GS2025-5

Geochronology and isotope geochemistry results from Russell Lake, northwestern Manitoba (parts of NTS 64C5, 6)

by T. Martins and C.G. Couëslan

Summary

Results from geochronological and radiogenic isotope analyses are presented here for the mapping project at Russell Lake, northwestern Manitoba. Geological bedrock mapping at a scale of 1:20 000 was conducted during the 2019 and 2020 field seasons. Outcrops at Russell Lake are dominated by the coeval sedimentary rocks of the Burntwood and Sickle groups, as well as by volcanic rocks and granodioritic intrusions. The Sm-Nd results for both the Burntwood and Sickle groups fit the range presented by previous authors. The four samples studied yield similar U-Pb dates, which suggests that the sediments from the Burntwood and Sickle groups were eroded from the same terrane. The Burntwood group samples seem to have less Archean zircon than the Sickle group, but this could be explained by the small number of samples targeting zircon cores.

In Brief:

- Geochronology and radiogenic isotopes are presented for the mapping project at Russell Lake
- Outcrops at Russell Lake are dominated by the coeval sedimentary rocks of the Burntwood and Sickle groups, as well as volcanic rocks and granodiorite intrusions
- The Sm-Nd results and the U-Pb dates for both the Burntwood and Sickle groups fit the range presented by previous workers

Citation:

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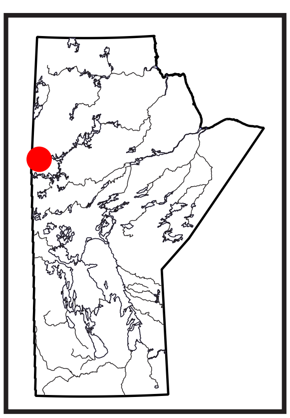
Introduction

A multidisciplinary mapping project was undertaken by the Manitoba Geological Survey (MGS) at Russell Lake during 2019 and 2020, which generated contributions in the annual report series and preliminary bedrock maps (Martins and Couëslan, 2019a, b, 2020a, b). The Quaternary geology of the area was also studied as part of this project and results include new sampling for till geochemistry and kimberlite indicator minerals as well as for ice-flow mapping (Hodder, 2019a, b, 2020, 2021). In this report, the results from geochronological and isotopic studies of representative rock units from the study area are presented.

Although the stratigraphy of the region is known (e.g., Zwanzig and Bailes, 2010), U-Pb zircon and whole-rock Sm-Nd results are scarce, especially along the north flank of the Kisseynew paleobasin. Representative samples from the metamorphosed mafic and sedimentary rock units were targeted for whole-rock Sm-Nd isotope geochemistry. Samples selected for detrital-zircon U-Pb geochronology are representative of the two major metasedimentary rock packages mapped at Russell Lake (Burntwood and Sickle groups). Gathering this type of information is important because it provides insight into the timing of deposition of the rocks in the study area, their provenance and the manner in which they compare with correlative units in other parts of the basin. The main objective for the detrital-zircon geochronology study is to better characterize the detrital sources of the Burntwood and Sickle groups along the northern margin of the Kisseynew domain (Figure GS2025-5-1).

All rocks in the study area were metamorphosed to at least upper-amphibolite–facies conditions (Lenton, 1981; Martins and Couëslan, 2019b); however, for the sake of brevity, the 'meta' prefix has been omitted from rock names. Where possible, protolith interpretation was used in the naming of rock units.



Previous work

The Russell–McCallum lakes area was previously mapped by Downie (1936) of the Geological Survey of Canada (GSC) at a scale of 1:253 440. Later, geological mapping by Hunter (1953) extended the regional coverage into McKnight Lake at a scale of 1:126 720. The MGS mapped the area in the 1970s. McRitchie (1975a, b) mapped Russell Lake on a scale of 1:31 680. The adjoining areas were mapped by Baldwin (1974) and Zwanzig and Wielezynski (1975a, b) at a scale of 1:31 680, and Pollock (1966) at a scale of 1:63 360. The area to the west of Russell–McCallum lakes was mapped by Gilboy (1976) at a scale of 1:100 000. Lenton (1981) mapped the area extending from the Russell–McCallum lakes area to McKnight Lake at a scale of 1:50 000. In 2019, the MGS initiated a multidisciplinary geological mapping project in the Russell–McMallum lakes area. Preliminary results of bedrock mapping at the 1:20 000 scale can be found in Martins and Couëslan (2019a, b, 2020a, b, c) and those from Quaternary studies in Hodder (2019a, b, 2020, 2021).

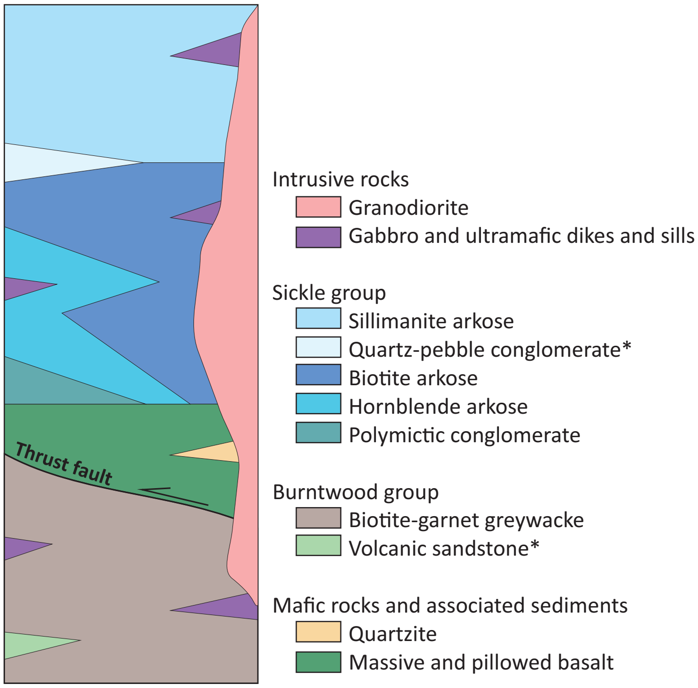


Figure GS2020-5-1: *Idealized, schematic stratigraphic column of the rock units of the Burntwood and Sickle groups at Russell Lake; asterisks indicate rock units not observed in the northern arm of the lake (after Martins and Couëslan, 2020b).*

The Russell Lake area was the target of economic studies focused on base-metal mineralization along the contact zone between rocks of the Burntwood and Sickle groups, the two major stratigraphic units of the area (Baldwin, 1976, 1980). There are records of base-metal exploration work in the area from 1954 until 1983 (e.g., Assessment Files 91616, 93803; Manitoba Business, Mining, Trade and Job Creation, Winnipeg). Airborne electromagnetic surveys located a number of conductors. The airborne anomalies were commonly followed up by diamond-drilling. Base- and precious-metal assay results (e.g., Ni, Au, Ag, Cu) were not promising and led to abandonment of the claims. However, significant graphite mineralization was reported in the majority of drillholes (e.g., Assessment Files 92387, 93001, 93804). For example, graphite was described in Assessment File 90985 submitted by Hudson Bay Exploration and Development Company Limited. The company drilled six drillholes in 1962 and reported up to 2.2 m (7.3 feet) of near-solid to solid graphite, pyrite and pyrrhotite, 1.9 m (6.2 feet) well-mineralized with graphite and 1.2 m (4.1 feet) mineralized with graphite.

Regional geology

The Kisseynew domain (KD) forms the large central part of the predominantly juvenile Paleoproterozoic internides, which make up the Reindeer Zone of the Trans-Hudson orogen (THO) in Manitoba (Figure GS2025-5-2; Stauffer, 1984; Lewry and Collerson, 1990). The KD is dominated by metamorphosed greywacke and mudstone of the Burntwood group, and arkosic rocks of the Sickle group. The provenance of the Burntwood group is interpreted to be the adjacent magmatic-arc terranes. Detritus from the arcs was deposited in coalescing turbidite fans (Bailes, 1980; Zwanzig, 1999). The turbidites were deformed and metamorphosed to amphibolite- and transitional granulite-facies, resulting in migmatization. Rocks from the Sickle group are typically metamorphosed arkosic units interpreted to have been deposited unconformably on the Lynn Lake arc massif (Zwanzig, 2008) and prograded over the Burntwood group prior to, and during, the onset of terminal continental collision. Both Burntwood and Sickle groups are intruded by granitoid rocks, including foliated granitoid bodies ranging from granite to tonalite and later pegmatite (e.g., Lenton, 1981; Zwanzig and Bailes, 2010; Zwanzig, 2019).

The geological setting of the KD is a matter of debate. Some authors (Ansdell, 2005; Corrigan et al., 2005, 2009) favour the interpretation of the KD as a back-arc basin to the Flin Flon volcanic arc that was filled during its opening. However, other authors (e.g., Zwanzig, 1999; Zwanzig and Bailes, 2010) favour an interpretation of a longer lived and dynamic evolution, in which the present geographic distribution of rocks resulted from crustal-scale overturning and oroclinal bending during continental collision.

The Russell Lake area is located within the Kisseynew north flank, a subdivision of the KD introduced by Zwanzig (2008; Figure GS2025-5-2). The Kisseynew north flank is dominated by Paleoproterozoic metasedimentary rocks of the Burntwood and Sickle groups, typically separated by the volcanosedimentary Granville complex, a composite assemblage of predominantly mafic rocks that includes remnants of ocean floor (Murphy and Zwanzig, 2021). The Kisseynew north flank is bounded to the north by the Lynn Lake domain, to the east by the northeastern Kisseynew subdomain and to the south by the central Kisseynew subdomain.

The majority of outcrops in the Russell lake area are dominated by sedimentary rocks of the Burntwood and Sickle groups, volcanic rocks and granodiorite bodies (Figure GS2025-5-3). The Burntwood and Sickle groups are interpreted to be coeval (e.g., Zwanzig and Bailes, 2010); therefore, the succession of units is not to be viewed as a true chronostratigraphic sequence (see Figure GS2025-5-1). For a detailed description of the rock units at Russell Lake, readers are referred to Martins and Couëslan (2019a, b, 2020a, b).

Results of whole-rock Sm-Nd isotope geochemistry

The results for the whole-rock Sm-Nd isotopic analyses of samples from the mapping area were published by Manitoba Agriculture and Resource Development (2020, 2021) but are also presented in Table GS2025-5-1 (sample locations are plotted in Figure GS2025-5-3). The results from this study yield initial εNd (calculated at 1840 Ma) of –1.2 and +0.7; crustal residence Nd-model depleted-mantle model ages (T_{DM}) of 2.39 and 2.29 Ga for

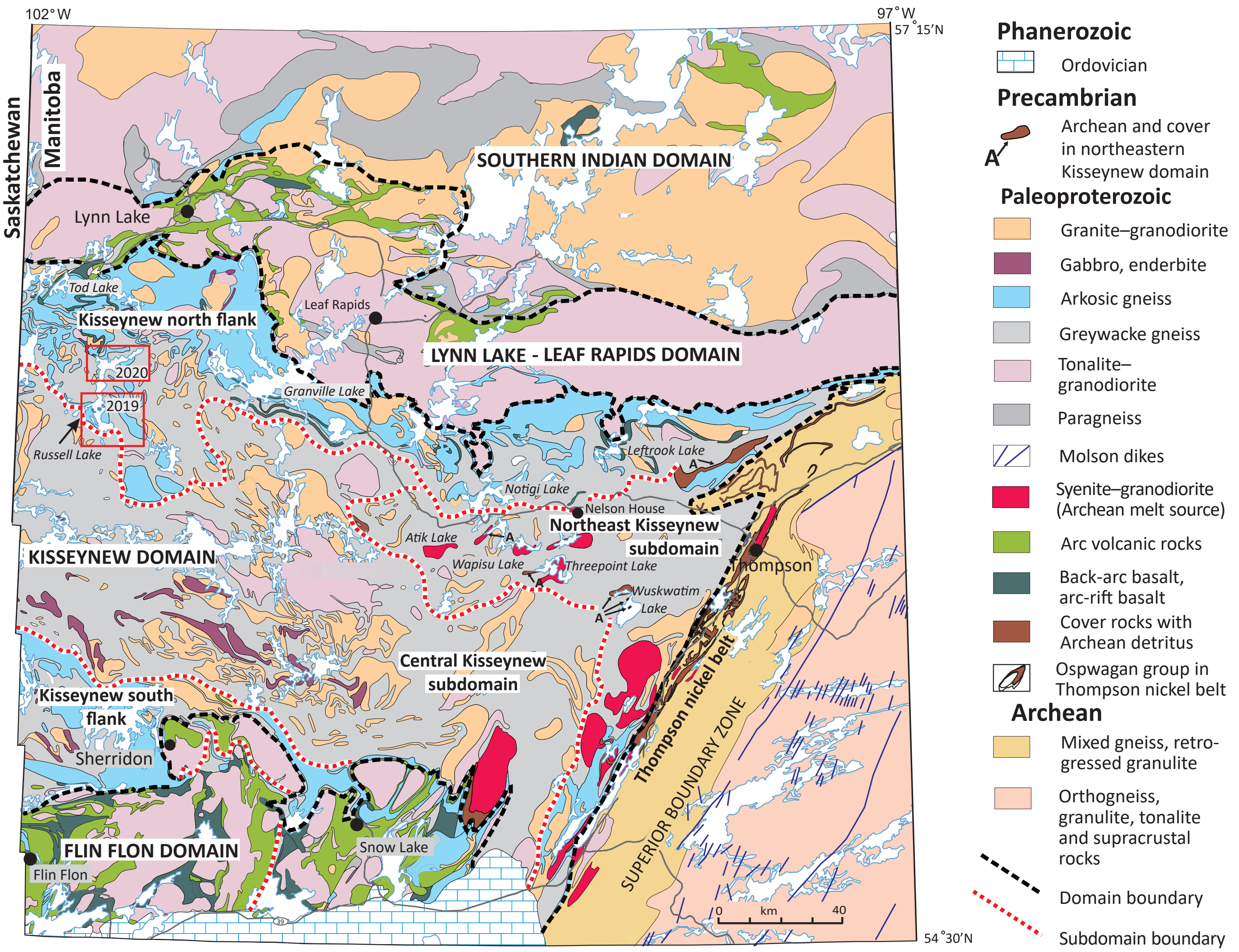


Figure GS2025-5-2: *Regional geology of the Trans-Hudson orogen in Manitoba, indicating the subdivision of the Kisseynew domain proposed by Zwanzig and Bailes (2010). Red rectangles outline the 2020 and 2019 study areas.*

the Burntwood group rocks; and εNd of –1.0 and +1.0, and T_{DM} of 2.36 and 2.33 Ga for the Sickle group rocks.

Results for initial εNd of the pillow basalt (unit 1a of Martins Couëslan, 2019b) mapped in the Russell Lake area were calculated at 1900 Ma and give an εNd(T) of +3.2. The initial εNd for the mafic sills and gabbro were calculated at 1840 Ma because these units intruded rocks of the Sickle and Burntwood groups. The mafic sills (unit 8 of Martins and Couëslan, 2020b) have a εNd(T) varying from +2.7 to +3.2 and the value for gabbro (unit 3 of Martins and Couëslan, 2019b) is +1.3.

Results of detrital-zircon U-Pb geochronology

Four samples were submitted for detrital-zircon U-Pb analyses by laser-ablation inductively coupled plasma–mass spectrometry (LA-ICP-MS) to the Micro-Analysis of Natural Trace-element and Isotope Systematics laboratory at the University of New Brunswick. A detailed method description can be found in Reid (2020).

Both cores and rims of separate zircon grains were targeted for analyses. Results were plotted on kernel density-estimate diagrams at 95%–105% concordance using IsoplotR, a free, open-source R package for geochronology (Vermeesch, 2018), and are reported with errors calculated at the 2σ level of uncertainty. Zircon morphologies from mineral separates recovered from each sample were diverse and ranged from rounded, equant grains, suggesting sedimentary transport, to long, euhedral and undamaged zircon crystals that were likely sourced from nearby rocks of igneous origin. The latter morphology seems to be dominant. Zircon grain sizes ranged from 40 to 150 µm.

A total of 73 analyses were performed on zircon-grains from mineral separates from Burntwood group greywacke sample 113-19-694B. Concentrations of U and Th were 1.65–79.3 ppm and 0.28–61.4 ppm, respectively; Th/U ratios ranged from

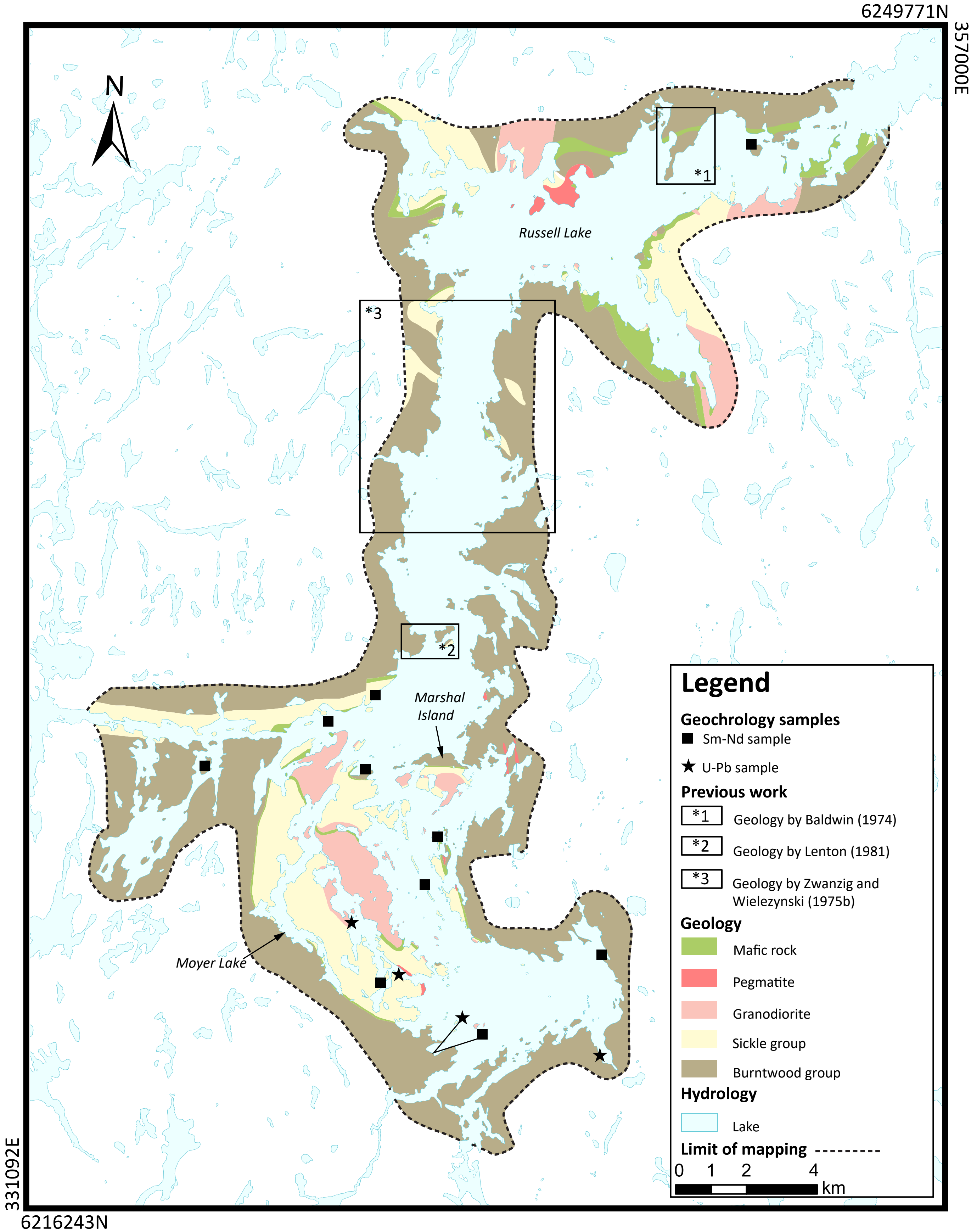


Figure GS2025-5-3: *Simplified geology of the Russell Lake area (after Martins and Couëslan, 2019a, 2020a), with location of samples collected for radiogenic isotope and geochronological studies. Co-ordinates are in UTM Zone 14, NAD83.*

Table GS20255-1: Compilation of Sm-Nd isotopic results from the Russell Lake project.

Sample number	Location	Sample locations (UTM) Easting	Northing	Lithology	Sm ppm	Nd ppm	$^{147}Sm/^{144}Nd$	$^{143}Nd/^{144}Nd_0$	Uncertainty*	eNd_0	$^{143}Nd/^{144}Nd_T$	T_{DM} Ga	~T(Ma)	CHUR @ T(Ma)	eNd_T
113-19-517A	Russell Lake	339502	6230080	pillow basalt	1.594	4.89	0.1969	0.512804	0.000009	3.2	0.510342	n/a	1900	0.510179	3.2
108-19-R029	Russell Lake	340558	6228727	mafic sill intruding Burn-twood group	7.544	36.608	0.1246	0.511930	0.000008	-13.8	0.510422	2.10	1840	0.510257	3.2
108-19-R123	Russell Lake	336023	6228817	mafic sill intruding Burn-twood group	4.528	19.19	0.1426	0.512127	0.000008	-10.0	0.510400	n/a	1840	0.510257	2.8
108-19-R127	Russell Lake	340985	6222691	mafic sill intruding Sickle group	3.682	14.77	0.1507	0.512221	0.000009	-8.1	0.510396	n/a	1840	0.510257	2.7
108-19-R006	Russell Lake	340829	6230815	mafic sill intruding Sickle group	2.610	10.13	0.1558	0.512284	0.000010	-6.9	0.510397	n/a	1840	0.510257	2.7
113-19-683C	Russell Lake	347226	6223486	gabbro intruding Burn-twood group	2.494	12.39	0.1217	0.511798	0.000008	-16.4	0.510324	2.25	1840	0.510257	1.3
108-19-R223	Russell Lake	351451	6246365	greywacke (Burntwood group; aluminous)	5.03	25.9	0.1176	0.511716	0.000007	-18.0	0.510292	2.29	1840	0.510257	0.7
113-19-651A	Russell Lake	342493	6220718	greywacke (Burntwood group; aluminous)	6.38	34.9	0.1106	0.511537	0.000010	-21.5	0.510197	2.39	1840	0.510257	-1.2
108-19-R067	Russell Lake	342592	6226816	hornblende arkose (Sickle group)	4.88	22.4	0.1317	0.511902	0.000008	-14.4	0.510307	2.33	1840	0.510257	1.0
108-19-R017	Russell Lake	342239	6225470	biotite arkose (Sickle group)	6.49	37.3	0.1050	0.511475	0.000006	-22.7	0.510204	2.36	1840	0.510257	-1.0

Depleted-mantle Nd-model (T_{DM}) not calculated for samples with $^{147}Sm/^{144}Nd > 0.14$

All samples relative to LaJolla isotope standard (0.511850) used to measure $^{143}Nd/^{144}Nd$ ratio

* Uncertainty is 2σ on $^{143}Nd/^{144}Nd$.

Depleted-mantle Nd-model ages (T_{DM}) uses the linear model of Goldstein et al. (1984)

Co-ordinates are in UTM Zone 14, NAD83

Abbreviation: CHUR, chondritic uniform reservoir

0.008 to 1.171. Zircon dates from this sample define one prominent peak at 1.85 Ga, with subordinate peaks found at 2.45–2.50 and 2.65–2.75 Ga (Table GS20255-2; Figure GS2025-5-4a). The oldest grain yielded a U-Pb age of ca. 3.33 Ga. A total of 105 analyses were performed on the zircon-grain separates from Burntwood group volcaniclastic sample 113-19-651B3. Concentrations of U and Th were 24.42–3190 ppm and 0.51–1680 ppm, respectively; calculated Th/U ratios ranged from 0.004 to 0.820. Calculated zircon ages from this sample define one prominent peak at 1.86 Ga (Table GS20255-2; Figure GS2025-5-4b).

A total of 105 analyses were carried out on the zircon separates from a sample of Sickle group polymictic conglomerate (108-19-136B). Concentrations of U and Th were 41.94–2264 ppm and 8.56–387.40 ppm, respectively; Th/U ratios ranged from 0.01 to 0.80. The calculated U-Pb ages define one prominent peak at 1.82 Ga and subordinate peaks at 2.25 and 2.35 Ga (Table GS20255-2; Figure GS2025-5-4c). A total of 113 analyses were performed on the zircon separates from the quartz-pebble conglomerate sample (108-19-090B) from the Sickle group. Concentrations of U and Th were 29.09–2290 ppm and 7.25–424 ppm, respectively; Th/U ratios ranged from 0.009 to 1.32. Zircon dates define one prominent peak at 1.86 Ga and subordinate peaks can be found at 2.35–2.68 Ga (Table GS20255-2; Figure GS2025-5-4d).

Discussion of Sm-Nd and U-Pb geochronology results

The results from Sm-Nd isotope analyses for both the Burntwood and Sickle groups fit the range compiled and presented by Murphy et al. (2021). Results from these authors for initial εNd calculated at 1840 Ma for the Burntwood samples from the Wuskwatim corridor vary between –1.34 and +2.66, with a mean Nd-model age of 2.32 Ga (varies between 2.54 to 2.13 Ga; average of 9 samples). For the Sickle group samples, εNd values vary between –1.65 and +3.62, and yield a mean Nd-model age of 2.32 Ga (varies between 2.43 to 2.03 Ga; average of 9 samples). The εNd(T) results for the pillowed basalt and the mafic sills (+2.7 to +3.2) suggest a juvenile magma source with little involvement of evolved crust in the magma petrogenesis. These types of signatures were also observed in rocks of the Lynn Lake greenstone belt (Beaumont-Smith and Böhm, 2002) and in the Granville complex volcanogenic rocks (Murphy and Zwanzig, 2021). The εNd(T) result for the gabbro (+1.3) is slightly more evolved, possibly due to interaction or recycling of some older material.

Regional geochronology studies indicate that 1814 ±1 Ma are dates of suspected metamorphic zircons in the Lynn Lake greenstone belt (Figure GS2025-5-2; Beaumont-Smith and Böhm, 2003). In the KD, east of the study area, ages ranging from 1805 ±3 to 1809 ±4 Ma (Rayner and Percival, 2007) are interpreted to be metamorphic, indicating high-grade metamorphism lasting about 10 million years. Furthermore, in the southern part of the KD, enderbite intruding the Burntwood Group was dated at ca. 1830 Ma (Gordon et al., 1990), providing a local minimum age of sedimentation. Recent work by Lawley et al. (2020) provided the first reproducible maximum depositional age for the Sickle group at 1836 ±15 Ma. For sample 108-19-136B, the polymictic conglomerate of the Sickle group, the prominent peak is at ca. 1.82 Ga (Figure GS2025-5-4c). Available imagery for zircon from this sample indicates that rims were preferentially targeted for analyses. Taking this into account and the known metamorphic ages for the region, the 1.82 Ga date is interpreted as a metamorphic age and not a minimum age of sedimentation.

The unimodal zircon age peak at ca. 1.86 Ga for the volcaniclastic unit (sample 113-19-651B3) effectively dates that section of the Burntwood group. The volcaniclastic material could be derived from younger units of the Wasekwan group of the Lynn Lake greenstone belt. The Wasekwan group comprises a mafic to felsic metavolcanic rock package and associated metasedimentary rocks dated at 1.91–1.85 Ga (e.g., Beaumont-Smith et al., 2006). The dominant peaks at 1.86–1.85 Ga for the remaining two samples could have been sourced from similar volcanic detritus, or either from the 1.86–1.85 Ga Chipewyan batholith (e.g., Meyer et al., 1992; Martins et al., 2019) or the ca. 1.86–1.85 Ga granitoid rocks (e.g., Burge Lake igneous suite; Beaumont-Smith

Table GS20255-2: Summary of geochronological results for the rock samples from the Russell Lake study area.

Sample ID	Rock type	Sample Locations (UTM)		Age range (Ga)	Dominant age peak (Ga)	Subordinate age peaks (Ga)
		Easting	Northing			
113-19-694B	Greywacke; Burntwood group	347177	6220658	3.33–1.72	1.85	2.45–2.50; 2.65–2.75; 3.33
113-19-651B3	Volcanoclastic; Burntwood group	342493	6220718	2.11–1.81	1.86	N/A
108-19-136B	Polymictic conglomerate; Sickle group	340166	6224405	2.36–1.56	1.82	2.25; 2.35
108-19-090B	Quartz-pebble conglomerate; Sickle group	341499	6222938	2.66–1.76	1.86	2.35–2.68

Co-ordinates are in UTM Zone 14, NAD83

Abbreviation: N/A, not applicable.

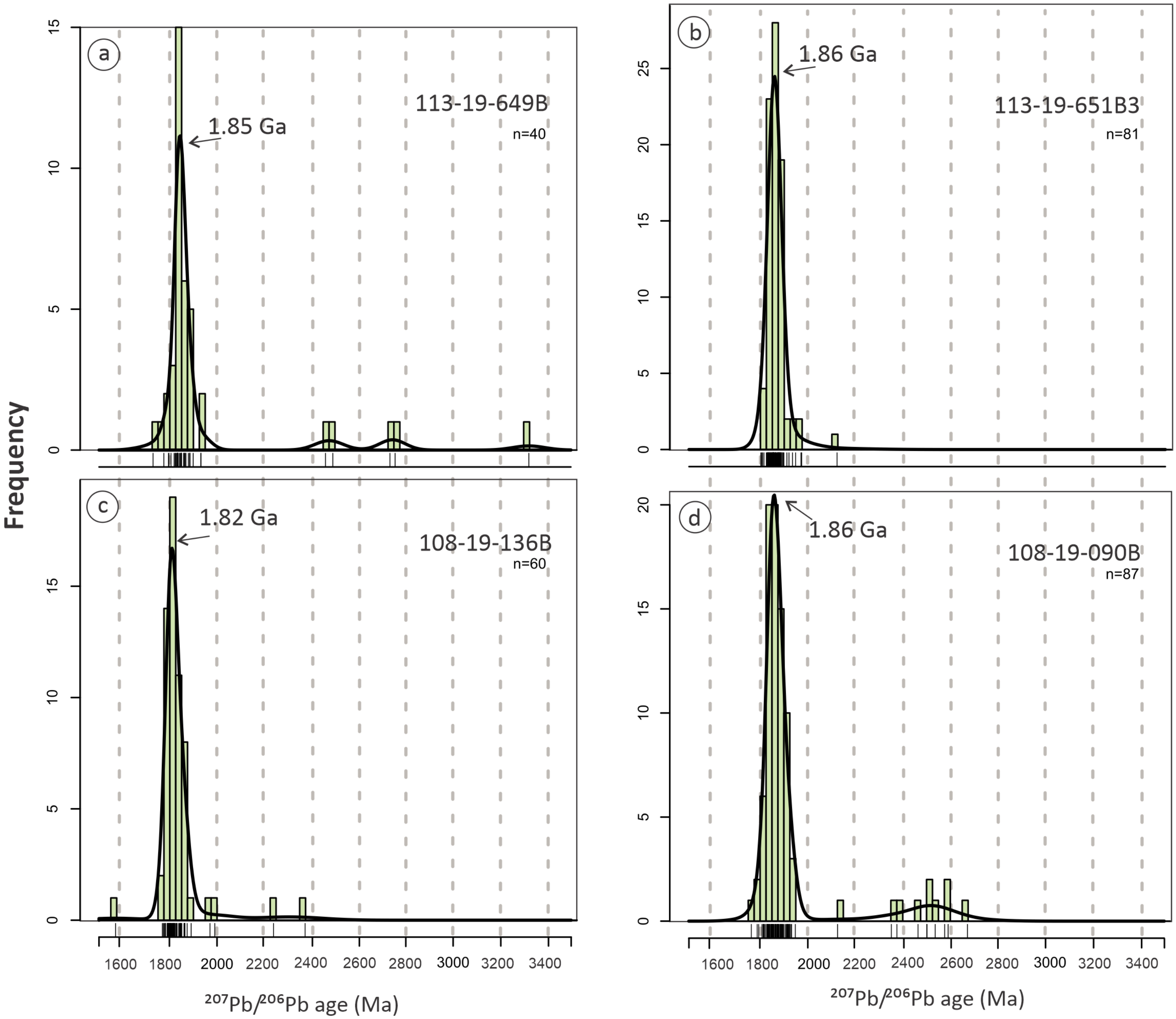


Figure GS2025-5-4: *Kernel density-estimate diagrams for results of detrital zircon U-Pb geochronology of rock samples from Russell Lake:* ***a)*** *sample 113-19-694B, Burntwood group; 347177E/6220658N;* ***b)*** *sample 113-19-651B3, Burntwood group (342493E/6220718N;* ***c)*** *sample 108-19-136B, polymictic conglomerate, Sickle group (340166E/6224405N);* ***d)*** *sample 108-19-090B, quartz-pebble conglomerate, Sickle group (341499E/6222938N). Probability curves are shown in black and histograms in light green, with a bin width of 25 million years. Co-ordinates are in UTM Zone 14, NAD83.*

et al., 2006). Multiple ca. 1.85 Ga zircons within all dated samples suggest not only a common source but also that the 1.86–1.85 Ga plutons were eroding at the time of sedimentation.

Zircon grains yielding ca. 1.89 Ga ages are also present in the samples from the study area. These grains could be derived either from the ca. 1.89–1.87 Ga Pool Lake suite (a variety of mafic, intermediate and felsic plutons) from the nearby Lynn Lake greenstone belt (Turek et al., 2000) or from the older rocks from the Wasekwan group. Another possible but distal source is the Southern Indian domain (Figure GS2025-5-2), where ca. 1.89 Ga felsic and mafic magmatism is recognized (e.g., Martins et al., 2019).

The scatter of ca. 3.33–2.25 Ga zircon ages indicates Meso- to Neoarchean and older Paleoproterozoic sources, possibly from the cratons adjoining the THO (i.e., Hearne and/or Sask). Alternatively, these results could have been sourced from inherited zircons hosted within the eroding Paleoproterozoic igneous intrusions. The Hearne craton is currently geographically located to the north and the Sask craton outcrops to the southwest in Saskatchewan, but its full extent is presently unknown. A crystallization age of a granodiorite gneiss at 2.52 Ga was reported in the Southern Indian domain (Figure GS2025-5-2; e.g., Martins et al., 2019, 2022) and ages of similar range are reflected in the dominant and subdominant detrital zircon populations in most Paleoproterozoic assemblages of that area (e.g., Martins et al., 2019). Zircon ages ranging between 2.55 and 2.45 Ga overlap with known ages from the Sask craton (e.g., Rayner et al., 2005) but were also identified elsewhere in the region further west in Saskatchewan (e.g., Rottenstone domain, Bickford et al., 2001; the Peter Lake domain, Maxeiner and Rayner, 2017; and plutons from the southern Hearne craton, Card et al., 2018). No event is known to have occurred during ca. 2.20–2.00 Ga. Some of the ca. 2.20–2.00 Ga zircon ages could be mixed ages (ablation of multiple age domains). Older zircon ages of ca. 2.12, 2.39, 2.51, 2.73, 3.02 and 3.35 Ga are also reported from Sickle group rocks in the Lynn Lake greenstone belt (Lawley et al., 2020). These grains are interpreted to have come from distal sources because no Paleoproterozoic or Archean rocks from this age range are currently exposed.

The results presented here are similar to the range of detrital zircon ages obtained for the Burntwood group (1896–1847 Ma) and Sickle group (1865–1845 Ma) reported by Murphy and Zwanzig (2021). This is consistent with the interpretation that the groups represent lateral marine and terrestrial facies (Zwanzig and Bailes, 2010) with the same detrital source. The coeval timing of marine and clastic sedimentation is further supported by the youngest detrital zircon $^{207}Pb/^{206}Pb$ ages yielded by samples from the Missi (1837 ±4 Ma) and Burntwood (1842 ±2 Ma) groups, which overlap within the 2σ level of analytical uncertainty (e.g., Ansdell and Norman, 1995).

Three of the four samples yield similar U-Pb dates, which suggests that the sedimentary rocks of the Burntwood and Sickle groups were eroded from the same terrane. Sample 108-19-136B yielded predominantly younger zircon ages, which are interpreted as metamorphic and provide little inheritance-source information. The Burntwood group samples seem to yield fewer Archean grains than the Sickle group, but this could be explained by a lack of targeted zircon cores creating analytical bias, or could be a statistical artifact.

Economic considerations

The timing of deposition for the Sickle group conglomerates and arkosic rocks coincides with the formation of major gold-bearing structures in the adjacent Lynn Lake belt (Lawley et al., 2020).

As pointed out by Martins and Couëslan (2019b), the Russell–McCallum lakes area shows clear evidence and economic potential for graphite mineralization. Natural graphite has several uses including anode material for Li-ion batteries, brake linings, lubricants, powdered metals, refractory applications and steelmaking (U.S. Geological Survey, 2019). Currently, natural graphite is a well-sought commodity mainly due to anticipated demand associated with the production of Li-ion batteries. Graphite is listed in Canada as a critical mineral (Natural Resources Canada, 2024) as well as in other countries such as the United States (U.S. Department of the Interior, 2018) and in Europe (European Commission, 2020).

Assay results from the 2019 field season reveal up to 3.31 wt. % total carbon in Burntwood group rocks (Martins and Couëslan, 2020b). Graphitic horizons can also be associated with enrichments in several transition metals (Couëslan, 2020). A graphitic sulphide-facies iron formation (>5 m thick) on the western shore of McCallum Lake was found to contain 0.82 wt. % total carbon, 63.8 ppm Co, 609 ppm Cu, 377 ppm Ni, 73.8 ppm Mo and 22.2 ppm U (Martins and Couëslan, 2020b).

Acknowledgments

The publications stemming from the Russell Lake project benefited from in-depth discussions with H. Zwanzig (Manitoba Geological Survey, emeritus). His extensive knowledge of the area greatly improved the understanding of the complex geological history of this portion of the Kisseynew domain. J. Janssens helped to produce the figures. Edits by M. Rinne and J. Macdonald helped improve earlier drafts of the manuscript. Technical editing services were provided by RnD Technical. D. O'Hara was responsible for layout and looked after all final editorial duties.

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