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Abstract: Precambrian rocks exposed on Southampton Island, Nunavut, are dominated by plutonic units, consisting mainly of tonalite-granodiorite-monzogranite and minor mafic units. Based on geochemistry, 80 plutonic samples analyzed can be subdivided into 1) a mafic group, 2) a syenite to quartz monzonite group, and 3) a voluminous tonalite to syenogranite group. Compositional gaps and field relationships argue against either a consanguineous or a co-genetic relationship between mafic and felsic compositions. Most samples are metaluminous, magnesian, calcic to calc-alkalic, and exhibit large variations in trace-element concentrations. Thirty regionally distributed Nd isotopic samples yielded T_{DM} ages ranging from 2.79 to 3.65 Ga, indicating a Meso- to Paleoarchean crustal substrate. Strongly negative ε_{Nd} (1.9 Ga) values (–4.91 to –19.81) argue against significant material input from depleted mantle sources (e.g. MORB) during Paleoproterozoic granitoid petrogenesis. Regional Nd isotopic data sets plus U-Pb crystallization data sets from these Precambrian rocks support correlation with the diamond-hosting Repulse Bay block of the Rae Province.

Résumé : Les roches précambriennes qui affleurent dans l'île Southampton, au Nunavut, sont constituées en prédominance d'unités plutoniques, formées principalement d'unités de tonalite-granodiorite-monzogranite et, dans une moindre mesure, d'unités mafiques. D'après leur composition géochimique, les 80 échantillons plutoniques peuvent être subdivisés en 1) un groupe mafique, 2) un groupe de syénite-monzonite quartzique et 3) un volumineux groupe de tonalite-syénogranite. Les lacunes dans les compositions et les relations observées sur le terrain militent contre un lien consanguin ou cogénétique entre les roches de composition mafique et de composition felsique. La plupart des échantillons sont métalumineux, magnésiens, calciques à calco-alcalins et présentent de grandes variations des concentrations des éléments en traces. Les compositions isotopiques de Nd de 30 échantillons répartis dans la région ont livré des âges modèles (TDM) compris entre 2,79 et 3,65 Ga, ce qui indique un substrat crustal du Mésoarchéen au Paléoarchéen. Des valeurs –Nd (1,9 Ga) fortement négatives (de –4,91 à –19,81) excluent un possible apport significatif de matériaux provenant de sources mantelliques appauvries (p. ex. basalte de dorsale médio-océanique [MORB]) pendant la pétrogenèse des granitoïdes au Paléoprotérozoïque. Des jeux de données de portée régionale sur les compositions isotopiques de Nd ainsi que sur les âges U-Pb de cristallisation soutiennent l'hypothèse d'une corrélation avec le bloc à minéralisation diamantifère de Repulse Bay, de la Province de Rae.

INTRODUCTION

Felsic plutonic rocks represent crustal probes whose Nd isotopic character can be used to map the distribution of crustal domains of different ages. The facility of this approach was first demonstrated by DePaolo (1981), and since has been employed on an orogen scale within the Canadian Appalachians (e.g. Whalen, 1993; Kerr et al., 1995), Archean western Superior Province (Tomlinson et al., 2004) and more recently within the Baffin segment of the Paleoproterozoic Trans Hudson Orogen (Whalen et al., 2007, 2010).

Application of Nd isotopic and linked geochemical studies to Southampton Island, Nunavut, was initiated by the Canada-Nunavut Geoscience Office and Geological Survey of Canada as part of the Southampton Island Integrated Geoscience (SIIG) project. Project objectives are focused toward advancing understanding of the crust in the Southampton region and its relationship with proximal terranes within the Trans Hudson Orogen (THO) (Tella et al., 2005, 2007). Nd isotopic data, together with U-Pb constraints, can help determine whether Southampton Island is underlain by continental crust (plus lithospheric mantle) formed within the age range (<3.6–2.8 Ga) considered most prospective for diamond-bearing kimberlites (Kjarsgaard, 2007).

GEOLOGICAL CONTEXT

Southampton Island, Nunavut is situated at the junction between the composite Archean Rae Domain (Melville Peninsula); the Archean Hearne and Chesterfield domains (western Hudson Bay); the Paleoproterozoic Meta Incognita terrane (south Baffin Island); and the Archean Sugluk terrane (Ungava Peninsula; Hoffman, 1990; Corrigan et al., 2009)(Fig. 1a). Prior to this study, reconnaissance geological data were available at 1: 1 000 000 scale. The coarse scale of mapping, coupled with the absence of both regional aeromagnetic data and any geochronological constraints for basement rocks, resulted in a significant geoscience knowledge gap which posed an impediment to energy and mineral exploration and regional tectonostratigraphic correlation. Based on 1:250 000 scale mapping carried out in 2007 and 2008, it is now known that a highland of plutonic-dominated Archean (~ 2792 Ma) rocks (Fig. 1b) is exposed on Southampton Island that includes high-grade remnants of Archean (>2.68 Ga) and Paleoproterozoic (<2.63 Ga) psammite and semipelite, as well as voluminous Paleoproterozoic plutonic rocks ranging from ultramafic (peridotite-dunite) to monzogranitic compositions (Sanborn-Barrie et al., 2007, 2008a, b; Chakungal et al., unpub. map). U-Pb age constraints (Rayner et al., unpub. data; Chakungal et al., unpub. map) reveal significant magmatic activity on Southampton Island during both the Neoarchean (ca. 2.77 to 2.61 Ga) and during the Paleoproterozoic, between ca. 1.93 Ga, the age of orthopyroxene-bearing tonalitic gneiss and blue quartz porphyry, and ca. 1.82 Ga, the age of equigranular, weakly foliated, late-tectonic biotite-monzogranite.

To better understand the nature of the crust on Southampton Island, widespread samples of intermediate to felsic plutonic rocks, along with selected mafic intrusive rocks, were analyzed for major- and trace-element geochemistry and Nd isotopic composition, thereby providing first-order characterization of the crust and insight into its antiquity and magmatic history. These data permit comparison with adjacent crustal blocks, such that correlations between compositionally and temporally similar crustal domains can be inferred and contrasts between dissimilar crustal blocks can be considered in an emerging regional tectonic context (i.e. Berman et al., 2007; Corrigan et al., 2009; Whalen et al., 2010).

SAMPLE SELECTION AND ANALYTICAL TECHNIQUES

Mainly felsic granitoid rocks, the most voluminous and ubiquitous plutonic rocks on Southampton Island, were chosen for crustal-evolution studies given that 1) their normally heavy rare-earth-element-depleted (HREE) chondrite-normalized rare-earth element (REE) patterns (i.e. high Nd/Sm) yield precise Nd isotopic model ages (DePaolo, 1981), and 2) such rocks usually represent non-mantle-derived crustal melts. Felsic plutonic rock samples were chosen for Nd isotopic analyses so as to achieve an adequate spatial distribution across basement exposures on Southampton Island (*see* Fig. 1) and to coincide, where possible, with U-Pb zircon dating sample sites (*see* Rayner et al., unpub. data; Chakungal et al., unpub. map). In addition, five mafic plutonic rocks were selected to help evaluate possible involvement of juvenile sources (e.g. the depleted mantle).

Approximately 5 to 6 kg of fresh rock material with no weathered surfaces was crushed to about pea size in a Cr-Fe jaw crusher, from which a split was then pulverized to flour consistency in a W-C crushing vessel. Geochemistry was carried out at the Geological Survey of Canada by a combination of XRF, ICP-MS, ICP-ES and wet-chemical techniques.

Neodymium isotopic analyses were carried out at the Isotope Geochemistry and Geochronology Research Centre (IGGRC), Department of Earth Sciences, Carleton University. Samples were dissolved in 0.26N HCl and loaded into a 14-ml Bio-Rad borosilicate glass chromatographic column containing a 2 cm high bed of Teflon powder coated with HDEHP [di(2-ethylhexyl) orthophosphoric acid] (Richard et al., 1976). Neodymium was eluted using 0.26N HCl, followed by Sm in 0.5N HCl. Total procedural blanks for Nd were <350 picograms. Samples were spiked with a mixed ^{148}Nd-^{149}Sm spike prior to dissolution. Concentrations are precise to ±1%, but ^{147}Sm/^{144}Nd ratios are reproducible to

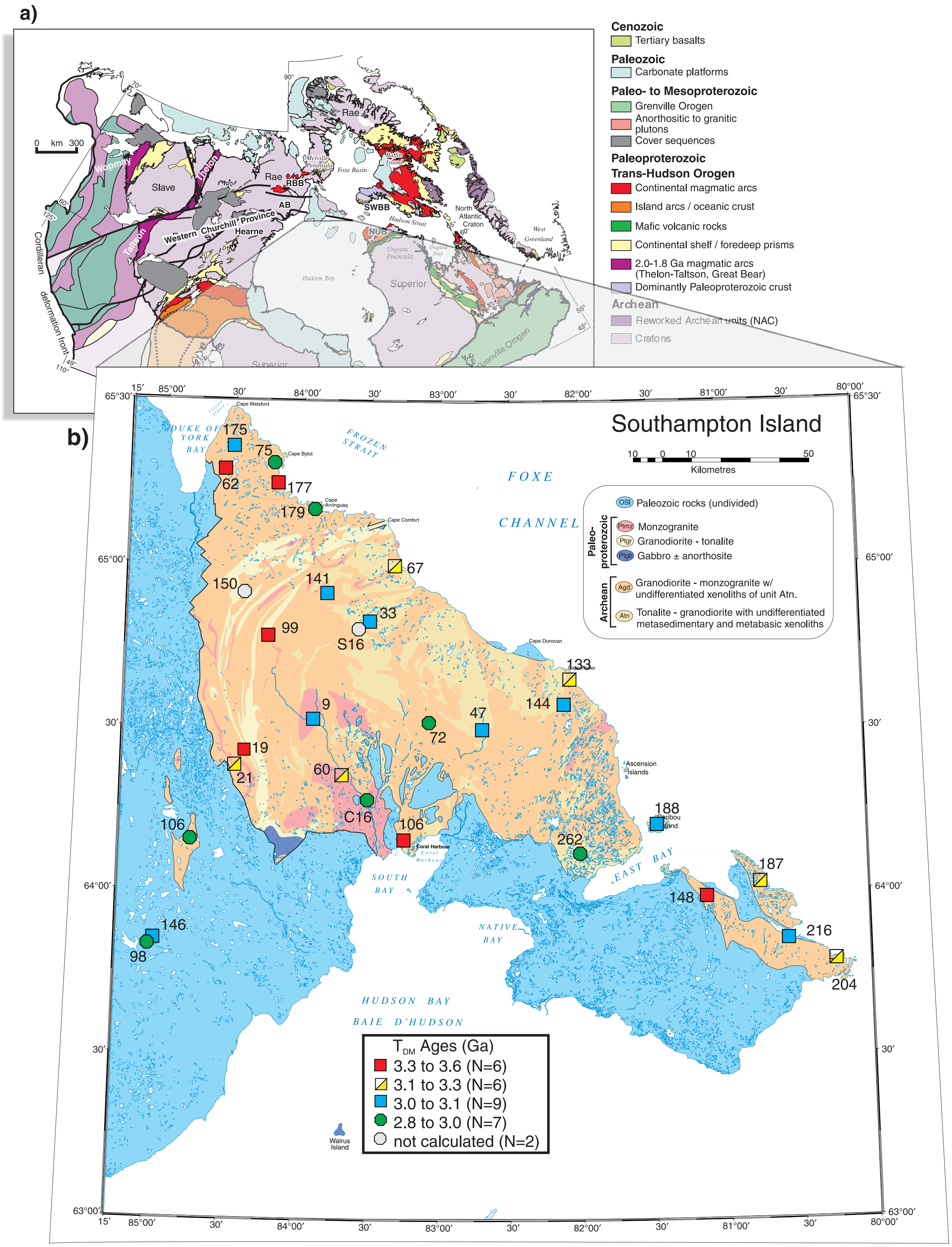

Figure 1. **a)** Simplified geological map modified from Corrigan et al. (2009), showing Precambrian terranes in Greenland and the Canadian Shield. Terrane abbreviations: AB, Armit block; NUB, northern Ungava basement; RBB, Repulse Bay block; and SWBB, Southwest Baffin Island basement. **b)** Simplified geology map of Southampton Island, with Nd isotopic samples studied in this paper subdivided based on calculated Nd model ages (in Ga) (after DePaolo, 1981). Sample numbers have been shortened (*see* Table 1 for unabbreviated numbers).

0.5%. Samples were loaded with H_3PO_4 on one side of a Re double filament, and run at temperatures of 1800 to 1875°C. Isotope ratios are normalized to $^{146}Nd/^{144}Nd$ = 0.72190. Analyses of the USGS standard BCR-1 yield Nd = 29.02 ppm, Sm = 6.68 ppm, and $^{146}Nd/^{144}Nd$ = 0.512668 ± 20 (n = 4). The La Jolla standard produced: Finnegan-MAT 261: $^{143}Nd/^{144}Nd$ = 0.511876 ± 18, n = 54 (Sept. 1992-Feb. 2004).

GEOCHEMISTRY

All plutonic rock samples analyzed are plotted on the IUGS-based normative Q′-ANOR granitoid rock =-classification diagram of Streckeisen and LeMaitre (1979) (Fig. 2a). Quartz-free samples, in some cases, slightly undersaturated, were projected upon the x axis. Three distinct compositional groups are represented: 1) a mafic group, only the

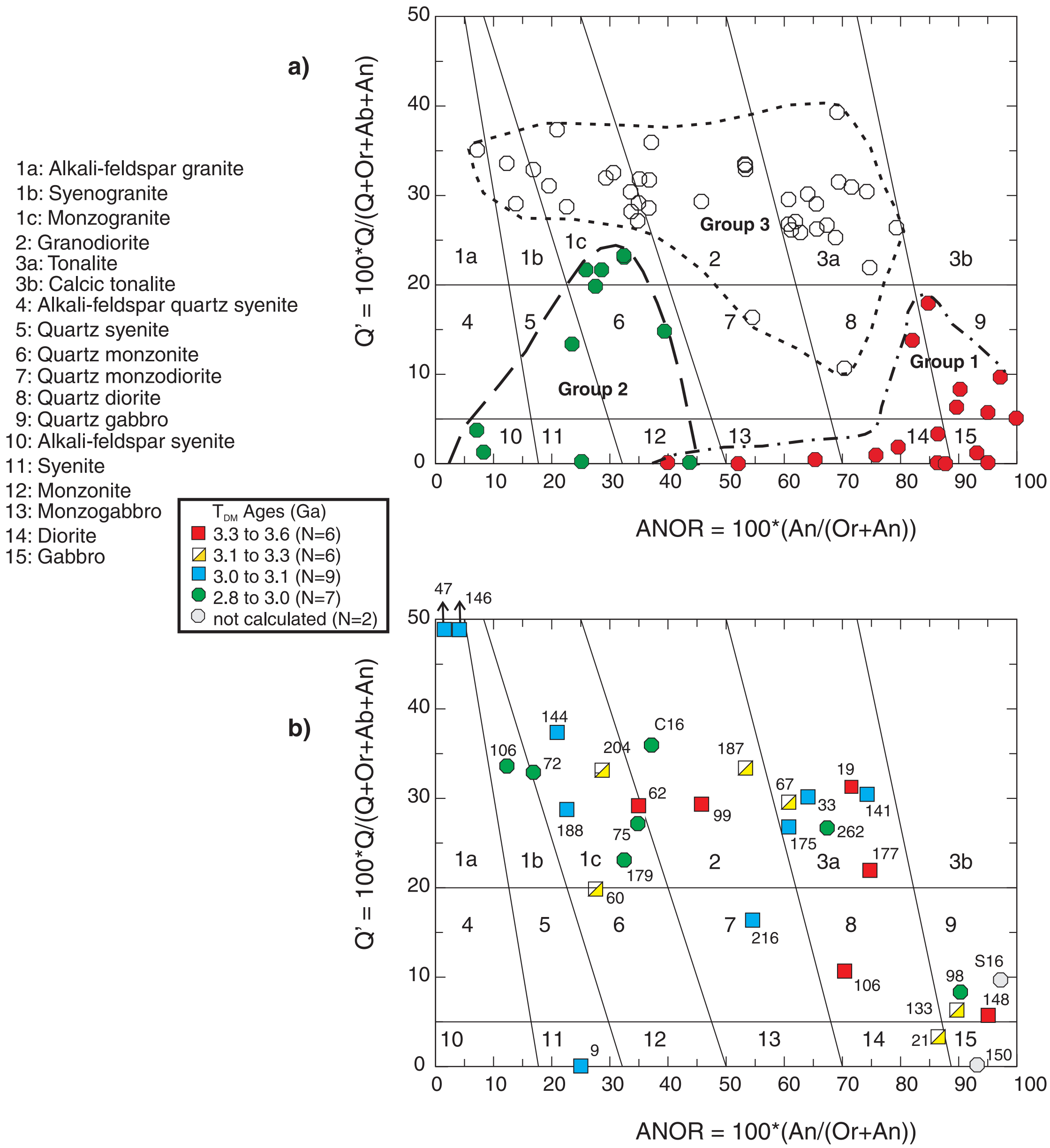

Figure 2. Southampton Island plutonic rock samples plotted on the IUGS-based CIPW normative Q'-ANOR classification diagram (Streckeisen and LeMaitre (1979). In **a)**, all geochemistry samples are plotted, whereas in **b)** only Nd isotopic samples are shown. In a) three sample groups are outlined by different broken lines: mafic (Group 1); syenite to quartz monzonite (Group 2); and, tonalite to syenogranite (Group 3) (see text for discussion).

most ANOR-rich members of which contain 5 to 18% quartz (Q); 2) a group of eleven, possibly consanguineous, syenite to quartz monzonite samples with <25% Q and <45% ANOR; and 3) a large sample group with >10% quartz (Q') and 80 to 10% calcic feldspar ANOR content, reflecting a compositional range from tonalite to syenogranite. As well, two samples (07CYA-B47 and 08CYA-C146; Fig. 2) contain very low CaO (thus low ANOR) and >50% Q', features incompatible with 'normal' granitoid rocks, and likely a reflection of alteration. The subset of samples chosen for Sm-Nd isotopic studies is shown in Figure 2b.

Although the rock-classification diagram used in Figure 2 is an excellent approach to highlight the plutonic lithologies present, the three-tiered scheme developed by Frost et al. (2001) provides a more comprehensive major-element-based classification of granitoid rocks. It utilizes 1) $FeO^{total}/(FeO^{total} + MgO)$ (Fe number or Fe*) versus SiO_2 (Fig. 3a) to assess whether a suite is ferroan or magnesian; 2) Na_2O+K_2O-CaO (alkali-lime index or MALI) versus SiO_2 to assess whether a suite is alkalic, alkali-calcic, calc-alkalic, or calcic (Fig. 3b); and 3) aluminum saturation index (ASI) $(Al/(Ca-1.67xP+Na+K))$ to establish whether the samples

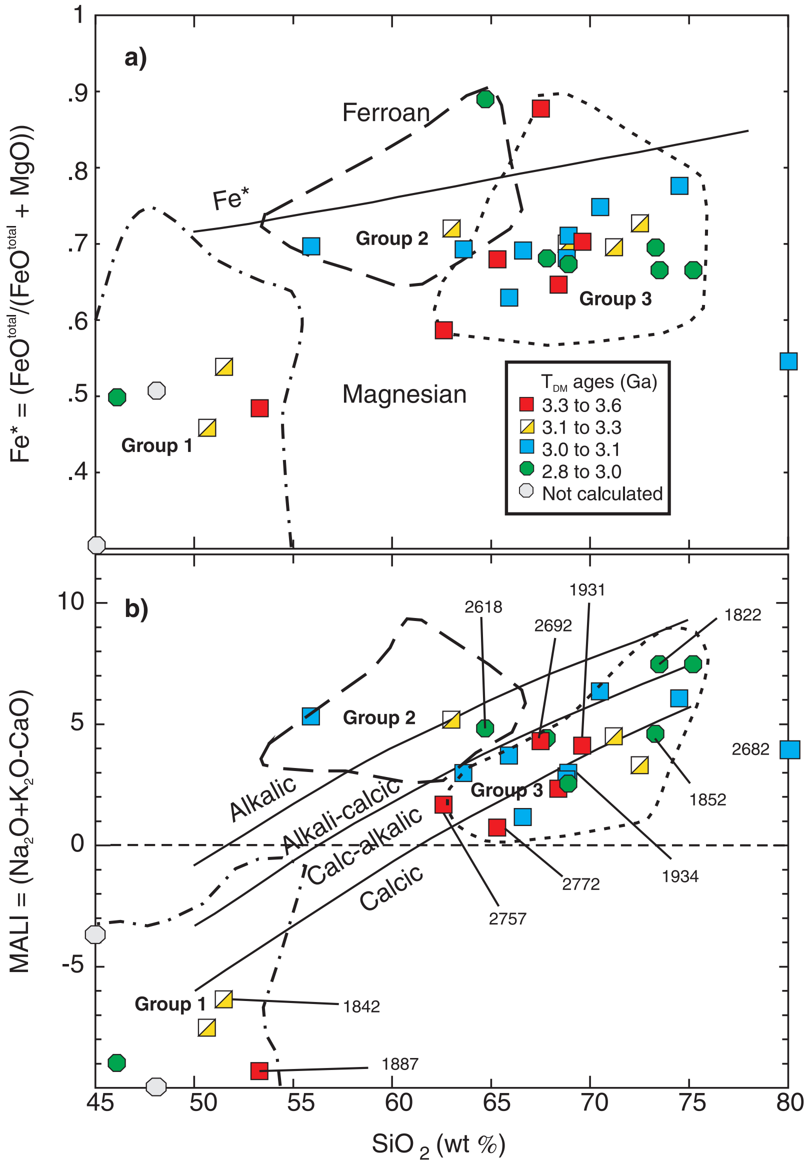

Figure 3. Southampton Nd isotopic samples plotted on the: **a)** $FeO^{total}/(FeO^{total} + MgO)$ (or Fe*) vs. SiO_2 and **b)** Na_2O+K_2O-CaO (or MALI) vs. SiO_2 granitic rock classification diagrams of Frost et al. (2001). In **a)** the boundary between ferroan and magnesian plutons and in **b)** ranges for the alkalic-calcic, calc-alkalic, and calcic rock series are shown. Together with aluminum saturation index (ASI) (not shown), these plots comprise a three-tiered geochemical scheme for granitoid rocks (*see* text for discussion). Also shown are the fields for the three groups outlined in Figure 2a. In **b)** U-Pb zircon ages in Ma have been added for dated samples (*see* Table 1 and text for discussion).

are peraluminous (ASI >1.0), metaluminous (ASI <1.0), or peralkaline (if Na+K >Al; not shown). Using this classification scheme, all but a few of the analyzed Southampton Island granitoid samples are magnesian and all are metaluminous, with the exception of the sillimanite-bearing 'S-type' granite (07CYA-B47C-03). With respect to their alkali-lime index, groups 1 and 3 (*see* Fig. 2) range from calcic, through calc-alkalic to alkali-calcic, whereas group 2 is alkalic to alkali-calcic.

Large trace-element concentration ranges exhibited by Southampton felsic granitoid samples are illustrated in Figure 4, with normalized La/Yb values (a measure of chondrite-normalized REE pattern slopes) ranging from 1 to 330. The REE variations overlap with, and exceed, values documented for both Archean TTG (tonalite-trondhjemite-granodiorite) suites and post-Archean granitoids by Martin (1986). Rather than being of TTG composition, however, a large proportion of the Southampton high La/Yb samples are granites, *senso stricto* (Fig. 2), such that they closely resemble recently documented adakitic granites (Xiao and Clemens, 2007; Wang et al., 2007). Of 24 Nd isotopic

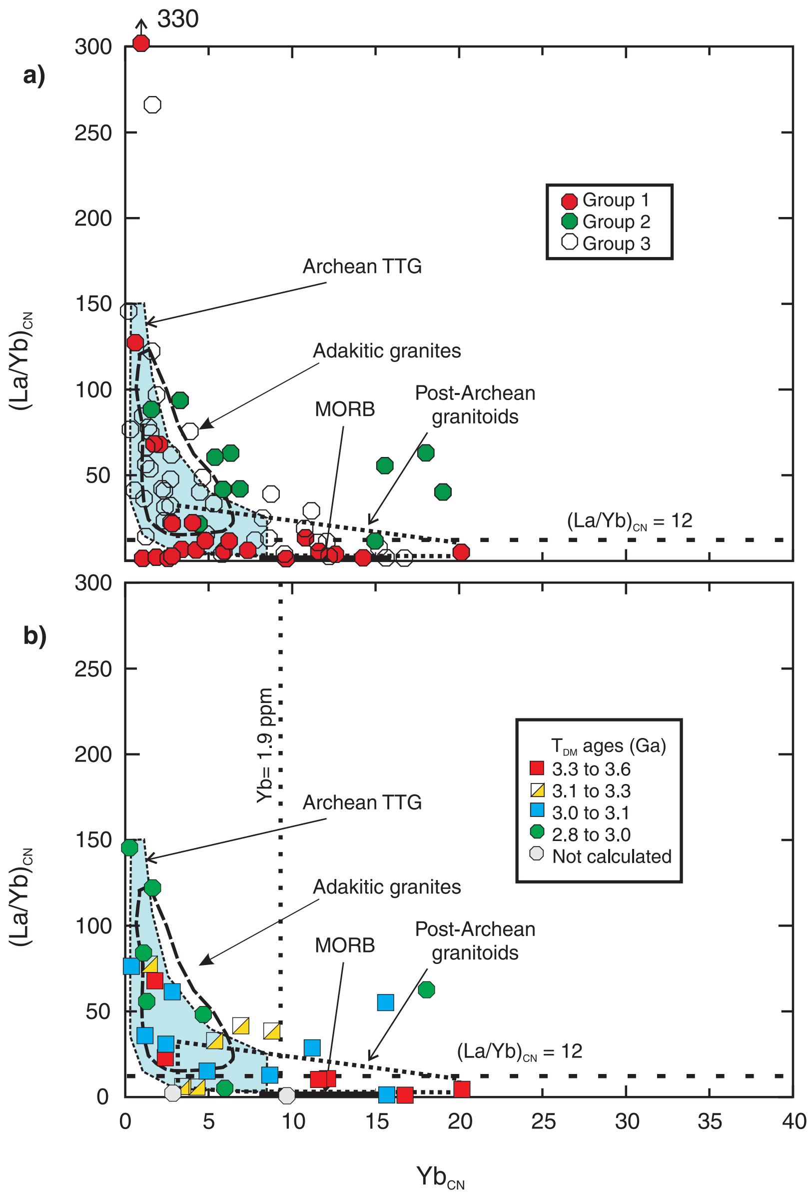

Figure 4. Southampton plutonic rock samples plotted on a chondrite normalized Yb versus La/Yb plot with fields for Archean TTG suite, post-Archean granitoids and MORB (after Martin, 1986). In **a)**, all geochemistry samples are plotted, whereas in **b)** only Nd isotopic samples are shown. Also outlined with a dashed line is the field of 32 Cretaceous adakitic granites (all suites except Fuziling; data of Wang et al. (2007)).

samples with >55% SiO_2, 20 exhibit $(La/Yb)_N$ >12, a characteristic of adakitic magmas (Fig. 4b, Table 1). As well, 12 of these samples display positive to flat Ba and Sr anomalies and an absence of negative Eu anomalies on primitive-mantle-normalized extended element plots (not shown), additional identifying features of TTG suites and adakitic granites (op. cit.). Two of these samples (07CYA-S106A-2 and 07CYA–B99A-1) have been dated at ca. 1822 and 1931 Ma, respectively (Rayner et al., unpub. data).

Some trace elements, including Rb, Nb and Y, are considered useful for granitoid rock tectonic classification (Pearce, 1996). In an Rb vs. Nb+Y diagram (Fig. 5a), most Southampton Island samples plot in the volcanic arc granite

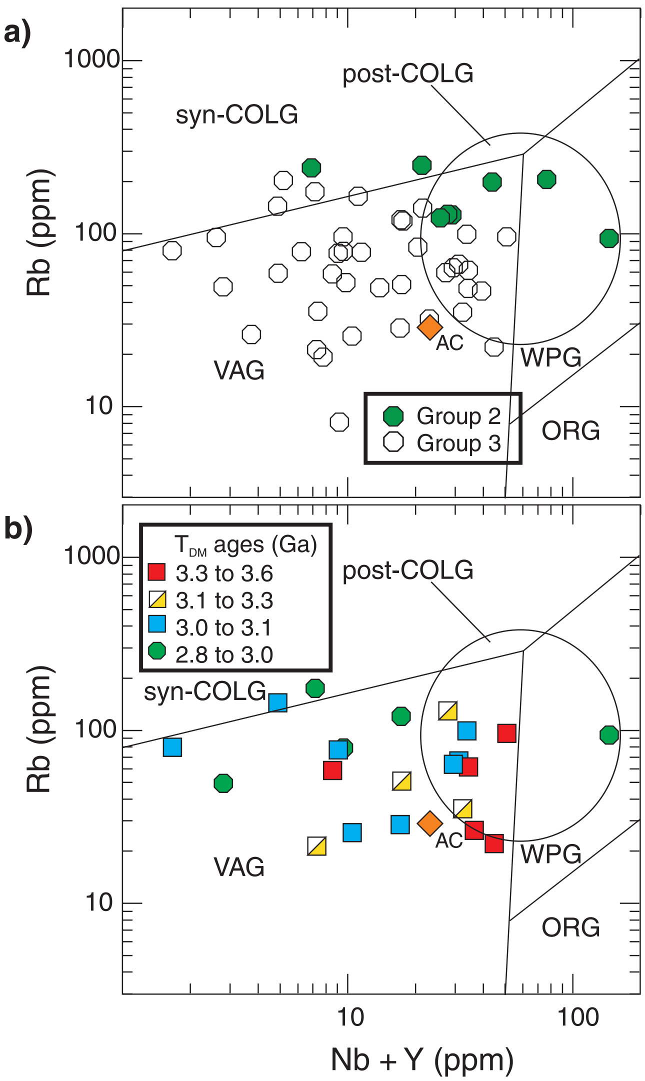

Figure 5. Felsic (>60% SiO_2) Southampton granitoid samples plotted on the Rb-Y+Nb (Pearce, 1996) granitoid tectonic classification diagram. In **a)**, all geochemistry samples are plotted, whereas in **b)** only Nd isotopic samples are shown. Granitoid type abbreviations: post-collisional (post-COLG); volcanic-arc (VAG); within-plate (WPG) and syn-collisional (syn-COLG). Diamond symbol labelled AC is the composition of Archean total crust from Rudnick and Fountain (1995).

(VAG) field, but extend into the within-plate granite (WPG) and sycollisional (syn-COLG) fields. About 30% of the samples, mainly belonging to group 2, plot in the area of overlap between granite types, in a region typical of post-collisional granites (post-COLG). In a plot of Nd samples on this diagram (Fig. 5b): 1) six of the nine samples characterized by >3.1 Ga model ages plot within, or on the boundary of, the post-COLG field; and 2) nine out of thirteen samples with <3.1 Ga model ages plot within or proximal to the VAG field. In general, this distribution suggests that post-COLG petrogenesis involved mainly crustal recycling, whereas VAG magmatism involved significant input from juvenile mantle sources.

ND ISOTOPES

Nd isotopic data were obtained from samples belonging to all three geochemical groups, including 7 samples from group 1, 2 from group 2, and 19 samples from group 3 (Fig. 2b, 3 and 4b). The Nd isotopic data (Table 1) are expressed as epsilon Nd calculated at time of their emplacement (ε_{Nd}(T)) for samples with U-Pb zircon constraints (Rayner et al., unpub. data; Chakungal et al., unpub. map) and, where undated, as ε_{Nd} values calculated at 2.9 and 1.9 Ga, the two major magmatic pulses on Southampton Island as reflected by U-Pb zircon geochronology. Table 1 also contains depleted mantle model ages (T_{DM}) calculated using the model of DePaolo (1981). Both ε_{Nd}(T) and ε_{Nd} (1.9 Ga) values are mainly strongly negative, ranging from –0.6 to –18.69 and –4.91 to –19.81 Ga, respectively. These values indicate derivation from a crustal reservoir with a long-term history of light REE enrichment. In addition, the absence of any positive or juvenile ε_{Nd}(T) or ε_{Nd}(1.9 Ga) values from Southampton Island granitoids, including mafic samples, argues against any significant material input from depleted mantle sources (e.g. MORB) during Paleoproterozoic granitoid petrogenesis. However, the ε_{Nd}(2.9 Ga) range of +2.59 to –7.43 suggests Mesoarchean granitoid magmatism likely involved mixing between juvenile and evolved Paleoarchean crust. This inference is supported by T_{DM} ages which span from 2.79 to 3.65 Ga (Table 1). Nd sample distribution within the Rb vs. Nb+Y diagram (Fig. 5b) described above, supports this interpretation.

Possible inter-relationships between bulk, whole-rock major- and trace-element and Nd isotopic compositions were explored to investigate further the petrogenesis of Southampton Island granitoid rocks. No apparent relationships between major- and/or trace-element compositions and Nd model ages is apparent in the geochemical diagrams (Fig. 2, 3, and 5), and no correlations were found between ε_{Nd} or T_{DM} values and indices of differentiation such as SiO_2, Rb, Th and Rb/Sr (not shown), as would be predicted for simple two-component mixing (e.g. between juvenile mantle- and old crustal-derived melts).

Table 1. Nd isotopic analyses of granitoid rocks from Southampton Island.

Sample No.	Easting	Northing	Lithology[a]	SiO_2 (wt.%)	$(La/Yb)_{CN}$	U-Pb age (Ma)	ε_{Nd} (T)	ε_{Nd} (1900 Ma)	ε_{Nd} (2900 Ma)	T_{DM}[b] (Ga)	$^{143}Nd/^{144}Nd$ (m)	$^{147}Sm/^{144}Nd$ (m)	Nd (ppm)	Sm (ppm)
07CYA-B047C-03	418588	7154388	sil-bt qtz-rich monzogranite	80.2	31.0	2682[1]	-3.64	-14.37	-0.63	3.09	0.510586	0.0912	13.92	2.10
07CYA-B075A-01	349802	7245995	amp-bt-mag monzogranite	67.8	48.1	-	-	-13.04	1.58	2.95	0.510570	0.0845	39.90	5.57
07CYA-B099A-01	346885	7189361	bt-opx granodiorite	69.6	22.9	1931[1]	-18.68	-19.06	-6.86	3.58	0.510493	0.1029	11.05	1.88
07CYA-C016A-01	379512	7130349	bt-mag granodiorite	73.3	122.1	1852[1]	-16.78	-15.98	0.82	2.99	0.510210	0.0677	21.45	2.40
07CYA-M009A-01	361210	7160558	amp-bt syenite	55.9	55.1	-	-	-15.24	0.23	3.03	0.510375	0.0779	148.09	19.09
07CYA-M033A-02	337387	7189565	bt-opx-grt tonalite	68.9	61.4	-	-	-14.69	0.54	3.01	0.510427	0.0798	24.58	3.24
07CYA-M062A-02	335137	7245377	amp-bt-mag monzogranite	67.5	10.8	2692[1]	-5.81	-12.24	-4.11	3.56	0.511232	0.1342	47.65	10.57
07CYA-M072A-01	401260	7154314	bt monzogranite	75.2	145.4	-	-	-12.73	4.47	2.79	0.510338	0.0647	5.08	0.54
07CYA-M141A-01	367557	7202757	opx-bt tonalite	66.6	15.2	-	-	-11.01	0.66	3.02	0.510956	0.1071	15.80	2.80
07CYA-M146A-03	303400	7085817	qtz-eye porphyry	65.9	12.8	1934[1]	-11.22	-11.63	0.47	3.03	0.510883	0.1038	16.82	2.89
07CYA-S106A-02	317882	7121964	bt syenogranite	73.5	84.0	1822[1]	-14.58	-13.34	2.59	2.89	0.510428	0.0744	13.27	1.63
07CYA-T067A-01	390376	7210650	opx-bt-mag tonalite	68.8	77.4	-	-	-16.25	-1.44	3.13	0.510386	0.0829	16.01	2.20
07CYA-T144A-01	446397	7162639	bt-mag monzogranite	74.5	76.4	-	-	-15.83	0.35	3.01	0.510276	0.0724	2.83	0.34
07CYA-X019B-03	335661	7149759	bt-amp tonalite	68.4	18.3	-	-	-19.81	-7.43	3.61	0.510437	0.1015	46.36	7.78
07CYA-M021A-01	332286	7147429	amp-cpx-bt diorite	50.7	6.2	-	-	-10.31	-1.45	3.25	0.511262	0.1287	6.26	1.33
07CYA-M150A-02	347176	7209657	ol-px peridotite	41.7	2.4	-	-	-6.80	-1.98	NC	0.511827	0.1596	2.83	0.75
07CYA-M098B-01	302838	7085319	amp qtz gabbro	46.1	5.1	-	-	-6.67	1.52	2.96	0.511511	0.1338	15.89	3.52
07CYA-M133A-04	456827	7158034	amp-cpx qtz gabbro	51.5	5.8	1842[1]	-10.30	-9.76	-0.45	3.15	0.511246	0.1252	6.50	1.35
07CYA-S16A-02			amp-cpx qtz gabbro	48.1	0.8	-	-	-4.91	-2.60	NC	0.512165	0.1789	5.87	1.74
07CYA-X060A-02	359397	7128151	pk-red amp-bt qtz monzonite	63.0	41.5	-	-	-14.20	-0.91	3.12	0.510637	0.0946	66.59	10.42
08CYA-C106A-02	389628	7114574	mg eq opx-bt qtz diorite gneiss	62.6	1.1	2757[2]	-4.71	-14.45	-3.08	3.32	0.510808	0.1093	33.77	6.11
08CYA-C175B-01	331043	7256059	mg-cg grey-pk Kfd-porph bt-amp tonalite	68.8	1.2	-	-	-14.45	-0.48	3.08	0.510559	0.0894	11.93	1.76
08CYA-C177A-01	342784	7248878	mg greasy bn amp-bt-opx tonalite	65.3	10.3	2772[2]	-3.48	-11.93	-2.23	3.30	0.511098	0.1222	17.02	3.44
08CYA-C179A-01	362713	7229632	v st fol mg eq amp-bt monzogranite	64.7	62.6	2618[2]	-0.61	-8.55	2.53	2.88	0.511139	0.1117	52.16	9.64
08CYA-J148A-01	495052	7096299	amp-bt gabbroic anorthosite	53.3	67.9	1887[2]	-13.37	-13.24	-3.25	3.38	0.511002	0.1199	3.63	0.72
08CYA-M187D-01	507637	7102666	mg-cg eq greasy bn bt-opx granodiorite	70.5	38.5	-	-	-14.13	-1.05	3.13	0.510662	0.0963	21.98	3.50
08CYA-M188A-03	476152	7122286	kfd-mega bt monzogranite	72.5	35.8	-	-	-16.51	-0.77	3.08	0.510284	0.0758	26.39	3.31
08CYA-M204B-01	538237	7073442	eq grey-pk gneissic bt monzogranite	71.2	33.0	-	-	-15.19	-0.98	3.11	0.510499	0.0876	18.93	2.74
08CYA-M216A-01	518861	7080362	wt mg-fg eq banded amp-bt qtz monzodiorite gneiss	63.6	28.7	-	-	-16.80	-0.47	3.06	0.510213	0.0713	39.81	4.70
08CYA-M262A-03	452030	7113509	grey mg eq bt-amp tonalite	68.9	55.9	-	-	-9.34	2.33	2.89	0.511041	0.1071	11.21	1.99

[a] Plutonic rock types based on Q'-ANOR diagram of Streckeisen and LeMaitre (1979) (see Fig. 2).
Abbreviations, minerals: amp - amphibole; bt - biotite; grt - garnet; kfd - K-feldspar; mag - magnetite; opx - orthopyroxene; qtz - quartz; sil - sillimanite (mostly Kretz, 1983); others: fg, mg, cg - fine-, medium-, coarse-grained; CN - chondrite normalized; eq - equigranular; fol - foliated; mega - megacrystic; pk - pink; v st - very strongly; wt - white

[b] Depleted mantle ages (T_{DM}) based on model of DePaolo (1981).
U-Pb zircon ages from [1] Rayner et al. (unpub data, 2010); [2] Chakungal et al. (unpub data, 2010).

DISCUSSION

Geochemical classification schemes highlight the presence of three plutonic rock groups on Southampton Island and the compositional gaps between these groups (Fig. 2 and 3). The gap between groups 1 and 3 provides evidence against either a consanguineous or a cogenetic relationship between mafic and felsic compositions, as do field relationships (Sanborn-Barrie et al., 2009) and geochronology (Chakungal et al., unpub. map). Most Southampton plutonic rocks analyzed are metaluminous, magnesian, and calcic to calc-alkalic. Based on comparisons with Paleozoic granitoid suites from known tectonic settings, Frost et al. (2001) concluded that magnesian granitoid rocks are closely affiliated to relatively hydrous, oxidizing magmas or source regions, consistent with a broadly subduction-related origin. Furthermore, they found that MALI variation within magnesian granitiods from calcic to alkali-calcic within Cordillera batholiths reflects increasing distance inboard from the subduction zone. Based on limited geochronological data for our geochemical samples (Table 1 and Fig. 3b), there is no correlation between MALI and pluton age as ca. 2757, 2692, 2618, 1930, and 1822 Ma samples all fall close to the calc-alkalic to alkali-calcic dividing line. According to Frost et al. (2001), samples belonging to consanguineous plutonic suites generally follow sub-parallel alkali-lime trends during differentiation (Fig. 3b). However, this relationship cannot be used to identify Southampton felsic plutonic suites for group 3 samples of different ages lie on the same trend. An alternative is that shared sample trends on Figure 4b reflect Paleoproterozoic partial melting of Archean crustal protoliths, an inference that is supported by the strongly negative ε_{Nd} (1.9 Ga) values (Table 1).

Although most felsic Southampton plutonic samples exhibit arc-like trace element signatures (Fig. 5a), such signatures are also characteristic of continental crust, including the Archean total crust composition of Rudnick and Fountain (1995), which plots within the high Nb+Y portion of the Southampton data set (point AC in Fig. 5). Evidence for a cogenetic relationship between mafic and felsic plutonic lithologies is lacking, as is Nd isotopic evidence for juvenile mantle input. On this basis, the petrogenesis of the high-quartz compositions (groups 2 and 3, Fig. 2) are most readily explained by partial melting (magmatic recycling) of crustal protoliths, although thermal input from mantle-derived magmas may have facilitated the melting processes.

The distinctive geochemical characteristics of both tonalite-trondhjemite-granodiorites (TTG) and adakitic granites are interpreted as reflecting partial melting under elevated P-T conditions with residual garnet and no residual plagioclase. In the case of TTG suites, their protoliths were garnet amphibolites (i.e. basaltic) and they formed in arcs, either as direct slab melts (Martin, 1986), or as melts of tectonically over-thickened mafic crust (Whalen et al., 2002). Adakitic granites, in contrast, are post-collisional and lack either a temporal or spatial association with subduction where previously identified in Tibet and central China (Xiao and Clemens, 2007; Wang et al., 2007), and recently in the Trans Hudson Orogen on Baffin Island (Whalen et al., 2010). Experimental data indicate protoliths of tonalitic-andesitic composition were partially melted at >1050° and >2 GPa, likely as a result of extreme crustal thickening followed by eclogitic keel delamination and partial melting of this sinking lower crustal material at mantle depths, during orogenic collapse (Xiao and Clemens, 2007). The implications of adakitic tonalite to syenogranite compositions for Southampton Island's tectonic evolution is likely not simple, since limited U-Pb dating has identified that samples with these features formed at both ca. 1930 Ma and ca. 1822 Ma (Table 1). Recycling of this geochemically distinctive signature (Fig. 4) by remelting felsic adakitic protoliths is not considered an option, given that feldspar should be a significant restite phase during partial melting of tonalitic or granitic protoliths. Restitic feldspar would imprint the partial melts with 'non-adakitic' negative Sr and Eu anomalies. As well, in the absence of additional collaborating lines of evidence, it would be highly speculative to propose repeated crustal over thickening and subsequent delamination events in the same area based on geochemistry alone.

Based on the apparent decoupling between bulk rock compositions and Nd isotopic compositions, as discussed above, the granitoid samples are interpreted as crustal probes that image the continental lithosphere beneath Southampton Island. Thus, spatial variation in T_{DM} values (i.e. Fig. 1) likely maps changes in age of the crustal substrate to Southampton Island. Although 5 out of 6 samples belonging to the 3.3 to 3.6 Ga T_{DM} group occur in a north-south corridor within the western part of the exposed basement, the 22 samples belonging to the other three groups with T_{DM} ages >2.8 and <3.3 Ga are fairly evenly distributed, including occurring proximal to >3.3 Ga samples. In the absence of supporting geological evidence, this distribution of T_{DM} ages does not provide convincing evidence for subdividing the exposed basement into different crustal age domains, but rather supports variable Paleoproterozoic reworking of a non-homogeneous Meso- to Paleoarchean crustal domain.

REGIONAL TECTONIC AND ECONOMIC IMPLICATIONS

In recent large-scale geological cartoon-map reconstructions for the Trans Hudson Orogen (THO), Corrigan et al. (2009) placed question marks around Southampton Island, highlighting a lack of information relevant to resolving whether it was correlative with either the Sugluk block (northern Ungava), the Rae Province, or southwestern Baffin Island. Regional Nd isotopic variations within proximal portions of the Western Churchill Province and the Trans Hudson Orogen (THO) within northern Ungava and southern Baffin Island (Fig. 1a) have been summarized in recent compilations by Skulski et al. (in press), Wodicka and Whalen (2006), and Wodicka et al. (2006). Within the Rae Province, the Armit block to the west exhibits a T_{DM} range of 2.5 to 2.8 Ga (average = 2.7; N = 5) and the Repulse Bay block to the northwest ranges from 2.8 to 3.6 Ga (average = 3.0; N = 18). To the east, the northernmost Ungava Superior Craton and Narsajuaq Arc exhibit T_{DM} ranges of 2.9 to 3.1 Ga (average = 3.0 Ga; N = 11) and 1.8 to 3.1 Ga (average = 2.4 Ga; N = 11). In southern Baffin Island, Archean basement and Narsajuaq Arc exhibit T_{DM} ranges of 2.9 to 3.5 Ga (average = 3.2; N = 4) and 2.6 to 3.6 Ga (average = 3.0 Ga; N = 17), respectively. For comparison, Southampton Island samples exhibit a T_{DM} range of 2.8 to 3.6 Ga (average = 3.1 Ga; N = 28) (Table 1). In general, both the Repulse Bay block and southern Baffin Island T_{DM} ranges overlap with those obtained in this study. Although our Nd data suggest that an affinity with the Suglak block, as exposed in Ungava, is unlikely, it is still permissive of either a Rae Province (Repulse Bay block) or southern Baffin Archean basement correlation. Basement U-Pb zircon crystallization ages, an additional correlation parameter, from the Rae within 250 km from Southampton Island range from 2.43 to 2.82 Ga (average = 2.63; N = 7) (Skulski et al., in press) whereas those from southwest Baffin Island and adjacent islands range from 2.82 to 3.00 Ga (N. Wodicka, pers. com., 2010). The range in basement crystallization ages from Southampton Island (2.62 to 2.77 Ga; Table 1)), overlaps closely those of proximal Rae Province, but are significantly younger than those obtained from southwest Baffin basement. In conclusion, based on available Nd model ages and U-Pb zircon crystallization ages, Southampton Island Archean basement can be correlated with the Repulse Bay block of the Rae Province to the northwest.

Based on known diamond-formation ages, the most promising exploration targets are continental blocks underlain by <3.6 Eoarchean crust (plus similar age lithospheric mantle), followed by Mesoarchean and Neoarchean blocks and then Paleoproterozoic continental blocks (Kjarsgaard, 2007). Based on this criterion, Southampton Island crustal ages (3.6 to 2.8 Ga; Fig. 1) fall within the most diamond-prospective age range. Further evidence for its diamond potential is that the Repulse Bay block, its most likely crustal domain correlative within the Rae Province, hosts significant diamond prospects (Skulski et al., unpub. data).

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