0625 to 2.0 mm (very fine 0.0625 to 0.125 mm; fine 0.125 to 0.25 mm; medium 0.25 to 0.5 mm; coarse 0.5 to 1 mm; very coarse 1 to 2 mm)
gravel >2.0 mm (granule 2 to 4 mm; pebble 4 to 64 mm; cobble 64 to 256 mm; boulder >256 mm)

† Pettijohn, Potter and Siever (1972) system to be modified by the use of mud-size particles as <0.0625 mm

^ Iron minerals (e.g., siderite, greenalite, magnetite, pyrite):
≥50%: use "ironstone" as a rock name (e.g., carbonate ironstone);
from 10 to <50%: use "ferruginous" as a modifier (e.g., ferruginous sandstone)

‡ For tuffaceous mudstone, pyroclastic material is 25 to 75%;
For tuffaceous sandstone, pyroclastic material is 25 to 75%;
For tuffaceous conglomerate, pyroclastic material is 25 to 75%;
For tuffaceous breccia, pyroclastic material is 25 to 75%

Table 16. Sedimentary rocks: pick lists.

Level 1	Sedimentary Rocks Pick Lists						
Level 2	Terrigenous-clastic Sedimentary Rock			Chemical Sedimentary Rock			
Level 3	Mudrock	Sandy Rock	Conglomeratic Rock	Carbonate Rock	Siliceous Rock	Ironstone	Sulphate Rock
Level 4	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided
	mudstone	sandstone	conglomerate	calcitic rock	chert	carbonate ironstone	barite rock
	sandy mudstone	muddy sandstone	muddy conglomerate	dolomitic rock	jasper	silicate ironstone	
	slightly conglomeratic sandy mudstone	slightly conglomeratic muddy sandstone	muddy sandy conglomerate		siliceous sinter	oxide ironstone	
	slightly conglomeratic mudstone	slightly conglomeratic sandstone	sandy conglomerate			sulphide ironstone	
	conglomeratic mudstone	conglomeratic sandstone	tuffaceous conglomerate				
	tuffaceous mudstone	conglomeratic muddy sandstone	tuffaceous breccia				
		tuffaceous sandstone					
Level 5	claystone	clayey sandstone	granule-rich conglomerate	limestone			
	sandy claystone	clayey silty sandstone	pebbly conglomerate	impure limestone			
	siltstone	silty sandstone	cobbly conglomerate	impure dolomitic limestone			
	clayey siltstone	orthosandstone	bouldery conglomerate	dolomitic limestone			
	clayey sandy siltstone	arenite		dolostone			
	sandy siltstone	feldspathic arenite		impure dolostone			
		subfeldspathic arenite		impure calcareous dolostone			
		lithic arenite		calcareous dolostone			
		sublithic arenite					
		quartz arenite					
		wacke					
		feldspathic wacke					
		lithic wacke					
		quartz wacke					

Table 23. Metamorphic rocks: classification.

Level 1	Metamorphic Rocks Classification — Rationale / References			
Reference	*modified from* Fettes and Desmons (2007), Soller (2004b); OGS	*modified from* Sawyer (2008), Fettes and Desmons (2007), Soller (2004b); OGS	*modified from* Fettes and Desmons (2007); OGS	*modified from* Fettes and Desmons (2007), Soller (2004b), Sawyer (2008); OGS
Level 2	**Level 3**	**Level 4**	**Level 5**	**Essential Characteristics / Comments**
Structural Basis	Schist	unsubdivided		-rock with schistose structure (schistosity that is well developed, either uniformly or in zones – rock splits on scale of 1 cm or less)
		ultramafic schist	phyllite	-colour index >90
		mafic schist	slate	-colour index 35 to 90
		intermediate schist		-colour index 15 to 35
		felsic schist		-colour index <15
	Gneiss	unsubdivided		-rock with gneissose structure (schistosity either poorly developed throughout the rock or in zones such that the rock splits on a scale of >1 cm); commonly with mineralogic or lithologic layering -colour index: ultramafic >90; mafic 35 to 90; intermediate 15 to 35; felsic <15
		ultramafic gneiss mafic gneiss intermediate gneiss felsic gneiss	unsubdivided	
			granular gneiss	-mylonitized diatexite; medium- to coarse-grained, annealed protomylonite
			irregular-layered gneiss	-annealed mesomylonite or folded ultramylonite; non-rectilinear layering
			lineated gneiss	-gneiss with a dominant linear fabric
			orthogneiss	-gneiss derived from an igneous rock
			paragneiss	-gneiss derived from a sedimentary rock
			porphyroclastic gneiss	-annealed protomylonite; fine grained with isolated large porphyroclasts
			straight gneiss	-annealed ultramylonite; well layered
	Granofels	unsubdivided		-rock with granofelsic structure: absence of schistosity such that mineral grains and aggregates of grains are equant, or if unequant, have a random orientation
		ultramafic granofels		-colour index >90
		mafic granofels		-colour index 35 to 90
		intermediate granofels		-colour index 15 to 35
		felsic granofels		-colour index <15
	Hornfels	unsubdivided		-contact metamorphic rock: hard; compact; any grain size; dominantly silicate and oxide minerals; jagged fractures; may retain some structural features from protolith
		ultramafic hornfels		-colour index >90
		mafic hornfels		-colour index 35 to 90
		intermediate hornfels		-colour index 15 to 35
		felsic hornfels		-colour index <15
	Metabreccia	unsubdivided		-metabreccia of undetermined origin
		block gneiss		-metabreccia with matrix exhibiting gneissose structure
		marble breccia		-metabreccia consisting (typically) of silicate rock fragments in marble (various proportions of calcite and/or dolomite)
		Fig. 27		
Compositional Basis	Mafic / Ultramafic Rocks	amphibolite	unsubdivided	-gneissose or granofelsic: green, brown or black amphibole (>30%) and plagioclase combined are ≥75%; amphibole ≥50% of total mafic minerals -may contain quartz, clinopyroxene, garnet, epidote-group minerals, biotite, titanite, scapolite
			ortho-amphibolite	-amphibolite derived from an igneous rock
			para-amphibolite	-amphibolite derived from a sedimentary rock
			feather amphibolite	-amphibolite with stellate or sheaflike groups of acicular amphibole on foliation planes
		eclogitoid	unsubdivided	-collective term for metamorphic rocks containing omphacite and garnet
			eclogite	-omphacite + garnet ≥75%, neither >75% individually; plagioclase free
			garnet omphacitite	-similar to eclogite except omphacite ≥75%
			omphacite garnetite	-similar to eclogite except garnet ≥75%
		serpentinite		>75% minerals of serpentine group
		Fig. 28		
	Metacarbonate Rocks	marble	unsubdivided	>50% carbonate minerals*; remainder is calc-silicate minerals[a] and impurities[†]
		pure marble	unsubdivided	>90% carbonate minerals*; remainder is calc-silicate minerals[a] and impurities[†]
			calcite marble	>90% carbonate minerals* of which calcite is >67%
			meso-carbonate marble	>90% carbonate minerals* of which calcite is 33 to 67%
			dolomite marble	>90% carbonate minerals* of which dolomite is >67%
		impure marble	unsubdivided	-carbonate minerals* 50 to 90%; remainder is calc-silicate minerals[a] and impurities[†]
			impure calcite marble	-carbonate minerals* 50 to 90% of which calcite is >67%
			impure meso-carbonate marble	-carbonate minerals* 50 to 90% of which calcite is 33 to 67%
			impure dolomite marble	-carbonate minerals* 50 to 90% of which dolomite is >67%
		carbonate-silicate rock	unsubdivided	-carbonate minerals* 10 to 50%; remainder is calc-silicate minerals[a] and impurities[†]
			calcitic carbonate-silicate rock	-carbonate minerals* 10 to 50% of which calcite is >67%
			meso-carbonate-silicate rock	-carbonate minerals* 10 to 50% of which calcite is 33 to 67%
			dolomitic carbonate-silicate rock	-carbonate minerals* 10 to 50% of which dolomite is >67%
		calc-silicate rock	unsubdivided	-calc-silicate minerals^ >45% and carbonate minerals* <10%; remainder is impurities[†]
			calcitic calc-silicate rock	-calc-silicate minerals^ >45% and carbonate minerals* <10% of which calcite is >67%
			meso-calc-silicate rock	-calc-silicate minerals^ >45% and carbonate minerals* <10% of which calcite is 33 to 67%
			dolomitic calc-silicate rock	-calc-silicate minerals^ >45% and carbonate minerals* <10% of which dolomite is >67%
		carbonate-bearing silicate rock	unsubdivided	-impurities[†] >45% and carbonate minerals* <10%; remainder is calc-silicate minerals^
			calcitic carbonate-bearing silicate rock	-impurities[†] >45% and carbonate minerals* <10% of which calcite is >67%
			meso-carbonate-bearing silicate rock	-impurities[†] >45% and carbonate minerals* <10% of which calcite is 33 to 67%
			dolomitic carbonate-bearing silicate rock	-impurities[†] >45% and carbonate minerals* <10% of which dolomite is >67%
	Meta-ironstone	unsubdivided		-iron minerals ≥50%; may be iron-rich oxide, pyroxene, silicate, or sulphide
		oxide meta-ironstone		-principal iron mineral is an oxide (e.g., magnetite, hematite)
		pyroxene meta-ironstone		-principal iron mineral is a pyroxene (e.g., ferrosilite) derived from a metamorphically upgraded carbonate (e.g., siderite)
		silicate meta-ironstone		-principal iron mineral is a silicate (e.g., amphibole, garnet)
		sulphide meta-ironstone		-principal iron mineral is a sulphide (e.g., pyrite, pyrrhotite)
		Fig. 29		
Migmatites	Metatexite	unsubdivided	<20% leucosome	-pre-partial-melting structures widely preserved in paleosome and possibly melanosome (residuum); neosome may be segregated into leucosome and melanosome
		patch metatexite	<20% leucosome; "lower" strain	-neosome occurs *in situ* as small, discrete patches
		dilation-structured metatexite	<20% leucosome	-domains of leucosome or neosome are controlled by dilational structures (formed during deformation)
		net-structured metatexite	<20% leucosome	-leucosome largely as veins forming a net-like pattern enclosing paleosome or residuum
		stromatic metatexite	<20% leucosome; "higher" strain	-neosome (leucosome and melanosome) or just leucosome occurs as laterally continuous parallel layers along compositional layering or foliation
	Diatexite	unsubdivided	>20% leucosome	-darker and lighter parts form schlieren and nebulitic structures, which merge into one another
		nebulite diatexite	>20% leucosome; "lower" strain	-neosome is diffuse and difficult to differentiate from paleosome
		schollen diatexite	>20% leucosome	-inclusions (as schollen or rafts) of paleosome (blocky to rounded or elongate) or rarely residuum
		schlieric diatexite	>20% leucosome	-characterized by schlieren (few schollen)
		diatexite migmatite	>20% leucosome; "higher" strain	-neosome dominant, melt pervasively distributed throughout
Metasomatic Rocks	Boundary	unsubdivided		-forms at the contact between any 2 rock types
		bimetasomatic rock		-involves replacement of (reaction between) both rocks from 2-way diffusion of different components by migration of stationary pore solutions
		fenite		-occurs as (high temperature) zoned aureoles around alkalic igneous complexes on a metre to kilometre scale: can involve replacement of a wide variety of country rock types -some fenites may be associated with an intrusive contact -typically consists of alkali feldspar, sodic amphibole, sodic pyroxene; may have nepheline, calcite, biotite/phlogopite; typical accessories are titanite, apatite
		rodingite		-typically involves replacement of dikes or inclusions of basic rocks within serpentinized ultramafic rocks; may also replace mafic/basic rocks associated with ultramafic rocks -consists mainly of grossular-andradite garnet and calcic pyroxene; typical accessories are vesuvianite, epidote, scapolite -may contain Fe and Au mineralization
	Contact	unsubdivided		-forms at or near the contact between a magmatic rock and another rock (country rock)
		endocontact zone		-involves replacement of the magmatic rock
		exocontact zone		-involves replacement of the country rock
		greisen	unsubdivided	-commonly associated with high-level, late-orogenic leucogranitoids; replaces granitoid and/or country rocks and may be zoned -consists of quartz and white mica commonly with topaz, fluorite, tourmaline; may contain minor amazonite, orthoclase, andalusite, diaspore -may host Be, W, Mo, Sn, Ta mineralization
			endogreisen	-replaces the granitoid rock
			exogreisen	-replaces the country rock
		skarn	unsubdivided	-forms at the contact between a magmatic rock (or other silicate rock) and typically a carbonate rock -consists mainly of Ca-, Mg-, Fe-, Mn-silicates, which are free from or low in H_2O -may host economic mineralization as a "skarn deposit"
			endoskarn	-forms at the contact, within the magmatic rock (or other silicate rock)
			exoskarn	-forms at or near the contact, within the country rock
			calc-skarn	-high- to medium-temperature skarn that forms at the contact typically in calcium carbonate rocks -consists mainly of granditic garnet, diopside, wollastonite, Mn-rich pyroxenoids -may host Fe, base metal, Cu, W, Mo, Be, B, U, REE mineralization
			magnesian skarn	-high-temperature skarn that forms at the contact typically in magnesian or calc-magnesian carbonate rocks -typically contains forsterite, diopside, spinel, periclase, clinohumite, phlogopite, pargasite -may host Fe, base metal, Cu, Au, Fe-Mg-borates, phlogopite mineralization

* specifically calcite, dolomite, and/or aragonite
[a] includes calc-silicate minerals
^ main calc-silicate minerals include: calcic garnet (ugrandite), calcic plagioclase, calcic scapolite, diopside-hedenbergite, epidote group minerals, grossular, johannsenite, prehnite, pumpellyite, titanite, vesuvianite, wollastonite
[†] includes graphite, magnetite, apatite, and all other silicate minerals

Table 24. Metamorphic rocks: pick lists.

Level 1	Metamorphic Rocks Pick Lists											
Level 2	Structural Basis					Compositional Basis			Migmatites		Metasomatic Rocks	
Level 3	Schist	Gneiss	Granofels	Hornfels	Metabreccia	Mafic / Ultramafic Rock	Metacarbonate Rock	Meta-ironstone	Metatexite	Diatexite	Boundary	Contact
Level 4	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided	unsubdivided
	ultramafic schist	ultramafic gneiss	ultramafic granofels	ultramafic hornfels	block gneiss	amphibolite	marble	oxide meta-ironstone	patch metatexite	nebulite diatexite	bimetasomatic rock	endocontact zone
	mafic schist	mafic gneiss	mafic granofels	mafic hornfels	marble breccia	eclogite	pure marble	pyroxene meta-ironstone	dilation-structured metatexite	schollen diatexite	fenite	exocontact zone
	intermediate schist	intermediate gneiss	intermediate granofels	intermediate hornfels		serpentinite	impure marble	silicate meta-ironstone	net-structured metatexite	schlieric diatexite	rodingite	greisen
	felsic schist	felsic gneiss	felsic granofels	felsic hornfels			carbonate-silicate rock	sulphide meta-ironstone	stromatic metatexite	diatexite migmatite		skarn
							calc-silicate rock					
							carbonate-bearing silicate rock					
Level 5	phyllite	granular gneiss				ortho-amphibolite	calcite marble					endogreisen
	slate	irregular-layered gneiss				para-amphibolite	meso-carbonate marble					exogreisen
		lineated gneiss				feather amphibolite	dolomite marble					endoskarn
		orthogneiss				garnet omphacitite	impure calcite marble					exoskarn
		paragneiss				omphacite garnetite	impure meso-carbonate marble					calc-skarn
		porphyroclastic gneiss					impure dolomite marble					magnesian skarn
		straight gneiss					calcitic carbonate-silicate rock					
							meso-carbonate-silicate rock					
							dolomitic carbonate-silicate rock					
							calcitic calc-silicate rock					
							meso-calc-silicate rock					
							dolomitic calc-silicate rock					
							calcitic carbonate-bearing silicate rock					
							meso-carbonate-bearing silicate rock					
							dolomitic carbonate-bearing silicate rock					

Table 31. Other rocks—fault rocks and impactite rocks: classifications.

Level 1	Other Rocks Classifications — Rationale / References			
Reference	Fettes and Desmons (2007)	Fettes and Desmons (2007); OGS	Fettes and Desmons (2007); OGS	Fettes and Desmons (2007); OGS
Fig. 31				
Level 2	**Level 3**	**Level 4**	**Level 5**	**Essential Characteristics; Comments**
Fault rocks	Cataclasite	unsubdivided		-fault rock with poorly developed or no schistosity; typically contains angular lithic fragments and porphyroclasts; matrix is aphanitic (particle size <0.1 mm)
		fault breccia		-relatively medium- to coarse-grained cataclasite with ≥30% visible fragments (>0.1 mm); cohesive and clay-poor incohesive varieties
		fault gouge		-fine- to ultrafine-grained cataclasite with <30% visible fragments (>0.1 mm); clay rich and generally incohesive; foliated or unfoliated
		fault pseudotachylite		-vitreous to flinty looking rock; occurs as planar veins, injection veins or matrix to breccias in dilational fractures in fault zones; cohesive
		protocataclasite		-cataclasite: matrix forms <50% of rock volume; cohesive or incohesive
		mesocataclasite		-cataclasite: matrix forms 50 to 90% of rock volume; cohesive or incohesive
		ultracataclasite		-cataclasite: flinty; matrix forms >90% of rock volume; cohesive or incohesive
	Mylonite	unsubdivided		-fault rock with well-developed schistosity, formed by tectonic grain-size reduction associated with crystal plasticity; typically contains rounded porphyroclasts and lithic fragments; commonly displays mineral or stretching lineation; indistinguishable in field from cohesive and foliated cataclasite
		protomylonite		-mylonite: <50% of the rock volume has undergone grain-size reduction
		mesomylonite		-mylonite: 50 to 90% of the rock volume has undergone grain-size reduction
		ultramylonite		-mylonite: flinty; >90% of the rock volume has undergone grain-size reduction
		phyllonite		-phyllosilicate-rich mylonite with lustrous sheen
		augen mylonite		-mylonite with augens (lensoid grains or grain aggregates, produced by deformation, around which foliation bends)
		blastomylonite		-significant grain growth related to or following mylonitization
Reference	*modified from* Fettes and Desmons (2007); OGS	OGS; *modified from* Fettes and Desmons (2007)	OGS; *modified from* Fettes and Desmons (2007)	OGS; *modified from* Fettes and Desmons (2007)
Fig. 33				
Impactite Rocks	Impact Pseudotachylite	unsubdivided		-aphanitic to fine-grained matrix with few to numerous clasts; vein-like to irregularly shaped bodies; matrix considered to result from frictional melting and/or fluidized particulate material
		clast-free impact pseudotachylite		-impact pseudotachylite; essentially no macroscopic clasts
		clast-poor impact pseudotachylite		-impact pseudotachylite; <25% macroscopic clasts
		clast-rich impact pseudotachylite		-impact pseudotachylite; >25% macroscopic clasts
	Impact Breccia	unsubdivided		-impact-generated breccias with a particulate (i.e., non-melt) matrix containing unshocked and shock-metamorphosed lithic and crystal clasts with or without impact melt clasts
		lithic impact breccia	unsubdivided	-impact breccia (typically heterolithic) with no melt particles
			monolithic breccia	-lithic impact breccia containing clasts of essentially 1 rock type; clasts may or may not have a wide range in stages of shock metamorphism
			heterolithic breccia	-lithic impact breccia containing clasts of many rock types; clasts may or may not have a wide range in stages of shock metamorphism
		suevite	unsubdivided	-heterolithic impact breccia with lithic and mineral clasts in all stages of shock metamorphism and glassy and/or recrystallized impact melt particles
			tuff-like suevite	-suevite with particle size proportions same as tuff[1]
			lithic tuff-like suevite	-suevite with particle size proportions same as lithic tuff[1]
			crystal tuff-like suevite	-suevite with particle size proportions same as crystal tuff[1]
			vitric tuff-like suevite	-suevite with particle size proportions same as vitric tuff[1]
			lapilli-tuff-like suevite	-suevite with particle size proportions same as lapilli-tuff[1]
			lapillistone-like suevite	-suevite with particle size proportions same as lapillistone[1]
			tuff-breccia-like suevite	-suevite with particle size proportions same as tuff-breccia[1]
			pyroclastic breccia-like suevite	-suevite with particle size proportions same as pyroclastic breccia[1]
			agglomerate-like suevite	-suevite with particle size proportions same as agglomerate[1]
	Impact Melt Rock		unsubdivided	
			Felsic	
			Intermediate	
			Mafic	
			Ultramafic	
			Granitoid	
			Syenitoid	
			Dioritoid	
			Gabbroid	
		unsubdivided	Granite	-impact melt with crystalline, semihyaline or hyaline matrix: contains various amounts of clastic debris generally having a variety of stages of shock metamorphism
		clast-free impact melt rock	Granodiorite	-impact melt as above: essentially no macroscopic fragments
		clast-poor impact melt rock	Quartz diorite	-impact melt as above: macroscopic clasts from 1 to 25%
		clast-rich impact melt rock	Quartz monzodiorite	-impact melt as above: macroscopic clasts >25%
			Quartz monzogabbro	
			Quartz gabbro	
			Norite	
			Felsic norite	
			Mafic norite	
			Quartz-rich norite	
			Granophyre	
			Plagioclase-rich granophyre	

[1]Particle size ranges: ash-size <2 mm; lapilli-size 2 to 64 mm; block-size and bomb-size >64 mm

Particle size proportions:		
	tuff	ash-size material >75%
	crystal tuff	of ash-size particles – crystal and crystal fragments : rock fragments *and* crystal and crystal fragments : pumice and glass fragments each >1:1
	lithic tuff	of ash-size particles – rock fragments : crystal and crystal fragments *and* rock fragments : pumice and glass fragments each >1:1
	vitric tuff	of ash-size particles – pumice and glass fragments : crystal and crystal fragments *and* pumice and glass fragments : rock fragments each >1:1
	lapilli-tuff	block-size + bomb-size material <25%; ash-size and lapilli-size material each <75%
	lapillistone	lapilli-size material >75%
	tuff-breccia	block-size + bomb-size material 25 to 75%
	pyroclastic breccia	block-size material >75%
	agglomerate	bomb-size material >75%

Table 32. Other rocks—fault rocks and impactite rocks: pick lists.

Level 1	Other Rocks Pick Lists				
Level 2	Fault rocks		Impactite rocks		
Level 3	Cataclasite	Mylonite	Impact Pseudotachylite	Impact Breccia	Impact Melt Rock
Level 4	unsubdivided fault breccia fault gouge fault pseudotachylite protocataclasite mesocataclasite ultracataclasite	unsubdivided protomylonite mesomylonite ultramylonite phyllonite augen mylonite blastomylonite	unsubdivided clast-free impact pseudotachylite clast-poor impact pseudotachylite clast-rich impact pseudotachylite	unsubdivided lithic impact breccia suevite	unsubdivided clast-free impact melt clast-poor impact melt clast-rich impact melt
Level 5				unsubdivided monolithic breccia heterolithic breccia tuff-like suevite lithic tuff-like suevite crystal tuff-like suevite vitric tuff-like suevite lapilli-tuff-like suevite lapillistone-like suevite tuff-breccia-like suevite pyroclastic breccia-like suevite agglomerate-like suevite	

Table 36. Intrusive rocks: modifier pick lists.

Intrusive Rocks Modifier Pick Lists

1	2	3	4	5	6	7	8
Intrusive Rocks	Colour Index	Unsubdivided					
		Holomelanocratic					
		Melanocratic					
		Mesocratic					
		Leucocratic					
		Hololeucocratic					
	Colour	Fresh	*user specify*				
		Weathered	*user specify*				
	Form	Undetermined					
		Dike	Unzoned				
			Zoned				
		Sill	Unzoned				
			Zoned				
		Sheet	Unzoned				
			Zoned				
		Irregular	Unzoned				
			Zoned				
		Stock					
		Pluton					
		Batholith					
		Diatreme					
		Rheomorphic intrusion					
	Contact	Not observed					
		Relationship to country rock	Undetermined				
			Concordant				
			Discordant				
			Conformable				
			Disconformable				
		Character	Undetermined				
			Chilled	Gradational			
				Sharp			
			Unchilled	Gradational			
				Sharp			
	Rock Fabric	Megascale	Unfoliated				
			Slaty¨				
			Phyllitic˜				
			Schistose				
			Gneissose				
		Mesoscale	Unfoliated				
			Slaty¨				
			Phyllitic˜				
			Schistose				
			Gneissose				
	Structure	Flow layering					
		Flow alignment	Unsubdivided				
			Defined by	Inclusions			
				Minerals	Pyroxene	Unsubdivided	
						Clinopyroxene	
						Orthopyroxene	
						Other	
					Amphibole	Unsubdivided	
						Hornblende	
						Other	
					Biotite		
					Feldspar	Unsubdivided	
						K-feldspar	
						Plagioclase	
					Feldspathoid	Unsubdivided	
						Nepheline	
						Other	
			Development	Weak			
				Moderate			
				Strong			
		Primary layering	Type	Unsubdivided			
				Cross-stratification	Unsubdivided		
					Cross-bedding		
					Cross-lamination		
				Graded bedding			
				Igneous lamination			
				Phase			
				Rhythmic			
				Scour channel			
				Trough banding			
			Defined by	Colour	*user specify*		
				Inclusions			
				Texture			
				Minerals	Olivine	Unsubdivided	
						Fayalite	
						Forsterite	
					Pyroxene	Unsubdivided	
						Clinopyroxene	
						Orthopyroxene	
						Other	
					Amphibole	Unsubdivided	
						Hornblende	
						Other	
					Biotite		
					Feldspar	Unsubdivided	
						K-feldspar	
						Plagioclase	
					Feldspathoid	Unsubdivided	
						Nepheline	
						Other	
					Quartz		
					Carbonates	Calcite	
						Dolomite	
						Other	
					Spinel group	Chromite	
						Magnetite	
						Other	
			Development	Weak			
				Moderate			
				Strong			
		Platy flow structure					
		Intrusion Breccia	Spatial association	Contact breccia			
				Internal			
				Both contact & internal			
			Fragments (general)	Contacts with matrix	Undetermined		
					Sharp		
					Gradational		
					Diffuse		
					Reaction rims		
				Proportion of breccia	<5%		
					5 to 10%		
					10 to 25%		
					25 to 50%		
					>50%		
				Variety	Monolithic		
					Bi-lithic		
					Heterolithic		
			Fragment type 1	Size (typical)	Small		
					Medium		
					Large		
					Very large		
					Extremely large		
				Shape (roundness class)	Very angular		
					Angular		
					Subangular		
					Subrounded		
					Rounded		
					Well rounded		
				Consistency (size, shape)	Not uniform		
					Moderately uniform		
					Uniform		
				Abundance	<5%		
					5 to 10%		
					10 to 25%		
					25 to 50%		
					>50%		
				Igneous clasts	Unsubdivided		
					Intrusive	Fine grained	Felsic
							Intermediate
							Mafic
							Ultramafic
						Medium to coarse grained	Granitoid
							Syenitoid
							Dioritoid
							Gabbroid
							Ultramafic
							Anorthositic
							Foid-bearing rock
							Foidolite
						Pegmatitic	
						Other	
					Volcanic	Composition	Felsic
							Intermediate
							Mafic
							Ultramafic
						Lavas	Massive flow
							Pillowed flow
							Lava-related breccia
						Pyroclastic	Tuff
							Lapilli-tuff
							Lapillistone
							Tuff-breccia
							Pyroclastic breccia
							Agglomerate
				Sedimentary clasts	Unsubdivided		
					Terrigenous-clastic	Mudstone	
						Sandstone	
						Conglomerate	
						Tuffaceous mudstone	
						Tuffaceous sandstone	
						Tuffaceous conglomerate	
						Tuffaceous breccia	
					Chemical	Carbonate rocks	Unsubdivided
							Calcitic
							Dolomitic
						Chert	
						Ironstone	Unsubdivided
							Magnetite
							Hematite
							Siderite
					Volcanic		Sulphide
				Metamorphic clasts	Textural	Schist	
						Gneiss	
						Granofels	
						Hornfels	
					Migmatites	Unsubdivided	
						Metatexite	
						Diatexite	
					Compositional	Amphibolite	
						Calc-silicate rock	
						Carbonate-bearing silicate rock	
						Carbonate-silicate rock	
						Marble	
						Meta-ironstone	
						Eclogite	
						Serpentinite	
					Metasomatic	Fenite	
						Skarn	
					Other		
			Fragment type 2	(Lists as with Fragment type 1)			
			Fragment type 3	(Lists as with Fragment type 1)			
		Orbicule					
		Schliere					
		Inclusion	Unsubdivided				
			Autolith				
			Xenolith				
			Sulphide-bearing				
	Texture	Crystal size	Glassy				
			Aphanitic	Unsubdivided			
				Cryptocrystalline			
				Microcrystalline			
			Phaneritic	Very fine grained			
				Fine grained			
				Medium grained			
				Coarse grained			
				Very coarse grained			
				Extremely coarse grained			
			Pegmatitic	Unsubdivided			
				Zoned			
		Crystal form (overall)	Equigranular	Unsubdivided			
				Xenomorphic-granular			
				Hypidiomorphic-granular			
				Idiomorphic-granular			
			Inequigranular				
			Graphic				
			Perthitic				
			Various				
		Crystal settling / growth	Type	Cumulate			
				Orthocumulate			
				Mesocumulate			
				Adcumulate			
				Crescumulate			
				Spinifex texture	Unsubdivided		
					Acicular		
					Platy olivine		
					Random olivine		
				Dendritic			
			Minerals	Olivine	Unsubdivided		
					Fayalite		
					Forsterite		
				Pyroxene	Unsubdivided		
					Clinopyroxene		
					Orthopyroxene		
					Other		
				Amphibole	Unsubdivided		
					Hornblende		
					Other		
				Biotite			
				Feldspar	Unsubdivided		
					K-feldspar		
					Plagioclase		
				Feldspathoid	Nepheline		
					Other		
				Quartz			
				Carbonates	Calcite		
					Dolomite		
					Other		
				Spinel group	Chromite		
					Magnetite		
					Other		
		Aphyric					
		Groundmass	Key Mineral Modifiers+	Mineralogy	Hornblende		
					Biotite		
					Muscovite		
				Relative Abundance	Biotite < Hornblende		
					Hornblende < Biotite		
					Biotite < Muscovite		
					Muscovite < Biotite		
			Important mineralogy	Mineralogy	Apatite		
					Beryl		
					Columbite-tantalite		
					Cordierite		
					Corundum		
					Fluorite		
					Garnet	Unsubdivided	
						Almandine	
						Grossular	
					Lepidolite		
					Sillimanite		
					Spodumene		
					Sodalite		
					Topaz		
					Tourmaline		
					Zeolite		
		Megacrystic	Megacryst	Mineralogy	Olivine	Unsubdivided	
						Fayalite	
						Forsterite	
					Pyroxene	Unsubdivided	
						Clinopyroxene	
						Orthopyroxene	
						Other	
					Amphibole	Unsubdivided	
						Hornblende	
						Other	
					Biotite		
					Feldspar	Unsubdivided	
						K-feldspar	
						Plagioclase	
					Feldspathoid	Unsubdivided	
						Nepheline	
						Other	
					Quartz		
					Carbonates	Calcite	
						Dolomite	
						Other	
					Spinel group	Chromite	
						Magnetite	
						Other	
				Form	Anhedral		
					Subhedral		
					Euhedral		
				Habit	Acicular		
					Equant		
					Prismatic		
					Sheet		
					Tabular		
				Size	Fine grained		
					Medium grained		
					Coarse grained		
					Very coarse grained		
					Extremely coarse grained		
				Abundance	<5%		
					5 to 10%		
					10 to 25%		
					25 to 50%		
					>50%		
		Porphyritic	Phenocryst	Mineralogy*			
				Formº			
				Habitˆ			
				Size†			
				Abundance‡			
				Seriate			
			Glomerocryst	Mineralogy*			
				Formº			
				Habitˆ			
				Size†			
				Abundance‡			
			Rapakivi texture	Size†			
				Abundance‡			
		Poikilitic	Oikocryst	Mineralogy*			
				Formº			
				Habitˆ			
				Size†			
				Abundance‡			
		Xenocrystic	Xenocryst	Mineralogy*			
				Formº			
				Habitˆ			
				Size†			
				Abundance‡			
		Comb texture					
		Graphic					
		Ocellar					
		Ophitic					
		Stellate					
		Symplectic					
	Secondary Features	Cavities	Druse				
			Miarolitic				
			Vug				
	Miscellaneous	Metamorphism	Unmetamorphosed				
		Unit name	Unofficial	*user specify*			
		Stratigraphy	Group	*user specify*			
			Formation	*user specify*			

+ Key Mineral Modifiers: to be listed in increasing order of abundance (e.g., hornblende-biotite granite contains more biotite than hornblende)
* Mineralogy: same as for Texture / Megacrystic / Megacryst / Mineralogy
º Form: same as for Texture / Megacrystic / Megacryst / Form
ˆ Habit: same as for Texture / Megacrystic / Megacryst / Habit
† Size: same as for Texture / Megacrystic / Megacryst / Size
‡ Abundance: same as for Texture / Megacrystic / Megacryst / Abundance
¨ Having the texture of slate, i.e., an aphanitic rock with well-developed schistosity, average grain size <0.1 mm (excluding porphyroblasts) (Soller 2004b).
˜ Having the texture of phyllite, i.e., a fine-grained phaneritic rock, well-developed continuous schistosity, silvery sheen on cleavage surfaces, average grain size from 0.1 to 0.25 mm (excluding porphyroblasts) (Soller 2004b).

Table 39. Volcanic rocks—lava: modifier pick lists.

Volcanic Rocks—Lava: Modifier Pick Lists						
1	2	3	4	5	6	7
Volcanic Rocks						
Lavas	Colour	Fresh surface	*user specify*			
		Weathered surface	*user specify*			
	Form	Undetermined				
		Lava flow	Cross section	Incomplete		
				Complete		
			Components	Massive		
				Pillowed	Intact pillows	
					Pillow breccia	
					Pillow shape	Amoeboid
						Bun-shaped
						Mattress
						Re-entrant
					Pillow size	Very small
						Small
						Medium
						Large
						Very large
					Selvage	Thin
						Medium
						Thick
				Pillow like	Unsubdivided	
					Flow lobe	
					Toe	
					Lava tube	
				Aa type	Clinker	
					Basal clinker	
					Welded flow breccia	
					Accretionary lava ball	
				Block lava type		
				Pahoehoe type	Unsubdivided	
					Corded	
					Elephant-hide	
					Entrail	
					Festooned	
					Filamented	
					Sharkskin	
					Shelly	
					Slab	
				Komatiite type	Unsubdivided	
					Undifferentiated	Unsubdivided
						Chilled flow top
						Fractured flow top
						Polyhedral joints
						Cumulate layer
						Chilled flow bottom
					Differentiated	Unsubdivided
						Chilled flow top
						Fractured flow top
						Polyhedral joints
						Spinifex texture
						Olivine spinifex texture
						Pyroxene spinifex texture
						Foliated zone (primary)
						Knobby texture
						Cumulate layer
						Chilled flow bottom
				Breccia	Unsubdivided	
					Autobreccia	
					Hyaloclastite	Fine
						Granular
						Breccia
						Coarse Breccia
					Shape (roundness class)	Very angular
						Angular
						Subangular
						Subrounded
						Rounded
						Well rounded
				Lava ball		
				Peperite		
		Subvolcanic dike				
		Subvolcanic sill				
		Vent				
	Thickness	Undetermined				
		Very thin				
		Thin				
		Medium				
		Thick				
		Very thick				
	Contact	Not observed				
		Condordant	Unchilled			
			Chilled			
			Gradational			
			Sharp			
		Discordant	Unchilled			
			Chilled			
			Gradational			
			Sharp			
		Relationship undetermined	Unchilled			
			Chilled			
			Gradational			
			Sharp			
	Rock Fabric	Megascale	Unfoliated			
			Slaty¨			
			Phyllitic˜			
			Schistose			
			Gneissose			
		Mesoscale	Unfoliated			
			Slaty¨			
			Phyllitic˜			
			Schistose			
			Gneissose			
	Structure	Flow alignment	Unsubdivided			
			Defined by	Inclusions		
				Minerals	Pyroxene	Unsubdivided
						Clinopyroxene
						Orthopyroxene
						Other
					Amphibole	Unsubdivided
						Hornblende
						Other
					Biotite	
					Feldspar	Unsubdivided
						K-feldspar
						Plagioclase
					Feldspathoid	Unsubdivided
						Nepheline
						Other
			Development	Weak		
				Moderate		
				Strong		
		Flow layering	Unsubdivided			
			Defined by	Colour	*user specify*	
				Inclusions		
				Texture		
				Minerals	Olivine	Unsubdivided
						Fayalite
						Forsterite
					Pyroxene	Unsubdivided
						Clinopyroxene
						Orthopyroxene
						Other
					Amphibole	Unsubdivided
						Hornblende
						Other
					Biotite	
					Feldspar	Unsubdivided
						K-feldspar
						Plagioclase
					Feldspathoid	Unsubdivided
						Nepheline
						Other
					Quartz	
					Carbonates	Calcite
						Dolomite
						Other
					Spinel group	Chromite
						Magnetite
						Other
			Development	Weak		
				Moderate		
				Strong		
		Spherule	Spherulite			
			Variole			
		Vesicle	Type	Unsubdivided		
				Elongate		
				Equidimensional		
				Irregular		
				Pipe		
				Radial		
			Abundance	<5%		
				5 to 10%		
				10 to 25%		
				25 to 50%		
				>50%		
		Amygdule	Type	Unsubdivided		
				Elongate		
				Equidimensional		
				Irregular		
				Pipe		
				Radial		
			Abundance	<5%		
				5 to 10%		
				10 to 25%		
				25 to 50%		
				>50%		
			Secondary mineral(s)	Analcite		
				Calcite		
				Chlorite		
				Epidote		
				Prehnite		
				Quartz		
				Sulfide		
				Zeolite		
				Other		
		Inclusion	Unsubdivided			
			Autolith			
			Xenolith			
			Nodule			
			Sulphide-bearing			
	Texture	Crystal size	Glassy			
			Aphanitic	Cryptocrystalline		
				Microcrystalline		
			Phaneritic	Very fine grained		
				Fine grained		
				Medium grained		
				Coarse grained		
		Crystal form (overall)	Equigranular	Unsubdivided		
				Xenomorphic-granular		
				Hypidiomorphic-granular		
				Idiomorphic-granular		
			Inequigranular			
			Vari-textured			
		Crystal settling / growth	Type	Cumulate		
				Orthocumulate	Unsubdivided	
					Poikilitic	
				Mesocumulate		
				Adcumulate		
				Crescumulate		
				Spinifex texture	Unsubdivided	
					Acicular	
					Platy olivine	
					Random olivine	
				Dendritic		
			Minerals	Olivine	Unsubdivided	
					Fayalite	
					Forsterite	
				Pyroxene	Unsubdivided	
					Clinopyroxene	
					Orthopyroxene	
					Other	
				Amphibole	Unsubdivided	
					Hornblende	
					Other	
				Biotite		
				Feldspar	Unsubdivided	
					K-feldspar	
					Plagioclase	
				Feldspathoid	Unsubdivided	
					Nepheline	
					Other	
				Quartz		
				Carbonates	Calcite	
					Dolomite	
					Other	
				Spinel group	Chromite	
					Magnetite	
					Other	
		Aphyric				
		Porphyritic	Phenocryst	Mineralogy	Olivine	Unsubdivided
						Fayalite
						Forsterite
					Pyroxene	Unsubdivided
						Clinopyroxene
						Orthopyroxene
						Other
					Amphibole	Unsubdivided
						Hornblende
						Other
					Biotite	
					Feldspar	Unsubdivided
						K-feldspar
						Plagioclase
					Feldspathoid	Unsubdivided
						Nepheline
						Other
					Quartz	
					Carbonates	Calcite
						Dolomite
						Other
					Spinel group	Chromite
						Magnetite
						Other
				Form	Anhedral	
					Subhedral	
					Euhedral	
				Habit	Acicular	
					Equant	
					Prismatic	
					Sheet	
					Tabular	
				Size	Fine grained	
					Medium grained	
					Coarse grained	
					Very coarse grained	
				Abundance	<5%	
					5 to 10%	
					10 to 25%	
					25 to 50%	
					>50%	
				Seriate		
			Glomerocryst	* Mineralogy		
				º Form		
				ˆ Habit		
				† Size		
				‡ Abundance		
		Trachytic				
		Xenocrystic	Xenocryst	* Mineralogy		
				º Form		
				ˆ Habit		
				† Size		
				‡ Abundance		
	Secondary Features	Cavities	Druse	Unsubdivided		
				Lithophysa		
				Steam hole / vent		
			Miarolitic			
			Pillow voids / shelves			
			Vug			
	Miscellaneous	Metamorphism	Unmetamorphosed			
		Unit name	Unofficial	*user specify*		
		Stratigraphy	Group	*user specify*		
			Formation	*user specify*		

* Mineralogy: same as for Texture / Porphyritic / Phenocryst / Mineralogy
º Form: same as for Texture / Porphyritic / Phenocryst / Form
ˆ Habit: same as for Texture / Porphyritic / Phenocryst / Habit
† Size: same as for Texture / Porphyritic / Phenocryst / Size
‡ Abundance: same as for Texture / Porphyritic / Phenocryst / Abundance
¨ Having the texture of slate, i.e., an aphanitic rock with well-developed schistosity, average grain size <0.1 mm (excluding porphyroblasts) (Soller 2004b).
˜ Having the texture of phyllite, i.e., a fine-grained phaneritic rock, well-developed continuous schistosity, silvery sheen on cleavage surfaces, average grain size from 0.1 to 0.25 mm (excluding porphyroblasts) (Soller 2004b).

Table 42. Volcanic rocks—pyroclastic: modifier pick lists.

Volcanic Rocks—Pyroclastic: Modifier Pick Lists						
1	2	3	4	5	6	7
Volcanic Rocks						
Pyroclastic	Colour	Fresh	*user specify*			
		Weathered	*user specify*			
	Contact	Not observed				
		Relationship undetermined	Sharp			
			Gradational			
		Condordant	Sharp			
			Gradational			
		Discordant	Sharp			
			Gradational			
	Rock Fabric	Megascale	Unfoliated			
			Slaty¨			
			Phyllitic˜			
			Schistose			
			Gneissose			
		Mesoscale	Unfoliated			
			Slaty¨			
			Phyllitic˜			
			Schistose			
			Gneissose			
	Structure	Nonbedded				
		Surface relationship	Top parallel to base			
			Top flat, base conforms			
		Bedform	Dune			
			Ripple			
			Plane bed			
		Bedding	Thickness	Very thinly laminated		
				Thinly laminated		
				Thickly laminated		
				Very thinly bedded		
				Thinly bedded		
				Medium bedded		
				Thickly bedded		
				Very thickly bedded		
				Extremely thickly bedded		
			Defined by	Not determined		
				Layer colour		
				Particle composition		
				Particle orientation		
				Particle packing		
				Particle shape		
				Particle size		
			Geometry	Parallel	Unsubdivided	
					Curved	Unsubdivided
						Draped
						In lee of obstacle
					Planar	Unsubdivided
						Draped bedding
						In lee of obstacle
					Wavy	Unsubdivided
						Draped bedding
						In lee of obstacle
				Nonparallel	Unsubdivided	
					Curved	Unsubdivided
						Draped
						In lee of obstacle
					Planar	Unsubdivided
						Draped bedding
						In lee of obstacle
					Wavy	Unsubdivided
						Draped bedding
						In lee of obstacle
		Internal depositional structure	Massive			
			Agglutinated			
			Cross-stratification	Unsubdivided		
				Cross-bedding	Unsubdivided	
					Tabular	Large scale
						Small scale
					Trough	
				Cross-lamination	Unsubdivided	
					Tabular	Large scale
						Small scale
					Trough	Large scale
						Small scale
				Dune	Unsubdivided	
					Small dune	
				Herringbone		
				Hummocky		
			Graded	Type	Normal	
					Reverse	
					Symmetrical	Normal to reverse
						Reverse to normal
					Density factor	Lithics: normal; pumice: none
						Lithics: normal; pumice: reverse
					Gradation	Single
						Multiple
				Defined by	Grains	
					Fragments	
			Turbidite (Bouma cycle)	Unsubdivided		
				A		
				B		
				C		
				D		
				E		
		Post-depositional structure	Bedding-plane sag			
			Convolute lamination			
			Erosional structure	Unsubdivided		
				Angular unconformity		
				Disconformity		
				Scour channel		
			Fluid-escape structure	Unsubdivided		
				Degassing pipe		
				Water-escape structure		
			Fold structure (prelithification)	Single bed		
				Multi-bed		
			Fumarole	Unsubdivided		
				Rootless		
			Sole mark			
			Load cast			
			Slump structure			
	Tephra	Ash particles	Size abundance	Fine ash < coarse ash		
				Fine ash ~= coarse ash		
				Fine ash > coarse ash		
		Crystal characteristics	Mineralogy	Olivine	Unsubdivided	
					Fayalite	
					Forsterite	
				Pyroxene	Unsubdivided	
					Clinopyroxene	
					Orthopyroxene	
					Other	
				Amphibole	Unsubdivided	
					Hornblende	
					Other	
				Biotite		
				Feldspar	Unsubdivided	
					K-feldspar	
					Plagioclase	
				Feldspathoid	Unsubdivided	
					Nepheline	
					Other	
				Quartz		
				Carbonates	Calcite	
					Dolomite	
					Other	
				Spinel group	Chromite	
					Magnetite	
					Other	
			Form	Anhedral		
				Subhedral		
				Euhedral		
			Habit	Acicular		
				Equant		
				Prismatic		
				Sheet		
				Tabular		
			Size	Very fine grained		
				Fine grained		
				Medium grained		
				Coarse grained		
				Very coarse grained		
			Abundance	<5%		
				5 to 10%		
				10 to 25%		
				25 to 50%		
				>50%		
		Lithic fragments	Size Ratios	Ash < Lapilli		
				Ash > Lapilli		
				Ash < Blocks and Bombs		
				Ash > Blocks and Bombs		
				Lapilli < Blocks and Bombs		
				Lapilli > Blocks and Bombs		
				Blocks only		
				Blocks < Bombs		
				Blocks > Bombs		
				Bombs only		
			Composition	Monolithic: typically more mafic than matrix		
				Monolithic: similar to matrix		
				Monolithic: typically more felsic than matrix		
				Heterolithic: typically more mafic than matrix		
				Heterolithic: similar to matrix		
				Heterolithic: typically more felsic than matrix		
		Fragment type	Essential	Shards	Unsubdivided	
					Bubble wall	
					Cuspate	
					Platy	
				Lapilli	Unsubdivided	
					Accretionary	
					Armoured	
					Cinder	
					Cored	
					Fiamme	
					Hydroclastic	
					Pumice	
				Blocks	Unsubdivided	
					Lava	
					Pyroclastic rock	
				Bombs	Unsubdivided	
					Breadcrust	
					Cored	
					Cow-dung	
					Fusiform	Unsubdivided
						Rotational
						Spindle-shaped
					Ribbon	
					Spherical	
			Accessory	Shards	Unsubdivided	
					Bubble wall	
					Cuspate	
					Platy	
				Lapilli	Unsubdivided	
					Accretionary	
					Armoured	
					Cored	
					Cinder	
					Fiamme	
					Pumice	
				Blocks	Unsubdivided	
					Lava	
					Pyroclastic rock	
				Bombs	Unsubdivided	
					Breadcrust	
					Cored	
					Cow-dung	
					Fusiform	Unsubdivided
						Rotational
						Spindle-shaped
					Ribbon	
					Spherical	
				Lava ball		
			Accidental	Lapilli	Unsubdivided	
					Intrusive rock	
					Lava	
					Metamorphic rock	
					Pyroclastic rock	
					Sedimentary rock	
					Other rock type	
				Blocks	Unsubdivided	
					Intrusive rock	
					Lava	
					Pyroclastic rock	
					Sedimentary rock	
					Metamorphic rock	
					Other rock type	
				Bombs	Unsubdivided	
					Breadcrust	
					Cored	
					Cow-dung	
					Fusiform	Unsubdivided
						Rotational
						Spindle-shaped
					Ribbon	
					Spherical	
	Texture	Particle sorting (size)	Grains	Poorly sorted		
				Moderately sorted		
				Well sorted		
			Fragments	Poorly sorted		
				Moderately sorted		
				Well sorted		
				Diverse		
		Particle roundness class	Grains	Very angular		
				Angular		
				Subangular		
				Subrounded		
				Rounded		
				Well rounded		
			Fragments	Very angular		
				Angular		
				Subangular		
				Subrounded		
				Rounded		
				Well rounded		
				Diverse		
		Interparticle relationship	Degree of Induration	Unwelded		
				Slightly welded		
				Strongly welded		
			Eutaxitic			
			Hydroclastic			
	Material Source	Unsubdivided				
		Proximal				
		Distal				
	Miscellaneous	Metamorphism	Unmetamorphosed			
		Unit name	Unofficial	*user specify*		
		Stratigraphy	Group	*user specify*		
			Formation	*user specify*		

¨ Having the texture of slate, i.e., an aphanitic rock with well-developed schistosity, average grain size <0.1 mm (excluding porphyroblasts) (Soller 2004b).
˜ Having the texture of phyllite, i.e., a fine-grained phaneritic rock, well-developed continuous schistosity, silvery sheen on cleavage surfaces, average grain size from 0.1 to 0.25 mm (excluding porphyroblasts) (Soller 2004b).

Table 45. Sedimentary rocks: modifier pick lists.

Sedimentary Rocks Modifier Pick Lists											
1	2	3	4	5	6	7	8	9	10	11	12
Sedimentary Rocks	**General matrix**	Colour	Fresh	*user specify*							
			Weathered	*user specify*							
	Rock Fabric	Megascale	Unfoliated								
			Slaty¨								
			Phyllitic˜								
			Schistose								
			Gneissose								
		Mesoscale	Unfoliated								
			Slaty¨								
			Phyllitic˜								
			Schistose								
			Gneissose								
	Primary structure	Syngenetic	Depositional	Nonbedded							
				Bedding	Thickness	Very thinly laminated					
						Thinly laminated					
						Thickly laminated					
						Very thinly bedded					
						Thinly bedded					
						Medium bedded					
						Thickly bedded					
						Very thickly bedded					
						Extremely thickly bedded					
					Definition (defined by)	Not determined					
						Layer colour					
						Particle composition					
						Particle orientation					
						Particle packing					
						Particle shape					
						Particle size					
					Geometry	Parallel	Unsubdivided				
							Curved	Continuous			
								Discontinuous			
							Planar	Continuous			
								Discontinuous			
							Wavy	Continuous			
								Discontinuous			
						Nonparallel	Unsubdivided				
							Curved	Continuous			
								Discontinuous			
							Planar	Continuous			
								Discontinuous			
							Wavy	Continuous			
								Discontinuous			
					Feature	Amalgamated					
						Downlap					
						Lag deposit	Mineralogical	Chromite			
								Ilmenite			
								Magnetite			
								Other			
							Particle size	Granule			
								Pebble			
								Cobble			
								Boulder			
						Offlap					
						Onlap					
						Other					
				Parting	Thickness	Papery					
						Fissile					
						Platy					
						Flaggy					
						Slabby					
						Blocky					
						Massive					
				Bed-surface structure	Bedform shape	Catenary					
						Cuspate					
						Linguoid					
						Lunate					
						Rhomboid ripple					
					Parting lineation						
					Ripple & dune bedform	Dunes					
						Ripples	Unsubdivided				
							Asymmetric ripple				
							Symmetric ripple				
				Internal depositional structure	Lamination	Fissile					
						Flat					
						Varve					
					Cross-stratification	Unsubdivided					
						Cross-bedding	Unsubdivided				
							Tabular	Large-scale			
								Small-scale			
							Trough				
						Cross-lamination	Unsubdivided				
							Tabular	Large-scale			
								Small-scale	Unsubdivided		
									Ripple	Unsubdivided	
										Climbing	
										Form-set	Unsubdivided
											Flaser
											Lenticular
							Trough	Large-scale			
								Small-scale	Unsubdivided		
									Ripple	Unsubdivided	
										Climbing	
										Form-set	Unsubdivided
											Flaser
											Lenticular
						Dune	Unsubdivided				
							Small dune				
						Herringbone					
						Hummocky					
					Graded bedding	Normal					
						Reverse					
					Massive structure						
					Turbidite (Bouma cycle)	Unsubdivided					
						A					
						B					
						C					
						D					
						E					
			Erosional	Basal-surface mark	Scour mark	Unsubdivided					
						Flute mark					
						Gutter cast					
						Longitudinal ridges & furrows					
						Obstacle scour					
						Transverse scour					
						Other					
					Tool mark	Unsubdivided					
						Bounce mark					
						Chevron mark					
						Groove					
						Prod mark					
						Skip mark					
						Other					
				Upper-surface mark	Water erosion structure	Unsubdivided					
						Obstacle scour					
						Rill mark					
						Swash mark					
						Other					
					Wind erosion structure	Unsubdivided					
						Sand tail					
						Other					
		Penecontemporaneous	Bed surface	Crystal cast	Unsubdivided						
					Ice-crystal cast						
					Salt-crystal cast						
					Other						
				Dropstone							
				Ice-wedge cast							
				Ice-wedge polygon							
				Rain print / hail imprint							
				Shrinkage crack							
				Other							
			Within-bed	Armoured mud ball							
				Columnar structure							
				Convolute lamination							
				Deformed cross-stratification							
				Fenestra							
				Mud ball							
				Olistostrome							
				Oolith							
				Pisoid							
				Rip-up							
				Other							
			Other								
	Biogenic structure	Descriptive attributes	Bioturbation								
			Stromatolite	Unsubdivided							
				Shape	Branching						
					Columnar						
					Conical						
					Domal						
					Flat						
					Other						
	Secondary structure	Pre-lithification deformation	Basal surface	Ball-and-pillow structure							
				Flame structure							
				Load cast							
			Upper-surface	Raindrop impression							
				Sand or mud volcano							
				Shrinkage crack							
				Syneresis crack							
			Within-bed	Convolute lamination							
				Dish & pillar structures							
				Overturned or over-steepened cross-bedding							
				Pull-apart structure							
				Sheet structure							
			Multi-bed	Growth fault							
				Sedimentary dike							
				Slump block							
				Slump fold							
				Slump scar							
				Soft-sediment fold							
				Supratenuous fold							
				Synsedimentary fault							
			Other								
		Sedimentary hardground	Beachrock								
			Submarine hardground								
			Other								
		Dissolution structure	Collapse breccia								
			Solution breccia								
			Stylolite								
			Other								
		Epigenetic growth structure	Cavity filling	Geopetal							
				Stromatactis							
				Vugs							
			Replacement-displacive	Concretion							
				Cone-in-cone							
				Duricrust	Calcrete						
					Ferricrete						
					Silcrete						
				Nodule	Pyrite						
					Chert						
			Other								
	Unclassified structure		Bed surface	Basal-surface (sole mark)							
				Upper-surface							
			Within bed	Breccia (unclassified)							
				Convolute stratification (unclassified)							
				Deformed laminae (unclassified)							
				Fenestra (unclassified)							
				Other							
			Multi-bed	Intraformational fold (unclassified)							
				Other							
			Other								
	Depositional fabric	Support	Matrix	Unsubdivided							
				Mud							
				Mud-sand							
				Sand							
			Clast	Unsubdivided							
				Granule							
				Pebble							
				Cobble							
				Boulder							
		Obliterated by	Bioturbation								
			Grain overgrowths								
			Recrystallization								
			Other								
	Texture	Particle Sorting (size)	Grains	Poorly sorted							
				Moderately sorted							
				Well sorted							
			Clasts	Poorly sorted							
				Moderately sorted							
				Well sorted							
		Particle Size	Mud	Unsubdivided							
				Clay							
				Silt							
			Sand		Very fine						
					Fine						
					Medium						
					Coarse						
					Very coarse						
			Gravel	Granule							
				Pebble	Fine						
					Medium						
					Coarse						
					Very coarse						
				Cobble	Small						
					Large						
				Boulder	Small						
					Medium						
					Large						
					Very large						
		Particle Shape	Grains	Equant							
				Oblate							
				Bladed							
				Prolate							
			Clasts	Equant							
				Oblate							
				Bladed							
				Prolate							
		Particle Rounding	Grains	Very angular							
				Angular							
				Subangular							
				Subrounded							
				Rounded							
				Well rounded							
			Clasts	Very angular							
				Angular							
				Subangular							
				Subrounded							
				Rounded							
				Well rounded							
		Particle Orientation	Clasts	Not preferred							
				Aligned							
				Imbricated							
		Particle Composition	Matrix	Argillaceous							
				Cherty							
				Feldspathic							
				Ferruginous	Unsubdivided						
					Goethitic						
					Hematitic						
					Magnetitic						
					Pyritic						
				Graphitic							
				Lithic							
				Micaceous							
				Quartzose							
				Siliceous							
				Tuffaceous							
				Volcaniclastic							
				Other							
			Ironstone	Unsubdivided							
				Iron oxide	Hematite						
					Magnetite						
					Other						
				Siderite							
				Sulphide	Unsubdivided						
					Pyrite						
					Pyrrhotite						
					Other						
				Iron silicate	Amphibole						
					Chlorite						
					Greenalite						
					Grunerite						
					Minnesotaite						
					Other						
			Sand & gravel size	Proportion by type	Oligomictic						
					Polymictic						
				Essentially monomineralic clasts	Unsubdivided						
					Feldspathic	Unsubdivided					
						Alkali Feldspar					
						Plagioclase					
					Siliceous	Quartz	Unsubdivided				
							Monocrystalline				
							Polycrystalline				
					Carbonate-rich	Unsubdivided					
						Calcitic					
						Dolomitic					
						Ankeritic					
						Magnesitic					
						Sideritic					
						Other					
					Micaceous	Biotite					
						Chlorite					
						Muscovite					
						Glauconite					
					Heavy Minerals	Apatite					
						Garnet					
						Hornblende					
						Magnetite					
						Monazite					
						Olivine					
						Tourmaline					
						Zircon					
						Other					
				Igneous clasts	Unsubdivided						
					Intrusive	Fine grained	Felsic				
							Intermediate				
							Mafic				
							Ultramafic				
						Medium to coarse grained	Granitoid				
							Syenitoid				
							Dioritoid				
							Gabbroid				
							Ultramafic				
							Anorthositic				
							Foid-bearing rock				
							Foidolite				
						Pegmatitic					
						Other					
					Volcanic	Composition	Felsic				
							Intermediate				
							Mafic				
							Ultramafic				
						Lavas	Massive flow				
							Pillowed flow				
							Lava-related breccia				
						Pyroclastic	Tuff				
							Lapilli-tuff				
							Lapillistone				
							Tuff breccia				
							Pyroclastic breccia				
							Agglomerate				
				Sedimentary clasts	Unsubdivided						
					Terrigenous-clastic	Mudstone					
						Sandstone					
						Conglomerate					
						Tuffaceous mudstone					
						Tuffaceous sandstone					
						Tuffaceous conglomerate					
						Tuffaceous breccia					
					Chemical	Carbonate rocks	Unsubdivided				
							Calcitic				
							Dolomitic				
						Chert					
						Ironstone	Unsubdivided				
							Magnetite				
							Hematite				
							Siderite				
							Sulphide				
				Metamorphic clasts	Textural	Schist					
						Gneiss					
						Granofels					
						Hornfels					
					Migmatites	Unsubdivided					
						Metatexite					
						Diatexite					
					Compositional	Amphibolite					
						Calc-silicate rock					
						Carbonate-bearing silicate rock					
						Carbonate-silicate rock					
						Marble					
						Meta-ironstone					
						Eclogite					
						Serpentinite					
					Metasomatic	Fenite					
						Skarn					
					Other						
				Other rock type clasts	Tectonite						
					Brittle fault rock						
					Cataclasite						
					Mylonite						
					Impact pseudotachylite						
					Impact breccia						
					Impact melt rock						
	Miscellaneous	Clast Provenance	Terrane source	Undetermined							
				Proximal							
				Distal							
		Metamorphism	Unmetamorphosed								
		Unit name	Unofficial	*user specify*							
		Stratigraphy	Group	*user specify*							
			Formation	*user specify*							
		Unconformity	Unsubdivided								
			Angular								
			Disconformity								

¨ Having the texture of slate, i.e., an aphanitic rock with well-developed schistosity, average grain size <0.1 mm (excluding porphyroblasts) (Soller 2004b).
˜ Having the texture of phyllite, i.e., a fine-grained phaneritic rock, well-developed continuous schistosity, silvery sheen on cleavage surfaces, average grain size from 0.1 to 0.25 mm (excluding porphyroblasts) (Soller 2004b).

Metamorphic Rocks: Structural, Compositional and Metasomatism Modifier Pick Lists

1	2	3	4	5	6	7	8
Metamorphic Rocks Structural, Compositional & Metasomatic categories	Overall outcrop	Colour Index	Unsubdivided				
			Holomelanocratic				
			Melanocratic				
			Mesocratic				
			Leucocratic				
			Hololeucocratic				
		Uniformity	Unsubdivided				
			Compositionally and texturally homogeneous				
			Compositionally homogeneous				
			Texturally homogeneous				
			Compositionally and texturally heterogeneous				
			Compositionally heterogeneous				
			Texturally heterogeneous				
		Bulk composition	Compositional	Carbonate rock			
				Calcite marble			
				Meso-carbonate marble			
				Dolomite marble			
				Impure calcite marble			
				Impure meso-carbonate marble			
				Impure dolomite marble			
				Calc-silicate rock			
				Carbonate silicate rock			
				Pelitic (muddy)			
				Psammitic (sandy)			
				Quartzose			
				Iron-rich			
				Sulphide-bearing			
			Mineralogical	Granitic			
				Granodioritic			
				Tonalitic			
				Syenitic			
				Monzonitic			
				Monzodioritic			
				Dioritic			
				Gabbroic			
				Hornblenditic			
				Pyroxenitic			
				Peridotitic			
				Anorthositic			
				Foidolitic			
	Components	Single					
		Multiple	*user specify*				
	Component 1	Type	Layer				
			Phase				
		Proportion of outcrop	<5%				
			5 to 10%				
			10 to 25%				
			25 to 50%				
			>50%				
		Protolith	Rock Type	Undetermined			
				Igneous	Unsubdivided		
					Intrusive		
					Volcanic		
				Sedimentary			
				Metamorphic			
			Relict structure	Unsubdivided			
				Augen			
				Flaser			
				Phacoidal			
				Porphyroclast			
				Schliere			
				Scholle			
				Ghost stratigraphy			
				Igneous textures	*user specify*		
				Sedimentary features	*user specify*		
		Layering	Form	Nonlayered			
				Parallel	Unsubdivided		
					Curved	Continuous	
						Discontinuous	
					Planar (straight)	Continuous	
						Discontinuous	
					Wavy	Continuous	
						Discontinuous	
				Nonparallel	Unsubdivided		
					Curved	Continuous	
						Discontinuous	
					Planar (straight)	Continuous	
						Discontinuous	
					Wavy	Continuous	
						Discontinuous	
					Boudinage		
					Contorted		
			Thickness	Nonlayered			
				Poorly developed layering; thickness unspecified			
				Layered; thickness unspecified			
				Extremely thinly layered			
				Very thinly layered			
				Thinly layered			
				Medium layered			
				Thickly layered			
				Very thickly layered			
				Extremely thickly layered			
		Grain characteristics	Groundmass	Crystal size	Ultra fine grained		
					Very fine grained		
					Fine grained		
					Medium grained		
					Coarse grained		
					Very coarse grained		
					Extremely coarse grained		
				Crystalloblast development	Idioblastic		
					Subidioblastic		
					Xenoblastic		
				Structure	Heteroblastic		
					Homeoblastic	Unsubdivided	
						Granoblastic	
						Granoblastic-polygonal	
						Lepidoblastic	
						Nematoblastic	
				Mineralogy+	Unspecified		
					Olivine	Unsubdivided	
						Fayalite	
						Forsterite	
					Pyroxene	Unsubdivided	
						Clinopyroxene	
						Orthopyroxene	
						Diopside	
						Omphacite	
						Other	
					Amphibole	Unsubdivided	
						Clinoamphibole	Unsubdivided
							Actinolite
							Cummingtonite
							Hornblende
							Tremolite
						Orthoamphibole	Unsubdivided
							Anthophyllite
							Gedrite
						Blue-green amphibole	
						Green amphibole	
						Black amphibole	
						Other	
					Sheet silicates	Biotite	
						Chlorite	
						Muscovite	
						Phlogopite	
						White mica	
						Clay minerals	
						Prehnite	
						Other	
					Aluminosilicates	Unsubdivided	
						Andalusite	
						Kyanite	
						Sillimanite	
					Garnet	Unsubdivided	
						Almandine	
						Grossular	
						Pyrope	
						Spessartine	
					Chloritoid		
					Chondrodite		
					Cordierite		
					Scapolite		
					Staurolite		
					Tourmaline		
					Feldspar	K-feldspar	
						Plagioclase	Unsubdivided
							Calcic
							Sodic
					Feldspathoid	Nepheline	
						Other	
					Quartz		
					Epidote group		
					Lawsonite		
					Pumpellyite		
					Carbonate minerals	Ankerite	
						Calcite	
						Dolomite	
						Other	
					Spinel group	Hercynite	
						Magnetite	
						Other	
					Zeolite group		
			Porphyroblasts	Size*			
				Habit	Unsubdivided		
					Acicular		
					Equant		
					Prismatic		
					Sheet		
					Tabular		
				Form	Unsubdivided		
					Hypidioblast		
					Idioblast		
					Xenoblast		
					Neoblast		
					Paleoblast		
					Reaction rims	Armoured relict	
						Atoll structure	
						Corona	
					Knotted [rock]		
					Spotted [rock]		
					Pseudomorph	Original mineral	*user specify*
						Final mineral	*user specify*
				Mineralogy+ ‡			
				Abundance			
					<5%		
					5 to 10%		
					10 to 25%		
					25 to 50%		
					>50%		
			Porphyroclasts	Size*			
				Habit^			
				Form†			
				Mineralogy+ ‡			
				Abundance~			
		Metamorphism	Facies	Zeolite			
				Subgreenschist			
				Greenschist			
				Epidote-amphibolite			
				Amphibolite			
				Hornfels			
				Sanidinite			
				Granulite			
				Glaucophane-schist			
				Eclogite			
			Grade	Very low			
				Low			
				Medium			
				High			
				Very high			
			History	Events	Monometamorphism		
					Polymetamorphism	*user specify*	
				Phases	Monophase		
					Polyphase	*user specify*	
				Type	Prograde		
					Retrograde	*user specify*	
	Component 2	All choices same as Component 1					
	Component 3	All choices same as Component 1					
	Miscellaneous	Unit name	Unofficial	*user specify*			
			Official	*user specify*			

+Key Mineral Modifiers: to be listed in increasing order of abundance (e.g., staurolite-garnet schist contains more garnet than staurolite).
* Size: same as for Component 1 / Grain characteristics / Groundmass / Crystal size (excluding "ultra fine grained" and "very fine grained").
^ Habit: same as for Component 1 / Grain characteristics / Porphyroblasts / Habit
† Form: same as for Component 1 / Grain characteristics / Porphyroblasts / Form
‡ Mineralogy: same as for Component 1 / Grain characteristics / Groundmass / Mineralogy
~ Abundance: same as for Component 1 / Grain characteristics / Porphyroblasts / Abundance

Table 49. Metamorphic rocks—metabreccia: modifier pick lists.

Metamorphic Rocks: Metabreccia Modifier Pick Lists

1	2	3	4	5	6	7
Metamorphic Rocks						
Metabreccias	Matrix	Colour Index	Unsubdivided			
			Holomelanocratic			
			Melanocratic			
			Mesocratic			
			Leucocratic			
			Hololeucocratic			
		Rock Fabric	Megascale	Unfoliated		
				Slaty[¨]		
				Phyllitic[˜]		
				Schistose		
				Gneissose		
			Mesoscale	Unfoliated		
				Slaty[¨]		
				Phyllitic[˜]		
				Schistose		
				Gneissose		
		Bulk composition	Compositional	Carbonate rock		
				Calcite marble		
				Meso-carbonate marble		
				Dolomite marble		
				Impure calcite marble		
				Impure meso-carbonate marble		
				Impure dolomite marble		
				Calc-silicate rock		
				Carbonate silicate rock		
			Mineralogical	Granitic		
				Granodioritic		
				Tonalitic		
				Syenitic		
				Monzonitic		
				Monzodioritic		
				Dioritic		
				Gabbroic		
				Peridotitic		
				Pyroxenitic		
				Hornblenditic		
				Anorthositic		
				Foidolitic		
				Pelitic (muddy)		
				Psammitic (sandy)		
				Quartzose		
		Proportion of breccia	<5%			
			5 to 10%			
			10 to 25%			
			25 to 50%			
			>50%			
		Protolith	Rock Type	Undetermined		
				Igneous	Unsubdivided	
					Intrusive	
					Volcanic	
				Sedimentary		
				Metamorphic		
			Relict structure	Unsubdivided		
				Augen		
				Flaser		
				Phacoidal		
				Porphyroclast		
				Schliere		
				Scholle		
				Ghost stratigraphy		
				Igneous textures	*user specify*	
				Sedimentary features	*user specify*	
		Layering	Form	Nonlayered		
				Parallel	Unsubdivided	
					Curved	Continuous
						Discontinuous
					Planar (straight)	Continuous
						Discontinuous
					Wavy	Continuous
						Discontinuous
				Nonparallel	Unsubdivided	
					Curved	Continuous
						Discontinuous
					Planar (straight)	Continuous
						Discontinuous
					Wavy	Continuous
						Discontinuous
					Boudinage	
					Contorted	
			Thickness	Nonlayered		
				Poorly developed layering, thickness not specified		
				Layered, thickness not specified		
				Extremely thinly layered		
				Very thinly layered		
				Thinly layered		
				Medium layered		
				Thickly layered		
				Very thickly layered		
		Grain characteristics	Crystal size	Ultra fine grained		
				Very fine grained		
				Fine grained		
				Medium grained		
				Coarse grained		
				Very coarse grained		
				Extremely coarse grained		
			Crystalloblast development	Idioblastic		
				Subidioblastic		
				Xenoblastic		
			Structure	Heteroblastic		
				Homeoblastic	Unsubdivided	
					Granoblastic	
					Granoblastic-polygonal	
					Lepidoblastic	
					Nematoblastic	
			Mineralogy[+]	Unspecified		
				Olivine	Unsubdivided	
					Fayalite	
					Forsterite	
				Pyroxene	Unsubdivided	
					Clinopyroxene	
					Orthopyroxene	
					Diopside	
					Omphacite	
					Other	
				Amphibole	Unsubdivided	
					Clinoamphibole	Unsubdivided
						Actinolite
						Cummingtonite
						Hornblende
						Tremolite
					Orthoamphibole	Unsubdivided
						Anthophyllite
						Gedrite
					Blue-green amphibole	
					Green amphibole	
					Black amphibole	
					Other	
				Sheet silicates	Biotite	
					Chlorite	
					Muscovite	
					Phlogopite	
					White mica	
					Clay minerals	
					Prehnite	
					Other	
				Aluminosilicates	Unsubdivided	
					Andalusite	
					Kyanite	
					Sillimanite	
				Garnet	Unsubdivided	
					Almandine	
					Grossular	
					Pyrope	
					Spessartine	
				Chloritoid		
				Chondrodite		
				Cordierite		
				Scapolite		
				Staurolite		
				Tourmaline		
				Feldspar	K-feldspar	
					Plagioclase	Unsubdivided
						Calcic
						Sodic
				Feldspathoid	Nepheline	
					Other	
				Quartz		
				Epidote group		
				Lawsonite		
				Pumpellyite		
				Carbonate minerals	Ankerite	
					Calcite	
					Dolomite	
					Other	
				Spinel group	Hercynite	
					Magnetite	
					Other	
				Zeolite group		
		Metamorphism	Facies	Zeolite		
				Subgreenschist		
				Greenschist		
				Epidote-amphibolite		
				Amphibolite		
				Hornfels		
				Sanidinite		
				Granulite		
				Glaucophane-schist		
				Eclogite		
			Grade	Very low		
				Low		
				Medium		
				High		
				Very high		
			History	Events	Monometamorphism	
					Polymetamorphism	*user specify*
				Phases	Monophase	
					Polyphase	*user specify*
				Type	Prograde	
					Retrograde	*user specify*
	Fragments	Contacts with matrix	Undetermined			
			Concordant	Sharp		
				Gradational		
			Discordant	Sharp		
				Gradational		
			Diffuse			
			Reaction rim			
		Proportion of breccia	<5%			
			5 to 10%			
			10 to 25%			
			25 to 50%			
			>50%			
		Variety	Monolithic			
			Bilithic			
			Heterolithic			
		Fragment type 1	Composition	Unsubdivided		
				Colour index	Ultramafic	
					Mafic	
					Intermediate	
					Felsic	
				Fabric basis	Schist	
					Gneiss	
					Hornfels	
					Granofels	
				Compositional	Carbonate rock	
					Calcite marble	
					Meso-carbonate marble	
					Dolomite marble	
					Impure calcite marble	
					Impure meso-carbonate marble	
					Impure dolomite marble	
					Calc-silicate rock	
					Carbonate silicate rock	
					Iron-rich	
					Pelitic (muddy)	
					Psammitic (sandy)	
					Quartzose	
					Sulphide-bearing	
				Migmatite	Metatexite	
					Diatexite	
				Mineralogical	Granitic	
					Granodioritic	
					Tonalitic	
					Syenitic	
					Monzonitic	
					Monzodioritic	
					Dioritic	
					Gabbroic	
					Hornblenditic	
					Pyroxenitic	
					Peridotitic	
					Anorthositic	
					Foidolitic	
			Size (typical)	Small		
				Medium		
				Large		
				Very large		
				Extremely large		
			Roundness	Very angular		
				Angular		
				Subangular		
				Subrounded		
				Rounded		
				Well rounded		
			Uniformity (size, shape)	Not uniform		
				Moderately uniform		
				Uniform		
			Abundance	<5%		
				5 to 10%		
				10 to 25%		
				25 to 50%		
				>50%		
		Fragment type 2	(Lists as with Fragment type 1)			
		Fragment type 3	(Lists as with Fragment type 1)			
	Miscellaneous	Unit name	Unofficial	*user specify*		
			Official	*user specify*		

[+]Key Mineral Modifiers: to be listed in increasing order of abundance (e.g., staurolite-garnet matrix contains more garnet than staurolite).
[¨] Having the texture of slate, i.e., an aphanitic rock with well-developed schistosity, average grain size <0.1 mm (excluding porphyroblasts) (Soller 2004b).
[˜] Having the texture of phyllite, i.e., a fine-grained phaneritic rock, well-developed continuous schistosity, silvery sheen on cleavage surfaces, average grain size from 0.1 to 0.25 mm (excluding porphyroblasts) (Soller 2004b).

Table 50. Metamorphic rocks—migmatite: modifier pick lists.

Metamorphic Rocks: Migmatite Modifier Pick Lists							
1	2	3	4	5	6	7	8
Metamorphic Rocks							
Migmatites	Neosome	Generation	Single				
			Multiple	*user specified*			
		Colour Index	Unsubdivided				
			Holomelanocratic				
			Melanocratic				
			Mesocratic				
			Leucocratic				
			Hololeucocratic				
		Bulk Composition	Unsubdivided				
			Granitic				
			Granodioritic				
			Tonalitic				
			Syenitic				
			Monzonitic				
			Monzodioritic				
			Dioritic				
			Gabbroic				
			Anorthositic				
			Foidolitic				
		Proportion of migmatite	<5%				
			5 to 10%				
			10 to 25%				
			25 to 50%				
			>50%				
		Layering	Form	Nonlayered			
				Parallel	Unsubdivided		
					Curved	Continuous	
						Discontinuous	
					Planar (straight)	Continuous	
						Discontinuous	
					Wavy	Continuous	
						Discontinuous	
				Nonparallel	Unsubdivided		
					Curved	Continuous	
						Discontinuous	
					Planar (straight)	Continuous	
						Discontinuous	
					Wavy	Continuous	
						Discontinuous	
					Boudinage		
					Contorted		
			Thickness	Nonlayered			
				Poorly developed, thickness unspecified			
				Layered, thickness unspecified			
				Extremely thinly layered			
				Very thinly layered			
				Thinly layered			
				Medium layered			
				Thickly layered			
				Very thickly layered			
				Extremely thickly layered			
		Texture	Groundmass	Crystal size	Ultra fine grained		
					Very fine grained		
					Fine grained		
					Medium grained		
					Coarse grained		
					Very coarse grained		
					Extremely coarse grained		
				Crystalloblast development	Idioblastic		
					Subidioblastic		
					Xenoblastic		
				Structure	Heteroblastic		
					Homeoblastic	Unsubdivided	
						Granoblastic	
						Granoblastic-polygonal	
						Lepidoblastic	
						Nematoblastic	
				Mineralogy[+]	Unspecified		
					Olivine	Unsubdivided	
						Fayalite	
						Forsterite	
					Pyroxene	Unsubdivided	
						Clinopyroxene	
						Orthopyroxene	
						Diopside	
						Omphacite	
						Other	
					Amphibole	Unsubdivided	
						Clinoamphibole	Unsubdivided
							Actinolite
							Cummingtonite
							Hornblende
							Tremolite
						Orthoamphibole	Unsubdivided
							Anthophyllite
							Gedrite
						Blue-green amphibole	
						Green amphibole	
						Black amphibole	
						Other	
					Sheet silicates	Biotite	
						Chlorite	
						Muscovite	
						Phlogopite	
						Prehnite	
						White mica	
						Clay minerals	
						Other	
					Aluminosilicates	Unsubdivided	
						Andalusite	
						Kyanite	
						Sillimanite	
					Garnet	Unsubdivided	
						Almandine	
						Grossular	
						Pyrope	
						Spessartine	
					Chloritoid		
					Chondrodite		
					Cordierite		
					Scapolite		
					Staurolite		
					Tourmaline		
					Feldspar	K-feldspar	
						Plagioclase	Unsubdivided
							Calcic plagioclase
							Sodic plagioclase
					Feldspathoid	Nepheline	
						Other	
					Quartz		
					Epidote group		
					Carbonate minerals	Ankerite	
						Calcite	
						Dolomite	
						Other	
					Spinel group	Hercynite	
						Magnetite	
						Other	
			Porphyroblasts	Size*			
				Habit	Unsubdivided		
					Acicular		
					Equant		
					Prismatic		
					Sheet		
					Tabular		
				Form	Unsubdivided		
					Hypidioblast		
					Idioblast		
					Xenoblast		
					Neoblast		
					Paleoblast		
					Reaction rims	Unsubdivided	
						Armoured relict	
						Atoll structure	
						Corona	
					Pseudomorph	Original mineral	*user specify*
						Final mineral	*user specify*
				Mineralogy[+] ‡			
				Abundance	<5%		
					5 to 10%		
					10 to 25%		
					25 to 50%		
					>50%		
			Porphyroclasts	Size*			
				Shape^			
				Form†			
				Mineralogy[+] ‡			
				Abundance˜			
		Metamorphism	History	Events	Monometamorphism		
					Polymetamorphism	*user specify*	
				Phases	Monophase		
					Polyphase	*user specify*	
				Type	Prograde		
					Retrograde	*user specify*	
	Paleosome	Colour Index	Unsubdivided				
			Holomelanocratic				
			Melanocratic				
			Mesocratic				
			Leucocratic				
			Hololeucocratic				
		Bulk Composition	Unsubdivided				
			Colour index	Ultramafic			
				Mafic			
				Intermediate			
				Felsic			
			Fabric basis	Schist			
				Gneiss			
				Hornfels			
				Granofels			
			Compositional	Carbonate rock			
				Calcite marble			
				Meso-carbonate marble			
				Dolomite marble			
				Impure calcite marble			
				Impure meso-carbonate marble			
				Impure dolomite marble			
				Calc-silicate rock			
				Carbonate silicate rock			
				Iron-rich			
				Pelitic (muddy)			
				Psammitic (sandy)			
				Quartzose			
				Sulphide-bearing			
			Migmatite	Migmatite			
				Diatexite			
			Igneous	Granitic			
				Granodioritic			
				Tonalitic			
				Syenitic			
				Monzonitic			
				Monzodioritic			
				Dioritic			
				Gabbroic			
				Anorthositic			
				Foidolitic			
		Layering	Form	Nonlayered			
				Parallel	Unsubdivided		
					Planar (straight)	Continuous	
						Discontinuous	
					Wavy	Continuous	
						Discontinuous	
					Curved	Continuous	
						Discontinuous	
				Nonparallel	Unsubdivided		
					Planar (straight)	Continuous	
						Discontinuous	
					Wavy	Continuous	
						Discontinuous	
					Curved	Continuous	
						Discontinuous	
					Contorted		
					Boudinaged		
			Thickness	Nonlayered			
				Poorly developed, thickness unspecified			
				Layered, thickness unspecified			
				Extremely thinly layered			
				Very thinly layered			
				Thinly layered			
				Medium layered			
				Thickly layered			
				Very thickly layered			
				Extremely thickly layered			
		Grain Characteristics	Groundmass	Size*			
				Shape^			
				Form†			
				Mineralogy‡			
			Porphyroblasts	Size*			
				Shape^			
				Form†			
				Mineralogy‡			
				Abundance˜			
			Porphyroclasts	Size*			
				Shape^			
				Form†			
				Mineralogy‡			
				Abundance˜			
		Protolith	Rock Type	Undetermined			
				Igneous	Unsubdivided		
					Intrusive		
					Volcanic		
				Sedimentary			
				Metamorphic			
			Relict structure	Unsubdivided			
				Augen			
				Flaser			
				Phacoidal			
				Porphyroclast			
				Schliere			
				Scholle			
				Ghost stratigraphy			
				Igneous textures	*user specify*		
				Sedimentary features	*user specify*		
		Metamorphism	Facies	Epidote-amphibolite			
				Amphibolite			
				Hornfels			
				Granulite			
				Sanidinite			
				Eclogite			
			Grade	High			
				Very high			
			History	Events	Monometamorphism		
					Polymetamorphism	*user specify*	
				Phases	Monophase		
					Polyphase	*user specify*	
				Type	Prograde		
					Retrograde	*user specify*	
	Miscellaneous	Unit name	Unofficial	*user specify*			
			Official	*user specify*			

[+]Key Mineral Modifiers: to be listed in increasing order of abundance (e.g., staurolite-garnet migmatite contains more garnet than staurolite)
* Size: same as for Neosome / Texture / Groundmass / Crystal size (excluding "ultra fine grained" and "very fine grained")
^ Habit: same as for Neosome / Texture / Porphyroblasts / Habit
† Form: same as for Neosome / Texture / Porphyroblasts / Form
‡ Mineralogy: same as for Neosome / Texture / Groundmass / Mineralogy
˜ Abundance: same as for Neosome / Texture / Porphyroblasts / Abundance

Fault Rocks Modifier Pick Lists

1	2	3	4	5	6	7
Fault Rocks						
Cataclasite, Mylonite, Fault pseudotachylite	Matrix	Cohesiveness	Cohesive			
			Incohesive			
		Material	Country rock			
			Carbonate			
			Chlorite			
			Epidote			
			Hematite			
			Quartz			
			Other	*user specify*		
		Colour	Fresh	*user specify*		
			Weathered	*user specify*		
		Fabric	Unfoliated			
			Foliated	Unsubdivided		
				Layered		
				Schistose		
				Gneissic		
	Fragments	General size	Unresolvable			
			Small			
			Medium			
			Large			
		Maximum size	Not applicable			
			Very small			
			Small			
			Medium			
			Large			
			Very large			
			Extremely large			
		Size variety	Small variation			
			Medium variation			
			Large variation			
		Typical Rounding	Not applicable			
			Very angular			
			Angular			
			Subangular			
			Subrounded			
			Rounded			
			Well rounded			
		Abundance of all fragments	Not applicable			
			<5%			
			5 to 10%			
			10 to 25%			
			25 to 50%			
			50 to 75%			
			>75%			
		Lithic composition	Undetermined			
			Colour index	Ultramafic rock		
				Mafic rock		
				Intermediate rock		
				Felsic rock		
			Igneous	Intrusive	Unsubdivided	
					Granitoid	
					Syenitoid	
					Dioritoid	
					Gabbroid	
					Peridotitic	
					Pyroxenitic	
					Hornblenditic	
					Anorthositic	
				Volcanic	Unsubdivided	
					Rhyolitoid	
					Dacitoid	
					Trachytoid	
					Andesitoid	
					Basaltoid	
					Phonolitoid	
					Tephritoid	
					Foiditoid	
					Komatiitoid	
					Melilitoid	
			Sedimentary	Terrigenous-clastic	Unsubdivided	
					Mudstone	
					Sandstone	
					Conglomerate	
				Chemical	Unsubdivided	
					Carbonate rock	
					Siliceous rock	
					Ironstone	
					Sulphate rock	
			Metamorphic	Unsubdivided		
				Fabric basis	Unsubdivided	
					Schist	
					Gneiss	
					Granofels	
					Hornfels	
					Metabreccia	
				Compositional	Unsubdivided	
					Mafic/ultramafic	
					Metacarbonate	
					Meta-ironstone	
				Migmatite	Unsubdivided	
					Metatexite	
					Diatexite	
				Metasomatic		
			Fault rock	Cataclasite series	Unsubdivided	
					Fault breccia	
					Fault gouge	
					Protocataclasite	
					Mesocataclasite	
					Ultracataclasite	
					Fault pseudotachylite	
				Mylonite series	Unsubdivided	
					Protomylonite	
					Mesomylonite	
					Ultramylonite	
					Phyllonite	
	Structures	Porphyroclast	Mineralogy	Unspecified		
				Olivine	Unsubdivided	
					Fayalite	
					Forsterite	
				Pyroxene	Unsubdivided	
					Clinopyroxene	
					Orthopyroxene	
					Diopside	
					Omphacite	
					Other	
				Amphibole	Unsubdivided	
					Clinoamphibole	Unsubdivided
						Actinolite
						Cummingtonite
						Hornblende
						Tremolite
					Orthoamphibole	Unsubdivided
						Anthophyllite
						Gedrite
					Blue-green amphibole	
					Green amphibole	
					Black amphibole	
					Other	
				Sheet silicates	Biotite	
					Phlogopite	
					Muscovite	
					Chlorite	
					White mica	
					Clay minerals	
					Prehnite	
					Other	
				Aluminosilicates	Unsubdivided	
					Andalusite	
					Kyanite	
					Sillimanite	
				Garnet group	Unsubdivided	
					Almandine	
					Grossular	
					Pyrope	
					Spessartine	
				Chloritoid		
				Cordierite		
				Scapolite		
				Staurolite		
				Tourmaline		
				Feldspar	K-feldspar	
					Plagioclase	Unsubdivided
						Calcic plagioclase
						Sodic plagioclase
				Feldspathoid	Nepheline	
					Other	
				Quartz		
				Epidote group		
				Lawsonite		
				Pumpellyite		
				Carbonate minerals	Calcite	
					Dolomite	
					Ankerite	
					Other	
				Spinel group	Hercynite	
					Magnetite	
					Other	
				Zeolite group	Unsubdivided	
					Laumontite	
					Stilbite	
				Carbonates	Unsubdivided	
					Ankerite	
					Calcite	
					Dolomite	
					Other	
			Habit	Acicular		
				Equant		
				Prismatic		
				Sheet		
				Tabular		
			Size	Fine grained		
				Medium grained		
				Coarse grained		
				Very coarse grained		
				Extremely coarse grained		
			Abundance	<5%		
				5 to 10%		
				10 to 25%		
				25 to 50%		
				>50%		
		Porphyroclast system	Mineralogy*			
			Habitˆ			
			Size†			
			Abundance‡			
		Mica fish	Mineralogy	Sheet silicates	Biotite	
					Chlorite	
					Muscovite	
					Phlogopite	
					Other	
			Size†			
			Abundance‡			
	Miscellaneous	Unit name	Unofficial	*user specify*		
			Official	*user specify*		

* Mineralogy: same as for Structures / Porphyroclast / Mineralogy
ˆ Habit: same as for Structures / Porphyroclast / Habit
† Size: same as for Structures / Porphyroclast / Size
‡ Abundance: same as for Structures / Porphyroclast / Abundance

Table 56. Impact pseudotachylite rocks: modifier pick lists.

Impact Pseudotachylite Rocks Modifier Pick Lists						
1	2	3	4	5	6	7
Impactite Rocks						
Impact pseudotachylite	Generations of pseudotachylite	1				
		2				
		3				
		4				
	Form	Vein				
		Vein network				
		Dike				
		Irregular body				
	Contacts	Not observed				
		Concordant	Sharp			
			Gradational			
		Discordant	Sharp			
			Gradational			
		Relationship undetermined	Sharp			
			Gradational			
	Occurrence	Undetermined				
		Contact between units				
		Within unit				
	Thickness	Very thin				
		Thin				
		Medium				
		Thick				
		Very thick				
		Diverse				
	Rock Fabric	Megascale	Unfoliated			
			Slaty¨			
			Phyllitic˜			
			Schistose			
		Mesoscale	Unfoliated			
			Slaty¨			
			Phyllitic˜			
			Schistose			
	Type	Monolithic				
		Bilithic				
		Heterolithic				
	Degree of host rock brecciation	Undetermined				
		Intact breccia				
		Slightly disrupted				
		Moderately disrupted				
		Highly disrupted				
		Chaotic				
	Matrix	Colour	Fresh	*user specify*		
			Weathered	*user specify*		
		Type	Undetermined			
			Glassy			
			Hypocrystalline			
			Holocrystalline			
			Comminuted material			
			Mixed melt & comminuted			
		Structure	Massive			
			Flow layering			
	Fragments	Typical size	Unresolvable			
			Small			
			Medium			
			Large			
		Maximum size	Very small			
			Small			
			Medium			
			Large			
			Very large			
			Extremely large			
		Abundance of resolvable	<5%			
			5 to 10%			
			10 to 25%			
			25 to 50%			
			>50%			
		Sorting (size)	Indeterminable			
			Poorly sorted			
			Moderately sorted			
			Well sorted			
		Rounding	Very angular			
			Angular			
			Subangular			
			Subrounded			
			Rounded			
			Well rounded			
		Composition	Igneous	Unsubdivided		
				Intrusive	Fine grained	Felsic
						Intermediate
						Mafic
						Ultramafic
					Medium to coarse grained	Granitoid
						Syenitoid
						Dioritoid
						Gabbroid
						Ultramafic
						Anorthositic
						Foid-bearing rock
						Foidolite
					Pegmatitic	
					Other	
				Volcanic	Composition	Felsic
						Intermediate
						Mafic
						Ultramafic
					Lavas	Massive flow
						Pillowed flow
						Lava-related breccia
					Pyroclastic	Tuff
						Lapilli-tuff
						Lapillistone
						Tuff breccia
						Pyroclastic breccia
						Agglomerate
			Sedimentary	Unsubdivided		
				Terrigenous-clastic	Mudstone	
					Sandstone	
					Conglomerate	
				Volcaniclastic	Tuffaceous mudstone	
					Tuffaceous sandstone	
					Tuffaceous conglomerate	
					Tuffaceous breccia	
				Chemical	Carbonate rocks	Calcitic
						Dolomitic
					Siliceous rock	
					Ironstone	Unsubdivided
						Hematite
						Magnetite
						Iron silicate
						Siderite
						Sulphide
					Sulphate rock	
			Metamorphic	Fabric basis	Schist	
					Gneiss	
					Granofels	
					Hornfels	
				Compositional	Amphibolite	
					Calc-silicate rock	
					Carbonate-bearing silicate rock	
					Carbonate-silicate rock	
					Marble	
					Eclogite	
					Serpentinite	
				Migmatite	Unsubdivided	
					Metatexite	
					Diatexite	
				Metasomatic	Fenite	
					Skarn	
			Other rock types	Brittle fault rock		
				Cataclasite		
				Mylonite		
				Impact pseudotachylite		
				Impact breccia		
				Impact melt rock		
	Miscellaneous	Shatter cones	in wall rock			
			in breccia fragments			
		Local unit name	Sudbury breccia			
		Possible alternative name	Monomict breccia			

¨ Having the texture of slate, i.e., an aphanitic rock with well-developed schistosity, average grain size <0.1 mm (excluding porphyroblasts) (Soller 2004b).
˜ Having the texture of phyllite, i.e., a fine-grained phaneritic rock, well-developed continuous schistosity, silvery sheen on cleavage surfaces, average grain size from 0.1 to 0.25 mm (excluding porphyroblasts) (Soller 2004b).

Table 57. Lithic impact breccia rocks: modifier pick lists.

Lithic Impact Breccia Rocks Modifier Pick Lists						
1	2	3	4	5	6	7
Impactite Rocks						
Lithic impact breccia	Form	Undetermined				
		Dike	Unzoned			
			Zoned			
		Subhorizontal tabular body				
		Irregular body				
	Contacts with country rock	Not observed				
		Concordant	Sharp			
			Gradational			
		Discordant	Sharp			
			Gradational			
		Relationship undetermined	Sharp			
			Gradational			
	Contact with fragments	Diffuse				
		Sharp				
		Reaction rims				
	Unit thickness	Undetermined				
		Thin				
		Medium				
		Thick				
		Very thick				
		Extremely thick				
	Layering	Not layered				
		Layered	Thin			
			Medium			
			Thick			
	Rock Fabric	Megascale	Unfoliated			
			Slaty¨			
			Phyllitic˜			
			Schistose			
		Mesoscale	Unfoliated			
			Slaty¨			
			Phyllitic˜			
			Schistose			
	Breccia type	Monolithic				
		Bilithic				
		Heterolithic				
	Degree of heterogeneity	Slightly mixed				
		Moderately mixed				
		Highly mixed				
		Chaotic				
	Matrix	Colour	Fresh	*user specify*		
			Weathered	*user specify*		
	Fragments	Typical size	Very small			
			Small			
			Medium			
			Large			
			Very large			
		Maximum size	Small			
			Medium			
			Large			
			Very large			
			Extremely large			
		Abundance of all fragments	<5%			
			5 to 10%			
			10 to 25%			
			25 to 50%			
			>50%			
		Sorting	Indeterminable			
			Poorly sorted			
			Moderately sorted			
			Well sorted			
		Rounding	Very angular			
			Angular			
			Subangular			
			Subrounded			
			Rounded			
			Well rounded			
		Composition	Igneous	Unsubdivided		
				Intrusive	Fine grained	Felsic
						Intermediate
						Mafic
						Ultramafic
					Medium to coarse grained	Granitoid
						Syenitoid
						Dioritoid
						Gabbroid
						Ultramafic
						Anorthositic
						Foid-bearing rock
						Foidolite
					Pegmatitic	
					Other	
				Volcanic	Composition	Felsic
						Intermediate
						Mafic
						Ultramafic
					Lavas	Massive flow
						Pillowed flow
						Lava-related breccia
					Pyroclastic	Tuff
						Lapilli-tuff
						Lapillistone
						Tuff breccia
						Pyroclastic breccia
						Agglomerate
			Sedimentary	Unsubdivided		
				Terrigenous-clastic	Mudstone	
					Sandstone	
					Conglomerate	
				Volcaniclastic	Tuffaceous mudstone	
					Tuffaceous sandstone	
					Tuffaceous conglomerate	
					Tuffaceous breccia	
				Chemical	Carbonate rocks	Calcitic
						Dolomitic
					Siliceous rock	
					Ironstone	Unsubdivided
						Hematite
						Magnetite
						Siderite
						Iron silicate
						Sulphide
					Sulphate rock	
			Metamorphic	Textural	Schist	
					Gneiss	
					Granofels	
					Hornfels	
				Migmatite	Unsubdivided	
					Metatexite	
					Diatexite	
				Compositional	Amphibolite	
					Calc-silicate rock	
					Carbonate-bearing silicate rock	
					Carbonate-silicate rock	
					Marble	
					Eclogite	
					Serpentinite	
				Metasomatic	Fenite	
					Skarn	
				Other		
			Other rock types	Brittle fault rock		
				Cataclasite		
				Mylonite		
				Impact pseudotachylite		
				Impact breccia		
				Impact melt rock		
				Sulphide-bearing		
	Miscellaneous	Shatter cones in fragments				
		Local unit name	Footwall breccia			

¨ Having the texture of slate, i.e., an aphanitic rock with well-developed schistosity, average grain size <0.1 mm (excluding porphyroblasts) (Soller 2004b).
˜ Having the texture of phyllite, i.e., a fine-grained phaneritic rock, well-developed continuous schistosity, silvery sheen on cleavage surfaces, average grain size from 0.1 to 0.25 mm (excluding porphyroblasts) (Soller 2004b).

Table 58. Suevite impact breccia rocks: modifier pick lists.

Suevite Impact Breccia Rocks Modifier Pick Lists						
1	2	3	4	5	6	7
Impactite Rocks						
Suevite	Form	Undetermined				
		Subhorizontal tabular body				
		Irregular body				
	Contacts	Not observed				
		Concordant	Sharp			
			Gradational			
		Discordant	Sharp			
			Gradational			
		Relationship undetermined	Sharp			
			Gradational			
	Unit thickness	Undetermined				
		Thin				
		Medium				
		Thick				
		Very thick				
		Extremely thick				
	Rock Fabric	Megascale	Unfoliated			
			Slaty¨			
			Phyllitic˜			
			Schistose			
		Mesoscale	Unfoliated			
			Slaty¨			
			Phyllitic˜			
			Schistose			
	Structure	Nonbedded				
		Bedding	Thickness	Thinly laminated		
				Thickly laminated		
				Very thinly bedded		
				Thinly bedded		
				Medium bedded		
				Thickly bedded		
				Very thickly bedded		
				Extremely thickly bedded		
			Defined by	Particle composition		
				Particle size		
				Particle shape		
				Particle orientation		
				Particle packing		
				Layer colour		
			Geometry	Parallel	Unsubdivided	
					Planar	Unsubdivided
						Bedding-plane sag
					Wavy	Unsubdivided
						Bedding-plane sag
					Curved	Unsubdivided
						Bedding-plane sag
				Nonparallel	Unsubdivided	
					Planar	Unsubdivided
						Bedding-plane sag
						Draped bedding
					Wavy	Unsubdivided
						Bedding-plane sag
						Draped bedding
					Curved	Unsubdivided
						Bedding-plane sag
						Draped bedding
		Internal depositional structure	Massive			
			Graded bedding	Type	Normal	
					Reverse	
					Symmetrical	Reverse to normal
						Normal to reverse
				Defined by	Grains	
					Fragments	
		Post-depositional structure	Fluid-escape structure	Unsubdivided		
				Degassing pipe		
				Water-escape structure		
			Load structure			
			Slump structure			
			Fold structure (prelithification)			
			Erosional structure	Unsubdivided		
				Angular unconformity		
				Disconformity		
	Matrix	General colour	Fresh	*user specify*		
			Weathered	*user specify*		
	Fragments	Overall variety	Somewhat monolithic			
			Essentially bilithic			
			Largely heterolithic			
		Size ratios	Lapilli > Ash			
			Lapilli < Ash			
			Ash > Blocks & Bombs			
			Ash < Blocks & Bombs			
			Lapilli > Blocks & Bombs			
			Lapilli < Blocks & Bombs			
			Blocks > Bombs			
			Blocks < Bombs			
		Ash-size particles	Size	Fine ash > coarse ash		
				Fine ash ~= coarse ash		
				Fine ash < coarse ash		
			Material	Shards	Type	Unsubdivided
						Bubble wall
						Cuspate
						Platy
						Dark, chloritized
					Abundance	<5%
						5 to 10%
						10 to 25%
						25 to 50%
						>50%
				Crystal particles	Mineralogy	Mafic minerals
						Feldspar
						Quartz
					Size	Fine grained
						Medium grained
						Coarse grained
					‡ Abundance	
				Irresolvable particles	‡ Abundance	
		Lapilli-size fragments	Size	Fine	‡ Abundance	
				Medium	‡ Abundance	
				Coarse	‡ Abundance	
			Sorting	Poorly sorted		
				Moderately sorted		
				Well sorted		
			Roundness	Very angular		
				Angular		
				Subangular		
				Subrounded		
				Rounded		
				Well rounded		
			Overall colour	Fresh	*user input*	
				Weathered	*user input*	
			Type	Shards	Type	Unsubdivided
						Bubble wall
						Cuspate
						Platy
						Dark, chloritized
					‡ Abundance	
				Simple "glasses"	Type	Felsic
						Intermediate
						Mafic
					‡ Abundance	
				Complex "glasses"	Type	Felsic
						Intermediate
						Mafic
					‡ Abundance	
				Aphanitic (melt)	Type	Massive
						Flow layering
					‡ Abundance	
				Lithic	Type	Felsic
						Intermediate
						Mafic
						Ultramafic
						Granitoid
						Syenitoid
						Dioritoid
						Gabbroid
						Anorthositic
						Ultramafic
						Peridotitic
						Pyroxenitic
						Hornblenditic
						Mudstone
						Sandstone
						Arenite
						Quartzite
						Conglomerate
						Sulphide-bearing
						Other
				Composite	Type	Accretionary
						Armoured
						Breccia
						Breccia in breccia
						Cored breccia
						Cored breccia in breccia
						Cored lithic
						Cored aphanitic melt
						Cored flow-layered melt
						Cored welded
						Welded
		Block-size particles	Size	Small	‡ Abundance	
				Medium	‡ Abundance	
				Large	‡ Abundance	
				Very large		
				Extremely large		
			Roundness	Very angular		
				Angular		
				Subangular		
				Subrounded		
				Rounded		
				Well rounded		
			Type	Aphanitic melt	Type	Massive
						Flow layering
						Spherulitic
						Welded
					‡ Abundance	
				Complex "glasses"	Type	Felsic
						Intermediate
						Mafic
					‡ Abundance	
				Lithic	Type	Felsic
						Intermediate
						Mafic
						Ultramafic
						Granitoid
						Syenitoid
						Dioritoid
						Gabbroid
						Anorthositic
						Ultramafic
						Mudstone
						Sandstone
						Arenite
						Quartzite
						Conglomerate
						Sulphide
						Other
				Composite	Type	Accretionary
						Armoured
						Breccia
						Breccia in breccia
						Cored breccia
						Cored breccia in breccia
						Cored lithic
						Cored aphanitic melt
						Cored flow-layered melt
						Cored welded
						Welded
		Bomb-size particles	Size	Small	‡ Abundance	
				Medium	‡ Abundance	
				Large	‡ Abundance	
				Very large		
				Extremely large		
			Roundness	Very angular		
				Angular		
				Subangular		
				Subrounded		
				Rounded		
				Well rounded		
			Type	Aphanitic melt	Type	Massive
						Flow layering
						Spherulitic
						Welded
					‡ Abundance	
				Simple	Type	Unsubdivided
						Breadcrust
						Cow-dung
						Fusiform
						Ribbon
						Rotational
						Spherical
						Spindle-shaped
					‡ Abundance	
				Composite	Type	Cored bomb
						Cored breccia
						Cored breccia in breccia
						Cored lithic
						Cored aphanitic melt
						Cored flow-layered melt
						Cored welded
					‡ Abundance	
	Miscellaneous	Shatter cones in fragments				
		Local unit name	Onaping Formation	Unsubdivided		
				Dowling Member		
				Sandcherry Creek Member		
				Garson Member		

‡ Abundance: same as for Fragments / Ash-size Particles / Material / Shards / Abundance

¨ Having the texture of slate, i.e., an aphanitic rock with well-developed schistosity, average grain size <0.1 mm (excluding porphyroblasts) (Soller 2004b).

˜ Having the texture of phyllite, i.e., a fine-grained phaneritic rock, well-developed continuous schistosity, silvery sheen on cleavage surfaces, average grain size from 0.1 to 0.25 mm (excluding porphyroblasts) (Soller 2004b).

Impact Melt Rocks Modifier Pick Lists

1	2	3	4	5	6	7
Impactite Rocks						
Impact melt rock	Form	Undetermined				
		Dike	Unzoned			
			Zoned			
		Subhorizontal tabular body				
		Irregular body				
	Contacts	Not observed				
		Concordant	Sharp			
			Gradational			
		Discordant	Sharp			
			Gradational			
		Relationship undetermined	Sharp			
			Gradational			
	Unit thickness	Undetermined				
		Thin				
		Medium				
		Thick				
		Very thick				
		Extremely thick				
	Character	Massive				
		Flow layering	Very thin			
			Thin			
			Medium			
			Thick			
			Very thick			
		Melt & breccia mixture				
	Rock Fabric	Megascale	Unfoliated			
			Slaty¨			
			Phyllitic˜			
			Schistose			
		Mesoscale	Unfoliated			
			Slaty¨			
			Phyllitic˜			
			Schistose			
	Matrix	Colour	Fresh	*user specify*		
			Weathered	*user specify*		
		Noncrystalline / aphanitic	Unsubdivided			
			Glassy/microcrystalline			
			Spherulitic			
			Hypocrystalline			
			Holocrystalline			
			Mixed noncrystalline & crystalline			
		Crystalline	Crystal size	Very fine grained		
				Fine grained		
				Medium grained		
				Coarse grained		
				Very coarse grained		
			Crystal habit	Equigranular	Unsubdivided	
					Xenomorphic-granular	
					Hypidiomorphic-granular	
					Idiomorphic-granular	
				Inequigranular		
			Crystal form (specific)	Acicular		
				Acicular daisy		
				Equant		
				Prismatic		
				Sheet		
				Tabular		
			Mineralogy	Olivine	Unsubdivided	
					Fayalite	
					Forsterite	
				Pyroxene	Unsubdivided	
					Clinopyroxene	
					Orthopyroxene	
					Other	
				Amphibole	Unsubdivided	
					Hornblende	
					Other	
				Biotite		
				Feldspar	Unsubdivided	
					K-feldspar	
					Plagioclase	Unsubdivided
						Calcic plagioclase
						Sodic plagioclase
				Feldspathoid	Unsubdivided	
					Nepheline	
					Other	
				Quartz		
				Carbonates	Calcite	
					Dolomite	
					Other	
				Spinel group	Chromite	
					Magnetite	
					Other	
		Texture	Undetermined			
			Homogeneous			
			Heterogeneous			
	Fragments	None				
		Roundness	Very angular			
			Angular			
			Subangular			
			Subrounded			
			Rounded			
			Well rounded			
		Sorting	Poorly sorted			
			Moderately sorted			
			Well sorted			
		Size	Typical	Very small		
				Small		
				Medium		
				Large		
				Very large		
				Extremely large		
			Minimum	Very small		
				Small		
				Medium		
				Large		
				Very large		
				Extremely large		
			Maximum	Very small		
				Small		
				Medium		
				Large		
				Very large		
				Extremely large		
		Abundance of all fragments	<5%			
			5 to 10%			
			10 to 25%			
			25 to 50%			
			>50%			
		Composition	Igneous	Unsubdivided		
				Intrusive	Fine grained	Felsic
						Intermediate
						Mafic
						Ultramafic
					Medium to coarse grained	Granitoid
						Syenitoid
						Dioritoid
						Gabbroid
						Ultramafic
						Anorthositic
						Foid-bearing rock
						Foidolite
					Pegmatitic	
					Other	
				Volcanic	Composition	Felsic
						Intermediate
						Mafic
						Ultramafic
					Lavas	Massive flow
						Pillowed flow
						Lava-related breccia
					Pyroclastic	Tuff
						Lapilli-tuff
						Lapillistone
						Tuff breccia
						Pyroclastic breccia
						Agglomerate
			Sedimentary	Unsubdivided		
				Terrigenous-clastic	Mudstone	
					Sandstone	
					Conglomerate	
				Volcaniclastic	Tuffaceous mudstone	
					Tuffaceous sandstone	
					Tuffaceous conglomerate	
					Tuffaceous breccia	
				Chemical	Carbonate rocks	Calcitic
						Dolomitic
					Siliceous rock	
					Ironstone	Unsubdivided
						Magnetite
						Hematite
						Iron silicate
						Siderite
						Sulphide
					Sulphate rock	
			Metamorphic	Textural	Schist	
					Gneiss	
					Granofels	
					Hornfels	
				Compositional	Amphibolite	
					Calc-silicate rock	
					Carbonate-bearing silicate rock	
					Carbonate-silicate rock	
					Marble	
					Eclogite	
					Serpentinite	
				Migmatite	Unsubdivided	
					Metatexite	
					Diatexite	
				Metasomatic	Fenite	
					Skarn	
				Other		
			Other rock types	Brittle fault rock		
				Cataclasite		
				Mylonite		
				Impact pseudotachylite		
				Impact breccia		
				Impact melt rock		
				Sulphide-bearing		
	Miscellaneous	Local unit name	Sudbury Igneous Complex	Main Mass	Unsubdivided	
					Upper zone	Unsubdivided
						Granite
						Granodiorite
					Middle zone	Unsubdivided
						Quartz monzogabbro
						Quartz gabbro
					Lower zone	Unsubdivided
						Quartz monzogabbro
						Quartz gabbro
					Contact sublayer	Unsubdivided
						Gabbronorite
						Norite
				Offset dike / internal offset dike	Unsubdivided	
					Granodiorite	
					Quartz monzodiorite	
					Quartz diorite	
			Onaping Formation	Onaping intrusion	Quartz diorite	
				Melt Body		
				Melt Dike		

¨ Having the texture of slate, i.e., an aphanitic rock with well-developed schistosity, average grain size <0.1 mm (excluding porphyroblasts) (Soller 2004b).
˜ Having the texture of phyllite, i.e., a fine-grained phaneritic rock, well-developed continuous schistosity, silvery sheen on cleavage surfaces, average grain size from 0.1 to 0.25 mm (excluding porphyroblasts) (Soller 2004b).

Table 62. Structural terms: modifier pick lists.

Structural Terms Modifier Pick Lists

1	2	3	4	5	6	7
Structural Terms	Fabric	Unfoliated				
		General	S-tectonite			
			L-S-tectonite			
			L-tectonite			
	Generation	Undetermined				
		a				
		b				
		c				
		d				
		e				
		0				
		1				
		2				
		3				
		4				
	Planar element	Foliation	Unsubdivided			
			Cleavage	Unsubdivided		
				Continuous	Slaty	
					Phyllitic	
				Spaced	Disjunctive	Unsubdivided
						Fracture
						Pressure solution
					Crenulation	Parallel
						Anastomosing
						Conjugate
			Schistosity	Unsubdivided		
				Poorly developed		
				Moderately developed		
				Well developed	Unsubdivided	
					Protomylonitic	
					Mesomylonitic	
					Ultramylonitic	
			Gneissose structure	Unsubdivided		
				Poorly developed		
				Moderately developed		
				Well developed	Unsubdivided	
					Protomylonitic	
					Mesomylonitic	
					Ultramylonitic	
	Linear element	Lineation	Unsubdivided			
			Boudin / boudin neck			
			Chocolate tablet structure			
			Crenulation			
			Elongation	Clast / fragment		
				Primary feature		
				Other	*user specify*	
			Fold hinge/axis			
			Intersection			
			Mineral			
			Mullion			
			Pencil structure			
			Ribbon structure			
			Rodding			
			Slickenside			
			Slickenfiber			
			Other			
	Fold	Main feature folded	Layering	Primary	Within layer	
					Multiple layers	
					Not specified	
				Nonprimary	Within layer	
					Multiple layers	
					Not specified	
			Foliation	Unsubdivided		
				Cleavage		
				Schistosity		
				Gneissose structure		
			Fracture			
			Dike			
			Vein			
			Fault			
			Shear			
			Other	*user specify*		
		Facing	Not apropos			
			Undefined			
			Anticline			
			Antiform			
			Antiformal syncline			
			Syncline			
			Synform			
			Synformal anticline			
		Orientation (axial plane/axis)*	Unsubdivided			
			Upright/horizontal			
			Upright/plunging			
			Vertical			
			Inclined/horizontal			
			Inclined/plunging			
			Reclined			
			Recumbent			
		Morphology	Asymmetry / symmetry	Undetermined		
				s		
				z		
				n		
				u		
				m		
				w		
			Interlimb angle	Unsubdivided		
				Gentle		
				Open		
				Close		
				Tight		
				Isoclinal		
				Elastica		
		Classification	Basis	Unsubdivided		
				Axial plane / bedding thickness	Parallel	Concentric
						Nonconcentric
					Similar	
				Axial surface continuity	Disharmonic	
					Harmonic	
					Polyharmonic	
			Form	Simple	Box	
					Chevron	
					Cuspate-lobate	
					Cylindrical	
					Drag	
					Fish-hook	
					Intrafolial	
					Kink – contractional	Monoclinal
						Conjugate
					Kink – extensional	Monoclinal
						Conjugate
					Mullion structure	
					Parasitic	
				Complex	Convolute	
					Polyclinal	
					Ptygmatic	
					Sheath	
					Superposed	
				Superposed pattern	Type 0: Redundant	
					Type 1: Dome-Basin	
					Type 2: Dome-Crescent-Mushroom	
					Type 3: Convergent-Divergent	
					Intermediate types	Unspecified
						Between types 0 & 1
						Between types 0 & 2
						Between types 0 & 3
						Between types 1 & 2
						Between types 2 & 3
	Fracture	Fault / fault array	Single			
			Multiple	Unsubdivided		
				En echelon		
				Imbricate		
			Megascopic	Undetermined		
				Back thrust		
				Decollement		
				Detachment		
				Flat		
				Ramp		
				Sole		
				Thrust		
			Mesoscopic	Undetermined		
				Dip-slip	Normal	
					Reverse	
				Oblique-slip		
				Strike-slip		
		Joint	Type	Nonsystematic		
				Systematic	No fold association (layers / strata)	unsubdivided
						conjugate
						orthogonal
					Fold association (layers / strata)	bedding
						cross
						longitudinal
						0kl
						h0l
						hk0
						hkl
				Sheet structure		
				Columnar	Unsubdivided	
					Upper colonnade	
					Entablature	
					Lower colonnade	
			Characteristics	Master	*user specify*	
				Plume structure	*user specify*	
				Typical length	*user specify*	
				Typical spacing	*user specify*	
			Temporal interrelationship	*user specify*		
		Miscellaneous	Anastomosing			
			Spheroidal weathering			
			Zipper			
	Kinematic Indicator	Fabric	S-C fabric			
			S-C-C' fabric			
			C-type shear band			
			C'-type shear band			
		Grains fractured-offset				
		Marker	Deflection			
			Displacement			
		Object rotated	Boudin	Unsubdivided		
				Layering		
				Clast / fragment		
				Dike		
				Vein		
				Other		
			Clast / inclusion			
			Crystal	Unsubdivided		
				Bookshelf sliding		
				Displaced	Unsubdivided	
					Mica fish (porphyroclast)	
			Mantled porphyroclast	Nonwinged object	Theta-type	
				Winged object	Phi-type	
					Sigma-type	
					Delta-type	stair stepping
						no stair stepping
					Complex	stair stepping
						no stair stepping
			Phenocryst			
			Porphyroblast			
		Riedel shears	Unsubdivided			
			Y shear			
			R_1 shear			
			R_2 shear			
			P shear			
		Slickenside steps				
		Strain fringe	Object	Undetermined		
				Clast / fragment		
				Phenocryst		
				Porphyroblast		
				Porphyroclast		
			Fringe material	Unsubdivided		
				Quartz		
				Carbonate		
				Chlorite		
				Feldspar		
				Pyrite		
				Other		
		Strain shadow	Object	Undetermined		
				Clast / fragment		
				Phenocryst		
				Porphyroblast		
				Porphyroclast		
			Shadow material	Unsubdivided		
				Quartz		
				Carbonate		
				Chlorite		
				Feldspar		
				Pyrite		
				Other		
		Veins	Sigmoidal			
		Vergence	Cleavage	Dextral		
				Sinistral		
				Neutral		
				Coplanar (undefined)		
			Fold	Dextral		
				Sinistral		
				Neutral		
	Sense of shear / direction	Undetermined				
		None				
		Object rotation	Clockwise	Antithetic		
				Synthetic		
			Counter clockwise	Antithetic		
				Synthetic		
		Strike-slip component	Undetermined			
			None			
			Dextral			
			Sinistral			
		Dip-slip component	Undetermined			
			None			
			Hanging wall (0<dip<90)	Down	to N	
					to NE	
					to E	
					to SE	
					to S	
					to SW	
					to W	
					to NW	
				Up	to N	
					to NE	
					to E	
					to SE	
					to S	
					to SW	
					to W	
					to NW	
			Horizontal plane	Top	Undetermined	
					to N	
					to NE	
					to E	
					to SE	
					to S	
					to SW	
					to W	
					to NW	
			Vertical plane	Down side	Undetermined	
					to N	
					to NE	
		Trend			to E	
		Plunge			to SE	
					to S	
					to SW	
					to W	
					to NW	
Symbol^	Planar element^	Bedding	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Igneous layering	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Igneous contact	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Compositional layering	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Compositional layering and foliation	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Foliation	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Cleavage	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Crenulation cleavage	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Displacement cleavage	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Brittle fault	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Brittle-ductile fault	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Ductile fault	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Axial plane fold	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Axial plane kink fold	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Fracture	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Joint	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
		Vein	*user specify*	Strike	*user specify*	
				Dip	*user specify*	
	Linear element^	Primary	*user specify*	Trend	*user specify*	
				Plunge	*user specify*	
		Paleocurrent	*user specify*	Trend	*user specify*	
				Plunge	*user specify*	
		Crenulation	*user specify*	Trend	*user specify*	
				Plunge	*user specify*	
		Intersection	*user specify*	Trend	*user specify*	
				Plunge	*user specify*	
		Slickenside	*user specify*	Trend	*user specify*	
				Plunge	*user specify*	
		Fold axis	*user specify*	Trend	*user specify*	
				Plunge	*user specify*	
		Kink fold axis	*user specify*	Trend	*user specify*	
				Plunge	*user specify*	
		Boudin neck	*user specify*	Trend	*user specify*	
				Plunge	*user specify*	
		Elongation	*user specify*	Trend	*user specify*	
				Plunge	*user specify*	
		Mineral	*user specify*	Trend	*user specify*	
				Plunge	*user specify*	
		Shattercone	*user specify*	Trend	*user specify*	
				Plunge	*user specify*	
		Other	*user specify*	Trend	*user specify*	
				Plunge	*user specify*	

* For a graphical depiction of this fold orientation terminology, see Figures 1 and 2 in Muir, Watkins and Berdusco (2000).
^ For symbols and acronyms, use Jackson, Muir and Romkey (1995); Muir (1995)

Table 64. Alteration terms: modifier pick lists.

Alteration Terms Modifier Pick Lists							
1	2	3	4	5	6	7	8
Alteration terms	Generation	Unspecified					
		a					
		b					
		c					
		d					
		e					
		1					
		2					
		3					
		4					
		5					
	Form	Pervasive	Type	Saturated			
				Disseminated			
				Saprolite			
				Paleosol			
			Alt'n assemblage*	Undetermined			
				Carbonate	Unsubdivided		
					Ankerite		
					Calcite		
					Dolomite		
					Magnesite		
				Oxide	Unsubdivided		
					Corundum		
					Hematite		
					Magnetite		
				Silicate	Unsubdivided		
					Aluminosilicates	Unsubdivided	
						Andalusite	
						Kyanite	
						Sillimanite	
					Amphibole	Unsubdivided	
						Actinolite-tremolite	
						Cummingtonite-grunerite	
						Hornblende	
						Anthophyllite-gedrite	
						Other	
					Chloritoid		
					Cordierite		
					Epidote group		
					Feldspar	Unsubdivided	
						Alkali feldspar	Unsubdivided
							Potassic
							Sodic
						Plagioclase	
					Garnet group		
					Phyllosilicates	Unsubdivided	
						Biotite-phlogopite	
						Chlorite	
						Green muscovite	
						Muscovite	
						Pyrophyllite	
						Sericite-paragonite	
					Pyroxene	Unsubdivided	
						Clinopyroxene	
						Orthopyroxene	
					Scapolite		
					Tourmaline		
				Sulphate	Unsubdivided		
					Alunite		
					Barite		
			Specifics	Relationship to stratigraphy	Undetermined		
					Inapplicable		
					Concordant		
					Paraconcordant		
					Discordant		
				Intensity	Very weak		
					Weak		
					Weak to moderate		
					Moderate		
					Moderate to strong		
					Strong		
					Intense		
				Boundary definition	Undetermined		
					Diffuse	Unspecified	
						Straight	
						Irregular	
					Gradational	Unspecified	
						Straight	
						Irregular	
					Sharp	Unspecified	
						Straight	
						Irregular	
				Textural preservation	High		
					Medium		
					Low		
					Obliterated		
				Texture	Replacement	Layering	
						Crystals	Groundmass
							Phenocrysts
							Porphyroblasts
						Fragments/clasts	
						Pseudobreccia	
						Other	
					Grain size	Aphanitic	
						Very fine grained	
						Fine	
						Medium	
						Coarse	
						Very coarse	
						Extremely coarse	
					Crystal habit	Equant	
						Prismatic	Unsubdivided
							Acicular
							Columnar
							Fibrous
						Tabular	Unsubdivided
							Bladed
							Platy
							Sheet
						Other	Unsubdivided
							Botryoidal
							Colloform
							Dendritic
							Mammillary
							Massive
							Plumose
							Radiating
							Reticulated
				Colour	Uniformity	Uniform	
						Motley	
						Varicoloured	
					Hue/saturation	*user specify*	
		Nonpervasive	Type	Disseminated			
				Cleavage controlled			
				Fault controlled			
				Fracture controlled			
				Intrusion controlled			
				Layer controlled			
				Shear controlled			
				Vein controlled			
				Boudin neck			
				Core			
				Domainal			
				Halo			
				Irregular			
				Mantle			
				Patchy			
				Porphyroblasts			
				Porphyroclasts			
				Pseudomorphs			
				Selvage			
				Spotty			
				Zonal			
				Other			
			Alt'n assemblage*	Undetermined			
				Carbonate	Unsubdivided		
					Ankerite		
					Calcite		
					Dolomite		
					Magnesite		
				Oxide	Unsubdivided		
					Corundum		
					Hematite		
					Magnetite		
				Silicate	Unsubdivided		
					Aluminosilicates	Unsubdivided	
						Andalusite	
						Kyanite	
						Sillimanite	
					Amphibole	Unsubdivided	
						Actinolite-tremolite	
						Cummingtonite-grunerite	
						Hornblende	
						Anthophyllite-gedrite	
						Other	
					Chloritoid		
					Cordierite		
					Epidote group		
					Feldspar	Unsubdivided	
						Alkali feldspar	Unsubdivided
							Potassic
							Sodic
						Plagioclase	
					Garnet group		
					Phyllosilicates	Unsubdivided	
						Biotite-phlogopite	
						Chlorite	
						Green muscovite	
						Muscovite	
						Pyrophyllite	
						Sericite-paragonite	
					Pyroxene	Unsubdivided	
						Clinopyroxene	
						Orthopyroxene	
					Scapolite		
					Tourmaline		
				Sulphate	Unsubdivided		
					Alunite		
					Barite		
			Specifics	Relationship to stratigraphy	Undetermined		
					Inapplicable		
					Concordant		
					Paraconcordant		
					Discordant		
			Fractures / faults	Sets	Single		
					Multiple		
				Style	Ladder		
					En echelon		
					Conjugate		
					Other		
				Abundance	Sparse		
					Several		
					Numerous		
				Spacing	*user specify*		
				Length	*user specify*		
			Wall rock	Boundary definition	Undetermined		
					Diffuse	Unspecified	
						Straight	
						Irregular	
					Gradational	Unspecified	
						Straight	
						Irregular	
					Sharp	Unspecified	
						Straight	
						Irregular	
				Intensity	Very weak		
					Weak		
					Weak to moderate		
					Moderate		
					Moderate to strong		
					Strong		
					Intense		
				Width of alteration	*user specify*		
				Textural preservation	High		
					Medium		
					Low		
					Obliterated		
				Texture	Replacement	Layering	
						Crystals	Groundmass
							Phenocrysts
							Porphyroblasts
						Fragments/clasts	
						Pseudobreccia	
						Other	
					Grain size	Aphanitic	
						Fine	
						Medium	
						Coarse	
						Very coarse	
						Extremely coarse	
					Crystal habit	Equant	
						Prismatic	Unsubdivided
							Acicular
							Columnar
							Fibrous
						Tabular	Unsubdivided
							Bladed
							Platy
							Sheet
						Other	Unsubdivided
							Botryoidal
							Colloform
							Dendritic
							Mammillary
							Massive
							Plumose
							Radiating
							Reticulated
				Colour	Uniformity	Uniform	
						Motley	
						Variegated	
					Hue/saturation	*user specify*	
		Veins	Min assemblage^	Undetermined			
				Quartz			
				Carbonate			
				Quartz-carbonate			
				Amphibole			
				Epidote			
				Hematite			
				Magnetite			
				Phyllosilicate	Biotite		
					Chlorite		
					Muscovite		
				Tourmaline			
				Other			
			Specifics	Relationship to stratigraphy	Undetermined		
					Inapplicable		
					Concordant		
					Paraconcordant		
					Discordant		
				Sets	Single		
					Multiple		
				Style	Ladder		
					En echelon		
					Conjugate		
					Stockwork		
					Other		
				Type	Nonfibrous	Unsubdivided	
						Cockade	
						Comb texture	
						Crack-seal growth	
						Crustified	
						Massive	
						Zoned	
					Fibrous	Unsubdivided	
						Antitaxial growth	
						Ataxial growth	
						Composite growth	
						Syntaxial growth	
				Boundary definition	Diffuse		
					Sharp		
				Abundance	Sparse		
					Several		
					Numerous		
				Intensity (alteration)	Very weak		
					Weak		
					Weak to moderate		
					Moderate		
					Moderate to strong		
					Strong		
					Intense		
				Spacing	*user specify*		
				Thickness	*user specify*		
				Length	*user specify*		
				Texture	Grain size	Aphanitic	
						Fine	
						Medium	
						Coarse	
						Very coarse	
						Extremely coarse	
					Crystal habit	Equant	
						Prismatic	Unsubdivided
							Acicular
							Columnar
							Fibrous
						Tabular	Unsubdivided
							Bladed
							Platy
							Sheet

* Alt'n = Alteration
^ Min = Mineral

Table 67. Mineralization terms: modifier pick lists.

Mineralization Terms Modifier Pick Lists

1	2	3	4	5	6	7	8
Mineralization terms	Generation	Unspecified					
		a					
		b					
		c					
		d					
		e					
		1					
		2					
		3					
		4					
		5					
	Form	Massive	Lustre	Metallic			
				Submetallic			
				Nonmetallic			
				Mixed			
			Min'n assemblage^	Undetermined			
				Carbonate	Unsubdivided		
					Azurite		
					Magnesite		
					Malachite		
				Element	Unsubdivided		
					Copper		
					Gold		
					Graphite		
					Silver		
				Halide	Unsubdivided		
					Fluorite		
				Oxide	Unsubdivided		
					Cassiterite		
					Chromite		
					Columbite-tantalite		
					Corundum		
					Cuprite		
					Ilmenite		
					Magnetite		
					Specularite		
					Uraninite		
				Phosphate	Unsubdivided		
					Apatite		
				Silicate	Unsubdivided		
					Amethyst		
					Beryl		
					Labradorite		
					Lepidolite		
					Sodalite		
					Spodumene		
					Topaz		
					Wollastonite		
				Sulphate	Unsubdivided		
					Barite		
				Sulphide	Unsubdivided		
					Common	Unsubdivided	
						Arsenopyrite	
						Chalcopyrite	
						Galena	
						Molybdenite	
						Pentlandite	
						Pyrite	
						Pyrrhotite	
						Sphalerite	
					Uncommon	Unsubdivided	
						Acanthite	
						Bornite	
						Boulangerite	
						Bournonite	
						Chalcocite	
						Cinnabar	
						Cobaltite	
						Covellite	
						Cubanite	
						Digenite	
						Enargite	
						Millerite	
						Nickeline	
						Orpiment	
						Realgar	
						Skutterudite	
						Stibnite	
						Tennantite	
						Tetrahedrite	
				Tungstate	Unsubdivided		
					Scheelite		
					Wolframite		
			Specifics	Mineral form	Botryoidal		
					Colloform		
					Mammilary		
					Reniform		
				Colour	Uniformity	Uniform	
						Motley	
						Variegated	
					Hue/saturation	*user entry*	
				Relationship to stratigraphy	Undetermined		
					Inapplicable		
					Concordant		
					Paraconcordant		
					Discordant		
				Stages	Undetermined		
					Single		
					Multiple		
				Boundary definition	Undetermined		
					Diffuse	Unspecified	
						Straight	
						Irregular	
					Gradational	Unspecified	
						Straight	
						Irregular	
					Sharp	Unspecified	
						Straight	
						Irregular	
				Thickness	*user specify*		
				Length	*user specify*		
		Nonmassive	Lustre	Metallic			
				Submetallic			
				Nonmetallic			
				Mixed			
			Type	Disseminated			
				Cleavage controlled			
				Fault controlled			
				Fracture controlled			
				Intrusion controlled			
				Layer controlled			
				Shear controlled			
				Vein controlled			
				Boudin neck			
				Core			
				Domainal			
				Halo			
				Mantle			
				Irregular			
				Patchy			
				Porphyroblasts			
				Porphyroclasts			
				Pseudomorphs			
				Selvage			
				Spotty			
				Zonal			
				Other			
			Min'n assemblage*				
			Specifics	Colour	Uniformity	Uniform	
						Motley	
						Variegated	
					Hue/saturation	User entry	
				Relationship to stratigraphy	Undetermined		
					Inapplicable		
					Concordant		
					Paraconcordant		
					Discordant		
			Fractures / faults	Sets	Single		
					Multiple		
				Style	Ladder		
					En echelon		
					Conjugate		
					Other		
				Abundance	Sparse		
					Several		
					Numerous		
				Spacing	*user specify*		
				Length	*user specify*		
			Wall rock	Boundary definition	Undetermined		
					Diffuse	Unspecified	
						Straight	
						Irregular	
					Gradational	Unspecified	
						Straight	
						Irregular	
					Sharp	Unspecified	
						Straight	
						Irregular	
				Width of mineralization	*user specify*		
				Texture	Preservation	High	
						Medium	
						Low	
						Obliterated	
					Replacement	Layering	
						Crystals	Groundmass
							Phenocrysts
							Porphyroblasts
						Fragments/clasts	
						Pseudobreccia	
						Other	
				Colour	Uniformity	Uniform	
						Motley	
						Variegated	
					Hue/saturation	*user specify*	
		Veins	Lustre	Metallic			
				Submetallic			
				Nonmetallic			
				Mixed			
			Min'n assemblage*				
			Specifics	Relationship to stratigraphy	Undetermined		
					Inapplicable		
					Conformable		
					Paraconformable		
					Discordant		
				Sets	Single		
					Multiple		
				Style	Ladder		
					En echelon		
					Conjugate		
					Stockwork		
					Stringer		
					Other		
				Type	Nonfibrous	Cockade	
						Comb texture	
						Crack-seal growth	
						Crustified	
						Massive	
						Zoned	
					Fibrous	Unsubdivided	
						Antitaxial growth	
						Ataxial growth	
						Composite growth	
						Syntaxial growth	
				Abundance	Inappropriate		
					Sparse		
					Several		
					Numerous		
					Plentiful		
				Spacing	*user specify*		
				Thickness	*user specify*		
				Length	*user specify*		
				Colour	Uniformity	Uniform	
						Motley	
						Variegated	
					Hue/saturation	*user specify*	
				Texture	Grain size	Aphanitic	
						Very fine	
						Fine	
						Medium	
						Coarse	
						Very coarse	
						Extremely coarse	
					Crystal habit	Equant	
						Prismatic	Unsubdivided
							Acicular
							Columnar
							Fibrous
						Tabular	Unsubdivided
							Bladed
							Platy
							Sheet

^ Min'n = Mineralization
* Min'n assemblage: same as for Form / Massive / Min'n assemblage

Table 71. Minerals included in pick lists: chief characteristics.

Minerals Included in Pick Lists: Chief Characteristics

Mineral	Abbreviation [*]	Class-Subclass / Group / Subgroup	Crystal System	Basic Formula [+]	Principal Colours	Hardness	Lustre	Principal Habits	Cleavage	Key Fracture	Typical Twinning	Key Features	Relationship / Member	Mindat [¤]	AGI [¤]	Wiki [¤]	BM [¤]	DHZ [¤]
acanthite	Acn	sulphide / - / -	monoclinic	Ag_2S	iron black	2 - 2.5	metallic	-crystals rare, prismatic, tabular; may be paramorphic after cubic high-temperature phase "argentite"	indistinct	uneven	polysynthetic		dimorphous with argentite, which is unstable below 179°C	x	x	x	x	
actinolite	Act	inosilicate / amphibole / clinoamphibole	monoclinic	$Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$	green, greenish black, grey green, black	5 - 6	silky, vitreous	-aggregates of long prismatic crystals; fibrous, radiated, columnar	distinct, good		simple or lamellar	may be asbestiform	actinolite-tremolite series	x	x	x		
adularia	Adl	tectosilicate / feldspar / alkali feldspar	monoclinic	$KAlSi_3O_8$	colourless, white, grey, yellow, pink	6 - 6.5	vitreous, pearly	pseudo-orthorhombic				found in some low-temperature hydrothermal deposits and schists	low- to moderate-temperature form of potassium (alkali) feldspar	x	x	x		
albite	Ab	tectosilicate / feldspar / plagioclase	triclinic	$NaAlSi_3O_8$	white to grey	6 - 6.5	vitreous		perfect	irregular, uneven	polysynthetic striae		Na-rich end member of albite-anorthite series and the albite-sanidine series; An_{0-10}	x	x		x	
alkali-feldspar	Afs	tectosilicate / feldspar / alkali feldspar	monoclinic, triclinic	$(K,Na)AlSi_3O_8$									-potassic-sodic feldspars with little calcium -includes microcline, orthoclase, sanidine, adularia, albite, anorthoclase, (plagioclase An <20%)	x	x		x	x
allanite (group)	Aln	sorosilicate / epidote / allanite	monoclinic	$CaCe(Al,Fe^{2+})_3(SiO_4)_3(O,OH)$	dark brown, violet brown, black	5.5 - 6	vitreous, resinous	prismatic	imperfect	irregular, uneven	polysynthetic		subgroup of epidote group: includes allanite-Ce, allanite-La, allanite-Y	x		x		
almandine	Alm	neosilicate / garnet / pyralspite	isometric	$Fe_3^{2+}Al_2(SiO_4)_3$.	deep red, brownish red	7 -7.5	vitreous, resinous	dodecahedral	none	subconchoidal		form, colour, hardness	almandine-pyrope series almandine-spessartine series	x	x	x		
aluminosilicates	Als	neosilicate / aluminosilicate / -	orthorhombic, triclinic	Al_2SiO_5									-silicate with Al substituting for some Si in SiO_4 tetrahedra -polymorphs: kyanite, andalusite, sillimanite	x	x		x	
alunite	Alu	sulphate / - / -	trigonal	$KAl_3(SO_4)_2(OH)_6$.	white, pale greyish	3.5 - 4	vitreous, pearly	massive, granular, dense; rarely small rhombohedra	distinct, good	irregular, uneven			typically associated with acid-sulphate epithermal alteration	x	x		x	
amethyst	Amy	tectosilicate / quartz / -	hexagonal	SiO_2	purple to pale violet	7	vitreous	prismatic, pyramidal terminations	poor, indistinct	conchoidal	uncommon	colour, habit, hardness	defined by specific colour		x	x	x	
amphibole (group)	Amp	inosilicate / amphibole / -	orthorhombic, monoclinic	general formula[+]: $\mathbf{AB}_2\mathbf{C}_5((Si, Al, Ti)_8O_{22})(OH,F,Cl,O)_2$									major group; subgroups are clinoamphibole and orthoamphibole	x	x	x	x	x
andalusite	And	neosilicate / aluminosilicate / -	orthorhombic	Al_2SiO_5	pink to red brown, yellow, green, grey	6.5 - 7.5	vitreous, subvitreous	prismatic, nearly square cross-section	distinct, good	irregular, uneven	rare	habit	trimorphous with kyanite, sillimanite	x	x		x	
andesine	—	tectosilicate / feldspar / plagioclase	triclinic	$(Na,Ca)(Al,Si)AlSi_2O_8$	white, grey, green	6 - 6.5	subvitreous, pearly	tabular; irregular grains	perfect, good	uneven, conchoidal	common, polysynthetic		lower-mid range of the albite-anorthite series; An_{30-50}	x	x		x	
andradite	Adr	neosilicate / garnet / ugrandite	isometric	$Ca_3Fe_2^{3+}(SiO_4)_3$	yellow to green	6.5 - 7	adamantine, resinous	dodecahedral	none	irregular, uneven			andradite-grossular series; andradite-schorlomite series	x		x	x	x
anhydrite	Anh	sulphate / - / -	orthorhombic	$CaSO_4$	colourless, bluish, grey to dark grey	3 - 3.5	vitreous, greasy	usually massive; fine granular, fibrous, radiated, plumose	perfect (3 directions)	irregular, uneven			anhydrous calcium sulphate (gypsum)	x	x		x	
ankerite	Ank	carbonate / dolomite / -	trigonal	$Ca(Fe^{2+},Mg,Mn^{2+})(CO_3)_2$	brown, white to grey	3.5 - 4	vitreous, pearly		perfect	subconchoidal	simple			x		x	x	
anorthite	An	tectosilicate / feldspar / plagioclase	triclinic	$CaAl_2Si_2O_8$	white to greyish	6 - 6.5	vitreous		perfect	irregular, uneven	polysynthetic		Ca-rich end member of albite-anorthite series; An_{90-100}	x		x		
anorthoclase	Ano	tectosilicate / feldspar / alkali feldspar	triclinic	$(Na,K)AlSi_3O_8$	white, colourless, greyish pink	6 - 6.5	vitreous to pearly	short prismatic, tabular, rhombic	perfect	uneven	polysynthetic		intermediate member of the high albite-sanidine solid solution series; Na:K ~ 1.70 to 9	x	x	x		
anthophyllite	Ath	inosilicate / amphibole / orthoamphibole	orthorhombic	$(Mg,Fe^{2+})_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$	white, greenish grey, brownish	5.5 - 6	vitreous, pearly		perfect	conchoidal			dimorphous with cummingtonite	x	x		x	
antigorite	Atg	phyllosilicate / serpentine / -	monoclinic	$Mg_3Si_2O_5(OH)_4$	green, green blue, apple green, white, brown black	3.5 - 4	vitreous, greasy	columnar	distinct, good	splintery		habit	polymorphous with chrysotile and lizardite	x	x	x		x
apatite	Ap	phosphates / - / -	hexagonal	$Ca_5(PO_4)_3(F,OH,Cl)$	green, bluish & greyish green	5	vitreous	tabular, prismatic, massive, granular	indistinct	conchoidal to uneven			-group of phosphate minerals: if unspecified, generally refers to fluorapatite #5 on Mohs hardness scale		x	x	x	
argentite	—	see "Relationship / Member"											outdated term – see acanthite					
arsenopyrite	Apy	sulphide / - / -	monoclinic	$FeAsS$	silver white to steel-grey	5.5 - 6	metallic	flat tabular to blocky, prismatic, striated faces	distinct, good	irregular, uneven				x		x	x	
augite	Aug	inosilicate / pyroxene / clinopyroxene	monoclinic	$(Ca,Na)(Mg,Fe^{2+},Al,Fe^{3+},Ti)[(Si,Al)_2O_6]$	brown green, black to green black	5.5 - 6	vitreous, resinous	stubby, prismatic	distinct, good	irregular, uneven	simple	habit; 2 prominent cleavages	-other variations: ferroaugite, subcalcic augite, subcalcic ferroaugite	x				
axinite (group)	Ax	cyclosilicate / - / -	triclinic	$(Ca,Mn,Fe)_3Al_2(BO_3)Si_4O_{12}(OH)$	brown, lilac brown, dark brown, plum blue, pale blue, golden yellow	6 - 7	vitreous	flattened, granular, massive			rare		group name for varieties of Fe, Mg and Mn borosilicates	x				
azurite	Az	carbonate / - / -	monoclinic	$Cu_3(CO_3)_2(OH)_2$	azure, blue	3.5 - 4	vitreous	tabular, prismatic	perfect	conchoidal	rare	colour		x			x	
barite	Brt	sulphate / barite / -	orthorhombic	$BaSO_4$	colourless, white	3 - 3.5	vitreous	prismatic	perfect	irregular, uneven		high density (4.5 g/cm^3)	recommended spelling is baryte (IMA^)	x	x	x		
barite group	—												includes: barite, celestite, anglesite					
beryl	Brl	cyclosilicate / beryl / -	hexagonal	$Be_3Al_2(Si_6O_{18})$	green, blue, yellow	7.5 - 8	vitreous, waxy	prismatic				gem varieties: dark green – emerald; pale blue green – aquamarine		x	x			
biotite	Bt	phyllosilicate / mica / -	monoclinic	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$	dark green, brown or black	2.5 (on cleavage)	vitreous, pearly	pseudohexagonal	perfect basal			cleavage flakes	biotite is now considered a series that includes phlogopite (K,Mg_3), siderophyllite (K,Fe^{2+}), annite (K,Fe_3^{2+}) and eastonite (K,Mg_2)	x		x	x	
bornite	Bn	sulphide / - / -	orthorhombic	Cu_5FeS_4	copper-like to brown; tarnish iridescent purplish	3	metallic	cubic, dodecahedral	poor, indistinct	conchoidal	penetration	colour		x			x	
boulangerite	Bl	sulphide / - / -	monoclinic	$Pb_5Sb_4S_{11}$	lead grey	2.5 - 3	metallic	acicular, plumose	distinct, good					x			x	
bournonite	Bou	sulphide / - / -	orthorhombic	$PbCuSbS_3$	steel grey	2.5 - 3	metallic	short prismatic	imperfect	irregular, uneven, subconchoidal	common			x			x	
brucite	Brc	hydroxide / - / -	trigonal	$Mg(OH)_2$	white, light greenish	2.5 - 3	vitreous, waxy	broad tabular, subparallel aggregates of plates; massive, fibrous	perfect	fibrous, micaceous				x			x	
bytownite	—	tectosilicate / feldspar / plagioclase	triclinic	$(Na,Ca)[Al(Si,Al)Si_2O_8]$	grey, greenish grey, white	6 - 6.5	subvitreous	tabular; irregular grains	perfect, good	step-like	common, polysynthetic		upper An range of the albite-anorthite series; An_{70-90}	x			x	
calcite	Cal	carbonate / calcite / -	trigonal	$CaCO_3$	white, yellow, red	3	vitreous, pearly	multiple	perfect	irregular, uneven	4 twin laws		#3 on Mohs hardness scale	x	x	x	x	
calcite group	—												includes calcite, magnesite, rhodochrosite, siderite, smithsonite					
carbon group	—												includes diamond, graphite					
carbonate (group)	Cb												includes calcite group, aragonite group (latter not included in this table)					
cassiterite	Cst	oxide / rutile / -	tetragonal	SnO_2	black, yellow, brown, red, white	6 - 7	adamantine, greasy	short to long prismatic	imperfect	irregular, uneven	common			x			x	
celestine	Clt	sulphate / barite / -	orthorhombic	$SrSO_4$	colourless to pale blue	3 - 3.5	vitreous, pearly	thin to thick tabular	perfect	irregular, uneven				x	x			
chalcocite	Cct	sulphide / - / -	monoclinic	Cu_2S	blue black, grey, black	2.5 - 3	metallic	prismatic, thick tabular	poor, indistinct	conchoidal	common			x			x	
chalcopyrite	Ccp	sulphide / - / -	tetragonal	$CuFeS$	brass yellow; iridescent tarnish	3.5 - 4	metallic	equant to wedge-shaped tetragonal	poor, indistinct	irregular, uneven	penetration			x			x	
chert	Cht	tectosilicate / quartz / -	hexagonal, trigonal	SiO_2	grey, white	6.5 - 7	waxy, dull	microcrystalline, cryptocrystalline	none	splintery, conchoidal			quartz or fibrous chalcedony	x	x			
chlorite	Chl	phyllosilicate / chlorite / -	monoclinic	$(Mg,Fe^{2+})_5Al_2Si_3O_{10}(OH)_8$	greenish; may be blackish, bluish, yellowish	2 - 2.5	greasy, pearly, dull	pseudohexagonal	perfect				"chlorite" is the name for a group of species (commonly clinochlore (Mg-rich), chamosite (Fe-rich)) but is used here as an inclusive field name	x	x			
chloritoid	Cld	nesosilicate/ - / -	monoclinic, triclinic	$(Fe^{2+},Mg,Mn^{2+})Al_2(SiO_4)O(OH)_2$	dark green to dark grey	6.5	vitreous, pearly	thin to thick plates or massive aggregates, micaceous crystals	perfect		polysynthetic			x	x	x		
chondrodite	Chn	nesosilicate / humite / -	monoclinic	$(Mg,Fe^{2+})_5(SiO_4)_2(F,OH)_2$	yellow, red, brown	6 - 6.5	vitreous, resinous	flattened, granular, massive	poor, indistinct		simple, lamellar			x				x
chromite	Chr	oxide / spinel / -	isometric	$Fe^{2+}Cr_2O_4$	black, brownish black	5.5	metallic	massive; finely granular, also octahedral		irregular, uneven			2 series of chromite: hercynite (Fe^{2+}); magnesiochromite (Mg(Cr,Al,Fe))	x	x		x	
chrysotile	Ctl	phyllosilicate / serpentine / -	various	$Mg_3Si_2O_5(OH)_4$	greenish, white, grey	2.5	silky	asbestiform, fibrous				habit: most important type of asbestos	polytypes are clinochrysotile (most common), orthochrysotile, parachrysotile	x				
cinnabar	Cin	sulphide / - / -	trigonal	HgS	reddish, brownish red	2 - 2.5	adamantine	rhombohedral or thick tabular to short prismatic	perfect	irregular, uneven	common	colour, cleavage		x			x	
clay minerals	—	phyllosilicate / clay / -	monoclinic, triclinic	various									clay minerals is a term for a group of subgroups (kandites [kaolinites], illites, smectites and vermiculites) that cannot generally be identified in the field					x
clinoamphibole	Cam	inosilicate / amphibole / -	monoclinic	various									includes hornblende, cummingtonite, grunerite, tremolite, actinolite, riebeckite, glaucophane, arfvedsonite		x			
clinopyroxene	Cpx	inosilicate / pyroxene / -	monoclinic	various									includes diopside, hedenbergite, clinoenstatite, clinohypersthene, clinoferrosilite, augite, acmite, pigeonite, spodumene, jadeite, omphacite		x			
clinozoisite	Czo	sorosilicate / epidote / -	monoclinic	$Ca_2Al_3(Si_3O_{12})(OH)$	colourless, green, grey	7	vitreous	elongate, massive, fibrous or granular	perfect	irregular, uneven				x			x	x
cobaltite	Cbt	sulphide / - / -	orthorhombic	$CoAsS$	reddish silver white, steel grey	5.5	metallic	cubic, pyritohedrons	perfect	irregular, uneven	common			x		x		
columbite-tantalite	Col	oxide / - / -	orthorhombic	$(Fe,Mn)(Nb,Ta)_2O_6$	iron black to brownish black; commonly iridescent tarnish	6 - 6.5	submetallic, subresinous	short prismatic	distinct	subconchoidal	contact twins, repeated twins		-has been considered as the group name for the columbite-tantalite near-solid solution series or more specifically the Fe-Mn series -terms columbite and tantalite are now considered obsolete by the IMA^, but used here as a field term	x			x	
copper	Cu [†]	element / copper / -	isometric	Cu	copper red; tarnishes to black or green	2.5 - 3	metallic	cubic, octahedral (rare)				colour, hardness (ductile, malleable)					x	
copper group	—												includes: copper, gold, silver				x	
cordierite	Crd	cyclosilicate / - / -	orthorhombic	$(Mg,Fe^{2+})_2Al_4Si_5O_{18}$	grey, blue, blue violet	7 - 7.5	vitreous	massive or irregular grains, can be pseudohexagonal	imperfect, fair	subconchoidal								
corundum	Crn	oxide / hematite / -	trigonal	Al_2O_3	colourless, white, blue, red, pink, yellow	9	adamantine, vitreous	tabular to short prismatic; also shapeless grains		irregular, uneven		gem varieties: ruby, sapphire	#9 on Mohs hardness scale	x			x	
covellite	Cv	sulphide / - / -	hexagonal	CuS	indigo blue or darker; often iridescent	1.5 - 2	submetallic	crystals rare – hexagonal plates	perfect	irregular, uneven				x			x	
cubanite	Cbn	sulphide / - / -	orthorhombic	$CuFe_2S_3$	brass to bronze yellow	3.5	metallic	elongated, thick tabular		conchoidal	common			x		x		
cummingtonite	Cum	inosilicate / amphibole / clinoamphibole	monoclinic	$(Fe,Mg)_7 Si_8O_{22}(OH)_2$	pale to dark brown, translucent dark green	5 - 6	vitreous		perfect	acicular or fibrous	simple, lamellar	may be asbestiform	Mg end member of the cummingtonite-grunerite series					
cuprite	Cpr	oxide / - / -	isometric	Cu_2O	dark red to cochineal red	3.5 - 4	adamantine, submetallic, earthy	octahedral, dodecahedral, granular	imperfect, fair	conchoidal				x			x	
diamond	Dia	element / carbon / -	isometric	C	wide variety	10	adamantine, greasy	octahedral	perfect	irregular, uneven	common	hardness; gem variety: diamond	#10 on Mohs hardness scale	x			x	
diaspore	Dsp	hydroxide / diaspore / -	orthorhombic	$AlO(OH)$	white, brown, colourless	6.5 - 7	vitreous, pearly	thin platy, tabular, acicular	perfect	conchoidal				x			x	
digenite	Dg	sulphide / - / -	trigonal	Cu_9S_5	grey to greyish black	2.5 - 3	metallic	massive, pseudocubic	poor, indistinct	conchoidal				x		x		
diopside	Di	inosilicate / pyroxene / clinopyroxene	monoclinic	$MgCaSi_2O_6$	light to dark green, brown, colourless	5.5 - 6.5	vitreous, dull	short prismatic	distinct, good	irregular, uneven			forms solid solution series with augite and hedenbergite	x			x	
dolomite	Dol	carbonate / dolomite / -	trigonal	$CaMg(CO_3)_2$	colourless, white, grey	3.5 - 4	vitreous, pearly	rhombohedral, prismatic, commonly striated	perfect	subconchoidal	common			x			x	
dolomite group	—	carbonate / dolomite / -	trigonal	general formula[+]: $Ca\mathbf{D}^{2+}(CO_3)_2$									-includes ankerite, dolomite, kutnohorite & minrecordite -results from substitution of some Ca by Mg, Fe, or Mn	x			x	
dravite	Drv	cyclosilicate / tourmaline / -	trigonal	$Na(Mg_3)Al_6(Si_6O_{18})(BO_3)_3(OH)_4$	pale brown to dark brown	7	vitreous, resinous	equant, short to long prismatic; striated	poor, indistinct	irregular, uneven, conchoidal	rare			x	x	x		
elbaite	Elb	cyclosilicate / tourmaline / -	trigonal	$Na(Li_{1.5}Al_{1.5})Al_6(Si_6O_{18})(BO_3)_3(OH)_4$	green, red to pink, blue, orange, yellow, colourless	7.5	vitreous, resinous	prismatic to acicular; striated	poor, indistinct	irregular, uneven, conchoidal	rare		principal gem variety of tourmaline	x	x	x		
enargite	Eng	sulphide / - / -	orthorhombic	Cu_3AsS_4	greyish black to black	3	metallic; tarnishing dull	tabular, prismatic, granular	perfect	irregular, uneven	common			x				x
enstatite-ferrosilite	En	inosilicate / pyroxene / orthopyroxene	orthorhombic	$MgSiO_3$ - $FeSiO_3$	white, yellowish green, brown	5 - 6	vitreous, pearly	usually irrregular grains; prismatic	distinct, good	irregular, uneven	simple		forms enstatite-ferrosilite series	x			x	
epidote	Ep	sorosilicate / epidote / clinozoisite	monoclinic	$Ca_2(Al_2Fe^{3+})(Si_3O_{12})(OH)$	yellowish green, green	6	vitreous, pearly	prismatic, fibrous, granular	perfect	irregular, uneven	common			x			x	
epidote group	—		monoclinic, orthorhombic	general formula[+]: $\mathbf{E}_2\mathbf{F}_3(Si_2O_7)(SiO_4)O(OH)$									includes allanite, clinozoisite, epidote, piemontite, zoisite, others	x				
erudite	n/a											remarkably learned	not an electronic variety of rudite; cf. skutterudite			Oxford		
fayalite	Fa	nesosilicate / olivine / -	orthorhombic	$(Fe^{2+})_2SiO_4$	greenish yellow, yellow, brown	7	vitreous, greasy	granular masses; crystals rare, generally rounded grains	indistinct			gem variety: peridot	forms solid solution series with forsterite and with tephroite	x			x	x
feldspar (group)	Fsp	tectosilicate / feldspar / -	monoclinic, triclinic	general formula[+]: $\mathbf{G}Al(Al,Si)_3O_8$		6							-major group: includes alkali feldspar subgroup, plagioclase series subgroup and barian feldspars (celsian, hyalophane) #6 on Mohs hardness scale	x	x	x	x	x
feldspathoid (group)	Fsd	tectosilicate / feldspathoid / -	isometric, hexagonal										includes leucite, nepheline, sodalite, nosean, hauyne, lazurite, cancrinite, melilite		x	x	x	
fluorite	Fl	halide / - / -	isometric	CaF_2	colourless, violet blue, purple, various others	4	vitreous	cubic, octahedral	perfect		common		#4 on Mohs hardness scale			x	x	
forsterite	Fo	nesosilicate / olivine / -	orthorhombic	Mg_2SiO_4	green, pale yellow, white	7	vitreous	euhedral to subhedral	perfect	conchoidal		gem variety: peridot	forms solid solution series with fayalite			x	x	
fuchsite	Fu	phyllosilicate / mica / -	monoclinic	$K(Al,Cr)_3Si_3O_{10}(OH)_2$									-member of mica group synonym: chromian muscovite	x				
galena	Gn	sulphide / - / -	isometric	PbS	lead grey	2.5	metallic, dull	cubic, octahedral	perfect	subconchoidal	can produce striations on faces	high density (7.58 g/cm^3)		x		x	x	
garnet (group)	Grt	nesosilicate / garnet / -	isometric	general formula[+]: $\mathbf{H}_3\mathbf{J}_2(SiO_4)_3$		6.5 - 7.5							-includes 2 solid solution series: pyralspite (named from *pyr*ope- *al*mandine-*sp*essartine); and ugrandite (named from *u*varovite-*gr*ossular-*and*radite)			x		x
gedrite	Ged	inosilicate / amphibole / orthoamphibole	orthorhombic	$(Mg,Fe^{2+})_5Al_2(Si_6Al_2O_{22})(OH)_2$	pale greenish grey brown	5.5 - 6	vitreous to silky	bladed & prismatic; fibrous & sheath-like	good, perfect	splintery								
glauconite	Glt	phyllosilicate / mica / -	monoclinic	$(K,Na)(Fe^{3+},Al,Mg)_2((Si,Al)_4O_{10})(OH)_2$	blue green, yellow green, green	2	dull, earthy	aggregates, scaly particles	perfect	micaceous				x		x		
glaucophane	Gln	inosilicate / amphibole / clinoamphibole	monoclinic	$Na_2Mg_3Al_2Si_8O_{22}(OH)_2$	grey to lavender blue	5 - 6	vitreous	prismatic to acicular	perfect			bluish colour (see also riebeckite) may be asbestiform	forms solid solution series with ferroglaucophane	x		x		
goethite	Gth	hydroxide / - / -	orthorhombic	$FeO(OH)$	brownish black	5 - 5.5	adamantine, silky, metallic, dull	various: prismatic, acicular, reniform, botryoidal, bladed	perfect	irregular, uneven				x			x	
gold	Au [†]	element / copper / -	isometric	Au	rich yellow, paling to whitish yellow with increasing silver	2.5 - 3	metallic	crystal rare – octahedral, dodecahedral, cubic	none	hackly	common	colour, hardness (ductile, malleable), density (19.3 g/cm^3)		x			x	
graphite	Gr	element / carbon / -	hexagonal	C	black to steel grey	1 - 2	submetallic to dull	platy	perfect	micaceous		hardness		x			x	
greenalite	Gre	phyllosilicate / serpentine / -	monoclinic	$Fe_{2-3}(SiO_5)(OH)_4$	green, light yellow green	2.5	dull, earthy	ellipsoidal granules, minute crystals	none				iron-rich member of serpentine group	x		x		
green muscovite	gMs	phyllosilicate / mica / -	monoclinic	Ba-muscovite – $(K,Ba)(Al,Mg)_2(AlSi_3O_{10})(OH)_2$ Cr-muscovite – $K(Al,Cr)_3Si_3O_{10}(OH)_2$ V-muscovite – no specific formula	bright green, pale green, bluish green	see muscovite	vitreous, pearly	pseudohexagonal	perfect basal			colour (relative to most muscovite); cleavage flakes	-this term is listed because of local occurrences of barian muscovite ("oellacherite"), chromian muscovite (fuchsite) and vanadian muscovite, each of which display a range in shades of green; -this general field term is preferrable to using the term "fuchsite" (Cr-muscovite), without knowledge of the appropriate trace element	x				
grossular	Grs	nesosilicate / garnet / ugrandite	isometric	$Ca_3Al_2(SiO_4)_3$	brown, orange, red, yellow, green	6.5 - 7	vitreous, subvitreous	dodecahedral	none	irregular, uneven	none	habit, hardness	andradite-grossular series grossular-uvarovite series					
grunerite	Gru	inosilicate / amphibole / clinoamphibole	monoclinic	$Fe_2^{2+}(Fe^{2+},Mg)_5Si_8O_{22}(OH)_2$	green, brown to dark grey	5 - 6	vitreous, pearly	fibrous, columnar, or massive aggregates of prismatic crystals	perfect				Fe end member of cummingtonite-grunerite series	x		x	x	
gypsum	Gp	sulphate / - / -	monoclinic	$CaSO_4 \cdot 2H_2O$	colourless to white	2	vitreous, subvitreous, silky	various: tabular, prismatic, acicular, warped surfaces, granular masses	perfect, good	splintery, conchoidal	common; "swallowtail", cruciform	hardness, cleavage	#2 on Mohs hardness scale	x			x	
halite	Hl	halide / - / -	isometric	$NaCl$	colourless to white (without impurities)	2.5	vitreous	cubic, massive, or octahedral (rare)	perfect	conchoidal		salty taste, hardness, cubic cleavage	isomorphous with sylvite	x	x		x	
hematite	Hem	oxide / hematite / -	trigonal	Fe_2O_3	steel grey to black as crystals, rust red in fine-grained earthy material	5 - 6	metallic, submetallic, dull, earthy	various: thick to thin tabular, platy, fibrous, reniform, botryoidal, earthy	none	irregular, uneven, subconchoidal	lamellar		forms a solid solution with ilmenite above 950°C	x		x	x	
hematite group	—												includes corundum, hematite, ilmenite				x	
hornblende	Hbl	inosilicate / amphibole / clinoamphibole	monoclinic	$(Ca,Na)_{2-3}(Mg,Fe^{2+},Fe^{3+},Al)_5(Al,Si)_8O_{22}(OH,F)_2$	black, dark green	6	vitreous to dull	columnar; prismatic; irregular grains and massive	imperfect	uneven	common					x	x	
humite (group)	Hu												includes humite, chondrodite and several uncommon minerals	x				
ilmenite	Ilm	oxide / hematite / -	trigonal	$Fe^{2+}TiO_3$	iron black, black	5 - 6	metallic, submetallic	thick tabular	none	conchoidal, subconcoidal	common			x			x	
jadeite	Jd	inosilicate / pyroxene / clinopyroxene	monoclinic	$Na(Al,Fe^{3+})Si_2O_6$	apple green, greenish white, blue green	6.5	subvitreous, pearly	fine-grained granular or dense masses	good	splintery	lamellar	often used as a decorative stone						
jasper	Jas	tectosilicate / quartz / -	hexagonal, trigonal	SiO_2	red; also yellow, brown, green	6.5 - 7		microcrystalline, cryptocrystalline		smooth			variety of chalcedony					
kalsilite	Kls	tectosilicate / feldspathoid / -	hexagonal, trigonal	$KAlSiO_4$	colourless	6			poor				-member of nepheline group -dimorphous with kaliophilite	x	x			
kyanite	Ky	neosilicate / aluminosilicate / -	triclinic	Al_2SiO_5	blue, white, light grey	5.5 - 7	vitreous, subvitreous, greasy	tablets, bladed masses, may be bent or twisted	perfect	splintery	lamellar	colour, anisotropic hardness (varies on crystallographic direction)	-trimorphous with andalusite and sillimanite	x	x	x	x	
labradorite	Lab	tectosilicate / feldspar / plagioclase	triclinic	$(Na,Ca)[Al(Si,Al)Si_2O_8]$	grey, greenish grey, white; blue to green play of colours	6 - 6.5	subvitreous	tabular; irregular grains	perfect, good	step-like	common, polysynthetic		upper-mid An range of the albite-anorthite series; An_{50-70}	x	x			
laumontite	Lmt	tectosilicate / zeolite / -	monoclinic	$CaAl_2Si_4O_{12} \cdot 4H_2O$	colourless to white, pink, grey	3.5 - 4	vitreous, pearly	small prismatic; massive	perfect	irregular, uneven			member of zeolite group	x			x	
lawsonite	Lws	sorosilicate / - / -	orthorhombic	$CaAl_2(Si_2O_7)(OH)_2 \cdot H_2O$	colourless, white, greyish blue, pale blue	7.5	vitreous, greasy	prismatic, tabular; massive, granular	perfect	irregular, uneven	crystal twinning common		commonly associated with glaucophane	x		x	x	
lepidolite	Lpd	phyllosilicate / mica / -	monoclinic	$KLi_2Al(Si_4O_{10})(OH)_2$	pale lilac, colourless	2.5 (on cleavage)	vitreous, pearly		perfect								x	
leucite	Lct	tectosilicate / feldspathoid / -	tetragonal	$K(AlSi_2O_6)$	white, grey	5.5 - 6	vitreous	trapezoidal, pseudocubic	poor, indistinct	conchoidal	common			x	x		x	
leucoxene	—				yellow to brown								-field term: not a mineral *per se*, but a fine-grained alteration product of titanium minerals such as ilmentie, perovskite, titanite -typically consists mainly of rutile	x	x	x		x
limonite	Lm	hydroxide / - / -		$\sim FeO(OH) \cdot nH_2O$	light brown to brown, yellow, red	4 - 4.5	earthy	amorphous to cryptocrystalline	none	uneven			-field term: not a mineral *per se*, but a mixture of undifferentiated hydrated iron oxides, mainly goethite, also hematite, lepidocrocite	x	x	x		x
lizardite	Lz	phyllosilicate / serpentine / -	hexagonal	$Mg_3(SiO_5)(OH)_4$	white, yellow, green	2.5	greasy	flat platelets, scaly					-hexgonal form of chrysolite -several polytypes exist: rhombohedral, trigonal, hexagonal, monoclinc	x	x	x		x
magnesite	Mgs	carbonate / calcite / -	trigonal	$MgCO_3$	colourless, white, greyish white, yellow, brown	3.5 - 4.5	vitreous	rhombohedral; massive, fine to coarse; earthy; lamellar; coarsely fibrous	perfect	conchoidal	none		forms a series with siderite					
magnetite	Mag	oxide / spinel / -	isometric	Fe_3O_4; $[Fe^{2+}Fe_2^{3+}O_4]$	black, greyish black	5.5 - 6.5	metallic, submetallic	octahedral, dodecahedral; massive, granular (coarse or fine)	none	irregular, uneven	common	strong magnetic character	2 series with magnetite – jacobsite (Mn^{2+}); magnesioferrite $(MgFe^{3+})$	x	x		x	
malachite	Mlc	carbonate / - / -	monoclinic	$Cu_2(CO_3)(OH)_2$	bright green, various shades of darker green	3.5 - 4	adamantine, silky, dull	botryoidal; fibrous; massive; rare acicular prisms	perfect	irregular, uneven, subconchoidal	common	colour, habit		x		x	x	
manganite	Man	hydroxide / - / -	monoclinic	$Mn^{3+}O(OH)$	grey black, black	4	submetallic	short, striated; long prismatic; columnar to fibrous	perfect	irregular, uneven	penetration			x			x	
marcasite	Mrc	sulphide / - / -	orthorhombic	FeS_2	pale brass yellow, tin white (fresh)	6 - 6.5	metallic	tabular, pyramidal, globular, reniform	distinct, good	irregular, uneven	common		dimorphous with pyrite	x	x		x	
melilite	Mll	sorosilicate / melilite / melilite	tetragonal	$(Ca,Na)_2(Al,Mg,Fe^{2+})(Si,Al)_2O_7$	yellow, greenish brown	5 - 5.5	vitreous, greasy	massive, granular	distinct	uneven			important end members are akermanite and gehlenite	x	x	x		x
melilite group	—			general formula[+]: $Ca_2\mathbf{K}(\mathbf{L}SiO_7)$									isomorphous solid solution series	x				
mica group		phyllosilicate / mica / -											includes biotite, lepidolite, muscovite, paragonite, phlogopite, sericite					
microcline	Mc	tectosilicate / feldspar / alkali feldspar	triclinic	$KAlSi_3O_8$	white, grey, greyish yellow, salmon pink, brick red, bluish green	6 - 6.5	vitreous	short prismatic; granular, massive	perfect	irregular, uneven	polysynthetic		trimorphous with orthoclase and sanidine	x	x	x	x	
microlite	Mcl	oxide / pyrochlore / -	isometric	$(Na,Ca)_2(Ta,Nb)_2O_6(O,OH,F)$	pale yellow to reddish brown	5 - 5.5	vitreous, resinous	octahedral; irregular, masses	imperfect, fair	irregular, uneven	rare	may be radioactive	Ta end member of the pyrochlore-microlite series	x	x	x		
minnesotaite	Mns	phyllosilicate / - / -	triclinic	$(Fe,Mg)_3(Si_4O_{10})(OH)_2$	greenish grey to olive brown	1.5 - 2	resinous, waxy, greasy	fine-grained dense masses of microscopic plates or needles	perfect	irregular, uneven			isostructural with pyrophyllite-talc group	x	x			
millerite	Mlr	sulphide / - / -	trigonal	NiS	pale brass yellow, iridescent tarnish	3 - 3.5	metallic	acicular; radiating groups; rarely granular	perfect	irregular, uneven	none			x				
molybdenite	Mol	sulphide / - / -	hexagonal	MoS_2	lead grey, bluish grey	1 - 1.5	metallic	tabular; pliant flakes; fine-grained massive	perfect			habit, hardness; resembles graphite		x	x		x	
monazite	Mnz	phosphates / - / -	monoclinic	$(Ce,La,Nd,Th)(PO_4)$	yellowish, reddish brown to brown; various others	5 - 5.5	subadamantine, vitreous, resinous	small, flattened or elongate prismatic, striated	distinct, good	irregular, uneven	common		-the formula & characteristics listed here are for monazite-(Ce), which is the most common type -other types: -(La), -(Nd), -(Sm)	x				
muscovite	Ms	phyllosilicate / mica / -	monoclinic	$KAl_2(AlSi_3O_{10})(OH)_2$	colourless, pale grey brown green	2.5 (on cleavage)	vitreous, pearly	pseudohexagonal	perfect basal			cleavage flakes					x	
nepheline	Nph	tectosilicate / feldspathoid / -	hexagonal	$(Na,K)AlSiO_4$	white, grey, yellowish	5.5 - 6	vitreous, greasy	short prisms; granular, compact; massive	poor, indistinct	subconchoidal				x				
nickeline	Nkn	sulphide / - / -	hexagonal	$NiAs$	pale copper red; blackish tarnish	5 - 5.5	metallic	generally massive, reniform; rarely tabular	imperfect	conchoidal	fourlings		outdated synonym: niccolite	x		x		
oligoclase	Olg	tectosilicate / feldspar / plagioclase	triclinic	$(Na,Ca)[Al(Si,Al)Si_2O_8]$	colourless, white	6 - 6.5	vitreous	tabular; irregular grains	perfect, good	step-like	common, polysynthetic		low An range of the albite-anorthite series; An_{10-30}	x	x			
olivine (group)	Ol	nesosilicate / olivine / -	orthorhombic	general formula[+]: $\mathbf{M}_2SiO_4$									includes forsterite, fayalite, tephroite and others		x	x		x
orpiment	Orp	sulphide / - / -	monoclinic	As_2S_3	orange yellow to lemon yellow	1.5 - 2	pearly, resinous	small prismatic, columnar or fibrous masses	perfect			colour		x	x		x	
orthoamphibole	Oam	inosilicate / amphibole / -	orthorhombic										includes anthophyllite, gedrite, holmquistite	x				
orthoclase	Or	tectosilicate / feldspar / alkali feldspar	monoclinic	$KAlSi_3O_8$	white, pink, colourless, greenish, grayish yellow	6	vitreous	short prismatic	perfect	irregular, uneven, conchoidal	common, striations absent		trimorphous with microcline and sanidine	x	x		x	
orthopyroxene	Opx	inosilicate / pyroxene / - orthopyroxene	orthorhombic										includes enstatite, bronzite, orthoferrosilite	x	x			
paragonite	Pg	phyllosilicate / mica / -	monoclinic	$NaAl_2(AlSi_3O_{10})(OH)_2$	colourless, pale yellow, pale green, greyish white	2.5		massive, fibrous, scaly	perfect	micaceous	common		Na analogue of muscovite		x	x		
pectolite	Pct	inosilicate / pyroxenoid / -	triclinic	$NaCa_2(SiO_3)_3H$	colourless, white, pale pink, greenish, pale blue	4.5 - 5	subvitreous, silky	tabular, acicular, radiating fibrous, globular masses	perfect	irregular, uneven	common		member of pyroxenoid group	x	x	x	x	
pentlandite	Pn	sulphide / - / -	isometric	$(Fe,Ni)_9S_8$	light bronze brown or bronze yellow	3.5 - 4	metallic	massive, granular aggregates	none	conchoidal				x			x	
periclase	Per	oxide / - / -	isometric	MgO	colourless, greyish white, yellow	5.5	subvitreous	octahedral; irregular, rounded grains	perfect	irregular, uneven								
perovskite	Prv	oxide / - / -	orthorhombic	$CaTiO_3$	dark brown, black red brown	5.5	adamantine, metallic, submetallic	cubic, pseudocubic, massive granular	imperfect, fair	irregular, uneven, subconchoidal	penetration			x				
petalite	Ptl	tectosilicate / feldspathoid / -	monoclinic	$LiAl(Si_4O_{10})$	colourless, grey, white, pink, green	6.5	vitreous	tabular or elongated	perfect	conchoidal	common			x				
phlogopite	Phl	phyllosilicate / mica / -	monoclinic	$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$	dark green, brown or black	2.5 (on cleavage)	vitreous, pearly	pseudohexagonal	perfect basal			cleavage flakes	part of the biotite-phlogopite series	x			x	
piemontite	Pmt	sorosilicate / epidote / -	monoclinic	$Ca_2(Al_2Mn^{3+})(Si_3O_{12})(OH)$	red, red violet, red black	6 - 6.5	vitreous	prismatic, bladed, acicular	perfect	irregular, uneven	uncommon, lamellar			x		x		
plagioclase (group)	Pl	tectosilicate / feldspar / plagioclase	triclinic	$(Na,Ca)[Al(Si,Al)Si_2O_8]$							twinning striations common		solid solution series (Na-Ca) with An content as follows: albite (0-10), oligoclase (10-30), andesine (30-50), labradorite (50-70), bytownite (70-90), anorthite (90-100)		x		x	
prehnite	Prh	phyllosilicate / - / -	orthorhombic	$Ca_2Al_2Si_3O_{10}(OH)_2$	colourless to grey to yellow, pale green, white	6 - 6.5	vitreous, pearly	crystals uncommon; usually as reniform, globular, granular aggregates	distinct, good	irregular, uneven	fine lamellar			x			x	
pyrite	Py	sulphide / - / -	isometric	FeS_2	pale brass yellow, iridescent tarnish	6 - 6.5	metallic	cubic, octahedral, striated, granular; various others	poor, indistinct	irregular, uneven, conchoidal	interpenetrating		dimorphous with marcasite	x				
pyrochlore	Pcl	oxide / pyrochlore / -	isometric	$(Na,Ca)_2(Nb,Ta)_2O_6(OH,F)$	brown, yellow brown, reddish brown, orange, black	5 - 5.5	vitreous, resinous	octahedral; irregular masses	distinct, good	irregular, uneven, splintery	rare	may be radioactive	Nb end member of the pyrochlore-microlite series	x	x			
pyrolusite	Pyl	oxide / rutile / -	tetragonal	MnO_2	black, very dark grey	6 - 6.5 2 (when massive)	metallic; dull to earth	massive; fibrous, reniform, botryoidal; granular to powdery; dendritic growths	perfect	irregular, uneven	polysynthetic			x	x	x	x	
pyrope	Prp	nesosilicate / garnet / pyralspite	isometric	$Mg_3Al_2(SiO_4)_3$	blood red, orange red, purple red, pink	7.5	vitreous	dodecahedra, trapezohedra; fine to coarse granular	none			colour, habit, hardness	almandine-pyrope series pyrope-spessartine series	x	x	x		
pyrophyllite	Prl	phyllosilicate / - / -	monoclinic	$Al_2(Si_4O_{10})(OH)_2$	white, grey, pale green, pale yellow	1 - 1.5	pearly, dull	lamellar crystal, spherulitic aggregates, compact fine-grained masses	perfect			very similar to talc		x		x	x	
pyroxene (group)	Px	inosilicate / pyroxene / -	multiple	general formula[+]: $\mathbf{NP}Si_2O_6$	various								major group; subgroups are clinopyroxene and orthopyroxene	x	x	x	x	x
pyroxenoid	—	inosilicate / pyroxenoid / -											-unofficial name for a small group of minerals chemically analogous to pyroxene but having a different mineral structure (SiO_3 chains) -includes wollastonite, pectolite, rhodonite		x	x	x	
pyrrhotite	Po	sulphide / - / -	monoclinic	$Fe_{1-x}S$ $(0 \leq x \leq 0.17)$	bronze brown, dark brown, tarnishing darker	3.5 - 4	metallic	rarely tabular to platy; commonly massive, granular	none	subconchoidal		weakly magnetic; similar in appearance to pentlandite		x		x		
quartz	Qz	tectosilicate / quartz / -	hexagonal, trigonal	SiO_2	colourless, white, pink, yellow, smoky grey, violet (see "amethyst")	7	vitreous	6-sided prismatic, pyramidal terminations, massive	poor, indistinct	conchoidal	uncommon	hardness, habit, commonality	major group: many varieties – macrocrystalline (see also "amethyst"); cryptocrystalline (see also "jasper", "chert") #7 on Mohs hardness scale	x	x	x	x	x
realgar	Rlg	sulphide / - / -	monoclinic	As_4S_4	dark red to orange red	1.5 - 2	resinous, greasy	short, prismatic, striated; fine granular; incrustation	distinct, good			colour, hardness		x			x	
rhodochrosite	Rds	carbonate / calcite / -	trigonal	$MnCO_3$	pink, rose, red, yellowish grey, brown	3.5 - 4	vitreous, pearly	rhombohedral, coarsely granular, columnar, botryoidal	perfect	irregular, uneven, conchoidal	uncommon, lamellar		isomorphous with calcite and siderite	x	x		x	
rhodonite	Rdn	inosilicate / pyroxenoid / -	triclinic	$MnSiO_3$	red, pink, brownish red	5.5 - 6.6	vitreous, pearly	tabular, usually massive, coarse to fine granular or dense aggregates	perfect	irregular, uneven	lamellar	colour		x			x	
riebeckite	Rbk	inosilicate / amphibole / clinoamphibole	monoclinic	$Na(Fe_3^{2+}Fe_2^{3+})(Si_8O_{22})(OH_2)$	black, light blue to blue black, grey blue, grey	5 - 5.5	vitreous, subvitreous	prismatic, acicular, radiating, fibrous	perfect	splintery		may be asbestiform	forms a series with magnesioriebeckite	x		x	x	
rutile	Rt	oxide / - / -	tetragonal	TiO_2	blood red, reddish brown, brownish yellow, greyish black, black	6 - 6.5	adamantine, metallic	prismatic, acicular, striated faces	distinct, good	irregular, uneven	common		trimorphous with anatase and brookite	x	x		x	
rutile group	—	oxide / - / -	tetragonal	general formula[+]: $\mathbf{Q}^{4+}O^2$									includes cassiterite, pyrolusite, rutile	x				
sanidine	Sa	tectosilicate / feldspar / alkali feldspar	monoclinic	$KAlSi_3O_8$	colourless, white, grey, yellowish white, reddish white	6	vitreous	short prismatic	perfect	irregular, uneven	common; striations absent		-trimorphous with microcline and orthoclase -forms a solid solution with high albite	x	x		x	
scapolite (series)	Scp	tectosilicate / scapolite / -	tetragonal	general formula: $(Na,Ca,K)_4Al_3(Al,Si)_3Si_6O_{24}(Cl,F,OH,CO_3,SO_4)$	[Na] varieties: bluish, brownish, colourless, violet; [Ca] varieties: colourless, white, grey pink, violet	[Na] 5.5 - 6 [Ca] 5 - 6	vitreous, resinous, pearly	combinations of prisms and pyramids; massive, granular	distinct, good	irregular, uneven, conchoidal			-general term -forms a solid solution series between marialite $Na_4(Al_3Si_9O_{24})Cl$ and meionite $Ca_4(Al_6Si_6O_{24})CO_3$	x	x	x	x	x
scheelite	Sch	tungstate / - / -	tetragonal	$CaWO_4$	tan, golden yellow, white, greenish, dark brown	4.5 - 5	adamantine, vitreous	dipyramidal	distinct, good	irregular, uneven, subconchoidal	common			x		x		
schorl	Srl	cyclosilicate / tourmaline / -	trigonal	$Na(Fe^{2+})_3Al_6(Si_6O_{18})(BO_3)_3(OH)_4$	bluish black to black	7	vitreous, resinous	elongated prismatic to acicular; striated	poor, indistinct	irregular, uneven, conchoidal	rare		schorl is the most common species of tourmaline	x	x	x		
sericite	Ser	phyllosilicate / mica / -	monoclinic	$KAl_2(AlSi_3O_{10})(OH)_2$	white, pale green	2.5 (on cleavage)	vitreous, pearly	pseudohexagonal	perfect basal			cleavage flakes	-consists mostly of fine-grained muscovite or near-muscovite composition, possibly some illite -some sources consider the term includes paragonite	x	x	x		x
serpentine (group)	Srp	phyllosilicate / serpentine / -	monoclinic, triclinic	general formula[+]: $\mathbf{R}_2Si_2O_5(OH)_4$	various shades of green, white, grey	2.5 - 4							includes many minerals: most commonly antigorite, lizardite, chrysotile (itself a subgroup)	x	x	x	x	x
siderite	Sd	carbonate / calcite / -	trigonal	$FeCO_3$	yellowish brown, greyish brown, pale yellow, grey	3.5 - 4.5	vitreous, silky, pearly	rhombohedral, thin to thick tabular, granular, botryoidal, massive	perfect	irregular, uneven, conchoidal	uncommon, lamellar	-density (3.96 g/cm^3) compared to other carbonates:	isomorphous with magnesite and rhodochrosite	x	x		x	
sillimanite	Sil	neosilicate / aluminosilicate / -	orthorhombic	Al_2SiO_5	colourless, white, yellow, brown, green, grey	6.5 - 7.5	subvitreous, greasy, silky	commonly fibrous in wavy bundles; coarse prismatic masses	perfect	irregular, uneven			-trimorphous with andalusite and kyanite -the term "fibrolite" has been used to refer to the fibrous form of sillimanite	x	x		x	
silver	Ag [†]	element / copper / -	isometric	Ag	silver white; readily tarnishes dark grey to black, brown	2.5 - 3	metallic	crystals rare (cubic, octahedral, dodecahedral); massive – scales, leafy, wire-like, plates, veins	none	none	penetration	colour, tarnish, hardness (ductile, malleable)		x	x		x	
skutterudite	Sk	sulphide / - / -	isometric	$(Co,Fe,Ni)As_{2-3}$	tin white to silver grey; grey tarnish	5.5 - 6	metallic	cubic	distinct, good	irregular, uneven, conchoidal			structurally related minerals: ferroskutterudite $((Fe,Co)As_3)$, nickelskutterudite $(NiAs_{2-3})$	x				
smithsonite	Smi	carbonate / calcite / -	trigonal	$ZnCO_3$	white, grey, yellow, green to apple green, blue, pink	4 - 4.5	vitreous, pearly	rarely rhombohedral; botryoidal, reniform, incrustations, coarsely granular	very good	irregular, uneven, subconchoidal	none		limited solid solution with rhodochrosite (Mn) and with siderite (Fe)	x		x		
sodalite	Sdl	tectosilicate / feldspathoid / -	isometric	$Na_8(Al_6Si_6O_{24})Cl_2$	azure blue, light green to dark blue, white, light yellow,	5.5 - 6	vitreous, greasy	rarely dodecahedral; massive to granular	poor, indistinct	irregular, uneven, subconchoidal	common	colour		x	x		x	
specularite	Spc	oxide / hematite / -	trigonal	Fe_2O_3	black, steel grey, silvery	5 - 6	metallic, submetallic	specular flakes; tabular disk-like crystals					variety of hematite	x	x		x	
spessartine	Sps	nesosilicate / garnet / pyralspite	isometric	$(Mn^{2+})_3Al_2(SiO_4)_3$	red, reddish orange, reddish brown, yellowish brown	6.5 - 7.5	vitreous	dodecahedral		subconchoidal		colour, habit, hardness	almandine-spessartine series pyrope-spessartine series	x				
sphalerite	Sp	sulphide / - / -	isometric	ZnS $[(Zn,Fe)S]$	low Fe: translucent; yellow, yellow brown,orange red high Fe: opaque; red brown, dark brown, black	3.5 - 4	low Fe: adamantine high Fe: resinous to submetallic	tetrahedra, coarse to fine granular, concretionary, botryoidal	perfect	conchoidal			-with sufficient Fe, sphalerite is black & opaque and known as marmatite -dimorphous with wurtzite	x	x	x	x	
sphene	—	see "Relationship / Member"											outdated term – see titanite					
spinel	Spl	oxide / spinel / -	isometric	$MgAl_2O_4$	black, blue, red, violet, green, brown, pink	7.5 - 8	vitreous	octahedral, dodecahedral; massive, granular or rounded grains	none	irregular, uneven, splintery, conchoidal	common	gem form: ruby	3 series with spinel: hercynite (Fe^{2+}); gahnite (Zn); magnesiochromite [Mg(Cr,Al, Fe)]	x			x	
spinel group	—	oxide / spinel / -	isometric	general formula[+]: $\mathbf{ST}_2O_4$									3 main series: spinel series (*B* = Al); magnetite series (*B* = Fe), chromite series (*B* = Cr)	x			x	
spodumene	Spd	inosilicate / pyroxene / clinopyroxene	monoclinic	$LiAlSi_2O_6$	white, greyish white, yellow, light to emerald green	6.5 - 7	vitreous, dull	long prismatic, platy masses	perfect					x				
staurolite	St	nesosilicate / - / -	monoclinic	$(Fe^{2+},Mg,Zn)_2Al_9Si_4O_{22}(OH,O)_2$	dark brown, reddish brown, yellow brown	7 - 7.5	subvitreous, resinous	prismatic, commonly twinned	distinct, good	subconchoidal	common, cruciform	colour, habit		x			x	x
stibnite	Stn	sulphide / - / -	orthorhombic	Sb_2S_3	lead grey with pale blue tint, iridescent tarnish	2	metallic	stout to slender prismatic, striated, acicular, granular	perfect	subchoncoidal	rare			x			x	
stilbite	Stb	tectosilicate / zeolite / -	monoclinic	$(Ca,Na_2,K_2)(Al_2Si_7O_{18}) \cdot 7H_2O$	white, colourless, red, light yellow, light to dark brown	3.5 - 4	vitreous, pearly	sheaf-like aggregates of cruciform penetration twins, radiated masses	perfect	irregular, uneven	ubiquitous, cruciform, penetration		stilbite is now considered a series (not distinguishable without tests): varieties include stilbite-Ca: $NaCa_4(AlSi_{27}O_{72}) \cdot nH_2O$ (much more common); and stilbite-Na: $(Na,Ca,K)_{6-7}(Al_8Si_{28}O_{72}) \cdot nH_2O$	x	x	x		
stilpnomelane	Stp	phyllosilicate / - / -	triclinic	$(K,Ca,Na)(Fe^{2+},Mg,Al,Fe^{3+})_8(Si,Al)_{12}(O,OH)_{36} \cdot nH_2O$	red, brown, black, dark green, dark reddish brown	3 - 4	pearly to vitreous	plates or scales, plumose or radiating fibrous, incrustations	perfect					x		x		
sylvite	Syl	halide / - / -	isometric	KCl	colourless, grey, white, yellowish to orange red	1.5 - 2	vitreous	cubic; massive; coarsely granular	perfect	irregular, uneven		bitter taste; sectile compared to halite	isomorphous with halite	x		x	x	
talc	Tlc	phyllosilicate / - / -	monoclinic, triclinic	$Mg_3(Si_4O_{10})(OH)_2$	colourless, white, pale green, bright to dark green, grey	1	subvitreous, resinous, waxy, pearly	platy, compact, fine-grained masses	perfect	fibrous, micaceous		hardness, soapy-greasy feel	#1 on Mohs hardness scale	x	x	x	x	
tennantite	Tnt	sulphide / - / -	isometric	$(Cu,Ag,Fe,Zn)_{12}As_4S_{13}$	grey black, steel grey	3 - 4.5	metallic	tetrahedral to rounded crystals; massive, granular		subconchoidal			forms a solid solution series with tetrahedrite; difficult to visually distinguish the two	x	x	x		
tetrahedrite	Ttr	sulphide / - / -	isometric	$(Cu,Fe,Ag,Zn)_{12}Sb_4S_{13}$	steel grey to iron black	3.5 - 4	metallic	tetrahedral; massive		subconchoidal			forms a solid solution series with tennantite; difficult to visually distinguish the two	x	x	x		
titanite	Ttn	nesosilicate / - / -	monoclinic	$CaTiSiO_5$	usually brown; colourless, green, yellow, rose red, black	5 - 5.5	adamantine, resinous	wedge-shaped crystals; massive, granular	distinct, good	subconchoidal	contact & cruciform	colour, wedge shape		x		x	x	
topaz	Tpz	nesosilicate / - / -	orthorhombic	$Al_2SiO_4(F,OH)_2$	colourless, white, pale blue, light green yellow, red	8	vitreous	long to short prismatic	perfect	irregular, uneven, subconchoidal			can form gem quality crystals #8 on Mohs hardness scale					
tourmaline (group)	Tur	cyclosilicate / - / -	trigonal	general formula[+]: $\mathbf{U}(\mathbf{V}_3)\mathbf{W}_6(\mathbf{X}_6O_{18})(BO_3)_3\mathbf{Y}_3\mathbf{Z}$	various; most commonly black		vitreous, resinous	prismatic, striated	poor, indistinct	irregular, uneven, conchoidal		habit	includes dravite, schorl among many other varieties	x		x		
tremolite	Tr	inosilicate / amphibole / clinoamphibole	monoclinic	$Ca_2Mg_5(Si_8O_{22})(OH)_2$	white, brown, grey, light green, colourless, light yellow	5 - 6	vitreous, silky	elongated, stout prismatic, bladed, fibrous, granular, columnar aggregates	prefect		common	may be asbestiform	actinolite-tremolite series	x	x	x		
uraninite	Urn	oxide / - / -	isometric	UO_2	black, brownish black,	5 - 6	greasy, submetallic, dull	octahedral, cubic, dodecahedral, massive, botryoidal, reniform		irregular, uneven, conchoidal	rare	density (10.95 g/cm^3), radioactivity		x			x	
uvarovite	Uv	nesosilicate / garnet / ugrandite	isometric	$Ca_3Cr_2(SiO_4)_3$	green, emerald green, greenish black	6.5 - 7	vitreous	dodecahedral, trapezohedral		irregular, uneven, conchoidal		habit, colour, hardness	andradite-uvarovite series grossular-uvarovite series	x	x	x		
vesuvianite	Ves	sorosilicate / - / -	tetragonal	$(Ca,Na)_{19}(Al,Mg,Fe^{3+})_{13}(B,Al,Fe^{3+})_5(SiO_4)_{10}(Si_2O_7)_4(OH,F,O)_{10}$	brown, yellow, light green, emerald green, white, red, purple	6.5	vitreous, resinous	short pyramidal to long prismatic, columnar, granular, massive	poor, indistinct	irregular, uneven, subconchoidal	on a very fine scale			x				
wolframite	Wlf	tungstate / - / -	monoclinic	$(Fe^{2+},Mn^{2+})WO_4$	greyish black, brownish black	4 - 4.5	submetallic	tabular or short prismatic	perfect	irregular, uneven	common		chemically intermediate in the ferberite (Fe) - huebnerite (Mn) series	x		x	x	
wollastonite	Wo	inosilicate / pyroxenoid / -	triclinic	$CaSiO_3$	white, grey white, light green, pinkish	4.5 - 5	vitreous, pearly	cleavable fibrous masses; granular, compact	perfect	irregular, uneven	common			x	x		x	
zeolite (group)	Zeo	tectosilicate / zeolite / -		general formula: $(Na_2,K_2,Ca,Ba)[(Al,Si)O_2]n \cdot xH_2O$									group of large number of minerals: included here are laumontite and stilbite	x				x
zincite	Znc	oxide / - / -	hexagonal	$(Zn,Mn^{2+},Fe^{2+})O$	red, orange, yellow, white	4	subadamantine	crystals rare, hemimorphic, massive, rounded masses	perfect	conchoidal			isomorphous with bromellite (BeO)	x	x		x	
zircon	Zrn	nesosilicate / - / -	tetragonal	$ZrSiO_4$	colourless, yellow, grey, reddish brown, green, brown, black	7.5	adamantine, vitreous; greasy (when metamict)	tabular to square prismatic	poor, indistinct	conchoidal				x			x	
zoisite	Zo	sorosilicate / epidote / -	orthorhombic	$Ca_2Al_3Si_3O_{12}(OH)$	greyish white, grey, yellowish brown, pink, green, colourless	6 - 7	vitreous	aggregates of long prismatic crystals, striated, columnar, massive	perfect	irregular, uneven, conchoidal				x	x		x	

[*] Abbreviations: left justified are from Whitney and Evans (2010), Fettes and Desmons (2007); right justified are proposed for this study as they are not in the cited sources.
[†] Element symbol (metal)
^ IMA = International Mineralogical Association
[¤] Sources of information: Mindat = www. Mindat.org; AGI = Neuendorf, Mehl and Jackson (2005); WIKI = www.wikipedia.org; BM = Berry and Mason (1959); DHZ = Deer, Howie and Zussman (1966)

[+] Explanation for "general formula" under **Basic Formula**: italicized letters (shown as ***Bold***) refer to various possible combinations of cations as listed below (simplified for this table). Actual letters used vary depending on the reference source used.
- Amphibole group: ***A*** = Na, K, Ca, Pb; ***B*** = Li, Na, Mg, Fe, Mn, Ca; ***C*** = Li, Na, Mg, Fe, Mn, Zn, Co, Ni, Al, Cr, V, Ti, Zr
- Dolomite group: ***D*** = Mg, Fe, Mn, Zn
- Epidote supergroup: ***E*** = Ca, Mn, Sr, large REE; ***F*** = Al, Fe, Mg, Mn, V
- Feldspar group: ***G*** = Na, K, Ca, Ba, Rb, Sr, Fe
- Garnet group: ***H*** = Ca, Mg, Fe, Mn; ***J*** = Al, Fe, Cr, Mn, Ti, V
- Melilite group: ***K*** = Ca, Mg, Na, Fe, Al, Be, Zn, B; ***L*** = Al, Si, B
- Olivine group: ***M*** = Mg, Fe, Ca, Mn, Ni
- Pyroxene group: ***N*** = Ca, Na, Mg, Fe; ***P*** = Mg, Fe, Cr, Mn, Al, Li, Ti
- Rutile group: ***Q*** = Ti, Mn, Sn, Pb, Ge, Te
- Serpentine group: ***R*** = Mg, Al, Mn, Zn, Fe, Ni, Si, Li
- Spinel group: ***S*** = Mg, Fe, Co, Ni, Cu, Zn, Mn; ***T*** = Al, Fe, Cr
- Tourmaline group: ***U*** = Ca, Na, K; ***V*** = Al, Fe, Li, Mg, Mn; ***W*** = Al, Cr, Fe, V; ***X*** = Si, Al, B; ***Y*** = O, OH; ***Z*** = F, O, OH