Report of Investigation 2024-7

BEDROCK GEOLOGIC MAP OF THE BIG HURRAH-COUNCIL-BLUFF AREA, SOUTHERN SEWARD PENINSULA, ALASKA

Melanie B. Werdon, Rainer J. Newberry, Jennifer E. Athey, David J. Szumigala, Lawrence K. Freeman, Laurel E. Burns, and Shelley A. Hicks

Big Hurrah Mine stamp mill. Photo: Melanie B. Werdon, June 24, 2004.

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State of Alaska
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BEDROCK GEOLOGIC MAP OF THE BIG HURRAH-COUNCIL-BLUFF AREA, SOUTHERN SEWARD PENINSULA, ALASKA

Melanie B. Werdon[1], Rainer J. Newberry[1], Jennifer E. Athey[1], David J. Szumigala[1], Lawrence K. Freeman[1*], Laurel E. Burns[1*], and Shelley A. Hicks[2]

INTRODUCTION

Bedrock geologic mapping in the blueschist-facies-metamorphosed, Late Proterozoic to Devonian Nome Complex was conducted by the Alaska Division of Geological & Geophysical Surveys (DGGS) on southern Seward Peninsula, Alaska. This map, covering portions of the Solomon C-4, C-5, D-4, D-5, and the southern Bendeleben A-4 quadrangles, includes new mapping by DGGS in summer 2006, and incorporates previous mapping conducted by DGGS in 2003 and 2004 (Newberry and others, 2005a,b; Werdon and others, 2005a,b,c). Surficial geologic mapping was also conducted in the area (Stevens, 2005a,b; 2024). This 595-square-mile, 1:50,000-scale, bedrock geologic map coincides with portions of the DGGS Council airborne magnetic and resistivity survey (Burns and others, 2003). The geophysical survey and geologic map are part of the State of Alaska's Airborne Geophysical/Geological Mineral Inventory program, the focus of which is to enhance public knowledge of Alaska's geology and mineral districts.

More than 1 million ounces of placer gold have been extracted from the map area since the turn of the century, with most production derived from the Casadepaga and Solomon rivers and Ophir Creek (U.S. Geological Survey [USGS], 2016). Widespread low-sulfide, gold-bearing quartz veins of Cretaceous age were the primary lode source for the placer gold. Approximately 27,000 ounces of gold were produced from low-sulfide quartz veins at the Big Hurrah lode gold mine between 1903 and 1907 (Read and Meinert, 1986). Other notable lode gold prospects in the map area include Silver (Flynn), West Creek, and an unnamed prospect at the head of Albion Creek. The Bluff area along Norton Sound has both lode gold and mercury prospects. The map area contains numerous occurrences of silicified marble with anomalous geochemistry (±Au, ±Cu, ±Hg, and less commonly ±As, ±Pb, ±Zn) of uncertain age and genetic origin (Asher, 1969; Werdon and others, 2005d, 2007; USGS, 2016). Various lithologies of the Layered sequence subdivision of the Nome Complex, primarily the Mixed unit, have the potential to host sedimentary exhalative (SEDEX) mineralization of Late Devonian to possibly Mississippian(?) age, as found elsewhere on the Seward Peninsula (Ayuso and others, 2014; Shanks and others, 2014; Slack and others, 2014).

METHODS

This bedrock geologic map was produced from about 400 person-days of field work conducted during August 2003, June through August 2004, and June and July 2006. Field observations and rock samples were collected at 6,674 stations throughout the map area and adjacent portions of the Solomon and Bendeleben quadrangles. Airborne magnetic and resistivity data (Burns and others, 2003) were used to identify anomalies for field investigation, locate geophysically inferred faults and unit boundaries in the field, and extend mapped contacts through regions covered by vegetation or surficial deposits. Additionally, vertical derivative and unsuper-

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vised- and supervised-classification techniques were applied to the geophysical data and subsequently used for enhancing map interpretations. Magnetic susceptibility measurements were made on outcrops and hand samples throughout the map area to characterize lithologic units and to verify their signature in airborne magnetic data. Small shovels were used to dig down to bedrock where thinly covered by surficial deposits.

Unit descriptions are based on field observations, petrographic study, and modal analysis of 698 thin sections, geochemical analyses, and geochronologic data. Approximately 125 rocks were analyzed for major- and minor-oxides and trace elements (Werdon and others, 2005d; 2007). These data were used to determine permissible protoliths for metamorphic rocks, and to assign root names and trace-element-indicated tectonic settings to igneous and metamorphosed igneous rocks according to established petrologic nomenclature. Hundreds of hand-held X-ray fluorescence (XRF) analyses were made on cut surfaces of fine-grained metamorphic rocks in the field to help distinguish their composition and unit assignment. One U-Pb laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) detrital zircon analysis was obtained to determine the age of a felsic metavolcanic rock. Thirty-six $^{40}Ar/^{39}Ar$ laser step-heating analyses were obtained for minerals from metamorphic rocks, metamorphic veins, hydrothermal veins (± gold-bearing), and igneous rocks, as well as whole-rock analyses of Quaternary basalt (Layer and others, 2015). These data were used to constrain depositional and protolith ages, compositions and paleo-tectonic settings, and the nature and timing of metamorphism, intrusive and extrusive igneous rocks, and late-metamorphic and hydrothermal veins that are both gold-bearing and barren. To evaluate the map area's mineral-resource potential, 426 rocks that were either visibly mineralized or had features that suggested the potential to be mineralized, were analyzed for geochemical trace elements (Werdon and others, 2005d; 2007).

OVERVIEW

Bedrock geologic units in the map area are dominantly part of the Nome Complex, interpreted as a Late Proterozoic to Devonian, rifted continental margin (Till and others, 2014b) that was subducted and metamorphosed to blueschist facies in the Jurassic (Forbes and others, 1984; Thurston, 1985; Patrick, 1987; Patrick and Evans, 1989), and subsequently partially overprinted by amphibolite-facies and greenschist-facies mineral assemblages during exhumation in the Cretaceous. Along the northern edge of the map, just south of the Bendeleben Mountains, amphibolite-facies rocks with Proterozoic and Paleozoic protolith ages are present in high-angle-fault contact with Nome Complex rocks to the south. Although these rocks are higher in metamorphic grade, their protoliths may be equivalent to those of the Nome Complex (Till and others, 1986). Early Cretaceous syenite dikes occur in the northern half of the Solomon C-5 Quadrangle, and Late Cretaceous gabbro dikes are scattered throughout the map area. A Quaternary volcanic vent and associated basalt flows crop out along Bear River in the southwestern Solomon D-4 Quadrangle.

NOME COMPLEX

Definition

The Nome Complex is a regionally extensive suite of metasedimentary and metaigneous rocks that covers most of the Seward Peninsula, Alaska. Till and others (1986) interpreted the Solomon Schist and Casadepaga Schist (originally defined by Smith, 1910) as being part of the Nome Group (originally defined by Collier and others, 1908). Till and others (1986) also included (and defined) the Mixed unit, Impure marble unit, and isolated marble bodies containing conodonts of Devonian through Cambrian age in the Nome Group. Recently, Till and others (2014b) renamed the Nome Group to Nome Complex, and subdivided it into the Layered sequence, Low-grade layered sequence, Scattered metacarbonate rocks, and Metaturbidite subdivisions. Their Layered sequence subdivision includes the units Impure marble, Casadepaga Schist, Mixed, Calcareous metasiliceous, and Pelitic schist (the original name, Solomon Schist, is retained by DGGS to help distinguish this pelitic schist from the numerous other pelitic schists in the map area). The Layered sequence also hosts intrusive and (or) extrusive mafic rocks in all units except the Solomon Schist. The Layered sequence subdivision is partially age equivalent to the Scattered metacarbonate rocks subdivision; these isolated marble bodies are interpreted to be remnants of a Devonian- to Cambrian-age carbonate platform deposited on basement (Dumoulin and others, 2014). In the Nome Quadrangle immediately west of the map area, the Mixed unit and Casadepaga Schist contain isolated orthogneiss bodies with Neoproterozoic U-Pb ages (Patrick and McClelland, 1995; Amato and others, 2014). These and other Seward Peninsula orthogneiss bodies are interpreted to be pieces of basement rock to the Nome Complex that were detached and structurally incorporated in the Nome Complex during Mesozoic deformation (Till and others, 2014b).

DGGS's mapping (this study) mostly follows Till and others' (2011) primary breakdown of Layered sequence subdivisions and units, but further subdivides mappable units based on lithologic composition. Exceptions to exact subdivision and unit correlations include: (1) in DGGS mapping, large marble bodies are assigned to unit DOm of the Mixed unit, whereas Till and others (2011) group the large marble bodies spatially found near the Mixed unit–Solomon Schist contact in the northeast quarter of the Solomon D-5 Quadrangle into unit 'Pzm' of the Scattered metacarbonate subdivision; (2) Till and others (2011) assign two dolomitic marble bodies with Devonian conodont ages in the Bluff area along Norton Sound to unit 'Ddm' of the Scattered metacarbonate subdivision, whereas DGGS includes them in unit DOm of the Mixed unit; and (3) Till and others (2011) break out the Calcareous metasiliceous subdivision (Dcs) of the Nome Complex, which in DGGS mapping is grouped into unit DOs of the Mixed unit of the Layered sequence subdivision because the exact boundary between variably calcareous schist and other pelitic schist horizons in the Mixed unit is uncertain.

Depositional Ages and Environments

Below, units in the Layered sequence subdivision of the Nome Complex in the map area are discussed from oldest to youngest, with interpreted protolith depositional and igneous ages based on conodont, SHRIMP and conventional U-Pb, and detrital zircon U-Pb constraints presented in Amato and others (2014), Dumoulin and others (2014), Till and others (2014a,b), and this study. Age data in the map area are sparse; hence, much of the interpretation of original depositional ages of the Layered sequence subdivision is based on regional correlations to areas of the Nome Complex with better age constraints. In the map area, units of the Layered sequence include the Ordovician Casadepaga Schist, Ordovician to Devonian Mixed unit, Ordovician to Devonian metamorphosed mafic intrusions, and Devonian Solomon Schist.

Casadepaga Schist is composed of interlayered metasedimentary and metaigneous rocks, including intermediate-composition schist and semi-schist interpreted herein as metamorphosed graywacke of approximately andesitic composition, minor pelitic schist, calcareous schist, and lesser mafic schist layers and marble. The Casadepaga Schist is interpreted to represent a metamorphosed volcanic–sedimentary sequence. The Ordovician age assignment for the Casadepaga Schist is based on an Ordovician conodont age in the Nome Quadrangle, and detrital zircon analyses indicating an Ordovician or younger depositional age (Dumoulin and others, 2014; Till and others, 2014a,b). A pre-Middle Devonian age constraint for the Casadepaga Schist is provided by a SHRIMP U-Pb age of 391 ±3 Ma on the Kiwalik Mountain granitic orthogneiss that intrudes the Casadepaga Schist north of the Bendeleben Mountains (Amato and others, 2014).

The Mixed unit exhibits considerable lithologic variability and is dominantly composed of metasedimentary rocks, including pelitic schist, marble, impure marble, siliceous schist, graphitic schist, and graphitic quartzite. Rare, thin, discontinuous chlorite-bearing schist layers are also present in the map area. The Mixed unit lacks significant epidote-group minerals (usually <2 percent), which distinguishes it from the generally epidote- and clinozoisite-rich Casadepaga Schist. Graphite is also largely restricted to the Mixed unit, although it is also present in very minor amounts in the Solomon Schist. Graphitic lithologies likely represent restricted-basin sedimentation along the rifted continental margin. Mixed unit schist (unit DOs) immediately adjacent to Solomon Schist generally lacks other Mixed unit lithologies; it is correlative with the Calcareous metasiliceous unit of Till and others (2011) but is not broken out as a separate map unit due to unclear boundaries with other Mixed unit lithologies. Till and others (2014a,b) interpret the Calcareous metasiliceous unit and Solomon Schist to represent Middle Devonian or younger siliciclastic input to the rifted continental margin.

Along the Nome–Council road in the Solomon D-4 Quadrangle, an outcrop of a ~1-m-thick, foliation-parallel layer of white, foliated, very soft, white mica-rich, white mica + quartz schist contains up to 20 percent 1-mm-diameter feldspar porphyroblasts or potentially relict phenocrysts (location marked by yellow star on map). It is hosted by graphitic quartzite (unit DOq) of the Mixed unit. Detrital zircon analysis of a sample selected from the center of the white schist layer shows that 80 percent of the zircon grains form a tight cluster with a weighted-mean-average age of 368.9 ±1.5 Ma (interpreted as an Upper Devonian igneous age), with 20 percent of the zircon-grain population derived from older sedimentary sources (2-sigma error on igneous age; P. O'Sullivan, written commun.; this study). This igneous age is significantly younger than the 391–390 Ma ages of metafelsite, orthogneiss, and foliated granites on the Seward Peninsula, and is younger than, but closer in age to metarhyolite associated with volcanogenic massive sulfide deposits in the Ambler Belt of the southern Brooks Range (381–376 Ma; summary of U-Pb ages in Amato and others, 2014). Major-oxide and trace-element data suggest the schist may be a felsic- to intermediate-composition metavolcanic rock (sample 06MBW299A, Werdon and others, 2007), but mixing with minor detrital material precludes a definitive conclusion about its composition or trace-element-indicated tectonic setting. The schist could be a felsic tuff that mixed with sedimentary material on the sea floor; in this scenario it would constrain quartzite (unit DOq) of the Mixed unit to be Upper Devonian. Alternatively, if the felsic volcanic rock were a sill that incorporated detrital material as it intruded carbonaceous, quartz-rich sedimentary rocks, it constrains the quartzite to be pre-Upper Devonian.

Additional age constraints on the Mixed unit come from the Calcareous metasiliceous subdivision (unit Dcs) of Till and others (2011), included as part of unit DOs of the Mixed unit in DGGS mapping, which contains detrital zircons indicating a depositional age of Middle Devonian or younger (Till and others, 2014a,b). In the Solomon C-5 and D-5 quadrangles, the Mixed unit contains abundant marble bodies, one of which yielded an Ordovician conodont age (Dumoulin and others, 2014). In the northwestern Seward Peninsula, the Mixed unit contains dolomitic marble, which yielded a Silurian conodont age (Dumoulin and others, 2014). Northeast of the Bendeleben Mountains, the Mixed unit was intruded by the Kiwalik Mountain granitic orthogneiss with a SHRIMP U-Pb zircon age of 391 ±3 Ma, hence, the Mixed unit in that region is pre-Middle Devonian or older (Amato and others, 2014).

Mafic metaigneous rocks found in the Mixed unit and Casadepaga Schist in the map area include granofels and mafic schist. Sub-equidimensional bodies, which are usually granofels dominated with lesser mafic schist, likely represent mafic intrusions; Till and others (2011) interpret coarse-grained granofels to have textures suggestive of a coarse-grained gabbroic protolith. Thin, elongate bodies, up to 10.5 km in length, are variably granofels or mafic schist dominated; they cross, and less commonly are parallel to, primary lithologic unit boundaries, which suggests they represent both gabbro dikes and either gabbro sills or extrusive basalt flows, respectively.

Major-oxide geochemical data indicate these mafic metaigneous rocks comprise two compositional groups (Werdon and others, 2005d; 2007). In the map area, mafic schist and granofels bodies were distinguished on the basis of their weight percent P_2O_5 and weight percent TiO_2 values (unit Omg by P_2O_5 <0.25 and TiO_2 <2.0; unit DOg by P_2O_5 >0.25 and TiO_2 >2.0); Nb values >11 parts per million (ppm) in unit DOg were also used to distinguish it from lower Nb values in unit Omg. Ayuso and Till (2007, 2014) conducted additional trace-element, rare-earth-element, and isotopic analysis of the two metabasite types. Unit Omg correlates with their low-TiO_2 basalt with a composition between normal mid-ocean-ridge basalt (MORB) and enriched MORB. Unit DOg correlates with their high-TiO_2, alkali to subalkali basalt with a composition between enriched MORB and ocean island basalt. Both units are interpreted to have formed in a continental tectonic setting and are related to the early stages of continental rifting, with unit DOg forming first under deeper, normal-crustal-thickness conditions, and unit Omg forming under shallower crustal conditions, presumably after rift-related crustal thinning had progressed (Ayuso and Till, 2014).

In the map area, unit Omg most commonly occurs in the Ordovician Casadepaga Schist. Two volumetrically minor, foliation-sub-parallel intrusions(?) of Omg crop out in marble (unit DOm) of the Mixed unit in the western Solomon C-5 and D-5 quadrangles. Marble with an Ordovician conodont age (Till and others, 2011) is located ~9 km from the marble bodies hosting the two metabasites. An Ordovician age is assigned to unit Omg.

Unit DOg is commonly found in both the Mixed unit and Casadepaga Schist. Where present in the Mixed unit, unit DOg is nearly always found in close spatial proximity to the Mixed unit–Casadepaga Schist contact. For this study, the Ordovician to Devonian age assignment for unit DOg is based on its cross-cutting relationship with Mixed unit graphitic quartzite (DOq), which in one location in the map area hosts an Upper Devonian, metamorphosed, felsic volcanic tuff or sill. If it is a tuff, it requires quartzite host rocks (unit DOq) to be Upper Devonian in age; also, since unit DOg cross-cuts DOq, this would require DOg to be Upper Devonian or younger. In this scenario, DOg could be related to proposed Devonian rifting of the continental margin (fig. 13, Till and others, 2014b). If the felsic metavolcanic schist is a sill, a strictly Ordovician age for DOg is permissible; in this case, DOg could be related to proposed Ordovician rifting of the continental margin (fig. 12, Till and others, 2014b), which is the preferred model for continental rifting and mafic-magmatism evolution during the Ordovician (Ayuso and Till, 2014). The presence of unit DOg in both Casadepaga Schist and Mixed unit requires these two units to have been in spatial proximity to each other by Devonian time.

Solomon Schist is characterized by its highly uniform pelitic composition, gray-colored white micas, general absence of graphite, abundance of chloritoid, and numerous quartz veins and boudins parallel to foliation. The Solomon Schist was historically viewed as the oldest unit in the Nome Complex due to the numerous isoclinally folded quartz veins that were thought to represent a pre-Paleozoic deformation (Smith, 1910; Young, 1995). DGGS mapping locally shows identical textures in pelitic layers of the Mixed unit and unit Osg of Casadepaga Schist. Further, detrital zircon U-Pb ages indicate detrital material was derived from sources as young as late Middle Devonian (Till and others, 2014a,b), indicating a post–late Middle Devonian depositional age for Solomon Schist. Notably, metamorphosed mafic rocks (units DOg and Omg) are not present in the Solomon Schist.

Relationships Among Nome Complex Units

The Nome Complex underwent blueschist-facies metamorphism, deformation, and exhumation during the Jurassic to Cretaceous Brookian Orogeny. Blueschist-facies metamorphic units were assembled by under-plating processes, and from top to bottom the typically observed, regional-scale, structural stacking order of Layered Sequence units on the Seward Peninsula is Ordovician Impure marble, Ordovician Casadepaga Schist, Ordovician to Devonian Mixed unit, Devonian Calcareous metasiliceous unit, and Devonian Solomon (Pelitic) Schist (fig. 7, Till and others, 2014b). Structural stacking did not preserve the original age-based sedimentary depositional order.

Based on the regional-scale, generalized, older-over-younger structural stacking order, contacts between the Ordovician Casadepaga Schist, Ordovician to Devonian Mixed Unit, and Devonian Solomon Schist are represented as thrust faults on the map. The Casadepaga Schist generally topographically overlies the Mixed unit, and along this contact, lithologic units in both the Casadepaga Schist and Mixed unit are truncated. Additionally, the Ordovician Casadepaga Schist variably overlies all lithologic units in the Mixed unit, including: (1) the Upper Devonian, or Upper Devonian or older quartzite (unit DOq); (2) the Middle Devonian or younger Calcareous metasiliceous unit (of Till and others, 2011), included as part of unit DOs in DGGS mapping; and (3) marble (unit DOm), which along strike in the Solomon C-5 Quadrangle contains conodonts indicating an Ordovician age. As such, the Casadepaga Schist-over-Mixed unit contact is interpreted as a thrust fault formed during early ductile, blueschist-facies, collision-related underplating.

Similarly, the Mixed unit most commonly topographically overlies the Solomon Schist, which is exposed in the cores of folds. In general, the Solomon Schist–Mixed unit contact does not have lithologic truncations, and the late Middle Devonian or younger Solomon Schist is primarily overlain by: (1) large marble bodies (unit DOm of the Mixed unit) of uncertain age, which in part may correlate with unit 'Pzm' of the Scattered metacarbonate subdivision of the Nome Complex (Till and others, 2011; 2014b); and (2) the Middle Devonian or younger Calcareous metasiliceous unit of Till and others (2011), included as part of unit DOs in DGGS mapping. Because age constraints on the Solomon Schist overlap those of unit DOs of the Mixed unit, but uncertainties exist regarding relationships with and ages of the marbles, the Solomon Schist–Mixed unit contact could represent: (1) structurally juxtaposed units during ductile deformation; (2) a partial unconformable contact; or (3) a lateral facies change.

Although the structural stacking order of units is generally consistent with regional observations, there are many exceptions widely distributed throughout the map area. Locally, the Mixed unit topographically overlies the Casadepaga Schist, the Solomon Schist overlies the Mixed unit, and in the Solomon D-5 Quadrangle, the Casadepaga Schist directly overlies an overturned antiform cored by Solomon Schist.

Although underplating during subduction of the continental margin likely shuffled units into the general older-over-younger stacking arrangement of mapped units, alternative interpretations can be made for the various contact relationships present in the map area. Recumbent isoclinal folding, and limited but demonstrated brittle low-angle faulting (discussed below), can explain repetition or out-of-order stacking of some lithologies. Because the Mixed unit is defined to include heterogeneous lithologies with Ordovician, Silurian, and Devonian ages, and local age constraints are insufficient to know which lithology in the map area is which age, interpreting depositional versus ductile–structural contact relationships is problematic. Additionally, because the Nome Complex is modeled as a Late Proterozoic to Devonian continental margin, with Ordovician and Devonian rifting events (Till and others, 2014b), relict rift-related lateral stratigraphic discontinuities and unconformities would be expected to be present as well. All of these possibilities lead to uncertainty in contact relationships shown on the map. As such, this map should be considered a record of locations of the actual presence of various lithologies, and as additional age constraints become available, contacts can be reinterpreted as appropriate to fit new data.

Structural Character and Features

Lithologic layering is most commonly subparallel to foliation, suggesting transposition of original layering. Isoclinal folds, which fold foliation and foliation-parallel quartz veins, are present in all subdivisions and units of the Nome Complex. Locally, isoclinal folds parallel to the main foliation produced structurally thickened units, which are most prominently visible in marbles (unit DOm) both north and south of the east fork of the Solomon River in the Solomon C-5 Quadrangle (fig. 1).

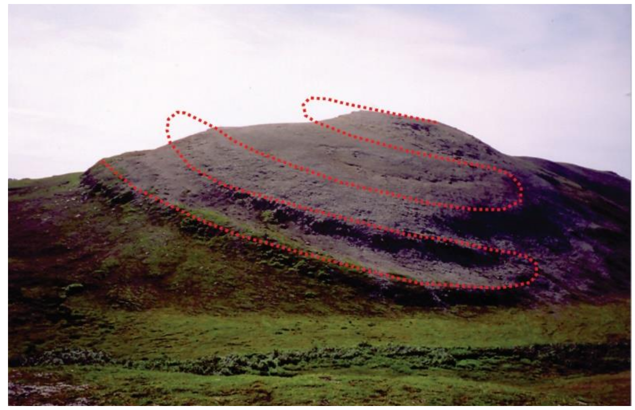

Figure 1. Isoclinally folded, structurally thickened, Mixed Unit marble (unit Dom). Photo: Melanie Werdon, 2004.

Lithology-parallel foliation in the central map area is flat lying to broadly folded. Lithology-parallel foliation in the northeastern one-third of the map area is tightly folded to overturned. The Mixed unit and Casadepaga Schist were folded together, under ductile conditions, into overturned folds whose axial planes strike northwest, and dip moderately to the northeast. Along the northeastern edge of the map, overturned folds in the Mixed unit have axial planes that generally strike north–south and dip east. Similarly, foliation along the western edge of the map is tightly folded. Also in the western map area, an out-of-order structural stacking is present, where Casadepaga Schist directly overlies an overturned antiform of Solomon Schist. The overturned folding of foliation and foliation-parallel lithologic layering, and structurally out-of-place stacking of Nome Complex subdivisions, took place during ductile conditions.

In the northeastern Solomon C-5 Quadrangle, two low-angle faults are exposed near the base of a prominent, steep-sided hill, nicknamed "Glaucophane Volcano" (based on the presence of glaucophane at the summit, and its volcano-like shape; fig. 2). The topographically highest, upper fault block consists of Casadepaga Schist (unit Osg) in high-angle fault contact with mafic granofels

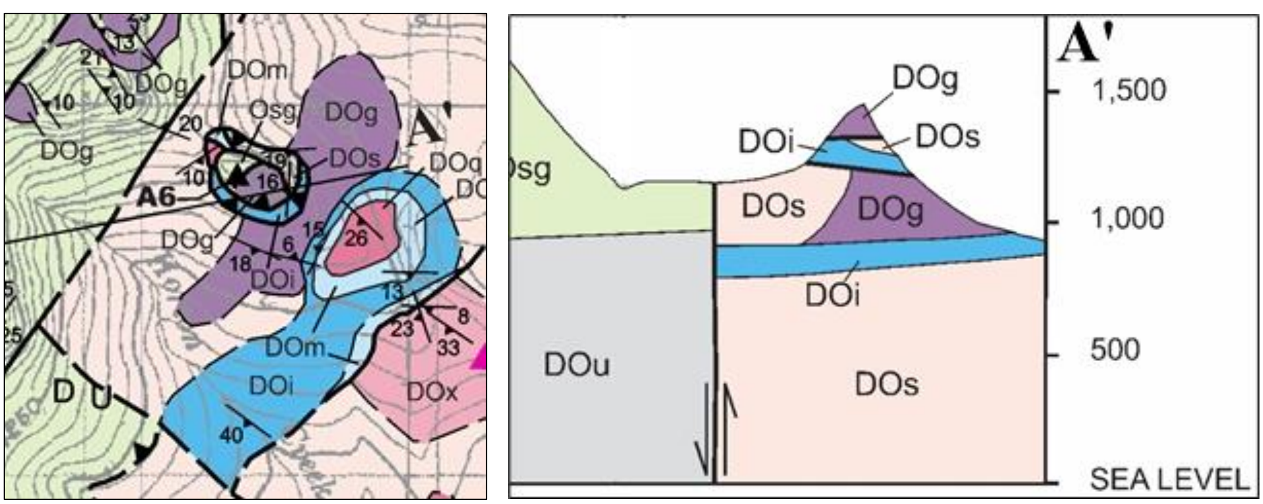

Figure 2. Low-angle fault zones and repetition of Mixed Unit and Casadepaga Schist lithologies.

(unit DOg). These two units structurally overlie an approximately 75-m-thick, subhorizontal zone of folded, faulted, and quartz-veined Mixed unit. Beneath this fault zone, undisturbed Mixed unit schist (unit DOs) and mafic granofels (unit DOg) are present. This fault zone demonstrates that some of the region's low-angle faulting and repetition of units occurred in the brittle realm.

In the Solomon D-5 Quadrangle, a low-angle fault exposed in the core of a broad antiform folds foliation (fig. 3). Above the fault plane, graphitic quartzite exhibits planar foliation. Below the fault plane, quartzite is intensely folded, with northeast-over-southwest shear sense. Quartz veins and angular breccia clasts are found along the fault plane. These features indicate that some of the broader folding of foliation in the Nome Complex formed at shallow levels in the brittle realm.

Late, high-angle faults are found throughout the map area, and are variably expressed as linear topographic depressions, lithologic truncations in the geologic map, and (or) discontinuity zones in airborne geophysical data (Burns and others, 2003). Prominent high-angle-fault orientations trend northwest, north–south, and northeast; the former two generally truncate the latter. Locally, drag folds of foliation are present adjacent to high-angle faults, and record both normal and reverse offset. A late, east–west-trending, north-side-up, high-angle normal fault exposes high-grade amphibolite-facies rocks of Proterozoic and Paleozoic age (units PzPh and PzPa) south of the Bendeleben Mountains along the north edge of the map. This fault, and other nearby high-angle faults, offset Quaternary glacial deposits along the south side of the Bendeleben Mountains (Stevens, 2005a,b).

METAMORPHIC CONDITIONS AND GEOCHRONOLOGIC AGES

The Nome Complex underwent blueschist-facies metamorphism and deformation in the Jurassic (Forbes and others, 1984; Thurston, 1985; Patrick, 1987; Patrick and Evans, 1989). Metamorphism progressed from lawsonite–blueschist

Figure 3. Graphitic quartzite (unit DOq) cut by brittle, low-angle thrust fault; planar foliation above fault and highly folded foliation within fault zone. Photo: Melanie Werdon, July 10, 2006.

to epidote–blueschist facies (Thurston, 1985), with rare, local eclogite-facies rocks (Patrick, 1987). Proposed models for exhumation, and the change from blueschist- to albite–epidote–amphibolite- to greenschist-facies conditions include either a protracted, single-cycle, isothermal decompression event (Patrick, 1987), or a multi-stage process of initial blueschist-facies metamorphism followed by a separate, overprinting greenschist-facies event to account for observed late structural fabrics (Hannula and others, 1995).

In the map area, rocks of appropriate (mafic) bulk composition display a variety of primary and overprinting mineral assemblages. Petrographic and microprobe analyses indicate the assemblage ferroglaucophane + epidote + garnet + titanite was stable at peak blueschist-facies conditions. Textural relationships indicate barroisite, a sodic-calcic amphibole, crystallized after glaucophane, during albite–epidote amphibolite-facies metamorphism.

Occasional actinolite rims on barroisite, or more rarely on glaucophane, indicate relatively calcium-rich amphibole growth during greenschist-facies conditions. Variable degrees of hydration during post-blueschist-facies metamorphism have resulted in variably retained blueschist-facies mineral assemblages. Blueschist-facies mafic rocks are extensively retrograded and contain diamond-shaped, fine-grained plagioclase + chlorite aggregates, which are interpreted to represent glaucophane pseudomorphs formed during greenschist-facies conditions. The persistence of euhedral pseudomorphs suggests recrystallization was not accompanied by widespread penetrative deformation in the map area. Local biotite replacement of chlorite and white mica likely either represents greenschist-facies metamorphism or thermal anomalies above hypothetical buried Cretaceous intrusions.

Glaucophane and paragonite yielded stair-stepped, $^{40}Ar/^{39}Ar$ weighted-mean-average cooling ages of 164.1 ±4.4 Ma and 208.7 ±1.9 Ma, respectively (app. 1; map locations A1, A2; Layer and others, 2015); no age interpretations could be made for other dated samples of glaucophane, barroisite, and an amphibole of unknown composition (map locations A2, A3, A4). Biotite, likely formed near the blueschist–greenschist transition zone, yielded a stair-stepped, $^{40}Ar/^{39}Ar$ weighted-mean-average cooling age of 186.2 ±2.0 Ma (map location A5; Layer and others, 2015). White mica from Casadepaga Schist (unit Osg) located in the upper plate of a low-angle thrust fault, yielded an $^{40}Ar/^{39}Ar$ weighted-mean-average cooling age of 143.7 ±4.1 Ma (map location A6; Layer and others, 2015). These $^{40}Ar/^{39}Ar$ age estimates support the interpretation that blueschist-facies metamorphism took place in the Jurassic, but the stair-stepped nature of the spectrum precludes definitively pinning down the exact cooling ages of minerals formed during blueschist-facies conditions. Similar complex $^{40}Ar/^{39}Ar$ spectrum were reported for white mica in blueschist-facies rocks in the Nome and Teller quadrangles, west of this map area (Hannula, 1993; Hannula and McWilliams, 1995), which they attributed to incorporation of excess argon. White micas from structurally shallower levels in their map area yielded $^{40}Ar/^{39}Ar$ plateau ages of 116 to 125 Ma, which they interpret as a minimum age for blueschist-facies metamorphism.

In contrast, amphibolite-facies rocks north of the Bendeleben fault, and in an uplifted, fault-bounded block immediately south of the fault, contain metamorphic minerals with much younger cooling ages than minerals from the Nome Complex. Biotite from staurolite schist (unit PzPh) yielded a plateau age of 87.3 ±0.3 Ma (map location A7), and two amphibole separates from an amphibolite (unit PzPa) yielded a two-run-average plateau age of 83.9 ±0.3 Ma (map location A8; Layer and others, 2015). As these metamorphic cooling ages overlap the age range of biotite from gabbro dikes scattered throughout the map area (discussed below), we propose exhumation of these amphibolite-facies rocks are broadly tectonically related to mafic intrusive activity.

METAMORPHIC AND HYDROTHERMAL VEIN AGES

Post-peak-blueschist-facies minerals in the map area were also dated. A mafic granofels body with epidote-rich layers (unit DOg) is cut by winchite + white mica veins. Winchite from one vein yielded an $^{40}Ar/^{39}Ar$ plateau age of 138.6 ±1.0 Ma, and white mica from the same vein yielded a weighted-mean-average age of 127.4 ±3.4 Ma (map location A9; Layer and others, 2015). In another experiment, 15 white mica separates from a single quartz + white mica + chlorite + magnetite vein cutting foliation in Casadepaga Schist (unit Osg) were step heated; seven spectrum yielded $^{40}Ar/^{39}Ar$ plateau ages ranging from 129.0 ±0.8 Ma to 116.7 ±0.7 Ma, and eight spectrum yielded $^{40}Ar/^{39}Ar$ weighted-mean-average ages ranging from 132.9 ±2.8 Ma to 117.9 ±2.8 Ma (map location A10; Layer and others, 2015). The range of ages suggests multiple white mica populations may be present in the vein or the spectrum record a complex cooling history. The youngest $^{40}Ar/^{39}Ar$ plateau age (116.7

±0.7 Ma) records the age of the last micas to crystallize in the vein.

Numerous veins from known lode gold mines, prospects, and newly discovered lode gold occurrences were sampled for ore-geochemical assay and $^{40}Ar/^{39}Ar$ dating as part of this study. Quartz-, white mica-, and gold-bearing veins may also contain ± albite, ± chlorite, ± various carbonate minerals, ± graphite/hydrothermal carbon, ± magnetite, ± specular hematite(?), ± arsenopyrite, ± stibnite, ± pyrite, ± pyrrhotite, and ± iron oxide (after sulfide), and have geochemical signatures that variably include Ag, As, Au, Cu, Hg, Pb, Sb, W, and Zn (Werdon and others, 2005d; 2007). These hydrothermal veins are structurally controlled, occur along both low- and high-angle faults, and were variably active during quartz and gold deposition; most veins cut foliation. The veins are generally considered to have formed in brittle shear zones and extensional fractures broadly related to Cretaceous folding (Ford, 1993; Ford and Snee, 1996; Pink, 2010). Hydrothermal white mica $^{40}Ar/^{39}Ar$ ages in the map area range from 131.1 ±1.3 Ma to 106.2 ±0.5 Ma (map locations A11–A23; Layer and others, 2015). For comparison, white mica from gold-bearing quartz veins at Rock Creek lode gold mine in the Nome Quadrangle were also dated; they yielded $^{40}Ar/^{39}Ar$ ages of 102.3 ±0.7 Ma and 112.3 ±0.8 Ma (sample numbers 04Z638A, 04Z641A; Layer and others, 2015). In addition, one gold-bearing quartz vein from the Bluff prospect in the southern map area contains arsenopyrite and adularia; adularia yielded an $^{40}Ar/^{39}Ar$ age of 104.6 ±0.2 Ma (map location A24; Layer and others, 2015). White mica from veins at Bluff yielded $^{40}Ar/^{39}Ar$ ages ranging from 108 to 109 Ma (Ford, 1993; Ford and Snee, 1996; Layer and others, 2015).

There is significant overlap between $^{40}Ar/^{39}Ar$ ages reported for white mica from the plane of foliation in metamorphic rocks of the Nome Complex (approximately 132–116 Ma; Hannula, 1993; Hannula and Williams, 1995; Layer and others, 2015), and ages reported for hydrothermal white mica and adularia from barren and gold-bearing quartz veins on the southern Seward Peninsula (131.1–102.3 Ma; Layer and others, 2015). The partially overlapping $^{40}Ar/^{39}Ar$ ages indicate closure of metamorphic white micas and gold-mineralizing events are coeval Early Cretaceous events. The low- and high-angle brittle fault and vein structures exhibit complex histories, and record multiple (or sub-continuous[?]) hydrothermal fluid flow and mineralizing events between ~131.1 and 102 Ma in the Nome Complex.

IGNEOUS ROCKS

Three types and ages of igneous rocks are present in the map area; (1) rare syenite dikes; (2) widespread but volumetrically minor alkali–gabbro dikes; and (3) a small basalt volcano. Biotite from a syenite dike (unit EKs) in the northern half of the Solomon C-5 Quadrangle yielded an $^{40}Ar/^{39}Ar$ plateau age of 107.2 ±0.6 Ma (map location A25, Layer and others, 2015). Assay of the dike indicates it has a slightly elevated gold content (Werdon and others, 2005d). This igneous biotite age overlaps hydrothermal white mica ages from gold-bearing quartz veins, which suggests these dikes are broadly related to the hydrothermal event. Narrow, alkali–gabbro dikes (unit LKg) with arc-related trace-element signatures of Late Cretaceous age (83.9 ±0.3 Ma to 80.1 ±1.3 Ma) are scattered throughout the map area (map locations A26–A31, Layer and others, 2015). These dikes are predominantly northeast-trending, and to a lesser extent, north–south-trending, and are hosted by high-angle faults. Alkalic basalt flows and their associated northwest-trending vent site crop out along Bear River in the Solomon D-4 Quadrangle (Till and others, 1986; Werdon and others, 2003). Three whole-rock samples yielded an $^{40}Ar/^{39}Ar$, three-run-average plateau age of 0.780 ±0.011 Ma (map location A32; Layer and others, 2015).

DESCRIPTION OF MAP UNITS
BEDROCK UNITS
Igneous Rocks

Qb Basalt vent and flows (Quaternary)—Aphanitic, variably vesicular to scoriaceous, locally amygdaloidal basalt present as vent and associated flow deposits. Vent located at apex of small hill (likely a paleo-topographic high) approximately 150 m above Bear River in the Solomon D-4 Quadrangle. Vent deposits of interlayered ropey flows, spatter, and other ejecta form prominent tors and are oxidized brown to reddish-brown near vent site; dark gray on fresh surfaces. Lava flowed in both northeast and southwest directions away from the west–northwest-trending vent axis. Basalt flows form a 6.5-km-long terrace along the southeastern edge of Bear River. Basalt flows distal to the vent site are not oxidized; dark gray to black, massive, blocky, and locally columnar jointed. Amygdules variably contain calcite, quartz, and chlorite. Major- and minor-oxide and trace-element analyses indicate the basalt is alkalic and formed in a within-plate, extension-related tectonic setting (Werdon and others, 2005d; 2007). The basalt is normally magnetized and has a high magnetic susceptibility. Three whole-rock samples yielded an $^{40}Ar/^{39}Ar$, three-run-average plateau age of 0.780 ±0.011 Ma (map location A32; Layer and others, 2015). May correlate with similar-age (0.81 ±0.09 Ma; K-Ar whole rock) Gosling Volcanics, northwest flank of Bendeleben Mountains (Kaufman and Hopkins, 1985).

LKg Gabbro dikes (Late Cretaceous)—Fine-grained, equigranular to locally porphyritic, and (or) amygdaloidal gabbro dikes sparsely distributed throughout map area. Dikes primarily strike northeast and locally intrude northeast-trending high-angle faults; a few dikes strike north–south. Dikes are brown to orange weathering, dark gray, ± biotite phyric, and up to 3 m in width. Modal composition of 0–25 percent clinopyroxene (occasionally concentrically zoned and twinned), 0–10 percent olivine, 0–5 percent orthopyroxene, 10–93 percent feldspar (rarely porphyritic), 0–40 percent biotite, 0–6 percent opaque minerals, trace hornblende, and accessory apatite. Secondary minerals include chlorite, serpentine, talc, sericite, and carbonate. Major- and minor-oxide and trace-element analyses indicate the dikes are alkaline and have arc-related trace-element signatures (Werdon and others, 2005d; 2007). Magnetic susceptibility is high (0.40–16.9, averaging 5.86×10^{-3} Système International [SI]). $^{40}Ar/^{39}Ar$ biotite plateau ages in the map area are Late Cretaceous and include 80.1 ±1.3 Ma, 82.6 ±0.3 Ma, 82.7 ±0.3 Ma, 82.7 ±0.3 Ma, 83.5 ±0.4 Ma, and 83.9 ±0.3 Ma (map locations A26–A31; Layer and others, 2015). Correlate with mafic dikes of similar composition, tectonic setting, orientation, and age in the Bendeleben and Kigluaik Mountains (Calvert and others, 1999; Amato and others, 2003).

EKs Syenite dikes (Early Cretaceous)—Fine-grained, equigranular syenite dikes exposed in two road cuts just south of the East Fork bridge, and at the head of a small unnamed tributary north of Big Hurrah Creek in the northern Solomon C-5 Quadrangle. Maximum dike width approximately 5 m. Brown weathering, brownish-gray colored. Modal composition from one thin section is 25 percent nepheline, 26 percent K-feldspar, 10 percent plagioclase, 30 percent biotite, and accessory garnet, magnetite, and apatite. Secondary minerals include analcite, white mica, and carbonate. Has major- and minor-oxide and trace-element characteristics of within-plate, extensional magmatism (Werdon and others, 2005d; 2007). Magnetic susceptibility is high (0.98–1.38, averaging 1.24×10^{-3} SI). $^{40}Ar/^{39}Ar$ biotite plateau age of 107.2 ±0.6 Ma (map location A25; Layer and others, 2015).

May correlate with undated alkalic dikes, nepheline syenite, and pseudoleucite porphyries in the Solomon C-2, C-3, and D-3 quadrangles (Till and others, 2011), and with alkalic dikes and plutons elsewhere on the Seward Peninsula (Miller, 1972; Amato and others, 2003).

Metamorphic Rocks

SEDIMENTARY AND IGENEOUS ROCKS METAMORPHOSED TO BLUESCHIST FACIES: NOME COMPLEX

Solomon Schist and Marble

Ds Quartz–white mica schist (late Middle Devonian or younger)—Fine- to medium-grained, foliated, light- to medium-gray, quartz-rich schist, commonly with numerous quartz veins parallel to foliation. Bands, 1–2 cm thick, of granular interlocking quartz grains interlayered with schist are considered diagnostic of this unit (Till and others, 2011). Generally contains 20–70 percent quartz, 12–40 percent white mica, 0–30 percent plagioclase + chlorite pseudomorphs of glaucophane, 5–20 percent chlorite (with white mica:chlorite greater than or equal to 2:1), 0–15 percent chloritoid, and 0–5 percent carbonate. Trace biotite replacing chlorite variably present. Contains <1.5 percent accessory minerals including tourmaline (pleochroic colors brown and rare green), apatite, pyrite, ilmenite, rutile, and zircon. Characteristically lacking significant epidote-group minerals (<2 percent) and porphyroblastic feldspar. Protolith is interpreted to be siliciclastic pelitic sedimentary rocks. Magnetic susceptibility is low (0.00–0.70, averaging 0.26×10^{-3} SI). Forms a pronounced resistivity low in airborne geophysical data in the map area (Burns and others, 2003). Solomon Schist collected at Bermudez Bluff in the Solomon D-5 Quadrangle contains a largely Ordovician detrital zircon population, but also contains detrital zircons as young as late Middle Devonian (conventional U-Pb analyses of zircon grains; Till and others, 2006). Combined, unit Ds and Dm are equivalent to unit 'Ds' of Till and others (2011).

Dm Marble (late Middle Devonian or younger)—Thin, discontinuous marble layers in Solomon Schist (Ds). Age assignment based on age of enclosing Solomon Schist. Combined, units Ds and Dm are equivalent to unit 'Ds' of Till and others (2011).

Metaigneous Rocks

DOg High-titanium mafic schist and granofels (Devonian to Ordovician)—Metamorphosed mafic bodies are medium- to dark-green colored, and texturally vary from medium-grained, foliated schist to massive, fine- to coarse-grained granofels. In the southwest portion of the map area, one intrusion contains angular xenoliths of graphitic quartzite (DOq) up to 15 cm in diameter. Modal composition varies widely, but generally contains 10–20 percent chlorite (4–40 percent range), 10–20 percent epidote + clinozoisite + zoisite (0–30 percent range), 10–15 percent garnet (0–30 percent range, locally porphyroblastic), 0–28 percent plagioclase, and 0–7 percent magnetite plus varying proportions of glaucophane (<50 percent, commonly porphyroblastic), actinolite (<10 percent), and barroisite (<20 percent). Glaucophane is commonly pseudomorphed by fine-grained aggregates of plagioclase + chlorite and in some cases replaced by barroisite. Secondary minerals include quartz (<25 percent), carbonate (<15 percent), white mica (<5 percent, with occasional higher values), and biotite (<3 percent, replacing chlorite). Contains trace apatite. High titanium content is expressed as titanite (commonly 10 percent), ilmenite (<5 percent), and minor rutile. Unit DOg was distinguished from unit Omg by having weight-percent P_2O_5 >0.25, weight-percent

TiO_2 >2.0, and Nb values generally greater than 11 parts per million (ppm) (Werdon and others, 2005d; 2007). Chemical and isotopic analyses indicate the protolith for unit DOg is an alkali to sub-alkali basalt with a composition between enriched MORB and ocean island basalt and is interpreted to have formed in a continental tectonic setting related to the early stages of continental rifting (Ayuso and Till, 2014). Magnetic susceptibility is variable but usually high (0.00–68.9, averaging 7.05×10^{-3} SI). Age assignment based on cross-cutting relationship with unit DOq, which hosts a Late Devonian metafelsite, and the conodont-based Ordovician age for the Casadepaga Schist and Mixed unit in the map area.

Omg Low-titanium mafic schist and granofels (Ordovician)—Green, medium- to coarse-grained, massive granofels and foliated mafic schist. Composition varies widely but generally contains epidote + clinozoisite (up to 45 percent), plagioclase (up to 40 percent; occasionally as porphyroblasts), and chlorite (up to 30 percent). Other common components include actinolite (up to 30 percent), barroisite (up to 30 percent), garnet (up to 30 percent), glaucophane and plagioclase + chlorite pseudomorphs of glaucophane (up to 25 percent), quartz (up to 20 percent), carbonate (up to 15 percent), white mica (up to 15 percent; one sample was identified as paragonite by X-ray diffraction), magnetite (up to 13 percent), and biotite after chlorite (up to 10 percent). Accessory minerals include apatite, ilmenite, rutile, and titanite. Secondary minerals include chlorite, quartz, carbonate, and white mica. Carbonate ± iron oxide veins and lenses locally cut foliation. Unit Omg was distinguished from unit DOg by having weight-percent P_2O_5 <0.25, weight-percent TiO_2 <2.0, and Nb values generally less than 11 ppm (Werdon and others, 2005d; 2007); major-element compositions suggest basaltic and sparse andesitic protoliths. Chemical and isotopic analyses indicate unit Omg basalt has a composition between enriched MORB and ocean island basalt, and is interpreted to have formed in a continental tectonic setting related to the early stages of continental rifting (Ayuso and Till, 2014). Magnetic susceptibility is highly variable (0.03–74, averaging 4.40×10^{-3} SI). Age assignment based on the conodont-constrained Ordovician age for the Casadepaga Schist and Mixed unit in the map area.

MIXED UNIT

The Mixed unit includes the following units: mixed metasedimentary rocks (DOx), impure marble (DOi), chlorite schist (DOms), marble (DOm), quartzite (DOq), graphitic schist and quartzite (DOsq), quartzite and schist (DOqs), and schist (DOs). Unit DOq of the Mixed unit also contains a body of metamorphosed felsic tuff or sill (discussed above) that is too small to break out as a mappable unit. Combined, these eight units are equivalent to unit 'DOx' of Till and others (2011). Calcareous metasiliceous subdivision 'Dcs' of Till and others (2011) is included within unit DOs. In part, unit DOm includes marbles assigned to unit 'Pzm' of Till and others (2011). The Mixed unit is assigned an Ordovician lower age following Till and others (2011). The upper age is estimated to be Upper Devonian based on the presence of the Late Devonian felsic tuff in unit DOq, or pre-Late Devonian if it is a felsic sill (this study).

DOx Mixed metasedimentary rocks (Devonian to Ordovician)—Composite unit primarily composed of schist (DOs) with lesser marble (DOm), impure marble (DOi), quartzite (DOq), and chlorite schist (DOms). Unit interlayering occurs on meter to tens-of-meters scale. Unit is variably graphitic. Magnetic susceptibility is generally low (0.00–3.41, averaging 0.11×10^{-3} SI).

DOi Impure marble (Devonian to Ordovician)—Blocky weathering, medium-grained, foliated, equigranular impure marble that contains millimeter- to centimeter-scale interlayers of calcareous schist and (or) white mica-rich horizons. Gray to light brownish-orange weathering, light gray colored. Composed of 52–84 percent carbonate (calcite and rare dolomite) with 7–20 percent quartz, 2–15 percent white mica, 0–12 percent plagioclase (some as porphyroblasts), and 0–10 percent chlorite. Accessory minerals include graphite, rutile, and pyrite. Magnetic susceptibility is low (0.00–0.50, averaging 0.06×10^{-3} SI).

DOms Chlorite schist (Devonian to Ordovician)—Medium-grained, variably porphyroblastic, chlorite-bearing schist lenses scattered throughout the Mixed unit. Gray weathering, light- to dark-gray colored. Average modal composition approximately 10–70 percent plagioclase as porphyroblasts (~An15–An20), 20–30 percent chlorite (10–94 percent range), 10–30 percent quartz (0–52 percent range), and 0–20 percent white mica (with chlorite > white mica). Less common components include <20 percent glaucophane and glaucophane pseudomorphs, <10 percent carbonate, <7 percent garnet, <5 percent actinolite, <2 percent biotite after chlorite, and <2 percent epidote + clinozoisite. Accessory minerals include apatite, graphite, ilmenite, magnetite, rutile, titanite, tourmaline (pleochroic colors include blue–green, green, and brown; commonly zoned), and zircon. Magnetic susceptibility is moderate (0.05–2.41, averaging 0.65×10^{-3} SI). Distinguished from Osg by its low modal epidote and clinozoisite percentages.

DOm Marble (Devonian to Ordovician)—Fine- to coarse-grained, foliated marble, with local karst topography in thicker marble bodies. Light gray weathering, white to gray to light tan colored, often with color banding parallel to foliation. Composed of 85–100 percent carbonate (calcite and rare dolomite) with <5 percent each of minor components graphite, white mica, quartz, plagioclase, chlorite, tremolite, and opaque minerals. The marble is cut by scattered calcite ± quartz ± iron oxide ± graphite veins. Magnetic susceptibility is low (0.00–0.27, averaging 0.02×10^{-3} SI). Most gold-bearing veins in the Bluff area are hosted by this unit.

DOq Quartzite (Devonian to Ordovician)—Black, fine-grained, foliated graphitic quartzite; locally interlayered with centimeter- to meter-thick, dark gray to black, graphitic schist layers, which constitute less than 10 percent of this quartzite-dominated unit. Modal composition approximately 85–91 percent quartz, 4–10 percent white mica, 2–10 percent graphite, and 0–3 percent chlorite. Analysis of a dark gray, graphitic quartzite from the Big Hurrah mine area in the Solomon C-5 Quadrangle yielded 5.13 percent carbon (Werdon and others, 2005d). Magnetic susceptibility is generally low (0.00–3.05, averaging 0.25×10^{-3} SI).

DOsq Graphitic schist and quartzite (Devonian to Ordovician)—Composite unit of undifferentiated, fine- to medium-grained, locally interlayered, graphitic schist and quartzite; approximately 75-80 percent of the unit is schist. Dark gray to black weathering, dark gray to black colored. Schist commonly contains 45–80 percent quartz, 0–30 percent carbonate (generally 10–30 percent), 2–10 percent white mica, 0–5 percent graphite, 0–3 percent chlorite, and 0–2 percent feldspar (rarely, feldspar up to 25 percent). Contains rare glaucophane replaced by chlorite, plagioclase, quartz, and white mica. Quartzite typically contains 85–93 percent quartz, 1–15 percent white mica, 2–10 percent graphite, 0–10 percent carbonate, and minor accessory rutile. Scattered 0.25–0.5-mm-wide calcite and (or) quartz veinlets cut foliation. Magnetic susceptibility is low (0.00–0.60, averaging 0.09×10^{-3} SI). Most gold-bearing veins in the Big Hurrah creek area are hosted by this unit.

DOqs Quartzite and schist (Devonian to Ordovician)—Unit composed of fine-grained, equigranular, poorly foliated, non-graphitic to rarely slightly graphitic, micaceous quartzite and quartz-rich schist. Light to dark gray, blocky weathering. Modal composition 70–90 percent quartz, 3–30 percent white mica, and 0–10 percent calcite; rarely up to 30 percent calcite and up to 35 percent plagioclase. Accessory minerals include opaque minerals, tourmaline, zircon, and rarely, graphite. Locally cut by quartz veins. Magnetic susceptibility is low (0.00–0.36, averaging 0.14×10^{-3} SI).

DOs Schist (Devonian to Ordovician)—Medium-grained pelitic schist and lesser calcareous schist. Rarely contains thin, undifferentiated layers of quartzite (DOq), chlorite schist (DOms), and impure marble (DOi). Pelitic schist is light to dark gray colored. Modal composition of the schist is approximately 5–74 percent quartz, 3–57 percent white mica, and 0–25 percent chlorite (with white mica > chlorite). Unit also commonly contains plagioclase (up to 49 percent; commonly occurs as syn- and post-metamorphic porphyroblasts), glaucophane and glaucophane pseudomorphs (up to 39 percent), chloritoid (up to 35 percent), calcite + dolomite (15–30 percent), and garnet (up to 9 percent). Biotite (up to 15 percent) is present as wispy crystals finely intergrown with and replacing chlorite. Epidote and clinozoisite are present rarely and generally compose <2 percent of the rock. Accessory minerals include apatite, tourmaline (pleochroic colors include green–brown, green, brown, and blue–green; commonly zoned), titanite, graphite, ilmenite, pyrite, rutile, and zircon. Magnetic susceptibility is generally low (0.00–4.44, averaging 0.19×10^{-3} SI). Calcareous metasiliceous subdivision ‘Dcs’ of Till and others (2011) is included in unit DOs.

Casadepaga Schist

The Casadepaga Schist consists of interlayered mafic schist, semi-schist (interpreted to be metamorphosed graywacke derived from a primarily andesitic volcanic protolith), pelitic schist, and minor calcareous schist (Osg), as well as lesser impure marble (Oi). Combined, units Osg and Oi are equivalent to unit ‘Ocs’ of Till and others (2011). Assigned an Ordovician age based on detrital zircon geochronologic work by Amato and others (2003) and Till and others (2006; 2014a,b), which shows most grains fall in the 600–700 Ma range, but contain zircons as young as Ordovician. The Casadepaga Schist has a highly variable signature in airborne magnetic data (Burns and others, 2003), which is typical of volcanic sequences and reflects the variable titanite vs. rutile vs. ilmenite vs. magnetite content.

Osg Metasedimentary rocks and metagraywacke (Ordovician)—A composite unit consisting of interlayered mafic schist and semi-schist (interpreted to be metamorphosed graywacke, derived from a primarily andesitic volcanic protolith), pelitic schist, and minor calcareous schist. Forms light greenish-gray weathering, generally planar-foliated outcrops that exhibit local recumbent isoclinal folds. Magnetic susceptibility for these different units is highly variable (0.00–54.3, averaging 1.78×10^{-3} SI), which may reflect their varying proportions of titanite, rutile, ilmenite, and magnetite.

The pelitic schist is generally light greenish gray and composed of 5–77 percent quartz, 5–55 percent feldspar, 10–40 percent white mica, 0–20 percent epidote + clinozoisite, and 1–18 percent chlorite (with white mica:chlorite greater than 2:1). Minor components of the pelitic schist include glaucophane and glaucophane pseudomorphs, actinolite, biotite, carbonate, chloritoid, garnet, and tourmaline (pleochroic colors include blue–green and rare brown). Accessory minerals include apatite, ilmenite, magnetite, rutile, titanite, and zircon. Major-element chemistry suggests the protolith was a pelitic sedimentary rock (Werdon and others, 2005d; 2007).

The non-pelitic, mafic schist and semi-schist are light- to medium grayish green colored, fine- to medium-grained, foliated, and either equigranular or porphyroblastic, with plagioclase commonly present as syn- and post-metamorphic porphyroblasts up to 1.5 cm in diameter. Modal composition is 10–55 percent plagioclase, 5–46 percent quartz, and 0–25 percent chlorite. Other common components include barroisite (<30 percent), glaucophane and glaucophane pseudomorphs (<25 percent), epidote + clinozoisite (<27 percent), white mica (<25 percent), and carbonate (<15 percent). Less common minerals include actinolite, biotite, chloritoid, and garnet. Accessory minerals include apatite, ilmenite, magnetite, pyrite, rutile, titanite, tourmaline (pleochroic colors include blue–green and minor brown; commonly zoned), and zircon. Major oxide and petrographic analyses suggest this subunit is a meta-graywacke, primarily with andesitic and lesser basaltic protoliths (Werdon and others, 2005d; 2007). Some of the mafic schist and semi-schist may also represent highly altered, ± reworked mafic material (Till and others, 2014b).

Calcareous schist is present primarily as centimeter- to meter-thick, discontinuous layers within Og and Osg. Brownish gray weathering. Modal composition is 10–40 percent quartz, 10–25 percent carbonate, 10–25 percent clinozoisite, 0–25 percent actinolite, 0–20 percent chlorite, 0–20 percent glaucophane, 0–20 percent white mica, 0–10 percent plagioclase, 0–10 percent garnet, and 0–2 percent biotite. Accessory minerals include apatite, zircon, ilmenite, titanite, and rutile.

Oi Impure marble (Ordovician)—Medium-grained, tan, foliated impure marble located in the southeast corner of the northern half of the Solomon C-5 Quadrangle and in the southern Solomon D-4 quadrangle. Gradational into unit Osg. Impurities in the marble include up to 50 percent combined white mica, quartz, and plagioclase. Magnetic susceptibility is low (0.14–0.18, averaging 0.16 x 10^{-3} SI).

UNDIFFERENTIATED NOME COMPLEX

DOu Undifferentiated Nome Complex rocks (Devonian to Ordovician)—Nome Complex bedrock units that are either covered by glacial material or other surficial unconsolidated deposits or were not mapped.

Sedimentary and Igneous Rocks Metamorphosed to Amphibolite Facies

Amphibolite-facies rocks include staurolite schist (unit PzPh) and mixed pelitic schist and amphibolite (PzPa). Combined, these two units are equivalent to unit 'PzPh' of Till and others (2011); age assignment based on correlation with unit 'PzPh'.

PzPh Staurolite schist (Paleozoic to Proterozoic)—Fault-bounded wedge of amphibolite-facies rocks surrounded by lower-grade Nome Complex rocks in the Bendeleben A-4 Quadrangle. White, medium-grained, and equigranular. Modal composition of two samples is 60 percent quartz, 8–22 percent feldspar, 13–20 percent reddish biotite, 0–5 percent staurolite, 0–4 percent white mica, 2–3 percent magnetite, 0–2 percent garnet, and trace sillimanite, tourmaline (pleochroic colors are zoned brown, green, and gray-blue), apatite, and zircon. High quartz and aluminum content suggests a sedimentary protolith. Magnetic susceptibility is low (0.08–0.25, averaging 0.17 × 10^{-3} SI). Unit is coincident with a magnetic high in airborne geophysical data (Burns and others, 2003); perhaps this is due to an underlying, more magnetic unit. Biotite from this unit yielded a $^{40}Ar/^{39}Ar$ plateau age of 87.3 ± 0.3 Ma; interpreted as a cooling age (map location A7; Layer and others, 2015).

PzPa Schist and amphibolite (Paleozoic to Proterozoic)—Amphibolite-facies rocks north of the Bendeleben fault in the Bendeleben A-4 Quadrangle. Includes pelitic schist and amphibolite. Amphibolite is green, foliated, very fine grained, and trace-element contents indicate an arc setting for generation of the mafic igneous protolith (Werdon and others, 2005d). Magnetic susceptibility of amphibolite measured at a single location is moderate (0.31–0.69, averaging 0.58×10^{-3} SI). Schist is dark brown, wavy foliated, coarse grained, and contains biotite, quartz, and feldspar. Likely represents a pelitic protolith. Magnetic susceptibility of schist is low (0.23–0.30, averaging 0.25×10^{-3} SI). $^{40}Ar/^{39}Ar$ analyses of two amphibole separates yielded an average plateau age of 83.9 ±0.3 Ma; interpreted as a cooling age (map location A8; Layer and others, 2015).

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REFERENCES

Amato, J.M., Miller, E.L., Wright, J.E., and McIntosh, W.C., 2003, Dike swarms on Seward Peninsula, Alaska, and their implications for the kinematics of Cretaceous extension in the Bering Strait region: Canadian Journal of Earth Sciences, v. 40, no. 6, p. 865–886. doi.org/10.1139/e03-019

Amato, J.M., Aleinikoff, J.N., Akinin, V.V., McClelland, W.C., and Toro, J., 2014, Age, chemistry, and correlations of Neoproterozoic–Devonian igneous rocks of the Arctic Alaska–Chukotka terrane—An overview with new U-Pb ages, in Dumoulin, J.A., and Till, A.B., eds., Reconstruction of a Late Proterozoic to Devonian continental margin sequence, northern Alaska—Its paleogeographic significance, and contained base-metal sulfide deposits: Geological Society of America Special Paper 506, p. 133–172. doi.org/10.1130/2014.2506(02)

Asher, R.R., 1969, Geological and geochemical study, Solomon C-5 Quadrangle, Seward Peninsula, Alaska: Alaska Division of Geological & Geophysical Surveys Geologic Report 33, 64 p., 1 sheet, scale 1:4,000; 1 sheet 1:63,360 scale. doi.org/10.14509/362

Ayuso, R.A., and Till, A.B., 2007, Geochemical and Nd–Pb isotopic evolution of metabasites from attenuated continental lithosphere, Nome Group, Seward Peninsula, Alaska: Geological Society of America Abstracts with Programs, v. 39, no. 6, p. 489.

Ayuso, R.A., and Till, A.B., 2014, Geochemical and Nd–Sr–Pb isotopic evolution of metabasites from rifting of continental lithosphere, Seward Peninsula, Alaska, and implications for paleogeographic reconstruction, in Dumoulin, J.A., and Till, A.B., eds., Reconstruction of a Late Proterozoic to Devonian continental margin sequence, northern Alaska—Its paleogeographic significance, and contained base-metal sulfide deposits: Geological Society of America Special Paper 506, p. 133–172. doi.org/10.1130/2014.2506(05)

Ayuso, R.A., Till, A.B., Slack, J.F., and Forni, Francesca, 2014, Pb isotope geochemistry of stratabound Zn–Pb(–Ag–Au–Ba–F) deposits and occurrences in the Nome Complex, Seward Peninsula, Alaska—Metal sources and regional comparisons, in Dumoulin, J.A., and Till, A.B., eds., Reconstruction of a Late Proterozoic to Devonian continental margin sequence, northern Alaska—Its paleogeographic significance, and contained base-metal sulfide deposits: Geological Society of America Special Paper 506, p. 213–234. doi.org/10.1130/2014.2506(07)

Burns, L.E., Fugro Airborne Surveys, and Stevens Exploration Management, 2003, Plot files of the airborne geophysical survey data of the Council area, Seward Peninsula, Alaska: Alaska Division of Geological & Geophysical Surveys Geophysical Report 2003-1, 1 DVD. doi.org/10.14509/2884

Calvert, A.T., Gans, P.B., and Amato, J.M., 1999, Diapiric ascent and cooling of a sillimanite gneiss dome revealed by $^{40}Ar/^{39}Ar$ thermochronology—The Kigluaik Mountains, Seward Peninsula, Alaska, in Ring, U., Brandon, M.T., Lister, G.S., and Willett, S.D., eds., Exhumation processes—Normal faulting, ductile flow and erosion: London, Geological Society, Special Publications, v. 154, p. 205–232.

Collier, A.J., Hess, F.L., Smith, P.S., and Brooks, A.H., 1908, The gold placers of parts of Seward Peninsula, Alaska, including the Nome, Council, Kougarok, Port Clarence, and Goodhope precincts: U.S. Geological Survey Bulletin 328, 343 p., 4 sheets, scale 1:250,000.

Dumoulin, J.A., Harris, A.G., and Repetski, J.E., 2014, Carbonate rocks of the Seward Peninsula, Alaska—Their correlation and paleogeographic significance, in Dumoulin, J.A., and Till, A.B., eds., Reconstruction of a Late Proterozoic to Devonian continental margin sequence, northern Alaska—Its paleogeographic significance, and contained base-metal sulfide deposits: Geological Society of America Special Paper 506, p. 213–234. doi.org/10.1130/2014.2506(03)

Forbes, R.B., Evans, B.W., and Thurston, S.P., 1984, Regional progressive high-pressure metamorphism, Seward Peninsula, Alaska: Journal of Metamorphic Geology, v. 2, no. 1, p. 43–54. doi.org/10.1111/j.1525-1314.1984.tb00284.x

Ford, R.C., 1993, Geology, geochemistry, and age of gold lodes at Bluff and Mt. Distin, Seward Peninsula, Alaska: Golden, Colorado, Colorado School of Mines, unpublished Ph.D. dissertation, 302 p.

Ford, R.C., and Snee, L.W., 1996, $^{40}Ar/^{39}Ar$ thermochronology of white mica from the Nome district, Alaska—The first ages of lode sources to placer gold deposits in the Seward Peninsula: Economic Geology, v. 91, no. 1, p. 213–220. doi.org/10.2113/gsecongeo.91.1.213

Hannula, K.A., 1993, Relations between deformation, metamorphism, and exhumation in the Nome Group blueschist-greenschist terrane, Seward Peninsula, Alaska: Stanford, CA, Stanford University, Ph.D. dissertation, 171 p.

Hannula, K.A., and McWilliams, M.O., 1995, Reconsideration of the age of blueschist facies metamorphism on the Seward Peninsula, Alaska, based on phengite $^{40}Ar/^{39}Ar$ results: Journal of Metamorphic Geology, v. 13, no. 1, p. 125–139. doi.org/10.1111/j.1525-1314.1995.tb00209.x

Hannula, K.A., Miller, E.L., Dumitru, T.A., Lee, Jeffrey, and Rubin, C.M., 1995, Structural and metamorphic relations in the southwest Seward Peninsula, Alaska: Crustal extension and the unroofing of blueschists: Geological Society of America Bulletin, v. 107, no. 5, p. 536–553.

Kaufman, D.S., and Hopkins, D.M., 1985, Late Cenozoic radiometric dates, Seward and Baldwin Peninsulas, and adjacent continental shelf, Alaska: U.S. Geological Survey Open-File Report 85-374, 27 p., 1 sheet.

Layer, P.W., Werdon, M.B., Newberry, R.J., Drake, Jeffrey, and Benowitz, J.A., 2015, $^{40}Ar/^{39}Ar$ data, Seward Peninsula, Alaska: Alaska Division of Geological & Geophysical Surveys Raw Data File 2015-3, 59 p. doi.org/10.14509/29413

Miller, T.P., 1972, Potassium-rich alkaline intrusive rocks of western Alaska: Geological Society of America Bulletin, v. 83, no. 7, p. 2,111–2,128. doi.org/10.1130/0016-7606(1972)83[2111:PAIROW]2.0.CO;2

Newberry, R.J., Werdon, M.B., Stevens, D.S., Athey, J.E., and Szumigala, D.J., 2005a, Geologic map of the Council area, Solomon D-4 and Bendeleben A-4 quadrangles, Seward Peninsula, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations 2005-1d, 1 sheet, scale 1:50,000. doi.org/10.14509/14448

Newberry, R.J., Werdon, M.B., Athey, J.E., and Szumigala, D.J., 2005b, Bedrock geologic map of the Council area, Solomon D-4 and Bendeleben A-4 quadrangles, Seward Peninsula, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations 2005-1e, 1 sheet, scale 1:50,000. doi.org/10.14509/7194

Patrick, B.E., 1987, Petrological and structural studies in the Seward Peninsula blueschist terrane, Alaska: Seattle, WA, University of Washington, unpublished Ph.D. dissertation, 122 p.

Patrick, B.E., and Evans, B.W., 1989, Metamorphic evolution of the Seward Peninsula blueschist terrane, Alaska: Journal of Petrology, v. 30, no. 3, p. 531–555. doi.org/10.1093/petrology/30.3.531

Patrick, B.E., and McClelland, W.C., 1995, Late Proterozoic granitic magmatism on Seward Peninsula and a Barentian origin for Arctic Alaska–Chukotka: Geology, v. 23, no. 1, p. 81–84. doi.org/10.1130/0091-7613(1995)023%3c0081:LPGMOS%3e2.3.CO;2

Pink, C.L., 2010, Structural controls on gold mineralization at the Rock Creek deposit, Nome, Alaska—Implications for Middle Cretaceous lode emplacement on the southwest Seward Peninsula: Pocatello, ID, Idaho State University, M.Sc. thesis, 216 p.

Read, J.J., and Meinert, L.D., 1986, Gold-bearing quartz vein mineralization at the Big Hurrah mine, Seward Peninsula, Alaska: Economic Geology, v. 81, no. 7, p. 1,760–1,774. doi.org/10.2113/gsecongeo.81.7.1760

Shanks, W.C.P., III, Slack, J.F., Till, A.B., Thurston, R., and Gemery-Hill, P., 2014, Sulfur and oxygen isotopic study of Paleozoic sediment-hosted Zn–Pb(–Ag–Au–Ba–F) deposits and associated hydrothermal alteration zones in the Nome Complex, Seward Peninsula, Alaska, in Dumoulin, J.A., and Till, A.B., eds., Reconstruction of a Late Proterozoic to Devonian con tinental margin sequence, northern Alaska—Its paleogeographic significance, and contained base-metal sulfide deposits: Geological Society of America Special Paper 506, p. 235–258. doi.org/10.1130/2014.2506(08)

Slack, J.F., Till, A.B., Belkin, H.E., and Shanks, W.C.P., III, 2014, Late Devonian–Mississippian(?) Zn–Pb(–Ag–Au–Ba–F) deposits and related aluminous alteration zones in the Nome Complex, Seward Peninsula, Alaska, in Dumoulin, J.A., and Till, A.B., eds., Reconstruction of a Late Proterozoic to Devonian continental margin sequence, northern Alaska—Its paleogeographic significance, and contained base-metal sulfide deposits: Geological Society of America Special Paper 506, p. 173–212. doi.org/10.1130/2014.2506(06)

Smith, P.S., 1910, Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, Alaska: U.S. Geological Survey Bulletin 433, 234 p.

Stevens, D.S.P., 2005a, Surficial geologic map of the Big Hurrah area, northern half of the Solomon C-5 Quadrangle, Seward Peninsula, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations 2005-1b, 1 sheet, scale 1:50,000. doi.org/10.14509/14445

Stevens, D.S.P., 2005b, Surficial geologic map of the Council area, Solomon D-4 and Bendeleben A-4 quadrangles, Seward Peninsula, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations 2005-1f, 1 sheet, scale 1:50,000. doi.org/10.14509/14446

Stevens, D.S.P., 2024, Surficial-geologic map of the Big Hurrah-Council Bluff area, southern Seward Peninsula, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2024-6, 9 p., 1 sheet, scale 1:50,000. doi.org/10.14509/31054

Thurston, S.P., 1985, Structure, petrology, and metamorphic history of the Nome Group blueschist terrane, Salmon Lake area, Seward Peninsula, Alaska: Geological Society of America Bulletin, v. 96, no. 5, p. 600–617. doi.org/10.1130/0016-7606(1985)96<600:SPAMHO>2.0.CO;2

Till, A.B., Dumoulin, J.A., Gamble, B.M., Kaufman, D.S., and Carroll, P.I., 1986, Preliminary geologic map and fossil data, Solomon, Bendeleben, and southern Kotzebue quadrangles, Seward Peninsula, Alaska: U.S. Geological Survey Open-File Report 86-276, 71 p., 3 plates, scale 1:250,000.

Till, A.B., Dumoulin, J.A., Werdon, M.B., and Bleick, H.A., 2011, Bedrock geologic map of the Seward Peninsula, Alaska, and accompanying conodont data: U.S. Geological Survey Scientific Investigations Map 3131, 75 p., 2 sheets, scale 1:500,000.

Till, A.B., Aleinikoff, J.N., Amato, J.M., and Harris, A.G., 2006, New paleontologic and geochronologic protolith ages for the paleocontinental margin of Arctic Alaska (paper 8-6): Geological Society of America Abstracts with Programs, Western Regional meeting of the Alaska Section, May 8–10 2006.

Till, A.B., Amato, J.M., Aleinikoff, J.N., and Bleick, H.A., 2014a, U-Pb detrital zircon geochronology as evidence for the origin of the Nome Complex, northern Alaska, and implications for regional and trans-Arctic correlations, in Dumoulin, J.A., and Till, A.B., eds., Reconstruction of a Late Proterozoic to Devonian continental margin sequence, northern Alaska—Its paleogeographic significance, and contained base-metal sulfide deposits: Geological Society of America Special Paper 506, p. 1–28. doi.org/10.1130/2014.2506(04)

Till, A.B., Dumoulin, J.A., Ayuso, R.A., Aleinikoff, J.N., Amato, J.M., Slack, J.F., and Shanks, W.C.P., III, 2014b, Reconstruction of an early Paleozoic continental margin based on the nature of protoliths in the Nome Complex, Seward Peninsula, Alaska, in Dumoulin, J.A., and Till, A.B., eds., Reconstruction of a Late Proterozoic to Devonian continental margin sequence, northern Alaska—Its paleogeographic significance, and contained base-metal sulfide deposits: Geological Society of America Special Paper 506, p. 1–28. doi.org/10.1130/2014.2506(01)

U.S. Geological Survey, 2016, Alaska Resource Data File, new and revised records version 1.5.2: U.S. Geological Survey Open-File Report 2008-1225, 1,225 p. [Accessed May 12, 2016] www.usgs.gov/centers/alaska-science-center/science/alaska-resource-data-file

Werdon, M.B., Burns, L.E., Stevens, D.S.P., and Till, A.B., 2003, DGGS Airborne Geophysical/Geological Mineral Inventory Program—Preliminary geophysical and geological interpretations of the Solomon–Council area, Seward Peninsula, Alaska [abs]: Alaska Miners Association Annual Convention, November 3–8, 2003, p. 9–11.

Werdon, M.B., Newberry, R.J., Szumigala, D.J., Athey, J.E., and Hicks, S.A., 2005a, Bedrock geologic map of the Big Hurrah area, northern half of the Solomon C-5 Quadrangle, Seward Peninsula, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations 2005-1b, 1 sheet, scale 1:50,000. doi.org/10.14509/7193

Werdon, M.B., Newberry, R.J., Szumigala, D.J., Larry K. Freeman, and Athey, J.E., 2007, Major-oxide, minor-oxide, trace-element, geochemical, and non-carbonate carbon data from rocks collected in the Solomon and Nome quadrangles, Seward Peninsula, Alaska, in 2006: Alaska Division of Geological & Geophysical Surveys Raw Data File 2007-4, 49 p. doi.org/10.14509/15840

Werdon, M.B., Stevens, D.S., Newberry, R.J., Szumigala, D.J., Athey, J.E., and Hicks, S.A., 2005b, Geologic map of the Big Hurrah area, northern half of the Solomon C-5 Quadrangle, Seward Peninsula, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations 2005-1a, 1 sheet, scale 1:50,000. doi.org/10.14509/14447

Werdon, M.B., Stevens, D.S., Newberry, R.J., Szumigala, D.J., Athey, J.E., and Hicks, S.A., 2005c, Explanatory booklet to accompany geologic, bedrock, and surficial maps of the Big Hurrah and Council areas, Seward Peninsula, Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigations 2005-1, 24 p. doi.org/10.14509/7192

Werdon, M.B., Szumigala, D.J., Newberry, R.J., Athey, J.E., and Hicks, S.A., 2005d, Major-oxide, minor-oxide, trace-element, geochemical, and non-carbonate carbon data from rocks collected in the Solomon, Bendeleben, and Nome Quadrangles, Seward Peninsula, Alaska, in 2003 and 2004: Alaska Division of Geological & Geophysical Surveys Raw Data File 2005-2, 46 p. doi.org/10.14509/7130

Young, L.E., 1995, Possible thrust windows on the central Seward Peninsula, in Combellick, R.A., and Tannian, Fran, eds., Short notes on Alaska geology 1995: Alaska Division of Geological & Geophysical Surveys Professional Report 117, p. 97–113. doi.org/10.14509/2326