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A Late Triassic Rb-Sr phlogopite isochron age for a kimberlite dyke from the Rankin Inlet area, Nunavut[1]

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[1] Contribution to the Western Churchill NATMAP Project

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Abstract

A Rb-Sr phlogopite isochron age of 214.3 ± 1 Ma is reported for a kimberlite dyke from the Rankin Inlet area, western Churchill Province, Nunavut. The age is 20 Ma older than U-Pb perovskite ages for other kimberlite dykes in the same area, indicating a significant time span for kimberlite magmatism of the Rankin Inlet cluster in the Late Triassic to Early Jurassic.

Résumé

Un âge par isochrone Rb-Sr sur phlogopite de 214,3 ± 1 Ma a été attribué à un dyke de kimberlite de la région de Rankin Inlet, dans la Province de Churchill occidentale, au Nunavut. Cet âge est de 20 millions d'années plus ancien que ceux qu'ont livré par la méthode U-Pb sur pérovskite d'autres dykes de kimberlite situés dans la même région, ce qui indique que l'activité magmatique responsable de la mise en place des dykes de kimberlite de l'essaim de Rankin Inlet s'est échelonnée sur une longue période au Trias tardif et au Jurassique précoce.

INTRODUCTION

Recently identified kimberlite dykes hosted in greenschist-grade Archean supracrustal rocks in the Rankin Inlet area represent the first documented occurrence of kimberlite magmatism in the Hearne portion of the western Churchill Province (Fig. 1; Miller et al., 1998; Seller, 1999; Heaman and Kjarsgaard, 2000). The Hearne domain is composed of dominantly Neoarchean rocks, with rare indicators of Mesoarchean crust along its western and northern margins (Davis et al., 2000). The prominent northeastern structural grain of the Hearne domain is a composite fabric that reflects variable but widespread Paleoproterozoic reworking of the Archean crust at 2.5 Ga; 1.9 Ga, and 1.83 Ga (Davis et al., 2000). Proterozoic rocks include structural inliers of a deformed cover sequence (Hurwitz Formation) and extensive ca. 1830 Ma plutonic rocks. The extensive Paleoproterozoic plutonism and tectonic reworking of the Archean crust in the Churchill Province distinguishes this craton from the adjacent Slave and Superior cratons which record comparatively minor Paleoproterozoic thermal resetting and deformation.

The western Churchill Province is well known for its extensive Paleoproterozoic alkaline magmatic rocks represented by the ca. 1.83 Ga Christopher Island Formation (Peterson, 1994) of the Dubawnt Supergroup and associated minette dykes. The minette dykes occur throughout the Hearne and are documented within the Rankin Inlet area. The ca. 1.83 Ga Akluilâk lamprophyre dyke, located 100 km west of Rankin Inlet, is known to be diamond-bearing (MacRae et al., 1995).

The geology of the Rankin Inlet area is characterized by Archean volcanic and sedimentary rocks of the Rankin Inlet Group, overlain by Proterozoic sedimentary rocks correlative to the Hurwitz Group, all of which are intruded by ca. 1830 Ma granitoid bodies. (Fig. 2; Tella, 1994, 1995). A series of prominent west- to northwest-trending faults (Pyke Fault, Meliadine trend) offset the Archean rocks and are associated with significant gold mineralization.

SAMPLE DESCRIPTION

The kimberlite dykes in the Rankin Inlet area are described by Miller et al. (1998) and Seller (1999), and only a brief summary is presented here. The kimberlite dyke sample (Z4358) was recovered from a drill-core intersection (UTM: 15 581191E 6972964N), and was not exposed at surface. The kimberlite occurs as subvertical tabular dykes that vary up to 1–3 m in width. The dykes bifurcate into subparallel anastomosing veins and veinlets, and are internally heterogeneous due to flow differentiation and chilling against the wall rock. No significant thermal effects on wall rocks and wall-rock xenoliths have been noted. These features suggests that the dykes represent lower-hypabyssal-facies kimberlite (Mitchell, 1986). Petrographically, the dykes are characterized by two generations of olivine and phlogopite, with primary and secondary serpentine, primary calcite, perovskite, spinel, magnesioilmenite, apatite, pyrite, chalcopyrite, galena, and uraninite (Miller et al., 1998). Xenolithic material can be identified as being derived from the local, greenschist-facies, Archean, metavolcanic host rocks. The kimberlite is calcite-rich with $CO_{2(T)}$ contents of 27.6–29.5% and is compositionally highly evolved (Miller et al., 1998).

Phlogopite occurs as both a groundmass and phenocrystic phase. Both varieties are compositionally similar. Zoning in some of the phenocrystic phlogopite is characterized by high FeO and TiO_2 cores with increasing MgO and Al_2O_3 towards the rims.

ANALYTICAL METHODS

The sample was crushed and phenocrystic phlogopite separated by hand. Individual phlogopite crystals occur as 1–3 mm black euhedral booklets. Crystals were hand picked in alcohol under binocular microscope, and only grains free of visible alteration were selected for analysis. Mineral fractions were sequentially washed in an ultrasonic bath in ultra-pure water and acetone, dried and weighed. The samples were leached in 2N HCl for 10 minutes at room temperature following the method of Brown et al. (1989). The HCl supernatant was decanted and the residue washed in H_2O prior to addition of a mixed ^{85}Rb-^{84}Sr spike to both. The samples were dissolved in screw-top Savillex containers in HF-HNO_3 at 170°C for five days, dried down, and dissolved in 3.1 N HCl prior to column chemistry.

Rubidium and strontium were separated using standard cationic exchange chemistry and analyzed in static mode on a Finnigan-Mat 261 mass spectrometer. All errors are reported at 2σ level. Strontium isotopic data are normalized to $^{88}Sr/^{86}Sr$ value of 8.37521 and reported relative to a $^{87}Sr/^{86}Sr$ value of 0.710250 for the standard reference material NBS 987. Rubidium and strontium blanks were less than 50 and 300 pg respectively. Data regression was performed using Isoplot (Ludwig, 2000).

RESULTS

The isotopic data are presented in **Table 1**. Concentration data are reported relative to the initial pre-leach weights. No data are available for the leachate from Fraction LP1. Significant percentages of Sr were leached from all of the fractions, ranging from a low of 14% in leachate LP4, to a high of 65% in leachate LP2. In comparison, only 0.35–0.85% of Rb was contained in the leachates. The leached component has typically nonradiogenic compositions.

All four of the residue analyses and two of the leachates (LP3 and LP4) define a regression line (mean square of weighted deviates (MSWD) = 0.38) with a Late Triassic age of 214.3 ± 1 Ma (**Fig. 3**). The initial isotopic composition of 0.70520 ± 0.00003 falls within, but to the radiogenic end of, values for Group I kimberlites (Mitchell, 1986). Leachate LP2 plots significantly above the regression line, and was excluded from the age calculation. The large percentage of leachable Sr of relatively radiogenic composition in LP2 suggest that some of the leached Sr may be of secondary origin, possibly derived from a fluid that interacted with the Archean wall rocks, or postcrystallization remobilization of Sr within the kimberlite.

DISCUSSION

The 214.3 ± 1 Ma age is significantly older than perovskite ages of 196.2 ± 2.8 Ma and 192 ± 13 Ma determined for two different samples from the Rankin Inlet field (Heaman and Kjarsgaard, 2000), indicating that the Late Triassic–Early Jurassic event at Rankin Inlet spanned at least 20 Ma. The span of ages at Rankin Inlet is comparable to that documented for Jurassic kimberlite fields in east-central Canada. For example, the Kirkland Lake field spans 13 Ma (165–152 Ma) and the Timiskaming field approximately 21 Ma (155–134 Ma; Heaman and Kjarsgaard, 2000).

Heaman and Kjarsgaard (2000) interpreted the Late Triassic–Early Jurassic ages at Rankin Inlet as part of a progression in kimberlite ages along a southeast-trending zone from Rankin Inlet (214–192 Ma) through the Attawapiskat field in the James Bay lowlands (180 Ma), to the Kirkland Lake (165–152 Ma) and Timiskaming (154–134 Ma) kimberlite fields (Fig. 1). They correlated this trend with the inferred trace of the Great Meteor Hotspot track beneath the North American continent and suggested that Mesozoic kimberlite magmatism in eastern North America may be hotspot-related.

Miller et al. (1998) related the emplacement of the Rankin Inlet kimberlite dykes to Late Triassic to Early Jurassic regional reactivation in the western Churchill Province. Reactivation of the western Churchill Province is recorded by stratigraphic and sedimentological discontinuities within the early Mesozoic sedimentary rocks of the Hudson Bay platform (Embry 1991; Norris et al., 1993).

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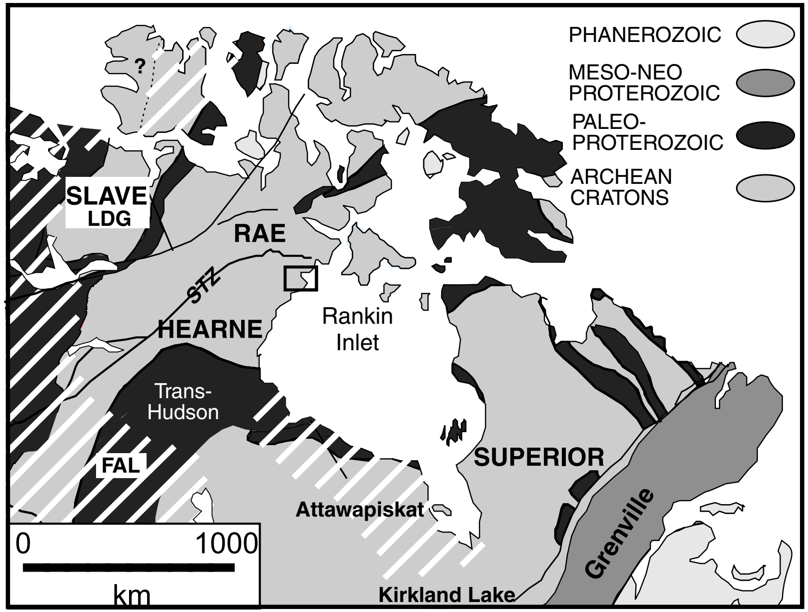

Figure 1. Simplified geological map showing location of the Rankin Inlet area relative to the distribution of Archean cratons within Canada. Approximate locations for some of the principal kimberlite fields are indicated for geographical reference (e.g. Attiwapiskat, Kirkland Lake, Fort à la Corne, Lac des Gras). Abbreviations: FAL: Fort à la Corne; STZ– Snowbird Tectonic zone; LDG– Lac des Gras. White hatched lines indicate Precambrian basement areas covered by Phanerozoic sedimentary sequences.

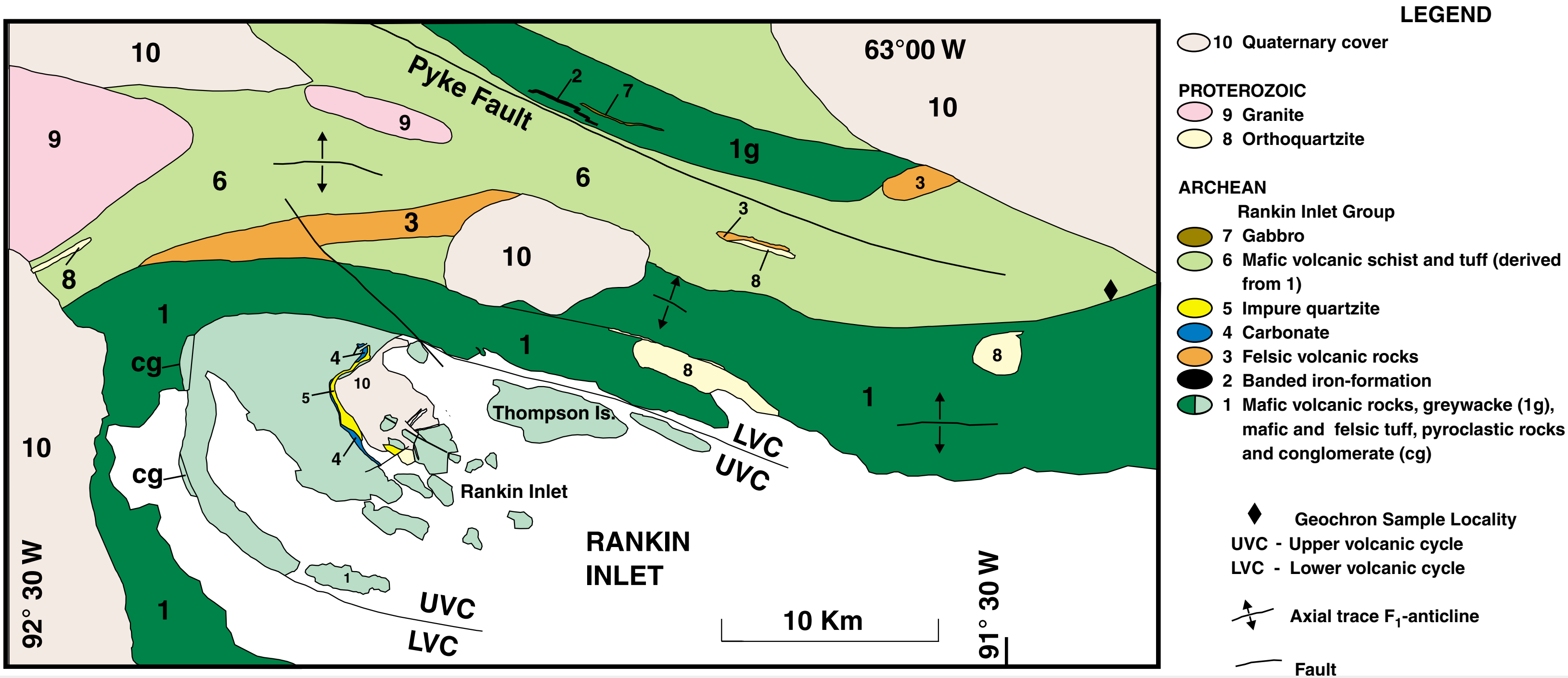

Figure 2. Geology of the Rankin Inlet area and location of kimberlite sample site (*after* Tella 1994, 1995).

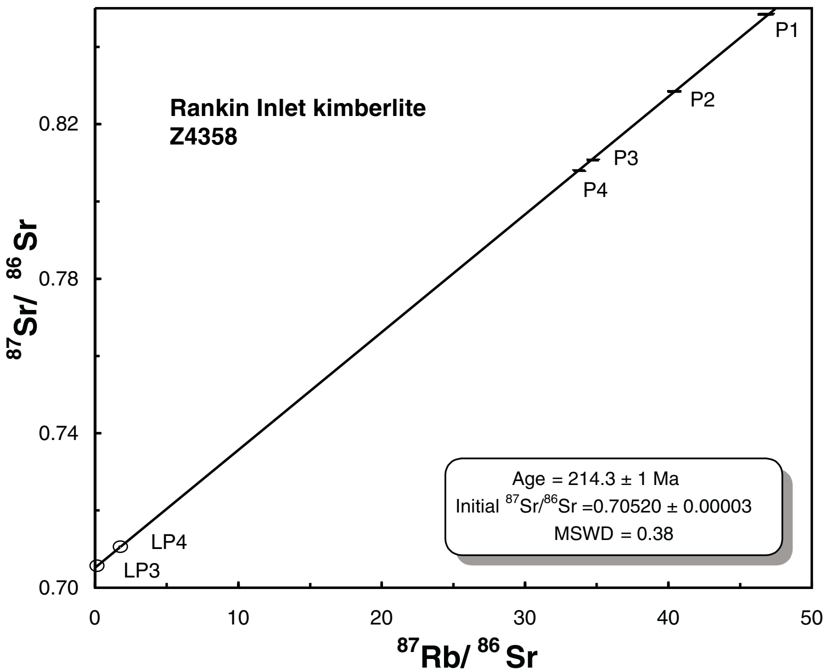

Figure 3. $^{87}Sr/^{86}Sr$ vs. $^{87}Rb/^{86}Sr$ for phlogopite fractions. Regression method from Ludwig (2000).

Table 1. Rb-Sr analytical data from sample Z4358.

Sample[1]	Weight (mg)	Rb[2] (ppm)	Sr[2] (ppm)	$^{87}Rb/^{86}Sr$[3]	$^{87}Sr/^{86}Sr$[4]
P1	37	299.8	18.80	46.77	0.848455
P2	31	297.2	21.53	40.41	0.828490
P3	17	448.1	37.71	34.73	0.810753
P4	11	415.1	35.90	33.78	0.807993
LP2		2.485	39.31	0.1829	0.706272
LP3		1.512	32.14	0.1373	0.705616
LP4		3.576	5.940	1.742	0.710498

[1]P = phlogopite residue; LP signifies corresponding leachate.
[2]Concentration data reported relative to initial weight prior to leaching.
[3]Estimated relative external error of 1% in ratio.
[4]Normalized to $^{88}Sr/^{86}Sr$ - 8.37521; relative external error 0.005%.