The Waugh Lake-Tazin River Network of Retrogressive Shear Zones at the Eastern Margin of the Taltson Magmatic Zone

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Summary

Preliminary field, microscope and isotope (U-Pb, $^{40}Ar/^{39}Ar$ and Sm-Nd) data suggest that parts of the greenschist faces Waugh Lake Complex near the northeastern corner of the Alberta shield may be directly derived from the adjacent crust, the Taltson magmatic zone, through shearing and metamorphic re-equilibration. The Waugh Lake Complex projects into belts of similar rocks in Saskatchewan and further into Northwest Territories, where they merge with major shear zones that overprint the Taltson magmatic zone. The reinterpretation of low-grade metasementary rocks as mylonite series rocks reveal a spectacular network of anastomosing shear zones more than 150 kilometres long in the hinterland of the southern Taltson-Thelon orogen.

Introduction

Rocks in the investigated area of the Taltson magmatic zone are assigned to the following major map units:

- Taltson basement complex dominated by orthogneiss with Archean (3.2-2.6 Ga) and Paleoproterozoic (2.4-2.1 Ga) protolith ages and T_{DM} and εNd values that overlap with values from the Rae Terrane to the east (McNicoll et al., 2000; De et al., 2000);
- Rutledge River Complex consisting of metre to kilometre-size lenses of migmatized schist and gneiss and characterized by the six-phase mineral assemblage typical for the granulite-upper amphibolite transition:

  garnet+cordierite+potassium feldspar+H_2O ↔ biotite+sillimanite+quartz

  Igneous zircon relics in the Rutledge River Complex range in age from ca. 2.6 to 2.0 Ga (Bostock and van Breemen, 1994), suggesting a close genetic relationship to the Taltson basement complex;
- Taltson age (1.99-1.92 Ga) plutons represented in the investigated area by the Colin Lake (ca. 1.97 Ga) and Andrew Lake (ca. 1.96 Ga) granitoid plutons; and
- Waugh Lake Complex consisting of greenschist facies rocks, interpreted either as an outlier of volcano-sedimentary strata deposited between 2.02 and 1.97 Ga in a small intra-arc basin related to the Taltson arc (e.g., Iannelli et al., 1995; McDonough and McNicoll, 1997; McDonough et al., 2000) or as a partly mylonitic succession (e.g., Godfrey, 1963, Salat et al., 1993; Pană, 2009).

Recent field, petrographic and analytical work in northeastern Alberta corroborated with previous data from neighbouring Saskatchewan and Northwest Territories revealed the high strain and retrogressive nature of most of the low-grade rocks and their belt-like extent over tens of kilometres near the eastern margin of the Taltson magmatic zone.

New Petrological and Geochronological Data from Waugh Lake Complex

The low-grade sequence exposed around Waugh Lake in the northeastern corner of Alberta, consists of biotite-rich quartzitic schist, fine- to medium-grained quartz-albite-chlorite-sericite schist and fine-grained, intermediate to mafic igneous pods, abundant quartz segregations and isolated lenses of various fragmental rocks (breccia to conglomerate) of either sedimentary or tectonic origin. Intense deformation is expressed by 1) heterogeneously penetrative, roughly northerly trending and steeply dipping foliation; 2) locally obvious high rotational strain; 3) lithological transitions through strain gradients and metamorphic reactions; 4) strain partitioning; and 5) lack of continuity of mappable units and widespread interlayering and folding of massive to foliated igneous rocks with various low-grade schist units.

Various foliated rocks of the Waugh Lake Complex yielded Sm-Nd $T_{DM(1.97Ga)}$ model ages ranging from 2.63 to 2.83 Ga, which coincide, within analytical error, with the adjacent Taltson plutons (2.67-2.81 Ga). Pairs of foliated and massive rocks previously interpreted as older metasedimentary and younger intrusive rocks, respectively, yielded almost identical Sm-Nd T_{DM} model ages and εNd values.

U-Pb zircon dating of a deformed igneous pod within the Waugh Lake Complex returned a ca. 1973 Ma emplacement age, which coincides within error with the adjacent Colin Lake pluton of the early Taltson plutonic suite. Isotope data are consistent with field and microscope observations and suggest that the greenschist faces Waugh Lake Complex may be largely derived through shearing and metamorphic re-equilibration of the adjacent Taltson magmatic zone crust.

Four $^{40}Ar/^{39}Ar$ plateau ages between 1840 and 1820 Ma from greenschist facies rocks of the Waugh Lake are contemporaneous with the late phases of strike-slip displacement on major shear zones overprinting the Taltson magmatic zone. Other low- to very low-grade metamorphic rocks, closely resembling sedimentary rocks within the Waugh Lake Complex, could be derived from a veneer of volcano-sedimentary cover of the Taltson crust and incorporated in this linear zone of late strain concentration and metamorphism. The deposition of such a sequence must be considerably younger than the hornblende and biotite cooling ages obtained regionally from the TMZ (ca. 1.9 and ca. 1.8 Ga, respectively) and older or contemporaneous to the timing of shear zones metamorphism at the shallowest structural level.

Regional Correlations

The steeply dipping and roughly northerly trending Waugh Lake Complex projects into similar rocks in Saskatchewan that define a narrow belt, 1–2 km wide and 40 km long from west of Harper Lake at 58°N latitude, to 60°N latitude where it bifurcates into NWT: the western branch joins the Bayonete Lake high- to low-grade shear zone at Bedodid Lake and the eastern branch joins in north of Hotel Lake at 60°25’N lat. A second belt of highly sheared granitoid gneiss incompletely reequilibrated under low-grade metamorphic conditions can be followed along a westerly convex trajectory in Saskatchewan, from west of Harper Lake to Kornash Lake and farther to 60°N latitude where it projects into the northerly trending Tazin River shear zone. Along Hill Island Lake in Northwest Territories, a belt of medium to low-grade rocks records strain partitioning during syntectonic exhumation of the Tazin shear zone. A quartz-albite-chlorite mylonite rock includes two zircon populations: one consisting of 2.17 Ga and 2.13 Ga colourless zircon grains, which are not uncommon in the western Rae crust, and the younger brown, high-U zircon population crystallized at ca. 1.92 Ga, during shearing at elevated temperatures (Bostock and van Breemen, 1994; van Breemen et al., 1987).

The peripheries of the Hill Island sequence may record the early Tazin shear zone tectonic overprint on the Rae crust at mid-crustal level (amphibolite facies mylonite), with foliations sealed by the ca. 1.93 Ga Natael granite and associated muscovite-bearing pegmatite. Subsequent syntectonic exhumation of the Tazin shear zone accompanied by strain localization within the central narrower greenschist to subgreenschist facies belt along the axis of the lake may have locally resulted in the highly strained, quartz-rich rock with a muscovite-biotite-chlorite retrogressive mineral assemblage dated by Bostock and van Breemen (1994). The zircon grains defining the regression line with a concordia intercept at ca. 1.92 Ga likely record metamorphic zircon growth in the lower amphibolite facies and Pb loss during subsequent tectonism under greenschist facies conditions.

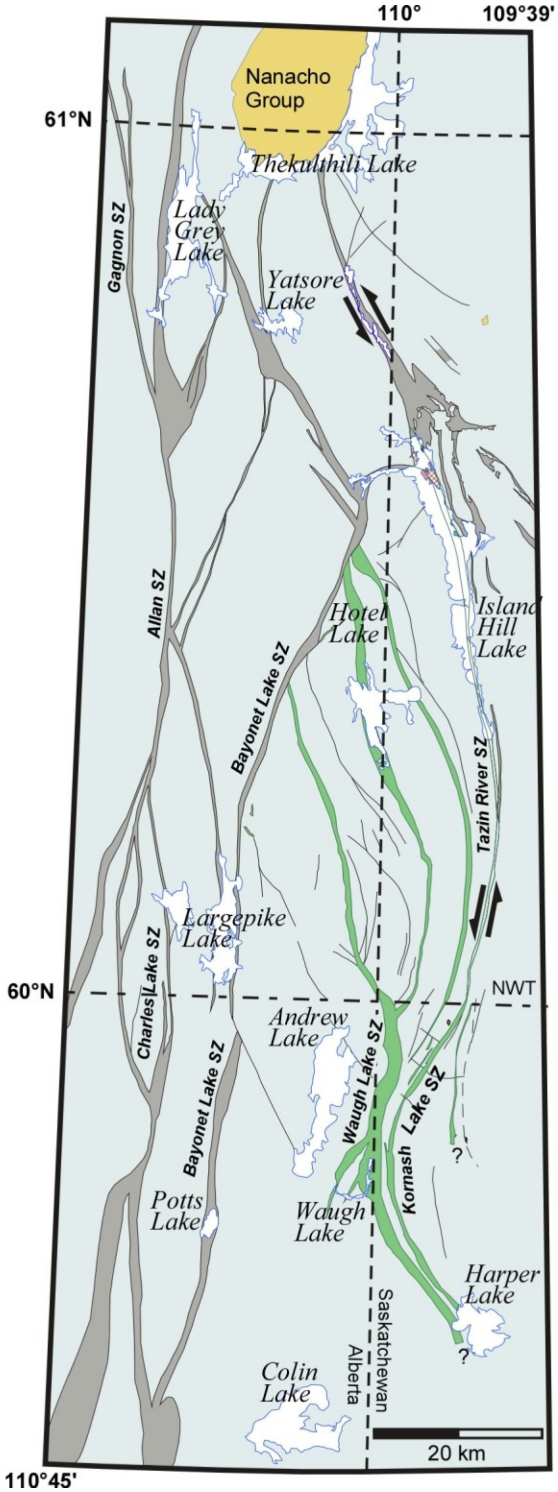

Figure 1. Low-grade shear zones near the eastern margin of the Taltson magmatic zone (in green). Gray belts are previously mapped high- to low-grade shear zones.

The merged Waugh Lake-Bayonete Lake shear zones join a northwesterly branch of the Tazin River shear zones near Natael Bay of Hill Island Lake and continue as a unique shear zone to at least Thekulthili Lake.

In this context, the dated sericite from the quartz clast–bearing samples would be the first reliable $^{40}Ar/^{39}Ar$ direct dating of the phyllonite texture within the Tazin River–Waugh Lake system of low-grade tectonite. The Tazin-Waugh tectonic system may represent late localization of strain under low-grade conditions during progressive exhumation of a major shear zone through the brittle-ductile and shallower structural levels. This interpretation is consistent with the evolution of known major Taltson shear zones, which record granulite to amphibolite tectonism between ca. 1940 and 1920 Ma, and greenschist-facies deformation at ca. 1800 Ma (Plint and McDonough, 1995; McDonough et al., 2000c). Polyphase deformation along these belts is emphasized by complex crosscutting relationships between tectonite and granitic pegmatite and/or quartz veins.

Although isolated occurrences of Taltson age plutons are known farther east, this network of anastomosing strike-slip shear zones appears to overprint the eastern margin of the ca. 2.0-1.9 TMZ. Tectonism along various segments of the shear zone network was diachronous, locally accompanied by late, often muscovite-bearing linear intrusions or granitic plugs of different ages (e.g., the ca 1.93 Ga Natael granite to 1.81 Ga Thekulthili granite plug), syn- to late-tectonic basalt/andesite dykes, as well as slivers of sedimentary rocks, all variously overprinted by strain.

Conclusions

Field and analytical data from northeastern Alberta suggest that low-grade lithotectonic assemblages record retrograde metamorphism and strong non-coaxial strain that overprinted Taltson magmatic zone crust.

Well-documented conclusions on the extent and tectonic significance of the proposed regional scale network of retrogressive shear zones require further detailed field and systematic analytical work.

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