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**Ontario Geological Survey
Open File Report 6346**

**Precambrian Geology of
Drury Township, Southwest
Sudbury Structure:
Explanatory Notes for
Preliminary Map P.3823**

2018



ONTARIO GEOLOGICAL SURVEY

Open File Report 6346

Precambrian Geology of Drury Township, Southwest Sudbury Structure:
Explanatory Notes for Preliminary Map P.3823

by

C.A. Gordon, R-L. Simard and C-A. Génèreux

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MAP

Map P.3823 Precambrian geology of Drury Township, southwest Sudbury Structureback pocket

DIGITAL DATA

Miscellaneous Release—Data 369

Geological, Geochemical and Geophysical Data for Drury Township, Southwest Sudbury Structure; by C.A. Gordon, R-L. Simard and C-A. Génèreux. This digital data release contains whole-rock geochemical and assay data, outcrop photographs, magnetic susceptibility and scintillometer geophysical data, as well as Summary of Field Work and Other Activities articles, conference abstracts and a poster related to the 1:15 000 scale bedrock mapping of Drury Township, part of the Southwest Sudbury bedrock mapping project. Data were collected during the summer field seasons of 2015 and 2016. These data complement OGS Preliminary Map P.3823, *Precambrian Geology of Drury Township, Southwest Sudbury Structure*, and OGS Open File Report 6346, *Precambrian Geology of Drury Township, Southwest Sudbury Structure: Explanatory Notes for Preliminary Map P.3823*. This release includes 175 images (as *.jpg* files), 3 Microsoft® Excel® (*.xlsx*) workbook files and 10 documents in portable document format (*.pdf*).

Miscellaneous Release—Data 369 (MRD 369) is available separately from this report. It is available on 1 CD or may be downloaded, for free, at

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Abstract

This report provides additional information with respect to the content and design of Ontario Geological Survey (OGS) Preliminary Map P.3823 (back pocket), which provides geological coverage of Drury Township in the southwestern portion of the Sudbury Structure. The mapping results described in this report and on the aforementioned OGS Preliminary Map P.3823 were collected as part of the multiyear Southwest Sudbury Structure bedrock geology mapping project.

Drury Township is located approximately 50 km west of Sudbury and covers the southwestern exposure of the Sudbury Igneous Complex (SIC). In the Drury Township map area 4 main rock packages are present: 1) felsic intrusive rocks, which include Archean basement rocks (Ramsey–Algoma granitoid complex) and Proterozoic felsic dikes; 2) Paleoproterozoic Huronian Supergroup metasedimentary and metavolcanic rocks; 3) the Sudbury Igneous Complex (1.85 Ga) and associated breccia rocks; and 4) Paleoproterozoic and Mesoproterozoic mafic intrusive rocks. The classification and subdivision of the rock packages in Drury Township is based on a combination of lithology, field relationships, geochemistry and geophysical properties. Geochronology results of samples collected from the Ramsey–Algoma granitoid complex, late felsic dikes and metasedimentary rocks of the Huronian Supergroup are presented.

Multiple generations of deformation have been identified in Drury Township. From oldest to youngest, these include 1) bedding-parallel thrust faults; 2) regional-scale folding and foliation; 3) structures related to the Sudbury impact event; 4) development of the Creighton–Victoria deformation zone; 5) northwest- and northeast-trending brittle faults; and 6) development of north-trending crenulation cleavage and kink bands.

Mineral occurrences shown on Map P.3823 are compiled from the Ontario Geological Survey's Mineral Deposit Inventory and from assay data related to this project. Significant nickel-copper-platinum group element mineralization in Drury Township is associated with 1) an SIC-related contact breccia zone, 2) an SIC-related offset dike (Worthington Offset dike), 3) an-SIC-related Sudbury Breccia and 4) shear zone-hosted sulphide occurrences. Smaller occurrences of sulphide mineralization have also been identified within gabbroic sills of the Nipissing Intrusive Suite. Other commodities reported in Drury Township include gold and uranium and thorium. Historical gold occurrences have been reported within quartz veins, but the presence of gold was not confirmed by this study. A narrow (up to a few metres wide) uranium- and thorium-rich horizon is present in the lower Matinenda Formation of the Huronian Supergroup. The uranium and thorium mineralization is associated with pyritic quartz arenite and/or quartz-pebble-rich conglomeratic subfeldspathic arenite and appears to be of similar character to the uraniferous quartz-pebble conglomerate horizon present in the Elliot Lake–Blind River area.

Precambrian Geology of Drury Township, Southwest Sudbury Structure: Explanatory Notes for Preliminary Map P.3823

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Introduction

This report provides additional information with respect to the content and design of Ontario Geological Survey (OGS) Preliminary Map P.3823 (Gordon, Simard and Génereux 2018a, back pocket), which provides geological coverage of Drury Township in the southwestern portion of the Sudbury Structure.

The OGS last mapped Drury Township over 50 years ago (Card 1965a, 1965b). The map area contains numerous past-producing mines and there is currently 1 operating mine (Totten Mine), several prospects and occurrences, as well as the potential for undiscovered deposits (Ontario Geological Survey 2018b). The geology of this part of the Sudbury Structure is more structurally complex than the North Range of the Sudbury Igneous Complex (SIC), and is poorly understood, consequently the need for collecting new geological and structural data to assist in mineral exploration.

The mapping results described in this report and on the aforementioned OGS Preliminary Map P.3823 were collected as part of the multiyear Southwest Sudbury Structure bedrock geology mapping project. This is the first of 2 township-scale maps focussing on Drury and Denison townships (Figure 1). The Southwest Sudbury Structure project was initiated by the OGS in 2015 as part of a multidisciplinary research program on low sulphide platinum group element (PGE)-rich Sudbury Footwall mineralization being conducted by the Mineral Exploration Research Centre (MERC) at the Harquail School of Earth Sciences, Laurentian University. Two graduate theses are associated with this collaboration: 1) the effects of brecciation, metamorphism and tectonic events on low-sulphide PGE mineralization in the South Range of the Sudbury Igneous Complex (cf. Génereux, Lafrance and Gordon 2017; Génereux et al. 2016; Gordon, Simard and Génereux 2015); and 2) surficial mapping with geochemical and mineralogical characterization of till to locate buried and/or near surface nickel-copper-PGE mineralization in Denison and Drury townships (cf. Hashmi 2015, 2016, 2018). An additional graduate thesis and 1 undergraduate thesis are also associated with the Southwest Sudbury Structure mapping project, both supported through collaborations between the OGS and the University of Waterloo and the University of Toronto. These are 1) sedimentary provenance of the Huronian Supergroup in the Sudbury area (Ménard 2017c); and 2) sedimentary provenance of the Matinenda and Ramsay Lake formations in Drury Township (Ménard 2017a, 2017b).

Regional Geology

Drury Township is located approximately 50 km west of Sudbury and includes the southwestern exposure of the Sudbury Igneous Complex (SIC). Drury Township straddles the boundary between the Archean Superior Province to the north and the Paleoproterozoic Southern Province to the south (*see* Figure 1). Within the study area, Archean rocks belong to the Ramsey–Algoma granitoid complex (Card 1979), which includes the Cartier (2642 Ma: Meldrum et al. 1997) and Birch Lake (2651 Ma: Kamo 2006; Easton and Heaman 2008) batholiths. The Archean basement rocks are intruded by the Paleoproterozoic rocks of the Matachewan dike swarm and the Drury Township intrusion of the East Bull Lake Intrusive Suite. The Matachewan dike swarm was emplaced in 2 main pulses. The first, earlier pulse at *circa* 2480 Ma is believed to have been coincident with emplacement of the East Bull Lake Intrusive Suite of layered intrusions (Krogh, Davis and Corfu 1984; James et al. 2002; Bleeker et al. 2012; Bleeker et al. 2015). The second and “main pulse” of the Matachewan dike swarm occurred at *circa* 2460 Ma (Heaman 1997; Bleeker et al. 2012; Bleeker et al. 2015).

The southern boundary of the Superior Province is overlain unconformably by the supracrustal rocks of the Huronian Supergroup, which were deposited in a continental rift and on a continental platform between 2450 and 2219 Ma (Krogh, Davis and Corfu 1984; Bennett, Dressler and Robertson 1991). The Huronian Supergroup is composed of metamorphosed sandstones, mudstones, carbonates, conglomerates and minor volcanic rocks, which are subdivided into the Elliot Lake, Hough Lake, Quirke Lake and Cobalt

groups (cf. Robertson, Card and Frarey 1969). Major, east-trending structures, such as the Murray and Creighton faults (*see* Figure 1), are thought to have originated as extensional faults during sedimentation (Card and Hutchinson 1972). From 2219 to 2210 Ma, the Huronian Supergroup and adjacent Archean granitoid rocks were intruded by the voluminous Nipissing Intrusive Suite (Noble and Lightfoot 1992; Corfu and Andrews 1986). Subsequent to the emplacement of the Nipissing Intrusive Suite, the area was intruded by mafic dikes related to magmatic events that both predate and postdate the Sudbury impact event. This includes, but is not restricted to, the east-northeast-trending Trap dike swarm (1750 Ma) (Bleeker et al. 2015) and the northwest-trending Sudbury dike swarm (1238±4 Ma) (Krogh et al. 1987).

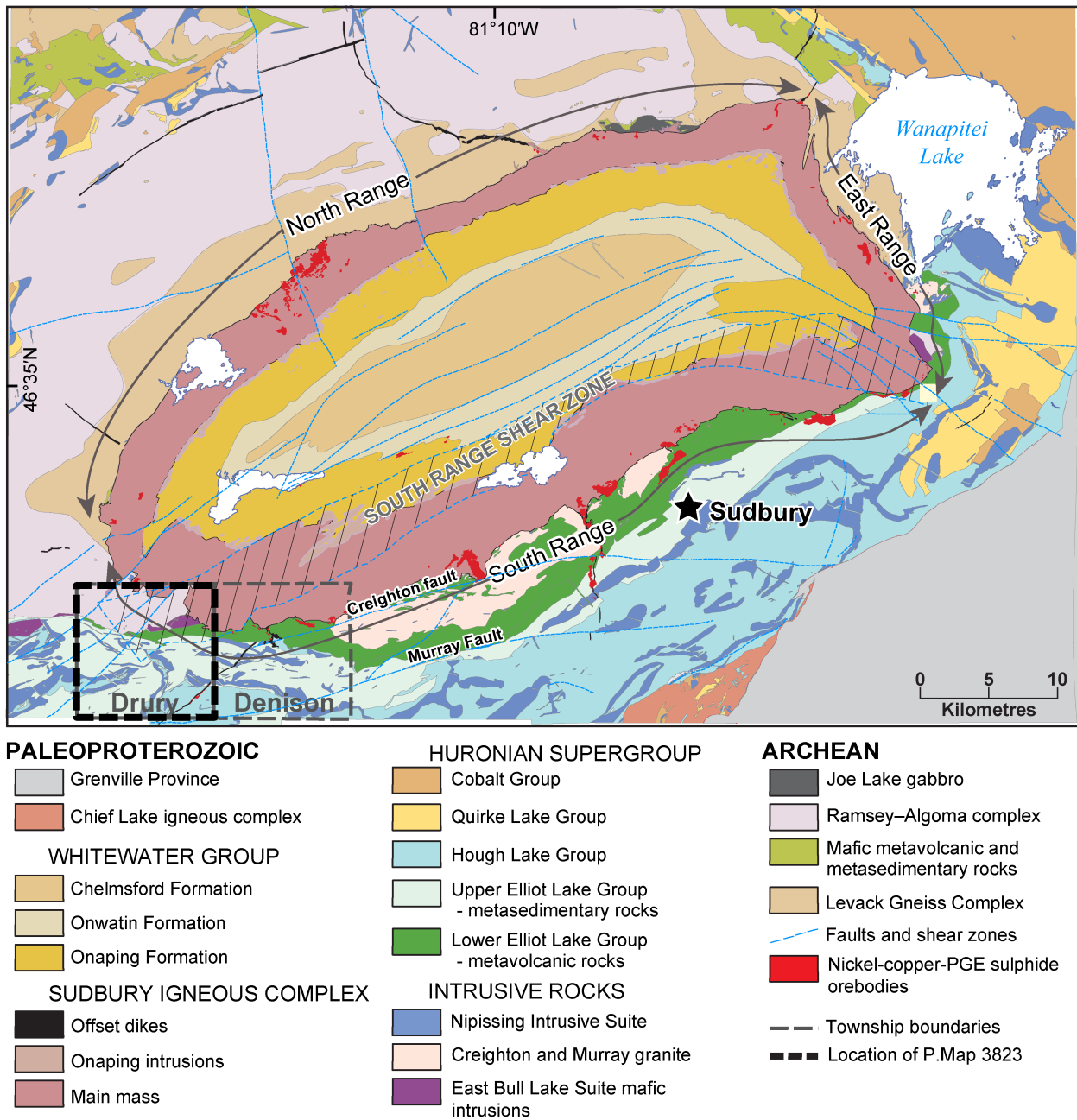


Figure 1. Simplified geological map of the Sudbury area (*modified from* Ames and Farrow 2007). The locations of Drury and Denison townships are shown in the lower left of figure.

Rocks of the Sudbury Structure, which have long been recognized as the remnant of an ancient meteorite impact crater formed at 1850 Ma (Dietz 1964; Krogh, Davis and Corfu 1984), crop out in the northeast corner of Drury Township. The Sudbury Structure rocks are made up of 1) the Main Mass of the SIC, consisting of lower noritic to gabbroic cumulates, a transitional quartz gabbro and an upper granophyre; 2) the Sublayer, which includes quartz-diorite offset dikes and the contact Sublayer; 3) brecciated and shock metamorphosed footwall rocks, which include the Footwall Breccia and Sudbury Breccia; and 5) crater-fill breccias overlain by sedimentary strata of the Whitewater Group (Giblin 1984; Dressler, Gupta and Muir 1991; Ames et al. 1997; Ames et al. 2002; Ames, Watkinson and Parrish 1998; *see* Figure 1). The world-class nickel-copper-PGE mineral deposits directly related to the Sudbury Structure rocks are classified into 3 main types based on their settings: 1) contact deposits, which are nickel-copper ores hosted in embayments at the base of the SIC; 2) offset deposits, which are nickel-copper-PGE ores hosted in quartz diorite offset dikes; and 3) footwall deposits, which include the nickel-copper-PGE and low-sulphide PGE deposits hosted by Sudbury Breccia (Ames and Farrow 2007).

The study area has been affected by multiple episodes of metamorphism and deformation. Regional metamorphic grade ranges from subgreenschist to amphibolite facies and generally increases to the south (Card et al. 1984). Country rock adjacent to the SIC were thermally metamorphosed but have since been overprinted by regional metamorphism (Dressler 1984a, 1984b; Dressler, Gupta and Muir 1991). Early folding of Huronian strata in the Southern Province fold belt is interpreted to have started prior to or concurrent with emplacement of the Nipissing Intrusive Suite, with significant regional folding continuing after the emplacement of the Nipissing sills (Card 1967; 1978; Card et al. 1984; Jackson 2001; Easton 2006; Bleeker et al. 2015). Deformation that occurred after the Sudbury impact event (1850 Ma) has been attributed to at least 2 compressional events, the combination of which resulted in 1) the elliptical shape of the SIC, 2) large-scale northeast-trending folding, 3) development of a prominent east-northeast-trending foliation and southeast-plunging lineation, and 4) major displacement along south-dipping reverse faults in the South Range shear zone and associated shears (e.g., Zolnai, Price and Helmstaedt 1984; Rousell 2009). The lower limit of post-SIC deformation is constrained by the age of undeformed Sudbury dike swarm (1238 ± 4 Ma) (Krogh et al. 1987). Post-SIC deformation has been attributed to the Geon 18 Penokean (Card 1978; Riller et al. 1999; Mukwakwami et al. 2014), and/or the Geon 17 Yavapai and Geon 16 Mazatzal orogenies (Bailey et al. 2004; Piercey, Schneider and Holm 2007; Raharimahefa, Lafrance and Tinkham 2014; Papapavlou et al. 2017). A thermal and magmatic event at *circa* 1450 Ma is also known to have affected the Sudbury area (Bailey et al. 2004; Piercey, Schneider and Holm 2007).

Methods

Bedrock mapping in Drury Township was completed over the 2015 and 2016 field seasons. Map P.3823 (back pocket) is published at 1:15 000 scale, rather than 1:20 000, in order to better represent the geology of the area. The Huronian Supergroup stratigraphy presented in this report is based on the stratigraphy for the Huronian Supergroup as presented in Robertson, Card and Fraey (1969) and Bennett, Dressler and Robertson (1991). Terminology for igneous rocks, other than the rocks of the Sudbury Igneous Complex, follows Le Maitre et al. (2002), and that for sedimentary rocks is based on Soller (2004). Although metamorphosed, sedimentary rocks of the Huronian Supergroup retain many primary sedimentary features, allowing for their description using the terminology of Soller (2004). In portions of this report, for brevity, the prefix “meta” is not used in the description of the main rock types present in the Huronian Supergroup.

Representative samples were collected for whole-rock geochemical analyses and U/Pb geochronology. Whole-rock geochemical analyses were conducted by the Geoscience Laboratories of the Ontario Geological Survey. Major and select trace elements were determined by X-ray fluorescence

spectrometry (XRF). Trace elements, including rare earth elements (REE), were analyzed by inductively coupled plasma mass spectrometry (ICP-MS). Selected metals were analyzed by inductively coupled plasma atomic emission spectroscopy (ICP-AES). Precious metals, Pt, Pd and Au, were analyzed by Pb-fire assay with ICP-MS finish. For additional details on analytical methods, please see Geoscience Laboratories 2018 Schedule of Fees and Services (Ontario Geological Survey 2018a). The full geochemical database is included in Gordon, Simard and G n reux (2018b).

U/Pb geochronology was conducted by the Jack Satterly Geochronology Laboratory at the Department of Earth Sciences, University of Toronto. U/Pb analysis was done by either isotope dilution thermal ionization mass spectrometry (ID-TIMS) or laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) methods, depending on the specific problem being addressed. U/Pb geochronology results are included in Gordon, Simard and G n reux (2018a).

Geology

The Drury Township map area is subdivided into 4 main rock packages: 1) felsic intrusive rocks, including Archean basement rocks and Proterozoic felsic dikes; 2) Paleoproterozoic Huronian Supergroup metasedimentary and metavolcanic rocks; 3) Sudbury Igneous Complex (SIC) (1.85 Ga) and associated breccia rocks; and 4) Paleoproterozoic and Mesoproterozoic mafic intrusive rocks.

Throughout Drury Township, the regional metamorphic grade ranges from lower greenschist to lower amphibolite facies and is overprinted by retrograde metamorphic events, which is consistent with the observations noted by Card (1965a, 1978). Partial melt segregations are locally preserved in mafic rocks of the Matachewan dike swarm and Drury Township intrusion adjacent to the SIC contact. These textures are interpreted to be resultant of thermal metamorphism during cooling of the SIC. However, the overall effects of thermal metamorphism are poorly preserved in Drury Township.

FELSIC INTRUSIVE ROCKS

Ramsey–Algoma Granitoid Complex (Unit 1)

The northern third of Drury Township consists mainly of a fairly homogeneous mass of granitoid rocks belonging to the Ramsey–Algoma granitoid complex. The dominant rock type observed consists of a pink, medium- to coarse-grained, equigranular to locally porphyritic monzogranite (unit 1a) (Photo 1A). Granite and granodiorite (unit 1b) were also locally identified (Photo 1B). The granitoid rocks are typically weakly to moderately foliated. Large clasts of feldspar porphyry (unit 1c) were identified within the Drury Township intrusion. Although an equivalent unit was not observed directly within the Archean basement exposure in Drury Township, it is interpreted that the porphyry clasts originated from the Ramsey–Algoma granitoid complex.

The contact between the monzogranite and the metasedimentary rocks of the Huronian Supergroup is exposed at 3 locations in Drury Township. At all locations, subvertical, east-trending, highly foliated, quartz-rich sandstones, interpreted as belonging to the Matinenda Formation, are found in sheared contact with moderately to highly foliated monzogranite (Photo 1C). Although this contact is known to be unconformable in multiple locations between Sudbury and Sault Ste. Marie (Young 1991; Gordon 2012), the intensity of the deformation observed throughout the map area has obscured the primary relationship between these units. The contact between the Archean monzogranite and the Drury Township intrusion is masked by Sudbury Breccia and is sheared at many locations.

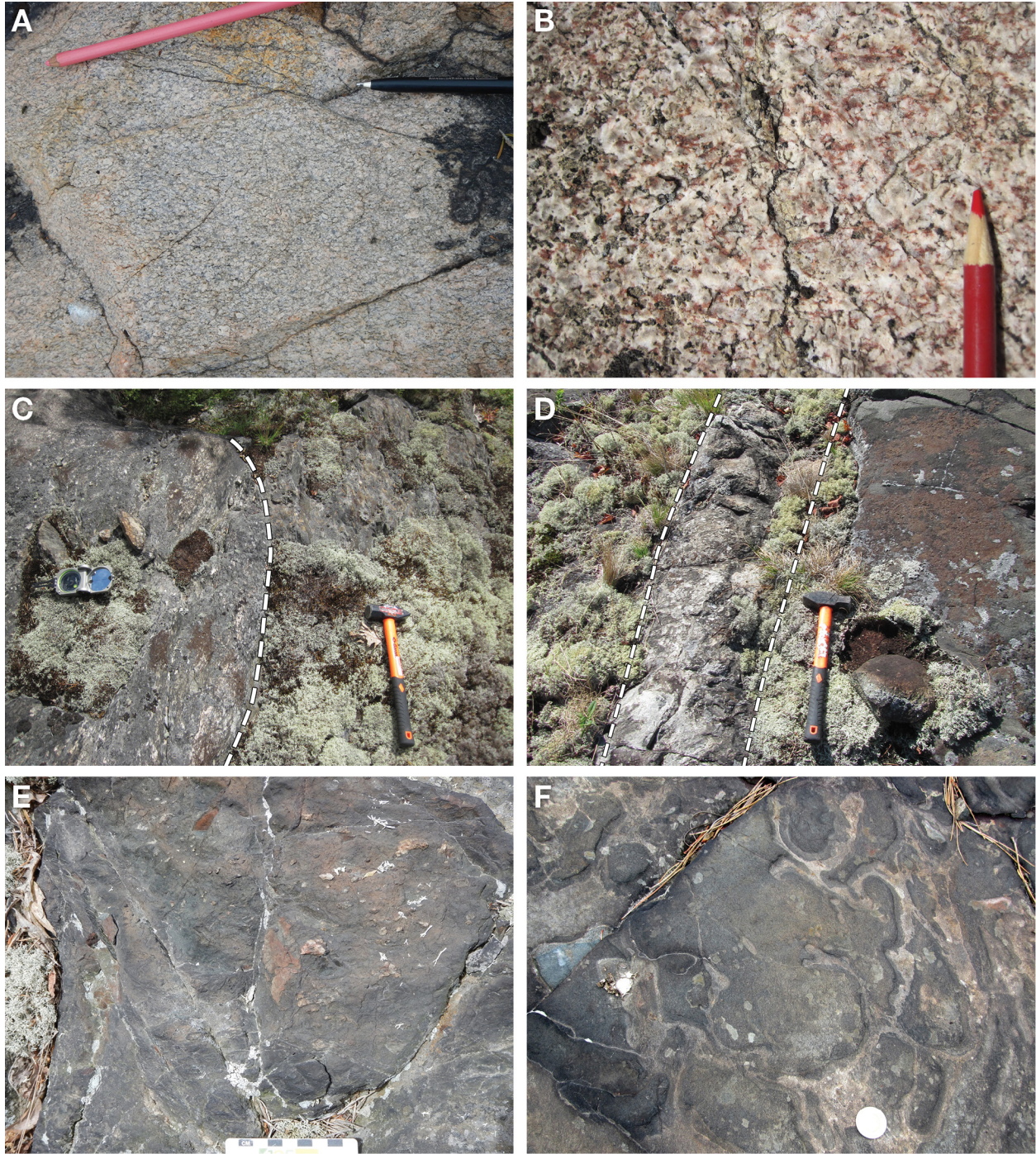


Photo 1. **A)** Weakly foliated monzogranite of the Ramsey–Algoma granitoid complex; UTM 457210E 5142194N. **B)** Massive, garnet-bearing granodiorite of the Ramsey–Algoma granitoid complex; UTM 459260E 5142470N. **C)** Sheared contact (dashed line) between monzogranite (left) and Matinenda Formation quartz arenite (right); UTM 457328E 5141820N. **D)** Sharp contact between a massive, fine-grained felsic dike (between dashed lines) and a moderately foliated, medium-grained gabbro of the Nipissing Intrusive Suite (right); UTM 460513E 5138116N. **E)** Massive basalt with quartz-filled amygdules and plagioclase phenocrysts (unit 5b), Elliot Lake Group, Huronian Supergroup volcanic rocks; UTM 465595E 5140474N. **F)** Subvolcanic sill with fine-grained, amoeboidal mafic lobes encompassed by a felsic, mica-rich, garnet-bearing matrix (unit 5c), southern Drury Township; UTM 460815E 5135999N. Objects used for scale: hammer = 40 cm long; open compass = 14.5 cm long; pen = 9 mm wide; colour pencil = 7 mm wide. All UTM co-ordinates provided using NAD83 in Zone 17.

Felsic Dikes of Unknown Affinity (Unit 21)

In the southern central portion of Drury Township, northwest-trending felsic dikes crosscut a folded mafic sill of the Nipissing Intrusive Suite. The felsic dikes are up to 5 m wide, quartz-rich, massive and contain clasts of the host Nipissing gabbro (Photo 1D). These dikes are not assigned to any known intrusive suite, but crosscutting relationships indicate that they are younger than the Nipissing Intrusive Suite and possibly postdate regional deformation.

HURONIAN SUPERGROUP

Metasedimentary and metavolcanic rocks of the Huronian Supergroup occur in the southern portion of Drury Township and are assigned to the Elliot Lake and Hough Lake groups, as described in their type sections in the Elliot Lake area (Robertson, Card and Frarey 1969; Young 1991; Bennett, Dressler and Robertson 1991, and references therein). The metasedimentary rocks have been further subdivided into the Matinenda, McKim, Ramsay Lake, Pecors and Mississagi formations based on field and geochemical characteristics. Characteristics of the different formations are summarized in Table 1. Overall, the formations in Drury Township are similar to their type sections with the exception of the Ramsay Lake Formation and the basal volcanic rocks of the Elliot Lake Group (*see* details below).

Most of the Huronian Supergroup strata are subvertical and are approximately west-northwest- to east-trending. Reversals of facing direction have been observed at multiple locations, and define the synclines, anticlines and thrust faults in the map area. Despite folding and faulting within formations, the overall younging direction of the stratigraphy is southward. Unit thicknesses stated in this report are apparent thicknesses.

Elliot Lake Group

METAVOLCANIC AND SUBVOLCANIC ROCKS (Unit 5)

Many of the rocks previously identified as metavolcanic rocks in Drury Township have been reclassified as ultramylonitic rocks in this study. These ultramylonitic rocks (unit 18) occur within a major, west-northwest- to east-trending mylonite zone (cf. Gordon, Simard and G n reux 2015; Simard, Gordon and G n reux 2016; G n reux et al. 2016; G n reux, Lafrance and Gordon 2017). They are described in greater detail in the section on “Structure”. A few, small exposures of mafic metavolcanic rocks (unit 5a), locally containing quartz-filled amygdules and plagioclase phenocrysts (unit 5b) (Photo 1E), are preserved in the eastern portion of Drury Township, where the mylonite zone splays into multiple, narrow shear zones. It has not been possible to assign the mafic metavolcanic rocks to either of the Elsie Mountain or Stobie formations, which have been defined in the vicinity of Copper Cliff, approximately 15 km to the east.

In the southern portion of Drury Township, northeast-trending mafic sills intrude the McKim Formation. These mafic sills (unit 5c) exhibit a distinct texture that consist of rounded, lobate mafic enclaves of fine-grained gabbro enclosed in a felsic, mica-rich, garnet-bearing matrix (Photo 1F). This is interpreted as a pepperite texture, formed as a result of a mafic sill intruding what were originally unconsolidated wet sediments of the McKim Formation.

MATINENDA FORMATION (Unit 6)

In Drury Township, the Matinenda Formation is up to 1 km thick, which includes thickening caused by folding. At the base of the unit, the metasedimentary rocks of the Matinenda Formation consist of greenish-beige, poorly sorted, subfeldspathic arenite, and quartz arenite (unit 6a) with quartz-pebble

Table 1. Characteristics of the Huronian Supergroup rocks in Drury Township.

| Formation <i>(exposed thickness)</i> | Rock Types and/or Facies | Other Characteristics | Key Geochemical Characteristics |
|--|---|--|---|
| Hough Lake Group | | | |
| Mississagi Formation <i>(1.5-2 km*)</i> | Grey to beige-pink, well-sorted, fine- to medium-grained subfeldspathic arenite and quartz arenite | Beds vary from very thin (1-2 cm) parallel and nonparallel to thick (15 up to 50 cm) with cross-beds. Locally preserved shattercones. | Similar major and trace element geochemistry to that of the Ramsay Lake Formation |
| Pecors Formation <i>(100-300 m*)</i> | Beige to grey, well-sorted, fine-grained siltstone and mudstone | Massive to medium bedded (10-30 cm), locally cross-beds, flame structures | Similar major and trace element geochemistry to that of the Ramsay Lake Formation |
| Ramsay Lake Formation <i>(≤300 m*)</i> | “Sandy” Beige, fine- to medium-grained subfeldspathic arenite to wacke and quartz arenite | Medium (≤30 cm), crudely bedded | Al, Ti and K content lower than that of the Matinenda and McKim formations |
| | “Grey” Grey, very coarse-grained quartz-rich conglomeratic wacke. 15-30% granite, amphibolite and quartz clasts (polymictic). | Massive to crudely bedded. Beds are thick (1 to >10 m) | |
| | “Beige” Beige, very coarse-grained, quartz-rich conglomeratic subfeldspathic arenite. 5-15% granite and quartz clasts (bilitic). Locally interbedded with fine- to very fine-grained subfeldspathic arenite | Thick (1 to >3 m), massive to crudely bedded. Sandstone beds are thin (1-5 cm) and locally contain ripples. | |
| Elliot Lake Group | | | |
| McKim Formation <i>(≤1.5 km*)</i> | Dark to medium grey, interbedded mudstone, siltstone and fine-grained sandstone grading upward into thinly bedded argillaceous mudstone and siltstone. Locally narrow quartz arenite interbedded with mudstone and siltstone in the lower 50 m. | Thickly laminated (3-10 mm) to very thinly bedded (1-3 cm) mudstone and siltstone, locally displaying graded beds, cross-beds, ripples and flame structures. Staurolite and chloritoid porphyroblasts predominantly in the muddier beds. | High aluminum content |
| Matinenda Formation <i>(~0.3-1.2 km*)</i> | Top Beige-white, medium- to very coarse-grained, subfeldspathic arenite and quartz arenite. Interbedded with thin (20-50 cm) siliceous siltstone and mudstone in the top 150 m. | Massive to bedded. Beds are medium to thick (50 to >300 cm) with local graded and cross-bedding. | High potassium content, LREE enrichment |
| | Basal Greenish-beige, medium- to very coarse-grained, subfeldspathic arenite and quartz arenite with local quartz-pebble-rich, slightly conglomeratic beds. | Massive to bedded. Beds are medium to thick with local graded and cross-bedding. Uranium-rich horizons. | |
| Volcanic and subvolcanic rocks <i>(volcanic unit ~900 m)</i> <i>(subvolcanic unit ~50 m)</i> | Aphanitic to plagioclase-phyric, massive mafic metavolcanic rocks. Fine-grained, mafic amoeboidal lobes (5 cm up to 2 m in diameter) within medium-grained, mica-rich interlobate material. | Locally amygdaloidal | |

*Unit thicknesses are apparent thicknesses and include thickening by folds and potential thrust repetitions.

Abbreviation: LREE – light rare earth elements.

conglomeratic beds (unit 6c). The sandstones (unit 6a), which constitute the bulk of the formation, are massive to bedded (Photo 2A), locally displaying graded beds and cross-bedding. These stratigraphically lower sandstones grade upward into white, medium- to fine-grained, subfeldspathic arenite and quartz arenite. Where exposed, the transition with the overlying McKim Formation is gradational and consists of medium- to fine-grained subfeldspathic and quartz arenite interbedded with thin siltstone and mudstone beds (unit 6b). Along the contact with the Archean monzogranite and the Drury Township intrusion, the rocks of the Matinenda Formation are strongly foliated, and exhibit stretched beds and a well-developed, steeply southeast-plunging stretching lineation. Moving southward, the intensity of the deformation

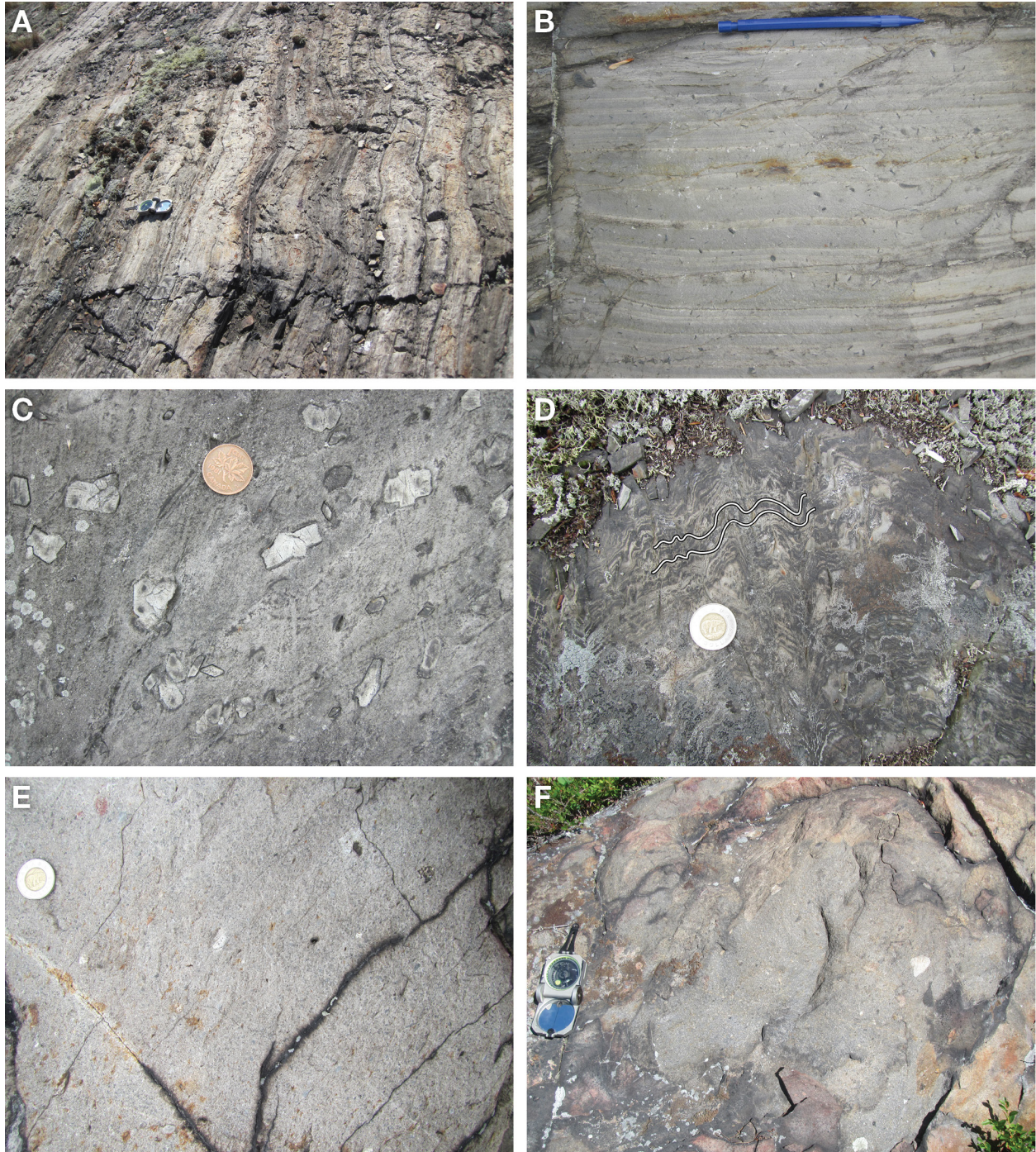


Photo 2. **A)** Strongly deformed sandstones (unit 6a) of the Matinenda Formation, showing north-trending kink bands; compass points north; UTM 457303E 5141791N. **B)** Thickly laminated mudstones (unit 7a) of the McKim Formation with staurolite and chloritoid porphyroblasts; UTM 461520E 5136144N. **C)** Large staurolite porphyroblasts, replaced by white mica and silica, in mudstones of the McKim Formation; UTM 458058E 5138955N. **D)** Small-scale folds (outlined) in mudstones of the McKim Formation; UTM 462442E, 5137360N. **E)** “Beige member” conglomeratic sandstone (unit 8a) of the Ramsay Lake Formation, with granitoid and quartz clasts; UTM 462829E 5137895N. **F)** “Grey member” conglomerate (unit 8b) of the Ramsay Lake Formation, with granitoid, quartz and fine-grained mafic clasts; UTM 459887E 5138040N. Objects used for scale: open compass = 14.5 cm long; pencil = 9 mm wide; coin (penny) = 1.9 cm across wide; coin (twoonie) = 2.8 cm across. All UTM co-ordinates provided using NAD83 in Zone 17.

decreases rapidly and the presence of primary depositional structures (e.g., graded beds, cross-bedding) are preserved. Metre-scale folds were identified locally within the Matinenda Formation based on the reversals of facing directions.

McKIM FORMATION (Unit 7)

The McKim Formation is one of the most aerially extensive units in southern Drury Township. The preserved sequence is up to 1.5 km thick, which includes significant thickening by folding. In Drury Township, the McKim Formation consists of interbedded metamorphosed mudstone, siltstone (unit 7a) and minor sandstone (unit 7b). The metasedimentary rocks are typically thickly laminated to thinly bedded and commonly display cross-bedding, graded beds, ripples and scour marks (Photo 2B). Stauroilite and chloritoid porphyroblasts are present, predominantly in the muddier beds (Photo 2C). The metamorphosed mudstones and siltstones are moderately to strongly foliated and commonly exhibit outcrop-scale folds that are parasitic to the mapped anticlines and synclines (Photo 2D). The contact with the overlying Ramsay Lake Formation is exposed in only 1 locality in Drury Township, in the southeast corner of Drury Township. There, the interbedded metamorphosed mudstone and siltstone of the McKim Formation are overlain by 1) a 2 m thick quartz arenite bed, 2) up to 30 m of feldspathic arenite and wacke beds, and finally, by 3) the “beige” member of the Ramsay Lake Formation (*see* details below).

Hough Lake Group

RAMSAY LAKE FORMATION (Unit 8)

The Ramsay Lake Formation is the lowermost formation of the Hough Lake Group. It is historically described as a clast-rich diamictite (Young 1991; Long 2009; Bennett 2006). In Drury Township, the preserved sequence is up to 300 m thick. Based on colour and composition of the matrix, clast type and clast abundance, the Ramsay Lake Formation has been subdivided into 2 basal metaconglomerate units, the “beige” (unit 8a) and “grey” (unit 8b) members, and an upper metasandstone unit, the “sandy” (unit 8d) member. The “beige” member is the most common rock type of the Ramsay Lake Formation in Drury Township. It is a bilithic conglomeratic subfeldspathic arenite with a beige, poorly sorted, very coarse-grained, quartz-rich matrix and contains 5 to 15% clasts of granite and quartz. Clast composition varies within the “beige” member from granite and quartz (unit 8a) to dominantly quartz (unit 8c) (Photo 2E). The “grey” member (unit 8b) is consistent with the classic description of the Ramsay Lake Formation (cf. Young 1991; Bennett, Dressler and Robertson 1991, and references therein). It is made-up of a polymictic conglomeratic wacke or sandstone with a poorly sorted, grey, very coarse-grained, quartz-rich matrix and contains 15 to 30% clasts made-up of granite, amphibolite and quartz (Photo 2F). Locally, the conglomeratic rocks in both the “grey” and “beige” members are interbedded with fine- to very fine-grained subfeldspathic arenite. The upper portion of the Ramsay Lake Formation is classified as the “sandy” member (unit 8d). It is composed of crudely bedded, poorly sorted, fine- to medium-grained subfeldspathic arenite, wacke and quartz arenite. All of the sandstones and conglomeratic sandstones are strongly to moderately foliated and lineated.

PECORS FORMATION (Unit 9)

The Pecors Formation is 100 to 300 m thick and exposed between the Ramsay Lake and Mississagi formations in the southeastern corner of Drury Township. The formation consists of beige to grey, fine-grained siltstone and mudstone that are variably foliated (Photo 3A). The siltstone and mudstone are thickly laminated and locally exhibit cross-beds and load structures. Contacts between the Pecors Formation and adjacent Mississagi or Ramsay Lake formations are not exposed.

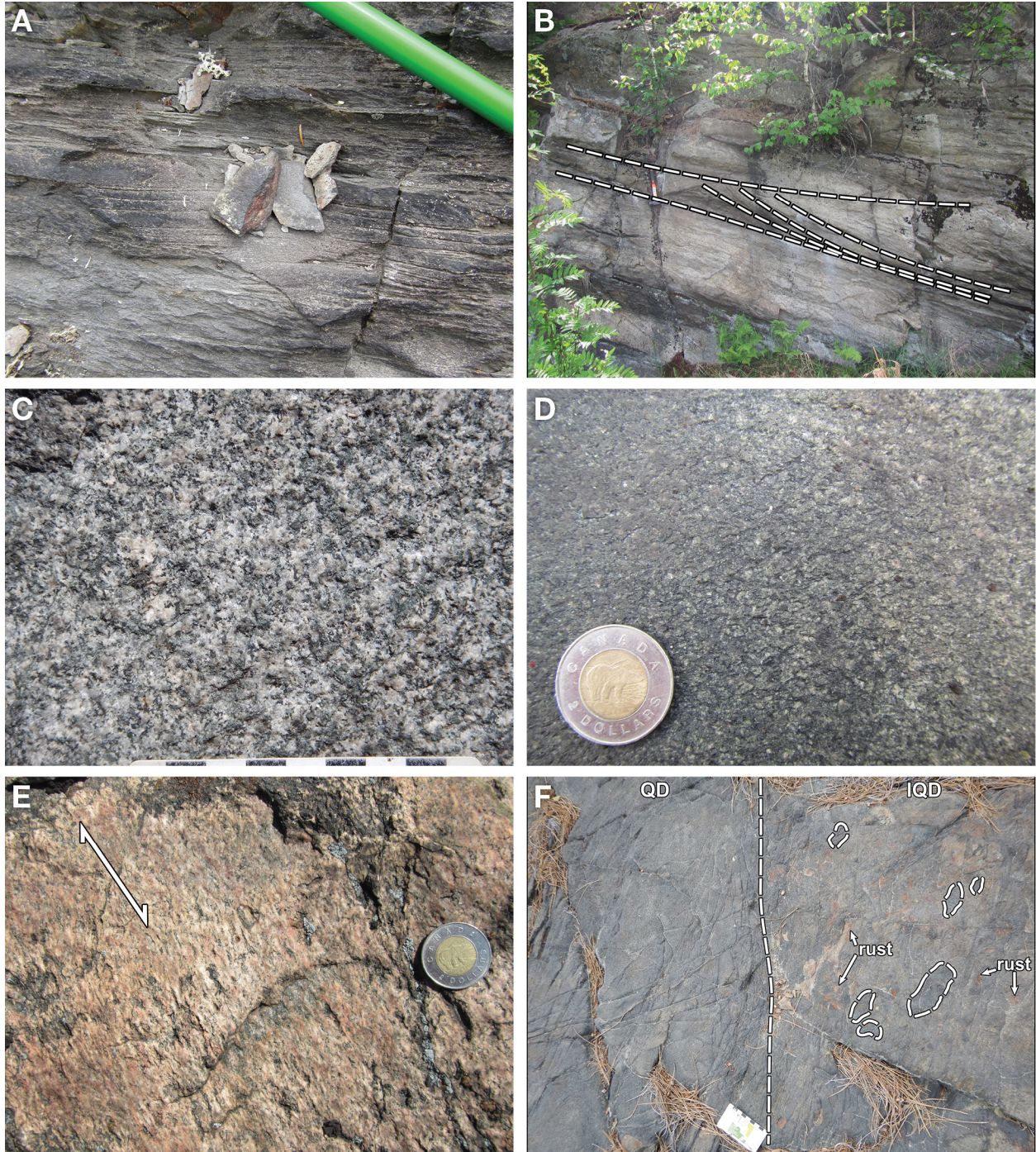


Photo 3. **A)** Thickly laminated mudstone of the Pecors Formation (unit 9); UTM 464559E 5136589N. **B)** Cross-bedded, fine-grained subfeldspathic arenite (unit 10a), Mississagi Formation; UTM 464600E, 5135829N. **C)** Massive, medium-grained quartz-bearing norite, basal norite, Sudbury Igneous Complex; UTM 462415E 5144445N. **D)** Medium-grained melanocratic quartz gabbro, transition zone, Sudbury Igneous Complex (SIC); UTM 465258E 5144355N. **E)** Foliated medium-grained monzogranite, granophyre, SIC; UTM 465451E 5143875N. **F)** Sharp contact between quartz-diorite (“QD”, on left) (unit 14b) and inclusion-bearing quartz-diorite (unit 14a) with 10% sulphide burns (“IQD”, on right) of the Worthington Offset dike (white dashed lines outline some of the inclusions); UTM 465613E 5136852N. Objects used for scale: hammer = 40 cm long; colour pencil = 7 mm wide; coin = 2.8 cm across. All UTM co-ordinates provided using NAD83 in Zone 17.

MISSISSAGI FORMATION (Unit 10)

The Mississagi Formation is at least 2 km thick, including thickening by folding, and is exposed in the southeastern corner of Drury Township. The metasandstones of the Mississagi Formation (unit 10a) consist of well-sorted, grey to beige-pink, fine- to medium-grained subfeldspathic arenite and quartz arenite that are variably foliated. The sandstone units are thinly to thickly bedded and commonly display cross-beds (Photo 3B). Locally, the medium- to fine-grained sandstone units contain beds of siltstone (unit 10b). Contacts between the Mississagi Formation and adjacent McKim or Pecors formations are not exposed.

SUDBURY IGNEOUS COMPLEX AND ASSOCIATED BRECCIA UNITS

Rocks of the Sudbury Igneous Complex (SIC) are exposed in the northeast corner of Drury Township. Associated breccias are present throughout Drury Township in all units older than *circa* 1850 Ma. Characteristics of the SIC and associated breccia units are summarized in Table 2.

Main Mass Sudbury Igneous Complex (Units 15, 16 and 17)

The SIC, as exposed in the northeastern corner of Drury Township, exhibits the complete Main Mass stratigraphic sequence (cf. Giblin 1984; Dressler, Gupta and Muir 1991; Ames et al. 1997; Ames et al. 2002; Ames, Watkinson and Parrish 1998). It is important to note that the nomenclature used to classify rock types of the SIC does not always conform to the IUGS definition of those rock types (cf. Therriault, Fowler and Grieve 2002). For example, the South Range norite is compositionally and mineralogically more comparable to quartz monzogabbro than a true norite (Therriault, Fowler and Grieve 2002). However, for the sake of consistency and to avoid confusion, classic Sudbury nomenclature for the Main Mass of the SIC was used in this study.

The Main Mass stratigraphic sequence as exposed in Drury Township includes, from bottom to top:

- 1) South Range norite (unit 15): a weakly to moderately foliated, medium-grained, leucocratic to mesocratic quartz-bearing monzogabbro (Photo 3C).
- 2) Transition zone quartz gabbro: a moderately foliated, strongly magnetic, medium-grained, melanocratic to mesocratic quartz gabbro and monzogabbro with cumulous magnetite and apatite (unit 16) (Photo 3D).
- 3) Granophyre: a weakly to moderately foliated, medium- to coarse-grained, leucocratic monzogranite (unit 17a) (Photo 3E). Graphic textures were not observed on outcrop.

Offset Sublayer (Worthington Offset Dike) (Unit 14)

The well-documented Worthington Offset dike (Grant and Bite 1984) trends northeast across the southeastern corner of Drury Township and truncates metasedimentary rocks of the Hough Lake and upper Elliot Lake groups. The Worthington Offset dike displays both the inclusion-bearing (unit 14a) and inclusion-free (unit 14b) quartz diorite phases. The inclusion-free phase (unit 14b) consists of variably foliated, fine- to medium-grained quartz diorite and is in sharp contact with the inclusion-bearing quartz diorite phase. The inclusion-bearing quartz diorite (unit 14a) is a breccia made-up of 30 to 80% clasts (ultramafic, mafic, sedimentary, quartz) in a fine- to medium-grained quartz diorite matrix (Photo 3F). Clasts are very poorly sorted and range from less than a centimetre to several metres in width. The inclusion-bearing quartz diorite is generally present within the core of the Worthington Offset dike, flanked along margins by inclusion-poor quartz diorite. The inclusion-bearing quartz diorite is variably mineralized with up to 30% sulphide minerals and hosts several mineral deposits in the area (*see* section on “Mineralization”).

Table 2. Characteristics of Sudbury Igneous Complex rocks and associated breccias in Drury Township.

| Unit | General Description | Other Characteristics |
|---|--|---|
| Main Mass | | |
| Granophyre | Medium- to coarse-grained, equigranular, leucocratic, monzogranite. Moderate to strongly foliated. | |
| Transition quartz gabbro | Medium-grained, mesocratic to melanocratic, strongly magnetic quartz gabbro. Weakly to moderately foliated. | Low Ni content, gabbroic composition, La/Sm = 4.4-5.8, Tb/Lu = 2.1-3 |
| “Norite” | Medium-grained, leucocratic to mesocratic, equigranular, quartz-bearing monzogabbro. Massive to locally foliated. | Intermediate composition, La/Sm = 5.6-7.4, Tb/Lu = 2-2.3. Contains nickel-copper mineralization. |
| Contact Breccia | | |
| Type 1: Norite to leuconorite, inclusion-rich | Fine- to medium-grained, locally plagioclase-phyric, norite to leuconorite matrix with 30-85% inclusions of varying composition and size (mainly gabbroids and plagioclase-phyric, fine-grained mafic rocks, lesser amount of granite; 0.2 cm to >1 m, very poorly sorted). Generally, the matrix contains <5% disseminated sulphide minerals. | Highly magnetic; locally sheared; contains nickel-copper-PGE mineralization. |
| Type 2: Norite, inclusion-poor | Fine- to medium-grained norite matrix with <30% inclusions mainly of mafic composition (aphanitic to coarse-grained gabbroids) and varied size (1-15 cm, poorly sorted). The matrix contains 5-15% blebby sulphide mineralization throughout (0.2-1 cm diameter). | Contains nickel-copper-PGE mineralization. |
| Type 3: Leuconorite, inclusion-rich | Fine- to medium-grained leuconorite matrix with 35 to >60% small inclusions (0.5-100 cm, averaging 3 cm in size, moderately sorted) of gabbroids, plagioclase-phyric, fine-grained mafic rocks, and granite. | Not magnetic; locally sheared. |
| Type 4: Leucogabbro to anorthosite, inclusion-rich | Medium- to coarse-grained, heterogeneous leucogabbro to anorthositic matrix with 10-15% inclusions mainly of mafic composition (fine grained, green, averaging 3-5 cm in size but up to 30 cm diameter). Crosscut by fine-grained mafic dikes (Sudbury Breccia dikelets?). Gossan covers approximately 60% of exposure. | Contains nickel-copper-PGE mineralization. |
| Worthington Offset Dike | | |
| Inclusion-bearing quartz diorite <i>(20 to >50 m thick; generally present in the core of Worthington Offset dike)</i> | Fine- to medium-grained, variably foliated quartz diorite matrix with 30-80% inclusions of highly variable composition and size (ultramafic and mafic intrusive, sedimentary, quartz fragments; 0.5 cm to >3 m, very poorly sorted). The matrix contains 15 to >40% blebby sulphide mineralization. | Contains nickel-copper-PGE mineralization; host of the Totten Mine deposit. |
| Quartz diorite <i>(varied in thickness (up to 30 m) on margins of the Worthington Offset dike)</i> | Fine- to medium-grained, massive, some large country-rock xenoliths close to contact, contains <5% inclusions; <5% disseminated sulphide minerals in matrix. Variably foliated. | Intermediate composition, high Cr, Ni and Cs content, La/Sm = 5.1-6.3, Tb/Lu = 1.9-2.1 |
| Sudbury Breccia | | |
| Breccia belts | Clast-rich, poorly sorted, variably foliated, bilithic and heterolithic breccia belts. Matrix between clasts composes >40% of the outcrops, is fine grained and dark green to grey. Clasts range from <1 cm up to 8 m in diameter. | Occurs predominately along major lithological contacts. |
| Localized breccia veins/veinlets | Very fine-grained, variably foliated, dark green, chloritic rock. Forms veinlets and veins of varied thickness (<1 cm to >1 m). Varies from monolithic to heterolithic, clast rich to clast poor. Flow structures locally preserved. Minor disruption of host rock. | Present in varied amounts in all map units older than <i>circa</i> 1850 Ma. |

Contact Breccia (Unit 13)

An extensive breccia zone is present at the basal contact of the SIC in Drury Township. The contact breccia is heterolithic in matrix composition and clast type, variably gossanous and laterally discontinuous. The contact breccia is variably mineralized and hosts several mineral deposits in the area (*see* details below). Historically, the breccia has been classified as Sublayer and Footwall Breccia (*cf.* Dressler 1984a). However, the exposure, deformation and complexity of the breccia zone hindered the ability to either confirm or refine the classic subdivision in this study. Alternatively, the breccia zone

has been subdivided into 4 main types based on matrix composition, clast type and clast abundance as observed in outcrop:

- 1) Clast-rich (30 to 85% clasts) heterolithic breccia with abundant gabbroic and lesser amounts of granitoid clasts in a fine- to medium-grained, locally magnetic noritic to leuconoritic matrix (unit 13a) (Photos 4A and 4B).
- 2) Clast-poor (<30% clasts) heterolithic breccia with a fine- to medium-grained noritic matrix (unit 13b) (Photo 4C).
- 3) Heterolithic breccia (35 to >60% clasts) with abundant granitoid clasts and few mafic clasts in a pink-weathering leucogabbroic to intermediate matrix (unit 13c) (Photo 4D).
- 4) Heterolithic breccia with gabbroic and leucogabbroic clasts in a variably textured, anorthositic to leucogabbroic matrix (unit 13d) (Photos 4E and 4F).

The highest concentration of sulphide minerals was observed in breccia types 1 and 2 within the noritic matrix. Breccia types 1, 2 and 3 occur at the SIC–Archean granitoid contact. Breccia type 4 occurs exclusively at the SIC–Drury Township intrusion contact.

Sudbury Breccia (Unit 12)

All map units within Drury Township that are older than *circa* 1850 Ma contain various amounts of impact breccia known locally as Sudbury Breccia. Sudbury Breccia has been defined as veins and irregular bodies that consist of subrounded clasts, mainly derived from adjacent host rocks, set in a very fine-grained to aphanitic matrix (Speers 1957; Dressler 1984a, 1984b; Müller-Mohr 1992). In Drury Township, Sudbury Breccia occurs as a moderately to strongly foliated, fine-grained, dark green to greenish-yellow chloritic rock that occurs as veinlets and veins of various thickness (0.5 cm to >1 m) and orientation (Photos 5A, 5B and 5C). There are both clast-poor and clast-rich varieties. Clasts are subrounded to rounded and typically sourced from adjacent host rock. Thicker breccia veins, usually clast-rich, are concentrated in corridors along major lithologic contacts and structures. Most host rock units contain up to 5% of thin Sudbury Breccia veinlets, but the amount varies considerably from one area to another, and identification is strongly affected by the quality of the outcrop exposure. In general, breccia exposures were mapped and classified according to their host rock and are displayed on Map P.3823 as such. The presence of breccia is indicated by the Sudbury Breccia mapcode, 12b, added to the host rock mapcode. The triangle pattern on Map P.3823 indicates mappable areas where breccia veinlets are greater than 15 cm in thickness and/or where Sudbury Breccia makes-up at least 25% of the outcrop.

Throughout Drury Township, clast-rich heterolithic Sudbury Breccia occurs as irregular elongated zones or “belts” that range from a few metres to several hundred metres in width. Map unit 12a indicates areas where the host rock could not be identified and where the breccia matrix makes up at least 25 to 50% of the outcrop. Two significant heterolithic Sudbury Breccia “belts” were identified at 1) the contact of the Drury Township intrusion and the Archean monzogranite, and 2) following the contacts between the folded sedimentary rocks and Nipissing gabbro in south-central Drury Township. The breccia matrix is very fine-grained, moderately to strongly foliated and typically makes-up more than 40% of the outcrops (Photo 5D). Clasts are subrounded to rounded, slightly flattened, and range in size from smaller than 0.5 cm to larger than 50 m. Clasts are generally derived from the adjacent host rocks, but exotic clasts are also observed. Where the contact is exposed, there is a gradational transition from host rock to Sudbury Breccia veins to the clast-rich heterolithic Sudbury Breccia “belt”. It is characterized by a rapid increase in the abundance and thickness of the chloritic veinlets in the host rock, to clast-rich “monolithic” (host-rock derived) Sudbury Breccia, to a “heterolithic” Sudbury Breccia (a mix of host rocks and exotic clasts).

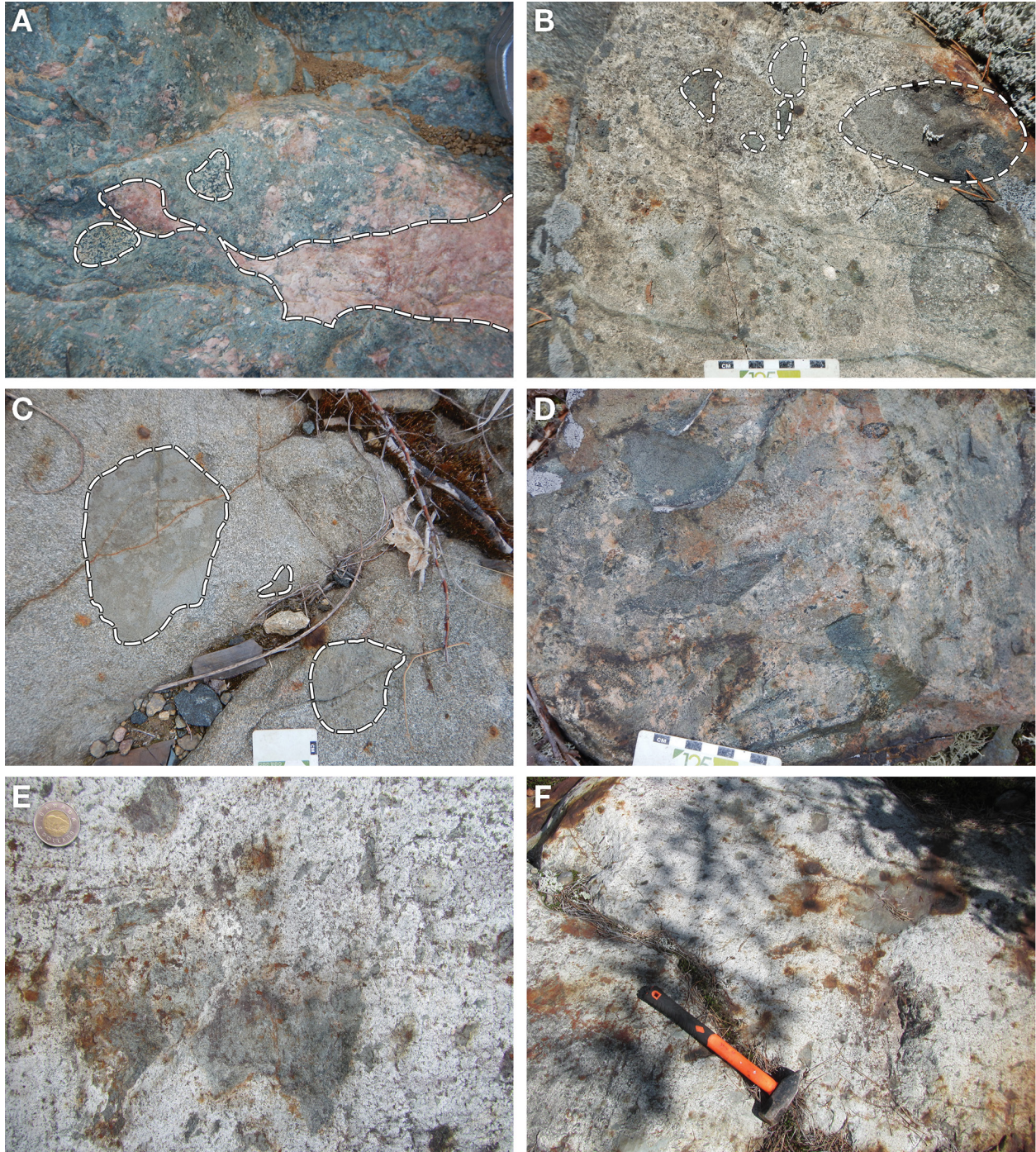


Photo 4. **A)** Inclusion-rich heterolithic breccia with ~80% inclusions of varied composition (gabbroids, granite; white-dashed outlines) in a fine-grained noritic matrix, SIC contact breccia type 1; UTM 461523E 5143919N. **B)** Inclusion-rich heterolithic breccia with ~40% inclusions of varied composition (gabbroids, granite; white-dashed outlines) in a medium-grained noritic matrix, SIC contact breccia type 1; UTM 460702E 5144357N. **C)** Inclusion-poor heterolithic breccia showing 5% sulphide burns (pyrrhotite-chalcopyrite blebs) and ~15% mainly mafic inclusions (white dashed outlines) in a fine-grained noritic matrix, SIC contact breccia type 2; UTM 461644E 5144488N. **D)** Inclusion-rich heterolithic breccia with inclusions of varied composition (gabbroids, granite) in leucocratic, varietal matrix, SIC contact breccia type 3; UTM 460732E 5144295N. **E)** Inclusion-rich breccia, showing fine-grained mafic clasts and sulphide burns in an anorthositic matrix, SIC contact breccia type 4. **F)** Inclusion-rich breccia, showing fine-grained mafic clasts in an anorthositic matrix and centrimetre- to metre-scale gossan patches, SIC contact breccia type 4. Objects used for scale: compass = 7 cm across; coin = 2.8 cm; hammer = 40 cm long. All UTM co-ordinates provided using NAD83 in Zone 17.

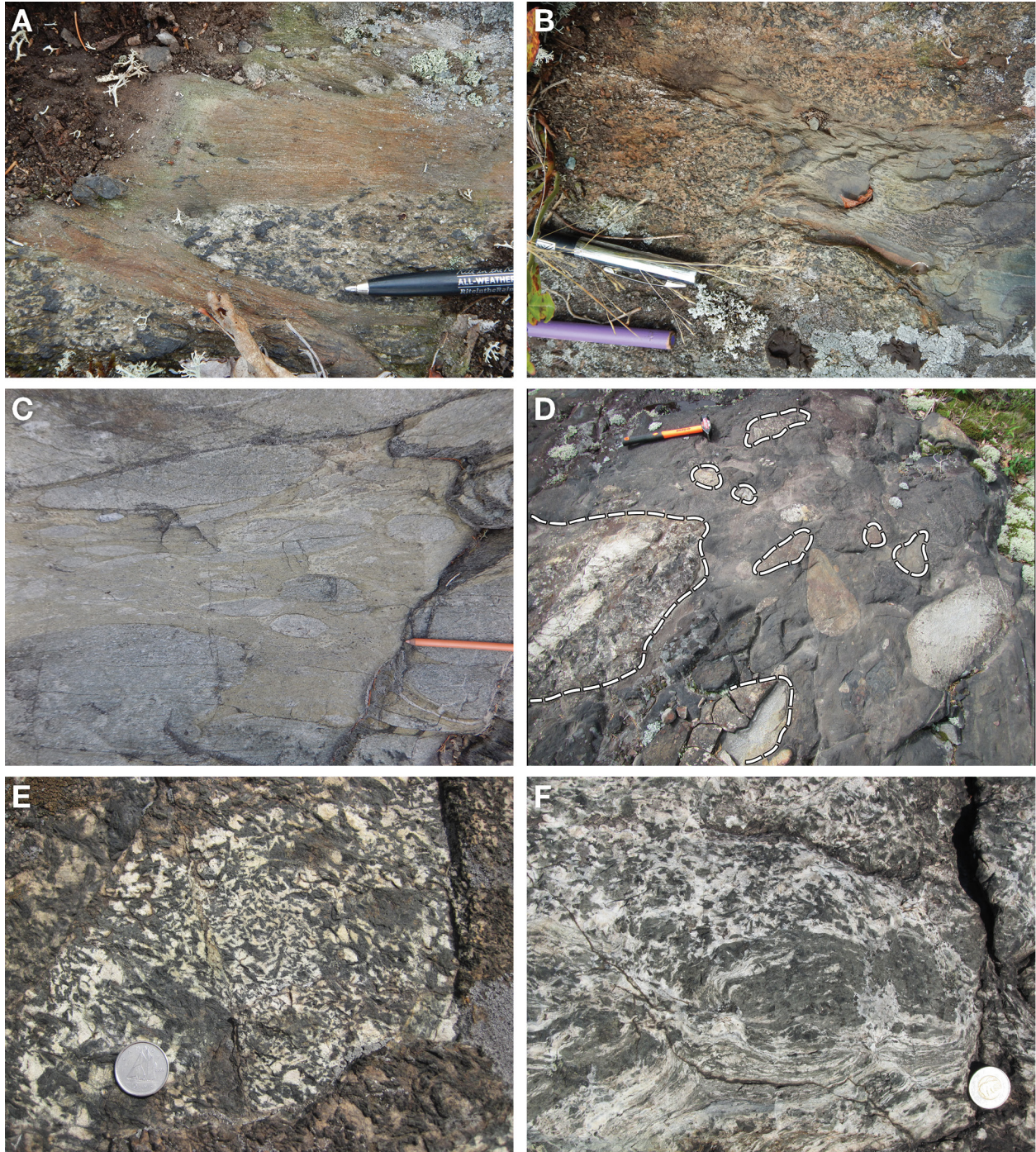


Photo 5. **A)** Clast-bearing, very fine-grained, strongly foliated and chloritized Sudbury Breccia in a deformed granitoid in the mylonite zone; UTM 459148E 5141173N. **B)** Chloritized Sudbury Breccia exhibiting “flame-like” injection in the host rock with preserved flow-like structures in a relatively undeformed gabbronorite “boudin” in the mylonite zone; UTM 459138E 5141199N. **C)** Classic Sudbury Breccia with rounded pebbles and cobbles in quartz arenite of the Matinenda Formation; UTM 459266E 5140716N. **D)** Clast-rich heterolithic Sudbury Breccia showing abundant subrounded clasts (white dashed outlines); UTM 465320E 5141911N. **E)** Varitextured leucogabbronorite of the Drury Township intrusion; UTM 461351E 5140738N. **F)** Foliated anorthositic gabbronorite of the Drury Township intrusion at the contact with the SIC, showing segregation of partial melt; UTM 465320E 5141911N. Objects used for scale: hammer = 40 cm long; colour pencil = 7 mm wide; pen = 9 mm wide; coin (twoonie) = 2.8 cm across; coin (dime) = 1.8 cm across. All UTM co-ordinates provided using NAD83 in Zone 17.

MAFIC INTRUSIVE ROCKS

The classification and subdivision of mafic intrusions in Drury Township is based on a combination of field relationships, geochemistry and geophysical properties. Characteristics of each intrusive type are summarized in Table 3.

Drury Township Intrusion (Units 2 and 3)

The Drury Township intrusion, currently interpreted to be one of several layered intrusions related to the East Bull Lake Intrusive Suite (Prevec 1993), is up to 2 km in thickness and is exposed at the Ramsey–Algoma granitoid complex – Huronian Supergroup – Sudbury Igneous Complex contact. The Drury Township intrusion is composed of medium- to coarse-grained, locally pegmatitic, varitextured leucogabbro (unit 3) (Photos 5E and 5F). A marginal gabbroic phase (unit 2), up to 100 m in thickness,

Table 3. Characteristics of intrusive rocks in Drury Township.

| Rock Suite (Age) | Rock Type | Occurrence or Trend | Description | Structure | Key Geochemical Characteristics |
|--|---|---|---|---|---|
| Sudbury dike swarm (1238 Ma ^a) | Olivine gabbro | northwest | Fine- to medium-grained, mesocratic to leucocratic, locally plagioclase-phyric. Strongly magnetic. | Massive | Alkali-basaltic composition, enriched Ba content |
| Felsic intrusions of unknown affinity | Quartz-rich granitoid | northwest | Fine-grained, equigranular, leucocratic. | Massive | |
| Mafic intrusions of unknown affinity | Diorite | east-northeast | Fine-grained, equigranular, mesocratic to melanocratic. | Massive to weakly foliated | Intermediate composition, La/Sm = 4.2-6.7, Tb/Lu = 2.4-3.5 |
| Trap dike swarm | Diorite | east-west | Fine-grained, equigranular, mesocratic. | Massive | High-Fe tholeiite, intermediate composition, La/Sm = 2.85-4.2, Tb/Lu = 1.77-2.4 |
| Nipissing Intrusive Suite (2219 to 2210 Ma ^b) | Gabbro | Sills in and at contacts of the HSG rocks; majority of the larger sills intruded at the contact between the McKim and Ramsay Lake formations. | Fine- to medium-grained, mesocratic; thicker intrusions (>250 m) are locally pegmatoidal and crudely layered with melanocratic basal zones. | Folded and weakly to strongly foliated | Group 1: High Cr, Ni and Cs content, high Mg (4-20 wt %), La/Sm = 2-5.2, Tb/Lu = 1.5-2.1 Group 2: Enriched Nb, Ta and Cs content, La/Sm = 2.7-5.9, Tb/Lu = 1.7-2.3 |
| Matachewan–Hearst dike swarm (2473 to 2455 Ma ^c) | Gabbro | northwest and northeast | Fine- to medium-grained, mesocratic, locally plagioclase-phyric | Pervasive, moderate to strong foliation | High-Fe tholeiite, gabbroic composition, low Ba and Cs content, La/Sm = 2.6-4.3, Tb/Lu = 1.5-2 |
| Drury Township intrusion (Historically assigned to the East Bull Lake Intrusive Suite, 2480 Ma ^d) | Anorthositic gabbro, gabbro | Occurs at the contact of the Ramsey–Algoma complex, HSG and SIC | Medium- to coarse-grained, locally pegmatoidal, varitextured, leucocratic | Variably deformed | Leucogabbroic composition, high Ba content, low Cs content, La/Sm = 2.4-5.1, Tb/Lu = 1.3-2.1 |
| Ramsey–Algoma granitoid complex (circa 2645 Ma ^e) | Monzogranite, granite and garnet-bearing granodiorite | Northern third of Drury Township | Medium- to coarse-grained, locally developed potassium feldspar megacrysts | Massive to moderately foliated | |

^aAge from Krogh et al. (1987).

^bAges from Noble and Lightfoot (1992), Corfu and Andrews (1986) and Gordon (2014).

^cAge from Heaman (1997).

^dAges from Krogh, Davis and Corfu (1984), James et al. (2002), Bleeker et al. (2012) and Bleeker et al. (2015).

^eAge from Kamo (2016).

Abbreviations: HSG – Huronian Supergroup; SIC – Sudbury Igneous Complex

was identified where the contacts of the Drury Township intrusion were not sheared. In general, igneous layering typical of other East Bull Lake Suite intrusions was not identified. This may be due to exposure and the fact that the intrusion has been significantly affected by deformation, regional metamorphism and/or SIC thermal metamorphism. The contact between the Drury Township intrusion and Ramsey–Algoma monzogranite is obscured by a zone of heterolithic Sudbury Breccia but is interpreted to be intrusive. The southern contact of the Drury Township intrusion is obscured by both Sudbury Breccia and the major east-trending mylonite zone. Large feldspar porphyry and granitic rafts up to 700 m in length, which likely originated from the Ramsey–Algoma complex, have been observed throughout the intrusion.

Matachewan Dike Swarm (Unit 4)

In the northern half of Drury Township, northwest- and northeast-trending mafic dikes (units 4a and 4b, respectively) crosscut the Drury Township intrusion and Archean basement. These mafic dikes are variably foliated, fine- to medium-grained, mostly equigranular and locally plagioclase-phyrlic (Photo 6A). Interestingly, the northwest- and northeast-trending mafic dikes are present in abundance north of the Superior–Southern provinces contact but appear to be absent in the Huronian Supergroup. This suggests that the dikes are Paleoproterozoic in age but predate deposition of the Huronian Supergroup. Based on similar petrographic and geochemical characteristics, the northeast- and northwest-trending mafic intrusions are both interpreted to be a part of the Matachewan dike swarm. Although the northeast trend for the Matachewan dike swarm in the Sudbury area is atypical, it is proposed that the northeast-trending mafic dikes might represent a small-scale, concentric dike swarm related to the Matachewan magmatic event.

In addition to the northwest- and northeast-trending mafic dikes, an east-trending mafic dike (unit 4c) was identified within the northwestern corner of Drury Township. The east-trending mafic dike is metamorphosed, intrudes the Ramsey–Algoma granitoid complex, is moderately magnetic and is moderately foliated. Overall, the east-trending mafic dike is similar in appearance to that of the other Matachewan dikes with the exception of trend and magnetic character. It has tentatively been classified as a Matachewan dike but has been assigned a unique map unit identifier, unit 4c.

Nipissing Intrusive Suite (Unit 11)

Several large and small, roughly east-trending, variably foliated and folded mafic sills, historically assigned to the Nipissing Intrusive Suite (e.g., Dressler 1984b, 1984c), are intrusive into the Huronian Supergroup rocks and Archean basement. Individual sills can reach up to 400 m in thickness and extend over 2 km in length. The larger sills typically occur near or at the contact between the Ramsay Lake and McKim formations. The larger sills are crudely differentiated, with medium- to coarse-grained gabbro (unit 11a) and melagabbro phases (unit 11b) (Photos 6B and 6C). Pegmatoidal and/or anorthositic pods occur within the thicker portions of sills (unit 11c) (Photo 6D). Smaller, narrower mafic sills consist of undifferentiated, fine-grained mesogabbro to melagabbro (unit 11d).

Trap Dike Swarm (Unit 19)

East-trending mafic dikes crosscut the Worthington Offset dike, Sudbury Breccia, Nipissing sills and Huronian Supergroup. They occur in abundance in the southern half of Drury Township and appear to crosscut folded and faulted Huronian Supergroup stratigraphy. The east-trending dikes are massive, fine-grained and equigranular (Photo 6E). Based on trend and field relationships, these mafic intrusions are believed to postdate the SIC event and are tentatively assigned to the Trap dike swarm (1750 Ma; cf. Bleeker et al. 2015).

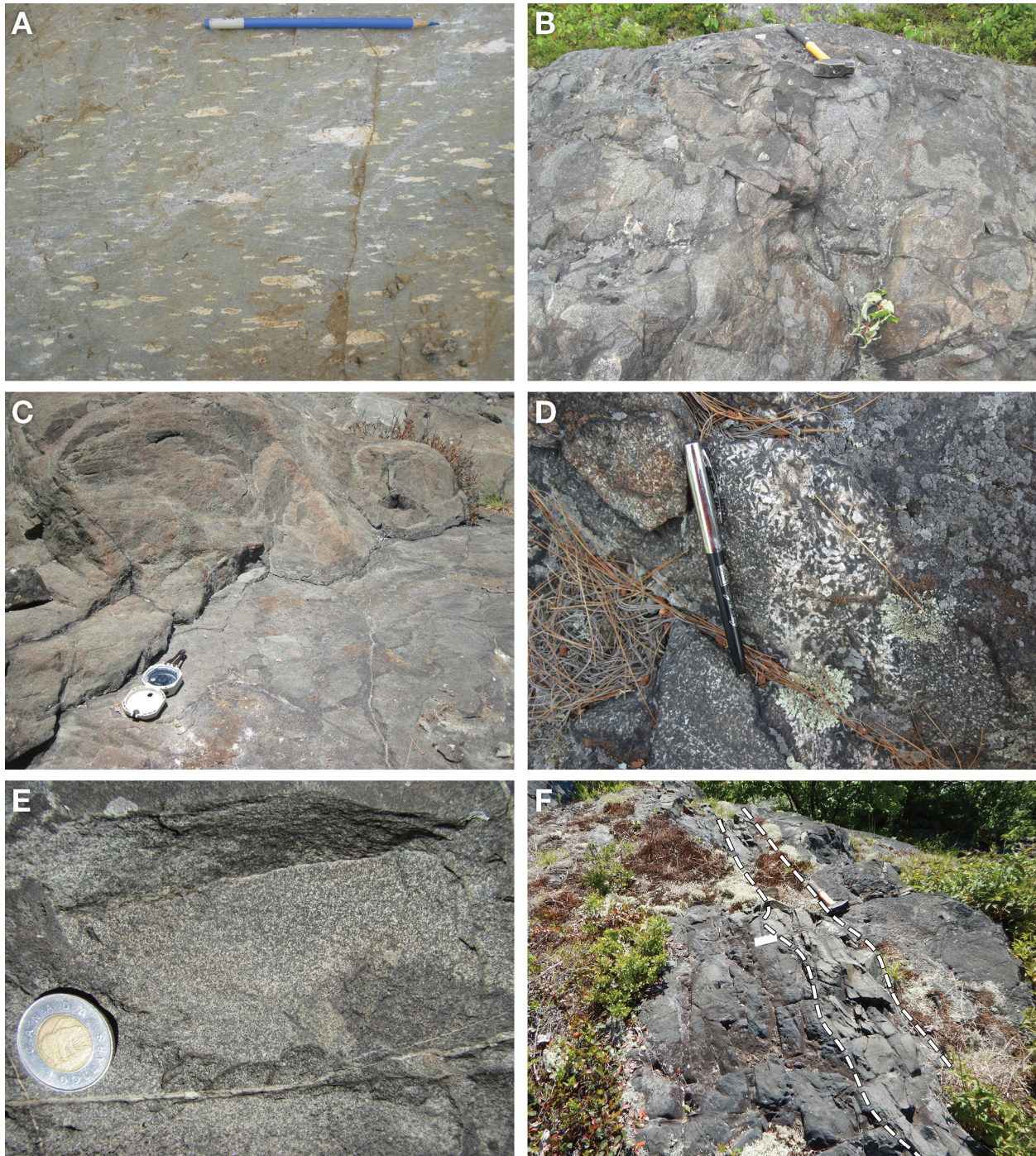


Photo 6. **A)** Foliated, plagioclase-phyric mafic dike (unit 4) of the Matachewan dike swarm; UTM 463808E 5141341N. **B)** Mesocratic gabbro of the Nipissing Intrusive Suite (unit 11); UTM 459144E 5137996N. **C)** Melanocratic gabbro of the Nipissing Intrusive Suite; UTM 457912E 5137823N. **D)** Mesocratic gabbro of the Nipissing Intrusive Suite, showing a coarse-grained, leucocratic patch; UTM 458738E 5137915N. **E)** Fine- to medium-grained diorite of the Trap dike swarm (unit 19); UTM 464109E 5136483N. **F)** Fine-grained mafic dike of unknown affinity (unit 20) (outlined) in sharp contact with host gabbro of the Nipissing Intrusive Suite; UTM 465923E 5137365N. Objects used for scale: hammer = 40 cm long; open compass = 14.5 cm long; colour pencil = 7 mm wide; pen = 9 mm wide; coin = 2.8 cm across. All UTM co-ordinates provided using NAD83 in Zone 17.

Mafic Dikes of Unknown Affinity (Unit 20)

Narrow, east-northeast–trending mafic dikes crosscut Archean basement, Nipissing sills and Huronian Supergroup strata throughout Drury Township. These east-northeast–trending mafic dikes appear to crosscut folded Nipissing sills and Huronian Supergroup stratigraphy. The mafic intrusions are fine- to medium-grained, locally plagioclase-phyric and are variably foliated (Photo 6F). The emplacement age of these mafic intrusions is not known. They may represent one or more magmatic events that occurred prior to and/or after the Sudbury impact event (1850 Ma). These east-northeast–trending mafic dikes have been distinguished from mafic intrusions of similar appearance and orientation (i.e., Trap dike swarm) based on geochemistry (*see* details below) and degree of deformation.

Sudbury Dike Swarm (Unit 22)

Undeformed, northwest-trending olivine gabbro dikes of the Sudbury dike swarm crosscut the Archean basement, Drury Township intrusion, Huronian Supergroup and Sudbury Igneous Complex-related units. The location, width and extent of the Sudbury dike swarm as shown on Map P.3823 (back pocket) is based on a combination of outcrop exposure, airborne magnetic data (where high-resolution geophysical data was available) and compiled data from Card (1965b). These dikes are fine- to medium-grained and locally plagioclase-phyric (phenocrysts up to 3 cm long) (Photo 7A). They have moderate to high magnetic susceptibility ($29\text{--}37 \times 10^{-3}$ SI units), which is unique for mafic intrusions in this area (*see* Table 4).

Structure

Multiple generations of deformation have been identified in Drury Township and are discussed below in the order of oldest to youngest. For additional information on deformation in Drury Township see G n reux, Lafrance and Gordon (2017), G n reux et al. (2016), Simard, Gordon and G n reux (2016), and Gordon, Simard and G n reux (2015).

BEDDING-PARALLEL THRUST FAULTS

Early deformation resulted in bedding-parallel thrust faults recognized in Drury Township on the basis of stratigraphic repetition and/or omission of specific Huronian Supergroup formations. This includes 1) McKim Formation at the southern and stratigraphic basal contact of a north-facing Matinenda Formation sequence (i.e., respectively younger formation below an older formation); 2) McKim–Ramsay Lake–McKim formation sequence (stratigraphic repetition); and 3) Mississagi–McKim formation sequence (Ramsay Lake Formation is absent). The thrust faults are folded along with Huronian Supergroup strata and therefore are interpreted to predate regional folding.

REGIONAL FOLDING AND FOLIATION

The present structural configuration of the Huronian Supergroup strata in Drury Township is strongly controlled by kilometre-scale, northeast-trending folds. These large-scale folds are related to the regional northeast- and east-trending fold structures in the Southern Province fold belt (i.e., Porter synclinorium, Baldwin anticlinorium, Agnew Lake anticline; cf. Card 1978). Adjacent to the Superior–Southern provinces unconformity in Drury Township, smaller scale folds are west-northwest to east-trending, which follows the orientation of the Superior–Southern provinces unconformity. Throughout Drury Township, the majority of Nipissing sills are folded by the regional fold structures, which indicates that folding postdated Nipissing magmatism. This supports regional tectonic interpretations that a significant

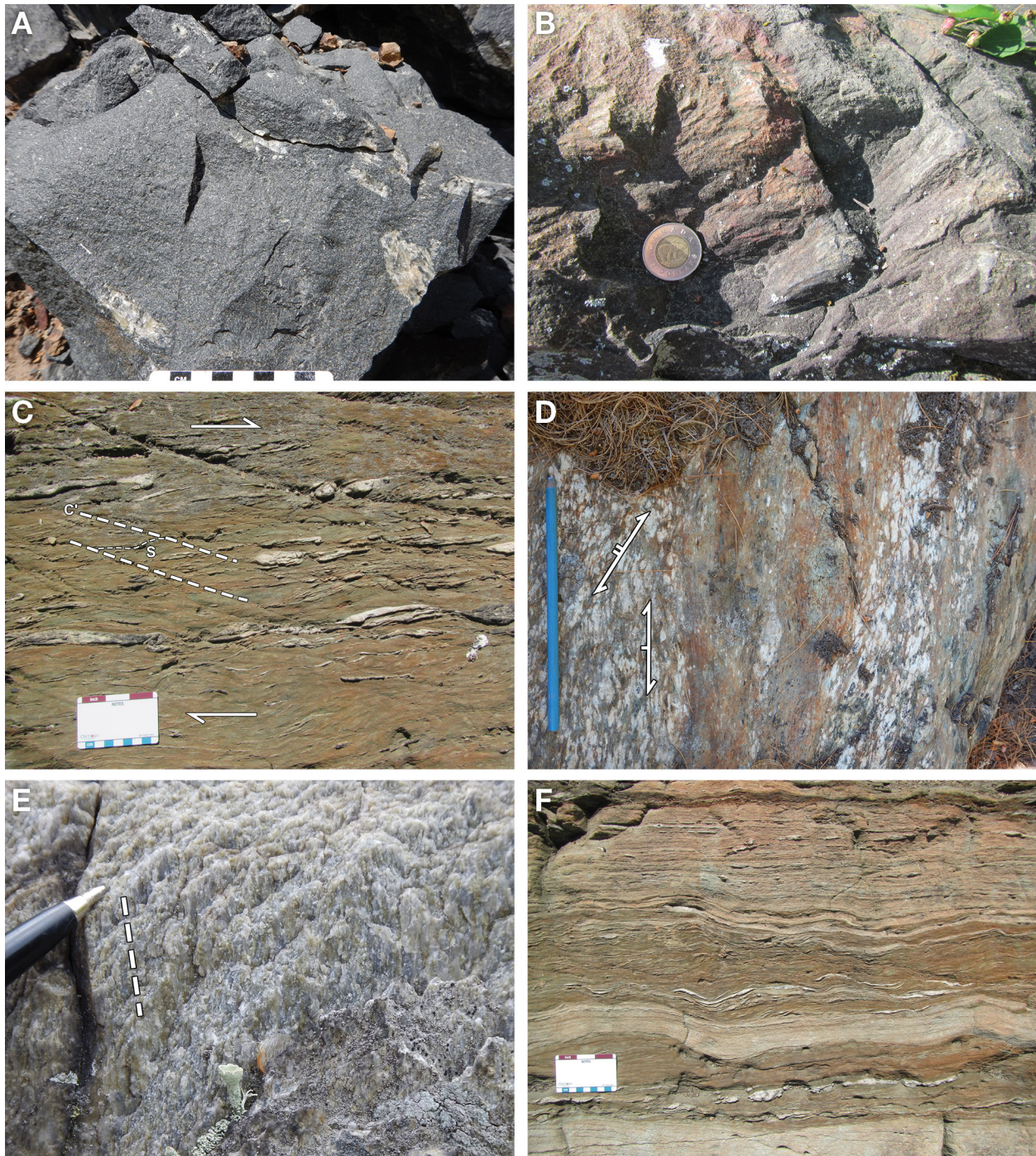


Photo 7. **A)** Plagioclase-phyric olivine gabbro of the Sudbury dike swarm (unit 22); UTM 465251E 5136623N. **B)** Shatter cones in quartz arenite of the Mississagi Formation; UTM 465595E 5136481N. **C)** Chlorite-rich ultramylonite (unit 18a) from the core of the Creighton–Victoria deformation zone mylonite showing dextral S-C' fabric; UTM 457340E 5141996N. **D)** Highly foliated to mylonitic anorthositic gabbronorite (unit 3) of the Drury Township intrusion at the northern edge of the Creighton–Victoria deformation zone mylonite; UTM 464684E 5141216N. **E)** Intense stretching lineation (dashed line) in subfeldspathic arenite of the Matinenda Formation (UTM 459266E 5140716N). **F)** Layered ultramylonite from the core of the Creighton–Victoria deformation zone mylonite; UTM 457340E 5141996N. Objects used for scale: coin = 2.8 cm across; pen = 9 mm wide; colour pencil = 7 mm wide. All UTM co-ordinates provided using NAD83 in Zone 17.

component of folding of Huronian Supergroup strata occurred after the emplacement of the Nipissing sills (Noble and Lightfoot 1992; Corfu and Andrews 1986; Card 1978; Bennett, Dressler and Robertson 1991; Easton 2006). In the southern portion of Drury Township, north-trending heterolithic Sudbury Breccia belts crosscut Mississagi Formation strata, but do not appear to be folded with the Mississagi Formation strata. This map pattern suggests folding started prior to the emplacement of the breccia belt, which is consistent with regional interpretations of deformation occurring prior to the SIC event in the Southern Province (Card et al. 1972; Rousell, Gibson and Jonasson 1997; Riller et al. 1999; Jackson 2001; Easton 2006). However, Sudbury Breccia veins are folded with Huronian Supergroup stratigraphy along smaller scale northwest- and east-trending folds adjacent to the Superior–Southern provinces unconformity. The breccia matrix is also strongly foliated which indicates deformation continued after the emplacement of Sudbury Breccia.

A moderate to strong regional foliation is ubiquitous throughout all units of the Huronian Supergroup in Drury Township, and is axial planar to regional folds and associated parasitic folds. In many exposures, regional foliation is overprinted by a second, moderately to strongly developed foliation, that forms an approximately 10 to 30° angle anticlockwise to the regional foliation.

IMPACT-RELATED STRUCTURES

Structures associated with the Sudbury impact event (1850 Ma) include:

- 1) Sudbury Breccia – A significant amount of Sudbury Breccia was recognized throughout Drury Township in all rock units older than *circa* 1850 Ma. Sudbury Breccia typically occurs at, but is not restricted to, lithologic and structural contacts. Most exposures of Sudbury Breccia are strongly foliated as a result of regional deformation that occurred after the SIC event, which rendered identification of internal structure and formal “classification” into different Sudbury Breccia types difficult. However, when less deformed, additional characteristics, such as flow-like structures, are preserved in the fine-grained breccia matrix (Photo 5B).
- 2) Shattercones – Shattercones were identified within arenites of the Mississagi Formation in the southeastern corner of Drury Township (Photo 7B) and are indicated on the map face. Most of the shattercones are presently oriented with apices dipping 45 to 65° to the northeast. No attempt has been made to determine the pre-deformation orientation of the shattercones.

CREIGHTON–VICTORIA DEFORMATION ZONE

Historically, post-Sudbury impact event ductile structures in Drury Township have been described as the southwestern extension of the greater than 50 km long by 1 to 10 km wide South Range shear zone (Shanks and Schwerdter 1991). This zone represents a northeast-trending, southeast-dipping zone of reverse shear that crosscuts the Sudbury Structure (Burrows and Rickaby 1930). In the southwestern corner of the Sudbury Structure, the South Range shear zone is further defined, by Dubois and Benn (2003), as a band of L-S tectonites bounded to the north by the Cameron Creek fault and to the south by the Creighton fault. Mapping in Drury Township confirmed the presence of a significant zone of ductile shear (cf. Gordon, Simard and Généreux 2015; Simard, Gordon and Généreux 2016; Généreux et al. 2016), but the trend and extent differs from that described by Shanks and Schwerdter (1991) and Dubois and Benn (2003). In Drury Township, a west-northwest– to east–trending mylonite zone, up to 500 m wide, is present along the contact between the Huronian Supergroup to the south and Archean granitoid basement – Drury Township intrusion – heterolithic Sudbury Breccia belt to the north. The boundary between the mylonite zone and its host rocks is relatively sharp in the granitoid rocks but more gradual in the Huronian Supergroup metasedimentary units, Drury Township intrusion and the breccia belt. The mylonite zone is continuous along strike across Drury Township. In the vicinity of Fairbank Lakes Road

(eastern Drury Township), the mylonite zone splays into an array of narrow shear zones that define a deformation corridor roughly bound by east-trending shear zones that align with the Creighton and Victoria faults to the east. This deformation corridor continues eastward through Denison Township (cf. Génèreux, Lafrance and Gordon 2017; Gordon and Génèreux 2017). The mylonite zone and the deformation corridor will henceforth be referred to as the Creighton–Victoria deformation zone (CVDZ).

The mylonite zone in the CVDZ is characterized by a strong west-northwest– to east–trending subvertical foliation, and a steeply plunging eastward-trending stretching lineation (Photos 7C, 7D and 7E). The 100 m wide core of the mylonite zone is strongly layered (ultramylonite; unit 18a, Photo 7F) and displays good shear sense indicators that correspond to dextral (horizontal) shearing in the west (Génèreux et al. 2016), and south-over-north dextral (oblique) shearing to the east (Génèreux, Lafrance and Gordon 2017). The mylonite zone is proposed to have formed as a result of at least 2 separate events: 1) south-over-north-dextral (oblique) shearing with mylonitization and development of a steeply plunging lineation, followed by 2) a dextral reactivation event (Génèreux et al. 2018; Génèreux, Lafrance and Gordon 2017; Génèreux et al. 2016). A polyphase deformation hypothesis is consistent with regional studies on the Creighton fault (Rousell, Gibson and Jonasson 1997; Zolnai, Price and Helmstaedt 1984). Adjacent to the southern contact of the CVDZ, Sudbury Breccia, Huronian Supergroup strata and Nipissing sills are folded by the aforementioned west-northwest– to east–trending folds and exhibit a strongly developed axial planar foliation which parallels that of the mylonite fabric. These west-northwest– to east–trending folds are interpreted to be coeval with the earlier shear zone formation event (Génèreux et al. 2018).

NORTHEAST- AND NORTHWEST-TRENDING FAULTS

Numerous faults, including the previously documented Fairbank Lake and Cameron Creek faults, crosscut the different units of Drury Township. Fault traces shown on the map face are based on a combination of displacement of marker units (such as the SIC), interpretation from airborne magnetic data (where high-resolution data was available) and data compiled from Card (1965b). Faults are subdivided into 2 groups based on orientation:

- 1) Northeast-trending faults – This fault group includes the Cameron Creek, Fairbank Lake (north and south branches), Chicago and Vermillion Lake faults as well as unnamed faults of similar orientation. These northeast-trending faults produce significant lateral and vertical offset of SIC-related rocks, Huronian Supergroup strata and Nipissing sills but do not affect the mafic dikes of the Sudbury dike swarm (*circa* 1238 Ma). Interestingly, there is no obvious offset of the CVDZ, but the northeast-trending faults do truncate both regional northeast-trending folds and the west-northwest- and east-trending fold structures interpreted to be coeval with CVDZ formation event (cf. Génèreux et al. 2018). This suggests brittle deformation postdates that of regional folding and the development of the CVDZ. Shanks and Schwedtner (1991) and Dubois and Benn (2003) also suggested northeast-trending brittle fault structures in this part of the Sudbury Structure post-date ductile shearing in the South Range shear zone.
- 2) Northwest-trending faults – Only one significant northwest-trending fault was identified in Drury Township, where folded rocks of the Mississagi Formation are juxtaposed against the Ramsey Lake and Pecors formations. The map pattern suggests the northwest-trending fault truncates folded Huronian Supergroup strata but does not appear to affect mafic rocks of the Worthington Offset dike or Trap dike swarm. However, numerous northwest-trending faults, most of which displace rocks of the SIC and related units, have been identified in adjacent townships (e.g., Denison Township; cf. Gordon and Génèreux 2017) and throughout the Sudbury Structure (cf. Dressler 1984a; Rousell 1984).

CRENULATION CLEAVAGE AND KINK BANDS

Rotation of regional foliation and mylonite fabric has resulted in localized, roughly north-northwest-trending, crenulation cleavage and kink bands. The crenulation cleavage and kink bands are particularly well developed in highly foliated sedimentary rocks of the Matinenda and McKim formations and overprint the CVDZ (Photos 8A and 8B). Most kink bands observed are S-shaped, or sinistral, with only a few conjugate sets forming centimetre-scale box-folds (Généreux et al. 2016). Throughout Drury Township, these outcrop-scale structures seem to be preferentially concentrated in areas defining north-trending corridors. Conversely, between these corridors, the density of these structures is significantly lower. However, these corridors do not appear to significantly influence the overall map pattern in Drury Township.

Geophysical Properties

Magnetic susceptibility measurements were collected throughout Drury Township using hand-held KT-10 magnetic susceptibility meters. Reported measurements for each lithology at individual outcrops is an average of 10 readings. Measurements of uranium, thorium and potassium were collected using hand-held gamma-ray scintillometers. All uranium, thorium and potassium data were recorded using a Radiation Solutions Inc. (RSI) RS-125 Super-SPEC gamma-ray spectrometer, serial number 2643, or a Radiation Solutions Inc. (RSI) RS-230 BGO Super-SPEC gamma-ray spectrometer, serial number 3592. Data were recorded using the assay mode with a 300-second count time. Data collected during the 2015 and 2016 field seasons are summarized in Tables 4 and 5. Full data sets are included in Gordon, Simard and Généreux (2018b).

MAGNETISM

Granitic rocks of the Ramsey–Algoma granitoid complex (unit 1) exhibit uniformly low magnetic susceptibility readings (0.03 to 3.5×10^{-3} SI units) with the exception of the feldspar porphyry rocks (unit 1c), which exhibit higher magnetic susceptibility readings (12.9 to 23.5×10^{-3} SI units). Quartz-rich granitic rocks of the unknown felsic intrusive dikes (unit 21) exhibit low magnetic susceptibility readings (0.1×10^{-3} SI units). Mafic rocks of the Drury Township intrusion (units 2 and 3), Matachewan dike swarm (unit 4), Nipissing Intrusive Suite (unit 11), Trap dike swarm (unit 19) and unknown mafic intrusive suite (unit 20) exhibit generally low magnetic susceptibility readings (0.2 to 2.8×10^{-3} SI units). Mafic rocks of the Sudbury dike swarm (unit 22) exhibit the only consistently high magnetic susceptibility readings (18.2 to 35.2×10^{-3} SI units) in comparison to the other mafic and intermediate intrusive rocks in Drury Township.

Granitic rocks of the SIC Main Mass granophyre (unit 17) gave consistently high magnetic susceptibility readings (16.3 to 31.7×10^{-3} SI units). Rocks of the Worthington Offset dike (unit 14) and Main Mass norite (unit 15) exhibit generally low magnetic susceptibility readings (0.2 to 1.9×10^{-3} SI units) outside of sulphide mineralized exposures. Rocks of the Main Mass quartz gabbro (unit 16) exhibit significant variation in magnetic susceptibility readings (1.2 to 18.2×10^{-3} SI units).

Magnetic susceptibility readings varied slightly among the different rock types of the Huronian Supergroup sedimentary formations but showed no systematic variation with stratigraphic height or formation. Arenites of the Matinenda (unit 6a), McKim (unit 7b), Ramsay Lake (unit 8d) and Mississagi (unit 10a) formations exhibit uniformly low magnetic susceptibility readings (0.02 to 0.4×10^{-3} SI units). Magnetic susceptibility readings of the sandy matrices of the conglomeratic units of the Matinenda (unit 6c) and Ramsay Lake formations (unit 8a, b and c) also exhibit low magnetic susceptibility readings (0.03 to 0.4×10^{-3} SI units). The siltstones and mudstones of the Matinenda (unit 6b), McKim (unit 7a) and

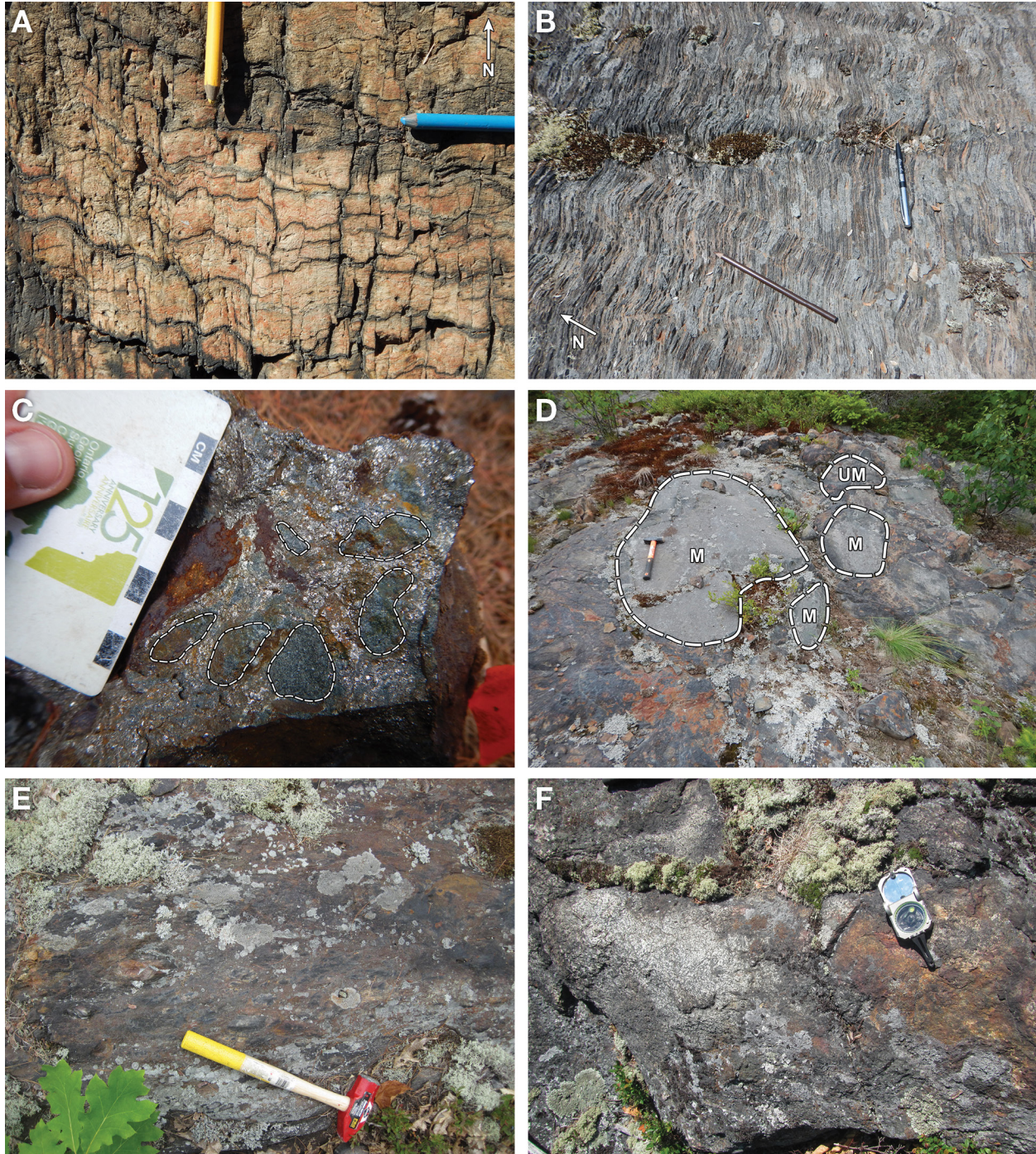


Photo 8. **A)** North-trending crenulation cleavage overprinting regional foliation in mudstones of the McKim Formation; UTM 458343E 5140053N. **B)** Strongly foliated mudstone of the McKim Formation showing well-developed kink bands; UTM 456399E 5141427N. **C)** Semi-massive sulphide mineralization enclosing mafic inclusions (white dashed outlines) in the inclusion-rich noritic breccia, SIC contact breccia type 1; UTM 460691E 5144145N. **D)** Mineralized inclusion-bearing quartz diorite of the Worthington Offset dike with numerous large mafic (“M”) and ultramafic (“UM”) inclusions (white dashed outlines); UTM 465801E 5137070N. **E)** Disseminated sulphide mineralization concentrated in a gossan zone in Sudbury Breccia; UTM 458097E 5140971N. **F)** Gossanous exposure of leucocratic patch within gabbro of the Nipissing Intrusive Suite; UTM 460635E 5138214N. Objects used for scale: hammer = 40 cm long; open compass = 14.5 cm long; colour pencil = 7 mm wide; pen = 9 mm wide. All UTM co-ordinates provided using NAD83 in Zone 17.

Table 4. Summary of magnetic susceptibility and scintillometer measurements from intrusive and Sudbury Igneous Complex-related rocks in Drury Township.

| Unit or Dike Swarm | Map Unit | Rock Type | Average Scintillometer Data | | | | Magnetic Susceptibility (x 10 ⁻³ SI units) | |
|--|----------|---------------------------------|-----------------------------|------------------------|-------------------------|-----|---|-----|
| | | | K (wt %) (min - max) | U (ppm) (min - max) | Th (ppm) (min - max) | n | Average (min - max) | n |
| Intrusive Units | | | | | | | | |
| Ramsey–Algoma granitoid complex | 1a,b | monzogranite, granite | 3.2 (0.8 - 5.4) | 4.4 (1.1 - 15.8) | 29.6 (4.4 - 81.3) | 43 | 0.2 (0.03 - 3.5) | 72 |
| | 1c | feldspar porphyry | --- | --- | --- | 0 | 18.7 (12.9 - 23.5) | 4 |
| Unknown felsic intrusive | 21 | quartz-rich granitoid | 0.8 | 3.6 | 12.2 | 1 | 0.1 | 1 |
| Drury Township intrusion | 2,3 | gabbro, leucogabbro | 0.5 (0.1 - 1.2) | 0.3 (0 - 1.1) | 2.3 (1 - 5.1) | 27 | 0.5 (0.2 - 2.8) | 46 |
| Matachewan dike swarm | 4a | gabbro, microgabbro | 0.6 (0.1 - 1.3) | 0.8 (0.1 - 1.7) | 2.8 (1.3 - 6.8) | 4 | 0.7 (0.4 - 1.3) | 17 |
| | 4b | gabbro, microgabbro | 0.5 (0.2 - 0.9) | 0.6 (0.0 - 1.4) | 3 (1.1 - 6.4) | 14 | 0.8 (0.4 - 2.2) | 21 |
| Nipissing Intrusive Suite | 11 | gabbro, melagabbro, microgabbro | 0.5 (0.0 - 1.5) | 0.7 (0.0 - 2.1) | 2.9 (0.5 - 7) | 107 | 0.6 (0.2 - 1.4) | 171 |
| Trap dike swarm | 19 | diorite | 1.2 (0.3 - 1.8) | 1.7 (0.4 - 2.7) | 6 (3.2 - 11.2) | 15 | 0.7 (0.5 - 0.8) | 14 |
| Unknown mafic intrusive | 20 | diorite | 1.2 (0.7 - 2) | 1.1 (0.2 - 2.4) | 5.7 (2.2 - 9.5) | 8 | 0.6 (0.4 - 0.8) | 10 |
| Sudbury dike swarm | 22 | olivine gabbro, microgabbro | 1.1 (0.6 - 1.6) | 0.9 (0.2 - 1.4) | 3.7 (1.3 - 5.8) | 22 | 27.5 (18.2 - 35.2) | 28 |
| Sudbury Igneous Complex – Main Mass and Offset dike | | | | | | | | |
| Main Mass granophyre | 17 | monzogranite | 1.0 (0.1 - 2.5) | 2.8 (2 - 3.3) | 14 (9 - 17.1) | 3 | 26.5 (16.3 - 31.7) | 3 |
| Main Mass quartz gabbro | 16 | quartz gabbro | 0.8 (0.7 - 1) | 1.4 (1 - 1.7) | 6.6 (4.1 - 9.4) | 4 | 8.7 (1.2 - 18.2) | 4 |
| Main Mass norite | 15 | quartz diorite | 1.2 (0.1 - 2.1) | 1.5 (0.2 - 4) | 6.3 (1.3 - 15.1) | 29 | 0.4 (0.2 - 1.9) | 31 |
| Worthington Offset dike | 14 | quartz diorite | 1.7 (0.4 - 2.8) | 2.1 (0.5 - 4.2) | 8.9 (3.2 - 14.2) | 11 | 0.6 (0.4 - 1.5) | 11 |

Abbreviations: K = potassium, U = uranium, Th = thorium, wt % = weight percent, ppm = parts per million, n = number of samples.

Notes: Magnetic susceptibility measurements were collected using hand-held KT-10 magnetic susceptibility meters. Reported measurements for each lithology at individual outcrops is an average of 10 readings. All uranium, thorium and potassium data were recorded using a Radiation Solutions Inc. (RSI) RS-125 Super-SPEC gamma-ray spectrometer, serial number 2643, or a Radiation Solutions Inc. (RSI) RS-230 BGO Super-SPEC gamma-ray spectrometer, serial number 3592. Data were recorded using the assay mode with a 300-second count time.

Table 5. Summary of magnetic susceptibility and scintillometer measurements from rocks of the Huronian Supergroup in Drury Township.

| Formation | Map Unit | Rock Type | Average Scintillometer Data | | | | Magnetic Susceptibility (x 10 ⁻³ SI units) | |
|--|----------|---|-----------------------------|------------------------|-------------------------|----|---|-----|
| | | | K (wt %) (min - max) | U (ppm) (min - max) | Th (ppm) (min - max) | n | Average (min - max) | n |
| Mississagi Formation | 10 | arenite | 1.7 (0.7 - 3.3) | 3.2 (0.3 - 13.1) | 9.2 (3.1 - 27.6) | 32 | 0.1 (0.04 - 0.3) | 34 |
| Pecors Formation | 9 | siltstone, mudstone | 2.5 (2.1 - 2.9) | 4 (3.4 - 4.5) | 14.9 (12.5 - 17.8) | 3 | 0.3 (0.3 - 0.5) | 4 |
| Ramsay Lake Formation | 8a,b,c | polymictic conglomerate, quartz pebble conglomerate, slightly conglomeratic sandstone | 2.1 (0.9 - 4.2) | 7.4 (2.8 - 13.2) | 21.1 (7 - 36.8) | 33 | 0.1 (0.05 - 0.4) | 41 |
| | 8d | arenite | 2 (0.2 - 3.8) | 4.4 (0.7 - 7.8) | 13.8 (4 - 22) | 18 | 0.2 (0.03 - 0.3) | 24 |
| McKim Formation | 7a | siltstone, mudstone | 2.0 (0.5 - 3.9) | 4.2 (0.9 - 8.0) | 14.4 (4.5 - 38.1) | 88 | 0.3 (0.1 - 0.5) | 103 |
| | 7b | arenite | 2.4 (0.8 - 4.8) | 4.7 (2.6 - 7.2) | 15.1 (10.5 - 26.9) | 10 | 0.2 (0.03 - 0.4) | 16 |
| Matinenda Formation* | 6a | arenite | 2.5 (0.6 - 4.6) | 8 (0.6 - 37.2) | 35 (2.3 - 143.4) | 38 | 0.1 (0.02 - 0.3) | 51 |
| | 6b | siltstone, mudstone | 1.8 (0.6 - 3.0) | 4.9 (3.9 - 6.0) | 14.7 (12.6 - 16.0) | 4 | 0.4 (0.2 - 0.6) | 9 |
| | 6c | quartz pebble conglomerate, slightly conglomeratic sandstone | 2.2 (0.4 - 3.5) | 17.5 (0.5 - 87.4) | 44.9 (3.4 - 142.7) | 6 | 0.04 (0.03 - 0.1) | 7 |
| Huronian Supergroup mafic volcanic rocks | 5a,b | basalt | 1.3 (1.0 - 1.8) | 1.1 (0.8 - 1.4) | 5.3 (4.5 - 6.2) | 3 | 0.57 (0.55 - 0.58) | 3 |

Abbreviations: K = potassium, U = uranium, Th = thorium, wt % = weight percent, ppm = parts per million, n = number of samples.

*Averages do not include measurements from U-Th occurrences or discretionary occurrences.

Notes: Magnetic susceptibility measurements were collected using hand-held KT-10 magnetic susceptibility meters. Reported measurements for each lithology at individual outcrops is an average of 10 readings. All uranium, thorium and potassium data were recorded using a Radiation Solutions Inc. (RSI) RS-125 Super-SPEC gamma-ray spectrometer, serial number 2643, or a Radiation Solutions Inc. (RSI) RS-230 BGO Super-SPEC gamma-ray spectrometer, serial number 3592. Data were recorded using the assay mode with a 300-second count time.

Pecors (unit 9) formations exhibit similar but overall slightly higher magnetic susceptibility readings than that of the arenite and conglomeratic units (0.1 to 0.6×10^{-3} SI units). Mafic volcanic rocks of the basal Huronian Supergroup (unit 5) gave uniform magnetic susceptibility readings (0.55 to 0.58×10^{-3} SI units).

RADIOMETRIC DATA

A narrow (up to a few metres wide) uranium- and thorium-rich horizon was identified in the Matinenda Formation through gamma-ray scintillometer-determined assay values collected on the ground. The mineralized lenses themselves are discontinuous, but the horizon can be traced for at least 3 km along strike and appears to be repeated through folding (*see* section on “Mineralization”). In addition to

identifying uranium and thorium anomalies in Drury Township, the hand-held scintillometer was a useful in-field tool in the discrimination between mafic and intermediate intrusive suites, felsic intrusive suites, rocks of the SIC, as well as in the stratigraphic correlation of the Matinenda Formation across Drury Township.

Based on similar potassium, uranium and thorium contents, the mafic and intermediate intrusive suites can be subdivided into 2 groups: 1) Drury Township intrusion (units 2 and 3), Matachewan dike swarm (unit 4) and Nipissing Intrusive Suite (unit 11); and 2) Trap dike swarm (unit 19), unknown mafic intrusive suite (unit 20) and Sudbury dike swarm (unit 22). In general, rocks of Group 1 contain lower potassium, uranium and thorium content than those of Group 2 (*see* Table 4). In comparison with mafic and intermediate rocks of the SIC, the Worthington Offset dike (unit 14), Main Mass norite (unit 15) and Main Mass quartz gabbro (unit 16), Group 1 rocks are lower in potassium and thorium content and Group 2 rocks are lower in thorium content (*see* Table 4). In comparison with the mafic volcanic rocks of the Huronian Supergroup (unit 5), Group 2 rocks exhibit similar potassium, uranium and thorium contents (*see* Tables 4 and 5).

There are significant differences in the potassium, uranium and thorium contents between the felsic rocks of the Ramsey–Algoma granitoid complex (unit 1), felsic dikes of unknown affinity (unit 21) and felsic rocks of the SIC Main Mass granophyre (unit 17). In general, the monzogranite and granitic rocks of the Ramsey–Algoma granitoid complex (unit 1) contain the highest potassium, uranium and thorium contents (*see* Table 4). The felsic dikes of unknown affinity (unit 21) and felsic rocks of the SIC Main Mass granophyre (unit 17) exhibit similar potassium, uranium and thorium contents, both of which are lower than that of the Ramsey–Algoma granitoid complex (*see* Table 4).

The potassium content of the Huronian Supergroup sedimentary formations in Drury Township exhibits minor variation but in general averages range from 1.7 to 2.5 weight %. Local arenite units of the Matinenda (unit 6a) and McKim (unit 7b) formations exhibit the highest readings of potassium (4.6 to 4.8 weight %). With respect to uranium and thorium content, the Mississagi (unit 10), Pecors (unit 9), Ramsay Lake (unit 8) and McKim (unit 7) formations, as well as siltstone units of the Matinenda Formation (unit 6b), are all uniformly low. Averages range from 3.2 to 7.4 ppm U and 9.2 to 21.1 ppm Th. However, typical uranium and thorium background ranges (i.e., outside of the uranium and thorium mineralized horizon) of the arenite and conglomeratic units of the Matinenda Formation (units 6a and 6c, respectively) are elevated overall compared to the other Huronian Supergroup formations. Averages range from 8.0 to 17.5 ppm U and 35 to 45 ppm Th.

Geochemistry

This section focusses on basic characterization of the metasedimentary and metavolcanic rocks of the Huronian Supergroup, mafic intrusions in Drury Township, and the mafic rocks of the Sudbury Igneous Complex (SIC). A comprehensive geochemical discussion is beyond the scope of this report and is not presented here. The purpose of this section is to highlight geochemical features that were used in combination with field, petrographic and geophysical properties to subdivide and classify the sedimentary formations and mafic rock suites in Drury Township. A summary of geochemical characteristics is included in Tables 1, 2 and 3. The full geochemical data set is included in Gordon, Simard and G n reux (2018b).

METASEDIMENTARY ROCKS

Matinenda Formation (Unit 6)

Samples of sandstone were collected from various stratigraphic levels throughout the Matinenda Formation. Compared to overlying Huronian Supergroup formations in Drury Township, arenites of the Matinenda Formation are generally enriched in potassium (Figure 2A). The titanium and aluminum contents are very similar to that of sandstones from the Ramsay Lake Formation (Figure 2B). Their average upper continental crust–normalized rare earth element (REE) profiles are characterized by light rare earth element (LREE) enrichment (Figure 3A). Negative Eu anomalies are common but not ubiquitous throughout the formation (*see* Figure 3A) and likely reflect horizons with accumulated monazite (Easton and Heaman 2011).

McKim Formation (Unit 7)

Samples of mudstone, siltstone, arenite and wacke were collected from various stratigraphic levels throughout the McKim Formation. Compared to metasedimentary units of the other Huronian Supergroup formations in Drury Township, the McKim Formation metasedimentary rocks are enriched in aluminum and titanium (*see* Figures 2A and 2B). Their average upper continental crust–normalized REE profiles are relatively flat with the exception of a few samples of the quartz-rich arenite, mudstone and siltstone beds, which exhibit slight depletion or enrichment in the LREE (Figures 3B, 3C and 3D).

Ramsay Lake Formation (Unit 8)

Samples were collected from the “grey”, “beige” and “sandy” members of the Ramsay Lake Formation in Drury Township. In general, each member exhibits lower potassium content than that of the metasedimentary rocks of the Matinenda and McKim formations, and lower titanium and aluminum

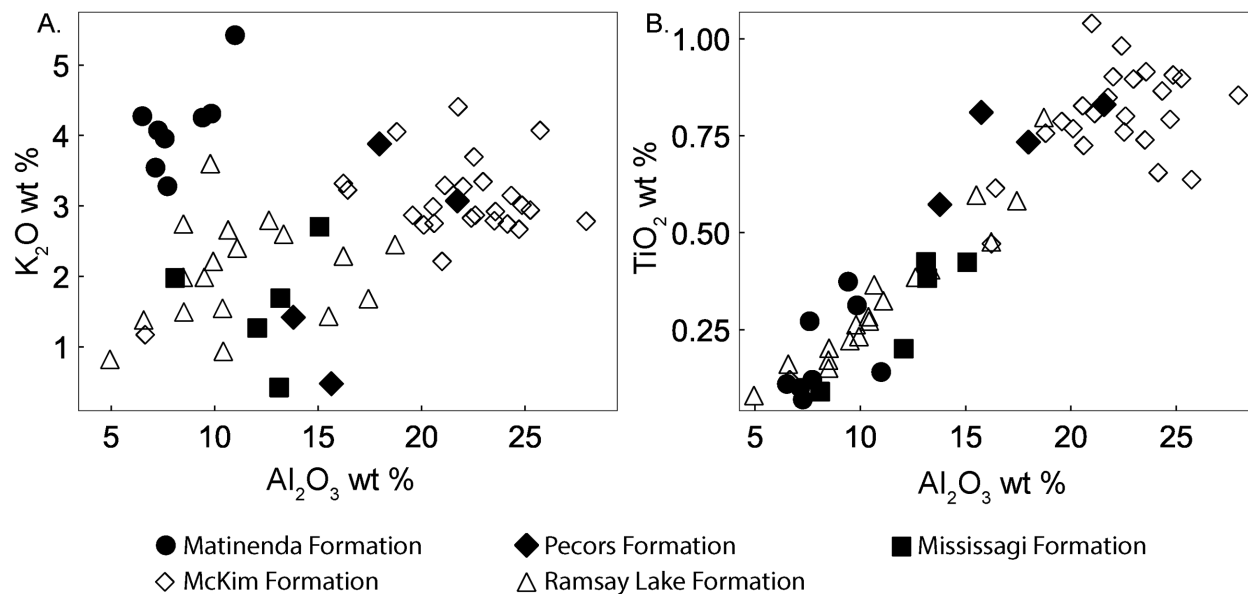


Figure 2. Major element binary diagrams for metasedimentary rocks of the Matinenda, McKim, Pecors, Ramsay Lake and Mississagi formations of the Huronian Supergroup. **A)** Al₂O₃ weight % vs. K₂O weight %. **B)** Al₂O₃ weight % vs. TiO₂ weight %.

content than that of metasedimentary rocks of the McKim Formation (*see* Figures 2A and 2B). The average upper continental crust–normalized REE profiles of arenite from sandy beds within the Ramsay Lake Formation are relatively flat with a few samples exhibiting LREE enrichment (Figure 3E). The average upper continental crust–normalized REE profiles of conglomeratic sandstones are highly varied (Figure 3F). The scatter is likely due to the presence of clasts in the conglomeratic units although sandy beds, with few to no visible clasts, were targeted for analysis.

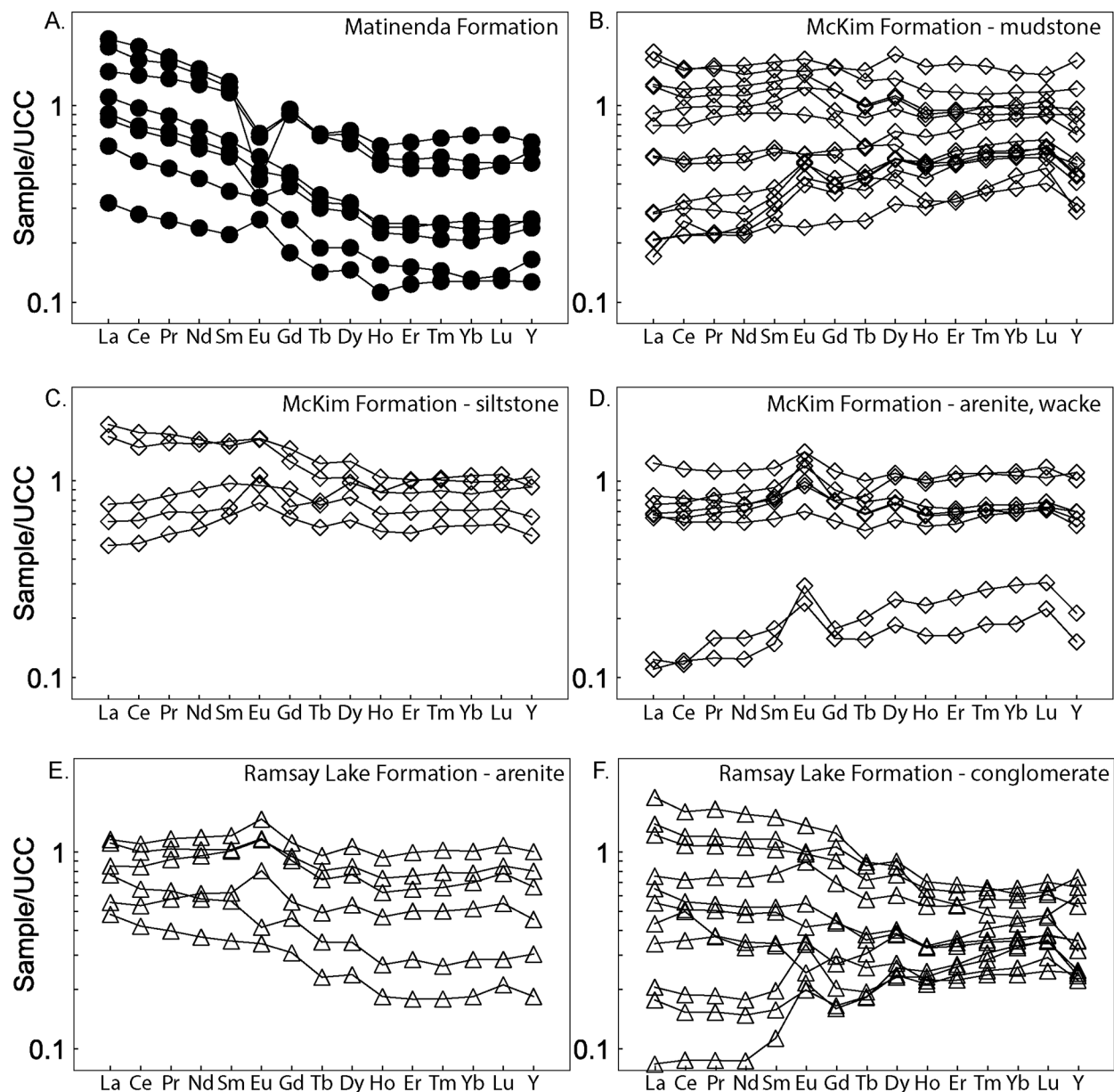


Figure 3. Average upper continental crust (UCC)–normalized rare earth element plots for metasedimentary rocks of the A) Matinenda Formation, B, C and D) McKim Formation, and E and F) Ramsay Lake Formation. Normalizing values are from Taylor and McLennan (1981).

Pecors Formation (Unit 9)

Mudstone and siltstone samples were collected from the Pecors Formation in Drury Township. In general, the metasedimentary rocks of the Pecors Formation are geochemically very similar to those of the McKim Formation with respect to titanium and aluminum content (*see* Figure 2B). However, the siltstones of the Pecors Formation are lower in potassium (*see* Figure 2A). The average upper continental crust-normalized REE profiles are overall very flat with variable depletion of the LREE (Figure 4A).

Mississagi Formation (Unit 10)

Sandstone samples were collected from various stratigraphic heights throughout the Mississagi Formation. In general, the metasedimentary rocks of the Mississagi Formation are geochemically similar to those of the Ramsay Lake Formation in terms of potassium, titanium and aluminum content (*see* Figures 2A and 2B). The average upper continental crust-normalized REE profiles are relatively flat and exhibit slight depletion in the LREE (Figure 4B).

METAVOLCANIC AND SUBVOLCANIC ROCKS (Unit 5)

Two samples were collected from the small amount of preserved metavolcanic rocks in eastern Drury Township (units 5a, 5b). The metavolcanic rocks exhibit geochemical characteristics consistent with alkalic basalt and basaltic trachyandesite compositions (Figure 5). The mantle-normalized trace element patterns are characterized by enrichment in incompatible lithophile elements Cs, Tl, Rb, Ba, Th, U and light rare earth elements (LREE, La to Eu), relative to moderately incompatible lithophile elements Y and heavy rare earth elements (HREE, Gd to Lu), with positive Ba and negative Nb, Ta and Ti anomalies (Figure 6A). Metavolcanic rocks are geochemically distinct from other mafic suites in Drury Township by their alkalic character and highly fractionated REE profiles (*see* Figures 5, 6A and 7).

One sample was collected of a mafic enclave from the pepperite exposure (unit 5c) in south-central Drury Township. The mafic enclave exhibits geochemical characteristics consistent with subalkalic, basaltic andesite compositions (*see* Figure 5). The mantle-normalized trace element pattern is characterized by enrichment in incompatible lithophile elements Cs, Tl, Rb, Ba and LREE, relative to moderately incompatible lithophile elements Y and HREE, with positive Ba and negative Th, U, Nb and Ta anomalies (Figure 6A). Interestingly, the trace element pattern is nearly indistinguishable from that of the metavolcanic rocks and mafic intrusions of unknown affinity (unit 20) (*see* Figures 6A and 6B). The mafic enclave from the pepperite exposure is geochemically distinct from other mafic suites in Drury Township by its subalkalic character coupled with the highly fractionated REE profile (*see* Figures 5, 6A and 7).

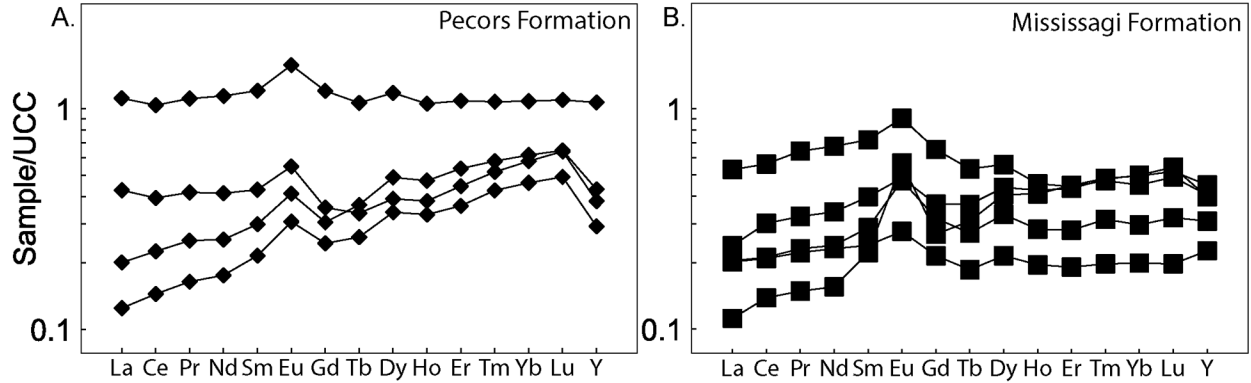


Figure 4. Average upper continental crust (UCC)-normalized rare earth element plots for metasedimentary rocks of the A) Pecors Formation and B) Mississagi Formation. Normalizing values are from Taylor and McLennan (1981).

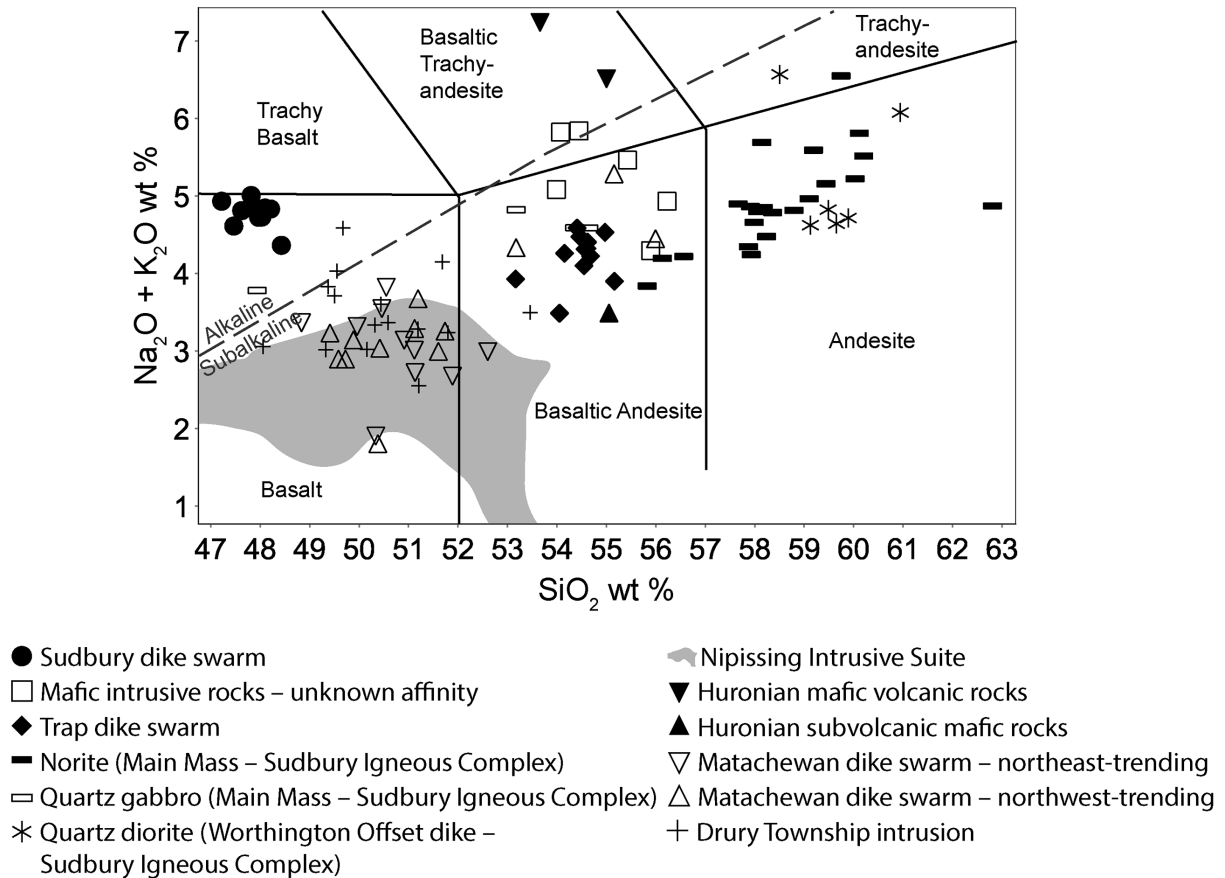


Figure 5. Total alkalis versus SiO_2 (TAS) diagram (after Le Bas et al. 1986) for mafic rock suites in Drury Township. Dotted line distinguishes alkaline field from subalkaline field. The whole rock chemical composition of rocks from the Huronian Supergroup (volcanic and subvolcanic), Matachewan dike swarm (northeast- and northwest-trending dikes), Sudbury dike swarm, Trap dike swarm and mafic intrusive rocks of unknown affinity are interpreted to be representative of the parental melt composition (i.e., noncumulate rocks). Rocks of the Sudbury Igneous Complex, Drury Township intrusion and Nipissing Intrusive Suite are not representative of the parental melt composition but are included on the TAS diagram for the sole purpose of comparison of Si content to that of the other mafic suites. Shaded field indicates area occupied by samples of the Nipissing Intrusive Suite. Only samples with < 0.2 weight % sulphur and less than 3 weight % loss on ignition are included on the diagram.

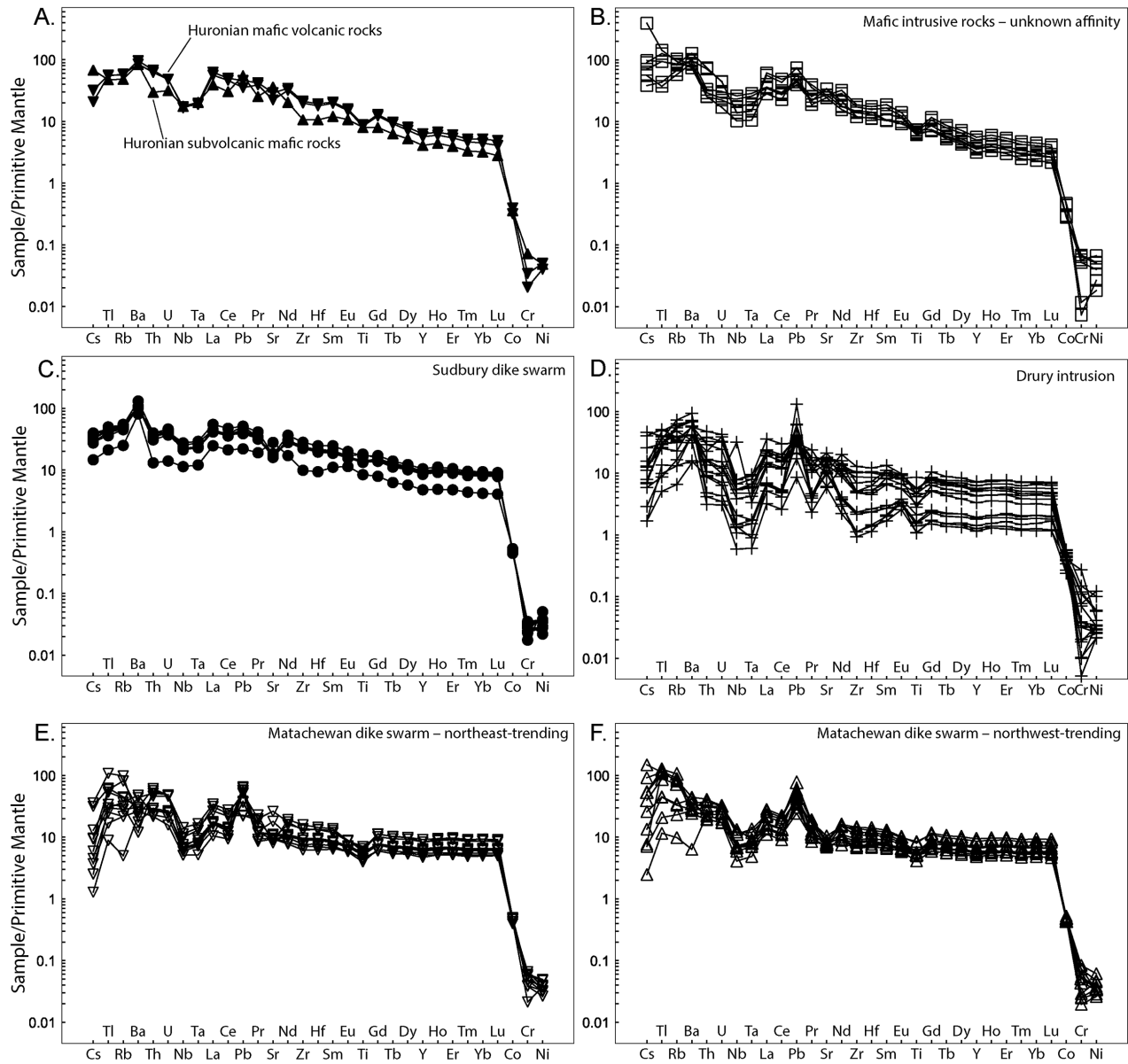
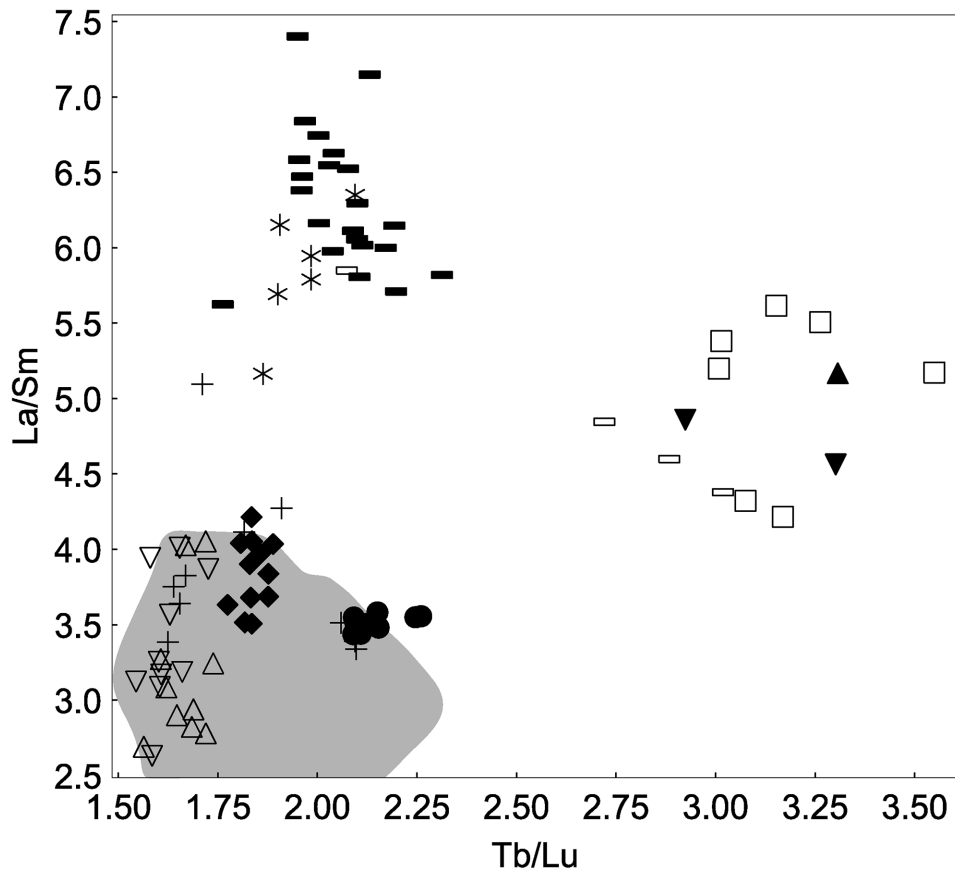


Figure 6. Primitive mantle-normalized trace element plots for mafic rocks of the **A)** Huronian Supergroup (volcanic and subvolcanic), **B)** mafic intrusive rocks of unknown affinity, **C)** Sudbury dike swarm, **D)** Drury Township intrusion, **E)** Matachewan dike swarm (northeast-trending dikes), and **F)** Matachewan dike swarm (northwest-trending dikes). Normalizing values are from Sun and McDonough (1995). Only samples with less than 0.2 weight % sulphur and less than 3 weight % loss on ignition are included on the diagrams.



- Sudbury dike swarm
- Mafic intrusive rocks – unknown affinity
- ◆ Trap dike swarm
- Norite (Main Mass – Sudbury Igneous Complex)
- ◻ Quartz gabbro (Main Mass – Sudbury Igneous Complex)
- * Quartz diorite (Worthington Offset dike – Sudbury Igneous Complex)
- Nipissing Intrusive Suite
- ▼ Huronian mafic volcanic rocks
- ▲ Huronian subvolcanic mafic rocks
- ▽ Matachewan dike swarm – northeast-trending
- △ Matachewan dike swarm – northwest-trending
- + Drury Township intrusion

Figure 7. Tb/Lu *versus* La/Sm for mafic rocks of the Huronian Supergroup (volcanic and subvolcanic), Drury Township intrusion, Matachewan dike swarm (northeast- and northwest-trending dikes), Nipissing Intrusive Suite, Sudbury dike swarm, Trap dike swarm, mafic intrusive rocks of unknown affinity, and norite, quartz gabbro and quartz diorite of the Sudbury Igneous Complex. Shaded field indicates area occupied by samples of the Nipissing Intrusive Suite. The Tb/Lu *versus* La/Sm plot is used here to highlight the relative enrichment in the light rare earth elements and relative depletion in the heavy rare earth elements demonstrated by the primitive mantle-normalized rare earth element profiles shown in Figures 6, 9 and 10. Samples that are enriched in light rare earth elements will have high La/Sm. Samples that are depleted in the heavy rare earth elements will have high Tb/Lu. Only samples with less than 0.2 weight % sulphur and less than 3 weight % loss on ignition are included on the diagram.

ALKALIC MAFIC INTRUSIONS

Sudbury Dike Swarm (Unit 22)

Olivine gabbro of the Sudbury dike swarm exhibit geochemical characteristics consistent with alkalic basalt compositions (*see* Figure 5). Their primitive mantle–normalized patterns are characterized by slight enrichment in incompatible lithophile elements Cs, Tl, Rb, Th, U and LREE, relative to moderately incompatible lithophile elements Y and the HREE, with negative Nb and Ta anomalies, and a distinct positive Ba anomaly (*see* Figure 6C). Compared to the other mafic intrusions in Drury Township, rocks of the Sudbury dike swarm are distinguished geochemically by their alkalic character, high Ba content, low Si content and moderately fractionated REE profile (*see* Figures 5, 6C and 7).

SUBALKALIC MAFIC INTRUSIONS

Drury Township Intrusion (Units 2 and 3)

Leucogabbroic and gabbroic rocks of the Drury Township intrusion are of broadly basaltic geochemical affinity (Prevec and Baadsgaard 2005; *see* Figure 5). Their primitive mantle–normalized trace element profiles display a significant range in the absolute amount of trace elements (Figure 6D). This range is reflective of the cumulate nature of the Drury Township intrusion. However, what is important is that the profiles exhibit a relatively consistent pattern, which is characterized by enrichment in incompatible lithophile elements Tl, Rb, Th, U and LREE, relative to moderately incompatible lithophile elements Y and the HREE, with positive Pb and Ba anomalies, and negative Cs, Nb, Ta and Ti anomalies (*see* Figure 6D). Rocks of the Drury Township intrusion can be distinguished geochemically from many of the other mafic suites in Drury Township by their moderately fractionated REE profiles (*see* Figure 7). Where the REE profiles fall within the same range as that of other mafic intrusions (Matachewan dike swarm, Nipissing Intrusive Suite, Trap dike swarm; *see* Figure 7), the Drury Township intrusion can be distinguished from the Nipissing Intrusive Suite and Matachewan swarm by its enriched Ba content coupled with Cs depletion, and from the Trap dike swarm by its lower silica content (*see* Figures 6 and 5).

Matachewan Dike Swarm (Unit 4)

The northwest- and northeast-trending mafic dikes of the Matachewan dike swarm in Drury Township (units 4a and 4b, respectively) exhibit indistinguishable major and trace element geochemistry (Figures 5 to 8). Samples from the northwest- and northeast-trending Matachewan dikes are of basaltic or gabbroic composition and exhibit high Fe tholeiitic affinities (*see* Figures 5 and 8). The primitive mantle–normalized trace element profiles are characterized by enrichment in the incompatible lithophile elements Tl, Rb, Th, U and LREE, relative to moderately incompatible lithophile elements Y and HREE, with positive Pb, and negative Cs, Ba, Nb, Ta and Ti anomalies (Figures 6E and 6F). Rocks of the Matachewan dike swarm are distinguished geochemically from many of the other mafic suites in Drury Township by their weakly fractionated REE profiles (*see* Figure 7). Where the REE profiles fall within the same range as that of other tholeiitic mafic intrusions (Drury Township intrusion, Nipissing Intrusive Suite; *see* Figure 7), the Matachewan dike swarm is distinguished by its depleted Ba and Cs content (*see* Figures 6D, 6E and 6F).

Nipissing Intrusive Suite (Unit 11)

Samples from the mesocratic and melanocratic gabbroic phases of the Nipissing sills contain Mg content that ranges from 3.5 weight % in the most leucocratic phases to 20 weight % in the melanocratic phases,

which is significantly more magnesian than other mafic intrusive suites in Drury Township (Figure 8). The primitive mantle–normalized trace element patterns are quite varied. However, 2 geochemically distinct groups have been identified within the Nipissing Intrusive Suite in Drury Township to date and are discussed below.

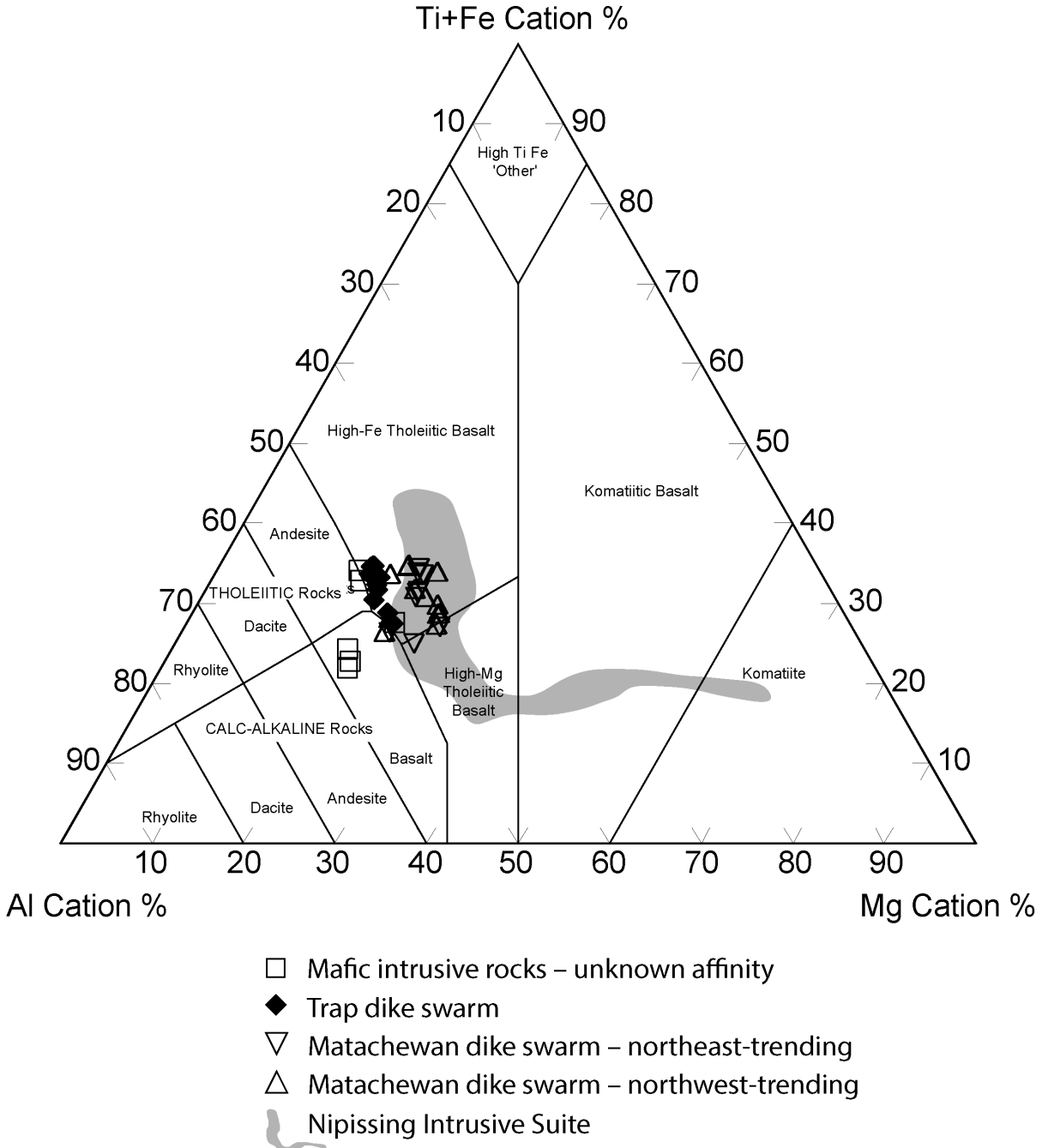


Figure 8. Jensen cation diagram (Jensen 1976) for mafic rocks of the Trap and Matachewan dike swarms (northeast- and northwest-trending dikes) and mafic intrusions of unknown affinity. Subalkaline mafic suites where the whole rock chemical composition is interpreted to be representative of the parental melt composition (i.e., noncumulate rocks) are plotted. Only samples with less than 0.2 weight % sulphur and less than 3 weight % loss on ignition are included on the diagram.

GROUP A

The primitive–normalized trace element profiles of Group 1 are characterized by enrichment in the incompatible lithophile elements Tl, Rb, Th, U and LREE, relative to moderately incompatible lithophile elements Y and HREE, with a strong positive Cs anomaly, and negative Ba, Nb, Ta, Sr and Ti anomalies of variable magnitude (Figure 9A). The strong positive Cs anomaly appears to be a distinctive characteristic of the Nipissing Intrusive Suite in Drury Township, with the exception of samples collected from within or adjacent to the CVDZ, which display flat to negative Cs anomalies and significant scatter in Tl, Rb and Ba (Figure 9B). The negative Cs anomaly and scatter in Tl, Rb and Ba, is likely the result of alteration within and adjacent to the CVDZ. Compared to other mafic suites in Drury Township, the majority of rocks from this group are relatively enriched in Cr and Ni (*see* Figures 9A and 6).

GROUP B

This group is distinct from all mafic rock suites in Drury Township by the lack of an Nb-Ta anomaly on the primitive mantle–normalized trace element profile (Figures 9C and 9D). The primitive mantle–normalized trace element profiles of Group 2 are characterized by enrichment in the incompatible lithophile elements Cs, Tl, Rb, Th, U, Nb, Ta and LREE, relative to moderately incompatible lithophile elements Y and HREE, with positive Pb and negative Sr anomalies of variable magnitude (Figure 9C). Again, the positive Cs anomaly appears to be a unique characteristic of the Nipissing mafic sills, with the exception of samples collected from within or adjacent to the CVDZ (*see* Figures 9C and 9D).

Trap Dike Swarm (Unit 19)

Mafic intrusions of the Trap dike swarm are high-Fe tholeiites with compositions consistent with basaltic andesites or diorites (*see* Figures 5 and 9). The primitive mantle–normalized trace element profiles are characterized by enrichment in the incompatible lithophile elements Tl, Rb, Th, U and LREE, relative to moderately incompatible lithophile elements Y and HREE, with positive Pb and negative Ba, Nb, Ta, and Ti anomalies of variable magnitude (*see* Figure 9E). Rocks of the Trap dike swarm are distinguished geochemically from the other mafic suites in Drury Township by their intermediate compositions and moderately fractionated REE profiles (*see* Figures 5 and 7).

Mafic Intrusions of Unknown Affinity (Unit 20)

This suite of mafic intrusions, although virtually indistinguishable in the field from the Trap dikes, possesses a distinctive geochemical signature. Most samples plot within the subalkalic field on a total-alkali-silica (TAS) diagram but have a range that extends to the boundary with the alkaline field (*see* Figure 5). They are intermediate in composition, with most samples plotting in the basaltic andesite or diorite field (*see* Figure 5). Their primitive mantle–normalized trace element patterns are characterized by overall enrichment in incompatible lithophile elements Cs, Tl, Rb, Th, U and LREE, relative to moderately incompatible lithophile elements Y and HREE, with positive Ba and Pb, and negative Nb, Ta and Ti anomalies (*see* Figure 6B). One sample exhibits strong enrichment in Cs (*see* Figure 6B). The most distinctive geochemical feature of these mafic intrusions is the significant depletion in the HREE compared to all other mafic intrusive suites in Drury Township (*see* Figure 7). Interestingly, the REE content is very similar to that of the much older, Huronian Supergroup metavolcanic and subvolcanic rocks (*see* Figure 7).

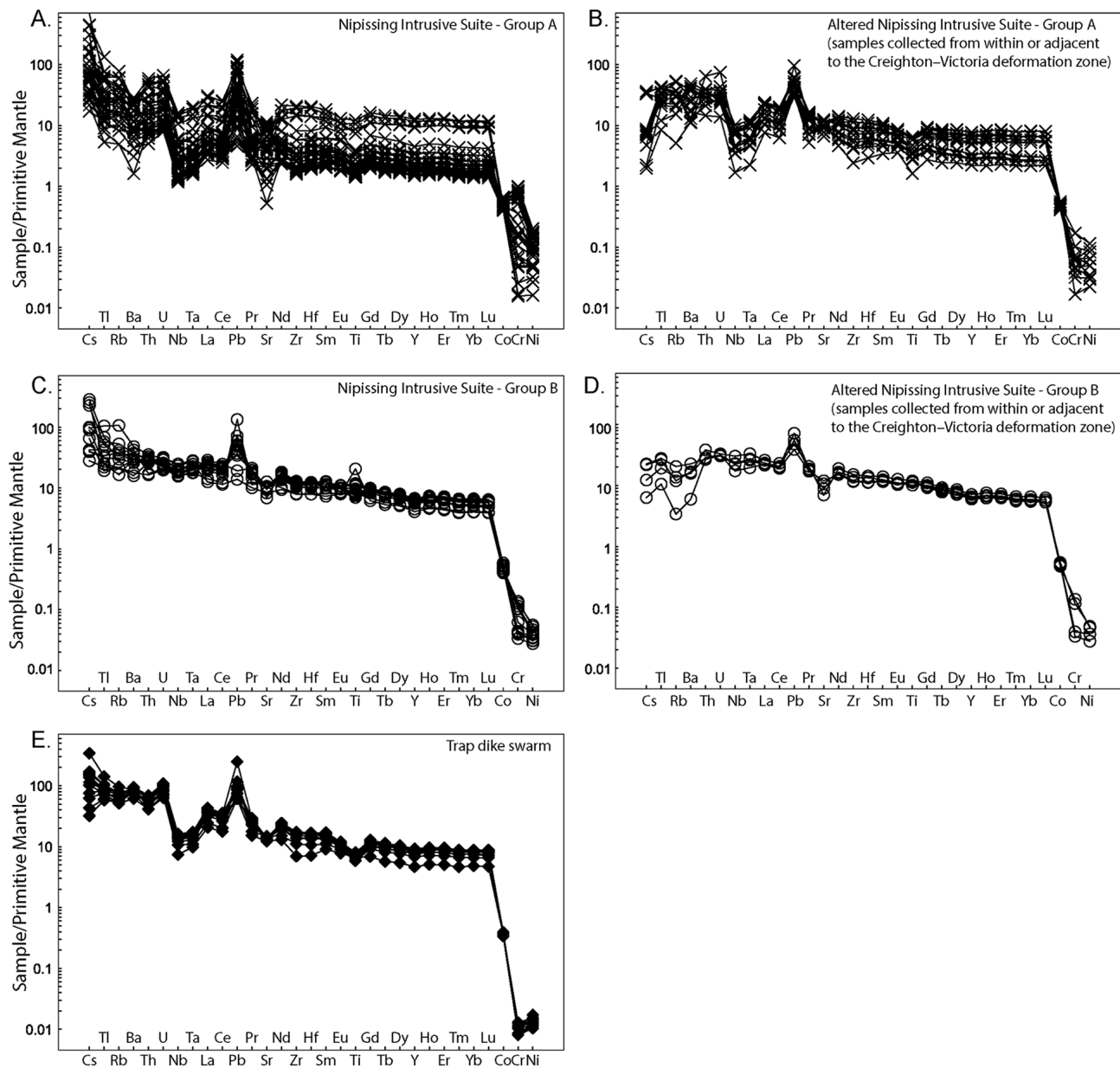


Figure 9. Primitive mantle-normalized trace element plots for mafic rocks of the **A, B, C** and **D**) Nipissing Intrusive Suite, and **E**) Trap dike swarm. Normalizing values are from Sun and McDonough (1995). Only samples with less than 0.2 weight % sulphur and less than 3 weight % loss on ignition are included on the diagrams.

SUDBURY IGNEOUS COMPLEX

The Sudbury Igneous Complex (SIC) has been the focus of numerous geochemical studies. It is generally accepted that the SIC formed through differentiation of an impact melt sheet of intermediate to felsic, generally granodioritic, composition (Therriault, Fowler and Grieve 2002).

Main Mass (Units 15 and 16)

SOUTH RANGE NORITE (Unit 15)

Rocks of the South Range norite are silica-rich compared to mafic suites not related to the SIC in Drury Township (*see* Figure 5), which is consistent with their more intermediate, monzogabbroic compositions (cf. Therriault, Fowler and Grieve 2002). The primitive mantle-normalized trace element profiles are characterized by enrichment in the incompatible lithophile elements Tl, Rb, Th, U and LREE, relative to moderately incompatible lithophile elements Y and HREE, with positive Pb and negative Cs, Nb, Ta and Ti anomalies (Figure 10A). The South Range norite is distinguished geochemically from other mafic suites in Drury Township by high La/Sm (*see* Figure 7).

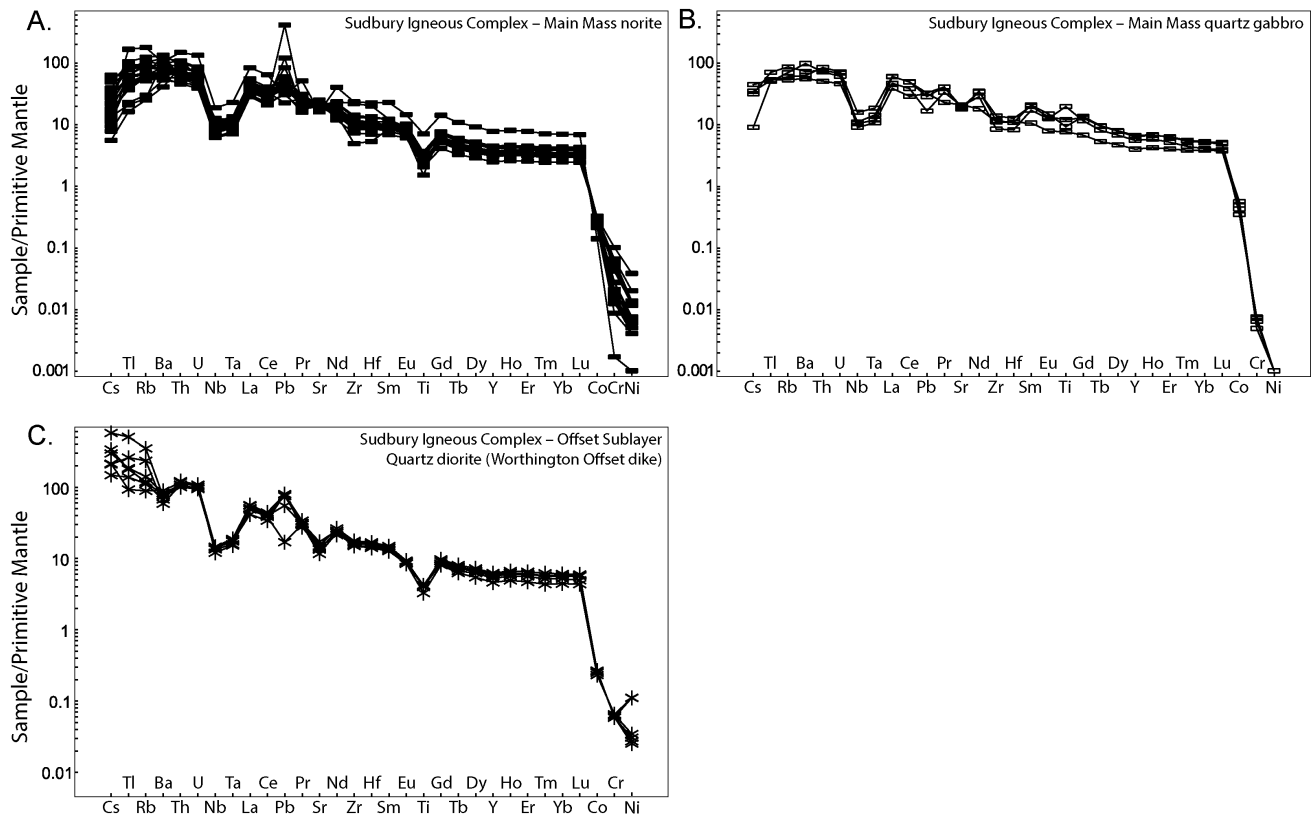


Figure 10. Primitive mantle-normalized trace element plots for mafic rocks of the Sudbury Igneous Complex: **A)** Norite (Main Mass), **B)** Quartz gabbro (Main Mass), and **C)** Quartz diorite (Worthington Offset dike). Normalizing values are from Sun and McDonough (1995). Only samples with less than 0.2 weight % sulphur and less than 3 weight % loss on ignition are included on the diagram. Note that the y axis on diagrams A and B are a different scale than that of diagram C.

TRANSITION ZONE QUARTZ GABBRO (Unit 16)

Rocks of the transitional quartz gabbro have silica content more consistent with intermediate to mafic compositions (*see* Figure 5). The primitive mantle–normalized trace element profiles of the quartz gabbro are characterized by enrichment in the incompatible lithophile elements Tl, Rb, Th, U and LREE, relative to moderately incompatible lithophile elements Y and HREE, with negative Cs, Pb, Nb and Ta anomalies (*see* Figure 10B). Interestingly, the REE profiles of the quartz gabbro exhibit a lower La/Sm and higher Lu/Tb than that of the South Range norite (*see* Figure 7). The transitional quartz gabbro unit is distinguished from most other mafic suites in Drury Township by high Tb/Lu and low Ni content (*see* Figures 7 and 10B).

Worthington Offset Dike (Unit 14)

Rocks from the quartz diorite matrix of the Worthington Offset dike exhibit major and trace element geochemical characteristics that are similar to that of the South Range norite (*see* Figures 5 and 7). The primitive mantle–normalized trace element profiles are characterized by enrichment in the incompatible lithophile elements Cs, Tl, Rb, Th, U and LREE, relative to moderately incompatible lithophile elements Y and HREE, with positive Pb, and negative Ba, Nb, Ta, Sr and Ti anomalies of varied magnitude (Figure 10C). Compared to the South Range norite, the quartz diorite is comparatively enriched in Cs, Tl, Cr and Ni (*see* Figure 10C). The quartz diorite unit is distinguished from other mafic suites not related to the SIC in Drury Township by high La/Sm and overall high REE content (*see* Figures 7 and 10C).

Geochronology

Geochronology results of samples collected from the Ramsey–Algoma granitoid complex, late felsic dikes and metasedimentary rocks of the Huronian Supergroup as part of this project are discussed in this section. In addition to what is presented below, samples were collected from the Drury Township intrusion, a Nipissing sill and a northeast-trending Matachewan mafic dike for the purpose of obtaining emplacement ages. Unfortunately, the mafic intrusion samples did not yield sufficient material to analyze. Prevec (1993) had attempted to determine an emplacement age for the Drury Township intrusion but recovered shocked zircons that yielded an age of 1855 ± 10 Ma. The locations of all samples collected for geochronology are indicated on Map P.3823 (back pocket). The location for the Prevec (1993) sample is approximate. The “map reference” numbers provided in this section correspond to numbers beside the sample location symbols on the map face of Map P.3823.

RAMSEY–ALGOMA GRANITOID COMPLEX (Unit 1)

The transition between the Cartier and Birch Lake batholiths of the Ramsey–Algoma granitoid complex is reportedly within Drury Township, but the placement of the contact between the 2 batholiths has not been specifically determined (Tolman 1929; Meldrum et al. 1997). A medium-grained, pink monzogranite collected in the northwestern corner of Drury Township was selected for geochronology using isotope dilution thermal ionization mass spectrometry (ID-TIMS) to determine the age of felsic plutonism and compare it with the age of the Cartier and Birch Lake batholiths. The monzogranite sample yielded discordant U/Pb zircon ages from which a minimum age of 2645 ± 1 Ma was determined based on the mean $^{207}\text{Pb}/^{206}\text{Pb}$ age, assuming no lead loss (Kamo 2016) (map reference number 1 on Map P.3823). This age suggests the granitoid rocks, at least the western portion of Drury Township, are older than the Cartier batholith (2642 Ma: cf. Meldrum et al. 1997) and more similar in age to the Birch Lake batholith (2651 Ma: cf. Kamo 2006; Easton and Heaman 2008).

FELSIC DIKES OF UNKNOWN AFFINITY (Unit 21)

In Drury Township, 2 felsic dikes were identified that appear to crosscut folded mafic sills of the Nipissing Intrusive Suite. These felsic dikes do not exhibit any significant deformation and are interpreted to postdate major deformation in the map area. A sample was collected to determine the igneous crystallization age. Geochronology of the felsic dike sample by ID-TIMS yielded discordant U/Pb zircon ages from which an upper intercept age of 2722 ± 12 Ma was determined (Kamo and Hamilton 2017) (map reference number 2 on Map P.3823). The authors of this report have concluded that this age reflects an inherited zircon population that was assimilated from older Archean host rocks and this is not representative of the emplacement age of the felsic dikes.

MATINENDA, RAMSAY LAKE AND MISSISSAGI FORMATIONS OF THE HURONIAN SUPERGROUP (UNITS 6, 8A AND 10A)

In Drury Township, the Ramsay Lake Formation largely consists of a conglomeratic subfeldspathic arenite (“beige” member; unit 8a), which differs significantly from the classic type section of the Ramsay Lake Formation. To further investigate this unit, a BSc study was initiated involving the use of laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) to compare the detrital zircon populations of the “beige” member of the Ramsay Lake Formation in Drury Township with that of classic Ramsay Lake and Matinenda formations. A brief summary of results is presented here but see Ménard (2017a, 2017b), and Davis and Sutcliffe (2017, 2018) for the full data set, results and discussion.

The zircon population of the Matinenda Formation sample is characterized by a unimodal peak at *circa* 2640 Ma, with a few older zircons at 2750 to 3816 Ma (Ménard 2017a; Davis and Sutcliffe 2017) (map reference number 3 on Map P.3823). A second Matinenda Formation sample from a different locality in Drury Township also has a peak at *circa* 2665 Ma, with older zircons ranging in age from 2792 to 3100 Ma (Ménard, personal communication, March 2018) (map reference number 4).

The Ramsay Lake Formation sandstone sample from Baldwin Township (located approximately 25 km west of Drury Township and not shown on Map P.3823) exhibits a bimodal age distribution that is more typical of the upper Huronian Supergroup formations (cf. Rainbird and Davis 2006; Craddock et al. 2013), with peaks at *circa* 2680 and 2730 Ma (Ménard 2017a). In contrast, the “beige” member of the Ramsay Lake Formation in Drury Township contains 2 main populations of zircons with peaks at 2630 Ma and 2660 Ma, with a third, poorly defined range of 2480 to 2590 Ma (Ménard 2017a) (map reference number 5). This is distinct from that of the Matinenda and the Ramsay Lake formations samples collected in Drury and Baldwin townships, respectively. Two additional samples of the Ramsay Lake Formation from Drury Township are being analyzed by Ménard as part of her MSc thesis (map reference numbers 6 and 7).

A sample of the Mississagi Formation in Drury Township has a main peak at *circa* 2680 Ma, a smaller peak at 2763 Ma, and older zircons at 2809 and 3530 Ma (Davis and Sutcliffe 2018) (map reference number 8), similar to results reported by Rainbird and Davis (2006) and Easton and Heaman (2008).

Mineralization

Mineral occurrences shown on Map P.3823 (back pocket) are compiled from the Mineral Deposit Inventory (MDI) (Ontario Geological Survey 2018b) and from assay data related to this project. Additional discretionary occurrences are present in Drury Township, but are not included on Map P.3823 to reduce clutter (*see* Ontario Geological Survey 2018b; Gordon, Simard and Généreux 2018b).

NICKEL-COPPER-PLATINUM GROUP ELEMENTS

Contact Breccia Zone

Nickel-copper-platinum group element (PGE) mineralization associated with the SIC contact breccia is an extensive but discontinuous zone of disseminated to massive sulphide mineralization. Nickel-copper mineralization was observed on surface within all breccia types identified in Drury Township (types 1 to 4, *see* “Geology” section). Pyrrhotite, chalcopyrite and local arsenopyrite are the dominant sulphide phases observed on outcrop, but pentlandite is also a known common sulphide phase that has been documented at many of these occurrences (e.g., southern extension of the Sultana deposit (occurrence 3, Map P.3823), southern Trill Township; Sultana South (occurrence 5, Map P.3823), MDI41I05NE00050: Ontario Geological Survey 2018b). Typically, the breccia matrix contains less than 5% disseminated sulphide, with local metre-scale pods of blebby to semi-massive sulphide mineralization. However, the highest concentrations of sulphides appear to be spatially associated with breccia types 1 and 2, within the noritic matrix. In these occurrences, the matrix contains 5 to 20% fine to blebby sulphide with pockets where sulphide mineralization is semi-massive to massive and completely encloses silicate inclusions, and forms gossans larger than 10 m² (Photo 8C). Many of the country rock fragments also contain internal disseminated sulphide mineralization.

Offset Sublayer (Worthington Offset Dike)

In Drury Township, the Worthington Offset dike is host to Totten Mine (occurrence 1, Map P.3823; MDI41I06NW00004: Ontario Geological Survey 2018b), as well as the past-producing Worthington Mine (*circa* 1890, occurrence 2, Map P.3823; MDI41I06NW00005: Ontario Geological Survey 2018b). The observed surface nickel-copper-PGE mineralization consists of lenses of disseminated to blebby, locally semi-massive sulphide within a quartz diorite matrix surrounding amphibolite and other country rock fragments (Photo 8D). Sulphide mineralization ranges from 5% up to 25% of the rock and consists predominantly of pyrrhotite with variable amounts of chalcopyrite and pentlandite. All observed mineralization is associated with the matrix of the inclusion-bearing quartz diorite phase and is present in the core of the dike.

Sudbury Breccia

Sudbury Breccia-hosted mineralization has been documented within the heterolithic Sudbury Breccia belts identified in Drury Township (e.g., occurrences 21 and 41, Map P.3823). Mineralization consists of disseminated to blebby pyrrhotite and chalcopyrite concentrated in pockets, up to 100 by 30 cm in size. Within the mineralized pockets, sulphide mineralization constitutes 5 to 15% of the rock and occurs within the fine-grained breccia matrix (Photo 8E). In addition, smaller offshoots of Sudbury Breccia located outside of the main breccia belts also contain disseminated sulphide mineralization concentrated in gossan zones that range from a few centimetres up to several metres in width.

Nipissing Intrusive Suite

Irregular, localized zones of sulphide mineralization are hosted by metagabbro interpreted to belong to the Nipissing Intrusive Suite. Mineralization consists of blebby to semi-massive pyrrhotite and chalcopyrite in a massive, medium-grained to locally pegmatoidal leucogabbro (Photo 8F). There are no obvious signs of Sudbury Breccia associated with these mineral occurrences.

Shear Zone-Hosted Sulphide Mineralization

Many of the historic copper-nickel showings in Drury Township, excluding those associated with the SIC and offset dikes, are hosted in sheared, locally silicified, mafic intrusive rocks (cf. Card 1965a, 1965b). Mineralization is characterized by discontinuous lenses of pyrrhotite, chalcopyrite and bornite along various northeast- and east-trending shear zones where they truncate the Drury Township intrusion and larger Nipissing sills. This includes the Chicago Mine (*see* occurrence 4, Map P.3823), which is hosted in a west-trending shear zone (Card 1965a). On outcrop, mineralization at the Chicago Mine occurrence consists of a gossan zone, at least 50 m wide, exposed on both sides of Fairbanks Lake Road, in sheared, fine-grained mafic dikes that crosscut a strongly foliated, anorthositic gabbroic rock (Drury Township intrusion) (Photo 9A). A second notable mineralized shear zone occurrence is present adjacent to the southern contact of the Drury Township intrusion within mylonite of the Creighton–Victoria deformation zone (*see* occurrence 15, Map P.3823). Here, a 12 m wide gossan zone, containing 20 to 25% disseminated to blebby chalcopyrite and pyrrhotite, is present along an east-northeast–trending shear zone that crosscuts fine-grained mafic dikes and leucogabbroic rocks of the Drury Township intrusion (Photo 9B).

GOLD

Historical gold occurrences in Drury Township, with copper, PGE and silver as secondary commodities, are reported within quartz veins. The quartz veins crosscut Archean granitoid basement rocks, mafic sills of the Nipissing Intrusive Suite and metasedimentary strata of the Huronian Supergroup. The quartz veins and associated mineralization appear to be of limited extent.

URANIUM-THORIUM

A narrow (up to a few metres wide) uranium- and thorium-rich horizon is present in the lower Matinenda Formation. The uranium and thorium mineralization is associated with pyritic quartz arenite and/or quartz-pebble-rich conglomeratic subfeldspathic arenite and appears to be of similar character to the uraniferous quartz-pebble conglomerate horizon present in the Elliot Lake–Blind River area (cf. Robertson 1976). The mineralized lenses themselves are discontinuous, but the horizon can be traced

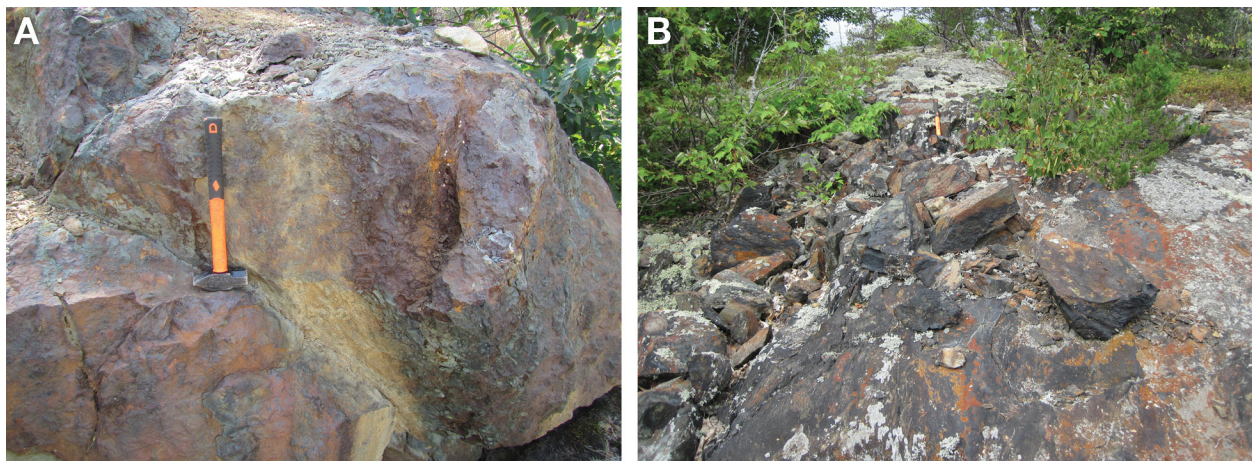


Photo 9. **A)** Exposure from a 50 m wide gossan zone containing disseminated to massive sulphide mineralization associated with the Chicago Mine occurrence; UTM 464328E 5142244N. **B)** Shear zone, 12 m wide, containing disseminated to semi-massive sulphide mineralization; UTM 463757E 5140815N. Objects used for scale: hammer = 40 cm long. All UTM co-ordinates provided using NAD83 in Zone 17.

for at least 3 km along strike and appears to be repeated through folding. Gamma-ray scintillometer-determined assay values are elevated compared to background readings, and range from 123.7 to 330.8 ppm equivalent U and 222.8 to 846.8 ppm equivalent Th. Typical background equivalent U and Th values for surrounding country rock are 0.3 to 37.2 ppm equivalent U and 2.3 to 38.1 ppm equivalent Th, respectively. The mineralized horizon is coincident with an airborne gamma-ray spectrometric high for both equivalent uranium and thorium (Hetu 1989). This horizon corresponds with 2 previously identified radioactive occurrences (*see* occurrences 6 and 10, Map P.3823; MDI41I05NE00042 and MDI41I05NE00054, respectively) and is on strike with the past-producing Agnew Lake uranium mine, which is located just 5 km to the west of Drury Township.

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References

- Ames, D.E., Bleeker, W., Heather, K.B. and Wodicka, N. 1997. Timmins to Sudbury transect: New insights into the regional geology and setting of mineral deposits; Geological Association of Canada–Mineral Association of Canada, Joint Annual Meeting, Ottawa 1997, Field Trip Guidebook B6, 133p.
- Ames, D.E. and Farrow, C.E.G. 2007. Metallogeny of the Sudbury mining camp, Ontario; *in* Mineral Deposits of Canada: A Synthesis of Major Deposit-Types, District Metallogeny, the Evolution of Geological Provinces, and Exploration Methods, Geological Association of Canada, Mineral Deposits Division, Special Publication No.5, p.329-350.
- Ames, D.E., Golightly, J.P., Lightfoot, P.C. and Gibson, H.L. 2002. Vitric compositions of the Onaping Formation and their relationship to the Sudbury Igneous Complex, Sudbury Structure; *Economic Geology*, v.97, p.1541-1562.
- Ames, D.E., Watkinson, D.H. and Parrish, R.R. 1998. Dating of the regional hydrothermal system induced by 1850 Ma Sudbury impact event; *Geology*, v.26, p.447-450.
- Bailey, J., Lafrance, B., McDonald, A.M., Fedorowich, J.S., Kamo, S. and Archibald, D.A. 2004. Mazatzal–Labradorian-age (1.7–1.6 Ga) ductile deformation of the South Range Sudbury impact structure at the Thayer Lindsley Mine, Ontario; *Canadian Journal of Earth Sciences*, v.41, p.1491-1505.
- Bennett, G. 2006. The Huronian Supergroup between Sault Ste Marie and Elliot Lake; 52nd Institute on Lake Superior Geology, Field Trip Guidebook, Proceedings, v.52, pt.4, 65p.
- Bennett, G.B., Dressler, B.O. and Robertson, J.A. 1991. The Huronian Supergroup and associated intrusive rocks; *in* *Geology of Ontario*, Ontario Geological Survey, Special Volume 4, Part 1, p.549-591.
- Bleeker, W., Hamilton, M.A., Ernst, R.E. and Söderlund, U. 2012. Resolving the age structure of the Matachewan event: Magmatic pulses at ca. 2445–2452 Ma, 2458–2461 Ma, and 2475–2480 Ma; unpublished CAMIRO Reports A96, A97, and A98, 17p.

- Bleeker, W., Kamo, S.L., Ames, D.E. and Davis, D. 2015. New field observations and U-Pb ages in the Sudbury area: Toward a detailed cross-section through the deformed Sudbury Structure; *in* Targeted Geoscience Initiative 4: Canadian Nickel-Copper-Platinum Group Elements-Chromium Ore Systems – Fertility, Pathfinders, New and Revised Models, Geological Survey of Canada, Open File 7856, p.151-156.
- Burrows, A.G. and Rickaby, H.C. 1930. Sudbury Basin area; 38th Annual Report of the Ontario Department of Mines, v.38, pt.3, 55p.
- Card, K.D. 1965a. Geology of Hyman and Drury townships, District of Sudbury; Ontario Department of Mines, Report 34, 38p.
- 1965b. Hyman and Drury townships, Sudbury District; Ontario Department of Mines, Map 2055, scale 1:31 680.
- 1967. Geology of Denison–Waters area; Ontario Department of Mines, Open File Report 5007, 112p.
- 1978. Geology of the Sudbury–Manitoulin area; Ontario Department of Mines, Report 166, 238p.
- 1979. Regional geological synthesis, central Superior Province; *in* Current Research, Geological Survey of Canada, Paper 79-1A, p.87-90.
- Card, K.D., Church, W.R., Franklin, J.M., Frarey, M.J., Robertson, J.A., West, G.F. and Young, G.M. 1972. The Southern Province; *in* Variations in Tectonic Styles in Canada, Geological Association of Canada, Special Paper, v.11, p.335-380.
- Card, K.D., Gupta, V.K., McGrath, P.H. and Grant, F.S. 1984. The Sudbury Structure: Its regional geological and geophysical setting; *in* The Geology and Ore Deposits of the Sudbury Structure, Ontario Geological Survey, Special Volume 1, p.25-43.
- Card, K.D. and Hutchinson, R.W. 1972. The Sudbury structure: Its regional geological setting; *in* New Developments in Sudbury Geology, Geological Association of Canada, Special Paper 10, p.67-78.
- Corfu, F. and Andrews, A.J. 1986. A U-Pb age for mineralized Nipissing diabase, Gowganda; Canadian Journal of Earth Sciences, v.23, p.107-109.
- Craddock, J.P., Rainbird, R.H., Davis, W.J., Davidson, C., Vervoort, J.D., Konstantinou, A., Boerboom, T., Vorhies, S., Kerber, L. and Lundquist, B. 2013. Detrital zircon geochronology and provenance of the Paleoproterozoic Huron (~2.4–2.2 Ga) and Animikie (~2.2–1.8 Ga) basins, Southern Superior Province; Journal of Geology, v.121, p.623-644.
- Davis, D.W. and Sutcliffe, C.N. 2017. U-Pb geochronology by LA-ICPMS in samples from northern Ontario; internal report prepared for the Ontario Geological Survey, Jack Satterly Geochronology Laboratory, University of Toronto, Toronto, Ontario, 131p.
- 2018. U-Pb geochronology by LA-ICPMS in samples from northern Ontario; internal report prepared for the Ontario Geological Survey, Jack Satterly Geochronology Laboratory, University of Toronto, Toronto, Ontario, 43p.
- Dietz, R.S. 1964. Sudbury Structure as an astrobleme; Journal of Geology, v.72, p.412-434.
- Dressler, B.O. 1984a. The effects of the Sudbury Event and the intrusion of the Sudbury Igneous Complex on the footwall rocks of the Sudbury Structure; *in* The Geology and Ore Deposits of the Sudbury Structure, Ontario Geological Survey, Special Volume 1, p.97-136.
- 1984b. General geology of the Sudbury area; *in* The Geology and Ore Deposits of the Sudbury Structure, Ontario Geological Survey, Special Volume 1, p.57-82.

- 1984c. Sudbury Geological Compilation; Ontario Geological Survey, Map 2491, Precambrian Geology Series, scale 1:50 000.
- Dressler, B.O., Gupta, V.K. and Muir, T.L. 1991. The Sudbury Structure; *in* Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, p.593-625.
- Dubois, A.J. and Benn, K. 2003. Structural analysis and three-dimensional modelling of the southwestern Sudbury Basin: Implications and recommendations for mineral exploration; Ontario Geological Survey, Open File Report 6121, 38p.
- Easton, R.M. 2006. Precambrian geology, Porter and Vernon townships; Ontario Geological Survey, Preliminary Map P.2845, scale 1:20 000.
- Easton, R.M. and Heaman, L.M. 2008. Detrital zircon geochronology of Huronian Supergroup sandstones located within the Vernon structure, north of Espanola, Ontario; abstract *in* 54th Institute on Lake Superior Geology, Proceedings, v.54, pt.1, p.21-22.
- 2011. Detrital zircon geochronology of Matinenda Formation sandstones (Huronian Supergroup) at Elliot Lake, Ontario: Implications for uranium mineralization; abstract *in* 57th Institute on Lake Superior Geology, Proceedings, v.57, pt.1, p.31-32.
- Généreux, C-A., Lafrance, B., Simard, R-L. and Gordon, C.A. 2016. Mylonite zone and regional deformation in Drury Township, near Sudbury; *in* Summary of Field Work and Other Activities, 2016, Ontario Geological Survey, Open File Report 6323, p.19-1 to 19-10.
- Généreux, C-A., Lafrance, B. and Gordon, C.A. 2017. The Creighton Fault and its relation to the mylonite zone in Drury Township, Southwest Sudbury Structure; *in* Summary of Field Work and Other Activities, 2017, Ontario Geological Survey, Open File Report 6333, p.16-1 to 16-10.
- Généreux, C-A., Lafrance, B., Tinkham, D.K. and Gordon, C.A. 2018. Polyphase deformation in the southwest Sudbury impact structure; Geological Association of Canada–Mineralogical Association of Canada, Vancouver 2018 Joint Annual Meeting.
- Giblin, P.E. 1984. History of exploration and development, of geological studies and development of geological concepts; *in* The Geology and Ore Deposits of the Sudbury Structure, Ontario Geological Survey, Special Volume 1, p.3-23.
- Gordon, C.A. 2012. Preliminary results from the Otter–Morin bedrock mapping project, Southern and Superior provinces; *in* Summary of Field Work and Other Activities, 2012, Ontario Geological Survey, Open File Report 6280, p.17-1 to 17-10.
- 2014. Precambrian geology of Morin and Otter townships; Ontario Geological Survey, Preliminary Map P.3778, scale 1:20 000.
- Gordon, C.A. and Généreux, C-A. 2017. Preliminary results from geological mapping in Denison Township, southwest Sudbury Structure; *in* Summary of Field Work and Other Activities, 2017, Ontario Geological Survey, Open File Report 6333, p.15-1 to 15-15.
- Gordon, C.A., Simard, R-L. and Généreux, C-A. 2015. Geology and low-sulphide platinum group element mineralization of Drury Township, South Range, Sudbury Igneous Complex; *in* Summary of Field Work and Other Activities, 2015, Ontario Geological Survey, Open File Report 6313, p.21-1 to 21-18.
- 2018a. Precambrian geology of Drury Township, southwest Sudbury Structure; Ontario Geological Survey, Preliminary Map P.3823, scale 1:15 000.
- 2018b. Geological, geochemical and geophysical data for Drury Township, southwest Sudbury Structure; Ontario Geological Survey, Miscellaneous Release—Data 369.

- Grant, R.W. and Bite, A. 1984. Sudbury quartz diorite offset dikes; *in* The Geology and Ore Deposits of the Sudbury Structure, Ontario Geological Survey, Special Volume 1, p.275-300.
- Hashmi, S. 2015. Quaternary geology and geochemical and mineralogical signature of surficial media in Drury and Denison townships, city of Greater Sudbury; *in* Summary of Field Work and Other Activities 2015, Ontario Geological Survey, Open File Report 6313, p.29-1 to 29-7.
- Hashmi, S. 2016. Quaternary geology, Drury and Denison townships; Ontario Geological Survey, Preliminary Map P.3801, scale 1:20 000.
- 2018. Quaternary geology and surficial media sampling in Drury and Denison Townships, city of Greater Sudbury; Ontario Geological Survey, Open File Report 6342, 133p.
- Heaman, L.M. 1997. Global mafic magmatism at 2.45 Ga: Remnants of an ancient large igneous province?; *Geology*, v.25, p.299-302.
- Hetu, R. 1989. Airborne gamma ray spectrometric colour maps for Sudbury and District, northern Ontario; Geological Survey of Canada, Open File 2151, 11 maps, scale 1:50 000.
- Jackson, S.L. 2001. On the structural geology of the Southern Province between Sault Ste. Marie and Espanola, Ontario; Ontario Geological Survey, Open File Report 5995, 55p.
- James, R.S., Easton, R.M., Peck, D.C. and Hrominichuk, J.L. 2002. The East Bull Lake intrusive suite: Remnants of a ~2.48 Ga large igneous and metallogenic province in the Sudbury area of the Canadian Shield; *Economic Geology*, v.97, p.1577-1606.
- Jensen, L.S. 1976. A new cation plot for classifying subalkalic volcanic rocks; Ontario Department of Mines, Miscellaneous Paper 66, 22p.
- Kamo, S.L. 2006. Report on U-Pb geochronological data from the southern Abitibi Subprovince, Bannockburn–Montrose and Vernon townships, and the Grenville Front region, Thistle–Sisk townships, Ontario; internal U/Pb age report prepared for the Ontario Geological Survey, Jack Satterly Geochronology Laboratory, Department of Geology, University of Toronto, Toronto, Ontario, 20p.
- 2016. Part A: Report on the U-Pb ID-TIMS geochronology for the Ontario Geological Survey: Bedrock Mapping Projects, Ontario, Year 1: 2015–2016; internal report prepared for the Ontario Geological Survey, Jack Satterly Geochronology Laboratory, University of Toronto, Toronto, Ontario, 48p.
- Kamo, S.L. and Hamilton, M.A. 2017. Part A: Report on U-Pb ID-TIMS geochronology for the Ontario Geological Survey: bedrock mapping projects, Ontario, Year 2: 2016–2017; internal report prepared for the Ontario Geological Survey, Jack Satterly Geochronology Laboratory, University of Toronto, Toronto, Ontario, 72p.
- Krogh, T.E., Corfu, F., Davis, D.W., Dunning, G.R., Heaman, L.M., Kamo, S.L., Machado, N., Greenough, J.D. and Nakamura, E. 1987. Precise U-Pb isotope ages of diabase dikes and mafic to ultramafic rocks using trace amounts of baddeleyite and zircon; *in* Mafic Dike Swarms, Geological Association of Canada, Special Paper 34, p.147-152.
- Krogh, T.E., Davis, D.W. and Corfu, F. 1984. Precise U-Pb zircon and baddeleyite ages for the Sudbury area; *in* The Geology and Ore Deposits of the Sudbury Structure; Ontario Geological Survey, Special Volume 1, p.431-446.
- Le Bas, M.J., Maitre, R.W., Streckeisen, A. and Zanettin, B. 1986. A chemical classification of volcanic rocks based on the Total Alkali-Silica diagram; *Journal of Petrology*, v.27, p.745-750.
- Le Maitre, R.W., ed., Streckeisen, A., Zanettin, B., Le Bas, M.J., Bonin, B., Bateman, P., Bellieni, G., Dudek, A., Efremova, S., Keller, J., Lameyre, J., Sabine, P.A., Schmid, R., Sorensen, H. and Woolley, A.R. 2002. Igneous rocks, a classification and glossary of terms: Recommendations of the International Union of Geological Sciences Subcommittee on the Systematics of Igneous Rocks, 2nd Edition; Cambridge University Press, New York, 236p.

- Long, D.G.F. 2009. Huronian Supergroup; *in* A Field Guide to the Geology of Sudbury, Ontario; Ontario Geological Survey, Open File Report 6243, p.14-30.
- Meldrum, A., Abel-Rahman, A.M., Martin, R.F. and Wodicka, N. 1997. The nature, age and petrogenesis of the Cartier Batholith, northern flank of the Sudbury Structure, Ontario; *Precambrian Research*, v.82, p.265-285.
- Ménard, J.A. 2017a. Sedimentary provenance of the Matinenda and Ramsay Lake formations in Drury Township using laser ablation detrital zircon analysis; unpublished BSc thesis, McMaster University, Hamilton, Ontario, 47p.
- 2017b. Sedimentary provenance of the Matinenda and Ramsay Lake formations in Drury Township using laser ablation detrital zircon analysis; abstract *in* Geological Association of Canada–Mineralogical Association of Canada, 2017 Joint Annual Meeting, Kingston, Ontario, v.40, p.261.
- 2017c. Sedimentary provenance of the Elliot Lake and Hough Lake Groups, Huronian Supergroup, Sudbury area; *in* Summary of Field Work and Other Activities, 2017, Ontario Geological Survey, Open File Report 6333, p.17-1 to 17-7.
- Mukwkwami, J., Lafrance, B., Leshner, C.M., Tinkham, D.K., Rayner, N.M. and Ames, D.E. 2014. Deformation, metamorphism, and mobilization of Ni-Cu-PGE sulfide ores at Garson Mine, Sudbury; *Mineralium Deposita*, v.49, no.2, p.175-198.
- Müller-Mohr, V. 1992. Breccias in the basement of a deeply eroded impact structure, Sudbury, Canada; *Tectonophysics*, v.216, p.219-226.
- Noble, S.R. and Lightfoot, P.C. 1992. U-Pb baddeleyite ages for the Kerns and Triangle Mountain intrusions, Nipissing diabase, Ontario; *Canadian Journal of Earth Sciences*, v.29, p.1124-1129.
- Ontario Geological Survey 2018a. Geosciences Laboratories 2018 schedule of fees and services; Ontario Geological Survey, 36p. https://www.mndm.gov.on.ca/sites/default/files/2018_geo_labs_brochure.pdf
- 2018b. Mineral Deposit Inventory; Ontario Geological Survey, Mineral Deposit Inventory (May 2018 update), online database.
- Papapavlou, K., Darling, J.R., Storey, C.D., Lightfoot, P.C., Moser, D.E. and Lasalle, S. 2017. Dating shear zones with plastically deformed titanite: New insights into the orogenic evolution of the Sudbury impact structure (Ontario, Canada); *Precambrian Research*, v.291, p.220-235.
- Piercey, P., Schneider, D.A. and Holm, D.K. 2007. Geochronology of Proterozoic metamorphism in the deformed Southern Province, northern Lake Huron region, Canada; *Precambrian Research*, v.157, p.127-143.
- Prevec, S.A. 1993. An isotopic, geochemical and petrographic investigation of the genesis of early Proterozoic mafic intrusions and associated volcanism near Sudbury, Ontario; unpublished PhD thesis, University of Alberta, Edmonton, Alberta, 223p.
- Prevec, S.A. and Baadsgaard, H. 2005. Evolution of Paleoproterozoic mafic intrusions located within the thermal aureole of the Sudbury Igneous Complex, Canada: Isotopic, geochronological and geochemical evidence; *Geochimica et Cosmochimica Acta*, v.69, no.14, p.3653-3669.
- Raharimahefa, T., Lafrance, B. and Tinkham, D.K. 2014. New structural, metamorphic, and U-Pb geochronological constraints on the Blezardian Orogeny and Yavapai Orogeny in the Southern Province, Sudbury, Canada; *Canadian Journal of Earth Sciences*, v.51, p.750-774.
- Rainbird, R.H. and Davis, W.J. 2006. Detrital zircon geochronology of the western Huronian basin; *52th Institute on Lake Superior Geology, Proceedings*, v.52, pt.1, p.55-56.

- Riller, U., Schwerdtner, W.M., Halls, H.C. and Card, K.D. 1999. Transpressive tectonism in the eastern Penokean orogen, Canada: Consequences for Proterozoic crustal kinematics and continental fragmentation; *Precambrian Research*, v.93, p.51-70.
- Robertson, J.A. 1976. The Blind River uranium deposits: The ores and their setting; Ontario Division of Mines, Report 147, 73p.
- Robertson, J.A., Card, K.D. and Frarey, M.J. 1969. The federal–provincial committee on Huronian stratigraphy progress report; Ontario Department of Mines, Miscellaneous Paper 31, 26p.
- Rousell, D.H. 1984. Structural geology of the Sudbury Basin; *in* The Geology and Ore Deposits of the Sudbury Structure, Ontario Geological Survey, Special Volume 1, p.83-95.
- 2009. Structural geology; *in* A Field Guide to the Geology of Sudbury, Ontario; Ontario Geological survey, Open File Report 6243, p.75-94.
- Rousell, D.H., Gibson, H.L. and Jonasson, I.R. 1997. The tectonic, magmatic and mineralization history of the Sudbury Structure; *Exploration and Mining Geology*, v.6, p.1-22.
- Shanks, W.S. and Schwerdtner, W.M. 1991. Structural analysis of the central and southwestern Sudbury Structure, Southern Province, Canadian Shield; *Canadian Journal of Earth Sciences*, v.28, p.411-430.
- Simard, R-L., Gordon, C.A. and Génèreux, C-A. 2016. Geology of Drury Township, southwest Sudbury structure: An overview; *in* Summary of Field Work and Other Activities, 2016, Ontario Geological Survey, Open File Report 6323, p.16-1 to 16-19.
- Soller, D.R., ed. 2004. Sedimentary materials: Science language for their classification, description and interpretation in digital geologic-map databases, Appendix C1; *in* North America Geologic-Map Data Model Science Language Technical Team Report, Sedimentary Subgroup, United States Geological Survey, Open File Report 2004-1451, 595p.
- Speers, E.C. 1957. The age relations and origin of common Sudbury Breccia; *Journal of Geology*, v.65, p.497-514.
- Sun, S.S. and McDonough, W.F. 1995. The composition of the Earth; *Chemical Geology*, v.120, p.223-253.
- Taylor, S.R. and McLennan, S.M. 1981. The composition and evolution of the continental crust: rare earth element evidence from sedimentary rocks; *Philosophical Transactions of the Royal Society*, v.A301, p.381-399.
- Therriault, A.M., Fowler, A.D. and Grieve, R.A.F. 2002. Sudbury Igneous Complex: A differentiated impact melt sheet; *Economic Geology*, v.97, p.1521-1540.
- Tolman, C. 1929. The Birch Lake Batholith, Ontario; *American Journal of Science*, series 5, v.17, no.101, p.403-424.
- Young, G.M. 1991. Stratigraphy, sedimentology and tectonic setting of the Huronian Supergroup; Geological Association of Canada–Mineralogical Association of Canada–Society of Economic Geologists, Joint Annual Meeting, Toronto '91, Field Trip B5, Guidebook, 34p.
- Zolnai, A.I., Price, R.A. and Helmstaedt, H. 1984. Regional cross section of the Southern Province adjacent to Lake Huron, Ontario: Implication for tectonic significance of the Murray Fault zone; *Canadian Journal of Earth Sciences*, v.21, p.447-456.

Metric Conversion Table

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

OTHER USEFUL CONVERSION FACTORS

| | <i>Multiplied by</i> | |
|--------------------------------|----------------------|-------------------------------|
| 1 ounce (troy) per ton (short) | 31.103 477 | grams per ton (short) |
| 1 gram per ton (short) | 0.032 151 | ounces (troy) per ton (short) |
| 1 ounce (troy) per ton (short) | 20.0 | pennyweights per ton (short) |
| 1 pennyweight per ton (short) | 0.05 | ounces (troy) per ton (short) |

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

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