UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

RECONNAISSANCE GEOLOGIC MAPS AND SAMPLE DATA, TELLER A-1, A-2, A-3, B-1, B-2, B-3, C-1, AND BENDELEBEN A-6, B-6, C-6, D-5, D-6 QUADRANGLES, SEWARD PENINSULA, ALASKA

By

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Introduction

The U.S. Geological Survey's Heavy Metals program for the Seward Peninsula has been primarily concerned with a semi-detailed mapping program to prepare dependable 1:250,000 scale maps of the Teller, Nome, Bendeleben and Solomon 1:250,000 quadrangles. During the course of mapping, numerous samples of altered bedrock along faults, near igneous contacts, and altered rocks along thrust faults were collected and analyzed for gold and other elements. In areas containing numerous placer gold deposits, known rare metals in placer concentrates, or lode prospects, reconnaissance geochemical surveys were made, by use of the -40 or -80 mesh fraction of total stream sediments. Because of the intense current interest in the Far North, brought on by the discoveries of oil at Prudhoe Bay, and the desire to make the known stratigraphic and structural geology of the mapped portions of the Seward Peninsula immediately available for industry, the semi-detailed mile-to-the-inch maps are being released to the Open Files. The locations and analyses of all mineralized bedrock or stream sediment samples are added to the maps and included in the text to bring the economic information up to date.

Analytical Methods

All analyses for gold were by atomic absorption, using a 5-gram sample; because most of the gold is particulate, repeat analyses for gold were highly erratic. Gold detected at the level of .02 ppm (parts per million), or about 2 cents per ton, is considered anomalous, for most samples contained less than .02 ppm. Mercury was determined by mercury detector, a value of .09 ppm was considered as threshold, and above that value, anomalous. Splits of most samples were analyzed by the semiquantitative spectrographic analyses, and reported values for silver, arsenic, beryllium, bismuth, cobalt, copper,

molybdenum, nickel, lead, antimony, tin, tungsten, and zinc are based on such analyses. Because the detection limits of certain elements are high, e.g., As 200, Sb 200, W 200, Zn 200, any sample showing an (L) (detected, but below the amount of dependable determination at the levels quoted) for As, Sb, W or Zn was considered to contain these elements in anomalous amount.

A special problem arises with respect to mercury, for a Hiller 12-E helicopter was used in the field. Because the 12-E has a centrifugal clutch filled with mercury, and becuase the clutch may leak, all mercury values were suspect. In fact, a definite correlation was established at places between a slipping clutch and high mercury values in stream sediments, which normally were collected very close to the landed helicopter. Such values were discarded, but all stream sediment sample results are suspect. The problem is further complicated by the widespread occurrence of cinnabar in the placer gold areas, as well as by the fact that metal-rich lodes are enriched in mercury. In addition, replicate analyses for mercury on splits of the same sample were very erratic--values reported varied up to 800 percent, and averaged 300 percent. Nevertheless, it remains true that mercury showed a dependable correlation with high metal values in mineralized samples.

GENERAL GEOLOGY

Although the geology of each quadrangle is discussed separately in the following pages, a general summary of the geology of Seward Peninsula is appropriate. Prior to the present mapping, the knowledge of Seward Peninsula, except for the Nome area, was based entirely upon reconnaissance surveys dating from about 1901-1910. With the mapping of two quadrangles in the York Mountains (fig. 1) between 1960-1965 (Sainsbury, 1965; in press) the stratigraphy and structure became better known. Of greatest importance was the recognition that rocks of the Seward Peninsula are part of a great belt of thrust faulting. The thrust belt has been named the Collier thrust belt, to honor A. J. Collier, U.S. Geological Survey, who did reconnaissance mapping on the Seward Peninsula between 1900-1910, and who first recognized that limestones of the York Mountains were not in normal stratigraphic position above the underlying "Slates of the York Region" (Collier, 1902, p. 18-19).

Recognition and mapping of the thrust belt have clarified relations which puzzled the earlier workers, as, for instance, the apparent interbedding of low rank and mildly deformed rocks with intensely deformed and high-rank metamorphic rocks (Smith, 1910, p. 26, 52). The recognition of a regional metamorphism, impressed upon the thrust sheets and becoming progressively stronger eastward and southeastward from the western Seward Peninsula, also has helped clarify these puzzling relations.

For the interested reader, the more recent publications dealing with the geology of the Seward Peninsula are listed in the bibliography of this report.

Stratigraphy

Stratified rocks of Precambrian, Paleozoic, Tertiary and Quaternary age are known on that part of the Seward Peninsula covered by this report. Rocks of Jurassic and Cretaceous age are widespread on the eastern Seward Peninsula (Patton, 1967; Miller, 1969) but are not discussed herein.

Precambrian Rocks.--Older rocks of Precambrian age form the bedrock of most of the Kigluaik and the Bendeleben Mountains; rocks of younger Precambrian age are widespread over the Seward Peninsula. The oldest rocks consist of ortho- and paragneisses, crystalline marble with olivine or monticellite, and thick biotite-garnet-andalusite schists. An age date, using the rubidium/-strontium method on whole rock, of 750 m.y. was obtained by Carl Hedge (oral

communication, 1969) on paragneiss collected by Sainsbury from the Kigluaik Mountains; this age is believed to represent the age of metamorphism, not the ultimate age. These older rocks have been divided into several units on maps accompanying this report; they were originally called the Kigluaik Group by Moffit (1910), who also recognized several subdivisions.

A thick sequence of greenish-colored schists with numerous intercalated schistose marbles is younger than the Kigluaik Group but probably is still of Precambrian age. These schists, characterized by chlorite-epidote-albite-actinolite (or glaucophane)-garnet, calcite schists, probably represent an ancient volcanic terrane. They are called the Nome Group in this report, although the Nome Series originally included numerous thrust slices of marble of Paleozoic age, and was considered to be "of Paleozoic or possibly Pre-cambrian age" (Brooks, Richardson and Collier, 1901). The Nome Group rocks represent blueschist or retrograded blueschist rocks that were subjected to intense dynamic metamorphism sometime in the latest Precambrian (Sainsbury, Colemen and Kachadoorian, in press).

Above the Nome Group rocks is a thick sequence of black, graphitic, slaty rocks that originally consisted mainly of silt-sized quartz grains in a carbonaceous matrix. Now metamorphosed to slates containing white mica, graphite, and, locally, calcite, these rocks were called the "Slate of the York Region" by Collier (1902) and the Kuzitrin Series by Brooks (1901). In this report they are called the "Slate of the York Region," and are shown by map symbol pOs. They are believed to be of Late Precambrian age, although they can be demonstrated only to be of pre-Ordovician age, hence the map symbol pOs.

The "Slate of the York Region" grades upward, in the York Mountains, into a thin-bedded, argillaceous dolomitic limestone, definitely of pre-Ordovician and probably of Latest Precambrian age, which is succeeded by an unknown thickness of thin-to medium-bedded dolomitic and argillaceous limestone. These rocks are described in detail by Sainsbury (1965). They outcrop over wide areas of the Teller B-3 of this report (p01).

Paleozoic Rocks.--The oldest rocks of known Paleozoic age on the Seward Peninsula are Ordovician carbonate rocks. The entire Ordovician is represented by several distinct units (Sainsbury, 1965) in an almost unbroken sequence of completely unmetamorphosed carbonate rocks in the York Mountains. The transition to Silurian carbonate rocks is shown in a thrust plate in the eastern York Mountains (Sainsbury, in press) west of the Don River. Carbonate rocks of Late Silurian(?) age are exposed in a small window in the thrust sheets in the Teller C-3 quadrangle (not included in this report) east of the point where the north fork of Arctic Creek takes a right-angle bend to the west. Similar-appearing carbonate rocks probably of similar age outcrop at the northeast edge of the Teller B-3 quadrangle (SOdl).

Carbonate rocks of probably Devonian age are exposed in a small klippe of marble on the top of Harris Dome, east part of Bendeleben C-6 quadrangle, for fossils of possible Devonian age were obtained there in 1968 (Sainsbury, personal observation). Whether the entire Devonian system is represented or not cannot be determined yet.

Carbonate rocks of probable Mississippian age are reported from a large area of contorted limestone in the Teller C-6 quadrangle (Collier, 1908, p. 81) not included in this report. No rocks of Pennsylvanian or Permian age are known on the Seward Peninsula.

Mesozoic Rocks.--Rocks of Mesozoic age in the area covered by this report consist entirely of felsic intrusive rocks of Mid- to Late Cretaceous age. These intrusive rocks generally are biotite granite, with grain size ranging

from fine-grained to coarsely porphyritic. The fine-grained intrusives are restricted to the Kigluaik Mountains, whereas the porphyritic granites comprise isolated stocks at scattered localities on the central and western parts of the peninsula. The known tin and beryllium deposits are associated with the porphyritic granites (Knopf, 1906; Sainsbury, 1965).

Tertiary Rocks.--Rocks of Tertiary age on the central and western Seward Peninsula consist of isolated, small exposures of lignitic beds in the lake-covered flats of the Kuzitrin and Noxapaga Rivers in the Bendeleben B-5 quadrangle, and of a single boulder found on the inner edge of Lopp Lagoon, in the Teller C-6 quadrangle (not included in this report). It is probable that Tertiary rocks cover large submarine areas off Nome and the westernmost Seward Peninsula (Hopkins, 1968, oral communication). Coal-bearing rocks of Tertiary age also occur in Coal Creek, a tributary of the Sinuk River, north of Nome (Collier, et. al., 1908, p. 83).

Quaternary Rocks.--Extensive lava fields of Quaternary age cover large areas in the central Seward Peninsula, and make up a large area of the Teller B-3 quadrangle (this report). They are not well studied--those in the Teller B-3 quadrangles locally are nepheline-bearing alkalic basalts. Cemented conglomerates that represent old deltaic deposits occur at scattered localities near present streams along the York Terrace, of probable Yarmouth age, in the Teller B-4 and B-5 quadrangles. They are described in a previous report (Sainsbury, 1967).

Unconsolidated deposits of Quaternary age are widespread in the area covered by this report. They include glacial deposits of Wisconsinan age along the north front of the Kigluaik Mountains, older, high-level gravels related to a former base level, of which the Kougarok Gravels, discussed under the Bendeleben C-6 quadrangle, are of possible economic interest, and extensive deposits of silt and loess along the major rivers and the flats surrounding Imuruk Basin.

ECONOMIC GEOLOGY

Only the salient features of the economic geology of the central and western Seward Peninsula are discussed in this report. The economic geology of each quadrangle included with this report is discussed in the following text sections keyed to each quadrangle.

The Seward Peninsula has produced more than 6,000,000 ounces of gold and more than 2,000 long tons of tin (U.S. Geological Survey, 1964), which constitute the bulk of the metallic minerals produced. Large reserves of fluorite containing beryllium minerals, and significant reserves of tin and tungsten are known in the Lost River area, Teller B-5 quadrangle (Sainsbury, 1963; Lorain, et. al., 1958). All the significant lode deposits of tin and beryllium are associated with porphyritic biotite granite stocks which are enriched in tin, and considerably enriched in beryllium, in comparison to "normal" granites (Sainsbury and Hamilton, 1967; Sainsbury, 1965). The main tin lodes at Lost River are localized in dikes intruded into normal faults of a strong set trending about N. 75°-85° E. in the central York Mountains, whereas the beryllium deposits mainly are localized along thrust faults where they are intersected by lamprophyre dikes intruded into the normal faults. Mineral deposition is post-granite age; east-trending faults and dikes contain ore--but a strong set of N-S faults is barren.

Going eastward and southeastward for about 50 miles from Lost River, the N-S faults swing to about N. 15°-20° E. and many of them are hydrothermally altered and cemented by white quartz and tawny jasperoid. In the Kigluaik Mountains and the central Seward Peninsula these faults contain anomalous amounts of metals, including gold, but no major deposits are known. Near Nome, mineralized faults of this system contain gold and silver-bearing minerals. Erosion of these mineral deposits has contributed large amounts of gold to placer deposits, such as that on Anvil Creek (Hummel, 1960).

In the central Seward Peninsula, both north and south of the Kigluaik Mountains, numerous copper prospects are known. The present study has shown that these belong to two distinct types:

The most common type, exemplified by the numerous small deposits in Iron Creek in the Solomon D-6 quadrangle (not included in this report), and the Ward Mountains copper prospects in the Teller C-1 and D-1 quadrangles (C-1 is included with this report) consist of trace to minor amounts of copper sulfide (and secondary azurite and malachite) in banded quartz which has replaced carbonate rocks in the upper plates of thrust faults. Of these, only the Ward Mountain deposit has produced a few tons of ore, and the prospectors were constantly puzzled by the fact that shafts that started in copper-bearing material ran out of mineral "as soon as they went out of the lime" (oral communication, Hugo Lindfors, 1967). More than a dozen prospects of this type were visited in 1967-68; they differ only in the relative amount of replacement quartz. There is nothing to suggest that these lodes ever will be commercially profitable, for copper minerals do not penetrate the rocks beneath the thrust plates.

The second type of copper deposit is exemplified by small deposits which have been explored in the Nome D-1 quadrangle (see Hummel, 1962). There copper-bearing replacement quartz occurs on the borders of metamorphosed intrusive rocks originally of dioritic composition.

Chalcopyrite also occurs in schistose silicified limestone now in the chloritic schists of the Nome Group; subsequent movement has deformed and broken the copper-bearing beds so that the possibility of minable lodes is considerably reduced. None have been explored sufficiently to establish minable reserves.

Elsewhere in the Nome and Solomon quadrangles, earlier workers noted the tendency for copper minerals to occur at the contact between heavy-bedded limestone and the underlying schist; Smith (1910, p. 141) discussed several of these in which replacement quartz with traces of copper sulfides lies at the base of limestone now known to be thrust.

Sharply defined vein deposits characterized by antimony-bearing minerals are widespread in the Nome area (Smith, 1909, p. 28); one of the largest is in Rocky Mountain Creek, Solomon D-6 quadrangle (not included in this report), where a strong vein with up to 6 feet of solid sulfides can be traced about 3,000 feet (Sainsbury, 1953, personal observation). Similar veins, but smaller and less continuous, are exposed at many places, a typical one being on the northwest bank of the Pilgrim River just south of the edge of the Bendeleben D-6 quadrangle. Many of these veins carry considerable silver and gold; their development has not been attempted because of the high antimony content. Most of these antimony-bearing veins are relatively young, possibly of Tertiary age.

Cinnabar is present in concentrates from many of the placer gold concentrates in the Seward Peninsula. Cinnabar nuggets as much as 1 inch in diameter have been observed in placer concentrates in the Teller A-3 quadrangle, leading to the hope that lode deposits may be found. As mercury and gold often are associated geochemically, the widespread occurrence of the two metals in the Seward Peninsula is not uncommon. As pointed out in a detailed report on an area around Serpentine Hot Spring, Bendeleben D-6 quadrangle (included in this report) an increase in mercury content is characteristic of bedrock samples containing trace to large amounts of lead, zinc, silver, copper, antimony, gold, arsenic and tin (Sainsbury, Hudson, Kachadoorian and Richards, in press).

This brief summary of the types of lode deposits in central and western Seward Peninsula is not complete--detailed information is available in the

reports listed in the references. However, it is important to realize that diverse types of mineral deposits, of probably diverse ages, are known on the Seward Peninsula. Moreover, many of the richer gold placers, including rich placers in the Nome area, and all the tin placers can be spatially correlated with lode deposits such as discussed herein.

INDIVIDUAL GEOLOGIC QUADRANGLE MAPS

The short text that follows gives the salient geologic relations and rock units of each individual quadrangle, and briefly describes the economic geology. It should be borne in mind that the extensive tundra cover effectively obscures much of the bedrock geology. Mapped margins of the tundra are rather arbitrary, but down slope from the mapped contact, bedrock is almost completely mantled by an unbroken mat of vegetation.

TELLER A-1

General Geology

Except for the Kigluaik Mountains, most of the bedrock of the Teller A-1 quadrangle is covered by tundra, silt, glacial moraine and numerous thaw lakes. The silts mainly represent flood-plain deposits of the Kuzitrin and Kruzgamepa Rivers. The moraines, related to Wisconsinan glaciation, lie along the north front of the mountains, and for the most part are bounded on the south by the Kigluaik fault, which is still active and extends across the entire quadrangle.

Layered bedrock units in the Kigluaik Mountains consist of Precambrian rocks older than the Nome Group. These rocks belong to the Kigluaik Group of Moffit (1913, p. 20), Collier (1908, p. 56), and Brooks, Richardson and Collier (1901, p. 27). Several units have been differentiated but, owing to incomplete mapping in the central part of the quadrangle, they are not everywhere delineated on the geologic maps. The oldest rocks are plagioclase-quartz-biotite-hornblende paragneisses (p€gnl) with interbedded calc-silicate rocks; these rocks underlie the dense crystalline marble or limestone (p€m) that forms much of the bedrock in the central Kigluaik Mountains. An upper paragneiss unit (p€gnu) has been dated by the whole-rock rubidium-strontium method as 750,000,000 years (Carl Hedge, oral communication, 1969). This date probably represents the age of the metamorphism rather than the absolute age. Thick biotite-garnet schist (p€b) with a unit of calcareous interbeds (p€bm) lies above the upper gneiss. Marys Mountain, a low hill rising from the silt flats of the Kuzitrin and Kruzgamepa Rivers, consists of similar metamorphic rocks cut by numerous dikes of granite.

Fine-grained biotite granite of probable Cretaceous age forms numerous stocks in the western part of the Kigluaik Mountains, as well as large numbers of sills and dikes (not mapped) in the biotite schist to the east. Granitic orthogneiss is included in the granite locally.

Ore Deposits

No lode or placer deposits in the Teller A-1 quadrangle have been mined and no large anomalies in mineralized rock were detected by sampling. No stream sediment or panned concentrate samples were collected.

Numerous altered zones along faults, near granite contacts, and associated with calc-silicate bands are plainly visible. A few samples of such altered rocks contained anomalous amounts of metals, as listed in table 1. The calc-silicate and tactite zones have not been sampled in detail, and scheelite could be more common than indicated. In many samples of rocks, ubiquitous graphite appears as small gray metallic-appearing flakes resembling sulfides, but analyses of such rocks consistently are disappointing.

A system of faults striking about N-S is well developed in the Teller A-1 (and A-2) quadrangles; these faults are late and commonly are cemented by chalcedonic silica and white quartz, with pyrite locally abundant. Several

samples of one such fault zone in the valley west of the lake at altitude 1,340 feet contained anomalous amounts of silver, arsenic, molybdenum, antimony and mercury, but less than .02 ppm of gold.

TELLER A-2

General Geology

Much of the Teller A-2 quadrangle is covered by tundra, water and unconsolidated deposits of glacial moraine, outwash, or stream-deposited silt and sands. Bedrock is exposed on ridgetops in the northwest, and in the Kigluaik Mountains that continue westward from Teller A-1. Schists and metamorphic rocks of the Kigluaik Group are exposed continuously in the Kigluaik Mountains south of the Kigluaik Fault. Several metamorphic units are differentiated: the oldest consists of interbedded gneisses, schists, and calc-silicate rocks (p€mu), injected by gneissic fine-grained granitic gneiss (Kgn). It is overlain by a sequence of marbles and calc-silicate rocks (p€bm), intercalated with thick biotite-garnet schist (p€b) against the Kigluaik Fault. A small stock of fine-grained biotite granite (Kgf) intrudes the marble unit and has created tactite lenses with bits of scheelite locally. Exposures in the northwest and along Tuksuk Channel consist of the chloritic schists and schistose marbles of the Nome Group.

Unconsolidated deposits consist of large moraines of Wisconsinan age along the entire front of the Kigluaik Mountains and an apron of outwash deposits beyond. The moraines are cut and displaced by the Kigluaik Fault. Between the outwash fans and Imuruk Basin, collapsed banks of thaw lakes show tawny-colored stratified sand with silt lenses (Qss), overlain by loess and tundra. The lowlands in the north and east part of the quadrangle consist of organic-bearing silts with massive ice lenses exceeding 50 feet in thickness and several hundred feet long. The ice lenses have formed the overlying silt into domes, creating a strange hummocky topography suggestive of old moraine. Thawing of the ice lenses, which also occur in the stratified sand-silt deposits south of Imuruk Basin, has created numerous thaw lakes. Imuruk Basin is expanding to the south by coelescense of such thaw lakes. Exposures along Tuksuk Channel show gravels of local origin overlain by well-washed, stratified gravels lithologically similar to the Kougarok Gravels described in the Bendeleben B-6 quadrangle. A well-preserved terrace cut on bedrock at an elevation of about 18 feet on the northeast side of the peninsula in the northwest part of Imuruk Basin is covered by shell-bearing gravels of foreign lithology. The terrace is believed to represent a remnant of the Sangamon terrace, which is extensive west of Grantley Harbor in Teller B-3 (Sainsbury, 1967).

Ore Deposits

Small amounts of graphite is the only mineral commodity that has been mined in the Teller A-2 quadrangle. No large anomalies were detected by sampling; analyses of samples of bedrock and stream sediments or concentrates that contained anomalous amounts of metals are listed in table 1.

The graphite was mined just south of the Kigluaik Fault on an unnamed tributary of Glacier Canyon Creek in the east part of the quadrangle. It occurs as massive lenses several inches in thickness, and as disseminated blebs and flecks in intensely altered rocks near the fault. A mineral spring issues from rocks just upslope from the adit, and is coating the stream gravels bluish-white. A stream sediment sample below the fault contains anomalous gold and zinc, which, in conjunction with the altered aspect of the rocks nearby, suggests that the area is hydrothermally altered.

Numerous silicified zones and quartz veins along faults, well exposed on the northwest shorelines of Imuruk Basin, were sampled and analyzed for gold; none contained gold in amounts as much as .02 parts per million. However, fine flakes of gold can be panned from beach gravels near these fault zones. Garnet in extensive red garnetiferous sands west of Windy Cove was derived

from garnet schists of the Kigluaik Mountains and, in marked contrast to the garnet-bearing beach sands of the Nome area (Moffit, 1913), contain practically no gold.

A sample of tactite developed near a small plug of biotite granite near Oro Grande Creek in the extreme southeast corner of the quadrangle contained trace amounts of tungsten and zinc; panned concentrates from the soil contained trace amounts of antimony and zinc.

The mineral potential of the Teller A-2 quadrangle does not appear encouraging; best lode possibilities are probably for scheelite-bearing tactite, such as near the granite that intrudes the marble unit in the Kigluaiks. Gold does not seem to be abundant in beach sands or outwash gravels.

TELLER A-3

General Geology

The quadrangle is extensively mantled by tundra. A large glacial moraine of Wisconsinan age (Qm) covers the southeast part. Bedrock, exposed along the ridges and streams, is generally younger than in the A-1 and A-2 quadrangles.

Bedrock units consist of chloritic schists and marble schists of the Nome Group (p€cl), graphitic "Slates of the York Region" (pOs), the thin-bedded argillaceous and dolomitic limestones of the pre-Ordovician unit (pOl), and altered mafic intrusives (pOg). Where numerous gabbroic rocks have intruded the graphitic slates, iron and magnesium added in variable amounts to the slates has developed abundant chlorite, and given the slates a green color. At places, the green coloration is so marked that the contact between chloritic slates and altered mafic rock is difficult to ascertain. These highly chloritic slates are differentiated on the geologic map (pOsg).

Structural relations are complex and have not been worked out in detail because of the extensive tundra cover (Qc) and the reconnaissance nature of the mapping. The argillaceous and dolomitic limestones are in fault contact with the "Slates of the York Region"; the Nome Group chloritic schists and limestone are in part in fault contact with the slates also, but locally appear transitional with them.

Ore Deposits

For more than 50 years, placer gold has been mined by small-scale methods and by dredges in several streams in the Teller A-3 quadrangle. Dredges operated on Gold Run south of its confluence with the Bluestone River, and on Dese Creek, which flows into Grantley Harbor. Small-scale mining utilizing sluice boxes and bulldozer has been done principally on the Right Fork of the Bluestone River, and on Coyote and Dese Creeks and is now in progress on Eagle Creek, the southwest headwaters of the Right Fork of the Bluestone River.

Many concentrates from dredges and placer gold mines contain cinnabar, cassiterite or platinum-group metals, as well as numerous other metals. Cinnabar is widespread, and platinum-group metals are relatively common in concentrates from Gold Run. Nuggets of cinnabar as much as an inch in diameter are found locally, leading to the inference that there are lodes of cinnabar.

Geochemical Survey

A stream sediment survey was completed in 1967 utilizing the -80 mesh fraction of total stream sediment. All samples were analyzed for mercury, copper, lead, zinc, and nickel; other elements were determined by semiquantitative spectrographic analyses. The location of all sediment samples is plotted on the quadrangle map; samples containing anomalous mercury or other metals are circled and are listed in table 2.

As expected because of the widespread occurrence of cinnabar in placer concentrates, numerous stream sediments contained anomalous mercury. A few contained other metals, principally arsenic, copper, lead, zinc, gold, and tin. Because mercury and gold often are associated geochemically, mercury may be useful in suggesting areas of undiscovered placer and lode gold. However, as

native mercury is used in all placer gold camps as an amalgamating agent for fine gold, the analytical results for mercury should be treated with caution.

Nevertheless, certain facts should be noted: 1) All samples on Dese Creek up to the hot spring deposits just above Soda Creek contain anomalous mercury. Although the abandoned dredge sits just above the hot springs, mercury-bearing stream sediments continue upstream from the dredge. Samples of spongy limonitic deposits and sinter from the hot springs contain anomalous mercury, silver and gold. 2) The entire Bluestone River, its Right Fork, and that portion of Gold Run flowing northerly, contain anomalous mercury. That the mercury is not entirely related to mercury loss from amalgamating plants is shown by the continuation of anomalous contents of mercury upstream from mining operations on Gold Run and Alder Creek and in unmined tributaries such as Ring Creek. 3) Placer operations on Eagle Creek, by Bon V. Davis, have recovered pebbles of cinnabar, which accounts for the mercury in sediments of that stream. Dredge concentrates from Gold Run and Dese Creek also contain cinnabar, showing that natural sources of mercury exist there. 4) Many of the mercury anomalies seem correlative with faults, or with linears assumed to be faults, suggesting that the faults may be mineralized.

TELLER B-1

General Geology

The southern half of the quadrangle, like the adjoining part of the A-1 quadrangle to the south, is essentially covered by silt and tundra; frost-broken bedrock is exposed only on the tops of the highest hills. Less extensive tundra cover in the north exposes bedrock geology that is characterized by extreme complexity of thrust faulting, and by increasing metamorphism of the rocks in the thrust plates going east.

Imbricate thrust sheets involve chloritic schists of the Nome Group (p€cl), graphitic "Slates of the York Region" (pOs), pre-Ordovician thin-bedded argillaceous dolomitic limestone (pOl), and numerous thrust slices of carbonate rocks of diverse appearance (Pzl). East of a line running N-S near the center of the quadrangle, all the carbonate rocks begin to show marked recrystallization, development of a sugary texture, and loss of original colors. The limestones in the western half probably will be subdivided and found to be fossiliferous with additional mapping; those in the east half probably will not because of metamorphism.

The thrust plates are cut by a strong system of faults trending about N. 15° E., a second strong set trending E-W, and a third strong set trending about N. 20° W.; the resulting distribution of rocks in the north-central part of the quadrangle is chaotic. In the northeast part of the quadrangle, which was mapped in more detail than the rest, large thrust plates of marble "bury" the structure in the underlying Nome Group rocks, which strike northwesterly under the thrust plates.

South of the inferred Kaviruk fault, outcrops consist mostly of chloritic schists of the Nome Group. This fault continues into the Bendeleben B-6 quadrangle, where it separates major rock units.

The Nome Group on the long ridge along the border in the northeast are largely converted to garnet-glaucophane rocks of the blueschist facies.

Ore Deposits

No productive lode or placer deposits are known in the Teller B-1 quadrangle. At many places, the limestone along thrust faults is altered; at some places, it is silicified and faintly pyritized. Most striking of the altered areas are the small blocks of red-stained carbonate along Coco Creek, in the northeast corner of the quadrangle. These, as well as the carbonates in the large thrust plate west of the creek, are replaced irregularly by sideritic

carbonate containing numerous small quartz veinlets. Samples of the eastern blocks contained trace amounts of gold (table 1) (samples ACB 332, 334), as did samples of altered limestone with quartz veinlets at the base of the thrust block between Hunter and Johnston Creeks (ACB 427). Spectrographic analyses of these samples are not yet available.

TELLER B-2

General Geology

Most of the bedrock of the Teller B-2 quadrangle is covered by tundra and silt. Bedrock exposures are limited to hilltops, and even here it is reduced by frost action to a broken mass of disoriented fragments. Except for a small fault block of metamorphosed Paleozoic marbles (Pzm) in the extreme northeast corner, only chloritic schists and intercalated schistose marble of the Nome Group are exposed. Numerous schistose marbles are intercalated in the chloritic schists; these usually give rise to hilltops bare of tundra. Locally, as in the west-central and east-central parts of the quadrangle, the marbles exceed a hundred feet in thickness; many contain impure calcite-chlorite schists.

An extensive silt blanket mantles the slopes up to an altitude of about 250 feet; numerous thaw lakes are developed in the silt areas. Alluvium along the larger streams consists of gravel. A small thermal spring on Black Crook Creek, a tributary of Igloo Creek near the eastern boundary of the quadrangle, has associated with it a small area of gravels cemented by hydrous iron oxide.

Ore Deposits

No productive lode or placer deposits are known in the Teller B-2 quadrangle. At a few places, fine-grained silica has replaced schistose marble at the contacts with chloritic schist or along crosscutting faults, giving rise to stained quartz veins. A few of these were sampled. None contained detectable gold but samples of banded quartz cutting limestone on the hill between the

Agiapuk River and Igloo Creek contained anomalous amounts of copper, lead and zinc (table 1). The veins are too small to be of economic interest, although erosion of such veins might produce small placer gold deposits. Present knowledge indicates that the Teller B-2 quadrangle is but poorly mineralized.

TELLER B-3

General Geology

Bedrock is exposed in about half the quadrangle and surficial deposits and water cover the remainder.

Bedrock consists of chloritic schists of the Nome Group (p€cl), graphitic "Slates of the York Region" (pOs), altered mafic intrusives of pre-Ordovician age (pOg), intensely deformed thin-bedded dolomitic and argillaceous limestones of pre-Ordovician age (pOl), Ordovician and Silurian carbonates (SOdl), undifferentiated Paleozoic rocks (Pzm), and extensive fields of Pleistocene lava (Qtl). A small segment of a thrust plate of Middle and Upper Ordovician limestones, largely dolomitized and with abundant silicified tabulate corals, lies on the northwest boundary of the quadrangle (Omu). All the older rocks are believed to be in thrust fault contact. The pre-Ordovician limestones are intensely deformed. The lavas unconformably overlie the older bedrock units as well as unconsolidated gravels in the valley of the Agiapuk River. Mukacharni and Eva Mountains, as well as a small hill to the north, are eroded volcanic necks of lava breccia.

Unconsolidated deposits consist of the beach and terrace deposits of Sangamon age (Qsb), of terrace deposits (Qt), of a thick silt blanket (Qs) along the Agiapuk River in the eastern part, of modern alluvium, and of extensive tundra on all but the limestones, which are bare or have thin tundra cover.

Ore Deposits

Placer gold has been mined in Sunset and McKinley Creeks, flowing south to Grantley Harbor, and in Allene Creek and a small unnamed stream east of Sunrise Creek, flowing north into the Agiapuk River. Fine flakes of gold can be panned from beach gravels along Grantley Harbor, generally where white quartz boulders become common.

Altered quartz-bearing fault zones, or banded quartz veins, occur at several places in the quadrangle. No lodes have been mined, although numerous prospect pits have been dug on altered zones and quartz veins, especially those veins cutting the schistose limestone (p€ls) northwest of Saturday Creek in the east-central part of the quadrangle. Highly anomalous amounts of mercury and gold occur in altered slates beneath the thrust in the extreme northeast part of the quadrangle, and may reflect escapement of mercury along the thrust from Pleistocene volcanic centers to the south. Bedrock samples with anomalous metals are shown on the quadrangle map and listed in table 1.

Owing to the general dearth of good placer deposits, stream sediments in the quadrangle were not sampled systematically.

TELLER C-1

General Geology

The low-lying areas are mantled by tundra; the higher areas are relatively free of cover, especially those underlain by carbonate rocks. Bedrock geology, like in the Teller B-1, is characterized by extreme complexity of thrust faulting.

Imbricate thrust sheets involve chloritic schists of the Nome Group (p€cl), which are moderately to intensely silicified, and thick sections of carbonate rocks of Paleozoic age. In general, the carbonate is exposed in the higher areas and the silicified chloritic schists in the lower. In the incompletely mapped west and southwest part of the quadrangle, the carbonate rocks are but moderately recrystallized. Locally, as in the west headwaters of the north fork of Budd Creek, the limestones are dolomitized but may still be assigned to units originally defined in the York Mountains, some 70 miles west.

The thrust sheets are strongly folded and locally may be recumbent, as suggested by the carbonate rocks on the east side of Kougarok Mountain. Although reconnaissance mapping has not delineated all the thrusts, there is no question but that imbricate sheets of chloritic schists are interleaved with carbonate rocks locally (headwaters of the north fork of Budd Creek). The thrust sheets are cut by strong faults of a system striking about N. 10°-20° E., continuous with the set described in the Teller B-1 quadrangle.

The east front of the limestone terrane is marked by thrusts; eastward, much of the country is tundra-covered, and relations cannot be adequately determined. A steeply dipping and continuous belt of dark-gray, sheared marble within the Nome Group is distinctive, and has been separated on this quadrangle map (p€ld). In the northeast part of the quadrangle, this dark carbonate merges with other carbonate rocks, some of which are micaceous, that may be part of a unit of tectonic origin similar to the one in the Bendeleben C-6 and B-6 quadrangles.

As in the Teller B-1 quadrangle, the degree of recrystallization of the carbonate rocks increases from faint on the west border to complete on the east. Limestones in the west locally are fossiliferous and probably can be subdivided; those on the east are too crystalline for subdivision.

Probably the most distinctive feature of the quadrangle is the widespread silicification of carbonate rocks and schists along zones. Many of these silicified zones may be mineralized.

Ore Deposits

Copper prospects and the possibilities of gold placers exist in the quadrangle.

A small amount of copper has been shipped from the Ward Mountain prospects in a klippe of carbonate rocks at the extreme north-central part of the quadrangle. The carbonate rocks are extensively silicified along the thrust and along small fractures in the overlying carbonates. Chalcopyrite, and minor amounts of other copper sulfides, are disseminated along faint laminae in the silicified carbonate and are concentrated in joints. Malachite and azurite give bright hues to hand-sorted piles of ore. However, both the silicification and the copper minerals are highly erratic and no continuous orebody is apparent.

At two places on the east front of the carbonate hills at the head of Henry Creek, large masses of contorted carbonate above thrust faults have been completely replaced by silica. The southern one has been prospected by two small adits. The adits expose minute amounts of copper sulfides almost entirely restricted to strong vertical joints. Although the silicified areas are several hundred yards long, copper stains are restricted to the southerly one—even here the copper content of minable tonnages probably does not exceed 0.1 percent. Only traces of gold occur in even the richer specimens.

Elsewhere in the quadrangle, especially in the drainages of Budd Creek, silicified areas of schist and limestone altered rocks along faults contain anomalous amounts of metals, especially mercury and arsenic (table 1). Cinnabar nuggets occur in placer concentrates from Windy Creek, suggesting that here as elsewhere on the Seward Peninsula, gold and mercury are genetically related. It is entirely possible that undiscovered gold placers may be found in streams draining the area of silicified rocks.

No geochemical reconnaissance was made of the quadrangle owing to termination of the field season.

BENDELEBEN A-6

General Geology

Except for the Kigluaik Mountains in the southwest, the Bendeleben A-6 quadrangle is an area of subdued hills, tundra-covered slopes, and lake-dotted lowlands. Exposed rocks are similar to those in the Teller A-1 quadrangle adjoining on the west.

Bedrock consists mainly of metamorphic rocks of the Kigluaik Series intruded by numerous stocks of biotite granite, quartz-monzonite(?), and coarse-grained pegmatite. Chloritic schists of the Nome Group crop out over a few square miles between the east end of the Kigluaik Mountains and the Pilgrim River. Graphitic "Slates of the York Region" occur on the east end of the mountains and in the northwest part of the quadrangle.

The igneous rocks are more diverse than to the west. Most notable is the occurrence of numerous stocks of gneissic biotite granite. Coarse-grained pegmatites, often displaying boudinaged borders and cataclastic texture, are larger and possibly more common than in the adjoining Teller A-1 quadrangle. These pegmatites seem more numerous near the gneissic granites; neither granites nor pegmatites intrude the "Slates of the York Region" or the Nome Group, leading to the possibility that they are of Precambrian age. None of the pegmatites examined contain discernible rare minerals or beryl, although black tourmaline is common.

Extensive lake-covered lowlands along the Pilgrim (Kruzgamepa) and Kuzitrin Rivers consist principally of silt and, south of the Pilgrim River, glacial outwash and moraine. Of special note is a well-marked terrace along the south side of Hen and Chickens Mountain; exposures through disrupted tundra show this terrace to consist of well-washed sand.

Ore Deposits

No productive lode or placer deposits of note are known in the Bendeleben A-6 quadrangle. However, numerous granitic rocks, large and continuous alteration zones along faults, and heavily stained bands of metamorphic rocks give hope that lode deposits may exist. Many such altered zones were sampled, generally by collection of about 10 or 20 pounds of chips of stained or altered rocks. A few stream sediments, and panned concentrates, were collected downstream from some altered areas, especially in the eastern part of the Kigluaik Mountains. None of the samples of bedrock contained commercial amounts of minerals, yet most contained anomalous molybdenum and zinc, and some contained, in addition, one or more of the following: copper, lead, arsenic, gold, antimony, tin, tungsten, beryllium and bismuth (table 1).

The widespread occurrence of trace amounts of molybdenum in bedrock and relatively strong anomalies in stream sediment samples, most of which contained anomalous gold, molybdenum, copper and zinc, is especially noteworthy. Nowhere else in the several quadrangles here discussed was such a consistent molybdenum anomaly found. The geochemical anomalies may be related either to mineralization along the numerous faults, or to the gneiss unit (p€gn) which probably includes unmapped orthogneisses or gneissic granitic rocks.

The Bendeleben A-6 quadrangle also contains, in the northeasternmost corner, the westernmost of a series of altered dikes (Tka) generally trending easterly. These altered dikes are largely replaced by adularia, and contain anomalous amounts of lead, silver, zinc and tin. In the adjoining Bendeleben A-5 quadrangle, not included in this report, silver-bearing galena is developed where these dikes cut marble beds.

BENDELEBEN B-6

General Geology

Tundra covers a large part of the Bendeleben B-6 quadrangle also. The Kougarok River flows south through a broad swampy lowland in the southeast.

Exposed bedrock consists of the Nome Group, graphitic "Slates of the York Region," and a carbonate unit that includes partly recrystallized dark limestone. The contacts between most units are probably thrust faults, as clearly shown by the crosscutting relation of the chloritic schists with respect to limestones in the northwest part of the quadrangle. The chloritic schists not uncommonly are glaucophane-bearing; the massive garnet-glaucophane rocks could represent metagabbros, for locally they are clearly intrusive into nonchloritic rocks. Both the graphitic slates and chloritic schists locally are intensely deformed, sheared, and contain abundant highly contorted quartz veinlets, especially in areas where poorly exposed limestones disappear abruptly, suggesting proximity to large faults or thrust faults.

A widespread calcareous schist (BCls) within the Nome Group may be a tectonic unit in part. It includes dark limestones and marble schists as well as yellowish-orange weathering micaceous schists with ground-up quartz veinlets and could represent a mashed-up zone along a major thrust fault; moreover, certain other zones which appear transitional between graphitic schist and chloritic schist could represent zones of tectonic mixing of the two distinct rock types.

A small expanse of altered limestone, originally medium- to thick-bedded and dark-gray in color, in Henry Creek, a tributary of Garfield Creek in the northeast part of the quadrangle, dips beneath intensely sheared and altered slaty rocks on the south; it is interpreted as a window in a thrust sheet.

Surficial gravels of two distinct ages, both of economic importance, cover large areas of the lower country in the eastern part of the quadrangle. The

older, high-level gravel was called the Kougarok Gravel of Pliocene to Pleistocene age by Hopkins (1963). In 1967, Sainsbury, then Sainsbury and Kachadoorian in company with Hopkins, revisited many of the type outcrops of the Kougarok Gravel. Considerably more work in 1967 and 1968 by Sainsbury and Kachadoorian cast serious doubts on the stated extent, age and thickness of these gravels. They are now believed to be principally of Pleistocene age, based upon the widespread occurrence of fossil ice-wedge casts scattered throughout the gravels where best exposed in gravel pits at Brakes Bottom and Kougarok landing strip (Bendeleben B-6 quadrangle). At these localities, the Kougarok Gravels consist of shingled subrounded gravel with occasional cobbles or boulders up to 2 feet in diameter; quartz makes up 50 percent of the gravels and chloritic schists and graphitic slate much of the remainder. Lenses of sand and organic matter, with wood (C^{14} date is >35,000 years) are common throughout the gravel. The gravels extend up the Kougarok River as far as Neva Creek, where layers of chloritic schist boulders and angular garnet-glaucophane rock are commonly interbedded with stream-laid sands rich in red garnet.

The Kougarok River has trenched the Kougarok Gravels on the east, leaving a sloping gravel face almost a hundred feet high. On the west, the gravels are largely covered by tundra, but exposures in the placer mines in Quartz, Dahl and Atlas Creeks show that here the gravels thin to a few feet, and are overlain by thick silt which represents old loess. Fragments of lignite and carbonized wood in the Kougarok Gravels are believed by Sainsbury to come from coal-bearing Tertiary rocks that were exposed to stream action during deposition of the gravels, probably in pingo-like mounds such as are now seen in the Noxapaga River drainage, a few miles east of the Kougarok River.

Younger gravels along streams consist of both reworked Kougarok Gravel and stream sorted slope wash and alluvium related to the present drainage.

Ore Deposits

Placer gold is widespread in the Bendeleben B-6 quadrangle, especially in the drainage of the Kougarok River, but no lodes are known to have been mined. Placers in Dahl and Coffee Creeks have produced since about 1901 (Collier, et. al., 1908, p. 307); Dahl Creek is producing currently. The placers are described by Brooks (Collier, et. al., 1908, p. 294-336); extensive mining after World War II largely coincided with the earlier. No doubt many old channels lie buried beneath the Kougarok Gravels, but finding them will require expensive geophysical methods. In 1967, Thomas E. Smith of the Geological Survey made a seismic reflection profile along the line A-A' on the map, to test for an old channel of the Kougarok River. The single line shows a bedrock low along the projected N-S continuation of the Kougarok River; this possible old channel has not been tested by drill holes.

A preliminary evaluation of the gold content of the Kougarok Gravel was made in 1967 by panning of bulk samples taken perpendicular to the bedding across extensive faces of gravel at Brakes Bottom and east of Kougarok landing strip, as well as by panning gravels elsewhere. Concentrates were weighed and analyzed, and values computed back to original yardage. Although the detailed results are not presented here, they suggest that the Kougarok Gravel contains particulate gold in the range \$.05-\$.15 per yard, generally in fine colors. However, pannings of stream beds in small streams trenching the Kougarok Gravel contain gold in flakes to over 1/16 inch, and in greater amount than unreworked gravel, showing that a secondary concentration of gold occurs. As the extensive gravels on the west side of the Kougarok River between the mouth of Quartz Creek and the Kougarok airstrip are reworked gravels derived from the Kougarok Gravels, these extensive gravels may contain gold in commercial amounts. Ownership of these gravels is unknown, but old pits suggest claims may cover all or part of the gravels.

No lode mines are known in the Bendeleben B-6 quadrangle, but coarse gold intergrown with vein quartz is obtained from Dahl Creek and Wonder Gulch off Coffee Creek. Extensive areas of sericitized and bleached slate in Dahl Creek suggest acid alteration related either to hydrothermal water or to acid waters derived from oxidizing pyrite. Houston Alexander, a long-time miner on Dahl Creek states (oral communication, 1967) that an attempt was made at one time to mine an auriferous quartz ledge at the head of Wonder Gulch. No evidence of this old mine remains, but the creek is filled with iron-stained quartz boulders, which suggests a lode does exist. The old shaft at Dahl Creek, reported by Brooks (in Collier, et. al., 1908, p. 312) and restated by Hopkins (1967, p. C-30) as penetrating almost 200 feet of Kougarok Gravel, was not sunk in gravel but in a highly sericitized, clay-rich altered zone containing ground-up and angular vein quartz. Similar altered bedrock forms the main gold-bearing "false bedrock" throughout much of Dahl Creek. The widespread alteration, abundance of gold, and the angularity of gold and quartz, suggest that the zone of mineralized bedrock in Coffee Creek mentioned by Brooks (in Collier, et. al., 1908, p. 313) does exist and may warrant a serious evaluation.

The placer gold in Garfield Creek, in the extreme northeast end of the quadrangle, is associated with an intensely mashed and veined area of slaty rocks which are believed to mark nearness to a thrust fault. Placers on Crooked Creek, near Anderson Gulch, are associated with altered graphitic slate veined with abundant carbonate and quartz, and are near a known fault. The evidence from the entire quadrangle suggests that the gold in placers is near its original source in mineralized structures in bedrock.

BENDELEBEN C-6

General Geology

The Bendeleben C-6 quadrangle consists of generally rounded hills through which the Kougarok River flows. The lower slopes and valleys are mantled by tundra.

Bedrock units are similar to those in the B-6 quadrangle; in addition, an extensive thrust plate of metamorphosed carbonate rocks (Pzm) is preserved, as are small klippen of carbonate rocks elsewhere. The relations between the glaucophane-bearing chloritic schists (p€cl) and the graphitic "Slates of the York Region" is more complex than shown on the map, and probably involves imbricate thrust sheets. The graphitic unit contains interbeds of dark limestone which can be traced for several miles, and on the whole is more calcareous than to the south and west. In the northernmost part of the quadrangle, the graphitic rocks become phyllites; gravity data suggests that a ridge of granite underlies this area (oral communication, D. F. Barnes, 1967).

The carbonate rocks of the main mapped thrust plate are mostly recrystallized to sugary-textured marbles, but some of the original color differences between them remain. Relations are found which are similar to those near thrusts in unmetamorphosed carbonate rocks in the York Mountains, 70 miles west, as, for instance, extensive dolomitization along and above thrusts. Fossils of possible Devonian age were obtained from the upper klippe on Harris Dome; elsewhere the carbonates are similar in gross bedding and color characteristics to the Early Ordovician rocks of the York Mountains, but are moderately recrystallized. All are included in the map unit Pzm. Locally a calcareous schist underlies thrust plates of carbonate rocks, as well as other map units; it possibly is of tectonic origin.

Most of the lower hillslopes are covered completely by tundra that covers silt of variable thickness, completely masking bedrock. Meander cuts along

most streams disclose bedrock; the boundary between tundra (Qc) and bedrock is approximate only.

Ore Deposits

No lode deposits in the Bendeleben C-6 quadrangle have produced commercially, but productive placer gold deposits are widespread. Much of the Kougarok River above North Fork has been dredged or mined by dragline, as well as numerous small benches of the Kougarok River. A large area at the confluence of Taylor Creek with the Kougarok River was dredged after World War II; the dredge is maintained for future use (Harold Tweet, oral communication, 1967). Mining has been practically continuous along the Kougarok River upstream from Taylor Creek, and continuing up Macklin Creek and Washington Creek for several miles; the only active placer mine in 1967-68 was that of the Tweet brothers on Washington Creek on benches about 1 mile above the confluence of Macklin and Washington Creeks. A dredge also mined gravels on Harris Creek, a tributary of North Fork, in the thrust plate of carbonate rocks.

Most of the main placer gold deposits can be correlated spatially with altered fault zones, both of thrusts and high-angle faults. Such altered zones contain crushed quartz veinlets or fine-grained silica with pyrite. Dredge concentrates yield unweathered fragments of galena, pyrite, and a gray, silver-rich sulfide (ACB-279, table 1) as well as nuggets of gold cementing fractured quartz. Exposures of bedrock in dragline cuts west of the dredge in the Kougarok River just south of Taylor Creek disclose numerous hydrothermally altered zones in the graphitic rocks which contain fractured quartz veinlets as well as abundant pyrite. Samples of altered rocks contain anomalous mercury and arsenic, and pyrite concentrate contains detectable gold and numerous other metals (AHI 175, 177, table 1). Cassiterite occurs in the dredge concentrates from this area (ACB-282, table 1).

Banded fine-grained silica containing pyrite and traces of chalcopyrite locally has replaced carbonate rocks above thrusts; such replaced limestone is well exposed at the base of the two small klippen near the road in the central part of the quadrangle. Prospectors have made pits on many such replaced carbonates, but none were extensively explored.

BENDELEBEN D-5

General Geology

The bedrock geology of the westernmost part of the D-5 quadrangle, west of a strong N-S fault, is similar to that of the adjoining D-6 quadrangle, for it contains the east end of a biotite granite stock intruded into the graphitic "Slates of the York Region" (pOs). Both slate and granite are cut by faults which are especially numerous south of the granite. East of the strong N-S fault, imbricate thrust plates have juxtaposed marbles of Paleozoic age with micaceous calcite schists (pOlm), "Slates of the York Region" and chloritic schists of the Nome Group (p€cl). Limited exposures, and the reconnaissance nature of mapping, are not sufficient to delineate the relations of a dark limestone with interbedded slate that forms a belt several miles wide trending northeasterly across the quadrangle. This unit is shown as undifferentiated limestones of Paleozoic age (Pzmu), but it may prove to be a heretofore unrecognized series of rocks transitional above the graphitic slates. More detailed mapping is planned in 1969 to resolve the relations of this limestone to adjoining units.

The extent and complexity of thrusting is proved by the small window and klippe of intensely altered marbles (Pzm) in a wide expanse of limonitic-weathering micaceous marbles (pOlm) in the southeastern part of the quadrangle.

The southern part of the valley of the Goodhope River was filled by a lava flow of Quaternary or Tertiary age (QTl); the river subsequently has retrenched into the lava which is exposed at scattered localities along the valley. The lowlands in the north part of the quadrangle are completely mantled by tundra, as are most of the slopes to the south, but it is probably underlain by silt.

Ore Deposits

Placer gold has been mined along Humboldt Creek, which heads against the highly faulted area south of the granite. Large nuggets of cassiterite are recovered in placer concentrate (Sainsbury, Kachadoorian, Smith and Todd, 1968) on Humboldt Creek. The faulted area, as well as thrust faults east of Humboldt Creek, is extensively altered and veined with quartz. Detailed information on the area will be presented elsewhere (Sainsbury, Hudson, Kachadoorian and Richards, in publication), and only the more important conclusions are presented here.

The most favorable area for mineral deposits is in the southeast headwaters of Humboldt Creek, where numerous samples contain highly anomalous amounts of metal, and where float galena along an altered fault zone contains up to 5,000 ppm of silver, as well as highly anomalous amounts of gold, mercury, arsenic, copper, molybdenum, antimony, tin and zinc (samples AHI 453, 245 on map and in table 1). Of added interest are the mineralized fault zones and thrust faults east of Humboldt Creek. A highly oxidized fault zone on the Goodhope River yielded samples containing anomalous amounts of metal (AHI 133).

Geochemical Survey

Numerous samples of -80 mesh stream sediments were collected in drainages east of the granite; of these, only three contained anomalous metal (table 2). Stream sediments along and below the placer gold cuts did not indicate anomalous metals, even though large amounts of cassiterite occur with gold in the placers. Detailed work in 1968 (reported in Sainsbury, Hudson, Kachadoorian and Richards, in publication) showed that panned concentrates were much more effective in locating the mineralized areas.

BENDELEBEN D-6

General Geology

The general geology of the Bendeleben D-6 quadrangle is being described in considerable detail elsewhere (Sainsbury, Hudson, Kachadoorian and Richards, in publication), and only the more important features are discussed here. Most of the exposed bedrock is deformed graphitic slate and related rocks (pOs), which are part of a continuous belt along the Kougarok River from the Kuzitrin River, some 45 miles south. The graphitic slate is badly deformed and thrust faulted; near the granite stock intruded into it in the Serpentine Hot Springs area, it is converted to hornfels with abundant tourmaline, or, if calcareous, calc-silicate rocks. In the east part of the quadrangle, the graphitic slate is thrust over itself, and over gneiss of probable Precambrian age (p€gn). Dragfolds in the deformed rocks show horizontal fold axes overturned to the west, which suggests that the thrust sheets moved west in this area.

The biotite granite stock, of Tertiary or Cretaceous age, intrudes the thrust sheets; granite and surrounding rocks are cut by steep faults of several distinct systems (see geologic map).

Ore Deposits

Many of the faults, especially those trending northwesterly and northerly, are hydrothermally altered and veined with quartz. Anomalous amounts of many metals, including gold, silver, copper, lead, zinc, tin, mercury, arsenic, molybdenum, antimony, and tungsten occur in numerous samples of altered rocks along these faults; only a few selected samples are shown on the map. The reader is referred to the more detailed report for sample data for all the bedrock samples, as well as numerous stream sediments, panned concentrates of stream gravels, panned concentrates of bedrock samples, and discussion of radiometric anomalies around the granite.

Of especial interest is an altered area along the fault trending northwest across the headwaters of Kennedy Creek, at the southeast margin of the quadrangle. This altered zone is traceable for more than 2,000 feet, and is marked by abundant float of stained quartz. Bulk chip samples of the altered slate and of float quartz, all contained highly anomalous amounts of metals (table 1).

Placer gold has been mined on several streams in the southwestern part of the quadrangle, the placer on Macklin Creek in the south-central part being the largest and richest. Placers are correlative with a notable increase in quartz or sideritic carbonate in creek gravels or bedrock. No lodes have produced.

Geochemical Survey

Because of the widespread mineralization and placer gold, a reconnaissance geochemical survey was carried out using -40 mesh fraction of total stream sediments. The results, reported in table 2, show that many samples contain anomalous amounts of arsenic and zinc; several contain, in addition, one or more of the following: mercury, tungsten, tin, niobium and silver. Zinc is detected in many samples of stream sediments in the part of the quadrangle where placer gold occurs, suggesting that mineralized bedrock is common. However, the hills in the placer area are completely mantled by tundra over loess that buries bedrock, and the finding of mineralized bedrock in this area would be difficult and expensive.

Radiometric Anomalies

An airborne radiometric survey disclosed numerous anomalies near or in the granite and the gneiss. The anomalies are shown and discussed in the paper mentioned above. The anomaly of greatest magnitude lies along the granite beginning at the small lobe of granite on the south side of the stock near the east margin of the quadrangle and continues into the adjoining Bendeleben D-5 quadrangle. As the granite is known to contain radioactive accessory minerals, the anomaly, which has not been ground-checked, could represent disseminated radioactive accessory minerals.

Table 1.--Metal content, in parts per million, of samples of mineralized bedrock, Seward Peninsula, Alaska

[Abbreviations: S, selected specimen; C, random chip; PC, panned concentrate; (L), detected but below limit of dependable reading. No lode sample analyses listed because of erroneous laboratory treatment of samples. Analysts: K. J. Curry; R. L. Miller; W. R. Vaughn, U.S. Geological Survey.]

Laboratory No.	Type	Description	Anomalous metals and their anomalies 1/
		Teller A-1 quadrangle	
AHI-275	S	Quartz fragments along fault------------	Ag, 3; As, (L); Mo, 15; Sb, (L)
276	C	20 ft thick jasperized limestone along fault----------------------------------	Sb, (L)
277	C	30 ft thick jasperized limestone along fault----------------------------------	Ag, 1.5; Hg, 10
278	C	Altered granite plug near 277-----------	As, (L); Pb, 150
279	C	12 ft thick jasperized limestone along fault, adjoins 276 on east and 277 on west----------------------------------	Sb, (L)
344	C	Stained schist near fault---------------	Zn, (L)
345	C	Calc-silicate band 200 ft fromfault-----	Hg, 0.13, W, (L)
349	C	Altered gneiss and schist---------------	Sn, 50; Zn, 700
523	PC	Of 523A---------------------------------	Au, 2
523A	C	Altered graphitic schist----------------	Mo, 7; Zn, (L)

Laboratory No.	Type	Description	Anomalous metals and their anomalies 1/
		Teller A-2 quadrangle	
AHI-271	C	Calc-silicate band---------------------	Zn, (L)
272	C	Sulfided schist------------------------	Zn, (L)
645	PC	From soil------------------------------	Sb, (L); Zn, (L)
647a	S		High-grade graphite
		Teller B-1 quadrangle 2/	
ACB-332	C	Altered limestone----------------------	Au, 0.04
334	C	Silicified limestone-------------------	Au, 0.6
427	C	Silicified altered limestone-----------	Au, 0.2
		Teller B-2 quadrangle	
ACB-412	C	Silicified limestone-------------------	As, 100; Pb, 300; Zn, 500
413	C	---do----------------------------------	As, 150; Cu, 150; Pb, 150; Zn, 500
		Teller B-3 quadrangle	
ACB-346	C	Crushed silicified slate under thrust--	Au, 0.64; Hg, > 12.5
397	C	Iron-stained float along fault---------	Au, 0.06, Hg, 0.4

Laboratory No.	Type	Description	Anomalous metals and their anomalies 1/
		Teller C-1 quadrangle	
ACB-444	C	Stained quartz along thrust	Hg, 0.18; Zn, 300; Cu, 150
446	S	Copper-stained fragments	Hg, 0.35; Cu, 10,000, Zn, 500; Au, .1
447	C	Silicified limestone	Hg, 0.13; Cu, 700; Zn, (L); Au, .02
452	C	High-grade ore pile	Hg, 1.0; Cu, 7.10 percent; Zn, 7000; Au, .4
453	C	Rusty zone in silicified limestone	Hg, 0.13; Cu, 500; Zn, (L)
454	C	Silicified schist	Hg, 0.13; Cu, 150; Zn, (L)
455	C	Silicified limestone	Hg, 0.25; Zn, 500; As, (L)
480	C	Copper-stained silicified limestone	Au, 0.3; Hg, .35; Cu, 1500; Sn, 100; Zn, 300; As, (L)
AHI-145	C	Silicified schist	As, (L); Hg, 0.45; Zn, (L)
148	C	Iron-stained limestone along fault	As, (L); Hg, 0.10; W, (L)
149	C	Replacement quartz along fault	As, (L); Hg, 0.16; W, (L)
150	C	Silicified slate along fault	As, (200); Hg, 0.35; W, (L); Zn, (L)
151	C	Leached slate along fault	Ag, .7; As, (L); Hg, 0.35; Mo, 20; W, (L); Zn, (L)
152	S	Iron stained nodules, float	As, (L); Hg, 3.5; Co, 150; Pb, 150; W, (L); Zn, (L)
153	C	Oxidized chloritic schist along fault	As, (L); Hg, 2.8; Cu, 100; Zn, (L)
154	C	Stained schist	As, (L); Hg, 2.8; Pb, 150; Zn, (L), Mo, 7

Laboratory No.	Type	Description	Anomalous metals and their anomalies 1/
		Bendeleben A-6 quadrangle	
AHI-273	C	Stained gneiss	Pb, 150; Sn, 15
280	C	Silicified and pyritized gneiss and schist	Mo, 15; Zn, (L)
282	C	Float of altered rocks along fault	Mo, 20
293	C	Iron-stained float from cirque walls	Mo, 10; W, (L)
294	C	-----do	Mo, 20
313	C	Altered schist near fault	W, (L)
320	C	Altered gneiss near fault	Co, 7; Cr, 700; Cu, 300; Mo, 5; Ni, 150
321	C	-----do	Mo, 7; Pb, 300; Sn, 20
322	C	Iron-stained gneiss	Pb, 150
354	C	Stained schist surrounding quartz vein	Cu, 150; Mo, 15; Zn, 300
355	C	Altered graphitic schist	Ag, 2; Mo, 30; Zn, (L)
356	C	Altered granite and contacting schists	Mo, 7; Zn, (L)
358	C	Float of altered granitic rock	Hg, 0.22; Be, 15; Mo, 7; W, (L), Zn, 500
359	S	Float fragments of altered granitic rocks	Hg, 0.12; W, (L)
360	C	Oxidized schist	Be, 20
381	C	Altered granite	As, (L)
382	PC	Concentrate from sample 381	Au, 0.06
391	C	Calc-silicate band in gneiss	W, (L); Zn, (L)
392	C	Copper-stained pegmatite	Au, 0.08; Ag, 1; Bi, 15; Cu, 7000
394	S	Hand specimen of altered schist	Co, 70; Zn, (L)
539	C	Pegmatite dike	Be, 15; Pb, 150; Sn, 30

Laboratory No.	Type	Description	Anomalous metals and their anomalies[1/]
		Bendeleben A-6 quadrangle--continued	
AHI-541	S	Fragments of limonite nodules--------	Cu, 100; Mo, 30; Zn, 500
542	C	Altered graphitic schist------------	Ag, 2; Mo, 30; Zn, (L)
600	C	Stained chloritic schist------------	As, (L); Cu, 300; Sb, (L); Zn, (L)
663	C	Stained slate-----------------------	Mo, (20); Zn, (L)
		Bendeleben B-6 quadrangle (no bedrock samples listed)	
		Bendeleben C-6 quadrangle	
AHI-175	C	Ribbon vein quartz------------------	As, 200; Zn, (L)
177	PC	Pyrite concentrate, altered slate----	Au, 1.3; Ag, 2; As, >10,000; Hg, 0.75; Co, 200; Cu, 300; Pb, 300; Zn, 500
279	PC	Gray sulfides, dredge concentrate----	Ag, 2000; Bi, 7000, Pb, >10 percent

Laboratory No.	Type	Description	Anomalous metals and their anomalies[1/]
		Bendeleben D-5 quadrangle	
AHI-133	C	Iron-stained limestone near fault-----	As, (L); Hg, 0.30; Mo, 50; Zn, 200
219	C	Altered limestone near fault----------	Hg, 0.11; Ag, 7
245	S	Specimen, vein quartz-----------------	Au, 0.1; Ag, 500; As, (L); Hg, 4; Cu, 150; Sn, 30; W, (L); Zn, 1000; Mo, 30; Pb, >20,000; Sb, 150
297	C	Altered limestone near fault----------	W, (L); Zn, (L)
298	C	-----do-------------------------------	Au, 0.4; Ag, 15; Hg, 0.6; As, (L); Co, 150; Mo, 15; Sb, 500; Zn, 1500
330	C	Oxidized quartz breccia and quartz vein------------------------------	As, 200; Mo, 20; Sb, (L); Zn, 300
332	C	Iron-stained float--------------------	As, 200; Cu, 200; Mo, 30; Sb, 150; Zn, 1000
337	C	-----do-------------------------------	As, (L); Hg, 0.5; Co, 300; Mo, 20; Sb, (L); Zn, 700
375	C	Altered schist------------------------	As, 700; Hg, 0.35; Co, 30; Cu, 150; Mo, 70; Sb, (L); W, (L); Zn, 700
376	C	-----do-------------------------------	As, 700; Hg, 0.26; Co, 70; Cu, 300; Mo, 50; Sb, (L); W, (L); Zn, 700
377	C	Iron-stained float--------------------	As, 700; Hg, 0.20; Co, 100; Cu, 300; Mo, 15; Ni, 200; Zn, 300
453	C	Altered float with galena-------------	Au, 0.8; Ag, 5000; Hg, >10; As, 300; Cu, 1500; Mo, 50; Pb, >20,000; Sb, 3000; Sn, 500; Zn, 1,000

Laboratory No.	Type	Description	Anomalous metals and their anomalies 1/
		Bendeleben D-6 quadrangle	
AHI-189	C	Calc-silicate float------------------	Sn, 100; Zn, 300
198	C	Stained granite dike-----------------	Ag, 3; Hg, 0.14; Pb, 2000; Sn, 300
200	C	Altered schist-----------------------	Pb, 2,000; Zn, 500
201	S	Iron-stained float fragments---------	Au, 0.8; Ag, 700; As, >10,000
218	C	Float of small quartz vein-----------	Hg, 0.9; Cu, 150; Sb, (L); Hg, 0.65; Cu, 1,500; Mo, 30; Pb, 10,000; Sb, 150; Sn, 300; Zn, 5000
329	C	Float of oxidized quartz-------------	Cu, 100; Mo, 10; Zn, (L)
340	C	Oxidized float along fault-----------	As, 500; Co, 70;, Cu, 150; Mo, 50; Pb, 150; Zn, 700
366	C	Float schist with quartz veinlets----	Mo, 30; Pb, 200; Zn, 300
433	C	Float of altered rocks along fault---	Au, 0.02; Ag, 3; As, 300; Cu, 150; Pb, 1,500; Zn, 500
595	C	Quartz along fault-------------------	Au, 0.04; Hg, 0.11; As, 500; Cu, 100; Mo, 30; Pb, 300; Zn, 200
597	C	-----do------------------------------	Au, 0.06; As, 200; Cu, 150; Mo, 30; Sb, (L); Zn, (L)
598	C	-----do------------------------------	Au, 0.06; Hg, 0.14; Ag, 2; As, 300; Cu, 150; Mo, 30; Pb, 150; Sb, (L); Zn, (L)

1/ Semiquantitative spectrographic analyses are reported in percent to the nearest number in the six-step series 1.0; 0.7; 0.5; 0.3; 0.15; and 0.1; 0.07 etc. which represent approximate midpoints of group data on a geometric scale. The common ratio for the geometric series of the group limits is the 6th root of 10, approximately 1.4678. The assigned group for semiquantitative results will include the quantitative value about 30 percent of the time.

2/ Gold analyses only reported.

Table 2.--**Stream sediments containing anomalous mercury or other metals, Teller A-2, A-3, Bendeleben A-6, D-5, D-6 quadrangles, Seward Peninsula, Alaska.**

(All are -80 mesh fraction of total stream sediment)

[Analysts: K. J. Curry, R. L. Miller, W. R. Vaughn, U.S. Geological Survey]

Teller A-3

Lab. No.	Anomalous Metals (PPM) 1/	Lab No.	Anomalous Metals (PPM) 1/
ACM 595	Hg. 0.3	ACM 616	Hg, 0.13
596	Hg. 0.45	617	Hg, 1.10
597	Hg. 0.15	618	Hg, 3.00
598	Hg, 0.13	619	Hg, 2.00
602	Hg, 1.00	620	Hg, 2.60
603	Hg, 0.75	621	Hg, 0.60
604	Hg, 0.35	622	Hg, 0.50
605	Hg, 0.60	623	Hg, 0.5
606	Hg, 0.22	624	Hg, 0.28
607	Hg, 1.30, Au, .03	625	Hg, 0.15
608	Hg, 0.80	626	Hg, 0.60
609	Hg, 0.24, Au, .02	627	Hg, 0.18
610	Hg, 0.24, Au, .02	628	Hg, 1.00
611	Hg, 0.55	629	Hg, 0.30
612	Hg, 0.80	630	Hg, 0.22
613	Hg, 0.24	631	Hg, 0.18
614	Hg, 0.24	632	Hg, 0.26
615	Hg, 0.50	633	Hg, 0.70

Teller A-3

Lab. No.	Anomalous Metals (PPM)[1]
ACM 634	Hg, 0.40
635	Hg, 0.22
637	Hg, 0.14
638	Hg, 0.22
639	Hg, 0.14
640	Hg, 0.50
641	Hg, 0.18; Zn, 110
642	Hg, 0.14; Zn, 100
643	Hg, 0.10; Zn, 110
644	Hg, 0.30; Zn, 110
647	Hg, 0.34; Au, .06
648	Hg, 0.22
649	Hg, 0.28
651	Hg, 0.18; Au, 0.6
652	Hg, 0.10; Hg, .85
653	Hg, 0.22, Hg, 1.0
654	Hg, 0.24, Hg, .20
701	Hg, 0.50
702	Hg, 0.55
703	Hg, 0.40
704	Hg, 0.50
705	Hg, 0.55
706	Hg, 0.90

Lab No.	Anomalous Metals (PPM)[1]
ACM 707	Hg, 0.50
708	Hg, 0.15
709	Hg, 0.22
710	Hg, 0.11
711	Hg, 0.15
712	Hg, 0.15; Zn, 110
713	Hg, 0.18; Zn, 100
714	Hg, 0.22
715	Hg, 0.18
716	Hg, 0.22
719	Hg, 0.35; Zn, 120
720	Hg, 0.18; Zn, 140
721	Hg, 0.18; Zn, 140
723	Hg, 0.12; Pb, 40; Zn, 160
724	Hg, 0.26; Pb, 44; Zn, 190
726	Hg, 0.16
728	Hg, 0.15
729	Hg, 0.16; Zn, 140
731	Hg, 0.30
732	As, 40
734	Hg, 0.20
736	Hg, 0.13
738	Hg, 0.10

Teller A-3

Lab No.	Anomalous Metals (PPM)[1]
ACM 740	Hg, 0.50
741	Hg, 0.40
742	Hg, 0.14
743	Hg, 0.30
744	Hg, 0.35
745	Hg, 0.22
746	Hg, 0.30
747	Hg, 0.14
748	Hg, 0.60
749	Hg, 0.35
750	Hg, 0.18
752	Hg, 0.09
753	Hg, 0.35
754	Hg, 0.10
755	Hg, 0.14
757	Hg, 0.13
778	Hg, 0.20
783	Hg, 0.30; As, 40
786	Hg, 0.14
787	Hg, 0.10
788	Hg, 0.11
791	Hg, 0.11

Lab. No.	Anomalous Metals (PPM)[1]
ACM 793	Hg, 0.14
794	Hg, 0.11
798	Hg, 0.10

Lab No.	Anomalous Metals (PPM) 1/
Bendeleben D-6 (AHI's are - 40 mesh fraction, ACB's, ACM's are -80 mesh fraction)	
AHI 010	Au, 0.5
011	W, (L); As, (L)
012	Sn, 15; As, (L); W, (L)
013	W, (L)
021	W, (L)
022	Ag 1; As, (L); W, (L)
ACB 405	Zn, (L)
240	Hg, 0.14
023	W, (L); Zn, (L)
024	Hg, 0.11; W, (L); Zn, (L)
025	Ag 1, W, (L); Zn, (L)
026	Zn, (L)
027	Zn, (L)
028	As, (L); Zn, (L)
030	Zn, (L)
031	As, (L); Zn, (L)
032	As, (L); Zn, (L)
ACM 531	Hg, 0.36; Ag, 1; Zn, (L)
535	Sn, 150
536	Sn, 300; Nb, 70; W, (L)

Bendeleben A-6

Lab No.	Description	Anomalous metals, in ppm 1/
AHI 527	-40 mesh stream sediments	Au, 0.04; Mo, 20; Zn, 300
528	do	Au, 0.02; Cu, 100; Mo, 15; Zn, 200
529	do	Au, 0.06; As(L); Mo, 7; Zn, 200
530	Panned concentrate from AHI 529	Au, 0.02; As,(L); Cu, 150; Mo, 15; Zn, (L)
531	-40 mesh stream sediments	Au, 0.04; Mo, 10; Zn, 300
532	do	Au, 0.06; Mo, 15; Zn, 200
533	do	Cu, 150; Mo, 7; Zn, 300

Bendeleben D-5

Lab No.	Description	Anomalous metals, in ppm 1/
ACM 540	-80 mesh fraction; stream sediment	Sn, 50; Zn, (L)
542	do	Au, 0.1; Mo, 7
544	do	Mo, 7; Zn, 700

1/ Semiquantitative spectrographic analyses are reported in percent to the nearest number in the six-step series 1.0; 0.7; 0.5; 0.3; 0.15; and 0.1; 0.07 etc., which represent approximate midpoints of group data on a geometric scale. The common ratio for the geometric series of the group limits is the 6th root of 10, approximately 1.4678. The assigned group for semi-quantitative results will include the quantitative value about 30 percent of the time.

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