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Precambrian Geology of the Separation Lake Area, Northwestern Ontario

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ONTARIO GEOLOGICAL SURVEY

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Precambrian Geology of the Separation Lake Area, Northwestern Ontario

by

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Abstract

Archean rocks of the Separation Lake area consist of metavolcanic and metasedimentary rocks of the east trending Separation Lake greenstone belt, metasedimentary migmatites and plutonic rocks of the English River Subprovince and plutonic rocks of the Winnipeg River Subprovince.

The 45 km by 5 km greenstone belt lies along the subprovincial boundary. It consists of a lower sequence of mafic metavolcanic rocks, with intercalated magnetite–bearing iron formations, a single discontinuous clastic metasedimentary unit, and overlying subordinate felsic metavolcanic rocks. Gabbro sills intrude the mafic metavolcanic sequence. A thin unit of polymictic conglomerate and sandstone lies along the northern margin of the belt. Metamorphic grade is amphibolite throughout the belt.

Unaltered mafic metavolcanic rocks are high magnesian tholeiitic basalts. Trace element data show them to be of low potash ocean floor affinity, while rare earth element data indicate affinity with mid–ocean ridge basalts. Metagabbroic sills are chemically identical to metavolcanic rocks, indicating derivation from a common magma pool. Felsic metavolcanic rocks are fine–grained tuffaceous, calc–alkaline rhyolites and dacites. Limited rare earth element data for felsic metavolcanic rocks show variable chemistry, inconsistent with classification into FI, FII and FIII types.

Granitic rocks of both subprovinces are fundamentally similar in composition, being granites *sensu stricto*. Rare earth element data indicate that, for all except one suite, plagioclase fractionation played a major role in their evolution.

Hydrothermal alteration of some mafic metavolcanic rocks, indicated by abundant garnet, is confirmed by alkali element mobility, iron enrichment, and alumina, magnesium and calcium depletion. Rare earth element data support moderate alteration.

Two contrasting structural zones are separated by an east trending lineament that lies along the north side of the greenstone belt. A major open east–plunging fold to the north of the lineament contrasts with a predominantly homoclinal, north facing sequence with local west–plunging folds to the south of the line. The lineament also marks the boundary between migmatised supracrustal rocks to the north and non–migmatised supracrustal rocks to the south. This domain boundary does not coincide precisely with the subprovincial boundary as proposed by previous workers.

Sulphide zones in mafic metavolcanic rocks of the greenstone belt have to date yielded anomalous to low amounts of gold, copper and zinc. Gold varies from 10s of ppb to about 0.3 ounce Au per ton, while zinc and copper are common in the 1000 to 5000 ppm range, and rarely up to 5 to 10%. Three types of sulphide zones are indicated. Breccia–hosted, massive to stringer arsenopyrite–pyrrhotite zones host sphalerite, chalcopyrite and gold. Silicified, shear zone–hosted, massive to stringer pyrrhotite–pyrite zones host sphalerite and chalcopyrite. Iron formation and chert–hosted, massive to stringer veins of pyrite and pyrrhotite host gold, sphalerite and chalcopyrite. Examples include the Gauthier gold occurrence (breccia–hosted), Champion Bear Resources Ltd.'s Grid C base metal occurrences (silicified shear zone–hosted) and the Helder Lake gold occurrence (iron formation and chert–hosted). The iron formation units hold potential for discovery of other gold occurrences.

Rare metals such as lithium, beryllium and tantalum are hosted in pegmatites generated by the 3 km^2 Separation Rapids granitic pluton. The presence of petalite as the lithium aluminosilicate mineral in a number of attendant dikes draws comparison between the Separation Rapids dike swarm and other petalite–bearing pegmatites elsewhere in the world that host rare–metal producing mines. Discovery of other beryl occurrences up to 10 km distant from the Separation Rapids pluton during the present survey suggests that the rare–metal bearing pegmatite field may be larger than currently known.

Graphite occurrences in the migmatites of the English River Subprovince possibly resulted from pyrolization of organic material in precursor clastic sediments.

Uranium–enriched granitic pegmatites are present both in the migmatites of the English River Subprovince and in the granitic rocks of the Winnipeg River Subprovince.

The majority of the 87 samples taken for assay during the present survey were to test primarily for base metals from zones already tested by exploration companies. These in general confirmed previous results. However, samples taken from a number of other prospective sulphide zones and iron formations not previously explored returned anomalous to low base metal values. Further prospecting is warranted in these areas. Assay values for gold from all samples taken were uniformly low.

Descriptions are provided of all documented exploration done in the area up to the time of the present survey, with the exception of a few uranium properties previously described by other workers.

Dimension stone is another commodity worthy of investigation in the map area, particularly within the Winnipeg River Subprovince.

Surficial sediment sampling for geochemical, gold grain and heavy mineral analysis, conducted as an adjunct to the present bedrock mapping program, has identified several sites of interest for gold, base metals and rare–metal pegmatites.

Introduction

During the summers of 1992 (Blackburn et al. 1992) and 1993 Blackburn and Young 1993), the Archean bedrock geology of the Umfreville–Separation lakes area was mapped at a scale of 1:15 840. The project area lies about 50 km north of Kenora, and is confined by longitudes 94°09′ and 94°45′ E, and latitudes 50°11′ and 50°22′ N (Figure 1).

Road access is provided to the eastern portion by a network of logging roads of which the English River Road is the main artery; this road extends northward from Highway 658 at Redditt, and links via other logging roads with Ear Falls and Red Lake. Road access to the western portion is provided via the Snook Lake logging road off the Sand Lake Road, a connecting link between the English River Road and Highway 525. Further access within the area is provided by the major English River drainage system, of which Umfrefille and Separation lakes are part; numerous other smaller lakes in the study area drain into this system. On July 18, 1991 a major windstorm blew down extensive areas of mature trees over a combined area of 164 000 Ha between Umfreville Lake in the southwest and Packwash Lake in the northeast. This swath cut through the portion of the project area north and west of the English River Road. Salvage logging operations were undertaken in parts of the blowdown while the present survey was being done, thus providing new access. Major parts of the blowdown have not been and will not be salvaged, thus severely hampering access in some parts of the area.

HISTORY OF MINERAL EXPLORATION

Record of exploration in the Separation Lake greenstone belt and adjacent granitic and gneissic rocks extends back to the 1940s. During that period A. Gauthier discovered gold, along with zinc and other base metals, at Umfreville Lake (formerly Oneman Lake), and gold was discovered at Helder Lake at the east end of the belt. In the period 1948 to 1959 studies were done of the iron potential of the formation outcropping sporadically along the belt in the vicinity of Separation Lake. The companies involved were W.S. Moore Company of Duluth, Tombill Gold Mines Ltd. and Glen Echo Mines Ltd., Centurion Mines Ltd., and Juma Mining and Exploration Ltd. From 1968 to 1976 uranium was explored for by Can–Fer Mines Limited, Consolidated Summit Mines Ltd., and Noranda Mines Ltd. at the east end of Umfreville Lake. Uranium was also discovered near Treelined Lake, in proximity to graphitic rocks that were investigated in 1988 by Bellwether Resources Ltd. Base metal exploration was carried out in the 1970s, mostly on reconnaissance, by Selco Mining Corporation Limited and Sherritt Gordon Mines Limited (Breaks et al. 1975a, 1975b). However, there is no record of this exploration in the assessment files at the Kenora Resident Geologist’s office.

In 1985, the Gauthier (or Oneman Lake) occurrence at Umfreville Lake was examined by Sparton Resources Inc. for both gold and base metal potential. In 1988 M. Thorburn of Kenora found a single loose piece of high–grade, chalcopyrite–bearing “float” beside the English River road about two kilometres north of the Separation Lake bridge. In the same year, Noranda Exploration Co. Ltd. did lithogeochemical and soil geochemical surveys in the immediate area, but subsequently dropped the option.

In 1987 Shabu Gold Mines Ltd. began a program of exploration for gold at Helder Lake. The program was continued by Champion Bear Resources Ltd. under the direction of Independent Exploration Services Ltd. An airborne geophysical survey was followed up by a diamond drill program in 1988 at Helder Lake. Champion Bear Resources Ltd. then extended its claim holdings westward along the belt for a distance of 45 km to the Gauthier occurrence. A geophysical survey was flown over the additional claims in 1989. Field work in 1989 was concentrated on the Gauthier occurrence. In 1990 exploration was continued over a strike length of 10 km to the east from the Gauthier occurrence, with emphasis shifting to copper–zinc mineralisation. In 1991 and 1992 exploration was continued eastward to the English River Road.

PREVIOUS GEOLOGICAL WORK

The Separation Lake belt was previously mapped at reconnaissance scale (1:63 360) (Breaks et al. 1975a, 1975b) during a helicopter–supported regional–mapping program conducted between 1972 and 1976

(Breaks et al. 1978). In the 1988 field season, Sanborn–Barrie (1988) studied the boundary zone between the Winnipeg River and English River subprovinces, from the Manitoba border in the west to eastern Lac Seul in the east, and briefly discussed the general geology of the Separation Lake belt; that author concluded, based on structural relationships at the boundary, that the boundary between the subprovinces lies at the northern margin of the metavolcanic belt.

PRESENT SURVEY

The present survey was conducted in conjunction with other geoscience programs by the Ontario Geological Survey. This multi–disciplinary approach has led to the publication of a number of reports and maps subsequent to the present fieldwork. Later investigation of the area around known rare metal–bearing pegmatites at Separation Narrows (Breaks 1993; Breaks and Pan 1995; Breaks and Tindle 1994) has led to the discovery of new pegmatite dikes (Breaks and Tindle 1996). Reconnaissance bedrock mapping of a large area of migmatites and derived granitic rocks between Werner Lake and the western portion of the present map area has led to the publication of a map at 1:50 000 scale (Beakhouse 1997). Quaternary mapping and till sampling of a larger area (Morris 1999) led to the publication (Morris 1996) of geochemical and heavy mineral data for three localities identified as prospective for metals within the present Separation Lake map area: Helder Lake, Selwyn Lake and Separation Rapids. Separation Lake data were also included in a release of kimberlite heavy mineral indicators collected province–wide (Morris et al. 1995).

In the present survey, geological mapping was carried out at a scale of 1:15 840 by party leader C.E. Blackburn, senior assistant J.B. Young, and junior assistants T.O. Searcy and K. Donohue. Most of the portion of the map area west of the bridge on the English River Road over Separation Narrows was mapped in 1992, and that to the east and remaining portions to the west in 1993. Mapping procedures varied over the course of the project: in 1992, data from the hand–drawn field map was input to a Compaq 386/20 © computer, using Fieldlog © and AutoCAD ©; in 1993, data was transferred directly from the 1 inch to 1/4 mile air photographs into the computer in the field camp on a daily basis.

Because of the lack of adequate officially recognised names for topographic features and roads, it has been necessary to use a minimum of locally used names, names applied by mineral explorationists, and road names used by the Ministry of Natural Resources to facilitate description in the present report. These names are also shown on the geologic maps (OFM 241, OFM 242: back pocket) as follows: Boot Bay; Storm Bay; Trout Lake; Separation Rapids or Narrows; English River Road; Sand Lake Road; Umfreville Road; Snook Lake Road; Lennan Road; Aesthetic Road. Selwyn Lake, also an unofficial name, has been variously otherwise referred to as Celwyn or Celyn Lake in geologic reports of both the government and the mineral exploration industry.

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General Geology

REGIONAL GEOLOGICAL SETTING

Metavolcanic and subordinate metasedimentary rocks occur discontinuously along the English River–Winnipeg River subprovincial boundary from the Ontario–Manitoba border in the west to western

Lac Seul in the east, a distance of about 100 km. They represent the eastern extension of the Bird River greenstone belt in Manitoba (Cerny et al. 1981). The Separation Lake greenstone belt (Figure 2) is the largest segment, extending from the east shore of Umfreville Lake to Helder Lake, a distance of 45 km, and with a maximum width of 5 km.

The English River Subprovince, extending north from the Separation Lake belt to the Uchi Subprovince, is comprised of metasedimentary migmatites (50%), and felsic to intermediate plutonic rocks comprised of a tonalitic suite in the west and a granodiorite to granite suite in the east (Breaks 1991). Metamorphic grade varies from amphibolite to granulite, and has affected all rocks except those of a peraluminous suite north of the current map area (Breaks 1991).

The Winnipeg River Subprovince, south of the Separation Lake belt, is comprised of felsic to intermediate plutonic rocks ascribed by Beakhouse (1991) to two suites, an early tonalitic suite in the north and a later granitic suite in the south. Rocks of the tonalitic suite in the subprovince are metamorphosed to medium to high grade, while granitic suite rocks were either synchronous with or postdated regional metamorphism (Beakhouse 1991).

The Separation Lake metavolcanic belt consists predominantly of a lower sequence of mafic metavolcanic rocks, with intercalated magnetite–bearing iron formations, a single discontinuous clastic metasedimentary unit, and overlying subordinate felsic metavolcanic rocks. Gabbro sills intrude the mafic metavolcanic sequence. A thin unit of polymictic conglomerate and sandstone lies along the northern margin of the belt. Metamorphic grade is amphibolite throughout the belt.

SEPARATION LAKE MAP AREA

An east–trending lineament, which is in part defined by the Selwyn Lake fault, conveniently divides the mapped area in two. To the south of the lineament, supracrustal sequences are interpreted to face homoclinally northward, except in the east where broad folding is defined by magnetite–bearing iron formation units. Facing of sequences is defined by scarce top determinations in pillowed mafic metavolcanic rocks: tectonic flattening, further discussed below, has rendered the vast majority of pillows useless for such determinations. To the north of the lineament, mafic amphibolites interpreted to be derived predominantly from mafic volcanic rocks are folded about the broad, steeply to moderately westerly–plunging Paterson Lake antiform.

Lithologic units for the Separation Lake map area are presented in Table 1.

Metavolcanic Rocks

Metavolcanic rocks of the Separation Lake belt are characterised by a bimodal sequence comprising predominant mafic flows and subordinate felsic pyroclastic rocks. Field observations, supported by lithogeochemistry, indicate that ultramafic and intermediate metavolcanic rocks are either absent or so rare as to have escaped detection at the current scale of mapping. The metavolcanic sequence extends the length of the belt as mapped, and continues to both the east and west as remnants in the predominantly granitic terrane.

Mafic metavolcanic rocks, metamorphosed to amphibolites, comprise about 80% of the north–facing sequence south of the Selwyn Lake lineament, with felsic metavolcanic rocks the remaining 20%. Mafic amphibolites comprise all of the identified metavolcanic rocks around the Paterson Lake antiform north of the fault. Around the Paterson Lake antiform, some quartz–rich phases of the migmatites that have been included with the metasedimentary rocks may be of felsic volcanic origin. However, textural, structural and mineralogical observations made in the field suggest it to be more likely that they are sedimentary in origin.

MAFIC METAVOLCANIC ROCKS

Mafic metavolcanic rocks consist of massive and pillowed flows, and rare pyroclastic rocks.

Pillowed flows are typical of the mafic metavolcanic sequence; however, intense deformation has rendered reliable top determinations impossible in all but a few cases. Grain size is commonly fine to medium grained, and primary textures, where preserved, include rare amygdules; plagioclase phenocrysts that are typical in discrete units of many mafic metavolcanic sequences in adjacent greenstone–rich subprovinces, such as the Wabigoon (Blackburn et al. 1991), are rare to absent in the Separation Lake belt. Metamorphic mineral assemblages are hornblende + plagioclase ± garnet ± epidote. Garnet commonly is abundant in pillow selvages, and in some places is so prevalent as to suggest hydrothermal alteration prior to metamorphism.

Mafic metavolcanic rocks are interpreted to have been almost entirely flows, pyroclastic rocks being positively identified in a single outcrop near Selwyn Lake. Metamorphic grade and state of deformation have rendered precise identification difficult, but the vast majority of the sequence was either massive flows or pillowed flows, the latter indicating submarine volcanism.

Non–deformed or weakly–deformed pillow structures are rare, and even where present, the shape and form of the pillows is such that top determinations can rarely be made. Reliable top determinations were made in 4 locations only. Three of these are in well exposed ice–scoured and water–washed outcrops along the English River between Separation Narrows and the northern margin of the greenstone belt (Photo 1). The fourth is in well–exposed, ice scoured rugged outcrops on the peninsula east of Fiord Bay, where it occurs in a large metavolcanic enclave and is therefore of limited regional significance. Interpillow material, in the form of hyaloclastite and its metamorphic counterparts, is common.

Amygdules are rare, even in well preserved flows, suggesting either deep submarine extrusion, or that the magma was not volatile–rich. They were observed in outcrops in the vicinity of the English River Road and the west shore of Separation Lake.

Flow thicknesses could not be determined with any degree of confidence, but are estimated to be on the order of metres to tens of metres based on a few pillowed flow tops. In places the flows have brecciated tops.

Mafic flows are mostly fine to medium grained. Isolated outcrops of coarser mafic rock, mostly in the vicinity and to the north of Separation Rapids, are either coarser portions of thick flows, or parts of subvolcanic gabbroic intrusions. In some outcrops gradation from coarse to finer grain size, and in some cases into well–defined pillow structures, confirms that not all of the coarse phases are of intrusive origin. This observation is supported by the evidence of coarser grained phases in feeder dikes to the flows that they intrude.

Porphyritic textures are rare, and phenocrysts consist of plagioclase only. Such feldspar–phyric flows were observed in the same general area as amygdular flows in the vicinity of the English River Road and the west shore of Separation Lake, and in the mafic enclave on the peninsula east of Fiord Bay. Individual plagioclase crystals rarely exceed 5 mm in diameter. Plagioclase–phyric units in which phenocrysts are up to centimetres in diameter, which are so characteristic of many mafic metavolcanic sequences in the Wabigoon and other predominantly metavolcanic subprovinces, are entirely absent.

Deformation of mafic metavolcanic rocks is moderate to intense, and generally increases both toward the margins of the greenstone belt and from south to north in the thickest part of the succession, between Separation Rapids and the south end of the Umfreville Road. Weakest deformation is indicated both by flattening and elongation of pillow shapes, and by discrete often narrow (tens of centimetres to metres) shear zones. Deformation is gradational to a thoroughly layered structure, in which dark coloured layers alternate with lighter layers, on the scale of 1 to 4 cm. Outcrops that are typical of this feature can be seen along the English River Road northeast of the Umfreville Road turn–off. The derivation of this layering from deformation of pillowed flows is confirmed in a few outcrops where passage can be seen across strike from elongate, but still clearly recognisable, pillow shapes into the characteristic layering. Metamorphic differentiation must play a part in this process also, since the dark layers are composed almost entirely of hornblende, and the light bands of diopside.

South of the Selwyn Lake lineament, the mafic metavolcanic sequence achieves a maximum estimated thickness of 2000 m in the central part of the belt. This estimate is based on a number of assumptions: (1) that the deepest part of the sequence lies in the core of the Separation Narrows anticline; (2) that, with no evidence to the contrary, the sequence is homoclinal from the core of the Separation Narrows anticline to the transition into the felsic metavolcanic rocks to the north; (3) that there is neither repetition nor cutting out of sections of the succession due to cryptic, unrecognised faulting parallel to the regional foliation trend; and (4) that the steep to vertical dips of foliation reflect steep to vertical dip of individual flow units. The latter assumption is born out by steep to vertical contacts of intercalated chemical and clastic metasedimentary units. This thickness diminishes to both the east and west, though the extent to which this is due to intrusion of granitic magma is not known. No top determinations have been made in the mafic sequence west of the English River, neither have they been made in the main part of the belt east of Separation Narrows: homoclinicity is assumed in the absence of evidence to the contrary.

The mafic metavolcanic enclave in the peninsula east of Fiord Bay is a detached remnant of the main belt. The single top determination from pillow lavas, which face west, probably reflects local folding, and provides little evidence for way up of the sequence as a whole. The gabbro sill and flanking iron formation units at the east end could overly or underlie the mafic metavolcanic sequence based on this information.

North of the Selwyn Lake lineament one mafic metavolcanic unit wraps almost continuously around the Paterson Lake granite in the Paterson Lake antiform. Other detached amphibolite units within the migmatite terrane are interpreted to be remnants of the larger mafic metavolcanic unit: no estimate can be made of the former thickness of the mafic metavolcanic succession in this area.

South of the Selwyn Lake lineament, hiatuses in mafic volcanism are indicated by two laterally continuous chert–magnetite iron formation units, and a discontinuous clastic unit. There is neither petrographic nor lithogeochemical evidence to suggest that these hiatuses represent termination of volcanic cycles and the onset of new cycles of different chemical affinity, since all metavolcanic rocks within the mafic succession are tholeiitic basalts.

Garnet is a common metamorphic mineral phase in parts of the mafic metavolcanic sequence, though its abundance is very variable. As a generalisation, it is largely absent east of Separation Narrows, and increases in abundance westward from Separation Narrows. It is especially abundant in 2 general areas: at the top of the mafic sequence in the vicinity of the Umfreville Road; and in proximity to the Selwyn Lake granitic intrusions. Commonly it is concentrated in pillow rims, and in individual bands within banded amphibolites, but in the two general areas mentioned above it can be pervasive throughout the rock over broad areas. In a few places porphyroblasts of hornblende accompany garnet (Photo 2). This zonal distribution is strongly suggestive of selective pre–metamorphism alteration by circulating hydrothermal solutions, and this is supported by association with adjacent sulphide zones in some places (Photo 3). Hydrothermal alteration is also indicated by development of calc–silicate pods, in some places with accompanying garnet, and calc–silicate zones in pillows and pillow–breccia.

FELSIC METAVOLCANIC ROCKS

Felsic metavolcanic rocks appear to be entirely pyroclastic: no felsic effusive flows have been recognised.

Felsic pyroclastic rocks have only been positively identified south of the Selwyn Lake lineament, apart from a single outcrop of felsic tuff within the migmatitic terrane on the south flank of the Paterson Lake antiform. The major unit, predominantly of tuff, with subordinate lapilli–tuff, appears to conformably overlie the mafic metavolcanic sequence. The eastward–thinning unit extends from about 1 km east of Selwyn Lake to the English River Road south of Trout Lake, a distance of 14 km. The unit has a maximum thickness of about 500 m, and averages 200 m over most of its length. Two narrower, discontinuous tuff units lie within the mafic metavolcanic sequence about 100 m below the major unit, one to the west and the second in the east in the vicinity of the English River Road.

Because of their position between the mafic sequence to the south and the metasedimentary migmatites to the north, and the location of a broad deformation zone in this vicinity, primary structures and textures have, in many places, been obliterated, commonly hindering precise identification of the precursor rock. Nonetheless, sufficient examples of relict textures seen in outcrop suggest that tuffs are the major component of the felsic metavolcanic sequence, and that lapilli–tuffs are subordinate. Relative distribution of tuffs and lapilli–tuffs is difficult to ascertain, because of both the monolithologic nature of the lapilli–tuffs, and degree of tectonism and recrystallisation. However, there is a general preponderance of coarser facies in the thicker part of the felsic volcanic sequence at the west end of the major unit (Photo 4). Nonetheless, good outcrop exposures along the English River Road, in the east, display examples of lapilli–tuff.

Both tuffs and lapilli–tuffs are commonly composed of quartz and feldspar crystals, the lapilli–tuffs being composed of both fine–grained felsic material, and lapilli–size aggregates of quartz and feldspar crystal tuff. This suggests that the fragments were derived by fragmentation of previously consolidated tuffaceous material. Accidental fragments include rare quartz clasts, suggesting an epiclastic component to the process of deposition. Very fine grained and commonly banded, cherty–looking phases are probably derived from very fine ash, but some may be of effusive origin. Bedding on the scale of one to 5 cm is common in some places, particularly those felsic pyroclastic rocks in the vicinity of the English River Road. Tectonic overprinting has probably accentuated the layering (Photo 5), in some places producing a fine lamination, resulting in a schistosity defined by elongation of micas. Biotite content varies from absent to about 30% in rocks mapped as felsic metavolcanics: rocks with high biotite content may be of epiclastic origin, but such distinction between pyroclastic and clastic processes of deposition is difficult because of degree of foliation.

In some places, and particularly in the section along the English River Road, partial melting of felsic metavolcanic rocks or suprajacent metasedimentary rocks has produced quartz veins and granitic dikes, either injected parallel to foliation, or as ptygmatic veins, or as gash–filled fractures (Photo 5).

Metasedimentary Rocks

CHEMICAL METASEDIMENTARY ROCKS

Magnetite–bearing iron formations occupy at least two stratigraphic levels within the mafic metavolcanic sequence south of the Selwyn Lake lineament. Typically the iron formations are layered, composite chert–magnetite beds on the order of 1 to 5 m wide with intervening mafic metavolcanic material. The chert–magnetite beds and mafic metavolcanic material may be aggregated into zones on the order of tens of metres wide. Sulphide minerals, predominantly pyrrhotite with subordinate pyrite, replace magnetite in places. The units are folded on mesoscopic and macroscopic scales, and brecciated in places.

Chert–magnetite iron formation units occur discontinuously over a strike length of 30 km from Helder Lake in the east to Separation Lake, and thence around the Separation Narrows anticline to the north end of Fiord Bay. Iron formation in the supracrustal enclave on the peninsula east of Fiord Bay represents the continuation of the major units east of the Fiord Bay lineament. Discontinuity of the units leads to difficulty in correlation, and hence precision in defining the number of units and their stratigraphic position. However, superposition in the core of the Separation Narrows anticline shows that at least two stratigraphic units exist. A lower unit is exposed in road cuts in the English River Road 2 km north of Separation Narrows, and an upper unit is exposed in outcrops at the Umfreville Road turnoff from the English River Road. Both units wrap in a broad arc around the Separation Narrows anticline, where they are exposed in outcrops on the English River.

Both units consist of chert (Photo 6) and magnetite–rich (Photo 7) bands on the order of 1 to 10 cm thick, alternating with massive mafic metavolcanic flows on the order of 0.5 to 2 m thick, aggregated into a unit on the order of 10 m thick. Pillowed mafic flows occur below and above the iron formations. The lower unit is well exposed in the road cut on the English River Road, where it is tightly folded in the core of the Separation Narrows anticline: this tight folding is characteristic of the lower unit in this area. The upper unit lies about 1000 m above the lower unit, and although similar in alternation of chemical metasedimentary beds and mafic metavolcanic flows, is distinctive by virtue of a 100 m thick gabbro sill that lies between a lower and upper member. The sill is discontinuous and, where absent, there appears to be only one iron formation member, strongly suggesting that the sill was emplaced preferentially within the pre–existing single iron formation unit.

Correlation of the two iron formation units both eastward toward Helder Lake, and to the southeast of the Fiord Bay lineament, is made difficult by discontinuity over distances in excess of 3 km strike length between exposed iron formations. However, the presence of a gabbro sill emplaced within the upper unit is distinctive and unique enough to suggest that wherever this occurs it is reasonable to correlate with the upper unit. On these grounds the upper unit is interpreted to extend eastward at least as far as a point 3 km south of Treelined Lake, and possibly as far to the east as the Lennan Road, where gabbro is closely spatially associated with iron formation. Correlation is also thus made with the unit occurring along the northern edge of the supracrustal enclave in the peninsula east of Fiord Bay. On this same basis the lack of a gabbro sill in conjunction with the 4 km long iron formation unit along the south side of the greenstone belt at Helder Lake suggests correlation with the lower unit in the core of the Separation Narrows anticline.

Iron formation is not generally present within the mafic metavolcanic sequence west of the English River, except at two places: in outcrops along the south margin of the belt east of Selwyn Lake; and in one outcrop north of Storm Bay.

Petrography of the iron formations is commonly a simple quartz–magnetite mosaic, with minor hornblende, or bladed to prismatic, polysynthetically–twinned grunerite. Garnet occurs in poikiloblastic growth in places, or in discrete garnet–rich layers between magnetite layers (Photo 7).

Sulphidisation of the magnetite is displayed in strongly oxidised, rusty outcrops, that have been the target of exploration for base metals (Photo 8).

CLASTIC METASEDIMENTARY ROCKS

Clastic metasedimentary rocks of the Separation Lake greenstone belt occur at two, and possibly three, stratigraphic levels. In the western half of the belt, a narrow unit of feldspathic arenite to wacke occurs within the mafic metavolcanic sequence about 500 m below its contact with the felsic metavolcanic sequence. A second mixed sandstone and conglomerate unit occurs within the mafic metavolcanic sequence where it narrows to about 1000 m, midway between Separation Lake and Helder Lake. A third, predominantly conglomeratic unit, lies to the north of, and in immediate contact with, the metavolcanic sequence in the central part of the map area.

The first of these units, the feldspathic arenite to wacke, is about 30 m wide and extends from north of Boot Bay at its east end, where it is crossed by the English River and Umfreville roads, to a point 3 km east of Selwyn Lake. The central portion is cut out by intrusion of the Separation Rapids pegmatitic granite pluton on the English River, and there is a 2 km gap in outcrop where the unit lies beneath a creek flowing from the east into the English River. The unit was intersected in drilling done by Champion Bear Resources Ltd. beneath the creek (A.P. Pryslak, personal communication, 1992), supporting the correlation of the two segments of the unit west and east of the English River. Minor garnet occurs in the unit east of the river. West of the river, the unit is characterised by abundant garnet, and in places also by andalusite. Presence of these metamorphic minerals indicates either that the sediments were more alumina–rich, or alumina enrichment was due to hydrothermal alteration, or increase in metamorphic grade: these possibilities are further assessed in the section on geochemistry.

The second, mixed sandstone and conglomerate, unit has only been seen in three outcrops, allowing definition of a 1.5 km strike length, and a maximum exposed width of about 10 m seen in one outcrop. Conglomerate and sandstone beds alternate, and proportions vary considerably between the three outcrops: the western–most contains 85% conglomerate; the eastern–most predominantly sandstone and pebbly sandstone. The central outcrop, entirely conglomerate, is too small (1 sq. m) to be representative. The conglomerates are predominantly matrix–supported, though deformation has obscured this in places. Clast types include mafic metavolcanic rocks, amphibolites, granitic and finer–grained, possibly felsic metavolcanic rocks, and quartz. Relative abundances vary between the three outcrops. Mafic clasts are predominant in the west and central outcrops and granitic in the east outcrop. Notably absent are any chert or magnetite clasts. Some granitic clasts are up to cobble size, but most clasts are in the pebble size range.

Most of the third unit, lying immediately north of the metavolcanic sequence, is easily accessed by the English River Road, which runs along or closely parallel to the unit over much of its strike length. The unit pinches out immediately west of the Umfreville Road, from where it extends eastward a distance of in excess of 8.5 km to a point on the English River Road near the northeast bay of Separation Lake. Maximum known outcrop width is up to 30 m, but outcrop distribution suggests the unit may achieve a width of about 250 m in its central portion.

General lack of diagnostic sedimentary structures and intensity of shearing has led to few reliable top determinations in this latter sedimentary sequence. However, it is determined to overlie the metavolcanic sequence on the basis of presence of mafic and felsic volcanic clasts, in addition to granitoid, dioritic, chert, magnetite ironstone, and quartzose clasts. This conclusion is supported by observation of north–facing cross bedding in one outcrop only, on the English River road, in sandstones near the base of the sequence. At this location felsic tuffs imperceptibly pass northward into massive to thickly bedded sandstones with no indication of unconformity. Isolated pebbles and narrow pebble beds in the sandstones accompany trough cross bedding that is truncated to the north, indicating superposition of the metasediments on top of the metavolcanic sequence. Also at this locality felsic metavolcanic rocks pinch out eastward, so that, to the east, the metasedimentary sequence directly overlies mafic metavolcanic rocks. The contact between the metasedimentary and the mafic metavolcanic rocks has not been observed in outcrop, so it is not known whether the contact is erosional or structural.

There is a very general progression upward in the sedimentary sequence from quartzo–feldspathic sandstones that in places are difficult to distinguish from underlying felsic tuffs, into interbedded conglomerates and sandstones. Interbeds of sandstone and conglomerate vary from very thickly bedded (1 to 3 m) to medium bedded (10 to 30 cm). This relationship may only hold true for the western portion of the unit, especially where it overlies the felsic metavolcanic rocks: the relationship cannot be shown at the east end, where the unit overlies mafic metavolcanics, but this may reflect smaller and fewer outcrops in this area.

Pebble counts taken at four well–exposed outcrops of conglomerate distributed along the length of the upper unit (Table 2: stations 1014, 0260, 2015 and 2027) indicate some general characteristics and lateral variations. For purposes of the count, mafic igneous rocks include fine and coarse grained metavolcanic pebbles and possible intrusive rocks, some dioritic. On three of the four outcrops, shearing and flattening is intense enough to have obliterated boundaries between many clasts (Photo 9). Most of the material identified as matrix is probably better considered to be sheared mafic and dioritic clasts, since granitic and fine grained felsic clasts generally have survived deformation. However, at Station 2015 some mafic boulders, on the order of 1 m by 10 cm on horizontal surfaces, have survived tectonism, presumably because of their size. At this outcrop clast size is generally large, with approximately 50% of clasts being in the boulder (>256 mm) size range, including numerous banded to massive chert–magnetite iron formation clasts. The sum of mafic igneous clasts and matrix (Table 2) in all 4 outcrops is over 50% (51 to 75%), indicating a preponderance of mafic source rock, but it is not possible to ascertain any trend in lateral variation. Granite clasts range in abundance from 15 to 33%, with no indication of a consistent lateral trend. Fine–grained felsic clasts range in abundance from 4 to 11%, with a weak trend toward an increase to the east. Chemical metasedimentary fragments, represented by chert and magnetite, increase in total abundance from 2% in the west to 10% in the east, while quartz clasts, which are often difficult to distinguish from chert, show no consistent lateral variation (range of 1 to 6%).

While not diagnostic, the above observations suggest that the source for the conglomeratic portions of the upper sedimentary sequence was predominantly the underlying mafic metavolcanic sequence. Percentages of chemical metasedimentary clasts, varying from 1.5% to 10%, are consistent with their abundance within this mafic sequence. The highest ironstone value is 3.5%, whereas the highest value for chert (6.5%) may reflect difficulty in distinguishing between chert and quartz. Incorporation of granitic clasts indicates erosion of plutons subjacent to the volcanic pile, possibly the Separation Lake and Tourist Lake granites. No pegmatite clasts were seen, supportive of the subsequent emplacement of the Separation

Rapids pegmatitic granite. The felsic pyroclastic sequence also provided conglomeratic material, but probably was more a source for the sandstone portions of the upper clastic sedimentary unit, with which it shows closer similarity in mineral proportions.

The initial depositional environment was probably one of alluvial or fluvial fans marginal to the uprising felsic volcanic pile, depositing sand–size fractions. A subsequent environment was probably of deeper water facies, possibly turbiditic, still resulting from erosion of the felsic volcanic pile, but interrupted by pulses of conglomeratic debris carried by turbidity currents into the evolving basin. Deeper erosion of the volcanic pile and the underlying granites provided material for the conglomerates.

The evolution and subsequent architecture of the upper unit has much in common with other mixed conglomerate and sandstone sequences that lie above thick volcanic successions in other subprovinces. Examples are the Manitou Group (Teal and Walker 1977), Abram Group (Turner and Walker 1973), and Seine metasediments (Wood 1980) in the Wabigoon Subprovince. For the Manitou Group, Teal and Walker (1977) interpret a subsiding basin marginal to a volcanic–plutonic terrain.

Tectonism within the upper metasedimentary unit is expressed in a variety of ways, such as folding in conglomerate and sandstone beds, and rotation of larger, particularly granitic, clasts (Photo 9).

The upper contact of the conglomerates with the migmatites to the north is mostly marked by an overburden–filled depression or valley. In some places a steep scarp faces toward the north. However, the contact is exposed in the large outcrop area north of the English River Road 1.5 km northeast of the Umfreville Road turn–off (Photo 10). Here there is an abrupt transition across a few centimetres from highly deformed conglomerates that show no evidence of melting, but are injected by granitic dykes, into a granitic migmatite phase. The implications of this are further discussed in the section on structure.

Mafic Intrusive Rocks

Medium to coarse grained mafic rocks are subordinate to finer grained mafic metavolcanic rocks, within which the coarse grained rocks are confined. Distribution and continuity of the coarse grained rocks suggests that the majority are intrusive, though some may be parts of massive flows. Field and chemical data suggest that the mafic intrusive bodies are synvolcanic, and co–magmatic with the mafic metavolcanic rocks.

Most of the mafic intrusive bodies occur as sills or lenses within the mafic metavolcanic rocks in the central portion of the Separation Lake greenstone belt. North of Separation Rapids, three sills, stacked one above the other, are wrapped around the Separation Narrows anticline. The central sill intrudes a chert–magnetite iron formation unit. On the peninsula east of Fiord Bay of Separation Lake, a single large sill–like body similarly lies between two units of chert–magnetite iron formation, and, on this basis, is correlated with it. Other discontinuous lensoid bodies in this central location may be dismembered portions of these sills, discrete small intrusions, or, in some cases, the central portions of thick flows within which slow cooling allowed the development of coarse, gabbroic textures. Where the coarse–grained phases are bordered by narrow shear zones, these distinctions are difficult to make. On the geologic maps (back pocket), only those coarse gabbroic bodies that show no evidence of gradation into finer grained flows are indicated as mafic intrusive rocks.

None of the three sills in the central portion of the belt show evidence of systematic layering, though there is variation from melano to leucocratic phases, and in grain size from <2 mm to >1 cm. Larger grain size seems to accompany development of poikilitic texture. Contacts between the different gabbro phases are irregular but their overall thickness, up to about 150 m, probably precluded conditions suitable for the development of cumulate textures.

Other lenses of coarse mafic igneous rock are strung out intermittently along the length of the greenstone belt between the west end of Separation Lake and Helder Lake. This discontinuity, and the fact that some of the lenses are closely spatially associated with chert–magnetite iron formation either stratigraphically below or above, strongly suggests the lenses to be tectonically dismembered from the central gabbro sill in the Separation Narrows anticline. In some cases, for example in a lens near the Lennan Road, pulses of magma injection, similar to that seen in the three sills in the Separation Narrows anticline, are indicated by grain size and compositional changes at internal, irregular, contacts. In one lens, also near the Aesthetic road, centimetre–size layering was observed in leucogabbro, with some evidence of cross stratification. Calc–silicate alteration, in pods and filling fractures, was observed at these same two lenses.

No coarse grained mafic intrusive igneous bodies have been mapped west of the English River: the three stacked sills in the Separation Narrows anticline effectively represent the westernmost occurrence of intrusive gabbroic bodies. The structural implications of this observation are discussed in the section on structure in this report.

Textures vary from coarse gabbroic, to poikilitic, and mineralogy is remarkably uniform. Minor amounts of weakly porphyritic phases, in which plagioclases are up to 1 to 2 cm in diameter, occur, but there is no indication of distinct layering based on mineral content and/or crystal size, such as is seen elsewhere in the adjacent Wabigoon Subprovince (e.g. Mulcahy Lake gabbroic intrusion, Sutcliffe 1984). This would suggest that large magma chambers in which crystal fractionation could take place were not a feature of mafic igneous rock evolution in the Separation Lake greenstone belt.

Green amphibole pseudomorphs after pyroxene poikilitically or poikiloblastically enclose interstitial plagioclase, commonly twinned on the albite law. Interstitial brown biotite and epidote are commonly present in very minor amounts (<1%). No garnet was observed in the gabbros, either in those portions which maintained their integrity, or where tectonism has produced a cataclastic texture, supporting the interpretation that development of garnet in the mafic metavolcanic rocks is related to hydrothermal alteration prior to tectonism.

Cataclastic textures seen in thin section include development of phenoclasts up to 1.5cm in long dimension, consisting of green amphibole aggregates with interstitial plagioclase, in a finer–grained ground mass of similar amphibole and plagioclase. In some cases porphyroblastic horneblende is present.

High–Grade Metasedimentary Rocks

The English River Subprovince is characterized by highly metamorphosed and migmatized sedimentary rocks along with peraluminous granitoid rocks related to the migmatization process (Breaks 1991). To the north of the map area, leucocratic plutonic rocks of tonalitic to granitic composition occur in several discrete stocks and batholiths that have been interpreted (Breaks 1991) to be unrelated to the migmatization process.

Within the map area, the migmatitic metasedimentary rocks show considerable diversity due to both primary differences in their composition and depositional characteristics and superimposed metamorphic/migmatitic processes. The sedimentary origin of the migmatite paleosome is evident from the local preservation of bedding and pelitic composition of many of these rocks. The most common variety is composed of feldspar + quartz + biotite ± garnet. Alternating layers of finer grained (0.5–1mm), granoblastic material and coarser grained (1–2 mm), porphyroblastic material with the latter having a higher proportion of biotite and garnet are commonly present. These layers are interpreted to reflect primary interbedding of wacke and finer grained, more clay–rich (siltstone or mudstone) deposits. Commonly, schlieren of the schist occur in the granitic melt phase.

Quartz–rich metasedimentary rocks are widespread as a minor component within the more typical variety and locally predominate in units up to 200 m thick. Such a unit hosts the Treelined Lake graphite deposit between Trout and Treelined lakes. These silica–rich units may represent less pelitic rocks, but could also reflect silica mobility.

The primary sedimentary characteristics exert considerable control on the superposed secondary processes. The more pelitic layers are more coarsely recrystallized and commonly contain large (<3 cm) garnet porphyroblasts. The more pelitic layers also contain a higher proportion of granitic mobilizate as discussed below.

The granitic component of the migmatites typically constitutes from 20 to 40 % of the rock but ranges from 5 to 70 %. As the abundance of granitic component increases, the migmatite grades into peraluminous granite. Where the granitic component of the migmatite is minor (<20%) it is invariably pegmatitic and concentrated as concordant lenses, commonly with mafic selvages, in the more pelitic layers. At high (>50%) percentages of granitic component and in relatively more homogeneous peraluminous granites, the texture is commonly medium grained equigranular with irregular alkali granite pegmatitic patches.

Quartz + feldspar + biotite ± garnet gneisses that grade laterally and across strike into the more common schists of the same mineralogy, are present at a number of places within the migmatites around the Paterson Lake antiform. These gneisses are generally more quartz rich than the schists. They have mostly been interpreted as metasedimentary in origin, but field relationships, their common massive appearance, and their low ferromagnesian content suggest that some may be of felsic volcanic origin. In fact at one location, close to the nose of the Paterson Lake antiform, quartzo–feldspathic rocks of similar type were mapped as felsic tuffs. These quartz + feldspar + biotite ± garnet gneisses are further discussed in the section on geochemistry.

Mafic xenoliths or layers, in which horneblende is the dominant ferromagnesian phase, occur locally in the migmatites, particularly around the Paterson Lake antiform and at Helder Lake.

Polymictic conglomerate is present in a number of locations, some of which contrast with those described by Breaks (1991) in being well within the subprovince and interlayered with the finer grained migmatitic metasedimentary rocks. Conglomerate occurs in a large area of outcrop north of the English River Road, and east of the road providing access to the area between Trout and Treelined lakes. Further north, conglomerate has been mapped at three places, two north of the Upper Kettle Rapids pluton, on the north shore of the westerly bay off the English River, and the third along the Umfreville Road, 2 km north of the Trout Lake pluton. These three occurrences may be part of the same unit, now disrupted by the migmatisation process: if this is the case, they provide a stratigraphic marker within the migmatite terrane.

A pebble count taken at the occurrence of conglomerate along the Umfreville Road contrasts markedly in pebble type and abundance with pebble counts taken at the four occurrences of conglomerate in the greenstone belt (Table 2: station 2185). The count at station 2185 included no chert or ironstone clasts, very few mafic igneous clasts (4%), and a greater proportion of felsic fine grained clasts (19% versus 4 to 11% in the conglomerates of the greenstone belt) and quartz clasts (11% versus 1 to 6% in the conglomerates of the greenstone belt). In addition granite clasts comprise only 9% (total of granite and garnet–rich granite) of pebbles in the Umfreville road conglomerate, in contrast to 15 to 30% in the greenstone belt conglomerates. Most notably, no matrix was counted in the Umfreville Road conglomerate, but quartz + feldspar + biotite ± garnet schist, a clast type not recognised anywhere in the conglomerates of the greenstone belt, accounted for 57% of the pebbles counted. This marked difference in type and abundance can be explained in part by difference in metamorphic grade between the greenstone belt and the migmatites. Many of the schist clasts may be equivalent to matrix counted in the conglomerates of the greenstone belt. The presence of schist clasts does however raise the possibility of erosion of a precursor schist hinterland. The absence of chert and ironstone clasts and the low amounts of granite clasts (9%) and mafic igneous clasts (4%) in the Umfreville road conglomerate, now distant from the greenstone belt contact, may be due to one or more factors. It may reflect depletion of these materials as erosion progressed in the source area, or that the source area differed from the conglomerates of the greenstone belt, or that metamorphism has rendered identification of these clast types difficult. It should be understood that all the above observations are based on a pebble count from one occurrence only in the migmatite area, which may not be representative of all such occurrences.

Granitic Rocks

Granitic rocks of the English River Subprovince include those intimately associated with migmatites, and discrete plutons that intrude the migmatite terrain (Upper Kettle Rapids, Trout Lake, Treelined Lake, and Helder Lake plutons) that were derived by anatexis of the English River sedimentary rocks. The latter include rafts of still–recognisable metasedimentary restite, and clots composed of biotite and quartz, with or without garnet. All these granites, except the Helder Lake pluton, lie to the north of the Separation Lake greenstone belt, and are bordered outside of the current map area to the north by the Fletcher Lake batholith and Gone Lake stock (Breaks et al, 1993).

A discrete pluton, the Paterson Lake stock, lies in the core of the Paterson Lake antiform, and thus may be considered either to be south of the greenstone belt, or to lie within it. On metamorphic and structural grounds it is here considered to be part of the English River Subprovince.

Granitic bodies internal to the greenstone belt include the two stocks east of Selwyn Lake, and the pegmatitic granites along the English River, comprising the Separation Rapids pluton.

Granitic rocks of the Winnipeg River Subprovince lie south of the Separation Lake greenstone belt, and include those west of the English River Road, here referred to as the Tourist Lake granites, and those east of the road at Separation Lake, and referred to here as the Separation Lake granites. These two broad areas are part of the "metamorphosed felsic to intermediate intrusive rocks" mapped by Breaks et al. (1983) that lie north of the Lount Lake batholith.

Biotite is by far the predominant mafic component in all granitoid bodies, except the grey granitoid phase of the Separation Lake granites, where amphibole is an additional component: amphiboles have not been identified in hand specimen in the rest of the granitoid bodies. White mica is a major component of some of the pegmatites. Thin section study confirms the predominance of biotite as the mafic phase: exceptions to this are noted in the descriptions of individual granitic bodies below.

Garnet is common in granites associated with the migmatites, in the Selwyn Lake lenses, and in the pegmatites along the English River. It is absent in the Paterson Lake stock, and rare in the Tourist Lake and Separation Lake granites.

Development of foliation is variable, but no granitoid bodies are entirely devoid of foliation.

Thin section study of representative samples from all the major granitic bodies shows remarkable similarities in many components. Major similarities are noted here, and exceptions are noted in the descriptions of individual phases that follow. Textures are universally granitic, though deformation and/or recrystallisation modify this to varying degree. Plagioclase is commonly untwinned, though almost every sample contained some plagioclase with albite twins. Myrmekite is a component of most of the granites, but varies considerably in degree of development. Potash feldspar is invariably microcline, and occasionally also combined with Carlsbad twins. Biotite is commonly brown, though minor green biotite is present in some phases, as noted below. Accessory minerals include zircon, sphene and apatite, though the latter two may be characteristic of different phases. Epidote is an uncommon secondary component, except in the grey phases of the Separation Lake granites. Thin section study confirms that overall rock colour (e.g. pink, grey, white) is not a good discriminant between granites, granodiorites and tonalites, and that pink colouration is most likely due either to oxidation of minor iron–bearing primary phases or secondary introduction of iron–bearing compounds.

One hundred and seventy five granitoid samples, representative of all major granitic phases, were slabbed, the slabbed surfaces etched with hydrofluoric acid, and then immersed in sodium cobaltinitrite solution, which stained potash feldspar bright yellow. Visual estimates were made of percentages (modal abundances) of quartz, plagioclase feldspar, potash feldspar and mafic minerals (Table 3). From the data, totals of quartz (Q), potash feldspar (A) and plagioclase (P) normalised to 100% were plotted in QAP diagrams (Figure 3).

MIGMATITE–ASSOCIATED GRANITES

Granitoid rocks that accompany high–grade metasedimentary rocks north of the greenstone belt are medium to coarse grained, equigranular, foliated to non–foliated, and predominantly grey in colour. They are granites, with 5 – 25% biotite, and although garnet is commonly present in the metasedimentary restite component of the migmatite, it is rarely present in the granites: of 5 samples examined in thin section only one contained garnet, and then only a few grains. An exception to this rule lies in the grey quartzo–feldspathic rocks that contain quartz + biotite ± garnet clots. Of the 5 samples studied in thin section, 3 contained green biotite, either as the predominant biotite, or intergrown in subordinate amounts with brown biotite.

The envelope to 28 samples taken from throughout the migmatite terrain covers a broad area in the granite (*sensu stricto*) field in the QAP diagram, with marginal overlap (one sample) into the quartz monzonite field (Figure 3a). This field encompasses the envelope to samples from the Upper Kettle Rapids, Trout Lake, Treeline Lake and Helder Lake granites. Only three samples show marked deviation from the norm, due to abnormal plagioclase/K–spar ratios.

UPPER KETTLE RAPIDS, TROUT LAKE AND TREELINED LAKE GRANITES

Three granitic plutons derived by partial melting of sedimentary rock occur within the migmatite terrain (part of the Treelined Lake granitic complex of Breaks and Pan, 1995). The Upper Kettle Rapids pluton is irregular in shape, and the largest of the three. It extends from Upper Kettle Rapids on the English River, where it is at a maximum width of 3 km from north to south, in a narrow, arc shape marginal to the Separation Lake greenstone belt, eastward to the vicinity of the Lennan Road turnoff on the English River Road. The eastern termination of the pluton is transitional into the granites associated with migmatites that extend along the north boundary of the greenstone belt to Helder Lake, so that no contact can be shown on the geological map. The Trout Lake pluton is roughly circular, with a diameter of about 3 km. The dimensions of the Treelined Lake pluton are unknown, as only a small portion at the south end of Treelined Lake was mapped.

Granitic rocks of this suite are medium to coarse grained, equigranular, predominantly massive, and pink to grey in colour. Minor sedimentary restite is present in places. They are granites, with about 10% biotite. Garnet occurs either as millimetre–size euhedral crystals, or in clots up to 5 cm in diameter that also contain quartz and biotite: the clots also occur with no garnet present. Garnet is unevenly distributed, and absent over large areas. Rare black tourmaline was noted at one locality only, in clotty granite, close to the contact with mafic metavolcanic rocks of the greenstone belt along the Lennan Road. Thin section study of a number of samples from the suite also indicated minor white mica, either intergrown with biotite or interstitial to other mineral grains.

Clotty granites of the type described here have been mapped elsewhere within the English River subprovince, in most cases close to the southern boundary with the Winnipeg River subprovince. Breaks (1991) and Breaks and Bond (1993) concur with Morin and Turnock (1975) that the clots represent refractory relics of metasedimentary material due to anatexis.

The envelope to 23 samples from the Upper Kettle Rapids, Trout Lake and Treelined Lake granites covers a broad area of the granite (*sensu stricto*) field in the QAP diagram, and lies within the broader field for granites of the migmatite terrain (Figure 3a, Clotty Granites field).

HELDER LAKE GRANITES

An elongate granitic body centred on Helder Lake is similar in composition to the Upper Kettle Rapids, Trout Lake and Treelined Lake plutons within the migmatites. However, it differs in that it is a relatively inclusion free body within the amphibolites that are injected by granite at the east end of the Separation Lake metavolcanic belt. Biotite is the predominant mafic mineral, though minor hornblende is present where amphibolitic screens are more abundant. Garnet occurs in clots with quartz and biotite, but is rare in comparison to that in the three plutons in the metasedimentary migmatite terrane. Helder Lake granites were probably derived by partial melting of metasedimentary rock now represented by the migmatite terrane.

The envelope to 5 samples from the Helder Lake granites falls entirely in the granite (*sensu stricto*) field in the QAP diagram, and within that of the clotty granite plutons, and the broader field for granites of the migmatite terrain (Figure 3a).

PATERSON LAKE GRANITES

Paterson Lake granitoids are remarkably uniform throughout the portions of the pluton mapped. Because of this apparent uniformity, time available, and difficulty of access due to almost total blowdown of trees, only the contact area of the pluton with the greenstone belt, the shore line of Paterson Lake, and some of the shore line of Umfreville Lake were mapped: the western extent of the pluton is unknown. The rocks are medium to coarse grained, predominantly equigranular, though seriate to megacrystic phases were observed at Umfreville Lake, and predominantly massive and pink in colour. They are granites, with about 15% biotite. Garnet is not present in these rocks. Two thin sections studied showed presence of rhombic and anhedral sphene.

The uniform nature of the pluton is attested to by the small size of the envelope to 13 samples plotted in the QAP diagram (Figure 3b). It falls predominantly in the granite (*sensu stricto*) field, with some overlap (one sample) into the quartz monzonite field.

SELWYN LAKE GRANITES

Selwyn Lake granitoids are medium to coarse grained, equigranular, foliated, and grey in colour. They are granites, with about 15% biotite, and rarely contain garnet. They occur in two stocks, emplaced at about the same stratigraphic level into the mafic metavolcanic rocks. Degree of foliation suggests that they have undergone the same deformation as the metavolcanic rocks and were therefore emplaced pre– to syntectonically. Thin section study of 4 samples from the west lens and one from the east lens show recrystallisation textures (polygonal to sutured grain boundaries) and high degree of strain (wavy extinction) particularly in and between quartz grains, but also in feldspars. Grain size reduction, particularly in quartz is also a common feature. Plagioclase is invariably sericitised to a greater or lesser degree, and this is evident in hand specimen where plagioclase commonly has a whiter, more opaque appearance than surrounding potash feldspar and quartz. Very minor garnet is present in two of the studied samples from the west stock.

The envelope to 12 samples plotted in the QAP diagram (Figure 3a) falls predominantly in the granite (*sensu stricto*) field, with some overlap (one sample) into the quartz monzonite field.

SEPARTATION RAPIDS PEGMATITIC GRANITES

Granitoid rocks of the Separation Rapids pluton, emplaced into the volcanic belt in the vicinity of the English River, 4 km west northwest of Separation Rapids, are predominantly pegmatitic to coarse grained, with some aplitic phases. They are pink to white in colour, and vary in composition from granites to granodiorites to tonalites, though colour is not a good discriminant. Garnet is present in the more plagioclase–rich varieties, in both aplites and pegmatites. Pale green beryl was found in garnet–bearing tonalites by the present survey, and Breaks (1993) subsequently found other occurrences of beryl and other rare metal bearing minerals (see section on rare metals). Muscovite is the predominant mica, especially in tonalite. Large pink blocky potash feldspar crystals are common in and define granodioritic and granitic pegmatites and coarse grained phases can be megacrystic. Layering, defined by crystal size and composition, is common.

The pegmatite field associated with the pluton extends eastward at least as far as the English River Road, and possibly westward on the order of 2 km from the English River, where muscovite and garnet bearing bodies, mappable at the current scale, occur. Green beryl was found in one such pegmatite in this area. Further extension of the field is indicated by an unconfirmed green beryl occurrence (a single crystal observed in outcrop but not sampled) in pegmatitic granite within the Tourist Lake granites, outcropping along the creek flowing northward into Storm Bay at its east end. A confirmed occurrence of green beryl (X–ray diffraction of several grains), at one location only, in pegmatite on the peninsula east of Fiord Bay, greatly increases the possible extent of the field generated by the Separation Rapids pluton. The possibility of other as yet undiscovered rare metal–bearing plutons and attendant pegmatite fields is raised by this discovery.

The pegmatitic character of most of the Separation Rapids granites precludes meaningful estimates of modal abundances in most cases. However, 5 relatively finer grained and homogeneous samples show marked scatter in the QAP diagram, falling in 3 fields: granite (*sensu stricto*) granodiorite and tonalite (Figure 3c).

TOURIST LAKE GRANITES

Tourist Lake granitoids, named after Tourist Lake just south of the mapped area and 2 km south of Selwyn Lake, are medium to coarse grained, equigranular to megacrystic, foliated to nonfoliated, and pink in colour. They are granites, with 10 – 20% biotite. Garnet is absent to rare in these rocks. Thin section study of 3 samples showed presence of abundant apatite in one sample, and brown to olive green biotite in another.

Toward the east, in the vicinity of Storm Bay, typical Tourist Lake granites cut grey granites similar to the grey phase of the Separation Lake granites, suggesting continuity between Tourist Lake granites and the Separation Lake granites.

At least some of the pegmatitic phases near the greenstone belt contact may be of the Separation Rapids pluton pegmatite association, though pink pegmatites that cut grey granites are more likely of the pink phase of the Separation Lake granites.

The envelope to 23 samples covers a broad area of the granite (*sensu stricto*) field in the QAP diagram (Figure 3d), with overlap into the granodiorite (2 samples) and quartz monzonite (one sample) fields. Three other samples show marked deviation from the norm, toward the plagioclase corner of the diagram.

SEPARATION LAKE GRANITES

To the east of the south salient of the greenstone belt, in the vicinity of the English River Road, a variable suite of pale to dark grey rocks are inter–leaved with amphibolites, and intruded by pink granites.

Grain size of the grey granites varies from fine to coarse. They are predominantly foliated, and contain both amphibole and biotite. They vary widely in major mineral content, so that the envelope to 29 slabbed and stained samples occupies a broad area in the QAP diagram, overlapping the granite (*sensu stricto*), granodiorite, tonalite, and quartz–rich monzonite and monzodiorite fields (Figure 3d). Garnet is absent from these rocks. Their wide compositional variety and common interleaving with mafic metavolcanic rocks, either as lit–par–lit units or showing boudinage suggests these rocks to be hybrid phases derived by contamination of silicic magmas by incorporation of mafic volcanic rocks. Thin section study of 3 samples confirmed green euhedral amphibole, and presence of minor epidote in all three, and sphene in 2 out of 3.

Pink granites invariably intrude the grey phase. They are massive, rarely contain mafic xenoliths, medium to coarse grained, equigranular to megacrystic to pegmatitic. Dikes of pink phase granites are pegmatitic to aplitic, and markedly discordant to grey phase rocks. Magnetite is a common accessory mineral in the pegmatites.

The envelope to 26 samples of the pink phase granites is markedly removed from that of the grey phase. It occupies a large area in the granite (*sensu stricto*) field in the QAP diagram (Figure 3d), with marginal overlap (4 samples) into the granodiorite and quartz monzonite fields, and corresponds very closely to that of the Tourist Lake granites, supporting their continuity.

Late mafic dikes cut both the grey and the pink granites, indicating late emplacement, unrelated to mafic volcanism in the Separation Lake greenstone belt.

GEOCHEMISTRY

Eighty five samples (Table 4) were selected for major and minor oxides and trace element analyses (Table 5). The samples included 45 mafic metavolcanic rocks, 11 metagabbros, 10 felsic metavolcanic rocks, 5 clastic metasedimentary rocks, 8 granitic rocks, and 6 quartz – feldspar – biotite – garnet gneisses (Figure 4).

Major and minor oxides were analysed in all 85 samples to provide both petrogenetic discrimination and to provide benchmark data in unaltered to least altered samples against which potentially altered samples could be measured.

Trace elements were selected for 3 purposes: for petrogenetic discrimination; to provide stable or immobile elements against which alteration may be measured; and to indicate background levels of elements of potential economic interest in unmineralized samples.

All samples were analysed for the following trace elements: Rb, Sr, Y, Zr, Sc, V, Zn, Cu. In addition, mafic rocks (mafic metavolcanic rocks and metagabbros) were analyzed for Ni. Other elements were provided as part of the analytical packages into which each of the requested elements fell.

Thirty three (Table 6) of the 85 samples were selected for rare earth element analysis: 15 mafic metavolcanic rocks, 6 metagabbros, 3 felsic metavolcanic rocks, all 8 granitic rocks, and 1 quartz – feldspar – biotite – garnet gneiss. Samples were selected primarily for petrogenetic discrimination, except for 8 potentially altered mafic metavolcanic rocks. The other 7 mafic metavolcanic rocks test for both lateral and vertical variation in chemical composition. Three of the metagabbro samples were taken from each of the 3 conformable metagabbro bodies in the Separation Narrows anticline. These test vertical variation in chemical composition between the 3 bodies, and provide comparison with one sample from the conformable body on the peninsula east of Fiord Bay. The other 2 were taken from smaller bodies in the east end of the belt. All gabbro samples also test similarity with enclosing basalts. The 3 felsic metavolcanic rocks test for lateral variation in chemical composition. The gneiss was selected for comparison with the felsic metavolcanic rocks and the granitic rocks. Data are presented on chondrite normalised plots according to Sun (1982).

Mafic Metavolcanic Rocks

The 45 mafic metavolcanic rock samples included 24 fine grained and aphanitic samples chosen as being unaltered to least altered. They are distributed throughout the belt, and at various stratigraphic levels, in order to test lateral and vertical variation. The other 21 samples were chosen for their potentially altered nature, and are discussed in the section on alteration.

Twenty three of the 24 unaltered to least altered samples fall in the basalt range of 45 to 52% SiO_2, the other one (0113) being slightly over, and therefore strictly basaltic andesite (Figure 5a). For the purposes of the current discussion it is included in the mafic metavolcanic suite, and considered to be basalt.

All 24 unaltered to least altered basalt samples are subalkaline (Figure 5b) and tholeiitic (Figure 5c) according to the classification of Irvine and Baragar (1971), but straddle the tholeiitic and calc–alkaline fields in the FeO* + TiO_2 / Al_2O_3 / MgO cation diagram (Figure 5d) of Jensen (1976). This compares well with Breaks and Bond (1993), who found all 14 mafic metavolcanic samples that they collected from the same area to be tholeiitic, and dominantly high–Mg, according to the cation diagram. Data points are scattered in the diagrams, and no evolutionary trend is discernible, indicating no systematic lateral or vertical variation to have been detected by the present survey. Samples are low to medium potash (Figure 5e), though sample 1282 deviates from the rest (0.99% K_2O).

Unaltered samples show tight clustering on diagrams utilising titanium and the trace elements Zr, Y, and Sr, all considered to be relatively immobile in environments of alteration (Pearce and Cann 1973), and fall in fields characteristic of low potash ocean floor tholeiitic basalts (Figures 5f, 5g and 5h).

The 24 samples can be considered to be typical of the Separation Lake basalt suite for comparison with potentially altered basalts.

Chondrite normalised rare earth element data for 7 unaltered metabasalts (Figure 8a) show flat patterns at 8 to 10 X chondrites, typical of mid–ocean ridge basalts, and show neither lateral nor vertical variation. One sample (4003) shows an unexplained positive Eu anomaly at about 15 X chondrites.

Metagabbros

The 11 metagabbro samples are all coarse, poikilitic, and unaltered. Six are representative of the 3 sill–like bodies stacked one above the other and folded around the Separation Narrows anticline. Two samples were selected from each body. They were interpreted to be from the same magma pool as the metabasalts, and were chosen to test that hypothesis.

All 11 samples fall in the basalt field (Figure 6a) of LeMaitre (1989), and are subalkaline (Figure 6b) and tholeiitic (Figure 6c) according to the classification scheme of Irvine and Baragar (1971). They plot as high magnesium tholeiitic to marginally basaltic komatiitic in the $FeO^* + TiO_2/Al_2O_3$ / MgO cation plot (Figure 6d) of Jensen (1976). There is no systematic difference between samples from each of the 3 gabbro sills. Like the unaltered basalts, gabbros are low potash (Figure 6e), though sample 2375 deviates from the rest (0.76%).

The 11 samples show a similar clustering on diagrams utilizing titanium, Zr, Y, and Sr (Pearce and Cann 1973) to the 23 samples typical of the Separation Lake basalt suite, in fields characteristic of low potash ocean floor tholeiitic basalts (Figures 6f, 6g and 6h).

The above observations, though not definitive, suggest that differentiation has not played an important part in the evolution of the gabbros, and that they are part of the same magma pool as the basalts.

Chondrite normalised rare earth element data for 6 gabbros (Figure 8b) all show flat patterns at 5 to 10 X chondrites. There is no discernible difference among samples from the 3 conformable metagabbros in the Separation Narrows anticline and the similar metagabbro on the peninsula east of Fiord Bay. Patterns are similar to those for unaltered basalts (Figure 8a), thus supporting their derivation from a common magma pool.

Granitic Rocks

The 8 granitic rock samples were taken as representative of the Paterson Lake granite (1 sample), the Selwyn Lake granite (2 samples), granites in the migmatite terrane (4 samples), and the Helder Lake granite (1 sample).

Inspection of analyses of major and minor oxides and trace elements (Table 5) shows the fundamental similarity in composition of all samples. This is confirmed in the mesonormative QAP plot (Figure 7a), where all samples except 1366, a Paterson Lake granite, closely cluster in the granite *sensu stricto* field: sample 1366 is also in the granite *sensu stricto* field, but displaced toward the plagioclase corner. These results compare well with determinations of modal mineral abundances (Figure 3), which indicated the essential granite *sensu stricto* composition of the major plutonic bodies.

For purposes of comparison with problematical quartz – feldspar – biotite – garnet rocks, and with felsic metavolcanic rocks, the granitic rocks were also plotted on discriminant diagrams for volcanic rocks (Figures 7b to e).

Chondrite normalized REE patterns for granitic rocks (Figure 8c) show steep to moderate negative slope patterns, and all except that for Paterson Lake granite (1366) show negative Eu anomalies. Eu anomalies are pronounced for 2 samples of Selwyn Lake granite (0237 and 1262), 2 samples of Kettle Rapids granite (2176 and 4153) and Helder Lake granite (2230), but less so for Trout Lake and Treelined Lake granites (2134 and 2348 respectively). These patterns indicate that plagioclase fractionation played a major role in evolution of all these bodies except the Paterson Lake granite.

Felsic Metavolcanic Rocks

The 10 felsic metavolcanic rock samples are all fine grained, tuffaceous, and relatively unaltered. They were chosen so as to be distributed as evenly as possible along the length of the felsic volcanic unit at the top of the volcanic pile. This was done to test for lateral variation in chemical composition.

All 10 samples fall in the dacite to rhyolite range in terms of their SiO_2 values, being over 66% (Figure 7b). All are subalkaline (Figure 7c), and calc–alkaline (Figure 7d) according to the classification scheme of Irvine and Baragar (1971), and also in the FeO* + TiO_2 / Al_2O_3 / MgO cation diagram (Figure 7e) of Jensen (1976), and range from dacite to rhyolite.

When plotted in the mesonormative QAP plot for plutonic rocks, for purposes of comparison, they show considerable scatter compared with granitic rocks (Figure 7a).

There is no evidence of systematic lateral chemical variation within the felsic pyroclastic rocks.

Chondrite normalized REE data for 3 felsic pyroclastic rock samples (Figure 8d) show variable patterns that are also distinct from other rock types. The pattern for sample 0025 shows a steep negative slope from 200 x chondrites for light REEs and heavy REE depletion down to 3 x chondrites, distinctly different from that for samples 0032 and 0178. The latter show tendency to flat patterns at 10 x chondrites, light rare earth element (La and Ce) enrichment, and moderate positive Eu anomalies. Comparisons with patterns for Archean rhyolite types FI, FII and FIII (Condie 1981; Lesher et al. 1986) are difficult to make. Sample 0025 is similar to FI (depleted in heavy REEs and lacking a Eu anomaly), whereas 0032 and 0178 though flatter, lack the negative Eu anomaly characteristic of FII and FIII rhyolites. The potential for discovery of economic base metal accumulations in the felsic metavolcanic sequence should not be based on only three samples, but it is worth noting that to date no appreciable base metal occurrences have been found associated with felsic metavolcanic rocks (see Recommendations for Exploration).

Quartz-Feldspar-Biotite-Garnet Gneisses

The 6 samples of gneiss are all representative of the problematical felsic rocks that occur within the migmatites north of the volcanic belt, that have been interpreted to be of metasedimentary rather than metavolcanic origin. They were selected for comparison with the felsic metavolcanic rocks, and with the granitic rocks, particularly those in the migmatite terrane.

All samples are subalkaline (Figure 7c) and calc–alkaline (Figure 7d) according to the classification of Irvine and Baragar (1971), but 2 samples fall in the tholeiitic field in the FeO* + TiO_2 / Al_2O_3 / MgO cation diagram (Figure 7e) of Jensen (1976).

When plotted for comparison purposes in the normative QAP plot for plutonic rocks (Figure 7a), all samples fall in the granite *sensu stricto* field, except sample 1397, which is anomalously high in quartz, reflecting a high (80%) SiO_2 and low (6.08%) Al_2O_3 content. In this respect they show closer comparison with the granitic rocks, though clustered in a different part of the field, than with the felsic tuffs, which show considerable scatter (Figure 7a).

The chondrite normalized REE pattern for one sample of quartz – feldspar – biotite – garnet gneiss (0350) shows a steep pattern (Figure 8e), similar to one of the felsic tuff samples (0025, Figure 8d). However the slope for the gneiss flattens at the HREE end in comparison with that of the tuff. Although conclusions based on one sample are very tentative, the dissimilarity of the pattern for the gneiss to either those for felsic tuffs (Figure 8d) or granitic rocks (Figure 8c), suggests that there is no simple genetic connection with either rock type.

Clastic Metasedimentary Rocks

The 5 clastic metasedimentary rock samples are all fine grained sandstones. All are from the narrow unit within the mafic volcanic sequence. One (sample 0312) is from the portion east of the English River, and contains only minor metamorphic garnet as an indicator mineral. The four from west of the river contain increased amounts of garnet, and in addition metamorphic andalusite. They were therefore suspected to be more altered than the sample from east of the river.

Examination of the data (Table 5) shows that relative to sample 0312, those from west of the river are enriched in SiO2 (except 1238), TiO_2, Al_2O_3, Na_2O, and K_2O, and depleted in total iron, MnO, MgO (except 1260), CaO, and P_2O_5. Sample 0312 is chemically distinct, but differences are not large. Although there is alumina and alkali enrichment in samples from west of the river, depletion in iron, manganese, magnesium and calcium is inconsistent with increased appearance of garnet, should alteration be invoked as the controlling factor. Therefore it is likely that metamorphic conditions (higher temperature and/or pressure) controlled development of these minerals rather than hydrothermal alteration.

ALTERATION

Alteration facies in the map area are limited by amphibolite grade metamorphism. There is a distinct lack of the carbonate–rich alteration zones and quartz veining so prevalent in most greenstone belts metamorphosed to greenschist facies.

Evidence of alteration zones in the volcanic sequence is limited to the mafic metavolcanic rocks. The amphibolite facies mineral assemblage of these rocks (dominantly hornblende and plagioclase, with minor garnet) is, in places, modified so that garnet becomes the predominant component. Commonly these garnet amphibolites are developed in proximity to sulphide zones, many of which have been tested in the exploration program of Champion Bear Resources Ltd. Such development of garnet suggests modification of the original basaltic composition, involving, in particular, alumina, iron, magnesium, or calcium. This could have been accompanied by alkali element mobility.

To test this hypothesis, 21 samples identified in the field as mafic metavolcanic samples were considered as being potentially altered. The samples included 15 garnet–bearing amphibolites, 5 amphibolites with no garnet, and one considered to be strongly silicified basalt. The latter sample (0081) was alternatively considered to be from a chert horizon (see discussion in the section on Champion Bear Resources Ltd.). All 21 samples generally show deviation from typical Separation Lake suite basalts in discrimination plots (Figures 5): three samples lie in the alkaline field in Figure 5b (0003, 0072, 1110).

For typical Separation Lake basalt suite samples, as defined in the section on geochemistry, the following are the ranges for major element oxides:

- K_2O ranges from 0.05 to 0.56% (discounting sample 1282, at 0.99%)
- Na_2O ranges from 0.63 to 2.68%
- MgO ranges from 4.24 to 9.09%
- CaO ranges from 9.96 t0 16.55%
- FeO ranges from 7.00 to 11.44%
- Fe_2O_3 ranges from 2.27 to 5.03%
- Al_2O_3 ranges from 14.56 to 19.16% (discounting sample 4384, at 13.45%).

When potentially altered rocks are compared against these, the samples as a group show the following tendencies:

- increase in K_20 in 9 samples, by as much as 1.12%, up to 1.68% (only one sample shows a decrease)
- decrease in Na_2O in 6 samples, by as much as 0.59%, down to 0.04% (only two samples show an increase)
- decrease in MgO in 12 samples, by as much as 2.92%, down to 1.32% (no samples show an increase)

- decrease in Al_2O_3 in 13 samples, by as much as 4.24%, down to 10.32% (three samples show an increase)

- decrease in CaO in 19 samples, by as much as 8.41%, down to 1.55% (no samples show an increase)

- increase in FeO in 15 samples, by as much as 10.12%, up to 21.56% (two samples show a decrease)

- no appreciable change in Fe_2O_3 (two samples show a decrease)

It is concluded from these observations that sodium and potassium were relatively mobile, total iron was enriched (as expressed by FeO), and that alumina, magnesium and calcium were depleted. It is inconclusive whether alumina depletion is explained in relative terms (i.e. relative to the marked iron enrichment), or in absolute terms (i.e. mobility). High garnet content can be attributed to high iron content, regardless of lowering of calcium, aluminum and magnesium.

REE patterns for 6 out of 8 of the potentially altered metabasalts (Figure 8f) show deviation from the flat patterns typical of the unaltered metabasalts, and also a higher concentration spread (5 to 20 x chondrites). Eu shows slight positive anomalies in 5 samples (0072, 0217, 1020, 1258, 1431). Two of these samples (0217 and 1431) show a moderate slope in their patterns. One sample (0341) shows a slight negative Eu anomaly.

A seventh sample (0263), although flat, shows a concentration of 20 X chondrites, higher than any of the unaltered basalts.

The patterns support the interpretation of alteration for these samples. In general REE patterns should not be drastically affected by alteration, unless it is intense: the patterns shown here support moderate alteration.

The eighth sample (0081), originally chosen as silicified basalt, is plotted in Figure 8c, where it shows a steep slope and marked negative Eu anomaly, similar to patterns for the granitic rocks. This calls into question its derivation either by silicification of basalt, or as chert, and suggests derivation by felsic igneous processes (see further discussion in the section on Champion Bear Resources Ltd.).

STRUCTURE

Analysis of structural data collected during the mapping of the Separation Lake belt indicates presence of a boundary between two structural zones that also coincide with two contrasting metamorphic regimes. The boundary is a curvilinear line defined by the Selwyn Lake fault and, further east along part of the English River Road, the contact between amphibolite grade rocks of the metavolcanic belt and the migmatites of the English River Subprovince (Figure 9). The boundary is here named the Selwyn Lake – English River Road lineament.

Open east–plunging folding about the Paterson Lake antiform north of this line contrasts with predominantly homoclinal, vertical to steeply dipping sequences, with local westerly–plunging folding about the Separation Narrows anticline, to the south of the line.

Although mafic metavolcanic rocks are ubiquitously metamorphosed to amphibolites, those to the north of the Selwyn Lake fault occur in attenuated units, many of which are lensoid, and interspersed within migmatitic quartzo–feldspathic rocks and granitic phases. The quartzo–feldspathic rocks are interpreted to be metasedimentary, but some may be remnants of felsic metavolcanic rocks. The Selwyn Lake – English River Road lineament also demarks the boundary between migmatised and non–migmatised supracrustal rocks.

Within the southern metavolcanic sequence, degree of deformation increases from south to north across the width of the belt. In the south, pillow lavas are relatively weakly deformed such that top determinations were made in a few places (Photo 1). In the north, increasing deformation has imparted a layering to the same rocks such that their derivation from pillow lavas is not obvious (Photo 2). The overlying felsic metavolcanic rocks are mylonitised in places (Photos 5) and pseudotachylite was observed in a few outcrops (Photo 11). Evidently a zone of intense deformation coincides with the transition from felsic metavolcanic rocks to metasedimentary rocks of the English River Subprovince.

Major Folding

PATERSON LAKE ANTIFORM

Lack of primary criteria to define facing in the amphibolites marginal to the Paterson Lake granitic pluton allow only to define the Paterson Lake fold structure (Figure 9) as an antiform. Contacts between units, such as mafic lenses, migmatitic units, and granitic rocks are vertical to steeply dipping, mostly away from the centre of the fold structure. The structure is defined largely on the basis of continuity of amphibolite lenses, nowhere exceeding 400 m in width, around the east end of the Paterson Lake stock.

SEPARATION NARROWS ANTICLINE

Three iron formation units and two concordant gabbros define a major fold structure north of Separation Narrows (Figure 9). Reliable pillow–top determinations in interlayered mafic metavolcanic rocks at two locations on the English River indicate the north limb of the fold structure to face to the north, thus indicating the fold to be an anticline. North–facing pillows in one outcrop south of the major fold axis, about one kilometre west of Separation Rapids (Photo 1), indicate a flexure on the southern limb of the fold, in the form of a syncline–anticline couple (Figure 9). This couple is outlined by the morphology of one of the iron formation units, and an adjacent conformable gabbro.

Minor Structures: Foliations, Lineations and Minor Folds

Mineral lineations around the Paterson Lake antiform plunge between 45 and 75° to the east, while those associated with the Separation Narrows anticline plunge between 45 and 70° to the west and southwest. Axes of most minor folds distributed around these same major folds have similar plunge, though some plunge to the west in the Paterson Lake antiform, and to the east in the Separation Narrows anticline. Where lineations and fold axes can be observed together in outcrop, they are also seen to be concordant. Minor folds on the limbs of the Paterson Lake antiform are predominantly Z folds on the north limb (Photo 12) and S folds on the south limb (Photo 13), though crenulations with no dominant Z or S form are also common. Minor folds associated with the Separation Narrows anticline (Photo 8) cannot be analysed in this way, because of multiple folding on all scales, reflected in the syncline–anticline couple south of the major axial plane (Figure 9).

Dominant foliations measured throughout the mapped area are preferentially oriented east–west, in most places parallel to bedding, either observed or implied, but transect the noses of major fold structures such as the Paterson Lake antiform and the Separation Narrows anticline (Figure 9). On fold limbs it was not generally found possible to discriminate between foliations (S_1) produced prior to the major folding event (D_2) and those produced during it (S_2). However, in some places two foliations are present, one (S_1) parallel to bedding, the other (S_2) at a low angle to it. The later foliations (S_2) are axial planar to major and minor fold structures. Mineral lineations lie in the plane of foliation S_1, and the intersection of S_1 and S_2 defines a lineation which is generally concordant with mineral lineation, suggesting mineral lineation to have formed during D_2. However, in a few places an angular discordance was observed between intersection and mineral lineations, suggesting mineral lineation to have developed also during D_1.

The above analysis suggests that major and minor folds and lineations were produced during the same deformation episode (D_2), which folds, and in some places transposes, a pre–existing foliation (S_1, produced during deformation D_1). In the nose of the major Paterson Lake antiform the dominant foliation is axial planar to the antiform, such that the pre–existing S1 foliation has been transposed into the new S2 foliation.

Garnet porphyroblasts in metasedimentary migmatites on the north limb of the Paterson Lake antiform show evidence of protracted peak metamorphic conditions during and following major deformation. At one location, garnets show synkinematic dextral rotation (Photo 14) during development of Z folds (Photo 12). At another location, garnet porphyroblasts overprint crenulation folds, indicating post kinematic garnet growth.

Faulting

Discrete, major, brittle faults are rare in the Separation Lake map area, a feature not uncommon in areas that have undergone regional high–grade metamorphism, such that stress is taken up on the regional scale by folding and ductile deformation rather than faulting. Only two major faults, the Selwyn Lake fault and the Fiord Bay fault, have been identified in the current survey, and a number of shorter faults at high angle to strike of rock units (Figure 9).

SELWYN LAKE FAULT

A pronounced east–trending linear feature, defined by a steep south–facing scarp at Selwyn Lake and by a 3 to 4 kilometre long valley occupied by the smaller lake northeast of Selwyn Lake, defines the location of the Selwyn Lake fault. The fault juxtaposes mafic amphibolites and metasedimentary migmatites to the north against amphibolitic metavolcanic rocks to the south. To the north of the fault, units strike between northeast and east–northeast; to the south, units strike easterly. Sense of movement on the fault is not well defined, but a considerable vertical component is suggested by contrast in metamorphic grade. The length of the fault is similarly ill–defined. To the west it may extend into the zone of deformation that hosts the Gauthier gold and base metal prospect, as suggested by folding and brecciation there, and to the east it may extend eastward into the migmatite terrain, or turn to the southeast and extend along the migmatite–metavolcanic contact.

The Selwyn Lake fault is sinistrally offset 0.4 km by a north–northeast striking fault at the east end of Selwyn Lake, one of three well–defined faults oriented at high angle to it. Variable sense of offset of units across these three faults, and the fact that the other two faults do not offset the Selwyn Lake fault, suggests that the dominant movement on all three is vertical. All three faults are defined by steep–sided deep valleys with west–facing scarps.

FIORD BAY FAULT

A pronounced northeast–trending lineament along Fiord Bay of Separation Lake can be followed across the north end of the lake between islands to the northeast bay. This zone of weakness is considered to be a fault on the basis of correlation of displaced units on either side. The gabbro sill that lies between two iron formation units in the Separation Narrows anticline is correlated with the similarly associated gabbro sill and iron formations in the metavolcanic outlier east of Fiord Bay. Dextral offset of about 3km is indicated when these units are projected toward the fault plane (Figure 9).

Subprovincial Boundary: Discussion

In a regional study of the boundary zone between the English River and Winnipeg River subprovinces, Sanborn–Barrie (1988) considered the north boundary of the Winnipeg River Subprovince to lie at the northern margin of the metavolcanic belt. She cited evidence, mostly outside of the present map area (Sanborn–Barrie 1988, Figure 12.3), for trends of early gneissosity (S_1) being different in the two adjacent subprovinces, and for the prominent schistosity (S_2) overprinting the gneissosity to be the product of a later deformation (D_2). This S_2 coincides with axial–planar foliations recorded in the present map area.

Sanborn–Barrie (1988) also contends that a domain characterised by westerly plunging lineations lies along this subprovincial boundary, and transects both metasedimentary rocks of the English River

Subprovince and metavolcanic rocks of the Separation Lake belt. This is in contrast with easterly plunging lineations that are said by her to be characteristic of the northern part of the English River Subprovince. The presence of easterly plunging lineations around the Paterson Lake antiform contradicts this analysis, since they lie well within Sanborn–Barrie's westerly plunging domain (Sanborn–Barrie 1988, Figure 12.4).

Within the present map area a case can be made for contrasting structural domains on either side of the Selwyn Lake – English River Road lineament, thus transecting the lithologic boundary between the metavolcanic rocks of the Separation Lake belt and the high grade metasedimentary rocks to the north. The juxtaposition of metasedimentary migmatites against un–migmatised conglomerates suggests either a rapid metamorphic gradient, or more likely the uplifting of the migmatites along a fault (Figure 9). Wetherup (1995), in a study of structural and metamorphic conditions in the outcrops along the English River Road 1 km east of the Umfreville Road turnoff, concluded that metamorphic minerals indicate no appreciable change in metamorphic grade across this contact: however, metamorphic minerals present are stable under conditions ranging from greenschist to granulite facies. The present writers therefore conclude that Wetherup's (1995) study does not sufficiently constrain change in metamorphic conditions across the contact. As well, Wetherup (1995) concluded from study of microfabrics in units on either side of the contact that pure strain observed is attributable to a single deformational event. However, the study does not, in the opinion of the present authors, disprove a possible earlier deformational event such as uplift of the migmatites along a fault.

The coincidence of a zone of mylonitisation within the felsic metavolcanic rocks immediately south of the conglomerates, also observed by Wetherup (1995), suggests late movement along this broad zone, perhaps coincident with D_2 deformation as represented by such F_2 fold structures as the Paterson Lake antiform and the Separation Narrows anticline. There is no evidence in the present map area to suggest that S_1 structures within the English River and Winnipeg River subprovinces diverged from each other prior to D_2, as stated by Sanborne–Barrie (1988). This is of significance because Sanborn–Barrie suggested this divergence to indicate that the English River and Winnipeg River "terranes were formed and initially deformed as separate blocks or belts" (Sanborn–Barrie 1988, p. 106), and thus implies a subprovincial boundary mappable at field scale. The present survey does not support this view.

Card and Ciesielski (1986) discussed subdivision of the Superior province into subprovinces on the basis of lithologic, structural, metamorphic, metallogenic, geophysical and isotopic age attributes. They outlined (Card and Ciesielski 1986, Figure 6) the Bird River metasedimentary–metavolcanic belt in Manitoba, part of which is continuous with the Separation Lake belt in Ontario, as a distinct subprovince. At the present state of understanding this may be a preferable view. Polymictic conglomerates and arenites at the top of the sequence in the Bird River belt in Manitoba have been described by Trueman et al. (1976) as being continuous with English River metasedimentary migmatites. It might also be proposed that polymictic conglomerates and arenites of the Separation Lake greenstone belt are the lower metamorphic grade correlatives of similar lithologic sequences within the migmatites of the English River Subprovince to the north. If such sedimentary facies transitions are permissible along subprovincial boundaries, then the criteria applied by Card and Ciesielski (1986) in Manitoba can be applied in the Separation Lake area. Also in Manitoba, the Lamprey Falls Formation, a mafic metavolcanic unit of the Bird River belt, is considered to be fault bounded on both its north and south margins (Cerny et al. 1981). The Lamprey Falls Formation is the along–strike equivalent of the Separation Lake belt. However, present mapping does not indicate the Separation Lake belt to be similarly fault bounded.

In conclusion, the present survey supports division of the map area into two domains on structural and metamorphic grounds. The domain boundary, here named the Selwyn Lake – English River Road lineament, does not coincides with the English River – Winnipeg River subprovincial boundary defined by Sanborn–Barrie (1988). Neither does it coincide with either of the subprovincial boundaries implied by assigning the Separation Lake greenstone belt to a separate subprovince, the Bird River subprovince proposed by Card and Ciesielski (1986). There may be an inherently unresolvable problem in establishing subprovincial boundaries at field map scale based on as many as six attributes (lithologic, structural, metamorphic, metallogenic, geophysical and isotopic age).

METAMORPHISM

Metamorphic conditions throughout a large region that encompasses the present map area have been discussed by Thurston and Breaks (1978), Breaks (1991) and Breaks and Bond (1993). These studies indicated that the Separation Lake greenstone belt lies immediately south of a large area of granulite grade metamorphism, the Umfreville – Conifer lakes granulite zone, that encompasses migmatites of the English River subprovince. Metamorphic mineral assemblages in migmatitic rocks observed during the present survey are not sufficiently diagnostic, but suggest that the granulite isograd lies to the north of the map area, as indicated by presence of sillimanite and absence of cordierite in aluminous assemblages. G. Beakhouse (Geologist, OGS) noted (in Blackburn et al. 1992) the assemblage quartz – feldspar – biotite ± garnet ± cordierite to be common in English River subprovince migmatitic metasedimentary rocks. However, cordierite was observed by Beakhouse only outside of the present map area, in derivatives of wacke along the north shore of the English River where it exits into Umfreville Lake. Sillimanite is present in aluminous and carbonaceous metasedimentary migmatites within the map area, but the general absence of garnet as a co–existing phase suggests the presence of sillimanite to be controlled by bulk chemistry rather than by difference in metamorphic grade. Sillimanite crystals up to 2 cm long were found in graphitic zones at the Harrison South showing on Trout Lake, and in a graphitic sample donated by L. Chastko (Geologist, Independent Exploration Services Ltd., Winnipeg) that he collected from Grid G of Champion Bear Resources Ltd.

The amphibolite grade of most of the greenstone belt is indicated by presence of hornblende in mafic metavolcanic and intrusive rocks, in contrast to actinolitic amphibole and chlorite. As discussed in the section on alteration, local abundance of garnet in mafic rocks suggests hydrothermal alteration rather than change in metamorphic grade.

The appearance of porphyroblastic andalusite and garnet in high–grade, clastic metasedimentary rocks near the top of the mafic volcanic sequence west of the English River contrasts with absence of andalusite and minor presence of garnet in the same unit east of the river. These differences suggest either compositional change or change in metamorphic conditions, as discussed in the section on geochemistry.

The relationship between peak metamorphic conditions and deformation history is unclear for most of the map area. However, as discussed above, garnet porphyroblasts observed in the Paterson Lake antiform suggest peak conditions to have been obtained over a protracted period during and following major deformation. This specific conclusion cannot be extended to the rest of the map area.

Economic Geology

Diverse types of known mineral occurrences are associated with a variety of geological settings:

Base metals – zinc and copper occurrences in the Separation Lake metavolcanic belt are associated with mafic metavolcanic rocks.

Gold – occurrences in the Separation Lake belt are in sulphide zones contained within amphibolites derived from mafic volcanic rocks.

Uranium – present in low amounts in granitic rocks and in metasedimentary migmatites on either side of, and within, the Separation Lake metavolcanic belt.

Graphite – present in metasedimentary migmatites of the English River Subprovince.

Rare metals – beryllium, lithium, tantalum and tin occur in granitic pegmatites in the Separation Lake metavolcanic belt.

BASE METALS AND GOLD

Sulphide zones of varying type and mineral association have, to date, yielded anomalous to low amounts of gold, copper and zinc. Gold varies from 10s of ppb up to about 0.3 ounce Au per ton, while zinc and copper are common in the 1000 to 5000 ppm range, and rarely up to 5 to 10%. These sulphide zones occur within metavolcanic rocks, predominantly in the mafic metavolcanic rocks south of the Selwyn Lake lineament. The present investigation suggests their classification into the following scheme:

- breccia–hosted, massive to stringer arsenopyrite–pyrrhotite zones, hosting sphalerite, chalcopyrite and gold;
- silicified, shear zone–hosted, massive to stringer pyrrhotite–pyrite zones, hosting sphalerite and chalcopyrite;
- iron formation and chert–hosted, massive to stringer veins of pyrite–pyrrhotite, hosting gold, sphalerite and chalcopyrite.

Breccia Zones

At the Gauthier occurrence, first reported on by Thomson (1947), gold, zinc and copper occur in an arsenopyrite–rich sulphide–bearing brecciated zone on the order of 100 m wide, within amphibolites that are the westernmost extension of the greenstone belt south of the Selwyn Lake lineament. Sulphides present – in addition to abundant arsenopyrite which can be on the order of 30 to 40% – are pyrite, pyrrhotite, sphalerite, and chalcopyrite. Galena has also been reported but was not found during the present study. Gold values obtained by Champion Bear Resources Ltd. are erratic but may be related to arsenopyrite content: up to 0.7 ounce gold per ton and 4% zinc have been obtained from grab samples (Assessment Files, Resident Geologist’s office, Kenora).

Silicified Shear Zones

The second type of sulphide zone is characteristically present near the top of the mafic metavolcanic sequence, close to or in some cases at the transition into felsic metavolcanic rocks. They are interpreted to be shear zone–hosted on the basis of their lateral continuity and presence in that portion of the volcanic sequence that is known to have been subject to intense deformation (see discussion under Structure). The conformable, siliceous, cherty–looking zones are on the order of 5 to 10 m wide, and can be traced along strike for distances up to at least 1000 m. Sulphides are unevenly distributed within the zones, from disseminated to massive, in some places imparting a layering. Massive portions vary from containing barren pyrite–pyrrhotite to containing sphalerite and chalcopyrite which is either intimately intermixed with the barren sulphides or disposed within late fractures. Gold values obtained on assay from this type of sulphide zone by Champion Bear Resources Ltd. are uniformly low (Assessment Files, Resident Geologist’s Office, Kenora).

Iron Formation and Chert Zones

The third type, hosted in iron formation, is found at various places within the folded magnetite–bearing to chert–rich chemical metasedimentary units within the mafic metavolcanic rocks east of the English River. Pyrrhotite and pyrite occur within the more–or–less magnetite–bearing layers, and in some places completely replace magnetite. Trace to 5% sphalerite and chalcopyrite, the latter being more common, have been recorded in drill holes of Champion Bear Resources Ltd., and assay values obtained from this type of zone have to date shown trace to low gold and base metals (Assessment Files, Resident Geologist’s Office, Kenora). The Helder Lake occurrence, one of the earliest found in the Separation Lake greenstone belt, is hosted in lean iron formation that is bordered to the north by a pyrite–pyrrhotite zone. It was reported on by R. Thomson in 1947 (Assessment Files, Resident Geologist’ office, Kenora). It has only yielded trace to low gold and base metals (Assessment Files, Resident Geologist’s office, Kenora).

GRAPHITE

High–grade metamorphism within the English River Subprovince, resulting in migmatisation of clastic sedimentary rocks, has produced concentrations of graphite, possibly due to pyrolization of organic material (Storey 1990). Where flake size is sufficiently large, deposits can be of economic interest.

Storey (1990) and Redden (1993) have described a number of graphite occurrences in the vicinity of Trout and Treelined lakes. Most of them are small, and the graphite not of the flake variety. However, one occurrence, the Harrison South showing, has attracted considerable interest because of potential flake size, concentration, and zone width and length (see: Treelined Lake Graphite Prospect). Graphite occurs intermittently over a strike length of 2 to 3 km within migmatitic metasediments that appear to be more siliceous than average quartz–feldspar–biotite schists of the subprovince, but the extent of these more siliceous units is uncertain. Other known occurrences are mostly around the shore line of Trout Lake, but this distribution is probably artificial, due to preferential exposure and ease of discovery. Nonetheless, their distribution around the Trout Lake clotty granite pluton at a distance of about 1 km is suggestive of a genetic relationship: other graphite occurrences could be prospected for in this vicinity. Pegmatitic phases of the anatectic granites of the migmatite terrain are prevalent at the Harrison South showing, suggesting that better showings may be found in proximity to such pegmatites.

URANIUM

Uranium–enriched granitic pegmatites within the Separation Lake map area have been grouped into two distinct types (Breaks and Bond, 1993): the metasedimentary migmatite association, and the potassic granitoid suite association. Of the three occurrences investigated by Breaks and Bond (1993), one (Umfreville Lake occurrence) is of the former association, one (Selwyn or Celyn Lake occurrence) of the latter association, and one (Davidson occurrence) showing mixed characteristics.

The associations are defined primarily on the basis of location, either within the migmatite terrain, or, in the case of the potassic granitoid suite association, with the granites of the Winnipeg River Subprovince, and postulated to have been derived by two distinct processes. Uranium mineralization of the metasedimentary migmatite association are generally considered by Breaks and Bond (1993) to be hosted in white–weathering, coarse grained to pegmatitic granitic rocks derived by anatexis from metasedimentary rocks. In contrast, they consider uranium mineralisation of the potassic granitoid suite association to be hosted in pink–weathering, coarse grained to pegmatitic rocks that contain no evidence of derivation by anatexis, as indicated by a lack of metasedimentary paleosome and melanosome constituents.

None of the four occurrences were studied in any detail during the present survey.

RARE METALS

A few small crystals of beryl were first noted in the Separation Lake map area by Stockwell (1932) “in a large pegmatite dyke cutting volcanics on the east shore of English River 2 miles northwest of Separation rapids”. The precise location of this pegmatite is uncertain, but was probably the same as that located during a pegmatite reconnaissance program by Storey (1990), who sampled a pegmatite dike on the east shore of the English River that contained accessory red garnet and green apatite. Storey also sampled three pegmatite dikes along the English River Road, which contained 348, 134 and 128 ppm Li respectively, and one of which returned anomalously high beryllium (675 ppm).

Over the period 1990–91, while exploring for base metals and gold, geologists working for Champion Bear Resources Ltd. discovered other pegmatite dikes that contained pale green beryl crystals in the general area between the English River and the English River Road, north of Separation Narrows. These in turn were visited during the 1992 season of the present survey, at which time other beryl–bearing dikes were discovered. In 1993 F. Breaks (Geologist, OGS) conducted a brief survey of the Separation Rapids pluton and dikes known to contain beryl. This work resulted in the discovery of other rare–metal bearing minerals (Breaks 1993). The following description is condensed from the latter account.

The 3 km^2 Separation Rapids pluton, outcropping along the English River, has generated a rare–element pegmatite field with minimum presently known dimensions of 0.5 by 3.5 km. Breaks (1993) compares the pluton in size and constituent granitic units to the Greer Lake pluton 55 km to the northwest in the Winnipeg River Pegmatite District of southeast Manitoba (Cerny et al. 1981). Similarities include presence of cordierite, beryl, cassiterite and ferrocolumbite, and the common presence of primary layering between pegmatitic leucogranite, sodic aplite, potassic pegmatite and coarse grained granite. Breaks found beryl at 5 localities in the pluton, either as a primary phase, or secondary with garnet, muscovite and biotite after cordierite. Primary beryl tends to be of the white variety, whereas secondary beryl is commonly pale blue.

The preliminary studies show that the dikes of the attendant pegmatite field contain the same characteristic minerals as those of the pluton, and that at least two of them also contain petalite as the lithium aluminosilicate mineral. Such petalite–bearing pegmatites are host to rare–metal producing mines elsewhere in the world, including the Tanco orebody marginal to the Greer Lake pluton in Manitoba (Cerny et al. 1981). Other minerals include spodumene commonly intergrown with quartz, a dark green tourmaline (elbaite), and columbite–tantalite. In one dike, petalite megacrysts up to 32 by 67 cm, commonly coalesced, have been found. Contact metasomatism of the mafic metavolcanic host rocks is indicated by development of a narrow zone of biotite, tourmaline and holmquistite, a purple lithium–rich amphibole, around one of the pegmatites.

ASSAY DATA

Assay results from 87 samples taken during the 1992–1993 field season and from 9 samples taken on a property visit to Champion Bear Resources Ltd.'s grids in 1991 are presented in Table 7, and their location given in Figure 10.

All but two samples (0337–2, 1281–1) were taken to test for base metals primarily. Gold and silver were determined in all cases, and returned nil to trace in all but two samples assayed at the Timiskaming Testing Laboratory, including the two taken from quartz veins for gold. Samples assayed at the Geoscience Laboratories, Sudbury, all assayed below the detection limit of <0.01 ounce gold per ton, except for one (2476–4) of 3 samples from the Gauthier prospect, which assayed 0.07 ounce gold per ton. It is of note that no samples from the Helder Lake prospect assayed above detection limit for gold.

A majority of samples were taken from zones already explored by Champion Bear Resources Ltd. by stripping, trenching, and diamond drilling, and in general confirm results gained by them. Other samples were taken to test prospective zones of sulphide concentration, mostly in the mafic metavolcanic rocks, and iron formation.

Three samples taken at the Gauthier prospect on Champion Bear Resources Ltd.'s Oneman Grid confirm the favourability of the sulphide breccia zone for base metals, and the preferable association with arsenopyrite. Of the 3 samples (2476–1, –2, –4) the sample with highest arsenopyrite (2476–4) also ran the highest zinc value (9620 ppm) and the second highest copper value (460 ppm). This was the same sample that ran 0.07 ounce gold per ton.

Samples taken south of the Selwyn Lake fault, within the greenstone belt, on the Oneman and Extension grids from workings of Champion Bear Resources confirm zinc in the range of 100s ppm to 1% (samples 0078–1, 0189–1, 0192–1, 0217–2, 0238–1, 0254–1, 0337–1, 1272–1, 91–007, 91–008, 91–009) from most trenches. The best zinc values (7850 ppm and 7150 ppm) were obtained from the original Alcock prospect trenches. Copper values from these same samples are mostly in the 100s of ppm range. Four samples taken from prospective sulphide zones not previously worked (samples 0070–2, 0072–1, 0074–1, 0348–1) did not indicate elevated zinc and copper values.

Samples taken at the northeast end of the Extension Grid in the migmatites north of the Selwyn Lake fault (samples 2494–1, 2512–1, and –2) show elevated zinc and copper values up to 3420 ppm zinc and 356 ppm copper.

Samples taken on B Grid (0031–3, 0081–1, 91–005) from Champion Bear Resources Ltd. workings gave support to elevated zinc and copper values.

Samples taken on C Grid (91–001, 91–002, 91–006) gave low zinc and copper values from zones explored by Champion Bear Resources Ltd., but were not representative of the better zones on this grid.

Samples taken on J Grid (1203–4, 91–003) from iron formation indicate no elevated zinc or copper where sulphides are lacking (1203–4), but slight elevation (315 ppm) where sulphides are present (91–003). A sample (1386–2) from the same or similar iron formation unit to the east on I Grid showed no elevated metal values. One (sample 4020–1) of 2 samples of sulphidized iron formation taken from trenches at the Boot Bay iron prospect showed slight elevation in copper and zinc (163 ppm and 300 ppm respectively).

A sample taken on H Grid (0399–1) from a small pit in the vicinity of Champion Bear Resources Ltd.'s drill holes CB039 and CB042 returned elevated copper (2245 ppm) but not zinc. Some of the other samples taken from prospective sulphide zones (0055–1, 0056–1, 1328–2) and iron formation (1280–1, 1298–1, 1306–2, 1327–1) in this general area indicated slight copper elevation, but not zinc.

Samples taken on G Grid (0351–2, 0351–4, 91–004) from trenches of Champion Bear Resources Ltd. in garnet–bearing felsic granitoids or gneisses that contain sulphides and/or graphite (also investigated for uranium by Can–Fer Mines Ltd. in 1969) suggested low but slightly elevated zinc values. A sample from a similar sulphide–bearing zone not previously tested (1399–1) showed no elevated metal values. A sample (0380–3) of similar garnet–bearing felsic rock containing sulphides on Grid E that had been sampled previously by Champion Bear Resources Ltd. showed slight elevation in copper. Also on Grid E a sample (1321–2) from a sulphide–bearing zone between granitic and migmatitic rocks returned no elevated metal values.

At Helder Lake a total of 9 samples were taken from various points along the chert–magnetite iron formation that hosts the Helder Lake sulphide occurrence, both in the iron formation and in adjoining rock units. Best assays came from the west end of the zone, in iron formation (sample 2336–1: 307.3 ppm copper, 133.5 ppm zinc, 321.60 ppm cobalt). Other iron formation samples from the east end (2326–2, 4280–1) did not assay elevated base metal values. Four samples of massive pyritic sulphide breccia (2330–4, –5, –6, –7) and a sample of similar breccia and quartz vein material (2330–3) from the original Helder Lake prospect did not assay elevated base metal or gold values.

During the present program a cache of exploration drill core was discovered on the southwest shore of Helder Lake during routine survey work. There is no record of these holes in the assessment files, Resident Geologist's office, Kenora, and the company or individual responsible is unknown. The location of the cache and evidence of overgrown drill roads in the immediate vicinity suggest that all 4 holes were drilled close by. Composite samples (2236–1, –2, –3, –4) were taken from each hole, representative of split sections. Elevated copper values were recorded from 3 holes, and elevated zinc from one of the 3 holes.

Elevated zinc values were obtained on assay of 2 samples (2142–1, 2157–1) from a 2 m wide rusty chert zone along the southern margin of the greenstone belt east of the Lennan Road. The samples were taken from each of 2 shallow pits sunk by Champion Bear Resources Ltd. The zone was traced along strike over a distance in excess of a kilometre, and does not appear to have been tested along its length. Elevated zinc and copper values were also obtained (sample 2155–1) from previously untested rusty zones in amphibolite intruded by granitic rock along strike about 1 km to the east of the chert unit.

Five samples (2023–1, –2, –3, 2024–1) taken from a 500 m long conspicuous gossanous zone beside and parallel to the English River Road all returned low copper and zinc values on assay.

Five samples taken from within the migmatites north of the greenstone belt in the vicinity of Trout Lake, including 2 (2090–11 and 2106–2) associated with graphitic concentrations, returned low copper values, and low to slightly elevated zinc values on assay. However, one sample (4166–2) from the migmatites, a silicified and sulphidized schist, taken immediately east of Treelined Lake, returned 660 ppm zinc on assay. There is no evidence of previous exploration in this vicinity.

Five samples from the greenstone enclave east of Fiord Bay returned low copper and zinc values on assay. Three of these (4098–2, 4100–2, 4111–2) tested weakly sulphidized chert–magnetite iron formation. Two samples were taken from weakly sulphidized iron formation on the southeast shore of Fiord Bay: slightly elevated zinc (285 ppm) was found in one of them (4329–1). A sample (4331–1) of sulphidized iron formation from an island in Separation Lake 1km east of the Separation Narrows bridge returned an elevated zinc value of 860 ppm.

Description of Properties

Information on work done in the area has been mostly taken from the Assessment Files in the Resident Geologist's Office, Kenora. Because the Separation Lake greenstone belt was not actively prospected until the 1940s, there is no record of work done prior to this period in the older publications of the Provincial and Federal governments.

An effort has been made to describe the occurrences and prospects as entities rather than as parts of successive properties. However, in recent years a number of companies, and Champion Bear Resources Ltd. in particular, have enhanced knowledge of some of the older prospects, and discovered new occurrences as a result of their broad exploration activities. In these cases a number of prospects are discussed under more than one heading. Where a number of occurrences were covered as part of a broader based program, the date of the work done is indicated in the title.

During the 1950s and 1960s numerous uranium occurrences were prospected both within and external to the Separation Lake greenstone belt. Those uranium prospects that lie within the area mapped in the present survey are listed on the geologic map for completeness. Those that have been more recently described and further studied by Breaks and Bond (1993) are not discussed here.

Figure 11 shows the locations of properties discussed below.

ALCOCK PROSPECT (1)

A property at Selwyn (alt. Celynn, Celyn) Lake consisting of 24 claims staked by C. Alcock of Kenora was visited by E.O. Chisholm, Resident Geologist, Kenora, in 1948. Mr. Alcock had discovered a number of occurrences of base metal sulphide minerals scattered within the claim group. A sketch map (Assessment Files, Resident Geologist's Office, Kenora) shows the location of three of the zones referred to by Chisholm, though others indicated are not discussed.

On claim 12267, the Alcock prospect, at least 6 pits had been opened up, south of the small lake immediately northeast of Selwyn Lake, and reportedly in hornblende schists and quartz schists. Chisholm noted pyrite, pyrrhotite, sphalerite, and minor chalcopyrite, and in one pit "lead" (read galena) or molybdenite. Assays recorded by Chisholm ranged from 0.10 to 1.20% Zn, 0.9 to 1.0% Pb, and 0.56% Cu.

On claim 12272 a similar occurrence to those on claim 12267 was noted, north of the north end of a small lake at the main granite–greenstone contact as now mapped. Assay results showed 1% Zn at this locality.

Chisholm also reports fayalite in narrow bands up to 6 inches wide, in a unit 50 feet wide and 1500 feet long, within biotite schists north of the small lake immediately northeast of Selwyn Lake, on the west boundary of claim 12275. The identity of the fayalite was confirmed by "X–ray determination". The significance of the fayalite was not discussed by Chisholm, but fayalite, the iron–rich end member of the forsterite–fayalite series, is not uncommon in thermally metamorphosed sediments.

The Alcock prospect is further discussed in connection with exploration done by Champion Bear Resources Ltd.

CANADIAN NICKEL COMPANY LTD., 1963 (2)

In January, 1963, the Canadian Nickel Company Ltd. diamond drilled one hole off the ice at the west end of Selwyn Lake, immediately south of the north shore. The hole was drilled to the south at –55°, to a depth of 474 feet, presumably to test a conductor beneath the lake. According to the log (Assessment Files, Resident Geologist's Office, Kenora) "gneissic amphibolite" and massive very weakly mineralised greenstone were intersected. Pyrite and pyrrhotite are recorded, in association with quartz stringers, and in sheared and silicified zones. No base metal minerals are recorded.

CENTURION MINES LTD., 1959 (3)

In 1957, joint venture partners Tombill Gold Mines Ltd. and Glen Echo Mines Ltd. conducted exploration of the iron formations at Separation Lake, that included diamond drilling of 8 holes. In 1959, Centurion Mines Ltd. diamond drilled an additional 24 holes (numbered 1 to 8, 9A, 10, 11, 11A, 12 to 23) to test magnetic highs outlined by the former partners. The work was done on claims of the same group as the former operators, but the relationship between the two interests is not known.

All of the latter holes were drilled along strike to the east of those put down by the Tombill–Glen Echo partnership, discontinuously over a distance of about 10 km. All holes were drilled to the north at –45° dip, and ranged in length from 176 feet to 410 feet. All except holes 19 and 20 seem to have been located within the confines of the greenstone belt: the latter 2 are difficult to locate because of lack of map control, but appear to be within the granitic rocks south of the belt. Logs on file (Assessment Files, Resident Geologist's Office, Kenora) indicate "banded iron formation" to have been intersected in all but 9 holes (holes 8, 9, 11, 12 to 15, 19, 20) and pyrite and/or pyrrhotite to have been commonly present. However, no indication of presence of magnetite is given, though Fe assays in the range 20 to 40% suggest that to be the case. Widths of "banded iron formation" are commonly narrow, about 2 to 12 feet, but some are in the 30 to 40 feet range.

The exploration program demonstrated the narrow widths, lack of continuity and low iron content of the iron–bearing zones, and no further work is recorded on these claim groups. Interest in the Separation Lake area in terms of exploration for iron ore ended at this time.

CHAMPION BEAR RESOURCES LTD. AND SHABU GOLD MINES LTD., 1987-1992 (4)

In 1987 Shabu Gold Mines Ltd. began a program of exploration for gold at Helder Lake that was continued in 1888 by Champion Bear Resources Ltd. under the direction of Independent Exploration Services Ltd. The exploration program developed over the period up to 1992 into a combined gold and base metal search by Independent Exploration Services Ltd. for Champion Bear Resources Ltd., extending westward along the entire Separation Lake greenstone belt.

Helder Lake Program

In 1987 stripping, trenching, and surface sampling were done at the Helder Lake occurrence. Assay results for Au and As suggested that gold is erratically distributed within the lean chert–magnetite iron formation, in association with arsenopyrite. The three best assays from 64 channel and grab samples were: 6430 ppb Au and 65385 ppm As; 2230 ppb Au and 26733 ppm As; and 2090 ppb Au and 22084 ppm As (Figure 12).

Following an airborne geophysical survey, a diamond drilling program of 17 holes (CB1 to CB17) was undertaken in 1988 along the iron formation that hosts the Helder Lake occurrence (assessment files, Resident Geologist's office, Kenora). The primary target was the original occurrence, intersected in holes CB1 to CB3, which demonstrated that a massive sulphide–bearing breccia between 12 and 20 feet thick overlies banded chert–magnetite iron formation 45 to 166 feet thick. Subsequent drilling to the west southwest (holes CB4, 8 and 9) indicated the continuity of these units up to a kilometre along strike, and to the east northeast (holes CB5, 6, 10, 14, 15 and 16) a distance in excess of 2 km. However, the sulphide breccia zone is not, in all cases, present (CB15), and where present may be separated from the underlying iron formation by amphibolite (CB9). Arsenopyrite is commonly but erratically present in the banded iron formation, as indicated by assay values, but gold assays are uniformly low, as are base metal (Cu, Pb, Zn) values. Marginally anomalous copper and zinc were assayed from the sulphide breccia in holes CB3, 4, 5, 6, 8, 9, 14 and 16. Holes 11, 12, 13 and 17 did not intersect the iron formation, though massive sulphide zones were intersected in CB12 and 13, with marginally anomalous Cu and Zn.

Umfreville to Separation Lakes Claim Group

In 1989 the company extended its claim holdings westward along the belt for a distance of 45 km to the Gauthier occurrence at Umfreville Lake, and conducted an airborne survey over the additional claims. Field work in 1989 was concentrated on the Gauthier occurrence, which was stripped and sampled. The company reported (Champion Bear Resources Ltd., press release, September 5, 1989) that continuous mineralization had been traced over a strike length of more than 1000 m and a width of 100 m. Assay values from grab samples were up to 0.70 ounce Au per ton, 1.87 ounces Ag per ton and 4 percent Zn. In 1990 exploration was continued over a strike length of 10 km to the east from the Gauthier occurrence, in an attempt to trace the zone along strike. New copper–zinc mineralization was discovered during the geologic mapping. The zone at the Gauthier prospect was not traceable and it was suggested that the newly investigated occurrences could be in a different geologic setting. In early 1991, 40 holes for a total of 4324 metres were diamond drilled on targets at the west end of the property. Twenty two of these holes tested the Gauthier prospect, and a further 18 tested the new base metal targets along strike to the east (assessment files, Resident Geologist's office, Kenora). In a press release in April, 1991, the company stated that at the Gauthier prospect gold is associated with subparallel silicified breccia zones that had been drilled over a strike length of 900 m and to a depth of 100 m. Company geologists interpreted the mineralization at the newly discovered occurrences to be at the contact between rhyolite and basalt, and to be different from the gold–arsenic association at the Gauthier prospect. They stated that this contact had been traced for a strike length of 30 km and that low copper and zinc values were obtained on assay from all 13 holes that intersected it, over widths of up to 24 m, in semi–massive and stringer sulphide–bearing zones. Best values found included 0.30% zinc over 24 m, 0.34% zinc over 9.3 m, and 0.45% zinc over 4.3 m (assessment files, Resident Geologist's office, Kenora). Over the summer of 1991 further geological mapping, trenching and sampling was conducted on the base metal targets outlined by geophysical surveys, and in the winter of 1991–92 a 59 hole drill program tested these same targets (assessment files, Resident Geologist's office, Kenora).

In summary, over the period 1990 to 1992, 99 holes were diamond drilled in total on the following grids (Figure 13): Oneman Lake and Extension Grids, 51 holes; Grid A, 5 holes; Grid B, 8 holes; Grid C, 10 holes; Grid D, 2 holes; Grid H, 7 holes; Grid I, 13 holes; grid J, 3 holes. Twenty two of these were drilled on the Gauthier prospect, and the remaining 77 tested base metal targets to the east. Most of these latter holes were drilled south of the Selwyn Lake fault, the exceptions being holes 103, 109–111, 121, 122 on the Oneman and Extension grids, and 123 and 124 on Grid D. No drilling was done on Grids E, F, and G on the north arm of the Patterson Lake anticline.

Review by the present authors of logs of all of these holes by Champion Bear Resources Ltd. geologists suggests the following general conclusions bearing on economic mineralization:

- zinc in the range >1000 ppm up to 5000 ppm is common in sulphide zones in mafic metavolcanic rocks south of the Selwyn Lake fault. Close to the contact with felsic metavolcanics rocks, quartz–rich and cherty–looking sections in the mafic metavolcanic rocks, that also host sulphides, returned the most persistent analyses in this range, and over the greatest widths. Visible sphalerite is noted in many of these sections.

- copper, although anomalous in most holes, rarely exceeds 1000 ppm. Notable exceptions are at Little Selwyn Lake (holes 101, 102), at the east end of the Extension Grid (holes 115, 118, 141), on A Grid (holes 35, 36), and on H Grid (holes 38, 39, 40, 41, 42). These values commonly accompany zinc in the same range.

- gold values, where analysed, are uniformly low, mostly in the trace to 10s of ppb range. These include holes 35 and 36 on A Grid, hole 120 on the Extension Grid, and all holes on Grid H.

- in the migmatitic rocks north of the Selwyn Lake fault, zinc mineralization >1000 ppm is confined to narrow sections, with visible sphalerite in fractures. Copper content is in the 10s to 100s of ppm range.

- arsenopyrite is uncommon compared with pyrite and pyrrhotite, in contrast to the Gauthier prospect. It was noted in hole 142 on the Extension grid.

On the geologic maps accompanying this report (back pocket), mineral and element content have been indicated beside appropriate drill holes. Base metal and other minerals of economic interest are indicated where noted as visible in drill logs, in any quantity. These include sphalerite, chalcopyrite, beryl, and iron formation. Metallic elements zinc, copper, and gold have been indicated where analyses reported in drill logs indicated presence above the following concentrations:

- zinc, percent times width in feet > 1.5 (values range up to 35.4, but are mostly <10)
- copper, holes with values >1000 ppm, regardless of width
- gold, trace or higher values.

GAUTHIER PROSPECT PROGRAM

Following the surface stripping, mapping and sampling program in 1989, as discussed above, a diamond drill program in 22 holes was conducted to define the distribution of gold in three dimensions.

Surface mapping by the present author on the grid laid down by Champion Bear Resources Ltd. (Figure 14) indicated that the mineralization is contained within a narrow (about 150 m wide), east–striking amphibolite enclave within granites. The amphibolites are derived from mafic metavolcanic rocks, as indicated by remnant pillow lava shapes. Sulphide mineralization, in places with massive arsenopyrite, is in breccia zones adjacent to alteration zones marked by abundant garnet, in folded banded amphibolite. Unmineralised granitic and pegmatitic dikes cross–cut the breccia and folds in the banded amphibolite, indicating emplacement subsequent to major deformation; however, many of the dikes themselves are folded and boudinaged, suggesting that their emplacement occurred during but late in the deformation phase, and post mineralisation. The brecciated and sulphide–rich zones define two parallel units (1 and 2) about 50 m wide and 50 m apart, striking westerly, parallel to the length of the enclave, and separated by massive, relatively undeformed amphibolite.

Compilation of assay data from the drill holes by Champion Bear Resources Ltd. indicated that there is a zonal pattern to the distribution of gold, that conforms to considerable degree to the two units outlined in the surface mapping (Figure 14). Three zones A, B and C are defined by elevated gold values: zone A corresponds to unit 1, and B and C to unit 2. The best intersections indicated in the longitudinal section are in holes CB001, CB004 and CB114, all on line 7+00E, and hole CB021 on line 10+25E, in the vicinity of the main surface showings.

GAUTHIER PROSPECT (5)

In the late 1930s A. Gauthier of Kenora became aware of the potential for gold on a peninsula on the east side of the main part of what was then Oneman Lake, but was unable to interest any parties in further work.

The property was visited by Robert Thomson, Resident Geologist, Kenora, in August 1947, at which time the prospect was situated at the centre of a claim group consisting of 4 claims held by Mr. Gauthier and 3 other partners. Thomson (1948 and Assessment Files, Resident Geologist’s Office, Kenora) recorded that the property lay within an area of “schist and granulite”. He recorded it to be 500 ft wide at maximum, within predominant granitic rocks, and to extend from the west side of the claim group to an arm of the lake, and possibly beyond on the opposite shore. Thomson’s account indicates that he was uncertain of the origin of the rock as either sediment or volcanic flows, and that minerals present were amphibole, biotite, feldspar, quartz, and very minor garnet in places. He appears to have used the term granulite in the sense of a granular aggregate of these minerals rather than in the metamorphic sense of the word.

Zinc, in the form of sphalerite, and gold were known to occur, and were being prospected for. Thomson also noted abundant arsenopyrite, lesser amounts of pyrite, and rare galena and chalcopyrite. He noted that the occurrences were exposed over a length of about 230 ft, and 30 ft width, and that 7 small pits had been sunk.

Thomson reported that Mr. Gauthier had obtained an average of about 0.07 ounce Au per ton from some 40 grab samples that he took at the time of his original work, and that samples taken in 1947 from 6 of the trenches assayed between 0.05 and 0.12 ounce Au per ton, and one sample assayed 0.38 ounce Ag per ton. Two samples taken by Thomson assayed 7.84% Zn, 0.04 ounce Au per ton, and trace Ag, and 2.77% Zn respectively.

The Gauthier prospect was further investigated in 1985 by R. Crowley for Sparton Resources Inc. Little if any work had been done on the occurrence since the 1940s, but Mr. Crowley located and sampled the 7 pits noted by Robert Thomson. He also discovered a new occurrence 300 m east of the Gauthier occurrence. Assay results from the pits were lower than those obtained previously, the highest values being 1155 ppb Au, 11 ppm Ag, and 22000 ppm Zn. Crowley also noted the association with arsenopyrite, and obtained the highest assay (17.34% As) from the new occurrence, which also coincided with one of the higher gold assays (1150 ppb Au). However, Mr Crowley recommended that no further exploration for gold be conducted by the company.

The Gauthier prospect is further discussed in connection with exploration done by Champion Bear Resources Ltd.

HELDER LAKE OCCURRENCE (6)

A sulphide occurrence at Helder Lake was visited by R. Thomson, Resident Geologist, Kenora, in September, 1947. The occurrence was in the southeast corner of a parcel of 36 claims held by parties unknown to Thomson. The occurrence had been brought to Thomson’s attention by H. Hawes, of Kenora, who had recently diamond drilled at the occurrence. From the condition of the 5 trenches on the property Thomson estimated that they had been made about 10 years previously.

Thomson (Assessment Files, Resident Geologist’s Office, Kenora) recorded that rocks in the vicinity of the occurrence were “quartzitic schist and granulite, amphibole schist, and biotite gneiss”. Minor amounts of garnet and of magnetite were found in a few places. He appears to have used the term granulite in the sense of a granular aggregate of minerals rather than the metamorphic sense of the word.

Thomson considered that the presence of pyrite and pyrrhotite in considerable amounts had attracted prospecting, for either gold or base metals, but he was unable to find such minerals on surface in “interesting amount”. Additional sulphide minerals noted by Thomson included arsenopyrite and a few specks of chalcopyrite. Assay results from 4 samples taken from 3 of the 5 trenches ranged from nil to 0.02 ounce Au per ton. The only result given for base metals was a nil value for zinc from 2 samples.

Despite the discouraging results obtained, Thomson suggested that the occurrence of sulphide minerals along a “crush” zone, and its position on the side of a well–marked topographic depression, was encouraging. He noted that the recent drilling, the results of which were not known to him, had been laid out to test the downward extension of the sulphide mineralisation in the trenches. The depression, concealed by overburden, had not been tested.

Thomson evidently did not appreciate the significance of the siliceous rock, calling it quartzite, or the amount of magnetite, which he only mentions in passing: the siliceous rock, which is well banded, with variable amounts of magnetite, is a lean chert–magnetite iron formation.

The Helder Lake occurrence is further discussed in connection with exploration by Shabu Gold Mines Ltd. and Champion Bear Resources Ltd.

JUMA MINING AND EXPLORATION LTD., 1957 (7)

Juma Mining and Exploration Ltd. held 108 contiguous claims at the east end of the Separation Lake greenstone belt in 1957. The claims adjoined to the west those held by the joint venture partnership of Tombill Gold Mines Ltd. and Glen Echo Mines Ltd, and were probably staked following the airborne magnetic survey flown for the latter partnership in the winter of 1956–57.

The claim group extended from a point about 3 km west southwest of the west end of Helder Lake to a point about 3 km east northeast of the east end of the same lake, and was 3 to 4 claims wide. The group was predominantly over the greenstone belt, and extended along the south side of Helder Lake, where it overlapped somewhat on to the granitic rocks south of the belt.

A report by A.S. Bayne (Assessment Files, Resident Geologist's Office, Kenora) indicates that prospecting for iron deposits, which included the use of a dip needle, was carried out over the claim group. Eleven outcrops are discussed in the report, but because of the absence of an accompanying map, they cannot be related to the present geological survey. However, it is evident that the previously–discovered Helder Lake sulphide occurrence described herein was encountered. Several shallow pits were blasted on the more promising occurrences, and 4 representative bulk samples totalling 500 lb. were taken for beneficiation purposes.

From the descriptions of the outcrops it is evident that the occurrences discovered were similar to those noted during the present survey, and probably included a number of them, and were of only marginal significance in terms of prospecting for iron ore. There is no mention in the report of any other minerals of possible economic significance.

NORANDA EXPLORATION CO. LTD., 1983 (8)

In 1983 Noranda Exploration Co. Ltd. contracted Questor Surveys Ltd. to conduct an airborne magnetometer survey over an arcuate 100 km long by 15 km wide area between Sand Lake in the west and Aerobus Lake in the east, by way of Lennan Lake. The survey took in that part of the presently mapped area south of a line between Tourist Lake, Treelined Lake and Helder Lake and was part of a broad exploration program carried out by that company over the Winnipeg River Subprovince for base metals. At the west end of the surveyed area, only that part of the survey west of Separation Lake was submitted for assessment credit. None of the four isolated magnetic highs targeted within the submitted area lay within the presently mapped area (Assessment Files, Resident Geologist's Office, Kenora).

NORANDA EXPLORATION CO. LTD. (THORBURN CLAIMS), 1988 (9)

In 1987 M. Thorburn of Kenora reported that he had discovered, at the side of the English River Road which was currently under construction, a single 5 lb. loose rock sample that was identified by the Resident Geologist's Office in Kenora to contain massive sphalerite and chalcopyrite. In 1988 Noranda Exploration Co. Ltd. conducted a prospecting and sampling program over a 27 claim group centred on the discovery locality, that the company optioned from Mr. Thorburn. One hundred and twelve rock samples taken from various locations on the property were analyzed for copper, zinc and gold. One hundred and thirty one B–horizon soil samples were analyzed for copper, zinc and gold. Seventeen of the rock samples were also submitted for whole rock analyses (Assessment Files, Resident Geologist's Office, Kenora: the whole rock data is not available).

Soil samples were uniformly low: Au all <5 ppb; Zn all but 9 samples <100 ppm, the highest being 230 ppm; Cu all but 7 samples <50 ppm, the highest being 88 ppm. Rock samples were as follows: Au mostly <5 ppb, the highest being 80 ppb; Zn all in the 10s to 100s ppb range; Cu in the 10s to 100s ppb range, with two samples of 2350 and 3050 ppm.

Noranda did not pursue the property further.

NORONT RESOURCES LTD., 1987 (10)

A graphite zone at the boundary between the metasedimentary rocks of the Separation Lake greenstone belt and the granitic and migmatitic rocks of the Winnipeg River Subprovince where it is crossed by the Umfreville Lake Road was trenched for Noront Resources Ltd. in 1987 (Assessment Files, Resident Geologist's Office, Kenora). No further results obtained by the company are recorded.

The trenching by the side of the road uncovered both graphite and metallic sulphides. A sample of the latter taken during the present survey assayed 108 ppm Cu and 138 ppm Zn (Table 7, sample 1014–1).

TIBBO H.G., 1984 (11)

In 1984 H. Tibbo prospected for gold over magnetite–bearing zones north of Separation Narrows (4 claims), and at the former Boot Bay iron prospect at the north end of Separation Lake (2 claims). Mr. Tibbo concentrated his efforts where he considered iron sulphides to have developed as a result of sulphidisation of magnetite iron formation (H. Tibbo, personal communication, 1985). North of Separation Narrows 81 samples at 4 separate locations were taken, and at the Boot Bay prospect 46 samples at 3 separate locations were taken. All samples returned trace Au only on assay, except for 3 that assayed 0.01 once per ton Au each.

TOMBILL GOLD MINES LTD. - GLEN ECHO MINES LTD., 1957 (12)

In 1934 J. Gordon and H. Hawes of Dryden and Kenora discovered iron occurrences north of Separation Lake, in the vicinity of Boot Bay. Several test pits were sunk but they were unable to sell their claims, which subsequently lapsed. The occurrences were again staked in 1948, and considered for restaking in 1954 by W.S. Moore Co. of Duluth. M.W. Bartley was commissioned to examine the occurrence and make recommendations. Representative samples were taken from 3 widely separated locations along strike and sent for metallurgical testing. The results of the testing were considered favourable, but the width of known iron formation precluded open pit mining.

In 1957 Tombill Gold Mines Ltd. and Glen Echo Mines Ltd. re–examined the property in a joint venture. Airborne magnetic surveys flown at 1/4 mile spacing during the winter of 1956–57 on behalf of the companies had delineated an east northeast trending belt of magnetic anomalies within the Separation Lake greenstone belt, between the English River and Helder Lake, and another belt east of Fiord Bay. The maximum magnetic high of 16 000 gammas was located on the east shore of Boot Bay. In the spring of 1957 follow–up ground magnetic surveys were conducted over two groups totalling 212 claims covering the northern and southern belts respectively. The survey was run over northerly oriented grid lines on 400 ft spacings. A compilation map of the ground survey at a scale of 1 inch equals 1000 feet, showing contours at 30 000 and 20 000 gammas (Assessment Files, Resident Geologist’s Office, Kenora) purports to show the location of iron–bearing zones, and is useful in demonstrating the continuity of iron–bearing horizons.

Stripping and test pitting was done on the zone east of Boot Bay and the zone east of Fiord Bay, followed by diamond drilling in 8 holes on the zone east of Boot Bay (Boot Bay prospect). Holes were drilled to the south to intersect the steeply northerly dipping iron–bearing units at high angle, and ranged in length from 414.5 feet to 732 feet. Best magnetite–bearing core lengths obtained were as follows: hole A3 – 150 feet; hole A5 – 125 feet; hole A8 – 225 feet. No indication is given of grade. Iron sulphides were recorded with magnetite in all holes, mostly in minor amounts, but up to 20% over a width of 5 feet in one hole, and over 20% over 6 feet in another. Trace chalcopyrite was recorded at one spot in each of 2 holes only.

Reports by J.H. Low, and by N.H. Black, for the joint venture partners, and by W.G. Johnston of the Resident Geologist’s Office, Kenora (assessment Files, Resident Geologist’s Office, Kenora) all consider the iron deposits to be of replacement type, in tuffaceous bands within the predominant amphibolitic mafic metavolcanic rocks.

TREELINED LAKE GRAPHITE PROSPECT (13)

In 1976, two potential uranium occurrences between Trout and Treelined lakes, that also contained considerable amounts of graphite, were brought to the attention of the Resident Geologist Office in Kenora by prospectors J. Harrison and G. Perkins of Eagle River. Both showings proved to be of negligible interest for uranium, but the potential of one of them for flake graphite was apparent. The latter (Figure 15), termed the Harrison South showing by Redden (1993), was on the north shore of the south bay of Trout Lake. The other, termed the Harrison North showing by Redden (1993) was about 1500 m to the north, in–shore from the east side of the same lake. The Harrison North showing had been trenched and pitted for uranium about 1968. Little if any work has been done on the latter occurrence since the 1970s. It was not located during the present survey, but was visited by C. Storey in 1984, who observed only minor graphite over <0.5 m widths (Redden 1993).

Between 1984 and 1986 C. Storey (1990) and J. Redden (1993) conducted independent examinations of the original Harrison South showing as part of industrial mineral studies for the Government of Ontario. Redden obtained an average of 3.7% graphite from 8 samples taken across a 2.4 m wide schistose zone exposed in the original trench (Figure 15, Trench 1). Storey visually estimated graphite zones to vary from 1% to 15% graphite, and to vary in width from 0.5 m to >5 m in the same general vicinity. Point counts on thin sections taken from graphite–rich material done by Storey indicated 17% to 20% total opaques, of which most was said to be graphite. Storey (1990) estimated grain size of graphite flakes to range from <0.1 mm to >2 mm. Redden (1993) also discovered 10 other minor occurrences of graphitic metasediments around the shoreline of Trout Lake, 3 of which were along strike to the south west, on an island and on the south shore of the lake.

Twenty claims were staked around the Harrison South showing by G. Zebruck and R. Kuehnbaum in 1987, and a 2.5 m chip sample taken by them from the original trench assayed 4.31% C. The occurrence was further examined for its graphite potential over the period 1987 to 1990, firstly by Bellwether Resources Limited on 37 contiguous unpatented claims, including the 20 co–owned by G. Zebruck and R. Kuehnbaum, and latterly by Zebruck and Kuenbaum.

Bellwether Resources Limited conducted ground electromagnetic and magnetic surveys, geological mapping, and trenching and sampling of the graphite–bearing zone (Assessment Files, Resident Geologist Office, Kenora), which was determined to extend along a southwest–trending peninsula and thence discontinuously inland toward Treelined Lake over a distance on the order of 2500 m. Corresponding EM and magnetic anomalies were located along this zone, and two trenches were initially excavated across the main 1200 m long anomalous zone at the southwest end, that included the original Harrison South showing. One of these trenches (Figure 15, Trench 1) was on the original trenched area, and the second (Figure 15, Trench 2) 100 m to the east. Systematic sampling across these trenches returned assay values ranging from 0.08% C to 6.94% C, including an 18 m section grading 3.72% C.

Four additional trenches (Figure 15, at lines 1500E, 1800E, 1900E and 2000) were excavated on the main zone, and two along strike to the northeast, at lines 2700E and 2800E. Geological mapping by K.F. O'Flaherty for the company led him to suggest that the graphitic zone lies within migmatitic metasedimentary rocks of probable arkosic derivation, that are intruded by anatectic granitic and pegmatitic rocks.

Five of the 6 trenches on the main zone were sampled by K.F. O'Flaherty, and showed exposed graphite mineralization over widths varying from 23 to 65 m according to O'Flaherty. On the basis of the sampling of the trenches O'Flaherty calculated the average grade to be 1.46% graphitic carbon over a 46 m width, and 500 m length. Higher grade intervals included 4.21% C over 2.5 m, itself within 2.77% over 12.5 m, and 3.55% C over 5 m. Many samples contained more than 2% C.

Subsequent to Bellwether Resources Limited dropping the option Zebruck and Kuehnbaum further prospected the 37 claims and the surrounding area, both for further graphite occurrences, particularly along strike from the known zone, and to test for any base and precious metal mineralisation. No further graphitic metasedimentary occurrences beyond those discovered by Redden (1993) were discovered. Most sulphide–bearing samples assayed for base (Co, Cu, Mn, Mo, Ni, Pb and Zn) and precious (Au and Ag) metals from both the main graphite zone and elsewhere on the property returned uniformly low values. However, two grab samples from the main zone assayed 650 ppm Zn (Trench 1) and 605 ppm Zn (Trench at line 1800E). Three large samples taken from trenches 1 and 2 assayed 8.10% C, 3.55% C, and 5.32% C.

The differing values for carbon obtained by various sampling techniques on the property indicate the inherent difficulties in sampling graphitic zones in which high grade metamorphism, including migmatisation, has recrystallised and redistributed carbon in metasedimentary rocks. Numerous pegmatitic phases of the anatectic granites, as dikes and irregular lenses, intrude the graphitic zone, and have incorporated graphite, which locally occurs as lenses and pods in the pegmatite. Magnetic signature of the zone is provided by disseminated pyrrhotite within both the migmatitic metasedimentary rocks and the pegmatites. The leucocratic nature, essentially due to low biotite content, of the metasedimentary host to the zone, led O'Flaherty to the assumption that they were derived from arkoses. However, under such high grade metamorphic conditions, leading to anatexis, the composition of the sedimentary precursor is uncertain: mobility of silica may have been a factor. Such leucocratic rocks are not uncommon generally in the English River metamorphic terrain in the Separation Lake map area (see section on High Grade Metasediments).

UMFREVILLE LAKE URANIUM OCCURRENCE (CAN FER MINES LTD.) (14)

During the late 1960s and early 1970s a number of parties became interested in the uranium potential of the Separation Lake area. Radioactive anomalies detected by airborne radiometric surveys were investigated on the ground. Can Fer Mines Ltd. did work on a number of such properties, one of which lay at the margin of the currently mapped area, in the northwest, along the English River.

That property, consisting of 34 claims, straddled the main channel of the English River, and encompassed land on either side, to the northwest and southeast. In 1968 the company trenched and sampled a uranium occurrence on the northwest portion, outside of the currently mapped area. This occurrence was not visited during the present survey. In 1969 magnetometer, geological, and scintillometer surveys were conducted over the entire claim group on a grid with 400 foot spacings (Assessment Files, Resident Geologist's Office, Kenora). More detailed scintillometer readings over closer grid lines were taken at the original occurrence on the northwest land portion.

On the southeast land portion the geological survey indicated granites, granite gneisses and paragneiss, and "discontinuous bands of iron formation". The scintillometer survey indicated only background radiation in comparison to that at the uranium occurrence on the northwest land portion. The magnetometer survey indicated a number of highs that coincide with "iron formation", and are probably pyrite–pyrrhotite zones. One such high correlates with a graphite and magnetite–bearing zone that was investigated during the present survey. The zone was also investigated by Champion Bear Resources Ltd.(Grid G).

Recommendations For Exploration

The history of geological investigations, prospecting and mineral exploration in the Separation Lake map area points up some interesting trends in the search for economic minerals. It also stresses the wisdom of re–examining previously known occurrences that were either little–investigated or investigated for a commodity differing from that of current interest.

RARE METALS

The discovery by Stockwell during a reconnaissance of the English River system (Stockwell 1932) of beryl in a pegmatite dike appears to have held little interest until the 1980s, when Storey reinvestigated granitic pegmatites during a regional program to evaluate industrial mineral potential (Storey 1990). Subsequent discovery of other rare–metal bearing minerals, and in particular the lithium mineral petalite, by Breaks (1993) indicated this to be a prime area for exploration for deposits of the Tanco type.

Subsequent to the present field program, discovery of further pegmatite bodies (Breaks and Tindle 1996) has led to exploration by Avalon Ventures Ltd., Tanco Ltd. and Emerald Fields Resources, with considerable success.

Location of other beryl–bearing pegmatites during the present field program at Separation Lake suggests that further rare–metal deposits should be explored for. One such occurrence is on the peninsula east of Fiord Bay and north of Walleye Lake, almost 10 km southeast of the currently known Separation Lake rare metal pegmatite field.

GOLD

The emphasis on prospecting for gold in the 1940s, led to the subsequent discovery of gold– and base metal–bearing sulphide zones at Helder Lake and at Umfreville Lake. Sparton Resources Inc. re–investigated the Gauthier occurrence (Umfreville Lake) in 1985, and Shabu Gold Mines Ltd. to re–investigated the Helder Lake occurrence in 1987, both primarily for their gold potential. Although the Helder Lake occurrence has not proven to date to be significant, work by Champion Bear Resources Ltd. has shown the Gauthier occurrence to warrant further deep exploration drilling.

In the 1950s the evaluation of the Separation Lake iron formations for their iron potential demonstrated their essential low grade and low tonnage potential, but delineated their extent along the belt. However, in the 1980s the potential for oxide facies iron formations to act as chemical and structural traps for gold carried in hydrothermal solution again made the iron formations of exploration interest. H.Tibbo sampled the old trenches in the vicinity of Boot Bay, where iron sulphides have replaced magnetite (Assessment Files, Resident Geologist’s Office, Kenora). Results were discouraging, as have been those obtained by Champion Bear Resources Ltd. in the same area. However, the present survey leads to the suggestion that the iron formations on the peninsula east of Fiord Bay are the dismembered correlatives of those in the Separation Narrows anticline, probably offset along the Fiord Bay fault. Isolated outcrops of iron formation are present in the vicinity of Separation Narrows, and on the east shore of Fiord Bay. This observation, coupled with the magnetic signature on airborne geophysical surveys, leads to the possibility of continuity of iron formation along the English River eastward to Separation Lake, to be offset southwestward along the Fiord Bay fault. Breaks in magnetic signature, particularly where tight folding is demonstrated or expected, may indicate replacement of magnetite by pyrite during hydrothermal alteration, and hence represent a good exploration target for gold.

GRAPHITE

The interest in uranium in pegmatite dikes and granitic rocks in the 1960s and 70s, although itself demonstrating the limited potential of the Separation Lake area for this commodity, did lead to the discovery of graphite at Trout Lake. In the 1980s, the industrial mineral potential evaluations of Storey (1990) and Redden (1993), followed by work done by Bellwether Resources Limited, demonstrated the potential for favourable flake size of the graphite, localised concentrations, and the continuity of the main graphite–bearing zone over a distance up to 2.5 km on land. The occurrence has not been drilled, neither has the possibility of its extension southwestward beneath Trout Lake been tested by geophysical surveys and/or drilling. The possibility of other deposits within the migmatite terrain also exists, particularly in proximity to anatectic, commonly biotite–quartz–garnet clotty, granites.

BASE METALS

The discovery in the 1940s of the Gauthier occurrence at Umfreville Lake, and the realization of its potential for base metals, coupled with the discovery of the Alcock occurrence in the same decade, led Champion Bear Resources Limited in the 1980s to re–evaluate the base metal potential of the major portion of the Separation Lake greenstone belt. The association of base metals with sulphide zones in the mafic metavolcanic sequence is well established, though there seems to be little association with the felsic metavolcanic rocks. The limited analytical results obtained from the present survey suggest that there has been selective hydrothermal alteration of the mafic metavolcanic sequence, and that there is a spatial relationship between the more intensely altered rocks and known base metal bearing sulphide zones. More detailed lithogeochemical sampling in the vicinity of the known zones may pinpoint other base metal targets.

DIMENSION STONE

The potential for discovery of granitic rocks suitable for quarrying as dimension stone has been investigated south of the present map area. This has been done within the extension of the Tourist Lake granites, along the Sand Lake Road by Storey (1986), and subsequently between Snook and Tourist lakes by G. Zebruck (Hailstone and Storey, 1984; and Assessment Files, Resident Geologist's office, Kenora). Only that portion of the Tourist Lake granites adjacent to the greenstone belt was mapped during the present survey. However, large outcrops of pink granite were traversed south of Selwyn Lake. Much of this rock is massive, remarkably uniform in composition, lacking foliation and preferred crystal orientation, has few vertical fractures, and wide–spaced horizontal fractures. The potential of these and adjacent but unmapped outcrops for dimension stone should be examined. The building stone potential of a large part of the Winnipeg River Subprovince, of which the Tourist Lake granites are a part, has been pointed out by Storey (1986; Hailstone and Storey, 1994).

SURFICIAL SEDIMENT SAMPLING

Humus and "B" and "C" horizon till samples collected by Morris (1996) as part of a Quaternary geological mapping (Morris 1999) and drift geochemistry program in the Separation Lake greenstone belt area give further data for exploration for gold, base metals and rare–metal pegmatites. The samples were collected for geochemical, gold grain and heavy mineral (metamorphosed magmatic sulphide indicator mineral) analysis.

Samples were collected by Morris (1996) for orientation and regional surveys. The orientation surveys, conducted at Helder Lake, Selwyn Lake and Separation Rapids within the present map area, were conducted to characterize the geochemical and heavy mineral response in till samples over specific types of mineralization.

When observations from the orientation surveys were applied to the data collected in the regional survey, several sample sites of interest for exploration for gold, base metals and rare–metal pegmatites were identified by Morris (1996). The reader is referred to this report for further information.

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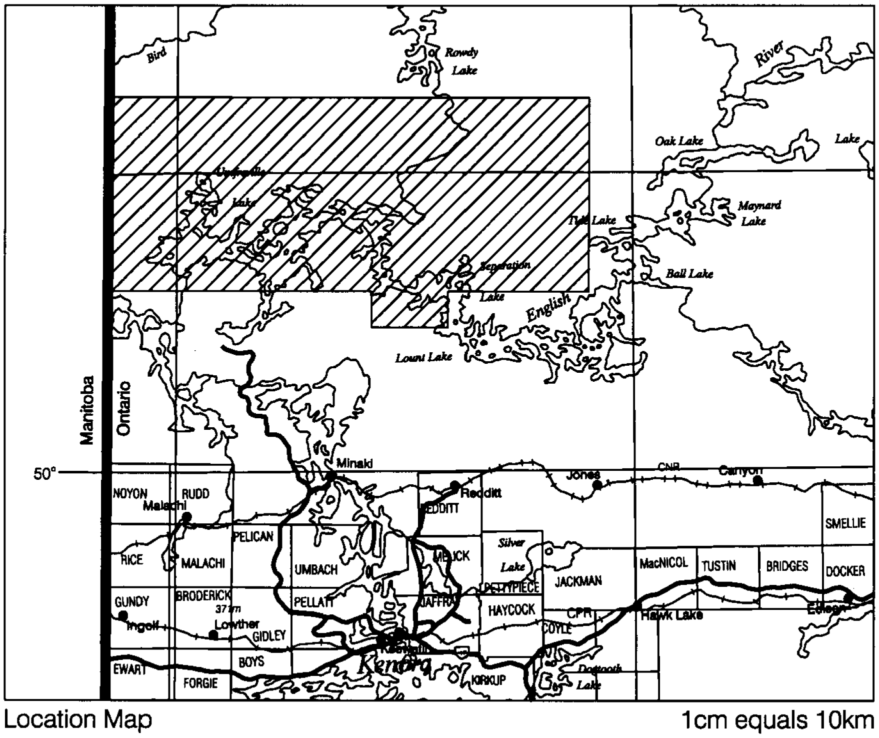

Figure 1. Key map showing location of the Separation Lake area.

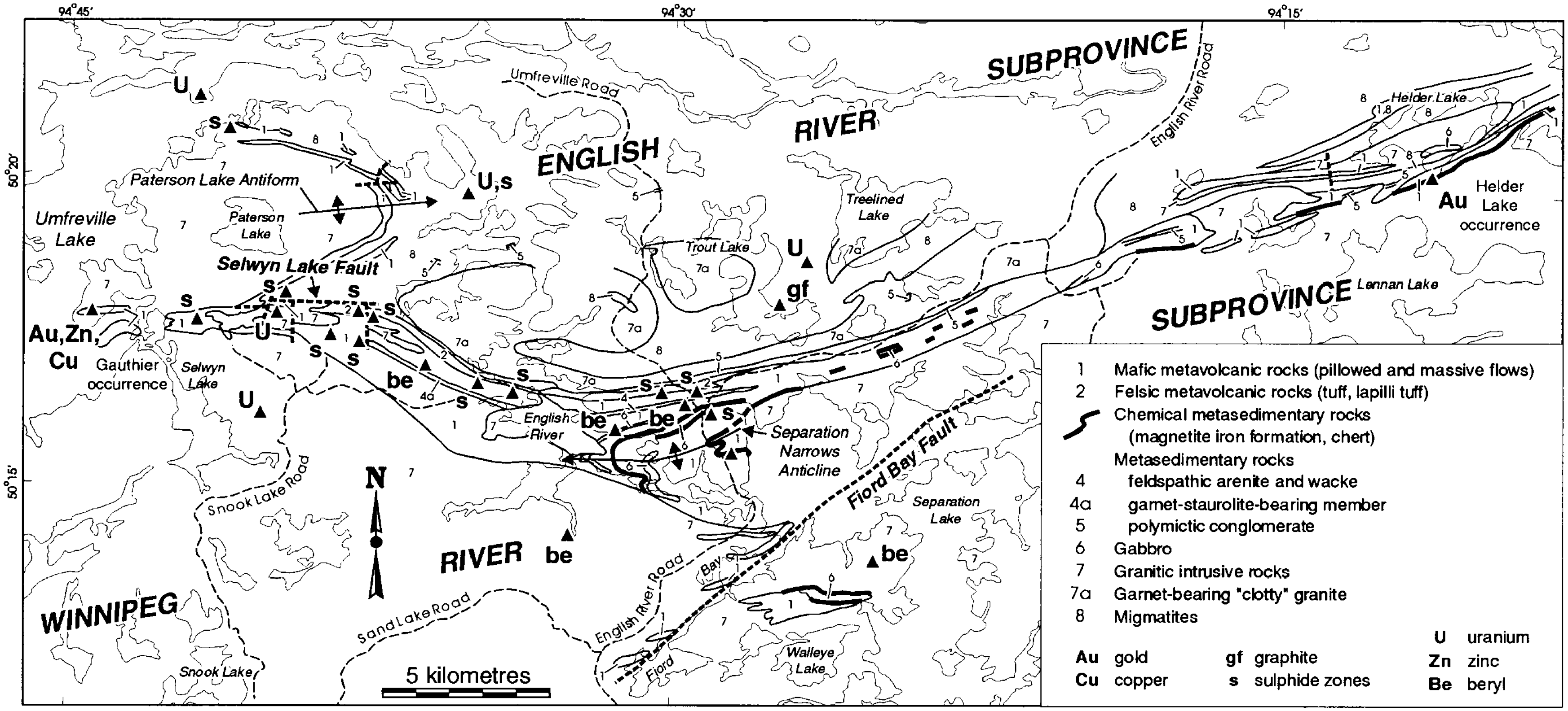

Figure 2. Separation Lake area: general geology and mineral occurrences.

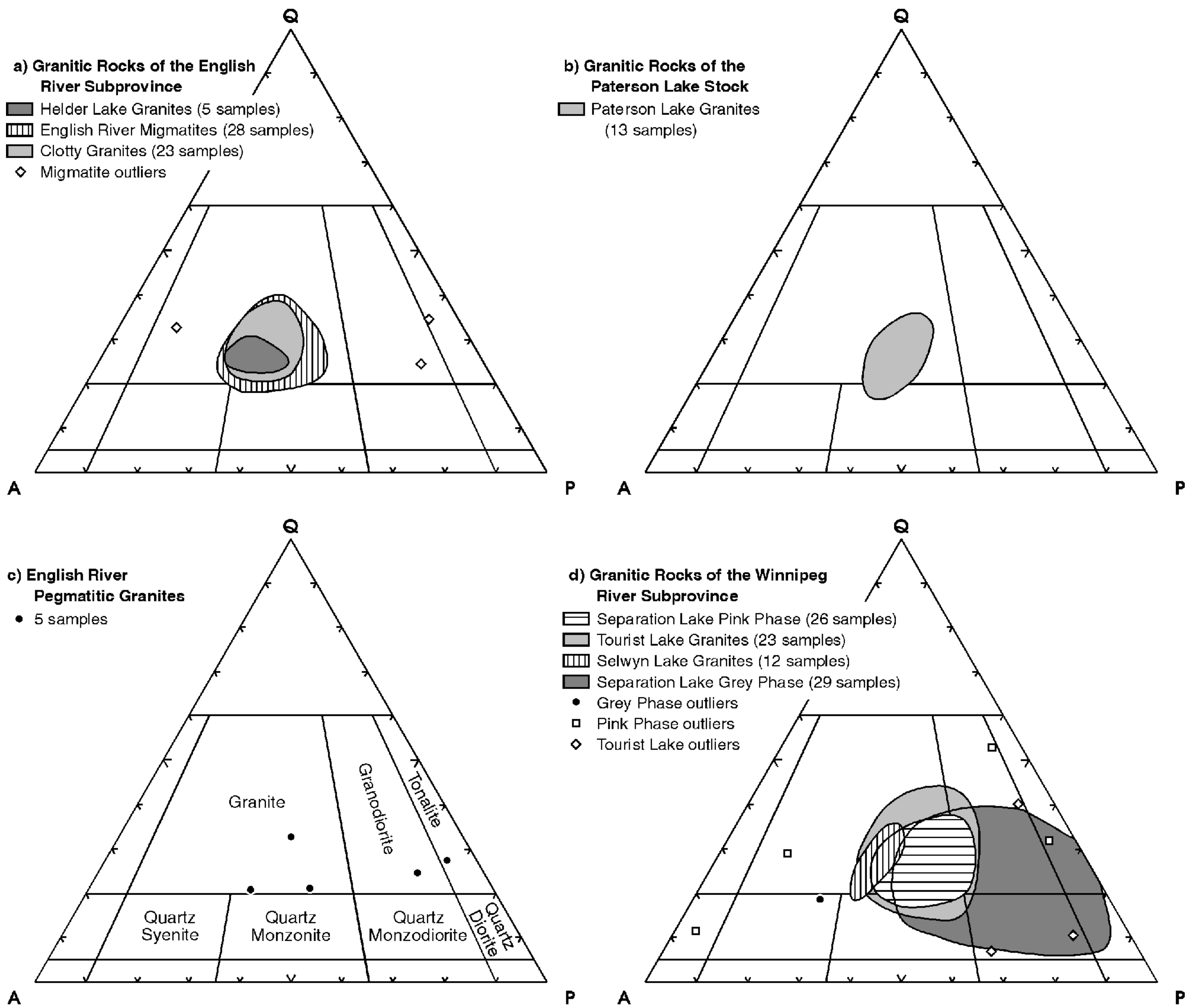

Figure 3. Modal quartz (Q), alkali feldspar (A), plagioclase (P) diagrams for granitic rocks

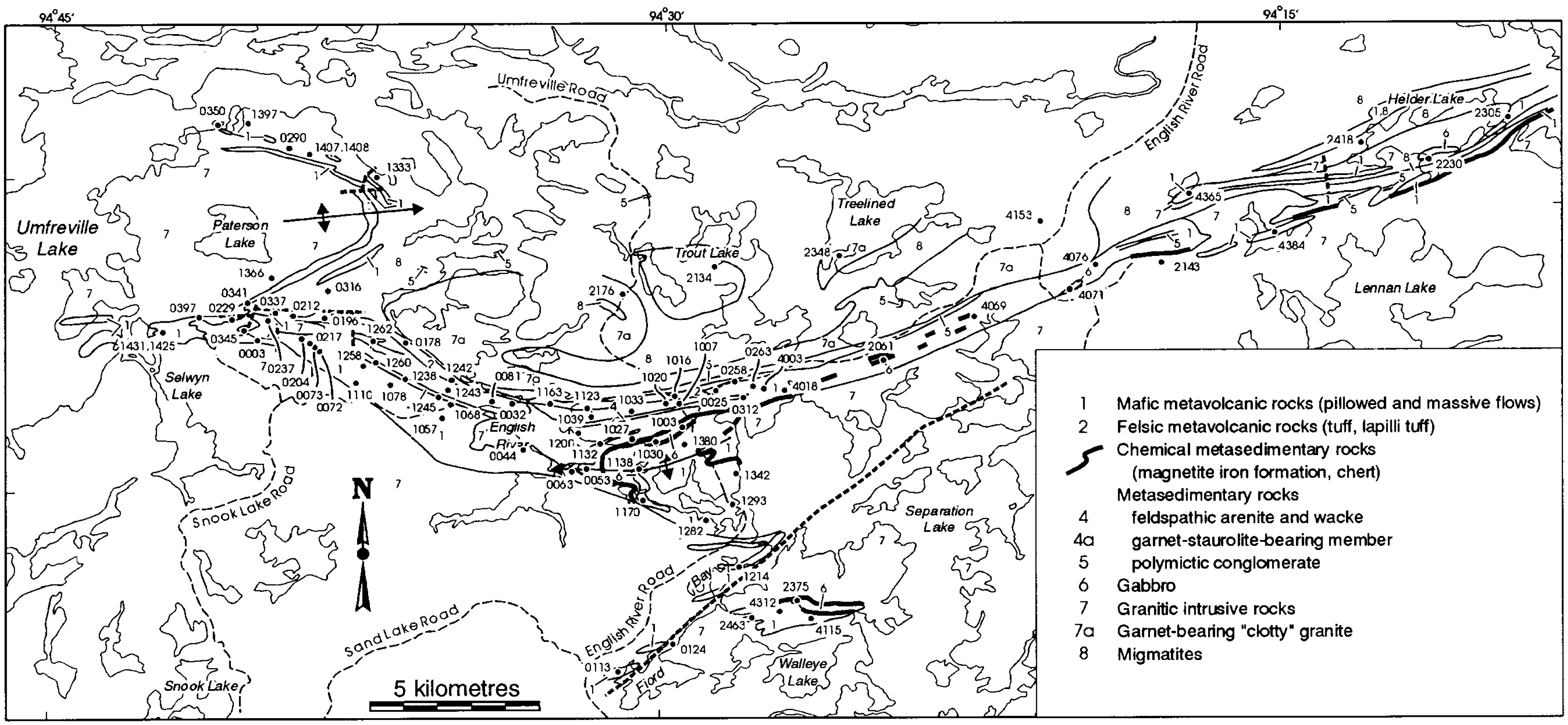

Figure 4. Separation Lake area: geochemical sample locations, keyed to Tables 4, 5 and 6.

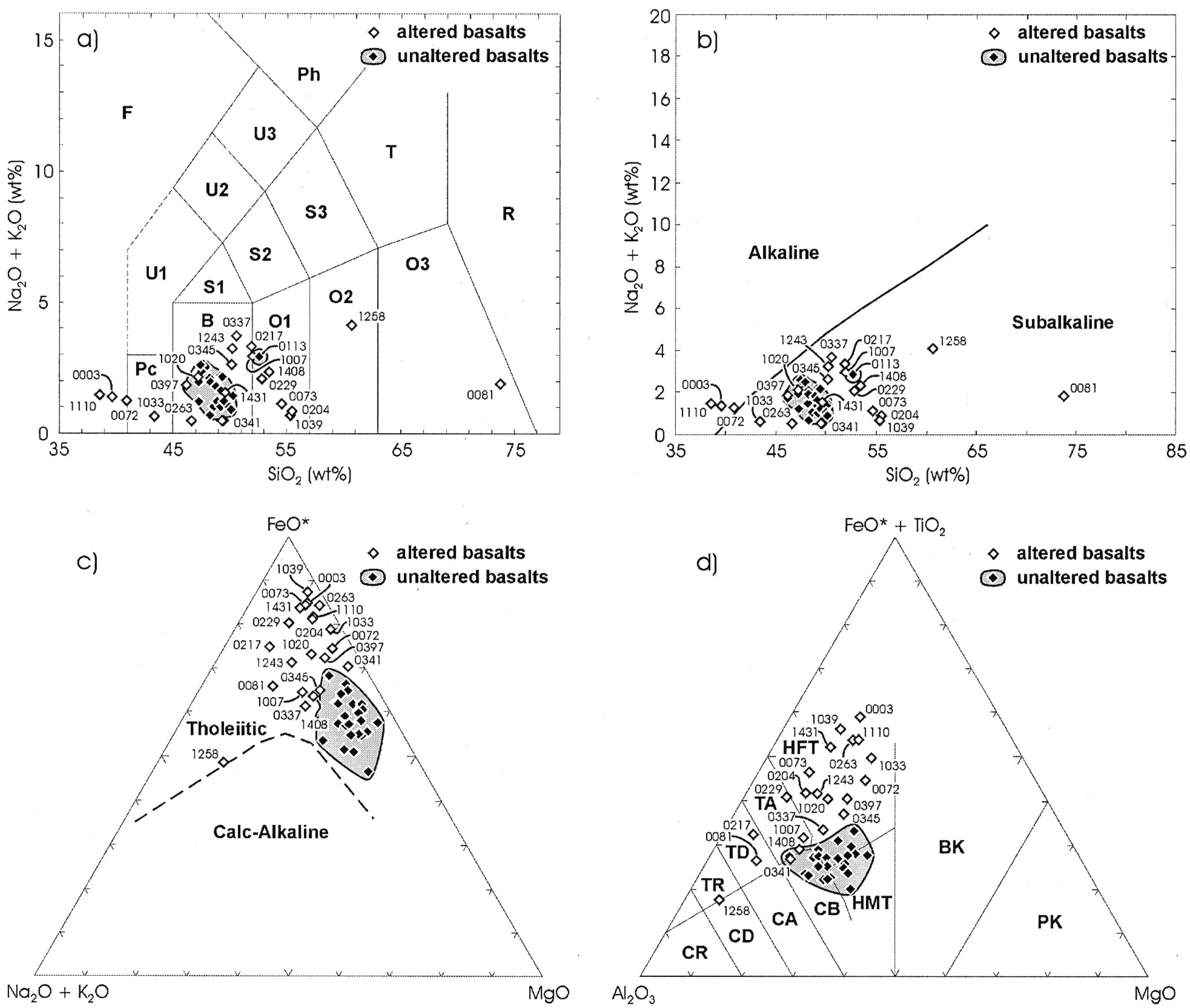

Figure 5. Discrimination diagrams for basaltic rocks, according to: LeMaitre (1989) a, e; Irvine and Baragar (1971) b, c; Jensen (1976) d; Pearce and Cann (1973) f, g, h. Abbreviations: (a) F–foidite; U1–tephrite, basanite; U2–phonotephrite; U3–tephriphonolite; S1–trachybasalt; S2–basaltic trachyandesite; S3–trachyandesite; O1–basaltic andesite; O2–andesite; O3–dacite; B–basalt; Pc–picrobasalt; Ph–phonolite; T–trachyte; R–rhyolite (d) TR–tholeiitic rhyolite; TD–tholeiitic dacite; TA–tholeiitic andesite; HFT–high iron tholeiite; HMT–high magnesium tholeiite; CR–calc–alkaline rhyolite; CD–calc–alkaline dacite; CA–calc–alkaline andesite; CB–calc–alkaline basalt; BK–basaltic komatiite; PK–peridotitic komatiite (f and g) OFB–ocean floor basalts; LKT–low potash tholeiites; CAB–calc–alkaline basalts; IAB–inter arc basalts (h) low potash tholeiites plot in A and B; ocean floor basalts plot in B; calc–alkali basalts plot in B and C; ocean island or contiental basalts plot in D.

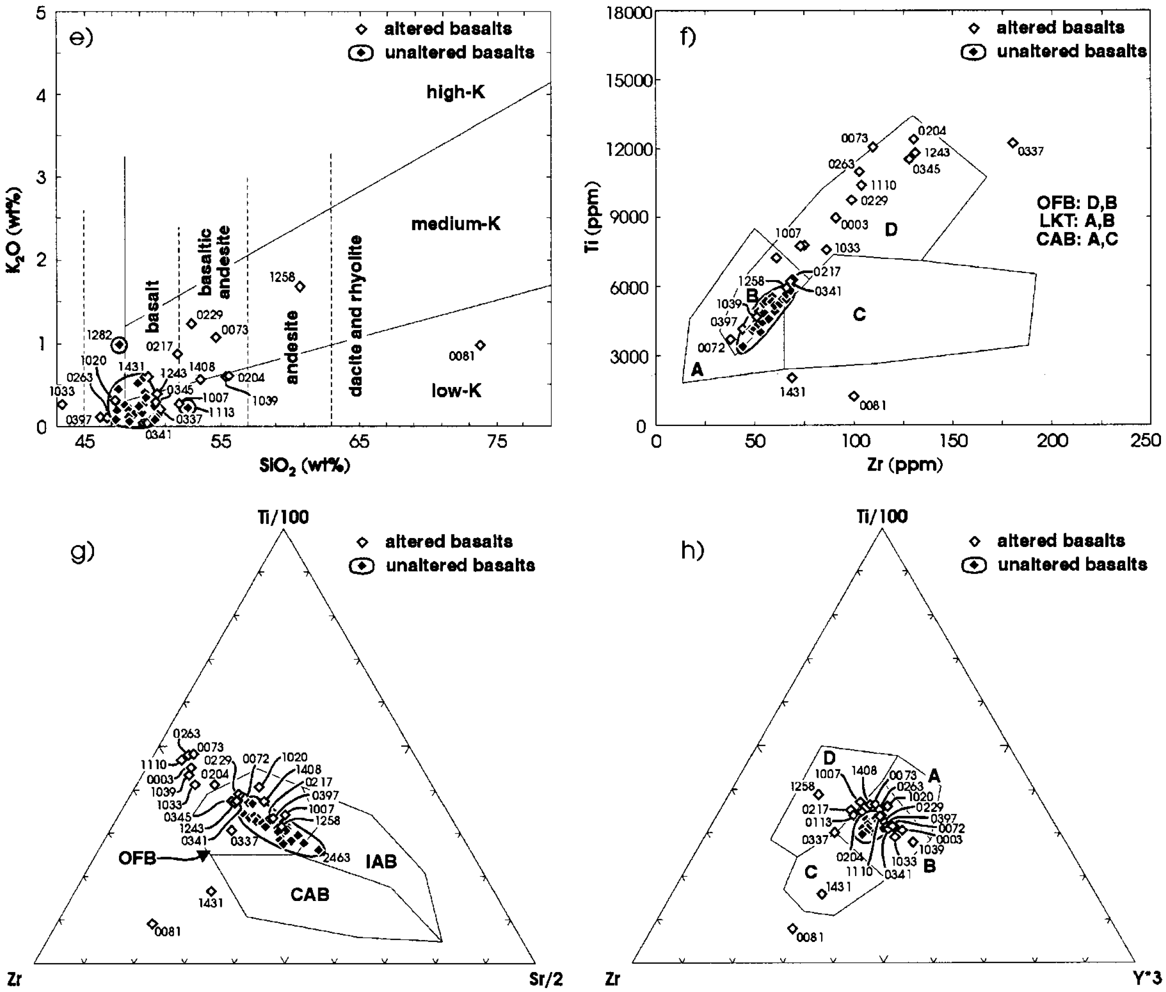

Figure 5. Continued

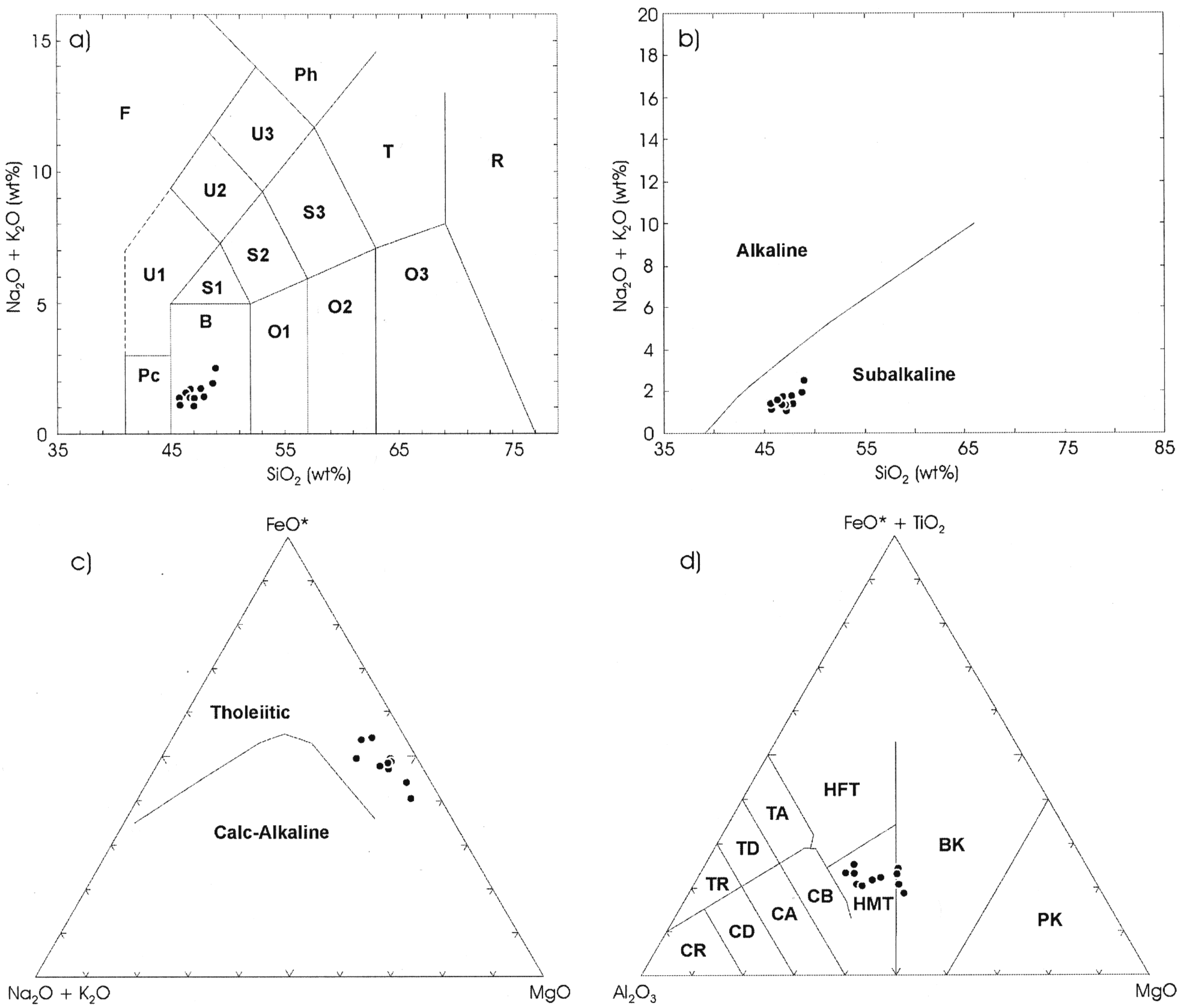

Figure 6. Discrimination diagrams for gabbroic rocks, according to: LeMaitre (1989) a, e; Irvine and Baragar (1971) b, c; Jensen (1976) d; Pearce and Cann (1973) f, g, h. Abbreviations as in Figure 5.

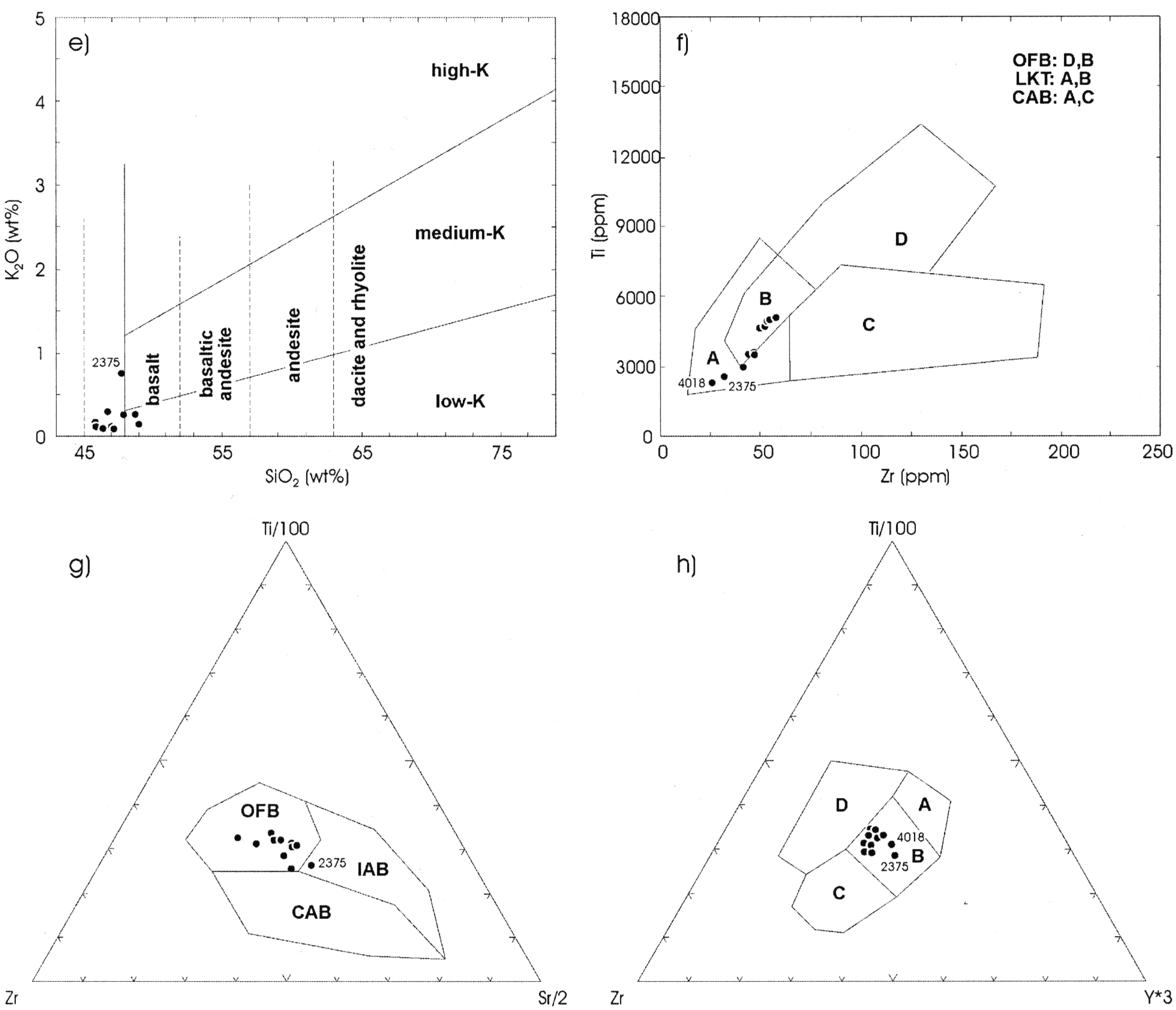

Figure 6. Continued.

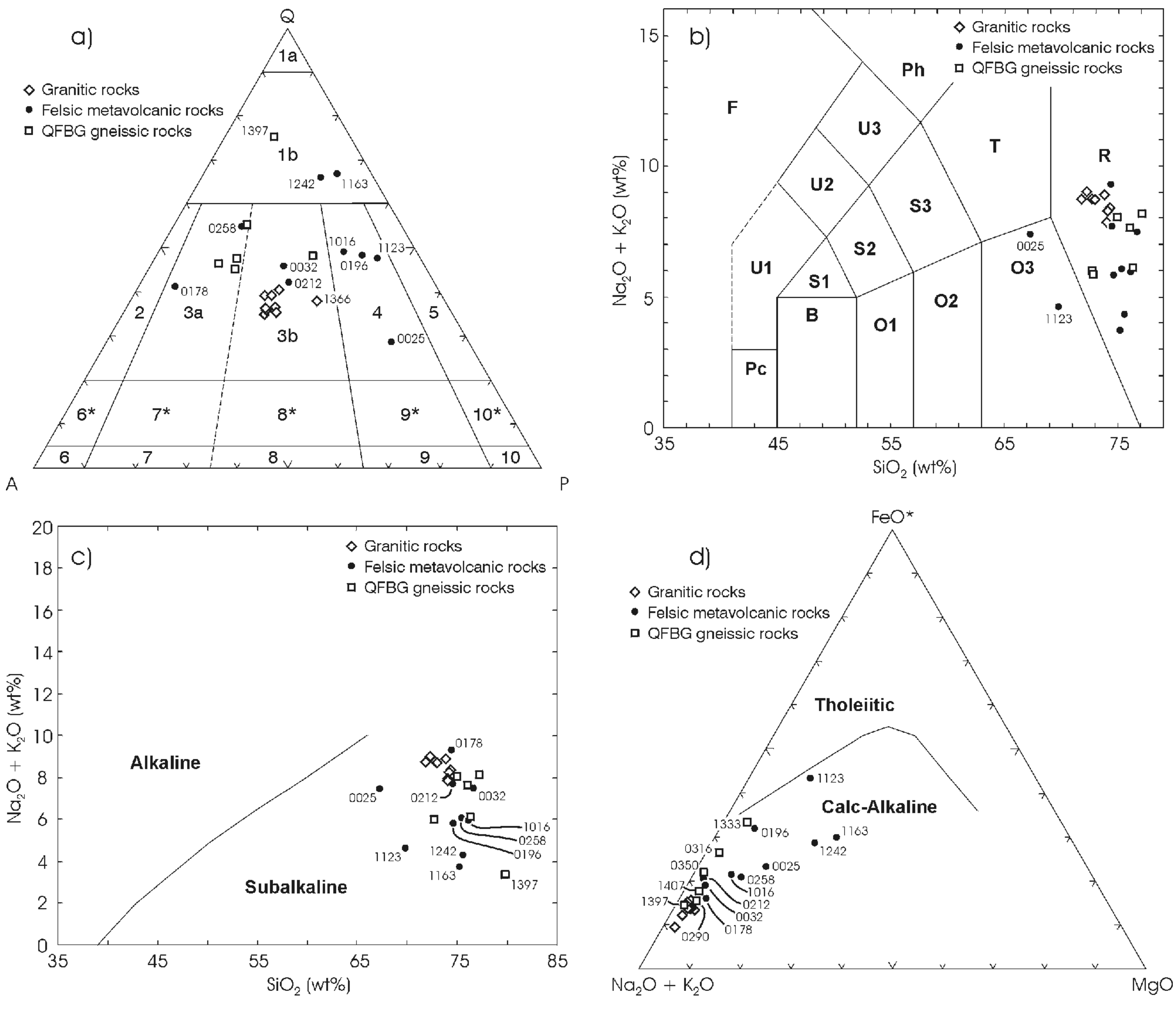

Figure 7. Discrimination diagrams for granitic rocks, felsic volcanic rocks and quartz–feldspar–biotite–garnet gneisses. Abbreviations: (a) 1a–quartzolite; 1b–quartz–rich granitoids; 2–alkali granite; 3a and b–granite; 4–granodiorite; 5–tonalite; 6*–alkali quartz syenite; 7*–quartz syenite; 8*–quartz monzonite; 9*–quartz monzodiorite; 10*–quartz diorite; 6–alkali syenite; 7–syenite; 8–monzonite; 9–monzodiorite; 10–diorite, norite, gabbro (b) as in Figure 5a (e) as in Figure 5d.

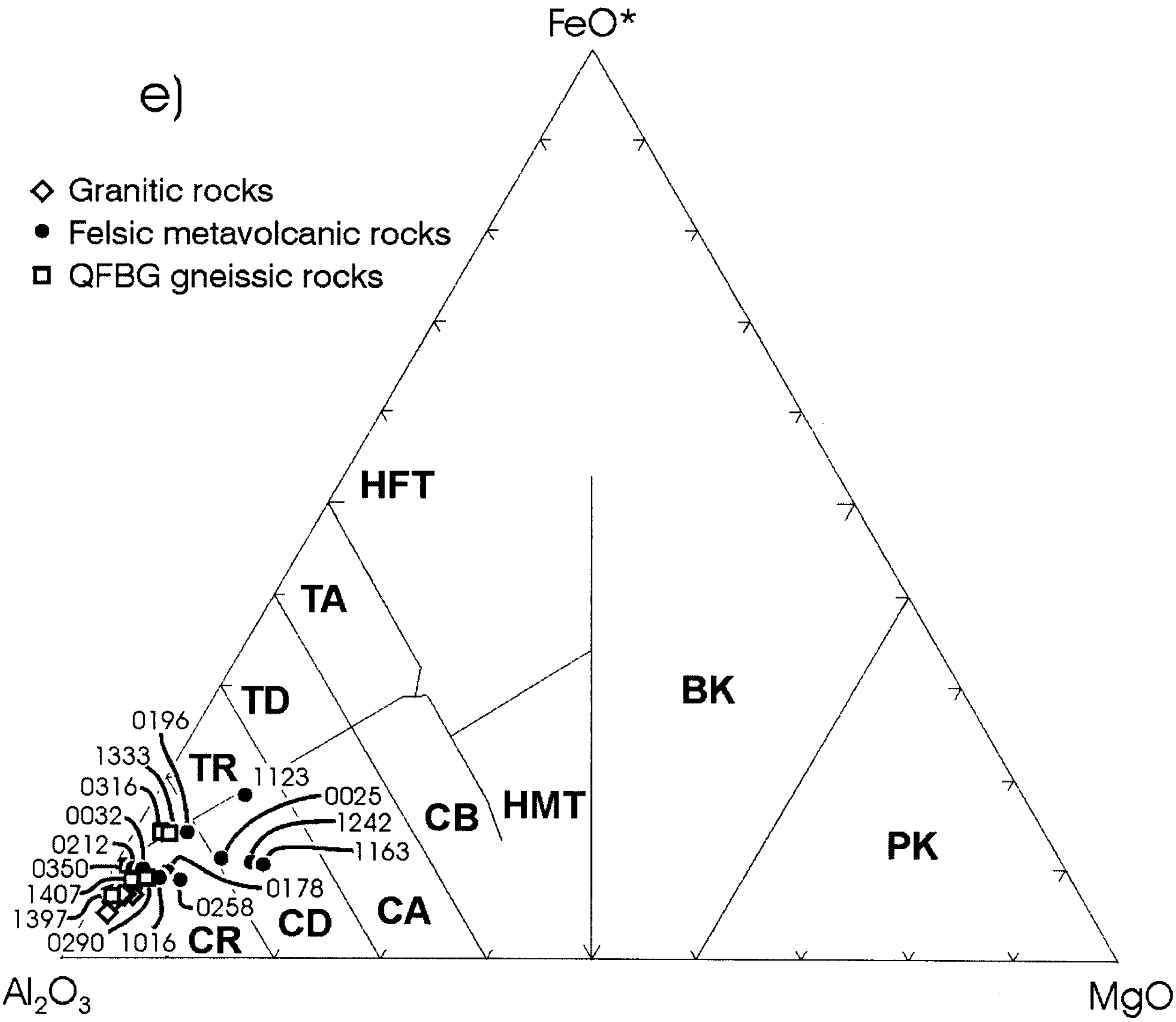

Figure 7. Continued.

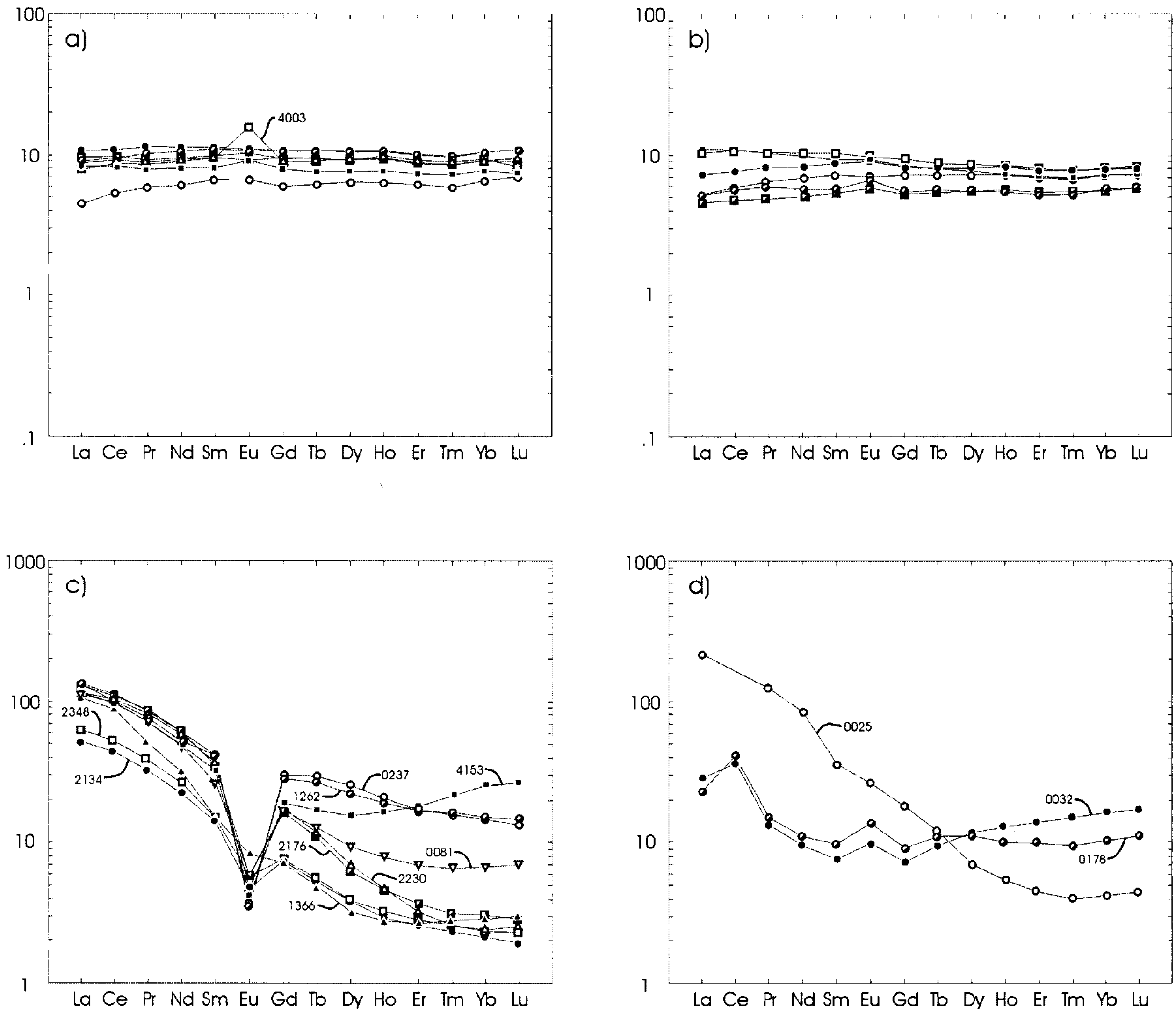

Figure 8. Chondrite normalized rare earth element patterns (Sun 1982) for (a) mafic metavolcanic rocks (b) metagabbros (c) granitic rocks (d) felsic metavolcanic rocks (e) gneisses and (f) potentially altered mafic metavolcanic rocks.

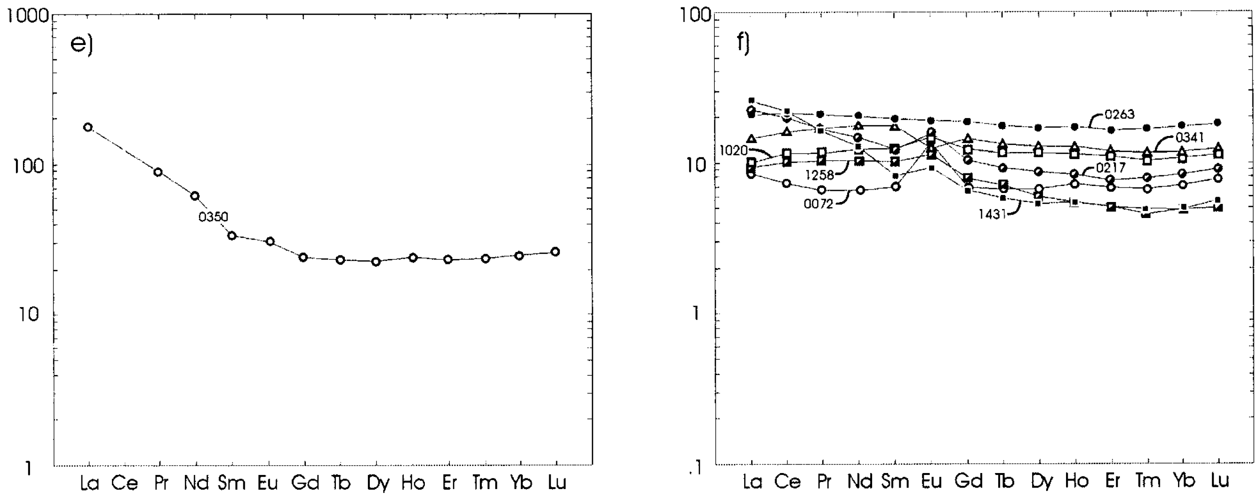

Figure 8. Continued.

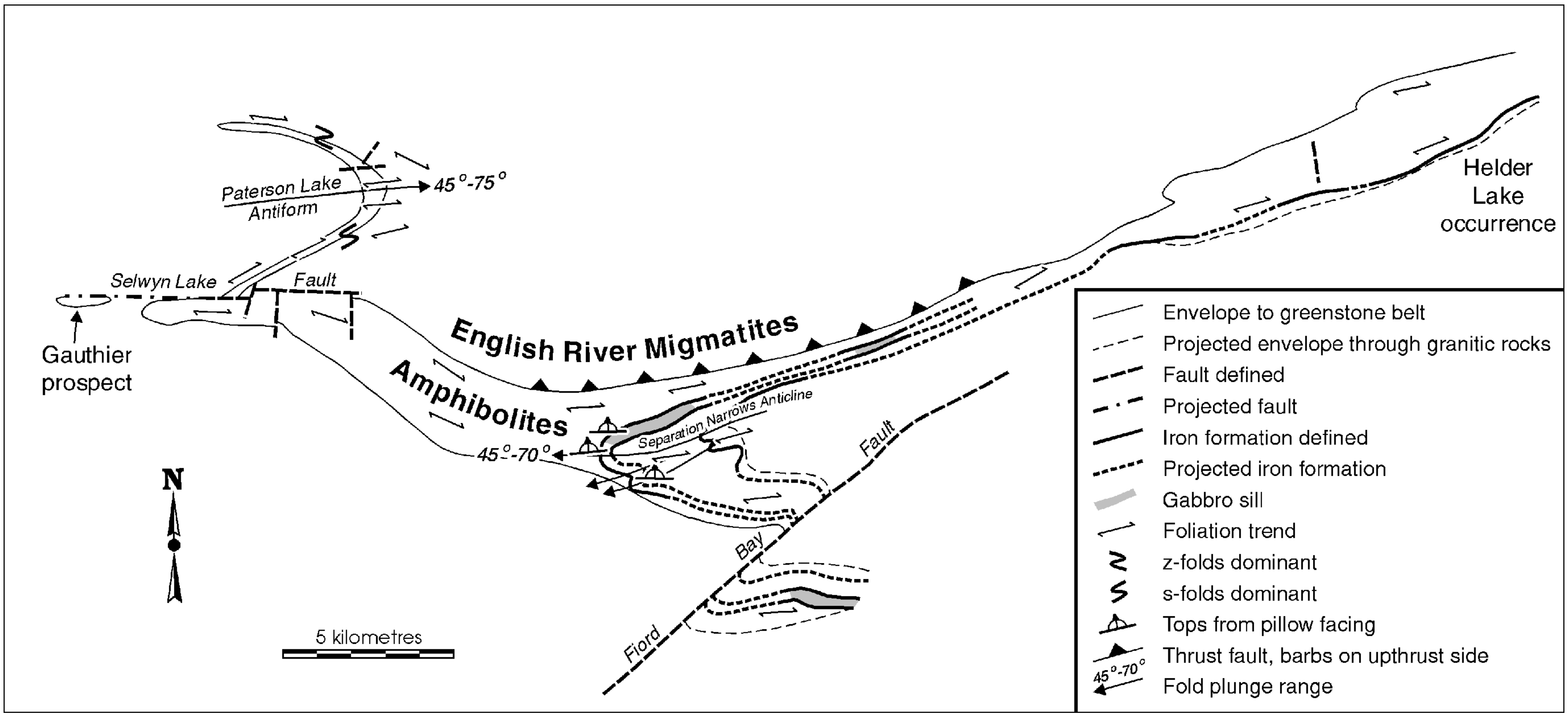

Figure 9. Separation Lake area: interpretative structural geology

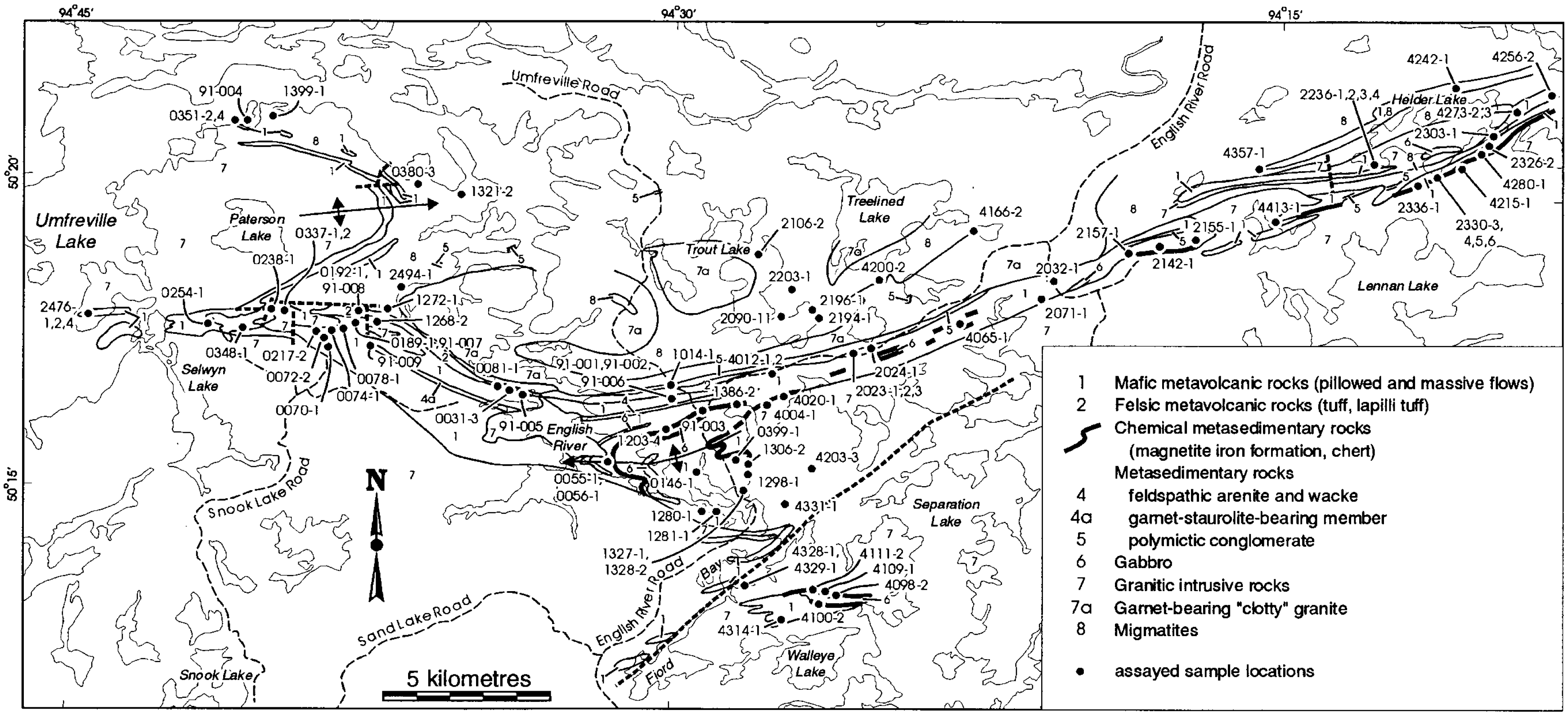

Figure 10. Separation Lake area: assayed sample locations, keyed to Table 7.

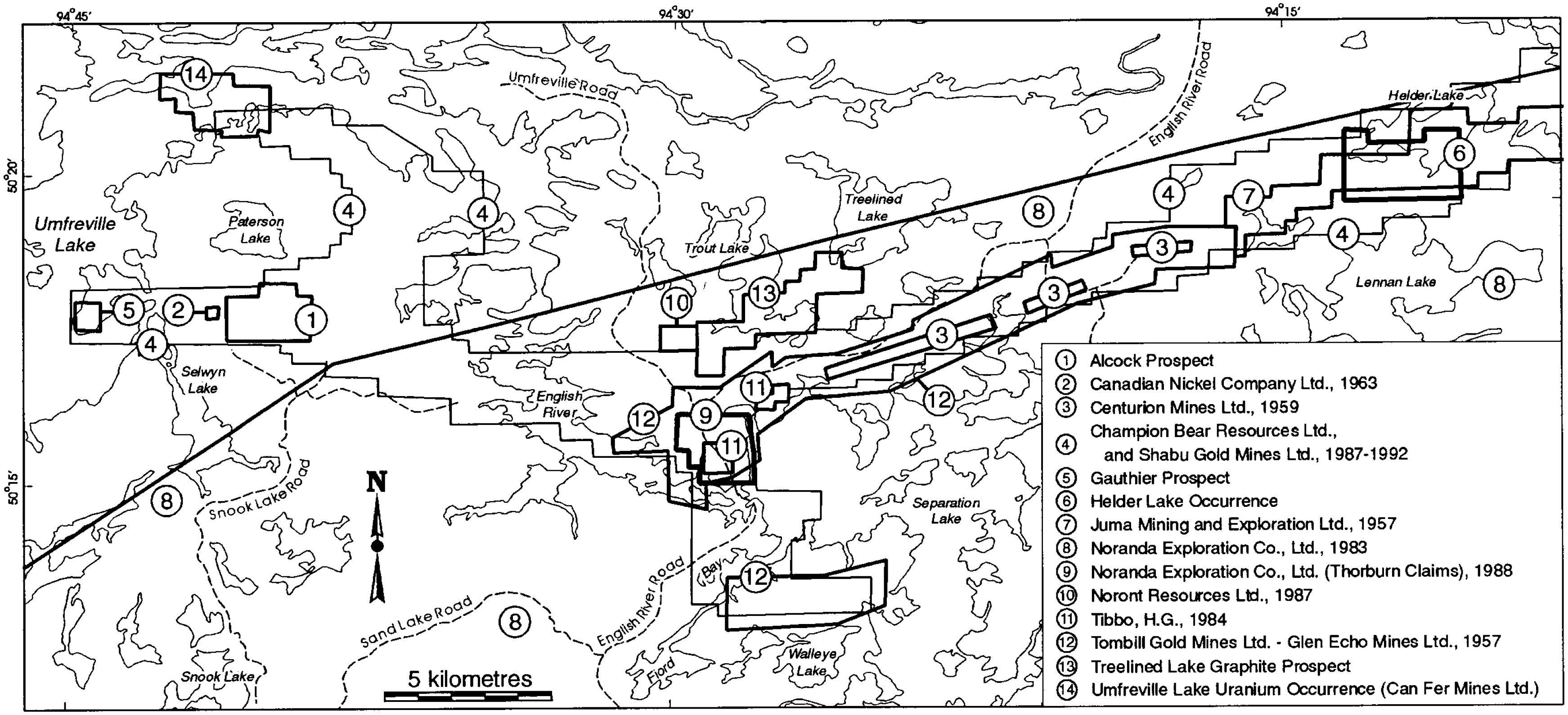

Figure 11. Separation Lake area: property locations.

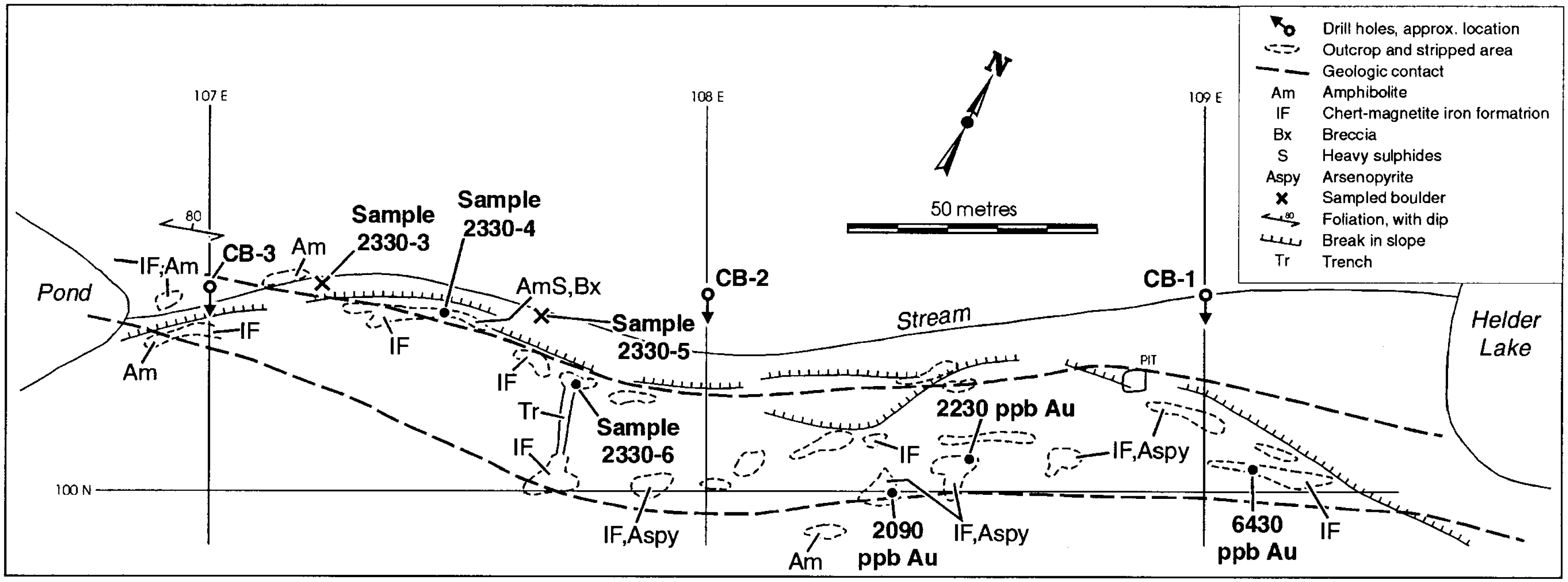

Figure 12. Helder Lake occurrence. Sketch map of outcrops, trench and pit, location of assayed samples, drill holes, and assay values referred to in the text. Geological interpretation by C.E. Blackburn, on grid of Champion Bear Resources Ltd.

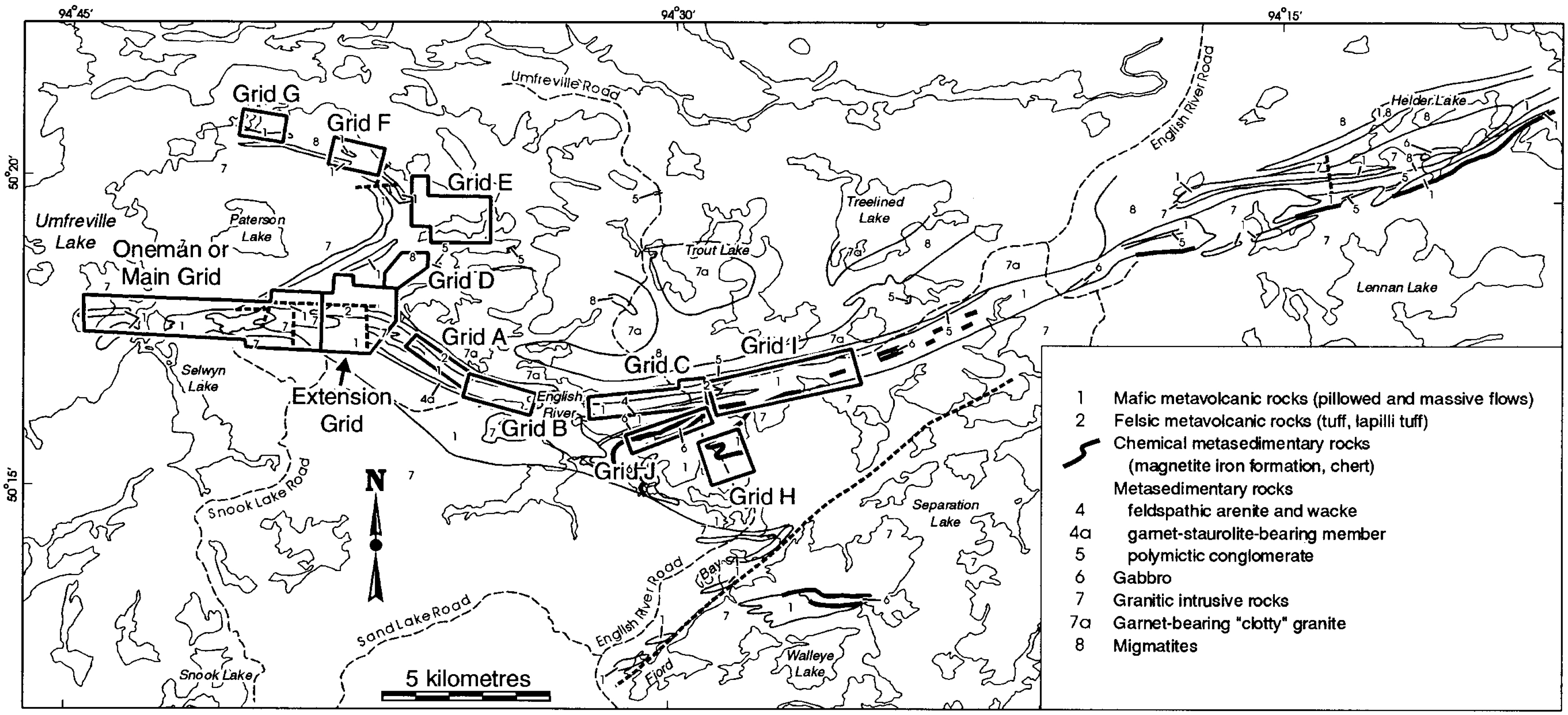

Figure 13. Champion Bear Resources Ltd. grid locations.

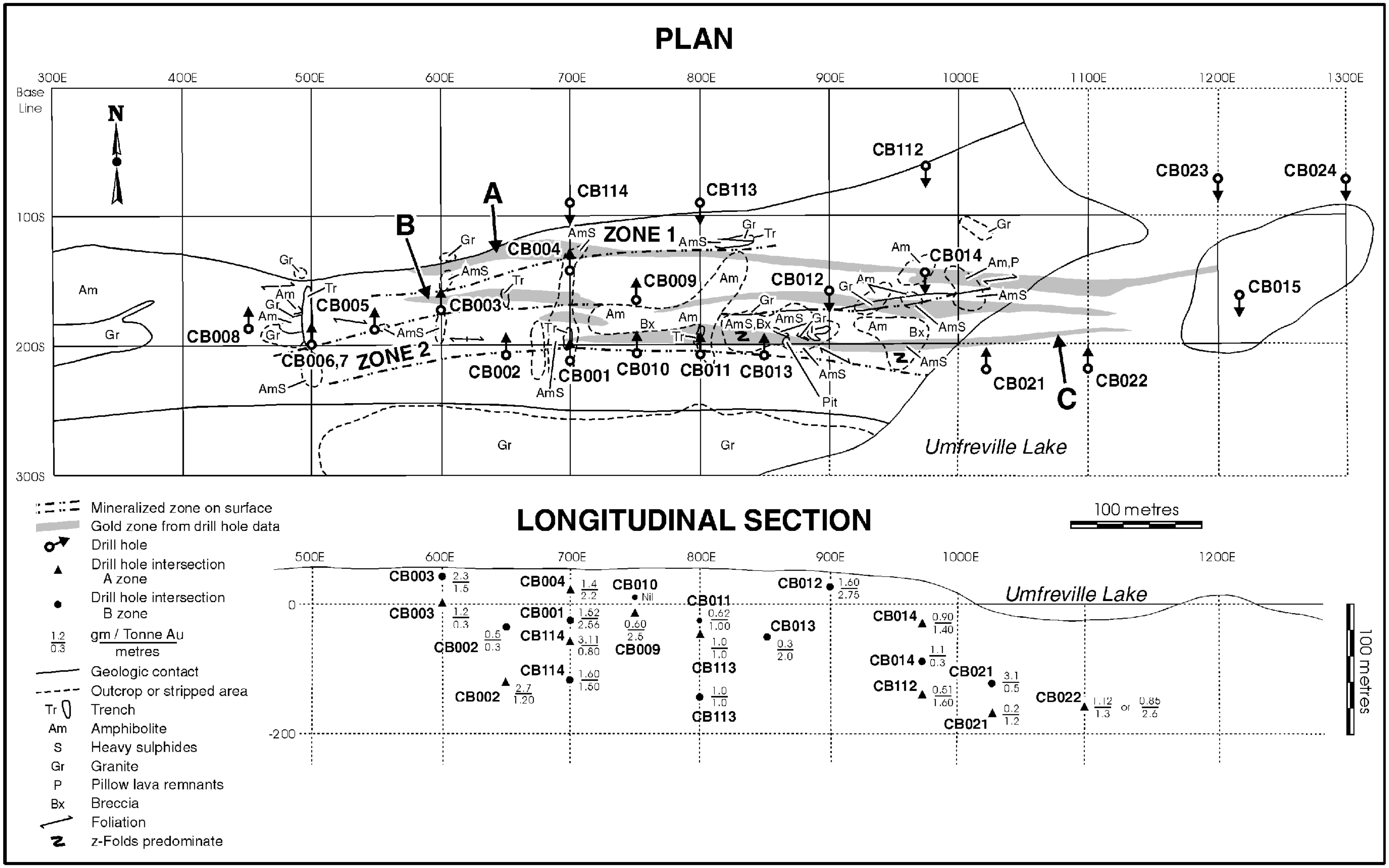

Figure 14. Gauthier prospect. Plan and longitudinal section (projected on line 200S) after A.P. Pryslak for Champion Bear Resources Ltd., with modifications and addition of trenches, stripped areas and outcrops by C.E. Blackburn. Drill hole intersections in the C zone are omitted from the longitudinal section.

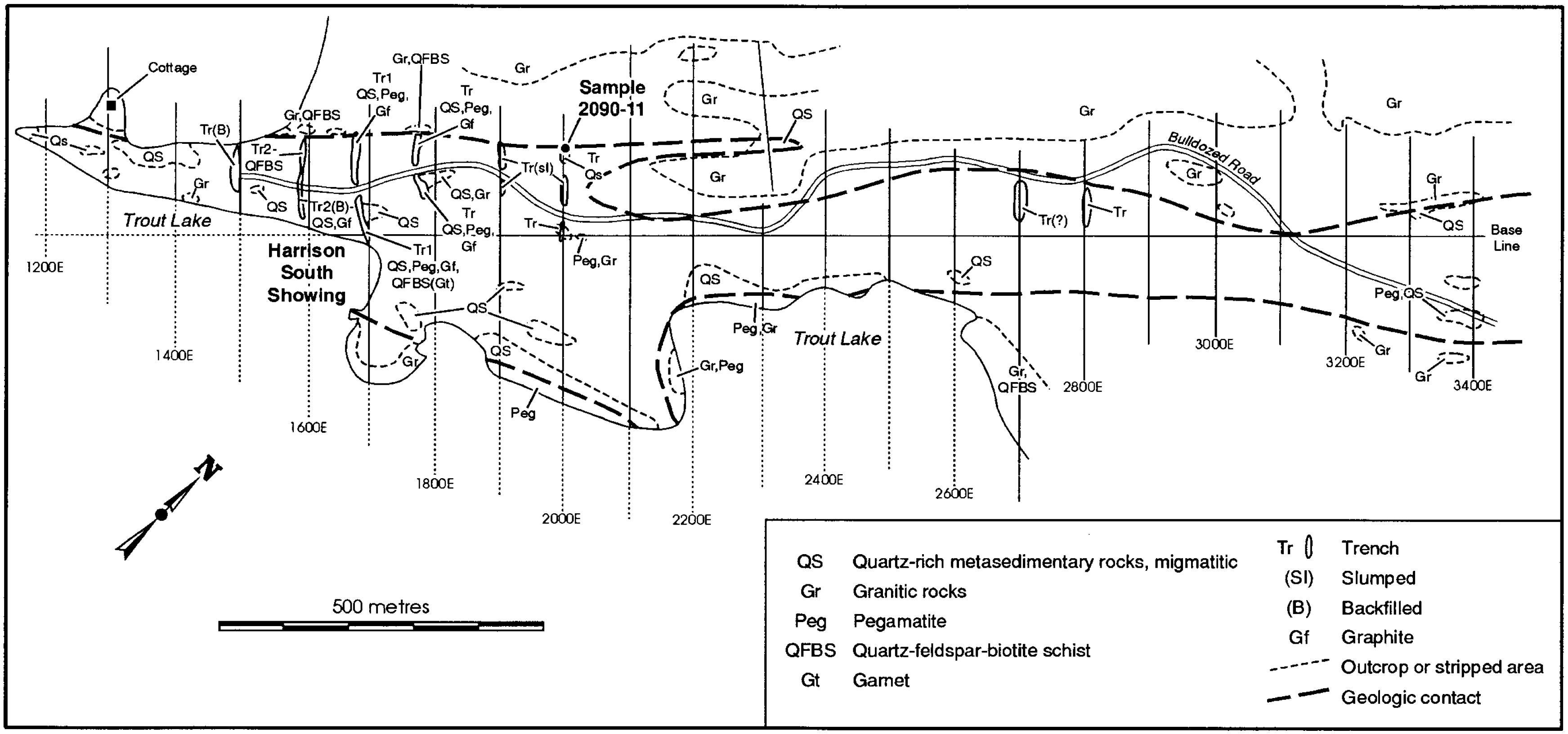

Figure 15. Treelined Lake graphite prospect. Sketch map of outcrops and trenches. Geological interpretation by C.E. Blackburn, on grid of Bellwether Resources Limited.

Photo 1. Pillowed mafic metavolcanic rocks showing reliable northerly top determinations (toward hammer head). North shore of English River, about one kilometre west of Separation Narrows.

Photo 2. Garnet and hornblende porphyroblasts in strongly deformed pillowed mafic metavolcanic rocks. Outcrop is close to the southeast arm of the small lake 2 km east of Selwyn Lake (adjacent to location of Photo 3).

Photo 3. Sulphide zone in mafic metavolcanic rocks. Sample 0217-2 (Table 7) from this outcrop assayed 261 ppm Cu and 2000 ppm Zn. Champion Bear Resources Ltd. drill hole CB 017 undercut the sulphide zone. Outcrop is close to the south shore of the small lake 2 km east of Selwyn Lake (adjacent to location of Photo 2).

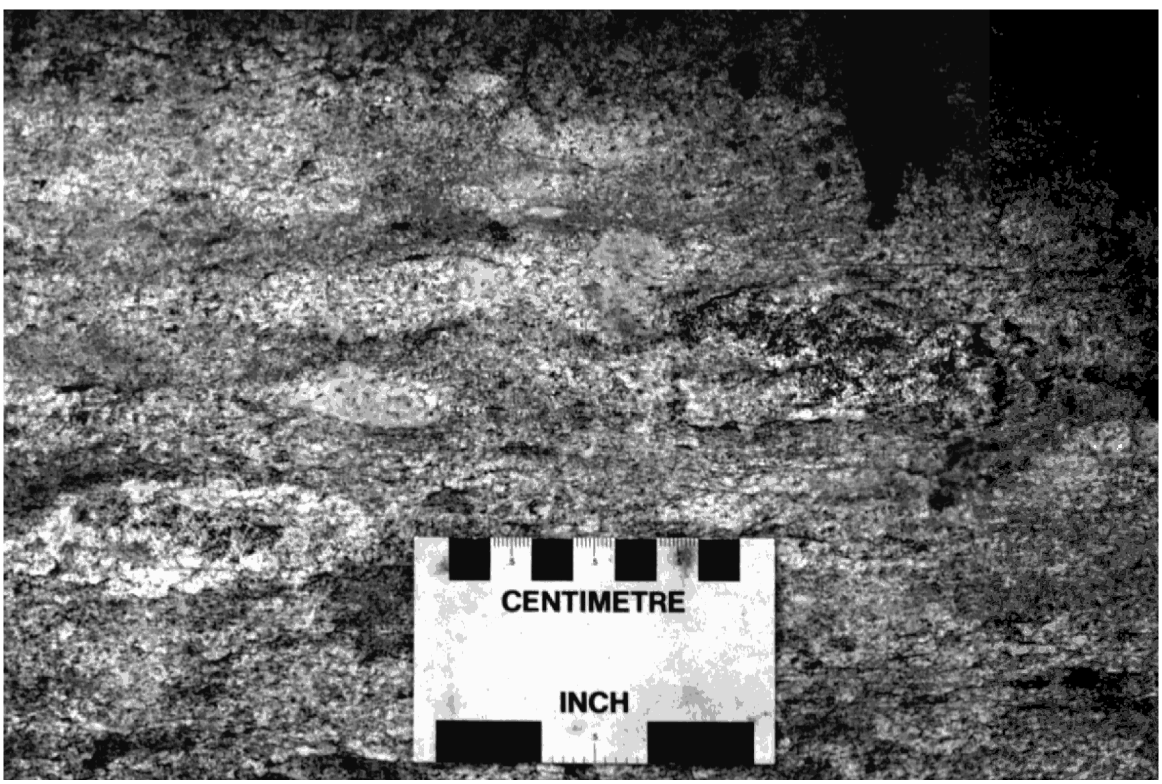

Photo 4. Felsic lapilli-tuff. Tectonism has blurred distiction between monolithologic clasts and matrix of similar composition. Outcrop is about 300 m northwest of the small lake 2 km east of Selwyn Lake, in the same general area as Champion Bear drill holes CB 125 and CB 126.

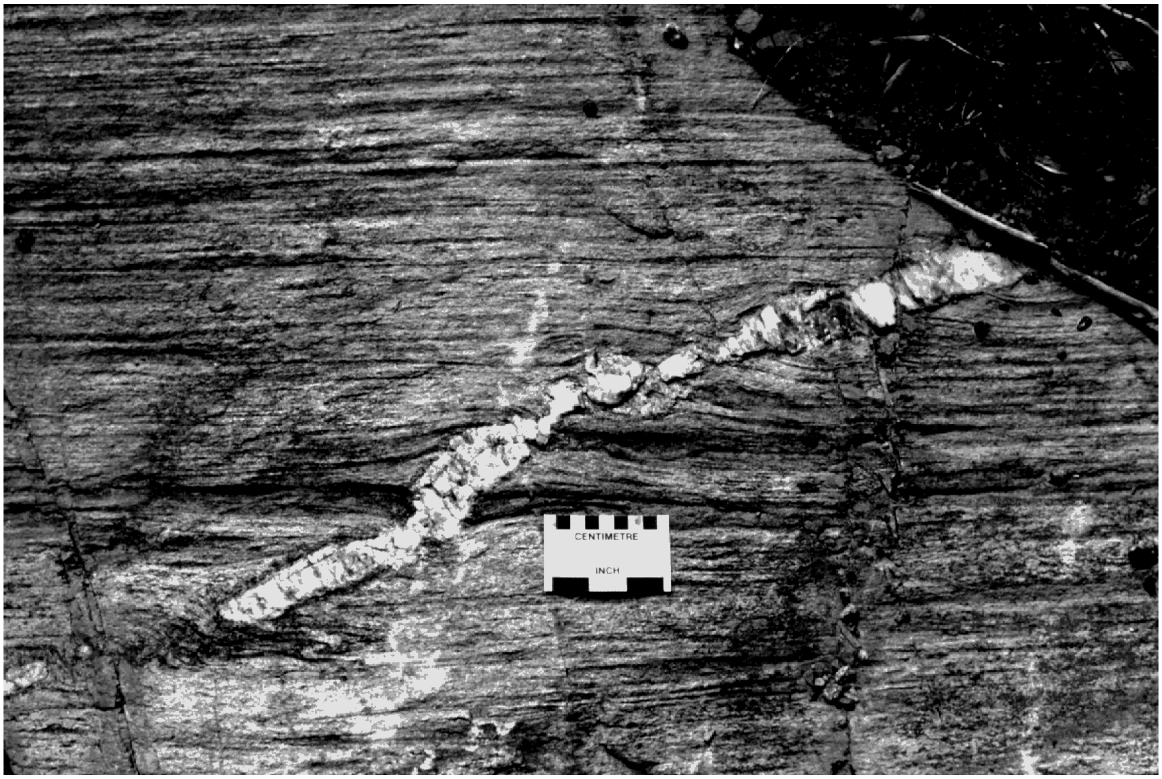

Photo 5. Very finely laminated felsic tuff transected by quartz vein occupying tension gash, and displaying subsequent boundinage or ptygmatic style. Outcrop is beside the English River Road, 1.3 km northeast of Umfreville Road turn-off.

Photo 6. Bedded chert layers in chert-magnetite iron formation. Note spaced cleavage at about 45° to bedding. Trenched and stripped area at the turn-off of the Umfreville Road from the English River Road (same location as Photo 8).

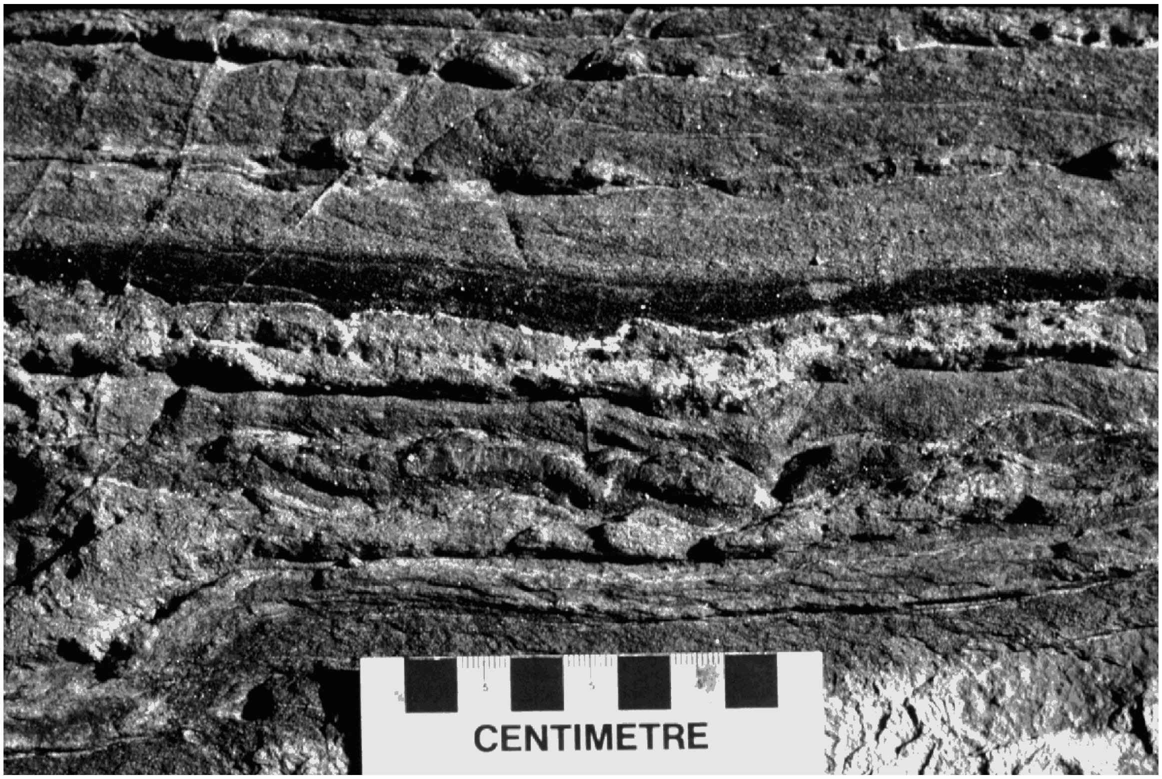

Photo 7. Alternating magnetite and garnet layers in chert-magnetite iron formation. The outcrop is located on the north limb of the lower iron formation unit in the core of the Separation Narrows anticline, about 0.5 km east of the English River Road.

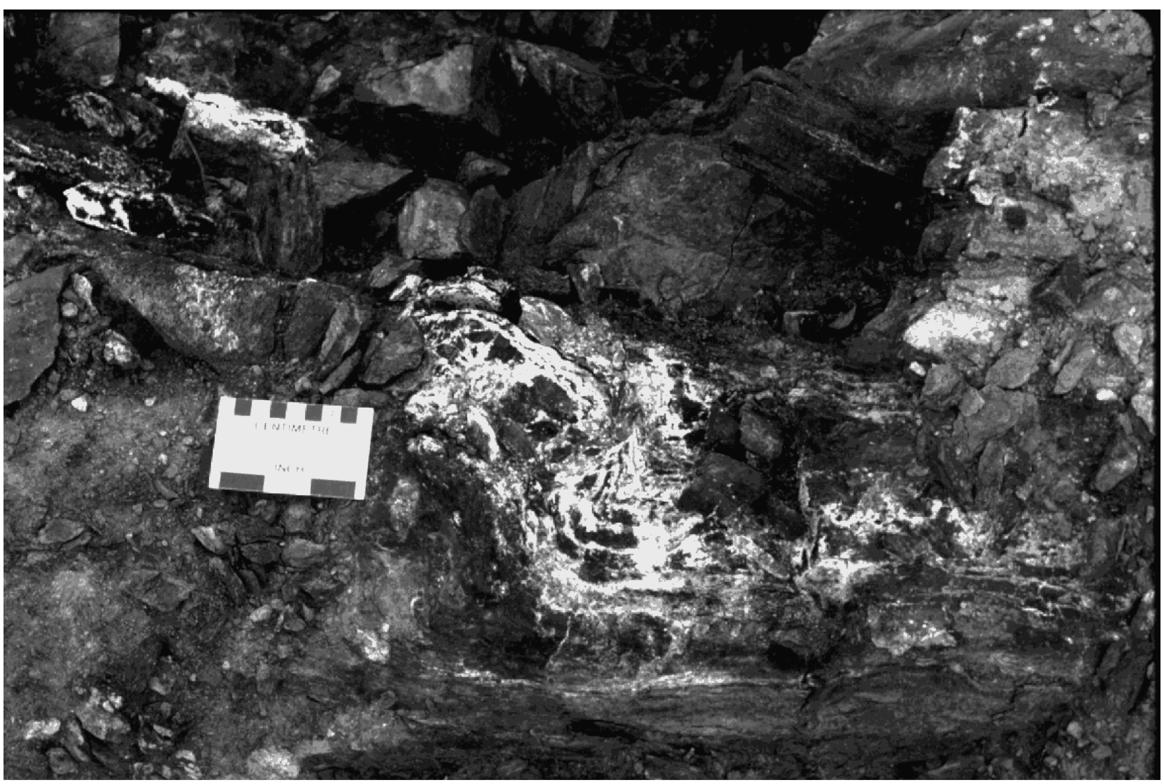

Photo 8. Z-fold in sulphidized magnetite iron formation. Weathering of the sulphide minerals has produced a rusty gossan, and a white oxide, possibly hydrozincite, indicative of zinc mineralization. Trenched and stripped area at the turn-off of the Umfreville Road from the English River Road (same location as Photo 6).

Photo 9. Polymictic conglomerate comprised predominantly (~ 70%) of granitic and mafic igneous clasts, and subordinate (~10%) fine grained felsic, chert, ironstone and quartz clasts. Matrix comprises about 20%. A pebble count from this outcrop is given in Table 2, at station 0260. Note tension gash in rotated granitic clast, indicating a dextral shear component.

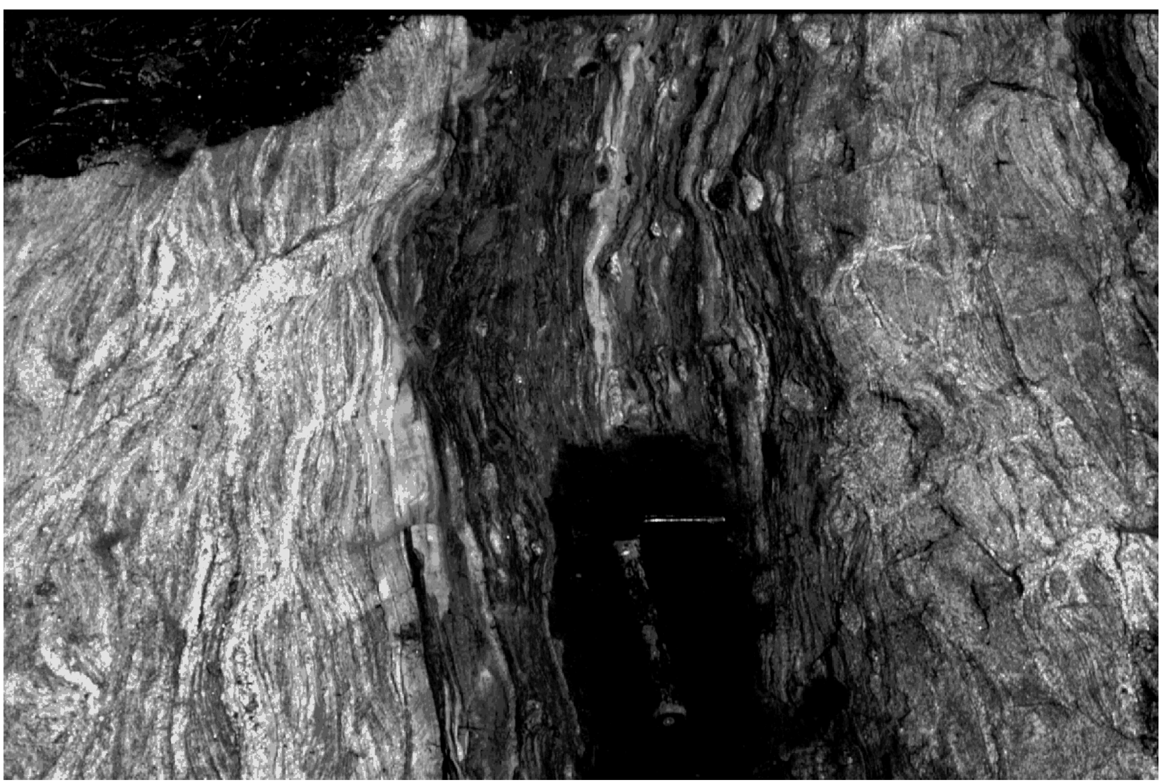

Photo 10. Contact zone between polymictic conglomerates and migmatites. A narrow conglomerate unit (<1 m wide) is bounded by granitic migmatite (to the left) and a granitic dike (to the right). Large outcrop 200 m north of the English River Road, 1.5 km northeast of the Umfreville Road turn-off.

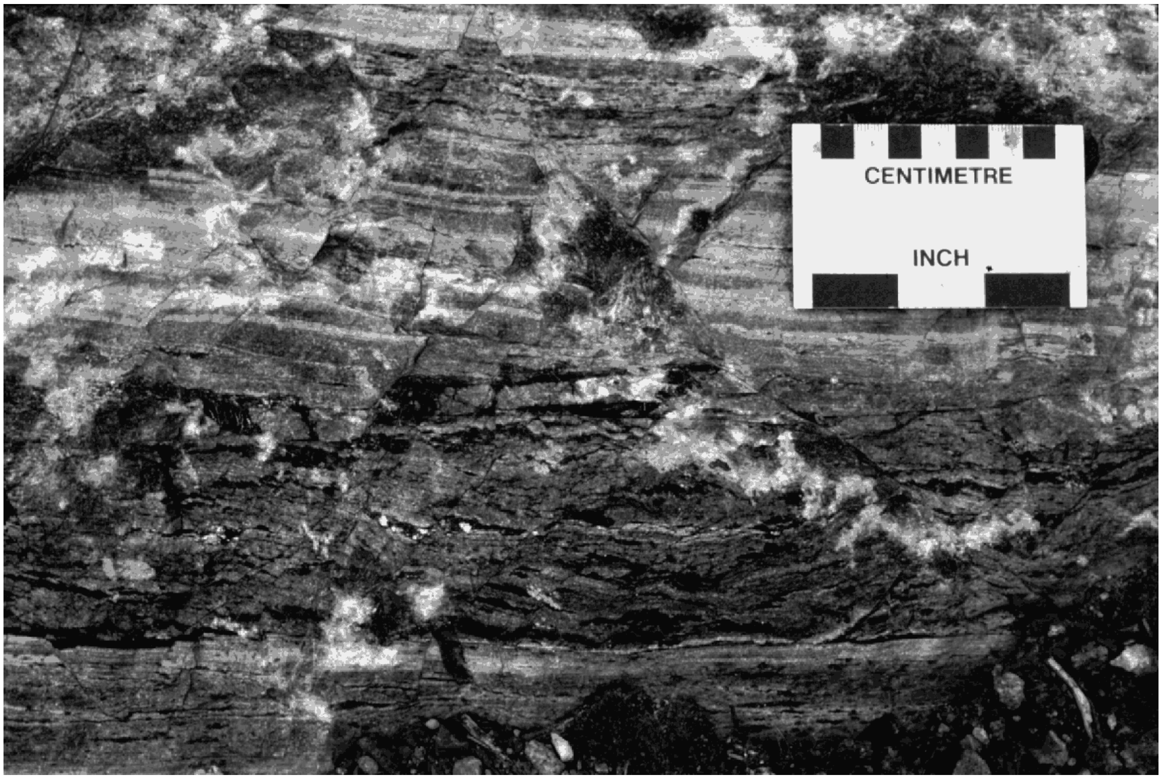

Photo 11. Pseudotachylite in mylonitized rocks along the contact between mafic metavolcanic and overlying felsic metavolcanic rocks. The pseudotachylite is the dark vein-like material in the centre of the photograph. South side of English River Road, 2 km northeast of the Umfreville Road turn-off.

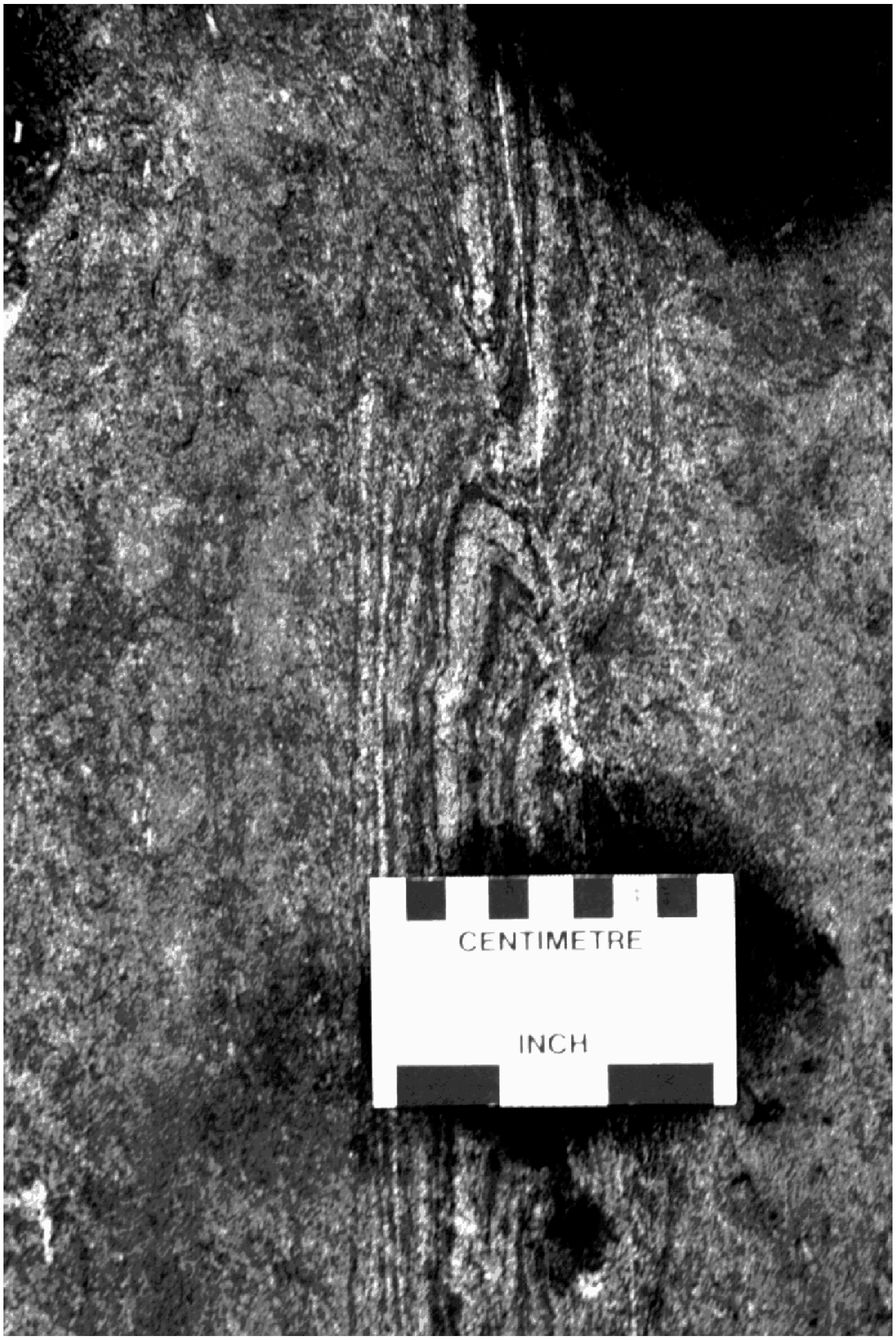

Photo 12. Attenuated Z-fold in feldspar-quartz-biotite+garnet schist on the north limb of the Paterson Lake antiform. Same outcrop as in Photo 14.

Photo 13. S-fold in amphibolitic mafic metavolcanic rocks on the south limb of the Paterson Lake antiform.

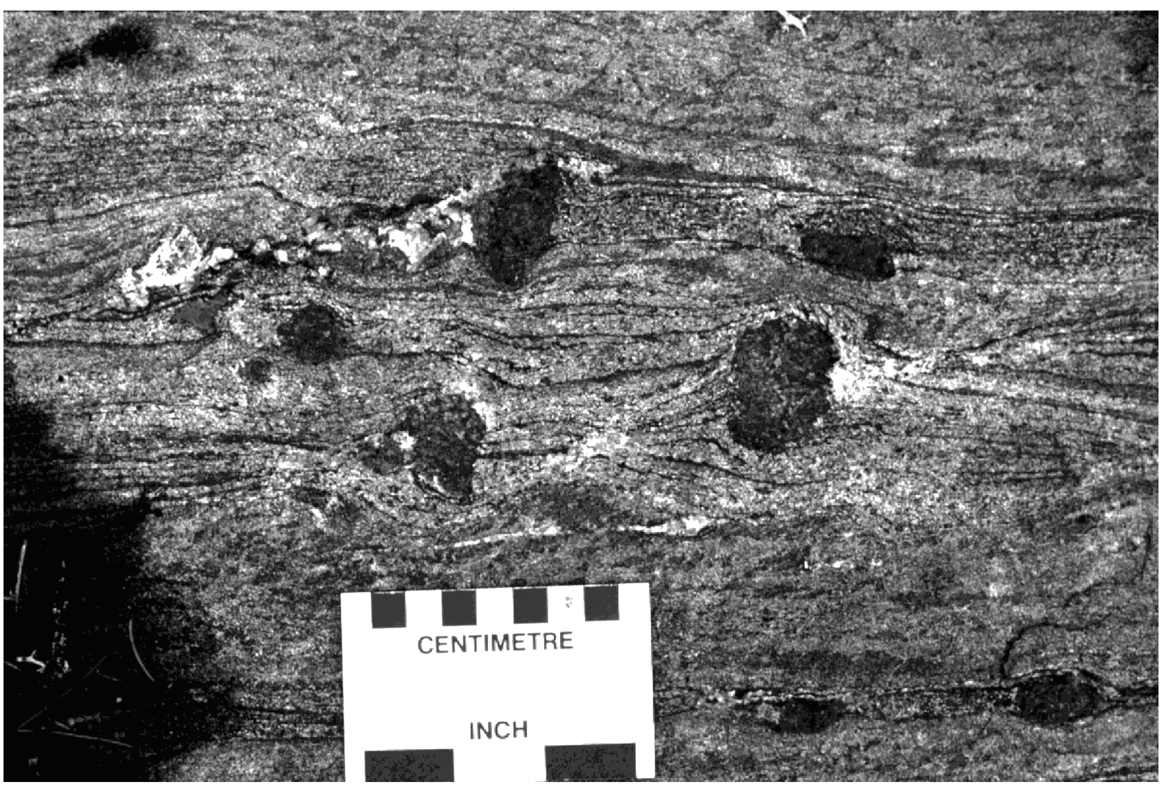

Photo 14. Garnet porphyroblasts in feldspar-quartz-biotite+garnet schist on the north limb of the Paterson Lake antiform. Morphology of garnet crystals indicates synkinematic growth during dextral shear. Same outcrop as in Photo 12.

Table 1. Table of Lithologic Units for the Separation Lake Area

PHANEROZOIC
CENOZOIC
QUATERNARY
PLEISTOCENE AND RECENT
Glacial, glaciofluvial, stream, lake and swamp deposits

Unconformity

PRECAMBRIAN

ARCHEAN
NEOARCHEAN

FELSIC TO INTERMEDIATE PLUTONIC ROCKS

Massive to foliated, equigranular to porphyritic to megacrystic: granite, granodiorite, tonalite, monzonite and monzodiorite. Pegmatite.

MIGMATITES: HIGH GRADE METASEDIMENTARY AND ASSOCIATED GRANITIC ROCKS
Feldspar+quartz+biotite±garnet±cordierite schist, mafic (plagioclase+pyroxene+horneblende) layers. Polymictic conglomerate. Biotite±muscovite granite to granodiorite, and pegmatite.

MAFIC INTRUSIVE ROCKS
Aphyric to plagioclase- to horneblende-phyric leucogabbro and melagabbro.

CLASTIC METASEDIMENTARY ROCKS
Feldspathic to quartzose arenite and wacke. Argillite. Polymictic conglomerate. Quartz-feldspar-biotite schist.

CHEMICAL METASEDIMENTARY ROCKS
Chert-, magnetite- and sulphide-bearing.

FELSIC METAVOLCANIC ROCKS
Quartz+feldspar crystal tuffs, lapilli-tuffs and tuff-breccias.

MAFIC METAVOLCANIC ROCKS
Massive to pillowed, equigranular to plagioclase-phyric flows and brecciated flows. Tuffs and lapilli-tuffs.

Table 2. Percent Clast Distribution in Conglomerates

Station	1014	0260	2015	2027	2185
No. of counts	156	234	238	241	125
Mafic igneous	26	35	33	51	4
Matrix	49	22	20	0	0
Granite	15	33	27	25	5
Felsic fine-grained	7	4	6	11	19
Chert	2	2	5	6	0
Ironstone	0	0	3	4	0
Quartz	1	4	6	3	11
Garnet-rich granite	0	0	0	0	4
Q-F-B-G schist	0	0	0	0	57

Geographic coordinates of stations:

1014	50° 16' 50" N	94° 30' 00" W
0260	50° 17' 03" N	94° 28' 30" W
2015	50° 17' 11" N	94° 27' 05" W
2027	50° 17' 44" N	94° 24' 20" W
2185	50° 19' 47" N	94° 30' 32" W

Table 3. Estimated modal mineralogical abundances, felsic to intermediate intrusive rocks.

Migmatite-associated Granites

Sample No.	Potash Feldspar	Plagioclase Feldspar	Quartz	Mafic Minerals	Other Minerals Present
0158-2	45	25	25	5	
0271-1	30	30	25	15	
0248-1	35	30	25	10	
0328-1	30	20	25	25	
1115-1	35	25	20	20	
1117-1	25	35	25	15	
1120-1	35	20	20	25	
1195-1	30	30	20	20	
0317-1	30	20	30	20	
0317-2	25	20	30	25	
1012-1	25	25	25	25	
1322-1	30	25	25	20	
2178-1	35	30	20	15	Garnet
7217-1	30	25	25	20	
2136-1	40	30	20	10	
2125-1	35	35	25	5	Garnet
2077-1	30	30	30	10	
2110-1	50	10	30	10	
4146-1	30	25	30	15	Garnet
4154-1	35	30	15	20	
4154-2	10	50	20	20	
4294-1	30	30	30	10	Garnet
4089-1	<5	50	30	15	
4360-1	25	30	30	15	
2431-1	40	30	20	10	Garnet
2428-1	30	40	20	10	
2418-2	35	25	35	5	
2306-1	40	25	20	15	
2308-1	30	40	20	10	
4256-1	45	20	20	15	Garnet
4255-1	30	30	20	20	

Upper Kettle Rapids, Trout Lake and Treelined Lake Granites

Sample No.	Potash Feldspar	Plagioclase Feldspar	Quartz	Mafic Minerals	Other Minerals Present
1112-1	35	30	20	15	Garnet
1112-3	40	30	20	10	Garnet
0026-1	30	30	0	10	
0037-1	35	25	30	10	
0035-1	30	30	30	10	
0186-1	30	30	30	10	
1173-1	30	20	25	25	
1176-1	30	25	20	25	
4182-1	40	30	20	10	
2174-1	40	30	20	10	
2176-1	40	20	20	20	
2171-1	35	25	20	20	
4484-1	30	20	30	20	
4480-1	30	20	30	20	
4479-1	25	25	30	20	
7190-1	35	25	20	20	
4134-1	35	35	20	10	
4043-1	30	25	30	15	
4067-1	35	35	20	10	
2020-1	40	30	25	5	
4153-1	25	30	25	20	
2134-1	40	30	25	<5	Garnet
2348-1	45	25	20	10	Garnet

Helder Lake Granites

Sample No.	Potash Feldspar	Plagioclase Feldspar	Quartz	Mafic Minerals	Other Minerals Present
2239-1	40	20	20	20	
2235-1	35	25	20	20	
2236-5	40	25	20	15	
2230-2	30	30	20	20	Garnet
2297-1	35	20	25	20	

Separation Rapids Pegmatites

Sample No.	Potash Feldspar	Plagioclase Feldspar	Quartz	Mafic Minerals	Other Minerals Present
0040-1	30	30	30	10	
0051-1	45	30	20	5	
0408-1	35	40	20	5	
1004-1	<5	60	25	10	Garnet
1046-1	10	50	20	20 (Mu)	Garnet

Paterson Lake Stock

Sample No.	Potash Feldspar	Plagioclase Feldspar	Quartz	Mafic Minerals	Other Minerals Present
1193-1	30	25	25	20	
0391-1	25	30	30	15	
1366-1	25	30	30	15	
0383-1	25	35	25	15	
0393-1	35	30	20	15	
0322-1	30	30	25	15	
0292-1	25	30	15	30	Kspar Megs.
0166-1	35	5	25	5	
0332-1	35	30	25	10	
1371-1	50	20	25	5	Plag. Megs.
7204-1	30	30	20	20	
7195-1	45	35	15	5	
7211-1	25	25	25	25	

Selwyn Lake Granites

Sample No.	Potash Feldspar	Plagioclase Feldspar	Quartz	Mafic Minerals	Other Minerals Present
0205-1	30	30	30	10	
0213-1	30	30	30	10	
0228-1	50	20	10	20	Garnet
0230-1	40	25	20	15	Garnet
0237-1	40	30	20	10	
0237-2	30	30	25	15	
0245-1	35	30	25	10	
0230-2	40	30	20	10	
1262-1	30	25	30	15	
1096-1	35	30	30	5	
1269-3	30	30	25	15	
2504-1	35	30	25	10	

Table 3. Continued

Tourist Lake Granites

Sample No.	Potash Feldspar	Plagioclase Feldspar	Quartz	Mafic Minerals	Other Minerals Present
1311-1	30	30	20	20	
1232-2	20	20	30	30	
0101-1	35	30	25	10	
0218-1	30	30	25	15	
0127-1	35	30	25	10	
0219-1	40	30	20	10	
0251-1	35	30	20	15	
1232-1	30	30	20	20	
1315-1	25	25	25	25	
1311-2	30	30	20	20	
0068-1	25	45	25	5	
0220-1	10	75	10	5	
1219-1	45	35	20	0	Garnet
0229-2	40	25	20	15	Garnet
2504-2	35	35	20	10	
2506-1	35	25	15	25	
2508-1	25	25	25	25	
2483-1	20	40	20	20	
2484-1	30	35	30	<5	
2477-1	20	35	40	5	
2388-1	35	30	25	10	
2389-1	15	40	40	<5	
2393-1	5	40	30	25	
2404-1	20	45	5	30	
2402-1	20	35	10	35	
2400-1	25	35	15	25	

Separation Lake Grey Granitic Rocks

Sample No.	Potash Feldspar	Plagioclase Feldspar	Quartz	Mafic Minerals	Other Minerals Present
0067-1	25	40	25	10	
0109-1	20	30	25	25	
0066-1	10	55	<5	30	
0092-1	15	55	<5	25	
1207-1	15	35	25	25	
0107-2	25	40	<5	30	
0121-1	<5	55	20	20	
1218-1	5	50	30	15	
4301-2	10	55	15	20	
4303-1	5	55	20	20	
4102-1	30	40	15	15	
4112-1	30	45	15	10	
4116-1	20	40	30	10	
4206-1	20	40	20	20	
4323-1	10	45	20	25	
4095-1	20	35	15	30	
7001-1	25	35	20	20	
7043-2	0	45	20	35	
4204-1	30	35	15	20	
7002-1	5	45	30	20	
7004-1	15	40	25	20	
2124-1	30	35	20	15	
4052-1	25	30	30	15	
4039-1	5	60	25	10	
2045-1	5	60	<5	30	
2420a-1	40	40	15	5	
2410-1	25	35	30	10	
4221-1	30	40	20	10	
4280-2	45	20	15	20	
2318-1	20	25	25	30	

Separation Lake Pink Granitic Rocks

Sample No.	Potash Feldspar	Plagioclase Feldspar	Quartz	Mafic Minerals	Other Minerals Present
0119-1	30	35	30	<5	
0107-1	5	60	30	5	
1210-1	20	35	25	20	
4296-1	35	30	20	15	
4317-1	30	40	15	15	
2465-1	30	40	20	10	
2121-1	30	40	30	0	
2040-1	30	35	30	5	
7030-1	25	30	20	25	
7030-3	25	30	20	25	
7042-1	40	10	20	30	
2118-4	80	5	10	5	
4306-1	35	40	20	5	
7003-1	20	40	25	15	
7108-1	5	40	50	<5	

Separation Lake Pink Granitic Rocks (contd.)

Sample No.	Potash Feldspar	Plagioclase Feldspar	Quartz	Mafic Minerals	Other Minerals Present
7158-1	25	40	15	20	
4019-1	35	35	25	5	
2065-1	30	40	15	15	
4035-1	30	40	25	5	
2034-1	25	50	20	5	
2043-1	40	35	20	5	
4424-1	25	30	20	25	
4425-1	30	25	25	20	
4422-1	30	30	20	20	
4378-1	30	30	20	20	
2444-1	40	30	20	10	
2256-1	25	30	30	15	
2253-1	40	30	20	10	
4219-1	15	35	30	20	
4206-2	20	35	25	20	

Table 4. Location and Description of Geochemically Analysed Samples, Separation Lake Area

Sample Number	UTM Grid	Easting	Northing	Field Description
0003	015	381145	5572165	Altered mafic flow, garnet-bearing
0025	015	394397	5570487	Felsic tuff
0032	015	388791	5570370	Felsic tuff
0044	015	388954	5569036	Unaltered mafic flow
0053	015	390772	5568465	Unaltered mafic flow
0063	015	390375	5568341	Matgabbro
0072	015	382848	5571771	Altered mafic flow, garnet-bearing
0073	015	382815	5571935	Altered mafic flow, garnet-bearing
0081	015	388063	5570474	Altered mafic flow, strongly silicified
0113	015	391663	5562166	Unaltered mafic flow
0124	015	393406	5563066	Unaltered mafic flow
0178	015	385417	5571859	Felsic tuff
0196	015	383328	5572718	Felsic tuff
0204	015	382434	5572116	Altered mafic flow, garnet-bearing
0212	015	382416	5572756	Felsic tuff
0217	015	382585	5572012	Altered mafic flow, garnet-bearing
0229	015	380519	5572588	Altered mafic flow, garnet-bearing
0237	015	381267	5572697	Selwyn Lake (west) granite
0258	015	394744	5570782	Felsic tuff
0263	015	395438	5570788	Altered mafic flow, garnet-bearing
0290	015	382440	5577450	Quartz-feldspar-biotite-garnet gneiss
0312	015	395137	5570557	Metasandstone
0316	015	383210	5573371	Quartz-feldspar-biotite-garnet gneiss
0337	015	381696	5572917	Altered mafic flow
0341	015	380888	5573064	Altered mafic flow, garnet-bearing, scistose
0345	015	380802	5572303	Altered mafic flow
0350	015	380184	5578247	Quartz-feldspar-biotite-garnet-gneiss
0397	015	379357	5572711	Altered mafic flow, garnet-bearing
1003	015	393486	5569563	Metagabbro
1007	015	393281	5570289	Altered mafic flow, garnet in outcrop
1016	015	393212	5570394	Felsic tuff
1020	015	392943	5570273	Altered mafic flow, garnet-bearing
1027	015	391772	5569165	Unaltered mafic flow
1030	015	392534	5569245	Metagabbro
1033	015	392068	5570075	Altered mafic flow, garnet-bearing
1039	015	391242	5570029	Altered mafic flow, garnet-bearing
1057	015	386513	5569816	Unaltered mafic flow
1068	015	386394	5570349	Metasandstone
1078	015	385330	5570819	Unaltered mafic flow
1110	015	384011	5570918	Altered mafic flow, garnet-bearing
1123	015	391057	5570243	Felsic tuff
1132	015	391264	5568993	Metagabbro
1138	015	392303	5568285	Metagabbro

Table 4. Continued.

Sample Number	UTM Grid	Easting	Northing	Field Description
1163	015	389442	5570341	Felsic tuff
1170	015	392386	5567411	Metagabbro
1200	015	390737	5569511	Unaltered mafic flow
1214	015	395326	5565345	Unaltered mafic flow
1238	015	385590	5570938	Metasandstone
1242	015	386785	5570905	Felsic tuff
1243	015	386251	5570717	Altered mafic flow
1245	015	386110	5570627	Metasandstone
1258	015	384271	5571412	Altered mafic flow
1260	015	384460	5571485	Metasandatone
1262	015	384669	5571867	Selwyn Lake (east) granite
1282	015	394407	5566895	Unaltered mafic flow
1293	015	395278	5567246	Unaltered mafic flow
1333	015	384789	5576637	Quartz-feldspar-biotite-garnet gneiss
1342	015	395216	5568547	Unaltered mafic flow
1366	015	381623	5573649	Paterson Lake granite
1380	015	393406	5569044	Unaltered mafic flow
1397	015	380912	5578194	Quartz-feldspar-biotite-garnet gneiss
1407	015	383122	5577295	Quartz-feldspar-biotite-garnet gneiss
1408	015	383108	5577203	Altered mafic flow
1425	015	378492	5572135	Unaltered mafic flow
1431	015	378481	5572325	Altered mafic flow, garnet-bearing
2061	015	399526	5571579	Metagabbro
2134	015	394672	5574180	Trout Lake granite
2143	015	406924	5574258	Metagabbro
2176	015	391942	5573373	Upper Kettle Rapids granite
2230	015	415074	5577099	Helder Lake granite
2305	015	417436	5578280	Unaltered mafic flow
2348	015	398321	5574397	Treelined Lake granite
2375	015	397232	5564460	Metagabbro
2418	015	413062	5577823	Unaltered mafic flow
2463	015	395489	5564028	Unaltered mafic flow
4003	015	396006	5570501	Unaltered mafic flow
4018	015	396618	5570517	Metagabbro
4069	015	401890	5572393	Unaltered mafic flow
4071	015	404830	5573517	Metagabbro
4076	015	405507	5574193	Unaltered mafic flow
4115	015	397604	5563799	Unaltered mafic flow
4153	015	404016	5575130	Upper Kettle Rapids granite
4312	015	396588	5564287	Unaltered mafic flow
4365	015	408641	5576110	Unaltered mafic flow
4384	015	410519	5575183	Unaltered mafic flow

Table 5. Major and Minor Oxides (in wt. %)and Trace Element Abundances (in ppm), Separation Lake Area

Sample Number	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	CO_2	LOI	Ni	Co	Sc	V	Cu	Zn	Rb	Sr	Nb	Zr	Ti	Y	Th
0003	39.66	1.49	10.32	9.90	21.56	2.33	4.13	8.91	0.92	0.46	0.13	0.30	0.08	39	32	36	303	15	159	16	36	5	91	8933	38	10
0025	67.27	0.52	16.64	1.00	1.85	0.05	1.63	3.25	4.41	3.02	0.30	0.39	0.84	28	12	9	78	20	57	100	790	7	152	3135	10	13
0032	76.66	0.14	12.60	0.68	1.23	0.03	0.36	0.31	2.96	4.53	0.05	0.30	0.53	5	5	2	5	5	60	221	39	19	267	851	21	20
0044	49.32	0.98	16.95	2.96	8.95	0.22	5.28	13.48	0.78	0.25	0.09	0.30	0.38	133	52	45	300	113	100	18	170	4	68	5845	21	10
0053	47.43	0.88	16.38	3.36	10.33	0.23	7.76	11.44	2.15	0.20	0.09	0.30	0.56	160	51	42	279	166	100	16	78	4	63	5288	18	10
0063	45.80	0.59	15.79	2.85	8.68	0.17	12.97	8.89	1.03	0.12	0.07	0.30	2.63	416	61	30	187	19	79	20	53	3	47	3507	13	10
0072	40.93	0.62	12.80	8.08	16.24	1.46	6.71	10.73	0.89	0.37	0.09	0.30	0.72	59	10	35	191	6	68	12	46	4	38	3717	14	10
0073	54.67	2.01	14.91	6.70	14.79	0.65	2.76	1.55	0.04	1.08	0.19	0.30	0.08	34	37	46	418	47	129	26	39	5	110	12050	34	10
0081	73.76	0.21	10.81	0.96	5.30	0.14	1.32	2.70	0.91	0.98	0.06	0.30	1.80	10	12	4	18	45	110	77	54	10	100	1259	15	24
0113	52.62	0.75	17.30	2.89	7.00	0.20	5.43	9.96	2.68	0.23	0.07	0.30	0.76	157	51	36	242	17	90	6	95	3	51	4478	12	10
0124	49.00	0.73	16.22	3.21	9.37	0.22	6.95	12.23	1.01	0.24	0.07	0.30	0.44	122	45	41	259	8	88	9	81	4	52	4376	16	10
0178	74.42	0.11	12.66	0.78	1.20	0.01	0.63	0.06	1.01	8.30	0.05	0.30	0.38	5	5	1	5	7	73	183	56	21	258	659	16	22
0196	74.64	0.27	13.64	1.09	2.06	0.06	0.69	1.41	3.72	2.11	0.06	0.30	0.59	6	5	5	16	16	100	202	76	19	288	1613	23	16
0204	55.60	2.07	13.46	4.91	10.82	0.54	2.69	7.27	0.26	0.61	0.19	0.30	0.10	49	37	34	402	27	122	25	95	7	130	12410	34	10
0212	74.52	0.16	13.74	0.96	1.20	0.04	0.26	0.72	3.11	4.60	0.05	0.45	1.22	5	5	2	8	15	78	135	44	19	262	941	31	17
0217	51.86	1.05	22.15	3.13	12.68	0.33	1.81	2.32	2.45	0.87	0.06	0.30	0.51	192	58	60	330	8	97	86	116	4	69	6295	16	10
0229	52.87	1.62	16.39	3.61	13.94	0.45	2.16	5.76	0.82	1.23	0.15	0.30	0.08	67	46	45	357	70	105	524	107	7	99	9712	34	10
0237	74.15	0.10	13.18	0.76	0.83	0.02	0.19	0.74	2.83	5.44	0.04	0.30	0.52	5	5	4	5	5	68	778	31	43	123	600	44	48
0258	75.39	0.15	13.45	0.85	1.07	0.05	0.87	1.29	0.95	5.10	0.05	0.30	0.65	5	5	4	10	7	55	210	63	17	133	905	14	25
0263	46.73	1.83	11.46	5.76	21.12	0.82	4.38	5.89	0.39	0.10	0.16	0.30	0.08	37	47	37	344	131	159	6	32	7	103	10971	33	10
0290	77.17	0.13	11.58	0.34	1.26	0.02	0.37	0.21	1.61	6.55	0.05	0.30	0.42	5	5	2	5	5	109	222	51	16	233	767	17	18
0312	53.04	0.96	16.57	2.41	11.20	0.31	5.77	8.23	0.47	0.02	0.08	0.30	0.33	151	52	40	274	146	151	5	88	4	80	5731	8	10
0316	74.96	0.15	13.30	1.84	1.35	0.04	0.32	0.33	2.07	6.00	0.05	0.52	0.73	5	5	2	5	9	64	225	42	18	277	899	20	17
0337	50.65	2.05	16.30	3.18	11.53	0.19	5.32	7.10	3.50	0.20	0.32	0.30	0.25	27	33	28	254	10	180	6	195	12	180	12272	34	10
0341	49.38	1.04	19.60	2.82	9.41	0.16	4.48	10.16	0.45	0.04	0.32	0.30	0.73	147	69	40	281	370	178	5	73	4	68	6235	24	10
0345	50.25	1.92	13.62	3.85	11.98	0.25	5.62	9.10	2.35	0.29	0.17	0.30	0.33	46	44	43	424	38	93	7	129	8	128	11528	36	10
0350	76.30	0.16	12.36	0.57	1.26	0.04	0.16	0.73	1.37	4.75	0.05	0.30	0.57	5	5	2	5	6	78	176	69	19	312	959	39	18
0397	46.25	0.69	14.16	5.08	15.59	0.72	5.87	9.00	1.69	0.12	0.07	0.30	0.19	144	46	39	224	20	83	10	79	4	44	4137	16	10
1003	46.78	0.61	15.13	2.69	9.96	0.21	12.03	10.2	1.42	0.28	0.06	0.30	0.70	315	61	24	186	84	144	12	67	3	47	3645	11	10
1007	52.01	1.29	16.07	3.11	9.93	0.37	4.04	9.23	2.68	0.28	0.10	0.41	0.76	112	58	42	345	30	108	6	151	4	75	7758	19	10
1016	76.10	0.17	13.66	0.83	1.05	0.04	0.64	1.33	3.43	2.52	0.05	0.30	0.81	5	5	4	13	7	53	206	51	20	133	1001	26	28
1020	47.33	1.20	14.35	5.20	13.31	0.60	4.43	9.78	1.81	0.32	0.09	0.30	0.56	116	54	39	316	53	121	102	88	5	61	7194	22	10
1027	48.33	0.87	15.20	3.17	10.75	0.23	8.99	10.25	1.91	0.19	0.08	0.30	0.49	143	53	42	281	64	114	11	84	4	60	5216	17	10
1030	47.04	0.59	17.83	2.25	8.80	0.17	10.14	11.22	1.27	0.10	0.06	0.30	0.58	310	60	27	178	211	78	8	89	3	45	3537	12	10
1033	43.43	1.26	11.30	5.29	20.90	1.28	6.18	8.78	0.37	0.26	0.12	0.33	0.08	59	40	35	289	20	267	19	43	5	86	7554	33	10
1039	55.41	0.78	10.63	6.14	19.95	0.39	2.92	1.99	0.08	0.59	0.11	0.30	0.08	76	32	29	202	131	473	22	21	3	51	4676	24	10
1057	50.11	0.92	14.56	3.27	10.31	0.20	7.15	12.03	0.89	0.11	0.08	0.30	0.38	119	49	43	289	133	95	7	94	4	64	5485	19	10
1068	55.83	1.51	22.37	4.25	6.69	0.21	2.02	0.77	1.15	1.60	0.08	1.80	2.62	180	77	54	383	285	110	197	75	5	106	9076	16	10
1078	49.27	0.70	15.44	3.16	11.44	0.45	6.34	11.46	1.46	0.17	0.07	0.30	0.35	139	45	42	245	64	85	7	94	3	50	4185	15	10
1110	38.53	1.73	11.98	10.6	18.96	1.63	4.99	9.71	0.97	0.49	0.18	0.30	0.34	39	35	40	347	13	149	20	28	6	104	10371	34	10
1123	69.83	0.41	14.18	1.48	3.20	0.11	1.28	3.91	2.63	1.99	0.11	0.59	1.00	9	6	8	22	22	93	105	76	16	286	2440	35	20
1132	47.09	0.50	18.25	2.18	8.90	0.17	9.94	11.46	1.02	0.08	0.06	0.30	0.60	276	55	24	158	162	103	10	90	3	42	2986	10	10
1138	48.74	0.78	16.33	2.99	9.41	0.20	8.41	10.90	1.71	0.25	0.08	0.30	0.49	142	48	34	246	113	89	10	93	3	53	4688	15	10

Table 5. Continued

Sample Number	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	CO_2	LOI	Ni	Co	Sc	V	Cu	Zn	Rb	Sr	Nb	Zr	Ti	Y	Th
1163	75.21	0.17	13.56	1.06	1.49	0.02	1.98	1.50	1.95	1.79	0.05	0.30	1.11	5	5	2	8	11	95	90	94	18	277	995	16	17
1170	47.95	0.77	14.74	2.94	10.19	0.21	11.98	9.36	1.17	0.25	0.07	0.30	0.73	297	61	32	229	128	98	19	84	3	50	4604	14	10
1200	50.20	0.68	16.40	2.89	8.61	0.19	6.36	13.35	0.84	0.08	0.07	0.30	0.54	131	45	43	252	144	83	5	71	3	49	4101	15	10
1214	47.36	0.92	18.05	3.56	8.68	0.19	6.88	12.08	1.66	0.28	0.09	0.30	0.77	113	43	37	272	125	93	9	87	3	66	5491	19	10
1238	58.82	1.41	21.26	2.40	7.30	0.29	1.62	1.85	2.01	0.61	0.07	0.47	1.24	27	15	54	361	61	112	39	88	6	133	8471	19	10
1242	75.60	0.16	13.35	0.94	1.59	0.02	1.75	0.79	2.09	2.22	0.05	0.30	1.53	5	5	2	7	14	87	105	105	19	273	947	34	13
1243	50.32	1.97	13.97	4.50	12.78	0.45	3.54	8.70	2.85	0.37	0.18	0.30	0.34	36	36	45	450	41	117	22	137	7	131	11798	38	10
1245	52.83	1.21	22.05	3.96	8.39	0.18	4.04	2.25	1.27	1.06	0.08	0.97	1.76	51	27	50	340	116	112	41	69	3	85	7242	17	10
1258	60.65	0.99	18.91	1.45	3.94	0.21	1.42	6.41	2.44	1.68	0.10	0.30	0.62	209	105	33	287	124	48	52	128	4	66	5935	9	10
1260	54.97	0.98	17.27	2.61	9.73	0.18	5.92	4.15	2.27	0.53	0.10	0.30	1.16	102	43	38	270	88	126	18	266	4	85	5857	6	10
1262	74.28	0.11	12.99	0.70	0.85	0.02	0.18	0.72	2.72	5.65	0.04	0.33	0.63	5	5	4	5	6	58	588	30	30	129	659	44	56
1282	47.61	0.57	17.88	2.74	7.52	0.19	9.09	11.24	1.34	0.99	0.06	0.30	0.71	202	45	32	189	114	80	335	84	3	44	3411	12	10
1293	48.00	0.77	16.64	3.11	8.28	0.20	8.13	11.90	2.24	0.26	0.08	0.30	0.57	129	42	34	236	81	98	8	111	4	57	4592	15	10
1333	72.72	0.20	14.67	1.80	1.62	0.05	0.49	1.61	2.55	3.44	0.05	0.30	0.7	5	5	3	8	9	64	114	209	17	250	1199	22	14
1342	49.48	0.95	16.03	3.38	8.64	0.19	7.48	11.49	1.76	0.40	0.09	0.30	0.60	116	42	37	269	62	84	19	95	4	66	5689	19	10
1366	74.04	0.17	13.27	0.96	0.42	0.05	0.42	1.08	3.71	4.13	0.06	0.30	0.35	5	5	3	11	5	41	156	278	9	116	1019	6	18
1380	46.22	0.67	19.16	3.23	8.49	0.22	7.78	12.16	1.62	0.11	0.08	0.30	0.68	127	45	33	207	102	81	5	106	4	53	3993	14	10
1397	80.00	0.09	6.08	0.26	0.35	0.01	0.07	0.14	1.19	2.23	0.05	0.30	0.29	5	5	1	5	5	67	72	31	7	149	534	5	10
1407	76.08	0.14	13.46	0.69	1.10	0.02	0.30	0.24	1.89	5.75	0.05	0.30	0.48	5	5	2	5	11	62	205	48	14	266	845	9	13
1408	53.49	1.29	16.28	2.76	8.68	0.28	4.06	9.87	1.78	0.56	0.10	0.30	0.63	121	59	42	340	21	109	22	114	4	73	7710	21	10
1425	50.21	0.75	18.84	3.01	9.44	0.42	4.24	11.47	1.15	0.24	0.08	0.30	0.40	166	55	45	271	19	96	9	88	3	54	4478	16	10
1431	49.70	0.34	11.20	7.46	15.75	1.09	2.79	8.18	0.94	0.59	0.09	0.30	0.83	15	12	8	53	67	275	19	67	5	69	2038	13	10
2061	46.88	0.83	18.16	2.32	9.61	0.16	8.59	10.53	1.09	0.28	0.09	0.30	0.51	254	53	20	166	130	105	34	120	3	53	4976	14	10
2134	73.83	0.13	14.34	0.42	0.57	0.01	0.25	0.67	3.02	5.91	0.11	0.30	0.40	5	5	2	5	5	31	229	87	6	82	779	6	12
2143	48.99	0.83	15.74	2.65	8.13	0.18	8.17	11.16	2.37	0.15	0.08	0.30	0.58	131	44	37	196	122	68	6	114	4	53	4976	16	10
2176	72.98	0.21	15.09	0.56	0.92	0.02	0.31	0.67	3.14	5.57	0.16	0.30	0.48	5	5	3	8	5	49	304	82	15	142	1259	9	36
2230	72.30	0.25	14.28	0.78	0.80	0.01	0.37	0.60	3.04	5.98	0.16	0.30	0.52	5	5	2	10	5	57	382	78	22	155	1499	9	43
2305	49.52	0.88	16.25	3.51	8.58	0.31	6.06	11.64	0.88	0.34	0.09	0.30	0.89	129	47	41	269	24	99	13	70	4	55	5276	17	10
2348	72.77	0.14	14.73	0.58	0.74	0.02	0.26	0.68	2.94	5.80	0.14	0.30	0.57	5	5	3	5	5	27	200	98	4	93	839	7	10
2375	47.72	0.43	15.24	2.63	8.10	0.19	9.61	12.35	1.00	0.76	0.06	0.30	0.88	147	48	41	179	11	94	80	84	3	32	2578	11	10
2418	48.95	0.89	16.77	3.78	8.50	0.22	5.56	11.48	1.28	0.52	0.08	0.30	0.68	145	50	43	277	9	97	8	111	3	56	5336	19	10
2463	48.34	0.69	15.96	2.98	8.36	0.17	7.41	14.06	0.63	0.05	0.07	0.30	0.71	135	43	38	228	147	79	5	139	5	48	4137	15	10
4003	47.37	0.80	17.97	2.59	7.87	0.19	6.92	13.58	1.13	0.07	0.10	0.32	0.66	138	45	39	248	22	91	6	125	4	53	4796	18	10
4018	45.76	0.39	15.61	2.84	7.68	0.17	13.52	10.61	1.20	0.17	0.05	0.30	1.25	335	60	26	130	123	74	20	49	3	26	2338	9	10
4069	48.26	0.82	14.89	3.53	9.53	0.20	7.68	11.45	1.35	0.11	0.08	0.30	0.77	126	50	42	261	145	99	5	107	4	52	4916	18	10
4071	46.36	0.85	15.83	2.61	8.92	0.20	10.87	10.97	1.49	0.09	0.03	0.30	0.75	321	56	23	163	6	95	5	102	3	58	5096	15	10
4076	48.68	0.90	16.73	2.97	10.04	0.25	5.44	12.43	0.86	0.15	0.08	0.30	0.62	141	57	46	282	116	110	5	75	4	56	5396	19	10
4115	48.37	0.82	15.56	2.64	7.40	0.24	5.31	16.55	1.73	0.20	0.09	0.30	0.47	115	41	35	238	36	99	10	131	5	60	4916	18	10
4153	74.02	0.09	12.26	0.62	0.98	0.09	0.23	0.90	2.81	5.15	0.06	0.30	0.52	5	5	6	5	9	30	210	54	5	104	540	31	35
4312	50.29	0.81	16.63	2.27	7.15	0.24	4.94	14.73	1.33	0.10	0.10	0.30	0.53	92	45	38	242	35	83	10	112	4	55	4856	19	10
4365	47.55	0.89	18.55	2.91	7.61	0.15	6.97	11.28	2.15	0.44	0.10	0.30	0.75	149	40	23	178	24	81	18	122	5	59	5336	17	10
4384	49.20	0.93	13.45	5.03	9.81	0.23	6.58	10.86	1.63	0.56	0.08	0.30	0.69	62	48	41	270	105	107	8	104	4	59	5575	19	10

Table 6. Rare Earth Element Abundances (in ppm), Separation Lake Area

Sample Number	Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
0025	10.52	71.16	-	15.94	53.14	7.40	2.02	0.53	0.59	2.40	0.42	1.01	0.14	0.93	0.15
0032	24.37	9.46	31.28	1.73	6.02	1.55	0.76	0.41	0.47	4.01	0.99	3.10	0.52	3.57	0.58
0063	13.44	1.73	5.02	0.84	4.32	1.46	0.53	0.28	0.36	2.45	0.55	1.57	0.23	1.60	0.24
0072	15.53	2.82	6.31	0.85	4.16	1.40	1.04	1.90	0.24	2.31	0.56	1.52	0.24	1.55	0.26
0081	17.78	42.34	85.23	9.23	30.70	5.41	0.45	4.61	0.59	3.19	0.61	1.56	0.23	1.48	0.24
0178	19.28	7.65	35.24	1.96	7.02	1.96	1.06	0.49	0.55	3.88	0.78	2.22	0.33	2.24	0.37
0237	17.91	7.38	17.26	2.17	9.29	2.47	1.22	2.86	0.39	2.97	0.65	1.72	0.28	1.86	0.31
0237	50.30	38.03	85.86	9.85	32.61	8.38	0.28	8.39	1.52	8.68	1.59	3.85	0.56	3.25	0.46
0263	35.37	6.79	18.71	2.70	12.91	3.95	1.46	5.17	0.86	5.84	1.32	3.66	0.58	3.79	0.61
0341	28.37	4.78	13.81	2.17	10.98	3.57	0.96	3.97	0.61	4.35	0.98	2.67	0.41	2.60	0.42
0350	43.87	57.94	-	11.60	38.98	6.89	2.35	1.17	1.16	7.86	1.83	5.25	0.83	5.54	0.88
1003	7.69	1.70	4.90	0.77	3.61	1.16	0.51	0.19	0.28	1.89	0.42	1.17	0.18	1.25	0.20
1020	25.18	3.34	10.00	1.51	7.64	2.54	1.14	3.40	0.52	3.95	0.87	2.43	0.37	2.35	0.39
1057	20.27	2.91	8.14	1.33	6.69	2.28	0.81	0.47	0.53	3.70	0.83	2.25	0.34	2.28	0.37
1138	15.33	2.37	6.55	1.06	5.21	1.75	0.70	0.33	0.40	2.77	0.63	1.73	0.27	1.76	0.28
1200	7.01	1.48	4.60	0.76	3.84	1.36	0.51	0.22	0.31	2.19	0.49	1.39	0.21	1.45	0.24
1258	10.44	3.06	8.82	1.33	6.45	2.04	0.88	2.19	0.27	2.06	0.42	1.15	0.17	1.09	0.17
1262	46.90	43.60	95.93	11.14	37.22	8.52	0.27	7.85	1.35	7.62	1.48	3.76	0.58	3.33	0.49
1342	19.91	3.52	9.35	1.49	7.13	2.31	0.84	0.46	0.53	3.62	0.80	2.28	0.34	2.33	0.36
1366	5.99	34.89	75.83	6.67	20.07	3.03	0.64	1.97	0.16	1.11	0.21	0.59	0.10	0.62	0.10
1431	13.97	8.48	18.88	2.12	8.07	1.66	0.72	1.80	0.20	1.82	0.42	1.14	0.18	1.07	0.19
2061	15.16	3.56	9.43	1.34	6.24	1.89	0.71	2.31	0.32	2.64	0.56	1.58	0.24	1.53	0.24
2134	7.11	17.23	37.83	4.25	14.11	2.88	0.36	2.05	0.18	1.32	0.23	0.57	0.08	0.47	0.07
2143	17.30	3.41	9.28	1.35	6.47	2.11	0.76	2.59	0.36	2.93	0.65	1.81	0.27	1.75	0.28
2176	10.11	42.07	94.28	11.33	38.27	7.15	0.45	4.60	0.48	2.16	0.36	0.83	0.11	0.67	0.10
2230	10.21	37.24	88.60	10.71	37.66	7.59	0.37	4.91	0.53	2.41	0.36	0.72	0.09	0.52	0.09
2305	18.74	3.16	8.36	1.21	5.90	1.99	0.80	2.58	0.40	3.17	0.72	1.94	0.30	1.98	0.31
2348	7.78	20.63	45.13	5.05	16.50	3.07	0.45	2.10	0.19	1.33	0.25	0.63	0.09	0.52	0.08
2375	11.67	1.51	4.14	0.63	3.14	1.07	0.45	1.47	0.18	1.90	0.44	1.23	0.19	1.24	0.20
246	16.01	2.65	7.22	1.04	5.10	1.63	0.71	2.19	0.31	2.62	0.60	1.64	0.25	1.70	0.25
4003	20.47	2.86	8.02	1.16	5.76	1.92	1.23	2.51	0.38	3.15	0.75	2.05	0.31	2.01	0.28
4069	19.45	2.53	7.36	1.11	5.60	1.92	0.71	2.57	0.38	3.22	0.73	1.97	0.30	2.04	0.32
4153	35.77	38.28	83.74	9.45	31.33	6.57	0.33	5.34	0.83	5.34	1.27	4.11	0.75	5.57	0.90

Table 7. Results of Assays, Separation Lake Area

Sample Number	Au Oz/Ton	Cu ppm	Pb ppm	Zn ppm	As ppm	Co ppm	Mo ppm	Ni ppm	V ppm
0031-1	Trace	350	<10	5075	<10				
0055-1	Nil	244	<10	40	130				
0056-1	0.003	23	<10	39	60				
0070-1	Nil	21	<10	14	<10				
0072-1	Nil	70	<10	52	30				
0074-1	Nil	67	<10	15	<10				
0078-1	Trace	42	<10	154	2590				
0081-1	Nil	27	<10	19	<10				
0146-1	Nil	35	<10	6	<10				
0189-1	Nil	368	<10	3400	20				
0192-1	Trace	75	<10	240	<10				
0217-2	Nil	261	<10	2000	<10				
0238-1	Nil	572	70	7150	<10				
0254-1	Nil	387	<10	3050	40				
0337-1	Trace	2170	<10	7850	2930				
0337-2	Trace				1900				
0348-1	Nil	98	<10	84	120				
0351-2	Nil	133	<10	100	<10				
0351-4	Nil	47	<10	127	<10				
0380-3	Nil	213	<10	22	<10				
0399-1	Nil	2245	<10	76	<10				
1014-1	<0.01	108		138	32	43	<6	60	
1203-4	Nil	54	<10	23	<10				
1268-2	Nil	530	<10	2425	<10				
1272-1	Nil	65	<10	61	<10				
1280-1	Trace	39	<10	35	<10				
1281-1	Nil				<10				
1298-1	Trace	23	<10	45	10				
1306-2	Nil	41	<10	15	<10				
1321-2	Nil	46	<10	30	<10				
1327-1	Nil	100	<10	23	<10				
1328-2	Nil	206	<10	14	<10				
1386-2	Nil	52	<10	15	<10				
1399-1	Nil	31	<10	15	<10				
2023-1	<0.01	6	<10	27	98	<5	<6	7	9
2023-2	<0.01	12	<10	143	9	41	<6	116	248
2023-3	<0.01	8	<10	76	23	38	<6	140	265
2024-1	<0.01	16	<10	69	242	34	<6	113	231
2032-1	<0.01	275	<10	77	35	30	<6	107	213
2071-1	<0.01	275	<10	265	8	32	<6	67	197
2090-11	<0.01	18	32	103	1	<5	<6	7	
2106-2	<0.01	23	21	35	28	5	<6	7	18
2142-1	<0.01	33	<10	182	145	7	<6	6	
2155-1	<0.01	193	<10	447	6	41	<6	105	
2157-1	<0.01	69	<10	486		32	<6	72	
2194-1	<0.01	20	<10	206	4	7	<6	13	
2196-1	<0.01	28	25	52	2	<5	<6	<5	

Sample Number	Au Oz/Ton	Cu ppm	Pb ppm	Zn ppm	As ppm	Co ppm	Mo ppm	Ni ppm	V ppm
2203-1	<0.01	7	33	13	2	<5	<6	<5	
2236-1	<0.01	480*	19	530*	455	21	8	47	
2236-2	<0.01	19	<10	64	6	<5	<6	<5	
2236-3	<0.01	396	<10	61	2	18	8	58	
2236-4	<0.01	381	17	69	3	7	40	57	
2303-1	<0.01	77	<10	142	17	30	<6	56	
2326-2	<0.01	8	<10	64	5	<5	<6	<5	
2330-3	<0.01	113	<10	66	49	7	<6	25	
2330-4	<0.01	27	<10	57	94	21	<6	8	
2330-5	<0.01	46	<10	149	17	9	<6	17	
2330-6	<0.01	25	<10	63	3	5	<6	<5	
2336-1	<0.01	307	<10	134	3	322	<6	62	
2476-1	<0.01	221		236					
2476-2	<0.01	560*		1490*					
2476-4	0.07	460*		9620*					
2494-1	<0.01	356		3420*					
4004-1	<0.01	38	<10	77	<1	<5	13	<5	<5
4012-1	<0.01	190	<10	150	11	24	<6	81	42
4012-2	<0.01	21	<10	130		50	<6	91	22
4020-1	<0.01	163	<10	300	32	39	<6	40	16
4065-1	<0.01	53	<10	80	266	30	<6	69	229
4098-2	<0.01	27	<10	110	8	<5	<6	9	10
4100-2	<0.01	27	<10	166	1	<5	<6	5	9
4109-1	<0.01	11	13	59	<1	<5	<6	7	52
4111-2	<0.01	15	<10	200	4	<5	<6	7	8
4166-2	<0.01	178	<10	660*	56	6	<6	47	
4200-2	<0.01	66	<10	71	32	15	<6	14	
4203-3	<0.01	65	37	112	<1	25	<6	60	
4215-1	<0.01	<5	<10	8	9	<5	<6	<5	
4242-1	<0.01	100	<10	117	5	5	<6	12	
4256-2	<0.01	59	<10	133	2	6	<6	15	
4273-2	<0.01	171	<10	138	3	29	<6	77	
4273-3	<0.01	117	<10	380	2	21	<6	48	
4280-1	<0.01	60	<10	35	90	6	<6	14	
4314-1	<0.01	18		17					
4328-1	<0.01	40		63					
4329-1	<0.01	95		285					
4331-1	<0.01	145		860*					
4357-1	<0.01	52		166					
4413-1	<0.01	5		91					
91-001	Trace	48		31	<10				
91-002	Trace	87		27	<10				
91-003	Trace	37		315	<10				
91-004	0.008	122		1310	<10				
91-005	Trace	468		162	<10				
91-006	Nil	834		130	<10				
91-007	Trace	837		3280	<10				
91-008	Nil	43		1230	<10				
91-009	Nil	68		122	<10				

Sample Number	Description	Location
0031-1	Silicified, sulphidized mafic metavolcanic rock	Champion Bear Grid B
0055-1	Mafic metavolcanic rock, finely disseminated sulphides	Islands in English River
0056-1	Mafic metavolcanic rock, finely disseminated pyrrhotite	Islands in English River
0070-1	Horneblende-rich mafic rock, oxidised	Champion Bear Extension Grid
0072-1	Amphibolite, oxidised	Champion Bear Extension Grid
0074-1	Garnet-amphibole-sillimanite bearing metavolcanic rock	Champion Bear Extension Grid
0078-1	Garnet-amphibole-sillimanite bearing metavolcanic rock	Champion Bear Extension Grid
0081-1	Silicified, sulphidized, metavolcanic rock	Champion Bear Grid B
0146-1	Mafic metavolcanic rock, weak sulphides	Separation Rapids
0189-1	Sulphide zone	East end of Champion Bear Extension Grid
0192-1	Silicified felsic metavolcanic rock	East end of Champion Bear Extension Grid
0217-2	Mafic metavolcanic rock, pyrrhotite zone	Champion Bear Extension Grid
0238-1	Sulphide zone in amphibolite	Champion Bear Extension Grid
0254-1	Mafic, brecciated rock	Champion Bear Oneman Grid
0337-1	Sulphide zone	East end of Champion Bear Oneman Grid
0337-2	Quartz vein	East end of Champion Bear Oneman Grid
0348-1	Amphibolite, weak sulphides	Champion Bear Oneman Grid
0351-2	Granitic rock, sulphidic	Champion Bear Grid G
0351-4	Granitic rock, graphitic	Champion Bear Grid G
0380-3	Silicified granitoid rock	Champion Bear Grid E
0399-1	Mafic metavolcanic rock, sulphide vein	Champion Bear Grid H
1014-1	Sulphide zone	Noront Resources' graphite occurrence, Umfreville Road
1203-4	Iron formation	Champion Bear Grid J
1268-2	Mafic metavolcanic rock, sulphides	East end of Champion Bear Extension Grid
1272-1	Tuff, sulphides	East end of Champion Bear Extension Grid
1280-1	Cherty iron formation	Separation Rapids
1281-1	Quartz vein	Separation Rapids
1298-1	Iron formation	Champion Bear Grid H
1306-2	Iron formation	Champion Bear Grid H
1321-2	Silicified granitic rock	Champion Bear Grid E
1327-1	Cherty iron formation	Separation Rapids
1328-2	Mafic metavolcanic rock, sulphides	Separation Rapids
1386-2	Iron formation	Champion Bear Grid I
1399-1	Banded quartz-feldspar rock	Champion Bear Grid G
2023-1	Silicified zone in amphibolite	English River Road, east end of Champion Bera Grid I
2023-2	Sulphidized banded amphibolite	English River Road, east end of Champion Bear Grid I

Sample Number	Description	Location
2023-3	Sulphidized amphibolite	English River Road, east end of Champion Bear Grid I
2024-1	Garnet-bearing amphibolite, weak sulphides	English River Road
2032-1	Rusty zone in pillowed mafic metavolcanic rocks	Aesthetic Road
2071-1	20 cm-wide rusty shear in pillowed metavolcanic rocks	Aesthetic Road
2090-11	Silicic metasedimentary rock, disseminated pyrite	Harrison graphite prospect, Trout Lake
2106-2	Quartz-graphite zone	North part of Trout Lake
2142-1	Silicified banded amphibolite, weak sulphides	Aesthetic Road area
2155-1	Silicified amphibolite, disseminated pyrite	Aesthetic Road area
2157-1	Silicified amphibolite, weak sulphides	Aesthetic Road area
2194-1	Quartz-feldspar-biotite schist, weak sulphides	Trout Lake
2196-1	Silicic metasedimentary rocks, weak sulphides	Trout Lake
2203-1	Silicic rock in granites, weak sulphides	Trout Lake area
2236-1	Diamond drill core composite	Cache on southwest shore, Helder Lake
2236-2	Diamond drill core composite	Cache on southwest shore, Helder Lake
2236-3	Diamond drill core composite	Cache on southwest shore, Helder Lake
2236-4	Diamond drill core composite	Cache on southwest shore, Helder Lake
2303-1	Silicified, schistose mafic metavolcanic rock, weak sulphides	Helder Lake
2326-2	Chert-magnetite iron formation, weak sulphides	Helder Lake
2330-3	Quartz vein, with massive pyrite breccia	Helder Lake prospect
2330-4	Massive pyritic sulphide breccia	Helder Lake prospect
2330-5	Massive pyritic sulphide breccia	Helder Lake prospect
2330-6	Massive pyritic sulphide breccia	Helder Lake prospect
2336-1	Chert-magnetite iron formation, arsenopyrite	Helder Lake prospect
2476-1	Sulphide breccia zone	Gauthier prospect
2476-2	Silicic breccia zone, arsenopyrite and pyrrhotite	Gauthier prospect
2476-4	Sulphide zone, arsenopyrite bearing	Gauthier prospect
2494-1	Graphitic schist, disseminated pyrite	Champion Bear Extension Grid
4004-1	Sulphidized banded iron formation	Boot Bay iron prospect
4012-1	Sulphidized amphibolite	English River Road, Champion Bear Grid I
4012-2	Sulphidized amphibolite	English River Road, Champion Bear Grid I
4020-1	Sulphidized banded iron formation	Boot Bay iron prospect
4065-1	Silicified mafic metavolcanic rock, pyrite stringers	North of the northeast bay of Separation Lake
4098-2	Chert-magnetite iron formation, sulphidized	North of Walleye Lake
4100-2	Chert-magnetite iron formation, sulphidized	North of Walleye Lake
4109-1	Sericitized granitic rock, sulphidized	North of Walleye Lake
4111-2	Chert-magnetite iron formation, sulphidized	North of Walleye Lake
4166-2	Quartz-feldspar-biotite schist, silicified and sulphidized	East of Treelined Lake

Sample Number	Description	Location
4200-2	Quartz-feldspar-biotite schist, silicified and sulphidized	South of Treelined Lake
4203-3	Sulphidized and silicified mafic metavolcanic rock	Island in the northwest bay of Separation Lake
4215-1	Silicic zone in granites, disseminated pyrite	Helder Lake
4242-1	Amphibolite, pyrite bearing	Helder Lake
4256-2	Silicified amphibolite, sulphides	East of Helder Lake
4273-2	Sheared amphibolite,disseminated pyrrhotite	Helder Lake
4273-3	Sheared amphibolite, sulphides	Helder Lake
4280-1	Chert-magnetite iron formation, sulphides	Helder Lake
4314-1	Sulphidized mafic metavolcanic rock	North of Walleye Lake
4328-1	Chert-magnetite iron formation, sulphidized	Fiord Bay
4329-1	Chert-magnetite iron formation, sulphidized	Fiord Bay
4331-1	Chert-magnetite iron formation, sulphidized	Island in the northwest bay of Separation Lake
4357-1	Amphibolite, weak pyrrhotite	5 km west of Helder Lake
4413-1	Chert-magnetite iron formation, weak sulphides	5 km west southwest of Helder Lake
91-001	Amphibolite, rusty	Champion Bear Grid C
91-002	Amphibolite, rusty	Champion Bear Grid C
91-003	Cherty iron formation	Champion Bear Grid J, fork of Umfreville and English River roads
91-004	Granitic rock, graphitic	Champion Bear Grid G
91-005	Silicified and sulphidized metavolcanic rock	Champion Bear Grid B
91-006	Sulphide breccia	Champion Bear Grid C
91-007	Sulphide breccia	East end of Champion Bear Extension Grid
91-008	Silicified felsic metavolcanic rock	East end of Champion Bear Extension Grid
91-009	Quartz-garnet-biotite rock	East end of Champion Bear Extension Grid

** indicates values for Cu and Zn that are above the normal detection range of the analytical method employed, and therefore subject to inaccuracy.*
All samples were collected during the 1992 and 1993 field seasons except samples 91-001 to 91-009, collected in 1991.
Distribution of samples by assay laboratory as follows:
Temiskaming Testing Laboratories: series 0000, 1000, and 91-000
Geoscience Laboratories, Sudbury: series 2000, 4000 (plus sample 1014-1 from the 1000 series

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 90**	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 which are 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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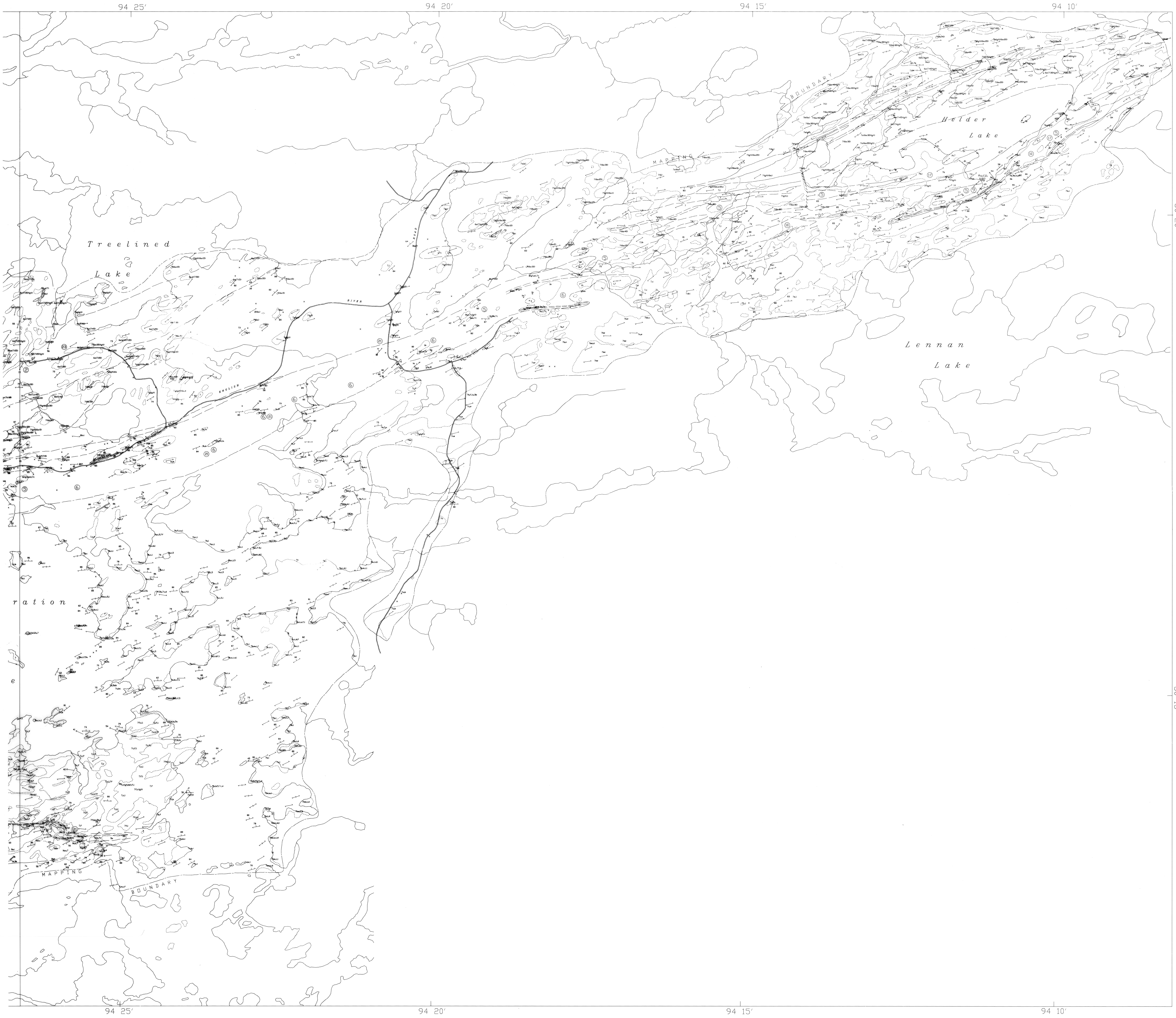

Ministry of Northern Development and Mines
Ontario

Mines and Minerals Division

Ontario Geological Survey

Open File Map 242

PRECAMBRIAN GEOLOGY

SEPARATION LAKE GREENSTONE BELT, EAST PART

Scale 1:20 000

500 m 0 0.5 1 km

LEGEND

PHANEROZOIC

CENOZOIC

QUATERNARY

PLEISTOCENE AND RECENT

Till, clay, sand and gravel

UNCONFORMITY

PRECAMBRIAN

ARCHEAN[a]

7 Granitoid Rocks[b]

- 7a Grey biotite granite, foliated
- 7b Pink biotite granite, massive to weakly foliated
- 7c Pegmatitic
- 7d Aplitic
- 7e Megacrystic/porphyritic
- 7f Feldspar-quartz-biotite+hornblende gneiss[d]
- 7g Granite with biotite-quartz+garnet clots

INTRUSIVE CONTACT

6 High Grade Metasedimentary Rocks[b,c]

- 6a Feldspar-quartz-biotite+garnet schist
- 6b Quartz-feldspar+garnet+biotite gneiss[e]
- 6c Feldspar-quartz-biotite+garnet schist with relic bedding
- 6d Polymictic conglomerate
- 6e Quartz-rich sandstone[f]
- 6f Garnet-pyroxene-plagioclase-quartz layers
- 6g Mafic plagioclase-pyroxene-hornblende layers
- 6h Gneissic

5 Mafic Intrusive Rocks[b,g]

- 5a Aphyric gabbro
- 5b Plagioclase-phyric gabbro
- 5c Hornblende-phyric gabbro

INTRUSIVE CONTACT

4 Medium Grade Clastc Metasedimentary Rocks[b]

- 4a Sandstone (arenite/wacke)
- 4b Feldspathic
- 4c Quartzose
- 4d Polymictic conglomerate
- 4e Argillite
- 4f Quartz-feldspar-biotite

3 Medium Grade Chemical Metasedimentary Rocks

- 3a Chert
- 3b Chert-magnetite ironstone

2 Felsic Metavolcanic Rocks[b]

- 2a Tuff
- 2b Lapilli-tuff, monolithic
- 2c Tuff-breccia, monolithic
- 2d Quartz crystals
- 2e Feldspar crystals
- 2f Quartz-feldspar+biotite schist

1 Mafic Metavolcanic Rocks[b]

- 1 Unsubdivided amphibolite
- 1a Massive amphibolitic flows
- 1b Pillowed amphibolitic flows
- 1c Plagioclase phenocrysts
- 1d Flow breccia and/or pillow breccia
- 1e Flow layering
- 1f Hyaloclastite
- 1g Amygdules
- 1h Banded amphibolite[h]
- 1j Tuff-breccia
- 1k Tuff
- 1m Biotite-quartz-feldspar schist

[a] *Subdivision of major rock units does not indicate age relationships.*

[b] *{gt} indicates presence of metamorphic garnet.*

[c] *Migmatitic association between granitic and high grade metasedimentary rocks indicated by brackets enclosing subordinate phase, and percentage where known; eg 7b(6a:10) indicates 10% schist component.*

[d] *May be hybrid granitoids, or metavolcanic enclaves, commonly as xenoliths and schlieren.*

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[g] *May include coarse phases of flows, and dikes.*

[h] *Tectonic banding, superimposed on pillowed, flow-brecciated and massive metavolcanic rocks.*

ABBREVIATIONS

asp	arsenopyrite	py	pyrite
Au	gold	sp	sphalerite
be	beryl	U	uranium
cp	chalcopyrite	Zn	zinc
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gn	galena	{gf}	graphite
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SYMBOLS

- Area of bedrock outcrop
- Small bedrock outcrop
- Geological boundary, observed
- Geological boundary, interpreted
- Fault
- Trench
- Bedding, top unknown (inclined)
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- Lava flow, top in direction of arrow
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- Foliation (dip unknown, inclined, vertical)
- Overprinted foliation (dip unknown, inclined)
- Joint (inclined)
- Diamond drill hole, with company number

CREDITS

This unedited Open File Map is presented for viewing in order to provide early access to recent geoscience mapping. This map is draft quality only and does not conform to the Ministry of Northern Development and Mines cartographic standards. This is a digitally-constructed geological map. The appearance of subsequent versions of this map will improve following cartographic adjustment and enhancement. It will be available for viewing and sale at Mines and Minerals Publication sales, Willet Green Miller Centre, Sudbury; at the Mines and Minerals Information Centre, Toronto; and at the Resident Geologist's office in Kenora.

Issued 1994.

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Blackburn, C.E., Young, J.B., Searcy, T.O. and Donohue, K. 1994. Precambrian Geology of the Separation Lake greenstone belt, east part; Ontario Geological Survey, Open File Map 242, scale 1:20 000.

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- Diamond drill hole, with company number

CREDITS

This unedited Open File Map is presented for viewing in order to provide early access to recent geoscience mapping. This map is draft quality only and does not conform to the Ministry of Northern Development and Mines cartographic standards. This is a digitally-constructed geological map. The appearance of subsequent versions of this map will improve following cartographic adjustment and enhancement. It will be available for viewing and sale at Mines and Minerals Publication sales, Willet Green Miller Centre, Sudbury; at the Mines and Minerals Information Centre, Toronto; and at the Resident Geologist's office in Kenora.

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Blackburn, C.E., Young, J.B., Searcy, T.O. and Donohue, K. 1994. Precambrian Geology of the Separation Lake greenstone belt, west part; Ontario Geological Survey, Open File Map 241, scale 1:20 000.