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CANADIAN GEOSCIENCE MAP 430

PRECAMBRIAN BEDROCK GEOLOGY

BOOTHIA PENINSULA

Nunavut

NTS 57-F and parts of 57-C, D, E, G and 67-D, E, H

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ABSTRACT

This new map of the Precambrian geology of Boothia Peninsula, Nunavut, is a key tool to strengthen the geoscience knowledge base of north-central Nunavut, and presents a significant update to knowledge acquired in 1962 (Blackadar, 1967) and 1986 to 1990 (Frisch, 2011). Through modern-concept bedrock mapping in 2017 and 2018 and supported by high-resolution geophysical and geochronological data sets, this map portrays in colours the location of at least 18 different crustal components that are distinguished on the basis of composition, mineral assemblage, and/or age. Several generations of folds and deformational fabrics are portrayed (line types), with zones of more intense and localized high strain (shear zones) also shown (red). The new knowledge highlights a complex polydeformed terrane that is distinct from rocks to the south and southeast, and shows that mineral exploration strategies for other parts of Nunavut may not be transferable to the Boothia Peninsula - Somerset Island region.

RÉSUMÉ

Cette nouvelle carte de la géologie précambrienne de la presqu'île de Boothia, au Nunavut, est un outil essentiel pour améliorer notre base de connaissances géoscientifiques sur le centre nord du Nunavut et offre une importante mise à jour des connaissances acquises en 1962 (Blackadar, 1967) et de 1986 à 1990 (Frisch, 2011). Élaborée suivant une approche moderne de la cartographie du substratum rocheux en 2017 et 2018, et étayée par des ensembles de données géochronologiques et géophysiques à haute résolution, cette carte illustre en couleurs l’emplacement d'au moins 18 différentes composantes de la croûte, qui se distinguent par leur composition, leur association de minéraux ou leur âge. Plusieurs générations de plis et de fabriques de déformation sont illustrées (types de lignes), et des zones de forte déformation plus intense et localisée (zones de cisaillement) sont indiquées en rouge. Les nouvelles connaissances permettent de mettre en lumière un terrane polydéformé complexe qui se distingue des roches présentes au sud et au sud-est; elles montrent aussi que les stratégies d'exploration minérale utilisées dans d'autres secteurs du Nunavut ne s'appliquent peut-être pas à la région de la presqu'île de Boothia-île Somerset.

SHEET 1 OF 1, PRECAMBRIAN BEDROCK GEOLOGY

GENERAL INFORMATION
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Digital compilation of field data by A. Ford, 2017 and 2018

Geological interpretation by M. Sanborn-Barrie, 2019

Geological data conforms to Bedrock Data Model v. 2.10 (Brouillette et al., 2019).

Geomatics by A. Ford

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Map projection Universal Transverse Mercator, zone 15
North American Datum 1983

Base map at the scale of 1:250 000 from Natural Resources Canada, with modifications
Elevations in metres above mean sea level

Proximity to the North Magnetic Pole causes the magnetic compass to be erratic in this area.
Mean magnetic declination 2023, 10°05′W, decreasing 28.8′ annually
Readings vary from 16°09′W in the NE corner to 4°13′W in the SW corner of the map.

This map is not to be used for navigational purposes.

Title photograph: shallow-dipping tonalite with amphibolitic layers (unit Ātn[Ādr]) representative of ca. 2.52 Ga basement exposed on Boothia Peninsula, Nunavut. Station 18SRB-R127. Photograph by D. Regis. NRCan photo 2019-254

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Data may include additional observations not portrayed on this map. *See* map info document accompanying the downloaded data for more information about this publication.

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Map Viewing Files

The published map is distributed as a Portable Document File (PDF), and may contain a subset of the overall geological data for legibility reasons at the publication scale.

Cartographic Representations Used on Map

This map utilizes ESRI Cartographic Representations in order to customize the display of standard GSC symbols for visual clarity on the PDF of the map only. The digital data still contains the original symbol from the standard GSC symbol set. The following legend features have Cartographic Representations applied:
- Axial trace of first generation, antiform, upright
- Axial trace of first generation, synform, upright
- Axial trace of second generation, antiform, upright
- Axial trace of second generation, synform, upright
- Axial trace of second generation, antiform, overturned
- Axial trace of second generation, synform, overturned
- Axial trace of third generation, antiform, upright
- Axial trace of third generation, synform, upright
- Axial trace of third generation, antiform, overturned
- Axial trace of third generation, synform, overturned
- Bedrock outcrop examined for this study
- Foliation mylonitic
- Ductile shear zone or shear band, sinistral
- Ductile shear zone or shear band, sinistral-reverse
- Ductile shear zone or shear band, reverse
- Ductile shear zone or shear band, dextral
- Ductile shear zone or shear band, dextral, vertical, estimated

- Ductile shear zone or shear band, unknown sense
- Mineral lineation, very strong linear fabric in mylonitic rocks
- Stretching lineation, very strong linear fabric in mylonitic rocks
- Intersection lineation, very strong linear fabric in mylonitic rocks

DEFINITION QUERIES USED ON MAP

This map utilizes definition queries in order to customize the display for visualization on the PDF of the map only and does not affect the digital data. The following features have a definition query applied:

- Geopoints - planar
- Geopoints - linear
- Geolines - shear
- Geolines - fault
- Geolines - unit construct line
- Geolines - contact
- Geolines - fold
- Map Units

DESCRIPTIVE NOTES

Introduction

The Boothia Peninsula – Somerset Island area is an under-explored frontier region where knowledge has stemmed from 1962 (Blackadar, 1967) and 1986 to 1992 (Frisch, 2011) geological mapping, undertaken without benefit of aeromagnetic constraints and with only limited U-Pb geochronology (Frisch and Hunt, 1993). Geomapping for Energy and Minerals (GEM) built upon this historical foundation through modern-concept bedrock mapping supported by high-resolution geophysical and geochronological data sets. This map, reports of field findings (Sanborn-Barrie et al., 2018, 2019), and value-added data sets (e.g. Regis and Sanborn-Barrie, 2023) are ensuring that relevant data and knowledge are accessible to a region of Nunavut (Figure 1) that may, due to increased shipping, be increasingly exposed to decisions related to resource assessment and economic development.

GEM invested in three high-resolution (400 m) aeromagnetic surveys that resulted in continuous coverage across the Boothia-Somerset corridor (Figure 2). These data reflect underlying units and structures, including those beneath till and Paleozoic strata (southwestern and northeastern Boothia Peninsula). Magnetically defined units and structures are indicated on the map using lines decorated with black dot (magnetic highs) and white dots (magnetic lows), especially where they influenced the geological interpretation.

Field relationships and supporting U-Pb geochronology (e.g. Regis and Sanborn-Barrie, 2023; unpublished data) have allowed determination of a chronology of lithological units shown in the map legend and described here from oldest to youngest. In addition, U-Pb monazite and zircon rim data have permitted relatively precise calibration of the region's tectonometamorphic history, which is integrated into the map legend (red font) to provide insight into the timing of multiple metamorphic events.

Lithology

Neoarchean Basement Complex

Isolated exposures of foliated orthopyroxene-bearing tonalite and clinopyroxene-biotite granodiorite (unit nAgg) underlie the Wrottesley River valley of northwestern Boothia Peninsula and constitute the oldest rock unit recognized. Widespread, moderately to strongly foliated K-feldspar porphyritic biotite-garnet quartz monzonite-granodiorite (unit nAgr) exposed throughout east-central Boothia Peninsula, constitutes a major component of its Neoarchean basement complex. Where highly strained, this unit is distinctly and spectacularly porphyroclastic with isolated feldspar porphyroclasts surrounded by fine, strongly foliated, dark biotitic matrix phases. Spatially associated with, and typically structurally overlying unit nAgr, is strongly foliated to gneissic, fine-grained, grey, biotite-magnetite tonalite (unit nAtn), locally associated with pink-white weathering granodiorite-monzogranite (unit nAgd). Tonalite and granodiorite may contain mafic layers and inclusions (unit Adr) typically composed of dark green-black hornblende-gabbro/amphibolite with lesser gabbroic anorthosite and anorthosite. Restricted exposures of orthogneiss migmatite (unit Agns) occur on coastal outcrops in the extreme southeast, and these may correlate with monzogranitic to granodioritic migmatitic gneiss (unit AOdgm) identified by Ryan et al. (2009) east and southeast of Taloyoak.

Clastic Sequence I

Rusty-weathering clastic metasedimentary rocks deposited at ca. 2.5 Ga (Siderian; Regis and Sanborn-Barrie, 2023) and their migmatized equivalents occur throughout central and eastern Boothia Peninsula and typically coincide with uniformly quiet magnetic zones of low amplitude (Figure 2). Biotite-graphite-garnet±sillimanite semipelite commonly with significant (>50%) inhomogeneous diatexite (5% to 30% paleosome) (unit Ssp) and/or homogeneous diatexite (peraluminous garnet±sillimanite±cordierite leucogranite with <5% paleosome) is widespread. Garnet-bearing psammite (unit Sps) occurs locally as ~6 to 60 cm wide layers with semipelite. These clastic rocks are infolded with Neoarchean plutonic rocks (units nAgr, nAtn, nAgg) from which they are inferred to be derived based on U-Pb zircon data (Regis and Sanborn-Barrie, 2023).

Intermediate to Mafic Plutonic Suite

Paleoproterozoic intermediate to mafic plutonic rocks (unit pPqd) dominated by orthopyroxene-magnetite±clinopyroxene±hornblende quartz diorite±diorite with locally associated gabbro anorthosite, cut clastic sequence I and some basement rocks. Associated gabbro (unit pPgb) and anorthositic rocks (unit pPan) are less common. These intermediate to mafic plutonic rocks are expressed by aeromagnetic highs (Figure 2), in contrast to the magnetically low metasedimentary rocks they cut, such that structures attributed to polyphase folding are evident. Minor monzogranite-quartz monzonite (unit pPgr) is spatially associated with units pPqd and pPgb and may be part of the same plutonic suite.

Leucogranite

Peraluminous garnet±sillimanite±cordierite leucogranite with <5% paleosome (unit pPl-gr), also known as homogeneous diatexite, commonly occurs as veins, dykes, and sills cutting units Ssp, nAgr, and occurring as discrete plutons. These bright white weathering rocks are especially voluminous north of Thom Bay (eastern Boothia Peninsula), where they host gossanous enclaves with elevated Au, Pt, Cr, and Ni contents

(Regis et al., 2019), and surrounding Lake Hansteen in the south. Leucogranite typically displays less strain than the rocks it cuts, suggesting emplacement during elevated geotherms, relatively late with respect to deformation.

Clastic-Carbonate Sequence II

Metasedimentary rocks exposed on northwestern Boothia Peninsula (west and southwest of Wrottesley Inlet) are dominated by garnet±sillimanite semipelite±psammite (unit Osp) cut by leucogranite veins, with minor quartzite (unit Oqz) and marble±calc-silicate (unit Omb). This clastic-carbonate sequence is significantly younger (Orosirian period) than similar-looking semipelitic rocks of unit Ssp and shows very different provenance (Regis and Sanborn-Barrie, 2023). Clastic sequence II is largely derived from source rocks with ages of 2020 to 1970 Ma, consistent with uplifted and eroded Thelon magmatic arc rocks, which are suspected, based on aeromagnetic trends, to form a north-trending belt some 160 km to the west below Phanerozoic strata. The presence of marble (~200 m by 50 m) north of Josephine Bay (*see also* Figure 8 of Sanborn-Barrie et al., 2018), suggests the younger clastic-carbonate sequence (units Osp–Omb) may extend south of Pasley Bay beneath Paleozoic strata and Quaternary cover.

Tectonized ca. 1.945–1.895 Ga Tonalitic suite

Buff-weathering orthopyroxene-bearing tonalite±trondjhemite (unit pPtn) occurs throughout northwestern Boothia Peninsula where it locally is observed to cut unit Osp. To the north, along the west coast of Somerset Island (not shown on this CGM map) foliated to gneissic granodiorite (unit pPgd) exposed near Howe Harbour cuts unit nAtn. Magnetite-bearing, quartz-poor monzonitic rocks occurring as dykes (unit pPmn$_d$) and salmon-weathering aplitic dykes (unit pPgr$_d$) cut unit nAgr proximal to sheared rocks of the Sanagak Lake shear zone (described in Structural Geology below).

Late- to Post-tectonic Syenitic Granitoid Rocks

Weakly foliated to massive orthopyroxene alkali-feldspar granite (unit pPch) and hornblende syenogranite (unit pPsy) to monzogranite (unit pPmz), underlie southernmost Boothia Peninsula. Locally within unit pPch, outcrop-scale xenoliths of migmatized orthogneiss and mylonitic orthogneiss reflect pre-existing units magmatically stopped by these late syenogranitic plutons (Osinchuk et al., 2019; Osinchuk, 2021).

Tectonometamorphism

The deformational history of Boothia Peninsula is polyphase with at least two, and typically three, penetrative deformation events reflected in most units, with the exception of late to post-tectonic granitoid rocks (e.g. units pPch, pPsy) that typically are weakly foliated to massive. In general, rocks across Boothia Peninsula display strongly developed, shallow to flat-lying fabrics. Lower strain 'windows' preserve folded layering with an axial planar S_1 foliation indicating that the prominent shallow tectonic fabric observed thoughout much of the map area is a composite S_1+S_2 transposition foliation.

F_2 folds and fabrics are refolded by upright F_3 folds, creating dome and basin (Type 2) and mushroom geometry (Type 3) interference patterns of 10 to 20 km scale, clearly evident in the aeromagnetic data (Figure 2). These folds and fabrics are sinistrally deflected by a regional southwest-striking, moderately northwest-dipping shear zone (Sanborn-Barrie et al., 2018; Drayson et al., 2019; Drayson et al., 2022) that extends at least 160 km, transecting the southern part of Boothia Peninsula (Figure 2), with apparent offset of ~30 km. This structure is marked by a number of northeast-trending linear lakes disposed along it including Sanagak Lake, such that it is here designated the Sanagak Lake shear zone.

Boothia Peninsula has been subject to multiple metamorphic events (red font on map legend) including two regional events and local evidence for contact thermal events. Widespread granulite-facies assemblages include monazite and metamorphic zircon dated at 2.45 and 2.39 Ga (Regis, unpublished data, 2020), and are attributed to the Arrowsmith Orogeny (Berman et al., 2013). Subsequent granulite-facies metamorphism, recognized at ca. 1920 Ma (Frisch and Hunt, 1993), attained conditions of 740° to 850°C and 6 to 8 kbar, locally up to 960°C and 8.7 kbar (Kitsul et al., 2000) are now distinguished as two stages of Thelon orogenesis at ca. 1.93 and 1.91 Ga (Regis, unpublished data, 2020). U-Pb titanite ages across Boothia Peninsula were interpreted as cooling through ~600°C (U-Pb titanite closure) by Frisch and Hunt (1993), but associated ultra-high temperature assemblages (Regis, unpublished data, 2020) point to reheating at this time, possibly due to back-arc extension.

Mineral Prospectivity

Boothia Peninsula contains numerous scattered sulphide occurrences, mostly associated with clastic supracrustal sequences and their melted derivatives. Whereas an earlier report for this area stated “On closer examination, superficially exciting gossan zones proved to be devoid of any significant metallic minerals and are seen to be the result of weathering of garnet-graphite-biotite-quartz feldspar schists and gneisses” (Blackadar, 1967, p. 14), many of the gossans sampled yielded anomalous polymetallic mineral values (Regis et al., 2019) which, although generally modest, demonstrate some economic mineral potential for base metals across the region.

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ADDITIONAL INFORMATION
The Additional Information folder of this product's digital download contains figures and tables that appear in the map surround as well as additional geological information not depicted on the map, nor this document, nor the geodatabase.
-PDF of each figure that appears in the CGM surround.

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COORDINATE SYSTEM
Projection: Universal Transverse Mercator
Units: metres
Zone: 15
Horizontal Datum: NAD83
Vertical Datum: mean sea level

BOUNDING COORDINATES
Western longitude: 97°00′00″W
Eastern longitude: 91°00′00″W
Northern latitude: 71°30′00″N
Southern latitude: 69°30′00″N

SOFTWARE VERSION
Data has been originally compiled and formatted for use with ArcGIS™ desktop version 10.8.2 developed by ESRI®.

DATA MODEL INFORMATION
Bedrock
Based on a data-centric approach, the GSC Bedrock Model was designed using the ESRI ArcGIS® environment. The model architecture is almost entirely tailored to the proprietary functionalities of the ESRI® File Geodatabase such as *SubTypes*, *Domain Values* and *Relationship Classes*.

Consult PDFs in Data folder for complete description of the model with its feature classes, tables, attributes, and domain values.

Note: the PDF document is not intended to describe the entire GSC Bedrock Model, but it provides a complete and detailed description of a subset of the model representing the published dataset.

For a more in depth description of the data model please refer to the official publication:

Brouillette, P., Girard, É., and Huot-Vézina, G., 2019. Geological Survey of Canada Bedrock Data Model and tools: design and user guide documentation including ArcGIS^{TM} add-ins; Geological Survey of Canada, Open File 8247, 129 p, 1 .zip file. https://doi.org/10.4095/314673