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RECONNAISSANCE GEOLOGIC MAP OF THE SOLOMON D-6 QUADRANGLE SEWARD PENINSULA, ALASKA

By C. L. Sainsbury, Travis Hudson,

Rodney Ewing, and Thomas Richards

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This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards or nomenclature

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Reconnaissance geologic map of the Solomon D-6 quadrangle, Seward Peninsula, Alaska

by

C. L. Sainsbury, Travis Hudson, Rodney Ewing, and Thomas Richards

INTRODUCTION

The Solomon D-6 15- by 30-minute quadrangle lies 20 miles northeast of Nome, Alaska, and adjoins on the east the Nome D-1 quadrangle mapped by Hummel (1962b) and on the west the Solomon D-5 quadrangle mapped by Smith (1910).

Placer gold has been produced from Iron Creek and many of its tributaries, and a small amount of copper was shipped from the Wheeler mine. Many lode prospects contain small amounts of copper in silicified limestone within and near the base of thrust plates of carbonate rocks. Other lodes consist of well-defined veins containing gold and base-metal sulfide minerals, but none has been commercially productive.

Mapped rock units include the "York Slate," of Precambrian age, which consists of a highly deformed and thick sequence of graphitic calcareous siltite, which contains thin limestone beds and intercalated(?) volcaniclastic rocks, and Paleozoic carbonate rocks, which have been converted largely to marble and schistose marble. Along and near the Kigluaik Mountains in the north part of the quadrangle, quartzofeldspathic gneisses of Precambrian age are intruded by fine-grained granite. A very thick sequence of schistose thin-bedded argillaceous and dolomitic limestone overlies the York Slate and is correlative with a similar rock originally mapped in the York Mountains.

Surficial deposits, consisting principally of moraine and stream-reworked moraine, mantle large parts of the quadrangle.

MAPPING METHODS

The area north of the Kruzgemapa River where road access is good was compiled from conventional ground traverses with some helicopter control. South of the Kruzgemapa River, mapping was done by a combination of foot traverses by Hudson and Ewing from field base camps, and by foot and light-aircraft traverses by Sainsbury. Approximately 10 man-days were spent north of the Kruzgemapa River, and about 20 man-days of foot traverse south of the river with supplementary mapping of about 25 hours from the light aircraft. About 6 hours of helicopter time were used to refine the map, collect samples, and map inaccessible areas of complex structure.

The responsibility for the final assignment of all units rests with Sainsbury, who also studied rock samples in the laboratory. Many of the carbonate rocks have an uncertain age, for most are metamorphosed to marble and the bedding has been almost obliterated by a strong cleavage, which precludes a definite age assignment.

GEOLOGY

Owing to the complex thrust and normal faulting the stratigraphic succession was determined by comparing lithologies with the type section as established in the York Mountains, some 70 miles west (Sainsbury, 1969).

Stratigraphy

York Slate

This formation, which crops out discontinuously throughout the Seward Peninsula, is correlative with a unit originally defined by Collier (1902) in the York Mountains, approximately 70 miles west. Owing to tectonism and thermal metamorphism, the York Slate in the Solomon D-6 quadrangle varies from a graphitic biotite-andalusite schist north of the Kruzgemapa River to a highly lineated graphitic phyllite cut by numerous quartz veinlets in the area south of the river. Where least deformed, the original texture is clearly visible, and the rock consists of rounded silt-sized quartz grains in a graphitic and carbonaceous matrix. Locally, carbonate cement is conspicuous. Where most intensely deformed beneath major thrust faults, the rock grades to a layered nongraphitic quartz gneiss. In all types of slate, the high silica content, which exceeds 81 percent in most rocks, and the graphite are diagnostic of the formation. Locally, thin interlayered dark-gray limestones in the slate are largely converted to marble or schist. The carbonate beds are most common in the upper part of the formation and many are mapped separately.

Chloritic and Feldspathic Schists

Chloritic schists and related rocks, which form great expanses of bedrock in the quadrangle, are believed to be largely intercalated in the slate and probably represent metamorphosed volcanic rocks. Equivalent rocks in nearby areas were referred to the Nome Group by Collier (1902), Moffit (1913), Hummel (1962a, b), and Sainsbury, Coleman, and Kachadoorian (1970). The mapping in 1970-1971 suggests that the Nome Group as originally defined contains rocks which probably include Precambrian and Paleozoic strata, as well as schistose mafic rocks which may be of much younger age. On the map of the Solomon D-6 quadrangle and on others prepared in 1971, the designation of Nome Group is abandoned, and the chloritic and feldspathic schists are included in the York Slate.

The chloritic rocks range from glistening schists and phyllites to more massive but still foliated rocks with a high percentage of feldspar. North of the Kruzgemapa River, as well as southeast of Salmon Lake, the chlorite flakes are larger, and biotite is present.

Variable lithologic types and textures are found in the large mass of feldspathic rocks northeast of the Casadepaga River, and metamorphosed mafic intrusive rocks younger than the slate may be included. In this area weakly foliated albite-chlorite schists are common.

Contacts between the slate and chloritic schists commonly are gradational, sometimes over several hundred feet of section, although the east contact of the belt of albite-chlorite schists crosscuts several other rock types, and is interpreted as a thrust-fault contact.

In the headwaters of Sherrett Creek, in the northeast part of the mapped area, the chloritic rocks are thermally metamorphosed, and calc-silicate rock has developed, suggesting that an intrusive rock underlies the area. To the east, the chloritic schists are transitional to slate or schistose limestone intercalated in the slates.

Carbonate Rocks

The carbonate rocks of the quadrangle include thin strata intercalated in slate or chloritic schist of Precambrian age, and thicker units assigned a late Precambrian and Paleozoic age.

Argillaceous dolomitic limestone and calcite-mica schists

A very thick sequence of thin-bedded schistose argillaceous limestones occupies much of the quadrangle and overlies the slate with a transitional contact. These limestones are clearly correlative with similar rocks first described by Sainsbury (1969) in the western Seward Peninsula, and assigned by him to the upper Precambrian. Between the Casadepaga and Eldorado Rivers, these rocks are continuously exposed, forming rounded hills bare of vegetation and with limonitic yellowish color. They are for the most part moderately schistose, with foliation planes crossing the argillaceous bands. Small vitreous quartz veinlets are locally common.

The belt of similar rocks along Telegram Creek is believed to be a more highly deformed equivalent of the thin-bedded limestones just described. Schists composed of calcite, chlorite, and white mica predominate in this area; some of the schists have noticeable graphite near contacts with the graphitic slates.

Carbonate rocks of Ordovician(?) age

Carbonate rocks which are lithologically similar to fossiliferous Lower Ordovician limestones of the western Seward Peninsula (Sainsbury, 1969) form hill 926 about 3 miles east of Salmon Lake. The rocks are markedly cleaved, but some bedding is still visible, showing that the rocks originally consisted of interbedded limestone with thin argillaceous partings. Structures suggestive of deformed fossils are sparingly present. Although most of the rocks are thin bedded, a few of the beds are as much as 18 inches thick.

Carbonate rocks of Devonian(?) age

Rocks assigned to the Devonian(?) are restricted to a single thrust plate between Gassman and Venetia Creeks. Extensive tectonic dolomite and dolomite breccia are developed near the thrust, and dolomite irregularly replaces the rest of the rocks. Where least altered, the limestones are dark gray to black, and contain bits and fragments of shale broken and scattered during deformation of the limestone. Although fossils were not observed, these carbonate rocks are lithologically identical to fossiliferous Devonian rocks on Harris Dome, about 40 miles to the north and east and are assigned to the Devonian.

Marble, limestone, and dolomite of undifferentiated Paleozoic age

A high ridge of hills east of Telegram Creek is composed of gray-weathering marble and limestone. Although most of the rocks are recrystallized to cleaved marble, bedding planes were observed locally. Color bands also indicate original differences in the limestones. No fossils were found in these carbonate rocks, but recrystallized chert is locally abundant as lentils and nodules. The rocks comprise a faulted thrust plate that extends into the adjoining quadrangle.

These carbonate rocks represent what must have been thousands of feet of beds before deformation, and they are assigned to the Paleozoic. They are most probably metamorphosed Ordovician rocks, but in the absence of fossils they cannot be assigned more closely than Paleozoic. Earlier workers (Smith, 1910) also correlated these rocks with the "Sowik limestone," which was considered to be of Ordovician(?) age.

East of the headwaters of American Creek, a dolomitized thrust sheet forms two klippen which are the northwest continuation of a larger thrust sheet. Converted entirely to dolomite that weathers faintly reddish to pale orange, the rocks are cut by innumerable quartz veinlets near the thrust. Silica, which migrated from the underlying siliceous graphitic York Slate, also has extensively replaced the brecciated dolomite near the thrust fault. No fossils were found, but these rocks are assigned to the Paleozoic because of their similarity to dolomitized Ordovician carbonate rocks of the York Mountains.

Impure marble and limestone of undifferentiated Paleozoic age

Included in the belt of carbonate rocks are impure marbles of probable Paleozoic age that are tectonically mixed with underlying chloritic schists or slate. On weathered outcrop these mixed rocks are marked by the sparse development of tundra, which reflects the impurities of the rocks, and by a distinctly more schistose structure. The impurities range from a small amount of chlorite or graphite to such amounts that the rocks are best called chlorite-calcite schists, or graphitic calcite schists. Even though they are grouped as one rock type on the map, they are characterized by diversity of lithology, weathering properties, and schistosity.

Limestone, marble, and impure marble of unknown age (ls and lsi)

Several small to extensive belts of carbonate rocks cannot be confidently assigned by age. These consist of highly deformed marble, marble schist, and impure carbonate schists which may be either Paleozoic or Precambrian carbonate rocks. They may be either in thrust-fault contact with underlying or overlying rocks, or tectonically mixed rocks.

In general, the carbonate rocks weather light gray to medium gray without discernible bedding. Variations in lithology, color, and texture occur within short distances and it is difficult to visualize these color changes as representing original lithologic variations. As most of these carbonate rocks occur in areas of great structural complexity, or near known thrust faults, it is most likely that their diversity of appearance and lithology is controlled in part by the tectonic mixing of units.

Conglomerate of Quaternary age

On Sherrett Creek, just south of the tractor trail, a cutbank exposes conglomerate that contains pebbles and cobbles of granite, gneiss, and biotite schist, which suggests a source area in the Kigluaik Mountains. The conglomerate is overlain by glacial moraine, and it is possible that the conglomerate represents an older lithified moraine of a glaciation earlier than represented by the extensive moraine that covers the valley of the Kruzgemapa River.

Metamorphic Rocks

In addition to local variations caused by tectonic events, a widespread thermal metamorphism accompanied the injection of large and small granitic bodies in the Kigluaik Mountains, producing schists and paragneisses. These metamorphic rocks were called the Tigaraha schists by Moffit (1913), and this designation is retained by Sainsbury, Coleman, and Kachadoorian (1970), who assign them to the Precambrian. Through the use of whole-rock rubidium-strontium methods, Carl Hedge determined age dates of approximately 750 m.y. from some of the paragneisses in the Kigluaik Mountains (Sainsbury and others, 1971), and thus corroborated a Precambrian age.

South of Salmon Lake, the slates show the beginning of thermal metamorphism, but biotite and andalusite do not become common until the Kruzgemapa River is crossed. Along the south side of the Kigluaik Mountains, graphitic biotite schists are in thrust-fault contact with biotite-chlorite schists. A sharp change occurs in the attitude of cleavage and schistosity across the thrust, but the main break in metamorphism occurs along a normal fault nearly parallel to the thrust fault.

In the headwaters of Crater Creek, the metamorphic rank increases sharply, and quartz-graphite-biotite paragneiss is developed. The large amount of graphite in these rocks suggests that they represent highly metamorphosed slate.

Intrusive Rocks

Mapped intrusive rocks in the Solomon D-6 quadrangle consist of numerous pluglike bodies of metagabbro, of which only the more obvious are shown, and of fine-grained granite in the Kigluaik Mountains. Numerous small dikes of mafic rocks, granitic rocks, and pegmatites are widespread in the Kigluaik Mountains, but are not shown on the map. Smith (1909) found no granitic intrusive rocks south of the Kruzgemapa River.

Although the granite is clearly Cretaceous in age the mafic intrusive rocks cannot yet be assigned a definite age. Some of the mafic rocks are intrusive into the Upper Precambrian thin-bedded limestones, as on the ridge between Gassman and Venetia Creeks, where mafic intrusives have metamorphosed the limestones and sharply tilted the cleavage. Elsewhere, mafic bodies intrusive into the limestone have been folded and metamorphosed with the enclosing rocks. Small bodies of chloritic schist in the Paleozoic carbonate rocks east of Telegram Creek could represent either slivers of schist folded or faulted into the carbonate rocks, or intrusive rocks folded and metamorphosed with the enclosing marble.

The age of the mafic intrusive rocks remains one of the most important unsolved problems of Seward Peninsula geology, with important ramifications on major problems such as the age of the blueschist rocks (Sainsbury and others, 1970), the depths at which thrusting occurred, and the age assignment of metamorphosed carbonate rocks intruded by gabbros. The problem is examined in some detail in this report.

Similar mafic rocks in the York Mountains, some 70 miles west, were assigned a pre-Ordovician age by Sainsbury (1969), based upon the fact that such rocks were common in the "York slate" of Precambrian age, rare in the overlying upper Precambrian thin-bedded limestones, and completely absent in the extensive Ordovician rocks. Similar relations held true for much of the Seward Peninsula, and metamorphosed mafic intrusive rocks have never been found by Sainsbury in fossiliferous Paleozoic carbonate rocks. On the basis of these relations established in the York Mountains, all carbonate rocks that were intruded by metagabbro were considered to be of Precambrian age. With additional work in areas as far as 100 miles distant, this criterion for a Precambrian age was cast in doubt, for at several places metagabbros were found in carbonate rocks that displayed relict bedding, chert, and structures suggestive of fossils, indicating a Paleozoic age. Moreover, it has become doubtful that thick and pure carbonate rocks occur in the Precambrian rocks of the Seward Peninsula.

Hummel (1962a, b) found large numbers of metamorphosed intrusive rocks in limestones in the Nome area adjoining the Solomon D-6 quadrangle. These intrusives range from metagabbro to metadiorite and granite, and may represent a long-lasting intrusive cycle (C. L. Hummel, oral commun., 1970, 1971). No similar suite of intrusive rocks is recognized in the Solomon D-6 quadrangle, but the gabbros and metagabbros are chemically and mineralogically equivalent in the two areas. If Hummel's assignment of a Paleozoic or younger age to the metagabbros is correct, then the altered limestones and marbles in the Solomon D-6 and Nome D-1 and C-1 quadrangles that are cut by metagabbros could be Paleozoic in age, and seemingly interstratified with rocks assigned by Sainsbury to the Precambrian as a result of thrust faults. Nevertheless, it remains true that rocks clearly datable by fossils as of Paleozoic age are seldom intruded by metagabbros, whereas all pre-Paleozoic rocks are intruded by numerous metagabbros, most of which are recrystallized to some degree and which were deformed during the Cretaceous thrusting (see Sainsbury and others, 1970, for mineral assemblages). However, as thrusting postdates all the carbonate rocks, it is entirely possible that many of the schistose marbles are dynamically deformed Paleozoic rocks. If so, intrusive mafic rocks may be as young as Early Cretaceous, and more than one intrusive cycle may be represented.

The granite body in the northwest corner of the quadrangle consists of unfoliated fine-grained granite or quartz monzonite, similar to many other plugs and stocks mapped elsewhere in the Kigluaik Mountains. A common characteristic, in addition to composition, is the unusually large amount of allanite--single thin sections commonly show numerous grains (as many as 28).

Structure

The geologic structure is extremely complex in much of the quadrangle, especially in the eastern part. West of the Casadepaga River, the argillaceous limestones may lie along a large complex synclinal structure trending north, but the northern border of the argillaceous limestones is marked by a thrust fault with thick breccia along the thrust.

East of the Casadepaga River, all foliation planes dip westerly, reflecting the intense eastward thrusting and the related folding. In this area prominent lineations (microfold axes and dragfold axes) are horizontal or plunge gently southeast or northwest, again the consequence of eastward thrusting. They clearly record eastward transport.

Along and east of Telegram Creek, thin bands of highly deformed rocks are bounded by strong normal faults trending northwest, and the foliation dips west more steeply than along the Casadepaga River. This zone of closely spaced faults continues into the adjoining quadrangle, and unquestionably marks a major and deepseated structurally complex belt.

Thrust faults are best observed at the base of the Paleozoic rocks between Gassman and Venetia Creeks, at the base of the large sheet of carbonate rocks east of Iron Creek, and at the base of the dolomite east of American Creek. Although the thrusting is unmistakable, it is worthwhile to list geologic conditions and criteria generally used to establish the thrust faults. These are:

1. Sharp discordance of rock units along the thrusts, with the thrust plane transecting bedding or structures in both upper and lower units.

2. Tectonic dolomite developed along the thrust, and extending irregularly above the fault. Dolomite is usually brecciated by continued movement.

3. Silicification of carbonate rocks along the thrust plane with the silica generally derived from the overridden rocks. Tremendous volumes of silica have been mobilized during the thrusting.

4. Fragments of foreign rocks, such as slates, chloritic schist, or metagabbro, dragged up into the carbonate rocks, where they lie completely surrounded by carbonate. These were commonly referred to as "tectoliths" during our mapping.

5. Slickensided dolomite, or slickensided silicified dolomite along suspected thrusts.

6. Lines of springs that issue at contacts suspected to be thrust faults, especially where the upper plate is carbonate rocks (see large springs west of the north end of the main thrust plate east of Iron Creek).

7. Intense crumpling of bedding or schistosity in rocks underlying major thrust plates of carbonate rocks.

8. Transecting of map units by other map units.

9. Oversteepening of bedding or schistosity at the base of overriding plates, a feature observed at many localities.

Even though all of these relations are seldom observed at a single thrust, several of them commonly are present and definitely serve to establish the thrust fault.

In the Kigluaik Mountains, which are bounded to the south by steeply dipping faults, the cleavage, bedding, and schistosity all dip south, away from the mountains. As pointed out by Hummel (oral commun., 1958), this reflects strong cross-folding on an east-west axis of structures originally trending north.

ECONOMIC GEOLOGY

Placer gold has been mined in moderate amounts from Iron Creek and its southerly continuations known as Dome and Telegram Creeks since about 1904. Smaller amounts of placer gold were mined from Venetia Creek, a tributary of the Eldorado River, and all the small tributaries of the Kruzgemapa (Pilgrim) River that enter from the south between the Eldorado River and Iron Creek (see Smith, 1909). Mining ceased before World War II, and most of the auriferous gravels have been worked more than once, leaving little chance for remaining workable placers. As in many other creeks, a dredge reworked much of the dredgable part of Dome Creek. The symbols on the map which depict placer mines are placed where the most obvious remnants of the old placer workings can be seen, or where old placers were mined (Smith, 1909). Although mining continued for many years, and some coarse gold and well-paying gravels were found, the Iron Creek area was not a major producer of gold.

Lode deposits, none of which have produced significant amounts of metal, consist of three distinct types. By far the most common are sheetlike bodies of silicified limestone along the base of thrust plates of carbonate rocks, where banded silica has completely replaced the limestone. Such silicified rocks almost everywhere carry small amounts of copper carbonates, with malachite being most common. At places, small amounts of chalcopyrite and pyrite are found, but nowhere is the grade sufficiently high to give promise of commercial production. A property known locally as the Wheeler mine, at the base of the thrust plate of carbonate rocks at the head of Sherrett Creek, has been explored by short shafts and adits, which are now inaccessible. Silica, accompanied by visible pyrite and chalcopyrite, has replaced the carbonate. The silicification selectively followed a vertically dipping strong joint system that strikes N. 65° E. Thin bands of chloritic schist within the marble were preferentially replaced. At the mine, the limestone is intricately folded, with the dragfolds isoclinal or steeply overturned to the east, which indicates eastward transport of the thrust plate.

Elsewhere along the main carbonate belt, numerous prospect pits show copper stains in silicified limestone at the base of thrust plates or, locally, near irregular masses of chloritic schists in the thrust plates. These schists could represent either metamorphosed mafic dikes or, more likely, thrust slivers of the overridden lower plate, which consists entirely of chloritic or feldspathic schists.

A second type of lode deposit consists of sulfide minerals, including pyrite, galena, boulangerite(?), sphalerite, and gold, which are found along altered zones a few feet wide in schist or limestone at the mouth of Iron Creek and nearby on the Kruzgemapa River. These were described by Smith (1909). Desultory prospecting of the lodes since 1904 has resulted in small exposures within single pits or short trenches. In late 1971, a diamond drill was moved into the area to drill the lodes, and further drilling is planned for 1972.

Elsewhere, particularly in highly deformed slates beneath thrust plates, small quartz veins are numerous. Many have been observed by earlier workers to contain small amounts of visible gold, pyrite, and galena. Although these veinlets probably have contributed much of the gold to the placers, nowhere do they form minable orebodies. Similar veinlets occur throughout the Seward Peninsula wherever the York Slate is intensely deformed, and especially beneath thrust plates of carbonate rocks.

Cinnabar has been reported from the gold placers of Dome Creek, and has been verified by laboratory tests in gravels of Auburn Creek, a tributary of the American River (Smith, 1909, p. 335).

The State of Alaska carried out a reconnaissance geochemical exploration in the drainage of Iron Creek (Asher, 1969). Asher recommends further prospecting in the area at the head of Sherrett Creek and northward to the Iron Creek drainage. Argentiferous galena has been found in this area. As discussed previously, the chloritic rocks in the headwaters of Sherrett Creek are thermally metamorphosed, which suggests that a buried granitic rock underlies this area.

In summary, the present work merely reinforces opinions expressed by earlier workers in the area that even though copper minerals are widespread in the mapped area, no deposits appear sufficiently rich or extensive to justify exploration. The veins containing gold and base-metal sulfide minerals may warrant some drill holes.

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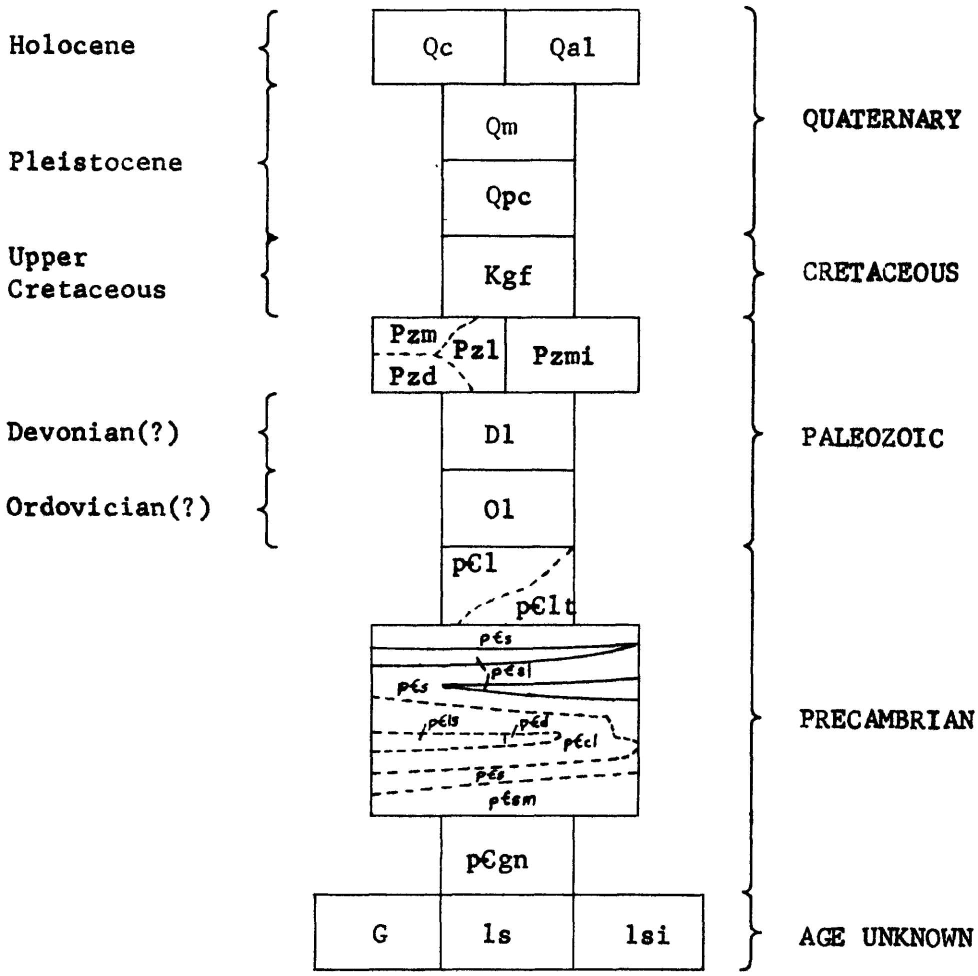
EXPLANATION

Correlation of map units



Description of map units

Qc — Surficial cover - principally tundra and soil; locally frost-riven regolith and colluvium partly covered by tundra

Qal — Alluvium - includes terrace gravels and reworked moraine

Qm — Morainal deposits - includes ground moraine of Nome River glaciation and, at mouth of Crater Creek, terminal and ground moraine of Salmon Lake glaciation. Moraine mostly tundra covered (not shown)

Qpc — Conglomerate - lithified conglomerate containing clasts from both local and distant source areas. Could represent old glacial deposits

Kgf — Granite - fine-grained granite containing unusual amounts of allanite. Granite is postorogenic and is typical of numerous large and small bodies in both the Kigluaik and Bendeleben Mountains

MARBLE, LIMESTONE, AND DOLOMITE OF UNDIFFERENTIATED PALEOZOIC AGE

Pzm — Marble, schistose marble, and local dolomite of tectonic origin

Pzl — Limestone, marble, and dolomite; intensely deformed

Pzd — Dolomite and dolomite breccia of tectonic origin

IMPURE MARBLE AND LIMESTONE OF UNDIFFERENTIATED PALEOZOIC AGE

Pzmi — Schistose marble and limestone containing either chlorite, white mica, or graphite. Could represent either rocks originally impure or rocks mixed tectonically

CARBONATE ROCKS OF DEVONIAN(?) AGE

Dl — Limestone, dolomite, and shale - cleaved limestones with original bedding still visible; limestone originally dark gray and contained chert. Deformed remnant fossils resembling crinoid columnals. Shale as isolated fragments that represent broken-up original thin beds. Dolomite is of tectonic origin along thrust, and contains abundant silica in veinlets

CARBONATE ROCKS OF ORDOVICIAN(?) AGE

Ol — Calcite-mica schist, limestone, and dolomite - limestone originally consisted of interbeds of dolomitic limestone and argillaceous limestone in alternating layers ¼-½ inch thick. Original chert nodules now deformed and recrystallized. Age assignment based upon correlation with fossiliferous rocks of similar lithology in the York Mountains, about 70 miles west (Sainsbury, 1969). Rock is moderately metamorphosed

ARGILLACEOUS DOLOMITIC LIMESTONE AND CALCITE-MICA SCHIST

p€l	Dolomitic calcite-mica schists and schistose argillaceous dolomitic carbonate rocks. Originally consisted of rhythmically interbedded dolomitic limestone and argillaceous material. Lies transitionally above p€s. Weathers limonitic wherever exposed
p€lt	Tectonic equivalent of p€l; highly schistose with no original bedding recognizable

YORK SLATE

p€s	Faintly to moderately foliated graphitic siltite, phyllite, and calcareous graywacke
p€sl	Medium- to dark-gray schistose limestones that weather medium gray where undeformed; where deformed they are schistose marbles. Most common in upper part of unit
p€cl	Chlorite-albite-epidote-amphibole schists in part clearly of volcanic origin, and less schistose chlorite-epidote-plagioclase rocks that may represent intrusive rocks of much younger age
p€ls	Schistose limestone or marble apparently intercalated in p€cl unit; commonly contains quartz grains and chlorite
p€st	Tectonic equivalent of p€s; varies from highly crinkled phyllites to markedly deformed rocks with rolled quartz rods and, near major thrusts, to quartz gneiss with most of the graphite expelled
p€sm	Metamorphosed equivalent of p€s and p€st; principally biotite-andalusite schists and hornfelses with minor calc-silicate rocks
p€d	Dolomite and dolomite breccia probably of tectonic origin; weathers orange

PARAGNEISS

p€gn	Quartz-plagioclase-biotite gneiss with graphite locally and with minor interbeds of calc-silicate rocks. May represent highly metamorphosed York Slate in large part

UNITS OF UNKNOWN AGE

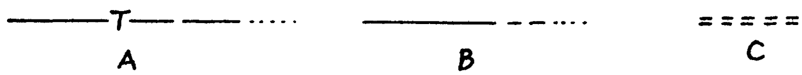
G	Gabbro and metagabbro - irregular bodies that locally intrude thrust sheets of Paleozoic carbonate rocks, as well as slate and chloritic schists. Many are garnet bearing. May be as young as Early Cretaceous and intruded during the thrusting. Only more conspicuous bodies are shown on map
ls	Marble and schistose limestone - isolated exposures of rocks so highly deformed that they cannot be assigned. Most weather gray to medium light gray

lsi	Impure marble and limestone - noticeable impurities include chlorite, graphite, quartz. Rocks may be in large part the result of tectonic mixing of diverse rock types

<u>NOTE</u>: All the symbols shown below may not appear on this map

Veins and mineralized areas

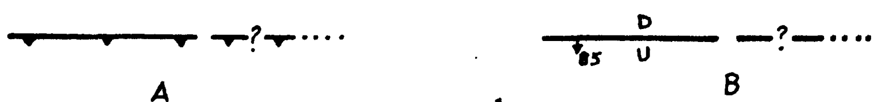
A. Mineralized faults with old prospect pits or trenches containing elements as shown
B. Widespread gossans with old prospect pits or trenches; contained elements unknown
C. Placer gold mine extending along stream or beach as shown
D. Placer gold mine of localized extent. On coastal plain symbol represents surface placers as well as old drift mines on buried beaches. Symbols for metals contained in prospects or mines: Au, gold; Ag, silver; Pb, lead; Sb, antimony; Zn, zinc; Cu, copper; CaF_2, fluorite



Contacts

A. Transitional over a few feet to hundreds of feet
B. Sharp contact well exposed
C. Open ends indicate that bed continues an unknown distance beyond exposure

All contacts dashed where inferred or approximately located, dotted where concealed



Faults

A. Thrust fault; sawteeth on upper plate. Dashed where approximately located, dotted where concealed, queried where inferred or doubtful
B. High-angle fault, showing dip. U, upthrown side; D, downthrown side. Dashed where approximately located or inferred, dotted where concealed, queried where doubtful

Strike and dip of foliation or cleavage

A. Strike and dip estimated by observation from low-flying aircraft
B. Strike and dip direction as determined by observation from low-flying aircraft
C. Strike and dip as measured on the ground
D. Strike and dip direction as determined on the ground

Anticline Syncline Drag folds

Folds

Showing approximate crestline and direction and amount of plunge where known

Prospect pit or trench

Abandoned dredge

Sinkhole

Cold-water spring

Landing area

Suitable only for high-performance short takeoff and landing (STOL) aircraft used during field operations in 1971; larger rocks removed