



Natural Resources
Canada

Ressources naturelles
Canada

**GEOLOGICAL SURVEY OF CANADA
OPEN FILE 8868**

**U-Pb geochronology data from the 2008-2011 Manitoba Far
North Geomapping Initiative**

N.M. Rayner

2022

Canada



GEOLOGICAL SURVEY OF CANADA OPEN FILE 8868

U-Pb geochronology data from the 2008-2011 Manitoba Far North Geomapping Initiative

N.M. Rayner

2022

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2022

Information contained in this publication or product may be reproduced, in part or in whole, and by any means, for personal or public non-commercial purposes, without charge or further permission, unless otherwise specified.

You are asked to:

- exercise due diligence in ensuring the accuracy of the materials reproduced;
- indicate the complete title of the materials reproduced, and the name of the author organization; and
- indicate that the reproduction is a copy of an official work that is published by Natural Resources Canada (NRCan) and that the reproduction has not been produced in affiliation with, or with the endorsement of, NRCan.

Commercial reproduction and distribution is prohibited except with written permission from NRCan. For more information, contact NRCan at copyright-droitdauteur@nrcan-rncan.gc.ca.

Permanent link: <https://doi.org/10.4095/329641>

This publication is available for free download through GEOSCAN (<https://geoscan.nrcan.gc.ca/>).

Recommended citation

Rayner, N.M., 2022. U-Pb geochronology data from the 2008-2011 Manitoba Far North Geomapping Initiative; Geological Survey of Canada, Open File 8868, 1 .zip file. <https://doi.org/10.4095/329641>

Publications in this series have not been edited; they are released as submitted by the author.

Description of Content

This report contains the U-Pb geochronological results for 14 rock samples from the far northeast (Seal River and Nejanilini Domains) and the far northwest (Wollaston and Mudjatik Domains) of Manitoba. 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 and mineral exploration clients.

This report contains 15 Excel spreadsheets, one corresponding to each sample, containing the results for sensitive high-resolution ion microprobe (SHRIMP) analysis (12 samples) and isotope dilution - thermal ionization mass spectrometry (ID-TIMS) analysis (2 samples) conducted at the Geological Survey of Canada (GSC). Each spreadsheet contains a worksheet containing the data and series of sheets containing the Concordia and other pertinent plots for each sample. The scanning electron microscope zircon images annotated with the SHRIMP spot location are included as separate Adobe pdf files. Details for each sample are given below and a summary of the interpreted age is provided on an accompanying kml file to be viewed in GoogleEarth.

Procedure

All samples were disaggregated using standard crushing/pulverizing techniques followed by density separation using the Wilfley table and heavy liquids. For SHRIMP analysis, zircon grains were selected after examination under a binocular microscope. The selected grains were cast in epoxy mounts IP564, IP580, IP583, IP601, IP614, IP616, IP635 and IP650. The mid-sections of the zircons were exposed through polishing with diamond compound, and internal features characterized in back-scattered electron mode (BSE) mode utilizing a Zeiss Evo 50 scanning electron microscope. Mount surfaces were evaporatively coated with 10 nm of high purity Au. For ID-TIMS analysis, individual zircon or monazite grains were selected by hand-picking. Zircon grains were treated with the chemical abrasion method (Mattinson, 2005) before being submitted for U-Pb chemistry. No pre-treatment (e.g. abrasion) was conducted before dissolution of monazite.

SHRIMP analytical procedures followed those described by Stern (1997). Fragments of the GSC zircon primary reference material (RM) 6266 ($^{206}\text{Pb}/^{238}\text{U}$ age = 559 ± 02 Ma; Stern and Amelin, 2003) and secondary zircon RM 1242 ($^{207}\text{Pb}/^{206}\text{Pb}$ age = 2679.7 ± 0.2 Ma, Davis et al., 2019) were analysed on same mount and under the same conditions as the unknowns. Analyses were conducted using an O- primary beam, with a spot size of either 23 μm , 16 μm or 12 μm at a beam current between 1-9 nA. The count rates of the isotopes of Hf, U, Th, Pb and \pm Yb were sequentially measured over five or six scans with a single electron multiplier. Off-line data processing was accomplished using Squid2.22 (Ludwig, 2009) software. Decay constants used follow the recommendations of Steiger and Jäger (1977). The 1σ external errors of $^{206}\text{Pb}/^{238}\text{U}$ ratios reported in the data table incorporate a ± 1.0 - 1.3% error in calibrating the primary RM (see Stern and Amelin, 2003). Analyses of a secondary zircon RM 1242 were interspersed between the sample analyses to assess the requirement of an isotopic mass fractionation correction for the $^{207}\text{Pb}/^{206}\text{Pb}$ age. Intra-element mass fractionation corrections ranging between 1.003-1.007 were applied to some samples, while others did not require a correction. The measured weighted mean

$^{207}\text{Pb}/^{206}\text{Pb}$ age of SHRIMP analyses of 1242 zircon for each sample is recorded in the footnote of the data table as well as details of the analytical session (mount/session number, spot size, primary beam intensity). Common Pb correction utilized the Pb composition of the surface blank (Stern, 1997). 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 in the text are reported at 95% confidence, unless otherwise noted. Errors reported in the data tables are given at the 1s confidence interval.

Dissolution of minerals (zircon and monazite) 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).

Results

NEJANILINI DOMAIN

10304 (97-10-325): Migmatitic greywacke diatexite, Nejanilini Domain

The zircons derived from this sample consist primarily of subrounded grains. In BSE images some exhibit oscillatory zoned cores with unzoned, BSE-bright rims. A limited proportion of grains exhibit extensive fracturing with accompanying alteration. Fifty-seven analyses were carried out on 50 zircons yielding $^{207}\text{Pb}/^{206}\text{Pb}$ ages ranging between 1793-2564 Ma. All analyses with the exception of one data point plot within 11% discordance of concordia. The majority of the detrital zircon ages fall between 2300 Ma and 2500 Ma, with some sporadic younger peaks. The youngest non-rim zircon yields two reproducible ages with a weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ age of 1985.7 ± 9.8 Ma ($n = 2$, MSWD = 0.21) which is interpreted as the maximum age of deposition. The youngest ages (< 1900 Ma) correspond to analyses from zircon rims, yielding a weighted mean age of 1821 ± 17 Ma ($n = 6$, MSWD = 1.7). As these rims are also characterized by low Th/U (0.03-0.14) these are interpreted to represent the age of a metamorphic overprint on the greywacke, likely related to the migmatization event.

10305 (97-10-454): Charnockitic gneiss, Nejanilini Domain

The zircons yielded from this sample are primarily subhedral, with the majority showing faint, narrow oscillatory zoning. Several zircons have abundant fractures and inclusions as well as alteration features in highly fractured grains. Some zircons also show patchy zonation in electron backscatter images. Thirty-two analyses carried out on 26 grains returned $^{207}\text{Pb}/^{206}\text{Pb}$ ages between 2483-3170 Ma that fall along a discordia chord. A single zircon returned a substantially older age of 3170 ± 5 Ma which is interpreted as inherited. From the discordant array, a cluster of the oldest, most concordant analyses yielded a weighted mean age $^{207}\text{Pb}/^{206}\text{Pb}$ of 2692.4 ± 8.7 Ma ($n = 11$, MSWD = 3.0). This age is interpreted as the igneous crystallization age. A regression through this array yields a lower intercept at 1.52 Ga (upper intercept anchored at interpreted crystallization age). The significance of this age is uncertain, as it is not a known time of metamorphism in the region. It may be the result of a combination of ancient (ca. 1.8 Ga from the Trans-Hudson Orogeny) resetting combined with modern Pb-loss, and thus not an age of geological significance.

10306 (96-10-1468): Potassium feldspar porphyritic biotite granite, Dickins River Pluton, Nejanilini Domain

This sample contains a variety of euhedral grains with faint oscillatory zoning, and a small portion of sub-rounded grains with rounded xenocrystic cores surrounded by oscillatory zoned rims. Thirty-three analyses were carried out on 33 grains and returned $^{207}\text{Pb}/^{206}\text{Pb}$ ages between 1769-3272 Ma. The xenocrystic cores analysed in 8 zircons yielded ages from 2544-3272 Ma and are interpreted as inherited. The euhedral grains were interpreted as yielding a crystallization age of 1828.7 ± 4.3 Ma (weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ age, $n = 25$, MSWD = 1.9).

10449 (52-10-2277-A01): Granodiorite, Caribou River Pluton, Nejanilini Domain

The zircons are subhedral with limited faint oscillatory zoning. Twenty-one analyses carried out on 19 grains returned $^{207}\text{Pb}/^{206}\text{Pb}$ ages between 1758-1849 Ma. The zircons from this sample yielded a weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ age of 1823.2 ± 4.5 Ma ($n = 20$, MSWD = 0.71) which is interpreted as an igneous crystallization age. One reversely discordant analysis was excluded from the calculation.

SEAL RIVER DOMAIN

10225 (97-09-215): Biotite granite-granodiorite gneiss, near Eppler Lake, Seal River Domain

The zircons obtained from this sample are primarily euhedral to subhedral. These grains are predominantly un-zoned or show faint zoning with some inclusions and fractures. Thirty-three analyses were carried out on 28 zircons yielding a range of $^{207}\text{Pb}/^{206}\text{Pb}$ ages from 3262-3515 Ma falling along a discordia chord. The weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ age of a cluster of the oldest 14, concordant analyses is 3493.3 ± 4.3 Ma ($n = 14$, MSWD = 1.5) which is interpreted as the crystallization age of the granite-granodiorite and making it the oldest known rock in Manitoba. A metamorphic (or polymetamorphic) history is indicated by the drift to younger ages due to Pb-loss. While the timing of this overprint cannot be confidently constrained, the lower intercept of the chord through the data indicates a ca. 2.7 Ga lower intercept which is a known time of magmatism in this area.

9848 (96-08-10): Quartzite, Nowell Lake Basin, Seal River Domain

The zircons derived from this sample are both rounded and irregular in shape, with some grains exhibiting alteration textures and inclusions. Sixty-six analyses were carried out on 61 zircons, yielding $^{207}\text{Pb}/^{206}\text{Pb}$ ages ranging from 2078-3097 Ma. The most prominent detrital mode on the age frequency/probability density diagram is at approximately 2520 Ma, with subordinate peaks at 2.3-2.4 Ga. Older grains are rare and do not define particular modes. The three youngest analyses from this sample are replicate ages of zircon grain 103, which returned a weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ age of 2109 ± 27 Ma ($n = 3$, MSWD = 1.4, 2s). This age is interpreted as the maximum age of deposition.

10450 (96-10-1520): Quartz arenite, Sequence 3, Seal River Domain

The zircons in this sample are primarily euhedral prisms or fragments with some more rare rounded or highly altered grains present. Sixty-three analyses were conducted on 60 grains, and yielded $^{207}\text{Pb}/^{206}\text{Pb}$ ages between of 2109-2723 Ma. There are two prominent age modes at 2550-2600 Ma and 2600-2730 Ma. A $^{207}\text{Pb}/^{206}\text{Pb}$ weighted mean age of the youngest group of ages with an overlapping 1σ error was used to calculate a maximum age of deposition (Dickinson & Gehrels, 2009) from the youngest population of grains. This method yielded an age of 2565.7 ± 4.6 Ma ($n = 12$, MSWD = 0.35). The four youngest analyses (from 2 grains) are from high U, altered grains and yielded non-reproducible results for which no geological interpretation can be made.

10307 (96-10-1406): Two-mica granite, intruding Sequence 2, Seal River Domain

The zircons recovered from this sample are turbid to opaque, inclusion rich and not suitable for SHRIMP analysis. Monazite was also recovered and analysed by TIMS. The weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ age of three concordant fractions is 1764.9 ± 0.9 Ma (MSWD = 0.61) which is interpreted as the crystallization age of the monazite.

10308 (52-10-2187): Quartz-feldspar porphyry, Sosnowski Lake assemblage, Seal River Domain

The zircons recovered from this sample are pale brown, prismatic and slightly turbid with oscillatory zoning visible in plane light. Facets appear to be slightly rounded. Three concordant TIMS fractions yield a weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ age of 2691.8 ± 3.6 Ma (MSWD = 2.8). This is tentatively interpreted as the crystallization age of the porphyry, however given the resorbed appearance of the zircons could represent an inherited component.

NORTHWEST MANITOBA

10543 (107-11-063): Feldspathic arenite, Snyder Lake, Wollaston Domain

The morphology of zircons in this sample is a mix of euhedral, angular and rounded grains, with only a few exhibiting oscillatory zonation. Seventy-two analyses were carried out on 63 grains, yielding a range of $^{207}\text{Pb}/^{206}\text{Pb}$ ages of 1765-2732 Ma. While there are clusters of analyses at ca. 1.99 Ga and between 2.5-2.6 Ga, the provenance profile is not characterized by well-defined modes. The youngest zircon to yield a reproducible age result is grain 33, which yielded a $^{207}\text{Pb}/^{206}\text{Pb}$ weighted mean age of 1914 ± 12 Ma ($n = 3$, MSWD = 0.26). This age is interpreted as the maximum age of deposition. While some younger ages were observed in this sample these were derived from rims, or come from grains where the young age is not reproducible and is thus interpreted to represent Pb-loss.

10544 (107-11-067): Orthogneiss, Snyder Lake, Mudjatik Domain

The zircons collected from this sample are varied and complex. Several grains feature cores, fine oscillatory zonation with abundant inclusions and alteration, surrounded by a highly fractured rim. A smaller subset of grains feature broad or patchy zonation showing variation in U-content in BSE response. Several of the zircons derived from this sample show substantial

alteration, and have inclusions. Thirty-three analyses conducted on 27 grains, yield a $^{207}\text{Pb}/^{206}\text{Pb}$ age range of 2452-3174 Ma. The 3 oldest $^{207}\text{Pb}/^{206}\text{Pb}$ ages returned are derived from grains with unzoned/faintly zoned cores, which differ from the predominant zircon characteristics of the sample, therefore these grains are interpreted as inherited. The remaining analyses of finely zoned, high U, altered zircons fall along a discordant array. A small cluster of eight analyses at the upper intercept of this array yield a weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ age of 2711.7 ± 6.5 Ma ($n = 8$, MSWD = 2.2). This was interpreted as the best representation of an igneous crystallization age. Two other slightly older (2744 Ma, 2762 Ma) analyses are tentatively interpreted as inherited as well.

10545 (97-11-002): Psammitic gneiss, Snyder Lake, Wollaston Domain

The zircons in this sample are predominantly rounded, with rare occurrences of alteration. Sixty-six analyses were conducted on 59 grains, yielding a $^{207}\text{Pb}/^{206}\text{Pb}$ age range of 1862-2586 Ma. There are two distinct age modes, the older mode comprises approximately 2/3rd of the population and is centred at 2550 Ma. The younger, subordinate mode spans 1862-1936 Ma, and is defined by 3 zircon grains with replicate analyses. Zircon 27 was analyzed 5 times yielding a weighted mean age of 1881 ± 16 Ma ($n = 5$, MSWD = 1.8), which is interpreted as the maximum age of deposition.

10546 (97-11-064-A): Calcsilicate conglomerate, Snyder Lake, Wollaston Domain

The zircon yield of this sample was limited, with the few grains recovered showing varied textures and morphologies. Fourteen analyses carried out on 14 zircons yield a $^{207}\text{Pb}/^{206}\text{Pb}$ age range of 1881-2669 Ma. The majority of ages returned are discordant and no replicate analyses were carried out. The spread in the resulting ages indicates a variable provenance in detrital zircon. Due to the presence of grains in the range of 1.9 Ga, this rock is interpreted as Paleoproterozoic or younger.

10547 (97-11-072): Orthogneiss, Snyder Lake, Wollaston Domain

Zircons in this sample are predominantly euhedral to subhedral. In BSE images, faint concentric zoning is common; however, several zircons exhibit irregular, patchy zonation. Twenty-seven analyses were conducted on 19 zircons and returned $^{207}\text{Pb}/^{206}\text{Pb}$ ages ranging 2487-2658 Ma as well as a single substantially older 2860 Ma analysis. This ca. 2.86 Ga zircon is interpreted as inherited. The next 9 oldest analyses yield a weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ age of 2637 ± 13 Ma ($n = 9$, MSWD = 1.4), which is interpreted as the igneous crystallization age. Younger analyses tend to be more discordant, suggesting Pb-loss. Several grains show narrow, high-U rims with abundant fracturing, but none of these rims are sufficiently wide to analyze.

10548 (97-11-080): Orthogneiss, Snyder Lake, Wollaston Domain

Zircons from this sample comprise large, blocky grains with or without oscillatory zoning and containing an abundance of inclusions. Several of the grains have thin, irregular U-rich rims. Twenty-four analyses were conducted on 22 zircon grains and yielded $^{207}\text{Pb}/^{206}\text{Pb}$ ages in the range of 2508-2626 Ma, as well as one substantially younger 1815 Ma age. The 12 oldest zircons from this range yield a weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ age of 2607.1 ± 4.3 Ma ($n = 12$, MSWD = 1.7), which

is interpreted as the age of igneous crystallization. Younger Archean results fall along a discordia chord from this older cluster and are interpreted to reflect Pb-loss. A low Th/U (0.03) rim on grain 114 yielded the single Proterozoic result of 1815 ± 20 Ma (2s) which is interpreted as a metamorphic age.

Acknowledgements

The author is grateful for the support and assistance of the staff of the Geochronology Laboratories of the Geological Survey of Canada. In particular, R. Chung, R. Christie, J. Peressini and T. Pestaj are thanked for their careful efforts and excellent work. P. Hunt provided the necessary high-quality scanning electron microscope images. Quinn Emon ably assisted with the preparation of the digital files herein. The manuscript benefitted from a thorough review by Christian Böhm of the Manitoba Geological Survey.

References

- Davis, W.J., Pestaj, T., Rayner, N., McNicoll, V.M., 2019. Long-term reproducibility of $^{207}\text{Pb}/^{206}\text{Pb}$ age at the GSC SHRIMP lab based on the GSC Archean reference zircon z1242. Geological Survey of Canada, Scientific Presentation 111, 1 poster, <https://doi.org/10.4095/321203>
- Dickinson, W. R., & Gehrels, G. E., 2009. Use of U-Pb ages of detrital zircons to infer maximum depositional ages of strata: A test against a Colorado Plateau Mesozoic database. *Earth and Planetary Science Letters*, 288(1-2), 115-125. <https://doi.org/10.1016/j.epsl.2009.09.013>
- Ludwig, K. 2009. SQUID 2: A User's Manual, rev. 12 Apr, 2009. Special Publication 5, Berkeley Geochronology Center, Berkeley 110p.
- 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.
- 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.
- Roddick, J.C. 1987: Generalized numerical error analysis with application to geochronology and thermodynamics; *Geochimica et Cosmochimica Acta*, **51**, 359-362.
- Steiger, R.H., and Jäger, E., 1977, Subcommittee 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, 1-31.