New U-Pb geochronological results from Hall Peninsula, Baffin Island, Nunavut

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This work was part of the 2012–2014 Hall Peninsula Integrated Geoscience Program (HPIGP), led by the Canada-Nunavut Geoscience Office (CNGO) in collaboration with the Government of Nunavut, Aboriginal Affairs and Northern Development Canada, and the Geological Survey of Canada. It involved strong contributions from the universities of Alberta, Dalhousie, Laval, Manitoba, Ottawa and Saskatchewan, and the Nunavut Arctic College. It has benefitted from support by local and Inuit-owned businesses and the Polar Continental Shelf Program. The focus is on bedrock (1:250 000 scale) and surficial (1:100 000 scale) geology mapping. In addition, a range of thematic studies is being conducted that includes Archean and Paleoproterozoic tectonics, geochronology, landscape uplift and exhumation, microdiamonds, sedimentary-rock xenoliths and permafrost. The goal is to increase the level of geological knowledge and better evaluate the natural-resource potential in this frontier area.


Abstract

Ages for ten bedrock samples from across southern Hall Peninsula, Baffin Island, Nunavut were determined by zircon U-Pb geochronology. Ages for the basement complex in the eastern portion of the peninsula include tonalite gneiss dated at 2841±3 Ma and deformed megacrystic granite with a crystallization age of 2701±2 Ma. Four metasedimentary samples from locations across the peninsula are demonstrably Paleoproterozoic, with a significant 2.1–1.9 Ga zircon population and maximum ages of deposition that range from 2126±16 to 1906±9 Ma. A quartzite sampled from within the gneissic basement–dominated eastern half of the peninsula contains only Archean detritus and is interpreted to represent a locally sourced, basal clastic package. Metasedimentary rocks in the west are cut by extensive granulite-grade diorite to monzogranite dated at 1892±7 Ma. White-weathering monzogranite cutting psammite and amphibolite yields an age of 1873±6 Ma. Because this monzogranite was subsequently affected by a regionally pervasive, east-west shortening, deformation episode (D1), this age is also a maximum age constraint on the timing of D1 deformation. A sample of weakly to undeformed leucogranite with distinct lilac-coloured garnet is dated at 1867±8 Ma, bracketing the end of D1.

Résumé

Les âges radiométriques de dix échantillons provenant de localités dans le sud de la péninsule Hall, dans l’île de Baffin, au Nunavut, ont été obtenus au moyen de la datation U-Pb sur zircon. Les âges associés au socle de la partie orientale de la péninsule proviennent d’un gneiss tonalitique dont l’âge a été établi à 2841±3 Ma et d’un granite mégacristallin dont l’âge de cristallisation a été fixé à 2701±2 Ma. Quatre échantillons métasédimentaires provenant de localités situées dans l’ensemble de la péninsule datent de la période Paléoprotérozoïque, ainsi que le démontre une population de zircons notable dont l’âge a été établi à 2,1–1,9 Ga et une période de sédimentation qui aurait eu lieu, au maximum, entre il y a 2126±16 Ma et 1906±9 Ma. Un échantillon de quartzite provenant du socle gneissique, qui caractérise la partie orientale de la péninsule, ne renferme que des débris archéens et on estime qu’il s’agit d’un ensemble clastique basal d’origine locale. Les roches métasédimentaires à l’ouest sont recoupées par de grandes unités dioritiques à monzogranitiennes métamorphisées au faciès des granulites dont l’âge a été établi à 1892±7 Ma. Un monzogranite, auquel l’altération confère une teinte blanchâtre, recoupe la psammite et l’amphibole et a donné un âge U-Pb de 1873±6 Ma. La phase de déformation intense d’échelle régionale caractérisée par un raccourcissement est-ouest (D1) qu’a subi subséquemment le monzogranite fait que l’âge établi représente également la limite maximum d’âge pouvant correspondre à la phase de déformation D1. Un échantillon de leucogranite à grenats de couleur lilas distinctif et dont le degré de déformation varie de faible à inexistant permet de fixer la fin de l’épisode D1 à 1867±8 Ma.

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Summary of Activities 2013
Introduction

The Hall Peninsula Integrated Geoscience Project (HPIGP) is being led by the Canada-Nunavut Geoscience Office in collaboration with Geological Survey of Canada (GSC) and a number of university and community partners. The focus is on bedrock and surficial mapping and a range of thematic studies that includes Archean and Paleoproterozoic tectonics and geochronology. This paper presents the first results from a comprehensive U-Pb geochronology research program carried out by the geochronology laboratories of the GSC in support of new 1:250 000 geological maps of Hall Peninsula, Baffin Island, Nunavut (Figure 1; Machado et al., 2013a). A detailed summary of the geology of Hall Peninsula can be found in Machado et al. (2013b), but is briefly summarized here. The eastern half of the peninsula is dominated by an orthogneiss complex ranging in composition from tonalite to syenogranite. Clastic metasedimentary rocks ranging from quartzite to psammitite, from the central and eastern part of the peninsula, are commonly interbedded with thin mafic horizons tentatively interpreted as gabbroic sills, minor marble or calcsilicate and minor iron formation (Machado et al., 2013a, b). Psammitite and minor quartzite in the west are more rarely observed in association with mafic or calcareous rocks, and instead are intruded by voluminous granulite-grade monzogranite to diorite as well as white-weathering, garnet-biotite leucogranite, interpreted as the product of partial melting of the metasedimentary rocks.

In this paper, zircon U-Pb results from 10 samples from across Hall Peninsula are presented. The samples were analyzed using the sensitive high-resolution ion microprobe (SHRIMP) at the GSC. A separate section for each sample contains lithological and zircon descriptions, as well as a discussion of the geochronological results and interpretation. The objective of the geochronology research component of the Hall Peninsula Integrated Geoscience Project is to provide temporal pins for the geological observations. The suite of dated samples achieves this objective by characterizing the age range of the exposed tectonostratigraphic basement, constraining the maximum age of deposition of extensive metasedimentary assemblages and characterizing their provenance signature, and bracketing the timing of deformation through age determinations of Paleoproterozoic plutonic suites.

Analytical procedures

Seven of the ten samples were disaggregated using standard crushing and pulverizing techniques followed by density separation using a Wilfley table; the remaining three samples were comminuted using a CNT Spark-2 electric pulse disaggregator (EPD; Rudashevsky et al., 1995). All samples were subsequently separated by density using heavy liquids. A magnetic separator was used to isolate a zircon separate. Details regarding the procedure, or any deviations from it, are noted in the sections relating to specific samples.

The SHRIMP analytical procedures followed those described by Stern (1997), with standards and U-Pb calibration methods following Stern and Amelin (2003). Briefly, zircons were cast in 2.5 cm diameter epoxy mounts (GSC epoxy mounts #670, 677, 679, 690) along with fragments of the GSC laboratory standard zircon (z6266, with $^{206}\text{Pb} / ^{238}\text{U}$ age = 559 Ma). The midsections of the zircons were exposed using 9, 6 and 1 µm diamond compounds, and the internal features of the zircons (such as zoning, structures and alteration) were characterized in backscattered electron (BSE) mode using a Zeiss Evo® 50 scanning electron microscope. The count rates of 11 masses including background were sequentially measured with a single electron multiplier. Offline data processing was accomplished using SQUID2 (version 2.22.08.04.30, revised April 30, 2008). The 1σ external errors of $^{206}\text{Pb} / ^{238}\text{U}$ ratios reported in the data table incorporate the error in calibrating the standard. Common Pb correction used the Pb composition of the surface blank (Stern, 1997). Details of the analytical session, including spot size, number of scans, calibration error and the applications of any intra-element fractionation corrections are given in the footnotes of the data table (Rayner, 2014). Isoplot v. 3.00 (Ludwig, 2003) 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 and on the figures are reported at the 2σ uncertainty level. Probability density diagrams were generated using AgeDisplay (Sircombe, 2004).

Results

Basement rocks

Tonalite, Beekman Peninsula (12MBC-F105A)

Sample description

A sample of tonalite gneiss was collected on Beekman Peninsula, to contribute to the age characterization of the eastern, tonalite-dominated portion of Hall Peninsula (Figure 1). The tonalite sample is exposed in contact with, and structurally above, a metasedimentary panel comprising psammitite, semipelite, calcsilicate and garnet amphibolite. The contact between the tonalite and the metasedimentary package is parallel with the penetrative fabric found in both units, although the intensity of the fabric increases with proximity to the contact. The tonalite is characterized by banding corresponding to the injection of thin monzogranite stringers (Figure 2a) that are not present in the adja-

\(^2\)CNGO Geoscience Data Series GDS2014-001, containing the data or other information sources used to compile this paper is available online to download free of charge at http://cngo.ca/summary-of-activities/2013/
Figure 1: Simplified geology of Hall Peninsula, Nunavut (modified from Machado et al., 2013a), showing the locations of zircon geochronology samples described in this paper. Abbreviated sample names are given for clarity. The prefix 12MBC- is used for all samples in the text. Mineral abbreviations: Bi, biotite; Grt, garnet; Hbl, hornblende; Kfs, potassium feldspar; Mag, magnetite; Ms, muscovite; Opx, orthopyroxene; Sill, sillimanite.
cent supracrustal units. These stringers were avoided during sampling for geochronology.

Zircon description

This sample was disaggregated using standard crushing and grinding procedures. A magnetic separator was used to isolate a zircon separate and the grains were hand-picked from the nonmagnetic @ 3° side-slope fraction. Abundant, large zircon grains were recovered. The zircon population consistently exhibits oscillatory zoning (Figure 3a, b). Rare grains have thin, unzoned, high-U (bright in BSE images) rims (Figure 3b, grain 60).

Results and interpretation

A total of 38 analyses were conducted on 28 separate zircon grains, yielding $^{207}\text{Pb}/^{206}\text{Pb}$ ages between 2869 Ma and 1779 Ma (Rayner, 2014). The majority of the analyses form a cluster with a mean age of 2841 ±3 Ma (n = 20, mean square of weighted deviates [MSWD] = 1.7), which is interpreted as the crystallization age of the tonalite (Figure 3c). Two zircons yield slightly older ages of ca. 2.87 Ga, interpreted as an inherited component. Younger ages not included in the calculation of the weighted mean include analyses from zircon rims, as well as replicate analyses within zircon cores. These younger ages are largely nonreproducible. Analysis of two high-U, low U-Th unzoned rims suggest a ca. 1.8 Ga metamorphic overprint. This overprint may be responsible for minor Pb loss from the Archean zircon, accounting for some of the scatter to younger ages. A third high-U, low U-Th rim yields a discordant $^{207}\text{Pb}/^{206}\text{Pb}$ age of ca. 2.1 Ga, interpreted as a mixed age due to overlap of the analytical spot onto an Archean core.

Strongly deformed megacrystic granite, central Hall Peninsula (12MBC-F96A)

Sample description

A basement sample of strongly deformed, K-feldspar megacrystic granite was collected from within east-central Hall Peninsula, approximately 40 km west of Allen Island (Figures 1, 2b, c). This unit was formerly described as rapakivi granite (Machado et al., 2013a, b). The granite is in contact with, and is structurally above, a west-dipping metasedimentary assemblage including psammite-semipelite, as well as minor marble, quartzite and diorite. It is inferred that the plutonic phase is part of the eastern basement gneiss complex. The contact between the metasedimentary assemblage and the deformed megacrystic granite is tectonized, and clear intrusive relationships are not preserved.

Zircon description

This sample was disaggregated using standard crushing and grinding procedures. A magnetic separator was used to isolate a zircon separate and the grains were hand-picked from the nonmagnetic @ 3° side-slope fraction. Abundant, large, prismatic zircon grains were recovered (Figure 3d).
In BSE images, the zircons are commonly oscillatory zoned (Figure 3e). Rare grains have thin, unzoned, high-U (bright in BSE images) rims (Figure 3e, grain 10).

Results and interpretation

A total of 38 analyses were conducted on 27 separate zircon grains, yielding $^{207}\text{Pb}/^{206}\text{Pb}$ ages between 2708 and 1832 Ma (Rayner, 2014). A cluster of the 13 oldest zircons yield a weighted mean $^{207}\text{Pb}/^{206}\text{Pb}$ age of 2701 ±2 Ma (MSWD = 0.9), which is interpreted as the crystallization age of the tonalite (Figure 3f). Twenty analyses yield dates between 2689 and 2463 Ma and are not included in the calculation of the weighted mean. These younger ages are generally not reproduced by replicate analyses on the same grain and are interpreted to represent nonzero age Pb loss. Analysis of five high-U, low U-Th unzoned rims yield ages between 1856 and 1832 Ma. These ages are interpreted to record a metamorphic overprint related to the Trans-Hud-
son Orogen; however, due to the limited number of analyses and their nonreproducibility, no metamorphic age is reported here.

**Supracrustal rocks**

**Psammite, Beekman Peninsula (12MBC-F104A)**

Sample description

Sample 12MBC-F104A is a biotite-garnet psammite from an extensive metasedimentary panel exposed on Beekman Peninsula (Figure 1). The metasedimentary assemblage includes minor semipelite, calcisilicate and garnet amphibolite. An early, pervasive metamorphic foliation defined by aligned biotite and sillimanite (S_{bi}) dips to the southwest and is subsequently folded. The sampled psammite was collected from approximately 100 m structurally below the tonalite gneiss described earlier (sample 12MBC-F105A). The psammite is progressively more flaggy approaching the contact with the strongly foliated tonalite. The sampled horizon is steeply west-dipping and characterized by a well-developed parting parallel to foliation (Figure 4a). This sample was collected for U-Pb detrital zircon geochronology to characterize the metasedimentary packages from eastern Hall Peninsula and to test whether these include Archean and/or Paleoproterozoic strata.

Zircon description

This sample was disaggregated using standard crushing and grinding procedures. A magnetic separator was used to isolate a zircon separate and the grains were hand-picked from the nonmagnetic @ 10° side-slope fraction. Abundant, large, zircon grains were recovered, ranging in colour from colourless to dark brown (Figure 5a). Most grains do not preserve well-defined facets and appear subrounded, either due to sedimentary transport or metamorphic resorption. Oscillatory zonation is commonly observed in BSE images, as are thin, high-U rims.

Results and interpretation

A total of 68 analyses were conducted from the internal zones/cores of 65 separate grains. Only Archean detrital ages are preserved in the quartzite (Figure 5b; Rayner, 2014). The youngest, concordant grain yields a single spot 207Pb/206Pb age of 2678 ±8 Ma, interpreted as the maximum age of deposition of the sediment. Replicate analyses on younger grains were not reproducible and therefore not considered as a reliable measure of the youngest detrital zircon. Significant detrital modes are present at 2.68, 2.72, 2.78 and 2.8–2.85 Ga (Figure 5b), which correspond to recently determined ages of basement on Hall Peninsula, including the overlying deformed megacrystic granite (this paper; Scott, 1999). An additional six analyses were carried out on zircon rims, yielding ages between 1878 and 1769 Ma (Rayner, 2014). A small cluster of four analyses yielded an imprecisely constrained mean 207Pb/206Pb age of 1861 ±25 Ma, interpreted to represent a metamorphic overprint and the minimum age of deposition. Based on the similarity of its lithological associations and deformation state with other metasedimentary sequences described herein, this quartzite is interpreted to be part of the Paleoproterozoic assemblage. As both the quartzite-psammite and overlying deformed megacrystic granite are strongly
lineated, the interface does not represent simply an unmodified depositional contact. Based on the presence of exclusively Archean sources, however, the author tentatively proposes that the quartzite represents a basal sequence containing locally sourced detritus.

Quartzite, central Hall Peninsula (12MBC-K97A)
Sample description

The quartzite sample was collected from a doubly plunging synformal basin in the central part of the peninsula (Figure 1). The quartzite panel is a minor constituent of an amphibolite–metasedimentary assemblage, which is cut by ultramafic and monzogranitic plutonic bodies, subsequently deformed then bisected by undeformed pegmatite dikes. This quartzite sample is part of the Qaqqanittuaq area described in greater detail in MacKay et al. (2013a, b) and was collected for U-Pb detrital zircon geochronology to further characterize the metasedimentary packages on Hall Peninsula.

Figure 4: Sedimentary samples and field relationships, Hall Peninsula: a) geochronology sample location (block beneath hammer) of flaggy psammite (12MBC-F104A); view to northwest, geologist is 170 cm tall; b) detail of quartzite sample 12MBC-F96B; c) horizontal exposure of quartz-rich psammite (sample 12MBC-R15A) collected for geochronology, hammer is 90 cm long; d) overview of locality for sample 12MBC-B95A; marble in foreground overlain by psammite (white-cream weathering), which is in turn overlain by gossanous semipelite and finally by semipelite with minor psammite, forming the cliff; view to west, hammer is 40 cm long; inset: detail of sample collected from the upper horizon of semipelite in the cliff; pen magnet is 12 cm long.
Zircon description

The sample was disaggregated using standard crushing and grinding procedures. A magnetic separator was used to isolate a zircon separate and the grains were hand-picked from the nonmagnetic @ 10° side-slope fraction. Detrital zircons recovered from the quartzite are commonly colourless to medium brown (Figure 5c). Many are well rounded, presumably due to sedimentary transport.

Results and interpretation

A total of 68 analyses were conducted on 63 separate zircon grains to define the detrital zircon provenance profile for quartzite sample 12MBC-K97A (Figure 5c; Rayner, 2014). Nine analyses form a cluster at ca. 2.13 Ga, and the maximum age of deposition is constrained by four replicates on grain 42 with a mean 207Pb/206Pb age of 2126 ±16 Ma. The majority of the detrital zircons yield Archean ages with prominent modes between 2880 and 2700 Ma, similar to the prominent modes recorded in sample 12MBC-F96B and consistent with the age of basement documented on Hall Peninsula. Twenty analyses yielded Mesozoic to Eoarchean ages (3.78–2.96 Ga), ages hitherto undocumented on Hall Peninsula.

Quartzite, western Hall Peninsula (12MBC-R15A)

Sample description

A sample was collected from a thin (15 cm) panel of quartzite (Figure 4c) sitting within a more extensive exposure of psammite and structurally below a large outcrop of marble. Although there is little evidence in this location for the extensive in situ partial melting observed elsewhere in the western portion of Hall Peninsula, the psammite is intruded by white-weathering, lilac garnet–bearing leucogranite and minor orange-weathering, biotite-orthopyroxene monzogranite. Every effort was made to avoid the plutonic phases during sampling. This sample was chosen for detrital zircon analysis to more fully characterize the provenance profile of sedimentary rocks across Hall Peninsula and for comparison with the demonstrably Paleoproterozoic se-

Figure 5: Probability density diagrams and histograms for detrital zircon samples from Hall Peninsula. Dark grey curves include only data that fall within the ±5% concordance threshold; light grey curves incorporate all data. Replicates and metamorphic overgrowths are not plotted, regardless of concordance. The bin width is 10 Ma. Maximum ages of deposition (MDA) are reported at the 2σ confidence level (see text for discussion and Rayner [2014] for results). Results are presented with the sample in the lowest structural setting at the bottom of the page (a) and the sample with the highest structural setting at the top of the page (e): a) results from sample 12MBC-F104A; inset: transmitted light image of recovered zircons; scale bar is 300 µm; b) results from sample 12MBC-F96B; inset: transmitted light image of recovered zircons; scale bar is 300 µm; arrows indicate metamorphic overgrowths; c) results from sample 12MBC-K97A; inset: transmitted light image of recovered zircons; scale bar is 300 µm; d) results from sample 12MBC-R15A; inset: transmitted light image of recovered zircons; scale bar is 300 µm; e) results from sample 12MBC-B95A; inset: transmitted light image of recovered zircons; scale bar is 300 µm.
quences identified to the east (samples 12MBC-F104A, -F96B, -K97A).

Zircon description

This sample was disaggregated using standard crushing and grinding procedures. A magnetic separator was used to isolate a zircon separate and the grains were hand-picked from the nonmagnetic @ 10° side-slope fraction. Zircons recovered from the quartzite are commonly subrounded, with aspect ratios of 2:1–4:1, pale brown to medium brown, with oscillatory zoning visible in plane light (Figure 5d). A distinct population of equant, clear, colourless, inclusion- and fracture-free grains is also present. In BSE images, many grains exhibit unzoned overgrowths and the equant and colourless grains are also typically unzoned.

Results and interpretation

A total of 86 analyses were carried out on 71 individual zircon grains yielding dates ranging from 3701 to 1827 Ma (Figure 5d; Rayner, 2014). There is a small cluster of ages between 2.4 and 2.3 Ga that is not apparent in the other samples of this study. Older ages are represented by single data points, whereas the majority of the analyses are younger than 2.0 Ga. Given the prevalence of monzogranite injection at the sampling site, as well as the high metamorphic grade inferred from the extensive partial melting of semipelitic phases elsewhere in the western portion of the peninsula, some of these young results likely represent a metamorphic overprint or thin magmatic injection and not the youngest detrital component. Examination of the morphological and zoning characteristics of the analyzed zircon, as well as replicate analyses to evaluate reproducibility, were necessary to identify the youngest demonstrably detrital grain and constrain the maximum age of deposition. Unzoned tips, rims and equant zircon grains generally yield the youngest dates (1886–1832 Ma) and are inferred to represent a metamorphic overprint. Replicate analyses on both unzoned and zoned zircon are commonly nonreproducible. The youngest zoned zircon with reproducible analyses (grain 11; Rayner, 2014) yielded a weighted mean 207Pb/206Pb age of 1906 ±9 Ma, which is considered to be the maximum age of deposition of the quartzite-psammite assemblage.

Quartzite, western Hall Peninsula (12MBC-B95A)

Sample description

Sample 12MBC-B95A was collected approximately 10 km south-southwest of sample 12MBC-R15A described above. It comprises psammite and gossanous semipelite with extensive partial melting, and has been intruded by lilac garnet–bearing leucogranite. It lies structurally above a small exposure of marble, which is the along-strike equivalent of the large marble outcrop described above as adjacent to sample 12MBC-R15A. Given the consistent westerly dips across the western portion of the peninsula, this sample is the structurally highest unit targeted for geochronology. The sample was taken from a thin (50 cm) horizon of relatively pure quartzite within the psammite (Figure 4d).

Zircon description

This sample was disaggregated using standard crushing and grinding procedures. A magnetic separator was used to isolate a zircon separate and the grains were hand-picked from the nonmagnetic @ 10° side-slope fraction. Zircons recovered from the quartzite are equant to elongate, colourless to medium yellow-brown to medium brown (Figure 5e). Most are well rounded. The majority of zircon crystals have distinct high-U (bright in BSE) rims. In some cases, these clearly truncate internal zoning, indicating a later phase of zircon growth (Figure 5e). In other cases, the high-U zircon is concordant with zoning in the inner part of the grain and may simply represent a change in zircon composition during growth.

Results and interpretation

A total of 56 analyses were carried out on 49 zircon grains, yielding a virtually unimodal age range from 1967 to 1837 Ma (Figure 5e; Rayner, 2014). As in sample 12MBC-R15A, some of these young results likely represent a metamorphic overprint and not the youngest detrital component. Twelve of the fourteen youngest analyses are from zircon with elevated U content (greater than 1500 ppm, most greater than 2000 ppm). Many are unzoned or faintly zoned and some are from distinct secondary phases (rims, patchy overgrowths). Although these do not form a statistically significant age cluster, the author interprets these to represent new zircon growth and/or a disturbance of the U-Pb isotopic system and therefore does not consider their ages to be detrital or a good measure of the age of the youngest detrital zircon. The youngest low-U, clearly zoned zircon with reproducible results yields a weighted mean 207Pb/206Pb age of 1907 ±9 Ma, which is considered as the maximum age of deposition of the psammite. The age constraint is statistically equivalent to the maximum age constraint presented for sample 12MBC-R15A above.

Paleoproterozoic plutonic rocks

Biotite-orthopyroxene monzogranite, western Hall Peninsula (12MBC-B97A)

Sample description

Orange-brown–weathering, biotite–hornblende–orthopyroxene–magnetite–bearing granodiorite to granite is a major unit in western Hall Peninsula. It was observed to cut the metasedimentary package and is itself cut by a white-weathering, lilac garnet–bearing leucogranite. Fine-grained varieties are commonly very friable in outcrop. The unit sampled for geochronology is medium grained (5–10 mm) and forms cliffs at the intrusive contact with marble (Figure 6a).
Zircon description

Electric pulse disaggregation was used to comminute this sample. A magnetic separator was used to isolate a zircon separate and the grains were hand-picked from the non-magnetic @ 5° side-slope fraction. Abundant pale to medium brown zircons with resorbed or rounded facets were recovered from a sample of orthopyroxene-bearing monzogranite. Clear, colourless prismatic zircon is rare. In some cases this morphology is present as cores with pale to medium brown rims (Figure 7a).

Results and interpretation

A total of 40 analyses were carried out on 30 separate zircon grains, yielding ages between 2516 and 1802 Ma (Rayner, 2014). Ages older than 1.92 Ga are not clustered and mainly occur as unique results. These are most often recorded in zoned zircon cores. Two clusters of results occur at ca. 1.89 Ga and 1.83 Ga. The older cluster comprises analyses of zoned and unzoned zircon, whereas the younger cluster comprises only unzoned zircon (Figure 7b). Both groups have similar ranges of U and U-Th values. Replicate analyses of young (ca. 1.83 Ga) unzoned zircon are commonly nonreproducible and also record older, ca. 1.89 Ga, ages (see Rayner, 2014; grains 42, 56, 80, 105). On the basis of zoning and the preservation of older ages in some portions of unzoned zircon grains, the older cluster of results are interpreted to represent the crystallization age of the monzogranite at 1892 ±7 Ma (weighted mean $^{207}$Pb/$^{206}$Pb age; MSWD = 1.6; Figure 5c). The younger cluster at 1828 ±3 Ma (MSWD = 0.75), including reproducible repli-

Figure 6: Paleoproterozoic plutonic samples and field relationships, Hall Peninsula: a) cliff exposure (height approximately 100 m) of biotite-orthopyroxene-garnet monzogranite cutting marble at station 12MBC-B97A; b) amphibolite-metasedimentary assemblage (background) cut by monzogranite (grey resistant unit in foreground, station 12MBC-K79B), both deformed; c) weakly to undeformed lilac garnet-bearing monzogranite (sample 12MBC-B96A); c) detail of geochronology sample illustrating foliation; c) field of view is approximately 10 cm high.

Figure 7: Zircon images and concordia diagrams for the western Hall Peninsula plutonic rocks. Ellipses plotted and mean ages are reported at the 2σ confidence level; black scale bars on transmitted light images are 300 µm, white scale bars on backscattered electron (BSE) images are 20 µm: a) transmitted light image of zircon grains recovered from sample 12MBC-B97A; b) BSE images of zircons from sample 12MBC-B97A; c) concordia diagram of U-Pb results from sample 12MBC-B97A; d) transmitted light image of zircon grains recovered from sample 12MBC-K79B; e) BSE images of zircons from sample 12MBC-K79B; f) concordia diagram of U-Pb results from sample 12MBC-K79B; g) transmitted light image of zircon grains recovered from sample 12MBC-B96A; h) BSE images of zircons from sample 12MBC-B96A; i) concordia diagram of U-Pb results from sample 12MBC-B96A; all data shown in the concordia plot were used to calculate the crystallization age; data with UO/U higher than 7.5 were not plotted or included in calculations (see text for discussion).
Figure 1

c) 12MBC-B97A opx-monzogranite western Hall Peninsula
Crystallization age 1892 ± 7 Ma
n = 10
MSWD = 1.6
Metamorphic overprint 1628 ± 3 Ma
n = 7
MSWD = 0.75

f) 12MBC-K79B monzogranite central Hall Peninsula
Crystallization age 1873 ± 6 Ma
n = 8 (dark grey ellipses)
MSWD = 1.7

i) 12MBC-B96A lilac garnet monzogranite western Hall Peninsula
Crystallization age 1867 ± 8 Ma
n = 9 (dark grey ellipses, UO/U < 7.5)
MSWD = 2.6
cates, is interpreted to represent a metamorphic overprint resulting in the partial to complete recrystallization of igneous zircon.

Monzogranite, central Hall Peninsula (12MBC-K79B)

Sample description

Within the doubly plunging synformal basin in the Qaqqanittuaq area (see MacKay 2013a, b) is a monzogranitic dike that cuts the amphibolite/metasedimentary assemblage (see station 12MBC-K97A, this paper) and has been subsequently deformed (Figure 6b). The age of the monzogranite will constrain the minimum age of the deposition of the sedimentary assemblage into which it intrudes as well as the maximum age of the pervasive east-vergent deformation (D₁ + D₂; see Steenkamp et al., 2014).

Zircon description

Electric pulse disaggregation was used to comminute this sample. A magnetic separator was used to isolate a zircon separate and the grains were hand-picked from the non-magnetic @ 3° side-slope fraction. From the abundant recovery, two main morphological zircon types are recognized. Clear, colourless, prismatic and well-faceted zircon is present as discrete grains as well as cores (Figure 7d). Pale brown, elongate, prismatic, highly fractured zircon comprises overgrowths around colourless zircon cores as well as entire grains.

Results and interpretation

A total of 35 analyses were carried out on 25 separate zircon grains, yielding ages from 2722 to 1849 Ma (Rayner, 2014). The crystallization age of the monzogranite is recorded in high-U zircon and zircon rims with a weighted mean ⁹⁷⁷Pb/⁹⁰⁹Pb age of 1873 ±6 Ma (n = 8, MSWD = 1.7). Three slightly younger analyses are excluded from the calculation of the weighted mean and are considered to have been affected by a small amount of Pb loss. Ages older than 2.1 Ga are recorded in low-U zircon grains and zircon cores and are interpreted to represent inherited material. Replicate analyses from the low-U zircon grains form a linear array on the concordia diagram (Figure 7f) but are nonreproducible (see Rayner [2014], grains 13, 25, 34, 49; Figure 7e). The spread along an apparent discordia curve as well as the nonreproducibility of results suggests that some or all of the spread in ages is due to a disturbance in the U-Pb isotopic system, either through diffusive Pb loss or zircon recrystallization. The ca. 2.7 Ga upper intercept of this ‘discordia’ cannot represent the crystallization age of the monzogranite because field relationships indicate it cuts sedimentary rocks with a maximum age of deposition of 2126 ±16 Ma (sample 12MBC-K97A).

Lilac garnet leucogranite, western Hall Peninsula (12MBC-B96A)

Sample description

A weakly to undeformed, white-weathering, lilac garnet-bearing leucogranite cuts the strongly foliated psammitesemipelite assemblage of sample 12MBC-B95A described above (Figure 6c). Correlative units are interpreted to intrude into the orange-brown–weathering, orthopyroxene-bearing plutonic suite (e.g., sample 12MBC-B97A), thus yielding the characteristic alternating bands of rusty-white and brown rocks across western Hall Peninsula. The age of the monzogranite provides an additional constraint on the minimum age of deposition of the metasedimentary units. The low degree of strain recorded in the leucogranite suggests that pervasive east-west shortening (D₁ + D₂) was largely over by the time of emplacement.

Zircon description

Electric pulse disaggregation was used to comminute this sample. A magnetic separator was used to isolate a zircon separate and the grains were hand-picked from the non-magnetic @ 10° side-slope fraction. The zircon grains are prismatic but strongly resorbed, with few facets preserved (Figure 7g). The BSE images reveal unzoned zircon inner regions separated from unzoned zircon outer regions by a zone of vermicular zircon alteration (Figure 7h). The alteration appears relatively dark in BSE images, likely due to the increased presence of OH−, Ca and Ba, which reduces the mineral density (and BSE response) relative to unaltered zircon. The unzoned outer parts of the grains are typically very thin (>5 µm) but in some cases are wide enough to permit analysis (see Rayner, 2014; grain 36).

Results and interpretation

A total of 25 analyses were carried out on 20 separate zircon grains. Zircon outboard of the zone of alteration has lower U concentrations (400–900 ppm) than zircon inside the alteration zone (typically 6000 ppm, up to 12 000 ppm). There is no correlation between age and analysis location either inside or outside the alteration zone. Due to the anomalously high U concentrations of some of these zircon grains and their effect on the zircon crystal lattice, the ionization and sputtering behaviour of these grains differs from the zircon standard used to calibrate U-Pb fractionation. This anomalous behaviour is best recognized in the measured ²³⁸U/¹⁶⁶O/²³⁸U ratio of the sample in comparison to the zircon standard. The U-Pb age determined by ion probe depends on a fractionation correction that involves UO/U (Stern, 1997). The measured UO/U ratio of the standard during this analytical session is 6.7–7.3. The measured UO/U ratio for the sample over the same session is 6.3–8.3; therefore, the U-Pb age of any analysis with a UO/U value outside of the calibration range (>7.5) is not considered reliable. For this reason, such results are not plotted on the concordia diagram (Figure 7i). The weighted mean ⁹⁷⁷Pb/
206\(^{\text{Pb}}\) ages of the nine remaining zircons is 1867 ±8 Ma (MSWD = 2.6), which is interpreted as the crystallization age of the lilac garnet–bearing leucogranite. Although the 206\(^{\text{Pb}}\)/204\(^{\text{Pb}}\) ages should be unaffected by the calibration effect, their high-U content makes them prone to isotopic disturbance and therefore analyses with high UO/U were also excluded from the calculation of the weighted mean.

**Economic considerations**

Precise, absolute age constraints are an essential component of modern mapping because they provide temporal calibration of geological observations, strengthen regional correlations and place time brackets on tectonometamorphic events. The geochronology results presented in this paper set the stage for further understanding of the basement substrate, host to diamondiferous kimberlites at Chidliak (Pell et al., 2012; From et al., 2014). The clear recognition of a Paleoproterozoic age for sedimentary rocks across Hall Peninsula permits continued study of the origin and evolution of these base-metal prospective rocks. Further comparisons of the provenance profiles of sedimentary rocks across Hall Peninsula with similar datasets from Lake Harbour Group rocks on southern Baffin Island (host to coloured gemstones), Tasiyuk gneiss in Labrador (Scott and Gauthier, 1996; Scott, 1999) or possible equivalents in Greenland (Thrane and Connelly, 2006) will contribute to the assessment of regional tectonostratigraphic correlations.

**Conclusions**

The crystallization age of 2844 ±3 Ma for a tonalite gneiss from Beekman Peninsula (12MBC-F105A) replicates the basement ages reported by Scott (1999) from nearby Allen Island (2835 ±11 Ma) and Brevoort Island (2844 ±6 Ma), as well as at Okalik Bay (2848 ±3 Ma), roughly 60 km to the north. A crystallization age of 2701 ±2 Ma for a distinct, strongly deformed megacrystic granite containing K-feldspar porphyroclasts rimmed by plagioclase (sample 12MBC-F96A) is inferred to correspond to a similar rock type extensively exposed at the head of Smith Channel (unit Ergr from Machado, 2013a). Four of the five metasedimentary samples described in this paper are demonstrably Paleoproterozoic, with significant 2.1–1.9 Ga detritus and maximum ages of deposition that range from 2126 ±16 to 1906 ±9 Ma. These Paleoproterozoic sedimentary units are distributed across the entire map area. Those from the east contain dominant to subdominant Archean detritus, whereas this detrital component is less pronounced to absent in the west. One quartzite sample (sample 12MBC-F96B), associated with marble and mafic sills within the gneissic basement–dominated eastern half of the peninsula, contains only Archean detritus and may represent a locally derived, basal sedimentary package. The 1892 ±7 Ma orthopyroxene-bearing monzogranite (sample 12MBC-B97A) is consistent with that of a comparable lithology dated by Scott (1999, sample D350, 1890 ±3 Ma) and located roughly along strike, approximately 30 km to the north. Likewise, white-weathering monzogranite and leucogranite samples 12MBC-K79B and -B96A yield overlapping ages of 1873 ±6 Ma and 1867 ±8 Ma, respectively, which also correspond to the results for similar rock types described by Scott (1999, samples D320, D108).

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