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Description of Content

This report contains U-Pb geochronological results for 16 rock samples from the Southern Indian Lake, Lynn Lake and Kisseynew domains of northern Manitoba collected between 1999 and 2002. While results from other samples collected during this time interval were published previously, the results included here were not, primarily due to uncertainty about the interpretation of the results. The purpose of this report is to release the existing data with the required sample and laboratory metadata along with a limited, preliminary interpretation so that this information is available for consideration by future researchers.

This report contains two Excel spreadsheets, each containing the results for either isotope dilution thermal ionization mass spectrometry (ID-TIMS, Appendix 1) analysis or sensitive high resolution ion microprobe (SHRIMP, Appendix 2) analysis conducted at the Geological Survey of Canada. Each spreadsheet consists of a worksheet containing the data and a series of sheets containing the concordia diagram for each sample. For the six samples analysed by SHRIMP, the scanning electron microscope zircon images annotated with the SHRIMP spot location are included as separate Adobe pdf files. Details for each sample (location, lithology, interpretation of results) are given below and a summary of the interpreted age is provided on an accompanying kml file to be viewed in GoogleEarth.

Analytical Methods

All samples were disaggregated using standard crushing/pulverizing techniques followed by density separation using the Wilfley table and heavy liquids. Zircon grains were selected after examination under a binocular microscope.

Zircon grains analysed by ID-TIMS were treated with the air abrasion method (Krogh, 1982) or the chemical abrasion method (Mattinson, 2005) before being submitted for U-Pb chemistry. Dissolution

of zircon in concentrated HF, extraction of U and Pb, and mass spectrometry followed the methods described by Parrish et al. (1987). Data reduction and numerical propagation of analytical uncertainties follow Roddick (1987). Decay constants used follow the recommendations of Steiger and Jäger (1977).

For SHRIMP analysis, zircon grains were cast in 2.5 cm diameter epoxy mounts along with fragments of the GSC laboratory standard zircon (z6266, with 206Pb/238U age = 559 Ma). The mid-sections of the zircons were exposed using 9, 6, and 1 μm diamond compound. The internal features of the zircons (such as zoning, structures, alteration, etc.) were characterized in cathodoluminescence (CL) and/or back-scattered electron (BSE) mode utilizing scanning electron microscope. Hard-copy images of the zircon grains were numbered and annotated with the location of the SHRIMP spot. Scans of these annotated images are included as separate pdf files for each sample. SHRIMP analytical procedures followed those described by Stern (1997) and Stern and Amelin (2003). Off-line data processing was accomplished using customized in-house software. Decay constants used follow the recommendations of Steiger and Jäger (1977). The 1σ external errors of $^{206}Pb/^{238}U$ ratios reported in the data table incorporate the error in calibrating the reference material. Common Pb correction utilized the Pb composition of the surface blank (Stern, 1997).

For both TIMS and SHRIMP results, Isoplot v. 4.15 (Ludwig, 2012) was used to generate concordia plots and calculate weighted means. The error ellipses on the concordia diagrams and the weighted mean errors are reported at the 95% confidence level.

Results

Lab number: 5803
Sample number: CXA99-D005
Lithological description: Coarse-grained megacrystic granite; weak foliation
Location: approx. 75 km east of the town of Lynn Lake
Latitude: 56.7297°N (all coordinates reported using NAD27 datum)
Longitude: 99.9921°W (all coordinates reported using NAD27 datum)

Five TIMS fractions were analysed yielding discordant (1-2%) $^{207}Pb/^{206}Pb$ ages between 1798.4-1822.5 Ma (Appendix 1). A free regression through all 5 fractions yields an upper intercept age of 1834±22 Ma, but with excess scatter (MSWD = 7.5). While imprecise, this is the best estimate of the crystallization age of the megacrystic granite phase of the Eden Lake pluton. Alternatively, a minimum crystallization age could be constrained by the $^{207}Pb/^{206}Pb$ age of the least discordant fraction which is 1822.5±2.2 Ma.

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Lab number: 6208
Sample number: CXA99-D002
Lithological description: Fine-grained, homogeneous, tonalite/diorite; weak foliation
Location: About 2 km southeast of Ruttan mine
Latitude: 56.4787°N
Longitude: 99.6192°W

Three TIMS fractions yield an upper intercept age of 1881.5±2.5 Ma (MSWD = 0.17) which is the crystallization age of the tonalite/diorite (Appendix 1).

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Lab number: 6209
Sample number: CXA99-D004
Lithological description: Homogeneous, partly recrystallized, moderately foliated granodiorite
Location: Road-cut outcrop between Leaf Rapids and Lynn Lake
Latitude: 56.6033°N
Longitude: 99.9358°W

Five TIMS zircon fractions were analysed (Appendix 1). The crystallization age of this sample of the Outlaw Bay tonalite is best constrained by the weighted mean $^{207}Pb/^{206}Pb$ age of 3 fractions (2 concordant/near-concordant and 1 discordant) at 1861.3±2.5 Ma (MSWD = 0.13). One concordant fraction with a $^{207}Pb/^{206}Pb$ age of 1852 Ma and one discordant fraction with an age of 1822 Ma were excluded from the calculation.
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Lab number: 6323
Sample number: CXA99-D001
Lithological description: Foliated medium-grained granodiorite
Location: On highway between Thompson and Leaf Rapids, approx. 80km south of Leaf Rapids
Latitude: 55.82°N (coordinate approximate based on notes)
Longitude: 99.6°W (coordinate approximate based on notes)

Four TIMS zircon fractions were analysed (Appendix 1). Two of them (Z1A, Z1B) contain elevated levels of common Pb and thus returned imprecise results. The two low common Pb fractions are approximately 0.8% discordant. Thus the best estimate for the crystallization age of the granodiorite is the oldest of these at 1836.7±2.2 Ma. As this age is derived from a discordant $^{207}Pb/^{206}Pb$ age, it should be considered a minimum age.

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Lab number: 6324
Sample number: CXA99-D003
Lithological description: Massive magnetite-biotite granite
Location: Roadcut between Leaf Rapids and Ruttan mine
Latitude: 56.77°N (coordinate approximate based on notes)
Longitude: 100.4°W (coordinate approximate based on notes)

The crystallization age of this granite is 1860.7±2.0 Ma, constrained by the weighted mean $^{207}Pb/^{206}Pb$ age of 3 TIMS fractions (MSWD = 0.28, Appendix 1)

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Lab number: 7035
Sample number: CXA-01-D45A
Lithological description: Meta-andesite, sub-volcanic intrusion, mixing of andesitic and rhyolitic magma
Location: Pukatawagan Bay
Latitude: 57.07942°N
Longitude: 98.83274°W

Five TIMS zircon fractions yielded non-reproducible discordant (2.7-5.7%) results ranging from 1794-2986 Ma ($^{207}Pb/^{206}Pb$ age, Appendix 1). Two TIMS titanite fractions returned near-concordant but non-reproducible $^{207}Pb/^{206}Pb$ ages of 1785 Ma and 1797 Ma. No crystallization age determination was possible for this sample.

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Lab number: 7479
Sample number: CXA-02-N5a
Lithological description: Diorite
Location: Granville Lake
Latitude: 56.2720°N
Longitude: 100.6051°W

This sample is part of a suits of sills with unique geochemistry referred to as the Blacktrout diorite which elsewhere has returned an Archean Sm-Nd model age (Murphy and Zwanzig, 2021) but whose crystallization age was unknown. No zircon was recovered from this sample. Three titanite fractions were analysed by TIMS and returned a concordia age of 1773±17 Ma (MSWD of concordance + equivalence = 1.9, Appendix 1). This is considered a cooling age for this diorite.

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Lab number: 7480
Sample number: CXA-02-D66a
Lithological description: Magnetite-biotite granite in tectonic contact with Sickle group quartzite
Location: Granville Lake
Latitude: 56.3352°N

Longitude: 100.4130°W

The crystallization age of this granite is 1857.7±3.7 Ma, constrained by upper intercept of a regression through 3 TIMS fractions (MSWD = 2.6, Appendix 1).

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Lab number: 7483
Sample number: CXA-02-D66b
Lithological description: Muscovite-bearing impure quartzite
Location: Granville Lake
Latitude: 56.3352°N
Longitude: 100.4130°W

Thirty-four zircons were analysed by SHRIMP and gave ages ranging from 1.85 Ga to 1.94 Ga with the dominant mode at 1.87 Ga (Appendix 2). Replicate analyses were conducted on the youngest grains and constrain the maximum age of deposition for this sample at 1849±30 Ma (grain 94, n=4, MSWD = 0.35, probability = 0.79).
This quartzite is in contact with variably foliated biotite granite (CXA-02-D66a, described above) that shows a strain increase towards the contact with the quartzite. The presence of pebble conglomerate in the quartzite and the absence of quartzite xenoliths in the granite, suggest that this may be a reworked unconformity. However, the possibility that it is a reworked intrusive contact could not be ruled out in the field. It was hoped that U-Pb analysis of both the quartzite and the granite would resolve this issue. While the age of the granite and the youngest detrital zircon overlap within error, the data are more consistent with a reworked unconformable relationship, rather than an intrusive one.

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Lab number: 7497
Sample number: CXA-02-D37
Lithological description: Biotite monzogranite
Location: Granville Lake
Latitude: 56.29635°N
Longitude: 100.51063°W

Three zircon TIMS fractions returned discordant (1.7-12%) results with an upper intercept of 1854±40 Ma (MSWD = 5.3). Given the poor fit of the regression, the resulting error is very large. Instead, the best estimate of the crystallization age of the monzogranite is 1848.4±2.0 Ma, the $^{207}Pb/^{206}Pb$ age of the most concordant fraction. As this analysis is slightly discordant, this is considered a minimum age of crystallization.

Two fractions of monazite were also analysed by TIMS and they return a mean $^{207}Pb/^{206}Pb$ age of 1807.1±2.1 (MSWD = 2.1) which is interpreted as a metamorphic age.

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Lab number: 7498
Sample number: CXA-02-D28
Lithological description: Granite cutting mafic volcanic rocks

Location: Granville Lake
Latitude: 56.29518°N
Longitude: 100.8394°W

The crystallization age of this granite is 1791.2±1.1 Ma, constrained by upper intercept of a regression through 5 TIMS fractions (MSWD = 1.06, Appendix 1).

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Lab number: 7481
Sample number: CXA-02-N1
Lithological description: Wacke
Location: South end of Wheatcroft Lake
Latitude: 56.19569°N
Longitude: 100.7191°W

Thirty-four detrital zircons were analysed by SHRIMP; their ages range from 1.83 Ga to 1.90 Ga with the dominant mode at 1.85 Ga (Appendix 2). Replicate analyses were conducted on the youngest grains to try and constrain the maximum age of deposition. Three replicates on grain 66 yields a weighted mean $^{207}Pb/^{206}Pb$ age of 1836±12 Ma (MSWD = 2.2) which is indistinguishable from the dominant mode. In order to resolve this further, five single grain TIMS fractions were analysed. These yielded concordant to near-concordant $^{207}Pb/^{206}Pb$ ages between 1852.3-1856.6 Ma (Appendix 1). The maximum age of deposition is considered to be 1855.1±1.8 Ma, the $^{207}Pb/^{206}Pb$ age of the most concordant TIMS analysis.

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Lab number: 7482
Sample number: CXA-02-N4
Lithological description: Highly strained conglomerate
Location: Muhekan Bay, south end of Granville Lake
Latitude: 56.23591°N
Longitude: 100.68160°W

Thirty-five detrital zircons were analyzed by SHRIMP and gave ages ranging from 1.81 Ga to 2.56 Ga (Appendix 2). The older ages (2.30 –2.56 Ga) are observed in 5 grains. Plotted on a cumulative probability curve, the majority of the data form a roughly Gaussian distribution curve, centered at ca. 1.86 Ga. These thirty analyses, ranging from 1813 to 1892 Ma, were pooled to yield a weighted mean $^{207}Pb/^{206}Pb$ age of 1857±7 Ma, with an MSWD of 0.57 indicating no detectable geological scatter in the dataset. Since the youngest zircon is not statistically distinct from the rest of the analysed zircons, a single youngest detrital grain is not identified.

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Lab number: 7494
Sample number: CXA-02-D20
Lithological description: Fine-grained to massive rock with feldspar crystals; possible felsic volcanic
Location: South end of Granville Lake
Latitude: 56.22814°N

Longitude: 100.59357°W

Forty-two zircons were analysed by SHRIMP and gave ages ranging from 1774 Ma to 1923 Ma (Appendix 2). The weighted mean $^{207}Pb/^{206}Pb$ age of 37 of these analyses is 1873±4 Ma (MSWD = 0.83). The zircons recovered from this sample are slightly rounded/resorbed, not the sharply faceted prisms one would expect in a volcanic rock, thus these zircons may be volcaniclastic in origin. This result is most cautiously interpreted as the maximum depositional age of this volcanic/hypabyssal/volcaniclastic rock. Five young analyses were excluded from this calculation, one discordant (17%) analysis, two from low U zircon with large errors (±40 and ±57 1s) and two low Th/U analyses (ca. 1.78-1.79 Ga). While these zircon are not distinctive in appearance, they are distinctive in composition and are inferred to represent a metamorphic overprint.

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Lab number: 7552
Sample number: CXA-02-N8
Lithological description: Syenogranite, moderately to strongly deformed
Location: East of the Thompson-Leaf Rapids road, south of Leaf Rapids
Latitude: 56.212°N
Longitude: -99.991°W
The crystallization age of this syenogranite is 1861±6 Ma, constrained by the weighted mean $^{207}Pb/^{206}Pb$ age of 11 SHRIMP analyses (MSWD = 0.42, Appendix 2). In addition, two low Th/U zircons yield a weighted mean $^{207}Pb/^{206}Pb$ age of 1808±12 Ma (MSWD = 0.015) which is interpreted to represent a metamorphic overprint. A single low U zircon returned a $^{207}Pb/^{206}Pb$ age of 2064 Ma, which is interpreted to be inherited. This sample was collected in order to test whether or not Archean basement rocks are present locally to account for the Archean model age of the nearby Black Trout diorite (see titanite data for CXA-02-N5a above).

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Lab number: 7554
Sample number: CXA-02-N9
Lithological description: Syenogranite gneiss
Location: East side of the Thompson-Leaf Rapids road, south of Leaf Rapids, right by the highway
Latitude: 56.212°N (location approximate)
Longitude: -99.991°W (location approximate)

The crystallization age of this syenogranite gneiss is 1883±6 Ma, constrained by the weighted mean $^{207}Pb/^{206}Pb$ age of 13 SHRIMP analyses (MSWD = 0.45, Appendix 2). In addition, two low Th/U zircon rims yield a weighted mean $^{207}Pb/^{206}Pb$ age of 1821±12 Ma (MSWD = 0.62) which is interpreted to represent a metamorphic overprint. This sample was collected in order to test whether or not Archean basement rocks are present locally to account for the Archean model age of the nearby Black Trout diorite (see titanite data for CXA-02-N5a above).

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References:

Krogh, T.E. 1982: Improved accuracy of U-Pb zircon ages by the creation of more concordant systems using an air abrasion technique. Geochimica et Cosmochimica Acta, **46**, 637-649.

Ludwig, K. 2012. User's manual for Isoplot/Ex rev. 3.70: a Geochronological Toolkit for Microsoft Excel. Special Publication, 5, Berkeley Geochronology Center, Berkeley, 76p.

Mattinson, J.M. 2005: Zircon U–Pb chemical abrasion ("CA-TIMS") method: Combined annealing and multi-step partial dissolution analysis for improved precision and accuracy of zircon ages. Chemical Geology, 220, 47-66.Roddick, J.C. 1987: Generalized numerical error analysis with application to geochronology and thermodynamics; Geochimica et Cosmochimica Acta, **51**, 359–362.

Murphy, L.A. and Zwanzig, H.V. 2021: Geology of the Wuskwatim–Granville lakes corridor, Kisseynew domain, Manitoba (parts of NTS 63O, P, 64A–C); Manitoba Agriculture and Resource Development, Manitoba Geological Survey, Geoscientific Report GR2021-2, 94p.

Parrish, R.R., Roddick, J.C., Loveridge, W.D. and Sullivan, R.W. 1987: Uranium-lead analytical techniques at the geochronology laboratory, Geological Survey of Canada; *in* Radiogenic Age and Isotopic Studies: Report 1, Geological Survey of Canada. **87**-2, 3–7.

Stacey, J.S. and Kramers, J.D. 1975. Approximation of terrestrial lead isotope evolution by a two-stage model. Earth Planet. Sci. Lett., v.26, p. 207-221.

Steiger, R.H., and Jäger, E. 1977: Subcommission on geochronology; Convention on the use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, 36, 359-362.

Stern, R.A. 1997: The GSC Sensitive High Resolution Ion Microprobe (SHRIMP): analytical techniques of zircon U-Th-Pb age determinations and performance evaluation: in Radiogenic Age and Isotopic Studies, Report 10, Geological Survey of Canada, Current Research 1997-F, p. 1-31.

Stern, R.A., and Amelin, Y., 2003: Assessment of errors in SIMS zircon U-Pb geochronology using a natural zircon standard and NIST SRM 610 glass. Chemical Geology, **197**, 111-146.