It is recommended that reference to the Content be made in the following form:

Easton, R.M. 2010. Precambrian geology of Cavendish Township and environs, Grenville Province; Ontario Geological Survey, Preliminary Map P.3605, scale 1:20 000.

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Marginal Notes

GEOLOGICAL OVERVIEW

The map area straddles 2 geological domains of the Central Metasedimentary Belt, namely, Harvey–Cardiff domain and Bancroft terrane (Figure 1). Harvey–Cardiff domain consists of a southern subdomain (*see* Figure 1) dominated by several types of mafic to intermediate gneiss (units 1 to 4, 18), calcite and dolomite marble (units 5 and 6), and tonalite gneiss complexes (unit 16) and a northern subdomain (*see* Figure 1) dominated by calcite and dolomite marble (units 10 and 11), metavolcanic, metavolcaniclastic, and metasedimentary rocks (units 7 to 9), and gabbro-diorite intrusions (unit 23). Bancroft terrane consists of calcite and dolomite marbles (units 13 and 14), siliciclastic metasedimentary rocks (units 12 and 15), and syenite suite (unit 21) and alkalic gabbro (unit 20) intrusions. Methuen Suite monzogranite intrusions (unit 24) occur throughout the map area. Catchacoma Suite monzogranite intrusions (unit 27) contain elevated thorium contents (>25 ppm) and are among the youngest rocks within the map area and are roughly coeval with the pegmatitic granite bodies (unit 28) that host most of the radioactive mineralization within the map area.The Salerno Creek deformation zone marks the boundary of Harvey–Cardiff domain. Higher strain rocks of indeterminate protolith within the deformation zone are portrayed as unit 25. Areas within the deformation zone where the original protolith can be identified are indicated by the appropriate rock unit code (mainly intrusive rocks of units 20, 23 and 24). Metamorphic grade in the map area is middle to upper amphibolite facies in the southern subdomain of Harvey–Cardiff domain, and middle amphibolite facies in Bancroft terrane and the northern subdomain of Harvey–Cardiff domain.

MINERAL EXPLORATION AND EXTRACTION

Exploration for metallic and nonmetallic minerals has been carried out at numerous localities in and around Cavendish Township since before the turn of the century. Bright (1987, 1988) provides a summary of this early exploration history. Since the discovery and development of economic uranium deposits in the Bancroft region during the early 1950s, subsequent exploration efforts in Cavendish Township have focussed on uranium, mainly in 2 spurts. The first, between 1954 and 1956, led to the discovery of several prospects, past-producers, or producers (e.g., Nos. 2, 4, 6, 7, 8, 9, 14, 21, 22, 25) and deposits, including the Cavendish Mine (No. 3). Subsequently, many of these prospects, past-producers, or producers, in addition to new ones, were re-evaluated during the next uranium boom between 1974 and 1978, mainly by companies such as Kerr Addison Mines Limited and Imperial Oil Limited (Nos. 16, 17 and 18). In 1974–1979, Insulite Development Corporation Incorporated tested a phlogophite-vermiculite deposit (No. 13) in weathered marbles located along Beaver Lake Road. Subsequent exploration work by Regis Resources Limited led to the discovery of vermiculite mineralization near Horseshoe Lake (No. 29), which had proven and probable reserves of 890 000 tonnes at 21% vermiculite. Production took place between 2005 and 2009, at which time the known reserves were exhausted and operations ceased. Aggregate and dimension stone extraction from Methuen (unit 24) and Catchacoma (unit 27) suite plutons has occurred (Nos. 10, 11 and 15). In addition, several Paleozoic outliers (units 29 and 30) in the southern part of Cavendish Township are currently being exploited as sources of stone for aggregate and landscaping purposes (Nos. 12 and 19).

PREVIOUS AND CURRENT WORK

Cavendish Township was mapped at 1:15 840 scale by Bright (1981a, 1981b). In addition, detailed mapping at 1:15 840 scale was conducted in the marble and pegmatite belt located south of Picard Lake by Esso Minerals (Lowe 1975). Two different interpretations of the regional geology of the township are provided by 1:50 000 scale compilation maps produced by Bright (1987, 1988) and Lumbers and Vertolli (2000a, 2000b). Henderson (1992) and O'Connor (2010) conducted mapping and structural studies along parts of the Salerno Creek deformation zone. Jessett (2010) conducted geochemical and isotopic studies of the Glamorgan gabbro (unit 20) within the map area in Glamorgan Township. In the 1970s, the University of Toronto and the Geological Survey of Canada operated a geophysical test range to the west of Salmon Lake. The approximate boundary of this former test range is indicated on the map face. Preliminary reports on mapping in Cavendish Township based on this study were presented in Easton (2007, 2008a, 2008b). A comprehensive summary of the geology and mineral deposits of Cavendish Township is presented in Easton (2011). Geochemical, geophysical and assay data collected as part of this project are presented in Easton (2010).

NOTES REGARDING DATA TYPES PRESENTED ON THE MAP FACE

Outcrop Data

Outcrops shown on the map face are of 2 types, and vary in accuracy of position. Outcrops visited during the course of mapping between 2007 and 2009 were all located using GPS (global positioning system) technology. In contrast, outcrops compiled from Bright (1981a, 1981b) and Lowe (1975) from paper maps were originally located using pace and compass methods, and in some instances, outcrop size may have been exaggerated. Thus, both the size and location of these previously mapped outcrops are less well known. Compiled outcrops are indicated by a "C" in front of the rock code, and are included because they provide important constraints on the location of contacts and the distribution of rock units, even with the uncertainties in their location. Due to access restrictions to the Kawartha Highlands Signature Site Park imposed in 2008, much of the area underlain by the Anstruther gneiss complex was compiled from Bright (1981a, 1981b) in conjunction with the interpretation of airborne magnetic and gamma-ray spectrometric data.

The geology of the area surrounding Cavendish Township that is shown on the map face is compiled from Armstrong and Gittins (1970a, 1970b), Bright (1987, 1988) and Lumbers and Vertolli (2000a, 2000b), supplemented by interpretation of airborne magnetic and gamma-ray spectrometric data available for the area. Map units defined on the basis of geophysical data are indicated by "G" in front of the rock code. The geology of Galway Township in the southwest corner of the map face is poorly known, and is the least reliable portion of the compiled surround geology.

Field Trip Stops

A Friends of the Grenville field trip was run between Buckhorn and Gooderham in September 2009 (Easton and Carr 2009). The majority of the field trip stops from this trip are located within the map area and are indicated on the map face. These stops are located mainly along Peterborough County Road 507 and the Salmon Lake Road.

Geochronological Data

U/Pb zircon, titanite and monazite geochronology data collected as part of this study are summarized in Easton and Kamo (2008, 2009, 2011) and are indicated on the map face, along with data from previous U/Pb, Nd/Sm and Ar/Ar geochronologic studies (Berger and York 1981; Burr and Carr 1994; Jessett 2010; Mezger et al. 1993; Turner 1999).

Lake Sediment Geochemistry

The map area is covered by a lake sediment geochemical survey (Geological Survey of Canada 2009). Most of the stations within the study area showed no responses for elements such as As, Co, Cu, Ni, Pb and Zn; unfortunately, Au was not analyzed. Stations showing above background levels for various metals, predominantly U, are indicated on the map face. Multi-element anomalous readings from large, populated lakes such as Catchacoma, Fortescue and Mississagua lakes may reflect anthropogenic contamination and thus may not be geologically significant.

Magnetic Data

The magnetic field in the map area (Figure 2) is dominated by 2 main geologic units. The first is a linear, approximately 1 to 1.5 km wide, north- to northeast-trending, magnetic and associated Bouguer gravity high that is coincident with the metavolcanic belt (units 7 and 8) present within the northern subdomain of Harvey–Cardiff domain. Magnetic susceptibility measurements of rocks within the metavolcanic belt indicate magnetic susceptibilities of 10 to 100 x 10^{-3} SI (Easton 2010) in contrast to much lower values (<2 x 10^{-3} SI) observed in most other rock units within the northern subdomain (Easton 2010). This magnetic and gravity high can be traced to the south beneath gneissic rocks (units 1 to 4, 19) of the southern subdomain (*see* Figure 2), although the magnetic character of the anomaly becomes more diffuse because of both the thickness of the overlying rock units and the presence of a large Methuen Suite granite intrusion (unit 24j) within the exposed southern subdomain rocks.

Mineral Deposit Data

Mineral deposit data shown on the map consists of occurrences (not numbered), prospects (numbered), past-producers (numbered), and producers (numbered). In addition to historic occurrences compiled from Bright (1981a, 1981b) and Ontario Geological Survey (1983), new occurrences based on assay data contained in Easton (2010) are also shown on the map face. Where available, Mineral Deposit Inventory (MDI) numbers are included in the list of prospects, past-producers, and producers in the map legend. Easton (2010) provides additional details regarding the selection and the location of historic mineral occurrences within the map area. Mineral Deposit Inventory occurrences with uncertain locations, or which could not be located during the course of the mapping program, are not shown on the map, and are identified as problematic in Easton (2010). Diamond-drill hole data shown on the map face are from Ontario Geological Survey (2005). Where available, company drill-hole numbers are presented beside the respective diamond-drill hole. Numerous overburden drill holes are present in the area around Vermiculite Canada (No. 29) and in the Beaver Lake area (No. 13), but are not indicated on the map face.

Radiometric Data

The map area is covered by a high-resolution, airborne, gamma-ray spectrometric survey (Carson et al. 2004a, 2004b, 2004c). Two types of airborne gamma-ray spectrometric anomalies are highlighted on the map face. The first consists of combined uranium and thorium anomalies that are associated with large bodies of pegmatitic granite (unit 28). Most of the historic major radioactive mineral occurrences in the area are associated with these anomalies. The second consists of thorium anomalies (Figure 3) that are associated with the Catchacoma suite of late, monzogranite intrusions (unit 27) that occur within the southern subdomain of the Harvey–Cardiff domain. Some historic, thorium-dominated, radioactive mineral occurrences and prospects occur within the Catchacoma Suite intrusions (e.g., No. 25).

In addition to the airborne radiometric anomalies shown on the map face, also displayed are significant spot assay mode scintillometer readings for U and Th collected by field party personnel, mainly from radioactive mineral occurrences. A complete listing of all the ground scintillometer data collected during the mapping program is found in Easton (2010).

Zones of Weathering

[illegible]

TECTONIC HISTORY OF CAVENDISH TOWNSHIP

[illegible]

ECONOMIC GEOLOGY

Zinc

[illegible] dolomitic marble (Easton 1992). In northern Harvey–Cardiff subdomain, the thickest accumulation of dolomitic marble (unit 11) occurs north of Galloway Lake, on both flanks of the metavolcanic belt (*see* Figure 1). This area also contains several zinc in soil and zinc assay anomalies. Within Bancroft terrane, there are few wide expanses of dolomitic marble (unit 14); however, exploration diamond drilling in the area northeast of Fortescue Lake indicates the presence of intercalated calcitic, dolomitic and silicate-rich marbles (Northgate Exploration Limited 1989). Consequently, the Bancroft terrane marble belts (unit 13) are prospective targets for zinc mineralization even though the surface exposure of dolomitic marble is limited.

Uranium

The Imperial Oil Ganymede prospect, past-producer or producer (No. 18) warrants further exploration, as it lies at the eastern margin of a large, moderate U and Th airborne gamma-ray spectrometric high (map face), and yielded favourable spot assay results (*see* map face and Easton 2010), considerably higher than those from the neighbouring Imperial Oil Asarco occurrence (occurrence 17) to the north. Ganymede is located at the edge of a large, poorly exposed pegmatite body which underlies most of the extent of the airborne anomaly. The pegmatite body associated with Ganymede may be the southern extension of the pegmatite body hosting the Cavendish Mine that has been offset 1.5 km to the southwest along a major north-northeast-trending fault. Exploration of this pegmatite at this time is difficult, however, as it lies in the 500 to 600 m wide zone of blow-down that occurred in the summer of 2006 across much of south-central Cavendish Township.

The northernmost equivalent uranium anomaly near the Cavendish–Anstruther township boundary is as large as the anomaly found near the Cavendish Mine, yet there are no historic radioactive occurrences within this anomaly (*see* map face). Normally, this anomaly would be a prime target for further exploration; however, most of this anomaly lies within the Kawartha Highlands Signature Site. The Kelbee prospect, past-producer or producer (No. 20), just to the southwest, yielded favourable spot assay results (*see* map face and Easton 2010), but it also lies within the Kawartha Highlands Signature Site.

Vermiculite

Marble belts (units 5 and 6) located in the southern subdomain of Harvey–Cardiff domain appear to have the highest potential for hosting additional vermiculite deposits. Exploration should take into account the antiformal character of these marble belts as well as the fact that they may be offset up to 1 km across major east-northeast-trending faults in the area.

The vermiculite deposits at Vermiculite Canada and the historic showings along the Beaver Lake road are hosted by a chemically distinctive calc-silicate rock (unit 6c) that occurs in close proximity to a unit of relatively pure dolomite marble. The calc-silicate rock of unit 6c is dominated by talc-tremolite-quartz-calcite, and has a pink-green colour on weathered surfaces. It is characterized by low Al_2O_3, high MgO, moderate SiO_2, CO_2 and K_2O contents, low values for all of the other alkali elements (Ba, Na, Rb, Sr), and negligible total rare earth element (REE) contents. This chemical composition suggests primary deposition of the calc-silicate protolith as a glauconite-silica-carbonate mud that was subsequently metamorphosed to form the assemblage talc-tremolite-quartz-calcite, an ideal precursor for forming the low-iron vermiculite present at Vermiculite Canada (Easton 2008a, 2011). Rocks of unit 6 appear to be more abundant west of the northerly trending thrust fault near Peterborough County Road 507 that appears to divide the southern subdomain of Harvey–Cardiff domain into 2 lithologically different parts.

In addition to bulk rock composition, another factor critical with respect to development of significant vermiculite mineralization in Harvey–Cardiff domain is the presence of topographically low areas, which were protected from erosion during Quaternary glaciation by the topographically higher and more resistant Anstruther and Burleigh gneiss complexes (Easton 2007, 2011).

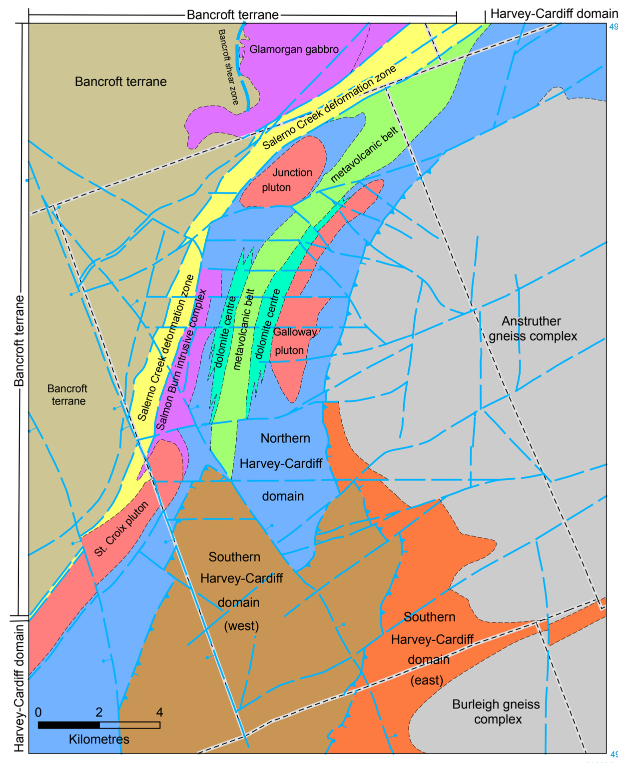


Figure 1. Main tectonic elements of the Cavendish map area. [illegible]

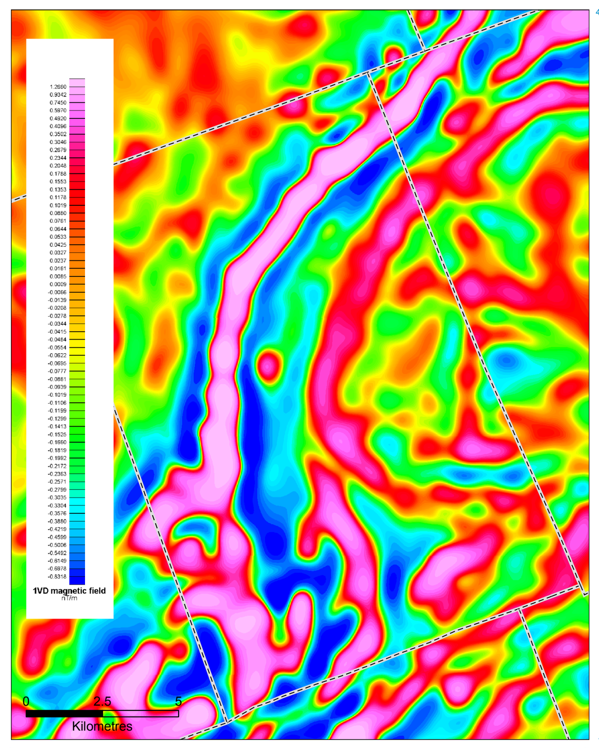


Figure 2. Airborne first vertical derivative of the total magnetic field of the Cavendish area. [illegible] Data from Ontario Geological Survey [illegible]

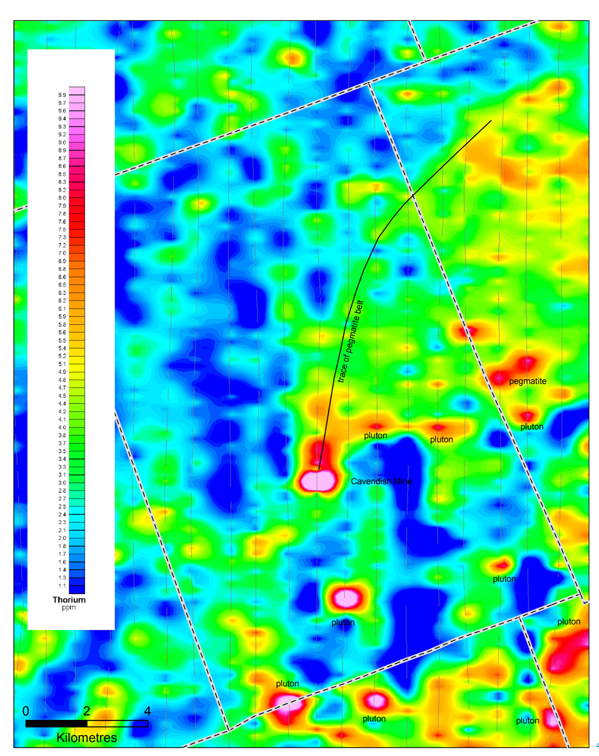
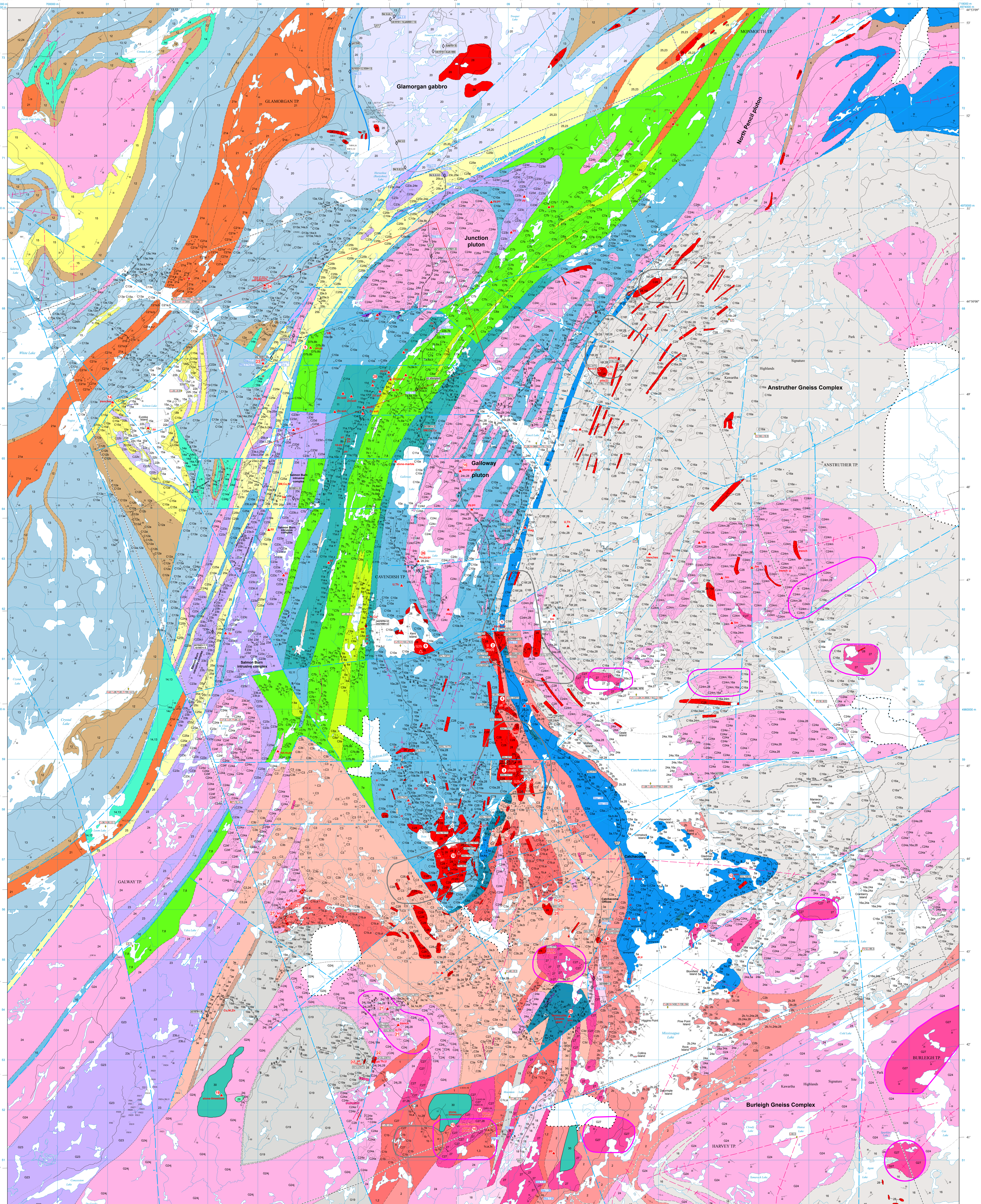


Figure 3. [illegible]



ABBREVIATIONS

[illegible]

PROSPECTS, PAST-PRODUCERS AND PRODUCERS

[illegible]

DIAMOND-DRILL HOLE ABBREVIATIONS

[illegible]

LEGEND

PHANEROZOIC

CENOZOIC

QUATERNARY

PLEISTOCENE AND RECENT

[illegible]

PRECAMBRIAN

MESOPROTEROZOIC

BANCROFT TERRANE AND HARVEY–CARDIFF DOMAIN

[illegible]

Ontario

Ontario Geological Survey

MAP P.3605

PRECAMBRIAN GEOLOGY

CAVENDISH TOWNSHIP and ENVIRONS, GRENVILLE PROVINCE

Scale 1:20 000

500 m 0 0.5 1 km

NTS Reference: 31 D/9, 16

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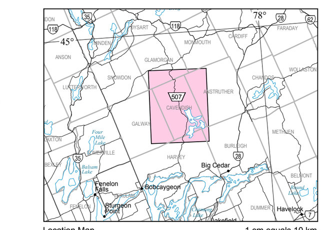

SYMBOLS

[illegible]

SOURCES OF INFORMATION

[illegible]

CREDITS

[illegible]