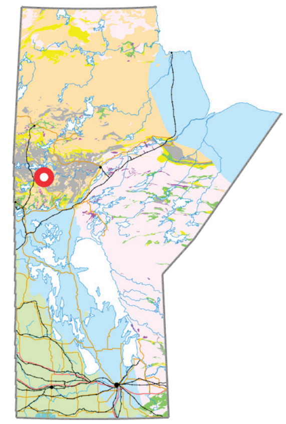
Burntwood Lake intrusive complex



UTM: 404188E, 6148584N; NAD83, UTM Zone 14

Area: Burntwood Lake; 70 km northwest of Snow Lake; central Kisseynew domain

NTS: 63N8

Access: via floatplane

Rare Metals *in* Manitoba

Introduction

The Burntwood Lake intrusive complex was identified by the Manitoba Geological Survey (MGS) in the early 1970s during regional mapping, and later examined in detail by McRitchie (1987) as a potential host for zirconium mineralization. In 2011, the MGS evaluated its potential for rare earth element (REE) mineralization (Martins et al., 2011a). The Burntwood Lake area has seen relatively little exploration but there are records of a radiometric airborne geophysical survey conducted for uranium exploration in 1954 (Assessment File 91616, Manitoba Growth, Enterprise and Trade, Winnipeg), and a magnetic survey and till sampling for diamond exploration in 1993 (Assessment File 94323, Manitoba Growth, Enterprise and Trade, Winnipeg).

Geological setting

The Burntwood Lake intrusive complex is located in the central Kisseynew domain (KD), 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 Burntwood 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 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 (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 Burntwood Lake intrusive complex

The Burntwood Lake intrusive complex is a compositionally and texturally heterogeneous syenite body that intruded Burntwood group metasedimentary rocks and peraluminous granitic rocks. This syenite body was examined by MGS in 2011 and the following description is simplified from Martins et al. (2011a). The intrusion includes two main phases: pink-beige syenite and red syenite (Figure 1). Both phases are locally cut by quartz bearing pegmatite bodies (not shown on Figure 1). Minor phases include fluorite-bearing quartz syenite as well as a band of massive apatite (up to 15 cm thick). The syenite intrusion shows wide variations in texture and modal compositions at outcrop scale, suggesting the possibility of several other intrusive phases, but contact relationships were obscured in 2011 by mature vegetation and extensive lichen and moss cover. Heterogeneous single outcrops locally vary from fine- to coarse-grained and contain from 5% to 80% mafic minerals.

Compiled by T. Martins

Published by Manitoba Geological Survey 2016

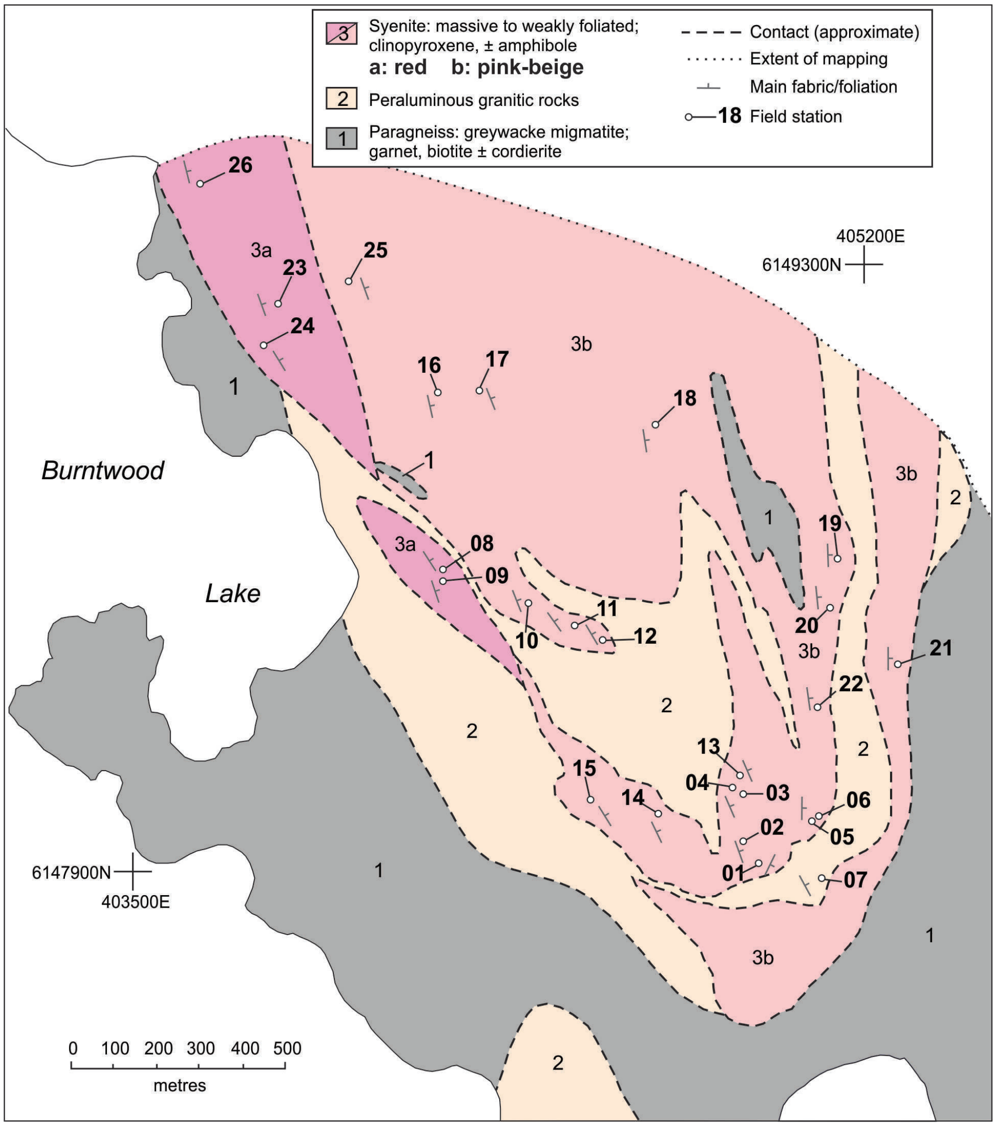


Figure 1: *Detailed geological map of the Burntwood Lake intrusive complex (modified from Martins et al., 2011a).*

The pink-beige and red syenite phases vary from fine- to coarse-grained, massive to weakly foliated, and are metaluminous (Figure 2). Common mineralogy is feldspar, clinopyroxene, apatite and titanite. Minor components are biotite and quartz (up to 3%), and trace amounts of sulphide. The fluorite-bearing quartz syenite is fine grained, massive and appears relatively homogeneous. It contains pinkish-beige feldspar, quartz, clinopyroxene and fluorite and is interpreted to represent a more highly fractionated phase of the intrusive complex. Fluorite-bearing feldspathic veins are locally present within the pink-beige syenite phase. Fine-grained massive apatite was observed in a narrow (<15 cm) discontinuous band. It is unclear if this band represents metasomatic veins or cumulate layers.

The different phases of syenite include zones that contain relatively equant clots, irregular patches, discontinuous layers and veins of mafic minerals (mainly clinopyroxene, biotite, titanite and hornblende). The contacts of these features vary from diffuse to sharp. Apatite is typically enriched in these zones, composing up to 10% of the rock, and trace amounts of carbonate are locally

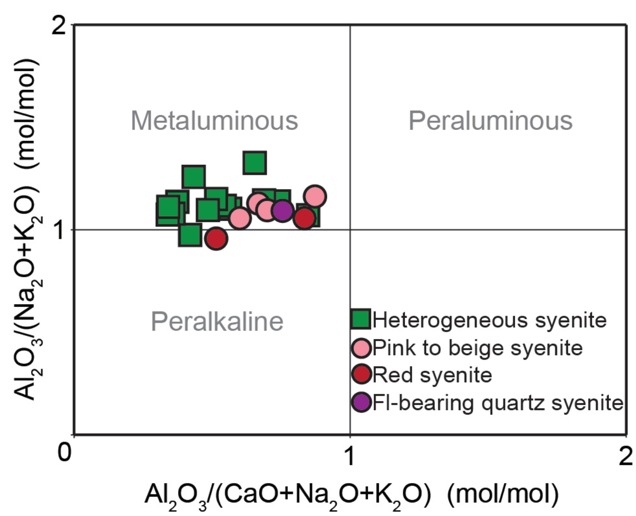


Figure 2: *Aluminum Saturation Index diagram showing the largely metaluminous nature of the syenite phases of the Burntwood Lake intrusive complex. Abbreviations: Fl, fluorite.*

present. These zones may represent either magmatic (cumulate and/or fractionated) or metasomatic phases, or possibly entrained xenolithic material. In addition to these zones, local diffuse zones and veins within the alkali-feldspar syenite contain up to 7% titanite and often have a bleached white or light green colour, perhaps representing zones of metasomatism.

The syenite is commonly granoblastic and primary textures are largely recrystallized (Martins et al., 2011a), indicating that it pre-dates the latest stages of regional metamorphism. This could also be the result of metasomatism.

Exploration potential

Martins et al. (2011a) described the Burntwood Lake intrusive complex as having many similarities to the Eden Lake (EL) complex, which contains occurrences of REE-Th-U mineralization and several carbonatite bodies (e.g. Mumin, 2010), and has been explored for REE (e.g. Assessment File 74371, Manitoba Growth, Enterprise and Trade, Winnipeg). These similarities include: textural and modal heterogeneity; dominantly metaluminous geochemistry (Figure 2); trace element concentrations (Figure 3a–d); enrichment in Ba, Sr and REE; and abundant clinopyroxene, titanite, apatite, and locally carbonate and fluorite. As with the EL complex, at least some of the heterogeneity of the Burntwood Lake intrusive complex (e.g. massive apatite band, titanite enriched zones, mafic-rich layers, extreme variations of concentrations of mafic minerals) appears to be the result of metasomatism[1]. This metasomatism could have resulted from carbonatitic magmatism of a carbonatite body that is not presently exposed or alternatively a volatile-rich syenite magma that leat to autometasomatism.

Martins et al. (2011a) described local Th and REE enrichment in veins and massive apatite that are encouraging from the perspective of exploration potential

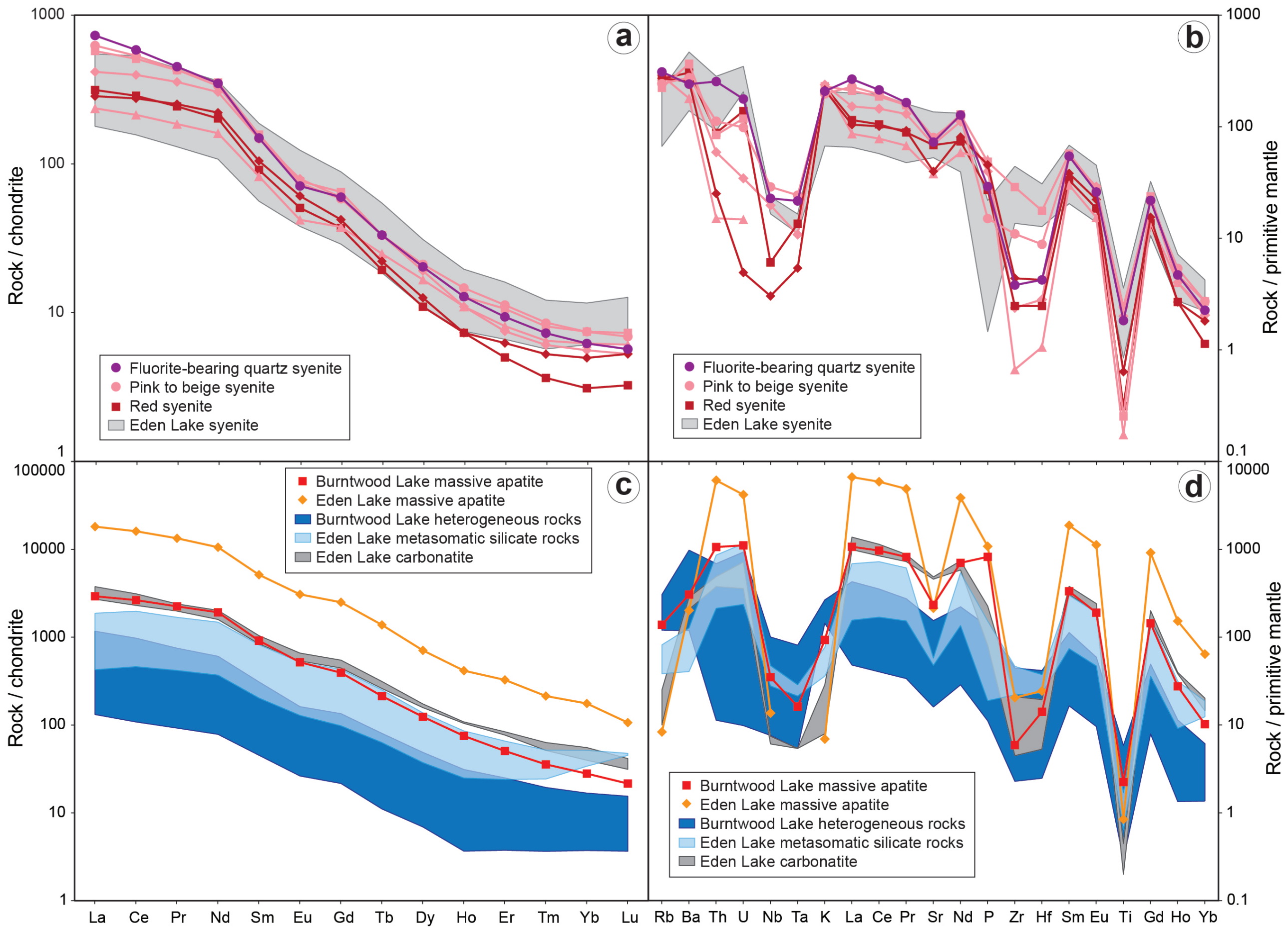


***Figure 3:** Normalized trace element compositions of rocks from the Burntwood Lake intrusive complex (Martins et al., 2011b); **a)** Chondrite-normalized REE diagram and **b)** primitive mantle normalized multi-element diagram of non-metasomatized rocks; **c)** Chondrite-normalized REE diagram and **d)** primitive mantle-normalized multi-element diagram for heterogeneous rocks, which likely represent a combination of magmatic and metasomatic rocks. The grey field outlines representative analyses of metasomatic rocks from the Eden Lake complex; analyses of carbonatite and a massive apatite vein from Eden Lake are also given for comparison; Data for the Eden Lake rocks are from Couëslan (2005) and Chakhmouradian et al. (2008). Trace element normalization factors are from McDonough and Sun (1995).*

[1] Alkaline-silicate and carbonatitic magmatism is commonly accompanied by characteristic sodic or potassic metasomatism, coupled with silica-loss, in the country rock; these processes are commonly known as fenitization.

(complete whole rock geochemistry dataset can be found in Martins, 2012). Field analyses with a hand held spectrometer indicated 8048 ppm Th and 557 ppm U for the Th-enriched vein, whereas the massive apatite vein yielded a total REE+Y content of 3810 ppm (whole rock geochemical analysis) which is comparable to the total REE+Y contents reported at EL (3439–4330 ppm; e.g. Couëslan, 2005; Chakhmouradian et al., 2008).

There is a well known spatial association (and inferred temporal relationship) between alkaline igneous rocks and carbonatitic magmatism (Woolley, 2003). However, a similar association of silica-saturated syenite and quartz syenite is also recognized and suggests potential may exist for carbonatite at Burntwood Lake. Examples of this type of association include the EL complex (Chakhmouradian et al., 2008), the Maoniuping REE deposit in China (Xu et al., 2003), and the Tamil Nadu carbonatites in India (Schleicher et al., 1998).

Martins et al. (2011a) argue on the basis of geochemical and mineralogical similarities that the Burntwood Lake intrusive complex and EL complex could be derived from a geochemically similar (mantle?) source. The location of both complexes within the internal zone of the Trans-Hudson orogen in Manitoba, and specifically within or along the margins of the Kisseynew basin, implies regional potential for other intrusive complexes of this type.

References

Ansdell, K.M., Lucas, S.B., Connors, K. and Stern, R.A. 1995: Kisseynew metasedimentary gneiss belt, Trans-Hudson orogen (Canada): back-arc origin and collisional inversion; Geology, v. 23, no. 11, p. 1039–1043.

Chakhmouradian, A.R., Mumin, A.H., Demény, A. and Elliott, B. 2008: Postorogenic carbonatites at Eden Lake, Trans-Hudson Orogen (northern Manitoba, Canada): geological setting, mineralogy and geochemistry; Lithos, v. 103, p. 503–526.

Couëslan, C.G. 2005: Geochemistry and petrology of the Eden Lake carbonatite and associated silicate rocks; M.Sc. thesis, University of Western Ontario, London, Ontario, 201 p.

Gordon, T.M. 1989: Thermal evolution of the Kisseynew sedimentary gneiss belt, Manitoba: metamorphism at an early Proterozoic accretionary margin; *in* Evolution of Metamorphic Belts, J.S. Daly, R.A. Cliff and B.W.D. Yardley (ed.), Geological Society, Special Publication 43, p. 233–243.

Gordon, T.M., Hunt, P.A., Bailes, A.H. and Syme, E.C. 1990: U-Pb ages from the Flin Flon and Kisseynew belts, Manitoba: chronology of crust formation at an Early Proterozoic accretionary margin; *in* The Early Proterozoic Trans-Hudson Orogen of North America; J.F. Lewry and M.R. Stauffer (ed.), Geological Association of Canada, Special Paper 37, p. 177–199.

Kraus, J. and Menard, T. 1997: A thermal gradient at constant pressure: implications for low- to medium-pressure metamorphism in a compressional tectonic setting, Flin Flon and Kisseynew Domains, Trans-Hudson Orogen, central Canada; Canadian Mineralogist, v. 35, no. 5, p. 1117–1136.

Machado, N., Zwanzig, H. and Parent, M. 1999: U-Pb ages of plutons, sedimentation, and metamorphism of the Paleoproterozoic Kisseynew metasedimentary belt, Trans-Hudson Orogen (Manitoba, Canada); Canadian Journal of Earth Sciences, v. 36, no. 11, p. 1829–1842.

Martins, T., Couëslan, C.G. and Böhm, C.O. 2011a: The Burntwood Lake alkali-feldspar syenite revisited, west-central Manitoba (part of NTS 63N8); *in* Report of Activities 2011, Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, p. 79–85.

Martins, T., Couëslan, C.G. and Böhm, C.O. 2011b: The Burntwood Lake alkali-feldspar syenite revisited, west-central Manitoba (part of NTS 63N8); Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, Manitoba Mining and Minerals Convention 2011, Winnipeg, Manitoba, November 17–19, 2011, poster presentation.

Martins, T. 2012: Whole-rock geochemistry of the Burntwood Lake alkali-feldspar syenite, west-central Manitoba (part of NTS 63N8); Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, Data Repository Item DRI2012001, Microsoft® Excel® file.

McDonough, W.F. and Sun, S.-S. 1995: The composition of the Earth; *in* Chemical Evolution of the Mantle, W.F. McDonough, N.T. Arndt and S. Shirey (ed.), Chemical Geology, v. 120, p. 223–253.

McRitchie, W.D. 1987: Burntwood Lake syenite; *in* Report of Activities 1987, Manitoba Energy and Mines, Geological Services, p. 65–69.

Mumin, H. 2010: The Eden Lake Rare Metal (REE, Y, U, Th, Phosphate) Carbonatite complex Manitoba "Updated Report"; Medallion Resources Ltd.; NI 43-101 report, 110 p. plus six appendices.

Schleicher, H., Kramm, U., Pernicka, E., Schidlowski, M., Schmidt, F., Subramanian, V., Todt, W. and Viladkar, Sh. 1998: Enriched subcontinental upper mantle beneath southern India: evidence from Pb, Nd, Sr, and C–O isotopic studies on Tamil Nadu carbonatites; Journal of Petrology 39, p. 1765–1785.

White, D.J. 2005: High-temperature, low-pressure metamorphism in the Kisseynew domain, Trans-Hudson orogen: crustal anatexis due to tectonic thickening?; Canadian Journal of Earth Sciences, v. 42, no. 4, p. 707–721.

Woolley, A.R. 2003: Igneous silicate rocks associated with carbonatites: their diversity, relative abundances and implications for carbonatite genesis; Periodico di Mineralogia 72, p. 9–17.

Xu, C., Huang, Z., Liu, C., Qi, L., Li, W. and Guan, T. 2003: Geochemistry of carbonatites in Maoniuping REE deposit, Sichuan Province, China; Science in China (Series D) 46, p. 246–256.

Zwanzig, H.V. 1990: Kisseynew gneiss belt in Manitoba: stratigraphy, structure, and tectonic evolution; *in* The Early Proterozoic Trans-Hudson Orogen of North America; J.F. Lewry and M.R. Stauffer (ed.), Geological Association of Canada, Special Paper 37, p. 95–120.

Zwanzig, H.V. 1997: Kisseynew metasedimentary gneiss belt, Trans-Hudson orogen (Canada): back-arc origin and collisional inversion: discussion and reply; Geology, v. 25, no. 1, p. 90–92.

Zwanzig, H.V. 1999: Structure and stratigraphy of the south flank of the Kisseynew Domain in the Trans-Hudson orogen, Manitoba: implications for 1.845–1.77 Ga collision tectonics; Canadian Journal of Earth Sciences, v. 36, no. 11, p. 1859–1880.

Zwanzig, H.V. and Bailes, A.H. 2010: Geology and geochemical evolution of the northern Flin Flon and southern Kisseynew domains, Kississing–File lakes area, Manitoba (parts of NTS 63K, N); Manitoba Innovation, Energy and Mines, Manitoba Geological Survey, Geoscientific Report GR2010-1, 135 p.