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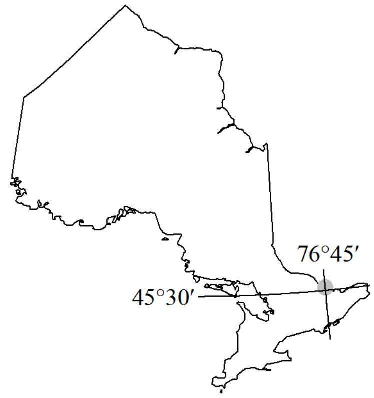
13. Project Unit 13-013. Faulting History, Terrane Subdivision and Mineral Potential of the Cobden Area, Northeastern Central Metasedimentary Belt, Grenville Province



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INTRODUCTION

The Cobden NTS map sheet (31 F/10) straddles the Ontario–Quebec 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. Reconnaissance mapping and sampling of the Cobden area was begun during part of the 2013 field season, with additional follow-up work planned for 2014. 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

The Cobden map area is split in two by a previously undocumented north-trending fault, herein termed the Ross fault (*see* Figure 13.1). The two-thirds of the Cobden area west of the Ross fault 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) (*see* Easton, this volume, Article 12). In contrast, the eastern one-third of the Cobden area is underlain by calcite and dolomite marble, which locally preserve relict stratigraphy. The marbles are intruded by the Chenaux gabbro (1231±2 Ma, Pehrrson, Hanmer and van Breemen 1996), which locally preserves primary mineralogy (*see* Azar and Easton, this volume, Article 14). Also present in the eastern one-third of the area, adjacent to the Ottawa River, are several small areas of amphibolite and granodioritic gneiss. These areas of gneiss have a sheet-like geometry and may have been thrust on top of the marbles. 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. The Sullivan Island carbonatite complex (Lumbers 1982a) (*circa* 1053 Ma: Lumbers et al. 1990) is located in the extreme north corner of the Cobden area at the junction of the Ross fault and the Ottawa River (*see* Figure 13.1).

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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).

Ross Fault

As noted previously, the Ross fault juxtaposes higher metamorphic grade rocks to the west from lower grade rocks to the east. North of Foresters Falls, gneissic tectonites of the Central Metasedimentary Belt boundary tectonic zone (CMBBTZ), which developed under upper amphibolite metamorphic conditions, are juxtaposed against lower amphibolite facies, relatively clean, dolomite marbles that locally preserve relict stratigraphy. Further south, marble tectonic breccia units of the Central Metasedimentary Belt that were intruded and metasomatized by rocks of the Late Syenite suite (1090 to 1030 Ma) occur west of the Ross fault, again juxtaposed against lower amphibolite facies, clean, calcite and dolomite marbles.

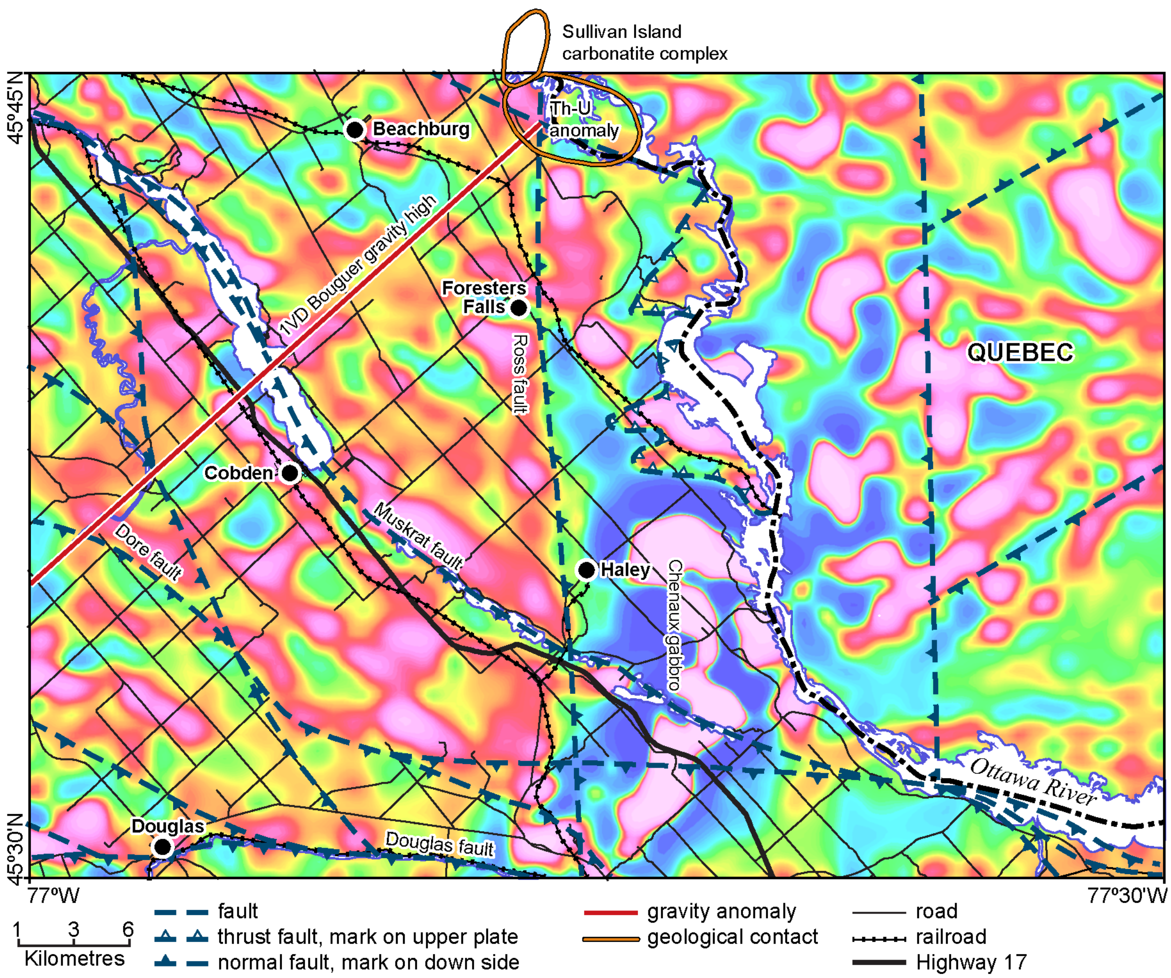

Figure 13.1. Map showing the first vertical derivative (1VD) of the magnetic field for the Cobden area of Ontario and Quebec. Red colours indicate highs, blue colours lows (range 0.6 to -0.4 nT/m). Also shown are major faults in the area identified by this study, and by Lumbers (1982b) and Russell and Williams (1985). The north-trending Ross fault follows a prominent break in the magnetic field, which also corresponds to a major change in the bedrock geology, as discussed in the text. Magnetic data *from* Ontario Geological Survey (1999).

The Ross fault trends almost due north, and extends for at least 28 km across the map area. It forms a prominent lineament on both the low-resolution total magnetic field and first vertical derivative of the magnetic field (*see* Figure 13.1) maps of the area (Ontario Geological Survey 1999). The area west of the fault is characterized by a higher magnetic background in the total field, and by prominent northwest-trending linear features in the first vertical derivative magnetic data (*see* Figure 13.1). In contrast, the area east of the fault is characterized by a lower total magnetic signature and minimal internal magnetic structure, consistent with the abundance of marbles with low magnetic susceptibility (typically $<0.5 \times 10^{-3}$ SI units) east of the fault. The fault likely continues into the Admaston–Horton map area to the south (*see* Duguet, Dubé-Bourgeois and Ma, this volume, Article 15), but its magnetic signature is harder to define due to changes in the local geology.

The Ross fault also marks a change in the Bouguer gravity field (Ontario Geological Survey 1999), with the area east of the fault having higher gravity values than the area to the west. Similarly, in the first vertical derivative of the Bouguer anomaly field, a northeast-trending gravity high, noted by Easton, Duguet and Magnus (2011) and which corresponds to anomaly 24 in Dufréchou and Harris (2013), is truncated against the Ross fault north of Foresters Falls (*see* Figure 13.1). Also, the Ross fault is located near or parallel to a large north-trending gravity lineament identified in Figure 7 of Dufréchou and Harris (2013). Thus, the Ross fault is both a significant geological and geophysical feature.

The trace of the Ross fault has not yet been observed on surface, but an outcrop located within 100 m of the fault trace is present on Kerr Line on the south side of Foresters Falls. This outcrop, just east of the fault, exposes both grain-size reduced, protomylonitic, calcite marble and a microbrecciated, fractured and chlorite-altered gabbro dike.

The amount of displacement and direction of motion across the Ross fault are more difficult to ascertain. This is in part because there is no unit east of the fault that can be correlated with a unit west of the fault. A regional magnetic anomaly to the south of the Cobden area that is associated with Mazinaw domain may be displaced 15 to 20 km to the north on the east side of the fault. Similarly, the Central Metasedimentary Belt boundary tectonic zone may be displaced a minimum of 10 km to the north on the east side of the fault.

Also unknown is whether displacement across the Ross fault is predominantly transcurrent, or vertical, or a combination of both. Given the proximity to the CMBBTZ, it is likely that uplift on the east side of the Ross fault would result in exposure of CMBBTZ or Central Gneiss Belt rocks, rather than relatively low-grade marbles. Thus, it is more likely that the fault was down-dropped to the east, preserving marbles that were higher in the superstructure of the Grenville orogen at *circa* 1060 Ma.

Ottawa–Bonnechere Graben Faults

Further complicating the map pattern of the Cobden area are several northwest-trending Ottawa–Bonnechere graben faults; most notable in the area are the Dore, Douglas and Muskrat faults (*see* Figure 13.1). All 3 appear to be down-dropped to the south, preserving Paleozoic limestones on their south flanks. Their relative age relationship to the Ross fault is not known. None is offset by the Ross fault. The Muskrat fault appears to affect the exposure level of the Chenaux gabbro (*see* Azar and Easton, this volume, Article 14), with deeper structural levels being exposed in the gabbro on the north side of the fault (consistent with south-side-down motion). This may indicate that the latest movement on the Muskrat fault occurred after major movement on the Ross fault.

There is a general lack of continuity of geological and geophysical features across the Ottawa River into Quebec (*see* Figure 13.1). This may be due to the presence of a major fault along the Ottawa River.

DISCUSSION

Terrane and Domain Subdivision

The complex faulting history makes assignment of rock packages in the Cobden area to the long-established terrane and domain subdivision of the Central Metasedimentary Belt problematic. For example, the marbles east of the Ross fault share many characteristics with those of Sharbot Lake domain further to the south, but, unlike the classic Sharbot Lake domain rocks, they occur north of the Robertson Lake mylonite zone. The marbles east of the Ross fault could also potentially belong to Black Donald domain, but this correlation cannot be firmly established as the marbles cannot be traced directly along strike to known Black Donald domain rocks. Attempting to unravel the terranes and/or domains present in the Cobden area will be a focus of the 2014 field season.

Location of the Central Metasedimentary Belt Boundary Tectonic Zone

It was thought previously that the Central Metasedimentary Belt boundary tectonic zone (CMBBTZ) was located immediately adjacent to the northwest corner of the Cobden area, at the junction of Highway 17 and Indian Road, and that there were no CMBBTZ rocks present in the Cobden area (cf. Ontario Geological Survey 1992). This is not the case. Partly metasomatized straight gneisses of the CMBBTZ are exposed on Highway 17 at the junction of Waterview Road, 11 km southeast of Highway 17 and Indian Road. In addition, partly metasomatized, straight and irregularly layered gneisses of the CMBBTZ occur for at least 9 km along the west side of the Ross fault, from Foresters Falls to the north boundary of the Cobden area. Straight and irregularly layered gneisses of the CMBBTZ are also cut by calcite veins of the Late Syenite suite on Kohlsmith Road, 2.5 km south-southeast of Cobden (*see* Easton, this volume, Article 12, Photo 12.3). Consequently, much of the northwestern corner of the Cobden area is underlain by rocks of the CMBBTZ.

The reason for this significant discrepancy in the position of the boundary is related to the historic lithological definition of the CMBBTZ boundary as being the first appearance of marble—be it marble tectonic breccia or belts of massive dolomite or calcite marble. The first appearance of marble is also generally coincident with the disappearance of large expanses of shallow-dipping, highly strained gneisses, e.g., straight gneisses, which constitute most of the CMBBTZ. In the Cobden area, applying this definition is difficult because of the presence of calcite vein dikes cutting straight gneisses of the CMBBTZ, as well as the apparent structural interleaving and/or injection of metasomatic pink calcite rock into rocks of the CMBBTZ (*see* Easton, this volume, Article 12). Furthermore, gentle, shallowly plunging open folds are present in the CMBBTZ in the northwestern part of the Cobden area, resulting in local folding of the Central Metasedimentary Belt boundary tectonic zone–marble contact. If one considers the metasomatic calcite rocks and veins to be marbles, then the CMBBTZ is roughly where it was previously located. On the other hand, if the boundary is defined as the disappearance of the highly flattened straight and irregularly layered gneisses and the presence of non-metasomatic marble, then the boundary is significantly further south, as noted above.

The location of the CMBBTZ is not just an academic exercise. The gneissic rocks of the CMBBTZ typically have low mineral potential. They likely underlie approximately 200 km^2 of the Cobden area, thereby reducing by approximately 30% the portion of the area that could have higher mineral potential.

ECONOMIC GEOLOGY

Industrial Minerals

The identification of the Ross fault addresses a long-standing geological conundrum; namely, why are there so many marble prospects, past-producers and producers in Horton and Ross townships (at least 11; *see* Storey and Vos 1981a) in what is ostensibly one of the highest metamorphic grade parts of the Central Metasedimentary Belt?

It is because the area east of the Ross fault represents a down-dropped block that preserves lower grade calcite and dolomite marbles. These marbles were deposited in a carbonate basin with a relatively low influx of siliciclastic or volcaniclastic material. The relative purity of the marbles, as indicated by their high brightness (typically >90%) and low silica contents has made them ideal for a variety of uses over the past 90 years, including lime production, and building, aggregate and terrazzo stone (Storey and Vos 1981a). The typically low zinc contents of the dolomite marbles (typically <30 ppm, Storey and Vos 1981a; preliminary unpublished data, this study) also made them excellent feedstock for the production of magnesium metal at the former Dominion Magnesium Ltd. (later Chromasco Ltd., later Timminico Ltd., MDI31F10SW00002) plant at Haley. It turns out that all of these prospects, past-producers and producers owe their presence to a unique combination of geological factors, most notably deposition in a basin relatively free of external detritus, and subsequent structural preservation due to faulting. Because of these unique circumstances, exploration for similar types of industrial mineral occurrences in the area should be restricted to the area east of the Ross fault. Potential targets for further exploration exist northeast of Foresters Falls, which contains abundant dolomite marbles, but few previously identified occurrences. In addition, although many of the dolomite marbles in Horton and Ross townships have low zinc contents, exploration for zinc sulphide or oxide mineralization should not be excluded. This is because almost no assay or geochemical data presently exist for the dolomite marbles northeast of Foresters Falls, and a grab sample collected by the author from the past-producing Payne Dolomite Quarry (MDI31F10SE0005) assayed 287 ppm Zn, which is highly anomalous for the area.

Iron and Nickel-Copper Mineralization

Iron and nickel-copper mineralization may be present in the Chenaux gabbro, as described in greater detail by Azar and Easton (this volume, Article 14).

Molybdenum Mineralization

Two molybdenite occurrences are present in the Cobden area, both west of the Ross fault: the Cole (MDI31F10SW00041) and Elliot (MDI31F10NW00010) occurrences (Carter, Colvine and Meyn 1980). Both are typical of the molybdenite occurrences present in the Brudenell and Cobden areas, consisting of large pyroxene-calcite-pyrite veins, with associated apatite, scapolite and titanite, that cut marble breccia and quartzofeldspathic gneiss. Similar veins are likely present elsewhere in the Cobden area west of the Ross fault. The small size of these veins limits their metallic mineral potential, but they may still be of interest as mineral collecting sites.

Potassium Alteration Zone

Rusty weathering pelitic, semi-pelitic and psammitic gneiss exposed on River Road (Renfrew County 1) at Smuggler's Hill (UTM 374150E 5042712N) yielded estimated anomalous potassium contents, ranging from 6.4 to 8.9 weight % K_2O, as determined by *in situ* gamma-ray spectrometric measurements. These anomalous potassium contents were only observed in this unit at Smuggler's Hill, and may be similar to an area of potassium enrichment previously described in the Horton map area, approximately 10 km to the southwest (Easton, Duguet and Magnus 2011; Duguet, Magnus and Ratcliffe 2012).

Radioactive Mineralization

Very few airborne gamma-ray spectrometric highs for uranium and thorium are present in the Cobden area (Carson et al. 2004a, 2004b), with the largest high located just south of the Sullivan Island carbonatite complex on the west side of the Ross fault. At the southwestern margin of this high, a syenite pegmatite vein exposed on Grants Settlement Road gave a scintillometer assay reading of 370 ppm U and 1809 ppm Th (UTM 361075E 5066294N). Further study of this anomaly will be undertaken during the 2014 field season. The only other significant scintillometer assay readings, out of a total of 338 measurements taken during the field season, were obtained approximately 700 m further south on Grants Settlement Road. Here, syenite veins injected into CMBBTZ gneisses gave scintillometer assay readings of 186 and 126 ppm U and 426 and 657 ppm Th (UTM 361513E 5065398N; 361397E 5065884N, respectively). Note these scintillometer readings are estimates of the uranium and thorium contents in this vein, and should be confirmed by conventional chemical analysis.

Rare Earth Element Mineralization

Both the pink-orange metasomatic marbles and the syenites of the Late Syenite suite may potentially host rare earth element (REE) mineralization (*see* Easton and Clarke, this volume, Article 11; Easton, this volume, Article 12). Preliminary data indicate that the highest rare earth contents are in large medium-grained red syenite dikes, which contain 1044 and 1062 ppm total REE (UTM 352019E 5048726N and 350711E 5050016N, respectively). No data are yet available regarding rare earth element content from any of the metasomatic marbles in the Cobden area.

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