The Burntwood Lake alkali-feldspar syenite revisited, west-central Manitoba (part of NTS 63N8)

T. Martins, C. G. Couëslan and C.O. Böhm

University of Manitoba

Summary

A five day geological investigation of the Burntwood Lake syenite was conducted in August of 2011 to evaluate the potential for rare-earth element mineralization. The syenite is located in the northwest arm of Burntwood Lake and is hosted by Burntwood Group metasedimentary rocks of the Kisseynew Domain and peraluminous granite. The syenite forms a heterogeneous intrusion that is modally and texturally diverse. The heterogeneity appears to be the result of a combination of crystal fractionation, metasomatism, and possibly contamination. A hand-held spectrometer was utilized in the field to search for zones of elevated radioactivity that could potentially correlate with elevated rare-earth element concentrations. A recessively weathered Th-enriched vein (spectral assay of 8048 ppm Th and 557 ppm U) was located along with discontinuous bands of massive apatite which are enriched in both rare-earth elements and Th. The rocks of the Burntwood Lake syenite are typically metaluminous to weakly peralkaline and are enriched in light rare-earth elements and large-ion lithophile elements, and depleted in high-field-strength elements. The Burntwood Lake syenite bears many mineralogical, textural, and geochemical similarities to the carbonatite-hosting syenite complex at Eden Lake, a target of rare-earth element exploration.

1) Geological mapping

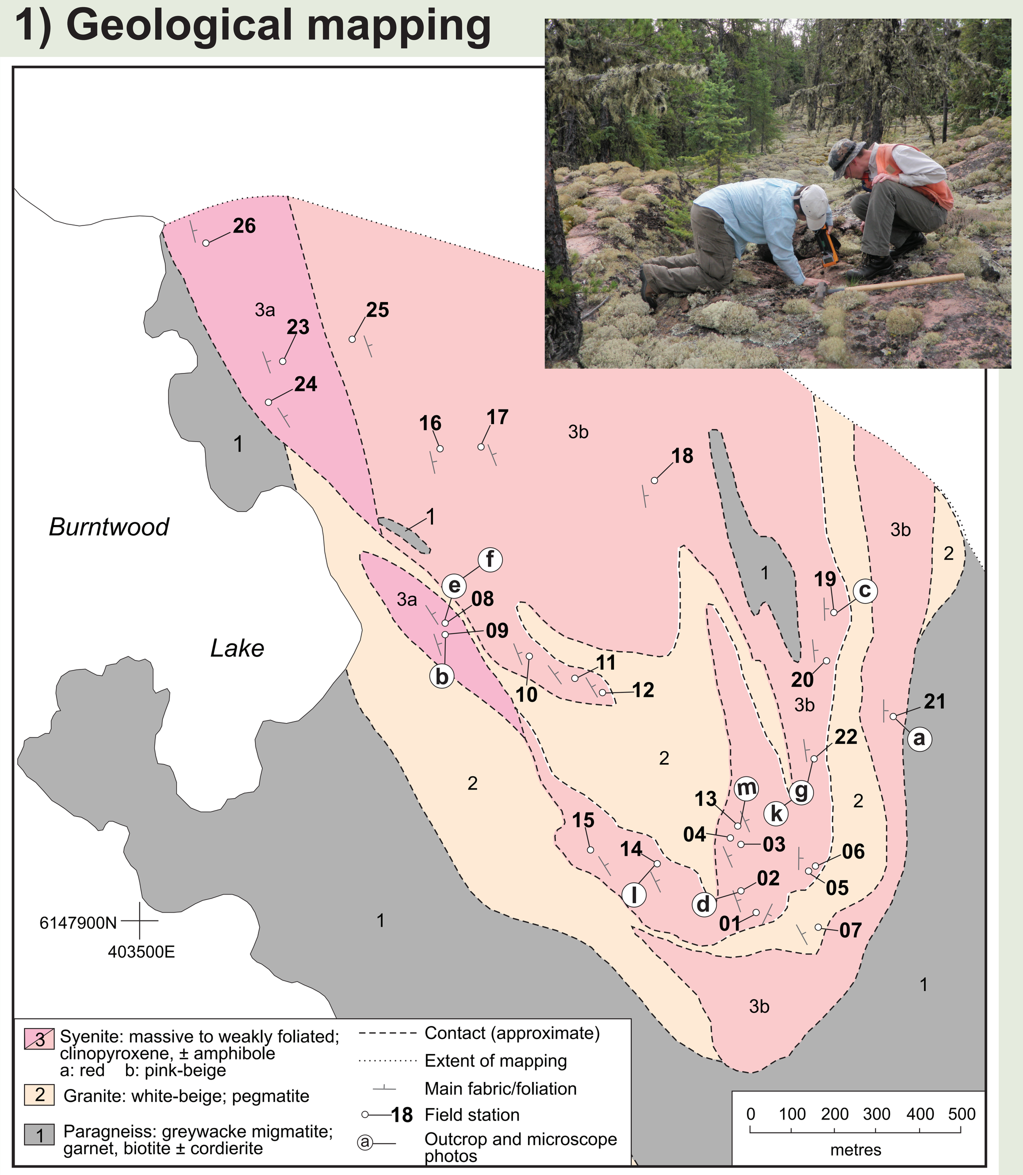

Figure 1: Simplified geological map of the Burntwood Lake syenite, after McRitchie (1987). Inset photograph illustrates the mature and extensive lichen and moss cover, which resulted in limited and poor outcrop exposures.

3) Petrography

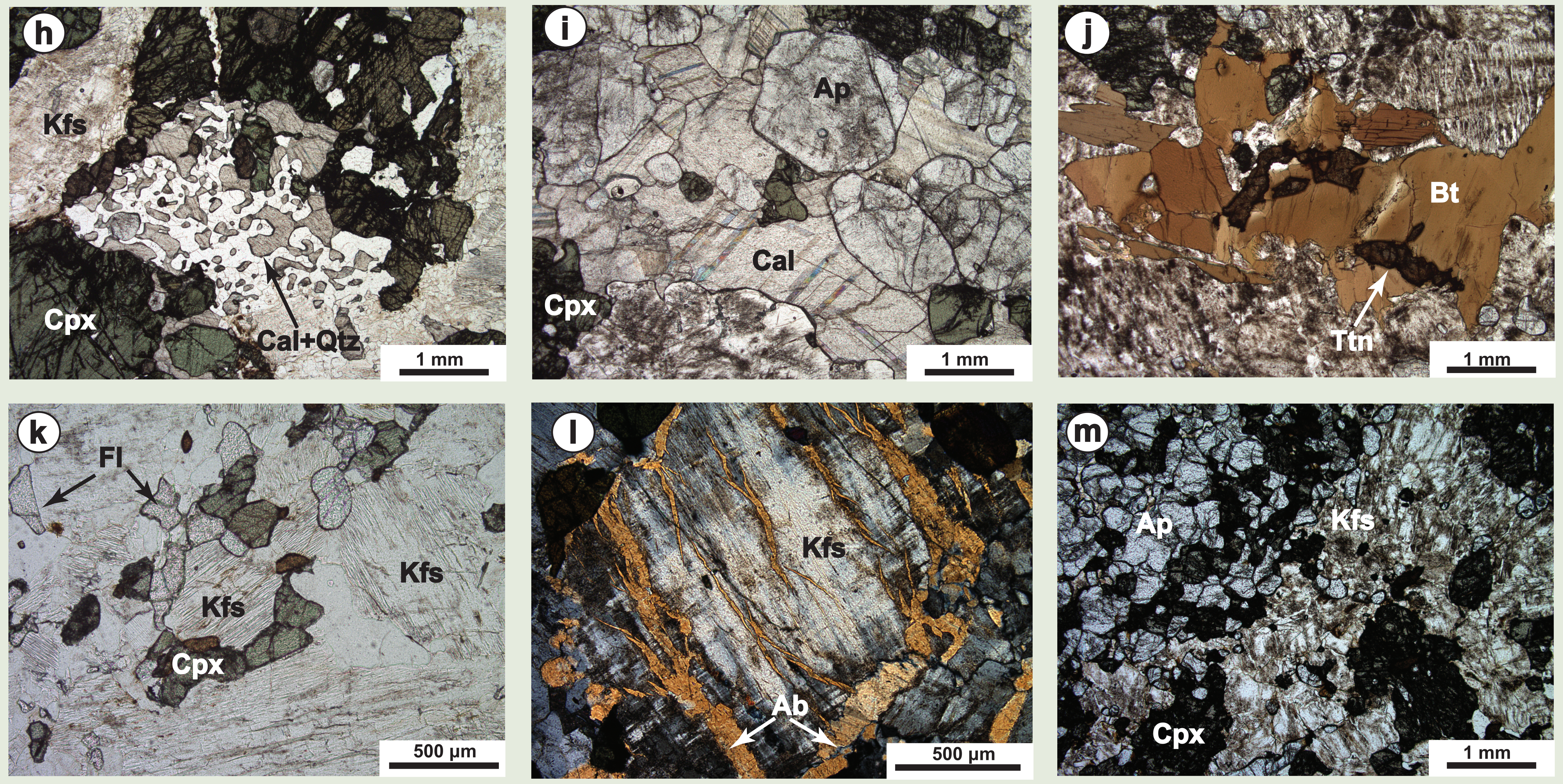

Figure 3: Microphotographs of thin sections of the Burntwood Lake syenite exemplifying interesting features and textures. **h**) Intergrowth of quartz (Qtz) and calcite (Cal) surrounded by clinopyroxene (Cpx) and potassium feldspar (Kfs). **i**) Association of calcite and apatite (Ap). Locally, association of clinopyroxene and calcite is observed. **j**) Late titanite (Ttn) intergrowing with biotite (Bt). Locally titanite overprints biotite and clinopyroxene. **k**) Quartz syenite with fluorite (Fl). **l**) Detail of potassium feldspar cut by replacement veins of perthitic albite (Ab) and with an aureole of recrystallised albite. **m**) Sharp contact of the massive apatite rock with the Burntwood Lake syenite. Images **h**) to **j**) are from samples collected by McRitchie in 1987.

2) Outcrop photographs

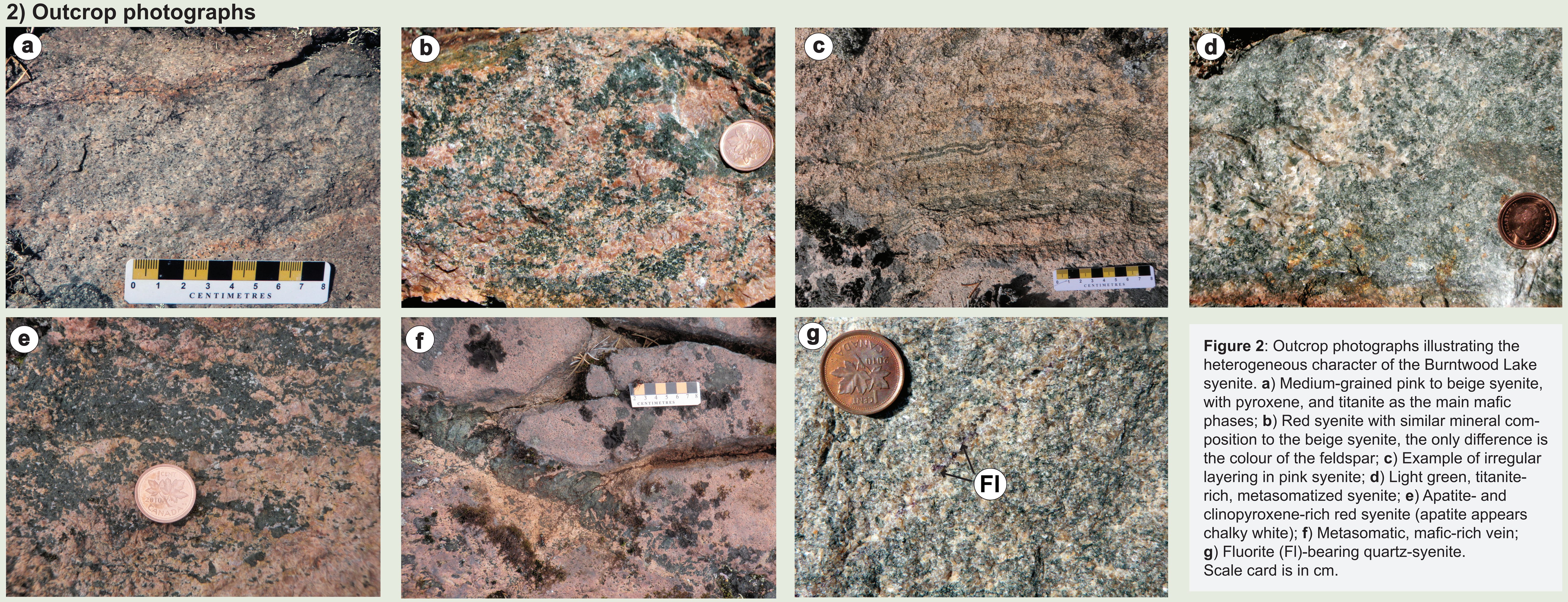

Figure 2: Outcrop photographs illustrating the heterogeneous character of the Burntwood Lake syenite. **a**) Medium-grained pink to beige syenite, with pyroxene, and titanite as the main mafic phases; **b**) Red syenite with similar mineral composition to the beige syenite, the only difference is the colour of the feldspar; **c**) Example of irregular layering in pink syenite; **d**) Light green, titanite-rich, metasomatized syenite; **e**) Apatite- and clinopyroxene-rich red syenite (apatite appears chalky white); **f**) Metasomatic, mafic-rich vein; **g**) Fluorite (Fl)-bearing quartz-syenite. Scale card is in cm.

4) Geochemistry

Table 1: Major and trace element concentrations of representative phases of the Burntwood Lake syenite. There is strong enrichment in the light rare-earth elements (LREE), Ba, Sr, Zr, and Th. The highest enrichments occur in the massive apatite rock, the mafic-rich syenite, the fluorite-bearing quartz syenite, and some of the heterogenous phases of the syenite.

Sample	11	26	22	013b	002A	14	006A
	Beige syen	Red syen	Fl Qtz syen	Ap massive rock	Metasom, Ttn-rich	Mafic-rich	Metasom
Oxide (wt%)							
SiO_2	61.98	59.77	63.79	34.67	59.13	59.4	58.31
Al_2O_3	15.46	12.78	13.77	5.43	13.65	14.07	12.59
Fe_2O_3	3.96	5.93	2.83	4.58	3.57	5.43	5.63
MnO	0.113	0.133	0.063	0.111	0.069	0.124	0.102
MgO	1.69	2.33	0.86	4.15	3.32	1.84	3.95
CaO	5.2	6.31	6.53	29.87	8.06	7.25	10.47
Na_2O	3.94	4.05	4.15	1.08	4.14	3.21	2.73
K_2O	6.67	6.18	5.23	2.69	4.67	6.76	5.1
TiO_2	0.051	0.128	0.425	0.451	1.172	0.364	0.39
P_2O_5	1	0.94	0.54	16.92	0.51	1.27	0.97
F	n/a	n/a	1.28	n/a	n/a	n/a	n/a
LOI	0.67	0.3	1.43	0.71	0.95	0.48	0.47
Total	100.7	98.85	100.9	100.7	99.24	100.2	100.7
Element (ppm)							
Sc	14	3	3	4	6	5	14
Be	4	2	4	5	4	5	4
V	59	59	26	61	33	49	59
Ba	6451	1674	2240	2015	3222	3576	6451
Sr	2928	792	2311	4638	3069	2541	2928
Y	22	11	32	113	30	34	22
Zr	299	46	321	62	469	45	299
Cr	40	bdl	bdl	bdl	bdl	bdl	bdl
Co	13	4	3	5	8	4	13
Ni	20	bdl	bdl	bdl	bdl	bdl	20
Cu	10	bdl	10	20	bdl	bdl	10
Zn	150	160	210	160	110	180	150
Ga	21	21	29	30	23	24	21
Ge	2	1	2	5	2	2	2
As	bdl	bdl	bdl	15	bdl	bdl	bdl
Rb	125	163	183	83	109	180	125
Nb	14	2	18	23	66	31	14
Mo	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Ag	1.1	bdl	1.2	0.9	1.8	bdl	1.1
In	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Sn	2	4	6	4	11	10	2
Sb	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Cs	bdl	bdl	bdl	0.8	bdl	bdl	bdl
La	134	67.6	243	693	126	225	134
Ce	306	169	542	1620	299	482	306
Pr	38.8	23.4	66.4	208	40.4	58.3	38.8
Nd	159	101	262	877	173	234	159
Sm	24.5	15.5	38.2	135	29.4	34.4	24.5
Eu	5.46	3.43	7.18	29.2	6.42	7.22	5.46
Gd	14.3	8.4	20.2	78.4	16.9	19.5	14.3
Tb	1.4	0.8	2	7.7	1.9	2	1.4
Dy	5.9	3.1	7.8	30.5	7.9	8.5	5.9
Ho	0.8	0.4	1.1	4.1	1.1	1.2	0.8
Er	1.9	1	2.2	8.1	2.6	2.9	1.9
Tm	0.2	0.13	0.27	0.88	0.27	0.34	0.2
Yb	1.1	0.8	1.5	4.5	1.5	2	1.1
Lu	0.16	0.13	0.2	0.53	0.2	0.27	0.16
Hf	6.1	1.2	7.3	4	8.6	1.5	6.1
Ta	0.6	0.2	0.7	0.6	1.8	3	0.6
W	bdl	bdl	3	2	1	bdl	bdl
Tl	0.7	1	1	0.5	0.7	1.1	0.7
Pb	41	11	40	59	31	28	41
Bi	bdl	bdl	bdl	1.1	bdl	bdl	bdl
Th	20.8	2	54.6	84.4	14.4	24.7	20.8
U	6.5	0.1	11.5	22.5	8.3	7.5	6.5
∑ LREE	**662.3**	**376.5**	**1151.6**	**3533**	**667.8**	**1033.7**	**662.3**
∑ HREE	**31.22**	**18.19**	**42.45**	**163.91**	**38.79**	**43.93**	**31.22**

Abbreviations: Ap, apatite; Fl, fluorite; LOI, loss-on-ignition; HREE, heavy rare earth-elements; Metasom, metasomatized; n/a, not analysed; Qtz, quartz; syen, syenite; Ttn, titanite

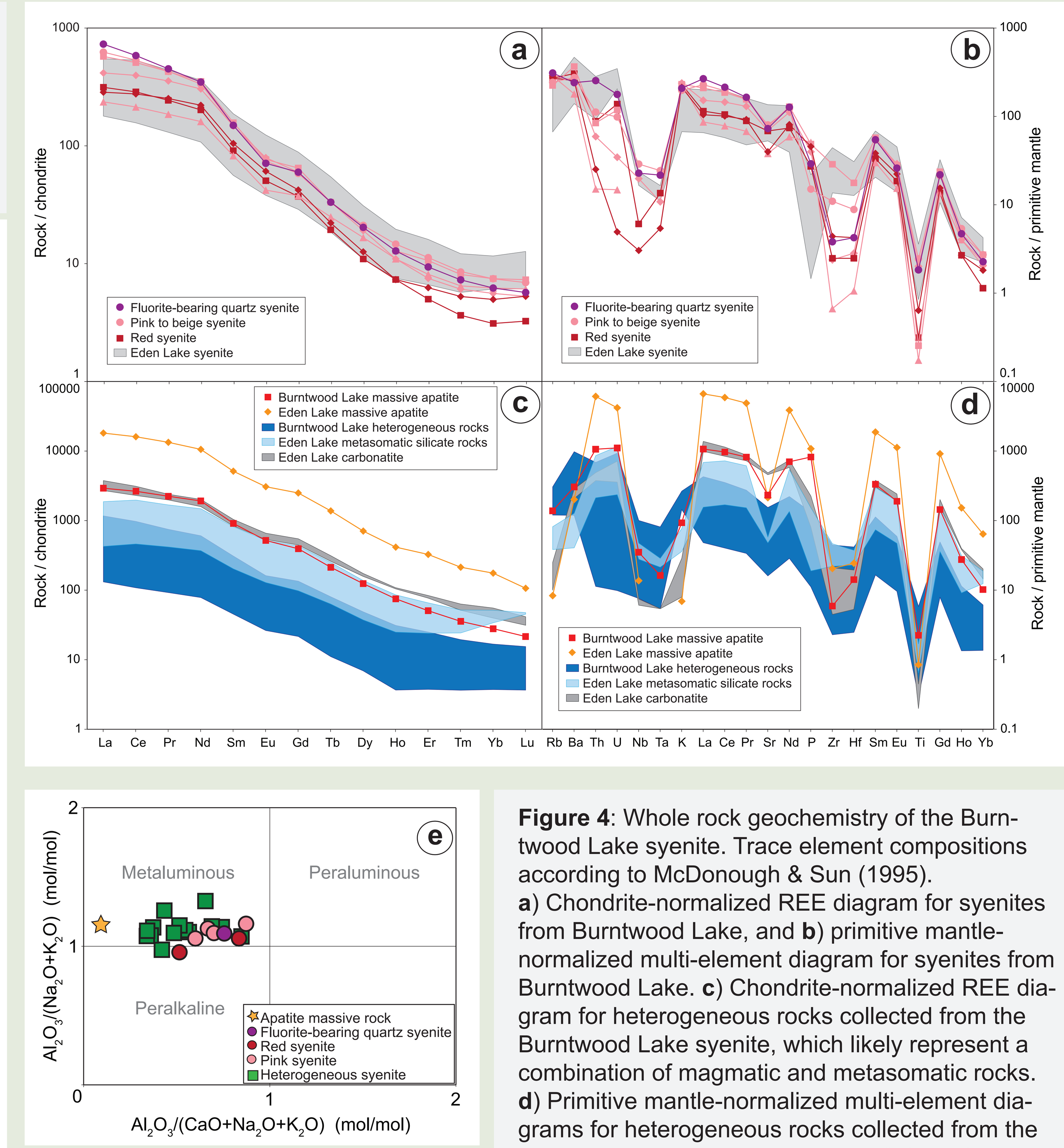

Figure 4: Whole rock geochemistry of the Burntwood Lake syenite. Trace element compositions according to McDonough & Sun (1995). **a**) Chondrite-normalized REE diagram for syenites from Burntwood Lake, and **b**) primitive mantle-normalized multi-element diagram for syenites from Burntwood Lake. **c**) Chondrite-normalized REE diagram for heterogeneous rocks collected from the Burntwood Lake syenite, which likely represent a combination of magmatic and metasomatic rocks. **d**) Primitive mantle-normalized multi-element diagrams for heterogeneous rocks collected from the Burntwood Lake syenite. 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). **e**) ASI diagram showing the largely metaluminous nature of the Burntwood Lake syenite phases.

5) Economic Considerations

Rare-earth elements (REE) have a wide variety of uses and are essential for hybrid vehicles, wind turbines and powerful magnets, just to mention a few applications. A growing demand for REE in recent years and reduced exports from China have led to an increase in worldwide exploration for this commodity. New sources for these elements are currently being explored across Canada, with the Nechalacho deposit at Thor Lake in the NWT and the Strange Lake deposit in Québec being the most advanced projects.

The Burntwood Lake syenite bears many similarities to the Eden Lake Complex, which has been an exploration target for REE mineralization for over a decade. Both syenite complexes are characterized by textural and modal heterogeneity; are dominantly metaluminous; are characterized by similar trace element geochemistry; and contain abundant clinopyroxene, titanite, apatite, and locally carbonate and fluorite. As with the Eden Lake syenite, at least some of the heterogeneity of the Burntwood Lake syenite appears to be the result of alkali metasomatism.

Encouraging evidence for both Th and REE enrichment was found in the form of Th-enriched vein (spectral assay of 8048 ppm Th and 557 ppm U) and massive apatite rock. Th- and REE-enriched veins at Eden Lake typically contain 1400–7400 ppm Th (Couëslan, 2005). The massive apatite vein with total REE+Y content of 3810 ppm is strikingly similar to the total REE+Y contents of carbonatite at Eden Lake (3439–4330 ppm, Couëslan, 2005; Chakhmouradian et al., 2008).

Geochemical and mineralogical similarities between the Burntwood Lake syenite and Eden Lake syenite suggest that the two complexes could be derived from a geochemically similar (mantle?) source. The location of both complexes within the internal zone of the Trans-Hudson Orogen of Manitoba implies that there could be potential for other similar intrusive complexes within the region; syenites reported at Brezden and McVeigh lakes (McRitchie, 1988) may warrant further investigation.

Manitoba

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