ISSN 1916-6117 (online)
ISBN 978-1-4606-4651-9 (PDF)
(for entire OFR 6300)

ISSN 0826-9580 (print)
ISBN 978-1-4606-4650-2 (print)
(for entire OFR 6300)

## THESE TERMS GOVERN YOUR USE OF THIS DOCUMENT

***Your use of this Ontario Geological Survey document (the "Content") is governed by the terms set out on this page ("Terms of Use"). By downloading this Content, you (the "User") have accepted, and have agreed to be bound by, the Terms of Use.***

**Content**: This Content is offered by the Province of Ontario's *Ministry of Northern Development and Mines* (MNDM) as a public service, on an "as-is" basis. Recommendations and statements of opinion expressed in the Content are those of the author or authors and are not to be construed as statement of government policy. You are solely responsible for your use of the Content. You should not rely on the Content for legal advice nor as authoritative in your particular circumstances. Users should verify the accuracy and applicability of any Content before acting on it. MNDM does not guarantee, or make any warranty express or implied, that the Content is current, accurate, complete or reliable. MNDM is not responsible for any damage however caused, which results, directly or indirectly, from your use of the Content. MNDM assumes no legal liability or responsibility for the Content whatsoever.

**Links to Other Web Sites**: This Content may contain links, to Web sites that are not operated by MNDM. Linked Web sites may not be available in French. MNDM neither endorses nor assumes any responsibility for the safety, accuracy or availability of linked Web sites or the information contained on them. The linked Web sites, their operation and content are the responsibility of the person or entity for which they were created or maintained (the "Owner"). Both your use of a linked Web site, and your right to use or reproduce information or materials from a linked Web site, are subject to the terms of use governing that particular Web site. Any comments or inquiries regarding a linked Web site must be directed to its Owner.

**Copyright:** Canadian and international intellectual property laws protect the Content. Unless otherwise indicated, copyright is held by the Queen's Printer for Ontario.

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

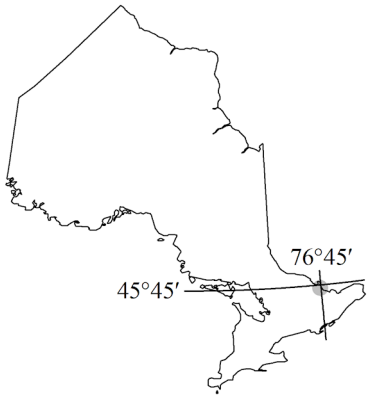
Easton, R.M. 2014. Geology and mineral potential of the Cobden area, northeastern Central Metasedimentary Belt, Grenville Province; *in* Summary of Field Work and Other Activities 2014, Ontario Geological Survey, Open File Report 6300, p.13-1 to 13-10.

**Use and Reproduction of Content**: The Content may be used and reproduced only in accordance with applicable intellectual property laws. *Non-commercial* use of unsubstantial excerpts of the Content is permitted provided that appropriate credit is given and Crown copyright is acknowledged. Any substantial reproduction of the Content or any *commercial* use of all or part of the Content is prohibited without the prior written permission of MNDM. Substantial reproduction includes the reproduction of any illustration or figure, such as, but not limited to graphs, charts and maps. Commercial use includes commercial distribution of the Content, the reproduction of multiple copies of the Content for any purpose whether or not commercial, use of the Content in commercial publications, and the creation of value-added products using the Content.

**Contact**:

| FOR FURTHER INFORMATION ON | PLEASE CONTACT: | BY TELEPHONE: | BY E-MAIL: |
|---|---|---|---|
| **The Reproduction of the EIP or Content** | MNDM Publication Services | Local: (705) 670-5691<br>Toll-Free: 1-888-415-9845, ext. 5691<br>(inside Canada, United States) | Pubsales.ndm@ontario.ca |
| **The Purchase of MNDM Publications** | MNDM Publication Sales | Local: (705) 670-5691<br>Toll-Free: 1-888-415-9845, ext. 5691<br>(inside Canada, United States) | Pubsales.ndm@ontario.ca |
| **Crown Copyright** | Queen's Printer | Local: (416) 326-2678<br>Toll-Free: 1-800-668-9938<br>(inside Canada, United States) | Copyright@gov.on.ca |

# 13. Project Unit 13-013. Geology and Mineral Potential of the Cobden Area, Northeastern Central Metasedimentary Belt, Grenville Province




**R.M. Easton**[1]

[1]Earth Resources and Geoscience Mapping Section, Ontario Geological Survey

## INTRODUCTION

The Cobden NTS 31 F/10 map area straddles the Ontario–Quebec provincial border, encompassing approximately 1088 km$^2$, of which 680 km$^2$ are in Ontario (Figure 13.1). The Cobden map area is bounded by latitudes 45°30′ to 45°45′N and longitudes 76°30′ to 77°00′W, and encompasses all or parts of Admaston, Bromley, Horton, Ross, Stafford, Westmeath and Wilberforce townships. Mapping of the Cobden area began in 2013 (Easton 2013), with an additional 5 weeks of mapping during the 2014 field season. The only previous mapping of this area consists of 1:100 000 scale mapping from the 1970s (Lumbers 1982a, 1982b). Despite the limited mapping base for the area, several mineral deposit inventories of Renfrew County, including the study area, were conducted in the late 1970s (Carter, Colvine and Meyn 1980; Storey and Vos 1981a, 1981b; Masson and Gordon 1981). All Universal Transverse Mercator (UTM) co-ordinates given in this article are provided in Zone 18, North American Datum 1983 (NAD83).

## GEOLOGICAL OVERVIEW AND TERRANE SUBDIVISION

As noted in Easton (2013), the Cobden map area is split in two by a previously undocumented north-trending fault, which he termed the Ross fault (*see* Figure 13.1). The two-thirds of the Cobden area west of the Ross fault, herein referred as the Bromley subdomain (*see* Figure 13.1), consists of high metamorphic grade paragneiss, orthogneiss and marble tectonic breccia, all of which are intruded and metasomatized by Late Syenite suite rocks (1090 to 1030 Ma). In contrast, the eastern one-third of the Cobden area, herein referred to as the Ross subdomain (*see* Figure 13.1), is underlain by calcite and dolomite marble, which locally preserve relict stratigraphy. The marbles are intruded by the Chenaux gabbro (1231±2 Ma: Pehrsson, Hanmer and van Breemen 1996), which locally preserves primary mineralogy. The Late Syenite suite and metasomatic rocks appear to be absent from the eastern one-third of the Cobden area. Metamorphic grade is estimated to be lower amphibolite facies east of the Ross fault and upper amphibolite facies west of the fault.

Also present in the eastern one-third of the area, adjacent to the Ottawa River, are several small areas of highly deformed, mafic and quartzofeldspathic gneiss that have a characteristic magnetic signature (Figure 13.2), and may be retrograded granulite facies rocks. These areas of gneiss have a sheet-like geometry and may have been thrust on top of the marbles (*see* Figure 13.1). These rocks are more abundant on the Quebec side of the Ottawa River. They cannot be assigned to any terrane or domain in Ontario and are herein referred to as the Rocher–Fendu subdomain, named after Lac du Roche–Fendu on

*Summary of Field Work and Other Activities 2014,*
*Ontario Geological Survey, Open File Report 6300, p.13-1 to 13-10.*

*© Queen's Printer for Ontario, 2014*

the Ottawa River where they are well exposed. Field party personnel verified the presence of cordierite in several localities in these high-grade gneisses (*see* Figure 13.1), as reported by Lumbers (1982a).

In addition to the Ross fault, the Cobden area is also cut by several northwest-trending, dominantly vertical faults related to the Ottawa–Bonnechere graben system, which locally preserve Upper Ordovician limestones of the Gull River and Bobcaygeon formations on their down-dropped sides (cf. Russell and Williams 1985).

## GEOPHYSICAL DATA

A high-resolution (200 m line-spacing) aeromagnetic and gamma-ray spectrometric survey was flown for the Ontario Geological Survey over much of Renfrew County, including the Cobden map area, during October 2013 (*see* Figure 13.2). The data from this survey were released in June 2014 (Ontario Geological Survey 2014). Key observations from this data set related to the geology of the Cobden area are as follows.

Easton (2013) interpreted the Ross fault as a near-vertical fault based on the previous low-resolution (800 m line-spacing) aeromagnetic data (Ontario Geological Survey 1999), but the high-resolution data indicates that it may dip moderately to the east. Magnetic features present in Bromley subdomain appear to continue for up to 500 m beneath mapped marbles belonging to the Ross subdomain (*see* Figure 13.2). It is not known if this indicates that the Ross fault is a thrust fault, or simply an east-dipping normal fault.

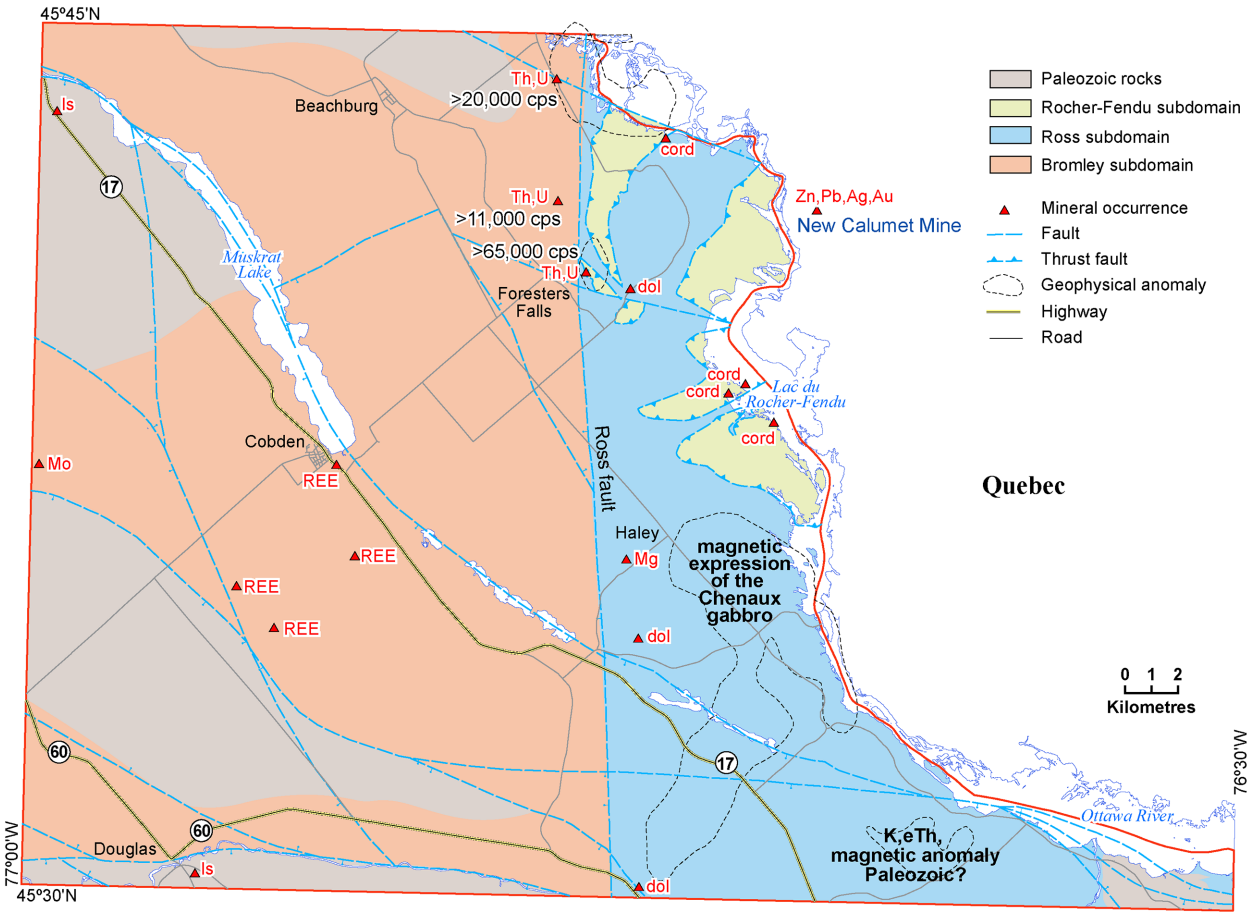



**Figure 13.1.** Simplified geological map of the Cobden area showing the location of subdomains, major faults and significant mineral occurrences. Abbreviations: Ag, silver; Au, gold; cord, cordierite; cps, counts per second; dol, dolomite; eTh, equivalent thorium; K, potassium; ls, limestone, Mg, magnesium; Mo, molybdenum; Pb, lead; REE, rare earth elements; Th, thorium; U, uranium; Zn, zinc.

Rocks of the Central Metasedimentary Belt boundary tectonic zone (CMBBTZ) exhibit strong, linear northwest or north-northwest magnetic trends, for example, on the north side of Muskrat Lake north of Cobden (*see* Figure 13.2). These trends correspond to differences in surface geological units as mapped by Lumbers (1982b), and confirm the observation made by Easton (2013) that rocks of the CMBBTZ underlie much more of the Bromley subdomain (i.e., occur further south) than previously indicated.

The high-resolution data confirm the highly magnetic character of the Chenaux gabbro (*see* Figure 13.2). Immediately east of Haley, a prominent, 3 km long, north-northeast–trending magnetic high could be a subsurface dike or subsurface extension of the Chenaux gabbro beneath marbles exposed on surface. It is not known if this subsurface magnetic anomaly has any association with the observed hydrothermal alteration of the dolomite marbles at Haley, as described under "Economic Geology".

The Cobden area is cut by at least 7 major west-trending mafic dikes that are interpreted to be part of the Grenville dike swarm, which was emplaced at *circa* 590 Ma (Kamo, Krogh and Kumarapeli 1995). It is possible that these dikes may be associated with west-trending faults, although, if that is the case, movement along those faults would be mostly vertical, as the faults do not appear to laterally offset either Precambrian or Paleozoic strata. These dikes occur in 3 main corridors, approximately 10 km apart, containing dikes with strike lengths ranging from 3 to 17 km (*see* Figure 13.2). One corridor lies in the area of Haley Station (4 km southwest of Haley), another immediately north of Cobden, and the third is located just north of the northern boundary of the Cobden NTS map area north of Beachburg. The majority of these

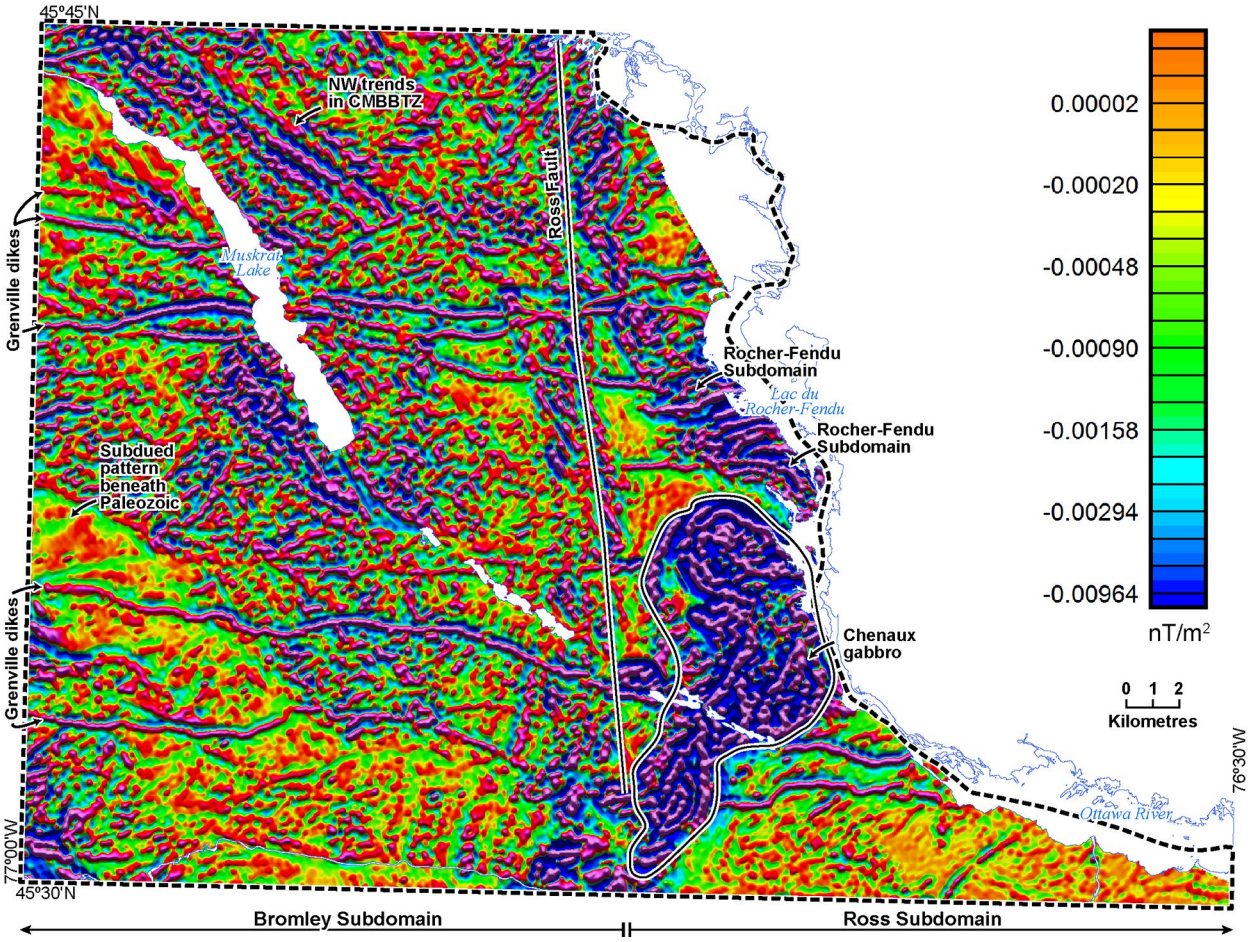



**Figure 13.2.** Map showing the second vertical derivative (2-VD) of the magnetic field for the Cobden area of Ontario, with key features indicated. See text for details. Magnetic data *from* Ontario Geological Survey (2014).

dikes occur beneath Paleozoic limestones, and have limited surface expression, although one of the dikes located east of Haley Station is overlain by a linear series of swamps. The dikes appear to cross the Ross fault without offset. The relationship between the dikes and the Rocher–Fendu subdomain is unclear, in part because of the higher magnetic character of that subdomain. In some instances, it appears that the dikes end at the subdomain boundary, but, in other instances, it appears that the dikes continue into the subdomain. Lumbers (1982b) mapped Grenville dikes within Rocher–Fendu subdomain, suggesting that the dikes did intrude the subdomain.

Paleozoic strata in the Cobden area are generally sufficiently thick (>>100 m) to subdue the magnetic character of the underlying Precambrian strata; this is particularly evident in first vertical derivative (1-VD) of the magnetic field. The only area where the Paleozoic strata may be thin (<100 m) occurs north of Beachburg.

The high-resolution gamma-ray spectrometric data (Ontario Geological Survey 2014) defines the same airborne gamma-ray spectrometric highs for uranium and thorium as those indicated by the data of Carson et al. (2004a, 2004b). Areas of active farming and/or areas underlain by Leda clay within the Cobden area are characterized by potassium and equivalent thorium (eTh) highs in the high-resolution gamma-ray spectrometric data. These anthropogenic anomalies limit the use of the gamma-ray spectrometric data to distinguish rock units over most of the Cobden area.

A subdued aeromagnetic signature coincides with an area of low potassium and low eTh in a 7 $km^2$ area in southeastern Ross subdomain (*see* Figure 13.1) bounded by Castleford, Eady, Mullins and River roads. The reason for this anomaly is not readily apparent, but it could indicate an area underlain by Paleozoic limestone.

# ECONOMIC GEOLOGY

## Industrial Minerals

Preliminary geochemical data from calcite and dolomite marbles of the Ross subdomain indicates that they are characterized by the presence of rare earth element patterns with negative cerium anomalies (Figure 13.3). Negative cerium anomalies in limestones are interpreted as indicating deposition in a marine environment with a minimal input of continental clastic debris (cf. Easton 1995). The only marbles not showing this signature are the dolomite and tremolite marbles found adjacent to the former magnesium metal plant at Haley (Dominion Magnesium Ltd., later Chromasco Ltd., later Timminico Ltd., MDI31F10SW00002). These magnesium-rich, and commonly silica-rich, marbles are characterized instead by very low total rare earth element (REE) contents, and concave patterns where lanthanum, cerium, praseodymium, ytterbium and lutetium are high, and samarium, europium, gadolinium and terbium are low (*see* Figure 13.3). This unusual pattern is interpreted to be the result of post-depositional alteration of the original carbonate rock in a high-fluid flow regime, which likely introduced silica into the system and which also removed elements such as zinc and some of the rare earth elements. Whether or not this hydrothermal alteration is related to a nearby subsurface aeromagnetic anomaly related to the Chenaux gabbro (*see* "Geophysical Data") remains to be determined.

Thus, the marbles that served as feedstock for magnesium metal production may be unique. Exploration for similar magnesium feedstock needs to focus not only on the presence of dolomite marbles, but also on the REE geochemistry of those dolomite marbles. Additional sampling of the marbles in Ross subdomain was conducted during the 2014 season in order to both expand the available data set and to support a BSc (Honours) thesis on strontium isotopes in the marbles that is being conducted at Carleton University by J. Forrester under the supervision of Professor N. Witting.

## Base Metal Mineralization

The potential for mafic and quartzofeldspathic rocks present in the Rocher–Fendu subdomain in Ontario to host volcanogenic massive sulphide (VMS) mineralization has previously gone unrecognized. In part, this was because it was not appreciated how similar these rocks are to the host rocks of the former New Calumet zinc-lead-silver-gold mine located immediately across the Ottawa River on Grand Calumet Island, Quebec (cf. Moorhouse 1941; Sangster 1967; Williams 1992) (*see* Figure 13.1). At the former New Calumet Mine, dolomite and calcite marbles (Ross subdomain) occur in the deeper footwall of the deposit, and are structurally overlain by mafic gneisses with arc-tholeiite geochemical affinities and biotite-sillimanite quartzofeldspathic gneisses (Williams 1992). The deposit itself is hosted in a package of mafic and quartzofeldspathic gneisses, with the mafic gneisses having an arc basalt-boninite geochemical affinity (Williams 1992). Also present at the mine are migmatitic gneisses containing orthoamphibole, garnet, cordierite and gahnite, and which host gold mineralization emplaced during a late-stage greenschist-facies metamorphic event (Williams 1990). The rock types, as well as the metallic mineralogy of the deposit (sphalerite, galena, pyrrhotite) are all consistent with the former New Calumet Mine being the product of a volcanogenic massive sulphide (VMS) mineralization system.

On the Ontario side of the Ottawa River, 2 areas within the Rocher–Fendu subdomain warrant exploration for similar mineralization. The first occurs in the vicinity of Killoran Bay. Garnet-cordierite–bearing quartzofeldspathic gneisses are abundant on the north side of Killoran Bay and on islands offshore, and occur immediately above the contact with Ross subdomain marbles. In addition, on the south side of Killoran Bay, a gossan zone, with a minimum width of 5 m, occurs in mafic gneiss located immediately above the contact with Ross subdomain marbles (UTM 367475E 5055695N). Cordierite-bearing gneisses are present structurally above the gossan zone. Assay samples from the gossan zone are pending, and the

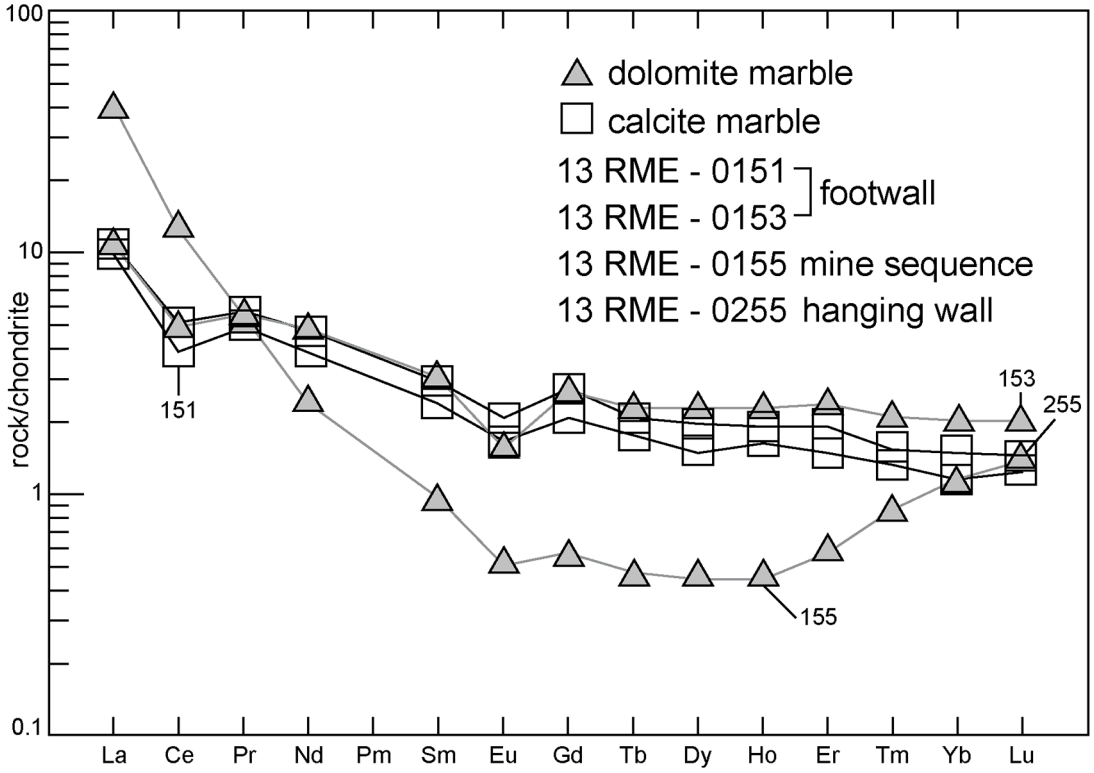



**Figure 13.3.** Representative rare earth element (REE) analyses of calcite and dolomite marbles from the area east of the Ross fault, including samples from the former Haley magnesium metal plant. The negative cerium (Ce) anomalies in 3 of the 4 samples are indicative of deposition in seawater (cf. Easton 1995). Normalizing factors used are *from* Sun and McDonough (1989). All analyses from the Geoscience Laboratories, Ontario Geological Survey, Sudbury.

chemical affinity of the host mafic gneiss is being determined. However, samples of similar mafic gneiss collected in 2013 along Kerr Line, 1.9 km to the west, have an arc-tholeiite geochemical signature. The second area occurs adjacent to the Ottawa River at Le Tombereau, just east of Norman Rapids, where Lumbers (1982a, p.21) reported a rusty schist unit in contact with cordierite-bearing quartzofeldspathic gneiss.

## Radioactive Mineralization

As discussed in Easton (2013), very few airborne gamma-ray spectrometric highs for uranium and thorium are present in the Cobden area, and all are located in Bromley subdomain (Carson et al. 2004a, 2004b). During the 2014 field season, field party personnel visited both the Vaughan and Forester Falls occurrences (Masson and Gordon 1981, p.126-128: MDI31F10NW00039 and MDI31F10NW00050, respectively), which are both located on an abandoned Canadian National Railways (CNR) right-of-way. The Vaughan occurrence is hosted in a Late Syenite suite syenite to quartz syenite intrusion and, although pegmatitic calcite-diopside-fluorite-apatite veins cut the syenite near the occurrence, the radioactive mineralization does not appear to be directly related to the veins. At the Vaughan occurrence, 3 separate scintillometer assay measurements gave readings of 271 to 281 ppm U and 1116 to 1432 ppm Th (UTM 361075E 5062404N), similar to values reported in Masson and Gordon (1981, p.128). The Forester Falls occurrence is located in a small pegmatite vein, and appears to contain limited radioactivity (12 ppm U, 60 ppm Th, UTM 362228E 5059841N).

More significant uranium mineralization was found hosted in rusty-weathering semi-pelitic and calcareous gneisses approximately 250 m north of the Forester Falls occurrence along the same CNR right-of-way. This occurrence does not seem to have been previously reported, and occurs at the southern limit of a 1.4 km long airborne gamma-ray spectrometric anomaly present in both the Carson et al. (2004a, 2004b) and Ontario Geological Survey (2014) surveys. At this new locality (UTM 362158E 5059911N), readings of over 65 000 total counts per second were obtained, the highest readings ever recorded by the author. A scintillometer assay measurement of 927 ppm U and 2717 ppm Th was obtained from rock at this site, with adjacent soils yielding values of 571 to 711 ppm U and 1787 to 2291 ppm Th. It should be noted that these scintillometer readings are estimates of the uranium and thorium contents in these rocks, and should be confirmed by conventional chemical analysis.

The host rock for this mineralization could not be determined, because of the aforementioned rusty weathering and the hazards associated with obtaining rock samples at this extremely radioactive site. Farther north (500 m; UTM 361837E 5060357N), a quartz syenite vein gave a scintillometer assay measurement of 166 ppm U and 270 ppm Th. Accordingly, it is possible that the airborne gamma-ray spectrometric anomaly in this area may be the result of radioactive mineralization in a variety of host rocks rather than being restricted to a single rock type.

Both the 65 000 counts per second occurrence, and another occurrence 5.5 km to the north on Grants Settlement Road described in Easton (2013) (UTM 361075E 5066294N), occur in Bromley subdomain immediately adjacent to the Ross fault (*see* Figure 13.1). The occurrence described in Easton (2013) is marginal to the Sullivan Island carbonatite complex, although it occurs in a syenite pegmatite vein cutting CMBBTZ rocks. Given their proximity and alignment along the Ross fault, it is possible that there may be some degree of structural control on the location of these 2 extremely thorium-rich occurrences (2717 and 1809 ppm Th, respectively).

**Table 13.1.** Rare earth element (REE) data for selected carbonate, syenite and mineral separates from Late Syenite suite rocks in the Cobden area. All analyses from the Geoscience Laboratories, Ontario Geological Survey, Sudbury.

| Sample | Total REE (in ppm) | Y (in ppm) | Rock Type or Mineral | Easting Zone 18 | Northing NAD83 | Comment |
|---|---|---|---|---|---|---|
| **Syenite** | | | | | | |
| 13RME-0068 | 1512 | 22 | Syenite | 352019 | 5048726 | Medium-grained red syenite, reported as 1044 ppm total REE *in* Easton (2013) |
| 13RME-0072 | 1457 | 58 | Syenite | 350711 | 5050016 | Medium-grained red syenite, reported as 1062 ppm total REE *in* Easton (2013) |
| 13RME-0259 | 2095 | 222 | Syenite | 353928 | 5053929 | Fine-grained, scapolitized syenite, Highway 17 just south of Cobden |
| 13RME-0404 | 750 | 52 | Syenite | 350967 | 5052930 | Medium-grained syenite, Cobden road |
| **Marble** | | | | | | |
| 13RME-0216 | 216 | 32 | Calcite marble | 353916 | 5053575 | Matrix, marble breccia |
| 13RME-0255 | 638 | 59 | Calcite marble | 357859 | 5048933 | Matrix, marble breccia, Highway 17 |
| 13RME-0262 | 689 | 43 | Calcite marble | 357541 | 5049284 | Matrix, marble breccia, Highway 17 |
| **Minerals** | | | | | | |
| 13RME-0139 | 1569 | 161 | Calcite | 354459 | 5050976 | From vein cutting varitextured and varigrained syenite, host syenite 381 ppm total REE |
| 13RME-0140 | 1647 | 154 | Calcite | 354470 | 5050932 | From vein cutting varitextured and varigrained syenite |
| 13RME-0141 | 2280 | 80 | Apatite | 354470 | 5050932 | From vein cutting varitextured and varigrained syenite |

## Rare Earth Element Mineralization

Easton (2013) suggested that both the pink-orange metasomatic marbles and the syenites of the Late Syenite suite may potentially host rare earth element (REE) mineralization in the Cobden area. This suggestion has been confirmed by geochemistry conducted on a variety of rock units located in Bromley subdomain. High REE contents (from 750 to 2095 ppm total REE) were found in several syenite phases, as summarized in Table 13.1. In addition, high REE contents (from 569 to 689 ppm total REE) have been found in non-apatite–bearing portions of the pink-orange calcite marble that forms the matrix to metasomatic marble breccia in Bromley subdomain (*see* Table 13.1). Mineral separates of both calcite and apatite from late calcite-diopside-apatite veins associated with the Late Syenite suite also have yielded high total REE contents (*see* Table 13.1). Interestingly, there does not appear to be any correlation between yttrium and total REE content in the Bromley subdomain samples (*see* Table 13.1), even though such a correlation was noted by Easton and Clarke (2013) in marbles in the Brudenell map area immediately to the southwest of the Cobden area. All of the samples reported in Table 13.1 were collected during the course of characterizing the geochemistry of typical Late Syenite suite rocks, rather than by any selective sampling protocol. However, in general, it appears that more uniform, medium-grained syenite phases (Photo 13.1A) are more likely to host REE mineralization than the varitextured and varigrained syenites (Photo 13.1B) that are most common in the Cobden area.

## FUTURE WORK

Two quartzite units, both containing 74 weight % $SiO_2$, were sampled for detrital zircon geochronology: the first quartzite is in Bromley subdomain (UTM 361321E 5044592N) and the second is 13 km to the east in Ross subdomain (UTM 373839E 5042734N). The purpose of this work is to compare

the depositional history and provenance of the clastic sedimentary rocks from the 2 subdomains. The main intermediate gneiss unit in the Rocher–Fendu subdomain was also sampled for geochronology, in part because of the limited information currently available from this subdomain, but also because of its possible economic significance. A deformed quartz syenite near Cobden was sampled for geochronology in order to determine its age relationship to other syenite intrusions in Bromley subdomain.


**Photo 13.1. A)** Fine- to medium-grained syenite of the Bromley subdomain, which is more likely to host rare earth element mineralization. Sample 13RME-0072 (*see* Table 13.1). UTM 350711E 5050016N. **B)** Varitextured and varigrained syenite typical of the Bromley subdomain, which is less likely to host rare earth element mineralization. UTM 353735E 5054135N. Hammer handle is 33 cm long.

# REFERENCES

Carson, J.M., Holman, P.B., Ford, K.L., Grant, J.A. and Shives, R.B.K. 2004a. Airborne gamma ray spectrometry compilation, equivalent uranium, Central Metasedimentary Belt, (Grenville Province), Ontario–Quebec; Geological Survey of Canada, Open File 4559, scale 1:250 000.

——— 2004b. Airborne gamma ray spectrometry compilation, equivalent thorium, Central Metasedimentary Belt, (Grenville Province), Ontario–Quebec; Geological Survey of Canada, Open File 4560, scale 1:250 000.

Carter, T.R., Colvine, A.C. and Meyn, H.D. 1980. Geology of base metal, precious metal, iron and molybdenum deposits in the Pembroke–Renfrew area; Ontario Geological Survey, Mineral Deposits Circular 20, 186p.

Easton, R.M. 1995. Regional geochemical variation in Grenvillian carbonate rocks: implications for mineral exploration; *in* Summary of Field Work and Other Activities 1995, Ontario Geological Survey, Miscellaneous Paper 164, p.6-18.

——— 2013. Faulting history, terrane subdivision and mineral potential of the Cobden area, northeastern Central Metasedimentary Belt, Grenville Province; *in* Summary of Field Work and Other Activities 2013, Ontario Geological Survey, Open File Report 6290, p.13-1 to 13-7.

Easton, R.M. and Clarke, S.A. 2013. Mineralogy of the rare earth elements in marbles from the Brudenell area, northeastern Central Metasedimentary Belt, Grenville Province; *in* Summary of Field Work and Other Activities, 2013, Ontario Geological Survey, Open File Report 6290, p.11-1 to 11-11.

Kamo, S.L., Krogh, T.E. and Kumarapeli, P.S. 1995. Age of the Grenville dyke swarm, Ontario–Quebec: Implications for the timing of Iapetan rifting; Canadian Journal of Earth Sciences, v.32, p.273-280.

Lumbers, S.B. 1982a. Summary of metallogeny, Renfrew County area; Ontario Geological Survey, Report 212, 58p.

——— 1982b. Cobden; Ontario Geological Survey, Map 2460, scale 1:100 000.

Masson, S.L. and Gordon, J.B. 1981. Radioactive mineral deposits of the Pembroke–Renfrew area; Ontario Geological Survey, Mineral Deposits Circular 23, 155p.

Moorhouse, W.W. 1941. Geology of the zinc-lead deposit on Calumet Island, Quebec; Geological Society of America Bulletin, v.52, p.601-622.

Ontario Geological Survey 1999. Single master gravity and aeromagnetic data for Ontario, ASCII, Excel® and Access® formats; Ontario Geological Survey, Geophysical Data Set 1035.

——— 2014. Ontario airborne geophysical surveys, magnetic and gamma-ray spectrometric data, grid and profile data (ASCII and Geosoft® formats) and vector data, Renfrew area; Ontario Geological Survey, Geophysical Data Set 1074.

Pehrsson, S., Hanmer, S. and van Breemen, O. 1996. U–Pb geochronology of the Raglan gabbro belt, Central Metasedimentary Belt, Ontario: Implications for an ensialic marginal basin in the Grenville Orogen; Canadian Journal of Earth Sciences, v.33, p.691-702.

Russell, D.J. and Williams, D.A. 1985. Paleozoic geology of the Cobden area, southern Ontario; Ontario Geological Survey, Preliminary Map P.2730, scale 1:50 000.

Sangster, A.L. 1967. Metamorphism of the New Calumet sulphide deposit, Quebec; unpublished MSc thesis, Carleton University, Ottawa, Ontario, 121p.

Storey, C.C. and Vos, M.A. 1981a. Industrial minerals of the Pembroke–Renfrew area, part 1: Marble; Ontario Geological Survey, Mineral Deposits Circular 21, 132p.

——— 1981b. Industrial minerals of the Pembroke–Renfrew area, part 2; Ontario Geological Survey, Mineral Deposits Circular 22, 214p.

Sun, S-s. and McDonough, W.F. 1989. Chemical and isotopic systematics of oceanic basalts: Implications for mantle compositions and processes; *in* Magmatism in ocean basins, The Geological Society, Special Publication No.42, p.313-345.

Williams, P.J. 1990. Evidence for a late metamorphic origin of disseminated gold mineralization in Grenville gneisses at Calumet, Quebec; Economic Geology, v.85, p.164-171.

——— 1992. Metamorphosed boninitic basalts, arc tholeiites, and cryptic volcanic stratigraphy from the Elzevir Terrane of the Grenville Province, Calumet Mine, Quebec; Canadian Journal of Earth Sciences, v.29, p.26-34.