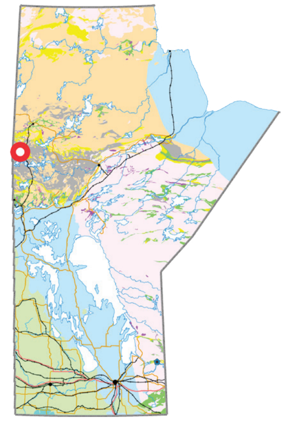
Brezden Lake intrusive complex

Rare Metals *in* Manitoba



UTM: 336590E, 6218008N; NAD83, UTM Zone 14

Area: Brezden Lake; southwest of Russell Lake; close to the north margin of the Kisseynew domain

NTS: 64C4

Access: via floatplane; located in a proposed rank 1 park

Introduction

There is no record of exploration for rare metals (RM) in the Brezden Lake (BL) intrusive complex. The area was mapped at a regional scale by the Manitoba Geological Survey (MGS) in the 1970s, and the complex was later mapped in detail by McRitchie (1988) as a potential host for zirconium mineralization. In 2012, the MGS carried out a reconnaissance study focused on the rare earth element (REE) potential of the complex (Martins et al., 2012a).

Geological setting

The BL intrusive complex is exposed over a length of about 4 km and a width of about 0.8 km, just east of Brezden Lake (Figure 1; Martins et al., 2012a). It intrudes turbiditic metasedimentary rocks of the Burntwood group (Zwanzig, 1990), and is situated very close (<10 km) to the 'North Flank Kisseynew subdomain' boundary defined by Zwanzig (2008) on the basis of U-Pb zircon geochronology, Sm-Nd isotope work, geochemistry and remapping of key areas of the Kisseynew domain (KD).

The KD is a metasedimentary basin in the internal zone of the Trans-Hudson orogen. The tectonic setting of the Kisseynew basin remains a matter of debate: it has been previously interpreted as a back-arc, intra-arc or fore-arc basin (Ansdell et al., 1995; Zwanzig, 1997; Zwanzig and Bailes, 2010). The Brezden Lake area is largely underlain by turbiditic metagreywacke of the Burntwood group (Zwanzig, 1990), which was deposited between ca. 1860 and 1840 Ma (Machado et al., 1999). Early folding and thrusting (D_1) occurred during the later stages of sedimentation (1842–1835 Ma; Machado et al., 1999; Zwanzig, 1999), prior to metamorphism in the KD, and was accompanied by intrusion of ca. 1840–1820 Ma calcalkalic plutons (Machado et al., 1999). The youngest calcalkalic intrusions in the KD constitute the enderbitic Touchbourne suite, which was intruded between ca. 1830 and 1820 Ma (Gordon et al., 1990; Machado et al., 1999), prior to the main tectonometamorphic event. Two generations of isoclinal, nappe-style folds (D_2-D_3; 1820–1800 Ma; Zwanzig, 1999) formed coeval with peraluminous granitoid intrusions (1820–1810 Ma; Kraus and Menard, 1997; White, 2005). The majority of the KD experienced low-pressure granulite-facies metamorphic conditions of 750° ±50°C and 5.5 ±1.0 kbar

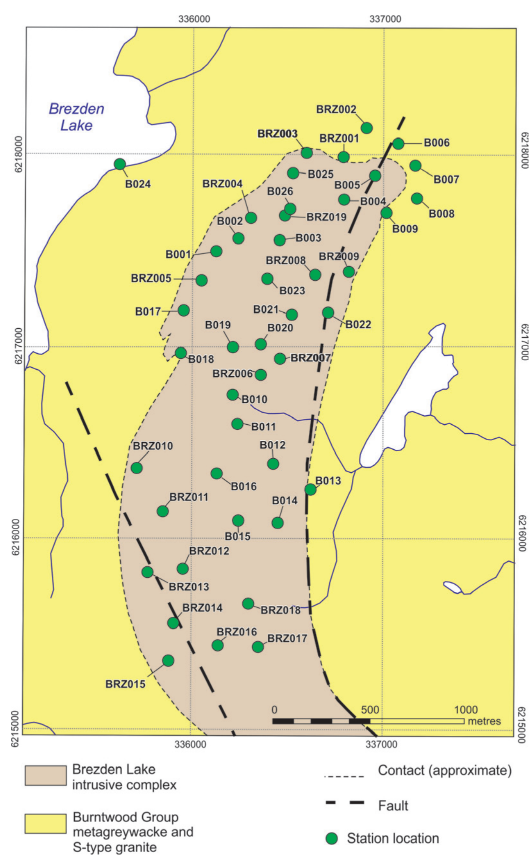


***Figure 1:** Simplified geology map of the Brezden Lake intrusive complex (modified after Martins et al., 2012a).*

Compiled by T. Martins

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(Gordon, 1989) following the D_2 deformation phase (White, 2005). Peak metamorphic conditions continued through D_3 folding. Folding and faulting associated with the regional D_4 and D_5 deformations continued until after ca. 1790 Ma (Zwanzig, 1999).

Geology of the Brezden Lake intrusive complex

The BL intrusive complex is a heterogeneous multiphase body that ranges in composition from granite to syenite (Martins et al., 2012a). Outcrop examination of the complex was hindered by mature vegetation cover in 2012, making it difficult to determine internal contact relationships. Single outcrops often include several different types of granitic and/or syenitic rocks, some of which are possibly metasomatic. From limited observations of rarely exposed textural relationships, the syenite appears to be older than the granite (syenite rafts were observed within the granite; Martins et al., 2012a).

Based on field observations, whole rock geochemistry and petrography, Martins et al. (2012a) defined the BL intrusive complex to include non-metasomatized and metasomatized rocks (Figure 2a-f). The non-metasomatized rocks include:

1) clinopyroxene granite—contains quartz, plagioclase, K-feldspar, clinopyroxene and minor apatite, magnetite, titanite and zircon;
2) amphibole-quartz syenite—contains quartz, plagioclase, K-feldspar, amphibole, biotite and zircon (crudely banded);
3) syenite—contains K-feldspar, clinopyroxene, plagioclase, titanite, amphibole, allanite, Fe-oxides (possibly ilmenite), chalcopyrite, zircon and apatite;
4) melasyenite—contains K-feldspar, biotite, clinopyroxene, amphibole, titanite, zircon, apatite, allanite, and Fe-oxides (possibly ilmenite), and chalcopyrite.

The metasomatized rocks also have similar mineralogy to what is described above but their modal proportions are variable. These rocks are very heterogeneous, contain greater proportions of allanite, titanite, zircon and apatite, and petrographic studies show complex replacement textures (petrographic descriptions of both non-metasomatized and metasomatized rocks can be found in Martins et al., 2012a). Other examples of metasomatic features identified at BL intrusive complex include clots of mafic minerals (biotite, clinopyroxene, titanite, zircon and amphibole), carbonate, allanite and other epidote group minerals, and higher concentrations of Sr, Ba and REE. These features are interpreted to result from metasomatism (Martins et al., 2012a). Heterogeneity and presence of metasomatism are common in these types of intrusions and can also be observed in the carbonatitic and syenitic intrusions at Eden Lake (e.g. Couëslan, 2005; Chakhmouradian et al., 2008) and the syenitic intrusion at Burntwood Lake (McRitchie, 1987; Martins et al., 2011).

Exploration potential

As with other localities in Manitoba with REE potential, such as Cinder Lake (e.g. Kressall, 2012) and Burntwood Lake (Martins et al., 2011), no carbonatite was identified in the BL complex. Carbonatite is often associated with REE-Th-U-Nb mineralization (e.g. Mountain Pass, California, Castor, 2008; Oka carbonatite complex, Quebec, Treiman and Essene, 1985; Maoniuping REE deposit, China, Xu et al., 2013; Bayan Obo, China, Le Bas et al., 1997), and thus has considerable significance for exploration potential. However, the apparent absence of carbonatite should not discourage mineral exploration, particularly if there is evidence of alkali and carbonate metasomatism, which may indicate interaction with carbonatite magmas or alternatively with alkaline intrusions (e.g. Chakhmouradian et al., 2008; Kressall, 2012). Occurrences in the Trans-Hudson orogen and particularly in the Kisseynew domain are good proxies for the BL complex because they could have a similar tectonic setting and age. Therefore, localities such as the Eden Lake complex (a target for REE exploration in Manitoba), and the Burntwood Lake intrusive complex (with demonstrated REE potential) offer good comparison scenarios.

Similarities between the BL complex, the Eden Lake complex, and the Burntwood Lake intrusive complex include:

- similar enrichment patterns for trace elements and REE (Figure 3a-d);
- enrichment in Ba, Sr and REE (up to 3055 ppm of total REE, which is comparable to total REE concentrations of 3585 ppm for the metasomatized syenite at the Eden Lake complex reported by Couëslan, 2005; complete whole rock geochemistry dataset available at Martins et al., 2012b);
- heterogeneity observed at the outcrop level and mineral modal heterogeneity;
- and complex mineral replacement textural relationships observed in thin section in clinopyroxene, titanite, allanite, zircon, apatite, and the presence of carbonate.

Some of the heterogeneity and mineral associations observed at BL are interpreted to be the result of alkali and carbonate metasomatism (Martins et al., 2012a). This type of metasomatism was possibly caused by an alkaline intrusion and/or carbonatitic magmatism. Also worth mentioning is the known association between syenites and carbonatitic magmatism found in several localities in the world (Woolley, 2003). Examples of this type of association include the Eden Lake complex (Chakhmouradian et al., 2008), the Maoniuping REE deposit in China (Xu et al., 2013), and the Tamil Nadu carbonatites in India (Schleicher et al., 1998). All of this may suggest the possibility of the presence of a carbonatite that is not exposed at the present day erosion level and potential for associated REE-Th-U-Nb mineralization. Alternatively the metasomatism observed at BL

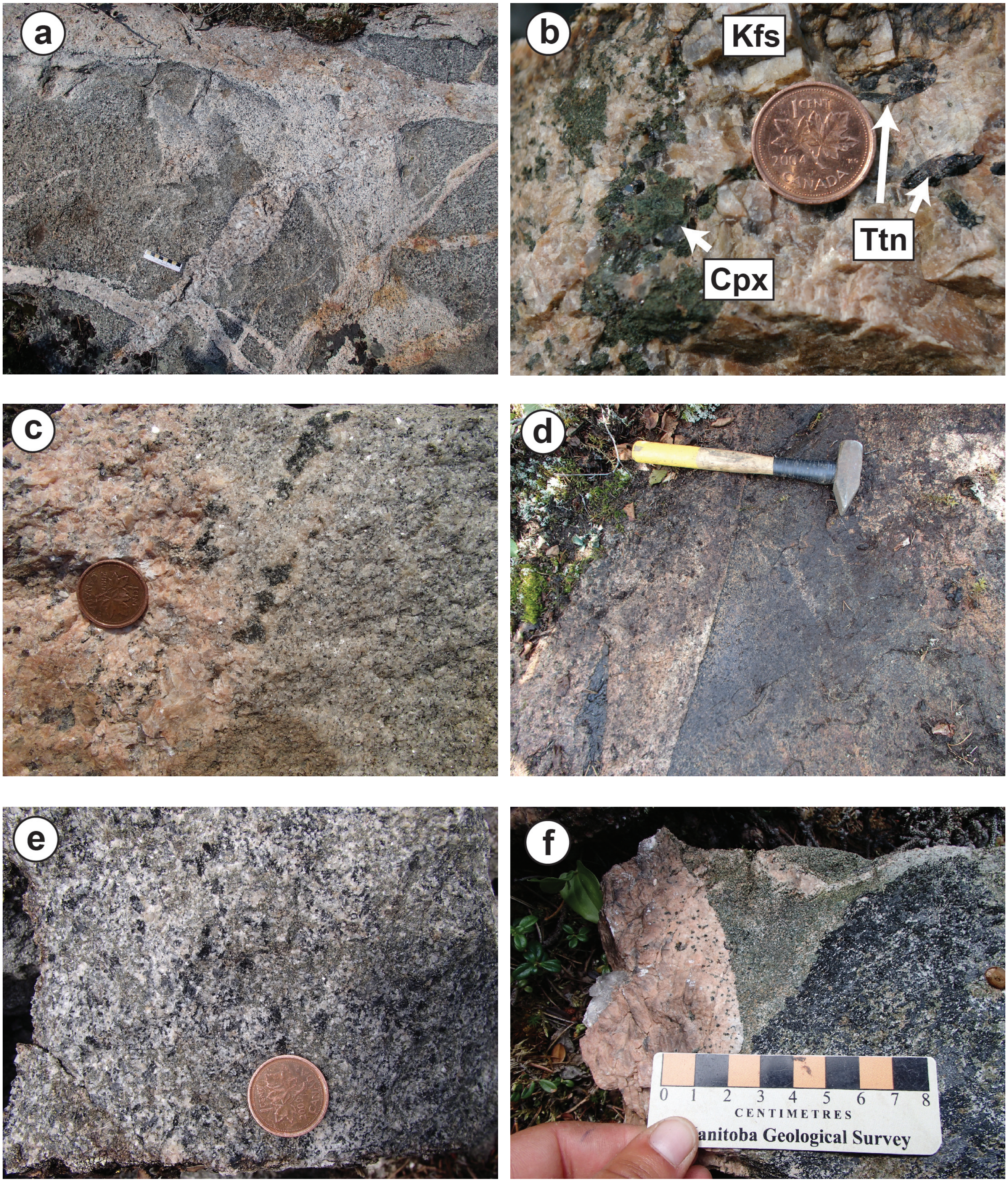

Figure 2: *Outcrop photographs of the different phases of the Brezden Lake intrusive complex, evidencing its heterogeneous character:* ***a)*** *pegmatite cutting melasyenite;* ***b)*** *coarse-grained syenite;* ***c)*** *medium-grained biotite syenite with centimetre-sized clots of mafic minerals (right) and coarse-grained syenite (left);* ***d)*** *non-metasomatic (left) and metasomatized (right) phases of syenite separated by a sharp boundary; the latter contains abundant mafic minerals;* ***e)*** *metasomatic phase of the syenite containing up to 15% interstitial carbonate;* ***f)*** *non-metasomatized (left) and metasomatized (right) phases of syenite; the sharp boundary within the metasomatized syenite is interpreted to result from different pulses of metasomatic fluids. Abbreviations: Cpx, clinopyroxene; Kfs, K-feldspar; Ttn, titanite.*

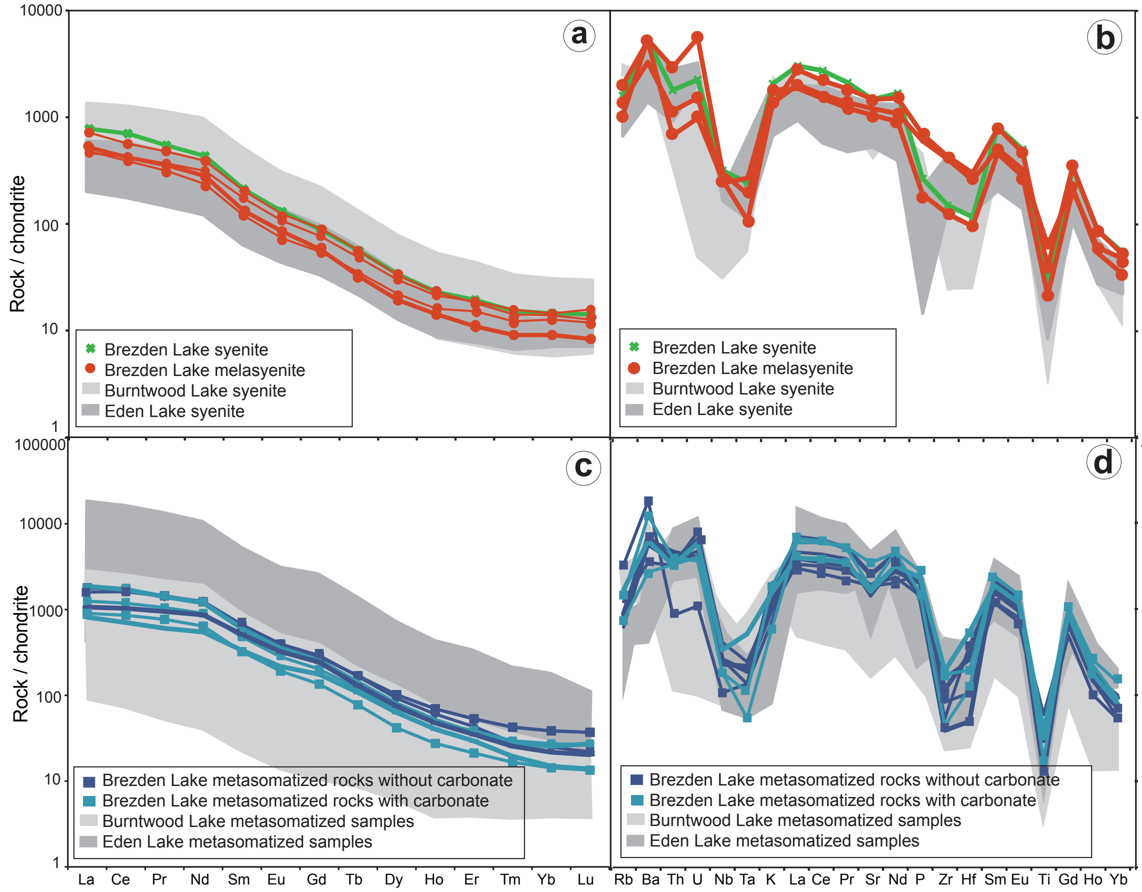

Figure 3: *Normalized trace-element compositions of samples from the Brezden Lake intrusive complex (normalization factors from McDonough and Sun, 1995) compared to Eden Lake and Burntwood Lake rocks:* ***a)*** *chondrite-normalized REE patterns for non-metasomatized rocks at Brezden Lake;* ***b)*** *primitive-mantle–normalized multi-element diagram for non-metasomatized rocks at Brezden Lake;* ***c)*** *chondrite-normalized REE patterns for metasomatized rocks of the Brezden Lake intrusive complex;* ***d)*** *primitive-mantle–normalized multi-element diagram for metasomatized rocks at Brezden Lake. Data for the Eden Lake rocks are from Couëslan (2005) and Chakhmouradian et al. (2008); data for the Burntwood Lake rocks are from Martins et al. (2011a).*

could be associated with an alkaline intrusion or the intrusion of a volatile-rich syenite.

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