Petrogenetic types, tectonic settings, and mineral potential of granitoids in the Lynn Lake region, northwestern Manitoba: Evidence from reconnaissance mapping, geological sampling and lithogeochemistry

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(presented at Manitoba Mining and Minerals Convention, November 18-20, 2015, Winnipeg)

Abstract

In 2015, the Manitoba Geological Survey continued its project to investigate the petrogenesis and metallogeny of granitoid rocks throughout Manitoba. Initiated in the spring of 2014, the main objectives of this project are to identify the various petrogenetic types of granitoid rocks in Manitoba and to investigate their geodynamic settings and mineralization potential. This report presents the preliminary results of fieldwork conducted in the Lynn Lake region. Granitoid rocks were examined and sampled to document field relationships, textures (fabrics), mineral assemblages, magnetic susceptibilities (MS), and presence of mineralization and/or alteration.

This study indicates that muscovite- and/or garnet-bearing granitic rocks characterized by low MS values (<0.1 × 10^{-3} SI units; i.e., strongly peraluminous S type, or ilmenite-series) were intruded mainly into domain boundaries, which may thus serve as a useful criterion for recognizing major tectonic or domain boundaries. These peraluminous granitic rocks may have formed in crust thickened as a result of terrane assembly and/or continental collision, and may have potential to host rare-metal and (or) Sn-W mineralization. In contrast, plutons consisting of quartz diorite, tonalite, granodiorite and granite are characterized by higher MS values (>0.1 × 10^{-3} SI units) and mineral assemblages typical of I-type granitoid rocks (e.g., amphibole ±biotite or biotite ±amphibole). Such plutons are abundant across the region, suggesting that this magmatism contributed significantly to crustal growth in the Trans-Hudson orogen, and may have been related to subduction tectonics.

It is worth noting that I-type or magnetite-series granitoid intrusions may have potential to host porphyry Cu, Au and Mo mineralization. In addition, subordinate A-type granitoid plutons in the region, characterized by relatively oxidized features (e.g., MS >0.5 × 10^{-3} SI units) and by the presence of sodic amphibole (±sodic pyroxene), likely emplaced in extensional settings, have potential for rare-metal (e.g., Nb, Ta) mineralization.

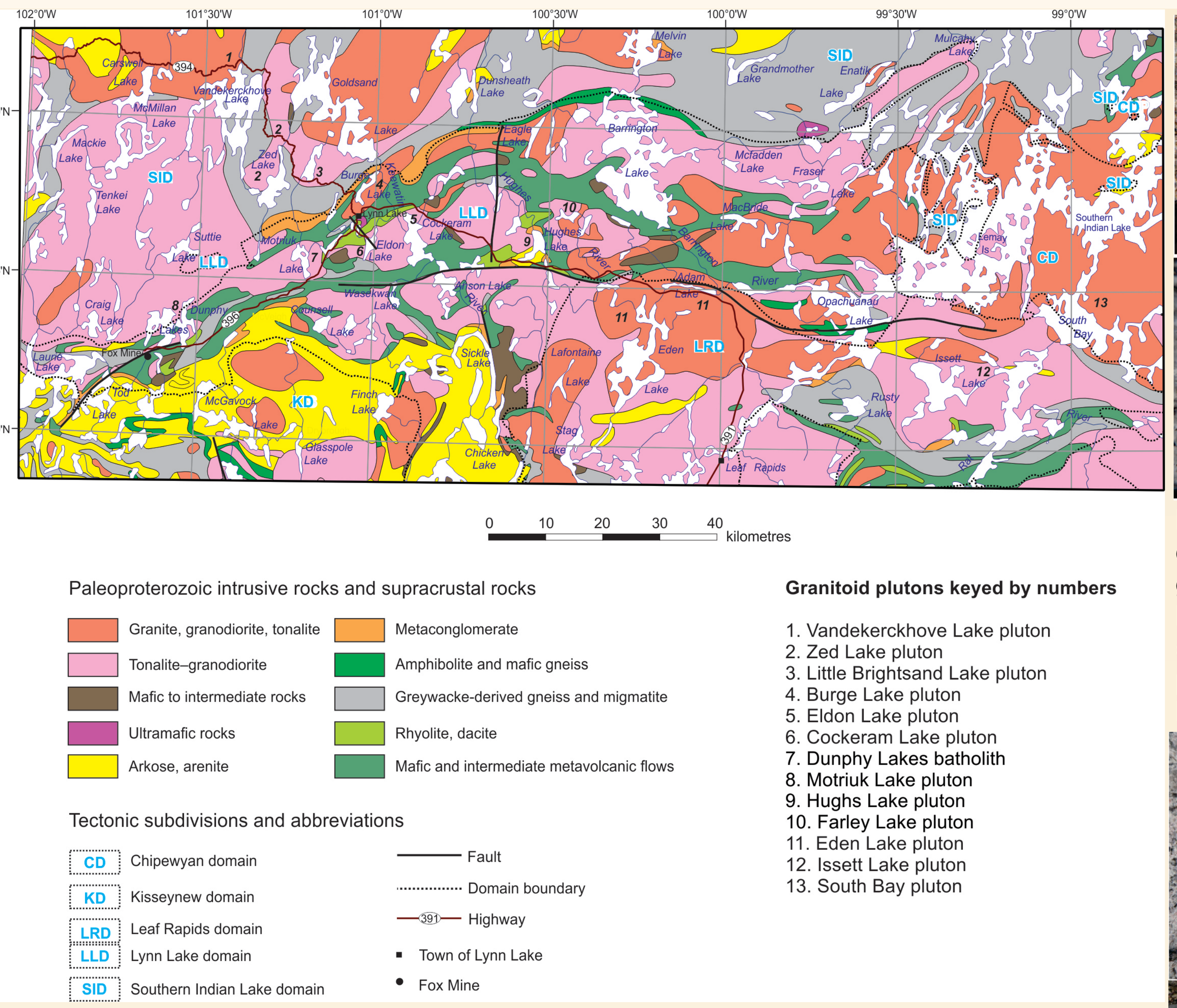

Fig. 1 Simplified geology of the Lynn Lake greenstone belt and adjacent domains, showing the dominance of granitoid rocks in the region. Numbered granitoid plutons or batholiths are referred to in the text. Nomenclature of tectonic entities or domains modified from Manitoba Energy and Mines (1986) and Zwanzig and Bailes (2010).

Petrogenetic types of granitoids

Classification of I- and S-type granites is based on their source rocks: I-type granites are derived from igneous sources, whereas S-type granites are sourced from sedimentary rocks (Chappell and White, 1974, 1992, 2001). Magnetite- and ilmenite-series granites are classified in terms of the abundance of Fe-Ti oxides that reflect redox conditions of granites. Magnetite-series granites contain appreciable amount of magnetite and ilmenite, while ilmenite-series granites contain ilmenite as dominant Fe-Ti oxides (Ishihara, 1977, 1981, 2004). In addition, A-type granites are characterized by the presence of annite-rich biotite and/or sodic amphibole or pyroxene, with high silica, alkalis, Fe/Mg, F, Zr, Nb, Ga, Sn, Y, and REE (except Eu) contents, and low Ca, Ba, and Sr (Whalen et al., 1987). The Manitoba Geological Survey would use these schemes in the study of granitoids in Manitoba.

Granitoids in the Southern Indian Lake domain (SID)

The SID is characterized by I-type and magnetite-series granites in terms of mineral assemblages, magnetic susceptibility (MS), and lithogeochemical characteristics, although S-type granites are evident and display the signature of ilmenite-series with low MS values (<0.1x10^{-3} SI) at the southern border with the Lynn Lake domain. Fig. 2 shows some typical granitoids in the SID.

Granitoids in the Lynn Lake domain (LLD)

The LLD is dominated by I- or magnetite-series granites (Fig. 3), which are grouped into pre-, and post-Sickle suite, and late intrusive suite. Magnetite-phyric QFP dikes in the late intrusive suite may play a role in Au mineralization as the fluids associated with these highly oxidized dikes are capable to transport gold.

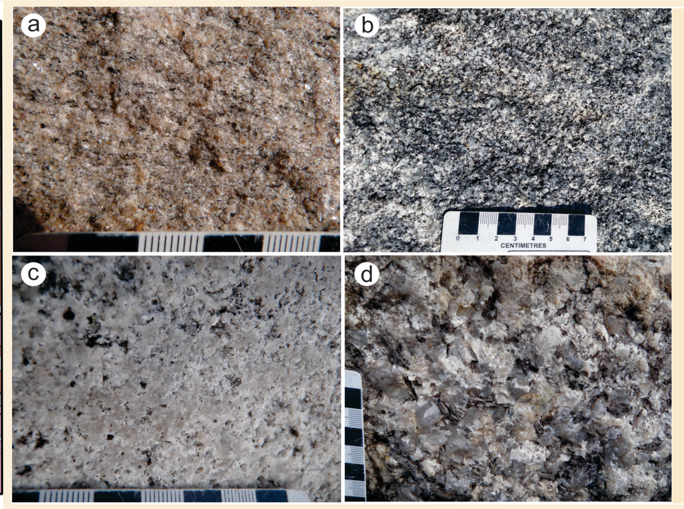

Fig. 2 Granitoids from the Southern Indian Lake domain: a) medium-grained granite with weak gneissic fabric, Vandekerckhove Lake pluton (1); b) medium-grained quartz diorite, Zed Lake pluton (2); c) coarse-grained leucogranite, Zed Lake pluton (2); and d) pegmatitic muscovite granite, Little Brightsand Lake pluton (3).

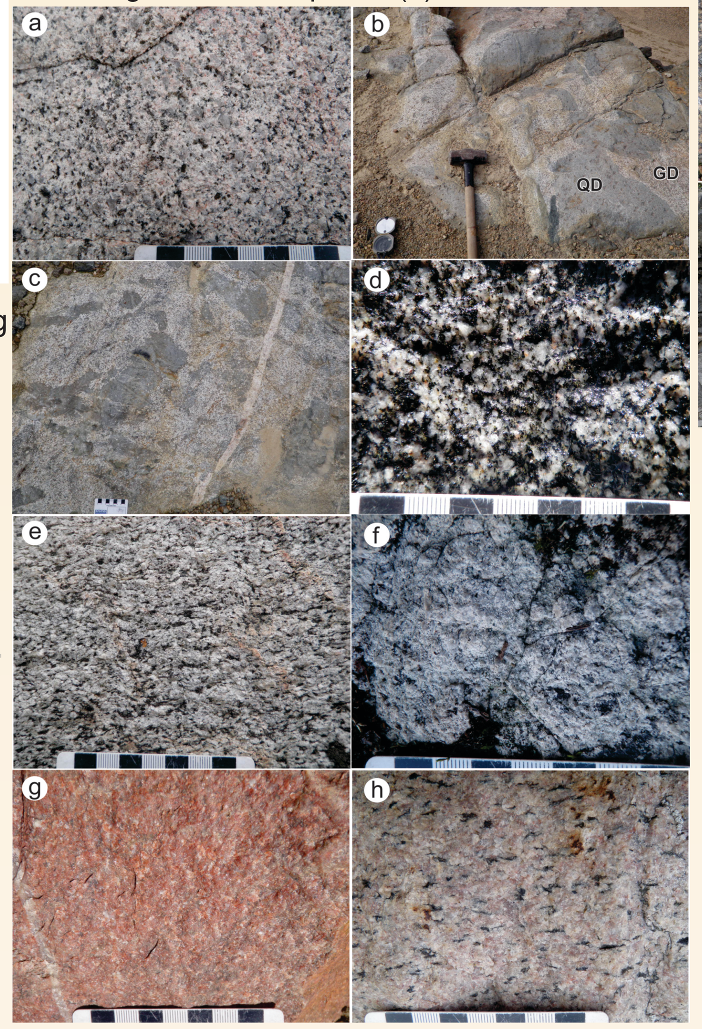

Fig. 3 Granitoids from the Lynn Lake domain: a) medium- to coarse-grained granodiorite, Burge Lake pluton (4); b) intrusion breccia, consisting of granodiorite (GD) intruding quartz diorite (QD), Cockeram Lake pluton (5); c) medium-grained tonalite with irregular xenoliths of plagioclase-phyric basalt cut by a late, thin pegmatite dike, Eldon Lake pluton (6); d) medium-grained tonalite, Motriuk Lake pluton (7); e) foliated medium-grained granodiorite, Dunphy Lakes batholith (8); f) porphyritic granite, Hughes Lake pluton (9); g) fine- to medium-grained quartz syenite, Hughes Lake pluton (9); and h) foliated coarse-grained granodiorite, Farley Lake pluton (10).

Granitoid rocks in the Chipewyan domain (CD)

Megacrystic K-feldpar granitoids are dominated in the CD, that are intruded by equigranular granites, then by pegmetite or aplite dikes (Fig. 5). These granites show high MS values, belonging to I-type or magnetite-series granitic rocks.

Granitoids in the Leaf Rapids domain (LRD)

Gneissic tonalite, granodiorite and late equigranular granitoid rocks are dominantly present in the LRD, which are generally characterized by high MS values of magnetite-series and I-type. A-type granitoids occur in the Eden Lake pluton. Few outcrops of muscovite-/garnet-bearing S-type granites occur at the northern margin of this domain (Fig. 4), most likely due to partial melting of thickened crust as a result of collision with the adjacent Chipewyan domain to the north.

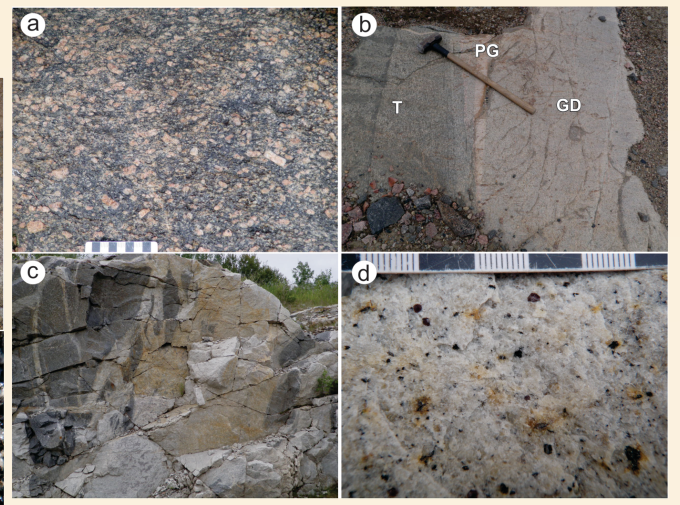

Fig. 4 Granitoids from the Leaf Rapids domain: a) K-feldspar megacrysts in porphyritic granodiorite, Eden Lake igneous complex (11); b) foliated, medium-grained tonalite (T) cut by foliated granodiorite (GD) and pegmatite/aplite (PG), Eden Lake igneous complex (11); c) medium-grained garnet-muscovite granite intruded into foliated tonalite, Issett Lake pluton (12); height of roadcut face is ~8 m; and d) medium-grained garnet-muscovite granite, Issett Lake pluton (12).

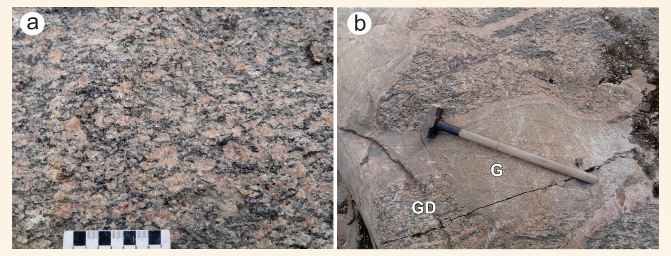

Fig. 5 Granitoids from the Chipewyan: a) megacrystic K-feldspar in foliated porphyritic granite, South Bay intrusion (13); b) medium-grained granite (G) intruded into foliated megacrystic granite (GD), South Bay intrusion, same location as (a)..

Lithogeochemistry

Figure 6 shows some key geochemical charateristics of granitoids from different plunic suites in different tectonic units in the Lynn Lake region, northwestern Manitoba. A few important features can be summarized as followings.

- Most granitoids are calcic to calcalkaline (Fig.6a, b), typical of magmatic arc products associated with plate subduction;
- Most granitoids are metaluminous to peraluminous, consistent with I-type granites (ACNK<1.1; Fig. c). However, some are strongly peraluminous (ACNK>1.1), consistent with S-type granites;
- These granitoids are dominantly orogenic, and could be related to subduction magmatism (Fig. 6b, e);
- Most granitoids are formed in volcanic arc environment (i.e. subduction-related), albeit some S-type granites may have been formed in thickened crustal environment due to continental collision (Fig. 6c);
- Some display A-type granites (6f), forming at an extensional setting.
- A spectra of granitoid rocks occur at a magmatic arc setting (Fig. 6d, g-j), exhibiting pronounced Nb (Ta), Ti negative anomalies.

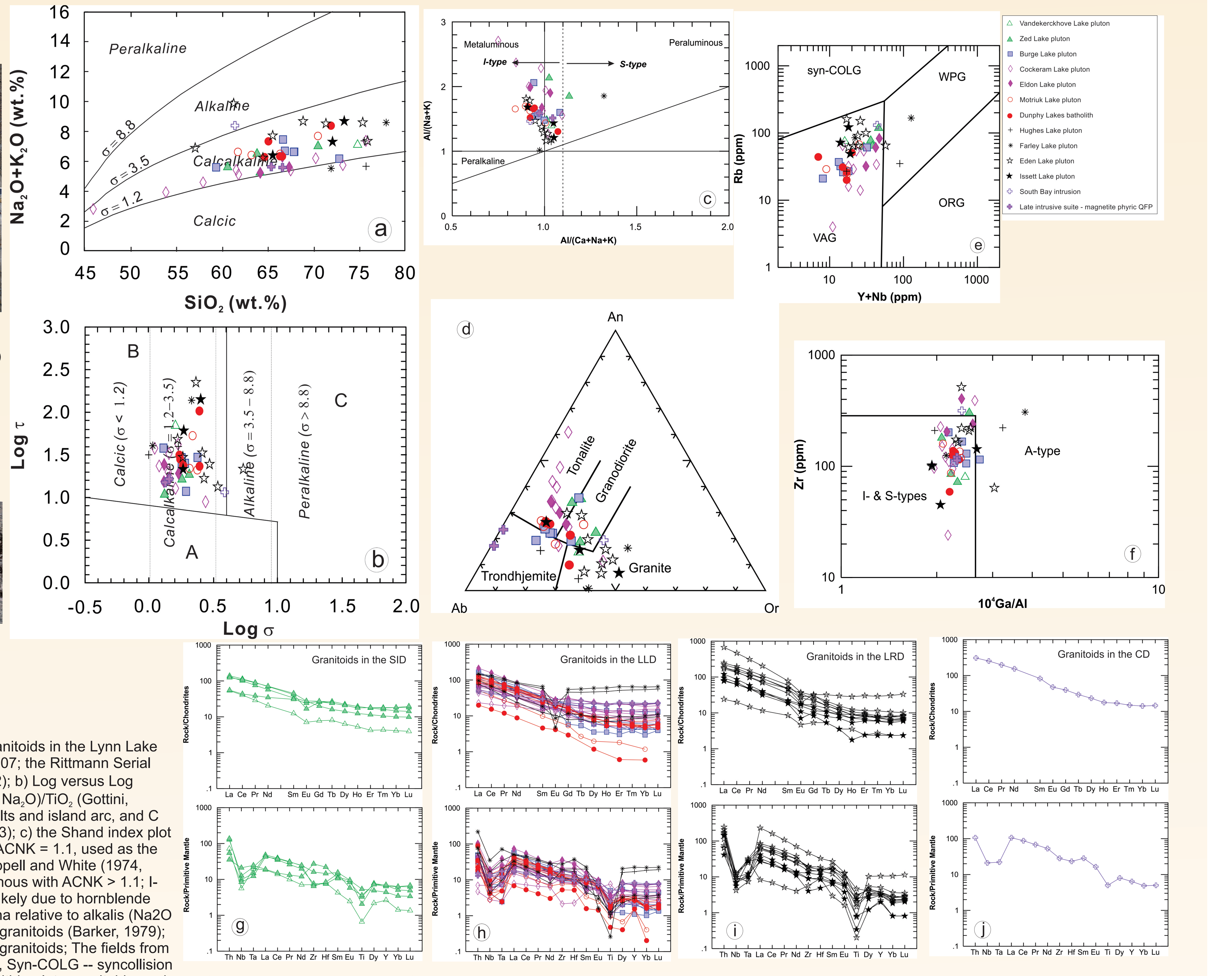

Fig. 6 Geochemical discrimination diagrams for granitoids in the Lynn Lake region: a) alkalinity of the granitoids (from Yang, 2007; the Rittmann Serial Index $\sigma = [Na_2O + K_2O]^2/[SiO_2 - 43]$, Rittmann, 1962); b) Log versus Log diagram used for the granitoids, where $\tau = (Al_2O_3 - Na_2O)/TiO_2$ (Gottini, 1968); Field A represents anorgenic, B orogenic belts and island arc, and C alkaline derivatives of A and B (from Rittmann, 1973); c) the Shand index plot (after Maniar and Piccoli, 1989) for the granitoids; ACNK = 1.1, used as the boundary of I- and S-type granites defined by Chappell and White (1974, 1992, 2001); S-type granites are strongly peraluminous with ACNK > 1.1; I-types metaluminous to moderately peraluminous (likely due to hornblende fractionation leading to residual melts rich in alumina relative to alkalis (Na2O and K2O); d) normative Ab-An-Or classification of granitoids (Barker, 1979); e) tectonomagmatic discrimination diagram for the granitoids; The fields from Pearce et al. (1984): ORG - ocean-ridge granitoids, Syn-COLG -- syncollision granitoids, VAG - volcanic-arc granitoids, WPG - within-plate granitoids; and f) A-type, and I- & S-type granite discrimination (Whalen et al., 1987). Chondrite-normalized REE and primitive-mantle normalized extented element plots for granitoids from the SID, LLD, LRD, and CD.

References cited in this poster are available from the XMY upon request.

Acknowledgments

We thank D. Drayson for enthusiastic and capable field assistance, and E. Anderson and N. Brandson for logistical support. Thanks go to G. Keller and P. Lenton for technical support; L. Chackowsky and B. Lenton for providing GIS data, digitizing map data and drafting figures; M. Pacey for assembling the digital database for a hand-held data-acquisition system; and G. Benger, C. Epp and V. Varga for cataloguing, processing and preparing the samples.