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Abstract

The Boothia Peninsula – Somerset Island region of north-central Nunavut is a frontier region (70-74°N, 94°W) long considered as part of Rae craton. Recent field mapping and acquisition of isotopic (U-Pb, Sm-Nd) data as part of the GEM-2 Boothia-Somerset project allowed this region's exposed Precambrian bedrock to be better characterized with respect to petrology and litho-geochemistry, and to be more extensively and more precisely time-calibrated. The discovery of unique, possibly exotic, basement characterized by a ca. 2.55-2.51 Ga TTG suite overlain by ca. 2.5 Ga metasedimentary rocks, cut by 2.49- 2.48 Ga plutons, are all atypical components of the Archean Rae crust. This new knowledge and the hint of similar 'Boothia terrane' crust south of Boothia Peninsula (Ryan et al., 2009), east of the Queen Maud block (Davis et al., 2014) in central Nunavut, and in northernmost Saskatchewan (Cloutier et al., 2021), raised the possibility this terrane may extend >1600 km across north-central Canada.

During the foundational year of GEM-GeoNorth, the extent of Boothia terrane crust was explored through legacy samples collected during the 2012 GEM Frontiers' transect across mainland Nunavut. As part of this new study, field descriptions, photographic records and legacy samples were examined, and new U–Pb zircon geochronology was acquired. The new data and knowledge were used to: i) identify new components of Boothia terrane on the mainland southwest of Boothia Peninsula; ii) further distinguish this crust from that of Rae affinity; and iii) better constrain the depositional age of Sherman Group metasedimentary rocks.

Introduction

Key objectives of GEM-2 were to investigate the orogenic architecture of the western Rae craton, its influence on the distribution of mineral resources, and the nature, extent and mineral prospectivity of its collisional zone (Thelon tectonic zone) with the Archean Slave craton (Fig. 1). This was accomplished by

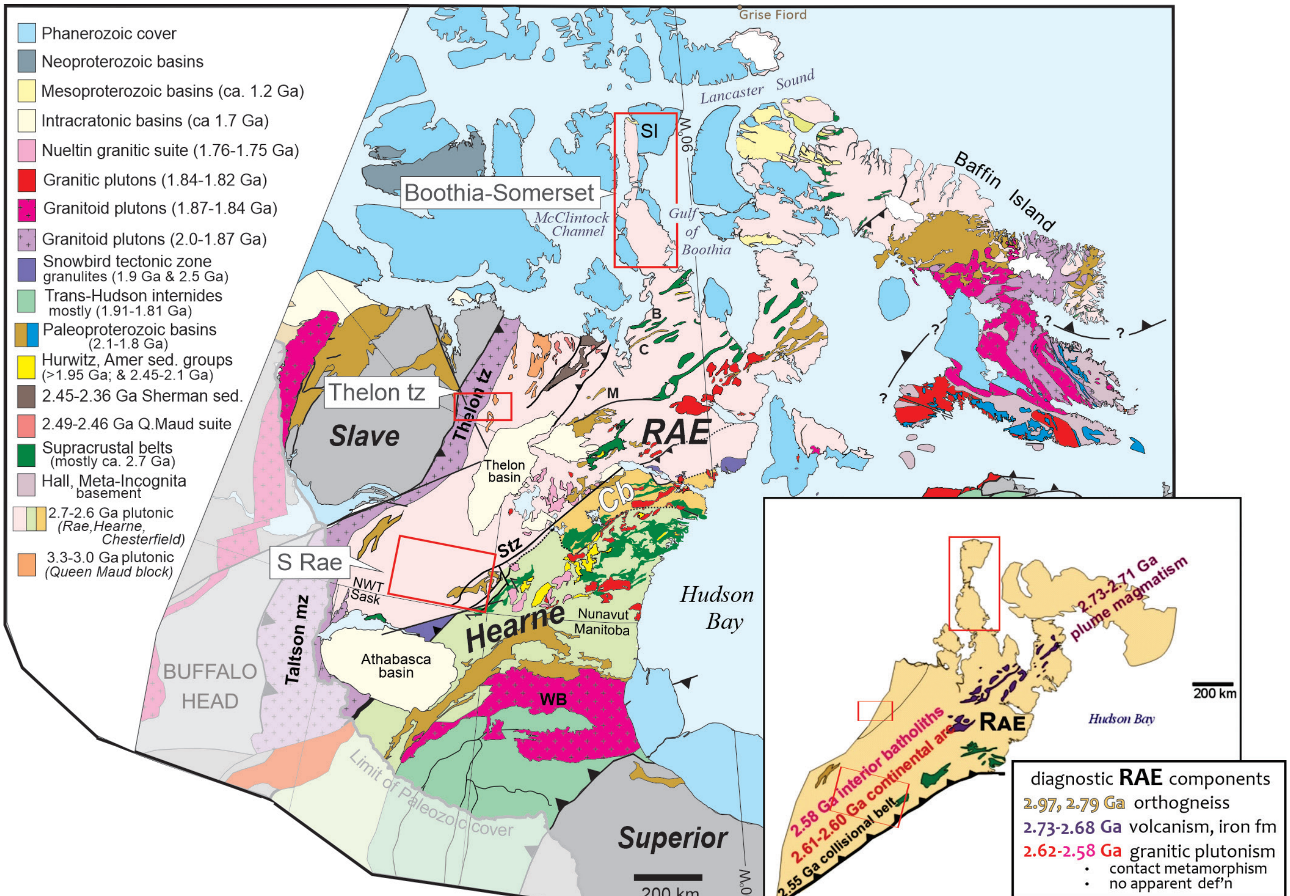

Figure 1: Pre-GEM-2 regional geological map of the Canadian Shield showing main lithotectonic units, select structures, and localities of units discussed in the text. Note that Boothia-Somerset is interpreted as a northern extension of Rae craton. Abbreviations: B-Barclay belt; C-Chantrey group, Cb-Chesterfield block; M-Montresor group, mz-magmatic zone, NWT-Northwest Territorial border, Sask-Saskatchewan provincial border, S-South, SI-Somerset Island, STz-Snowbird tectonic zone, tz-tectonic zone, WB-Wathaman Batholithic complex. Red rectangles highlight the location of the three GEM-2 research activities along the western Rae margin.

three concurrent research initiatives (Fig. 1): the Boothia-Somerset activity (Sanborn-Barrie et al., 2018, 2019; Regis et al., 2019), the Thelon-Chantrey activity (Berman et al., 2018; Whalen et al., 2018), and the south Rae activity (Pehrsson et al., 2015; Regis et al., 2017). A key discovery from the Boothia-Somerset activity was that this northernmost region held very little in common with 'classic Rae crust'. Whereas Rae is typified by 2.79-2.97 Ga plutonic rocks, infolded with 2.73-2.70 Ga metavolcanic belts and associated metasedimentary rocks, together cut by widespread 2.62-2.59 Ga granite (Fig. 1 inset), the Boothia-Somerset corridor is younger with extensive 2.56-2.51 billion year old plutonic rocks (Fig. 2) dominated by porphyroclastic quartz monzonite (Fig. 3a) and biotite tonalite-trondjemite-granodiorite (TTG suite, Fig. 3b).

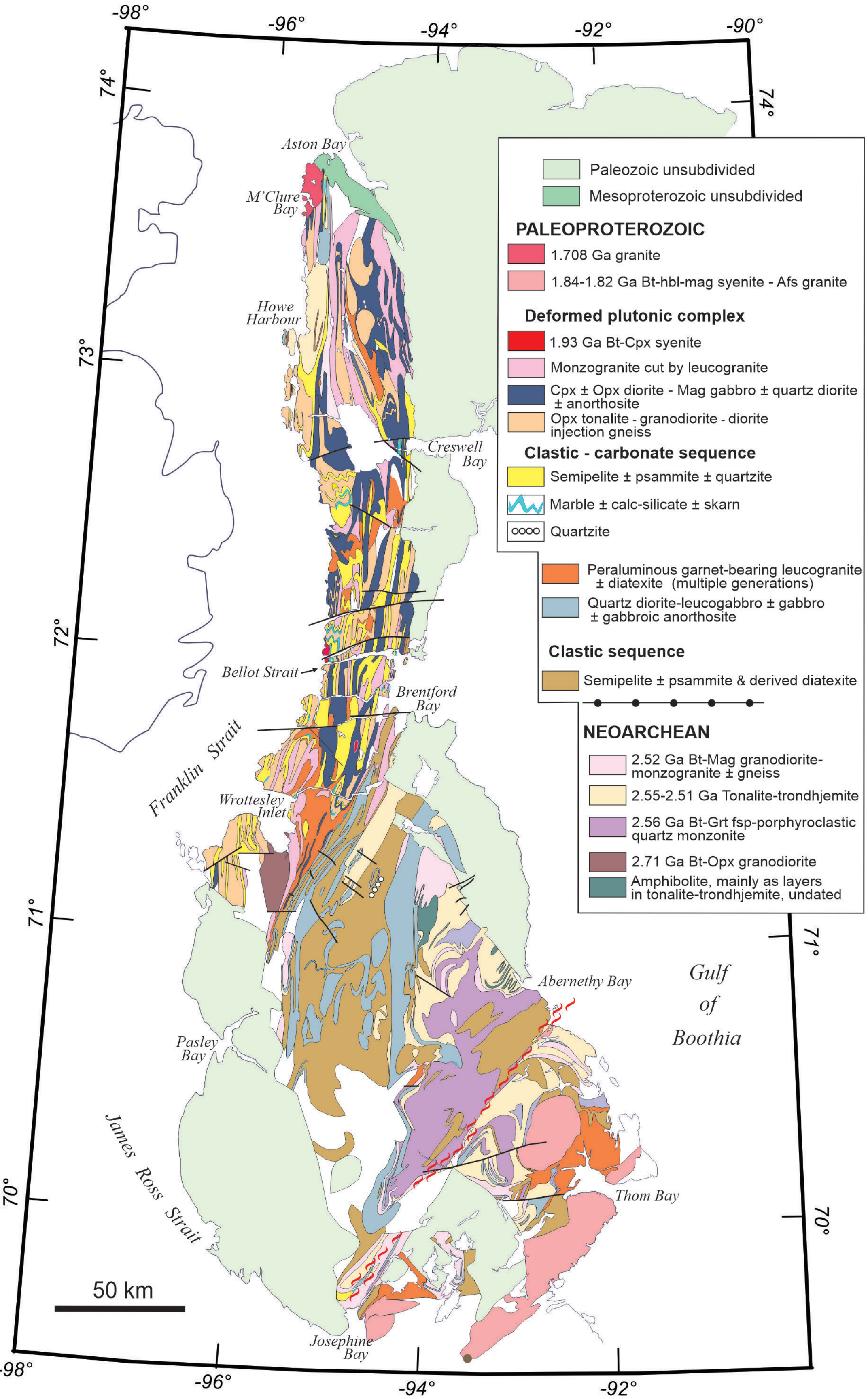

Figure 2: Lithological map of Boothia Peninsula – Somerset Island. Uncoloured (white) areas are unmapped due to lack of exposure. Mineral abbreviations in the legend are from Whitney and Evans (2010).

The ca. 2.56-2.51 Ga plutonic complex is associated with a clastic (semi-pelitic and psammitic) sequence (Fig. 3c) whose detrital zircon population is dominated by 2.55-2.51 Ga detritus (Regis and Sanborn-Barrie, in review), consistent with local derivation and lack of any significant 'Rae' input. The metasedimentary sequence is cut by 2.49-2.48 Ga quartz diorite (Fig. 3d) establishing a minimum depositional age and evidence of a dynamic setting of TTG magmatism closely followed by extensional unroofing and deposition. Collectively, these units are deformed and metamorphosed at high-grade conditions and developed shallow to flat-lying S_1+S_2 transposition fabrics at ca. 2.44 Ga and ca. 2.39-2.37 Ga (2-stage Arrowsmith Orogeny, Sanborn-Barrie and Regis, 2020).

The discovery that Boothia-Somerset crust is distinct from that of Rae craton, to which it had long been correlated, means that strategies for mineral exploration predicated on Rae crustal architecture may not apply. This discovery also raised the question of the extent of Boothia terrane crust (Fig. 4), the focus of this GEM GeoNorth activity.

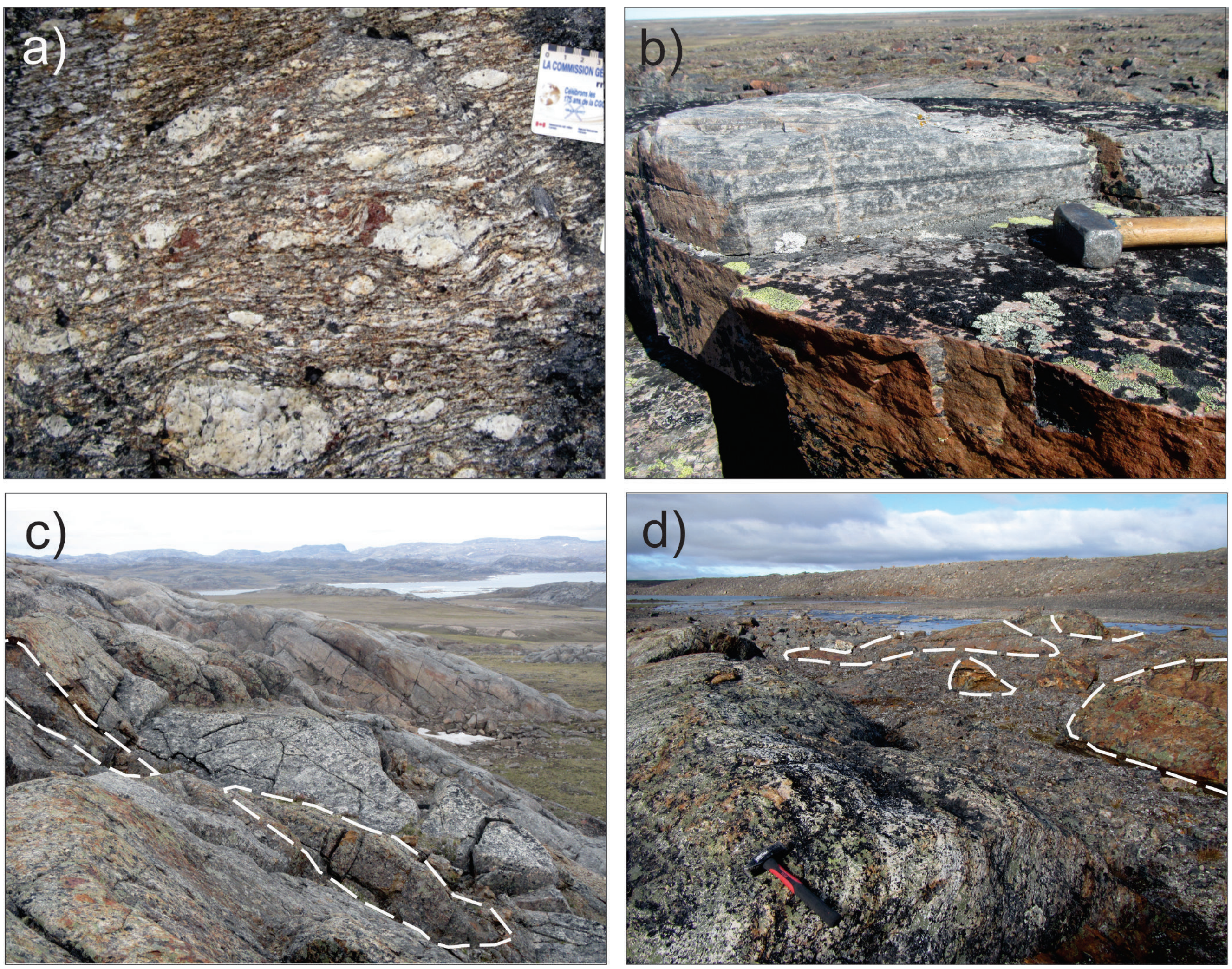

Figure 3: Lithologic units on Boothia Peninsula; a) weathered exposure of ca. 2.56 Ga feldspar porphyroclastic quartz monzonite (lilac unit in Figure 2); NRCan Photo 2022-354; b) field exposure of ca. 2.52 Ga tonalite exposed NW of Abernethy Bay (ochre unit in Figure 2); NRCan Photo 2022-353; c) field exposure of enclaves of psammite (dashed outline) cut by leucogranite diatexite at Thom Bay (orange unit in Figure 2); NRCan Photo 2022-352; d) field exposure of semipelite (dashed outline) cut by quartz diorite (below hammer); brown and blue units in Figure 2, respectively; NRCan Photo 2022-351.

Methodology

Legacy rock samples collected during a regional 2012 GEM Frontiers' transect, and their corresponding field observations, were examined to further investigate the potential for ca. 2.52 Ga Boothia correlative TTG-type crust to the southwest (e.g., Davis et al., 2014) and the possibility that the Sherman metasedimentary rocks (dark brown unit on Figs. 1, 4), previously interpreted to be deposited after 2.44 Ga (Schultz et al., 2007) might, in fact, be correlative with ca. 2.5 Ga metasedimentary rocks on Boothia Peninsula. Seven samples (Fig. 5b) were selected based on lithology, petrographic characterization, and outcrop location on which to undertake U-Pb zircon analysis.

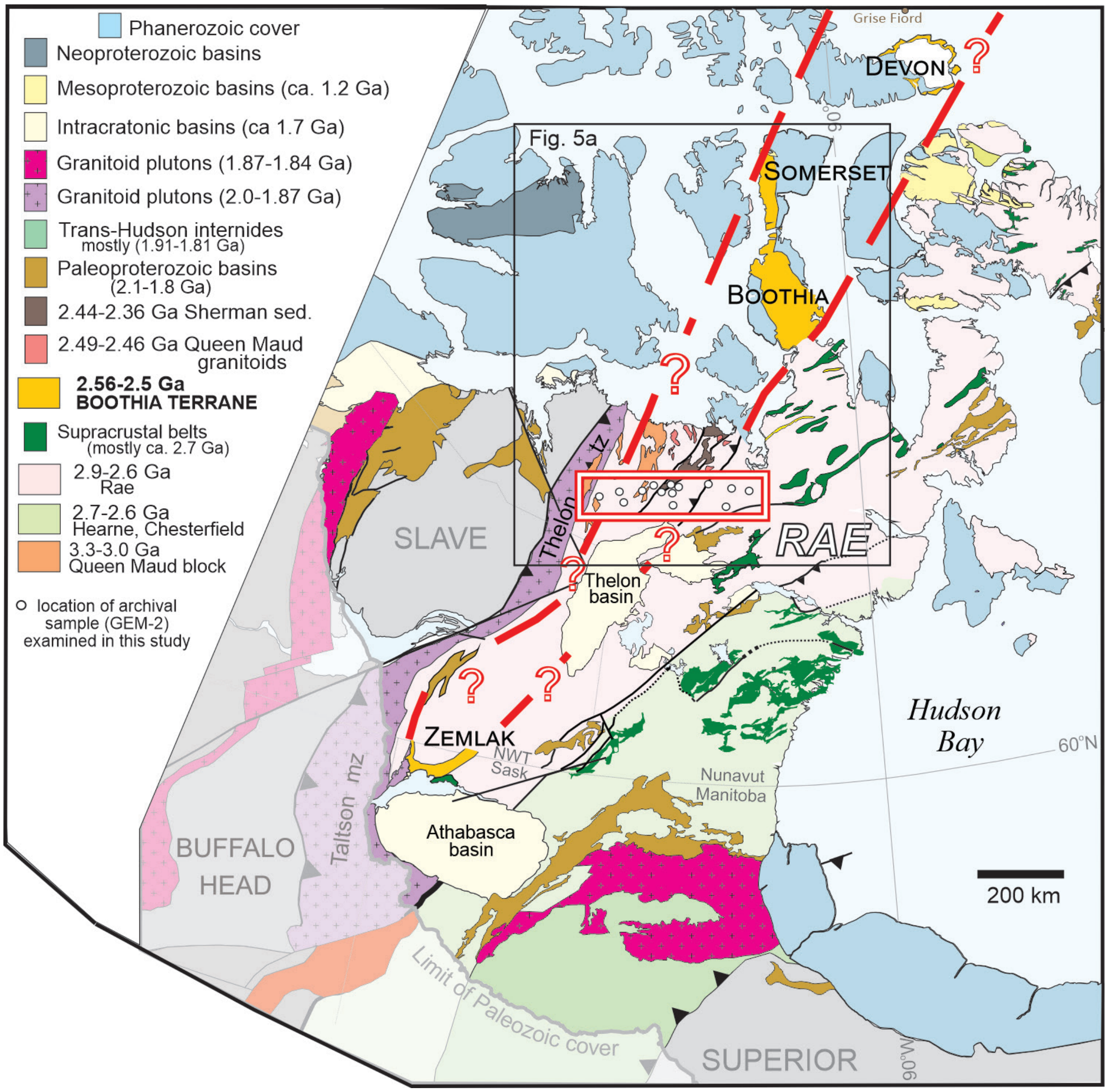

Figure 4: Simplified geological map showing extent of recognized ca. 2.55-2.5 Ga crust and the scope of the GEM 2012 Frontiers transect from which samples were examined for this GEM GeoNorth foundational year study. Black square denotes area shown in Fig. 5a.

Samples were disaggregated and prepared by standard techniques involving crushing, grinding, Wilfley™ table and heavy liquids at the Geochronology facility, Geological Survey of Canada (GSC), Ottawa. Zircon grains were separated using conventional magnetic techniques (Frantz™ isodynamic separator), hand-picked (~120 grains per sample) and mounted in 2.5 cm diameter epoxy discs, along with GSC laboratory reference zircon Z-6266 ($^{206}Pb/^{238}U$ age = 559 Ma). Zircon grains were hand-picked selecting different aspect ratios, morphology, circularity and colour in order to avoid human-induced selection bias in detrital geochronology. The mid-sections of the mounted zircon were exposed using 9, 6, and 1 µm diamond compound. The mount surface was then coated with 10 nm of high-purity Au. Zircon grains were imaged to reveal internal features (such as zoning, alteration, cracks) using backscatter electron (BSE) acquired using a Zeiss EVO 50 Scanning Electron Microscope (SEM). U–Pb geochronology analysis were performed using the Sensitive High-Resolution Ion Microprobe (SHRIMP II) housed in the J.C. Roddick Ion Microprobe facility (GSC, Ottawa).

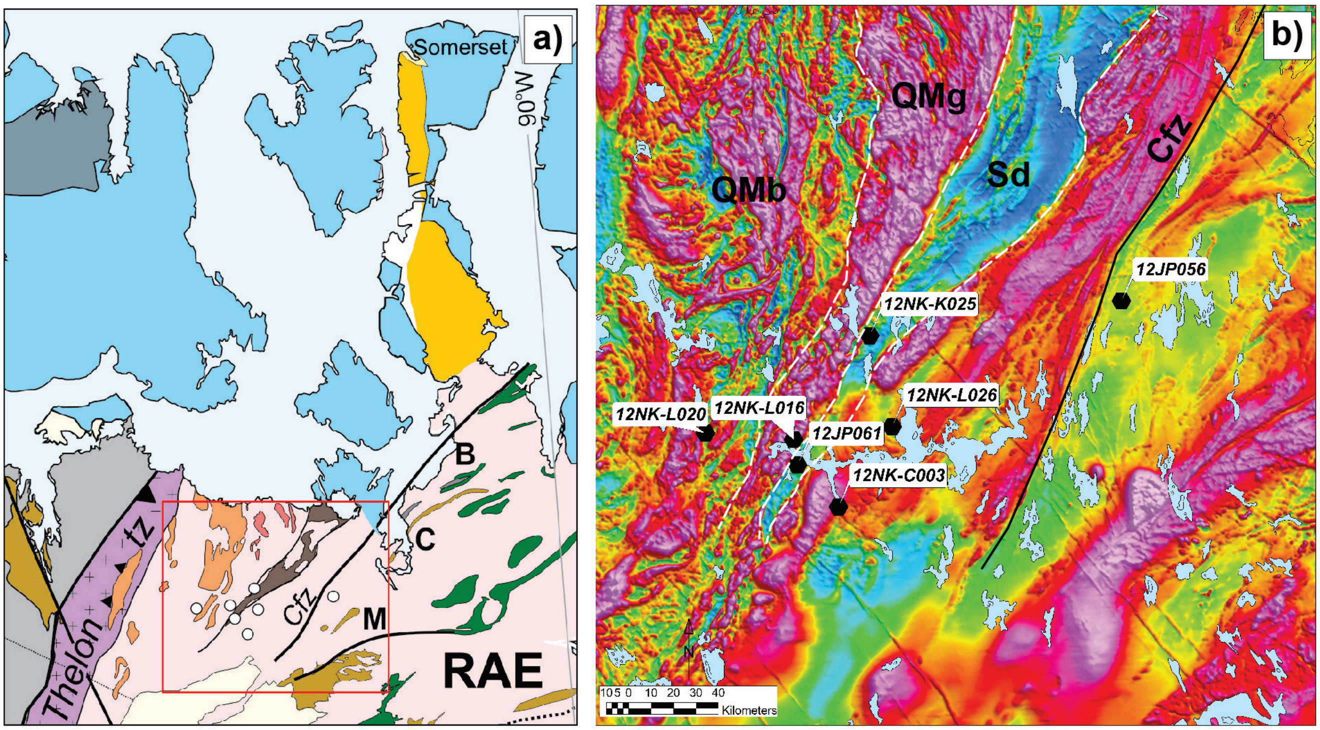

Figure 5: Location of analyzed samples. a) Geological bedrock map of 'mainland' region SW of Boothia Peninsula. See legend of Fig. 4 for rock units; b) aeromagnetic map for area denoted by red square outline in a) showing relevant crustal domains and sample locations. Abbreviations: B: Barclay belt; C: Chantrey belt; Cfz: Chantrey fault zone; M: Montresor belt; QMb: Queen Maud block; QMg: Queen Maud granitoids; Sd: Sherman domain.

U–Pb SHRIMP analytical procedures followed those given by Stern (1997), with standards and U-Pb calibration methods following Stern and Amelin (2003). Analyses were conducted using an O^{2-} primary beam with spot size of ~20 µm. The data were collected in sets of six scans throughout 11 isotope masses of Zr^+, U^+, Pb^+, Th^+, Yb^+ and Hf^+ (Appendix 1). The primary reference (Z-6266) and a secondary reference (Z-1242, Davis et al., 2019) were generally analyzed every sixth unknowns (Appendix 1). Off-line data reduction was accomplished using SQUID 2.5 (Ludwig, 2009). Common Pb correction utilized the Pb composition of the surface blank (see Stern, 1997). Decay constants follow the recommendations of Steiger and Jäger (1977).

Zircon errors are plotted on the figures at the 95% confidence (2σ) interval. Results for detrital samples are plotted on cumulative probability curve with a bin width of 10 Ma. All quoted ages in the text are calculated as the weighted mean of ^{204}Pb corrected ^{207}Pb/^{206}Pb age, with associated uncertainty at the 95% confidence (2σ) interval. Single ^{207}Pb/^{206}Pb dates are reported in the main text and figures at 1σ uncertainty.

Sample Descriptions and U-Pb Results

Sample descriptions and U-Pb zircon SHRIMP data are presented for mainland legacy samples from east to west (Fig. 5b).

Sample 12JP-056B-1 **(Z12696)**

Sample 12JP-056B-1, located 10 km east of the Chantrey fault zone (Cfz, Fig. 5a), is a fine-grained, low-grade (i.e., greenschist) grey-buff weathering siltstone with thinly bedded to laminated portions with minor biotite and muscovite. This siltstone could be part of the upper Montresor metasedimentary belt, mainly exposed ~50 km to the east and deposited after ca. 1.924 Ga (Percival et al., 2019), or an outlier of the much older ca. 2.7 Ga Barclay belt (Hinchey et al., 2007), exposed ca. 300 km to the northeast (B in Figs. 1 and 5a).

Zircon description

Zircon in siltstone *12JP-056B-1* occur as clear to light brown crystals. Most grains are euhedral prismatic and well faceted with sizes ranging from 50 to 250 µm (Fig. 6a inset). Some grains are fractured and slightly discolored. Cathodoluminescence (CL) images reveal in all zircon grains a well-developed oscillatory zoning with no evidence of core-rim relationships (e.g., grains #2 and #5, Fig. 6b inset).

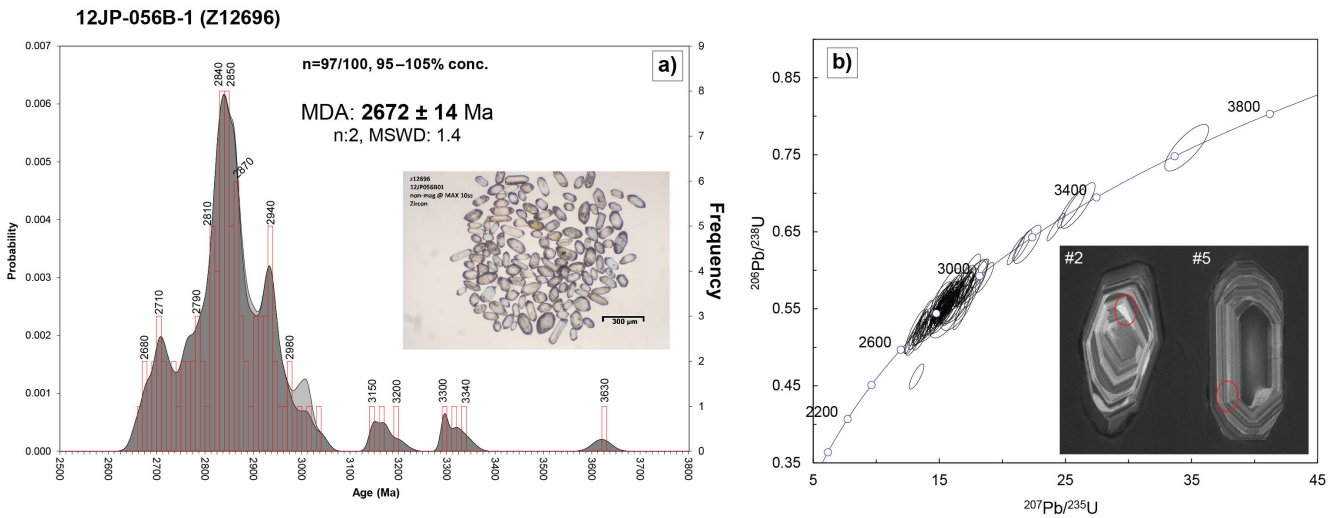

Figure 6: Sample 12JP-056B-1: a) Summary of detrital zircon U-Pb data shown on a probability density plot; darker fill indicates data screened for 95%-105% concordance; light grey includes all data. Histogram bin width is 10 Ma. MDA: maximum depositional age. MSWD: mean square weighted deviation. Inset shows plain light image of zircon. b) Concordia diagram showing U-Pb SHRIMP results. Error ellipses are at 95% confidence level. Inset shows CL images of grains #2 and #5 and analytical spot location (red ellipses are ~20µm).

Results and interpretation

One-hundred analyses carried out on ninety-two separate zircon grains, yield $^{207}Pb/^{206}Pb$ dates between 2661 and 3621 Ma (Fig. 6a,b, Appendix 1). The interpreted detrital age distributions are highlighted in the probability density diagram (Fig. 6a) with a majority of results between 2680 and 2980 Ma and prominent modes at 2840-2850 Ma (n=16), 2870 Ma (n=6), 2810 Ma (n=5) and 2940 Ma (n=5). The youngest detrital zircon yielded a weighted mean $^{207}Pb/^{206}Pb$ age of 2672 ± 14 Ma (MSWD: 1.4, n=2), interpreted as the maximum depositional age of siltstone 12JP-056B-1. The detrital profile and major modes (Fig. 6a) overlap with the results presented by Hinchey et al. (2007) for psammitic schist from the Barclay belt and suggest a correlation with this Neoarchean clastic succession.

Sample 12NK-L26A-1 (Z12702)

Sample 12NK-L26A-1 was collected ~30 km east of the Sherman domain (Sd, Fig. 5a,b) and ca. 20 km east of a strongly foliated hornblende-biotite monzogranite (L025) dated at 2506 ± 2.5 Ma (Davis et al., 2014). Sample L26A is a highly deformed, fine-grained mylonitic granodiorite with monzogranitic injections (Fig. 7a), both strongly deformed. The portion of this sample selected for U-Pb analyses represents the oldest component and does not include the monzogranitic phase.

Zircon description

Zircon grains are typically clear and colourless, stubby to elongated and prismatic (Fig. 7b upper). They range in size from 100 to 400 µm. In CL images zircon grains show oscillatory-zoned cores, and darker (in BSE images, Fig. 7b lower) homogeneous recrystallized and highly-fractured rims (10-50 µm thick; e.g., grain #100, Fig. 7b lower).

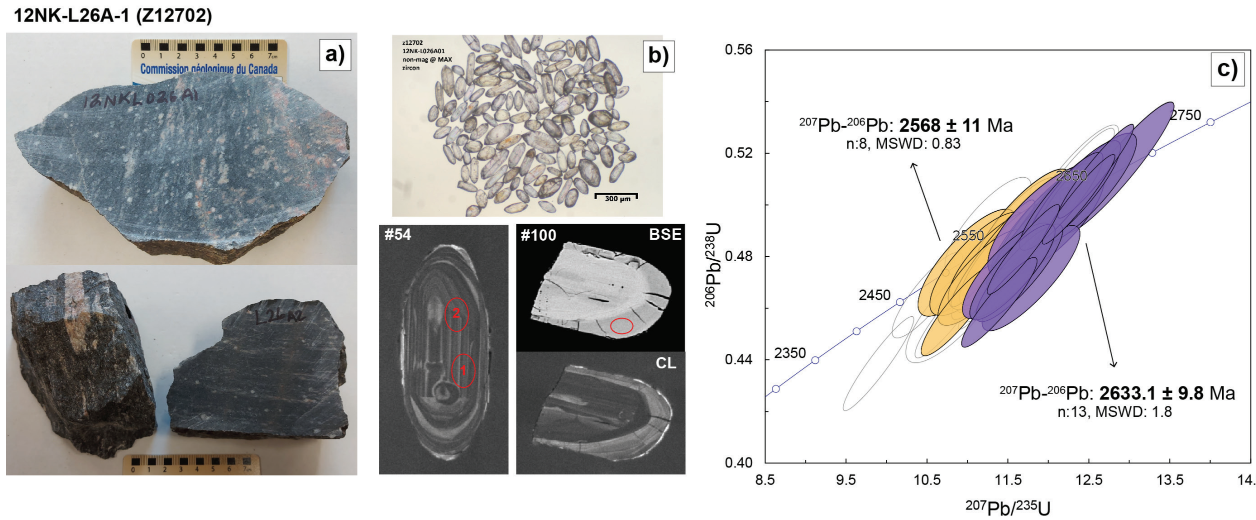

Figure 7: Mylonitic granodiorite 12NK-L26A-1: a) Granodiorite hand sample processed for U-Pb geochronology (upper); portion of sample showing younger monzogranitic phase avoided (lower). b) Plain light photomicrograph of zircon mounted for SHRIMP analysis and CL/BSE image of grains #54 and #100 with spot location (red ellipses are ~20µm). c) Concordia diagram showing U-Pb SHRIMP results. Error ellipses are at 95% confidence level. Amethyst color: oscillatory-zoned core analyses used for age calculation; orange color: rim analyses used for age calculation. MSWD: Mean Square Weighted Deviation. Grey-outlined ellipses are excluded from age calculations.

Results and interpretation

Forty-seven analyses on thirty-five grains yield dates ranging from 2666 to 2495 Ma (Fig. 7c, Appendix 1). The oldest thirteen analyses of oscillatory-zoned cores yield a weighted mean ^{207}Pb/^{206}Pb age of 2633.1 ± 9.8 Ma (MSWD: 1.8, Fig. 7c). This population is interpreted as the best estimate for the emplacement / crystallization of the granodiorite. The dark (in BSE, i.e., grain #100, Fig. 7c) recrystallized zones are characterized by low thorium (30-90 ppm; oscillatory-zoned cores have 100-521 ppm). Eight rim analyses yield a weighted mean ^{207}Pb/^{206}Pb age of 2568 ± 11 (MSWD: 0.83, Fig. 7c). This age is interpreted as an estimate for zircon recrystallization, either during a metamorphic event and/or related to crystallization/intrusion of the younger monzogranite phase(e.g., given the rock is mylonitic, the analysed portion could have included zircon derived from the late monzogranitic injections).

Sample 12NK-C3A-1 (Z12698)

Sample 12NK-C3A-1, located south of the Sherman domain (Fig. 5a,b), was selected to constrain U-Pb zircon crystallization and metamorphic ages. This is a composite sample of well-foliated, grey weathering, granodiorite-tonalite cut by boundinaged and dismembered cm-thick veins of pink K-feldspar porphyritic monzogranite (Fig. 8a). The two components are intimately interlayered at the mm-scale and it was not possible to separate them for geochronological analyses.

Zircon description

Zircon occur as euhedral to subhedral, prismatic colourless to pale brown crystals with variable turbidity (Fig. 8b inset lower right). Grains range in long dimension from 50 to 300 µm. CL images reveal complex internal zonation with partially embayed oscillatory-zoned cores that are overgrown by darker oscillatory-zoned rims (e.g., grain #106, Fig. 8c inset lower right). A small subset of grains preserve bright homogeneous and sector-zoned external rims (e.g., grain # 95, Fig. 8b inset upper left).

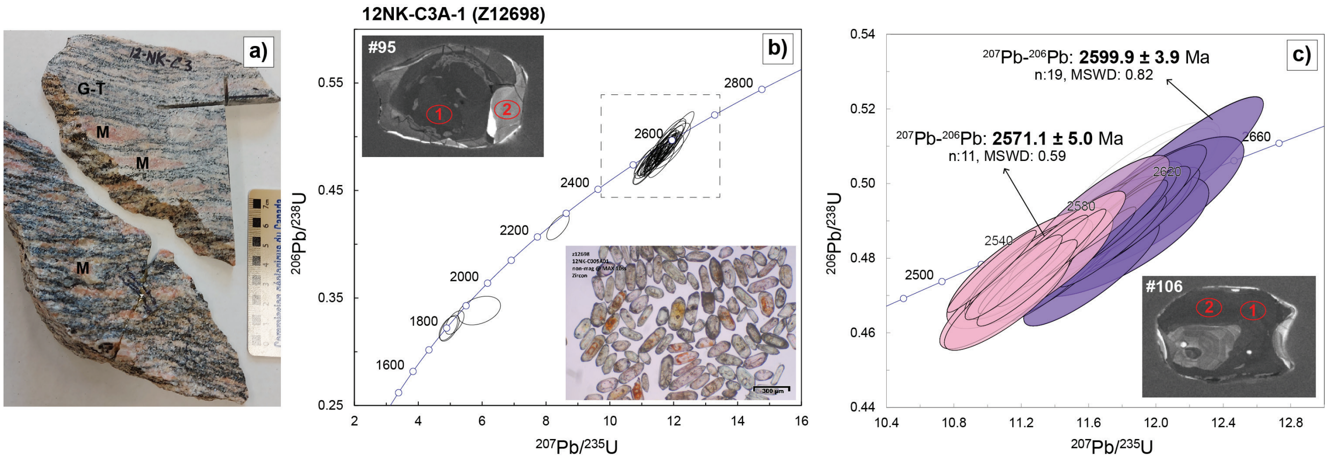

Figure 8: Composite plutonic sample 12NK-C3A-1: a) granodiorite-tonalite (G-T) interlayered with monzogranite (M); sample processed for U-Pb geochronology. b) Concordia diagram showing U-Pb SHRIMP results. Error ellipses are at 95% confidence level. Inset lower right shows plain light photomicrograph of zircon mounted for SHRIMP analysis. Inset upper left shows CL image of grain #95 and analytical spot locations (red ellipse is ~20µm). c) Concordia diagram showing U-Pb SHRIMP results older than 2.5 Ga. Amethyst ellipses represent oscillatory-zoned core analyses used for age calculation; pink ellipses represent oscillatory-zoned rim analyses used for age calculation. Inset lower right shows CL image of grain #106 and analytical spot locations (red ellipses are ~20µm). MSWD: Mean Square Weighted Deviation.

Results and interpretation

Forty-three analyses were carried out on twenty-four grains, targeting the three zones identified in CL. Three analyses of the external bright rims (e.g., grain #95) are characterized by low U (77-99 ppm) and Th (0-2 ppm) contents (Th/U:0.01-0.02) and define a poorly constrained population at 1840 ± 40 Ma (Fig. 8b). This age is interpreted as the time of metamorphic recrystallization/new growth. The remaining thirty-eight analyses (excluding two mixed dates, #95.3, #116.2 Appendix 1) range in age between 2536 and 2624 Ma. Nineteen reproducible analyses (e.g., grain #18, #60 Appendix 1) of the oscillatory-zoned cores yield a weighted mean $^{207}Pb/^{206}Pb$ age of 2599.9 ± 3.9 Ma (MSWD = 0.82, Fig. 8c). The cores are characterized by low (<52) Hf/Yb ratios. The darker, oscillatory-zoned rims overgrowing the cores (e.g., grain #106) show different chemistry with higher Hf/Yb ratios (53-80). Eleven analyses of these domains return a weighted mean $^{207}Pb/^{206}Pb$ age of 2571.1 ± 5.0 Ma (MSWD = 0.59, Fig. 8c). The core age of 2599.9 ± 3.9 Ma is interpreted as the crystallization age of the granodiorite-tonalite host rock, while the younger rim population, based on chemistry and texture, is suspected to reflect the crystallization age of the younger monzogranitic veins intruding the granodiorite host.

Sample 12JP61A-3 (Z12697)

A clastic sample 12JP61A-3 located in the low-magnetic Sherman domain (Sd, Fig. 5a,b) was selected for U-Pb detrital zircon analysis. The hand sample is a fine- to medium-grained garnet-biotite psammite with minor (<5%) garnet preserved, the majority mostly replaced by amphibole. This sample was analysed to test a previous interpretation (Schultz et al., 2007) that the Sherman metasedimentary rocks were deposited after 2.44 Ga and prior to ca. 2.39 Ga. Preliminary indication that the Sherman metasedimentary rocks are older than the interpretation of Schultz et al. (2007) is a GEM2-acquired metamorphic monazite age of 2504 ± 5 Ma (Berman et al., 2015) from this locality. U-Pb detrital data acquired on psammite 12JP061A-3 will help to better constrain the maximum depositional age of the Sherman sediments and test correlations to sedimentary sequences on Boothia Peninsula and Somerset Island.

Zircon description

Zircon recovered from psammite 12JP61A-3 is highly variable, and range from clear, colorless prisms to brown and highly fractured grains (Fig. 9a inset upper left). Most of the grains are anhedral and do not exhibit mechanical abrasion, consistent with minimal transport. Sizes range from 50 to 250 µm. Many grains show high degrees of alteration. CL images highlight their significant alteration and reveal that unaltered portions of the crystals preserve a faint oscillatory zoning (e.g. grain #13, Fig. 9a inset lower right). Some grains are homogenous in CL images (e.g., grain #31, Fig. 9b inset upper left).

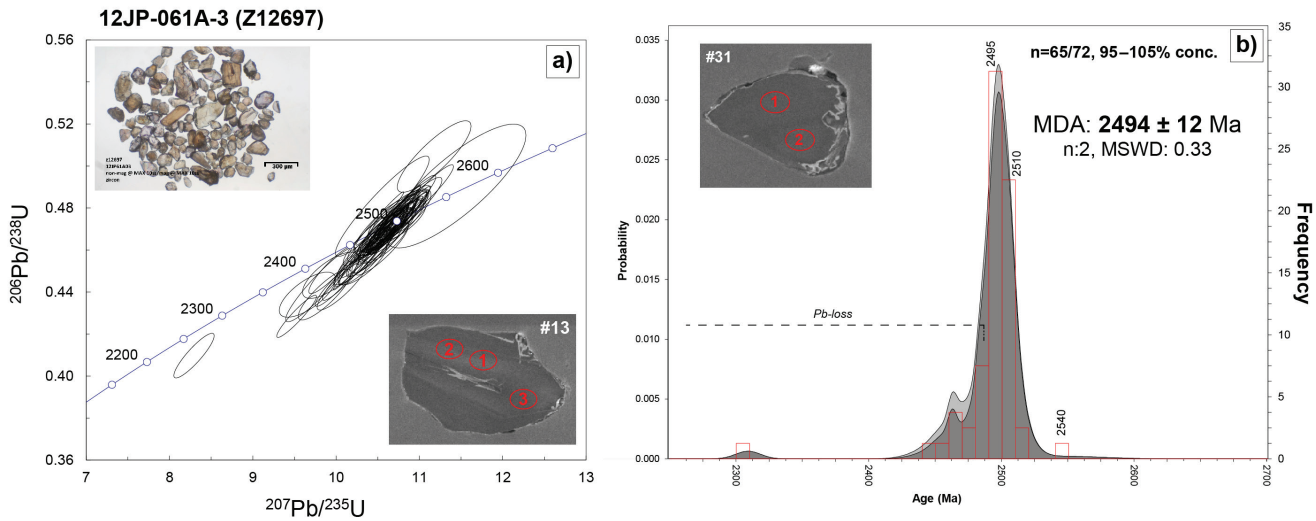

Figure 9: Psammite 12JP-61A-3: a) Concordia diagram showing U-Pb SHRIMP results. Error ellipses are at 95% confidence level. Inset upper left shows plain light photomicrograph of zircon mounted for SHRIMP analysis. Inset lower right shows CL image of grain #13 and analytical spot locations (red ellipses are ~20µm). b) Summary of detrital zircon U-Pb data shown on a probability density plot; darker fill indicates data screened for 95%-105% concordance; light grey includes all data. Histogram bin width is 10 Ma. MDA: maximum depositional age. Inset shows CL image of grain #31 and analytical spot location (red ellipses are ~20µm). MSWD: Mean Square Weighted Deviation.

Results and interpretation

Seventy-two analyses carried out on fifty-one separate zircon grains are almost unimodal and yield $^{207}Pb/^{206}Pb$ ages mainly between 2490 and 2510 Ma (Fig. 9b, Appendix 1). The chemical variability of the grains (204<U<2273 ppm; 19<Th<271 ppm; 39<Yb<450 ppm; 10863<Hf<29508 ppm) support a detrital origin for the sample. The $^{207}Pb/^{206}Pb$ age profile, which is dominated by 2510 Ma and 2495 Ma dates, also includes one grain at 2549 Ma and sporadic results between 2490 and 2309 Ma (Fig. 9b). The maximum age of deposition of the sample is constrained by the two oldest replicate analyses of grain # 31 at 2492 ± 12 Ma (MSWD: 0.33, Fig. 9b). Ages younger than ca. 2495 Ma are not reproducible and indicative of Pb-loss (e.g., grain #44, #62, #66, #82; Appendix 1).

Sample 12NK-K25A-1 (Z12699)

Sample 12NK-K25A-1 is a medium-grained, equigranular quartz diorite (Fig. 10a) located in the low-magnetic domain that corresponds mainly to Sherman metasedimentary rocks, ~2 km east of the interface with the magnetically high QMg (Fig. 5b). This sample is texturally and compositionally similar to ca. 2.48-2.49 Ga quartz diorite on Boothia Peninsula that cuts Boothia's older clastic sequence (e.g., Fig. 3d). Quartz diorite

12NK-K25A-1 is an important sample together with psammite 12JP61A-3 to establish correlations between the mainland Sherman domain and Boothia Peninsula.

Zircon description

Zircon recovered from quartz diorite 12NK-K25A-1 are of moderate quality, subhedral and elongated with rounded tips. Crystals range in size from 40 to 250 µm, are generally colorless to light brown in color and variably fractured (Fig. 10b upper). CL images (Fig. 10b lower) reveal two distinct internal zones: oscillatory-zoned cores overgrown by brighter and homogenous rims. Rims range in thickness from 5 to 50 µm.

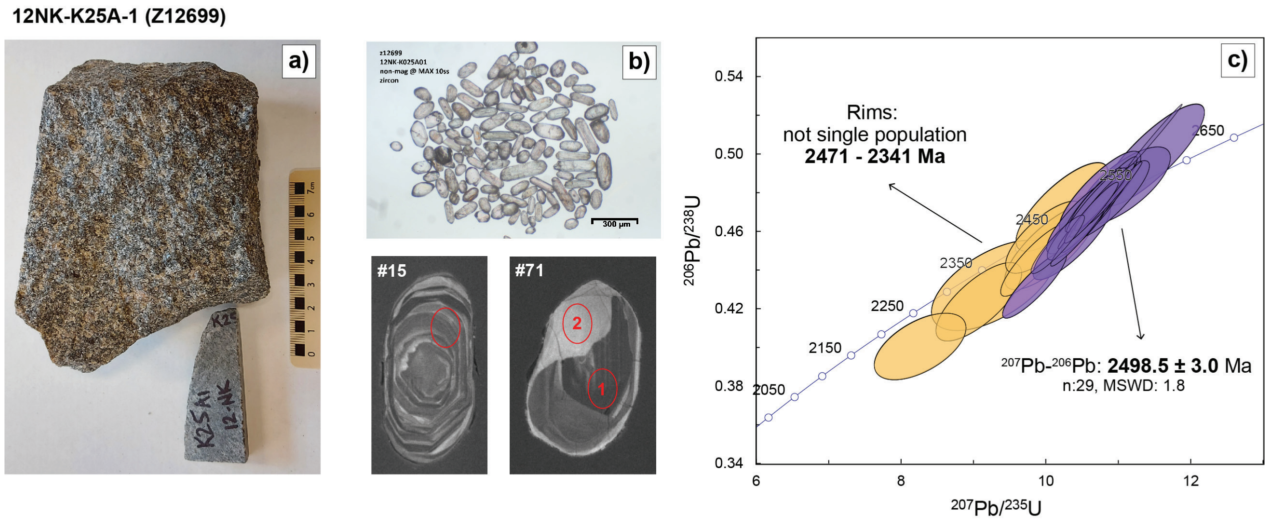

Figure 10: Quartz diorite 12NK-K25A-1: a) equigranular hand sample processed for U-Pb geochronology. b) Plain light photomicrograph of zircon mounted for SHRIMP analysis (upper), and CL image of grains #15 and #71 with analytical spot location (red ellipses are ~20µm), lower. c) Concordia diagram showing U-Pb SHRIMP results. Error ellipses are at 95% confidence level. Blue ellipses represent oscillatory-zoned core analyses used for age calculation; yellow ellipses represent rim analyses used for age calculation. MSWD: Mean Square Weighted Deviation.

Results and interpretation

Twenty-nine analyses of oscillatory-zoned cores yield a weighted mean $^{207}Pb/^{206}Pb$ age of 2498.5 ± 3.0 Ma (Fig. 10c), interpreted as the crystallization age of the quartz diorite. Seven analyses of the bright rims yield dates ranging between 2471 and 2341 Ma (Fig. 10c) and do not define a single age population. Based on zircon textures (i.e., one single rim generation), we interpret the oldest 2471 ± 28 Ma (1σ) as a minimum age of a Paleoproterozoic metamorphic recrystallization ± new growth event (i.e., Arrowsmith orogeny), followed by variable resetting and Pb-loss (e.g. at ca. 2.37 Ga–see sample L20–or younger).

Sample 12NK-L16B-1 (Z12700)

Tonalite (12NK-L16B-1) was sampled from the magnetically high domain that corresponds to ca. 2.46-2.5 Ga granodioritic rocks of Queen Maud granitoid belt (QMg, Fig. 5b). The tonalite is fine-grained, equigranular (Fig. 11a), and similar in texture to the basement tonalites (TTG suite) of Boothia Peninsula dated at ca. 2.52 Ga (Regis unpublished U-Pb data, 2018). U-Pb data for this tonalite will test the affinity of crust within this corridor on the mainland, where nearby quartz diorite (L15, Davis et al., 2014) dated at 2514 ± 3 Ma and tonalite (L23, Davis et al., 2014) dated at 2524 ± 3.5 Ma (metamorphosed at 2426 ± 7 Ma) are suggestive of Boothia terrane basement rocks.

Zircon description

Zircon occurs as subhedral prisms, many with slightly rounded terminations (Fig. 11b upper). Many grains are discoloured indicating alteration. In CL images, grains show a faint oscillatory zoning which is locally disrupted by secondary alteration particularly at grain margins (Fig. 11b lower). Some grains show homogeneous, dark rims in CL (10-70 µm thick, e.g., grains #58, #4, Fig. 11b lower).

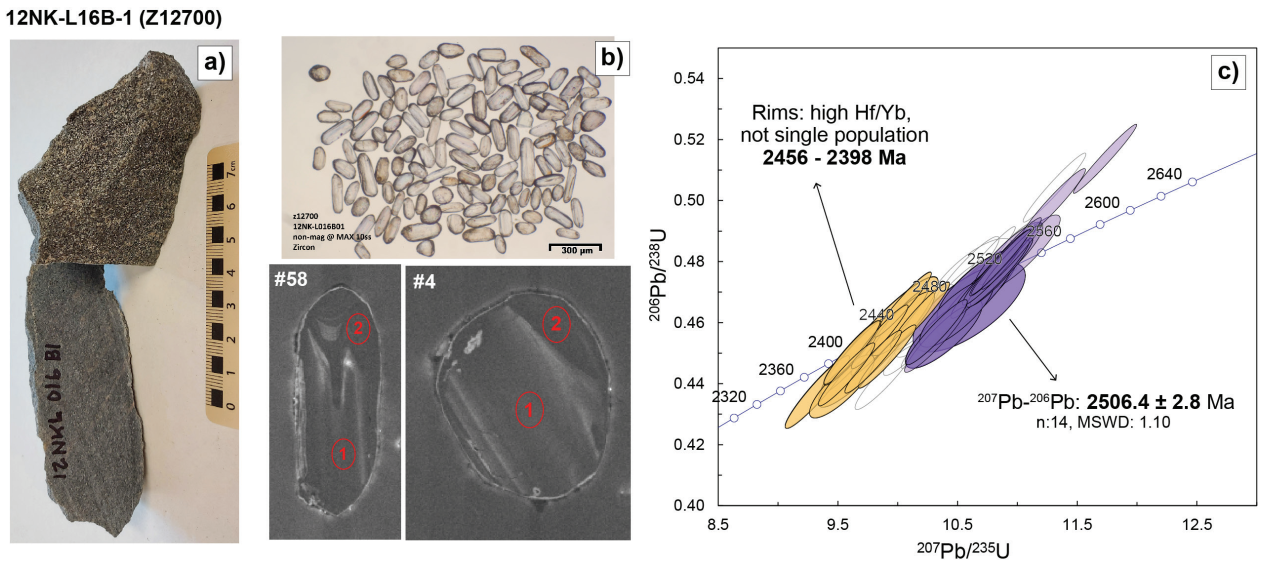

Figure 11: Tonalite 12NK-L16B-1: a) fine-grained hand sample processed for U-Pb geochronology. b) Plain light photomicrograph of zircon mounted for SHRIMP analysis (upper), and CL image of grains #58 and #4 with analytical spot locations (red ellipses are ~20µm), lower. c) Concordia diagram showing U-Pb SHRIMP results. Error ellipses are at 95% confidence level. Blue ellipses represent oscillatory-zoned core analyses used for age calculation; yellow ellipses represent rim analyses used for age calculation. MSWD: Mean Square Weighted Deviation. Grey-outlined ellipses not included in age calculations.

Results and interpretation

The oldest fourteen reproducible (e.g., grains #10, #45) oscillatory-zoned core analyses define an age population with weighted mean ^{207}Pb/^{206}Pb age of 2506.4 ± 2.8 Ma (MSWD: 1.1, Fig. 11c, Appendix 1). Cores are characterized by low Hf/Yb (<60). Darker, homogeneous rims with higher Hf/Yb (75-115) yield dates ranging from 2456 to 2398 Ma (Fig. 11c) and do not define a single age population. The core age is interpreted as the crystallization age of the tonalite while the younger rims, based on chemistry and textures, are interpreted to reflect a Paleoproterozoic metamorphic recrystallization stage(s) (i.e., Arrowsmith orogeny).

Sample 12NK-L20A-1 (Z12701)

Sample 12NK-L20A-1 was collected in the eastern Queen Maud Block domain (QMb, Fig. 5b), a magnetically complex domain that exposes ca. 3.0-3.25 Ga crust. The sample is a medium- to coarse-grained biotite-garnet semipelite, selected to test whether Sherman metasedimentary rocks might overlie the Mesoarchean QMb. At this locality, the semipelitic paragneiss is cut by m-scale sheets of white-weathering, strongly foliated, S-type garnet-sillimanite-biotite leucogranite containg a predominance of >2.8-3.2 Ga zircon (12NK-L20C, Davis et al., 2014) suspected to be inherited from the metasedimentary host rock (analysed in this study) and which precluded determination of a crystallization age for the associated S-type leucogranite.

Zircon description

Zircon grains recovered from the garnet-bearing semipelite are generally of moderate quality, rounded to elongated, prismatic, light to dark brown in color, and range in size from 100 to 350 µm (Fig. 12a, inset upper left). CL images reveal three distinct internal zones (Fig. 12a, inset lower right, Fig. 12c). Oscillatory-zoned cores are rare and are overgrown by two generations of rim. Most of the rounded grains only show the two generations of rims. The first Rim I is dark in CL (Fig. 12c) and characterized by low Yb concentrations (>50 ppm). It is mantled by a thick (50-100µm) bright sector-zoned Rim II (Fig. 12c), with higher Yb concentrations (50-300ppm). Rim II is the most abundant generation preserved in the grains recovered from semipelite 12NK-L20A-1.

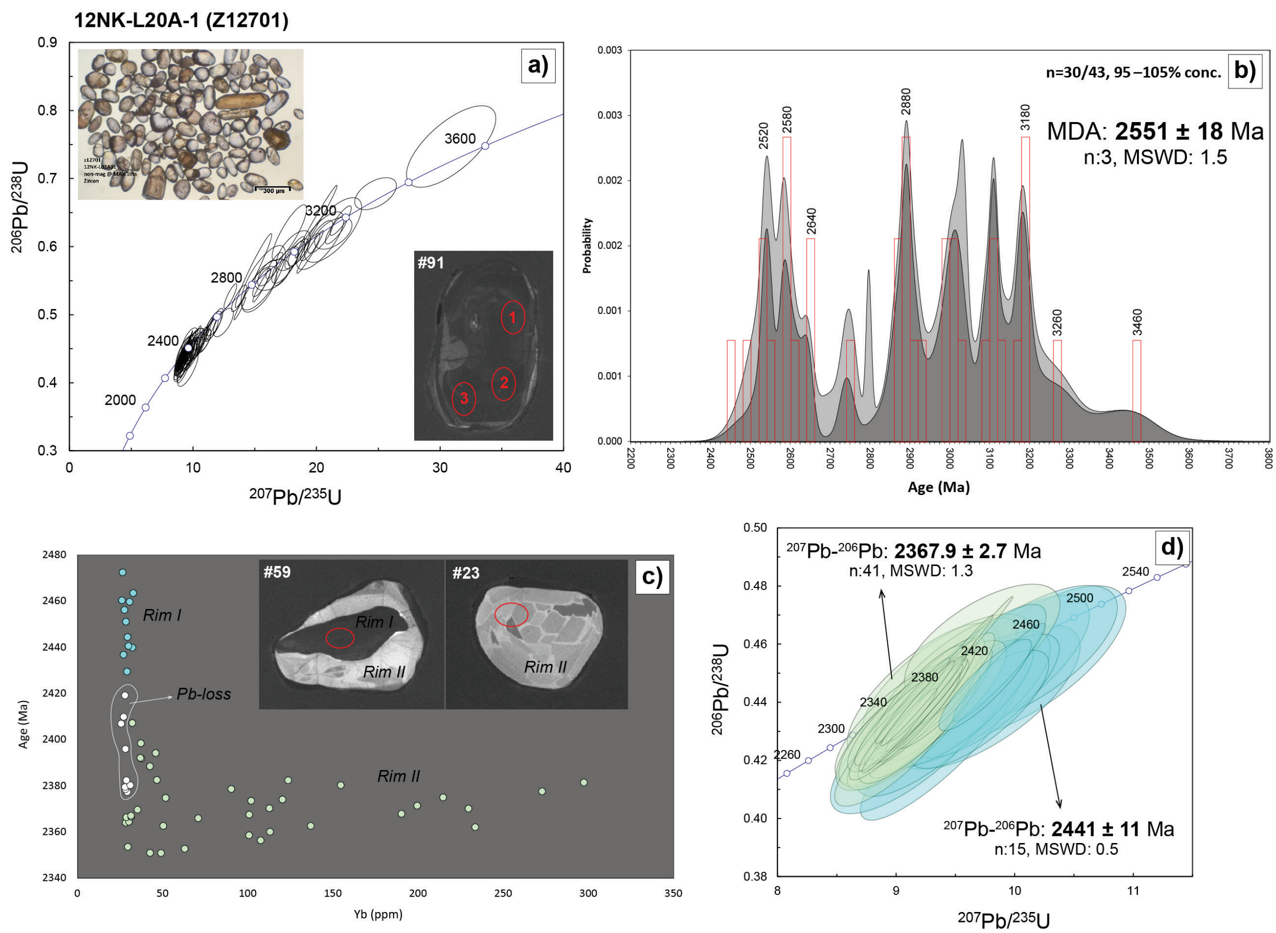

Figure 12: Semipelite 12NK-L20A-1: a) Concordia diagram showing U-Pb SHRIMP results. Error ellipses are at 95% confidence level. Inset lower right shows CL image of grain #31 and analytical spot location (red ellipses are ~20µm). Inset upper left shows plain light photomicrograph of zircon mounted for SHRIMP analysis. b) Summary of detrital zircon U-Pb data shown on a probability density plot; darker fill indicates data screened for 95%-105% concordance; light grey includes all data. Histogram bin width is 10 Ma. MDA: maximum depositional age. c) Age (million years) vs Yb (parts per million) plot for Rim I and Rim II analyses; inset shows CL image of metamorphic grains #59 and #23 and analytical spot location (red ellipses are ~20µm). d) Concordia diagram showing U-Pb SHRIMP results. Error ellipses are at 95% confidence level. Cyan ellipses represent Rim I analyses; light green ellipses represent Rim II analyses. MSWD: Mean Square Weighted Deviation.

Results and interpretation

Ninety-nine analyses were carried out on eighty-five separate zircon grains (Appendix 1). Approximately 60% of the analyses were conducted on the two rim generations. Fifteen analyses on dark Rim I domains (low Yb concentrations) yielded a weighted mean $^{207}Pb/^{206}Pb$ age of 2441 ± 11 Ma (MSWD: 0.5, Fig. 12d), while forty-one analyses on bright, sector-zoned rim II domains (with variable Yb concentrations) yielded a weighted mean $^{207}Pb/^{206}Pb$ age of 2367.9 ± 2.7 Ma (MSWD: 1.3, Fig. 12d). Some Rim I analyses returned ages overlapping with Rim II and are interpreted as affected by Pb-loss. The Rim I and Rim II ages are interpreted to reflect two Paleoproterozoic metamorphic recrystallization stages. Forty-three oscillatory-zoned detrital core analyses range in age between 3470 and 2448 Ma (Appendix 1), with major modes at ca. 3180 Ma, 2880 Ma and 2580 Ma (Fig. 12b). Given the presence of abundant metamorphic rims, the core dates are suspected to have been influenced, in part, by Pb-loss during protracted metamorphism. However, replicate analyses on the youngest reproducible grain provide a maximum depositional age of 2551 ± 18 Ma (n=3, MSWD: 1.5) for sample 12NK-L20A-1. The oldest metamorphic population at 2441 ± 11 Ma provides a minimum constraint for the deposition of this semipelite.

Summary of results

Investigation of the age and affinity of crust across the mainland southwest of the Boothia-Somerset region through U-Pb geochronology of seven legacy samples yielded the following findings. From east to west:

- siltstone (12JP56B-1) deposited after 2672 ± 14 Ma with major modes of 2840-2850, 2870, 2810 and 2940 Ma consistent with the Neoarchean Barclay belt deposited on, and derived from, Rae craton (Hinchey et al., 2007);
- mylonitic granodiorite (12NK-L26A-1) with an interpreted crystallization age of 2633.1 ± 9.8 Ma, pointing to correlation with a regional Rae craton-scale granitic suite (Hinchey et al., 2011, Peterson et al., 2015) informally designated the Snow Island suite;
- a composite plutonic rock (12NK-C3A-1) interpreted as 2599.9 ± 3.9 Ma granodiorite-tonalite cut by 2571.1 ± 5 Ma monzogranite, affected by recrystallization at 1840 ± 40 Ma, possibly related to the Hudsonian orogeny;
- psammite (12JP61A-3) deposited at ca. 2.5 Ga (i.e., after 2492 ± 12 Ma and prior to 2504 ± 5 Ma, its metamorphic monazite age) and derived from minimally transported 2500-2510 Ma source rocks;
- quartz diorite (12NK-K25A-1) dated at 2498.5 ± 3 Ma and affected by 2.47-2.34 Ga recrystallization, consistent with Arrowsmith orogeny;
- fine-grained tonalite (12NK-L16B-1) dated at 2506.4 ± 2.8 Ma affected by protracted/episodic 2.46-2.4 Ga recrystallization, consistent with Arrowsmith orogeny;
- semipelite (12NK-L20A-1) with detrital modes of 3.18, 3.1, 3.0, 2.88, 2.58 and 2.52 Ga consistent with both Mesoarchean Queen Maud and 2.55-2.52 Ga Boothia terrane provenance. This semi-pelite was deposited after 2551 ± 18 Ma and prior to 2441 ± 11 Ma, the oldest metamorphic zircon population (n=15), with subsequent metamorphic recrystallization at 2367.9 ± 2.7 Ma, consistent with protracted/episodic Arrowsmith orogenesis.

Conclusions

The new data presented here indicate that distinct age (i.e., 2.56-2.5 billion years) crust, which typifies the Boothia-Somerset domain, extends to the southwest across the Sherman domain where it is represented by ca. 2.52 Ga tonalite (12NK-L16B-1 *this study*; L15 and L23 of Davis et al. 2014), ca. 2.5 Ga psammite (12JP61A-3) derived from a 2.51-2.5 Ga source, and 2.49 Ga quartz diorite (12NK-K25A-1). Semi-pelite (12NK-L20A-1) containing detritus of both Boothia domain and Mesoarchean Queen Maud age also may have been deposited at ca. 2.5 Ga. These samples all record a ca. 2.47-2.37 Ga metamorphic overprint, attributed to the Arrowsmith orogeny.

In contrast, samples from the eastern part of the transect are of Rae affinity. These include the Barclay belt siltstone (12JP56B-1) and ca. 2.63-2.6 Ga Snow Island suite granodiorite (12NK-L26A-1, -C3A-1). These Rae affinity samples straddle the Chantrey fault zone (Fig. 5) suggesting this regional-scale structure does not represent the Rae terrane boundary.

Ongoing research throughout northwest Laurentia suggests that distinctive Boothia terrane crust is regionally extensive (Fig. 13): extending from eastern Devon Island (Laughton et al., 2022) through Boothia

Peninsula, to the mainland Sherman domain and further southwest underlying the Nonacho Basin (Regis et al., 2022) to Saskatchewan's Zemlak domain (Card et al., 2016; Cloutier et al., 2021). The GEM GeoNorth foundational year research presented here provides new geoscience data and knowledge for a remote region of Nunavut, supporting mineral resource assessments and aiding in the development of new mineral exploration strategies which, in turn, have the potential to provide economic development opportunities in Canada's north.

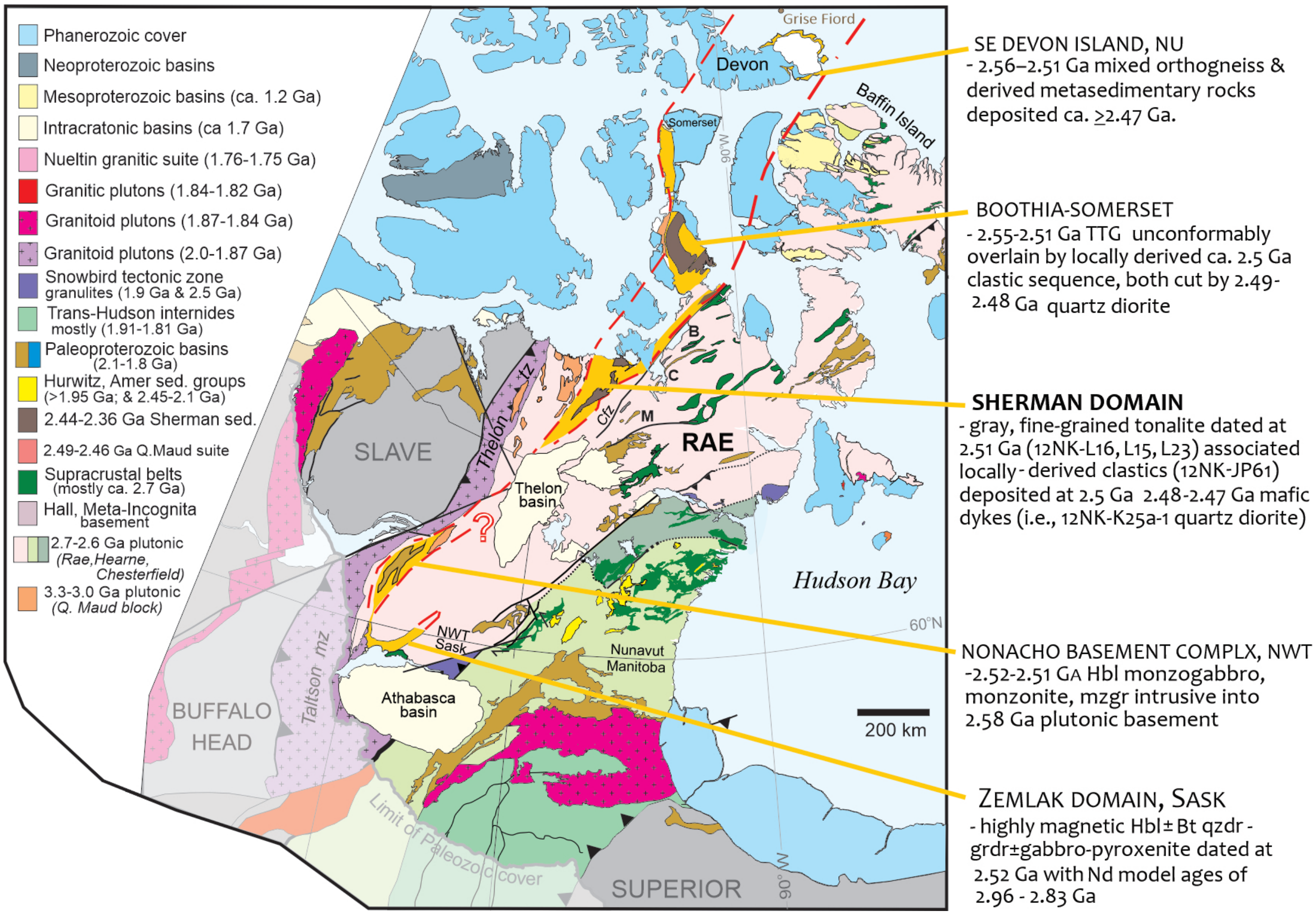

Figure 13: U-Pb analysis of legacy samples, re-interpretation of existing data sets, and integration with ongoing research is revealing a regionally-extensive, contiguous corridor of Neoarchean (2.55-2.51 Ga) crust and derived clastic rocks (yellow-orange unit), first discovered on Boothia-Somerset, extending from Devon Island in the NE (Laughton et al., 2022), through Boothia-Somerset and across the mainland Sherman region to form much of the basement to the Nonacho group (Regis et al., 2022) and linking to the Zemlak domain of Saskatchewan (Cloutier et al., 2021). This thoroughgoing terrane appears to have had little connection to Rae craton until after the 2.45 Ga Arrowsmith Orogeny.

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