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K.E. Ashton, C.D. Card, and O. van Breemen

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Cover:
Paleoproterozoic pink leucogranite from 8 km east-northeast of Uranium City (UTM 642420E, 6609320N, NAD 83). Sm-Nd isotopic values for crustal melt rocks such as these were analyzed to study the age of the crust into which they were emplaced.

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Abstract

Based on their inferred crystallization ages, five 1.9 to 1.8 Ga crustal melt granites sampled along a >100 km transect of the southern Rae Province north of the Athabasca Basin yield new T_{DM} determinations ranging between 3.24 and 2.75 Ga and strongly evolved ε_{Nd} values of -7.46 to -14.3. These values are consistent with derivation from a mixture of known 3.0 and 2.6 Ga granitoid rocks along with the *ca.* 2.3 Ga Murmac Bay Group. Paleoarchean crust previously inferred from detrital and inherited zircons must be restricted in areal extent, eroded away, or located at some distance from the study area. Two similar *ca.* 1.84 Ga crustal melt granites from the Rae Province, south of the Athabasca Basin, yield T_{DM} ages of 2.89 and 3.11 Ga with ε_{Nd} values of -6.4 and -11.3, respectively, suggesting a mainly Neoarchean source.

The Virgin Schist Group is a supracrustal succession spanning the Snowbird Tectonic Zone south of the Athabasca Basin. T_{DM} ages of 2.46 to 2.28 Ga from three intermediate to mafic rocks indicate a Paleoproterozoic age and possible involvement in development of the zone.

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Introduction

The southern Rae Province is flanked by the Taltson Magmatic Zone to the west and the Snowbird Tectonic Zone to the east (Figure 1). In northwestern Saskatchewan, north of Lake Athabasca, it is dominated by 3.0, 2.6, 2.3, and 1.9 Ga suites of granitoid rocks and derived orthogneisses (Persons, 1983; Hartlaub, 2004), and by subordinate supracrustal rocks including the *ca.* 2.3 Ga Murmac Bay Group (Ashton and Hunter, 2003; Hartlaub *et al.*, 2004) and the 2.02 to 1.97 Ga (McDonough and McNicoll, 1997) Waugh Lake Group (Iannelli *et al.*, 1995). Widespread upper amphibolite- to granulite-facies metamorphism of this basement complex at about 1.93 and 1.9 Ga preceded the deposition of several younger sedimentary successions. These include the 1.9 to 1.82 Ga Thluicho Lake Group,

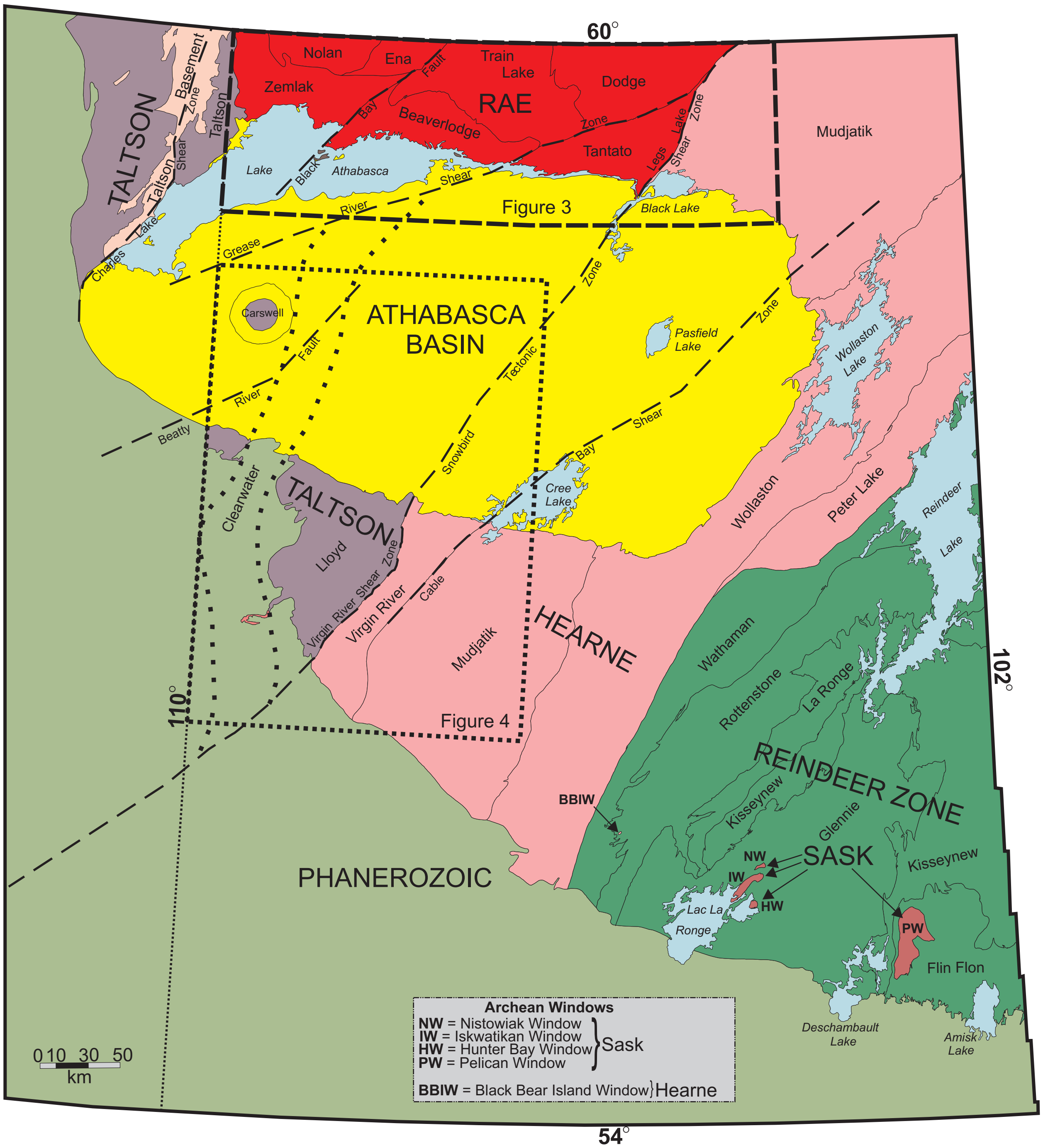

Figure 1 - Major lithotectonic components of the Precambrian Shield of northern Saskatchewan and northeastern Alberta. The areas shown in Figures 3 and 4 are outlined by dashed and dotted boxes, respectively.

which was metamorphosed to greenschist facies conditions either towards the end of the 1.93 Ga thermotectonic event and again at 1.90 Ga or for a sustained time interval at 1.90 Ga (Scott, 1978; Ashton and Hunter, 2003; Hunter *et al*., 2003, 2004), the *ca.* 1.82 Ga Martin Group (Tremblay, 1972; Mazimhaka and Hendry, 1984; Ashton and Hunter, 2003), and the *ca.* 1.75 to 1.6 Ga Athabasca Group (Ramaekers, 1990; Ramaekers *et al.*, in press).

Rocks south of the Athabasca Basin and west of the Snowbird Tectonic Zone, belonging to the Lloyd Domain (Figure 1), were interpreted to be Archean by previous workers (Lewry and Sibbald, 1980). This interpretation was based on a lithologic contrast across the Snowbird Tectonic Zone and the idea that the fabrics preserved west of the shear zone were older. Although the absolute ages of many of the lithologic elements in the Lloyd Domain remain undetermined, a significant Paleoproterozoic component has now been identified. The Lloyd Domain comprises granulite-facies metasedimentary rocks of the undated Careen Lake Group (Scott, 1985), an intrusive 1.99 to 1.97 Ga quartz diorite suite (Card, 2002; Stern *et al.*, 2003), and a variety of younger intrusive granites that have yielded *ca.* 1.93 to 1.91 Ga (Brouand *et al.*, 2002) and *ca.* 1.83 Ga ages (Stern *et al.*, 2003). The aeromagnetic signature of the Lloyd Domain (Figure 2) is divided by the north-trending Clearwater aeromagnetic high, which is underlain by *ca.* 1.84 Ga granites containing large rafts of *ca.* 2.5 Ga granite gneiss (Stern *et al.*, 2003). It is not known if the older granite gneiss is restricted to the Clearwater Domain or if it is also present in the Lloyd Domain. Granitoid gneiss hosting these younger intrusions in the area of the Carswell Structure has yielded a *ca.* 2.32 Ga age (Bell, 1985). Lower- to middle-amphibolite facies supracrustal rocks of the Virgin Schist Group (Wallis, 1970) lie along the Snowbird Tectonic Zone. Although these rocks have historically been placed in the Virgin River Domain, they actually occur at the junction between it and the Lloyd Domain, spanning the tectonic zone (Figure 1). Their age and origin are unknown.

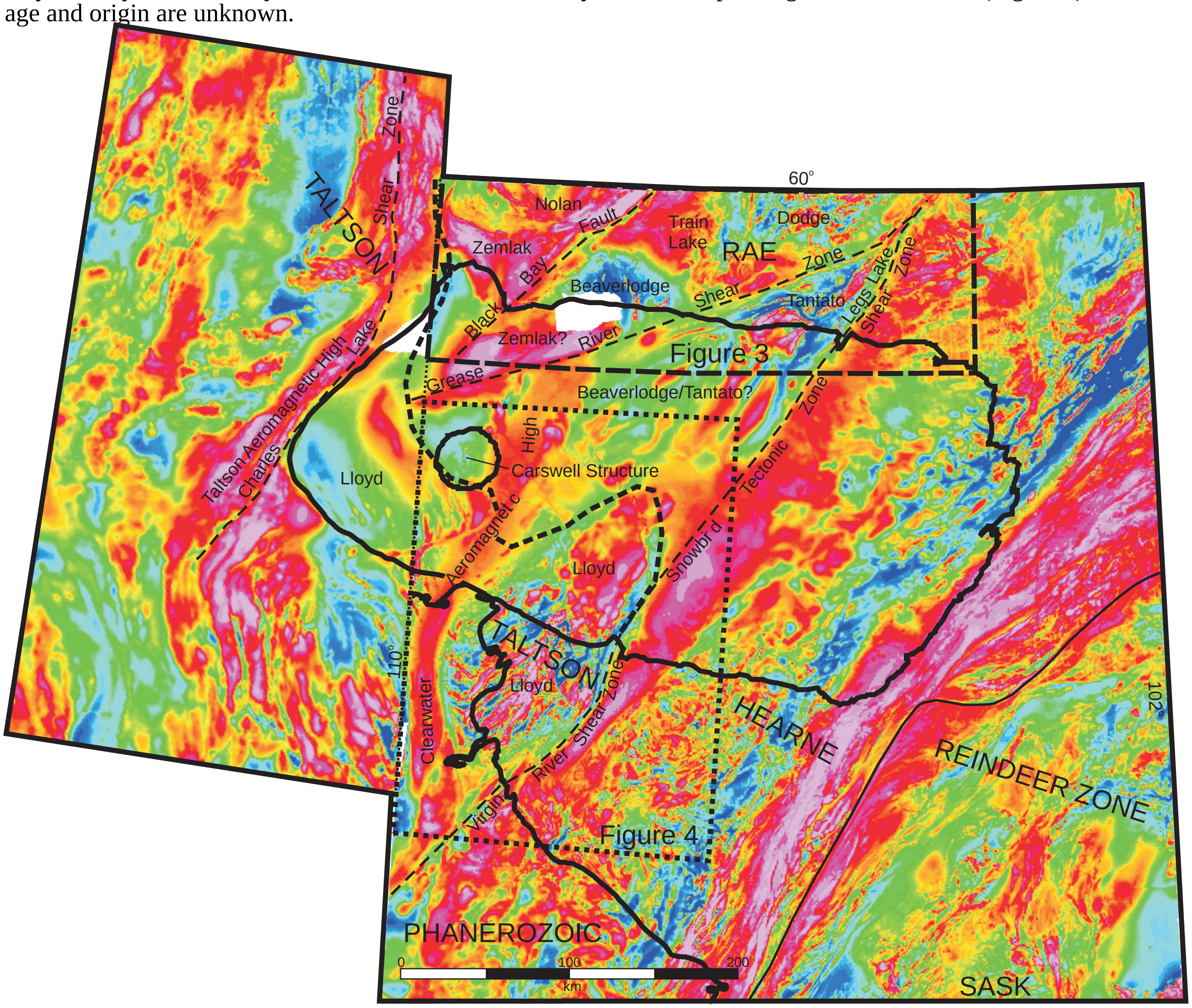

Figure 2 - Total field aeromagnetic image of rocks adjacent to and underlying the Athabasca Basin. The areas shown in Figures 3 and 4 are outlined by dashed and dotted boxes, respectively. Major structural features, lithotectonic domains mentioned in the text, and the Clearwater aeromagnetic highs are denoted. The northern extent of rocks thought to comprise the Lloyd Domain of the Taltson magmatic zone is marked by the short-dashed line. North of that dashed line are undifferentiated rocks of the Rae Province.

Previous Work

North of the Athabasca Basin

A recent geochronological study of the Beaverlodge Domain east of Uranium City (Figure 3) confirmed the presence of Mesoarchean granitoid rocks and revealed several lines of evidence suggesting that Paleoarchean rocks were exposed nearby (Hartlaub *et al.*, 2005). Variably recrystallized, medium-grained granitoid rocks, forming the basement to the Murmac Bay Group, originally yielded U-Pb zircon ages of 3014 ±10 and 3072 ±41 Ma (Persons, 1983). The recent U-Pb zircon study produced a 3060 ±40 Ma result from the latter unit, confirming its Mesoarchean age, and established a better-constrained 2999 ±7 Ma age at another locality (Hartlaub *et al.*, 2004).

A conventional U-Pb detrital zircon study of a quartzite and a psammite from the Murmac Bay Group indicated an even older source. The majority of detritus in the basal quartzite was >3.5 Ga, whereas the psammite contained a more mixed population ranging from about 2.6 to 3.6 Ga (Hartlaub *et al.*, 2004). When plotted together, two fractions from each sample formed a discordia line with a 3619 ±47 Ma upper intercept age that was inferred to be the age of a magmatic event in the source region of the sedimentary detritus (Hartlaub *et al.*, 2004). A follow-up laser ablation study of the quartzite sample confirmed this result. All 42 zircon grains yielded Paleoarchean ages, with peaks at 3.86, 3.76, and 3.72 Ga (Hartlaub *et al.*, 2006).

Due to their mid-crustal origin and low temperature of formation, crustal melts tend to incorporate and preserve abundant xenocrystic zircon, and therefore serve as useful probes of the middle crust. A laser ablation study of zircon from two *ca.* 1.9 Ga leucogranites in the Uranium City area yielded age ranges of 1897 to 3776 and 2174 to 3745 Ma, with peaks at about 2.3 and 3.0 to 3.3 Ga (Hartlaub *et al.*, 2006). These partly reflect the 2.3 and 3.0 Ga granitoid rocks known in the immediate region, but the older age determinations further support the presence of a Paleoarchean crustal component at 1.9 Ga.

Another useful method of estimating the broad geochronological make-up of the middle to lower crust in an area is to determine the depleted mantle ages (T_{DM}) of rocks now exposed at the surface using Sm-Nd systematics. In a previous study, four samples of the 3.0 Ga granite suite yielded T_{DM} ages in the 3.02 to 3.33 Ga range, suggesting a juvenile source component. The 2.6 Ga suite yielded 2.83 to 3.03 Ga T_{DM} ages, whereas the 2.3 Ga granite suite and Murmac Bay Group supracrustal rocks produced similar ages in the 2.75 to 3.21 Ga range (Hartlaub *et al.*, 2005). The fact that the values obtained from the 2.6 and 2.3 Ga granitoid rocks are significantly older than their crystallization ages further indicates the presence of older crustal material. The only analyzed member of the 1.9 Ga crustal melt suite also yielded a significantly older T_{DM} age of 3.18 Ga.

Although this previous T_{DM} study was regional in extent, including rocks from the Zemlak, Beaverlodge, Train Lake, and Dodge domains (Figure 3), rocks produced by crustal melting were under-represented. It was felt that another study focussing on such rocks would provide a better test as to whether the Paleoarchean source rocks that supplied xenocrysts and detrital zircons to the previously analyzed leucogranites and Murmac Bay Group rocks, respectively, were still present in abundance in the Uranium City area. To further test for regional disparities, samples were collected along an east-west transect from the central Train Lake Domain into the eastern Zemlak Domain.

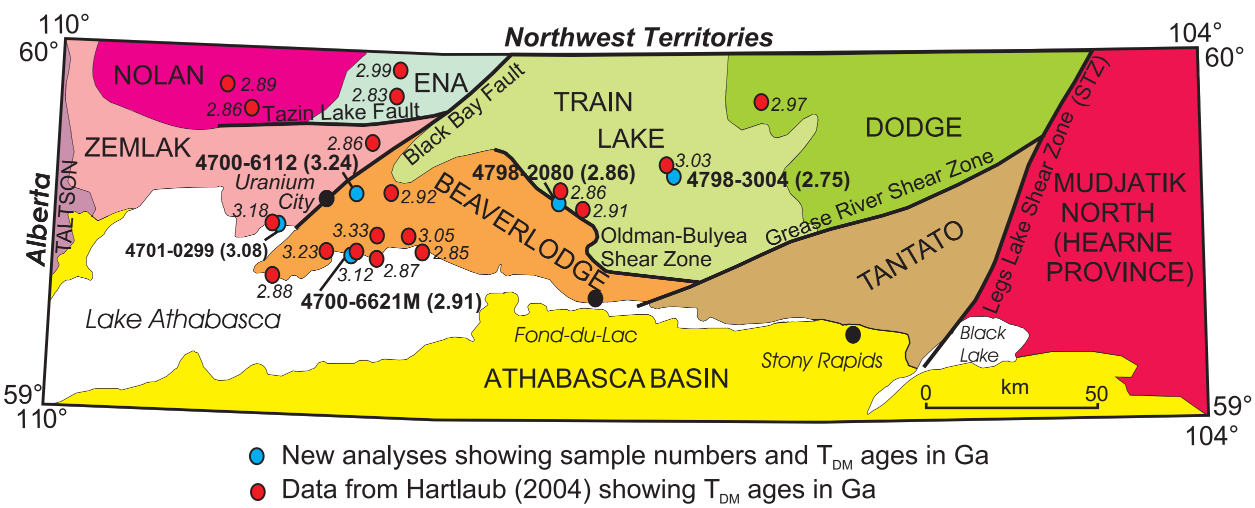

Figure 3 - Domainal map of the southern Rae Province north of Lake Athabasca illustrating results of a previous T_{DM} study (red dots) as well as those from this work (blue dots with ages in bold text - see Table 1). STZ, Snowbird Tectonic Zone.

South of the Athabasca Basin

Previous Sm-Nd isotopic studies have been restricted to a small area near the Snowbird Tectonic Zone where T_{DM}'s were obtained for late granite, mafic and tonalitic gneiss, mafic to ultramafic intrusive rocks, metasedimentary rocks, and various samples of the Clearwater Anorthosite Complex (Figure 4; Crocker *et al.*, 1993; Bickford *et al.*, 1994). With only a few exceptions, the T_{DM} ages were greater than 2.6 Ga. All of the samples had strongly negative ε_{Nd} values suggesting that they are not juvenile rocks or that the original isotopic ratios of the mantle were disturbed (Shirey, 1991). Study of the mantle separation age of the Clearwater Anorthosite Complex yielded a confusing assortment of T_{DM} ages ranging from 2.67 to 2.03 Ga (Crocker *et al.*, 1993). Attempts to determine its crystallization age produced equally equivocal results (Crocker *et al.*, 1993; Halls and Hanes, 1999; Heaman *et al.*, 1999) leaving the age of the anorthosite complex unsolved. The youngest sample previously analyzed was the *ca.* 1.82 Ga Junction granite, which stitches the Snowbird Tectonic Zone. It yielded a *ca.* 2.75 Ga T_{DM} age (Bickford *et al.*, 1994).

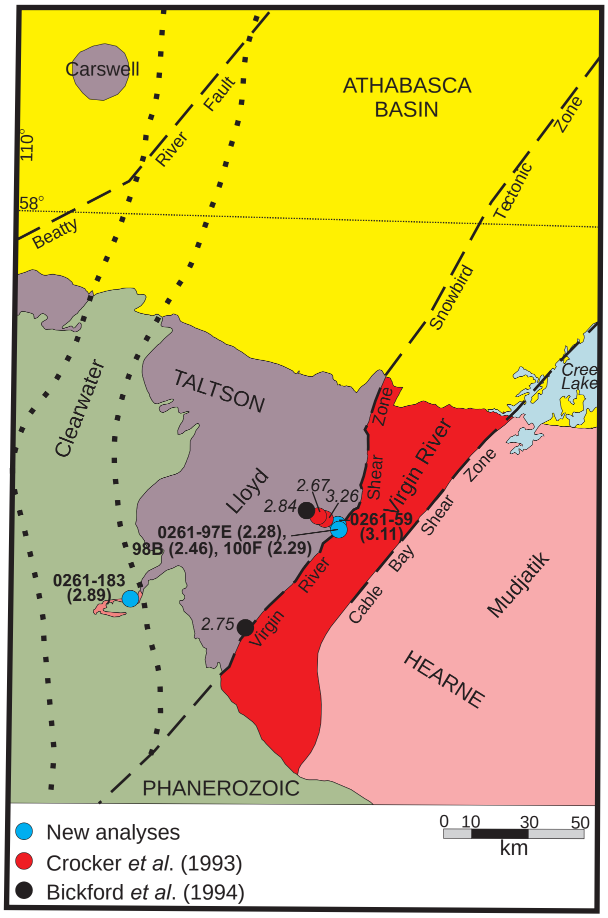

***Figure 4** - Domainal map of the Precambrian Shield southwest of the Athabasca Basin. Previous T_{DM} results are denoted by red and black dots, whereas those from this study are in blue. The calculated T_{DM} values that follow the sample numbers are as reported in Table 1.*

Analytical Techniques

The samples were analyzed at the Geological Survey of Canada following the techniques of Sm-Nd isotopic analyses outlined by Zdanowicz *et al.* (2006). Whole-rock powders were spiked with mixed ^{148}Nd-^{149}Sm tracers, and digested in a HF+HNO_3 mixture in Savillex PFA Teflon vials on a hot plate with surface temperature of 120°C. Samples were evaporated to dryness and treated with concentrated HCl and HNO_3 to break down the fluorides. After complete conversion to the chloride solution form, samples were re-dissolved in 4M HCl, and REE fractions (including Sm and Nd) were separated using cation-exchange chromatography on columns containing 0.5 ml of AG50x12W resin. Sm and Nd were subsequently separated using 0.5 ml columns filled with the Eichrom Ln-Spec REE-specific resin, and 0.23 to 0.50M HNO_3 as an eluant. The separation blanks were below 0.005 ng, and the dissolution blanks were below 0.02 ng. Samples were analyzed using the multi-collector ICP-MS Nu Plasma at the GSC. Sm and Nd were analyzed using an array of fixed Faraday collectors in static multi-collector mode. The isotopic ratios were corrected for spike contribution and mass discrimination by numeric solution of the isotope dilution equations with exponential normalization. Quality control was performed by monitoring the uniformity of non-radiogenic isotopic ratios: ^{145}Nd/^{144}Nd, ^{150}Nd/^{144}Nd, ^{150}Sm/^{152}Sm, and ^{154}Sm/^{152}Sm. In order to reduce long-term drift, all ^{143}Nd/^{144}Nd ratios were adjusted relative to ^{143}Nd/^{144}Nd=0.51186 in the La Jolla standard. Average ^{143}Nd/^{144}Nd values for standards BCR-1 and BCR-2 are 0.512640 ±0.00008 (2σ, 19 analyses) and 0.512642 ±0.000009 (2σ, 15 analyses), respectively.

Sm-Nd isotopic data for samples from this study are summarized in Table 1. For samples with known crystallization ages, Table 1 presents ε_{Nd} values that are deviations (x10^{-4}) in ^{143}Nd/^{144}Nd from bulk earth values at the time of igneous crystallization (Jacobson and Wasserburg, 1984). 'Crustal separation ages' were calculated relative to depleted mantle according the parameters of DePaolo (1981) and Goldstein *et al.* (1984). On a Nd isotope evolution plot (Figure 5) sample growth lines are shown as well as their intersections with depleted mantle growth curves based on the models of DePaolo (1981), Goldstein *et al.* (1984), and Nägler and Kramers (1998).

Table 1 - Sm-Nd results.

Sample Number	Rock Type	Domain	Age (Ga)	2σ	Nd (ppm)	Sm (ppm)	^{147}Sm/^{144}Nd[1]	2σ[1]	^{143}Nd/^{144}Nd[2]	2σ[2]	ε^{143}Nd[3]	2σ[3]	T_{DM} (D) (Ga)	T_{DM} (G) (Ga)
North of the Athbasca Basin (red on Figure 5)														
4798-3004	leucogranite	Train Lake	2.56	0.03	50.69	8.17	0.09741	0.00039	0.511039	0.000014	1.5	0.49	2.65	2.75
4798-2080	leucogranite	Train Lake	1.83	0.03	15.18	2.38	0.09488	0.00016	0.510910	0.000014	-9.8	0.48	2.76	2.86
4700-6621M	leucogranite	Beaverlodge	1.99	0.04	29.51	5.37	0.10997	0.00018	0.511160	0.000014	-6.7	0.53	2.79	2.91
4701-0299	leucogranite	Zemlak	1.94	0.04	15.45	2.01	0.07860	0.00011	0.510407	0.000015	-14.2	0.68	3.00	3.08
4700-6112	leucogranite	Beaverlodge	1.93	0.03	3.34	0.55	0.09965	0.00010	0.510710	0.000021	-13.6	0.55	3.16	3.24
South of the Athabasca Basin (black on Figure 5)														
0261-97E	meta-basalt	Virgin River			93.25	17.91	0.11611	0.00066	0.511685	0.000014	-18.6		2.13	2.28
0261-100F	mafic-ultramafic	Virgin River			74.28	14.56	0.11851	0.00035	0.511715	0.000013	-18.0		2.13	2.29
0261-98B	ferrugenous rock	Virgin River			21.41	4.76	0.13430	0.00019	0.511865	0.000015	-15.0		2.27	2.46
0261-183	biotite granite	Clearwater	1.84	0.03	12.40	2.51	0.12218	0.00014	0.511413	0.000014	-6.3	0.40	2.74	2.89
0261-59	biotite granite	Snowbird Tectonic Zone	1.83	0.03	204.15	36.93	0.10936	0.00013	0.511011	0.000013	-11.3	0.43	3.01	3.11

Notes:

1) Sm and Nd concentrations and ^{147}Sm/^{144}Nd ratios are corrected for blank of 2±2 pg for both Sm and Nd. The uncertainty is propagated into the error of ^{147}Sm/^{144}Nd ratio.

2) Nd isotopic ratios are corrected for fractionation relative to the ratio of ^{146}Nd/^{144}Nd=0.7219, using exponential law and real atomic masses. The ^{143}Nd/^{144}Nd isotopic ratios are adjusted to ^{143}Nd/^{144}Nd=0.51186 in the La Jolla standard.

3) ε^{143}Nd at the time indicated in the column "Age, Ga" relative to the accepted Chondritic Uniform Reservoir with ^{143}Nd/^{144}Nd=0.512636 and ^{147}Sm/^{144}Nd=0.1966.

4) Uncertainty in ε^{143}Nd is propagated to include uncertainties in age, ^{143}Nd/^{144}Nd and ^{147}Sm/^{144}Nd; D, model age calculated according to the model of DePaolo (1981); G, calculated according to the model of Goldstein *et al.* (1984).

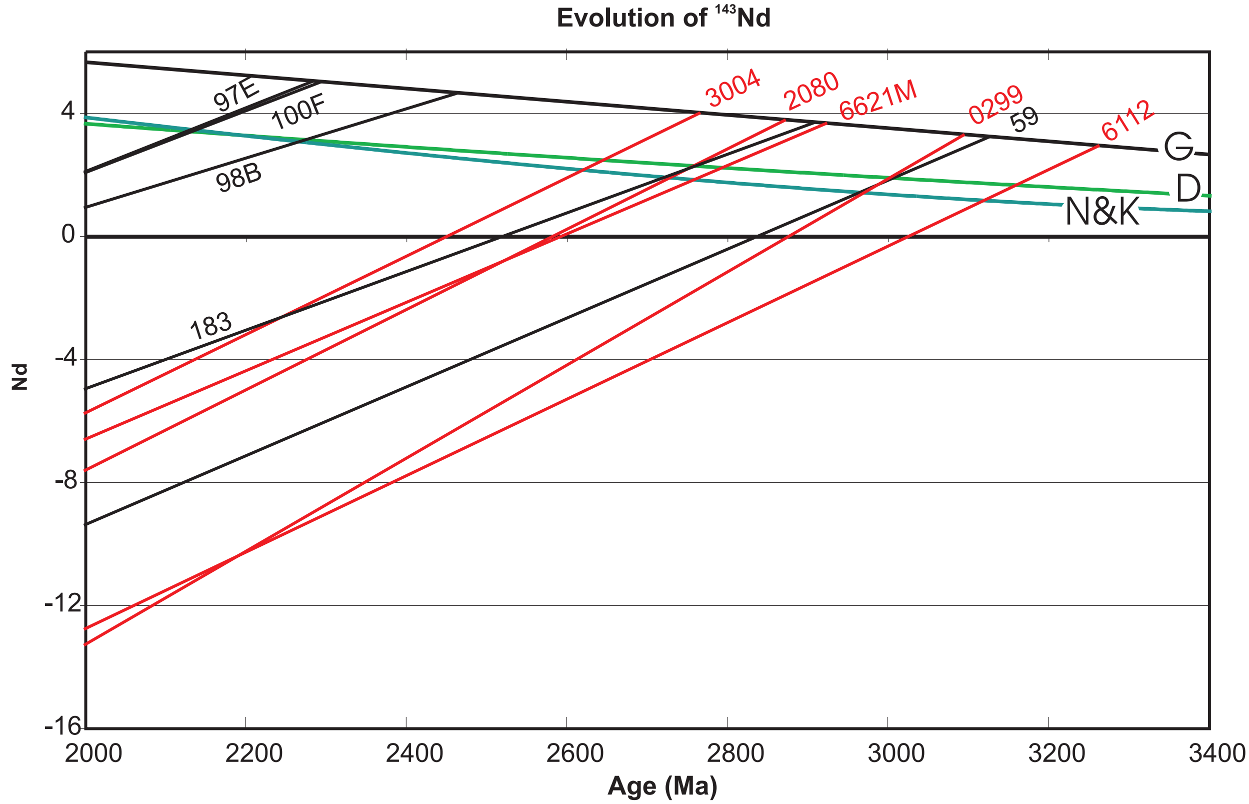

***Figure 5** - [143]Nd evolution trend of analyzed samples. Depleted mantle trends based on the evolution models of DePaolo (1981) (D), Goldstein* et al. *(1984) (G), and Nägler and Kramer (1998) (N&K). Samples north of the Athabasca Basin are in red, south of the Athabasca Basin are in black.*

Results

North of the Athabasca Basin

Five samples were analyzed from north of Lake Athabasca. In the Train Lake Domain (Figure 3), syn-tectonic, leucogranite sheets containing metre-scale inclusions of medium-grained amphibolite have intruded the dominant Archean granitoid host rocks, two of which have yielded U-Pb zircon ages of 2575 ±15 (Ashton *et al.*, 1999) and 2538 ±22 Ma (L. Heaman, pers. comm., 2005). The age of these crustal melt leucogranites is unknown, but they are thought to have formed either during *ca.* 1.90 Ga thermotectonism affecting the adjacent Tantato Domain (Baldwin *et al.*, 2003, 2004) or during a subsequent upper amphibolite facies overprint at about 1.81 Ga (Heaman *et al.*, 1999; Ashton *et al.*, 1999). The analyzed sample (4798-3004) intruded paragneisses of unknown age.

The Oldman-Bulyea Shear Zone defines the boundary between the Train Lake and Beaverlodge domains (Figure 3), and is interpreted as a thrust fault that was later re-activated as a ductile-brittle, normal fault (Card, 2001). Mylonites within the shear zone were locally intruded by weakly deformed, pink, medium-grained leucogranite plutons, which postdate the mylonitization, but were affected by the late normal shearing. One such pluton has yielded a poorly defined U-Pb zircon age of about 1.83 Ga (L. Heaman, pers. comm., 2005). A sample collected from the Bulyea Lake Pluton (4798-2080), containing both biotite and muscovite, is representative of this *ca.* 1.83 Ga late-tectonic suite.

These two samples of leucogranite from the central Train Lake Domain and Train Lake–Beaverlodge domain boundary yielded T_{DM} ages of 2757 and 2861 Ma, respectively, consistent with derivation from mainly Neoarchean (?) granitoids rocks (Figure 3). The 2861 Ma result is nearly identical to the younger of two T_{DM} ages (2.86 and 2.91 Ga) obtained from undated granodioritic rocks located within 10 km of the analyzed Bulyea Lake Pluton sample along the Train Lake–Beaverlodge domain boundary (Hartlaub *et al.*, 2005). The 2757 Ma T_{DM} age is significantly younger than the 3.03 Ga T_{DM} age obtained for the 2575 ±15 Ma granodioritic rock in the central Train Lake Domain. ε_{Nd} values calculated at 2.60 to 2.55 Ga for this and the two undated granodioritic rocks range from -0.1 to -1.2, indicating either a slight input from older sources or somewhat older crystallization ages (Hartlaub *et al.*, 2005). Together, these data suggest that the leucogranitic crustal melts analyzed in this study were mainly derived from the dominant 2.6 Ga granitoid suite exposed at surface, and that any potentially older source material at depth must be of relatively minor extent.

Two samples were collected from the Beaverlodge Domain (Figure 3). One is from a salmon pink, medium-grained leucogranite suite that is extensive throughout the Uranium City area. It intruded the Murmac Bay Group and has been affected by the widespread mylonitic to cataclastic deformation within that region. An exposure within the Uranium City town site has yielded a poorly constrained U-Pb age of 1933 Ma based on the $^{207}Pb/^{206}Pb$ age of the youngest of a scatter of mostly xenocrystic zircon fractions (Hartlaub *et al.*, 2005). A study of 23 zircon grains using the laser ablation technique yielded $^{207}Pb/^{206}Pb$ ages ranging from 2174 to 3659 Ma, consistent with there being Paleoarchean rocks in the source area. The sample collected for Nd analysis (4700-6112) comes from the same unit but a few kilometres to the east.

The other Beaverlodge Domain sample was collected from the Box Granite (4700-6621m), which hosts the Box gold deposit (Figure 3; Saskatchewan Geological Survey, 2003). It is a similar, though more brittly deformed, pink, medium-grained leucogranite that has yielded a poorly constrained U-Pb zircon age of 1994 ±37 Ma (Persons, 1983).

These two 1.9 Ga leucogranite samples from the Beaverlodge Domain yield T_{DM} ages of 2912 and 3241 Ma, consistent with the 3.02 to 3.33 Ga ages previously obtained for the *ca.* 3.0 Ga granitoid suite, the 3.00 to 3.21 Ga ages from the *ca.* 2.3 Ga granites, and the 2.75 to 3.21 Ga ages obtained from the Murmac Bay Group (Hartlaub *et al.*, 2005). This is taken to indicate that the leucogranites were derived from one, or more likely some mixture, of these three sources. These Mesoarchean results also suggest that significant volumes of Paleoarchean material were probably not present in the middle crust at 1.9 Ga.

The Feil Lake Granite is a weakly deformed, pink, medium-grained leucogranite centred about 10 km west of Uranium City in the eastern Zemlak Domain (Figure 3). The sample (4701-0299) was collected from a sheet that intruded more abundant intermediate orthogneisses. These sheets vary from hundreds of metres thick to centimetre scale where they form the leucosome component of injection migmatites. An attempt to date the sample using the conventional ID-TIMS technique yielded a scatter of mainly inherited ages. The youngest fraction produced a concordant result with a 1974 ±5 Ma $^{207}Pb/^{206}Pb$ age, which was considered to be the best estimate of the crystallization age (Hartlaub *et al.*, 2005). A 20-grain laser ablation study of the same sample, however, revealed ages ranging from 1897 to 3776 Ma (Hartlaub *et al.*, 2005), suggesting both a Paleoarchean source and that the crystallization age is constrained between 1900 and 1975 Ma.

The Feil Lake Granite sample yielded a 3078 Ma T_{DM} age, consistent with a recently published 3.18 Ga T_{DM} age for the same unit (Hartlaub *et al.*, 2005). This result is similar to the T_{DM} ages obtained from the western Beaverlodge Domain and suggests that the 3.0 Ga granitoid rocks extend west of the Black Bay Fault.

South of the Athabasca Basin

Two groups of samples were submitted from south of the Athabasca Basin. Late granites produced by crustal melting were included as a probe for the age of their source rocks. A suite of *ca.* 1.84 to 1.82 Ga biotite granites that include the *ca.* 1.82 Ga Junction granite (Bickford *et al.*, 1994) is similar in age, appearance, and bulk composition to the Hudson granites, which are common across the Rae and Hearne provinces in Nunavut (Peterson *et al.*, 2002). The Hudson granites are thought to have originated from melting at mid-crustal levels (Peterson *et al.*, 2002) and therefore are good probes for determining the ages of the crust from which they were sourced. The first of two samples collected from this suite was a weakly deformed, pink, equigranular biotite granite (sample 0261-183) of the *ca.* 1.84 Ga Clearwater granite (Figure 4; Stern *et al.*, 2003). The second granite (sample 0261-59) was nearly identical in appearance, but came from within the Snowbird Tectonic Zone. It has a U-Pb zircon age of 1.83 Ga (Stern *et al.*, 2003).

The samples of 1.84 to 1.83 Ga Hudson-type granite from the Clearwater Domain and Snowbird Tectonic Zone gave T_{DM} ages of 2882 and 3109 Ma respectively, which is somewhat older than the 2747 Ga T_{DM} age obtained for the Junction granite (Figure 4). The three results taken together indicate that Mesoarchean crust underlies some parts of the Lloyd Domain. The 2882 Ma result from the Clearwater Domain is consistent with derivation from Archean granitic gneiss, which occurs as 2529 ±16 Ma xenoliths and *ca.* 2545 Ma xenocrysts in the Clearwater granite (Stern *et al.*, 2003). Although Archean rocks have yet to be identified unequivocally in the Lloyd Domain, the 3.1 and 2.7 Ga model ages from the Snowbird Tectonic Zone suggest that the Paleoproterozoic intrusive rocks dominating the region were emplaced into a craton cored by Meso- to Neoarchean rocks.

The second group of samples comprises amphibolite-facies igneous rocks of the undated Virgin Schist Group (Figure 4). Three samples thought to have igneous protoliths were chosen in order to determine the maximum age of the Virgin Schist Group. The first was a meta-basalt (sample 0261-97E) that was interlayered with psammitic to psammopelitic rocks. The second was a mafic to ultramafic rock (sample 0261-100F) intercalated with psammopelitic to pelitic rocks. It is unclear whether its protolith was volcanic or intrusive. The final sample was a ferruginous rock interpreted as an intermediate volcaniclastic schist (sample 0261-98B).

The metabasalt and mafic-ultramafic rock from the Virgin Schist Group yielded T_{DM} ages of 2287 and 2297 Ma, respectively. The intermediate volcaniclastic schist gave a somewhat older 2465 Ma T_{DM} age, suggesting that the protolith was a epiclastic volcaniclastic rock with some input of sediment from an older source. All of the analyses indicate that the Virgin Schist Group is Paleoproterozoic, with a *ca.* 2.3 Ga maximum age, based on the model ages of the two unequivocally igneous samples. Regional metamorphism of the Virgin Schist Group is inferred to be either 1.9 or 1.8 Ga, which provides a minimum age of deposition. Based on a hypothetical 2.0 Ga crystallization age, the metabasalt and mafic-ultramafic rock have ε_{Nd} values of +2.13 and +2.09, respectively, indicating that they represent juvenile material.

Interpretation and Conclusions

Paleoproterozoic crustal melt rocks in the Train Lake Domain yield T_{DM} ages of 2757 and 2861 Ma that are consistent with derivation from the *ca.* 2.6 Ga granitoid rocks that spatially dominate the area and/or the older material that is responsible for the slightly evolved character of those 2.6 Ga granitoids. Significant volumes of Paleo- or Mesoarchean crustal material are not likely to be present in the west-central Train Lake Domain.

The results of this study confirm the presence of widespread Mesoarchean rocks in the western Beaverlodge and eastern Zemlak Domains, but do not suggest any large volumes of Paleoarchean rocks. Since the main indications of Paleoarchean material take the form of either detrital zircons from the Murmac Bay Group or inherited zircons from younger crustal melts that are partially derived by melting rocks of the Murmac Bay Group, it is suggested that the source is at some distance from the Uranium City area or has been removed by erosion.

The 2882 and 3109 Ma T_{DM} ages determined for the *ca.* 1.84 to 1.83 Ga granites in the eastern Lloyd and Clearwater domains suggest derivation from Meso- to Neoarchean crust. Although Neoarchean rocks have been identified in the Clearwater Domain, none have been identified in the eastern Lloyd Domain. The *ca.* 1.99 to 1.97 Ga quartz diorite suite that dominates the region is interpreted to be part of a continental magmatic arc within the Taltson magmatic suite (*e.g.*, Hoffman, 1988; Card *et al.*, in press). Given their model ages these two granites were likely derived from melting of the craton into which the quartz diorite suite was emplaced.

The two *ca.* 2.3 Ga T_{DM} ages obtained from mafic to ultramafic rocks of the Virgin Schist Group are thought to establish a maximum age for emplacement and deposition. The minimum age of the Virgin Schist Group is 1.8 Ga, the time of the youngest regional metamorphic event. E_{Nd} values from the two igneous samples, calculated at both 2.3 and 1.8 Ga, are positive, indicating derivation largely from juvenile magmas.

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