Descriptive Notes

Introduction

The Boothia Peninsula – Somerset Island area is an under-explored frontier region where knowledge has stemmed from 1962 (Blackadar, 1967) and 1988 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-scheme bedrock mapping supported by high-resolution aeromagnetic and radiometric surveys (Boucher et al., 2018; Dyck et al., 2018; Kimpe et al., 2018; Sanborn-Barrie et al., 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 traceable into the Precambrian basement where dark (at magnetic highs) and white (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Field relationships and supporting U-Pb geochronology (e.g. Regis and Sanborn-Barrie, 2023; unpublished data) have allowed determination of a chronology of lithological units shown in the map legend and described here from oldest to youngest.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 date 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 biotite matrix phases. Spatially associated with, and typically structurally beneath, the above two units, heterogeneous biotite-hornblende ± garnet tonalitic gneiss (unit nAgn) is locally associated with pink-white weathering granodiorite-monzogranite (unit nAgp). Tonalite and granodiorite may contain mafic layers and inclusions (unit nAn) typically composed of dark green-black hornblende-garnet-amphibolite with lesser gabbroic anorthosite and anorthosite. Restricted exposures of orthogneiss migmatite (unit Agno) 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 (Sidenian; 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-garnetite/limanite semipelite commonly with significant (>50%) inhomogeneous diatexite (0% to 30% paleosome) (unit Bap) and/or homogeneous diatexite (paratumorous garnetite/limanite/cordierite leucogranite with <5% paleosome) is widespread. Garnet-bearing psammite (unit Bpo) occurs locally as <6 to 60 cm wide layers with semipelite. These clastic rocks are infolded with Neoarchean plutonic rocks (units nAgr, nAtn, nAgp) 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 pPgd) dominated by orthopyroxene-magnetite/ilmenite/rare hornblende quartz diorite/diorite with locally associated gabbro anorthosite, cut clastic sequence I and some basement rocks. Associated gabbro (unit pPgb) and anorthosite 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 pPgd and pPgb and may be part of the same plutonic suite.

Leucogranite

Peraluminous garnetite/limanite/cordierite leucogranite with <15% paleosome (unit pPgr) also known as homogeneous diatexite, commonly occurs as veins, dykes, and sills cutting units Bap, 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 As, Pt, Cr, and Ni contents (Regis et al., 2019), and surrounding Lake Haselwen 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 garnetite/limanite semipelite/psammite (unit Oqz) 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 Bap 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 exhumed Paleoproterozoic rocks of the Rae domain, and subordinately from rocks with ages of 2.5 Ga, consistent with some 180 km to the west below Phanerozoic strata. The presence of marble (~200 m by 50 m) north of Josephine Bay (see also Figure 6 of Sanborn-Barrie et al., 2018), suggests the younger clastic-carbonate sequence (units Oqz–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/trondhjemite (unit pPtn) occurs throughout northwestern Boothia Peninsula where it locally is observed to cut unit Oqz. To the north, along the west coast of Somerset Island (not shown on this GEM map) foliated to gneissic granodiorite (unit pPgd) exposed near Howe Harbour cuts unit nAtn. Magnetite-bearing felsic to intermediate orthogneiss dykes (unit pPdm) and salmon-weathering quartz-diorite dykes (unit pPdq) 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 pPdhh) and hornblende syenogranite (unit pPsy) to monzogranite (unit pPmz), underlie southernmost Boothia Peninsula. Locally within unit pPdhh, outcrop-scale xenoliths of migmatized orthogneiss and mylonitic orthogneiss reflect pre-existing units magmatically stopped by these late syenogranitic plutons (Demchuk et al., 2019; Demchuk, 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 pPdh, pPhy) 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 S1 foliation indicating that the prominent shallow to flat-lying penetrative foliation (S2) is a composite fabric. In the central Boothia Peninsula, transposition of earlier structures and fabrics are refolded by upright F3 folds, creating dome and basin interference patterns (Figure 2). Two distinct phases (F3 and F4) of F3 folds are inferred to be aerial, clearly evident in the aeromagnetic data (Figure 2). These folds and fabrics are similarly deflected by a regional southeast-striking, moderately northeast-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 monazite-bearing units dated at ca. 1930 Ma (Regis et al., 2019; Regis and Sanborn-Barrie, 2023) and the Trans-Hudson Orogeny (Berman et al., 2013). Subsequent granulite-facies metamorphism, recognized at ca. 1820 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 (Kilfeather et al., 2009) are now distinguished as two stages of Thelon orogenesis at ca. 1.83 and 1.81 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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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 established by Blackadar (1967) and Frisch and Hunt (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 lithostratigraphic units 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 highlighted by lineaments (red lines). This compilation highlights a complex polyphemed 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 transferrable 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 mise à jour de celle de Blackadar (1967) et de Frisch et Hunt (Frisch, 2011). Élaborée suivant une approche moderne de la cartographie du substratum rocheux en 2017 et 2018, et étayée par des ensembles de données géophysiques haute résolution et géochronologiques, cette carte illustre en couleurs l'emplacement d'au moins 18 différentes compositantes 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 (types de lignes) et des 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 polyélémental complexe qui se distingue des roches au sud et au sud-est, et 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.

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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
1:200 000

Geological Survey of Canada
Canadian Geoscience Maps

Canada

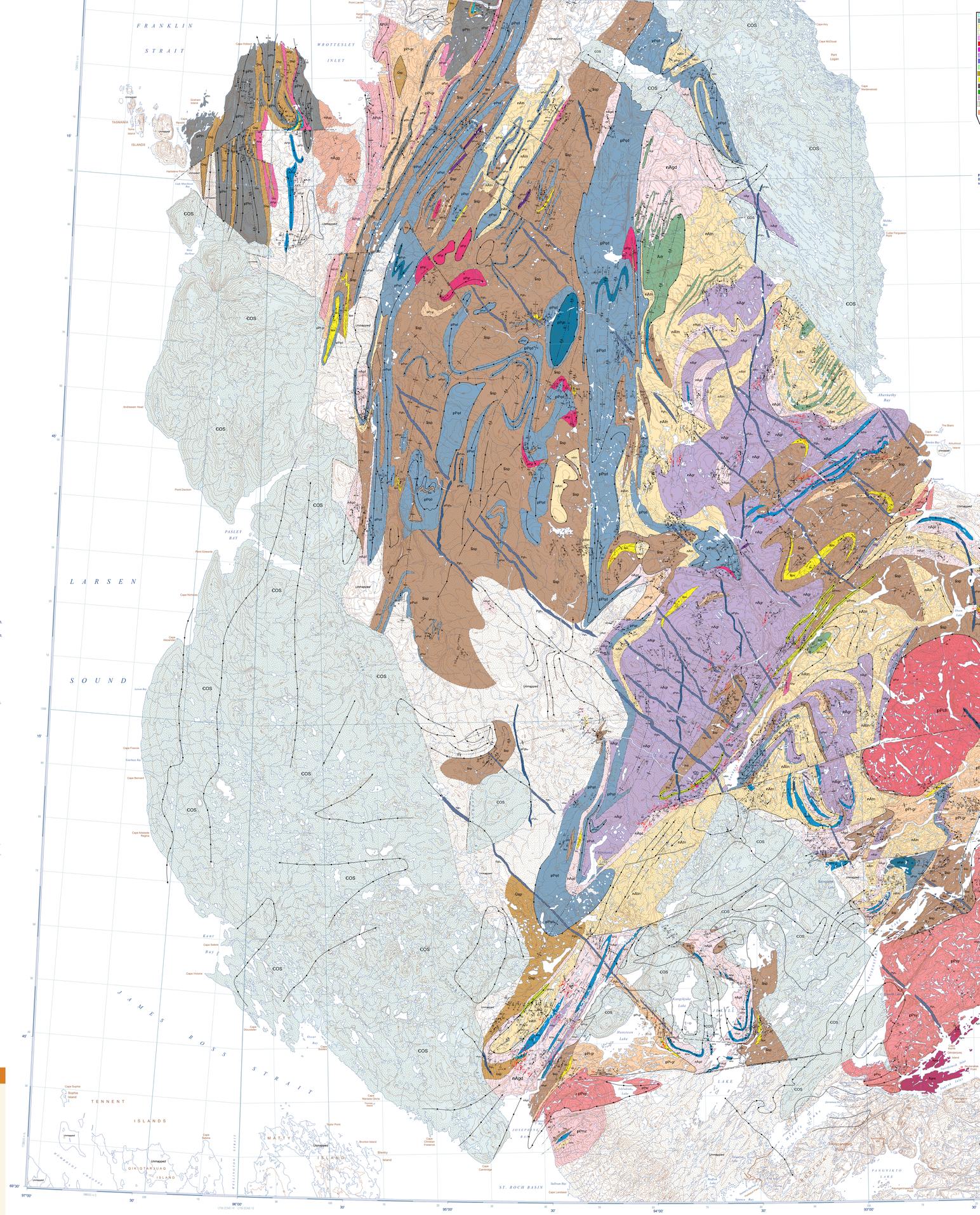

Figure 1. Geological map of northern Canada showing major geological provinces and tectono-magmatic elements, with the location of the GEM Boothia Peninsula – Somerset Island project (red rectangle). Abbreviations: BP=Boothia Peninsula; CH=Chesterfield block; mz=magmatic zone; sed=sedimentary; SI=Somerset Island; SG=Sowdlerd tectonic zone; tz=tectonic zone; WB=Wathaman batholith.

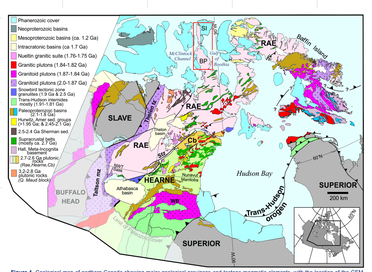

Figure 2. Total field aeromagnetic coverage for Boothia Peninsula and Somerset Island, Nunavut (Dumont, 2014a–j; Coyle et al., 2016a–f). Black and white arrows indicate positive magnetic anomalies associated with quartz diorite (unit pPgd); red arrows indicate the sinistral Sanagak Lake shear zone.

QUATERNARY

PLEISTOCENE – RECENT

Unconsolidated glacial till veneer (<1.5m thick, discontinuous) and till blanket (drapes).

PHANEROZOIC – UNDIVIDED

COS — Undivided strata of Upper Cambrian, Ordovician to Upper Silurian age, dominated by relatively flat-lying, pale grey to buff dolostone and dolomitic limestone, locally fossiliferous; lesser sandstone, siltstone, and shale (see Stewart and Ken, 1984a,b).

ARCHEAN–PROTEROZOIC (Age Unknown)

APgr — **Monzogranite:** Bt-monzogranite-quartz monzonite/leucogranodiorites syenogranite, age unknown.

APch — **Charnockite:** Opx-monzogranite-quartz monzonite, age unknown.

APdo — **Diorite - Quartz monzodiorite:** Variably magnetic mafic plutonic rocks, locally containing flat-lying S. foliation; age unknown.

NEO- TO MESOPROTEROZOIC

Gabbro dykes — **Gabbro dykes:** Unmetamorphosed and undeformed gabbro dykes; mainly southeast-striking, steeply dipping, typically strongly magnetic, locally east-striking; one dyke dated at 1.27 Ga (Fahrig and Jones, 1969; and Heaman, 1989) and ca. 720 Ma Franklin dyke swarm(s).

PALEOPROTEROZOIC

pPdh — **Ultramafic dykes/sills:** May include pyroxenite, gabbroic anorthosite.

pPgb — **Gabbro dykes:** Unmetamorphosed and undeformed quartz gabbro dykes; north-striking, steeply dipping.

Late- to post-tectonic granitic suite ca. 1820–1845 Ma

pPmz — **Monzogranite-syenogranite:** Bt±Grt monzogranite to syenogranite, commonly weakly foliated, potassium feldspar porphyritic and xenoliths of undated, strongly foliated to gneissic tonalitic rocks interpreted to be old nAtn; relatively low magnetic signature due to lack of magnetite, hornblende.

pPsy — **Quartz syenite-syenogranite:** Pink-weathering, Hb-Mag±Bt±Chl quartz syenite to syenogranite, typically weakly foliated; mafic minerals (Hb, Bt, magnetite, pyroxene (Opx+Cpx) now replaced by H5MB); locally containing xenoliths of orthogneiss and rounded xenocrystic clots of Bt-Grt-Sil-Crd-Spl residue.

pPdh — **Charnockite-monzogranite:** Brown-weathering, biotite-orthopyroxene monzogranite (charnockite) suite with A- to I-type granitoid major-element compositions and relatively low LREE/HREE fractionation; typically K/b porphyritic, slightly more evolved isotopic character (nf, Nd) than unit pPsy.

Felsic plutonic dykes ca. 1856–1894 Ma

pPgr₂ — **Granite dykes:** Granite dykes, aplitic texture; typically 2 to 10 cm wide; variably foliated and yet discordant to Sanagak Lake shear foliation, consistent with syntectonic/anatectonic emplacement with respect to Sanagak Lake shear zone.

M_{ON} ca. 1.87 Ga
[M_{ON} = 1.89 Ga = pyrite dyke, mylonitization along the sinistral Sanagak Lake shear zone

pPmz₁ — **Monzonite-quartz monzonite:** Notably quartz-poor felsic plutonic rocks including Bt±MagCh monzonite; fine-grained; variably foliated to mylonite; preferentially occurring as dykes proximal to the southeast-striking, sinistral Sanagak Lake shear zone.

M_{ON} ca. 1.91 Ga
late-stage Thelon Orogeny
M_{ON} ca. 1.94 Ga
early-stage Thelon Orogeny

pPr-p — **Leucogranite:** White-weathering leucogranite; typically peraluminous Grt-bearing with <10% Grt-Bt; Grt commonly pale lilac colour; rare silliminite (western peninsula); rare cordierite (western peninsula); multiple generations typically as weakly foliated sills or dykes cutting units Bap–Bpo, associated with unit Opz, cutting units pPfr and pPgd, and occurring as discrete plutons.

pPgd — **Granodiorite-monzogranite/tonalite:** Foliated granodiorite-monzogranite-tonalite; locally K/b porphyritic; may contain dioritic enclaves; observed to cut unit pPfr (i.e. at Creswell Bay).

pPfr — **Tonalite-diorite-trondhjemite:** Buff-weathering, Opx-tonalite-leucotonalite (trondhjemite)±quartz diorite with gabbroic layers; variable grain size; gabbroic layers, 3 to 30 cm wide, are typically medium-grained, magnetic, locally with anorthositic layers; Opx-tonalite-leucotonalite (trondhjemite) is spatially associated with the young clastic-carbonate sequence that it cuts; inferred to be Paleoproterozoic based on maximum age provided by Sm-Nd model age of ca. 2.3 Ga (E. Hegner, pers. comm., 1995, cited in Frisch and Hunt, 1993) and minimum age provided by U-Pb metamorphic zircon upper intercept age of 1921 ± 1.6 Ma (Frisch and Hunt, 1993).

OROSIRIAN

Clastic-carbonate sequence ca. >1.935 Ga <2.0 Ga

Opz — **Semipelite-pelite-psammite, diatexite:** Rusty-weathering, strongly foliated.

Omb — **Marble-calc silicate rock:** Light to medium grey, rubbly-weathering marble and pale grey-green banded calc-silicate; marble comprises granoblastic calcite with 1% to 10% olivine; calc-silicate contains interlayered silicates (10% to 30%) and both are associated with unit Opz; at locality 7 km north of Josephine Bay, marble contains 10 to 20 cm scale lenses/inclusions of massive garnet (80%) +Cpx (20%).

M_{ON} ca. 1.97 Ga contact metamorphism

Oqz — **Quartzite/psammite, leucogneiss diatexite:** Equigranular, fine-grained quartzite with up to 15% garnet; occurs as 50 cm layers contained within inhomogeneous diatexite.

unconformity

M_{ON} ca. 2.39 Ga
late-stage Arnaveetik Orogeny
M_{ON} ca. 2.44 Ga
early-stage Arnaveetik Orogeny

pPgr — **Granite-granodiorite:** Bt±Opx±Grt monzogranite-quartz monzonites granodiorite; nonmagnetic; occurs as kilometre-scale plugs and locally as marginal phase to unit pPgd.

M_{ON} ca. 2.49 Ga, contact metamorphism? related to unit pPgd, pPgb

Intermediate to mafic plutonic suite ca. 2.48–2.45 Ga

pPan — **Anorthosite-gabbroic anorthosite:** Chalky-weathering, plagioclase-rich, medium- to coarse-grained plutonic rocks.

pPgb — **Gabbro:** Cpx-Opx-Hb gabbro - quartz diorite - quartz monzodiorite.

pPgd — **Quartz diorite:** Cpx-Opx-MagSil quartz diorite - quartz monzodiorite ±olivine sieuogabbro/gabbroic anorthosite; pale to medium grey-green weathering; typically weakly to moderately magnetic; typically weakly foliated; occurs in coincident positive aeromagnetic anomalies; variably foliated to granoblastic equigranular, medium-grained texture; may contain patches of coarse-grained, weakly foliated Cpx-Pl indicative of late-tectonic in situ partial melting of these rocks; locally cut by coarse-grained monzogranite veins.

SIDERIAN

Clastic sequence ca. >2.49 Ga <2.51 Ga

Ssp — **Semipelite/pelite, diatexite:** Grt-Bt±Sil semipelite/pelite (upper amphibolite to granulite facies) interlayered with typically 50% inhomogeneous diatexite (melted sedimentary rock containing 10% to 30% paleosome, 70% to 85% leucosome of Bt+Grt±Sil monogranitic composition); locally screens and schlieren of psammite.

Sps — **Psammite:** Psammite/quartzite; light-grey weathering, >50% granoblastic quartz; typically occurring as enclaves and layers associated with 50% leucosome (monzogranitic to syenogranitic melt).

unconformity

NEOARCHEAN

Plutonic basement complex ca 2.5–2.56 Ga

nAgr — **Granodiorite-monzogranite:** Pale pink weathering, Bt-Mag±Hbl±Grt monzogranite-granodiorite-leucotonalite, variably foliated, typically strongly foliated to gneissic, variable grain size; texturally similar to and transitional with associated unit nAtn.

nAtn — **Tonalite-trondjhemite:** Fine- or medium-grained Bt-bearing tonalite - leucotonalite (trondjhemite)±quartz diorite/granodiorite; typically light grey weathering but may appear pink on weathered fresh fresh surfaces due to oxidation associated with fractures; equigranular, moderately to strongly magnetic; locally transitional with foliated to gneissic quartz diorite; commonly cut by pink, foliation-parallel monzogranite veins; younger and structurally overlying unit Agr.

nAgp — **Porphyroclastic granodiorite-monzonite:** K/b>P1 porphyritic Bt-Grt±Opx monzogranite - monzonite; white-weathering feldspar phenocrysts typically 1 to 4 cm length, commonly occurring as elongate to rounded variably recrystallized porphyroclasts in highly strained host rock; up to 10% almandine Grt, up to 30% Bt, variable Opx in diagnostic with Bt; peraluminous character (A/CNK = 1.0-1.1); occurs structurally below unit nAtn; cut by veins of unit pPgr and/or unit pPsy.

Plutonic remnants ca. 2.71 Ga

nAgg — **Granodiorite:** Beige-weathering, Cpx-Bt±Mag granodiorite; weakly magnetic, cut by diorite (units Adr or pPgd?); previously U-Pb zircon age of 2.67-70, Frisch and Hunt, 1993) derived upper intercept of 2.715 +67/-66 Ma and lower intercept of 1.8 +0.4/-0.3 Ga; Nd model age of 2.8 Ga (Frisch and Hunt, 1993) and inheritance but now known to have a crystallization age of ca. 2.71 Ga (D. Regis, unpub. data, 2019).

ARCHEAN

Adr — **Diorite-gabbro-gabbroic anorthosite:** Dark green-black weathering, fine-grained, moder