GS2024-11

Geochronological update of sedimentary, volcanic and plutonic rocks in the Snow Lake area, north-central Manitoba (parts of NTS 63J13, 63K16)

by K.D Reid

In Brief:

- New ages for the Ham Lake and Wekusko Lake plutons will provide constraints on early deformation in the Snow Lake area
- Detrital zircons from greywacke on File Lake will provide information on provenance for the Burntwood group along the south flank of the Kisseynew basin

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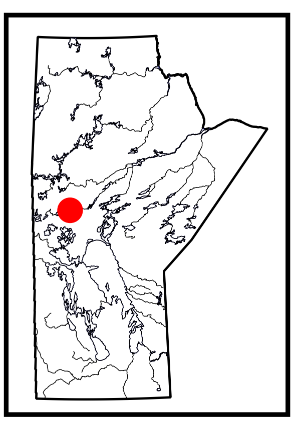

Summary

The broad economic mineral endowment of the Snow Lake region has made it the focus of extensive exploration and study for over a century. Throughout that period, detailed study and mapping have shown that various rocks in the Snow Lake area are in fact attributed to different lithotectonic assemblages (i.e., back-arc volcanic, arc volcanic, turbiditic greywacke) that may have formed in distinct tectonic environments during various time frames. Deformation and faulting related to the Trans-Hudson orogeny resulted in the juxtaposition of these assemblages. Attempts at placing absolute time constraints on both the formation of these assemblages and the subsequent deformation have been ongoing. The ongoing work has benefited from recent advances in U-Pb zircon geochronology that allow for more precise age determination using both laser-ablation inductively coupled plasma–mass spectrometry and isotope dilution–thermal ionization mass spectrometry. A rationale for resampling and dating certain igneous and sedimentary rocks of the Snow Lake area is presented in this report.

Introduction

As part of the multiyear program in the Snow Lake subdomain of the Reindeer zone of the Trans-Hudson orogen (THO) initiated in 2023 by the Manitoba Geological Survey (MGS), modern geochronological techniques were applied to rocks that have been well mapped but have poor or questionable absolute-age constraints. The core focus is centered around the File, Snow and Wekusko lakes areas (Figure GS2024-11-1). Thorough mapping campaigns have been carried out in these areas (e.g., Bailes, 1980; NATMAP Shield Margin Project, 1998; Gilbert and Bailes, 2005; Bailes and Galley, 2007) but, as much of the radiometric dating was completed in the 1980s and early 1990s, some ages are relatively imprecise. New geochronological sampling is briefly discussed in this report and, as more precise ages are obtained, the details will be released as Data Repository Items (DRI) and the implications of these results discussed in an Open File report (K.D. Reid, work in progress).

Geology of the File and Snow lakes areas

Rocks of the File, Snow and Wekusko lakes areas lie within the juvenile (internal) Reindeer zone of the THO, a collisional zone formed during the 2.0–1.8 Ga amalgamation of several oceanic arcs, back-arcs and Archean cratons to form the Laurentian supercontinent (Hoffman, 1988). This area encompasses the transition zone between the Snow Lake subdomain and the Kisseynew domain to the north (Figure GS2024-11-1). To the east, the Snow Lake subdomain is bounded by the Superior boundary zone, whereas to the south it continues under younger Phanerozoic platform carbonate rocks.

Volcanic rocks west of Reed Lake are considered part of the Amisk collage (Figure GS2024-11-1; Lucas et al., 1996). They are separated from the Snow Lake subdomain by the West Reed-North Star shear zone and from the Kisseynew domain by the Loonhead Lake fault. Stern et al. (1995) suggested that stratigraphic and geochemical differences between the Snow Lake arc assemblage and volcanic rocks of the Amisk collage were likely the result of their having formed in distinct tectonic settings.

The Loonhead Lake fault (LHLF) and the Snow Lake fault (SLF) are interpreted as thrust faults that developed during southwest-directed transport of greywacke and mudstone from the Kisseynew domain over the Snow Lake arc assemblage (SLA) and the Northeast Reed assemblage (NERA; Figure GS2024-11-1; Connors, 1996). The Loonhead Lake and Snow Lake faults are considered to have been potentially at one time a single thrust fault cut by the Ham Lake pluton (HLP; Figure GS2024-11-1). The Berry Creek shear zone separates the Snow Lake arc assemblage and the Herblet gneiss dome (HGD) from a northeast-trending panel of greywacke and mudstone 15–20 km wide referred to as the Central Wekusko block (CWB) by Ansdell et al. (1999; Figure GS2024-11-1). In the southwestern corner of the Wekusko Lake area, greywacke and mudstone are in structural contact with the Hayward

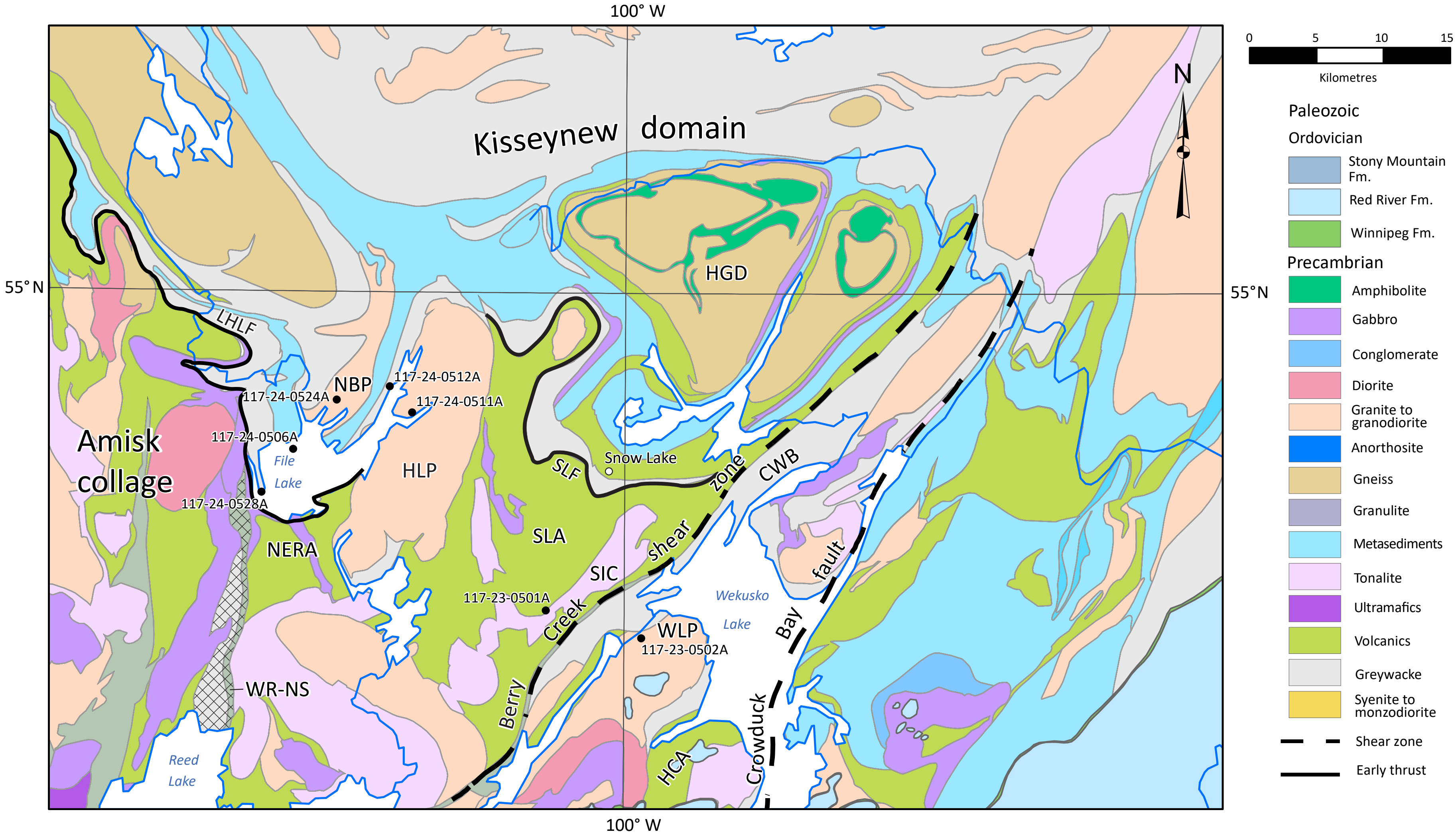

Figure GS2024-11-1: *Geology of the Snow Lake subdomain of the eastern Trans-Hudson orogen, modified from the 1:250 000 scale Precambrian bedrock geology map issued by the Manitoba Geological Survey (2022). Note the Kisseynew domain to the north and Paleozoic cover rocks to the south. The Central Wekusko fault block is shown relative to the Berry Creek shear zone and Crowduck Bay fault. Abbreviations: CWB, Central Wekusko fault block; HCA, Hayward Creek arc assemblage; HGD, Herblet gneiss dome; HLP, Ham Lake pluton; LHLF, Loonhead Lake fault; NBP, Nelson Bay rocks; NERA, Northeast Reed assemblage; SIC, Sneath intrusive complex; SLA, Snow Lake arc assemblage; SLF, Snow Lake fault; WLP, Wekusko Lake pluton; WR-NS, West Reed-North Star shear zone.*

Creek arc assemblage (HCA). Although no age determination is available for the Hayward Creek arc assemblage, it is thought to consist of ca. 1.89 Ga juvenile-arc rocks (Gilbert and Bailes, 2005).

Geochronological samples

Igneous rocks

Plutonic rocks

The Wekusko Lake granite (sample 117-23-0502A01; Figure GS2024-11-1) is a light grey to pink, massive, equigranular, medium-grained granite with biotite that is pseudomorphic after hornblende (Figure GS2024-11-2a). The intrusion was emplaced into mudstone and greywacke of the Burntwood group along the western side of Wekusko Lake, where the Burntwood group rocks are affected by two generations of folding: 1) an earlier isoclinal F_1 that transposes bedding and 2) a second generation of tight F_2 folding that refolds F_1. Map patterns show that emplacement of the granite body is synchronous with the second deformation event, as the main body intrudes into the nose of a northeast-trending F_2 fold but also has small protrusions cutting across F_2 folded limbs (Bailes and Galley, 2007). Zircon from the granite produced a discordant 1834 +8/-6 Ma age (Gordon et al., 1990), whereas a titanite fraction from the same granite yielded an age of 1841 ±5 Ma (David et al. 1996), which is within error of the zircon age. A new sample of the Wekusko Lake granite has been submitted to determine a more precise crystallization age and constrain the time of folding.

The Sneath Lake intrusive complex (SIC, Figure GS2024-11-1) occurs within the Anderson sequence volcanic rocks and presents many features of a high-level synvolcanic intrusion, including multiple intrusive phases, porphyritic character, columnar jointing, internal alteration and fragments of the distinctive Sneath megacrystic-quartz tonalite in the spatially associated Anderson-Stall rhyolite (Bailes and Galley, 2007). Although radiometric dating of a quartz-phyric–tonalite phase produced an age of 1886 +17/-9 Ma, within error of Chisel sequence rocks including the Stroud Lake felsic breccia at 1892 ±3 Ma (David et al., 1996) and the Richard Lake intrusive complex at 1889 +8/-6 Ma (Bailes et al., 1991), several questions remain unanswered. For example, were the Anderson sequence and Chisel sequence arcs formed at the same time and then structurally accreted together or was the Chisel sequence arc built on the Anderson sequence? A sample of Sneath Lake quartz-phyric tonalite (117-23-501A01; Figure GS2024-11-1) was collected and is being evaluated by Ballantyne et al. (2024) to help better understand the relationship between the volcanic rocks of the Anderson and Chisel sequences.

The Ham Lake pluton is an approximately 16 by 7 km, north-northeast-trending, massive granodiorite intrusion (Figure GS2024-11-1) that has a U-Pb zircon crystallization age of 1830 +27/–19 Ma (Gordon et al., 1990). It likely predates regional metamorphism (Bailes, 1980) and postdates F_1–F_2 folding and movement on the Loonhead Lake fault (Figure GS2024-11-1), which is interpreted by Connors (1996) as a major thrust fault that tectonically transported younger sedimentary rocks from the Kisseynew domain into the Snow Lake segment of the Flin Flon domain. A new sample (117-24-511A01, Figure GS2024-11-1, 2b) of the Ham Lake pluton was acquired to provide a more precise minimum age for the Loonhead Lake fault and associated thrusting of Burntwood group turbidites over the Flin Flon domain.

Rocks of probable volcanic origin

Harrison (1949) previously mapped Nelson Bay rocks (NBP, Figure GS2024-11-1) as foliated granite, but these were reinterpreted as a structural dome of predominantly recrystallized metavolcanic orthogneisses (Bailes, 1980). Additionally, a thin unit (<20 m thick) of fine-grained felsic orthogneiss occurs within the Missi group metasedimentary succession at File Lake; Bailes (1980) suggested it originally had been a felsic ash flow within the Missi sedimentary succession. Zwanzig and Bailes (2010) noted that the felsic rocks of the Nelson Bay dome structure and those within the Missi group shared geochemical similarities with the Cleunion rhyolite that occurs within the Missi group sediments further to the west. A sample from the Nelson Bay dome structure produced an age of 1832 ±2 Ma (David et al., 1996), indicating that these rocks are close in age to volcanic rocks observed elsewhere in the Missi group (e.g., Chickadee rhyolite 1836 ±1 Ma; Ansdell et al., 1999).

In the Nelson Bay area, the felsic rocks are light grey to pinkish grey, fine-grained, weakly granoblastic, with distinct layering that varies from centimetre- to metre-scale (Figure GS2024-11-2c). Structural measurements of this layering do support a domal structure; however, no features could be positively identified as pyroclastic or definitively volcanic in origin. At the northeastern end of Nelson Bay and within the Missi sediments at File Lake, the felsic rocks are nearly identical in appearance: both are siliceous, aphyric, laminated at the millimetre-scale, with a well-developed cleavage, and resemble tuffaceous rhyolite (Figure GS2024-11-2d, e). Samples from both locations (117-24-0524A01 and 117-24-0506A01, Figure GS2024-11-1) were collected for geochemical analyses and U-Pb zircon dating. The results should provide a basis for comparison with other Missi group volcanic stratigraphy (e.g., east of Wekusko Lake; see Reid et al. 2024) and help in determining minimum time constraints on observed deformation.

Original mapping by Bailes (1980) shows that the northeastern arm of File Lake contains a narrow band of mafic and felsic volcanic rocks (see units 14 and 14a in Bailes, 1980) that occurs within the Burntwood group. Re-examination of these outcrops revealed that rocks of probable volcanic origin are present, the most distinct of these being a monomictic mafic conglomerate/lapilli tuff and an adjacent aphyric rhyolite. Both mafic and felsic samples were collected for geochemical analysis, and a sample

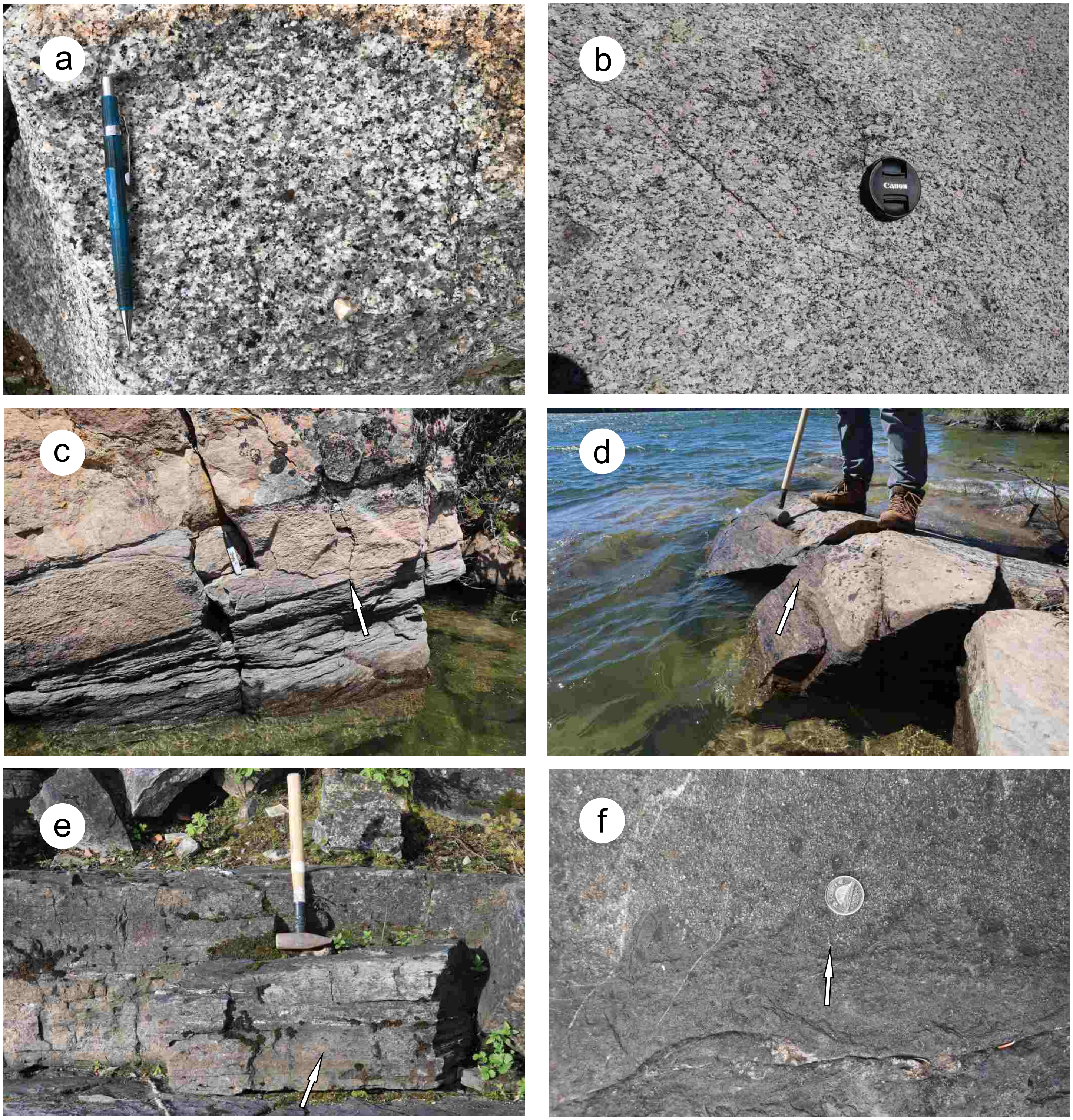

Figure GS2024-11-2: *Outcrop photographs from the Wekusko and File lakes areas:* ***a)*** *Wekusko Lake granite (436811E, 6069129N);* ***b)*** *very weakly foliated Ham Lake granite (420122E, 6086536N);* ***c)*** *centimetre- to metre-scale layered, fine-grained felsic volcanic rock from the Nelson Bay area at File Lake (arrow shows sharp contact between units; 413454E, 6086696N);* ***d)*** *millimetre- to centimetre-scale layered rhyolite at the northeastern end of Nelson Bay at File Lake (arrow points at layering; 414526E, 6087529N);* ***e)*** *millimetre- to centimetre-scale layered rhyolite within Missi group sandstone at File Lake (arrow points at layering; 411104E, 6083697N);* ***f)*** *soft sedimentary deformation (flame structures) at the contact between mud and sand bed (arrow) in the Burntwood group (408570E, 6080723N). All co-ordinates are in UTM Zone 14, NAD83.*

of the rhyolite (117-24-0512A01; Figure GS2024-11-1) was collected for radiometric dating.

Sedimentary rocks

Detailed mapping at File Lake by Bailes (1980) identified a 1000 m thick package of pebbly greywacke, greywacke and mudstone that was deposited by turbidity currents; these sediments were interpreted at the time to have been shed from the adjacent juvenile arc-volcanic rocks (Amisk group). However, analysis of detrital zircon from this package by David et al. (1996) revealed that the maximum age of sedimentation may be as young as ca. 1854 Ma at File Lake. A similar constraint on the maximum age of sedimentation was produced from greywacke and mudstone from the Wekusko Lake area, with the youngest concordant zircon yielding an age of 1859 ±7 Ma, which indicates the turbidites may be as much as 30 m.y. younger than the known age of juvenile-arc volcanism (e.g., Snow Lake arc assemblage ca.1.89 Ga). The small number of zircons used in the study by David et al. (1996) does not allow proper statistical comparison of provenance. A sandy bed sample (117-24-0528A01; Figure GS2024-11-2f) from the turbidite was collected at File Lake in 2024 to determine the overall provenance.

Discussion

Detailed field mapping of plutonic, volcanic and sedimentary rocks in the Snow Lake area (e.g., Bailes, 1980; Connors, 1996; Kraus and Williams, 1999; Bailes and Galley, 2007) has characterized the lithological and tectonic evolution of the region. However, many of the absolute age constraints for this region were obtained over 30 years ago and provided imprecise ages (e.g., 1830 +27/–19 Ma for the Ham Lake granite; Gordon et al., 1990). Advancements in sample preparation and treatment, as well as instrumentation, have shown that very accurate and precise ages can now be obtained from these rocks (e.g., 1833.9 ±1.2 Ma for the Stuart Lake granite; Reid, 2024). All new data and interpreted ages will be released in a DRI, as they become available, and the significance of these results will be discussed in an Open File report (K.D. Reid, work in progress).

A new absolute age constraint for the Sneath Lake tonalite will help gain a better understanding of the evolution of the juvenile Anderson sequence by allowing comparison with ages yielded by the arc-volcanic rocks of the Chisel sequence and will contribute to the work carried out by Ballantyne et al. (2024). Determining a precise crystallization age for the Ham Lake granite pluton will provide minimum constraints on the age of F_2 folding and the Loonhead Lake fault at File Lake. Similarly, an improved age determination for the Wekusko Lake pluton will provide constraints into F_2 folding in greywacke at Wekusko Lake. In addition to constraining the timing of deformation in the Snow Lake subdomain, precise ages for these plutons will also provide information on the evolution of successor-arc magmatism and allow comparison with known successor-arc volcanic rocks east of Wekusko Lake (e.g., Andsell et al, 1999; Reid, 2021). Building on the work by David et al. (1996), analysis of detrital zircon by laser ablation-inductively coupled plasma–mass spectrometry on the greywacke at File Lake will allow more thorough examination of the provenance of the greywacke at this location, relative to other greywacke units along the flank of the Kisseynew domain.

Economic considerations

Ore mineralizing events are often restricted to narrow windows of geological time and commonly associated with deformation and/or magmatic events. Therefore, it is important to understand geologically favourable time frames. For example, in the Snow Lake subdomain, orogenic gold mineralization is closely linked with early F_1 folding and thrust faulting such as those noted at the Nor-Acme anticline, Snow Lake thrust and McLeod Road thrust (Rubingh et al., 2020) but no absolute age constraints are available currently for these structures. Thrust faulting and folding extend into the File Lake area, where the Loonhead Lake fault is cut by the Ham Lake granite pluton, thus determination of the precise age of this pluton will help in establishing a minimum constraint on early deformation and allow comparison with the deformation/gold mineralizing time interval observed elsewhere in the Flin Flon domain (e.g., east of Wekusko Lake; Reid, 2021, 2024).

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