



**GEOLOGICAL SURVEY OF CANADA
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Plutonic and Volcanic Rocks of Cumberland Peninsula,
eastern Baffin Island, Nunavut**

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2012

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doi:10.4095/291453

This publication can be downloaded free of charge from GEOSCAN (<http://geoscan.ess.nrcan.gc.ca/>).

Recommended citation:

Whalen, J.B., Sanborn-Barrie, M., and Young, M., 2012. Geochemical data from Archean and Paleoproterozoic plutonic and volcanic rocks of Cumberland Peninsula, eastern Baffin Island, Nunavut; Geological Survey of Canada, Open File 6933. doi:10.4095/291453

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Geochemical Data from Archean and Paleoproterozoic Plutonic and Volcanic Rocks of Cumberland Peninsula, eastern Baffin Island, Nunavut

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The following report presents a compilation of the geochemical data collected as part of a multidisciplinary geoscience project on Cumberland Peninsula, eastern Baffin Island. Bedrock mapping and sample collection was undertaken during the summers of 2009 and 2010 as part of NRCan's Geomapping for Energy and Minerals (GEM) initiative. Prior to this, significant geoscience knowledge gaps existed due to limited and outdated mapping (Jackson 1971), as well as scant isotopic information. Collectively, new maps (Sanborn-Barrie et al. 2011a, b, c), geochronological results (Rayner et al., in press) and the geochemical data presented here contribute to a vastly improved understanding of the lithological associations, crustal architecture and mineral potential of this part of the eastern Canadian Arctic.

Regional Geology

It is now recognized that variably foliated to gneissic plutonic rocks of mainly Archean age underlie about 60% of Cumberland Peninsula and dominate its southern part (Figure 1). Associated with plutonic gneiss are metre- to km-scale discontinuous strands of semipelite, mafic metavolcanic rocks and amphibolite, determined by contact relationships and U-Pb isotopic data to comprise part of the Archean basement complex. In contrast, supracrustal rocks of a Paleoproterozoic cover sequence, the Hoare Bay group (Jackson 1971), form a coherent succession of metasedimentary and subordinate metavolcanic rocks across the central part of the peninsula (Figure 1). Semipelite and psammite dominate the cover sequence, with minor marble and quartzite in the west, and metavolcanic rocks with associated chert, iron formation and graphitic schist in the east. The change in minor lithofacies from west to east is consistent with a transition from a shelf to basin depositional setting.

Where the basement–cover contact is exposed, strongly deformed metasedimentary rocks, devoid of primary depositional features, are in contact with concordant plutonic mylonite gneiss, thereby highlighting a tectonic relationship. Both the basement complex and cover sequence are cut by foliated, locally K-feldspar porphyritic granodiorite±charnockite±quartz dioritic plutons and by unfoliated pegmatite intrusions. Fabrics and structures in the basement complex provide evidence of at

least two regional penetrative deformation events, the youngest of which is also recorded in the cover sequence. More detailed descriptions of Cumberland Peninsula's igneous rocks are given below.

Geochemical Database

This open file release contains 131 whole rock geochemical samples subdivided by year of analysis (121 samples in 2009 and 94 samples in 2010) and presented as Microsoft Excel[®] worksheet and tab-delimited text files. All samples are representative of surface silicate rocks of plutonic or volcanic origin. Information pertaining to analytical procedures, unfiltered data tables with detection limits, repeats, standards, etc., and a table of blind standards and duplicates analyzed with 2009 and 2010 sample batches, is presented as Adobe Acrobat[®], Microsoft Word[®] documents or Microsoft Excel[®] tables, as required, with the data type indicated by the file names.

Location Columns

The data tables contain location data for each sample in both the UTM, easting and northing (zone 21; NAD83) format and latitude and longitude coordinates in decimal degrees. All the location data was determined in the field by handheld GPS.

Field Name

Field names were assigned in the field during daily traverses for all rocks by macroscopic examination of weathered and fresh surfaces of samples, combined with visual estimation of mineral contents, magnetic properties and density.

Map Unit

This column provides the code of the map unit on new 1:100 000 scale bedrock maps (Sanborn-Barrie et al. 2011a, b, c, and in press) to which each sample is attributed. This information is intended to facilitate integration between the analytical data presented here and bedrock maps of Cumberland Peninsula.

CIPW Plutonic Rock Type

Plutonic rock type names are given for both plutonic and volcanic rock samples. These names were derived from the Cross-Iddings-Pirsson-Washington (CIPW) normative-based quartz-anorthite (Q-ANOR) plutonic rock classification diagram of Streckeisen and LeMaitre (1979) (Fig. 2a). As K-feldspar in the plutonic gneiss complex was almost invariably anhedral and beige to white in color,

field-based rock type names may reflect underestimation of the proportion of K-feldspar to total feldspar (i.e., field classification of granodiorite as tonalite). This is apparent through comparison of assigned field name with CIPW plutonic rock type name (Tables 1 & 2). Accordingly, Q-ANOR derived rock type names served as a useful means to verify field classification, and a valuable tool for subsequent geological map compilation.

Tectonic Setting

Tectonic settings of igneous rocks with <60% SiO₂ were assessed using the trace element La-Y-Nb diagram of Cabanis and Lecolle (1989) (Figures 3, 4). Most of the mafic samples were collected from volumetrically minor metavolcanic units, dykes and sills, and mafic inclusions hosted by felsic to intermediate plutonic rocks. In general, most mafic rocks determined to be Archean in age are Nb-depleted and exhibit volcanic tholeiite, back-arc basalt or calc-alkaline basalt signatures. In contrast, almost all mafic rocks determined to be Paleoproterozoic in age are Nb-enriched and exhibit within-plate signatures (continental tholeiite, alkali continental rift, E-MORB or transitional E-MORB-N-MORB). Not only does this trace element data contribute to understanding potential tectonic environment during formation, but this distinction provides a valuable tool for estimating the general age of supracrustal rocks in the absence of independent age information. In addition, geochemical characterization facilitated map-scale correlation of outcrop exposures, for instance, allowing delineation of an alkali continental rift horizon, some 60 km along strike, from north of Touak Fiord to Cape Dyer (Figure 4).

Group Column

Geochemical, geochronological and field criteria collectively highlighted major subdivisions of rocks exposed across Cumberland Peninsula. For instance, the plutonic basement complex comprises five main components: an Archean tonalitic gneiss component (APGC-TTG), K-infused plutonic rocks (APGC-K-infused), discrete Neoarchean granitic plutons (NA_{gr-gd}), Paleoproterozoic tonalitic sheets (Ptn) and intermediate to mafic plutonic rocks of uncertain age (PA). In addition to these 5 groups, Archean volcanic rocks (AV) are discriminated from Paleoproterozoic volcanic rocks (PMV) of the Hoare Bay cover sequence. Some of the younger rocks include a regionally extensive Paleoproterozoic plutonic batholithic complex, the Qikiqtarjuaq plutonic suite (QPS) that cuts both basement and cover rocks. These major subdivisions, or groups, which emerged through field relationships and the geochemical data presented here, are described further below.

Archean Plutonic Gneiss Complex (APGC; includes map units Atg, Atn, Agb)

The predominant lithology exposed throughout the southern part of the map area is strongly foliated to gneissic, tonalite to granodiorite in which gneissic banding is typically attributed to high strain and concordant felsic injections. Field relationships, U-Pb zircon geochronology and geochemistry have substantiated that the APGC is dominated by Meso- and Neoarchean plutonic components, cut by minor but widespread Paleoproterozoic sills.

(a) APGC-TTG group

Based on field relationships, the oldest component within the APGC consists of light grey weathering, biotite-bearing tonalite-trondhjemite±granodiorite rocks that are strongly foliated to gneissic and commonly contain mafic plutonic layers and lenses. U-Pb zircon dating of this component has yielded ages of ca. 2.94 to 2.99 Ga (Rayer et al., in press). At several localities, tonalite cuts gabbro (Agb) and diorite clearly establishing these mafic rocks as Archean and likely correlative with the mafic inclusions. Geochemical analyses of these U-Pb samples and other correlative samples have indicated that the oldest components exhibit the distinctive geochemical characteristics of Archean tonalite-trondhjemite-granodiorite (TTG) suites (cf. Martin, 1994; Drummond and Defant, 1990). TTG suites are ubiquitous and voluminous early formed components of Archean cratons (Condie, 1981). In Q-ANOR and SiO₂-K₂O diagrams (Figs. 2a and 2b), samples belonging to the TTG plutonic suite are readily identified by their low-K to medium-K content and high ANOR (i.e. low-K-feldspar).

(b) APGC-K-infused group

The APGC includes a variable proportion of sheets or injections of more K-rich granodioritic to monzogranitic plutonic rocks that are determined to cut the lower-K TTG suite in well exposed areas. As K-feldspar in these rocks is almost invariably anhedral and beige to white in color, it was very difficult to distinguish this component from the older TTG suite component during mapping and sampling. The higher-K component often contains fine- to medium-grained foliation-parallel veinlets of monzogranite, a feature which can aid in its identification in areas where crosscutting relationships between low-K and higher-K components are not obvious. Although great care was taken to exclude these latter veinlets during sample preparation, the host lithology was invariably found to be high-K. As it is likely that some proportion of samples included in this high-K suite represent older TTG suite rocks that have been overprinted by K-rich fluid metasomatism or magmatic injections, we refer to this APGC component as “K-infused”. U-Pb zircon dating of a number of APGC-K-infused samples yielded 2.70 to 2.78 Ga ages (Rayer et al., 2012) suggesting this higher-K component is contemporaneous with discrete Neoarchean granodiorite-granite plutons (*described below*). Given that

the Neoarchean suite preserves evidence of granulite facies metamorphism locally, the APGC-K-infused component may be petrogenetically linked to high P - T metasomatic or partial melting processes that accompanied its emplacement and/or formation.

(c) NA_{gd-gr} group (map units Amz, Agd)

The Archean basement complex is cut by several discrete, homogeneous, foliated granitic plutons of Neoarchean age (NA_{gr-gd}). These magnetically delineated plutons (see Figure 2 in Sanborn-Barrie et al., 2011a) are best exposed in the east near Exaluin Fiord, and in the southwest near Kumlien Fiord (Figure 4). In the east, the Exaluin stock is a composite pluton comprised of brown-weathering, orthopyroxene- and magnetite-bearing, K-feldspar megacrystic charnockite (Amz), typically exposed as inclusions within a pink weathering, equigranular granitic phase (Agd) which is dominant. Both phases contain a single, variably oriented, moderately developed foliation. Older and younger components of the Exaluin stock yielded U-Pb zircon ages of ca. 2.77 and ca. 2.70 Ga, respectively (Rayner et al., in press). In the southwest, elongate plutons of homogeneous, foliated, subhorizontally jointed granodiorite occur. Samples belonging to the NA_{gr-gd} group are enriched in K_2O (Figs. 2a and 2b), Ba and Sr with elevated Sr/Y. These geochemical characteristics are shared by many APGC-K-infused samples, supportive of a petrogenetic link between these Archean basement components.

(d) $P_{tn-qdr-sy}$ group (map units Ptn, Pmz)

Field observations supported by limited U-Pb zircon ages of ca. 1.87 and 1.88 Ga (Rayner et al., in press), have established that the APGC includes structurally conformable sheets of Paleoproterozoic tonalite, granodiorite and syenite. Geochemical samples representative of this map unit are geochemically indistinguishable from APGC-K-infused samples, which are known or inferred to be ca. 2.7 Ga (*see above*).

(e) PA group (map units PAtn, PAdr, PAgb, PAmv)

For the purposes of this geochemical analysis, where considerable uncertainty exists as to whether a plutonic sample is Paleoproterozoic or Archean in age, it has been assigned to the PA group. Included are diorite (PA_{dr}), tonalite (PA_{tn}), gabbro (PA_{gb}) and amphibolite (PA_{mv}). Either the samples were collected proximal to supracrustal exposures for which assignment of age was uncertain, or the field relations were equivocal with respect to the age of the host rocks.

Archean Volcanic Rocks (map unit Amv) – AV group

Narrow strands of Archean supracrustal rocks including semipelite, amphibolite, rare pillowed volcanic rocks (Amv) and felsic porphyry, form a minor, yet significant lithological component in southern, and likely northern, Cumberland Peninsula. In almost all instances, Archean mafic metavolcanic samples exhibit either back-arc basalt (BAB), volcanic-arc tholeiite (VAT) or calc-alkaline basalt (CAB) signatures based on the La-Y-Nb diagram of Cabanis and Lecolle (1989) (Figures 3 and 4). As most known Paleoproterozoic mafic rocks exhibit within-plate type signatures in this diagram, trace element characterization appears to be a discriminating tool for correlation and estimation of age of strands of supracrustal rocks of uncertain age.

Paleoproterozoic Intrusive Rocks

Qikiqtarjuaq Plutonic Suite- QPS group (map units Pdr, Pmz, Pgb)

The Qikiqtarjuaq plutonic suite (QPS) consists of relatively homogeneous, variably foliated biotite \pm garnet monzogranite, charnockite and locally K-feldspar porphyritic hornblende-biotite granodiorite, with minor diorite and quartz diorite, which extends more than 300 km from Pangnirtung to Qikiqtarjuaq (Figure 1). Designation of this belt as a suite is based on extensive exposures of compositionally similar rock types, which yielded similar U-Pb ages between ca. 1880 and 1894 Ma from seven localities (Rayner et al., in press; Rayner 2012 pers. com.). This plutonic suite is ~35 my older than the 1845-1865 Ma Cumberland batholithic complex (Whalen et al., 2010) exposed from Iqaluit to west of Cumberland Peninsula and formerly predicted to underlie this region. The QPS cuts the Paleoproterozoic Hoare Bay group cover sequence and the Archean basement complex (APGC). Fabrics and structures in the basement complex provide evidence of two regionally developed penetrative deformation events, the youngest of which is also recorded in the QPS and cover sequence. Some undated samples collected west of Cumberland Peninsula from exposures interpreted previously as Cumberland Batholith (St-Onge et al., 2006) have been given a 'QPS or CB' designation in the group column in order to reflect the uncertainty in their affiliation.

Paleoproterozoic Volcanic Rocks – PMV group (map units Pmv, Pum)

The Paleoproterozoic Hoare Bay group is dominated by metasedimentary rocks but includes a notable component of ultramafic to mafic metavolcanic rocks (map unit Puv_H). Ultramafic sills (Puv) with cm-scale, rust-weathering porphyroblasts of olivine \pm clinopyroxene are spatially associated with komatiitic rocks and locally appear to be transitional. Their spatial association, stratigraphic position and transitional relationship all point toward these sills as feeders to the extrusive units, a relationship

further supported by similar major and trace element geochemistry (Figure 3). Both the ultramafic extrusive rocks and ultramafic sills) generally exhibit within-plate geochemical signatures (CON, alkali-con rift, E-MORB, transitional N-MORB) on the La-Y-Nb diagram of Cabanis and Lecolle (1989) (Figure 3).

Younger Intrusive Rocks – YIR group (map units Pgd_{S-type}, Pgr)

Massive to weakly foliated peraluminous biotite-muscovite \pm garnet granodiorite-monzogranite dykes and sills (map unit Pgd_{S-type}) cut Archean and Paleoproterozoic rocks. At one locality this unit is dated at ca. 1.836 Ga (Rayner et al., in prep). Late felsic aplitic to pegmatitic dykes (Pgr) cut all rocks, exposures of which are well exposed in near-vertical cliff faces bordering fiords. These dykes include leucogranite, muscovite-garnet leucogranite and muscovite leucogranite.

Neoproterozoic Diabase Dykes (NeoProt dyke)

Neoproterozoic diabase dykes, that mainly trend northwest-southeast, cut all other units and can be traced for over 50 kilometers along strike. They are best exposed where they cut the Atg in southern Cumberland Peninsula and consistently yield a continental tholeiite geochemical affinity.

U-Pb Age (Ma) Column

This column provides published U-Pb ages obtained from samples (Rayner et al., in press). At the time this open file was prepared there were no published ages from samples collected in 2010 so this column contains no results.

Acknowledgements

This is a contribution to NRCan's Geomapping for Energy and Minerals (GEM) initiative. Mapping and sample collection in 2009 and 2010 by Brett Hamilton, Rae Keim, Carl Nagy, Greg Dobbelsteyn, Roxanne Takpanie-Brière, Jennifer Day, Matthew Pointing, Kate Rubingh, Luke Sheldon, John Percival, Beth Hillary and Nicole Rayner are greatly appreciated. Logistical support in the field was provided by Polar Continental Shelf Program (PCSP002-09, PCSP014-10) and expert helicopter support was ensured by pilots Dave Towersey (2009) and Krista Glover (2010) with Universal Helicopters Newfoundland Ltd.

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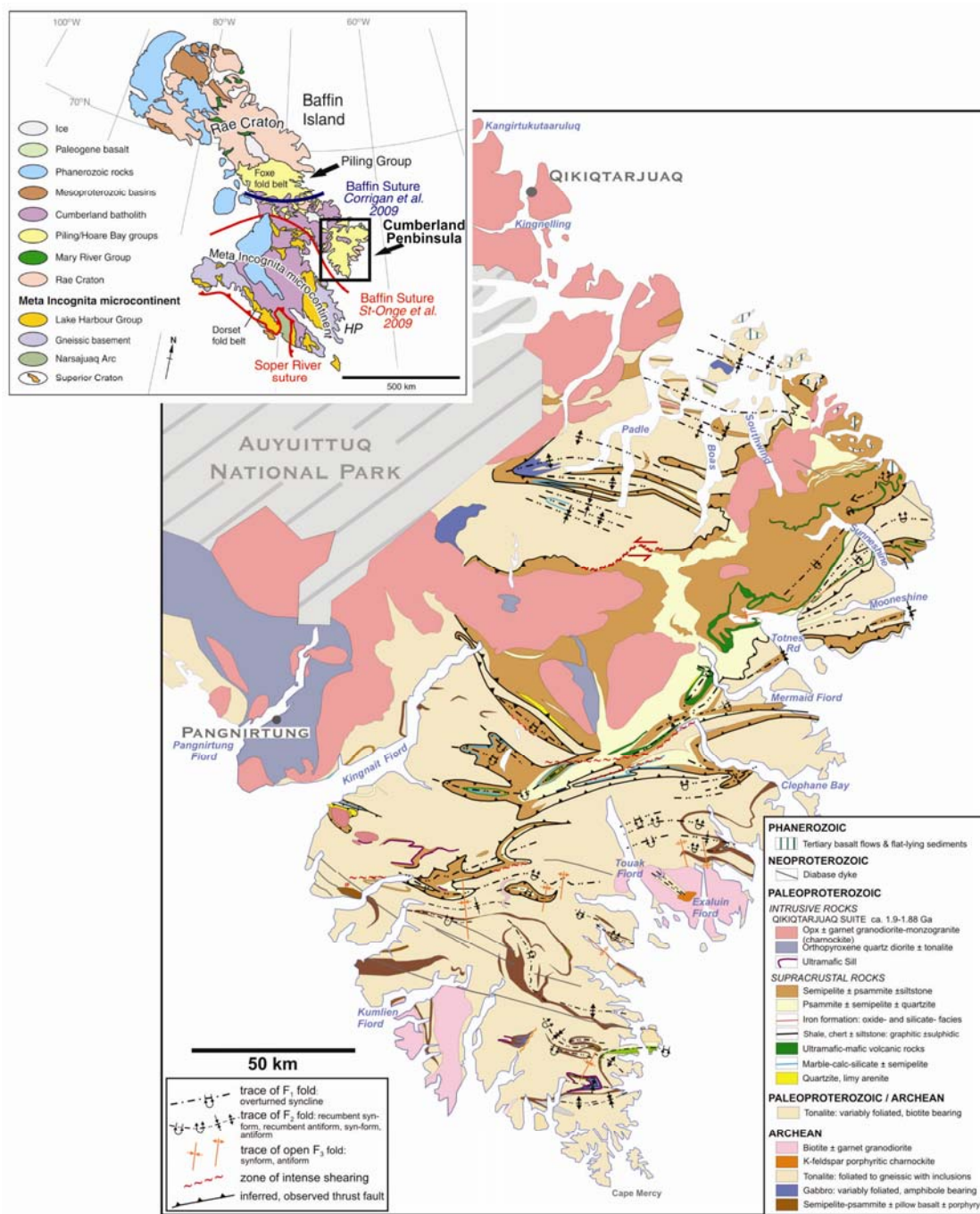


Figure 1

Simplified geological map of Cumberland Peninsula.

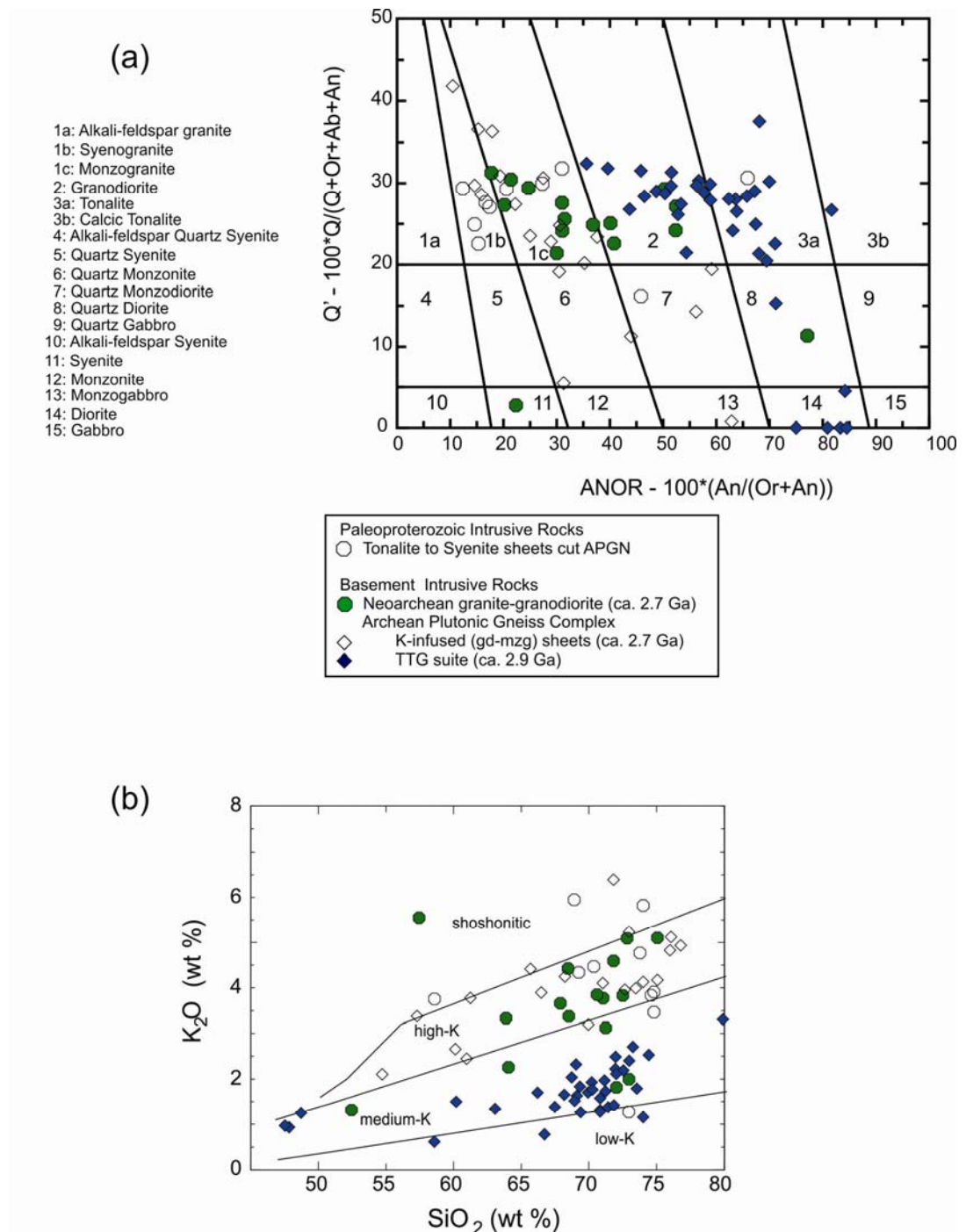


Figure 2

Archean granitoid rock samples from Cumberland Peninsula plotted on: (a) the normative Q' ($100 \cdot (Q/(Q+Or+Ab+An))$) versus ANOR ($100 \cdot (An/(Or+An))$) classification diagram (Streckeisen and LeMaitre, 1979); and (b) a SiO₂ vs. K₂O plot with suite subdivisions after LeMaitre (1989) (low-, medium-, high-K) and Peccerillo and Taylor (1976) (high-K, shoshonitic). Samples are subdivided into various age and geochemical groups, as shown in the symbol legend and discussed in the text.

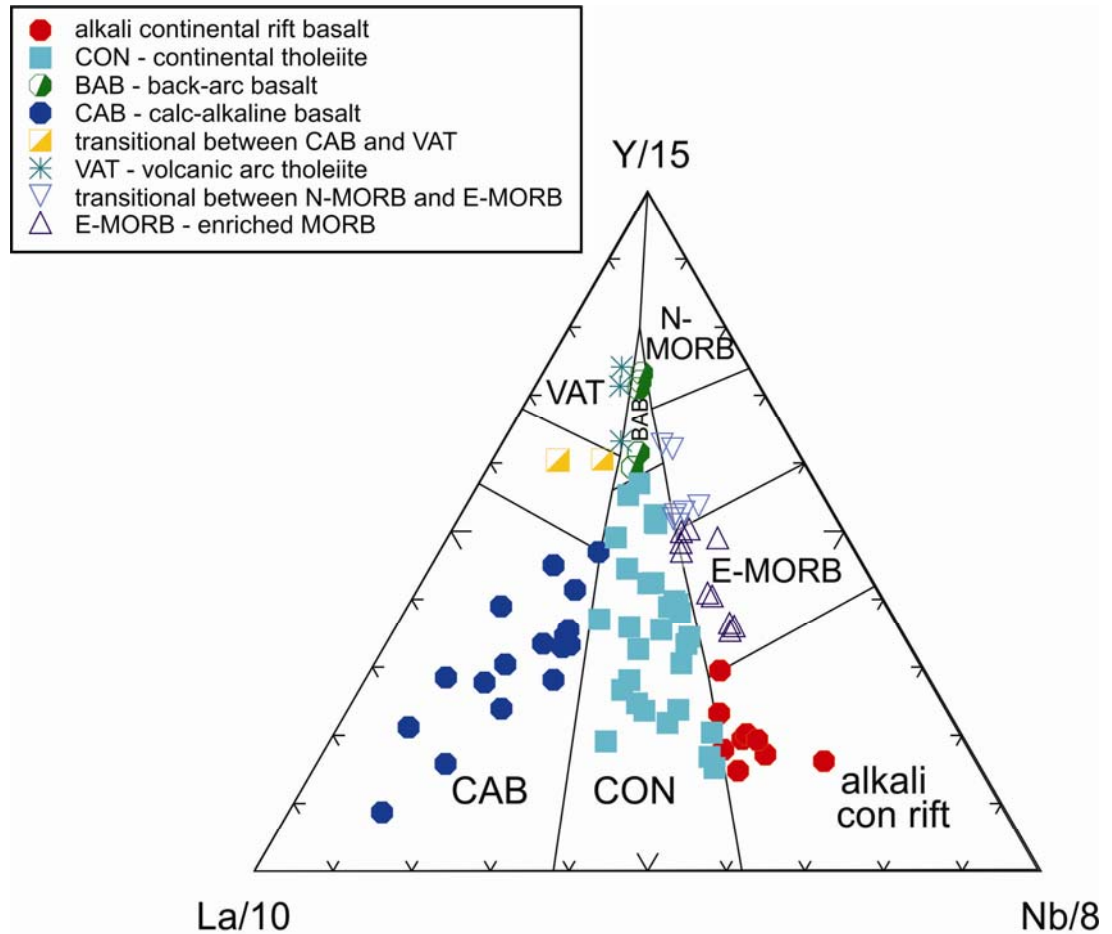


Figure 3

Mafic ($SiO_2 < 60$ wt.%) plutonic and volcanic rock samples from Cumberland Peninsula plotted on the Cabanis and Lecolle (1989) tectonic discrimination diagram for mafic volcanic rocks.

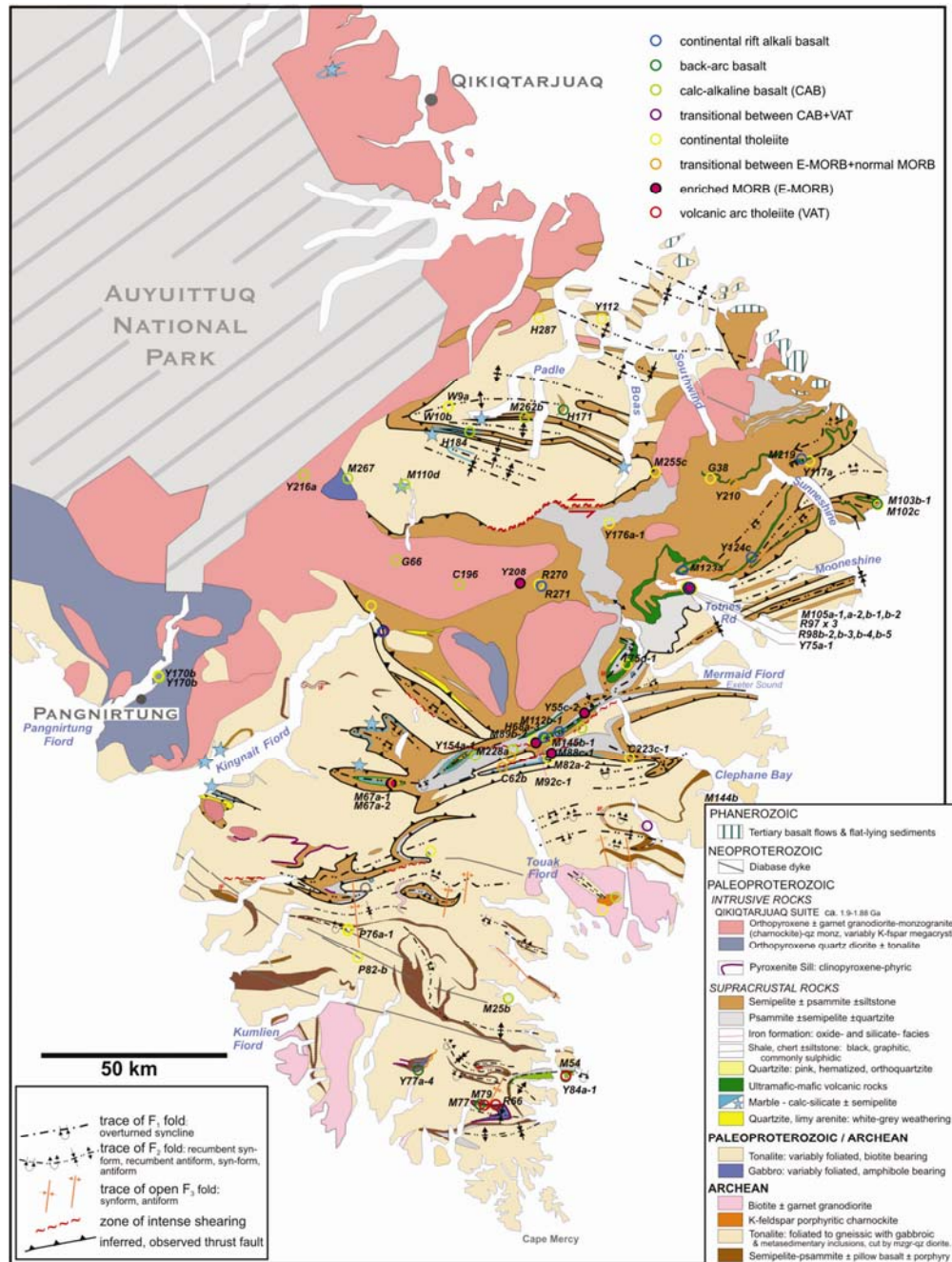


Figure 4

Simplified geological map of Cumberland Peninsula showing the distribution of mafic ($\text{SiO}_2 < 60$ wt.%) plutonic and volcanic rock samples. Samples have been subdivided based on the Cabanis and Lecolle (1989) tectonic discrimination diagram for mafic volcanic rocks (see symbol legend and Figure 3).

Contents

Readme_of_e.rtf – contents of the CD-ROM and file structure.

Of_6933.pdf – summary document outlining the database.

Contacts.pdf – contact information of principle geologists and laboratories.

licence_agreement_e.rtf – formal end-user licence agreement for digital data.

Primary Data Files

2009CP_processed_geochemistry.xls – *location, descriptive information and chemistry of silicate rock samples*

2010CP_processed_geochemistry.xls – *location, descriptive information and chemistry of silicate rock samples*

Background Information

Analytical Procedures

Geo_Labs_methods.doc – *Ontario Geological Survey laboratory methods manual*

Standards_duplicates.xls – *chemistry of standards and replicate analyses for 2009 and 2010 sample batches*

Unprocessed Analytical Data

09-0492-FEO-ION-Data.csv
09-0492-FEO-ION-QC.csv
09-0492-IMC-100-Data.csv
09-0492-IMC-100-QC.csv
09-0492-XRF-M01-Comment.pdf
09-0492-XRF-M01-Data.csv
09-0492-XRF-M01-FeO-Data.csv
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