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U-Pb Zircon Geochronology and Depositional History of the Montresor group, Rae Province, Nunavut, Canada

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J.A. Percival, W.J. Davis and M.A. Hamilton: U-Pb Zircon Geochronology and Depositional History of the Montresor group, Rae Province, Nunavut, Canada

Abstract: Paleoproterozoic metasedimentary successions of the northwestern Canadian Shield provide records of tectonic events, but definition of depositional ages has proved elusive. Previously little studied, the Montresor belt of western Nunavut yields new insight on the 2.2-1.8 Ga time window. Based on U-Pb analyses of detrital zircon in sedimentary rocks and igneous zircon in sills, arenite of the lower Montresor group was deposited between 2.194 and 2.045 Ga, and arkose of the upper Montresor group after 1.924 Ga, adding constraints on the Rae cover sequence. The lower Montresor arenite yielded an older (3.05-2.58 Ga), and a younger, more tightly constrained group (2.194 ± 0.014 Ga). Four of six zircon grains analysed from a gabbro sill within the lower Montresor have discordant $^{207}\text{Pb}/^{206}\text{Pb}$ ages (2.71, 2.66, 2.53, 2.39 Ga) and are considered to be inherited, whereas two grains provide an age of 2045 ± 13 Ma, interpreted to date crystallization and providing a minimum age for the lower Montresor package. Upper Montresor arkose contains detrital zircon with probability density peaks at 2.55-2.25 Ga and 2.1-1.92 Ga, along with scattered older grains (3.8-2.65 Ga). The youngest grain yields an age of 1924 ± 6 Ma, establishing a maximum age for sandstone deposition. Provenance is inferred to have been from the west, where igneous sources of 2.5-2.3 Ga (Queen Maud block) and 2.03-1.89 Ga (Thelon orogen) are known. Collectively, the new ages suggest a minimum 120 m.y. gap between deposition of the pre- 2045 ± 13 Ma lower and post- 1924 ± 6 Ma upper parts of the Montresor group. Similar age constraints may apply to other parts of the Rae cover sequence.

Keywords: U-Pb geochronology; zircon; Paleoproterozoic; Rae cover sequence; Depositional constraints

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Introduction

Unlike most Archean cratons, the Rae Province of northern Canada (Fig. 1) was tectonically thermally reworked during the ca. 2.35 Ga Arrowsmith and ca. 1.9-1.8 Ga Trans-Hudson orogenies (Berman et al. 2005; Berman 2010; Berman et al. 2013a; Pehrsson et al. 2013a,b), as well as being influenced by the ca. 2.0 Ga Thelon orogeny. The sporadically preserved Paleoproterozoic Rae cover sequence (Rainbird et al. 2010) serves both as a record of basin evolution during break-up of the Rae Province, and as a monitor of subsequent tectonism (Pehrsson et al. 2013a; Percival and Tschirhart, submitted).

Based on lithostratigraphic correlations and detrital zircon age constraints, the Rae cover sequence, comprising the Amer, Ketyet River, Montresor and Chantrey groups (Rainbird et al. 2010), appears to be part of a broad, intracontinental sedimentary system including the Piling and Penrhyn groups of the northeastern Rae (Morgan et al. 1975; Corrigan et al. 2009; St-Onge et al. 2009; Wodicka et al. 2014; Partin et al. 2014), and scattered basins of the southwestern Rae (Bethune et al. 2010; Ashton et al. 2013; van Breemen et al. 2013). In their sedimentary strata, the intracratonic facies record much of the Rae Province's Paleoproterozoic history, from rift and subsidence, to the influx of orogenic detritus, and in their post-depositional tectonic history, the effects of subsequent collision and mountain building. The modest metamorphic grade of the clastic sequences makes them attractive targets for studies of provenance and age determinations through detrital zircon geochronology. However, past efforts to date the quartz-rich units near the base of the sequence have yielded only Archean detritus, thus providing only loose constraints (2.5-1.9 Ga) on ages of sedimentary deposition. In this study, we explore the sedimentary record of the Montresor belt (Frisch and Patterson 1983), complementing the growing knowledge base for the Rae cover sequence (Rainbird et al. 2010; Partin et al. 2014; Ferderber et al. 2013).

Regional Geological Setting

The Rae Province extends from beneath Phanerozoic cover in Saskatchewan and Alberta through mainland Nunavut, NWT and central Baffin Island, to west-central Greenland (Fig. 1). Dominated by Meso- to Neoproterozoic plutonic rocks, it contains older vestiges and the widespread ca. 2.6 Ga Snow Island granitic suite (Peterson et al. 2010; 2015; Hinchey et al. 2011). These rocks were sporadically reworked during the ca. 2.35 Ga Arrowsmith orogeny (Berman et al. 2005; 2013a). The Rae cover sequence was deposited after the Arrowsmith event and prior to ca. 1.90 Ga (Rainbird et al. 2010). Only remnants of the cover sequence are preserved in the elongate, northeast-trending Ketyet River, Amer, Montresor and Chantrey belts in central Nunavut, as a result of deformation and metamorphism during the 1.9-1.8 Ga Trans-Hudson orogeny, followed by regional exhumation and erosion (Fig. 2).

To the west, the Rae Province is separated from the 4.0-2.5 Ga Slave craton by the ca. 2.0-1.9 Ga Taltson-Thelon orogen (Hoffman 1989; Berman et al. 2015b). It is bordered to the southeast by the Hearne Province and intervening ca. 1.9 Ga Snowbird tectonic zone (Hoffman, 1989; Berman et al. 2007; Martel et al. 2008).

A composite stratigraphic framework for the Rae cover sequence has been developed by Rainbird et al. (2010), based primarily on the Amer belt and tentative correlations with adjacent outliers. Despite complex folding and thrusting (Patterson 1986; Calhoun et al. 2014; Jefferson et al. 2015), primary stratigraphic relationships are preserved within the Amer belt, where four stratigraphic assemblages are recognized. Assemblage 1 has a locally preserved basal regolith, overlain by sandstone, conglomerate and a distinctive thick, white orthoquartzite unit. These rocks generally contain detrital zircon of only Archean age (3.0-2.6 Ga; Rainbird et al. 2010). Assemblage 2 consists mainly of quartz arenite and some dolostone and is distinguished from

Assemblage 1 by the presence of mafic volcanic flows and/or gabbroic sills. Detrital zircons from the correlated Quartzite Ridge provide a maximum depositional age of ca. 2.5 Ga (op cit.). Owing to the absence of zircon of Paleoproterozoic age, the depositional age of assemblages 1 and 2 is poorly constrained but considered to be 2.3-2.1 Ga. Assemblage 3 contains fine-grained marine clastic units and bedded to stromatolitic carbonate. Its base is an unconformity in the Ketyet River belt (op cit.). Detrital zircon populations include earliest Proterozoic (2.52-2.48 Ga) and younger (1.95-1.91 Ga) grains, providing a maximum depositional age. Assemblage 4 has a coarse basal conglomerate containing clasts from lower in the section, and has been interpreted as syntectonic molasse and flysch (Zaleski et al. 2000). The youngest detrital zircons provide a maximum depositional age of ca. 1.90 Ga (Rainbird et al. 2010).

Geology of the Montresor belt

Two main age groups are represented in the region (Figs. 3, 4): Archean (ca. 2.6 Ga) granite and orthogneiss with sparse paragneiss and amphibolite enclaves; and Paleoproterozoic units including metasedimentary rocks of the Montresor belt (Heywood 1961; Frisch and Patterson 1983; Frisch 1992; 2000) and minor plutonic rocks. Archean granitoid units range in composition from tonalite to granodiorite and granite (Frisch 2000). A K-feldspar porphyritic granodiorite from north of the Montresor belt yielded a U-Pb zircon age of 2589 ± 3 Ma (Fig. 3; Davis et al. 2014). Within the region these rocks range texturally from homogeneous and weakly foliated to augen gneissic, layered gneissic or mylonitic. They are generally metamorphosed to amphibolite facies, except south of the Amer mylonite zone, where some rocks attained granulite facies (Fig. 1; Fraser 1988; Tella 1994; Berman 2010), dated locally at ca. 1.82 Ga (U-Pb monazite; Berman 2010). At the regional scale, deformation and metamorphism of the Archean rocks is attributed to effects of both the ca. 2.35 Ga Arrowsmith and ca. 1.9-1.8 Ga Trans-

Hudson orogenies (Berman et al. 2005; Berman 2010; Berman et al. 2013a; Sanborn-Barrie et al. 2014).

The Archean units are have traditionally been considered to be depositional basement to the Montresor group, although no unconformity has been observed (Frisch and Patterson 1983; Frisch 2000). Recent results (Percival et al. 2015a) support a more complex relationship among the Archean and Paleoproterozoic units (Fig. 4), including elements of the fold-thrust belt interpretation established in the Amer belt, 50 km to the south (Patterson 1986; Rainbird et al. 2010; Tschirhart et al. 2013; Pehrsson et al. 2013a; Calhoun et al. 2014).

The northeastern end of the Montresor belt consists of a structural footwall complex made up of imbricated units including: augen gneiss, quartz arenite and related arkose, chert, dolostone and related calc-silicate rocks, as well as micaceous schist and wacke, the latter unit intruded by boudinaged sills of gabbro and foliated granodiorite. Assemblages in calc-silicate units including forsterite-diopside-tremolite indicate metamorphism to mid-amphibolite facies. All units are transected by sparse dykes up to ~10 m wide, of hornblende granodiorite, biotite granite and pegmatite. Contacts between augen gneiss and sedimentary units are characterized by deformation corridors of flaggy foliation, penetrative lineation, grain size reduction and obliteration of primary textures, and are interpreted as D₁ fault zones (Figs. 3, 4; Percival et al. 2015a,b). No conglomerate or other evidence of an unconformity has been observed at these contacts. Map patterns of units and fault zones suggest polyphase structural imbrication of gneisses and sedimentary units. The metasedimentary rocks of the footwall complex are collectively referred to as the lower Montresor group (Percival et al. 2015b). Lithologically, these units resemble regionally extensive quartzite, mudstone and dolostone strata exposed in the

lower parts of the Amer and Ketyet River belts (Rainbird et al. 2010), informally known as Ps1 and Ps2 (Paleoproterozoic sedimentary assemblages 1 and 2; Pehrsson et al. 2013a).

At structurally higher levels, in the core of the Montresor syncline, are weakly deformed and metamorphosed, fine-grained arkosic sandstone, siltstone and calcareous sedimentary units informally referred to as the upper Montresor group. These units correspond to assemblage 3 (Ps3) of the Amer and Ketyet River belts (Rainbird et al. 2010; Pehrsson et al. 2013a).

At the boundary between the footwall complex and overlying upper Montresor units near the southwestern end of the belt, the footwall complex consists of muscovite-andalusite-sillimanite-garnet schist indicating middle-amphibolite facies conditions (3.3 kbar, 575°C) at 1861-1844 Ma (Berman et al. 2015a; Dziawa 2016). The schistosity dips moderately northwest and is concordant with well-preserved bedding in the structurally overlying, weakly deformed sandstone, siltstone and minor carbonate units of the upper Montresor group. Metamorphic assemblages in these fine-grained metasedimentary units include muscovite-biotite and epidote-zoisite-clinzoisite-actinolite, defining middle greenschist-facies conditions, dated locally by metamorphic monazite at 1847 ± 15 Ma (Percival et al. 2015b). The interface between the upper and lower parts of the Montresor group is interpreted as a late- to post-metamorphic, low-angle extensional detachment fault (D_2) with vertical offset of several kilometres, to account for the missing upper greenschist- and lower amphibolite-facies rocks.

The base of the lower Montresor group is exposed in the southwestern part of the belt as a ductile high-strain zone separating amphibolite-facies schist from gneissic to mylonitic granitoid rocks. Although the age of the high-strain zone relative to other generations of structures is poorly constrained, metamorphic monazite yielded a broadly syn-metamorphic U-

Pb age of 1850 ± 5 Ma, and the event is interpreted as D₃ in the deformation chronology (Percival et al. 2015b).

Sedimentary units of the upper Montresor group include fine-grained, thinly laminated sandstone and siltstone, with sparse dolostone and calcareous sandstone. The siliciclastic units include laterally continuous beds with heavy mineral bands containing detrital magnetite, tourmaline, zircon and apatite that form prominent magnetic marker units. Aeromagnetic maps outline a pair of doubly-plunging, open, upright D₄ synclines (Tschirhart et al. 2015). Detailed analysis reveals low-angle layer truncations interpreted as D₁ thrusts (Tschirhart and Percival 2016; Percival and Tschirhart submitted). In the southwestern syncline, a prominent aeromagnetic low corresponds to a stratabound unit of altered, brecciated igneous rocks that can be extrapolated aeromagnetically for at least 50 km (Tschirhart et al. 2015).

U-Pb Geochronology

Analytical methods are described in Appendix 1 and results reported in Tables 1 and 2. The GSC SHRIMP (Sensitive High-Resolution Ion MicroProbe) was used for detrital zircon U-Pb analyses, whereas for gabbroic zircon, U-Pb analyses were conducted by ID-TIMS at the Jack Satterly Geochronology Lab at the University of Toronto. Isoplot version 3.00 (Ludwig 2003) was used to generate concordia plots and calculate weighted means. All error ellipses on the concordia diagrams and the weighted mean errors are reported at 2σ . Probability density diagrams were generated using AgeDisplay (Sircombe 2004).

A range of options exists for determining the maximum depositional ages of sedimentary rock units based on detrital zircon populations (e.g. Dickinson and Gehrels 2009). In this paper, our approach is guided by the distribution of relatively concordant ages in the detrital

populations. Hence, in one rock (sample 1), the maximum age is based on a cluster of statistically overlapping ages on zircons with similar compositional characteristics, whereas in another (sample 4), the age is based on multiple analytical spots on the youngest grain of a broad age spectrum.

Age constraints on deposition of the Montresor group

Quartz Arenite, lower Montresor group (sample 1 (14PBA-029; 11289))

This sample was taken from a ca. 1 km-wide, fault-bounded panel of homogeneous quartzite surrounded by gneissic granodiorite, constituting part of the putative basement unit of Frisch (1992; 2000) (Sample 1, Fig. 4). The rock is a massive, medium-grained, white to pale pink, sub-arkosic arenite (Fig. 5a; Pettijohn et al. 1987) comprising 90% quartz, 8% feldspar, 1% biotite, 1% muscovite and trace amounts of apatite, titanite and zircon. Zircons are 50 to 150 μm in maximum length, moderately to well rounded, and colourless to pale brown (Fig. 6). Most grains are fractured and many are metamict. Back scattered secondary electron (BSE) images of polished grains generally reveal growth zoning consistent with igneous crystallization.

The detrital zircon population (Fig. 7; Table 1) includes Mesoarchean (3.05-2.80 Ga) and Neoarchean (2.77-2.58 Ga) populations, with a few older grains (3.6-3.2 Ga). The largest peak on the probability density distribution plot (Fig. 7) is made up of 33 grains with ages centred on 2.19 Ga. These grains have uniformly low uranium concentrations (28-132 ppm U) relatively high Th/U (0.7-1.1), and may represent a single age source at 2194 ± 14 Ma. However, owing to relatively low lead contents there is significant analytical uncertainty, and a range of ages cannot be ruled out. Nevertheless, the 2.19 Ga cluster defines the maximum depositional age for the rock.

Granodiorite Sill, lower Montresor group (sample 2 (14PBA-027D; 11291))

Two samples were taken from rare boudinaged sills within a ca. 400-m-wide, fault-bounded panel of interlayered wacke, mudstone and dolostone (Samples 2, 3, Fig. 4). The panel is structurally underlain by granodiorite gneiss and overlain by massive white quartzite (Fig. 4). A sill of foliated granodiorite (14-PBA-027D; Z-11291; Fig. 5b; Table 1) is dominated by zircon with ca. 2.6 Ga ages, presumed to be inherited, but also includes a small population of Paleoproterozoic zircon with an age of 1849 ± 9 Ma. The latter have high uranium contents, Th/U ratios typical of igneous zircon, and could represent the crystallization age of the sill. The Neoproterozoic zircons are discordant with Pb-loss dominantly along a discordia line with a lower intercept defined by the ca. 1.85 Ga zircon age (Fig. 8). This age imposes a lower limit on the age of sedimentation for the lower Montresor group.

Pegmatitic Gabbro Sill, lower Montresor group (sample 3 (12PBAB-017E))

A second sample was collected from a pod of coarse gabbro, part of a bedding-parallel string of boudins (Fig. 5c). The sample yielded a small population of dominantly short, colourless or pale yellow-brown zircon prisms of variably quality, some of which are sharply terminated and some that are more rounded (suggesting a possible mixed magmatic and xenocrystic population)(Fig. 9). A subordinate population of irregular and anhedral grains is also present. Six of the best quality, short, clear, colourless, prismatic zircons were selected for analysis (Fig. 9). Data for four 2-3:1 prisms - sharply faceted to euhedral with only slight rounding, yield model $^{207}\text{Pb}/^{206}\text{Pb}$ ages of 2708 ± 2 Ma (Z1; 2.6% discordant; Table 2), 2659 ± 6 Ma (Z3; 4.4% discordant), 2534 ± 8 Ma (Z4; 8.5% discordant) and 2387 ± 7 Ma (Z6; 13.8% discordant), shown graphically in figure 10a. These older grains are characterized by relatively low U concentrations (66-97 ppm) and variable Th/U (0.2-0.9). A fifth, sharply faceted, short,

clear, colourless, low-U prism (Z2) yields a model $^{207}\text{Pb}/^{206}\text{Pb}$ age of 2047 ± 16 Ma and is essentially concordant, while a sixth grain (Z5) is about 3% discordant, with a $^{207}\text{Pb}/^{206}\text{Pb}$ age of 2040 ± 27 Ma (Fig. 10b). Both analyses show very low U levels (30-60 ppm), low total Pb (4-5 pg), and similar Th/U (0.58, 0.59). Free regression of the two latter analyses, whose $^{207}\text{Pb}/^{206}\text{Pb}$ ages overlap at the 2σ level of uncertainty, yields a lower intercept within error of the origin (Fig. 10b). Assuming zero-aged Pb-loss in these fractions yields a weighted average, or upper intercept age of 2045 ± 13 (MSWD = 0.2; probability of fit = 64%). Considering that the sill intrudes a sedimentary sequence, it is probable that the older zircon population is xenocrystic in origin. We consider the sharply faceted 2045 ± 13 Ma zircon population to have crystallized directly from the gabbroic magma, providing a robust estimate of the age of magmatic crystallization, and a minimum age for deposition of the lower Montresor host sedimentary unit.

Fine-grained sandstone, upper Montresor group (sample 4 (12PBAB-19A; 11290))

A sample of thinly-bedded, pink sandstone (Fig. 5d) was collected from within the magnetic marker sequences of the central Montresor belt (sample 4, Fig. 4). These pink, grey and green, thin-to thickly cross-bedded sandstones and siltstones dip gently to moderately south. Sparse metamorphic muscovite visible in thin section marks the only discernable foliation. Heavy minerals, including magnetite, tourmaline, apatite and zircon are concentrated in mm-scale bands (Fig. 11).

Detrital zircon grains are generally moderately rounded and prismatic, ranging from colourless to altered, turbid and darkly coloured (Fig. 12). They have relatively high uranium contents and many are discordant (Table 1). Age clusters are present at 2.55-2.25 Ga (18 of 59 grains) and 2.1-1.92 Ga (39 grains; Fig. 13). Older individual grains (3.8-2.65 Ga) round out the detrital population. Of the six youngest zircons, one concordant grain (Table 1, grain 9) yields a

weighted mean ($n=4$; $MSWD = 1.2$; probability = 0.31) age of 1923.8 ± 5.9 Ma, taken as the maximum depositional age of the rock.

Discussion

Provenance

Based on lithological similarities, the lower Montresor group has been correlated with the lower parts of the Amer and Ketyet River groups (Figs. 1, 14), specifically assemblages 1 and 2 (Rainbird et al. 2010). Detrital zircon populations from the basal quartz arenite units of these sections contain exclusively Archean grains (Rainbird et al. 2010; Ferderber et al. 2014). The equivalent white quartz arenite unit of the lower Montresor group was not sampled in this study. However, the Archean zircon population of the sub-arkosic arenite, with a broad range of ages between 3.05 and 2.60 Ga, resembles those of the Ayagaq formation of the Amer belt, the lowermost unit of the Ketyet River group (Rainbird et al. 2010), and the Lower Dewar Lakes formation of the Piling Group (Fig. 1; Wodicka et al. 2014), reflecting the diverse basement ages of the Rae Province. The Montresor sample differs significantly as it includes a prominent age peak at 2.19 Ga. Although this age is absent from the lower quartz-rich members of the Rae cover sequence, it is sparsely represented in younger rocks of the sequence, notably the upper Penrhyn (Fig. 1) and Karrat groups (Partin et al. 2014). Detritus of this age is abundant in the upper part of the Murmac Bay group in northern Saskatchewan (Fig. 1; 2171 ± 31 Ma youngest detrital grain; Ashton et al. 2013) and sparse in the Thluicho Lake group (Bethune et al. 2010), 900 km to the southwest, where no source has been identified. In the Piling Group, 1200 km to the east, upper Dewar Lakes quartzite contains two 2160 Ma grains and this age is considered to mark the onset of passive margin development and rifting by ca. 1980 Ma (Wodicka et al. 2014). A similar interpretation could apply to the lower Montresor group, whereby 2190 Ma would

represent initiation of subsidence (cf. Rainbird et al. 2010). The source of 2190 Ma detritus is unknown within the Rae Province (e.g. Ashton et al. 2013), although the volume of material in the Montresor sample (>40% of the zircon population) could indicate a proximal provenance. Magmatic rocks of 2190 Ma age are present regionally, in the form of the east-trending MacQuoid dyke swarm 300 km to the southeast and correlative Tulemalu dykes of the Chesterfield block, near the Rae- Hearne Province boundary (Fig. 1; Tella et al. 2001; Buchan and Ernst 2013). Pehrsson et al. (2002) noted the geochemical similarity of these dykes to tholeiitic flows characteristic of assemblage 2 in the Ketyet River belt. We speculate that the dykes and flows could have been part of a bimodal magmatic suite whose felsic component has now been eroded and incorporated into the Montresor group.

Sandstones of the upper Montresor group have been correlated lithologically with assemblage 3 of the Rae cover sequence (Rainbird et al. 2010), and the detrital zircon population supports the correlation (Fig. 14). In addition to Archean grains (3.8-2.65 Ga), Paleoproterozoic zircon clusters of 2.5-2.3 and 2.1-1.92 Ga (Fig. 11) likely represent contributions from the Arrowsmith and Thelon orogens respectively. This age spectrum, common in assemblage 3 of the Rae cover sequence, is generally attributed to derivation of sediments from the west, where sources include Paleo- to Mesoarchean gneisses (Davis et al. 2013; 2014) and 2.5-2.3 Ga plutonic rocks of the Queen Maud block (Schultz et al. 2007; Tersmette 2012; Davis et al. 2014) and Taltson basement complex (McNicoll et al. 2000), as well as 2.03-1.89 Ga plutonic and metamorphic rocks of the Thelon orogen (van Breemen et al. 1987; Bostock and van Breemen 1994; McDonough et al. 2000; Davis et al. 2014; Berman et al. 2015b).

Age Constraints

The depositional age of the basal quartz-rich units of the Rae cover sequence remains poorly constrained owing to the absence of Proterozoic detrital zircon. These rocks are generally considered to have been deposited in the 2.3-2.1 Ga age range (Rainbird et al. 2010), following the 2.5-2.3 Ga Arrowsmith orogeny. Mafic flows in assemblage 2 of the Amer belt are geochemically correlated with gabbro dated at 2153 Ma (LeCheminant and Roddick, unpublished, cited in Hadlari et al. 2004; Jefferson et al. 2015). At face value, the new geochronological data for the lower Montresor group strongly support this inference, by constraining deposition between 2194 ± 14 Ma and 2045 ± 13 Ma, however some uncertainty is imposed by local stratigraphic disruption by D₁ faults. The age bracket interpretation requires that the sub-arkosic arenite and wacke-mudstone-dolostone sedimentary units be part of the same stratigraphic assemblage, despite being structurally disrupted (Fig. 4). This interpretation is supported by the common association of quartzite-carbonate-wacke-mudstone in assemblage 2 of the Amer and Ketyet River belts (Rainbird et al. 2010). Based on the lithological similarities, we infer that the dated lower Montresor units belong to assemblage 2 (Fig. 14).

Mafic magmatism in the 2030 -2060 Ma age range is sparse but known from widespread locations in the Rae Province. Anorthositic rocks of the deep-crustal Penylan domain (Fig. 1) have ages of 2046 ± 18 , 2048 ± 22 , and 2032 ± 5 Ma (Davis et al. 2015). Gabbroic anorthosite from Southampton Island is 2058 ± 4 (Rayner et al. 2013).

While the new age data help constrain the timing of deposition of the lower Montresor group and by inference, the older parts of the Rae cover sequence, they raise questions about the topographic expression of the Arrowsmith orogen. Berman et al. (2013a) summarized pressure-temperature-time information for Arrowsmith orogenic events across the Rae Province, illustrating widespread thermal and tectonic effects. Continental arc plutonic rocks were

emplaced in the eastern Queen Maud block between ca. 2.55 and 2.32 Ga, followed by a collisional event ca. 2.35-2.30 Ga, which is sporadically preserved across a 2500 by 400 km region representing the basement on which the Rae cover sequence was deposited. The Arrowsmith magmatism, collisional tectonism and amphibolite-to granulite-facies metamorphism should have produced mountainous topography at 2.3 Ga, yet the quartz-rich rocks of the basal Rae cover sequence are interpreted to reflect “a protracted period of enhanced chemical weathering on a slowly subsiding, stable craton” (Rainbird et al. 2010). In particular, why are 2.45-2.30 Ga igneous rocks of the Queen Maud block (Schultz et al. 2007; Tersmette 2012; Davis et al. 2013; 2014), which are exposed less than 200 km northwest of the Montesor belt, not represented in the detrital zircon population? It seems unlikely that all topographic expression of the Arrowsmith orogeny was removed by 2045 Ma, considering that Arrowsmith-aged detritus (2.5-2.23 Ga) is abundant in the younger (ca. 1.9 Ga) sedimentary assemblages (3 and 4) of the Rae cover sequence, suggesting that units of Arrowsmith age were being eroded significantly at that time. Alternatively, it is conceivable that rocks of Arrowsmith age were not exhumed until ca. 1.9 Ga. Davis et al. (2014) reported U-Pb zircon evidence of a widespread thermotectonic event in the Thelon zone and Queen Maud block between ca. 1.93 and 1.90, and Berman et al. (2013b) described a number of areas where deep-crustal rocks with Arrowsmith high-grade metamorphic imprints also record metamorphism of Trans-Hudson age (1.90-1.83 Ga). This observation permits a scenario in which the Arrowsmith orogeny resulted in only minor crustal thickening, exhumation and erosion, such that deep-crustal units were not exposed until Thelon or Trans-Hudson time. Resolution of this question may lie in ongoing thermochronological studies aimed at defining the exhumation history of the Rae Province (D. Regis, pers. comm. 2016).

The sample of upper Montresor sandstone provides a maximum depositional age of 1923.8 ± 5.9 Ma. This sequence has been correlated on lithological grounds with assemblage 3 of the Amer and Ketyet River belts (Rainbird et al. 2010), and the spectrum of detrital zircon ages corresponds well (Fig. 14). The maximum depositional age may be close to the rock's actual age of deposition, based on the observations that: a) younger magmatic rocks are present in the Thelon orogen, at 1.91, 1.90, 1.89 Ga (Berman et al. 2015b) but are not present in the detrital population; and b) clastic rocks of assemblage 4 of the Rae cover sequence and correlative units contain detrital zircon in the 1.91-1.89 Ga age range (Laflamme et al. 2014; Partin et al. 2014; Wodicka et al. 2014). Assemblages 1 through 3 of the Rae cover sequence were deformed (D_1) during early Trans-Hudson orogenesis (Pehrsson et al. 2013) at ca. 1.9 Ga (Berman et al. 2007; Corrigan et al. 2009), prior to or during deposition of assemblage 4 units. In the Amer belt, the Itza Lake formation, representing assemblage 4, is virtually undeformed and metamorphic assemblages include clay minerals, indicating low-grade conditions (Jefferson et al. 2015). A small outlier of kaolinitic sandstone adjacent to the Amer belt was assigned an assemblage 4 designation and correlated with upper Montresor strata 110-180 km to the northeast (op cit.). However, in the Montresor belt proper, structural reconstruction indicates that the upper Montresor rocks were deformed by D_1 thrusts and a D_2 extensional detachment prior to development of the upright Montresor syncline (Tschirhart and Percival, 2016; Percival and Tschirhart, submitted). The D_2 low-angle, extensional fault is responsible for juxtaposing the greenschist-facies upper Montresor rocks with the amphibolite-facies lower Montresor units in the structural footwall complex (Percival et al. 2015b; Dziawa 2016). Combined, the geochronological, structural and metamorphic observations support assignment of upper Montresor strata in the Montresor belt to assemblage 3 of the Rae cover sequence.

Taken together, the age constraints for the Montresor group suggest a minimum gap of ca. 120 m.y. between deposition of the lower Montresor group, prior to 2045 ± 13 Ma, and the upper Montresor group, after 1923.8 ± 5.9 Ma. In the Montresor belt, the contact is a syn-to post-metamorphic extensional detachment fault (D_2) separating the lower-grade upper Montresor group from the higher-grade lower Montresor group, such that the nature of the original relationship is undefined. However, in the Ketyet River belt to the south, the base of assemblage 3 is an unconformity (Rainbird et al. 2010).

Rainbird et al. (op cit.) drew attention to similarities between the Rae cover sequence and Hurwitz Group of the Hearne Province to the southeast (Fig. 1). In addition to four stratigraphic assemblages deposited over approximately the same time interval (2.3-1.9 Ga; Aspler et al. 2001), the lower quartz-rich formations contain detrital zircon exclusively of Archean age, whereas the upper Hurwitz (sequence 3) is dominated by grains of Paleoproterozoic age (ca. 2.35-1.911 Ga), inferred to have been derived from the Taltson-Thelon orogen to the west ((Fig. 1; Davis et al. 2005). A disconformity between sequences 2 and 3 corresponds to a ca. 150 m.y. depositional hiatus from 2.11 to 1.96 Ga. We note that the minimum ca. 120 m.y. depositional gap between assemblages 2 and 3 in the Montresor group, bracketed by the new age constraints at 2.045-1.924 Ga, overlaps with the Hurwitz hiatus, supporting tentative linkages of the Rae and Hearne provinces prior to 1.9 Ga (Aspler et al. 2001; Rainbird et al. 2010). However, the significance of the stratigraphic similarities remains uncertain in light of mounting structural, metamorphic and tectonic lineage evidence pointing to the Snowbird tectonic zone (Fig. 1) as the ca. 1.9 Ga suture between the Rae and Hearne provinces (Berman et al. 2007; Martel et al. 2008; Pehrsson et al. 2013b).

Regional Structural Considerations

Results of the present study support broad correlation of Montresor belt strata with other parts of the Rae cover sequence, as well as with the Piling Group. Montresor quartz arenite was not sampled, because these rocks generally contain only Archean zircons (Rainbird et al. 2010), such that confirmation of correlation is not possible. However, accepting the lithological correlation of this unit as the regional stratigraphic base of the sequence, the lower Montresor quartz arenite is out of stratigraphic order, structurally overlying the wacke - mudstone - dolostone unit (Fig. 4). However, this thrust fault, along with those imbricating basement with cover, have less offset than those of the Amer belt 50 km to the south, where D₁ faults cut higher into the stratigraphic section (Patterson 1986; Calhoun et al. 2014; Jefferson et al. 2015). Furthermore, Amer basal quartzite is isoclinally folded, implying a more ductile deformation style than that observed in the basal Montresor units. Together, these observations point to a more distal orogenic setting for the Montresor belt during D₁ deformation.

The age of D₁ deformation is not directly constrained by the present data set. In the southwest Rae, the Murmac Bay Group (Fig. 1) was metamorphosed and deformed during the Taltson orogeny (1940-1930 Ma) and Snowbird phase of the Trans-Hudson orogeny (1910-1900 Ma; Bethune et al. 2013). There is no record of the 1940-1930 Ma event in the Montresor belt, which has a younger tectonometamorphic history based on the age of metamorphic monazite growth beginning ca. 1870 Ma (Davis et al. 2014; Percival et al. 2015b; Dziawa 2016). The deformational history of the belt is therefore related to effects of the Snowbird phase of the Trans-Hudson orogeny (Figs. 2, 14).

The D₂ extensional event had significant effect in the Montresor belt, juxtaposing the thin-skinned deformation style of the upper Montresor with the thick-skinned structural footwall

complex of imbricated basement and lower Montresor units. This event may also have been responsible for unroofing a region of granulite-facies rocks between the Amer and Montresor belts (Berman 2010), possibly along a north-dipping detachment ancestral to the Amer fault zone (Tella 1994; Percival et al. 2015b). In the Amer belt, Calhoun et al. (2013) recognized layer-parallel detachment faults focused in carbonate beds, suggesting that late Trans-Hudsonian extensional features could be more widespread than previously appreciated (cf. Corrigan et al. 2009).

Conclusions

The lower Montresor group is exposed in a series of fault-bounded panels, imbricated with Archean basement along D₁ thrust faults and out of stratigraphic order. Basal quartz arenite was not sampled for geochronology but is presumed to correlate with other quartz-rich members of the Rae cover sequence. An isolated panel of sub-arkosic arenite yielded a spectrum of detrital zircon ages with a cluster between 3.05 and 2.58 Ga and a peak at 2194 ± 14 Ma. The younger peak may define a single population, establishing the maximum age for deposition of the rock, and for imbrication with Archean basement gneisses. A second fault-bounded panel of wacke, mudstone and dolostone, lithologically similar to assemblage 2 of the Rae cover sequence, is cut by gabbro sills containing sparse zircon. Single grains yielded U-Pb ages of 2.71, 2.68, 2.53 and 2.39 Ga, whereas a pair of sharply faceted crystals provided an age of 2045 ± 13 Ma. The Archean grains are interpreted to be inherited, whereas the younger zircons are inferred to represent the crystallization age of the gabbro, providing a lower limit on the age of sedimentation. Together, the data bracket deposition of part of the lower Montresor group between 2194 ± 14 and 2045 ± 13 Ma, a constraint that may apply to correlative assemblage 2 units of the Rae cover sequence.

The upper Montresor group comprises a sequence of fine-grained sandstone and siltstone, including calcareous varieties, with interbedded dolostone. Exposed in an open synclinal structure, these weakly metamorphosed units have been correlated with assemblage 3 of the Rae cover sequence (Rainbird et al. 2010). The detrital zircon population is dominated by Paleoproterozoic age peaks at 2.55-2.25 and 2.1-1.92 Ga, interpreted as being derived from the Queen Maud block and Thelon orogen to the west. The youngest concordant grain, at 1923.8 ± 5.9 Ma provides a maximum age for submarine sandstone deposition. This may be close to the actual time of deposition, as the Thelon orogen continued to produce magmatic rocks until ca. 1890 Ma (Berman et al. 2015b).

As part of the Rae cover sequence, the Montresor belt was deposited on basement affected less than 250 m.y. previously by the Arrowsmith orogeny (Berman et al. 2013a). Paradoxically, detritus of Arrowsmith age is absent from the 2.19-2.045 Ga lower units of the Montresor group but abundant in the <1.924 Ga unit. This could be explained if rocks produced during the Arrowsmith orogeny were not exhumed until the Taltson-Thelon orogeny, or the early stages of the Trans-Hudson orogeny.

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Appendix 1: Analytical Methods**SHRIMP (Sensitive High-Resolution Ion MicroProbe)**

Samples were crushed by mechanical disaggregation, followed by sieving, and density separation using water panning at the Geochronology facility, GSC, Ottawa. SHRIMP analytical procedures modified from those described by Stern (1997), with standards and U-Pb calibration methods following Stern and Amelin (2003). Details regarding the procedure, or any deviations from it, are noted in the section relating to specific samples. Briefly, zircons were cast in 2.5 cm diameter epoxy mounts (along with fragments of the GSC laboratory standard zircon; z6266, with $^{206}\text{Pb}/^{238}\text{U}$ age = 559 Ma). The mid-sections of the zircons were exposed using 9, 6, and 1 μm diamond compound, and the internal features of the zircons (such as zoning, structures, alteration, etc.) were characterized in back-scattered electron mode (BSE) utilizing a Zeiss Evo 50 scanning electron microscope. The count rates at eleven masses including background were sequentially measured with a single electron multiplier. Off-line data processing was accomplished using SQUID2 (version 2.5; Ludwig 2009). 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 utilized the Pb composition of the surface blank (Stern 1997). Yb and Hf concentration data were calculated using sensitivity factors derived from standard 6222 with values of 229 and 8200 ppm respectively. Isoplot v. 3.00 (Ludwig 2003) was used to generate concordia plots and calculate regression ages and weighted means. The error ellipses on the concordia diagrams and the weighted mean errors are reported at 95% confidence intervals. Run condition for individual analytical sessions are given in Table 2.

TIMS (Thermal Ionization Mass Spectrometry)

Samples were processed in the Jack Satterly Geochronology Lab at the University of Toronto. Conventional crushing and grinding techniques (jaw crusher and disc mill) were employed, followed by a shaking water (Wilfley) table procedure to obtain a heavy mineral concentrate, and finally by Frantz magnetic and methylene iodide heavy liquid separations. Extra precaution was made to prevent any possible sample cross-contamination since the anticipated recovery of datable accessory phases in this rock was low. Following hand-picking of the best quality, fresh zircon, selected grains were photographed and then analyzed using conventional isotope dilution - thermal ionization mass spectrometry (ID-TIMS) methods. Zircons were pretreated with a chemical abrasion procedure involving annealing at 1000°C for 48 hrs and leaching in a dilute mixture of HF:HNO₃ for several hours at 200°C. Final weight estimates were made from a digital measurement of grain dimensions and the mineral's density. Zircon grains were washed on parafilm and loaded into Teflon bombs with concentrated HF along with a mixed ²⁰⁵Pb - ²³⁵U isotopic tracer solution (Krogh 1973). Dissolution occurred over three-four days at 195°C, after which fractions were dried down with phosphoric acid and loaded with silica gel directly onto outgassed rhenium filaments. Larger grain dissolutions were passed through ion exchange columns to obtain purified elutions of Pb and U. The isotopic compositions of Pb and U were measured using a single Daly collector with a pulse counting detector on a solid source VG354 mass spectrometer. A detector mass discrimination of 0.053% per atomic mass unit (AMU) and a dead time of 20 nsec were employed for Daly detector measurements. A thermal source mass discrimination correction of 0.1% per atomic mass unit was applied for both Pb and U. The assigned laboratory blank for U was 0.2 pg, while that for Pb is routinely measured below 1 pg. Error estimates were calculated by propagating known sources of analytical uncertainty for each analysis including within-run ratio variability, uncertainty in the fractionation correction, and

uncertainties in the isotopic composition of laboratory blank. Uncertainties for the ID-TIMS data are given at the 95% (2σ) confidence level. Initial corrections were made using an in-house data reduction program (UTILAGE). Decay constants used in age calculations are those of Jaffey et al. (1971). Graphical data presentation and quoted ages were generated using the Microsoft Excel Add-in Isoplot/Ex v. 3.00 of Ludwig (2003).

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FIGURE CAPTIONS

Figure 1: Regional geology of the northwestern Canadian Shield (after Aspler et al. 2001; Rainbird et al. 2010; Buchan and Ernst 2013; Davis et al. 2015) showing location of features referred to in the text, including dashed box: Figure 2; A: Amer belt; B: Boomerang belt; C: Chantrey belt; CB: Chesterfield block; HG: Hurwitz group; K: Ketyet River belt; M: Montresor belt; Md: MacQuoid dyke swarm; Mu: Murmac Bay group; N: Nonacho basin; PD: Penylan domain; Pe: Penrhyn Group; Pi: Piling Group; QMB: Queen Maud block; SI: Southampton Island; STZ: Snowbird tectonic zone; TTZ: Thelon tectonic zone; TMZ: Taltson magmatic zone; T: Tehery belt; Td: Tulemalu dyke swarm; Tl: Thluicho group. Patterned areas in the central Rae are the mid-Proterozoic Athabasca (At), Baker (Ba) and Thelon (Th) sedimentary basins.

Figure 2: Summary of Paleoproterozoic geological events of the Rae Province.

Figure 3: Simplified geology of the Montresor belt (after Percival et al. 2015b; Frisch 1992; Tella 1994) showing major features referred to in the text. Box shows location of figure 4.

Figure 4: Geology of the northeastern Montresor belt (after Percival et al. 2015b), showing location of dated samples.

Figure 5: Field photographs of dated units of the Montresor belt. a) pale pink, sub-arkosic arenite (sample 1: 14PBA-029; 11289) from the lower Montresor group. The unit occurs as a fault-bound panel in the structural footwall complex; b) granodiorite sill (sample 2: 14PBA-027D; 11291)(chipped, positive-weathering, 12 cm wide body), lower Montresor group; c) pegmatitic gabbro (sample 3: 12PBAB-017E) from 20 cm boudin in wacke, lower Montresor group; d) cross-bedded, fine-grained arkosic sandstone (sample 4: 12PBAB-19A; 11290), upper Montresor group.

Figure 6: Photomicrograph of the zircon population in sub-arkosic arenite (sample 1: 14PBA-029; 11289) of the lower Montresor group, prior to mounting for imaging and SHRIMP analysis.

Figure 7: Summary of detrital zircon U-Pb data for sub-arkosic arenite sample 1 (14PBA-029; 11289) of the lower Montresor group, shown on combined probability density plot (darker fill indicates data screened for 95-105% concordance, lighter grey fill includes all data) and histograms (grey outline; bin width = 20 Ma).

Figure 8: Concordia diagram for U-Pb zircon data from sample 2 (14PBA-027D; 11291).

Figure 9: Representative, largely prismatic igneous zircon population from pegmatitic gabbro, 12PBA-B017E (sample 2). Selected zircons chosen for analysis are labelled (Z1-Z6).

Figure 10: Concordia diagram for U-Pb zircon data from sample 3 (12PBA-B017E). a) full data set for individual grain analyses. Discordant oldest four fractions (shaded ellipses) are interpreted to be xenocrystic in origin. Inset (b) shows area for youngest two fractions; unshaded ellipses. b) enlarged region with detail for most sharply faceted short prisms Z2 and Z5.

Figure 11: Thin section photomicrographs of upper Montresor sandstone (sample 4: 12PBAB-19A; 11290) showing a) heavy mineral bands outlined by magnetite (opaque, between arrows); b) close-up showing a variety of heavy minerals including magnetite (mt), tourmaline (tm), apatite (ap) and zircon (zr).

Figure 12: Photomicrograph of the zircon population in sandstone of the upper Montresor group (sample 4: 12PBAB-19A; 11290), prior to mounting for imaging and SHRIMP analysis.

Figure 13: Summary of detrital zircon U-Pb data for cross-bedded arkosic sandstone sample 4 (12PBAB-19A; 11290) of the upper Montresor group, shown on combined probability density

plot (darker fill indicates data screened for 95-105% concordance, lighter grey fill includes all data) and histograms (grey outline; bin width = 20 Ma).

Figure 14: Summary of proposed correlations within the Rae cover sequence, updated from Rainbird et al. (2010) (Amer and Ketyet River groups) by including recent data from the Montresor group (this paper), Piling group (Wodicka et al. 2014) and Penhryn group (Partin et al. 2014). Assemblages 1, 2 and 3 were deformed during the ca. 1.9 Ga Snowbird phase of the Trans-Hudson orogeny prior to deposition of assemblage 4 and subsequent deformation during the main phase of the Trans-Hudson orogeny, ca. 1.85-1.78 Ga.

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Table 1: U-Pb SHRIMP analytical data

Spot name	Atomic Ratios															Model Age (Ma)							Disc. (%)
	U	Th	Th	Yb	Hf	²⁰⁴ Pb	%	f(206) ²⁰⁴	²⁰⁶ Pb*	²⁰⁸ *Pb	%	²⁰⁷ *Pb	%	²⁰⁶ *Pb	%	Corr	²⁰⁷ *Pb	%	²⁰⁶ Pb	± ²⁰⁶ Pb	²⁰⁷ Pb	± ²⁰⁷ Pb	
	(ppm)	(ppm)	U	(ppm)	(ppm)	²⁰⁶ Pb	err		(ppm)	²⁰⁶ *Pb	err	²³⁵ U	err	²³⁸ U	err	Coeff	²⁰⁶ *Pb	err	²³⁸ U	²³⁸ U	²⁰⁶ Pb	²⁰⁶ Pb	
SAMPLE 1: Sub-arkosic arenite 14PBA-029; 11289 (66.3419, -96.5780)																							
11289-001.1	80	51	0.66	163	9824	5.4E-04	24	0.94	27.7	0.196	5.0	7.522	2.2	0.4029	1.4	0.631	0.1354	1.7	2183	26	2169	30	-1
11289-003.1	52	38	0.76	155	9507	3.1E-04	41	0.55	17.7	0.227	5.7	7.553	2.4	0.3957	1.6	0.641	0.1384	1.9	2149	28	2208	32	+3
11289-004.1	63	30	0.49	118	8906	1.5E-04	58	0.27	27.1	0.112	8.0	13.276	2.1	0.5010	1.7	0.779	0.1922	1.3	2618	36	2761	22	+6
11289-005.1	53	33	0.65	124	9905	-1.3E-04	71	-0.23	17.6	0.217	5.9	7.793	2.3	0.3901	1.6	0.691	0.1449	1.7	2123	29	2286	29	+8
11289-006.1	51	36	0.73	143	9231	5.6E-04	33	0.97	17.0	0.206	6.9	7.163	3.0	0.3894	1.6	0.556	0.1334	2.5	2120	30	2143	43	+1
11289-008.1	54	27	0.52	111	9900	1.1E-04	58	0.19	33.3	0.139	5.8	32.122	1.9	0.7206	1.7	0.873	0.3233	0.9	3498	45	3586	14	+3
11289-014.1	67	42	0.66	133	9307	4.2E-04	32	0.74	24.1	0.168	6.3	7.792	2.4	0.4203	1.5	0.626	0.1345	1.9	2262	29	2157	33	-6
11289-015.1	33	27	0.84	71	8996	5.9E-04	33	1.01	15.0	0.260	6.2	13.577	2.6	0.5245	1.8	0.691	0.1877	1.9	2718	40	2722	31	+0
11289-016.1	113	63	0.57	140	10321	1.9E-04	33	0.33	46.6	0.156	4.2	10.849	1.6	0.4799	1.3	0.807	0.1640	1.0	2527	28	2497	16	-1
11289-020.1	79	44	0.57	211	8078	2.5E-04	35	0.44	34.4	0.153	5.5	15.089	1.9	0.5091	1.6	0.821	0.2150	1.1	2653	34	2943	17	+12
11289-023.1	96	87	0.94	269	9895	4.1E-04	27	0.71	32.5	0.249	4.0	7.252	2.0	0.3957	1.3	0.662	0.1329	1.5	2149	25	2137	27	-1
11289-028.1	53	60	1.17	273	9334	-1.1E-04	71	-0.20	18.4	0.350	4.2	8.078	2.2	0.4070	1.6	0.710	0.1439	1.6	2201	29	2275	27	+4
11289-029.1	220	213	1.00	115	7697	3.5E-04	18	0.60	90.4	0.301	2.2	12.163	1.4	0.4780	1.2	0.859	0.1845	0.7	2519	26	2694	12	+8
11289-032.1	81	65	0.82	161	9693	1.1E-04	58	0.18	35.8	0.231	7.4	13.026	1.9	0.5136	1.5	0.802	0.1839	1.1	2672	33	2689	18	+1
11289-037.1	72	69	0.99	194	9819	2.8E-04	33	0.49	34.2	0.256	4.0	16.174	1.8	0.5507	1.5	0.811	0.2130	1.1	2828	34	2929	17	+4
11289-044.1	53	32	0.62	136	9763	5.5E-04	33	0.95	18.7	0.176	11.1	7.701	2.9	0.4117	1.7	0.573	0.1357	2.4	2223	31	2172	41	-3
11289-047.1	161	86	0.55	229	8805	9.8E-05	41	0.17	71.2	0.153	3.6	14.371	1.4	0.5151	1.3	0.870	0.2023	0.7	2678	28	2845	12	+7
11289-048.1	46	30	0.67	136	9251	1.1E-03	26	1.87	14.9	0.188	8.8	7.077	3.7	0.3816	1.7	0.468	0.1345	3.3	2084	31	2158	57	+4
11289-052.1	110	98	0.92	352	8704	1.3E-04	35	0.23	59.9	0.254	5.4	22.245	1.5	0.6334	1.3	0.892	0.2547	0.7	3163	33	3214	11	+2
11289-055.1	46	23	0.52	112	9672	1.8E-04	58	0.31	16.6	0.132	12.3	7.737	2.4	0.4160	1.6	0.665	0.1349	1.8	2242	31	2162	32	-4
11289-058.1	139	133	0.99	366	9649	---	---	0.00	47.8	0.288	2.9	7.561	1.6	0.3996	1.3	0.820	0.1372	0.9	2167	23	2193	15	+1
11289-060.1	199	221	1.15	149	11337	4.2E-04	17	0.74	96.9	0.218	4.0	16.789	1.6	0.5677	1.2	0.769	0.2145	1.0	2898	28	2940	16	+2
11289-066.1	70	51	0.76	176	9824	5.1E-04	32	0.89	24.4	0.199	6.4	7.699	3.8	0.4081	1.7	0.443	0.1368	3.4	2206	32	2187	60	-1
11289-067.1	108	105	1.01	312	9263	2.7E-04	32	0.47	37.2	0.282	3.5	7.438	1.8	0.4027	1.3	0.748	0.1340	1.2	2182	25	2150	21	-2
11289-070.1	81	73	0.92	295	9420	2.2E-04	41	0.37	29.2	0.282	4.0	7.830	1.9	0.4177	1.4	0.747	0.1360	1.3	2250	27	2176	22	-4
11289-071.1	137	129	0.97	341	9670	1.9E-04	29	0.33	67.7	0.274	2.6	16.254	1.5	0.5740	1.3	0.867	0.2054	0.7	2924	30	2869	12	-2

11289-073.1	63	37	0.61	132	9617	-5.4E-03	10	-9.38	24.1	0.346	6.4	12.942	3.5	0.4479	1.8	0.520	0.2096	3.0	2386	36	2902	48	+21
11289-074.1	181	60	0.34	105	11363	2.5E-05	71	0.04	92.2	0.098	3.8	18.186	1.5	0.5943	1.2	0.851	0.2219	0.8	3007	30	2995	12	-1
11289-078.1	93	88	0.98	287	9541	3.3E-04	32	0.57	31.3	0.283	3.8	7.336	2.0	0.3912	1.4	0.678	0.1360	1.5	2129	25	2177	26	+3
11289-079.1	159	79	0.51	90	10606	7.8E-05	41	0.14	72.7	0.141	6.5	14.099	1.4	0.5325	1.2	0.887	0.1920	0.6	2752	28	2760	10	+0
11289-081.1	179	65	0.37	171	9917	2.6E-05	71	0.04	76.7	0.098	3.8	12.136	1.4	0.4978	1.2	0.888	0.1768	0.6	2604	26	2623	10	+1
11289-084.1	145	60	0.43	240	9760	3.8E-05	58	0.07	72.1	0.127	3.4	16.851	1.4	0.5784	1.2	0.902	0.2113	0.6	2942	29	2915	10	-1
11289-086.1	192	273	1.47	191	9187	7.7E-05	38	0.13	86.4	0.420	1.7	13.584	1.3	0.5232	1.2	0.896	0.1883	0.6	2713	27	2727	10	+1
11289-087.1	65	53	0.83	206	9485	8.7E-05	71	0.15	22.1	0.225	10.6	7.525	2.1	0.3953	1.5	0.688	0.1380	1.5	2148	27	2203	27	+3
11289-088.1	86	38	0.46	163	11721	3.3E-04	30	0.57	39.1	0.101	7.1	15.077	1.7	0.5312	1.5	0.835	0.2058	1.0	2747	33	2873	16	+5
11289-092.1	96	64	0.70	166	10523	2.3E-04	32	0.40	43.1	0.179	4.1	13.246	1.7	0.5252	1.3	0.814	0.1829	1.0	2721	30	2680	16	-2
11289-095.1	39	24	0.63	126	9043	7.5E-04	33	1.30	13.5	0.143	15.5	7.241	3.5	0.3988	1.8	0.526	0.1317	3.0	2164	34	2120	52	-2
11289-096.1	42	25	0.61	115	9611	9.9E-04	29	1.72	13.8	0.141	11.8	6.916	4.3	0.3790	1.8	0.430	0.1323	3.9	2072	33	2129	68	+3
11289-097.1	231	101	0.45	224	7760	8.9E-05	33	0.16	102.1	0.130	3.1	12.912	1.3	0.5149	1.2	0.924	0.1819	0.5	2678	26	2670	8	-0
11289-098.1	47	2	0.03	112	11464	6.9E-04	24	1.20	23.8	-0.003	279.4	17.782	2.1	0.5862	1.6	0.791	0.2200	1.3	2974	39	2981	20	+0
11289-099.1	28	18	0.68	129	9158	3.4E-04	58	0.59	9.4	0.174	9.9	7.467	3.2	0.3889	2.0	0.617	0.1393	2.5	2118	36	2218	44	+5
11289-101.1	51	33	0.68	134	9607	3.8E-04	38	0.65	17.9	0.209	6.1	8.087	2.4	0.4122	1.6	0.673	0.1423	1.7	2225	30	2255	30	+2
11289-102.1	140	62	0.46	218	10591	-1.4E-05	100	-0.02	70.0	0.127	3.5	16.952	1.3	0.5826	1.2	0.928	0.2111	0.5	2959	30	2914	8	-2
11289-107.1	42	32	0.78	126	9224	6.8E-05	100	0.12	14.9	0.217	6.1	7.658	2.4	0.4092	1.7	0.699	0.1357	1.7	2211	31	2174	30	-2
11289-109.1	157	57	0.37	185	8999	1.1E-05	100	0.02	76.1	0.100	3.9	16.492	1.4	0.5632	1.3	0.904	0.2124	0.6	2880	30	2924	10	+2
11289-110.1	49	39	0.83	331	7921	1.7E-04	50	0.29	22.4	0.223	5.6	15.658	2.2	0.5385	1.9	0.843	0.2109	1.2	2777	42	2913	19	+6
11289-112.1	129	52	0.42	147	10535	2.9E-04	28	0.49	63.5	0.102	7.1	15.950	1.8	0.5734	1.5	0.851	0.2017	0.9	2922	36	2840	15	-4
11289-113.1	55	37	0.70	151	9283	6.5E-04	30	1.13	19.2	0.198	7.2	7.312	3.1	0.4062	1.8	0.570	0.1306	2.6	2197	33	2105	45	-5
11289-119.1	53	41	0.80	183	8922	2.1E-04	50	0.37	18.4	0.250	5.2	7.724	2.3	0.4032	1.5	0.673	0.1390	1.7	2184	29	2214	30	+2
11289-120.1	53	38	0.75	149	9280	2.7E-04	45	0.46	18.6	0.220	5.6	7.859	2.4	0.4076	1.6	0.658	0.1398	1.8	2204	29	2225	31	+1
11289-123.1	57	39	0.70	135	9405	9.3E-04	26	1.61	18.9	0.193	8.4	7.168	4.6	0.3849	1.7	0.363	0.1351	4.2	2099	30	2165	74	+4
11289-125.1	41	15	0.38	201	7941	8.2E-04	26	1.43	18.5	0.113	10.7	14.719	2.4	0.5304	1.8	0.725	0.2013	1.7	2743	39	2836	27	+4
11289-126.1	52	54	1.06	276	8457	3.9E-04	41	0.67	17.8	0.311	5.2	7.670	2.6	0.3982	1.7	0.643	0.1397	2.0	2161	30	2223	34	+3
11289-127.1	195	128	0.68	205	9461	-2.8E-05	71	-0.05	82.5	0.192	2.8	11.979	1.5	0.4930	1.2	0.808	0.1762	0.9	2584	26	2618	15	+2
11289-128.1	76	67	0.92	237	9466	5.2E-05	100	0.09	26.6	0.252	4.9	7.826	2.0	0.4093	1.6	0.788	0.1387	1.2	2212	29	2211	21	-0
11289-129.1	100	68	0.70	129	7905	1.2E-04	45	0.20	44.8	0.184	3.9	13.567	1.6	0.5208	1.4	0.874	0.1889	0.8	2703	30	2733	12	+1
11289-130.1	44	32	0.75	130	9553	-8.6E-05	100	-0.15	14.8	0.206	7.0	7.698	2.4	0.3905	1.8	0.743	0.1430	1.6	2125	32	2264	28	+7
11289-131.1	67	29	0.45	152	11657	4.3E-04	38	0.74	31.7	0.137	8.7	15.909	2.3	0.5533	1.8	0.789	0.2086	1.4	2839	42	2894	23	+2

11289-132.1	95	62	0.68	161	10559	5.3E-05	100	0.09	33.6	0.182	5.7	7.643	2.0	0.4124	1.6	0.783	0.1344	1.3	2226	30	2156	22	-4
11289-133.1	54	48	0.92	73	8970	2.4E-04	50	0.41	24.2	0.271	5.3	13.307	2.2	0.5232	1.8	0.797	0.1844	1.3	2713	39	2693	22	-1
11289-134.1	69	63	0.94	286	9403	1.3E-04	71	0.23	24.6	0.288	5.2	8.153	2.3	0.4121	1.7	0.744	0.1435	1.5	2224	32	2270	26	+2
11289-135.1	132	116	0.91	349	9952	1.5E-04	45	0.26	45.7	0.236	3.9	7.663	1.7	0.4041	1.4	0.789	0.1376	1.1	2188	25	2197	18	+0
11289-137.1	204	110	0.56	209	9293	9.7E-05	41	0.17	87.3	0.156	3.5	11.957	1.6	0.4987	1.3	0.796	0.1739	1.0	2608	27	2595	16	-1
11289-138.1	119	51	0.44	68	9117	3.2E-04	30	0.55	66.4	0.111	6.3	23.755	1.7	0.6509	1.5	0.885	0.2647	0.8	3232	38	3275	12	+2
11289-141.1	52	22	0.43	122	8505	4.5E-04	38	0.78	24.6	0.115	9.9	16.322	2.4	0.5496	1.9	0.790	0.2154	1.4	2823	43	2947	23	+5
11289-142.1	85	64	0.77	191	9212	5.7E-04	27	0.98	37.6	0.212	5.4	12.709	5.7	0.5157	1.6	0.275	0.1787	5.5	2681	35	2641	91	-2
11289-143.1	62	49	0.82	198	9676	2.2E-04	58	0.37	20.9	0.215	10.3	7.618	2.4	0.3939	1.7	0.691	0.1403	1.8	2141	31	2231	30	+5
11289-145.1	77	14	0.19	67	11326	7.9E-04	23	1.37	34.5	0.031	27.7	14.324	2.2	0.5219	1.6	0.747	0.1991	1.5	2707	36	2819	24	+5
11289-148.1	55	35	0.66	150	10315	3.5E-04	50	0.60	18.7	0.185	8.2	7.543	2.9	0.3963	1.8	0.638	0.1380	2.2	2152	34	2203	39	+3
11289-149.1	86	57	0.68	242	9237	1.1E-04	58	0.20	43.4	0.194	4.9	18.597	1.8	0.5886	1.6	0.872	0.2291	0.9	2984	38	3046	14	+3
11289-150.1	108	86	0.83	161	8868	5.7E-04	24	0.99	47.1	0.217	4.8	13.086	1.9	0.5096	1.5	0.770	0.1862	1.2	2655	32	2709	20	+2
11289-153.1	128	31	0.25	73	11692	2.5E-05	100	0.04	56.5	0.069	6.6	13.689	1.5	0.5145	1.4	0.890	0.1930	0.7	2676	30	2768	12	+4
11289-154.1	187	89	0.49	193	11834	3.3E-04	33	0.57	78.7	0.113	7.2	11.646	1.9	0.4900	1.5	0.784	0.1724	1.2	2571	32	2581	20	+0
11289-155.1	107	72	0.70	245	10070	2.8E-05	100	0.05	52.9	0.201	3.9	17.439	1.6	0.5746	1.4	0.894	0.2201	0.7	2927	34	2981	12	+2
SAMPLE 2: Granodiorite sill 14PBA-027D1; 11291 (66.34086, -96.56123)																							
11291-047.2	780	205	0.27	110	11442	1.3E-05	41	0.02	221.4	0.080	1.8	5.123	0.9	0.3302	0.8	0.957	0.1125	0.3	1840	14	1840	5	+0
11291-047.1	822	214	0.27	127	11767	---	---	0.00	234.8	0.078	1.7	5.182	0.9	0.3325	0.8	0.963	0.1130	0.2	1850	14	1849	4	-0
11291-044.2	746	139	0.19	41	13273	-2.5E-06	100	0.00	205.8	0.057	2.2	5.008	0.9	0.3210	0.9	0.955	0.1132	0.3	1795	13	1851	5	+3
11291-041.1	984	285	0.30	119	11381	3.5E-06	71	0.01	283.4	0.089	1.5	5.238	0.9	0.3353	0.8	0.968	0.1133	0.2	1864	14	1853	4	-1
11291-044.1	932	171	0.19	44	12924	-1.8E-06	100	0.00	265.5	0.056	1.9	5.201	0.9	0.3316	0.9	0.972	0.1138	0.2	1846	15	1860	4	+1
11291-058.1	3005	271	0.09	573	15810	1.4E-03	2	2.50	996.7	0.053	2.5	7.257	1.3	0.3861	1.3	0.971	0.1363	0.3	2105	23	2181	5	+4
11291-002.1	68	25	0.38	131	10264	---	---	0.00	25.2	0.108	4.5	9.120	1.4	0.4342	1.2	0.860	0.1523	0.7	2325	24	2372	13	+2
11291-003.1	174	56	0.33	121	11594	1.5E-05	71	0.03	66.0	0.095	3.0	9.860	1.1	0.4418	1.0	0.926	0.1619	0.4	2359	20	2475	7	+6
11291-064.1	795	74	0.10	220	15085	7.5E-06	45	0.01	322.0	0.028	4.0	10.816	1.3	0.4713	0.8	0.648	0.1664	1.0	2489	18	2522	17	+2
11291-014.1	936	399	0.44	367	11795	6.1E-06	45	0.01	381.3	0.127	2.9	10.905	0.9	0.4745	0.8	0.982	0.1667	0.2	2503	17	2525	3	+1
11291-017.1	663	69	0.11	219	14079	2.5E-05	27	0.04	272.3	0.034	4.2	11.039	2.2	0.4781	2.0	0.922	0.1674	0.9	2519	42	2532	14	+1
11291-007.1	848	218	0.27	266	12782	6.9E-06	45	0.01	352.3	0.076	1.4	11.358	0.9	0.4838	0.8	0.980	0.1703	0.2	2544	18	2560	3	+1
11291-032.2	364	215	0.61	203	10333	1.2E-05	50	0.02	149.8	0.170	1.4	11.290	0.9	0.4797	0.9	0.962	0.1707	0.3	2526	19	2564	4	+2
11291-032.1	330	72	0.23	412	13011	2.0E-05	41	0.04	139.2	0.064	2.4	11.554	2.1	0.4909	1.1	0.530	0.1707	1.8	2574	23	2565	29	-0
11291-006.1	981	264	0.28	269	13183	6.9E-06	41	0.01	413.8	0.080	1.2	11.569	0.9	0.4912	0.8	0.980	0.1708	0.2	2576	18	2565	3	-1

11291-040.1	352	101	0.30	268	11326	1.3E-05	50	0.02	148.8	0.085	2.0	11.599	1.7	0.4923	1.1	0.672	0.1709	1.3	2580	24	2566	21	-1
11291-028.1	447	115	0.27	235	12625	3.8E-05	26	0.07	187.3	0.077	2.0	11.525	1.0	0.4873	0.9	0.910	0.1715	0.4	2559	19	2573	7	+1
11291-001.1	230	92	0.41	170	10257	3.6E-05	38	0.06	95.0	0.119	2.2	11.426	1.2	0.4804	1.1	0.959	0.1725	0.3	2529	24	2582	6	+2
11291-049.1	756	366	0.50	393	11816	-1.5E-06	100	0.00	322.5	0.142	1.1	11.872	0.9	0.4969	0.8	0.980	0.1733	0.2	2601	18	2589	3	-1
11291-004.1	218	74	0.35	137	11466	2.7E-05	45	0.05	92.4	0.094	6.4	11.870	1.4	0.4936	1.2	0.848	0.1744	0.7	2586	25	2600	12	+1
11291-037.1	216	90	0.43	184	10536	-5.3E-06	100	-0.01	94.3	0.121	2.2	12.226	2.6	0.5079	2.1	0.800	0.1746	1.6	2648	45	2602	26	-2
SAMPLE 4: Arkosic sandstone 12PBAB-19A; 11290 (66.60179, -95.90890)																							
11290-002.1	895	513	0.59	444	9308	3.3E-05	50	0.06	262.0	0.184	2.3	5.748	1.8	0.3406	1.7	0.953	0.1224	0.5	1890	28	1991	10	+6
11290-004.1	1616	774	0.49	290	12740	1.1E-05	71	0.02	468.5	0.148	2.0	5.746	1.8	0.3375	1.8	0.972	0.1235	0.4	1875	29	2007	8	+8
11290-004.1.2	1513	716	0.49	271	13295	6.4E-05	35	0.11	402.3	0.142	2.6	5.181	1.8	0.3096	1.7	0.947	0.1214	0.6	1739	26	1976	10	+14
11290-004.2	505	307	0.63	175	11340	1.6E-05	100	0.03	153.6	0.195	3.1	6.032	1.9	0.3539	1.8	0.922	0.1236	0.7	1953	30	2009	13	+3
11290-004.2.2	536	317	0.61	169	10813	7.4E-05	45	0.13	160.6	0.187	3.1	5.936	1.9	0.3491	1.8	0.915	0.1233	0.8	1930	29	2005	14	+4
11290-006.1	271	224	0.85	214	10237	3.9E-04	23	0.68	96.5	0.241	3.4	8.494	2.2	0.4145	1.8	0.856	0.1486	1.1	2235	35	2330	19	+5
11290-009.1	2156	77	0.04	119	13106	-3.9E-06	100	-0.01	627.7	0.010	6.6	5.512	1.7	0.3389	1.7	0.978	0.1180	0.4	1881	27	1926	6	+3
11290-009.1.2	2245	86	0.04	114	13332	4.4E-05	24	0.08	573.8	0.009	8.3	4.811	1.7	0.2976	1.7	0.981	0.1172	0.3	1679	24	1914	6	+14
11290-009.1.3	1607	139	0.09	83	9368	1.2E-05	58	0.02	342.7	0.028	8.3	4.045	3.3	0.2482	3.3	0.992	0.1182	0.4	1429	42	1929	7	+29
11290-009.2	1404	125	0.09	77	10737	1.8E-05	35	0.03	422.7	0.026	3.3	5.704	2.4	0.3504	2.4	0.993	0.1181	0.3	1936	40	1927	5	-1
11290-015.1	406	244	0.62	85	9692	1.9E-04	30	0.32	144.9	0.182	3.4	8.647	2.0	0.4157	1.8	0.899	0.1509	0.9	2241	35	2356	15	+6
11290-017.1	1004	369	0.38	311	7979	1.5E-04	21	0.26	382.0	0.112	2.9	9.396	2.0	0.4428	1.7	0.878	0.1539	0.9	2363	34	2390	16	+1
11290-018.1	1007	399	0.41	183	11685	4.8E-05	45	0.08	293.1	0.125	3.0	5.772	2.3	0.3387	1.7	0.748	0.1236	1.5	1880	28	2009	27	+7
11290-026.1	1588	519	0.34	543	10062	4.2E-05	50	0.07	468.4	0.101	3.4	6.005	2.0	0.3434	1.9	0.952	0.1268	0.6	1903	31	2054	11	+8
11290-028.1	108	35	0.34	148	10536	-2.2E-04	71	-0.37	47.0	0.122	10.8	13.364	3.3	0.5052	2.7	0.830	0.1918	1.8	2636	59	2758	30	+5
11290-034.1	2107	492	0.24	251	10605	7.8E-05	32	0.14	637.7	0.067	4.0	5.980	1.8	0.3523	1.7	0.947	0.1231	0.6	1946	29	2002	10	+3
11290-035.1	126	173	1.42	104	9723	1.5E-03	28	2.55	36.8	0.426	6.8	5.539	5.8	0.3391	2.5	0.435	0.1185	5.3	1882	42	1933	94	+3
11290-037.1	1205	521	0.45	192	10731	3.5E-05	50	0.06	429.7	0.128	2.8	8.810	1.8	0.4150	1.7	0.960	0.1540	0.5	2238	33	2390	9	+8
11290-039.1	643	352	0.56	351	9428	---	---	0.00	245.4	0.163	3.2	9.869	1.9	0.4442	1.8	0.945	0.1611	0.6	2369	36	2468	10	+5
11290-041.1	568	490	0.89	166	10409	-3.1E-05	71	-0.05	206.3	0.276	2.5	8.709	1.9	0.4225	1.8	0.936	0.1495	0.7	2272	34	2340	12	+3
11290-042.1	1269	564	0.46	411	11945	6.8E-05	50	0.12	348.8	0.135	3.9	5.330	2.0	0.3199	1.8	0.905	0.1209	0.8	1789	28	1969	15	+10
11290-046.1	1820	72	0.04	442	13952	1.1E-05	45	0.02	927.0	0.011	5.1	19.804	1.7	0.5931	1.7	0.992	0.2422	0.2	3002	40	3134	3	+5
11290-047.1	414	186	0.46	184	8759	4.0E-05	58	0.07	166.3	0.137	3.4	10.538	1.9	0.4679	1.8	0.945	0.1634	0.6	2474	36	2491	10	+1
11290-048.1	226	309	1.41	313	9550	4.1E-04	45	0.71	83.6	0.420	5.1	9.617	3.2	0.4313	2.4	0.756	0.1617	2.1	2312	47	2474	36	+8
11290-049.1	830	301	0.37	267	11332	6.1E-06	100	0.01	336.6	0.108	2.5	10.810	1.8	0.4719	1.7	0.973	0.1661	0.4	2492	35	2519	7	+1

11290-050.1	339	236	0.72	136	9344	4.5E-04	21	0.78	87.9	0.173	4.7	4.909	2.3	0.3019	1.8	0.788	0.1179	1.4	1701	27	1925	25	+13
11290-050.1.2	378	250	0.68	130	10278	4.6E-04	21	0.80	84.6	0.163	4.6	4.289	2.3	0.2606	1.8	0.780	0.1194	1.4	1493	24	1947	25	+26
11290-050.2	790	641	0.84	259	9407	7.3E-05	32	0.13	196.1	0.244	2.0	4.774	2.7	0.2889	2.6	0.976	0.1199	0.6	1636	38	1954	10	+18
11290-050.2.2	603	467	0.80	142	5538	1.4E-04	22	0.24	138.1	0.240	1.8	4.365	3.2	0.2666	3.2	0.983	0.1187	0.6	1524	43	1937	11	+24
11290-051.1	1390	234	0.17	120	12117	3.9E-05	32	0.07	419.8	0.046	3.3	6.012	1.9	0.3515	1.8	0.940	0.1241	0.6	1942	30	2015	11	+4
11290-052.1	150	24	0.17	146	10674	1.9E-04	41	0.32	59.5	0.058	9.5	10.448	2.2	0.4622	2.0	0.876	0.1640	1.1	2449	40	2497	18	+2
11290-057.1	858	381	0.46	228	9098	2.0E-05	58	0.04	258.0	0.128	2.4	5.954	1.8	0.3500	1.7	0.962	0.1234	0.5	1935	28	2006	9	+4
11290-062.1	6416	1496	0.24	817	12414	4.3E-05	25	0.07	1781.4	0.068	2.2	5.276	1.9	0.3232	1.8	0.985	0.1184	0.3	1805	29	1932	6	+8
11290-062.2	4434	793	0.18	505	12602	1.6E-05	32	0.03	1218.0	0.055	1.8	5.253	1.7	0.3198	1.7	0.990	0.1191	0.2	1789	26	1943	4	+9
11290-062.2.2	4228	740	0.18	390	10087	1.0E-05	41	0.02	1056.6	0.055	1.9	4.787	1.8	0.2909	1.8	0.991	0.1193	0.2	1646	26	1946	4	+17
11290-063.1	2435	1383	0.59	322	11276	2.2E-06	100	0.00	700.0	0.175	1.2	5.560	2.1	0.3346	2.1	0.992	0.1205	0.3	1861	33	1964	5	+6
11290-063.1.3	2195	1243	0.58	251	9399	---	---	0.00	569.9	0.175	1.5	5.053	1.8	0.3023	1.8	0.982	0.1212	0.3	1703	26	1974	6	+16
11290-063.1.3d	2060	1147	0.58	206	7572	1.3E-05	50	0.02	486.1	0.169	1.5	4.551	1.7	0.2747	1.7	0.980	0.1202	0.3	1564	23	1959	6	+23
11290-064.1	1375	503	0.38	260	11997	6.2E-06	71	0.01	473.3	0.109	1.8	7.909	2.2	0.4008	2.0	0.933	0.1431	0.8	2173	38	2265	14	+5
11290-065.1	730	347	0.49	202	10572	3.3E-05	41	0.06	281.7	0.142	2.1	10.083	2.2	0.4490	2.2	0.984	0.1629	0.4	2391	44	2486	7	+5
11290-066.1	736	368	0.52	370	10271	3.0E-05	50	0.05	219.8	0.147	2.4	5.864	1.9	0.3476	1.9	0.963	0.1223	0.5	1923	31	1991	9	+4
11290-067.1	993	388	0.40	208	12293	2.4E-05	50	0.04	287.3	0.118	2.4	5.595	1.9	0.3368	1.7	0.903	0.1205	0.8	1871	27	1964	14	+5
11290-069.1	1278	504	0.41	251	11575	4.7E-06	100	0.01	385.8	0.119	2.1	5.939	1.7	0.3514	1.7	0.974	0.1226	0.4	1941	28	1994	7	+3
11290-070.1	570	308	0.56	351	8795	2.3E-05	45	0.04	380.2	0.148	1.9	39.766	2.6	0.7766	1.7	0.673	0.3714	1.9	3705	48	3797	29	+3
11290-071.1	1244	1052	0.87	409	10147	---	---	0.00	370.9	0.254	1.6	5.843	1.7	0.3470	1.7	0.971	0.1221	0.4	1920	28	1987	7	+4
11290-075.1	469	296	0.65	194	8787	4.7E-05	41	0.08	270.4	0.171	2.4	25.304	1.9	0.6706	1.8	0.907	0.2737	0.8	3308	46	3327	13	+1
11290-076.1	406	281	0.72	137	10600	3.2E-05	71	0.06	104.8	0.201	3.0	4.978	1.9	0.3007	1.8	0.914	0.1201	0.8	1695	26	1957	14	+15
11290-076.2	1157	424	0.38	226	14132	4.0E-05	50	0.07	295.8	0.102	3.4	4.958	1.8	0.2976	1.7	0.941	0.1208	0.6	1679	25	1969	11	+17
11290-076.2.2	1268	457	0.37	212	13495	4.6E-05	45	0.08	302.7	0.102	3.3	4.614	1.8	0.2780	1.7	0.945	0.1204	0.6	1581	24	1962	11	+22
11290-078.1	1436	656	0.47	306	11219	9.4E-06	71	0.02	409.9	0.137	1.9	5.632	1.7	0.3322	1.7	0.974	0.1230	0.4	1849	27	2000	7	+9
11290-081.1	792	523	0.68	330	9287	6.4E-05	33	0.11	230.6	0.204	2.0	5.639	1.8	0.3389	1.7	0.953	0.1207	0.5	1882	28	1966	10	+5
11290-083.1	952	507	0.55	304	10291	1.9E-05	50	0.03	399.5	0.162	1.8	12.013	1.7	0.4887	1.7	0.979	0.1783	0.3	2565	36	2637	6	+3
11290-085.1	1112	429	0.40	240	11303	6.0E-05	32	0.10	401.4	0.116	2.5	9.535	1.9	0.4203	1.8	0.975	0.1645	0.4	2262	35	2503	7	+11
11290-088.1	1255	693	0.57	269	11450	6.9E-05	29	0.12	365.7	0.170	2.0	5.614	1.8	0.3391	1.7	0.960	0.1201	0.5	1882	28	1957	9	+4
11290-091.1	784	240	0.32	288	9859	7.2E-05	32	0.13	292.9	0.090	3.1	9.436	1.8	0.4352	1.7	0.963	0.1573	0.5	2329	34	2426	8	+5
11290-092.1	442	222	0.52	256	9834	1.4E-04	32	0.25	134.2	0.152	3.5	5.969	2.0	0.3534	1.8	0.901	0.1225	0.8	1951	30	1993	15	+2
11290-093.1	727	358	0.51	313	10218	4.1E-05	45	0.07	231.1	0.140	2.6	6.597	1.8	0.3703	1.7	0.953	0.1292	0.5	2031	30	2087	10	+3

11290-094.1	2441	2164	0.92	363	11981	2.0E-05	35	0.04	750.7	0.270	1.0	6.057	1.7	0.3580	1.7	0.984	0.1227	0.3	1973	28	1996	5	+1
11290-099.1	310	140	0.47	137	9609	9.3E-05	45	0.16	131.2	0.134	4.2	11.461	2.0	0.4926	1.8	0.923	0.1687	0.8	2582	39	2545	13	-2
11290-100.1	519	237	0.47	136	10495	5.5E-05	41	0.10	192.0	0.134	2.9	9.708	1.8	0.4308	1.7	0.958	0.1634	0.5	2309	34	2492	9	+9

Spot name follows the convention x-y.z; where x = sample number, y = grain number and z = spot number. Multiple analyses in an individual spot are labelled as x-y.z.z
Uncertainties reported at 1σ% and are calculated by numerical propagation of all known sources of error using Squid version 2.5. Errors in ages are 1 σ absolute in Ma.

f206²⁰⁴ refers to mole fraction of total ²⁰⁶Pb that is due to common Pb, calculated using the ²⁰⁴Pb-method; common Pb composition used is the surface blank
(²⁰⁴Pb/²⁰⁶Pb: 0.05770; ²⁰⁷Pb/²⁰⁶Pb: 0.89500; ²⁰⁸Pb/²⁰⁶Pb: 2.13840)

* refers to radiogenic Pb (corrected for common Pb)

Discordance relative to origin = 100 * (1-(²⁰⁶Pb/²³⁸U age)/(²⁰⁷Pb/²⁰⁶Pb age))

Calibration standard 6266; U = 910 ppm; Age = 559 Ma; ²⁰⁶Pb/²³⁸U = 0.09059

Th/U calibration: F = 0.03900*UO + 0.85600

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Table 2. Zircon U-Pb isotopic data for pegmatitic gabbro sill from the lower Montresor group (66.34089; -96.56443)

Fraction	Description	U (ppm)	Pb ^T (pg)	Pb _C (pg)	Th/U	²⁰⁶ Pb/ ²⁰⁴ Pb	²⁰⁶ Pb/ ²³⁸ U	± 2σ	²⁰⁷ Pb/ ²³⁵ U	± 2σ	²⁰⁷ Pb/ ²⁰⁶ Pb	± 2σ	Ages (Ma)						Disc. (%)
													²⁰⁶ Pb/ ²³⁸ U	± 2σ	²⁰⁷ Pb/ ²³⁵ U	± 2σ	²⁰⁷ Pb/ ²⁰⁶ Pb	± 2σ	
12PBA-B017E Pegmatitic gabbro sill, lower Montresor group.																			
Z1	1 2:1 clr, cls fl pr	82	19.38	0.34	0.705	3092	0.508485	0.002144	13.04336	0.05989	0.186041	0.000240	2650.2	9.2	2682.8	4.3	2707.5	2.1	2.6
Z2	1 2:1 clr, cls, sharp pr	33	5.30	0.65	0.575	493	0.374357	0.003184	6.51751	0.08742	0.126268	0.001124	2049.9	14.9	2048.3	11.8	2046.7	15.8	-0.2
Z3	1 2:1 sm, clr, cls, sl rnd	83	25.77	1.67	0.883	823	0.488028	0.001562	12.15297	0.06632	0.180608	0.000630	2562.1	6.8	2616.3	5.1	2658.5	5.8	4.4
Z4	1 3:1 sl irreg clr cls pr	97	49.36	4.23	0.616	667	0.440744	0.001171	10.18466	0.06497	0.167594	0.000785	2354.0	5.2	2451.7	5.9	2533.8	7.9	8.5
Z5	1 2:1 clr cls sharp pr	58	4.26	0.94	0.592	303	0.359738	0.003500	6.23777	0.12329	0.125760	0.001886	1980.9	16.6	2009.8	17.3	2039.5	26.6	3.3
Z6	1 brkn clr, cls pr tip	66	28.93	2.00	0.195	909	0.419436	0.001233	8.88509	0.04855	0.153637	0.000617	2257.9	5.6	2326.3	5.0	2386.8	6.8	6.4

Notes:
All analyzed fractions represent best optical quality (crack-, inclusion-, core-free), fresh (least altered) grains of zircon. Zircons were chemically abraded.
Abbreviations: Z - zircon; clr - clear; cls - colourless; fl - flat; pr - prism/prismatic; sl - slightly; sm - small; rnd - rounded; irreg - irregular; brkn - broken.
Pb^T is total amount (in picograms) of Pb.
Pb_C is total measured common Pb (in picograms) assuming the isotopic composition of laboratory blank: ²⁰⁶Pb/²⁰⁴Pb - 18.221; ²⁰⁷Pb/²⁰⁴Pb - 15.612; ²⁰⁸Pb/²⁰⁴Pb - 39.360 (errors of 2%).
Pb/U atomic ratios are corrected for spike, fractionation, blank, and, where necessary, initial common Pb; ²⁰⁶Pb/²⁰⁴Pb is corrected for spike and fractionation.
Th/U is model value calculated from radiogenic ²⁰⁶Pb/²⁰⁶Pb ratio and ²⁰⁷Pb/²⁰⁶Pb age, assuming concordance.
Disc. (%) - per cent discordance for the given ²⁰⁷Pb/²⁰⁶Pb age.
Uranium decay constants are from Jaffey et al. (1971).

Percival et al. Fig. 6

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Percival et al. Fig. 9

Percival et al. Fig. 11

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Percival et al. Fig. 12

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Percival et al. Fig. 11