Mineral Resources of Glacier Bay National Monument, Alaska

GEOLOGICAL SURVEY PROFESSIONAL PAPER 632

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By E. M. MacKEVETT, Jr., DAVID A. BREW, C. C. HAWLEY, LYMAN C. HUFF, *and* JAMES G. SMITH

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A reconnaissance study of the mineral deposits and their geologic setting and a geochemical sampling program in one of our wildest, most beautiful, and most remote national monuments

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By E. M. MacKevett, Jr., David A. Brew, C. C. Hawley, Lyman C. Huff, and James G. Smith

ABSTRACT AND SUMMARY

The U.S. Geological Survey investigation of the mineral-resource potential of Glacier Bay National Monument was made during the summer of 1966 at the request of the National Park Service for its use in planning future development of the monument. The most important results of field tests and laboratory analyses are herein summarized. Background on the geography, geology, and study methods used is given in the "Introduction."

The chief metallic commodities of potential economic importance are copper, molybdenum, nickel, gold, silver, titanium, and iron. A few other metals might constitute byproducts or form deposits in some favorable areas that are as yet unexplored or concealed. The belt of Tertiary sedimentary rocks that borders the Gulf of Alaska and probably occurs offshore is a possible host for petroleum, but the potential is low. The economic potential for nonmetallic deposits known in the monument, such as coal, limestone, and dolomite, is minimal because of their low grade, impurities, cheaper availability elsewhere, and other limiting factors.

The deposits considered to have the best economic potential include eight that were previously known and seven that were found during our investigations. The previously known deposits are the Nunatak molybdenum prospect; the Brady Glacier nickel-copper prospect; titanium, iron, and copper deposits associated with the layered mafic intrusive rocks of the Fairweather Range; the Alaska Chief copper prospect; gold- and ilmenite-bearing beach placers north and south of Lituya Bay; the Margerie copper prospect; and gold lodes in the Reid Inlet area and at the Sandy Cove prospect (fig. 1). The most attractive deposits found during our investigations include a copper-molybdenum deposit in the Bruce Hills; veins and altered zones north of White Glacier; base-metal lodes near Mount Brack; and copper deposits south of Rendu Glacier, near Gable Mountain, east of Dundas Bay, and west of Tarr Inlet (fig. 1).

The previously known deposits are described in the order of their probable economic potential. The Nunatak molybdenum prospect and the Brady Glacier nickel-copper prospect are those most likely to be developed in the near future. The deposits of potential significance that we found cannot be ranked without additional data, and, at this stage, are considered to have about the same potential. They are all partly or largely covered by snow, ice, or surficial deposits, and satisfactory appraisals of their configurations and grades require physical exploration. These newly found deposits are of interest because of their inferred sizes, their grades, and the possibility that concealed parts of some deposit may be larger and richer than is apparent from surface examination. These deposits would be regarded as exploration possibilities by most mining companies, but remoteness and difficult access are limiting factors in most cases. Probably none of these newly found deposits will prove to be of major importance, but they cannot be eliminated from consideration without exploration.

The investigations were thorough enough to conclude that most, if not all, sizable mineral deposits exposed in the Glacial Bay National Monument east of the Fairweather Range have been found. Some of the geochemical anomalies detected in stream-sediment samples from this same part of the monument may indicate the existence of concealed minor deposits. In the Fairweather Range itself, most of the planned fieldwork was prevented by bad weather, and only small parts of its eastern margin were examined; therefore, our appraisal of the deposits of the range is severely limited by lack of data.

MINERAL DEPOSITS

PREVIOUSLY KNOWN DEPOSITS

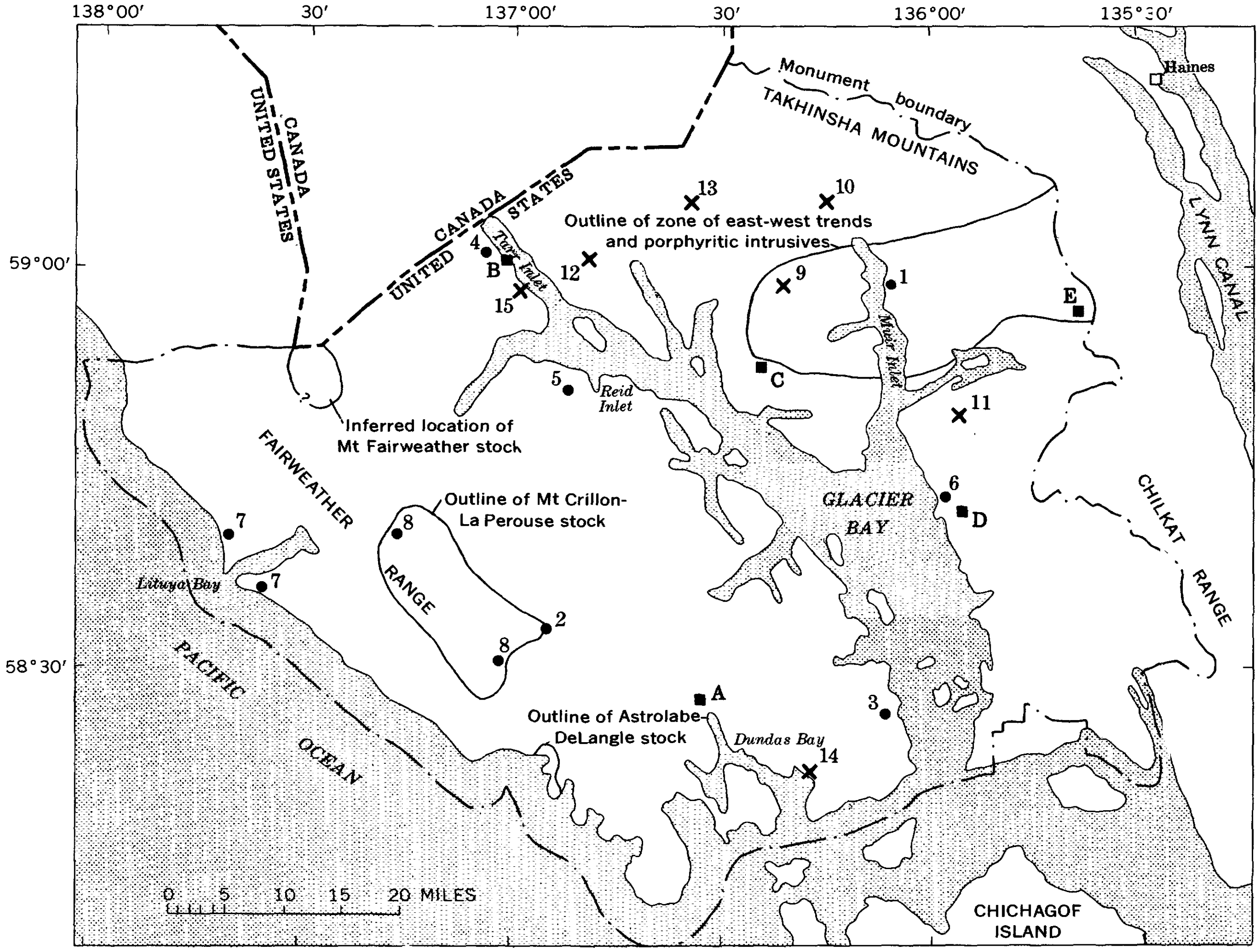
Nunatak Molybdenum Prospect

Deposits at the Nunatak molybdenum prospect (fig. 1, loc. 1) consist of abundant, closely spaced molydenite (MoS_2)-bearing quartz veins, minor molybdenite disseminated in hornfels, and a mineralized fault zone. The deposits have been described by Twenhofel (1946), and they were sampled and explored with two diamond-drill holes by the U.S. Bureau of Mines (Sanford and others, 1949). Mining companies have conducted limited exploration at the prospect. The deposits are mainly in hornfels, but locally, they occur in an intrusive igneous body mapped as quartz monzonite porphyry, which is exposed over a small area, and in a silicified zone near the edge of the igneous body. Pyrite (FeS_2), pyrrhotite ($Fe_{1-x}S$), chalocopyrite ($CuFeS_2$), and traces of silver are associated with the molybdenite in parts of the deposit.

Satisfactory estimates of the grade of the deposits will require bulk sampling, and adequate estimates of the reserves are contingent upon determining the extent of the deposits.

Our reserve estimate for the closely spaced molybdenite-bearing vein network, or stockwork, above sea level near Muir Inlet is 2,247,000 tons of material averaging 0.067 percent MoS_2 and 0.016 percent copper. Our estimate for the remainder of the stockworks and the fault zone deposit is 129,530,250 tons of material averaging 0.026 percent MoS_2 and 0.018 percent copper. The grades are based on assays of chip samples collected during our investigations. In addition, about 18,000,000 tons of material similar to that in the second category above are inferred to underlie the steep cliffs near the southern end of the stockworks. Reserves that are comparable in tonnage and grade to those above sea level probably also occur below sea level.

Twenhofel (1946, p. 17, 18) estimated that the whole stockwork contained 8,500,000 tons of material averaging 0.125



KEY TO LOCALITIES SHOWN ON MAP

1. The Nunatak Muir Inlet
2. Brady Glacier
3. Alaska Chief
4. Margerie Glacier
5. Reid Inlet
6. Sandy Cove
7. Lituya Bay placers
8. Mount Crillon gabbro
9. Bruce Hills
10. Mount Brack
11. White Glacier
12. South of Rendu Glacier
13. Gable Mountain
14. Altered zone east of Dundas Bay
15. West of Tarr Inlet

A. Main arm of Dundas Bay
B. West shore of Tarr Inlet
C. Mount Merriam
D. Miller Peak-Sandy Cove
E. Upper Berg Creek

FIGURE 1.—Map of Glacier Bay National Monument, Alaska, showing selected mineral deposits, geochemical anomalies, and outlines of some areas favorable for mineral deposits. •, previously known deposits with economic potential; X, deposits of possible economic interest found by USGS investigations; ■, geochemical anomalies.

percent MoS_2 and 91,500,000 tons of material averaging 0.080 percent MoS_2 and that the fault-zone deposit contained 540,000 tons of material averaging 0.169 percent MoS_2. Twenhofel's grade estimates are based mainly on channel samples and may be more representative than ours; none of his samples were analyzed for copper.

Three diamond-drill holes drilled by the American Exploration & Mining Co. in 1966 explored parts of the deposits between 400 feet above sea level and 300 feet below sea level. These cores are reported to indicate grades of MoS_2 similar to those in our and Twenhofel's samples.

The Nunatak molybdenum prospect contains a large reserve of low-grade molybdenum ore, and if the current trends in price and demand for molybdenum continue, it may be minable in the near future.

Brady Glacier Prospect

The Brady Glacier nickel-copper deposits are exposed on two small nunataks in Brady Glacier (fig. 1, loc. 2). The prospect is covered by patented claims held by the Newmont Mining Co. Published descriptions of the deposits are based on meager information (Berg and others, 1964, p. 115; Cornwall, 1966, p. 37). The deposits are localized near the base of layered gabbro and in adjacent periodotite that forms part of the layered mafic and ultramafic igneous rock complex known as the Crillon-LaPerouse stock. They consist of pyrrhotite ($Fe_{1-x}S$), pentlandite ($(Fe,Ni)_9S_8$), and chalcopyrite ($CuFeS_2$) that form disseminations, veinlets, and lenticular masses as much as 35 feet long and 5 feet in diameter). The prospect has been explored by 46 diamond-drill holes, many of which were drilled through several hundred feet of ice in the nearby glacier.

The nunataks have not been systematically sampled, but examination of their rocks indicate that disseminated sulfides are present nearly everywhere. The amounts are small, and the overall average grade would probably be less than 0.5 percent each nickel and copper. Several of the sulfide masses in the nunataks have been sampled, and the assays shows 2–3 percent nickel, 1–1.4 percent copper, and 0.25 percent cobalt. Individual massive sulfide lenses are small; however, five such bodies on the nunataks have lengths ranging from 15 to 35 feet and average widths of about 6 feet. The vertical extents of the lenses are probably comparable to these dimensions.

Diamond drilling thus far has shown that low-grade nickel-copper mineralization is widespread in the gabbro-peridotite complex, but more drilling is needed to establish continuity of the higher grade zones. By analogy with known commercial deposits of a similar nature elsewhere, it is possible that, as the basal contact of the layered complex is approached at greater depth, higher grades of nickel and copper mineralization will be encountered. The information available to us is inadequate for making any reserve estimates, but the results of exploration may be considered sufficiently favorable to encourage mining the deposits.

Fairweather Range

The layered mafic and ultramafic rocks of the Fairweather Range include the Crillon-LaPerouse and the Astrolabe-DeLangle stocks of Rossman (1963a) and an inferred intrusive mass near Mount Fairweather (fig. 1). These rocks have been little explored and prospected. Descriptions of them and brief accounts of their mineral deposits (fig. 1, loc. 8) are in Rossman (1963a) and in Kennedy and Walton (1946, p. 67–72).

Some layers in the layered complexes are known to contain large amounts of ilmenite in low-grade concentrations and lesser amounts of titaniferous magnetite. These and similarly mineralized layers that undoubtedly occur elsewhere in the complexes are a potential resource of titanium and iron. Minor amounts of vanadium are associated with the ilmenite and magnetite and constitute a remotely possible byproduct. Pods and lenses of massive sulfides, chiefly pyrrhotite ($Fe_{1-x}S$) with subordinate chalcopyrite ($CuFeS_2$), have been reported from some of the layers and contact zones of the complexes.

By analogy with other layered mafic and ultramafic intrusive masses, the poorly exposed and apparently largely concealed ultramafic rocks of the lower part of the complexes are possible hosts for chromite and platinum deposits. The peripheral and lower zones of the complexes may also contain sulfide deposits rich in nickel and copper and possibly small amounts of platinum.

The little-explored and prospected layered intrusive rocks of the Fairweather Range are potentially important because they contain known resources and are favorable hosts for a variety of mineral deposits. However, they occur largely in remote and rugged terrain where prospecting, exploration, and mining are difficult and costly.

Alaska Chief Prospect

The Alaska Chief copper prospect (fig. 1, loc. 3) consists of patented claims on a massive sulfide deposit in tactite, hornfels, and marble near a granitic mass. Workings at the prospect consist of a cleared and scraped area about 150 feet long and 55 feet wide and an adit 40 feet long. The deposit is exposed throughout the cleared area and less extensively in the adit. The lateral extent of the deposit could not be ascertained because its surface exposures are surrounded by densely vegetated steep hillsides that lack outcrops. Little is known of its subsurface configuration. The deposit consists of pyrite (FeS_2), pyrrhotite ($Fe_{1-x}S$), chalcopyrite ($CuFeS_2$), bornite (Cu_5FeS_4), and sphalerite (ZnS), and their oxidized derivatives. Chip samples from the cleared area contained about 1 percent copper, as much as 4.377 ounces of silver per ton, and lesser amounts of gold and zinc. Drilling or similar exploration will be required to determine the reserves of the deposits. The prospect has been briefly described by Reed (1938, p. 72, 73) and by the Wrights (1937, p. 221, 222).

Placer Deposits Near Lituya Bay

Placer deposits that contain gold and other heavy minerals are distributed irregularly along the beaches for about 20 miles northwest of Lituya Bay and 15 miles southeast of the bay (fig. 1, loc. 7). There may be similar placers just offshore beneath the Gulf of Alaska. The deposits consist of concentrations of heavy minerals in modern bare beach sands and in older beach sands whose surfaces are covered by vegetation. They have been worked intermittently since the early 1890's. Between 1894 and 1917 they produced gold valued at about $75,000 (Mertie, 1933, p. 135). Their production since 1917 has been minor. A little platinum has been recovered from the deposits. The placer deposits also contain concentrations of ilmenite and, to a lesser extent, of magnetite. The deposits have been investigated by Rossman (1957) and by Thomas and Berryhill (1962, p. 37–40); both of these investigations stressed their ilmenite content. They could be worked under favorable economic conditions for gold, and they also constitute a potential resource of titanium, and possibly iron.

Margerie Prospect

The Margerie copper prospect (fig. 1, loc. 4) is in granitic rock and hornfels. Its deposits consist of pyrrhotite ($Fe_{1-x}S$)-chalcopyrite ($CuFeS_2$) lenses, copper-bearing altered zones about 6 feet thick, and thin quartz veins. All the deposits examined appear to be too small or too lean to be exploitable; but the prospect has been little explored, and indications of mineralization are widespread in the general vicinity. The deposits were discovered in 1960, but they have not been described in the geologic literature.

Reid Inlet Gold Area and Sandy Cove Prospect

The gold lodes of the Reid Inlet gold area (fig. 1, loc. 5) and the Sandy Cove prospect (fig. 1, loc. 6) occur in narrow nonpersistent quartz veins and in the contiguous altered wall-rock. They are probably too small and too sporadically distributed to be minable now, but they probably would be amenable to small-scale mining during more favorable economic conditions.

The total value of gold production from mines in the Reid Inlet area was about $250,000 (Rossman, 1959, p. 39). The geology and ore deposits of the Reid Inlet area have been described by Rossman (1959). The Sandy Cove prospect was described by Reed (1938, p. 65–68).

Other Previously Known Deposits

Several other mineral deposits, such as those on Willoughby, Francis, and Marble Islands (Reed, 1938, p. 69–72), west of Rendu Inlet and on the southern part of Gilbert Island (Rossman, 1963b, p. K48–K50), have been reported in the monument. All of these probably have low potentials for mineral production.

DEPOSITS DISCOVERED DURING 1966

Several localities that contain mineral deposits of potential significance were discovered during the 1966 fieldwork (fig. 1). No ranking is implied by the sequence of the descriptions that follow. Most of these deposits are poorly exposed and require additional work for their satisfactory evaluation. Our brief examinations and limited sample data indicate that they warrant exploration.

The Bruce Hills deposits (fig. 1, loc. 9) are in and near a fault zone that cuts granitic rocks. They consist of stockworks of quartz veins, disseminations, and fracture coatings, and contain pyrite (FeS_2), chacopyrite ($CuFeS_2$), pyrrhotite ($Fe_{1-x}S$), molybdenite (MoS_2), and malachite ($Cu_2Co_3(OH)_2$).

The deposits near Mount Brack (fig. 1, loc. 10) occupy veins and altered zones in metamorphic rocks. They consist of sphalerite (ZnS), galena (PbS), and probably a sulfosalt, and contain minor amounts of silver.

Deposits north of White Glacier (fig. 1, loc. 11) are localized in small altered zones that cut limestone and marble and in large altered zones that cut mafic volcanic rocks. The altered zones in the limestone and marble contain chalcopyrite ($CuFeS_2$), particularly near intersections with dikes that cut the zones, and some altered zones in the volcanic rocks carry as much as 2 percent zinc.

A large mineralized altered zone is exposed in steep cliffs south of Rendu Glacier (fig. 1, loc. 12) near the contact between light-gray granitic rocks and metamorphic rocks. A sample of float from this zone contained 0.2 percent copper.

Mineralized joint coatings of unknown extent occur in coarse-grained dioritic rocks at Gable Mountain (fig. 1, loc. 13). The copper minerals in the joints are malachite ($Cu_2CO_3(OH)_2$) and chrysocolla ($CuSiO_3 \cdot 2H_2O$). A composite grab sample from the deposit contained 0.1 percent copper and minor quantities of silver and molybdenum.

Low-grade copper deposits occur in a large altered zone east of Dundas Bay (fig. 1, loc. 14). The altered zone, which is in quartz-rich metamorphic rock that locally is bounded by volcanic rocks, is as much as 300 feet wide and at least 1 mile long. Samples from the altered zone contained as much as 0.2 percent copper and traces of silver, molybdenum, and lead.

Disseminated sulfides and quartz veinlets that carry copper minerals occur in siliceous lenses within light-colored granitic rocks west of Tarr Inlet (fig. 1, loc. 15). A sample representative of the lenses yielded 0.1 percent copper.

Numerous other deposits, including a few that probably have potential equal to those described here, were found during our investigations.

GEOCHEMICAL ANOMALIES

The geochemical sampling program disclosed numerous areas with anomalous contents of metals. Five areas that contain significant anomalies were detected by examination of stream sediments, but most of the anomalies were revealed by analyzing mineralized rock samples. The geochemical sampling also provided information about "background" concentration of elements in geologically different terranes. Although some of the anomalous areas were revisited and resampled in detail, none have been thoroughly evaluated; almost all, the five significant anomalies in particular, deserve further sampling and search for the causes of the anomalously high metal contents. The data now available do not establish whether specific anomalies are derived from concealed mineral deposits with economic potential or from areas of widespread, but, nevertheless, insignificant mineralization. Comparison of the geochemical maps with the mineral-deposit maps shows that not all known mineral deposits have geochemical anomalies detectible by methods used in this study; the various factors causing this problem are discussed in the main part of this report. The discrepancy does not lessen the importance of the anomalies that were mapped.

A significant geochemical anomaly (fig. 1, loc. A) with as much as 150 ppm (parts per million) tungsten and 30 ppm tin occurs in stream sediments derived from light-colored granitic rocks and adjacent metamorphic rocks near the main arm of Dundas Bay. These stream-sediment samples were collected late in the fieldwork, and there was no opportunity to resample the streams in the area. Geologically, the area is favorable for tungsten and tin deposits.

Another unevaluated significant anomaly is on the west shore of Tarr Inlet (fig. 1, loc. B) not far south of a copper deposit. This anomaly contains 700 ppm copper, 200 ppm lead, 500 ppm tin, 1,000 ppm zinc, and anomalous amounts of other metals also. The anomaly is within a north-trending belt of mixed granitic and undifferentiated metamorphic rocks. The belt contains many small mineral deposits as well as the Reid Inlet gold area and appears favorable for base-metal deposits.

Anomalously high total heavy-metal, molybdenum, and strontium contents characterize an anomaly in stream sediments derived from a complex geologic terrane near Mount Merriam (fig. 1, loc. C) Large iron-stained zones in hornfels and marble adjacent to intrusive granitic bodies there may be the source of the anomalous elements. In as much as these zones have not been sampled and the stream sediments have not been resampled in detail, the anomaly is unevaluated; it is considered significant, however.

Sediments from several streams in the vicinity of Sandy Cove and Miller Peak (fig. 1, loc. D) have anomalous total heavy-metal, molybdenum, and strontium contents. These stream sediments have been resampled and the anomaly verified, but the source of the high metal content is not known. Granitic bodies intrude marble in this area, and there may be either widespread low-grade mineralization or hidden mineral deposits associated with the granitic rock-marble contacts.

Anomalously high chromium and copper values occur in the sediments of upper Berg Creek (fig. 1, loc. E) near the monument boundary. This anomaly has not been resampled or evaluated, but the geology of the drainage area suggests that the metals may be derived from a volcanic terrane. The contiguous area outside the monument has not been examined.

FAVORABLE AREAS

Specific areas in the Glacial Bay National Monument can be selected as being more favorable for mineral deposits than others from consideration of the distribution and characteristics of known mineral deposits, the results of geochemical sampling, and the geology. There is no certainty that these areas contain significant hidden mineral deposits, but they are liklier to than other areas.

The contact zones between granitic intrusive bodies and marble and other metamorphic rocks constitute favorable areas for several types of mineral deposits. Such contact zones are abundant in the monument east of the Fairweather Range. Spatial and probably genetic relations exist between many of the known mineral deposits and granitic masses. In some places, such as the Alaska Chief copper prospect and the Queen and Rendu Inlet iron deposits, the indications of genetic relationships are strong.

Another association between mineral deposits and granitic rocks may be exemplified by the light-colored unfoliated granitic rocks that occupy a northwest-trending belt from Dundas Bay (fig. 1, near loc. A) to beyond Johns Hopkins Inlet (pl. 1). With the possible exception of the Reid Inlet gold deposits, which are rather distant, only a few mineral deposits are known to be associated with this belt. However, many metallic elements are generally concentrated during the late evolutionary stages of similar granitic rocks, and such rocks are associated with deposits of tin, molybdenum, tungsten, beryllium, gold, and other metals.

The layered gabbro and ultramafic rock complexes of the Fairweather Range and their border zones (fig. 1, locs. 2, 8) are favorable hosts for nickel, copper, iron, titanium, platinum, and perhaps vanadium deposits of various types. These complexes are probably more likely to contain significant undiscovered mineral deposits than any other favorable area in the monument. However, exploration and development problems caused by the extremely rugged terrain and severe weather would be great. The beach and possible submarine placers on the Pacific Ocean shore west of the Fairweather Range (fig. 1, near loc. 7) contain iron- and titanium-bearing heavy minerals derived from the gabbro and ultramafic rock complexes as well as some gold and platinum. This area probably contains very large low-grade placer deposits.

A favorable belt of mixed rocks, including granitic intrusions and many kinds of metamorphic rocks, extends from the Brady Glacier northward past Reid and Johns Hopkins Inlets and along the west side of Tarr Inlet (fig. 1, south of loc. 5 north to 4). This belt contains many large iron-stained zones and many known mineral deposits, including those in the Reid Inlet gold area and the Margerie prospect. The marble and metamorphosed volcanic units are favorable hosts for deposits and are cut by at least two types of granitic intrusions.

In the Muir Inlet area and in areas to the east and west of the inlet is a structural zone with east to west trends (fig. 1, near locs. 1 and 9), rather than the north-northwest to south-southeast trends which typify the monument as a whole. The cause of these aberrant trends is not known, but the east-west zone is congruent with an area characterized by dikes and plugs of porphyritic intrusive bodies whose compositions are similar to many of the granitic rocks in the monument. In places, as at the Nunatak molybdenum prospect, the country rock has been shattered by these shallow-depth intrusions. This area of congruent east-west trends and porphyritic intrusions contains most of the molybdenum deposits known in the monument and is probably the most likely area in which to find hidden molybdenum-copper deposits.

A potentially favorable area (fig. 1, near loc. E) is included in the eastern end of the area just described. Granitic intrusive rocks, metamorphic rocks somewhat similar to those near Muir Inlet, and a generally higher background content of metals in stream sediments all suggest that the area on both sides of the boundary in the northeastern part of the monument may contain undiscovered mineral deposits of unknown size and significance.

Glacier Bay National Monument contains a few mineral deposits that are likely to be minable in the near future; some that may be minable in the more distant future, but which are not well enough known to be evaluated; some that probably would be minable with economic or technologic changes; and many that are insignificant. The economic potential for petroleum, coal, and nonmetallic commodities in the monument is low.

INTRODUCTION

The U.S. National Park Service, in November 1965, requested that the U.S. Geological Survey study the mineral resources and mineral-resource potential of Glacier Bay National Monument, Alaska. The purpose was to provide factual information for the use of the National Park Service in planning the future development of the monument for the public.

A Geological Survey field party investigated the mineral deposits of the monument and their regional geologic setting during the summer of 1966. Three concurrent methods of study were used. The most important method consisted of detailed field examination and a sampling of previously known deposits and of new deposits found during the course of the overall investigation. The second involved extensive collection and geochemical analysis of stream-sediment samples from all major drainages. About 2,700 stream-sediment and mineralized rock samples were analyzed. The third method was reconnaissance geologic mapping, which delineated the major rock units forming the host rocks of the mineral deposits, determined the bedrock compositions of the geochemically sampled drainage basins, and revealed new mineral deposits and areas favorable for deposits.

The investigation successfully covered almost all the monument, with only the high part of the Fairweather Range (fig. 2) and the Pacific coastal strip west of that range left unvisited. Eighty-eight mineral deposits, both newly found and previously known, are described in this report. Of this number, 16 deposits considered to be of greater economic interest than the rest are described in detail. Many insignificant mineral deposits were visited and sampled; their locations are given in this report, although they are not described.

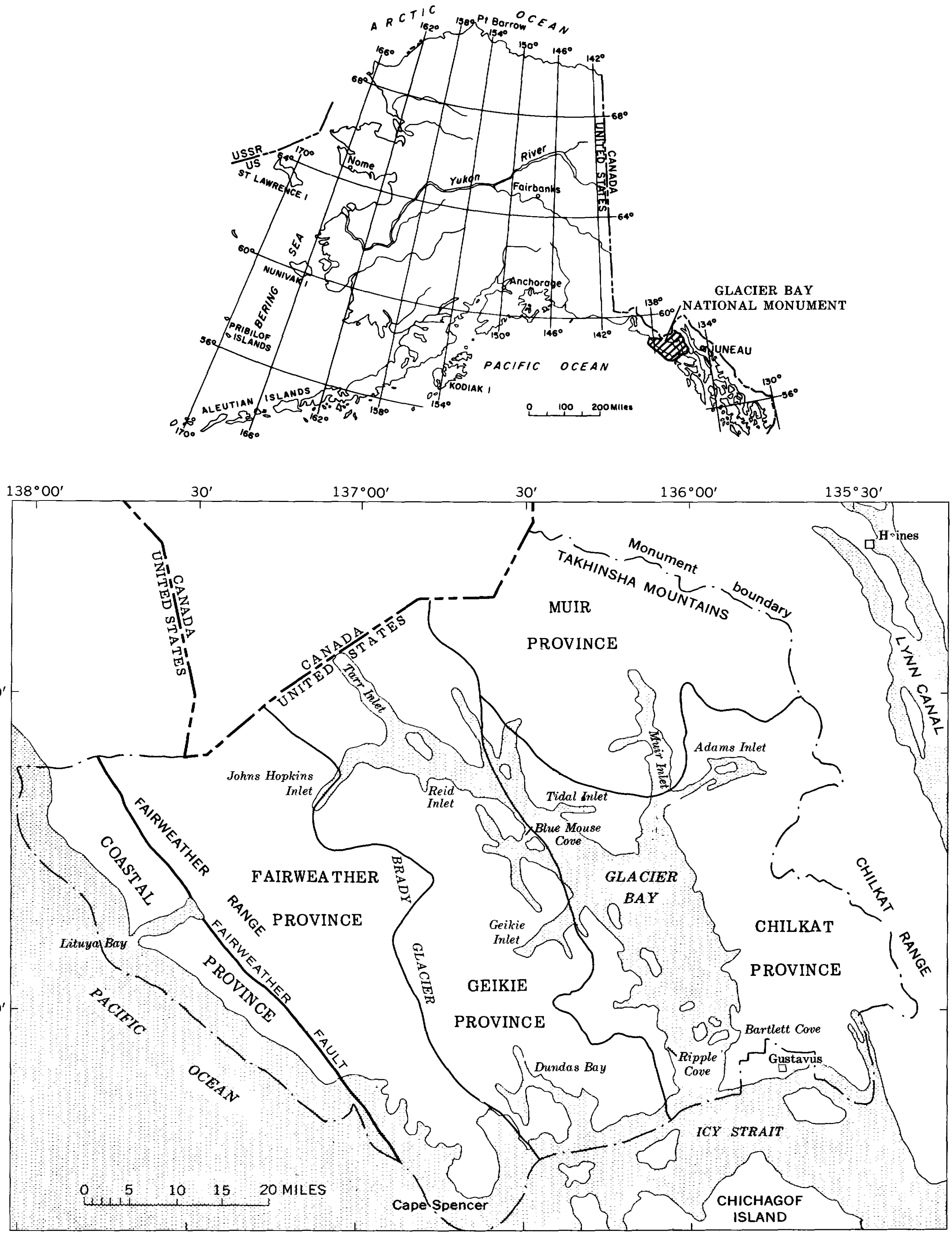


FIGURE 2.—Index map showing Glacier Bay National Monument, Alaska, and geologic provinces within the monument.

The geochemical sampling and analysis defined several significant geochemical anomalies, including some in areas known to contain mineral deposits. Most of the amomalies have not been evaluated completely, although some were resampled in detail.

The reconnaissance geologic mapping developed the regional framework of the mineral deposits and the background information essential to the interpretation of the geochemical data. The mapping also contributed greatly to the knowledge of the regional geology of this northern part of southeastern Alaska.

The geochemical sampling program relied heavily on rapid analyses of the samples. All stream-sediment samples were dried and sieved to -80 mesh shortly after collection, and the total heavy-metals content (copper, lead, and zinc) was determined on a split by conventional field tests (Huff, 1951; see "Methods of analysis"). The samples were then airmailed to the Geological Survey laboratories, where spectrographic analysis for 30 elements was made. Results were airmailed back to the field, usually arriving within 2–3 weeks from the time the sample was collected. Mineralized rock samples were in some cases screened by the total-heavy-metals test in the field before being sent to the laboratory for spectrographic analysis or assay. Samples were analyzed spectrographically by Nancy M. Conklin, J. C. Hamilton, R. G. Havens, Harriet G. Neiman, and A. L. Sutton, Jr.

D. A. Brew wrote the introductory material and regional geologic summary and prepared the lithology for the combined lithologic-mineral deposit location map. E. M. MacKevett, Jr., wrote all but one of the descriptions of the mineral deposits, incorporating geochemical material prepared by L. C. Huff. MacKevett was assisted by J. G. Smith in organizing data, by R. J. Wehr with laboratory studies, and by Susan R. Bartsch with drafting. H. R. Cornwall wrote the description of the Brady Glacier deposit. George Plafker is responsible for the summary of petroleum prospects in the Gulf of Alaska Tertiary province. C. C. Hawley prepared the maps showing the results of geochemical sampling and the discussions of geochemical anaomalies. Hawley and Huff wrote the section discussing the geochemical sampling program. MacKevett and Brew wrote the "Abstract and summary."

GEOGRAPHIC SETTING

Glacier Bay National Moument, Alaska, is an area of rugged glacier-clad mountains and steep-sided fiords within the St. Elias Mountains physiographic province in the northwestern part of southeast Alaska (fig. 2). Scenically and glaciologically, it is one of the most spectacular parts of Alaska. The magnificent Fairweather Range culminates in Mount Fairweather (15,300 ft) and forms an awe-inspiring devide between the Gulf of Alaska, only 12–15 miles west of the range crest, and the deep fiords of Glacier Bay proper, as close as 8 miles east of the crest. The rapid recession of the glaciers in Glacier Bay has not only provided an unparalled opportunity to study recessional glacial phenomena but has also exposed older glacial deposits and related features that are evidence for a complex sequence of relatively young glacial events.

The monument is located some 100 miles west-northwest of Juneau, Alaska, (fig. 2) and is accessible only by water or air. Small boats can reach Glacier Bay from the Inside Passage waters by way of Icy Strait. Reaching the Pacific coastal part of the monument involves an exposed and often rough run through Icy Strait and around Cape Spencer into the open ocean. Boating within Glacier Bay itself is less difficult and conditions are generally good during the summer months, although strong tides and sudden winds can abruptly change conditions. Charter float-equipped aircraft from Juneau and Haines reach the Bay in about an hour and can land in most fiords, except where icebergs are numerous. Ski-wheel aircraft have landed on several of the large glaciers. Alaska Airlines maintains regular daily air service to the permanent community at Bartlett Cove (monument headquarters) during June, July, and August and to Gustavus (just outside the monument) all year.

The monument has an area of about 3,900 square miles, excluding the water areas outside Glacier Bay proper. Of this area, 530 square miles (or about 14 percent) consists of the 50-mile-long Glacier Bay and its various arms and inlets. About 830 square miles (or 21 percent) is covered by glaciers. Much of the remaining 2,550 square miles is covered by snow all but 3 or 4 months of the year.

The land areas in the monument are all mountainous, except for a few broad plains underlain by glacial outwash in the southern and east-central parts. Four general types of mountains are found, reflecting differences in total relief, glacial history, and vegetation development. Toward the north-northwest, the lower, rounded summits and thickly forested steep slopes, typical of the Chilkat Range and the southern parts of the monument, give way to slightly higher, bare, serrated peaks and ridges that border steeply narrow steep-gradient valleys. Still farther north, coalescing valley glaciers and icefields convert similar peaks and ridges to nunataks. In the highest parts of the monument, the precipitous peaks of the Fairweather Range have impressive ice-fluted flanks that descend to heavily crevassed valley glaciers below.

The glaciers in the monument range from small hanging types common on most peaks to ones of great expanse, such as the Brady Glacier Icefield, 240 square miles in area; but most are valley glaciers 1–3 miles wide, which head in cirques or icefields at an altitude of 4,000–6,000 feet and descend almost to tidewater. The glaciers are, in general, quite crevassed and are easily traversed only in early summer. The Brady Glacier and Takhinsha Mountain Icefields are snow covered in their higher parts during most summers and are therefore more easily traversed.

At present, the ice in the glaciers may be as much as 1,000–1,500 feet thick in some of the deeper valley glaciers and as much as 1,000 feet thick on the broader and higher icefields. Adjacent to nunataks and valley walls the ice thickness increases rapidly, but the bedrock surface may be very irregular locally. Except for some stagnant ice at low altitude, all the glaciers in the monument are active, and there are signs that some are growing.

The fiords of Glacier Bay are steep sided and deep, local depths being greater than 1,000 feet. Shallower areas are found only near the broad expanses of outwash deposits in the southern part of the monument and over the small deltas associated with tidewater glaciers and the larger streams.

Most of the streams in Glacier Bay National Monument are small, have steep gradients, and drain areas of only a few square miles. In the southern part of the monument, however, several short, but vigorous, rivers drain relatively large areas. These rivers, most of their tributaries, and many of the other streams are swift and difficult to cross on foot. Almost all streams, regardless of size, were found to carry active stream sediment suitable for geochemical analysis.

The climate of the monument is generally maritime in the southern and lower altitude parts. Increasing altitude in the Fairweather Range, the presence of many glaciers, and the rain-shadow effect of the Fairweathers tend to make the northern part of the monument less humid and more like interior regions. No weather data are available for the northern or higher altitude parts, but data are available for Cape Spencer and Gustavus (fig. 2). These data, summarized in table 1, show that the months from February through July or August have the least precipitation, that the fall and early winter months have the most, and that the temperatures, are, in general, mild in both summer and winter.

TABLE 1.—*Average precipitation and average temperature for Cape Spencer (1937–66) and Gustavus (1940–66)*

[Data from U.S. Weather Bureau, 1937–66]

Month	Precipitation (inches)		Temperature (degrees Fahrenheit)	
	Cape Spencer	Gustavus	Cape Spencer	Gustavus
January	8.14	4.44	32.05	25.90
February	6.04	3.13	33.39	28.80
March	6.31	2.89	35.29	32.39
April	5.47	2.32	40.12	39.41
May	6.60	2.86	45.12	46.17
June	5.17	2.59	47.36	52.24
July	7.55	4.04	50.31	55.48
August	9.46	4.42	52.55	54.77
September	14.33	6.95	48.97	49.75
October	16.70	9.31	44.20	42.26
November	13.28	6.19	37.65	33.38
December	10.12	5.01	33.68	28.23
Annual average [1]	110.64	54.30	42.20	40.75

[1] Through 1965.

PREVIOUS INVESTIGATIONS

Glacier Bay has attracted many geologists and glaciologists during the past 90 years, mainly because of the rapid recession of the glaciers. Few of the earliest explorers and scientists came with economic interests in mind, but by 1892 some prospectors were in the area (Rossman, 1963b). In 1906, F. E. Wright and C. W. Wright (1937) studied the Johns Hopkins Inlet area and other parts of the monument; in 1919, J. B. Mertie visited the area. Buddington (Buddington and Chapin, 1929) visited the monument in 1924. Somewhat later, several other Geological Survey geologists (Reed, 1938; Twenhofel and others, 1949; Kennedy and Walton, 1946) visited specific mineral deposits then of interest or under development. Economic interest in the monument was lessened by prohibition of prospecting from 1924 to 1936.

In 1942, Twenhofel (1946) studied the Muir Inlet Nunatak molybdenum deposit in detail, and the U.S. Bureau of Mines sampled the deposit (Sanford and others, 1949). In 1949, D. L. Rossman began geologic studies in the monument, which are summarized in three reports (Rossman, 1959, 1963a, b). In 1950–51, J. F. Seitz studied the geology around Geikie Inlet (Seitz, 1959). Don J. Miller studied the Gulf of Alaska Tertiary province for several years; his mapping within the monument was incorporated by Rossman (1963a) after earlier open-filing (Miller, 1961). Reconnaissance studies in the Juneau 1:250,000 quadrangle part of the monument were made during the period 1956–58 (Lathram and others, 1959). A few mining companies, notably Fremont and Moneta-Porcupine, prospected in the monument during the late 1950's and early 1960's.

PRESENT INVESTIGATION

The Geological Survey party that made the studies reported herein was led by D. A. Brew and E. M. MacKevett, Jr., with Brew overseeing the operations and reconnaissance geologic mapping, and MacKevett, the studies of mineral deposits and the mineral-resource evaluation. In addition to Brew and MacKevett, the party consisted of Arthur B. Ford, Charles C. Hawley, Lyman C. Huff, A. Thomas Ovenshine, Arthur S. Radtke (until July 9), James G. Smith (after July 13), geologists, and Raymond J. Wehr, physical science technician. Huff and Hawley coordinated the geochemical studies throughout the project. Henry C. Cornwall joined the project temporarily early in August to study the Brady Glacier deposit.

The USGS R/V *Don J. Miller,* a 105-foot power barge manned by Robert D. Stacey, master; Allen Z. Komedal, chief engineer; and John J. Muttart, cook-seaman, was used as base for the field operations. The project was supported by a helicopter operated by National Helicopter Engineering Co., with Dan Ellis, pilot, and Howard Grannell, mechanic.

The party started fieldwork on May 24, 1966, and had excellent weather during May, June, and July. Frequent storms in August and early September hampered the studies, and the party left Glacier Bay on September 5, 1966.

The field studies were affected to a certain extent by the amount of snow cover present. Therefore, the sequence in which the different parts of the monument were studied is significant. In late May the investigations covered shoreline and island exposures along the west side of Glacier Bay from Ripple Cove to Blue Mouse Cove; in June, the northeastern and east-central parts of the monument; in July, the north-central, some of the northwestern, and the southeastern parts; and in August, the south-central part, the west-central, and some of the northwestern areas. In general, the amount of snow diminished rapidly through June and early July and slowly in July and August; in September the terrain above 4,000 feet was covered by new snow.

The results of the field studies are also a function of the way the data were gathered. All shoreline exposures within Glacier Bay and most of those along Icy Strait were traversed by slow-moving outboard-powered skiff, and frequent stops were made to examine the outcrops and obtain stream-sediment samples. Ridges accessible by helicopter and suitable for walking were traversed by geologists and examined in detail. The rougher ridges were examined aerially from the helicopter, and spot landings for outcrop study were made wherever possible. Some streams were traversed on foot to gather sediment samples and bedrock information, but most were sampled during helicopter spot landings.

ACKNOWLEDGMENTS

The cooperation of the U.S. National Park Service staff at Glacier Bay National Monument contributed greatly to the efficiency of the field operation. We should like to thank, in particular, Robert B. Howe, Superintendent, Charles Janda, ranger, and Kenneth Youmans.

We also thank the Newmont Mining Co. and American Exploration & Mining Co. for their cooperation in the appraisal of the Brady Glacier copper-nickel and the Muir Inlet Nunatak molybdenum deposits, respectively. L. F. Parker of Mount Parker Mining Co., visited the Survey geologists in the field on one occasion, as did Lawrence Duff, a private operator, both aided in locating prospects in the Reid Inlet area.

REGIONAL GEOLOGY

Knowledge of regional geology is important to this mineral resource appraisal in three ways: (1) the study of the rocks and their distribution aids in interpreting the geochemical data; (2) knowledge of the geologic framework of the known deposits leads to geologic insights about particular environments that need to be carefully evaluated in areas where no deposits are yet known; and (3) projection of known rock units from mapped areas into unmapped areas provides a basis for appraising the mineral potential of the unmapped areas.

The emphasis in this report is on the gross lithic and structural framework of the monument, and no detailed stratigraphic information is presented. The lithologic map (pl. 1) shows the major rock types and indicates the general geologic associations of the mineral deposits.

Glacier Bay National Monument consists of five distinct geologic provinces, each of which is characterized by specific structural and lithologic features. The Coastal province lies west of the Fairweather fault (fig. 2). The Fairweather province is east of the Fairweather fault and extends eastward to the Brady Glacier. The Geikie province extends north-northwestward through the center of the monument; at its northern end, it merges with the east-west-trending Muir province. The Chilkat province occupies the southeastern part of the monument. The features which characterize these provinces are discussed below.

STRATIGRAPHY

The bedrock stratigraphic section in the Glacier Bay National Monument ranges from Early Silurian through late Tertiary in age, with significant gaps in the late Paleozoic, late Mesozoic, and early Tertiary. The section is not well understood because of scanty fossil record, apparent abrupt facies changes, widespread metamorphism, and the disruption caused by intrusive bodies.

The Paleozoic part of the section crops out through the east half of the monument and is particularly well exposed in the Chilkat province (fig. 2). A stratigraphic thickness of 20,000 to 30,000 feet is estimated to be present. Detrital clastic rocks, mostly graywacke and argillite, of Silurian and possibly Devonian age are dominant; some discontinuous nonfossiliferous limestones are also present. To the north, these rocks appear to grade into a comparable section that contains significant amounts of volcanic rocks. In the western and northwestern parts of the Chilkat province are exposures of thick reef limestones whose correlation with the rest of the section is uncertain. Carbonate and detrital clastic units of Middle Devonian age occur in the north-central and northwestern parts of this province, and also in the Muir province. The relations between the known Devonian rocks and the known Silurian rocks are obscured by structural complexities and poor fossil control.

The Paleozoic rocks throughout most of the Chilkat province are not greatly metamorphosed, except adjacent to intrusions. In the Geikie and Muir provinces, these same rocks locally are highly metamorphosed, and it is difficult to correlate them with their less metamorphosed equivalents.

Mesozoic strata are found in the Coastal and Fairweather provinces along north-northwest trends similar to trends in the Mesozoic rocks of nearby Chichagof Island. They include three gross units of unknown thickness: (1) a low-grade metamorphic unit derived from mixed detrital clastic rocks and volcanic rocks, found only west of the Fairweather fault; (2) a biotite schist unit; and (3) an amphibolite unit. The schist unit is derived from a graywacke-shale sequence known to be of Jurassic and Cretaceous age on Chichagof Island, and the amphibolite may be equivalent to volcanic rocks of probable Triassic age in that same area.

Tertiary strata unconformably overlie the metamorphosed Mesozoic strata in the Coastal province; they consist of at least 12,000 feet of Miocene and Pliocene sandstone, shale, and minor volcanic rocks and conglomerate. The Tertiary strata probably extend offshore onto the continental shelf.

INTRUSIVE ROCKS

Intrusive rocks of probable late Mesozoic and perhaps Tertiary age dominate the Geikie and Muir geologic provinces and occur in all the other provinces to a lesser extent. Some of the foliated granitic rocks discussed below may actually be metamorphic rather than intrusive, but they are closely associated with the intrusives. The distribution of the different intrusive rocks is shown on plate 1, from which it is apparent that most of the known mineral deposits are spatially related to intrusions.

Most of the intrusives in the monument are mesozonal foliated granitic rock bodies. Hornblende quartz diorite, hornblende diorite, and biotite-hornblende quartz diorite are most common, but some biotite-hornblende granodiorite also occurs in foliated bodies. In general, foliation is parallel to that in the adjacent metamorphosed country rocks, but local divergences are present. This relation suggests that these bodies were intruded before the end of the episode in which the country rocks were deformed. Most of the foliated granitic bodies contain, and are locally bordered by, areas of hornblende quartz diorite gneiss, which commonly contains abundant inclusions and is in some places very heterogeneous.

Most of the mesozonal to epizonal unfoliated granitic rocks in the monument are in the Geikie province, but isolated bodies also occur in the Fairweather, Muir, and Chilkat provinces. Because these granitic bodies all lack well-developed foliation, their intrusion is considered to postdate deformation. Compositionally, the unfoliated granitic rocks range from hornblende-biotite granodiorite to biotite granite. These bodies generally are free of distinctive border zones, but they do contain large hornfels inclusions. The intrusion at Johns Hopkins Inlet (fig. 2; pl. 1) is unusual in that it is associated with very extensive and spectacular border zones of such inclusions.

A variety of dike rocks, ranging from aplites to lamprophyres, with andesites and diabases the most abundant, were mapped in the monument. They are particularly common in the western and northwestern part of the Chilkat province and in the metamorphic rocks in the Muir province. Many of the dikes probably are relatively young, and in many places have mineral deposits associated with them. The majority of dikes strike east or northeast, and they tend to occur in subparallel swarms.

A layered gabbro complex occupies a large part of the Fairweather province, and at least two other bodies of gabbro occur nearby. The gabbro in the synclinal structure of the largest complex is more than 30,000 feet thick. The regularly layered center of this mass is commonly bordered by a structurally complex zone of gabbro and ultramafic rocks that locally contains important sulfide deposits. Other mineral deposits are known to occur within the layered portion.

STRUCTURE

Each geologic province in the Glacial Bay National Monument has characteristic structural features, and two provinces—Muir and Chilkat—have unusual complications. Certain features, however, are common to the whole monument: (1) a dominant north to northwest strike of all units and planar structures within all units, (2) steep dips, and (3) repetition of section by large-scale folds. The major faults in the monument also strike north to northwest, although there are minor local divergences from this pattern.

In the Coastal province the moderately to gently dipping Tertiary strata form two northwest-trending synclines and one anticline, which have been displaced vertically by northwest-striking faults. Structures in the underlying Mesozoic rocks are not well known but probably are similar to those in the adjacent Fairweather province.

The Fairweather fault, which separates the Coastal and Fairweather provinces, is part of a high-angle fault system that extends for more than 280 miles from Yakutat Bay on the north to Chatham Strait and western Baranof Island on the south. The segment of the fault within Glacier Bay National Monument is near the central part of the system. The dominant fault movement is inferred to be vertical, with the west side down; but both historic displacement (Tocher and Miller, 1959) and inferred older movements farther south (Loney and others, 1967) suggest that a right-lateral component is also present.

Steeply dipping north- and northwest-striking foliation characterizes the Fairweather province, and the map units apparently are repeated by large folds. The emplacement of the large gabbro bodies had little structural effect on the country rock, except close to the contact.

The Geikie province is characterized by parallel north- and northwest-striking foliations in the country rocks and in the numerous granitic bodies. The distribution of country rock units implies complex folding, but the intervening intrusive masses make exact analysis difficult. In the northwestern part of the province, northwest strikes and steep westerly dips of contacts suggest that most of the rocks in the province may be stratigraphically below units mapped in the adjacent Fairweather province. Geikie province also contains a prominent north-northwest-striking zone of discontinuous faults.

The structures in the Muir province are very similar to those in the Geikie province, but contacts and foliations strike west to northwest and dip moderately to steeply to the north. These attitudes in the country rocks may be related to the configuration of the major intrusive bodies, but they may also represent preintrusion attitudes in part. In any case, the abrupt change from northerly trends near Muir Inlet to westerly trends only a few miles to the north suggest that one or more major structural discontinuities are involved. The distribution of map units in some areas between intrusive masses suggests that large folds, overturned to the south, may be present.

The same abrupt change in strike has been mapped in the northern part of the Chilkat province, near Tidal Inlet. There, the situation is complicated by an east-west fault zone and, farther to the east, by an important high-angle reverse fault that brings relatively simply folded Devonian strata over more highly folded Silurian(?) rocks. Outside the area of these complications, the rocks in the Chilkat province are characterized by northwest strikes, moderate to steep northeast dips, and large amplitude folds overturned to the southwest.

GEOCHEMICAL STUDIES

Geochemical studies in Glacier Bay National Monument consisted of the collection, analysis, and subsequent interpretation of more than 2,700 samples including (1) 1,200 stream-sediment samples, (2) 1,000 altered or mineralized rock samples, (3) 500 soil samples (4) 30 unaltered and unmineralized background level samples, and a few (5) panned stream-concentrate samples, (6) water samples, and (7) glacial-moraine samples. The resulting basic data and preliminary interpretations provide only a skeletal framework, and we believe that further geochemical interpretation of these data is possible. In particular, the relations between bedrock lithic types and metal content of locally derived stream sediments should be considered in detail. The following interpretations are preliminary and inconclusive.

Stream-sediment samples provide the greatest amount of available geochemical data on the composition of the rocks and surficial deposits and on abnormal accumulations of metals, which might indicate the presence of undiscovered buried mineral deposits. The density of stream-sediment samples varies greatly because large areas in the monument have glacial, rather than normal, stream drainage. In areas of normal drainage, there is more than one sample per square mile; in the glacier-covered areas, the samples are much more widely spaced.

The results of the stream-sediment studies are given in figures 3–7, on plates 2–8, and in tables 4–8. The concentrations of total heavy metals, chromium, copper, lead, molybdenum, and nickel are shown on individual maps, and one map (pl. 8) summarizes other elements, such as arsenic, beryllium, bismuth, cadmium, silver, strontium, tin, tungsten, and zinc, which were detected in anomalous amounts. Complete analytical data are given for several promising areas on separate maps and in tables. The analytical data derived from other samples are incorporated in the sections on mine and prospect descriptions.

METHODS OF ANALYSIS

Most samples were analyzed twice, first by a field geochemical prospecting test for total heavy metals (hereafter referred to as THM) and then spectrographically in the laboratory. The results of the THM tests were available 1 or 2 days after sample collection and were used to guide further sampling. The results of the spectrographic analysis were available to the field party within 2–4 weeks.

The THM field test was made in a portable laboratory aboard the R/V *Don J. Miller*. The test is of the type described by Huff (1951) in which the sample is digested by heating with acid, and the dissolved metal content determined by dithizone. This type of THM test extracts much more of the zinc, copper, and lead contained in the sample than does the commonly used cold citrate soluble THM test described by Hawkes (1963). The more complete extraction is of considerable importance at Glacier Bay because the oxidation of the rocks there varies widely, and more of the metal may be tightly bound than in a more temperate or thoroughly weathered region. It should be emphasized that the THM test samples only the acid-soluble part of the contained zinc, copper and lead. The spectrographic method, however, measures virtually all the metal present. Both the spectrographic and THM tests are semiquantitative; but, within limits of error, comparison of the THM and spectrographic analyses permits assignment of some anomalies to copper, lead, or zinc. For example, the THM test is especially sensitive to zinc, an element that has a poor spectrographic sensitivity (table 2). Stream-sediment samples that have high values of THM and low spectrographic values of copper and lead are therefore believed to have anomalous concentrations of zinc.

TABLE 2.—*Detection limits, in parts per million, for some elements determined by the six-step and direct-reader spectrographic methods*

Spectrographic method			Spectrographic method		
	Six-step	Direct-reader		Six-step	Direct-reader
Ag	1	1	Mo	3	10
As	2,000	2,000	Nb	10	40
Au	20	10	Ni	3	2
B	20	20	Pb	10	4
Ba	2	10	Sb	200	50
Be	1	1	Sn	10	20
Bi	10	9	Sr	5	10
Cd	50	50	Ti	2	10
Co	3	3	V	7	4
Cr	1	2	W	100	300
Cu	1	1	Y	10	5
La	30	20	Zn	200	200
Mn	1	5	Zr	10	10

The spectrographic method supplements the THM test because the latter does not detect elements such as chromium, molybdenum, nickel, tin, and tungsten. These and other elements are detected by spectrographic analysis if they are present in concentrations as high or higher than those given in table 2. The sensitivity for elements such as cobalt, copper, chromium, molybdenum, and nickel is low enough to detect minor concentrations of these elements, but the sensitivity for gold, tungsten, and zinc is high enough that these elements need tc be markedly enriched to be detectable.

Two slightly different spectrographic methods were used, referred to in table 2 as the six-step and direct-reader methods. The six-step method is similar to that described by Myers, Havens, and Dunton (1961) in that the concentrations are measured visually from photographic plates; it differs ir that concentration are reported in the six-step geometrical array, 1, 1.5, 2, 3, 5, 7, . . . , instead of the three-step array, 1, 3, 7, ... The direct-reader method refers to a direct-reading spectrograph in which the concentrations are measured automatically by photomultiplier tubes. The two methods are comparable in sensitivity and accuracy for most of the elements sought (table 2).

In addition to routine THM and spectrographic analyses, many mineralized rock samples were analyzed for molybdenum and gold in the laboratory by sensitive chemical methods.

SAMPLING AND SAMPLE PREPARATION

Stream-sediment samples were collected from both large and small streams. Most of the streams sampled were flowing, but some samples were taken from the dry beds of intermittent streams. Clayey and silty sand was collected; this material is generally present in considerable abundance in the major streams, but may be very scarce in steep, small, or intermittent stream courses. However, some clayey and silty sand may be found even in small streams in pockets behind boulders. The samples were placed in water-resistant paper bags, then dried at about 100°F. After drying, the sample was sieved at —80 mesh and that fraction was analyzed—first by the field THM test, then spectrographically.

ANOMALOUS AND BACKGROUND VALUES

Every region is characterized by a range of content values for each element; the average of these values is the background value. In many cases the median value is taken as background. Most samples have about this concentration, but a few will have much higher or much lower concentrations and these values are considered anomalous. High values are of special economic interest because they indicate areas of enrichment which may, in turn, be done to the presence of potential ore bodies. Most regions are underlain by many rock types, and because each rock type has a characteristic element content, background values are not constant. Therefore, any group of anomalous values must be interpreted with consideration of such variations.

The results of this geochemical investigation are reported (pls. 2–8) in ranges of concentration, each range being identified by a specific symbol. The data shown on the maps suggest patterns of element distribution.

TOTAL HEAVY METALS

Analyzed stream-sediment samples from Glacier Bay National Monument contain from 20 to 1,000 ppm zinc, copper, and lead extractable in hot acid. The median THM concentration is about 25 ppm, based on results from a set of samples from 915 localities (pl. 2), which include the average values from some duplicate analyses. About 75 percent of the samples contain less than 60 ppm; 90 percent, less than 100 ppm; and 95 percent, less than 120 ppm. The samples with 120 ppm or more THM are considered markedly anomalous.

COPPER

Copper ranges from about 5 to about 700 ppm in stream-sediment samples from the monument. The median copper content is about 40 ppm, based on the set of 636 samples (pl. 3) analyzed by the six-step method. About 95 percent of the samples contain less than 100 ppm, and the samples that contained 100 ppm or more copper are considered markedly anomalous.

LEAD

Lead was not detected by spectrographic analysis in the majority of Glacier Bay stream-sediment samples. The median value is therefore less than the spectrographic detectibilities (table 2), although it may be approximately the detectibility of the direct-reader method (4 ppm). Based on 636 samples (pl. 4) analyzed by the six-step method, about 85 percent of the samples contain less than 10 ppm; and 94 percent, less than 15 ppm. The values above 15 ppm are considered markedly anomalous.

MOLYBDENUM

Molybdenum is not reported in the majority of spectrographic analyses, but its median value may not be much less than the 3 ppm detectibility of the six-step method. In some areas many samples showed values by the direct-reader method of 5–10 ppm; these values are below the general detectibility of the method and therefore were not considered in the statistical analysis. They may, however, indicate areas of slightly anomalous molybdenum content and are given on the detailed maps (figs. 3–7). In a group of about 1,000 samples, molybdenum exceeded 10 ppm in only 36 samples (pl. 5). All values above 10 ppm are considered anomalous.

CHROMIUM

The chromium content of stream sediments in the monument ranges from less than 5 ppm to about 2,000 ppm (0.0005–0.2 percent). Based on a group of 957 samples (pl. 6), the median concentration is about 60 ppm and about 90 percent of the samples contain less than 100 ppm chromium. About 98 percent of the samples contain less than 200 ppm chromium. Samples containing 200 ppm or more chromium are considered markedly anomalous.

NICKEL

Nickel ranges from about 3 to 700 ppm in stream sediments in Glacier Bay National Monument. Based on the 636 samples (pl. 7) analyzed by the six-step method, the median value is about 15 ppm nickel. About 90 percent of the samples contain less than 30 ppm, and about 95 percent, less than 40 ppm nickel. Values of 40 ppm or more are considered markedly anomalous.

OTHER ELEMENTS

Based on the 636 samples (pl. 8) analyzed by the six-step method, the median cobalt concentration in stream-sediment samples is between 10 and 15 ppm, and about 90 percent of the samples contain less than 20 ppm cobalt. Cobalt is not shown on the maps, as it generally tends to vary directly with nickel.

Any tin and tungsten values detected by the spectrograph were considered anomalous and are shown on plate 8, along with any detected values of a group of rare elements including silver and arsenic. Values of strontium greater than 1,000 ppm were considered anomalous and are also shown on plate 8; although strontium is not very common in ore

TABLE 3.—*Semiquantitative spectrographic analyses in parts per million of representative unaltered rocks*

[O, looked for, but not found; . . . ., not looked for]

	Lab. No.	Field No.	Semiquantitative spectrographic analyses																		
			Ag	B	Ba	Co	Cr	Cu	Fe	La	Mn	Mo	Ni	Pb	Sc	Sn	Sr	Ti	V	Y	Zr
A. Detrital sedimentary rocks																					
1	D125435	Hx279A	0	....	100	5	70	20	20,000	0	500	0	15	0	....	0	200	1,000	50	15	....
2	D125436	Hx279B	0	....	300	15	50	100	50,000	0	70	0	30	0	....	0	200	5,000	150	10	....
3	D126165	Ov931	0	....	100	7	30	30	20,000	0	500	0	15	0	....	0	500	1,000	70	20	....
B. Limestone																					
1	D125437	Hx289	0	....	5	0	7	3	200	0	30	0	0	0	....	0	200	0	0	0	....
2	D125438	Hx524	0	....	150	0	5	7	100	0	15	0	0	0	....	0	100	0	0	0	....
3	D126163	Hx681	0	....	15	0	15	20	500	0	150	0	5	0	....	0	70	50	0	0	....
4	D1261104	Hx682	0	....	100	3	30	20	1,000	0	200	0	15	0	....	0	500	50	0	0	....
C. Mafic dikes and sills																					
1	D125449	Hx540	0	....	70	20	150	70	70,000	0	700	0	50	0	....	0	200	5,000	200	20	....
2	[1]D125938	Bd518B	0	....	50	10	0	7	>100,000	70	500	0	0	0	....	0	....	5,000	15	7	....
3	D125441	Ov282	0	....	10	30	1,000	50	70,000	0	700	0	300	0	....	0	70	1,500	150	10	....
4	D126156	Hx567	0	....	300	20	70	20	50,000	0	200	0	20	0	....	0	700	3,000	300	20	....
5	D126157	Hx575	0	....	30	30	200	70	>100,000	0	1,000	0	70	0	....	0	150	7,000	500	30	....
6	D126162	Sj52	0	....	100	30	70	200	>100,000	0	1,000	0	100	0	....	0	500	7,000	500	30	....
7	D124941	Hx405	0	....	300	30	200	50	70,000	0	1,000	0	100	0	....	....	....	7,000	200	20	....
[1] Also found 2 ppm Be, 10 ppm Nb.																					
D. Diorite, quartz diorite, and quartz monzonite or granodiorite (field identification)																					
1	D125155	Hx565	0	....	500	15	20	10	70,000	0	1,000	0	5	0	....	0	500	3,000	150	30	....
2	D125158W	Hx614	0	....	500	15	15	100	70,000	0	1,000	0	10	0	....	0	500	5,000	200	50	....
3	D125159	Hx654	0	....	700	7	30	30	50,000	0	700	0	10	0	....	0	500	2,000	100	10	....
4	D125439	Fa280	0	....	500	10	10	30	50,000	0	700	0	3	0	....	0	300	3,000	150	20	....
5	D125442	Hx460	0	....	300	15	15	70	70,000	0	1,000	0	7	0	....	0	500	5,000	200	20	....
6	D125443	Hx464	0	....	150	15	1.5	30	50,000	0	1,000	0	0	0	....	0	500	5,000	200	20	....
7	D125450	Bd554	0	....	200	15	20	70	50,000	0	1,000	0	7	0	....	0	300	5,000	150	20	....
8	[1]D124685	Hx377	0	....	700	5	3	7	30,000	0	500	0	0	0	....	0	....	2,000	20	20	....
9	D124072	Hx211A	0	....	1,000	10	10	15	50,000	0	1,000	0	3	0	....	0	....	5,000	200	30	....
[1] Also found 3 ppm Be.																					
E. Granite or aplite																					
1	[1]D125440	Fa312	0	....	300	0	5	7	7,000	0	700	0	0	10	....	0	20	150	0	10	....
2	[2]D125160W	Hx603B	0	....	200	0	5	5	10,000	0	200	0	0	15	....	0	20	50	0	15	....
3	D125154	Hx564	0	....	3,000	0	1	7	10,000	0	100	0	0	10	....	0	500	500	15	0	....
[1] Also found 7 ppm Be, Tr, Li.																					
[2] Also found 1 ppm Be, 10 ppm Nb.																					
F. Hornblende, garnetiferous rock of diorite composition and associated rocks																					
1	D125444	Hx491	0	....	100	20	30	150	30,000	0	1,000	0	20	0	....	0	300	1,000	200	10	....
2	D125446	Hx513A	0	....	15	20	20	100	70,000	0	700	0	15	0	....	0	500	5,000	200	0	....
3	D125447	Hx513B	0	....	30	50	50	150	>100,000	0	500	0	70	0	....	0	150	2,000	500	10	....
4	D126152	Hx485	0	....	100	20	50	30	>100,000	0	1,500	0	15	0	....	0	200	3,000	300	15	....

LITHOLOGIC UNIT

A1. Pale-gray calcareous siltstone with ellipsoidal masses of limestone, Tidal Formation of Rossman (1963b).
2. Dark-gray slaty argillite, interlayered with A1.
3. Interlayed siltstone and calcareous siltstone, Tidal Formation of Rossman (1963b).

B1. Gray finely crystalline massive limestone, Willoughby Limestone of Rossman (1963b).
2. Gray finely crystalline thin-bedded limestone.
3. Dark-gray carbonaceous limestone, Black Cap Formation of Rossman (1963b).
4. Limestone and argillite, interlayered, typical of Rendu Formation of Rossman (1963b).

C1. Mafic dike.
2. Mafic igneous rock, forms sill-like masses.
3. Mafic dike.
4. ....do........
5. ... do.... ..

C6. Mafic dike.
7. . do .... ..

D1. Biotite-hornblende granodiorite.
2. Biotite-hornblende quartz diorite.
3. Biotite-hornblende granodiorite or quartz monzonite.
4. Hornblede-biotite quartz diorite.
5. Biotite-hornblende diorite or granodiorite.
6. Hornblende diorite.
7. Hornblende-biotite diorite or granodiorite.
8. Biotite quartz monzonite.
9. Quartz monzonite or granodiorite.

E1. Leucogranite or quartz monzonite.
2. Leucogranite.
3. Aplite.

F1. Hornblende-garnet "diorite."
2. Gneissic diorite, disseminated sulfides visible.
3. Hornblendite associated with 2.
4. Hornblende-garnet "diorite."

minerals or in metal deposits, it is shown because it may indicate alteration or strontium metasomatism.

UNALTERED ROCKS

Rocks in Glacier Bay National Monument contain differing amounts of trace elements, depending on their origin, lithology, and major-element composition. Many samples would be required to define exactly the trace-element geochemistry of the bedrock units, but spectrographic analyses (table 3) of 30 apparently unaltered and unmineralized rocks provide a basis for some generalizations.

Limestones probably have lower trace-element contents than any other rock type common in the monument. The range in concentraion in four analyzed samples is 0–3 ppm cobalt, 5–30 ppm chromium, 3–20 ppm copper, and 0–15 ppm nickel. No lead or zinc was detected. Streams draining unaltered limestone terranes should, therefore, have a low content of these metals. Three analyzed samples of detrital clastic sedimentary rocks contain as much as 15 ppm cobalt, 70 ppm chromium, 100 ppm copper, and 30 ppm nickel, indicating that streams draining unaltered detrital clastic rock terranes should carry these metals in considerable abundance.

Of the igneous rocks in the monument, the diorite-granodiorite-quartz diorite suite was the most adequately sampled and analyzed. The average (arithmetic mean) concentration of selected elements is compared below with values for similar rocks reported by Turekian and Wedepohl (1961):

	Ba	Co	Cr	Cu	Ni	Sr
High calcium granitic rocks:						
1. Granodiorites and other granite rocks of Glacier Bay	506	12	14	40	5	443
2. Average of Turekian and Wedepohl (1961)	420	7	22	30	15	440

Based on only three samples, the leucocratic granitic rocks (which are mainly adamellites) have an appreciably different trace-element suite, including trace amounts of lead. Semiquantitative analysis shows that one sample contains 7 ppm beryllium and a trace of lithium, elements characteristic of some leucocratic granites that have associated ore deposits.

More mafic rocks, such as hornblendite and gneissic garnetiferous diorite, generally contain higher concentrations of the elements cobalt, chromium, copper, and nickel. Mafic dikes, including lamprophyres, locally contain very high concentrations of these elements, particularly chromium and nickel. The mafic dikes are locally abundant and probably contribute important amounts of these metals to stream sediments.

CAUSES OF ANOMALOUS VALUES

Anomalous concentrations of metallic elements occur in stream-sediment samples from various parts of Glacier Bay National Monument; some of these concentrations indicate the presence of mineralized rocks and are discussed in the following section. In a few places, similar anomalous concentrations indicate unusual amounts of metals contained in the country rocks or, directly or indirectly, the effects of glaciation.

Swarms of mafic dikes are the probable source of anomalous concentrations of metallic elements in some parts of the monument. Such dike swarms make up as much as 40 percent of the bedrock in some areas. Some of the dikes contain unusual amounts of elements such as chromium and nickel, and most are bordered by thin selvages of baked and bleached rock with abundant thin carbonate veinlets. Erosion of the dike and contact-zone rocks provides material relatively rich in metallic elements; hence, the presence of anomalous nickel and chromium in the stream sediments probably indicates the presence of dike swarms rather than ore deposits.

Aggrading glacial streams accumulated metal concentrates that may or may not be indicative of bedrock mineralization upstream. Some glacial outwash stream sediments show small, but real, concentrations of a suite of elements including iron, titanium, lanthanum, chromium, niobium, vanadium, yttrium, and zirconium. These concentrates were caused by a lag effect; the fast-moving glacial streams selectively carried off light minerals and left the heavy minerals that contain this suite of elements. That the same suite of metals was found in panning concentrates indicates the validity of the proposed mechanism.

RESULTS OF GEOCHEMICAL STUDIES

The geochemical studies show both many local concentrations of metals in stream sediments and systematic geographic distributions for individual elements. Some of the distribution patterns are related to mineral deposits in the bedrock, some to metal-rich country rocks, some to lag concentrates, and others are not clearly related to any of these. The distribution of anomalous values shown in figures 3–7 and on plates 2–8 are discussed below with reference to known geologic features. The interpretations given are necessarily brief, and further development of the detailed relations between stream-sediment metal contents and bedrock composition of the drainage basins involved is possible in some instances.

TOTAL HEAVY METALS

Anomalous THM values are widely scattered at Glacier Bay (pl. 2). Some of them cannot be assigned to any distinct mineralized zone and are interpreted to be the result of widely scattered, but individually small, centers of hydrothermal alteration and metallization.

Inspection of the map shows that THM values are generally higher in the relatively unmetamorphosed and predominantly detrital clastic Chilkat province than in the predominantly metamorphic and granitic Geikie or Muir province (fig. 2). Within the Chilkat province there are noticeable concentrations of anomalous THM values near the head of Excursion River, near Miller Peak and Sandy Cove, and northwest of Tidal Inlet near Mount Merriam. The areas near Miller Peak-Sandy Cove and Mount Merriam are underlain by a variety of sedimentary rocks cut by small stocks and are discussed under "areal descriptions."

Anomalously high samples near the head of Excursion River are close to a prominent fault zone, which controls the north-northwest course of the river and are probably related to mineralization along the fault zone, such as that known at the head of Adams Inlet. Farther east, additional subparallel faults are suggested by prominent topographic alinements. Some of the anomalous samples, particularly those in uppermost Berg Creek, show high copper and chromium contents also.

Isolated anomalous values scattered through the Chilkat province are probably related to additive contact metamorphism or related mineralization. Isolated anomalous THM values east, west, and south of Snow Dome are related to an abundantly iron-stained contact zone with small magnetite masses adjacent to a granodiorite stock. An isolated anomalous THM value north of the Nunatak molybdenum prospect probably reflects copper and zinc added during molybdenum mineralization. High THM values north and south of White Glacier probably result from the zinc and copper deposits (pl. 1, loc. 6) known in the area.

In the Geikie province, high THM values are concentrated near Dundas Bay. Many of these values are due to high copper contents, and they are discussed either with copper deposits or in the descriptions of the geochemical results in the eastern and western Dundas Bay areas. The Reid Inlet gold area is not marked by any conspicuous THM anomaly, even though the gold deposits contain some sphalerite,which should contribute zinc to the streams. One anomalously high and several moderately high values of THM (60–119 ppm) are found in the Reid Inlet area, however. A very metalliferous stream sediment (1,000 ppm) was found north of the area in Tarr Inlet.

Only a small number of stream-sediment samples were obtained from the Muir province because drainage is predominantly glacial. The region seems to have a low THM content.

COPPER

The copper distribution pattern (pl. 3) resembles that of the THM distribution, particularly in the generally higher metal values of the Chilkat province in comparison with the Muir and Geikie provinces. The pattern is not, however, identical with THM; part of the difference is due to test method: the THM test is most sensitive for zinc and less sensitive for copper and lead; hence, high THM does not necessarily indicate high copper. The difference between THM and copper values is very noticeable at the head of Excursion River and in the Miller Peak-Sandy Cove area. At both of these places, only part of the THM anomalies is due to copper and an appreciable part is due to zinc, as is shown by comparison of the THM and the copper, zinc, and lead spectrographic analyses. In other places, as in uppermost Berg Creek east of Adams Inlet, anomalies barely discernible in THM are better shown in copper.

No copper anomalies were found in the Muir province, although it should again be noted that this area is extensively covered by glaciers and has few flowing streams.

The Geikie province contains several conspicuous copper anomalies, even though the background copper content is lower here than the Chilkat province. The largest anomaly is east of Dundas Bay, where the copper content is as much as 300 ppm in streams draining a large altered and mineralized area (pl. 1). Near the head of Taylor Bay, copper and THM values are high in a small creek draining across a gold prospect (Rossman, 1963b, pl. 1). Most of the Reid Inlet gold area does not contain copper anomalies, but stream sediments collected east and west of the central part of the area do have anomalous copper contents. An isolated stream-sediment sample on the west side of Tarr Inlet contained 700 ppm copper. A single sample from near the south end of the peninsula between Tarr and Rendu Inlets shows a value that is barely anomalous, but may be significant, as the sample locality is near a locally magnetite-bearing batholithic contact zone.

LEAD

The distribution of lead resembles that of THM, but the correlation with the copper pattern is less marked. The data indicate broad areas of anomalous lead concentration in the southern part of the Chilkat province and in the northern and southern parts of the Geikie province (pl. 4).

Lead is somewhat enriched in two samples south of Snow Dome, one of which was marked by an anomalous THM value; these high values are probably derived from mineralization in a nearby contact zone. Lead also furnishes one of the few geochemical clues to the Reid Inlet gold area; anomalous amounts of lead are present in drainages on the Lamplugh Glacier side of the area. Galena present in the gold deposits probably explains the anomalous values.

A small lead and THM anomaly north of Marble Mountain may be related to hydrothermally altered limestone country rock. The highest lead value found (200 ppm) is from the west shore of Tarr Inlet and coincides with anomalous values in THM, copper, and other metals. Slightly enriched values of lead (16–24 ppm) occur in drainages entering the south side of Johns Hopkins Inlet and also east of the Tarr Inlet about due east of the 200 ppm anomaly noted above. At both places the streams drain leucocratic granitic rocks, the only unmineralized rocks in the monument which contain spectrographically detectable lead (table 3).

MOLYBDENUM

The largest area of anomalous molybdenum content is in the northernmost Chilkat province near Mount Merriam. Other areas of possible significance are near Miller Peak and Sandy Cove and at the head of Dundas Bay. Because of the relatively poor sensitivity (10 ppm), the spectrographic analyses indicated only markedly anomalous values of molybdenum. As a result, no regional molybdenum background was detected (pl. 5).

Detailed soil sampling (pl. 12) disclosed anomalous molybdenum values near the Nunatak molybdenum deposit. The stream-sediment sampling program did not detect the deposit, probably because of the recent glacial erosion which stripped off all enriched soil and because of the diluting effect of the surrounding extensive outwash deposits.

CHROMIUM AND NICKEL

Chromium (pl. 6) and nickel (pl. 7) have a distribution pattern that generally resembles the pattern for copper (pl. 3). As is true of all the metallic elements discussed, chromium and copper are regionally most abundant in the Chilkat province.

The largest chromium anomaly in the Chilkat province is in upper Berg Creek. This area, which is also the site of a copper anomaly, is underlain by mixed volcanic and detrital clastic rocks, and some iron-stained zones crop out nearby. The chromium anomaly may persist downstream to Adams Inlet. Another chromium anomaly traceable downstream was detected along a tributary on the west side of Queen Inlet in an area where limestone and limy sandstone are intruded by granitic rocks.

Two anomalous and several moderately high chromium values near Mount Wright are apparently caused by a mafic dike swarm, and isolated values elsewhere may mark mafic dikes. Nickel is also markedly enriched near Mount Wright.

OTHER ELEMENTS

Anomalous amounts of tin, tungsten, strontium, silver, and other metals are recorded on plate 8. Tungsten was found in only two samples at the head of Dundas Bay, near exposures of leucocratic granitic rocks. High tin content was noted there and at several other places, the most significant being the 500 ppm content of the highly anomalous stream sediment sample in Tarr Inlet.

Silver was found in amounts ranging from 1 to 10 ppm in samples from several scattered localities, including the Tarr Inlet sample and a sample found south of Margerie Glacier. Strontium is markedly enriched in two areas, the Miller Peak-Sandy Cove area and the Mount Merriam area. Both are also characterized by relatively high THM and molybdenum values.

AREAL DESCRIPTIONS

More detailed geochemical data are available for some of the areas of the monument in which mineral deposits are known or in which one or more geochemical anomalies were detected. Areas for which more complete data exist are western Dundas Bay, eastern Dundas Bay, Miller Peak-Sandy Cove, Mount Merriam, and Reid Inlet (figs. 3–7).

WESTERN DUNDAS BAY AREA

Scattered anomalous values of THM, beryllium, copper, molybdenum, tin, and tungsten occur in the western Dundas Bay area (fig. 3). Some of the high THM values are caused mainly by anomalously high copper concentrations, others by zinc.

Tungsten-tin-molybdenum anomalies occur in two streams entering the head of Dundas Bay (table 4 and fig. 3, samples 12, 13) The tungsten content of these samples is unusally high and molybdenum and tin are also noticeably enriched. The headwaters of the stream of sample 12 drain an area near the contact of older granitic rocks and a leucocratic pluton,

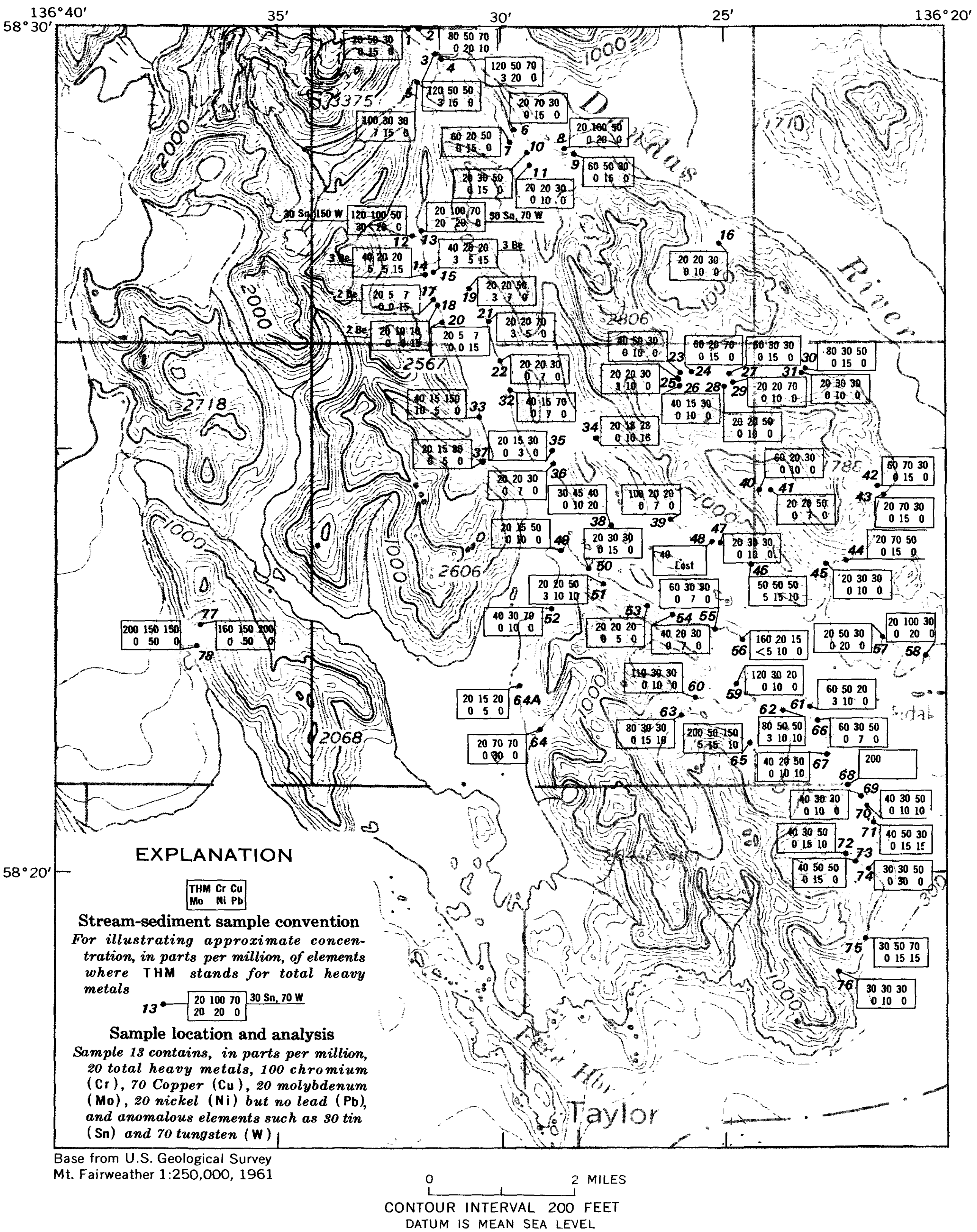


FIGURE 3.—Geochemical sampling map of the western Dundas Bay area.

TABLE 4.—*Total heavy-metals and semiquantitative spectrographic analyses, in parts per million, of stream-sediment samples, western Dundas Bay area*

[THM, total heavy-metals (Cu+Pb+Zn) field test; 0, looked for, but not found; ..., not looked for]

Loc. (fig.3)	Lab. No. D125–	Field No. 66–	THM	Semiquantitative spectrographic analyses																		
				Ag	B	Ba	Co	Cr	Cu	Fe	La	Mn	Mo	Ni	Pb	Sc	Sn	Sr	Ti	V	Y	Zr
1	720	Fd365	20	0	...	300	15	50	30	50,000	30	1,000	0	15	0	...	0	300	3,000	200	30	...
2	733	Bd643	80	0	...	300	20	50	70	70,000	30	1,000	0	20	10	...	0	500	5,000	200	30	...
3	721	Fd366	120	0	...	300	15	50	50	70,000	100	700	3	15	0	...	0	200	3,000	300	30	...
4	734	Bd644	120	0	...	300	20	50	70	70,000	30	1,000	3	20	0	...	0	300	5,000	200	30	...
5	722	Fd367	100	0	...	300	15	30	30	50,000	70	700	7	15	0	...	0	200	3,000	150	30	...
6	719	Fd364	20	0	...	300	15	70	30	50,000	30	1,000	0	15	0	...	0	500	5,000	200	20	...
7	732	Bd642	60	0	...	200	15	20	50	70,000	30	1,500	0	10	0	...	0	200	5,000	300	50	...
8	717	Ed362	20	0	...	200	20	100	50	50,000	30	1,000	0	20	0	...	0	500	5,000	200	30	...
9	730	Bd640	60	0	...	300	15	50	30	70,000	30	1,000	0	15	0	...	0	300	5,000	200	30	...
10	731	Bd641	20	0	...	300	15	30	50	70,000	30	1,000	0	15	0	...	0	300	5,000	200	30	...
11	718	Fd363	20	0	...	300	15	20	30	50,000	0	1,000	0	10	0	...	0	200	3,000	200	30	...
12	[1]723	Fd368	120	0	...	300	15	100	50	50,000	50	700	30	20	0	...	30	300	3,000	200	30	...
13	[2]787	Bd646	20	0	...	500	15	100	70	70,000	50	1,000	20	20	0	...	30	500	3,000	200	30	...
14	[3]454	Bd563	40	0	...	300	7	20	20	50,000	50	700	3	5	15	...	0	150	2,000	100	50	...
15	[3]453	Bd562	40	0	...	300	7	20	20	30,000	70	1,000	5	5	15	...	0	150	2,000	100	50	...
16	716	Fd361	20	0	...	300	20	30	30	70,000	30	1,000	0	10	0	...	0	300	5,000	300	30	...
17	[4]455	Bd565	20	0	...	200	0	5	7	20,000	150	500	0	0	15	...	0	100	1,000	30	30	...
18	[4]456	Bd566	20	0	...	200	3	10	10	15,000	50	1,000	0	0	15	...	0	100	700	30	30	...
19	452	Bd561	20	0	...	200	15	20	50	70,000	30	1,000	3	7	0	...	0	200	5,000	300	30	...
20	[4]457	Bd567	20	0	...	300	0	5	7	20,000	100	700	0	0	15	...	0	100	1,500	30	50	...
21	451	Bd560	20	0	...	200	15	20	70	50,000	30	1,000	3	5	0	...	0	300	3,000	200	30	...
22	474	Bd559	20	0	...	200	15	20	30	50,000	0	1,000	0	7	0	...	0	150	5,000	200	30	...
23	726	Bd636	40	0	...	200	15	50	30	50,000	30	700	0	10	0	...	0	200	3,000	200	20	...
24	727	Bd637	60	0	...	200	20	20	70	70,000	0	1,000	0	15	0	...	0	200	5,000	200	30	...
25	693	Fd356	20	0	...	300	15	30	30	50,000	30	1,000	3	10	0	...	0	300	3,000	200	20	...
26	694	Fd357	40	0	...	300	15	15	30	50,000	30	1,000	0	10	0	...	0	200	3,000	200	30	...
27	728	Bd638	60	0	...	300	15	30	30	70,000	0	1,000	0	15	0	...	0	300	5,000	200	30	...
28	695	Fd358	20	0	...	200	20	20	50	70,000	0	1,000	0	10	0	...	0	200	3,000	300	30	...
29	696	Fd359	20	0	...	200	10	20	70	50,000	0	1,000	0	10	0	...	0	200	2,000	150	30	...
30	729	Bd639	80	0	...	200	15	30	50	70,000	30	1,500	0	15	0	...	0	200	5,000	200	30	...
31	715	Fd360	20	0	...	200	15	30	30	70,000	0	1,000	0	10	0	...	0	200	5,000	300	30	...
32	473	Bd558	40	0	...	200	15	15	70	50,000	0	1,000	0	7	0	...	0	200	5,000	200	20	...
33	459	Bd569	40	0	...	150	15	15	150	>100,000	0	1,500	10	5	0	...	0	200	3,000	200	20	...
34	862	Ov1611	20	0	0	290	14	18	28	67,000	0	1,100	0	10	16	27	0	470	6,100	270	38	370
35	474	Bd556	20	0	...	200	20	20	30	50,000	0	1,000	0	7	0	...	0	200	3,000	200	20	...
36	471	Bd555	20	0	...	150	10	15	30	30,000	0	700	0	3	0	...	0	100	2,000	100	15	...
37	[3]460	Bd571	20	0	...	200	10	15	30	50,000	30	700	0	5	0	...	0	200	2,000	150	30	...
38	350	Bd552	20	0	...	200	15	20	30	30,000	0	1,000	0	7	10	...	0	200	3,000	150	15	...
	351	Bd553	20	0	...	250	15	70	50	40,000	0	1,000	0	15	30	...	0	300	3,000	200	20	...
39	742	Ov1612	20	0	...	200	15	20	20	50,000	0	1,000	0	7	0	...	0	200	3,000	150	30	...
40	724	Bd634	60	0	...	200	15	20	30	70,000	0	700	0	10	0	...	0	200	3,000	200	30	...
41	691	Fd354	20	0	...	200	15	20	50	50,000	0	1,000	0	7	0	...	0	200	3,000	200	30	...
42	725	Bd635	60	0	...	300	15	70	30	70,000	30	1,000	0	15	0	...	0	300	5,000	300	30	...
43	692	Fd355	20	0	...	300	20	70	30	70,000	30	1,000	0	15	0	...	0	300	5,000	300	30	...
44	347	Bd539	20	0	...	500	15	70	50	70,000	30	1,000	0	15	0	...	0	300	3,000	300	20	...
45	476	Sj14	20	0	...	300	15	30	30	100,000	30	1,000	0	10	10	...	0	300	5,000	300	30	...
46	744	Ov1616	50	0	...	300	15	50	50	50,000	0	1,000	5	15	10	...	0	200	5,000	200	20	...
47	743	Ov1614	20	0	...	300	15	30	30	50,000	0	1,000	0	10	0	...	0	200	3,000	200	20	...
48	([5])	Ov1615	40	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
49	482	Mk435	20	0	...	500	15	15	50	50,000	30	700	0	10	0	...	0	300	7,000	200	20	...
50	483	Mk436	20	0	...	500	15	30	30	50,000	30	1,000	0	15	0	...	0	300	5,000	200	20	...
51	484	Mk437	20	0	...	300	15	20	50	70,000	0	1,000	3	10	10	...	0	300	3,000	200	30	...
52	340	Fd287	40	0	...	200	20	30	70	70,000	30	700	0	10	0	...	0	300	7,000	200	30	...
53	485	Mk438	20	0	...	300	15	20	20	70,000	0	1,000	0	5	0	...	0	200	3,000	200	30	...
54	486	Mk439	40	0	...	200	15	20	30	70,000	0	1,000	0	7	0	...	0	150	3,000	200	20	...
55	487	Mk441	60	0	...	500	15	30	30	50,000	0	1,000	0	7	0	...	0	300	3,000	200	20	...
56	488	Mk443	160	0	...	300	30	20	15	>100,000	0	1,500	<5	10	0	...	0	300	3,000	200	20	...
57	697	Hf330	20	0	...	300	15	50	30	70,000	30	1,000	0	20	0	...	0	300	5,000	300	20	...
58	698	Hf329	20	0	...	300	15	100	30	70,000	30	2,000	0	20	0	...	0	500	5,000	500	30	...
59	489	Mk444	120	0	...	300	15	30	20	50,000	0	1,000	0	10	0	...	0	200	3,000	200	20	...
60	490	Mk446	110	0	...	300	15	30	30	50,000	0	1,000	0	10	0	...	0	200	5,000	200	20	...
61	495	Mk452	60	0	...	500	15	50	20	70,000	0	1,000	3	10	0	...	0	300	3,000	200	20	...
62	494	Mk450	80	0	...	200	15	50	50	50,000	0	1,000	3	10	10	...	0	200	2,000	150	20	...
63	492	Mk447	80	0	...	200	15	30	30	70,000	0	1,000	0	15	10		0	300	5,000	300	20	...
64	342	Fd290	20	0	...	200	20	70	70	70,000	0	700	0	30	0	...	0	300	3,000	200	20	...
65	493	Mk449	200	0	...	200	15	50	150	50,000	0	1,000	5	15	10	...	0	300	3,000	200	20	...
66	496	Mk453	60	0	...	150	15	30	50	70,000	0	1,000	0	7	0	...	0	150	2,000	150	20	...
67	509	Bd609	40	0	...	300	15	20	50	50,000	0	1,000	0	10	10	...	0	200	5,000	200	20	...
68	[6]510	Bd610	200																			
69	512	Bd613	40	0	...	300	15	30	30	50,000	0	1,000	0	10	0	...	0	200	3,000	150	20	...
70	511	Bd612	40	0	...	300	0	30	50	50,000	0	1,000	0	10	10	...	0	200	3,000	150	20	...

[1] Also found 150 ppm W.
[2] Also found 70 ppm W.
[3] Also found 3 ppm Be.
[4] Also found 2 ppm Be.
[5] Lost.
[6] Sample contaminated by waste from old cannery.

TABLE 4.—*Total heavy-metals and semiquantitative spectrographic analyses, in parts per million, of stream-sediment samples, western Dundas Bay area*—Continued

Loc. (fig.3)	Lab. No. D125–	Field No. 66–	THM	Semiquantitative spectrographic analyses																		
				Ag	B	Ba	Co	Cr	Cu	Fe	La	Mn	Mo	Ni	Pb	Sc	Sn	Sr	Ti	V	Y	Zr
71	513	Bd614	40	0	......	200	15	50	30	50,000	30	1,000	0	15	15	......	0	200	3,000	200	20	......
72	515	Bd617	40	0	......	300	15	30	50	70,000	30	1,000	0	15	10	......	0	300	3,000	200	20	......
73	514	Bd616	40	0	......	200	15	50	50	50,000	0	1,000	0	15	0	......	0	300	3,000	200	20	......
74	516	Bd618	30	0	......	150	30	30	50	70,000	0	1,000	0	30	0	......	0	200	3,000	200	20	......
75	517	Bd620	30	0	......	500	15	50	70	70,000	30	1,000	0	15	15	......	0	300	3,000	200	20	......
76	518	Bd621	30	0	......	300	15	30	30	50,000	0	1,000	0	10	0	......	0	300	3,000	200	20	......
64A	341	Fd289	20	0	......	150	15	15	20	50,000	0	1,000	0	5	0	......	0	150	2,000	150	15	......
Samples north of Taylor Bay																						
77	497	Mk456	160	0	......	150	30	150	200	70,000	0	1,000	0	50	0	......	0	300	5,000	300	20	......
78	498	Mk458	200	0	......	150	30	150	150	>100,000	30	1,000	0	50	0	......	0	300	7,000	500	20	......

and it seems probable that the source of the anomaly is mineralization along or near the contact.

The compositon of the leucocratic pluton itself is reflected in the beryllium and lead content of stream-sediment samples from areas underlain by the pluton (table 4, samples 14, 15, 17, 18, 20). The beryllium content of these samples is not high in terms of estimated crustal abundance, but because beryllium is generally present in the monument in concentrations of less than 1 ppm. the 2–3 ppm concentrations represent enrichment. Similarly, the lead content of these samples is only 15 ppm, a level that is not markedly anomalous around Glacier Bay, but is locally anomalous for the western Dundas, where lead content is generally low. Except for the 120 ppm THM value of nearby sample 12, the area with anomalous tungsten does not have anomalous THM content.

Samples that show anomalous values of THM interpreted to be due primarily to zinc or copper are concentrated in a small area on the west side of Dundas Bay, near samples 56, 59, 60 , and 65 (table 4). The high THM values of samples 56 and 59 are probably caused by zinc, as spectrographic determinations show no lead and near background values of copper. One markedly anomalous sample (No. 68, 200 ppm THM) is related to an abandoned cannery, as also evidenced by 0.1 percent tin (not given in table 4).

Anomalous THM and copper values are also found in an unnamed stream draining into the head of Taylor Bay (fig. 3 and table 4, samples 77, 78) from an area of gneissic rocks. Rossman (1963b) reported a gold prospect in the drainage.

EASTERN DUNDAS BAY AREA

A small area east of Dundas Bay and not far north of Icy Strait contains two THM anomalies (fig. 14). The first, near the shore, contains both high THM and copper values and occurs in an altered zone. The metal content of the zone ranges from 100 to 300 ppm copper and as much as 30 ppm lead (table 5, 2–5). This occurrence is described more completely under copper mineral deposits. The second anomaly, about 3 miles farther east, contains high THM values (table 5, samples 8–10, and possibly 18). The most metal-rich sample (No. 8) was taken from a streambed along the contact of an igneous pluton with limestone country rock. Near sample 18 on Icy Strait, limestone exposed along the beach contains jasperoid masses as much as a foot across. This THM anomaly is partly due to zinc, because the THM values in samples 8–10 are in excess of copper plus lead.

MILLER PEAK-SANDY COVE AREA

The Miller Peak-Sandy Cove area is on the east side of Glacier Bay, north of the mouth of Beartrack River and south of Mount Wright (fig. 5). The area contains the Sandy Cove gold-copper prospect, which is just to the east of sample locations 41 and 41A. In addition, there are several small areas of anomalous metal content, discussed geographically starting at the northwest part of the mapped area.

Stream-sediment samples collected south of Mount Wright, particularly samples 1–13 and 19, 22, and 23 (table 6), are generally characterized by anomalous or relatively high values in THM copper, chromium, and nickel. The area is mainly underlain by fine-grained detrital sedimentary rocks, subordinate limestone, and amygdaloidal basalt or andesite, which are all cut by numerous mafic dikes. Our interpretation is that the anomalous metal value are probably derived from the dikes or small-scale vein mineralization in the baked and altered adjacent country rock.

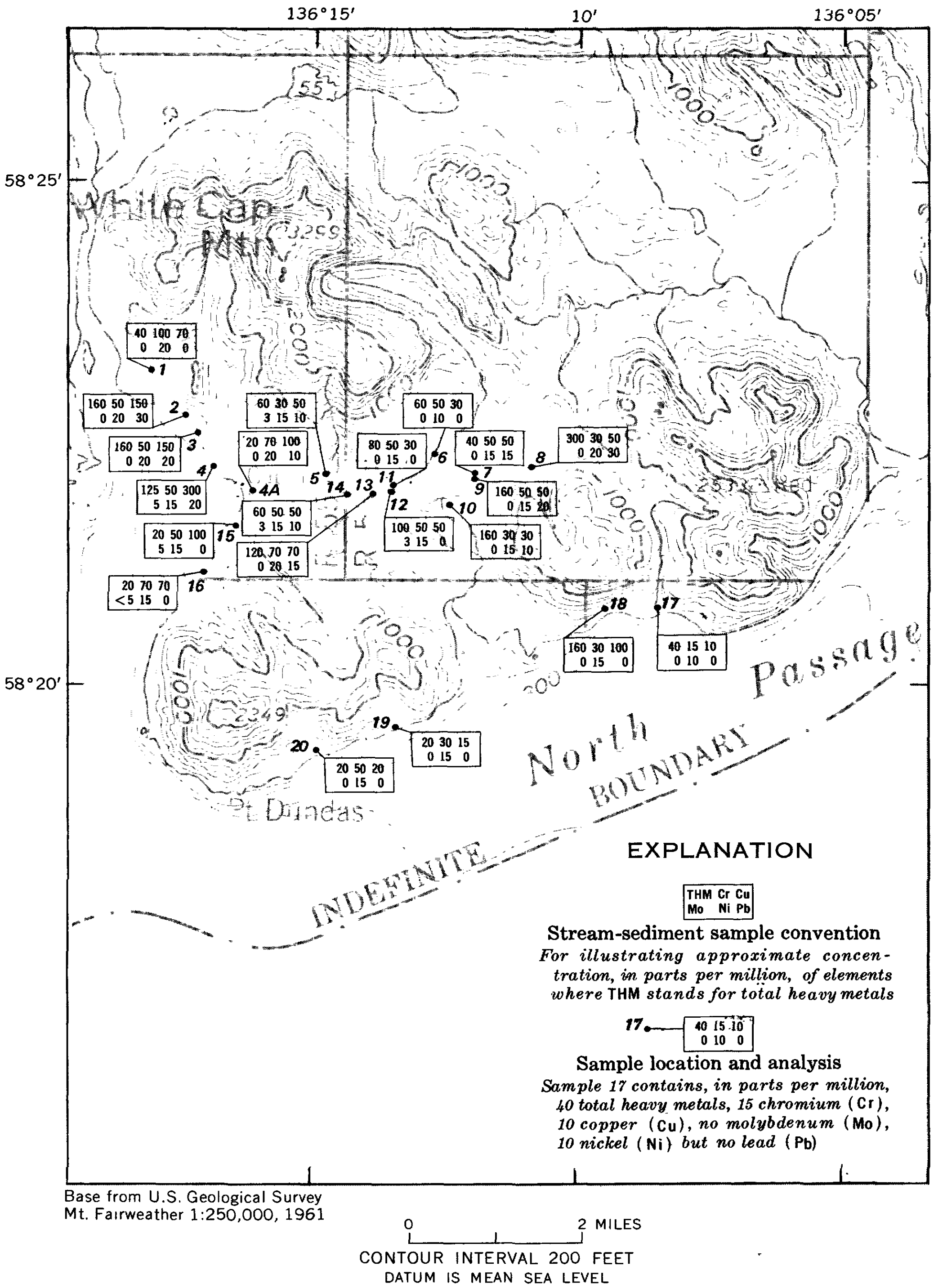


FIGURE 4.—Geochemical sampling map of the eastern Dundas Bay area.

Streams farther east (table 6, samples 14, 15) drain a mixed sedimentary terrane which includes limestone, and the THM values may largely represent zinc from mineralized carbonate rocks like those known to exist near White Glacier (pl. 1). Similar mineralization may exist to the south and southeast of samples 28–38, where the anomalous or relatively high values of THM and trace amounts of lead may be derived from a mixed sedimentary terrane.

A group of samples in a tributary stream east of the Beartrack River (particularly samples 56–59) show relatively high or anomalous values of THM

TABLE 5.—*Total heavy-metals and semiquantitative spectrographic analyses, in parts per million, of stream-sediment samples, eastern Dundas Bay area*

[THM, Total heavy-metals (Cu+Pb+Zn) field test; 0, looked for, but not found; . . . , not looked for]

Loc. (fig.4)	Lab. No. D125–	Field No. 66–	THM	Semiquantitative spectrographic analyses																		
				Ag	B	Ba	Co	Cr	Cu	Fe	La	Mn	Mo	Ni	Pb	Sc	Sn	Sr	Ti	V	Y	Zr
1	528	Hf320	40	0	...	300	15	100	70	70,000	30	1,000	0	20	0	...	0	300	5,000	300	70	...
2	529	Hf321	160	0	...	300	15	50	150	50,000	0	1,000	0	20	30	...	0	150	3,000	150	15	...
3	530	Hf322	160	0	...	200	15	50	150	50,000	0	1,000	0	20	20	...	0	150	3,000	200	15	...
4	533	Hf325	125	0	...	200	15	50	300	70,000	0	1,000	5	15	20	...	0	150	5,000	200	15	...
5	745	Ov1631	60	0	...	300	20	30	50	70,000	30	1,000	3	15	10	...	0	200	5,000	200	20	...
6	735	Hx552	60	0	...	200	10	50	30	70,000	30	700	0	10	0	...	0	200	3,000	200	20	...
7	739	Hx556	40	0	...	300	15	50	50	50,000	0	1,500	0	15	15	...	0	200	3,000	150	20	...
8	749	Ov1635	300	0	...	700	15	30	50	50,000	30	1,000	0	20	30	...	0	200	3,000	200	15	...
9	748	Ov1634	160	0	...	700	15	50	50	50,000	30	700	0	15	20	...	0	200	2,000	200	15	...
10	738	Hx555	160	0	...	500	10	30	30	30,000	0	700	0	15	10	...	0	150	3,000	150	15	...
11	736	Hx553	80	0	...	300	15	50	30	70,000	30	700	0	15	0	...	0	200	3,000	200	20	...
12	737	Hx554	100	0	...	300	15	50	50	70,000	0	1,000	3	15	0	...	0	200	5,000	200	30	...
13	747	Ov1633	120	0	...	200	20	70	70	70,000	0	1,000	0	20	15	...	0	200	5,000	200	20	...
14	746	Ov1632	60	0	...	200	20	50	50	70,000	0	1,500	3	15	10	...	0	200	3,000	200	15	...
15	689	Hf327	20	0	...	200	15	50	100	70,000	50	1,000	5	15	0	...	0	200	5,000	300	30	...
16	690	Hf328	20	0	...	200	20	70	70	> 100,000	30	1,000	<5	15	0	...	0	200	5,000	500	30	...
17	467	Hx480	40	0	...	1000	7	15	10	50,000	30	700	0	10	0	...	0	200	3,000	150	20	...
18	468	Hx479	160	0	...	300	15	30	100	50,000	0	1,000	0	15	0	...	0	150	3,000	200	20	...
19	339	Fd284	20	0	...	300	10	30	15	70,000	0	700	0	15	0	...	0	150	5,000	200	30	...
20	338	Fd283	20	0	...	300	15	50	20	70,000	50	700	0	15	0	...	0	150	7,000	200	30	...
4A	534	Hf326	20	0	...	300	15	70	100	70,000	30	700	0	20	10	...	0	200	3,000	200	15	...

and copper. The bedrock in the stream drainage is graywacke and argillite, and the origin of the THM and copper values is unknown.

Samples in the southwestern part of the area locally show anomalous values of THM, copper, molybdenum, and strontium. These values are probably related to a pluton near Miller Peak. Samples 92 and 99 show anomalous concentration of copper and molybdenum, respectively.

MOUNT MERRIAM AREA

There are no mines or prospects in the geologically complicated Mount Merriam area (fig 6; pl. 1), but there are many stream drainages containing anomalous concentrations of THM and molybdenum and some outcrops of unprospected mineralized rock. The high THM values seem to be due to zinc, for neither lead nor copper is abundant. The area is similar to the Sandy Cove-Miller Peak area in having numerous high strontium values, suggesting the possibility of either alteration or additive contact metamorphism in the hornfelses and marbles around the granitic stocks.

The highest concentrations of molybdenum are found in a small part of the area east of Composite Island (table 7, samples 8, 13, 14, 20, 21). Some of these samples also have high THM values, which are not confined to this small area, however. Molybdenum is present in greater-than-detectable quantities in all samples from the Mount Merriam area.

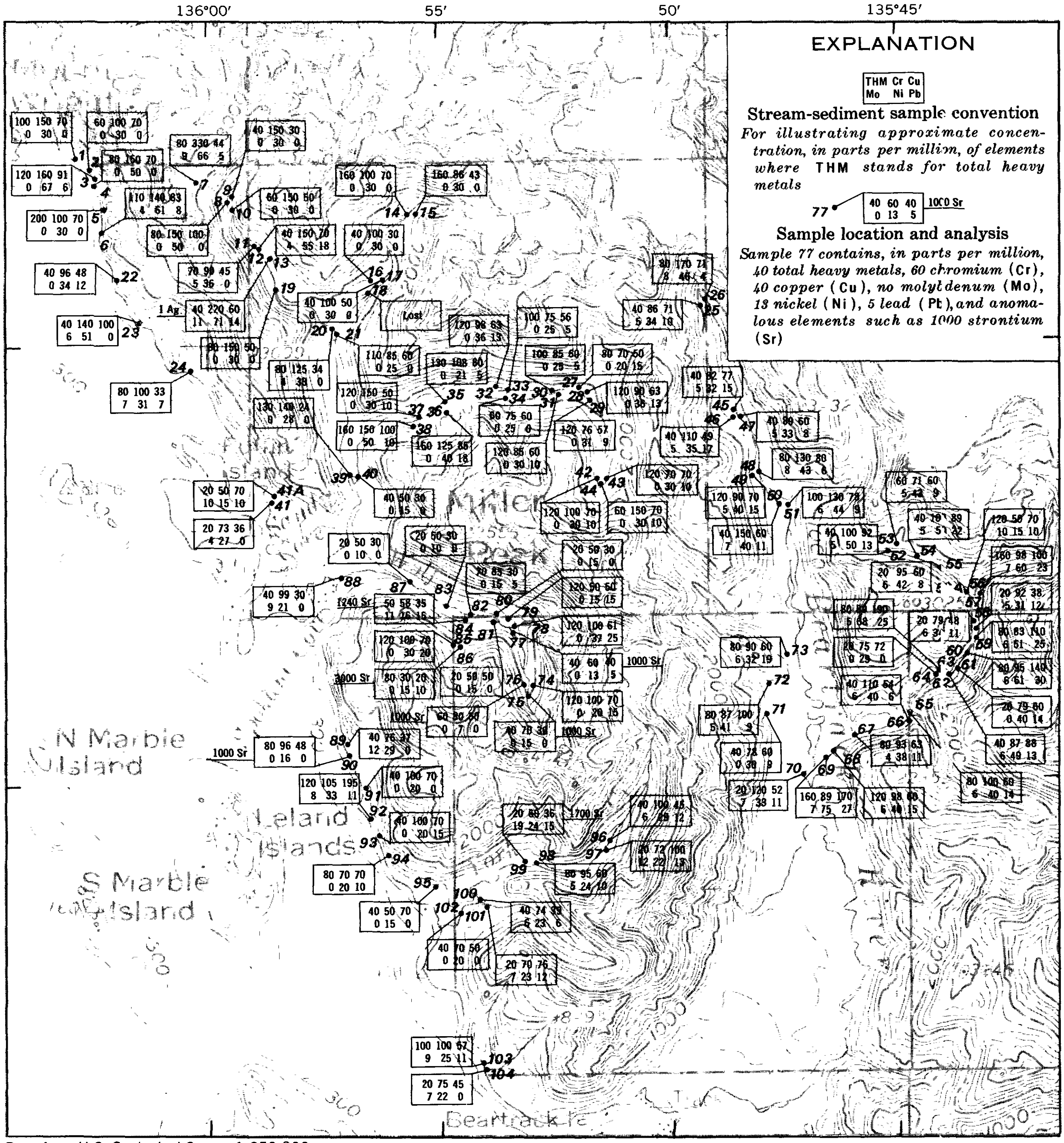
REID INLET GOLD AREA

The Reid Inlet gold area (fig. 7; pl. 1; tables 8, 11, 12) contains the main gold deposits of the monument, but it is not well marked by geochemical patterns.

The mixed greenstone and granite terrane west of Lamplugh Glacier has a distinct copper anomaly, and several of the samples, notably 8, 9 and 16 (table 8) east of Reid Inlet also contain anomalous amounts of copper. Most of the area, however, seems characterized by less than background amounts of copper. As the gold generally is accompanied by galena, lead might be expected to be abundant, but results show it to be only locally abundant (table 8, samples 1–4); a greater sample density might have given a stronger pattern. Since gold was found by panning in Ptarmigan Creek below the LeRoy mine and is visible in vein material elsewhere, the Reid inlet area seems to be an example of an area in which old-fashioned panning is more satisfactory than geochemical methods.

MINERAL DEPOSITS

Deposits of gold, silver, molybdenum, iron, nickel, titanium, copper, and other metals are known from Glacier Bay National Monument. Some of these deposits have been mined or explored on a small scale, but many of them are virtually unexplored. Two of the deposits, the Brady Glacier nickel-copper deposit and the Nunatak molybdenum deposit, have been investigated in some detail. The term "mineral deposit" is used broadly in this report to include anomalous concentrations of ore metals. The deposits described range from small insignificant mineral occurrences to some deposits that apparently are large or rich enough to warrant exploration.



Base from U.S. Geological Survey 1:250,000
Mt. Fairweather 1961 and Juneau 1962

0 2 MILES

CONTOUR INTERVAL 200 FEET
DATUM IS MEAN SEA LEVEL

FIGURE 5.—Geochemical sampling map of the Miller Peak-Sandy Cove area.

TABLE 6.—*Total heavy-metals and semiquantitative spectrographic analyses, in parts per million, of stream-sediment samples, Miller Peak-Sandy Cove area*

[THM, Total heavy-metals (Cu+Pb+Zn) field test; 0, looked for, but not found; ...., not looked for]

Loc. (fig.5)	Lab. No.	Field No. 66—	THM	Semiquantitative spectrographic analyses: Ag	B	Ba	Co	Cr	Cu	Fe	La	Mn	Mo	Ni	Pb	Sc	Sn	Sr	Ti	V	Y	Zr
1	D126106	Hf355	100	0	......	200	15	150	70	50,000	0	500	0	30	0	......	0	200	2,000	150	20	......
2	D126107	Hf356	120	0	......	150	15	100	70	50,000	0	500	0	30	0	......	0	150	3,000	200	20	......
3	D123511	Hx91	120	0	0	260	24	160	91	70,000	34	700	0	67	6	26	0	300	4,300	220	25	100
4	D126109	Hf358	80	0	......	150	15	150	70	70,000	0	1,000	0	50	0	......	0	100	3,000	150	30	......
5	D126108	Hf357	200	0	......	150	15	150	70	70,000	0	1,000	0	30	0	......	0	150	3,000	150	20	......
6	D123512	Hx92	120	0	0	260	25	140	83	56,000	47	900	4	61	8	25	0	350	4,500	210	31	100
	D126110	Hf359	100	0	......	200	20	100	100	70,000	30	1,000	0	30	0	......	0	150	3,000	150	30	......
7	D123528	Hx105	80	0	0	150	42	330	44	41,000	42	800	9	66	5	30	0	420	7,300	270	40	120
8	D125304	Hx465	80	0	......	200	30	150	100	70,000	30	700	0	50	0	......	0	200	5,000	200	20	......
9	D125317	Bd517	40	0	......	300	10	150	30	50,000	30	500	0	30	0	......	0	300	5,000	150	20	......
10	D125318	Bd518	60	0	......	300	15	150	50	50,000	30	500	0	30	0	......	0	300	3,000	150	20	......
11	D123531	Hx119	80	1	0	460	18	110	40	40,000	42	990	10	42	0	22	0	600	4,100	180	30	99
	D125305	Hx466	60	0	......	200	15	70	50	70,000	30	700	0	30	0	......	0	300	5,000	200	30	......
12	....	Hx118	40	0	0	810	25	150	70	49,000	29	800	8	59	15	28	0	330	5,100	250	32	110
	D125319	Bd519	20	0	......	700	20	150	70	70,000	0	1,000	0	50	20	......	0	200	3,000	200	20	......
13	D123532	Hx120	40	1	0	590	26	220	60	38,000	52	700	11	71	14	27	0	290	4,300	270	31	110
14	D123964	Bd150	160	0	......	200	15	100	70	50,000	20	500	0	30	0	......	0	......	3,000	700	15	......
15	D124081	Hx178	160	0	0	70	14	86	43	24,000	30	820	0	30	0	18	0	440	1,900	110	15	60
16	D125307	Hx468	40	0	......	150	15	100	30	50,000	30	700	0	30	0	......	0	300	3,000	200	20	......
17	D125306	Hx467	40	0	......	150	15	100	50	50,000	30	700	0	30	0	......	0	300	3,000	200	20	......
18	....	Bd521	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
19	D125320	Bd520	80	0	......	500	15	150	50	70,000	30	500	0	30	0	......	0	300	5,000	200	30	......
20	D124082	Hx180	120	0	0	240	16	100	38	33,000	41	910	7	36	0	22	0	590	5,400	150	35	100
	D125308	Hx469	40	0	......	300	15	150	30	70,000	30	700	0	30	0	......	0	300	5,000	200	20	......
21	D123965	Bd151	120	0	......	150	10	70	50	30,000	20	500	0	20	0	0	0	......	2,000	100	15	......
	D125321	Bd522	100	0	......	150	15	100	70	30,000	30	700	0	30	0	......	0	300	3,000	150	15	......
22	D123513	Hx95	40	0	0	440	13	96	48	61,000	38	800	0	34	12	21	0	400	4,100	200	28	120
23	D123514	Hx97	40	0	0	310	21	140	100	45,000	47	800	6	51	0	23	0	300	3,200	190	26	100
24	D123522	Hx99	80	0	0	300	14	100	33	33,000	39	500	7	31	7	20	0	600	4,200	160	23	130
25	D124288	Ov867	40	0	0	220	15	86	71	43,000	30	500	5	34	10	18	0	300	4,100	200	20	100
26	D124289	Ov868	80	0	0	160	23	170	71	30,000	40	700	8	46	4	24	0	420	6,000	260	30	100
27	D123967	Bd153	80	0	......	150	10	70	50	50,000	20	500	0	20	15	......	0	......	3,000	100	15	......
28	D124084	Hx182	120	0	0	170	13	90	63	34,000	28	790	0	36	13	19	0	330	3,200	140	18	82
29	D124085	Hx183	120	0	0	200	9	76	57	38,000	21	630	0	31	9	16	0	200	2,900	130	11	85
30	D125324	Bd525	100	0	......	200	15	70	70	30,000	0	500	0	20	0	......	0	200	3,000	150	15	......
	D125326	Bd527	100	0	......	200	15	100	50	50,000	0	300	0	30	10	......	0	200	3,000	200	15	......
31	D125325	Bd526	120	0	......	200	15	70	70	50,000	0	300	0	30	10	......	0	70	3,000	200	15	......
	D125310	Hx471	120	0	......	200	15	100	50	70,000	0	300	0	30	10	......	0	70	3,000	200	20	......
32	D124087	Hx185	120	0	0	220	10	98	63	44,000	23	820	0	36	13	16	0	240	3,700	120	14	98
33	D125327	Bd528	100	0	......	150	10	70	50	30,000	0	300	0	20	10	......	0	150	3,000	150	15	......
	D123968	Bd155	80	0	......	150	10	70	70	30,000	0	300	0	20	0	......	0	......	3,000	100	10	......
	D124086	Hx184	120	0	0	180	10	84	47	32,000	34	700	0	35	5	18	0	280	2,500	140	19	95
34	D123969	Bd156	80	0	......	100	7	50	70	20,000	0	300	0	20	0	......	0		1,500	70	10	......
	D125311	Hx472	40	0	......	150	15	100	50	30,000	30	300	0	30	0	......	0	200	2,000	200	15	......
35	D124088	Hx186	160	0	......	120	8	65	90	21,000	23	740	0	22	9	15	0	290	1,800	100	15	57
	D125312	Hx473	100	0	......	200	15	150	70	50,000	0	500	0	20	0	......	0	200	3,000	200	15	......
36	D123970	Bd157	160	0	......	150	15	100	70	30,000	0	700	0	30	15	......	0		2,000	100	15	......
	D125328	Bd529	160	0	......	150	15	150	100	30,000	0	700	0	50	20	......	0	150	3,000	150	15	......
37	D125329	Bd530	120	0	......	200	10	150	50	50,000	30	300	0	30	10	......	0	300	3,000	150	15	......
38	D125313	Hx474	160	0	......	200	20	150	100	50,000	30	700	0	50	10	......	0	150	5,000	200	20	......
39	D124093	Hx181	120	0	0	230	8	140	24	29,000	37	990	0	28	0	17	0	620	3,100	160	13	91
40	D123966	Bd152	40	0	......	200	7	50	30	30,000	0	300	0	15	0	......	0	......	2,000	100	15	......
41	D124150	Ov691	20	0	0	370	9	73	36	31,000	29	870	4	27	0	19	0	620	3,200	150	21	130
42	D125323	Bd524	120	0	......	200	15	100	70	50,000	0	200	0	30	10	......	0	100	3,000	200	15	......
43	D125309	Hx470	120	0	......	200	15	70	70	70,000	0	300	0	30	10	......	0	100	3,000	200	20	......
44	D125322	Bd523	60	0	......	200	15	150	70	50,000	0	300	0	30	10	......	0	200	3,000	200	15	......
45	D124327	Fd65	40	0	0	250	9	82	77	48,000	21	900	5	32	15	15	0	140	4,000	190	12	120
46	D124290	Ov871	40	0	0	190	12	110	49	26,000	28	610	5	35	17	14	0	180	3,200	180	20	98
47	D124291	Ov872	40	0	0	200	11	89	60	35,000	26	780	5	33	8	16	0	290	3,300	180	17	110
48	D124328	Fd56	8	0	0	200	20	130	80	49,000	31	700	8	43	6	23	0	400	5,000	270	17	120
49	D124292	Ov873	120	0	0	260	15	90	70	40,000	24	830	5	40	15	16	0	120	3,800	200	20	120
50	D124293	Ov874	40	0	0	170	23	150	60	33,000	43	700	7	40	11	21	0	430	4,500	230	17	100
51	D124329	Fd67	100	0	0	280	18	130	78	50,000	32	600	6	44	9	21	0	270	5,900	260	24	130
52	D124425	Ba310	40	0	0	210	12	71	60	36,000	22	870	5	43	9	14	0	370	2,900	150	26	100
53	D124426	Bd311	60	0	27	290	15	100	92	53,000	0	800	5	50	13	15	0	160	4,000	230	14	130
54	D124427	Bd312	40	0	22	300	11	100	89	44,000	0	760	5	50	22	15	0	150	3,500	240	15	130
55	D124428	Bd313	20	0	0	290	12	95	60	44,000	34	600	6	42	8	17	0	80	4,100	230	22	120
56	D124429	Bd314	160	0	0	360	19	98	100	45,000	30	730	7	60	23	18	0	190	3,700	250	20	120
57	D124431	Bd316	20	0	0	280	5	79	48	51,000	20	600	6	34	11	14	0	90	4,200	200	18	110
58	D124432	Bd317	20	0	0	300	6	92	38	32,000	24	870	5	31	12	17	0	130	3,700	210	26	120
59	D124433	Bd318	80	0	0	310	19	83	110	31,000	43	700	6	51	25	13	0	230	2,100	180	19	88
60	D124434	Bd319	80	0	0	330	23	95	140	63,000	22	1,000	6	61	30	20	0	80	4,500	230	30	130
61	[1]D124435	Bd320	20	0	0	300	9	79	60	41,000	0	60	0	40	14	16	0	100	3,500	180	19	140
62	D124436	Bd321	40	0	0	320	20	87	88	50,000	28	750	6	49	13	15	0	290	3,400	210	16	110
63	D124437	Bd322	80	0	0	360	28	89	190	60,000	35	810	5	68	25	16	0	270	3,900	210	17	100
64	D124438	Bd323	20	0	0	280	9	75	72	32,000	21	400	0	29	0	12	0	200	3,300	180	5	120
65	D124439	Bd325	80	0	0	290	13	100	60	35,000	29	720	6	40	14	15	0	260	3,900	200	19	110
66	D124440	Bd326	40	0	0	330	9	110	54	40,000	25	680	6	40	6	17	0	210	3,900	260	16	130
67	[1]D124534	Bd327	80	0	0	300	13	93	63	35,000	30	660	4	38	11	15	0	270	3,200	180	23	100
68	D124330	Fd68	120	0	0	300	11	98	60	46,000	25	750	6	40	15	15	0	230	3,900	210	16	110

[1] Also found 1 ppm Be.

TABLE 6.—*Total heavy-metals and semiquantitative spectrographic analyses, in parts per million, of stream-sediment samples, Miller Peak-Sandy Cove area*—Continued

Loc. (fig.5)	Lab. No.	Field No. 66—	THM	Semiquantitative spectrographic analyses																		
				Ag	B	Ba	Co	Cr	Cu	Fe	La	Mn	Mo	Ni	Pb	Sc	Sn	Sr	Ti	V	Y	Zr
69	D124508	Bd328	160	0	0	330	38	89	170	52,000	59	620	7	75	27	15	0	260	3,100	170	20	150
70	D124297	Ov878	20	0	0	200	16	120	52	28,000	40	700	7	33	11	21	0	410	3,100	240	28	110
71	D124296	Ov877	40	0	0	160	8	78	60	30,000	0	660	0	30	9	12	0	280	1,800	110	9	97
72	D124295	Ov876	80	0	0	240	13	87	100	51,000	34	400	5	41	9	15	0	160	3,100	200	17	100
73	D124294	Ov875	80	0	0	220	12	90	60	35,000	30	400	6	32	19	17	0	300	3,100	200	20	94
74	D125331	Bd532	120	0	......	500	15	100	70	50,000	0	300	0	20	15	......	0	300	3,000	150	20	......
75	D125315	Hx476	40	0	......	200	7	70	30	20,000	30	300	0	15	0	......	0	1,000	1,500	100	10	......
76	D125316	Hx477	60	0	......	200	15	30	50	50,000	30	700	0	7	0	......	0	1,000	3,000	200	15	......
77	D123971	Bd158	40	0	0	150	5	50	30	20,000	0	300	0	10	0	......	0	......	1,500	70	10	......
	D125301	Fd275	40	0	......	200	10	70	50	30,000	0	300	0	15	10	......	0	1,000	15,000	150	15	......
78	D124089	Hx187	160	0	0	170	15	100	52	36,000	26	860	0	43	30	16	0	290	2,200	120	11	73
	D125302	Fd276	80	0	......	200	15	100	70	50,000	30	700	0	30	20	......	0	150	3,000	150	20	......
79	D125332	Bd533	120	0	......	100	7	50	50	15,000	0	500	0	15	15	0	0	200	1,000	70	15	......
80	D125334	Bd535	20	0	......	150	7	50	30	15,000	30	200	0	15	0	......	0	700	2,000	150	10	......
81	D125333	Bd534	20	0	......	200	7	50	50	30,000	30	300	0	15	0	......	0	500	3,000	70	15	......
82	D123972	Bd159	120	0	0	150	7	7	30	30,000	0	500	0	15	10	......	0	......	1,500	70	10	......
	D125335	Bd536	20	0	......	200	5	100	30	20,000	30	300	0	15	0	......	0	700	3,000	100	15	......
83	D125336	Bd537	20	0	......	200	5	50	30	20,000	30	300	0	10	0	......	0	700	2,000	70	10	......
84	D124090	Hx188	40	0	0	110	8	45	20	22,000	59	630	21	17	9	23	0	480	1,000	79	28	60
	D125303	Fa277	60	0	......	200	15	70	50	70,000	0	700	0	15	20	......	0	2,000	3,000	200	20	......
85	D125330	Bd531	120	0	......	300	15.	100	70	50,000	30	500	0	30	20	......	0	500	3,000	150	15	......
86	D125314	Hx475	80	0	......	150	7	30	20	20,000	0	300	0	15	10	......	0	3,000	1,000	100	10	......
87	D125337	Bd538	20	0	......	200	5	50	30	30,000	30	300	0	10	0	......	0	700	3,000	100	15	......
88	D124411	Fd98	40	0	0	220	12	99	30	36,000	39	800	9	21	0	19	0	590	4,400	290	20	190
89	D124412	Fd101	40	0	0	200	14	76	37	31,000	44	400	12	29	0	19	0	830	2,000	160	25	92
90	D124413	Fd102	80	0	0	240	0	96	48	11,000	9	500	0	16	0	7	0	1,000	1,200	150	0	35
91	D126082	Hf350	40	0	......	300	15	100	70	50,000	0	500	0	20	0	......	0	500	3,000	200	20	......
92	D124414	Fd104	120	0	0	300	17	100	210	58,000	43	700	7	34	8	17	0	430	4,500	210	23	150
	D124313	Ov887	120	0	0	300	16	110	180	36,000	52	1,100	9	32	13	20	0	490	3,600	220	16	160
93	D126082	Hf349	40	0	......	300	15	100	70	50,000	0	500	0	20	15	......	0	300	1,500	150	20	......
94	D126080	Hf348	80	0	......	300	15	70	70	50,000	0	500	0	20	10	......	0	500	3,000	150	30	......
95	D125299	Mk433	40	0	......	300	15	50	70	50,000	30	1,000	0	15	0	......	0	300	3,000	200	30	......
96	D124285	Ov864	40	0	0	200	8	100	45	38,000	30	500	6	29	12	15	0	300	3,800	180	19	100
97	D124324	Fd61	20	0	0	350	11	72	100	50,000	41	1,300	12	22	13	20	0	610	2,800	240	17	100
98	D124325	Fd62	80	0	0	240	7	95	60	42,000	20	700	5	24	10	13	0	310	3,100	180	11	120
99	D124287	Ov865	20	1	0	110	13	60	36	32,000	60	400	19	24	15	23	0	1,700	1,400	120	34	82
100	D124326	Fd63	40	0	0	240	6	74	39	42,000	30	600	6	23	6	14	0	500	2,500	170	12	95
101	D124288	Ov866	20	0	0	300	12	70	76	41,000	32	900	7	23	12	17	0	450	3,500	180	19	98
102	D125298	Mk427	40	0	......	200	10	70	50	50,000	30	700	0	20	0	......	0	300	3,000	150	20	......
103	[1]D124312	Ov886	100	0	0	280	11	100	57	36,000	41	1,100	9	25	11	17	0	530	2,800	180	16	100
104	D124337	Fd75	20	0	0	390	9	75	45	47,000	43	1,100	7	22	0	17	0	530	4,300	240	26	160
56A	D124430	Bd315	120	0	26	300	24	100	100	54,000	29	760	6	69	16	17	0	160	4,100	260	30	110
41A	[2]D126084	Hf352	20	0	......	700	15	50	70	70,000	70	1,000	10	15	10	......	0	500	2,000	200	30	......

[1] Also found 1 ppm Be.

[2] 1.5 ppm Be.

LOCALITY LIST KEYED TO MAPS AND TABLES

All the deposits are listed alphabetically on page 30, together with the numbers that key them to figure 1 and plate 1, the commodity they are described under (listed as "Main commodity"), and references to tables and other figures and plates.

Our field investigations stressed evaluation of deposits of metallic commodities and involved examining (1) all known mines and prospects, (2) the many deposits discovered during the current investigation, and (3) some of the mineralized areas found by geochemical sampling. The mines and prospects were sampled and, in most cases, mapped in detail. The discoveries made during the current investigation were sampled, and their apparent sizes and probable grades were appraised. We tried to establish the geologic setting of the geochemically anomalous areas.

The current reconnaissance investigation provides information on the nature and distribution of the mineral deposits in the monument and a basis for delineating additional target areas favorable for ore deposits. The study is not detailed enough to provide evaluations as to the economic feasibility of developing and mining a specific deposit, either currently or in the future. Such evaluations would require more extensive investigation and physical exploration, metallurgical and cost-analysis surveys, and other studies necessary to establish the feasibility of present or future mining.

The examinations were limited by such factors as time, difficult access, and the poor exposures of some of the deposits. Evaluating the mountainous 3,900-square-mile Glacier Bay National Monument in only 3½ months necessitated cursory examinations of many deposits. Access was impeded by rough terrain that required time-consuming climbs and descents and by locally dense brush. Foul weather was another obstacle, and low clouds and inclement weather prevented much of the contemplated work in the higher parts of the Fairweather Range. Many of the deposits are partly covered and obscured by snow, ice, and vegetation, or by diverse postmetallization rocks and rock debris which prevent satisfactory

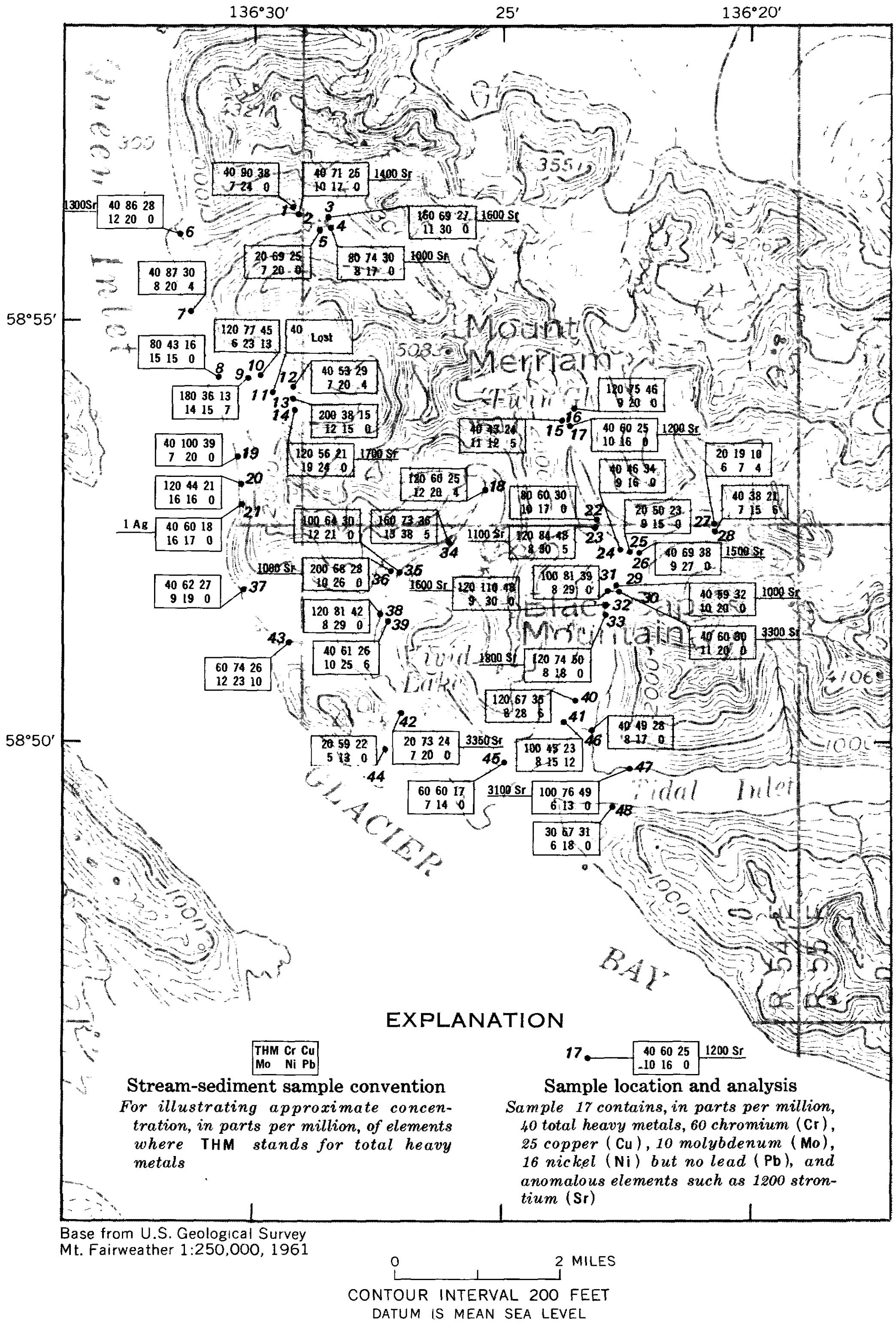


FIGURE 6.—Geochemical sampling map of the Mount Merriam area.

TABLE 7.—*Total heavy-metals and semiquantitative spectrographic analyses, in parts per million, of stream-sediment samples, Mount Merriam area*

[THM, Total heavy-metals (Cu+Pb+Zn) field test; 0, looked for, but not found; ...., not looked for]

Loc. (fig.6)	Lab. No.	Field No.	THM	Semiquantitative spectrographic analyses: Ag	B	Ba	Co	Cr	Cu	Fe	La	Mn	Mo	Ni	Pb	Sc	Sn	Sr	Ti	V	Y	Zr
1	252	Bd264	40	0	0	180	17	90	38	49,000	31	1,000	7	24	0	23	0	600	4,200	260	28	100
2	282	Ov861	40	0	0	200	7	71	25	27,000	48	400	10	17	0	18		1,400	1,900	120	34	100
3	250	Bd262	160	0	0	160	13	69	27	32,000	42	200	11	30	0	19	0	1,600	2,300	210	30	120
4	251	Bd263	80	0	0	160	9	74	30	26,000	36	600	8	17	0	18	0	1,000	2,000	130	31	81
5	281	Ov859	20	0	0	130	7	69	25	35,000	51	500	7	20	0	17	0	420	3,300	150	61	240
6	512	Bd334	40	0	0	210	13	86	28	34,000	38	400	12	20	0	20	0	1,300	3,700	180	37	110
7	511	Bd333	40	0	0	200	11	87	30	37,000	48	600	8	20	4	17	0	330	4,900	150	47	250
8	510	Bd332	80	0	0	110	9	43	16	15,000	45	600	15	15	0	16	0	600	1,000	88	29	66
9	280	Ov858	180	0	0	130	3	36	13	14,000	48	570	14	15	7	18	0	590	1,000	86	30	60
10	[1]249	Bd261	120	0	0	270	9	77	45	27,000	30	700	6	23	13	18	0	340	2,700	160	32	120
11	([2])	Ov857	40	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
12	247	Bd259	40	0	0	150	9	53	29	29,000	30	600	7	20	4	16	0	300	2,000	110	40	90
13	[1]248	Bd260	200	0	0	90	4	38	15	11,000	41	480	12	15	0	16	0	440	740	78	31	60
14	279	Ov856	120	0	0	200	6	56	21	23,000	60	630	19	24	0	17	0	1,700	1,200	150	26	73
15	238	Bd250	40	0	0	190	17	43	24	52,000	39	1,200	11	12	5	24	0	590	4,500	360	30	170
16	268	Ov844	120	0	0	280	14	75	46	60,000	37	1,000	9	20	0	23	0	800	5,700	390	29	140
17	267	Ov843	40	0	0	50	11	60	25	51,000	42	800	10	16	0	21	0	1,200	4,000	290	29	120
18	276	Ov853	120	0	0	140	13	60	15	56,000	45	1,000	12	20	4	23	0	600	4,000	440	36	100
19	424	Fd117	40	0	0	130	12	100	39	33,000	32	700	7	20	0	15	0	300	3,300	130	0	100
20	423	Fd116	120	0	0	600	19	44	21	32,000	47	500	16	16	0	23	0	520	2,800	100	30	83
21	422	Fd115	40	1	0	70	11	60	18	25,000	48	300	16	17	0	19	0	590	5,300	100	28	76
22	239	Bd251	80	0	0	200	14	60	30	46,000	39	1,100	10	17	0	21	0	610	3,900	300	26	130
23	269	Ov845	120	0	0	840	8	84	48	41,000	43	500	8	30	5	18	0	1,100	2,800	490	23	95
24	240	Bd252	40	0	0	240	17	46	34	59,000	41	1,100	9	16	0	24	0	770	4,500	300	30	110
25	241	Bd253	20	0	0	300	14	50	23	63,000	44	1,100	9	15	0	25	0	510	6,400	380	37	360
26	270	Ov846	40	0	0	150	14	69	38	43,000	38	500	9	27	0	20	0	1,500	3,400	220	23	99
27	266	Ov842	20	0	0	500	4	19	10	48,000	33	700	6	7	4	12	0	490	3,900	160	17	100
28	237	Bd249	40	0	0	300	15	38	21	57,000	26	1,000	7	15	6	20	0	600	4,000	220	23	95
29	272	Ov848	40	0	0	300	11	59	32	57,000	46	900	10	20	0	24	0	1,000	5,400	390	33	150
30	271	Ov847	40	0	0	140	10	60	30	34,000	42	400	11	20	0	18	0	3,300	2,400	140	25	86
31	[1]242	Bd254	100	0	0	290	6	81	39	32,000	37	400	8	29	0	16	0	880	8,000	210	23	90
32	273	Ov849	120	0	0	360	9	110	48	45,000	43	600	9	30	0	19	0	1,600	3,100	290	24	100
33	[1]274	Ov851	120	0	0	300	5	74	50	37,000	45	600	8	18	0	18	0	1,800	2,600	170	20	87
34	244	Bd256	160	0	0	130	20	73	36	56,000	44	900	13	38	5	28	0	820	5,300	570	32	100
35	245	Bd257	100	0	0	130	17	64	30	48,000	47	1,000	12	21	0	24	0	600	4,200	390	35	96
36	277	Ov854	200	0	0	210	7	68	28	28,000	50	300	10	26	0	17	0	1,000	1,800	210	23	83
37	509	Bd330	40	0	0	230	10	62	27	26,000	32	950	9	19	0	16	0	600	1,900	120	19	67
38	246	Bd258	120	0	0	230	13	81	42	38,000	37	600	8	29	0	20	0	580	3,000	240	23	85
39	278	Ov855	40	0	0	170	14	61	26	38,000	40	500	10	25	6	22	0	650	3,200	310	29	100
40	275	Ov852	120	0	0	450	9	67	35	40,000	31	500	8	28	6	16	0	990	2,400	180	19	89
41	243	Bd255	120	0	0	120	8	60	29	15,000	38	610	8	19	13	14	0	280	1,000	94	24	50
41	405	Hx285	80	0	0	60	3	30	16	13,000	38	450	8	11	10	10	0	300	720	60	13	44
42	255	Bd267	20	0	0	300	7	68	16	49,000	31	1,000	7	24	0	23	0	590	3,400	250	26	160
do	408	Hx293	20	0	0	300	8	75	31	36,000	36	800	6	15	0	17	0	660	3,300	190	0	150
43	[1]421	Fd114	60	0	0	180	15	74	26	42,000	45	1,000	12	23	10	24	0	690	5,300	310	36	120
44	407	Hx292	20	0	0	290	6	59	22	34,000	27	700	5	13	0	14	0	600	3,400	150	6	110
45	406	Hx287	60	0	0	200	5	60	17	21,000	31	690	7	14	0	12	0	300	1,400	120	14	110
46	404	Hx284	40	0	0	220	8	49	28	31,000	35	500	8	17	0	15	0	690	2,000	160	14	75
47	[1]403	Hx282	100	0	0	190	0	76	49	10,000	0	300	6	13	0	9	0	3,100	830	140	0	36
48	395	Hx273	30	0	0	330	8	67	31	61,000	37	900	6	18	0	17	0	990	4,300	210	20	120

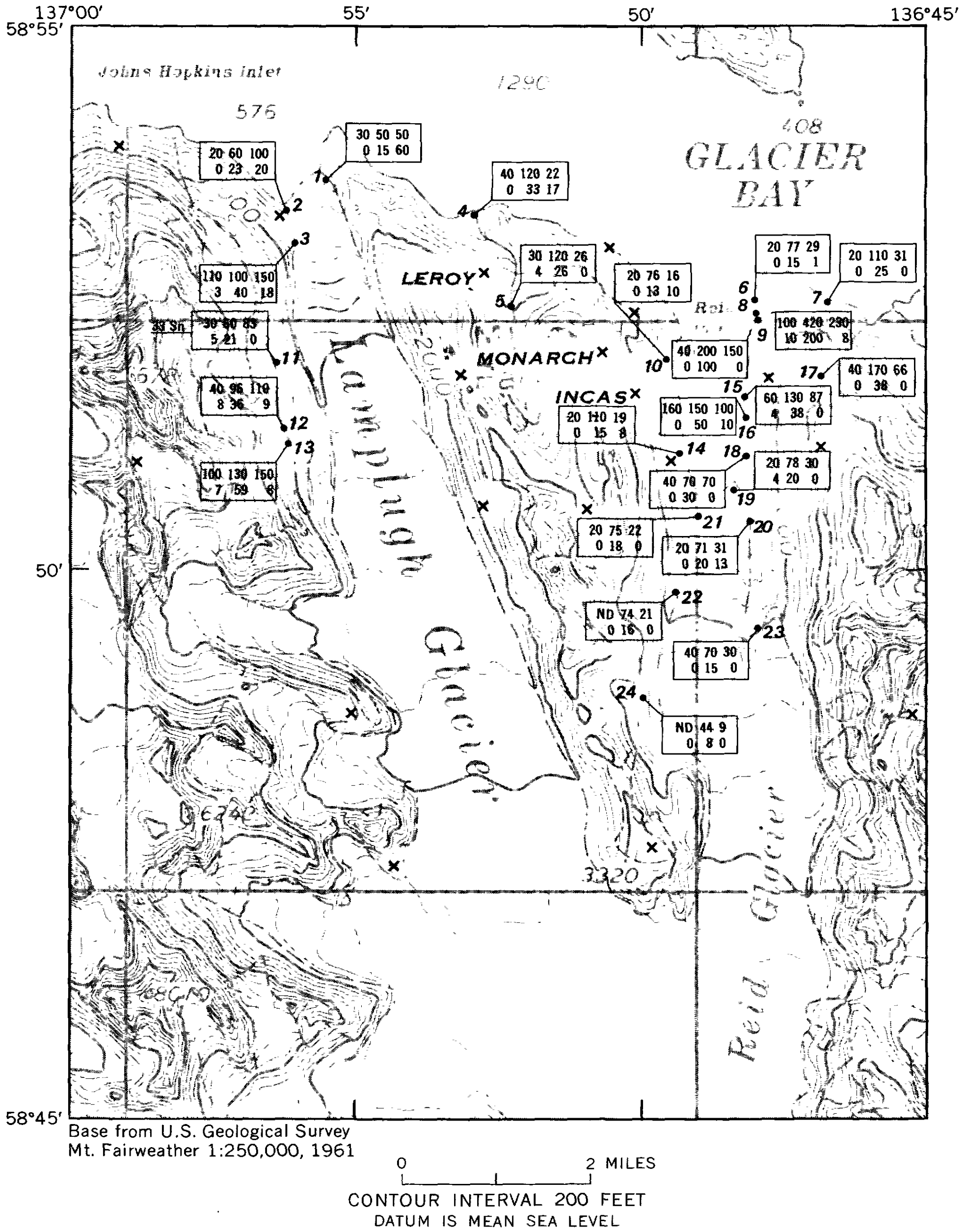
[1] Also found 1 ppm Be.

[2] Lost.

estimates of their size and extent. Despite these limitations, the coverage for most of the monument is good, and we believe that most large or significant deposits that crop out east of the Fairweather Range were examined. The results of the geochemical sampling program provide a basis for evaluating the sizable tracts of the monument where bedrock is covered. However, significant undiscovered deposits that might be found by extensive and thorough prospecting, using modern geophysical and geochemical methods, may exist in the monument, particularly in covered parts or in the Fairweather Range. Exploration of some known deposits may reveal larger and (or) richer ore bodies than those indicated by the surface examinations.

Most of the known mineral deposits within the boundaries of the monument are described in this report. The exceptions are the ilmenite-rich deposits that are widely distributed in the mafic layered intrusives of the Fairweather Range (Rossman, 1963a); these were not examined during the current investigations. Only a few ilmenite localities are discussed specifically because the limited geologic information concerning them indicates that they are similar. However, comparable ilmenite-rich deposits are probably extensive and widespread throughout the mafic layered intrusives.

The following part of this report consists of descriptions of the known metal-bearing mineral deposits within the monument. These descriptions



EXPLANATION

THM	Cr	Cu
Mo	Ni	Pb

Stream-sediment sample convention

For illustrating approximate concentration, in parts per million, of elements where THM *stands for total heavy metals*

11 — 30 60 83 / 5 21 0 — 33 Sn

Sample location and analysis

Sample 11 contains, in parts per million, 30 total heavy metals, 60 chromium (Cr), *83 copper* (Cu), *5 molybdenum* (Mo), *21 nickel* (Ni) *but no lead* (Pb), *and anomalous elements such as 33 tin* (Sn). ND *stands for not determined*

×

Location of mine, prospect, or mineral deposit

FIGURE 7.—Geochemical sampling map of the Reid Inlet gold area.

are based largely on field and analytical data obtained during the current project, but they also include pertinent information obtained from previous investigations. The parts of this report describing nonmetallic commodities and petroleum are based mainly on previous investigations.

It should be emphasized that all deposits examined in detail are reported on here, and all field and analytical data obtained are given for each deposit. Many other occurrences of metallic minerals were also noted, sampled, and analyzed, but they were deemed wholly insignificant because of limited grade or size and are therefore not described. The locations of such samples also are shown on plate 1. We have neither included nor excluded data arbitrarily.

METALLIC COMMODITIES

Metallic commodities in the monument include the following groups: Base and miscellaneous metals, precious metals, and iron and ferroalloy metals.

Locations of deposits that contain anomalous concentrations of one or more of the metallic commodities are shown on plate 1. Numbers or letters in the text refer to the deposit locality number or letter shown on plate 1 next to the circles. Each circle on plate 1 indicates a discrete deposit or a group of deposits. Analyzed samples that contain only background concentrations of ore metals are shown by solid dots or solid dots with a cross; their analyses are not included in this report. Individual deposits are described under the commodity that would most likely yield the major mineral values, and these descriptions are referenced in descriptions of other lesser commodities in the deposit.

The most important known deposits in the Monument are: the Nunatak molybdenum prospect (loc. 21), the Brady Glacier nickel-copper prospect (72), the Alaska Chief copper prospect (29), the Margerie copper prospect (19), the gold deposits of the Reid Inlet gold area and the Sandy Cove prospect (7), the placer gold deposits on the beaches near Lituya Bay (87, 88), and several iron and titanium deposits associated with the layered intrusives of the Fairweather Range.

BASE AND MISCELLANEOUS METALS

Anomalous concentrations of the following base and miscellaneous metals were found in the monument: Antimony, arsenic, bismuth, cadmium, copper, lead, tin, and zinc. Except for copper and zinc, none of these elements appear to occur in significant quantities, although a few, notably lead, may be considered possible byproduct metals. Minor occurrences of radioactive minerals have been reported from the monument, and these are also discussed briefly.

ANTIMONY

Antimony is a minor constitutent of several of the copper deposits, the Rendu Inlet silver deposit (loc. 37), and the silver-lead-zinc deposits near Mount Brack (12). Only two of our samples contained detectable antimony: one from the Mount Brack deposits contained 7,000 ppm antimony (table 9, loc.

TABLE 8.—*Total heavy-metals and semiquantitative spectrographic analyses, in parts per million of stream-sediment samples, Reid Inlet gold area*

[THM, Total heavy-metals (Cu+Pb+Zn) field test; 0, looked for, but not found; . . . ., not looked for]

Loc. (fig.7)	Lab. No.	Field No.	THM	Semiquantitative spectrographic analyses																		
				Ag	B	Ba	Co	Cr	Cu	Fe	La	Mn	Mo	Ni	Pb	Sc	Sn	Sr	Ti	V	Y	Zr
1	D125012-3	Hf240	30	0	.....	300	15	50	50	40,000	40	1,250	0	15	60	.....	0	.....	4,000	175	25	.....
2	D125014-5	Hf241	20	0	.....	225	18	60	100	60,000	0	1,000	0	23	20	.....	0	.....	5,000	175	20	.....
3	D125016-7	Hf242	110	0	.....	750	23	100	150	70,000	0	1,000	3	40	18	.....	0	.....	5,000	200	20	.....
4	D125898	Ov1777	40	0	0	900	11	120	22	81,000	25	700	0	33	17	13	0	820	3,600	190	20	96
5	D124746	Hf214	30	0	0	600	11	120	26	21,000	31	400	4	26	0	15	0	470	2,400	170	18	160
6	D124693	Ov1281	20	0	0	300	10	77	29	26,000	25	300	0	18	10	17	0	650	3,300	150	21	110
7	D124692	Fd184	20	0	0	230	7	60	29	20,000	33	200	0	15	9	13	0	450	2,700	110	17	92
8	D126218	Hf372	40	0	...	150	30	200	150	70,000	0	1,000	0	100	0	.....	0	500	5,000	500	30	.....
9	D124694	Ov1283	100	0	0	140	37	420	230	32,000	27	900	10	200	8	35	0	560	5,500	360	33	120
10	D124698	Ov1294	20	0	0	470	6	76	16	26,000	35	500	0	13	10	15	0	600	3,300	130	24	200
11	D124738	Fd201	30	0	0	300	11	60	83	23,000	0	400	5	21	0	20	33	320	4,200	200	21	200
12	D124737	Fd199	40	0	0	270	18	96	110	33,000	0	700	8	36	9	29	0	280	6,700	320	27	120
13	D124736	Fd198	100	0	0	180	28	130	150	32,000	0	900	7	59	8	30	0	280	5,700	310	28	89
14	D124697	Ov1293	20	0	0	460	9	110	19	30,000	59	700	0	15	8	17	0	670	4,500	140	30	370
15	D124695	Ov1285	60	0	0	270	17	130	87	33,000	28	200	4	38	0	18	0	600	3,100	180	16	110
16	D126217	Hf371	160	0	.....	200	30	150	100	50,000	0	1,000	0	50	10	.....	0	700	3,000	200	30	.....
17	D124713	Hf344	40	0	0	270	24	170	66	31,000	47	500	0	38	0	19	0	600	3,500	210	17	110
18	D126216	Hf370	40	0	.....	300	15	70	70	30,000	0	700	0	30	0	0	0	500	3,000	150	30	.....
19	D124742	Ov1286	20	0	0	390	11	78	30	23,000	24	300	4	20	0	14	0	720	2,100	140	14	98
20	D125909	Ov1832	20	0	0	740	14	71	31	95,000	32	700	0	20	13	9	0	230	3,000	140	15	100
21	D124696	Ov1292	20	0	0	430	7	75	22	31,000	39	500	0	18	0	13	0	500	2,700	130	15	120
22	D124745	Mk363	.....	0	0	340	0	74	21	20,000	0	500	0	16	0	13	0	520	1,900	100	7	190
23	D126068	Ov1843	40	0	.....	300	15	70	30	30,000	0	500	0	15	0	.....	0	500	3,000	150	15	.....
24	D124744	Mk359	.....	0	0	450	0	44	9	18,000	21	830	0	8	0	9	0	1,000	1,600	91	6	97

Locality list of deposits, Glacier Bay National Monument

Name of locality	No. on— Fig. 1	No. on— Pl. 1	Main commodity	Table giving analytical data	Detailed on— Figure	Detailed on— Plate
Adams Inlet		5	Cu	9		
Entrance of		22	Mo			
Alaska Chief	3	29	Cu	9	9	
Southwest of		30	Zn	9		
Blackthorn Peak, West of		51	Fe			
Blue Mouse Cove		42	Cu	9		
Brady Glacier	2	72	Ni	15	18	
East of		54	Fe	9		
East of lower		55	Au	9		
Lower		56	Mo			
Outwash of		59	Au			
Bruce Hills	9	34	Cu	9, 10	10	
Casement Glacier		9	Mo			
East of		4	Cu	9		
Nunatak on		3	Zn	9		
Charpentier Inlet		47	Mo	9		
Curtis Hills		23	Cu	9		
Dundas Bay, east of		33	Fe			
East side of	14	31	Cu	9		
Do		32	Cu	9		
West arm of		58	Cu	9		
West of		57	Au			
Dundas River		53	Au			
Fairweather Range	8	73	Fe			
		78	Cu			
		79	Ti			
		80	Ti			
		82	Cu			
		83	Fe			
		86	Cu			
Francis Island		28	Cu	9	8	
Gable Mountain	13	14	Cu	9		
Galena Prospect (Reid Inlet)		J	Au	11		
Geikie Inlet, west of		50	Mo			
North shore of		48	Mo	9		
Gilbert Island, Southwest end of		44	Cu	9		
Do		45	Cu	9		
Northern		43	W	9		
Highland Chief Prospect (Reid Inlet)		K	Au			
Hoonah Glacier, east of		75	Cu	9		
Do		77	Cu	9		
Hopalong and Whirlaway claims (Reid Inlet)		I	Au	11		
Hugh Miller Inlet		46	Zn	9		
Incas Mine, Reid Inlet		G	Au	11	14	
Johns Hopkins Inlet, north of		64	Cu	9		
Northwest shore of		76	Zn	9		
Johns Hopkins Inlet, South of		65	Cu	9		
South shore of		74	Mo	9		
Lamplugh Glacier, east of		F	Cu	11		
Southwest of		67	Cu	9		
West of head of		68	Ni	9		
Leroy Mine (Reid Inlet)		B	Au	9, 11		9
Lituya Bay	7	87	Au			
		88	Au			
Southeast arm of		84	Cu			
South of		85	Au			
Margerie	4	19	Cu	9		
McBride Glacier, west of		10	Au	9		
Minnesota Ridge		13	Cu	9		
Monarch Mines (Reid Inlet)		E	Au	11	12, 13	
Mount Abdallah		16	Ni	9		
Mount Brack	10	12	Zn	9		
Mount Cooper		66	Zn	9		
Mount Young, near		1	Cu	9		
Northwest of		2	Cu	9		
North Marble Island		24	Cu			
Nunatak, The	1	21	Mo	13, 14		11, 12
Oregon King Consolidated		81	Au			
Queen Inlet		40	Fe	9		10
Rainbow Mine (Reid Inlet)		C	Au	11	11	
Rambler Prospect (Reid Inlet)		L	Au	11		
Red Mountain, southwest of		20	Zn	9		
Reid Glacier, east of		69	Cu	9		
Reid Inlet	5	A–L	Au	11	11–14	9
Southeast of head of		71	Mo	9		
South end of ridge west of		70	Mo	9		
Rendu Glacier, south of	12	15	Cu	9		
Rendu Inlet		37	Ag	9		
Ridge west of		60	Mo			
West of		39	Fe	9	17	
West of mouth of		38	Cu	9		
Russell Island		61	Au	9		
Sand Cove	6	7	Au	9	15, 16	
Sentinel Mine (Reid Inlet		D	Au	11		
Shag Cove, west of		49	Cu	9		
South Marble Island		25	Cu	9		
Sunrise Prospect (Reid Inlet)		H	Au	11		
Tarr Inlet, west of	15	63	Cu	9		
West of mouth of		62	Cu	9		
West shore of		18	Cu	9		
West side of		17	Mo	9		
Terry Richtmeyer Prospect (Reid Inlet)		A	Au			
Tidal Inlet, south of		41	Cu	9		
Triangle Island		36	Mo			
Van Horn Ridge		11	Mo	9		
Wachusett Inlet, near head of		35	Mo	9		
White Glacier, north of	11	6	Cu	9		
Willoughby Island, northeast side of		26	Cu			
West side of		27	Cu			
Wood Lake, south of		52	Au			
York Creek, north of		8	Cu	9		

TABLE 9.—*Semiquantitative spectrographic analyses and gold analyses of mineral deposits* [1] *in the Glacier Bay National Monument, Alaska*

[Spectrographic analyses by J. C. Hamilton, Harriet Neiman, and A. L. Sutton, Jr. Gold analyses by Claude Huffman, Jr., J. D. Mensik, O. M. Parker, L. B. Riley, V. E. Shaw, J. A. Thomas, and J. E. Troxel. Au: A, analyzed by atomic absorption; B, analyzed by fire assay atomic absorption method]

Results are reported in parts per million, which for the spectrographic analyses have been converted from percent to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.15, and 0.1 . . . , which represent approximate midpoints of group data on a geometric scale. The assigned group for six-step results will include more accurately determined values for about 30 percent of the test results. Gold and silver values in ounces per ton are shown in parentheses below their corresponding parts per million values.

Symbols used: M, major constituent—greater than 10 percent; 0, looked for, but not detected; . . . ., not looked for; <, less than.

Besides the elements shown in the table, the following elements were also sought in all of the analyses: Be, Hg, La, Li, Pd, Pt, Ta, and Ti. Reported values for these, except Be, La, and Li, were always O.

Al, Ca, Mg, Si, and Sr were looked for and found in several of the analyses, but as they were not sought in most analyses, their values are not reported herein.

Locations of the deposits are shown on pl. 1; individual samples are described at the end of the table.

Locality	Sample 66A—	Au A	Au B	Ag	As	Ba	Bi	Cd	Co	Cr	Cu	Fe	Mn	Mo	Nb	Ni	Pb	Sb	Sn	Ti	V	W	Y	Zn
											Juneau quadrangle													
1	Bd-130B	....	....	1 (0.029)	0	700	0	0	70	1,500	150	M	300	7	10	150	150	0	0	3,000	1,500	0	70	700
	Bd-130C	....	....	10 (0.292)	0	3,000	0	0	7	500	150	30,000	150	15	10	150	150	0	0	2,000	700	0	100	1,500
2	Mk-270	<0.05 (<0.0015)	<0.05 (<0.0015)	0	0	50	0	0	15	0	300	30,000	300	0	0	3	0	0	0	1,500	0	0	30	0
	Mk-273	....	....	0	0	700	0	0	30	0	70	30,000	500	10	0	0	0	0	0	2,000	15	0	20	0
3	Mk-309	....	....	0	0	70	0	0	5	15	15	30,000	3,000	0	0	5	0	0	0	300	30	0	10	300
4	Mk-310	....	....	0	0	70	0	0	15	70	300	70,000	700	5	0	50	0	0	0	3,000	100	0	30	0
	Mk-311	....	....	0	0	70	0	0	20	30	300	70,000	700	5	0	50	0	0	0	3,000	150	0	30	0
5	Mk-156	....	....	0	0	300	0	0	30	150	150	70,000	700	0	0	30	0	0	10	3,000	150	0	30	0
	Mk-157	....	....	0	0	300	0	0	150	150	150	M	300	7	10	150	10	0	0	5,000	300	0	30	0
	Mk-159	....	....	0	0	300	0	0	150	150	150	M	700	7	10	150	30	0	0	5,000	150	0	30	0
	Mk-160	....	....	1 (0.029)	0	70	0	0	300	150	500	M	700	30	15	300	15	0	0	3,000	150	0	30	0
	Mk-162	....	....	0	0	200	0	0	100	150	300	M	700	15	10	200	15	0	0	3,000	200	0	30	0
	Mk-164	....	....	0	0	150	0	0	150	150	150	M	300	30	10	150	30	0	0	3,000	150	0	15	0
6	Mk-253	<0.2 (<0.008)	<0.05 (<0.0015)	0	0	70,000	0	0	0	7	150	70,000	2,000	0	0	5	0	0	0	100	0	0	0	0
	Mk-254	< .2 (0.006)	< .05 (<0.0015)	0	0	70,000	0	0	7	7	30	M	2,000	0	0	15	0	0	0	300	20	0	0	0
	Mk-256A	.4 (0.012)	< .05 (<0.0015)	20 (0.583)	0	2,000	0	0	50	200	30,000	50,000	500	0	0	200	30	0	10	2,000	100	0	10	0
	Mk-256B	.4 (0.012)	< .05 (<0.0015)	15 (0.338)	0	3,000	0	70	50	100	30,000	M	300	0	0	200	200	0	20	1,000	50	0	0	500
	Mk-257	< .2 (<0.006)	< .05 (<0.0015)	0	0	500	0	0	15	2	70	70,000	150	0	15	20	20	0	0	5,000	70	0	20	20,000
	Mk-258	< .2 (<0.006)	.05 (<0.0015)	0	0	200	0	0	10	15	50	70,000	200	0	0	15	50	0	0	5,000	150	0	20	0
	Mk-259	.2 (<0.006)	< .05 (<0.0015)	0	0	300	0	0	100	5	150	70,000	200	5	10	70	100	0	0	5,000	200	0	20	0
7	Mk-224	0.2 (0.006)	0.1 (0.003)	0.5 (0.437)	0	1,000	30	0	5	1.5	500	20,000	500	50	0	0	15	0	0	2,000	100	0	15	0
	Mk-225	28 (0.816)	33 (0.963)	50 (1.460)	0	150	300	0	7	0	50,000	M	50	0	0	3	100	0	0	150	0	0	0	0
	Mk-226	3 (0.087)	3 (0.087)	2 (0.058)	0	700	50	0	10	15	1,500	M	500	0	0	7	100	0	0	1,500	70	0	10	0
	Mk-227	.2 (0.006)	.1 (0.003)	5 (0.1460)	0	150	200	0	0	0	500	50,000	200	0	0	0	100	0	0	70	0	0	0	0
	Mk-228	6 (0.175)	6 (0.175)	5 (0.1460)	0	700	100	0	7	0	1,000	M	300	0	0	3	30	0	0	1,000	30	0	15	0
	Mk-229	< .2 (<0.006)	< .1 (<0.003)	0 (0)	0	300	0	0	0	1.5	100	70,000	70	0	0	0	0	0	0	150	0	0	10	0
	Mk-415	23 (0.671)	17 (0.495)	30 (0.875)	0	300	500	0	10	0	30,000	M	300	30	0	5	70	0	0	1,000	50	0	30	0
	Mk-415A	27 (0.788)	27 (0.788)	30 (0.875)	0	300	300	0	15	0	30,000	M	50	<10	0	3	50	0	0	500	20	0	0	0
	Mk-416	14 (0.403)	14 (0.403)	10 (0.292)	0	50	150	0	7	0	7,000	M	100	<7	0	3	150	0	0	50	7	0	0	0
	Mk-417	1 (0.029)	1 (0.029)	10 (0.292)	0	50	100	0	15	3	20,000	M	200	<7	0	5	30	0	0	300	20	0	15	0
	Mk-418	....	< .1 (<0.003)	0	0	3,000	0	0	10	1.5	70	50,000	500	10	0	0	10	0	0	2,000	150	0	20	0
	Mk-419	....	< .1 (<0.003)	0	0	2,000	20	0	7	5	50	50,000	150	20	0	0	0	0	0	1,500	70	0	10	0
	Hf-280B	....	.4 (0.012)	0	0	200	0	0	0	1.5	1,000	10,000	100	50	0	0	0	0	0	150	10	0	0	0
	Hf-280C	2 (0.058)	2 (0.588)	20 (0.583)	0	200	200	0	0	0	M	M	20	<15	0	0	50	0	0	10	0	0	0	0
8	Mk-431	<0.05 (<0.015)	<0.1 (<0.003)	0	0	150	0	0	150	70	1,500	50,000	1,500	<5	0	150	0	0	0	5,000	150	0	70	0
	Mk-434A	....	< .1 (0.003)	0	0	150	0	0	7	100	50	50,000	1,500	15	0	15	0	0	0	2,000	150	0	15	0
											Skagway quadrangle													
9	No analyses																							
10	Mk-411	3 (0.088)	3 (0.088)	0	7,000	1,000	0	0	15	7	150	70,000	2,000	0	0	20	0	0	0	300	20	0	0	0
	Mk-412	....	.3 (0.0088)	0	0	100	0	0	7	2	100	50,000	3,000	0	0	15	0	0	0	20	0	0	0	0
	Hx-251	1 (0.003)	1.5 (0.0045)	0	15,000	20	0	0	10	2	500	70,000	3,000	0	0	20	0	0	0	30	0	0	0	0

See footnotes at end of table.

TABLE 9.—*Semiquantitative spectrographic analyses and gold analyses of mineral deposits*[1] *in the Glacier Bay National Monument, Alaska*—Continued

Locality	Sample 66A—	Au A	Au B	Ag	As	Ba	Bi	Cd	Co	Cr	Cu	Fe	Mn	Mo	Nb	Ni	Pb	Sb	Sn	Ti	V	W	Y	Zn
	Skagway quadrangle—Continued																							
11	Mk-145A			0	0	500	0	0	10	20	20	50,000	300	0	0	3	20	0	0	3,000	150	0	15	0
	Mk-145B			0	0	300	0	0	15	30	50	70,000	300	5	0	5	10	0	0	5,000	200	0	15	0
	Mk-146			0	0	7	0	0	0	15	100	M	500	200	0	3	15	0	0	700	0	0	0	0
	Mk-151			0	0	200	0	0	30	30	70	50,000	1,000	5	0	15	0	0	0	3,000	300	0	30	0
12	Mk-315		0.3 (0.0088)	15 (0.437)	7,000	15	30	300	20	3	150	M	3,000	5	0	20	150	0	0	300	15	0	0	15,000
	Bd-280		3 (0.088)	30 (0.875)	30,000	15	30	150	30	1	70	70,000	3,000	0	0	7	7,000	7,000	0	150	0	0	10	3,000
	Bd-283B			0	0	7	10	0	150	1.5	300	M	150	15	0	70	10	0	0	30	10	0	15	0
	Hx-315A			0	0	70	0	0	30	30	150	70,000	1,500	0	0	30	15	0	0	700	150	0	30	700
	Hx-316B			0	0	150	0	0	15	70	100	70,000	700	7	10	70	0	0	0	3,000	200	0	70	0
13	Bd-185B			0	0	300	0	0	15	10	700	70,000	150	0	0	10	0	0	0	2,000	100	0	10	0
14	Bd-466B	<0.1 (<0.003)	<0.05 (<0.0015)	1 (0.029)	0	500	0	0	50	10	1,000	50,000	700	15	0	7	0	0	0	5,000	200	0	20	0
15	Bd-723			0	0	30	50	0	7	30	2,000	M	300	0	0	70	0	0	0	300	20	0	0	0
16	Bd-746			0	0	1,500	0	0	15	150	100	50,000	500	3	0	70	20	0	0	5,000	300	0	30	0
17	Mk-560	<0.05 (<0.0015)		0	0	1,000	0	0	10	50	100	30,000	500	100	0	30	10	0	0	2,000	100	0	15	0
	Mk-562	< .05 (<0.0015)		0	0	1,000	0	0	20	20	100	70,000	1,000	0	0	3	0	0	0	3,000	300	0	15	0
	Mk-563			0	5,000	300	70	0	50	7	200	70,000	700	0	0	5	0	0	0	5,000	200	0	15	0
18	Hf-360			0	0	70	50	0	7	30	1,500	M	1,000	0	0	15	0	0	15	3,000	150	100	15	0
19	Mk-550A	5 (0.146)		2 (0.058)	M	50	300	0	100	1	2,000	70,000	20	5	0	5	0	0	0	200	0	150	0	30
	Mk-550B	0.6		0	50,000	200	50	0	5	2	500	50,000	100	3	0	0	0	0	0	1,000	30	0	0	0
	Mk-552A			0	0	500	0	0	10	30	150	70,000	150	5	0	7	0	0	0	3,000	300	0	15	0
	Mk-552B			0	2,000	300	0	0	20	30	700	M	200	0	0	15	0	0	0	3,000	200	0	15	0
	Mk-553			0	0	30	150	0	15	15	3,000	M	150	0	0	15	0	0	0	500	30	3,000	10	0
	Mount Fairweather quadrangle																							
20	Mk-222			1.5 (0.044)	0	300	0	70	30	5	50	M	100	30	0	100	500	0	0	150	0	0	0	7,000
21	(2)																							
22	No analyses																							
23	Mk-185A			0	0	50	0	0	100	30	700	M	1,500	0	0	100	30	0	0	10,000	500	0	20	0
	Mk-187			0	0	200	0	0	15	700	100	50,000	1,500	0	0	150	0	0	0	5,000	300	0	20	0
	Mk-200			0	0	200	0	0	50	20	500	50,000	700	0	0	50	0	0	0	1,000	500	0	30	0
24	No analyses																							
25	Mk-36			0	0	150	0	0	30	200	150	M	1,500	0	0	100	0	0	0	7,000	700	0	30	0
	Mk-38			0	0	70	0	0	50	150	200	M	2,000	0	0	100	0	0	0	10,000	500	0	30	0
	Mk-339			0	0	70	0	0	30	200	200	70,000	1,500	0	0	100	10	0	0	5,000	300	0	20	0
	Mk-41			0	0	50	0	0	30	150	150	M	1,500	0	0	100	0	0	0	7,000	500	0	30	0
26, 27	No analyses																							
28	Mk-17			0	0	100	0	0	15	100	100	50,000	500	10	0	150	0	0	0	2,000	200	0	30	0
	Hf-183B			50 (1.460)	0	7	150	0	10	5	7,000	30,000	2,000	0	0	0	0	200	20	1,500	10	0	0	1,000
	Hf-183C			0	0	5	0	0	10	0	50	M	7,000	0	0	0	50	0	0	30	30	0	10	0
29	Mk-469	8 (0.234)	7 (0.205)	100 (2.917)	0	150	150	0	70	15	15,000	M	700	10	0	100	30	0	0	700	30	0	0	700
	Mk-470	6 (0.176)	5 (0.146)	140 (4.377)	0	20	70	0	70	20	15,000	M	1,000	5	0	100	20	0	0	500	20	0	0	700
	Mk-471	< .05 (<0.0015)	< .05 (<0.0015)	0	0	200	0	0	5	15	300	70,000	2,000	0	0	5	0	0	0	1,500	70	0	20	0
	Mk-472	.7 (0.021)	.8 (0.023)	0	0	300	20	0	15	30	1,000	70,000	3,000	0	0	20	0	0	0	2,000	100	0	20	0
	Mk-473	10 (0.292)	9 (0.263)	70 (2.043)	0	100	200	0	30	15	1,000	M	1,000	7	0	20	0	0	0	300	20	0	0	300
	Mk-475	2 (0.058)	3 (0.088)	100 (2.917)	0	200	100	0	200	15	M	M	1,000	5	0	150	0	0	0	500	20	0	0	1,000
	Mk-474	3 (0.0015) (3)	50 (0.0015)	50	0	100	300	0	300	30	15,000	M	5,000	7	0	500	15	0	0	1,000	50	0	0	1,500
30	Hx-504B			7	0	150	10	0	3	1.5	70	15,000	1,500	7	0	0	300	0	0	700	30	0	0	1,500
31	Mk-481			0	0	300	0	0	30	10	500	M	150	20	0	10	0	0	0	1,000	100	0	0	0
	Mk-482			0	0	300	0	0	20	7	700	30,000	300	20	0	5	10	0	0	1,000	70	0	0	0
	Mk-483			0	0	500	0	0	15	10	1,500	30,000	300	3	0	7	15	0	0	1,000	70	0	0	0
	Hx-543			1 (0.029)	0	500	0	0	10	20	1,000	50,000	500	0	0	20	30	0	0	3,000	200	0	15	0
	Hx-544			0	0	200	0	0	10	15	1,000	70,000	300	15	0	10	0	0	0	1,500	100	0	0	0
	Hx-544B			0	0	150	0	0	30	10	2,000	70,000	300	20	0	10	0	0	0	1,000	200	0	10	0
32	Hx-548			0	0	150	0	0	10	7	1,000	50,000	700	300	0	10	0	0	0	1,500	700	0	0	0
33	No analyses																							

See footnotes at end of table.

TABLE 9.—*Semiquantitative spectrographic analyses and gold analyses of mineral deposits*[1] *in the Glacier Bay National Monument, Alaska*—Continued

Locality	Sample 66A—	Au A	Au B	Ag	As	Ba	Bi	Cd	Co	Cr	Cu	Fe	Mn	Mo	Nb	Ni	Pb	Sb	Sn	Ti	V	W	Y	Zn
Mount Fairweather quadrangle—Continued																								
34	Mk-85A			0	0	50	0	0	20	2	3,000	M	300	1,000	0	5	0	0	0	500	0	0	0	0
	Mk-85B	<0.05 (<0.0015)	<0.05 (<0.0015)	0	0	1,500	0	0	7	7	3,000	50,000	300	30	0	3	0	0	0	2,000	70	0	15	0
	Mk-85C			0	0	700	0	0	7	7	2,000	50,000	150	7	0	0	0	0	0	2,000	50	0	10	0
	Mk-86A			0	0	500	0	0	0	2	70	20,000	50	20	0	0	0	0	0	700	20	0	0	0
	Mk-86B			0	0	500	0	0	5	1.5	100	20,000	50	30	0	0	0	0	0	700	20	0	0	0
	Mk-178			0	0	1,500	0	0	7	15	1,500	30,000	150	30	0	3	0	0	0	2,000	100	0	15	0
	Mk-179			0	0	3,000	0	0	7	15	300	30,000	150	15	0	3	0	0	0	1,500	70	0	15	0
	Re-56			1 (0.029)	0	700	0	0	30	30	3,000	70,000	300	70	0	7	0	0	10	3,000	150	0	20	0
35	Bd-273D			15 (0.338)	0	30	10	0	70	1	15,000	30,000	150	7,000	0	15	0	0	0	200	15	0	0	700
36	No analyses																							
37	Mk-542			0	0	1,000	0	0	3	3	7	15,000	700	0	0	3	0	0	0	50	7	0	0	0
	Mk-544	<0.05 (<0.0015)		0	0	200	0	0	3	2	20	50,000	1,000	15	0	0	0	0	15	700	50	0	15	0
38	Mk-558			0	0	200	0	0	10	300	15	30,000	150	0	0	30	0	0	0	2,000	150	0	10	0
	Mk-559			0	0	30	0	0	700	20	1,500	M	300	0	0	1,000	0	0	0	500	50	0	0	0
39	Mk-548			0	0	70	0	0	15	15	30	50,000	500	0	0	3	0	0	0	3,000	150	0	15	0
	Mk-549			0	0	10	0	0	3	0	7	M	3,000	0	0	0	0	0	0	700	50	0	0	0
	Hx-626			0	0	15	0	0	7	0	3	M	3,000	0	0	3	0	0	0	700	30	0	15	0
40	Mk-298A			0	0	70	0	0	10	15	30	M	700	0	0	5	0	0	30	1,500	50	0	20	0
	Mk-298B			0	0	100	0	0	10	20	50	M	500	20	0	5	0	0	30	1,500	50	0	20	0
	Mk-299			0	0	15	0	0	300	0	300	M	700	15	0	15	0	0	15	7	0	0	15	300
	Mk-303			0	0	7	0	0	7	0	15	M	1,500	5	0	3	0	0	0	70	0	0	50	0
	Mk-305			0	0	30	0	0	70	30	150	M	1,500	0	0	70	0	0	30	3,000	150	0	30	200
	Mk-321			0	0	10	10	0	50	0	200	70,000	50	7	0	0	0	0	0	700	0	0	50	0
	Mk-323			0	0	30	0	0	5	0	300	M	200	0	10	0	0	0	0	1,500	0	0	70	0
	Mk-324			0	0	30	0	0	30	1.5	30	M	300	7	0	0	10	0	30	3,000	15	0	150	0
41	Hx-260V	<0.2 (<0.006)	0.1 (0.003)	0	0	30	0	0	300	10	1,000	M	500	0	0	300	0	0	0	1,500	70	0	0	0
42	Mk-48			1 (0.029)	0	500	0	0	0	15	200	15,000	300	0	0	0	300	0	0	3,000	100	0	10	700
43	Hx-659A			0	0	5	0	0	7	2	150	M	3,000	5	0	10	0	0	0	150	30	150	0	0
44	Mk-84A			0	0	20	0	0	0	7	3	15,000	700	0	0	0	0	0	0	500	70	0	0	0
	Mk-84B			0	0	30	0	0	70	2	50	50,000	300	0	0	7	0	0	0	700	50	0	0	0
45	Mk-65			0	0	150	0	0	10	7	1,000	30,000	1,500	0	0	3	0	0	0	1,500	70	0	15	0
	Mk-67			10 (0.292)	0	700	0	0	20	7	7,000	50,000	1,000	2,000	0	3	0	0	0	3,000	100	0	15	0
	Mk-68			0	0	2,000	0	0	0	0	10	15,000	300	15	0	0	0	0	0	1,000	15	0	0	0
	Mk-69			0	0	500	0	0	10	10	7	30,000	1,000	0	0	3	0	0	0	2,000	150	0	15	0
	Mk-72			0	0	1,000	0	0	10	10	5	30,000	700	0	0	3	0	0	0	2,000	100	0	20	0
46	Bd-37B			0	0	1,000	70	0	150	15	15	M	300	7	10	15	0	0	0	1,500	70	0	15	1,500
47	Mk-423	<0.1 (0.003)		0	0	500	0	0	0	15	150	M	1,500	7	0	10	0	0	10	10,000	500	0	30	0
48	Hx-67			0	0	100	0	0	20	100	150	M	700	10	0	30	0	0	0	50	300	0	30	0
49	Hx-32A			0	0	50	0	0	10	15	100	50,000	700	0	0	10	0	0	0	3,000	100	0	30	0
	Hx-32B			1 (0.029)	0	15	0	0	200	1	3,000	M	700	0	0	10	0	0	0	70	15	0	0	700
50-53	No analyses																							
54	Mk-460A			0	0	30	0	0	30	7	1,000	M	1,000	15	0	30	0	0	0	700	30	0	0	0
	Mk-460B			0	0	7	0	0	70	7	1,000	M	1,000	7	0	50	0	0	0	150	30	0	0	0
55	Mk-455	<0.05 (<0.0015)		0	0	70	0	0	7	10	100	30,000	300	0	0	5	0	0	0	5,000	200	0	10	0
56, 57	No analyses																							
58	Hx-484A			0	0	30	0	0	150	30	10,000	M	1,000	0	0	0	15	0	0	2,000	200	0	15	0
56, 60	No analyses																							
61	Ov-2041	23 (0.670)	29 (0.845)	1 (0.029)	0	50	0	0	0	1	20	10,000	300	0	0	0	50	0	0	150	15	0	0	0
62	Fd-428B	<0.05 (<0.0015)		0	0	70	0	0	100	0	2,000	M	200	0	0	15	0	0	0	1,500	70	0	0	0
63	Hx-391			1 (0.029)	0	500	0	0	15	10	1,000	50,000	1,000	0	0	3	0	0	0	2,000	50	0	10	300

See footnotes at end of table.

TABLE 9.—*Semiquantitative spectrographic analyses and gold analyses of mineral deposits*[1] *in the Glacier Bay National Monument, Alaska*—Continued

Locality	Sample 66A—	Au A	Au B	Ag	As	Ba	Bi	Cd	Co	Cr	Cu	Fe	Mn	Mo	Nb	Ni	Pb	Sb	Sn	Ti	V	W	Y	Zn
									Mount Fairweather quadrangle—Continued															
64	Mk-396	0.1 (0.003)	....	0	0	200	0	0	5	50	10	20,000	700	0	0	15	0	0	0	700	70	0	10	0
	Mk-399	.1 (0.003)	0.09 (0.026)	1 (0.029)	0	2,000	0	0	15	10	1,000	70,000	700	0	0	3	30	0	0	2,000	150	0	15	0
	Mk-521	< .05 (<0.0015)	< .05 (<0.0015)	0	0	700	0	0	15	70	700	70,000	700	3	0	30	0	0	0	3,000	150	0	30	0
	Mk-522	< .05 (<0.0015)	< .05 (<0.0015)	0	0	150	0	0	15	1.5	70	20,000	150	0	0	3	0	0	0	300	15	0	0	0
	Mk-524	....		0	0	700	0	0	15	70	70	50,000	300	3	10	15	15	0	0	3,000	150	0	30	0
	Mk-525	< .05 (<0.0015)	< .05 (<0.0015)	0	0	300	0	0	20	30	70	70,000	700	3	0	15	15	0	0	1,500	150	0	15	0
	Mk-527	....		0	0	70	0	0	30	150	300	70,000	700	15	0	30	0	0	0	7,000	300	0	30	0
	Mk-528	....		0	0	700	0	0	20	30	150	70,000	700	7	0	15	0	0	0	7,000	300	0	30	0
65	Fd-397	<0.05 (<0.0015)	<0.05 (<0.0015)	0	0	300	0	0	15	3	1,500	70,000	300	30	0	7	0	0	0	1,500	150	0	30	0
66	Bd-382B	....		0	0	15,000	0	0	15	100	300	70,000	300	15	0	50	0	0	10	3,000	150	0	20	300
67	Bd-433A	<0.1 (<0.003)	....	0	0	50	0	0	30	10	300	M	1,000	<5	0	15	0	0	0	3,000	200	0	15	0
	Bd-433B	....		0	0	30	0	0	20	1	50	M	10	50	0	3	0	0	0	500	15	0	0	0
68	Ov-1903B	<0.05 (<0.0015)	....	0	0	150	0	0	150	200	150	M	200	20	0	300	0	0	0	1,500	150	0	10	0
69	Mk-566	....		0	0	15	0	0	0	2	7	20,000	300	0	0	7	0	0	0	20	15	0	0	0
	Mk-567	<0.05 (<0.015)	....	0	0	150	0	0	20	15	300	70,000	300	7	0	20	0	0	0	3,000	100	0	10	0
	Mk-568	< .05 (<0.0015)	....	0	0	150	0	0	30	10	1,000	M	200	0	0	50	0	0	0	1,000	30	0	0	0
70	Mk-366	<0.1 (<0.003)	....	0	0	300	0	0	15	50	150	50,000	1,000	7	0	30	10	0	0	3,000	200	0	30	0
	Mk-368	< .1 (<0.003)	.. ..	0	0	300	0	0	10	30	150	30,000	700	30	0	20	0	0	0	1,500	750	0	20	0
71	Mk-564	....		0	0	2,000	0	0	5	30	30	30,000	200	10	0	20	10	0	0	2,000	200	0	15	0
	Mk-565	....		0	0	10,000	0	0	7	30	50	20,000	150	15	10	30	10	0	0	2,000	700	0	15	0
72	([4])	....																						
73	No analyses	....																						
74	Fd-400A	....		0	0	700	0	0	7	15	150	15,000	700	30	0	15	15	0	0	1,500	200	0	30	0
75	Fd-402	....		0	0	500	0	0	15	30	300	30,000	500	15	0	15	10	0	0	2,000	70	0	20	0
76	Mk-531	....		0	0	700	0	0	15	150	70	70,000	700	3	10	30	10	0	0	3,000	150	0	30	300
77	Bd-702A	....		0	0	70	0	0	70	150	300	M	1,500	5	0	70	0	0	0	7,000	700	0	30	0
	Bd-702C	<0.05 (<0.0015)	<0.05 (<0.0015)	0	0	70	0	0	70	150	700	M	1,000	3	0	70	0	0	0	7,000	300	0	30	0
78–88	No analyses	....																						

[1] Excluding the Nunatak molybdenum prospect, the Brady Glacier nickel-copper prospect, and the Reid Inlet gold area.
[2] Nunatak molybdenum prospect, see table 13.
[3] Gold value from six-step spectrographic analyses.
[4] Brady Glacier nickel-copper prospect, see table 15.

SAMPLE DATA FOR TABLE 9

	Locality	Geologic setting	Sample 66A–	Description of sample
1	Juneau D-5 quadrangle, 1.8 miles N. 5° E. of Mount Young.	Iron-stained altered zones as much as 10 ft thick and 100 ft long in metavolcanic rocks, hornfels, and slate that are cut by numerous mafic dikes.	Bd-130B	Selected specimen of sulfides replacing metavolcanic rocks.
			Bd-130C	Grab sample of altered hornfels and slate.
2	Juneau D-5 quadrangle, 3.5 miles N. 27½° W. of Mount Young.	Bleached and altered zone 20 ft thick in granodiorite. Irregular-trending iron-stained zones cutting metavolcanic(?) rocks.	Mk-270	20-ft-long chip sample at 6-in. intervals across altered zone.
			Mk-273	Grab sample representative of iron-stained zones.
3	Juneau D-6 quadrangle, nunatak in Casement Glacier 2.1 miles S. 9° E. from northwest corner of quadrangle.	Quartz-ankerite-barite veins as much as 1 ft thick within 10–15 ft thick altered zone in thin-bedded hornfels.	Mk-309	Selected sample of veins.
4	Juneau D-6 quadrangle, 5 miles S. 21½° E. from northwest corner of quadrangle.	Altered granitic rock.	Mk-310	Composite grab sample.
			Mk-311	Selected sample of most altered rock.
5	Juneau D-6 quadrangle, north shore Adams Inlet near triangulation station "Upper."	Amygdaloidal basalt, weakly mineralized.	Mk-156	100-ft-long chip sample at 2-ft intervals.
			Mk-157	44-ft-long chip sample at 2-ft intervals.
			Mk-159	100-ft-long chip sample at 2-ft intervals.
			Mk-160	Selected sample representative of zone 4 ft long.
			Mk-162	100-ft-long chip sample at 2-ft intervals.
			Mk-164	110-ft-long chip sample at 2-ft intervals.

SAMPLE DATA FOR TABLE 9—Continued

	Locality	Geologic setting	Sample 66A–	Description of sample
6	Juneau D-6 quadrangle, north of White Glacier between 5 and 6 miles N. 30° E. from southwest corner of quarangle.	Barite-bearing altered zone 10 ft thick, adjacent to dike that cuts limestone.	Mk–253	10-ft-long chip sample across altered zone at 6-in. intervals.
		10-ft thick iron-stained shear zone cutting limestone; some dikes nearby.	Mk–254	Selected sample adjacent to north wall of dike.
		Altered zones between 1 ft and 200 ft thick cutting volcanic rocks.	Mk–256A	Selected specimens near dikes.
			Mk–256B	Selected sample of richest-appearing part of shear zone.
			Mk–257	6-ft-long chip sample at 6-in. intervals.
			Mk–258	200-ft-long chip sample at 1-ft intervals.
			Mk–259	50-ft-long chip sample at 1-ft intervals.
7	Sandy Cove prospect, Juneau C-6 quadrangle, 2.25 miles S. 29° E. from northwest corner of quadrangle.	Steep quartz veins as much as 1 ft thick cutting quartz monzonite. Local wall-rock alteration adjacent to veins. (See fig. 15.)	Mk–224	10-ft-long chip sample across face; sample interval 6 in.
			Mk–225	5-ft-long channel through high-grade zone in face.
			Mk–226	6-ft-long chip sample at 6-in. intervals.
			Mk–227	Selected sample representing entire width of a 4-in.-thick vein.
			Mk–228	5-ft-long channel sample across back of portal.
			Mk–229	Selected sample of 4-in.-thick pyrite-quartz vein.
			Mk–415	14-in.-long channel sample in face.
			Mk–415A	Selected sulfide-rich ore from high-grade zone in face.
			Mk–416	Selected sample representative of 6-in. of vein.
			Mk–417	1-ft-long channel sample across vein.
			Mk–418	Selected sample representative of altered wallrock.
			Mk–419	18-in. chip sample across altered wallrock at 2-in. intervals.
			Hf–280B	Selected sample of sulfide-rich ore.
			Hf–280C	Do.
8	Juneau C-6 quadrangle, north of York Creek about 7.5 miles S. 22½° E. from northwest corner of quadrangle.	Numerous pyrite-rich veins as much as 6 in. thick cutting hornfels.	Mk–431	Selected samples representative of pyrite-rich veins.
		Iron-stained breccia zone cutting hornfels.	Mk–434A	20-ft-long chip sample at 1-ft intervals across breccia zone.
9	Skagway A-3 quadrangle; location doubtful.	Molybdenite-bearing float found on moraine of Casement Glacier by Ohio State Univ. glaciologists in 1965.		
10	Skagway A-3 quadrangle, west of McBride Glacier 3.8 miles N. 65° W. of Coleman Peak.	Sulfide-bearing ankeritic zones at facies change between phyllite and marble.	Mk–411	Selected samples of richest-appearing sulfide-bearing rock.
			Mk–412	2-ft-long channel sample across ankeritic zone.
			Hx–251	
11	Skagway A-3 quadrangle, 2.7 miles N. 38° E. from southwest corner of quadrangle.	Small prospect pits and trenches on iron-stained breccia and shear zones between 1 and 12 ft thick. Country rock is granodiorite and hornfels.	Mk–145A	Selected sample from shear zone.
			Mk–145B	Selected sample from breccia zone.
			Mk–146	Iron-stained rock from shear zone, selected sample.
			Mk–151	Grab sample from iron-stained fault zone 12 ft thick.
12	Skagway A-4 quadrangle, approximately between 0.9 and 1.3 miles west of Mount Brack.	Altered zones as much as 30 ft thick enclosing discrete ankeritic veins as much as 1 ft thick in limestone, siltstone, shale, and graywacke; some mafic dikes.	Mk–315	Sulfide-rich float, source probably nearby.
			Bd–280	Grab sample from sulfide-rich vein, about 8 in. thick, that cuts a mafic dike.
			Bd–283B	Grab sample from pyritic vein about 1 in. thick.
			Hx–315A	Selected, probably representative, samples of thin sulfide-bearing quartz veins.
			Hx–315B	Grab sample from ankeritic shear zone 2 ft thick.
13	Skagway A-4 quadrangle, on Minnesota Ridge near Glacier Pass.	Copper- and iron-stained tonalite or granodiorite.	Bd–185B	Float.
14	Skagway A-5 quadrangle, Gable Mountain north of Carroll Glacier.	Joint coatings in dioritic rock throughout a large area.	Bd–466B	Composite grab sample.
15	Near southwest corner of Skayway A-5 quadrangle.	Iron-stained altered zone about 100 ft thick near contact between hornfels and instrusive rock.	Bd–723	Float, probably representative of altered zone.
16	Near southwest corner of Skagway A-5 quadrangle.	Lens of copper- and iron-stained hornfels about 10 ft long and 6 ft thick.	Bd–746	Grab sample from lens.
17	Skagway A-6 quadrangle, west of Tarr Inlet south of Margerie Glacier.	Altered and brecciated zones in granodiorite, generally between 2 and 12 ft thick.	Mk–560	Selected specimen.
			Mk–562	Composite grab sample from an altered zone about 12 ft thick.
			Mk–563	Grab sample representative of a 2-ft-thick altered zone.
18	Skagway A-6 quadrangle, west of Tarr Inlet south of Margerie Glacier.	Altered hornfels with sulfides as much as 2 ft thick.	Hf–360	Composite grab sample.
19	Margerie prospect, Skayway A-6 quadrangle, south of Margerie Glacier.	Quartz veins as much as 2 ft thick, altered zones as much as 12 ft thick, in hornfels and granodiorite.	Mk–550A	1-ft-long channel sample of quartz vein.
			Mk–550B	Do.
			Mk–552A	Do.
			Mk–552B	Chip sample at intervals of 4 in. across 5 ft of altered zone.
			Mk–553	Massive sulfide float, pyrrhotite rich.
20	Mount Fairweather D-1 quadrangle, 3 miles S. 37° W. from northeast corner of quadrangle.	Small pyrite-rich pods less than 6 ft long and 1 ft thick in limestone.	Mk–222	Selected specimen from pyrite-rich pod.

SAMPLE DATA FOR TABLE 9—Continued

	Locality	Geologic setting	Sample 66A—	Description of sample
21	Nunatak molybdenum prospect, Mount Fairweather D–1 quadrangle, 3.6 miles S. 77° W. from northeast corner of quadrangle.	Extensive stockworks of molybdenite-bearing quartz veins mainly in hornfels.		Analyses are shown in table 13.
22	Mount Fairweather D–1 quadrangle, north shore of Adams Inlet near entrance; locality not found.	Molybdenite coating fractures in metamorphic rocks (Smith, 1942, p. 178).		No analyses.
23	Mount Fairweather D–1 quadrangle, between 3.5 and 5.5 miles S. 45° E. from northwest corner of quadrangle. At north edge of Plateau Glacier.	Iron-stained zones 1–2 ft thick contiguous to mafic dikes that cut hornfels; some thin quartz veins in altered zones.	Mk–185A Mk–187 Mk–200	Selected specimen of pyritized and iron-stained hornfels. Grab sample representative of iron-stained zones. Selected sample representative of 6-in.-thick quartz vein.
24	Mount Fairweather C–1 quadrangle, North Marble Island, about 5.8 miles S. 38° W. from northeast corner of quadrangle.	Sulfides disseminated in marble near porphyritic dikes and also in the dikes (Reed, 1938, p. 69). Not found during present investigation.		No analyses.
25	Mount Fairweather C–1 quadrangle, south Marble Island about 7.4 miles S. 12½° W. from northeast corner of quadrangle.	Sulfides disseminated in mafic dikes and in silicified limestone and marble near dikes.	Mk–36 Mk–38 Mk–39 Mk–41	Selected sample near lower contact of large dike. Selected sample a few inches below upper contact of large dike. Selected sample of sulfide-bearing mafic dike. Do.
26	Mount Fairweather C–1 quadrangle, prospect on northeastern part of Willoughby Island about 8 miles N. 34° W. from southeast corner of quadrangle; location doubtful.	Sulfide replacement in limestone (Reed, 1938, p. 70–72). Not found during current investigations.		No analyses.
27	Mount Fairweather C–1 quadrangle, prospect on west side of Willoughby Island; location doubtful, probably about 8 miles N. 38½° W. from southeast corner of quadrangle.	Sulfide replacement of intersecting lamprophyre dikes that cut marble (Reed, 1938, p. 70–72). Not found during current investigation.		No analyses.
28	Mount Fairweather C–1 quadrangle, near southwest extremity of Francis Island.	Sulfides and their oxidation products in tactite near quartz diorite. (See fig. 8.)	Mk–17 Hf–183B Hf–183C	Sulfide-bearing float. Grab sample of copper-stained metamorphic rock. Grab sample of sulfide-bearing contact rock.
29	Mount Fairweather B–1 quadrangle, Alaska Chief prospect, 5.4 miles S. 42½° W. from northwest corner of quadrangle.	Sulfide-rich replacements and disseminations in metamorphic rocks near contact wih granodiorite; well-developed gossan. (See fig. 9.)	Mk–469 Mk–470 Mk–471 Mk–472 Mk–473 Mk–475 Mk–474	51-ft-long chip sample at 1-ft intervals. 53-ft-long chip sample at 1 ft intervals. 6-ft-long chip sample, at 6-in. intervals, across back of adit near face. 6-ft-long chip sample, at 3-in. intervals, across back of portal of adit. 51-ft-long chip sample at 1-ft intervals. Grab sample from ore pile. Soil sample.
30	Mount Fairweather B–1 quadrangle about 1 mile southwest of Alaska Chief prospect.	Shear zone in granodiorite or quartz monzonite.	Hx–504B	Grab sample from shear zone.
31	Mount Fairweather B–1 quadrangle, east side of mouth of Dundas River about 9 miles S. 11° E. from northwest corner of quadrangle.	Altered zone, more than 100 ft thick, in metamorphic rocks.	Mk–481 Mk–482 Mk–483 Hx–543 Hx–544 Hx–544B	Grab sample from altered zone. 30-ft-long chip sample at 1-ft intervals. Selected sample of sulfide-rich rock. Selected sample of pyritic schist. 40-ft-long chip sample at 2-ft intervals across best appearing part of altered zone. Selected sample of copper-stained rock from altered zone.
32	Mount Fairweather B–1 quadrangle, east shore of Dundas Bay, about 8 miles N. 17° E. of southwest corner of quadrangle.	Copper-stained quartz veins in cataclastic quartz diorite.	Hx–548	Selected sample representative of quartz veins and host rock.
33	Mount Fairweather B–1 quadrangle, about 8.8 miles N. 41° E. from southwest corner of quadrangle.	Iron deposit shown on unpublished map by Rossman. Probably along contact between quartz diorite and marble.		No analyses.
34	Mount Fairweather D–2 quadrangle, in Bruce Hills 1.4 miles S. 30° W. from northeast corner of quadrangle.	Narrow veins and extensive altered zones in fractured granodiorite with minor hornfels. (See fig. 10.)	Mk–85A Mk–85B Mk–85C Mk–86A Mk–86B Mk–178 Mk–179 Re–56	Selected specimen of sulfide-rich float; source probably nearby. Selected specimen of granodiorite with sulfide-bearing veinlets. Grab sample of gossan. Sulfide-bearing float. Selected sample of pyrite-rich vein. Grab sample representative of 4-ft-thick altered zone in granodiorite. Channel sample across 6-in.thick quartz vein. 6-ft chip sample at 6-in. intervals across altered zone.
35	Mount Fairweather D–2 quadrangle, on Wachusett Inlet 3.7 miles S. 20° W. from northeast corner of quadrangle.	Two molybdenite- and chalcopyrite-bearing quartz veins, 1–2 in. thick, in tonalite.	Bd–273D	Selected sample of richest-appearing material in vein.

SAMPLE DATA FOR TABLE 9—Continued

	Location	Geologic setting	Sample 66A—	Description of sample
36	Mount Fairweather D–2 quadrangle, on Triangle Island near north end of Queen Inlet.	A few hundred pounds of molybdenite were reportedly (Rossman, 1963b, p. K49) mined from Triangle Island in one day. No molybdenite was found on the island during the present study.		No analyses.
37	Mount Fairweather D–2 quadrangle, west of Rendu Inlet.	Two patented claims on short adit that is caved at portal; not found with certainty. Probably represented by a badly caved working on 6-in.-thick calcite-rich vein. Dioritic dike in footwall, marble in hanging wall.	Mk–542 Mk–544	Grab sample representative of vein. Selected specimen from a 6-in.-thick auxiliary vein.
38	Mount Fairweather D–2 quadrangle, west of mouth of Rendu nlet.	Irregular iron-stained altered zones, less than 1 ft thick and about 20 ft long, in marble.	Mk–558 Mk–559	Selected sample from altered zone. Selected sample from pyrite-rich lens, about 2 in. thick, near footwall of altered zone.
39	Mount Fairweather D–2 quadrangle, on ridge west of Rendu Inlet.	Irregular masses of skarn near contact between diorite and marble; local pyrite-rich lenses and altered zones. (See fig. 17.)	Mk–548 Mk–549 Hx–626	Selected sample representative of an altered zone, about 15 ft thick. Grab sample of skarn. Do.
40	Mount Fairweather D–2 quadrangle, east of Queen Inlet, northeast of Composite Island.	Magnetic in skarn near felsic intrusive rocks. Some irregular pyrite-rich zones mainly in nearby metamorphic rocks. (See pl. 10.)	Mk–298A Mk–298B Mk–299 Mk–303 Mk–305 Mk–321 Mk–323 Mk–324	18-ft-long chip sample at 6-in. intervals across skarn. Selected sample of magnetite and sulfides. Do. Grab sample of skarn and sulfides from 2-ft-thick skarn. Grab sample, sulfide-bearing altered zone. Selected sample of pyrite-rich vein 6 in. thick. Selected sample, pyrite-rich vein 4 in. thick. Grab sample representative of pyrite-rich pod 6 ft thick and 20 ft long.
41	Mount Fairweather D–2 quadrangle, 3.2 miles N. 11° W. from southeast corner of quadrangle.	Near contact between metamorphic rocks, chiefly marble, and altered hornblende diorite.	Hx–260V	Grab sample float of sulfide-bearing quartz vein.
42	Mount Fairweather D–2 quadrangle, southern part of Gilbert Island, north of Blue Mouse Cove.	Mineralized shear zones as much as 12 ft thick and a few quartz-calcite veins as much as 1½ ft thick.	Mk–48	Chip sample across the richest appearing 2 ft of an altered zone at 3-in. intervals.
43	Mount Fairweather D–2 quadrangle, north of summit of Gilbert Island.	Sulfide-bearing tactite 1 ft thick in marble 3 ft thick.	Hx–659A	Grab sample representative of a 1-ft-thick sulfide-bearing tactite zone.
44	Mount Fairweather D–2 quadrangle, island south of southwest tip of Gilbert Island.	Fractured quartz diorite that is cut by aplite and alaskite dikes and by thin veins and clay seams.	Mk–84A Mk–84B	Selected sample of quartz veins with minor sulfides. Grab sample of quartz veins with minor sulfides.
45	Mount Fairweather D–2 quadrangle, near southwest tip of Gilbert Island.	Bleached and fractured quartz diorite that contains sockworks of quartz veins and veinlets, abundant clay seams, and a few aplite dikes. Altered zone is several hundred feet long and at least 50 ft thick.	Mk–65 Mk–67 Mk–68 Mk–69 Mk–72	Selected specimen of a 6-in -thick quartz vein. Selected specimen of quartz vein (float). Grab sample from aplite dike. 100-ft-long chip sample taken at 4-ft intervals. 52-ft-long chip sample taken at 4-ft intervals.
46	Mount Fairweather D–2 quadrangle, west of Hugh Miller Inlet near southwest corner of quadrangle.	Three iron-stained pyritic quartz veins, each les than half an inch thick, in hornblende diorite.	Bd–37B	Selected sample of best appearing vein material.
47	Mount Fairweather C–2 quadrangle, about 0.7 mile northeast from the head of Charpentier Inlet.	Flat-lying altered zone about 50 ft thick in fine-grained diorite.	Mk–423	30-ft-long chip sample at 1-ft intervals over best appearing part of altered zone.
48	Mount Fairweather C–2 quadrangle, north shore, Geikie Inlet about 2 miles from entrance.	Sulfide-bearing greenschist, apparently large.	Hx–67	Selected sample.
49	Mount Fairweather C–2 quadrangle, west shore of Shag Cove near its entrance. About 7.2 miles S. 3° W. from northeast corner of quadrangle.	Quartz-pyrite veins in sheared quartzose zone.	Hx–32A Hx–32B	3-ft-long closely spaced chip sample of zone and quartz stringers. Selected sample typical of pyritic pod about 3 ft long and 6 in thick.
50	Mount Fairweather C–2 quadrangle, at a rather high elevation southwest of the head of Geikie Inlet; location doubtful.	Not found during present investigation. Molybdenite associated with garnet in tactite (Smith, 1942, p. 178).		No analyses.
51	Mount Fairweather C–2 quadrangle, west of Blackthorn Peak.	Magnetic anomaly noted by Seitz (1959, p. 16). Not found during present investigation.		No analyses.
52	Mount Fairweather C–2 quadrangle, south of Wood Lake; location doubtful.	Gold placer in glacially derived gravels (Rossman, 1963b, p. K50).		No analyses.
53	Mount Fairweather B–2 quadrangle; location doubtful.	Gold placer claims on upper Dundas River.		No analyses.
54	Mount Fairweather B–2 quadrangle, east of Brady Glacier, south of Abyss Lake.	Several lenses of magnetite-rich skarn as much as 10 ft thick and 30 ft long; minor sulfides.	Mk–460A Mk–460B	Selected sample of skarn. Grab sample of skarn.

SAMPLE DATA FOR TABLE 9—Continued

	Locality	Geologic setting	Sample 66A–	Description of sample
55	Mount Fairweather B–2 quadrangle, east of lower Brady Glacier.	On faulted quartz veins as much as 8 in. thick. Probably at or near locality described by Rossman (1963b, p. K50).	Mk–455	Composite grab sample from quartz veins.
56	Mount Fairweather B–2 quadrangle, on lower Brady Glacier.	Float from molybdenite-bearing quartz veins reported by Smith (1942, p. 177) and by Buddington and Chapin (1929, p. 329, 330).		No analyses.
57	Mount Fairweather B–2 quadrangle, south of West Arm of Dundas Bay.	Gold-bearing quartz veins reported by Rossman (unpub. data); not found during current investigation.		No analyses.
58	Mount Fairweather B–2 quadrangle, on island in West Arm of Dundas Bay.	Copper-bearing hornblendite dikes cutting diorite.	Hx–484A	Grab sample of copper-bearing hornblendite.
59	Mount Fairweather B–2 quadrangle, outwash of Brady Glacier.	Placer-gold deposits reported by Rossman (1963b, p. K50).		No analyses.
60	Mount Fairweather D–3 quadrangle, west of Rendu Inlet.	Molybdenite-bearing quartz veins, less than 2 in. thick, with minor chalcopyrite and pyrite.		No analyses.
61	Mount Fairweather D–3 quadrangle on north side of Russel Island.	Two quartz-calcite veins, 3–5 in. thick, within a 3-ft-thick altered zone cutting granodiorite.	Ov–2041	Selected sample of quartz veins
62	Mount Fairweather D–3 quadrangle, on west side of Tarr Inlet.	Several copper-bearing quartz-calcite veins as much as 6 in. thick within a 6-ft-thick zone of hornblende diorite pegmatite.	Fd–428B	Grab sample of veins.
63	Mount Fairweather D–3 quadrangle, west of Tarr Inlet.	Altered pale-green quartz monzonite with local disseminated sulfides and sulfide-bearing veinlets.	Hx–391	Grab sample containing sulfides
64	Mount Fairweather D–3 quadrangle, north shore of Johns Hopkins Inlet near west edge of quadrangle and extending into Mount Fairweather D–4 quadrangle.	Altered zones between 3 and 100 ft wide in metamorphic, intrusive, and volcanic rocks.	Mk–396 Mk–399 Mk–521 Mk–522 Mk–524 Mk–525 Mk–527 Mk–528	Grab sample from an altered zone about 100 ft wide. 8-ft-long chip sample at 6-in. intervals. 40-ft-long chip sample at 1-ft intervals. Selected sample of pyrite-rich part of altered zone. 75-ft-long chip sample at 1-ft intervals. Chip sample at 1-ft intervals across 10 ft of altered zone of Mk–524 nearest contact with granodiorite. 10-ft-long chip sample at 6-in. intervals. Grab sample representative of richest appearing part of a 30-ft-wide alteration zone.
65	Mount Fairweather D–3 quadrangle, south of Johns Hopkins Inlet west of Lamplugh Glacier.	Altered granitic rocks with copper stained fractures; altered zone is about 200 ft wide and extends several hundred feet along strike.	Fd–397	Composite grab sample.
66	Mount Fairweather D–3 quadrangle, west of Lamplugh Glacier.	Hornfels containing disseminated pyrite, appears to be part of extensive iron-stained area on southwest flank of Mount Cooper.	Fd–382B	Composite grab sample.
67	Mount Fairweather D–3 quadrangle, southwest of Lamplugh Glacier.	Copper-stained hornfels cut by a few quartz veins. Altered zone is more than a half mile long and a quarter of a mile wide.	Fd–433A Fd–433B	Selected samples of a pyritic quartz vein. Selected sample of copper-stained hornfels.
68	Mount Fairweather D–3 quadrangle, west of the head of Lamplugh Glacier.	Altered zone 60 ft thick at contact between intrusive and metamorphic rocks.	Ov–1903B	Selected sample of best appearing material in altered zone.
69	Mount Fairweather D–3 quadrangle, east of Reid Glacier.	Altered zones as much as 25 ft thick and a few narrow quartz veins in strongly folded metamorphic rocks, mainly marble.	Mk–566 Mk–567 Mk–568	Grab sample representative of 10-ft-thick altered zone. Grab sample representative of a 15-ft-thick altered zone. Float from quartz vein.
70	Mount Fairweather D–3 quadrangle, near south end of ridge west of Reid Glacier.	Altered zones as much as 6 ft thick in metamorphic rocks; a few quartz veins between 6 in and 4 ft thick.	Mk–366 Mk–368	5-ft-long chip sample at 4-in. intervals. 2-ft-long channel sample across a quartz vein.
71	Mount Fairweather C–3 quadrangle, east of Brady Galcier, south of the head of Reid Inlet.	Several widely spaced iron-stained alteration zones between 5 and 10 ft thick within a schist and hornfels sequence.	Mk–564 Fd–400A	Grab sample representative of an 8-ft-thick altered zone. Selected sample of best appearing mineralized part of alteration zone.
72	Brady Glacier nickel-copper prospect, on nunatak in Brady Glacier in the southwestern part of Mount Fairweather C–3 quadrangle.	Layered mafic and ultramafic intrusive rocks with disseminated and massive sulfides. (See fig. 18.)		
73	Mount Fairweather B–3 quadrangle, on Astrolabe Peninsula.	Magnetite- and ilmenite-bearing layered mafic intrusive rocks, widespread but mainly throughout a stratigraphic interval of about 1,000 ft (Rossman, 1963a, p. F44)		

SAMPLE DATA FOR TABLE 9—Continued

	Locality	Geologic setting	Sample 66A–	Description of sample
74	Mount Fairweather D-4 quadrangle, on south shore of Johns Hopkins Inlet west of Lamplugh Glacier.	Oxidized pyrite-bearing igneous complex about a quarter of a mile wide.	Mk-565	Composite grab sample.
75	Mount Fairweather D-4 quadrangle, south shore of Johns Hopkins Inlet east of Hoonah Glacier.	Pyritic hornfels between 4 and 6 ft thick.	Fd-402	Composite grab sample.
76	Mount Fairweather D-4 quadrangle, northwest shore of Johns Hopkins Inlet.	Hornfels with disseminated sulfides throughout an extensive zone.	Mk-531	Representative grab sample.
77	Mount Fairweather D-4 quadrangle, south of Johns Hopkins Inlet, east of Hoonah Glacier.	Large altered zone (several hundred feet thick) in hornfels near intrusive contact.	Bd-702A Bd-702C	Composite grab sample of sulfide-bearing hornfels. Composite grab sample of hornfels with gray sulfides.
78	Mount Fairweather C-4 quadrangle, both east and west of North Crillon Glacier.	Copper-stained amphibolite (Rossman, unpub. notes).		
79	Mount Fairweather C-4 and questionably C-5 quadrangle, northwest edge of Crillon-LaPerouse stock adjacent to North Crillon Glacier.	Layered mafic intrusive rocks in contact with schist (Rossman, 1963a, p. F42, F43; Kennedy and Walton, 1946, p. 67-72).		
80	Mount Fairweather C-4 and C-5 quadrangles, near contact of Crillon-LaPerouse stock adjacent to South Crillon Glacier.	Layered mafic intrusive rocks near contact with metamorphic rocks (Rossman, 1963a, p. F42-F43; Kennedy and Walton, 1946, p. 71).		
81	Mount Fairweather B-4 and C-4 quadrangles; location doubtful, Oregon King claims.	36 placer claims north of LaPerouse Glacier (Alaska Div. Mines and Minerals, written commun.)		
82	Mount Fairweather B-4 quadrangle, about 3 miles northwest of Mount Marchainville.	Large copper-stained zone in gneiss near intrusive contact (Rossman, unpub. notes).		
83	Mount Fairweather B-4 quadrangle, about 2½ miles north of Mount Marchainville.	Iron-stained zones in layered mafic intrusive rocks near contact with metamorphic rocks (Rossman, unpub. data.		
84	Mount Fairweather C-5 quadrangle, southwest shore of southeast arm of Lituya Bay.	Sulfides replacing dike (Kennedy and Walton, 1946, p. 71).		
85	Mount Fairweather C-5 quadrangle, southeast of Lituya Bay.	Hydrothermally altered zones with minor gold values (Rossman, 1959, p. 57, 58).		
86	Mount Fairweather C-5 quadrangle, moraine on North Crillon Glacier.	Copper-bearing float in moraine (Kennedy and Walton, 1946, p. 71).		
87	Mount Fairweather C-5 quadrangle, south of mouth of Lituya Bay.	Beach placers (Rossman, 1963a, p. F45-F46; Rossman, 1957; Martin, 1933, p. 133-135).		
88	Mount Fairweather C-6 quadrangle, north of mouth of Lituya Bay.	Beach placers (Rossman, 1963a, p. F45-F47; Rossman, 1957; Martin, 1933, p. 133-135).		

12, sample Bd-280), probably as a constituent of a lead-bearing sulfosalt; the other, from the Francis Island copper deposit (loc. 28, sample Hf-183B), contained 200 ppm antimony.

Tetrahedrite has been reported from the prospect on the west side of Willoughby Island (loc. 27) (Reed, 1938, p. 72), from the Rendu Inlet silver prospect (37) (A. F. Buddington, unpub. data, 1924) (Rossman, 1963b, p. K48, K49), and from Blue Mouse Cove on the south shore of Gilbert Island (42) (Rossman, 1963b, p. K50). Buddington (1924, unpub. notes) also reported jamesonite from the prospect on the west side of Willoughby Island and noted that an ore sample from there contained 25 percent antimony. L. F. Parker (oral commun., 1966) states that one of his samples from the north side of Johns Hopkins Inlet near locality 64 that was assayed by the State (then Territorial) Division of Mines and Minerals contained several percent antimony. None of our samples from that general vicinity contained antimony.

ARSENIC

Arsenic was detected in samples from many localities in the monument. It is particularly abundant in the Reid Inlet gold area (pl. 1) as a constituent of arsenopyrite that is associated with the gold lodes. Arsenic was also found in the Mount Brack argentiferous base-metals deposits (loc. 12), the Margerie copper prospect (19), on the west side of Tarr Inlet (17), and at a locality west of McBride Glacier (10).

Most of the accessible Reid Inlet gold deposits contain arsenic, which occurs commonly or entirely in arsenopyrite. The arsenic content of samples from the LeRoy mine (table 11, loc. B) is as much as 20,000 ppm. Samples from the Rainbow mine (C) contained as much as 1,500 ppm arsenic, and those from the Monarch mines (E) the Incas mine (G), and the Rambler prospect (L), respectively, contained maxima of 7,000, 20,000, and 50,000 ppm arsenic. Minor amounts of arsenopyrite are reported from the gold quartz veins of the Sunrise prospect east of Reid Inlet (Reed, 1938, p. 64). An unidentified arsenic mineral was collected from a narrow vein on the eastern shore of Reid Inlet (Rossman, 1959, p. 57). Arsenopyrite is also a probable accessory mineral in the unsampled and inaccessible gold lodes near Reid Inlet, whose geologic settings are similar to those of nearby arsenic-bearing deposits.

Two samples from the Mount Brack deposits (table 9, loc. 12) contained 7,000 and 30,000 ppm arsenic, respectively. These samples represent complex silver-bearing base-metal deposits, but the mineral host for the arsenic was not determined. A sample from a quartz vein at the Margerie copper prospect (19) carried more than 10 percent arsenic. Another sample from the same vein contained 50,000 ppm arsenic, and a sample from a nearby altered zone revealed 2,000 ppm arsenic. Arsenic at the Margerie prospect is incorporated in arsenopyrite. An altered zone on the west side of Tarr Inlet (17) south of the Margerie Glacier contained 5,000 ppm arsenic. Arsenic in quantities of 7,000 and 15,000 ppm was detected from a deposit localized at a facies change between marble and phyllite west of McBride Glacier (10).

Löllingite, an iron diarsenide, was questionably identified from the prospect on the northeast side of Willoughby Island (table 9, loc. 26) (Reed, 1938, p. 70, 71). Minor amounts of arsenic are reported in spectrographic analyses of the tactite that crops out south of Mount Merriam in the Mount Fairweather D–2 quadrangle (Rossman, 1963b, p. K41).

Many of the arsenic-bearing deposits are associated with gold and silver, and, as often is the case, the arsenic minerals may serve as useful indicators in prospecting for those precious metals.

BISMUTH

Small amounts of bismuth were detected in samples from 12 localities (pl. 1; tables 9, 11). The highest bismuth contents shown by the analyses were 500 ppm from the Sandy Cove gold-copper prospect (loc. 7), 300 ppm from the Margerie copper prospect (19), 200 ppm from the Alaska Chief copper prospect (29), and 150 ppm from the Francis Island copper prospect (28). No bismuth-bearing minerals were identified, but bismuth is probably a minor constituent of some of the sulfides or sulfosalts.

CADMIUM

Cadmium was detected from four localities in the monument (tables 9, 11): the Mount Brack argentiferous base-metal deposits (loc. 12), sulfide lenses southwest of Red Mountain (20), the LeRoy mine (B), and the copper-zinc deposits north of White Glacier (6). The most cadmium found, 1,000 ppm, was in a sample from the LeRoy mine. Cadmium proxies for zinc geochemically, and all the cadmium-bearing samples contained larger amounts of zinc than of cadmium. Probably most of the cadmium is a minor constituent of sphalerite, but possibly some of it forms the cadmium sulfide greenockite.

COPPER

DISTRIBUTION

Copper minerals are widespread and locally abundant throughout the monument (pl. 1). Among the previously known deposits whose major commodity is copper are those on the west side of Tarr Inlet (loc. 18), at the Margerie prospect (19), on Willoughby Island (26, 27), on Francis Island (28), at the Alaska Chief prospect (29), and at several localities in the Fairweather Range (78, 80, 82). In addition, copper constitutes a potential byproduct at the Brady Glacier nickel-copper deposit (72), the Nunatak molybdenum prospect (21), the Sandy Cove gold-copper prospect (7), and the Rendu Inlet silver prospect (37).

Most of the discoveries resulting from our investigations contain anomalous concentrations of copper. The most significant of these are north of White Glacier (pl. 1, loc. 6), near Gable Mountain (14), south of Rendu Glacier (15), near Dundas Bay (31), in the Bruce Hills (34), west of Shag Cove (49), and west of Tarr Inlet (62, 63).

TYPES OF DEPOSITS

The copper lodes occur in diverse types of deposits in several different geologic environments: they include (1) altered zones, mainly mineralized fault zones, (2) massive sulfide bodies, (3) veins, (4) fracture coatings, (5) local disseminations, (6) contact-metamorphic deposits, and (7) low-grade copper-bearing amygdaloid. A clear distinction of type is impossible for many deposits because of intergradation of types. Typical examples of these types are described below.

Deposits in altered fault zones are best exemplified by those east of Dundas Bay (pl. 1, loc. 31). The massive sulfide deposits are diverse and include replacements in metamorphic rocks as at the Alaska Chief prospect (29), the nickel-copper lenses in gabbro at the Brady Glacier prospect, and the cupriferous pyrrhotite-rich lenses(?) at the Margerie prospect (19). The copper-bearing veins are widely distributed but are generally narrow. They are predominantly quartz veins, but some contain moderate quantities of calcite. The gold-bearing veins at the Sandy Cove prospect (7) carry good copper values, and many other veins in the monument are enriched in copper. Stockworks of closely spaced veins and veinlets in bleached and altered metamorphic and intrusive rocks at the Nunatak molybdenum prospect (21) form deposits that are similar to some porphyry copper deposits. Similar stockworks form parts of the Bruce Hills deposit (34) and parts of the deposits at and near the southwestern end of Gilbert Island (44, 45). Copper minerals coat fractures at the deposit at Gable Mountain (14) and at a few other deposits. Disseminated copper minerals were noted in granodiorite in the Bruce Hills (34), in siliceous lenses west of Tarr Inlet (63), in hornblendite dikes near Dundas Bay (58), and in hornfels at a few localities near Johns Hopkins Inlet (75, 76). Copper minerals are subordinant constituents of some of the skarns, as at the Queen Inlet magnetite deposit (40) and the deposit south of Abyss Lake (54). A very lean copper deposit is localized in the amygdaloid on the north shore of Adams Inlet (5).

In general, the deposits range in size from isolated veins and lenses only a few inches thick, through sulfide bodies a few tens of feet in minimum dimension, to extensive networks of veins and mineralized zones that are several hundred feet wide. The deposits are in many different geologic settings, but most of them are in or near intrusive rocks.

Chalcopyrite is the predominant copper mineral in almost all the deposits. Bornite or tetrahedrite is the chief ore mineral in a few of the deposits and subordinate associates of chalcopyrite in several others. Secondary copper minerals, chiefly azurite, malachite, and chrysocolla, are sparsely distributed in a few of the lodes.

DESCRIPTIONS OF DEPOSITS

Mount Young Area

Several small base-metal and silver deposits occur near Mount Young (pl. 1, loc. 1). Only two of our samples from these deposits showed anomalous amounts of metals, and in these the minor zinc and silver values outweigh those of copper. However, the deposits are discussed under copper because some of them contain chalcopyrite and because copper minerals have been reported nearby.

The deposits are in a geologically complex area characterized by a variety of metamorphic rocks, small granitic plutons, and mafic dikes. The highest analytical results were from a sample consisting of sulfides, chiefly pyrite, replacing metavolcanic rocks and from a sample of altered hornfels and slate (table 9, loc. 1). These samples contained as much as 1,500 ppm zinc and slightly anomalous amounts of silver, chromium, copper, molybdenum, and lead. The deposits consist of short quartz veins that commonly are less than 6 inches thick and numerous altered zones, commonly about 2 feet thick, which were traceable for only a few tens of feet because of contiguous ice and snow. A few altered zones are as much as 10 feet thick and are exposed for about 100 feet. The altered zones transect metavolcanic rocks, schist, hornfels, slate, and marble; a few zones are localized along the margins of mafic dikes that cut the metamorphic rocks. The altered zones consist of hydrous iron sesquioxides, carbonate minerals, and quartz; subordinate pyrite, traces of chalcopyrite, probably a secondary zinc mineral, barite, and clay minerals are also present.

The quartz veins are best developed in the schist. They also occur in the other metamorphic rocks, along the margins of dikes, and as ladder veins within the dikes. Commonly, the veins contain minor amounts of pyrite and, rarely, traces of chalcopyrite. Assays of samples from three of the quartz veins all showed less than 0.0015 ounce per ton gold.

Several iron-stained ankeritic altered zones between 5 and 30 feet thick cut granitic rocks near locality 2, about 3.5 miles northwest of Mount Young (pl. 1). Samples from these zones contained slightly anomalous amounts of copper and molybdenum (table 9, loc. 2) and less than 0.0015 ounce per ton gold. Copper minerals have been reported near Mount Young and in samples taken a few miles west of Mount Young (Lathram and others, 1959, their Nos. 18, 20). The deposits near Mount Young which were examined are too lean to be of economic importance, but the abundant weak mineralization and concealment of much of the bedrock by snow and ice might warrant additional prospecting during a relatively snow-free summer or prospecting by geophysical methods.

East of Casement Glacier

Several altered zones cut the granitic rocks near the southeast edge of casement Glacier (pl. 1, loc. 4). These zones are 5–30 feet thick and probably are mineralized fault zones. They are best developed near contacts between the granitic rocks and hornfels. The zones contain scattered pyrite and an array of oxidized gangue minerals. Analyses of representative samples of these altered zones shows only slightly anomalous amounts of copper and molybdenum (table 9, loc. 4).

Many conspicuous altered zones as much as 50 feet thick occur near Snow Dome, about 5 miles northeast of locality 4 (pl. 1). They are mainly localized near contacts between granitic rocks and hornfels. Samples collected from these zones were virtually barren of ore metals.

North Shore of Adams Inlet

Weakly mineralized amygdaloidal lavas are exposed for about 500 feet along the north shore of Adams Inlet (pl. 1 loc. 5). A few steeply dipping mafic dikes cut the lavas. The lavas are flows of amygdaloidal and vesicular altered basalt as much as 15 feet thick. They are prophyritic with plagioclase (labradorite) phenocrysts in a highly altered very fine grained groundmass that probably orignally was intergranular or intersertal. Phenocrysts constitute about a third of the rock and are as much as 6 mm long, but typically about 3 mm long. The altered groundmass is composed of epidote, actinolite, and lesser amounts of calcite, dolomite, and chlorite. Minor amounts of pyrite are scattered throughout the lavas.

All the lavas are weakly mineralized by sulfides, most of which are localized along fractures and generally are most abundant near the dikes. The sulfides, which probably formed during the low-grade metamorphism of the lavas, consist of pyrite and trace amounts of chalcopyrite and pyrrhotite(?). Extensive sampling showed that the lavas are very low in metal content (table 9, loc. 5). All the samples contained slightly anomalous amounts of copper; one sample contained 300 ppm cobalt. Most samples contained trace amounts of molybdenum; one contained silver and tin.

The mafic dikes are also altered basalts, but they are more intensely altered than the lavas. They are porphyritic and consist of medium-grained plagioclase phenocrysts in a highly altered, very fine grained groundmass. The phenocrysts are probably oligoclase, and their cores are generally more altered than their rims. The goundmass is predominantly epidote and actinolite, but it contains small amounts of calcite, chlorite, and leucoxene. Pyrite and subordinate ilmenite and magnetite are scattered throughout the dikes.

North of White Glacier

Many mineralized zones are exposed north and northeast of a northward protruding lobe of White Glacier (pl. 1, loc. 6). These zones cut both limestone and the structurally overlying volcanic rocks. Some zones are near mafic dikes and a small granitic cupola that cuts the limestone. The altered zones in the limestone are less than 10 feet thick and generally not traceable for more than 100 feet. Those in the volcanic rocks are less numerous but larger and range in thickness from 2 to 200 feet; some of them can be traced for long distances.

The altered zones in the limestone contain abundant ankeritic carbonates and barite and lesser amounts of quartz, chlorite, pyrite, and copper minerals. Parallel sets of quartz veins between 1 and 4 inches thick transect some of the zones. Several zones are parallel to mafic dikes, and a few are cut by mafic dikes. The sulfide mineralization commonly is strongest near the borders of the dikes. Thin pyritic lenses occur on bedding surfaces in the limestone contiguous to the altered zones. Analyses of samples from altered zones that cut the limestone are shown in table 9 (loc. 6 Nos. 66AMk–253 through 256B). These zones locally carry significant amounts of copper and minor amounts of silver, zinc, and cadmium. Their gold content is negligible.

The altered zones in the volcanic rocks are conspicuously iron stained. A few locally contain abundant pyrite. A 6-foot-long chip sample representative of one of these zones carried 20,000 ppm zinc (table 9, loc. 4 No.66AMk–257). The host mineral for the zinc was not identified. Gold values in samples from these zones were negligible.

The deposits north of White Glacier appear to be locally rich enough and large enough to warrant prospecting. A few altered zones south of White Glacier south of locality 8 were examined, but samples from them yielded negative results.

North of York Creek

About 15 widely spaced pyrite-rich veins and altered zones containing pods of pyrite cut the hornfels country rock north of York Creek (pl. 1, loc 8). A sample representative of the hornfels consists mainly of quartz and tremolite and moderate amounts of plagioclase and minor biotite. Both the veins and the altered zones commonly strike betweeen N. 10° E. and N. 40° E. and dip steeply. They both consist mainly of quartz and smaller quantities of pyrite, pyrrhotite, and dolomite. Most of the veins are about 6 inches thick. A sample representative of one vein (table 9, loc. 8) contained 1,500 ppm copper and small amounts of cobalt and nickel. Some of the altered zones are brecciated, and some attain widths of about 50 feet. A chip sample across one of the altered zones (table 9, loc. 8) carried 15 ppm of molybdenum. The deposits north of York Creek are too small or too lean to justify exploration.

Minnesota Ridge

Copper minerals were found on Minnesota Ridge in a small outcrop within an extensive snowfield (pl. 1, loc. 13). The outcrop is composed of coarse-grained biotite-hornblende granodiorite or quartz diorite that is cut by a 3-foot-thick porphyritic andesite dike. The deposit consists of pyrite, chalcopyrite, and secondary copper or iron minerals that were probably deposited as open-space fillings along narrow joints with subordinate replacement of the adjacent wallrock. A sample of the richest appearing mineralized material contained 700 ppm copper (table 9, loc. 13). The size of the deposit is conjectural because of the snow cover, but the deposit is too low in grade to encourage exploration.

Gable Mountain

Outcrops of coarse-grained dioritic rocks, probably quartz diorite, are exposed irregularly in a largely snow-covered area near Gable Mountain north of Carrol Glacier (pl. 1, loc. 14). The deposits consist of joint coatings of unknown extent. The chief copper minerals are malachite and chrysocolla. A composite grab sample from the deposits contained 1,000 ppm copper and small amounts of silver and molybdenum (table 9, loc. 14). Remoteness, difficult access, and snow cover will inhibit the prospecting of these deposits.

South of Rendu Glacier

A mineralized altered zone is exposed at altitudes near 4,000 feet in the cliffs south of Rendu Glacier (pl. 1, loc. 15). The zone cannot be reached without a difficult rock climb, and, consequently, it was not examined closely. In aerial reconnaissance the altered zone appears to be in mixed rocks near the contact with a light-gray granitic pluton. It is exposed over a surface about 50 by 200 feet. The margins of the zone are partly concealed, and its actual dimensions may be much larger. A sample of float from the altered zone carried 2,000 ppm copper (table 9, loc. 15). A thorough examination of the deposit, including detailed sampling, is probably warranted despite the deposit's inhospitable setting and remoteness.

West Shore of Tarr Inlet

Copper lodes occur on the west side of Tarr Inlet about a mile south of Margerie Glacier (pl. 1, loc. 18). The deposits are fairly extensive and consist of alteration zones between 1 and 8 feet thick and local disseminated sulfides in hornfels. Chalcopyrite is the predominant copper mineral; it generally is associated with more abundant pyrite. A sample indicative of one of the best mineralized outcrops contained 1,500 ppm copper and minor amounts of bismuth, tungsten, and tin (table 9, loc. 18). This locality is probably at or near two lode claims for copper that are held by the Kenney Presbyterian Home, but no workings or claim markers were found in the vicinity. Claims on copper lodes were reportedly staked in the general area before 1906 (Wright and Wright, 1937, p. 221). A stream-sediment sample collected a few hundred feet south of locality 18 (see pl. 8) contained 700 ppm copper, 0.29 ounce per ton (10 ppm) silver, 10 ppm molybdenum, 10 ppm bismuth, 50 ppm cadmium, 30 ppm arsenic, 200 ppm lead, 500 ppm tin, and 1,000 ppm zinc. The mineralized zones are fairly widespread, and further exploration might be worthwhile.

Margerie Prospect

The Margerie prospect is in steep and rugged terrain south of Margerie Glacier at altitudes between 1,500 and 2,000 feet (pl. 1, loc. 19). The prospect is on several claims located in 1960 for the Moneta Porcupine Co. The deposits are in light-colored granodiorite and nearby high-rank metamorphic rocks, chiefly hornfelses. They consist of quartz veins, mineralized shear zones, and pyrrhotite-rich massive sulfide bodies. The quartz veins, which are as much as 2 feet thick, commonly strike northeast and dip gently south. Their chief sulfide minerals are arsenopyrite and chalcopyrite. Samples from the quartz veins carry as much as 2,000 ppm copper, more than 10 percent arsenic, minor amounts of bismuth, cobalt, and tungsten, traces of molybdenum, and as much as 0.145 ounce per ton (5 ppm) gold (table 9, loc. 19).

The altered zones strike about N. 30° W. and dip steeply to the southwest. They are about 6 feet thick and strongly sheared. Many of the nearby joints are coated with the alteration products and probably contain minor quantities or ore minerals. The altered zones are profusely iron stained, and their constituent minerals were not identifiable megascopically. Samples from the altered zones contained as much as 700 ppm copper and 2,000 ppm arsenic and slightly anomalous amounts of barium (table 9, loc. 19).

The massive sulfides were not found in place, but judging from float, they probably occur in the steep cliffs south of the prospect. The float is predominantly pyrrhotite associated with minor chalcopyrite, quartz, and an unidentified tungsten mineral. A sample of the massive sulfide contained 3,000 ppm copper and 3,000 ppm tungsten, the highest tungsten value of any of our samples (table 9, loc. 19).

The examination of the prospect was brief because of inclement weather. The prospect and its environs warrant a more thorough examination.

Curtis Hills

Several small mineral deposits were found in the recently deglaciated terrain west of the Curtis Hills (pl. 1, loc. 23). Hornfels is the predominant rock in the area; it is cut by a few steep mafic dikes and locally mantled by glacial drift and snow. The hornfels is composed largely of tremolite and lesser amounts of plagioclase, calcite, and quartz.

The deposits consist of narrow quartz veins, commonly less than 6 inches thick, and of altered zones, generally less than 2 feet thick. Many of the quartz veins are joint fillings. Pyrite is the only sulfide mineral recognized in both the veins and the altered zones.

Some of the deposits contain minor amounts of copper and chromium (table 9, loc. 23). Although the area is almost virgin because of its recent denudation, the deposits in it appear to be too small and too lean to encourage prospecting.

North Marble Island

North Marble Island (pl. 1, loc. 24) consists of massive white marble cut by a few mafic dikes. Most of the marble is fairly pure and consists of a mosaic of calcite crystals from 2–5 mm long. Some of the marble is dolomitic. The only sulfide mineral noted is pyrite that occurs disseminated in some of the dikes and in the silicified zones adjacent to the dikes.

Reed (1938, p. 69) reports sulfide bodies as much as 1½ feet thick and 15 feet long in the marble near some of the dikes and small deposits locally along the dikes and in joints within the dikes. He states that the sulfide deposits contain pyrite, pyrrhotite, chalcopyrite, and covellite. Buddington (unpub. data, 1924) reported a claim staked for nickel on North Marble Island. Rossman (1963b, p. K51) mentions a mass of sphalerite and magnetite which occurs in the limestone (marble) on North Marble Island.

South Marble Island

South Marble Island (pl. 1, loc. 25) is composed of medium-grained white marble cut by numerous mafic dikes. The marble is fairly pure and consists almost entirely of an interlocking network of calcite crystals. The dikes are more numerous and thicker than those on North Marble Island. Most of them strike northwest and dip northeast at moderate angles. The largest dike is about 50 feet thick and is characterized by very fine grained chilled basaltic borders and medium-grained gabbroic interiors. A thin section from the core of the largest dike reveals the rock to be equigranular with an average crystal size of about 2 mm. The thin section consists of about 55 percent labradorite and 30 percent pyroxene; the labradorite is slightly normally zoned. Both augite and pigeonite are present. Pyroxene rims are altered to green hornblende, which constitutes about 10 percent of the rock. Magnetite is a minor primary accessory mineral, and a little sericite is an alteration product of the plagioclase.

The mineral deposits are associated with the largest dikes and consist of disseminated pyrite within the dikes and pyrite-rich impregnations in the silicified wallrock near borders of the dikes. A few barren calcite veins cut some of the dikes. Samples from the deposits were all low grade and contained only slightly anomalous amounts of copper and nickel (table 9, loc. 25). Reed (1938, p. 69) states that the sulfide mineralization on South Marble Island is similar to that on North Marble Island but appears to be less intense.

Willoughby Island

Willoughby Island is underlain by massive light-gray limestone that has been locally converted to marble and is cut by many mafic dikes and a few felsic dikes. Glacial drift mantles some of the northeastern part of the island. Both the mafic and felsic dikes are very fine grained. The mafic dikes are 2–30 feet thick and retain relict pilotaxitic textures, but their original glassy groundmasses have been devitrified. They consist of labradorite microphenocrysts and andesine microlites associated with an array of very fine grained minerals including chlorite, potassium-feldspar(?), cristobalite(?), opaque dust, and calcite. Their primary mafic minerals have been obliterated. Reed (1938, p. 72) reports that one of the mafic dikes from a prospect on the west side of the island consists mainly of andesine with considerable chlorite, quartz, pyroxene, and magnetite, and a little calcite. The felsic dikes consist chiefly of quartz and plagioclase.

Minor amounts of oxidized, hydrothermally altered material occupy thin breccia zones contiguous to some of the mafic dikes and in the limestone and marble.

Two prospects are reportedly on Willoughby Island (Reed, 1938, p. 70), but despite an intensive search, neither was found. One of the reported prospects is on the northeast side of the island at an altitude of about 750 feet (pl. 1, loc. 26); the other is on the west side of the island at an altitude of about 450 feet (pl. 1, loc. 27). The northeastern part of the island is covered with dense brush, and the western part is rugged and in places covered with slide debris.

According to Reed (1938, p. 70, 71), the prospect on the northeastern part of the island (pl. 1, loc. 26) is apparently a sulfide replacement of limestone; that is, the deposit consists of massive pyrite with subordinate chalcopyrite and löllingite(?), exposed over an area 15 by 5 feet and for a height of 15 feet. One end of the deposit was covered with talus (Reed, 1938, p. 70, fig. 5). At least three other similar deposits have been reported from the northeastern part of the island.

The prospect (loc. 27) on the west side of the island is ambiguously reported to be both about 2 miles and about 1-¼ miles south of the northwest tip of the island (Reed, 1938, p. 70, 71). The prospect is in marble near two intersecting lamprophyre (mafic) dikes (Reed, 1938, p. 71, fig. 6). The ore forms irregular pods or kidneys along intersections of the dikes and thin veins along the dike contacts or along joints in the marble. It consists of chalcopyrite, pyrite, tetrahedrite, and an unidentified sulfide mineral. Reed (1938, p. 72) states that prospecting downward along the dike intersections might be justified. Buddington (unpub. data, 1924) reports that a sample probably from this deposit assayed 25 percent lead, 25 percent antimony, 1.74 ounces per ton gold, and 42 ounces per ton silver. It is not known whether this sample represents selected high-grade specimens or is representative of the vein material. Buddington (unpub. data, 1924) also reports jamesonite from an unspecified locality on the west side of Willoughby Island.

Francis Island

A copper-zinc-silver deposit is near the contact of quartz diorite and the predominantly marble country rock near the southwestern shore of Francis Island (pl. 1, loc. 28; fig. 8) near a prospect described by Buddington (unpub. data, 1924) that is now concealed by landslide debris. Outcrops are good in the nearshore cliffs but are sparse toward the interior of the island because of dense vegetation.

The quartz diorite is a coarse- to medium-grained rock that is hypidiomorphic granular in texture. It consists largely of plagioclase with calcic andesine cores and calcic oligoclase exteriors. Reddish-brown biotite and green hornblende are characteristic accessory minerals, and quartz is a minor interstitial phase. Magnetite is a minor accessory mineral. Pyrite is sparsely distributed in some of the quartz diorite, and in places is altered to hematite. Narrow seams of tremolite are irregularly distributed in some of the marble, and its presence, together with the coarseness of the marble, indicates that a pluton probably underlies the island at shallow depths.

The quartz diorite intrudes the marble, and its irregular salients cut the marble in a few places (fig. 8). A contact-metamorphic aureole consisting of tactite and hornfels as much as 5 feet thick has formed in the marble adjacent to the intrusive. The tactite consists largely of garnet and pyroxene, the hornfels, of tremolite and chlorite.

A brecciated, sheared, and silicified fault zone separates the quartz diorite and the tactite at the site of the deposit (fig. 8). The fault zone is as much as 10 feet wide, but because of cover, it can be traced on the surface for only about 50 feet. The ore minerals are irregularly distributed along the fault zone and comprise chalcopyrite, bornite, malachite, sphalerite(?), tetrahedrite(?), and chalcocite(?); all are associated with pyrite, secondary iron minerals, and pyrolusite(?).

Samples from the fault zone contained as much as 7,000 ppm copper, 1,000 ppm zinc, 200 ppm antimony, 150 ppm bismuth, and 1.46 ounces per ton (50 ppm) silver (table 9, loc. 28). Buddington (unpub. data, 1924) visited the prospect and reported that a small pocket of bornite with gold and silver values was found in the garnet-rich contact rock and that a quartz diorite dike was locally impregnated with pyrite and pyrrhotite.

A semiquantitative spectrographic analyses of an azonal soil sample collected during our initial examination of Francis Island contained abnormal amounts of copper, zinc, silver, and nickel and instigated the subsequent geochemical survey. Results of the survey are shown in figure 8. THM tests of soil samples collected during the survey (fig. 8) indicate that the ore mineralization is localized along the fault zone near the probable site of the prospect. Prospecting the shear zone might be warranted, but indications are that the deposit in small.

Alaska Chief Prospect

The Alaska Chief prospect is at an altitude of 1,150 feet in the mountains northwest of the mouth of Glacier Bay (pl. 1, loc. 29). The prospect was staked before 1906 and patented in 1924. It is on a densely vegetated steep hillside and formerly was accessible by a 2-mile-long trail from the beach, now badly overgrown and in disrepair. The prospect consists of a cleared and scraped area of about 150 by 55 feet in maximum dimensions and a short south-trending adit (fig. 9). Sulfide-rich bedrock has retarded reestablishment of vegetation in the cleared area. The Wrights (1937, p. 221, 222) report that a tunnel (adit) 130 feet long was driven from a point 60 feet beneath the surface workings, but neither the writers nor Reed (1938, p. 37), who examined the property in the 1930's, was able to find the tunnel.

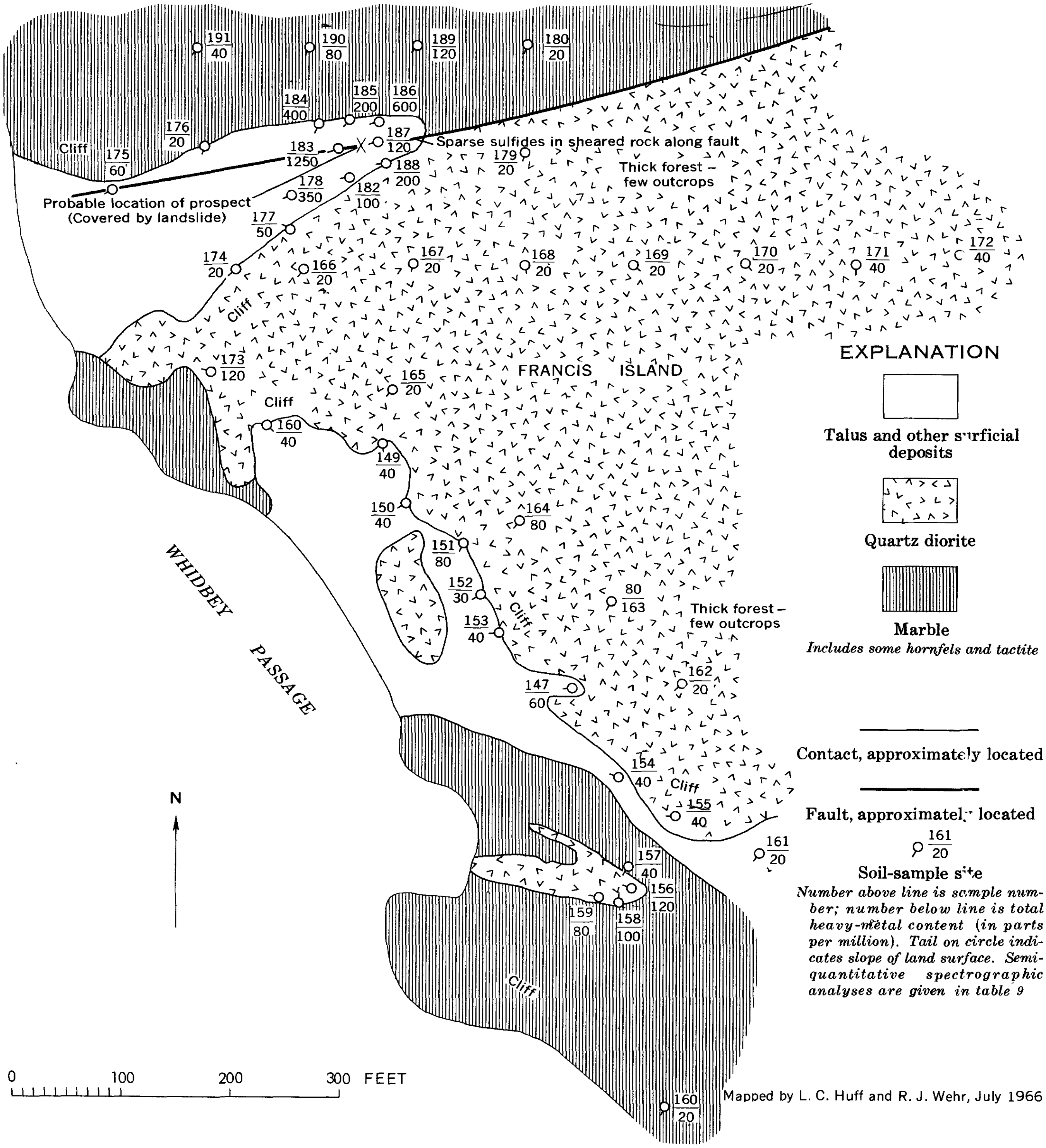


FIGURE 8.—Geologic sketch map of Francis Island prospect, showing geochemical sample locations.

The prospect is in calcareous contact rocks east of a granodiorite pluton that is associated with subordinate diorite. The intrusive contact and the bedding in the metamorphic rocks strike about N. 30° W. and dip steeply to the southwest. The metamorphic rocks are chiefly hornfels with subordinate tactite and marble. The hornfels consists mainly of plagioclase, quartz, amphibole, garnet, and chlorite. The tactite contains a similar mineral assemblage, but its predominant constituent is a grossularite-rich garnet. Reed (1938, p. 72) states that the contact rock consists mostly of zoisite and epidote but includes chlorite and calcite, and that the marble carries considerable quantities of chlorite, orthoclase, and quartz. The Wrights (1937, p. 221) also report calcareous argillite in the vicinity of the deposits.

The deposit is exposed over the entire extent of the cleared area and intermittently in the adit (fig. 9). It consists of massive sulfide replacements of the metamorphic rocks. The Wrights (1937, p. 221, 222) state that some of the mineralization consists of calcite veinlets along bedding planes and that the peripheral parts of the intrusive are locally mineralized. Reed (1938, p. 73) notes that mineralization less intense than that manifested in the cleared area extends over a wide area. Efforts to ascertain the extent of the deposit were unsuccessful because of the dense vegetation. The deposit's surface exposures locally consist of a gossan. Sulfide minerals in the deposit are pyrite, pyrrhotite,

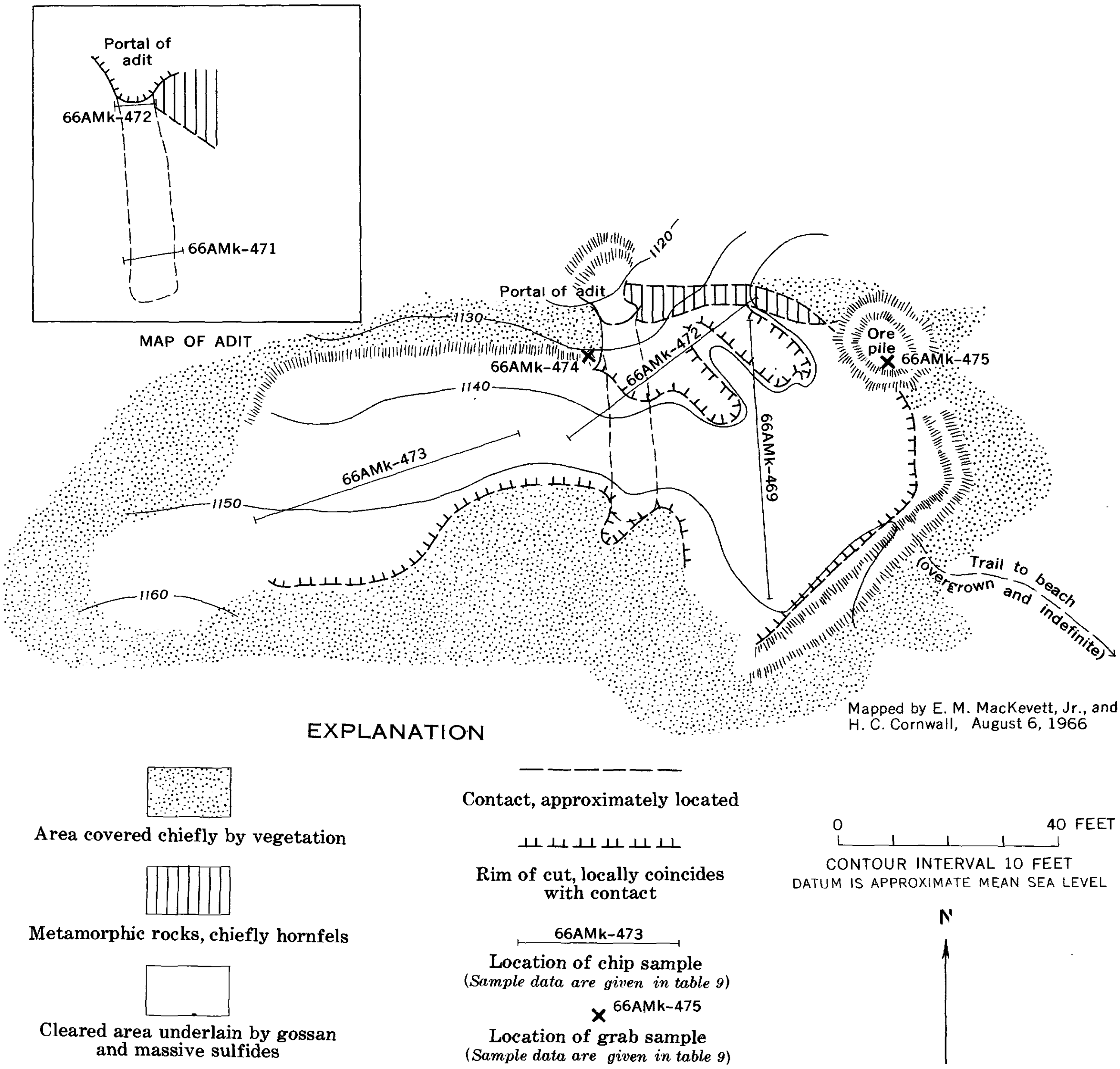


FIGURE 9.—Geologic sketch map showing sample locations at the Alaska Chief prospect.

chalcopyrite, sphalerite(?), and bornite. Oxidized parts of the deposit contain malachite and little azurite along with abundant secondary iron and manganese minerals. The gangue is predominantly calcite with lesser amounts of quartz.

Chip samples from the cleared area contained as much as 15,000 ppm copper, 700 ppm zinc, 0.232 ounce per ton (8ppm) gold, 4.377 ounces per ton (150 ppm) silver, and minor to trace amounts of nickel, molybdenum, bismuth, and cobalt. A grab sample from the ore pile contained more than 10 percent copper, 1,000 ppm zinc, 2.917 ounces per ton (100 ppm) silver and minor anomalous concentrations of cobalt, molybdenum, nickel, and bismuth. A soil sample collected below the cleared area contained 15,000 ppm copper, 1,500 ppm zinc, 1.46 ounces per ton (50 ppm) gold, 1.46 ounces per ton (50 ppm) silver, 300 ppm cobalt, 300 ppm bismuth, and 500 ppm nickel (see table 9, loc. 29; fig. 9.)

Reserve estimates at the prospect are contingent upon estimates of the deposit's size and configuration, neither of which is known. The deposit is exposed throughout the cleared area, which is about 150 feet long and 30 feet in average width. Assuming that the deposit extends to 50 feet beneath the surface, which is a third of its exposed length, the deposit holds 225,000 cubic feet of indicated reserves (150 by 30 by 50). About 8 cubic feet of the sulfide-rich rock would weigh a ton, and therefore the indicated reserve is 28,125 tons. The grade of this reserve as inferred by the surface sampling is slightly better than 1 percent copper. If the deposit extends to a depth of 100 feet below the surface, an additional reserve of 28,125 tons could be inferred. Additional inferred reserves of unknown tonnage and grade exist beyond the lateral limits of the cleared area and beneath the 100-foot subjacent projection of the cleared area.

Negative factors to be considered in the reserve and grade estimates are that the sample taken from the adit (table 9, loc. 29, sample No. 66AMk–471) was lean and that the surface samples consisted partly of gossan, which might be richer than the unoxidized ore.

Adequate reserve and grade estimates require additional exploration and more thorough sampling. The deposit justifies exploration on the basis of its indicated grade and the possibility that it is large. An exploration program consisting of diamond drilling and geophysical and geochemical methods to locate targets in the concealed areas probably is warranted.

East Side of Dundas Bay

Two copper-bearing deposits were found on the east side of Dundas Bay (pl. 1, locs. 31, 32). One deposit (31) occupies an extensive altered zone in quartz semischist that has sharp contacts with adjacent metabasalt. The altered zone is between 100 and 300 feet wide and is traceable for at least 1 mile. It strikes approximately N. 20° E. and dips steeply, and contains sporadically distributed pods of sulfides within abundant secondary iron minerals and also a few quartz veins. The sulfides are mainly pyrite and minor chalcopyrite. Malachite stains a small part of the zone. Semiquantitative spectrographic analyses of samples from the deposit contain as much as 2,000 ppm copper and traces of silver, molybdenum, and lead (table 9, loc. 31). The apparent size of the deposit makes it an exploration target even though its grade is somewhat low. The Wrights (1937, p. 222) state that a number of mining claims were located east of Dundas Bay for copper, lead, zinc, and gold.

The other deposit (32) is in cataclastic biotite-quartz diorite that has flaser structure. It consists of copper-bearing quartz veins between 1 and 2 inches thick which have formed along foliation planes. The extent of the deposit could not be determined because of poor exposures. A sample of the quartz veins contains 1,000 ppm copper and 300 ppm molybdenum (table 9, loc. 32), but the average copper and molybdenum contents of the deposit are much smaller, because the high values are in the quartz veins, which are 1 foot or more apart.

Bruce Hills

The Bruce Hills deposit is in the central part of the Bruce Hills north of Plateau Glacier (pl. 1, loc. 34). The deposit is in granodiorite near a steep fault zone that strikes N. 30° E. (fig. 10). Many of the rocks near the fault zone are shattered and brecciated, and several subsidiary faults diverge from the fault zone (fig. 10).

The part of the deposit that was examined occupies a spur that trends southwestward from the crest of the Bruce Hills. Rocks underlain by the fault zone are intensely shattered, heavily iron stained, and probably mineralized, but they have not been tested by sampling. The granodiorite contains a few small roof pendants of hornfels and is cut by several andesite dikes that strike about N. 70 ° E. and dip to the southeast. Surficial deposits comprising glacial till and talus partly cover the bedrock (fig. 10). The heavily iron-stained mineralized rocks are mostly altered granodiorite containing numerous sulfide-bearing thin quartz veins, disseminated sulfides, and mineralized fracture coatings. The ore minerals are associated with pyrite and (or) pyrrhotite and include chalcoyprite, molybdenite, malachite, and minor amounts of molybdite, sphalerite, and galena. Other minerals in the deposits include montmorillonite, chlorite, hematite, and goethite. Samples from the deposit carried as much as 3,000 ppm copper and 1,000 ppm molybdenum (table 9, loc. 34).

The summit regions and north slopes of the Bruce Hills were largely snow covered at the time of the examinations, and the extent of the deposit to the northeast could not be determined. Likewise, tracing the deposit to the southwest was precluded by cover, including snow and ice. A few small outcrops along the crest of the hills northeast of the area shown in figure 10 contain chalcopyrite and molybdenite and probably represent a continuation of the deposit. Probably the molybdenite occurrence in the north-central part of the Bruce Hills reported by Rossman (1963b, p. K49, K50) is a part of the deposit.

Forty-four azonal soil samples were collected at 50-foot intervals along several traverses at and near the deposit. Some of the samples were analyzed by the citrate-soluble cold THM test at the sample site,

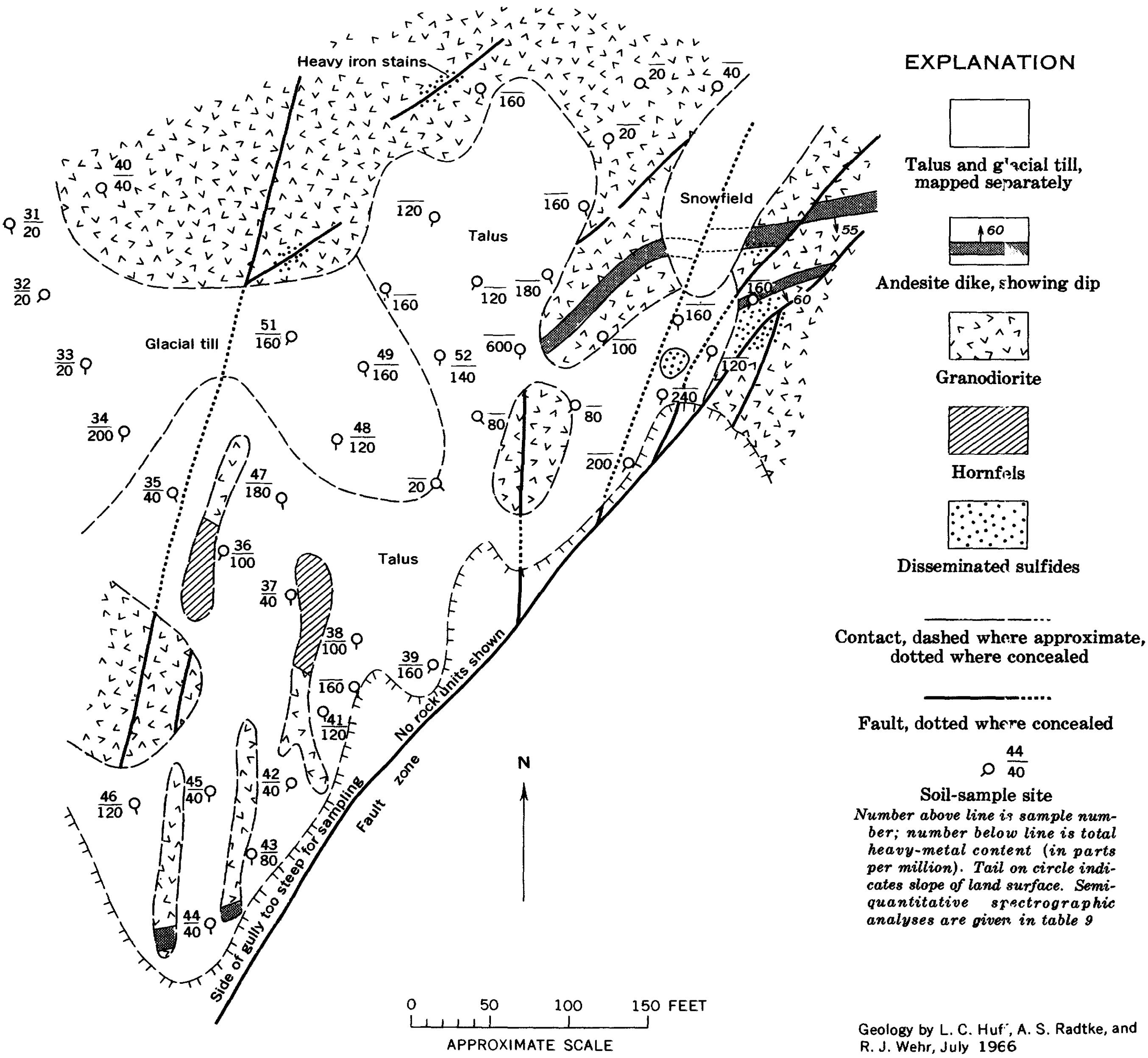


FIGURE 10.—Geologic sketch map of Bruce Hills copper-molybdenum deposit, showing geochemical sample locations.

and subsequently, all the samples were analyzed for THM by our usual test.

In order to check the analytical results, 24 of the samples were also analyzed by semiquantitative spectrographic methods. These analyses show that copper and molybdenum are the only ore metals present in abnormal amounts. From a comparison of the analytical results (table 10), the THM methods is judged to be a satisfactory exploration guide for this geologic situation.

TABLE 10.—*Comparison of analytical results on soil samples from the Bruce Hills Copper-molybdenum deposit*

[Total heavy-metals test by L. C. Huff and R. J. Wehr; analytical methods described under "Geochemical studies." Semiquantitative spectrographic analyses by R. C. Havens and Nancy Conklin]

Sample	Total heavy-metals test		Semiquantitative spectrographic analyses (parts per million)	
	Cold	Hot (parts per million)	Copper	Molybdenum
Re–31	½	20	73	0
32	½	20	57	0
33	½	20	84	0
34	1	200	120	0
35	1	40	73	0
36	1	100	170	7
37	1	40	180	15
38	1	100	150	5
39	2	160	320	15
40		40	26	0
41	3	120	100	5
41A	2	160	240	90
42	2	40	52	0
43	2	80	100	0
44	2	40	72	5
45	1	40	55	18
46	½	120	69	0
47	2	180	480	17
48	3	120	150	6
49	5+	160	170	10
50	3	160	130	77
51	5	160	130	72
52	5+	160	120	0
53	5+	600	710	12
54	3	180	170	9
55	5	120	98	0

Figure 18 shows that the highest THM content, 600 ppm, was detected in a soil developed on talus about 20 feet west of a large dike. Many of the soil samples collected in this vicinity have a THM content between 160 and 200 ppm.

Because of cover and limited access, little is known concerning its overall size and grade, but the results of our examination suggest that the deposit is worth exploring.

West of Mouth of Rendu Inlet

Several small altered zones crop out in bleached marble west of the mouth of Rendu Inlet (pl. 1, loc. 38). The altered zones strike northwestward and dip steeply. They are as much as 20 feet long and 1 foot thick, and contain scattered sulfides, chiefly pyrite, and abundant secondary iron minerals. A sample from one of the altered zones contained 1,500 ppm copper, 1,000 ppm nickel, and 700 ppm cobalt (table 9, loc. 38).

South of Tidal Inlet

Several thin quartz veins occur in marble near the contact with hornblende diorite on the eastern shore of Glacier Bay south of Tidal Inlet (pl. 1, loc. 41). The marble is white and massive, and near the contact it contains small amounts of wollastonite and garnet. Sulfide minerals in the veins include pyrite, chalcopyrite, and pyrrhotite(?). A sample representative of the veins carried 1,000 ppm copper, 300 ppm nickel, and 300 ppm cobalt (table 9, loc. 41).

Blue Mouse Cove

Three mineralized areas were examined on the southeastern part of Gilbert Island north of Blue Mouse Cove (pl. 1, loc. 42). The country rock is a complex assemblage of quartz diorite and younger granodiorite that has been cut by aplite and andesitic dikes. The first area, which is northwest of the easternmost tip of the island, is in a shear zone, 12 feet wide, adjacent to an andesitic dike. The shear zone consists of abundant quartz and dolomite and less abundant muscovite, secondary iron oxides, and an unidentified zinc mineral. The only anomalous sample from this zone (table 9, loc. 42) contained 700 ppm zinc and a trace of silver.

The other areas are on the south shore of Gilbert Island north of Blue Mouse Cove. They contain several nearly parallel calcite veins and a quartz-calcite vein. The veins strike about N. 80° W. and dip between 75° NE. and vertical. The calcite veins are as much as 6 inches thick, and the quartz-calcite vein is a maximum of 1½ feet thick. The veins contain minor amounts of pyrite and secondary iron minerals. None of the samples from the veins contained anomalous amounts of ore metals, and their analyses are not given. The quartz-calcite vein is probably the same vein that Rossman (1963b, p. K50) reports to contain tetrahedrite, pyrite, and some gold and silver. None of the three areas appears to be attractive for exploration.

Southwest Gilbert Island and Nearby Unnamed Island

Copper-molybdenum deposits are sparsely distributed in the southwestern part of Gilbert Island (pl. 1, loc. 45) and on the nearby small island to the south (44). The deposits have about the same potential for molybdenum as they do for copper. They consist of stockworks of numerous quartz veinlets in bleached and altered biotite-hornblende quartz diorite that is cut by alaskite dikes with minor aplitic phases. The quartz diorite is medium grained and has a hypidiomorphic granular texture. It consists of about 45 percent plagioclase (andesine), 30 percent blue-green hornblende, lesser amounts of quartz and red-brown biotite, and traces of zircon, sphene, apatite, epidote, and clinozoisite. The alaskite is strongly altered. It contains mainly plagioclase and quartz in near-equal amounts and about 15 percent potassium-feldspar. Some of the plagioclase is albite. Other minerals form less than 10 percent of the rock and include chlorite, muscovite, biotite, and epidote.

Numerous east-striking near-vertical faults with displacements of only a few inches transect the veinlets and their host rock. Most of these faults contain gouge seams an inch or so thick. The veinlets generally are less than 3 inches thick. They commonly strike between N. 20° W. and N. 40° W. and dip northeastward at moderate angles. Minor amounts of chalcopyrite and molybdenite are localized near the borders of some of the veinlets. The bleached and altered zones are exposed in seacliffs as much as 60 feet high. The northernmost mineralized zone is exposed for about half a mile along the face of the seacliffs and the southernmost zone for about one-sixth mile. These deposits probably include the few molybdenite-bearing veins near the western shore of Gilbert Island that were cited by Rossman (1963b, p. K49).

A selected specimen representative of the highest grade material from the northernmost altered zone contained 7,000 ppm copper, 2,000 ppm molybdenum, and 0.292 ounce per ton silver (table 9, loc. 45). More representative and more extensive samples from the stockworks of both altered zones were of much lower grade (table 9, locs. 44, 45). Despite the large size of the deposits, they probably are too low in grade to encourage exploration.

West of Shag Cove

A sheared and altered zone about 65 feet wide occurs in quartzose rocks on the west side of Shag Cove south of Geikie Inlet (pl. 1, loc. 49). The zone strikes N. 50° E. and dips 75° NW. It contains numerous thin quartz veins and several sulfide-rich pods that have the same general trend as the major structure. The quartz veins contain pyrite. A chip sample representative of part of the altered zone with abundant quartz veins yielded low values (table 9, loc. 49, sample 66AHx–32A). The largest visible sulfide pod is about 3 feet long and ½ foot thick. It consists of pyrrhotite and subordinate amounts of pyrite, chalcopyrite, azurite, and cuprite(?). A sample from this pod contained 3,000 ppm copper, 700 ppm zinc, 200 ppm cobalt, and a trace of silver (table 9, loc. 49, sample 66AHx–32B). The chances of finding minable quantities of ore in the altered zone are remote.

West Arm of Dundas Bay

A small island in the southern part of the west arm of Dundas Bay is composed of gneissic dioritic rocks cut by several hornblendite dikes as much as 10 feet thick (pl. 1, loc. 58). The dioritic rocks are locally garnetiferous. Some of the hornblendite dikes contain disseminations and impregnations of sulfide minerals, chiefly chalcopyrite. A sample of high-grade material from one of the dikes carried 10,000 ppm copper (table 9, loc. 58). The dikes might be worthy of additional prospecting, but the chances of finding minable deposits in them are poor.

West of Mouth of Tarr Inlet

A zone of pegmatitic hornblende diorite about 8 feet thick, cuts the predominant heterogeneous hornblende diorite west of the mouth of Tarr Inlet (pl. 1, loc. 62). In addition to the pegmatitic diorite, the zone contains quartz-calcite veins about 10 inches thick and a few thin aplite dikes. Besides abundant quartz and calcite, the veins carry chalcopyrite, pyrite, epidote, and chlorite. Fractures in the veins are coated irregularly with secondary copper minerals, chiefly chrysocolla. A sample of the veins contained 2,000 ppm copper (table 9, loc. 62).

West of Tarr Inlet

The leucocratic granitic rocks west of the medial part of Tarr Inlet (pl. 1, loc. 63) locally are altered and contain pale-pink to green siliceous lenses. The lenses carry abundant disseminated sulfides and sulfide-bearing veinlets. The sulfide minerals are pyrite and subordinate chalcopyrite. A grab sample from one of the lenses contained 1,000 ppm copper, 300 ppm zinc, and a trace of silver (table 9, loc. 63).

North of Johns Hopkins Inlet

Several altered and mineralized zones are exposed in the steep cliffs along the north shore of Johns Hopkins Inlet (pl. 1, loc. 64). They are distributed intermittently from near the point opposite Lamplugh Glacier westward for about 4 miles. Because of their number, proximity, and similarity, they are represented by a single symbol on plate 1. The altered zones near the eastern part of Johns Hopkins Inlet occur chiefly in septa of metamorphic rocks, mainly marble, within a predominantly dioritic terrane. Those near the western part are in greenstone, phyllite, or granodiorite, generally near intrusive contacts. A few of the altered zones are near mafic dikes.

The altered zones range in width from a few feet to several hundred feet and are exposed for lengths as much as 1,000 feet. They consist of assemblages of quartz, calcite and ankeritic carbonates, plagioclase (including albite) amphibole, muscovite, chlorite, barite, epidote, and secondary iron minerals. The zones locally contain lenses of sulfides and are cut by quartz and calcite veins. The sulfides are pyrite and very small amounts of chalcopyrite. The content of ore metals in the altered zones is low. The highest values that were obtained in any of our several chip samples from the zones were 1,000 ppm copper and traces of molybdenum and silver (table 9, loc. 64). The altered zones were examined by Reed during the 1930's (Reed, 1938, p. 58, 59). L. F. Parker (oral commun., 1966) reports that a sample from one of the altered zones contained several percent antimony.

Although some of the altered zones are large, all of them appear to be too low grade to encourage exploration.

South of Johns Hopkins Inlet

A large altered zone has formed in the granitic rocks south of John Hopkins Inlet west of the Lamplough Glacier (pl. 1, loc. 65). The altered zone is irregular in outline. It is as much as 100 feet wide and exposed for several hundred feet along its strike in the cliffs south of Johns Hopkins Inlet. The zone is cut by a few granitic dikes. Surfaces of the altered granitic rocks are coated by malachite, chrysocolla, and secondary iron minerals. A grab sample from the altered zone contained 1,500 ppm copper and 30 ppm molybdenum (table 9, loc. 65).

East of Lamplugh Glacier

A few sulfide-rich lenses are in hornblende diorite that crops out on the ridge east of Lamplugh Glacier in the Reid Inlet gold area (pl. 1, loc. F). The hornblende diorite contains abundant mafic inclusions and is cut by several aplite dikes. The lenses are as much as 10 feet long and 1 foot in diameter. They consist almost entirely of pyrite. Semiquantitative spectrographic analyses of a sample from the largest lens disclosed 1,000 ppm copper and traces of nickel, cobalt, and chromium (table 11, loc. F).

Southwest of Lamplugh Glacier

Pyrite-bearing quartz veins as much as 10 inches thick cut hornfels west of the upper part of Lamplugh Glacier (pl. 1, loc. 67). The veins strike about N. 22° W. and dip nearly vertical. Wallrock contiguous to the veins is heavily iron stained and sparsely copper stained. Samples from the veins and the adjacent wallrock contained only minor anomalous amounts of copper and molybdenum (table 9, 67).

East of Reid Glacier

Two altered zones, each about 10 feet thick, crop out east of the divide between Reid and Scidmore Glaciers at altitudes near 4,000 feet (pl. 1, loc. 69). The altered zones trend irregularly and cut fractured metamorphic rocks, mainly marble. A few quartz veins between 1 and 2 feet thick also transect the metamorphic rocks. The altered zones are conspicuously stained by reddish-brown secondary iron minerals, but they lack visible ore minerals. Samples from the altered zones carried negligible amounts of copper and molybdenum (table 9, loc. 69, samples 66AMk–566, 567). The quartz veins contain small quantities of sulfide minerals. A sample from a quartz vein yielded 1,000 ppm copper (loc. 69, sample 66AMk–568).

East of Hoonah Glacier

Two mineralized areas crop out east of Hoonah Glacier near the southeast shore of Johns Hopkins Inlet. The first of these, about three-quarters of a mile northeast of Hoonah Glacier (pl. 1, loc. 75), consists of disseminated pyrite in hornfels and appears to be extensive. The hornfels locally is faulted and brecciated. A sample from this deposit contained insignificant amounts of copper and molybdenum (table 9, loc. 75).

The second area is contiguous to Hoonah Glacier (pl. 1, loc. 77). It consists of a large altered zone several hundred feet thick that has formed in metamorphic rocks near their contact with granodiorite. The altered zone contains abundant pyrite disseminations and impregnations, mainly in biotite hornfels, and is conspicuously iron stained. Only a small part of it was examined. Samples from the zone yielded minor amounts of copper and molybdenum (table 9, loc. 77). Although the analyses indicated low contents of ore metals, a more thorough examination might find richer parts in the altered zone.

Fairweather Range

Copper minerals have been reported from many localities in the Fairweather Range. Most of the known occurrences are in the southern part of the range near or in rocks of the Crillon-LaPerouse layered gabbro stock. Rossman and members of his 1952 field party (unpub. data) mention copper-stained outcrops on both sides of North Crillon Glacier (pl. 1, loc. 78), from about 3 miles northwest of Mount Marchainville (82) and from a few other localities in the range.

A 5-foot-thick layer of gabbro that is exposed for several thousand feet along the south wall of the valley occupied by North Crillon Glacier (pl. 1, loc. 80) contains between 2 and 3 percent pyrrhotite and chalcopyrite (Kennedy and Walton, 1946, p. 71). Kennedy and Walton (p. 71) also report that many apparently similarly mineralized bands, including some much greater in thickness, crop out in the nearby cliffs. They also report (p. 71) that specimens collected by R. G. Goldthwait from the north wall of the South Crillon Glacier contained between 5 and 6 percent sulfide minerals, principally pyrrhotite and chalcopyrite. These specimens were from near the contact between the gabbro stock and schist. Many fragments of amphibole-quartz schist that are constituents of a moraine on North Crillon Glacier near altitudes of 2,000 feet are stained with copper carbonates (pl. 1, loc. 86) (Kennedy and Walton, 1946, p. 71).

The copper deposits in the Fairweather Range are in very rugged terrain, and they have not been examined in detail. Samples are not available from any of them, and little is known about their size and tenor. Probably the deposits merit additional prospecting, but their remoteness and difficult access are serious impediments to any contemplated prospecting or mining.

Southeast Arm of Lituya Bay

A gabbroic dike that cuts granitic rocks on the southwestern shore of the southeast arm of Lituya Bay (pl. 1, loc. 84) contains irregular veinlets and blebs of pyrrhotite (Kennedy and Walton, 1946, p. 71). Small amounts of chalcopyrite, which Kennedy and Walton (p. 71) estimate to constitute less than 1 percent of the rock, are associated with the pyrrhotite.

Other Deposits that Contain Copper

In addition to those deposits that contain copper as their principal potentially economic commodity, several other deposits in the monument are copper bearing. Among these are deposits at the Brady Glacier nickel-copper prospect (pl. 1, loc. 72), the Nunatak molybdenum prospect (21), the Sandy Cove gold prospect (7), and the Rendu Inlet silver prospect (37).

Chalcopyrite is an important constituent of the pyrrhotite-rich lenses, disseminations, and impregnations at the Brady Glacier nickel-copper prospect (pl. 1, and table 15, loc. 72). It is a minor constituent of the sizable lodes at the Nunatak molybdenum prospect (pl. 1, loc. 2), and probably copper would be recovered from it if the deposits were mined on a large scale. Chalcopyrite and bornite are associated with gold-bearing quartz veins at the Sandy Cove prospect (7). Samples from this prospect contained as much as 5 percent copper (table 9, loc. 7). Argentiferous tetrahedrite is the chief ore mineral at the Rendu Inlet silver prospect (pl. 1, loc. 37) (A. F. Buddington, unpub. data, 1924; Rossman, 1963b, p. K48, K49).

Chalcopyrite and subordinate secondary copper minerals are minor constituents of many other deposits in the monument, notably those of the Reid Inlet gold area (pl. 1), near the head of Wachusetts Inlet (pl. 1, loc. 35), and the skarns east of Queen Inlet (40), south of Abyss Lake (54), and west of Rendu Inlet (39). A reported copper occurrence at Beartrack Cove on the east side of Glacier Bay (Wright and Wright, 1937, p. 221) was not found during our investigations. The Wrights (1937, p. 221) also report finding large masses of pyrrhotite with some copper (chalcopyrite?) in moraine deposits near Adams Inlet. They also mention (p. 221) copper claims on the mountain between Queen and Tidal Inlets.

LEAD

The mineral deposits of the monument generally are low in lead content, and none of the known deposits could be worked for lead. Only two of the deposits, one reported from the west side of Willoughby Island (pl. 1, loc. 27) and the other near Mount Brack (12), contain lead in possible byproduct quantities. Buddington (unpub. data, 1924) reports jamesonite from an undisclosed locality on the west side of Willoughby Island. One sample, presumably from this locality and presumably of selected high-grade ore, contained 25 percent lead (A. F. Buddington, unpub. data, 1924). A sample from the Mount Brack argentiferous base-metal deposits, described under "Zinc," contained 7,000 ppm lead (table 9, loc. 12). Two other deposits whose principal commodity is zinc—the deposit southwest of Red Mountain (pl. 1 and table 9, loc. 20) and a deposit about a mile southwest of the Alaska Chief prospect (30)—contain minor amounts of lead. A few of the copper deposits contain trace to minor amounts of lead. Galena is a minor constituent of some gold-bearing quartz veins in the Reid Inlet gold area, notably those at the LeRoy mine (pl. 1, loc. B). A sample from the LeRoy mine carried 1,500 ppm lead (table 11, loc. B). However, the Reid Inlet gold deposits are too small to permit recovering their base metals at a profit. Samples from the Sandy Cove gold prospect contained minor to trace amounts of lead (table 9, loc. 7).

RADIOACTIVE ELEMENTS

No uranium or thorium minerals were found during our investigations, although radioactive minerals were looked for during the field examinations, and all samples were routinely checked with a Geiger counter. Rossman (1963b, p. K52) states that some of the altered zones near Sandy Cove contain between 0.001 and 0.003 percent U_3O_8. Seitz (1959, p. 116) reports that he checked the area that he mapped near Geikie Inlet for anomalous radioactivity, and that the results were negative. No favorable indications of uranium or thorium minerals were noted during the examinations. Possibly undetected deposits of these elements are in some of the leucocratic granitic rocks or in the altered zones.

TIN

No tin minerals were found, and no significant anomalous concentrations of tin were detected in the rock and ore samples that were analyzed. The largest amount of tin that was found in these samples was 30 ppm in a sample from the Queen Inlet magnetite deposit (pl. 1 and table 9, loc. 40). Smaller amounts of tin were detected in samples from several other localities (table 9).

A tin and tungsten anomaly in stream sediments was revealed by geochemical sampling near the north end of Dundas Bay. Samples from this area contained 30 ppm tin and as much as 150 ppm tungsten (table 4, locs. 12, 13). The provenance of the streams that yielded the anomalous samples consists partly of leucocratic granitic rocks, which are considered favorable for tin deposits, and prospecting the area seems justified.

Two stream-sediment samples collected in the northern part of the monument also contained anomalous amounts of tin. A sample collected on the west side of Tarr Inlet a few hundred feet south of locality 18 (pl. 1) contained 500 ppm tin, the largest amount of tin detected during the investigation, in addition to anomalous amounts of other metals. The second anomalous sample, from west of Lamplugh Glacier terminus, contained 33 ppm tin, but only ordinary concentrations of copper, lead, and molybdenum.

ZINC

DISTRIBUTION AND TYPES OF DEPOSITS

Although zinc is fairly widespread in the mineral deposits of the monument, most of the deposits in which it is the principal commodity are in the eastern part. Seven zinc deposits discovered during the investigation are described below. Zinc also occurs in seven deposits described under "Copper"; in the Queen Inlet magnetite deposit, described under "Iron"; and in a few lodes in the Reid Inlet gold area.

The zinc deposits are diverse in type, having formed in several geologic settings. They consist of veins, altered zones, disseminations, and local sulfide-rich replacements in a variety of host rocks. Sphalerite is the main zinc mineral in most of the deposits, but some deposits contain fine-grained encrustations of secondary zinc minerals. The best zinc deposits in the monument seem to be near Mount Brack (pl. 1, loc. 12) and in an altered zone north of White Glacier (6) (described under "Copper") that carries 2 percent zinc.

DESCRIPTIONS OF DEPOSITS

Nunatak on Casement Glacier

An iron-stained altered zone is exposed on a small recently denuded nunatak on Casement Glacier (pl. 1, loc. 3). The nunatak consists of thin-bedded limestone, argillite, and hornfels. The altered zone is about 30 feet thick and contains several quartz-ankerite-barite veins that are less than 1 foot thick. The veins and the altered zone strike N. 58° W. and dip vertically. Pyrite is the only visible sulfide mineral in either the veins or the altered zone. The deposit is low in grade, and its only anomalous ore-metal concentration consisted of 300 ppm zinc (table 9, loc. 3).

Mount Brack

The deposits near Mount Brack (pl. 1, loc. 12) consist of veins and altered zones in graywacke, limestone, hornfels, siltstone, and mafic dikes. The veins and altered zones strike north, and most of them dip east. Six veins were exposed at the time of our examination; others are probably concealed beneath the snow, which is widespread and perennial over much of the area. The veins are generally between 6 and 8 inches thick. They consist chiefly of quartz and calcite with, locally, abundant ankeritic carbonates, sulfides, and sulfosalts(?). Samples from the veins yielded higher values in zinc and most other ore metals than those from the altered zones. The vein samples (table 9, loc. 12, samples 66AMk–315, 66ABd–280) contained as much as 15,000 ppm zinc, 0.875 ounce per ton (30 ppm) silver, 7,000 ppm lead, 30,000 ppm arsenic, 7,000 ppm antimony, and 0.087 ounce per ton (3 ppm) gold. The presence of sulfosalts is inferred from the arsenic and antimony content of the samples.

Altered zones as much as 30 feet thick are fairly numerous near Mount Brack. They are composed principally of heavily iron-stained ankeritic carbonates, chlorite, quartz, and calcite and minor plagioclase and muscovite. Some of them enclose quartz-carbonate veinlets. Samples from the altered zones were lean; their maximum zinc content was 700 ppm. Indications of mineralization are widespread, and the general area probably merits prospecting.

Southwest of Red Mountain

Small pyrite-rich pods and impregnations occur in the Black Cap limestone, of Middle Devonian age, near a granodiorite cupola about $2\frac{1}{2}$ miles southwest of Red Mountain (pl. 1, loc. 20). The largest pod is about 10 feet long and 1 foot in diameter. It consists largely of pyrite and subordinate calcite and encrustations of a secondary zinc mineral, probably hydrozincite or smithsonite. A sample from the largest pod contained 7,000 ppm zinc, 500 ppm lead, 70 ppm cadmium, and a trace of silver. The deposits are too small to be of economic significance.

Southwest of Alaska Chief Prospect

An altered shear zone that cuts granitic rocks about a mile southwest of the Alaska Chief prospect contains minor zinc values (pl. 1, loc. 30). The altered zone is about 3 feet wide. Its attitude is N. 30° W., 80° SW. The granitic host rock at the deposit is granodiorite or quartz monzonite. A sample from the altered zone contained 1,500 ppm zinc, 300 ppm lead, and traces of molybdenum, bismuth, and silver (table 9, loc. 30). The deposit probably is too lean to encourage exploration.

Hugh Miller Inlet

Three thin pyrite-rich veins cut biotite-hornblende quartz diorite on the west side of Hugh Miller Inlet west of Gilbert Island (pl. 1, loc. 46). The veins strike between N. 40° W. and N. 55° W. and dip northeastward. A steep northwest-striking shear zone cuts the quartz diorite near the veins. The veins are heavily iron stained and consist of abundant pyrite and its alteration products and probably quartz, barite, and carbonate minerals. A sample from the veins yielded 1,500 ppm zinc, 70 ppm bismuth, and a trace of molybdenum (table 9, loc. 46). Possibly the veins represent a fringe zone of the previously described extensive low-grade copper-molybdenum deposits that are exposed on nearby parts of Gilbert Island (45). The veins probably are too small and too lean to warrant exploration.

Mount Cooper

Altered zones occur in iron-stained pyritic hornfels near a peak locally referred to as Mount Cooper, west of Lamplugh Glacier (pl., loc. 66). They are best developed near fine-grained porphyritic dikes that cut the hornfels. A sample from one of the zones contained 300 ppm zinc, traces of molybdenum, and 15,000 ppm barium (table 9, loc. 66). The dominant minerals in the altered zones are quartz, plagioclase, actinolite, and barite.

A large altered zone north of the ones examined was not sampled because of difficult access, but its composition is probably similar to the zone that was sampled.

Northwest Shore of Johns Hopkins Inlet

Iron-stained hornfels crops out for several hundred feet along the northwest shore of Johns Hopkins Inlet and probably extends for many hundreds of feet to the northwest (pl. 1, loc. 76). The hornfels contains abundant finely disseminated pyrite, but apparently it lacks significant amounts of ore minerals. A sample of the hornfels carried 300 ppm zinc and traces of lead and molybdenum (table 9, loc. 76).

Other Deposits That Contain Zinc

Zinc is a constituent of several deposits whose major commodity is copper, gold, or iron, described elsewhere in this report. The zinc-bearing deposits that are described under "Copper" include those near Mount Young (pl. 1, loc. 1), north of White Glacier (6), at the Margerie prospect (19), on Francis Island (28), at the Alaska Chief prospect (29), near Blue Mouse Cove (42), and on the west side of Tarr Inlet (63). Sphalerite occurs in the gold-quartz veins at the LeRoy and Rainbow mines in the Reid Inlet gold area (B, C). Minor amounts of zinc are associated with pyrite in contact-metamorphic rocks at the Queen Inlet magnetite deposit (40).

Samples from the Mount Young deposits contained as much as 1,500 ppm zinc (table 9, loc. 1). A sample representative of a 6-foot-wide altered zone north of White Glacier contained 20,000 ppm zinc (6). Quartz veins at the Margerie prospect carry traces of zinc (19). A selected sample from the Francis Island deposit yielded 1,000 ppm zinc (28). Chip samples from the Alaska Chief prospect contained as much as 700 ppm zinc, and a grab sample from the ore pile contained 1,000 ppm zinc (29). A sample from an altered zone near Blue Mouse Cove yielded 700 ppm zinc (42). Zinc is a minor constituent of siliceous lenses west of Tarr Inlet which contain disseminated sulfides (63). Samples from the LeRoy mine contained as much as 15,000 ppm zinc (table 11, loc. B), and a sample from the Rainbow mine carried 2,000 ppm zinc (C). Samples from the Queen Inlet magnetite deposit have a very low zinc content table 9, loc. 40). Conceivably, zinc constitutes a potential byproduct in a few of these deposits.

PRECIOUS METALS

Gold is the only precious metal that has been found in significant amounts within the monument. Silver is a constituent of several deposits, and small amounts of platium have been reported from a few of the placers.

GOLD

DISTRIBUTION AND OCCURRENCE

Both lode and placer deposits of gold are widespread in the monument. The lode deposits are mainly in the Reid Inlet gold area, but a few are known from elsewhere in the monument, notably at the Sandy Cove prospect (loc. 7). The best known of the placer deposits are on the beaches north and south of Lituya Bay (87, 88). (See pl. 1)

The lode deposits commonly occupy narrow nonpersistent quartz veins in granitic or metamorphic rocks. A few of them are sporadically distributed in thin altered zones adjacent to the quartz veins. Minor amounts of gold occur in some of the larger altered zones in the monument, and gold constitutes the main commodity of economic interest in a few of the altered zones. Gold is a minor constituent of a deposit that is localized along a facies change between marble and phyllite west of McBride Glacier (pl. 1, loc. 10). It is also a subordinate metal in some of the base metal deposits, as at the Alaska Chief prospect. The placer deposits comprise beach sands, outwash gravels, river and stream sediments, and a few residual placers.

LODE DEPOSITS

Reid Inlet Gold Area

The Reid Inlet gold area includes the ridge south of Glacier Bay which is bordered by Reid and Lamplugh Glaciers and by Reid Inlet (pl. 1). It also includes small parts of the terrain east of Reid Inlet and west of Lamplugh Glacier (pl.1). The area contains most of the gold lodes in the monument and also one small copper deposit. Gold has been produced at six properties that are designated as mines; there also are six prospects for gold in the area. The total value of the gold produced from the mines is about $250,000. The Reid Inlet gold area has been examined by several geologists and mining engineers and is the subject of a detailed report by Rossman (1959). Our studies were facilitated by the results of the earlier investigations, and in most instances, Rossman's maps have been used as bases for our sample localities and geologic data.

The Reid Inlet area is underlain chiefly by granodiorite and quartz diorite and by a few northwest-striking screens and septa of metamorphic rocks. Fine-grained mafic dikes are locally abundant in the area. Almost all the Reid Inlet deposits occupy thin nonpersistent quartz veins, the rest are sporadically distributed in narrow altered zones contiguous to the quartz veins. Iron stains on the veins and on altered rock near the veins permits them to be readily identified at a distance. None of the deposits appear to be amenable to large-scale mining.

Terry Richtmeyer prospect

A gold claim about 1,200 feet south of Glacier Bay and 2 miles west of Ptarmigan Creek is reportedly held by Terry Richtmeyer (Alaska Div. Mines and Minerals, written commun., 1966) (pl. 1, loc. A). We were unable to find the claim. It probably is on quartz veins in granitic rocks near their contact with hornfels.

LeRoy mine

The LeRoy mine, the largest mine in the Reid Inlet gold area, is a little less than 1 mile south of Glacier Bay, at altitudes between 950 and 1,000 feet (pl. 1, loc. B). The mineralized veins at the mine were discovered in 1938 by A. L. Parker and L. F. Parker (Rossman, 1959, p. 38). The mine workings consist of four southwest-trending adits with subsidiary raises and stopes and minor surface workings (pl. 9). The longest adit explores the LeRoy vein for about 240 feet.

The gold is in thin nonpersistent quartz veins and less extensively in narrow altered zones adjacent to the veins. The veins transect northwest-striking metamorphic rocks that dip steeply and form a screen between granitic masses. The metamorphic rocks consists of schist, slate, hornfels, and argillite and are differentiated into three units on plate 9. Petrographic studies of thin sections reveal that many of the rocks mapped as schist are schistose granodiorite that has been intensely sheared. With few exceptions the veins strike about N. 30° E. and dip between 50° and 80° NW. About 15 veins are exposed on the property. Most of them are only 1 or 2 inches thick, but one of them, the LeRoy vein (pl. 9) attains a thickness of about 3 feet. The veins are characterized by pinching and swelling and by a lack of continuity that appears an intrinsic feature compounded by faulting. The LeRoy vein, which has yielded the most production, apparently terminates southwestward near its contact with argillite (which Rossman (1959) considered to be a fine-grained mafic dike). The vein has been stoped throughout much of its extent both above and below the adit level. Some of the veins are strongly fractured and brecciated. Gold is distributed irregularly in the veins and uncommonly in the contiguous altered zones that generally are a few inches thick.

TABLE 11.—*Semiquantitative spectrographic analyses and gold analyses of samples from the Reid Inlet gold area*

[Spectrographic analyses by J. C. Hamilton, Harriet Neiman, and A. L. Sutton, Jr. Gold analyses by Claude Huffman, Jr., J. D. Mensik, O. M. Parker, V. E. Shaw, J. A. Thomas, and J. E. Troxel. Au: A, analyzed by atomic-absorption cyanide method; B, analyzed by fire assay atomic-absorption method]

Results are reported in parts per million, which for the spectrographic analyses have been converted from percent to the nearest number in the series 1, 0.7, 0.5, 0.3. 0.2, 0.150, and 0.1 . . . , which represent approximate midpoints of group data on a geometric scale. The assigned group for six-step results will include more accurately determined values for about 30 percent of the test results. Gold and silver values, in troy ounces per ton, are shown in parentheses below their corresponding parts per million values.

Symbols used; M, major constituent–greater than 10 percent; 0, looked for, but not detected; . . . ., not looked for; <, less than.

The following elements were looked for, but not found: Be, Bi, Hg, La, Li, Pd, Pt, Sb, Sn, Ta, Tl, W.

Locations of the deposits are shown on pl. 1; individual samples are described at the end of the table.

Sample 66A—	Ag	Al	As	Ba	Ca	Cd	Co	Cr	Cu	Fe	Mg	Mn	Mo	Nb	Ni	Pb	Si	Ti	V	Y	Zn	Au A	Au B
Locality A																							
[Location: Mount Fairweather D–3 quadrangle, 1,200 ft south of Glacier Bay, 2 miles west of Ptarmigan Creek. Geologic setting: 1 claim; uppub. data from Alaska Div. Mines and minerals]																							
No analyses																							
Locality B																							
[Location: LeRoy mine, Mount Fairweather D–3 quadrangle between Lamplugh Glacier and Reid Inlet. Geologic setting: Gold in quartz veins and contiguous altered zones within metamorphic rocks. Sample localities are shown on pl. 9]																							
Mk-326	0	10,000	20,000	70	10,000	0	7	1.5	3	7,000	1,500	150	0	0	0	0	M	300	15	0	0	0.3 (0.0088)	....
Mk-328	0	10,000	7,000	100	7,000	0	5	1.5	7	10,000	1,500	150	0	0	0	0	M	700	20	0	0	0.5 (0.015)	....
Mk-329	0	15,000	15,000	100	30,000	0	5	1.5	15	15,000	7,000	300	0	0	0	50	M	700	30	10	0	1.0 (0.029)	2.0
Mk-330	0	10,000	1,000	50	30,000	0	5	1.5	3	15,000	7,000	700	10	0	0	0	M	300	30	0	0	0.4 (0.012)	....
Mk-332	0	7,000	70,000	70	3,000	0	0	1.5	3	15,000	700	70	0	0	0	20	M	300	15	0	0	10 (0.292)	15 (0.450)
Mk-333	0	3,000	30,000	30	30,000	0	0	1	3	7,000	1,500	1,500	0	0	0	0	M	150	15	10	0	0.2 (0.006)	....
Mk-334	0	30,000	0	300	70,000	0	10	3	7	30,000	15,000	1,500	0	0	2	0	M	1,500	70	30	0	0.3 (0.0088)	....
Mk-383	1 (0.029)	20,000	2,000	200	7,000	70	5	2	50	30,000	5,000	200	0	0	0	1,500	M	2,000	30	0	500	11 (0.321)	8 (0.233)
Mk-384	1.5 (0.045)	7,000	1,500	100	30,000	100	7	1	20	15,000	2,000	300	0	0	0	500	M	500	15	0	500	17 (0.495)	16 (0.466)
Mk-385	10 (0.292)	30,000	7,000	200	30,000	300	7	2	70	70,000	7,000	500	0	0	0	7,000	M	1,500	50	0	2,000	12 (0.350)	13 (.379)
Mk-386	15 (0.450)	20,000	0	100	30,000	1,000	10	7	70	50,000	7,000	700	0	0	3	7,000	M	1,500	30	10	15,000	37 (1.079)	24 (0.699)
Locality C																							
[Location: Rainbow mine, Mount Fairweather D–3 quadrangle, west of Reid Inlet about 15 ft above mean high tide. Geologic setting: Intermittent quartz veins in an altered fault zone. Sample localities are shown in fig. 11]																							
Mk-387	0	30,000	1,500	1,000	3,000	0	0	5	20	10,000	1,500	300	0	0	0	70	M	700	15	0	0	4 (0.116)	7 (0.205)
Mk-388	10 (0.292)	30,000	5,000	300	20,000	0	0	2	20	15,000	3,000	500	15	0	0	500	M	700	20	10	0	52 (1.518)	58 (1.664)
Mk-389	10 (0.292)	30,000	1,500	700	700	0	0	7	50	15,000	1,500	200	10	0	3	300	M	1,000	20	10	0	57 (1.635)	55 (1.606)
Mk-390	70 (0.020)	30,000	1,000	1,000	5,000	0	0	0	100	10,000	8,000	150	15	0	0	500	M	500	10	0	2,000	350 (10.208)	330 (9.624)
Mk-391	0	50,000	0	500	10,000	0	0	1	7	15,000	5,000	300	0	0	0	0	M	1,000	15	10	0	.3 (0.0088)	.3 (0.0088)
Mk-392	0	30,000	0	500	30,000	0	7	100	15	20,000	10,000	700	0	0	15	0	M	1,500	50	10	0	.5 (0.015)	.3 (0.0088)
Locality D																							
[Location: Sentinel mine, Mount Fairweather D–3 quadrangle, west of Reid Inlet. Geologic setting: Altered fault zone in granodiorite]																							
Mk-393	0	30,000	0	1,000	30,000	0	10	50	50	30,000	10,000	700	0	0	5	0	M	2,000	50	10	0	4 (0.117)	3 (0.0875)
Locality E																							
[Location: Monarch No. 1 and No. 2 mines, Mount Fairweather D–3 quadrangle, west of Reid Inlet. Geologic setting: Quartz veins and adjoining altered wallrock in granitic rocks. Sample localities are shown in figs. 12 and 13]																							
Mk-337	0	70,000	0	200	30,000	0	10	10	30	50,000	30,000	1,000	0	10	15	0	M	3,000	150	10	0	0.08 (0.0023)	<0.05 (<0.0015)
Mk-339	0	M	0	700	7,000	0	0	20	7	15,000	5,000	300	0	0	3	0	M	1,500	20	10	0	.2 (0.006)	.4 (0.012)
Mk-340	0	70,000	1,000	500	1,500	0	0	5	7	20,000	5,000	700	0	0	0	0	M	1,500	30	10	0	.4 (0.012)	.3 (0.0088)
Mk-341	0	70,000	1,500	700	1,500	0	5	7	7	20,000	5,000	700	0	0	0	0	M	1,500	30	15	0	.2 (0.006)	.2 (0.006)
Mk-342	0	70,000	1,500	700	1,500	0	0	2	15	20,000	3,000	500	0	10	0	15	M	1,500	20	15	0	1 (0.029)	1 (0.029)
Mk-343	0	70,000	7,000	500	1,500	0	0	0	7	20,000	3,000	300	0	10	0	100	M	1,500	20	15	0	1 (0.029)	1 (0.029)
Mk-344	0	20,000	2,000	300	700	0	0	0	10	7,000	1,000	300	0	0	0	10	M	700	0	10	0	.9 (0.026)	.8 (0.0233)
Mk-345	0	30,000	1,500	700	10,000	0	0	1	10	10,000	2,000	700	0	0	0	0	M	500	10	0	0	.8 (0.023)	.6 (0.017)
Mk-346	0	10,000	0	150	20,000	0	0	10	10	7,000	2,000	500	0	0	0	0	M	300	0	0	0	.1 (0.0029)	.1 (0.0029)
Mk-348	0	70,000	1,500	500	2,000	0	7	20	7	20,000	10,000	700	0	0	5	10	M	2,000	50	15	0	.7 (0.020)	.8 (0.023)

TABLE 11.—*Semiquantitative spectrographic analyses and gold analyses of samples from the Reid Inlet gold area*—Continued

Sample 66A—	Ag	Al	As	Ba	Ca	Cd	Co	Cr	Cu	Fe	Mg	Mn	Mo	Nb	Ni	Pb	Si	Ti	V	Y	Zn	Au A	Au B
Locality F [Location: Mount Fairweather D–3 quadrangle, west of Reid Inlet. Geologic setting: Pyrite-rich pods of < 10 ft long and 1 ft thick in hornblende-rich diorite]																							
Mk–375	0	50,000	0	50	50,000	0	100	150	1,000	M	50,000	1,000	0	0	150	0	M	1,000	100	20	0	0 4 (0.012)	0.4 (0.012)
Locality G [Location: Incas Mine, Mount Fairweather D–3 quadrangle, west of Reid Inlet. Geologic setting: Quartz veins intermittently distributed in an altered zone within granodiorite. Sample localities are shown in fig. 14]																							
Mk–350	0	70,000	2,000	700	1,500	0	5	15	7	20,000	3,000	700	0	10	3	10	M	1,500	30	15	0	0.4 (0.012)	0.4 (0.012)
Mk–351	0	70,000	1,000	700	2,000	0	0	1.5	5	20,000	3,000	500	0	10	0	15	M	1,500	20	15	0	1 (0.029)	.7 (0.020)
Mk–352	0	30,000	20,000	2,000	30,000	0	5	100	7	20,000	3,000	1,500	0	0	15	0	M	1,500	30	0	0	1 (0.029)	1 (0.029)
Locality H [Location: Sunrise prospect, Mount Fairweather D–3 quadrangle, east of Reid Inlet. Geologic setting: Quartz veins cutting marble; some lamprophyre dikes in vicinity]																							
Mk–572	0	7,000	0	30	30,000	0	0	3	20	7,000	1,500	100	0	0	0	0	M	150	15	0	0	0 05 (0.0015)	....
Locality I [Location: Hopalong-Whirlaway prospect, Mount Fairweather D–3 quadrangle, east of Reid Inlet. Geologic setting: Quartz veins in granitic rock]																							
Mk–571	0	7,000	0	15	M	0	0	3	30	10,000	2,000	700	0	0	0	0	M	200	30	0	0	<0.05 (<0.0015)	....
Locality J [Location: Galena prospect, Mount Fairweather D–3 quadrangle, at an altitude of about 500 ft west of Reid Inlet. Geologic setting: Quartz vein]																							
No analyses																							
Locality K [Location: Highland Chief prospect, Mount Fairweather D–3 quadrangle, at altitude between 2,500 and 2,800 ft west of Reid Inlet. Geologic setting: Quartz veins in metamorphic rocks]																							
No analyses																							
Locality L [Location: Rambler prospect, Mount Fairweather D–3 quadrangle, east of Lamplugh Glacier. Geologic setting: Quartz veins in granitic rocks and uncommonly in metamorphic rocks]																							
Sj–5	0	M	0	1,500	700	0	0	10	50	30,000	10,000	100	0	0	0	300	M	5,000	200	20	0	0 05 (0.0015)	<0.05 (<0.0015)
Sj–6	0	10,000	5,000	150	300	0	15	1	150	20,000	1,000	30	0	0	0	50	M	700	15	0	0	5 (0 15)	4 (0.012)
Sj–7	0	3,000	2,000	50	7,000	0	30	1	200	70,000	500	150	<5	0	0	0	M	200	0	0	0	7 (0.204)	5 (0.15)
Sj–8	0	2,000	0	50	150	0	10	1	200	20,000	100	15	0	0	0	0	M	200	0	0	0	....	9 (0.263)
Mk–545	0	7,000	30,000	100	7,000	0	0	1.5	20	7,000	700	150	0	0	0	30	M	200	7	15	0	1 (0.029)	....
Mk–546	0	30,000	50,000	1,000	70,000	0	7	30	15	20,000	15,000	2,000	0	0	3	0	M	1,000	70	0	0	.5 (0 015)	....
Mk–547	0	10,000	0	150	30,000	0	0	5	7	7,000	1,500	300	0	0	0	0	M	300	15	10	0	< .05 (<0.0015)	....

DESCRIPTION OF SAMPLE

Locality A: No analyses.

Locality B:

66AMk–326	Chip sample 18 in. long at 2-in. intervals across quartz vein with minor horses.
Mk–328	Selected sample of entire width of 4-in.-wide quartz vein.
Mk–329	Selected sample representative of 3-in.-wide quartz vein.
Mk–330	Channel sample across 6-in.-thick quartz vein.
Mk–332	Channel sample across 8-in.-thick quartz vein.
Mk–333	Channel sample across 5-in.-thick quartz vein at surface.
Mk–334	Channel sample across 3-in.-thick quartz vein and 12-in.-thick adjacent altered zone.
Mk–383	Channel sample 15-in. long across quartz vein with subordinate altered wallrock.
Mk–384	Channel sample 8 in. long across quartz vein.
Mk–385	Channel sample 12 in. long across quartz vein and altered wallrock.
Mk–386	Selected sample representative of 1-in.-thick quartz vein and 1-in.-thick altered wallrock.

Locality C:

Mk–387	Grab sample from small ore pile near face.
Mk–388	Channel sample 1 ft long.
Mk–389	Grab sample from quartz vein.
Mk–390	Channel sample 1 ft long.
Mk–391	do
Mk–392	do

Locality D:

Mk–393	Channel sample, 1 ft long, near easternmost outcrop of altered zone.

Locality E:

Mk–337	Monarch No. 1, 29-in.-long channel sample.
Mk–339	Monarch No. 1, 10-in.-long channel sample across altered zone.

Locality E—Continued

66AMk–340	Monarch No. 1, channel sample 16 in. long.
Mk–341	Monarch No. 1, channel sample 24 in. long.
Mk–342	Monarch No. 1, channel sample 14 in. long.
Mk–343	Monarch No. 1, channel sample 12 in. long.
Mk–344	Monarch No. 2, channel sample 6 in. long.
Mk–345	do
Mk–346	do
Mk–348	Monarch No. 2, channel sample 8 in. long.

Locality F:

Mk–375	Grab sample of pyrite-rich pod.

Locality G:

Mk–350	Channel sample 10 in. long.
Mk–351	Channel sample 18 in. long.
Mk–352	Chip sample 4 ft long, at 4-in. intervals.

Locality H:

Mk–572	Selected sample representative of a 4-in.- thick quartz vein.

Locality I:

Mk–571	Grab sample representative of veins.

Locality J: No analyses.

Locality K: No analyses. Prospect concealed by snow during 1966.

Locality L:

Sj–5	Grab sample of sheared and altered granodiorite from contact with quartz vein (Sj–6).
Sj–6	Selected sample of 1-in. massive white unstained quartz vein.
Sj–7	Selected sample from sulfide-bearing quartz vein.
Sj–8	do
Mk–545	Grab sample from quartz veins 1–4 in. thick.
Mk–546	Grab sample from quartz vein 2 in. thick.
Mk–547	do

The veins consist mainly of quartz and minor amounts of feldspars, calcite, and clay minerals. The sulfide minerals arsenopyrite, pyrite, galena, sphalerite, and chalcopyrite are minor constituents of most of the veins. Subordinate amounts of silver are associated with the gold. The veins have been extensively sampled, and the locations and gold values in samples that were collected during the 1966 investigations and during a previous examination by the Territorial Department of Mines are shown on plate 9. Additional analytical and descriptive data germane to these samples are shown in tables 11 and 12. The richest sample represents a 6-inch-thick vein that is exposed at the surface and assayed 10.34 ounces per ton gold and 7.40 ounces per ton silver (pl. 9; table 12). Samples representative of the LeRoy mine lodes contained as much as 0.0045 ounce per ton (15 ppm) silver, 70,000 ppm arsenic, 1,000 ppm cadmium, 70 ppm copper, 1,500 ppm lead, 15,000 ppm zinc, and 0.699 ounce per ton (24 ppm) gold (table 11, loc. B). About $100,000 in gold has been produced from the mine.

TABLE 12.—*Assay data on the Leroy mine*
[From the Alaska Div. Mines and Minerals (formerly Territorial Dept. Mines and Mineralogy)]

Loc. (pl. 9)	Width (inches)	Au (ounces per ton)	Ag (ounces per ton)
Surface samples			
54–7	4	0.02	Nil
54–8	6	2.12	0.80
54–9	6	10.34	7.40
54–10	6	1.37	Trace
54–11	16	.50	Trace
Underground samples			
54–12	12	0.22	Trace
54–13	3	.11	Nil
54–28	28	.38	Trace
54–29	36	2.63	Trace
54–30	4	.25	Trace
54–31	6	.10	Nil
54–32	1	.46	Trace
54–33	12	1.56	Trace
54–34	22	.42	Trace
54–35	24	.73	Trace
1	(1)	.14	Nil
2	8	.36	Nil
3	(2)	.50	Nil
4	6	.56	Nil
5	(1)	.42	0.60
6	(1)	.26	Trace
7	(3)	2.90	.66
8[4]	12	.16	Nil
9	18	.70	1.80
10	(5)	.26	Trace

1 Selected sample.
2 Fines.
3 8 in. of drill core.
4 Location not known.
5 Grab sample.

The LeRoy mine and vicinity were studied by geochemical methods to determine whether soil sampling and analyses would aid in exploration for gold lodes in the Reid Inlet area. The original prospectors in the area relied heavily on panning to trace the gold-bearing veins. Where the veins are exposed, panning works well; but throughout much of the area the veins are covered by soil and galacial deposits. Most of the veins contain more sulfide minerals, including galena, than gold. Rather than analyze the samples for gold, it was decided to determine their THM content, which would reveal any abnormal amounts of lead.

Eighteen azonal soil samples were collected at 50-foot intervals along two horizontal traverses near altitudes of the lower and upper portals (pl. 9). In addition, 13 samples were collected from near the caved stope above the LeRoy adit. All the samples were collected within 250 feet of known gold-bearing veins and 11 were collected within 50 feet of known veins.

Analyses of the samples showed that none of them contained significant amounts of lead or more than 40 ppm total heavy metals. From these results it was concluded that the small amounts of lead in the ore could not be detected in soil diluted with glacial detritus, and that the soil-sampling methods used are not satisfactory for the Reid Inlet area.

Rainbow mine

The Rainbow mine is west of the mouth of Reid Inlet (pl. 1, loc. C). The mine workings explore an altered fault zone about 1 foot thick that contains vein quartz. The fault zone, which is traceable on the surface for about half a mile southwestward from sea level to altitudes slightly more than 1,000 feet, strikes about N. 30° E. and dips between vertical and 70° SE. The workings consist of a southwest-trending adit about 180 feet long, a short crosscut, stopes above the adit level, and a small pit near the southwesternmost outcrops of the zone (fig. 11). The portal of the adit is in sea cliffs about 15 feet above high-tide level. The fault zone cuts granodiorite and small masses of alaskite. A shattered and brecciated quartz-calcite vein a few inches thick occupies the fault zone. The vein contains gold and an assemblage of sulfide minerals similar to those at the LeRoy mine. The altered zone, which is marked by abundant secondary iron minerals and gouge, also contains widely scattered gold.

Analytical results of samples from the Rainbow mine are shown in table 11, loc. C). The highest gold value found in any of our samples from the monument, 10.211 ounces per ton gold, was detected in one of the samples from the mine. Besides gold, samples from the Rainbow mine carried as much as 2.043

ounces per ton silver, 1,500 ppm arsenic, 500 ppm lead, and 2,000 ppm zinc.

The Rainbow mine probably is the second largest gold producer in the Reid Inlet area, but its production data are unavailable. The mine was worked during 1945 and shortly thereafter, and its ore was transported by barge and truck to the mill at the LeRoy mine.

The Rainbow mine is similar geochemically to the LeRoy mine, and the soil conditions are comparable. The Rainbow mine was sampled for the same purpose as the LeRoy mine—that is, to find out if analysis of the soil for lead could help trace the veins where they are covered by soil and glacial material.

Most of the 12 soil samples that were collected were from the hillside 10–50 feet below an outcrop of the vein, where detection of an anomaly seemed most likely. None of these samples contained more than 40 ppm THM. These results support the conclusions made for the LeRoy mine—namely, that the amount of lead in the soils is too small to be useful in tracing the veins.

Sentinel mine

The Sentinel mine is west of the mouth of Reid Inlet at altitudes near 900 feet (pl. 1, loc. D). Ore at the mine is localized along a northwest-striking steep altered zone that cuts granodiorite. The altered zone is about a foot thick and consists of intensely altered and comminuted granodiorite that contains sparse impregnations of sulfides, abundant secondary iron minerals. and erratically distributed gold. Several other altered zones that are similar in attitude and character to the one at the mine are exposed on the hillside northeast of the property. A sample from one of these (table 11, loc. D) yielded negligible gold values. The mine has yielded a small undisclosed production of gold. It was worked by shallow surficial workings that are now obscured by overburden and vegetation.

Monarch mines

The Monarch mines are on the steep hillside west of Reid Inlet (pl. 1, loc. E). The Monarch No. 1 mine is at an altitude of about 1,875 feet, and the Monarch No. 2 mine, at an altitude of about 1,500 feet. Both of the mines were worked from adits, and both probably produced minor amounts of gold.

The adit at the Monarch No. 1 mine extends for about 210 feet southward from its portal (fig. 12). A small overstope was excavated about 70 feet from the portal. The adit explores an altered zone between

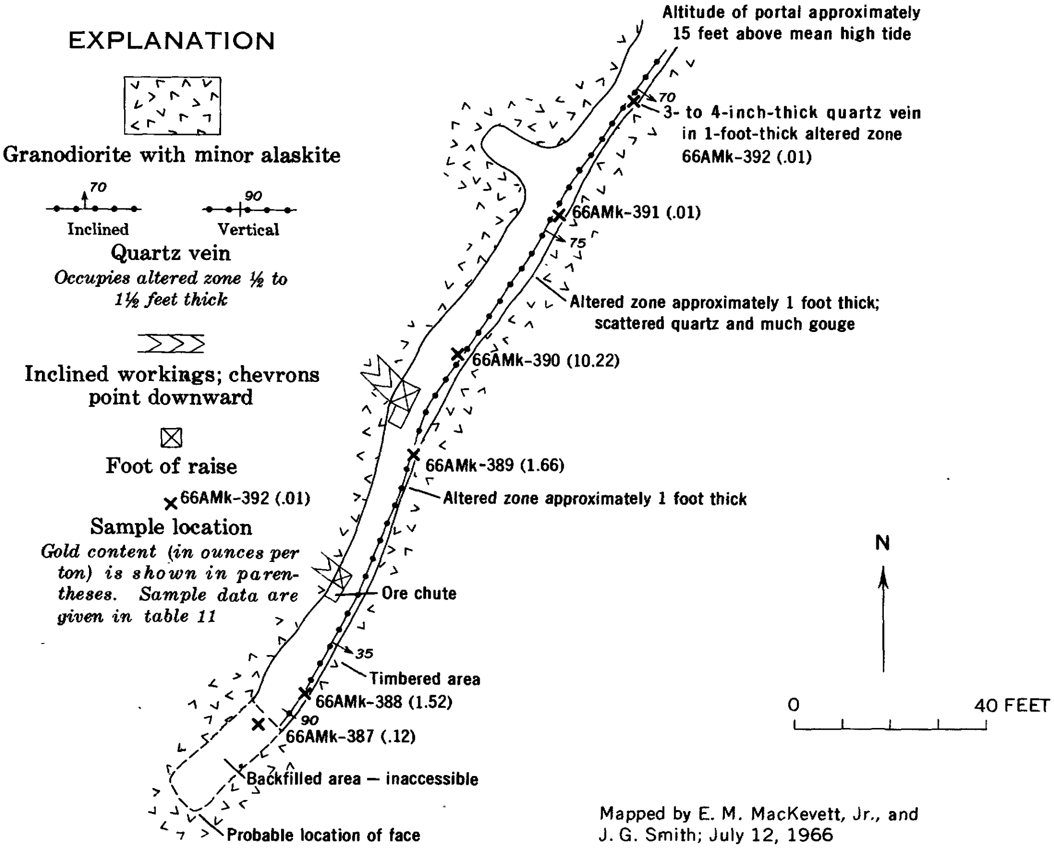


FIGURE 11.—Geologic sketch map showing sample locations at the Rainbow adit.

1 and 5 feet thick within granodiorite. The zone strikes northward and dips steeply to the west. It contains quartz veins and lenses a few inches thick and abundant gouge and breccia. The granodiorite wallrock is medium to coarse grained and hypidiomorphic granular in texture. It contains about 65 percent plagioclase, 15 percent quartz, and 10 percent potassium feldspar. The rock is cut by microfractures and is altered, resulting in the obliteration of its primary mafic minerals and replacement of the original plagioclase by oligoclase. Its minor constituents and alteration products consist of sphene, allanite, calcite, chlorite, epidote, and opaque minerals. The veins and lenses, and less commonly the altered zones, contain sparsely distributed arsenopyrite, pyrite, galena, and gold. Calcite and clay minerals constitute the lesser gangue minerals. Samples from the mine showed low values in gold and other ore metals (table 11, loc. E, samples 66AMk–337 through 66AMk–343).

Rossman (1959, p. 50) reports a few other gold-bearing veins near the Monarch No. 1 vein. One vein, a few hundred feet west of the Monarch No. 1 vein, crops out over a length of about 10C feet and is as much as 10 inches thick. Some of the partly decomposed weathered material at the surface of the vein has been mined. A small rich stringer vein about 5 inches thick is exposed several hundred feet west of the south end of the Monarch No. 1 vein.

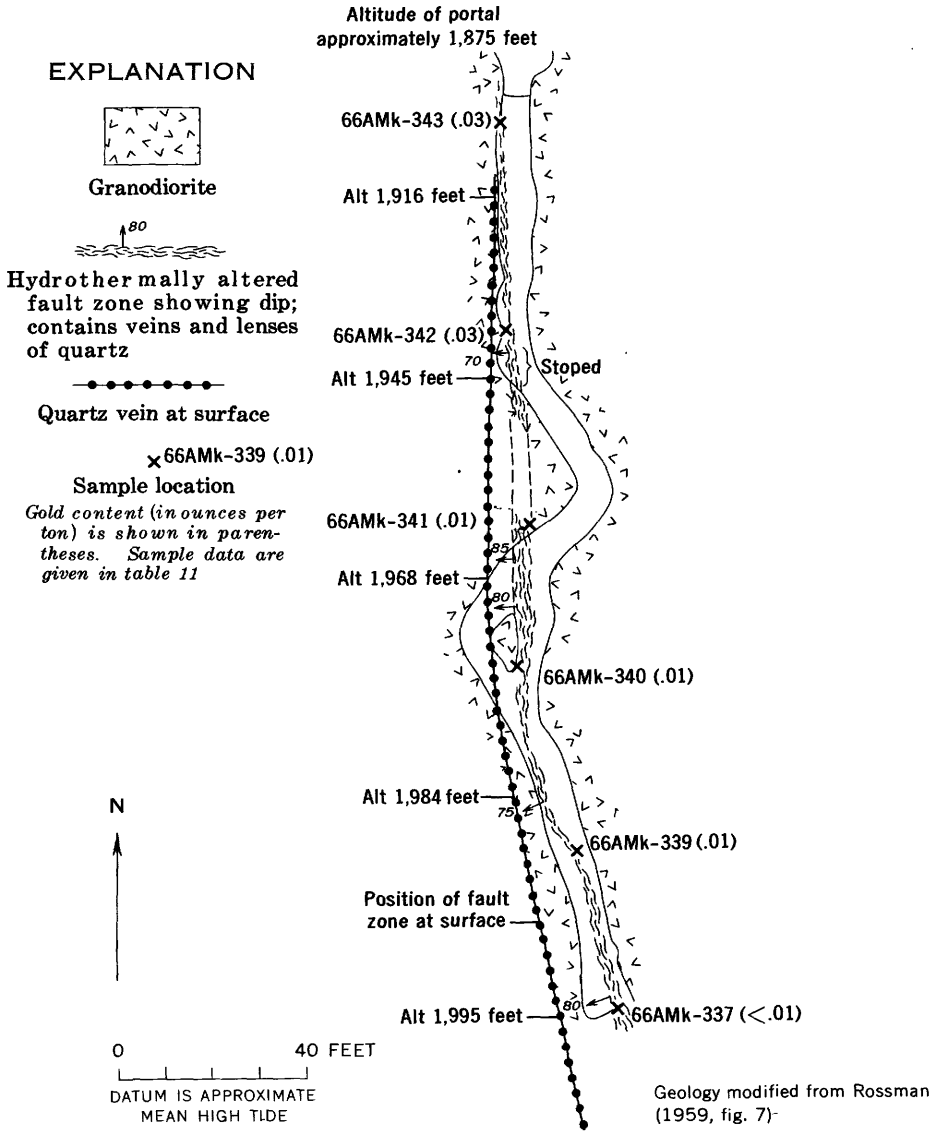


FIGURE 12.—Geologic sketch map showing sample locations at the Monarch No. 1 mine.

Workings at the Monarch No. 2 mine consist of a westward-trending crosscut adit about 120 feet long and two short drifts (fig. 13). The workings are in granodiorite that is cut by a few quartz veins and by northward-striking mafic dikes and faults. The granodiorite at the Monarch No. 2 mine is less altered, but slightly more deformed, than its counterpart at the Monarch No. 1 mine. The quartz veins strike northward and dip nearly vertical. They are between 2 and 8 inches thick and are bordered by thin gougey selvages. The veins contain sparsely distributed calcite, sulfides, and minor amounts of gold (table 11, loc. E., samples 66AMk–344 through 66AMk–348). A few other small quartz veins are near the Monarch No. 2 property (Rossman, 1959, p. 51).

Incas mine

The Incas mine is west of Reid Inlet at an altitude of about 1,000 feet (pl. 1, loc. G). The Incas lode, one of the first discoveries in the Reid Inlet area, was staked by Joseph Ibach in 1924 (Rossman, 1959, p. 46). The mine consists of about 200 feet of underground workings (fig. 14) and several trenches that are now badly caved and sloughed. The deposits are localized in quartz lenses in an altered fault zone within granodiorite. The fault zone strikes northward and dips steeply. It is between 1 and 3 feet thick and is traceable intermittently on the surface for about 1,000 feet. The granodiorite is medium grained and hypidiomorphic granular in texture. It contains about 60 percent plagioclase (sodic andesine), 20 percent quartz, 10 percent potassium feldspar, and 10 percent alteration products, chiefly epidote and chlorite. Much of the granodiorite has been deformed cataclastically. The quartz lenses contain minor amounts of calcite and sulfides, chiefly arsenopyrite, and sporadically distributed gold. The altered zone consists of hydrothermally altered granodiorite and traces of gold and sulfides. Our samples from the mine revealed only minor amounts of gold and ore metals (table 11, loc. G).

Rossman (1959, p. 48) states that several other veins and altered zones crop out in the vicinity of the mine. He also believes that the mine has not been explored sufficiently for evaluation of its economic possibilities. The small production from the property was probably mainly from surficial workings.

Sunrise prospect

The Sunrise prospect includes several shallow pits and trenches on the hillside east of Reid Inlet at altitudes near 800 feet (pl. 1, loc. H). Rocks at the prospect are marble and hornfels that strike northward and dip steeply. Subordinate fine-grained diorite or quartz diorite is also present. Several northeast-striking lamprophyre dikes, as much as 30 feet thick, cut the other rocks. The gold occurs principally in several subparallel narrow quartz-calcite veins whose attitudes are similar to those of the metamorphic rocks. The veins are between 2 and 12 inches thick and are discontinuous. Generally, their outcrop lengths are between 20 and 40 feet. Pyrite is the only metallic mineral noted in any of the veins.

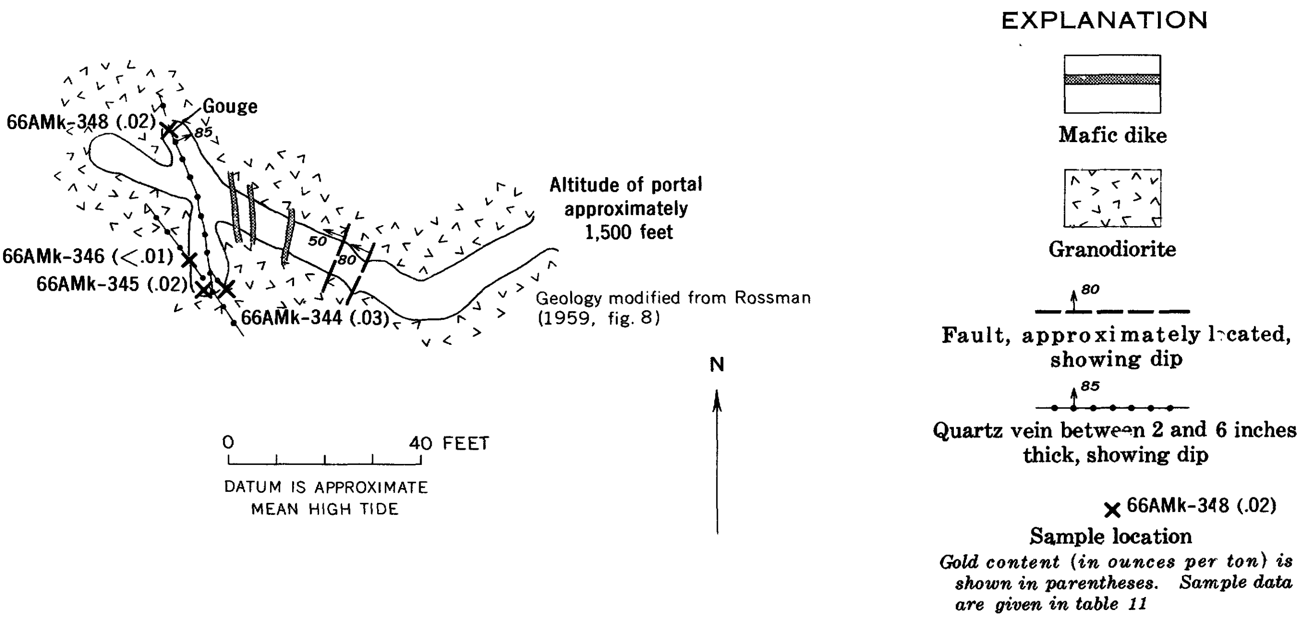


FIGURE 13.—Geologic sketch map showing sample locations at the Monarch No. 2 mine.

Reed (1938, p. 64) reports that a 10-inch sample across one of the veins carried 0.08 ounce of gold per ton and 0.20 ounce of silver per ton. A sample from the largest vein at the prospect carried negligible values (table 11, loc. H).

Thin altered zones are developed adjacent to some of the lamprophyre dikes; these zones and nearby parts of the dikes carry minor amounts of pyrrhotite, pyrite, and arsenopyrite. Rossman (1959, p. 56) reports minor amounts of scheelite from a quartz vein near the Sunrise prospect.

Hopalong and Whirlaway claims

According to Rossman (1959, p. 56), two claims were staked on the Whirlaway and Hopalong veins on the west side of the ridge east of Reid Inlet, at altitudes near 1,350 feet (pl. 1, loc. I). The veins cut fine-grained diorite or quartz diorite. They strike northward and dip vertical and are as much as 1 foot thick. The veins pinch and swell, and throughout most of their exposures are only a few inches thick. They can be traced for about 60 feet along their strike. Besides quartz, the veins contain abundant calcite, minor muscovite, uncommon pyrite and arsenopyrite, and probably erratically distributed gold. Our samples from them were virtually barren (table 11, loc. I). Rossman (1959, p. 56) states that a small amount of gold was recovered by sluicing the weathered surficial parts of the veins.

Galena prospect

The Galena prospect is west of Reid Inlet at an altitude of about 500 feet (pl. 1, loc. J). Its workings consisted of trenches that are now obscured by sloughing and overburden. The prospect was staked in 1936 or 1937. The rocks at the prospect are granodiorite, subordinate schist, and a few lamprophyre dikes. The prospect is on a vein between 4 and 18 inches thick that was exposed over a length of about 60 feet (Twenhofel and others, 1949, p. 33). The vein consists of banded and vuggy quartz with fairly abundant pyrite, sphalerite, and galena. A sample representing a 12-inch width of the vein contained 0.16 ounce per ton gold, 0.30 ounce per ton silver, and 0.79 percent zinc (Reed, 1938, p. 63).

Highland Chief prospect

The Highland Chief prospect is at altitudes between 2,500 and 2,800 feet west of the head of Reid Inlet (pl. 1, loc. K). Extensive snowfields, which persist throughout most summers, covered most of the prospect area during our examination. The rocks that were exposed consist of amphibolite, schist, and marble, locally penetrated by granodiorite salients. The metamorphic rocks form part of a northwest-trending screen and dip steeply. None of the reported quartz veins at the property were exposed. According to information quoted in Rossman (1959, p. 54), the main quartz vein at the prospect is as much as 6 feet thick and contains considerable free gold. Ross-

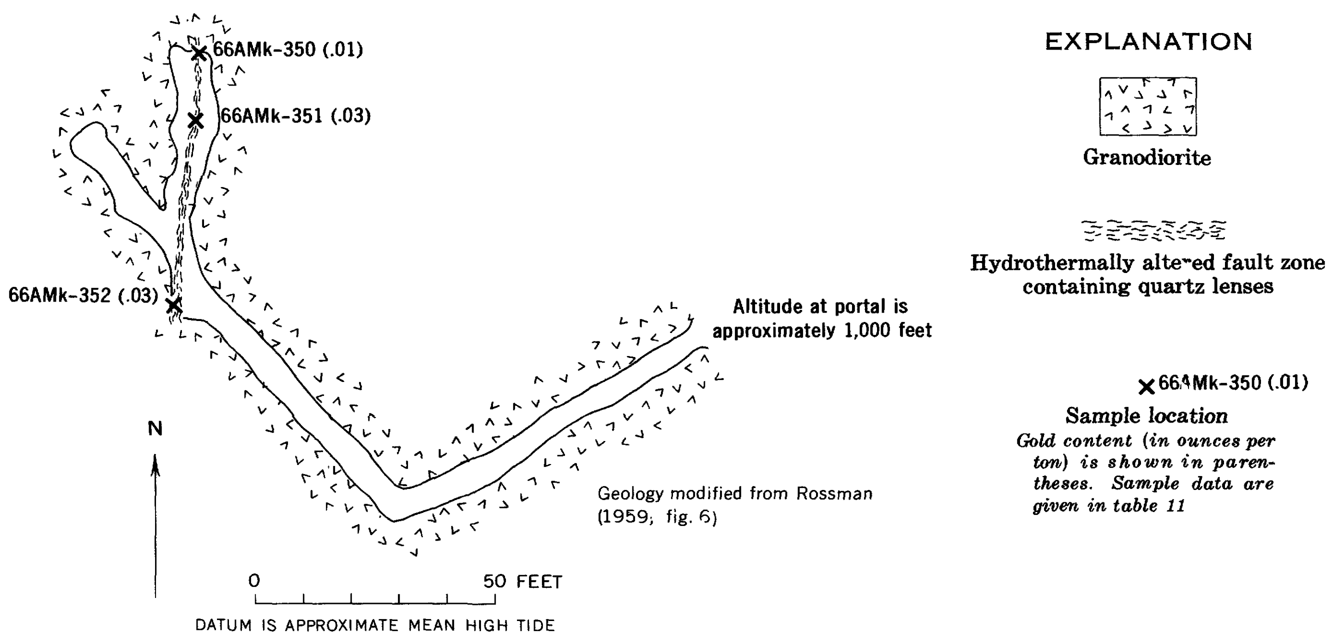


Figure 14.—Geologic sketch map showing sample locations at the Incas mine.

man (1959, p. 54) reports that other steep northwest-striking quartz veins near the prospect contain gold. These are alleged to be as much as 2 feet thick and traceable for as much as 700 feet along strike. The prospect probably is one of the most promising in the Reid Inlet area, but its exploration and development have been curtailed by the near-perennial snow cover.

Rambler prospect

The Rambler prospect is on the steep hillside east of Lamplugh Glacier (pl. 1, loc. L). It consists of a few small surficial pits on quartz veins, mainly within leucocratic granodiorite. The granodiorite contains a few small screens of metamorphic rocks and is cut by a few northeast-striking steep mafic dikes. The quartz veins commonly strike between N. 60° E. and east and dip steeply. They are mainly only 1 or 2 inches thick, but in places attain a thickness of 3 feet. Most of the veins pinch and swell conspicuously. Typically, the veins are exposed for less than 200 feet along their strikes and are bordered by narrow altered zones. The veins consist of quartz, calcite, feldspars, barite, scattered sulfides (mainly arsenopyrite, pyrite, and galena), and traces of gold. All our samples from the veins yielded low gold values (table 11, loc. L). High-grade samples rich in gold reportedly have been collected at the prospect (Rossman, 1959, p. 55; Lawrence Duff, oral commun., 1966).

Other lode deposits in the Reid Inlet area

Several other gold-bearing lodes have been reported from the Reid Inlet area, but they were not examined during our investigations. These include the A. F. Parker prospect and a few unexplored quartz veins.

The A. F. Parker prospect is about two-thirds of a mile northwest of the LeRoy mine at an altitude of 850 feet. The prospect was staked in 1938 and was worked by a 20-foot-long adit; it had a production of 7 or 8 tons of ore (Twenhofel and others, 1949, p. 33, 34). The prospect explores irregular quartz veinlets that are localized in a fault zone cutting granodiorite. The veinlets are between ½ and 1 inch thick within a gouge zone about 10 inches thick. The fault zone strikes N. 70° E. and dips 86° SE. At the face of the adit, the fault zone is truncated by a fault that strikes N. 66° E. and dips 64° NW. (Twenhofel and others, 1949, p. 34). The quartz veinlets contain galena, pyrite, and a little free gold.

Rossman (1959, p. 55, 56) reports a few other quartz veins in the Reid Inlet area that probably contain gold. These veins are little explored, but they probably are similar to the better known quartz veins in the area.

South of Lituya Bay

Rossman (1959, p. 57, 58, and his fig. 9) reports zones of hydrothermally altered rocks south of Lituya Bay and west of Crillon Glacier (pl. 1, loc. 85). These zones are reddish yellow and are developed in Tertiary volcanic and sedimentary rocks. They are readily susceptible to erosion, and their best outcrops are in streambanks, ravines, or gulleys. Most of the zones are virtually barren, but some of them contain gold. Their highest analyzed gold content was 0.24 ounce per ton (Rossman, 1959, p. 58, and his fig. 9). The zones are numerous and extensive and have been scarcely prospected. Parts of them may carry gold of higher grade than indicated by Rossman's samples; they probably merit additional prospecting.

Sandy Cove Prospect

The Sandy Cove prospect is northeast of Sandy Cove, an embayment of the eastern part of Glacier Bay, at altitudes near 110 feet (pl. 1, loc. 7). The prospect consists of three claims that probably were staked during the 1930's. It was explored by a northeastward-trending adit about 110 feet long and by a few surficial workings. The prospect is on a south-facing hillside that is partly covered by vegetation and soil. The ore deposits are localized in a series of northward-striking steep quartz veins and in the contiguous altered wallrock (fig. 15). Surface exposures of the veins and the altered zones are strongly oxidized and colored reddish brown by widely dispersed hydrous iron oxides. Most of the veins are in monzonite or quartz monzonite that forms small masses in marble country rock. Reed (1938, p. 66) considered the intrusive rock at the prospect to be monzonite; our petrographic studies indicate it is a quartz monzonite. The rock is medium-grained hypidiomorphic granular and consists mainly of plagioclase that is zoned from sodic andesine to calcic oligoclase. It contains about 25 percent potassium-feldspar and 10–15 percent each quartz and green hornblende. Minor accessory minerals and alteration products in the rock include sphene, apatite, allanite, epidote, chlorite, muscovite, calcite, pyrite, and magnetite. The quartz monzonite and monzonite are locally silicified near the altered zones and quartz veins.

The quartz veins range in thickness from 1 to 12 inches, and the altered zones are as much as 10 feet

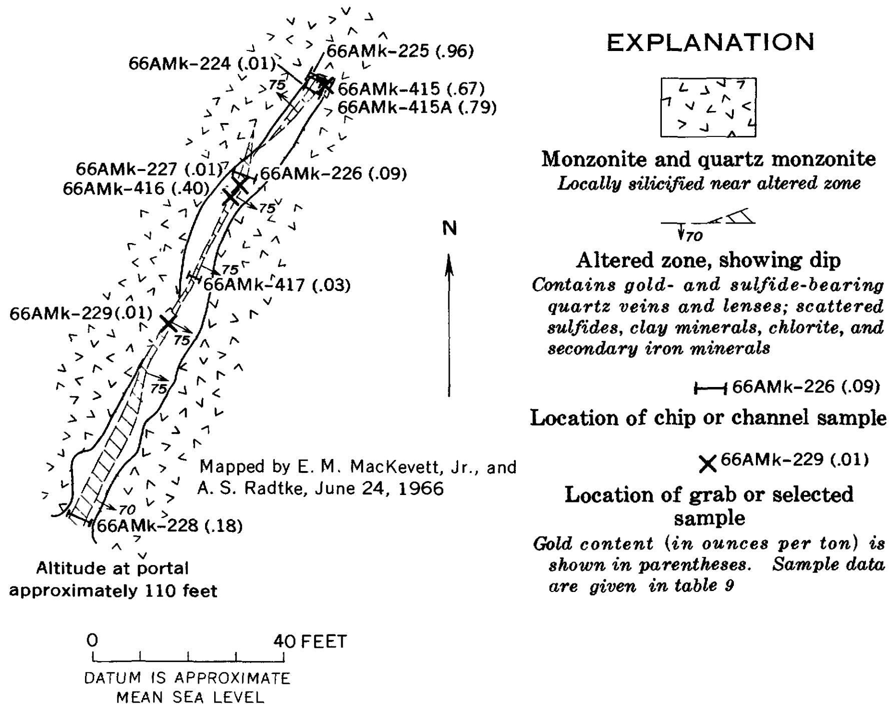


FIGURE 15.—Geologic sketch map showing sample locations at the Sandy Cove prospect.

thick. Most of the quartz veins are lenticular and discontinuous; some of them are in an en echelon pattern. In addition to quartz, their gangue minerals include ankeritic carbonates and probably barite. Sulfide minerals which locally make up the bulk of the veins consist of pyrite, chalcopyrite, and bornite. In places the sulfide minerals have been oxidized to malachite, chrysocolla, and diverse hydrous iron minerals. Gold is distributed erratically in the veins. The altered zones carry minor amounts of gold and sulfides.

Samples from the prospect contained as much as 0.96 ounce per ton (33 ppm) gold, 50,000 ppm copper, 1.46 ounces per ton (50 ppm) silver, 50 ppm molybdenum, 500 ppm bismuth, and 150 ppm lead (table 9, loc. 7). The richest samples were from near the face of the adit (fig. 15). The other veins and altered zones appear to be leaner in ore minerals than the ones exposed in the adit. Reed (1938, p. 68) reports gold and silver assay results for 39 samples that were cut in the adit. These samples contained as much as 0.51 ounce per ton gold and 2.4 ounces per ton silver. Their average content was 0.11 ounce per ton gold and 0.6 ounce per ton silver, and their median content was 0.04 ounce per ton gold and 0.3 ounce per ton silver. Reed (1938, p. 68) also reports that 4 tons of selected ore from near the portal of the adit contained 0.37 ounce per ton gold and 0.15 ounce per ton silver. Rossman (1963b, p. K52) detected between 0.001 and 0.003 percent U_3O_8 in samples from some of the altered zones near Sandy Cove.

Soil samples were collected at the Sandy Cove prospect in an effort to trace the vein that is exposed near the portal of the adit. A soil sample from just west of the adit contained 220 ppm THM, whereas one from just east of the adit contained only 20 ppm (fig. 16). Samples collected across the trend of the vein both to the northwest and to the southeast contained only background concentrations of heavy metals.

Glacial till from the hillside above the prospect dilutes the residual soil and interferes with the application of geochemical techniques. Despite this dilution, the soil samples collected close to, or just downhill from, mineralized areas seem to be geochemically anomalous. The lack of anomalous samples across the trend of the vein is interpreted as indicating that the veins pinches out near the surface both northwest and southeast of the adit. A sample collected downhill from the dump contained 480 ppm THM; this sample is believed to be contaminated by ore metals from the dump, however, and not to have any significance in prospecting.

The sampling and mapping disclosed several other veins northwest of the adit; they appear to form an en echelon pattern that trends northwestward. Soil

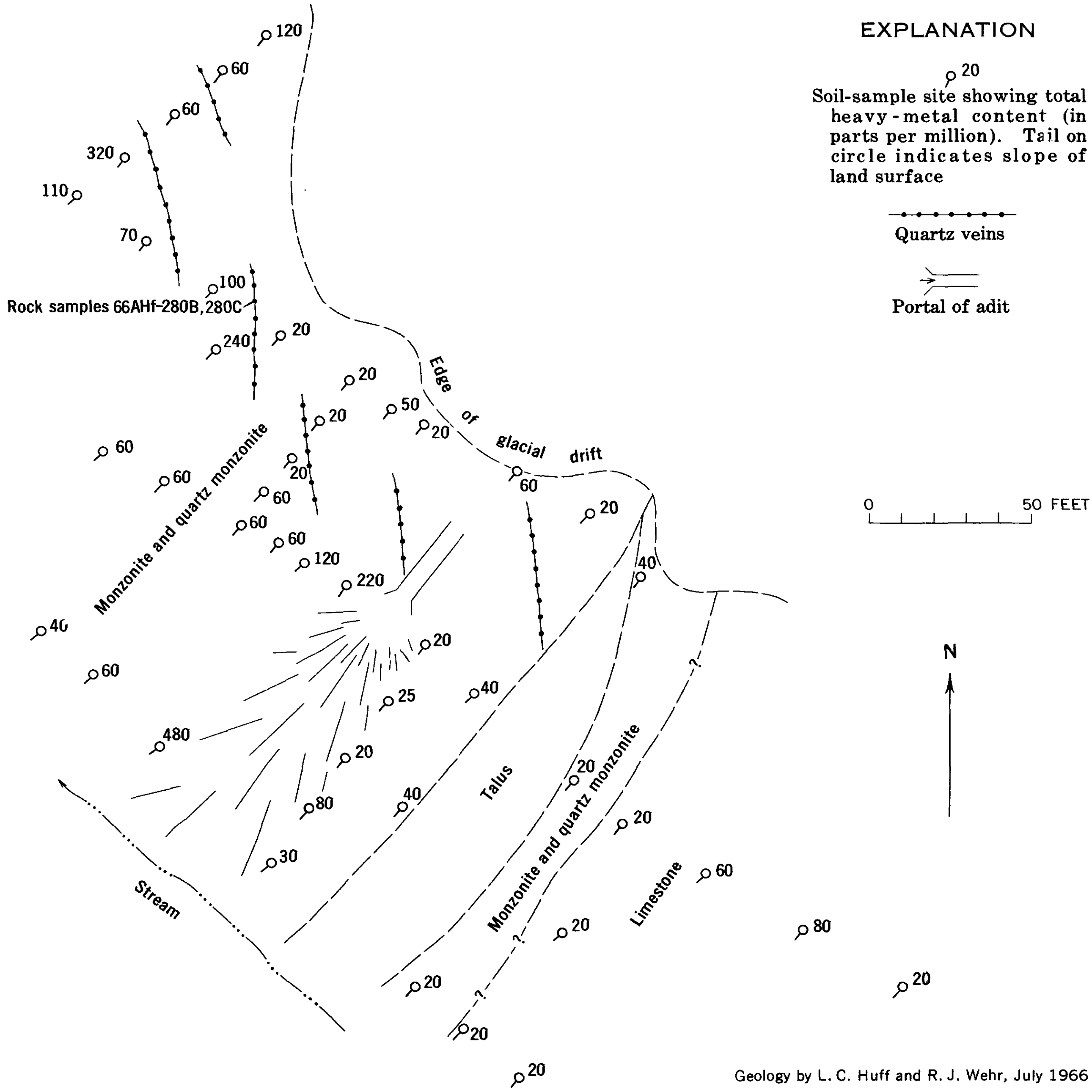


FIGURE 16.—Geochemical map of Sandy Cove gold-copper prospect.

sampling near these veins yielded geochemical anomalies. Rock sample 66AHf–280B, which had a copper content of 1,000 ppm (table 9, loc. 7), was collected near a soil sample that contained 240 ppm THM. A soil sample collected near a vein west of sample 66AHf–280B contained 320 ppm THM. Geochemical studies indicate that several veins merit further exploration.

The Sandy Cove desposits do not appear to be large enough or rich enough to encourage mining under current conditions. Possibly, they would be amenable to a small-scale mining operation under more favorable conditions. Copper is a possible byproduct in the ore. Further exploration of the prospect should attempt to find richer and larger lodes, possibly near intersections with crosscutting structures. The Wrights (1937, p. 221) noted old claims near Sandy Cove that were allegedly staked on pyrrhotite-rich lodes that contain some copper and nickel.

WEST OF MCBRIDE GLACIER

Gold is a minor constituent of altered zones west of the middle part of McBride Glacier (pl. 1, loc. 10). The altered zones are near an irregular, interfingered contact that marks a facies change between marble and phyllite. Small irregular masses of limy silicate rocks are near the contact. About 10 separate altered zones are present. They are less than 2 feet thick and less than 100 feet long and are virtually conformable with the bedding, which strikes about N. 85° E. and dips 25° NW. The altered zones are prevaded by intense iron staining derived from the alteration of their ankeritic carbonates and sulfide minerals. They also contain arsenopyrite and traces of gold. Samples from the zones carried as much as 15,000 ppm arsenic, 500 ppm copper, and 0.087 ounce per ton gold (table 9, loc. 10).

East of Lower Brady Glacier

Several small gold-bearing quartz veins crop out in the mountains west of Dundas Bay nearly east of the terminous of Brady Glacier (pl. 1, loc. 55). The veins are in mafic gneiss and diorite. They commonly are only a few inches thick and are exposed for short distances along their strikes. The veins presumably contain small amounts of gold, but no gold is visible in the hand specimens. A sample from one of the veins yielded negligible amounts of gold and other ore metals (table 9, loc. 55). The area has not been prospected thoroughly, and it may contain undiscovered gold-bearing veins of interest.

West of Dundas Bay

Rossman (unpub. data) mentions a lode gold occurrence on the north shore of the peninsula between Dundas Bay and its west arm (pl. 1, loc. 5). The deposit was not found during the 1966 fieldwork. It probably consists of small gold-bearing quartz veins in dioritic rocks.

Russell Island

Two thin gold-bearing quartz veins occur in an altered zone near the northeastern tip of Russell Island (pl. 1, loc. 61), which is about 3 feet thick and transects biotite-hornblende granodiorite. The veins and the altered zone strike N. 17° E. and dip vertically. The veins are between 2 and 5 inches thick. Neither the veins nor the altered zone can be traced for more than about 25 feet on the surface because of cover. Besides quartz, the veins contain fairly abundant calcite and minor pyrite. A sample of the veins carried 0.844 ounce per ton gold and traces of silver and lead (table 9, loc. 61).

Other Lode Deposits

Gold is a minor constituent of many of the deposits described elsewhere in this report, particularly some of the copper lodes (table 9). The Wrights (1937, p. 221) refer to gold occurrences in the schist belt south of Adams Inlet which were unsuccessfully explored during the early days. They also (p. 222) mention some old, and presumably abandoned, gold claims in the hills between the east and west arms of Dundas Bay. Buddington (unpub. data, 1924) notes that a claim was staked for gold at Dundas Bay, but no specific information concerning this claim is available. Buddington (unpub. data, 1924) further reports that specimens that contained free gold were found in the moraines of Johns Hopkins and Brady Glaciers.

Placer Deposits

Gold placer deposits are fairly widespread in the Glacier Bay National Monument, but the only significant producers are the beach placers north and south of Lituya Bay (pl. 1, locs. 87, 88). The placers include beach sands, stream deposits, old alluvial terrace and bench placers, glacial outwash, and minor residual placers that are associated with some lodes in the Reid Inlet area. No significant gold placer deposits were discovered during our investigations. Descriptions of the known placer deposits in the monument follow.

South of Wood Lake

Rossman (1963b, p. K50) reports that placer gold has been mined from glacially derived gravels south of Wood Lake in the upper part of the Dundas River drainage basin (pl. 1, loc. 52). The exact location of these deposits could not be ascertained. The general region has been deglaciated fairly recently, and probably its streams contain local auriferous placers.

Dundas River

According to records of the Alaska Division of Mines and Minerals, nine gold placer claims on the Dundas River are held by the Jimmie Martin estate. Little is known about the claims, but they are in the vicinity of locality 53 as plotted on plate 1.

Outwash of Brady Glacier

According to information cited in Rossman (1963b, p. K50, K51), placer mining of the outwash in front of Brady Glacier (pl. 1, loc. 59) was carried on for some time during the early part of the century. The gold in these deposits is very fine grained, floury, and difficult to recover. Probably attempts to mine it were of short duration and yielded only small amounts of gold.

Oregon King Consolidated

Thirty-six placer claims, mainly on the beaches, west of La Perouse Glacier (pl. 1, loc. 81), are held by the Oregon King Consolidated organization (Alaska Div. Mines and Minerals, written commun., 1966). The deposits have been explored intermittently during recent years and probably include a few stream and terrace deposits as well as the beach placers.

Lituya Bay

The most extensive and best gold placer deposits in the monument are in the beach sands near Lituya Bay (pl. 1, locs. 87, 88). Auriferous sands are distributed irregularly along the beaches for about 20 miles northwest of Lituya Bay and for about 15 miles southeast of the bay. They have been worked intermittently for many years. Mertie (1933, p. 133) states that mining by Americans near Lituya Bay commenced in 1894. The heyday of the mining was in 1896, when between 150 and 200 men were engaged in working the placer deposits. Between 1894 and 1917, the placers produced gold worth about $75,000 (Mertie, 1933, p. 135). A small amount of platinum was recovered also. Production since 1917 has been small.

The minable placers are formed largely by the reworking of older gold-bearing deposits, particularly of poorly consolidated terrace, bluff, and bench deposits near the seashore. This process is accelerated by large waves generated during storms, and the most favorable periods for mining are shortly after storms. Most of the gold in the deposits has been recycled and reconcentrated during several stages and has been transported by glacial processes. Consequently, it is extremely fine grained, floury, and difficult to recover. The deposits were worked by fairly primitive methods, including Long Toms and sluice boxes, and undoubtedly a sizable amount of the gold was not recovered.

The pay streaks generally are less than a few feet thick. They are in black sands that are rich in garnet and contain ilmenite, magnetite, and other heavy minerals that were concentrated by washing and gravity settling. The sparse platinum in the placers, like the gold, is very fine grained.

Rossman (1957) examined the beach deposits during 1952, and the descriptions given here are summarized from his report. The beach deposits overlie bedrock, glacial outwash, and moraines. All of them, except the modern bare beaches, are partly covered by alluvial fans, glacial outwash, or swamp deposits. The beach deposits include modern bare ocean beaches, tree-covered modern beaches, and older tree-covered modern beaches, and older tree-covered beaches. The beaches that lack vegetation are between 800 and 2,700 feet wide. Upper parts of all the bare beaches contain concentrations of heavy minerals that form deposits as much as several hundred feet wide and a few miles long. The vertical range of the heavy sand concentrations in the bare beaches is not known. Most cutbanks show layers of heavy mineral to depths of about 6 feet. The tree-covered beaches also contain concentrations of heavy minerals on their upper surfaces, but little is known of the extent and depth of these deposits. The main heavy minerals of all the beach sands, in general order of decreasing abundance, are garnet, pyroxene, ilmenite, amphibole, magnetite, staurolite, epidote, rutile, sphene, and zircon. The light fractions of the dark sands include quartz, feldspar, mica, calcite, and small rock fragments. Rossman was concerned mainly with the economic potential of the ilmenite in the sands. The heavy mineral sands near Lituya Bay were also investigated by the U.S. Bureau of Mines, mainly with emphasis on their iron and titanium content (Thomas and Berryhill, 1962, p. 37–39).

Mertie (1933, p. 135) reports that attempts to mine some of the bench and terrace deposits were largely unsuccessful. The Wrights (1937, p. 223) note that the counteraction of waves and stream currents near the mouth of a stream about 4 miles northwest of Lituya Bay is effective in concentrating heavy minerals.

The beach deposits near Lituya Bay are a potential source of additional gold production and minor amounts of platinum and possibly ilmenite. They could be worked on a small scale under favorable economic conditions, or possibly some of them could be worked on a large scale by dredging. Little is known concerning the possibility of offshore placer deposits near Lituya Bay, although the presence of such deposits is conceivable.

Other Placer Deposits

Small amounts of gold have been recovered by mining the residual and weathered material that overlies some of the gold lodes in the Reid Inlet area. Surficial parts of many of these lodes are for the most part residual placers. Gold is sparsely distributed in colluvium and in stream placers in the Reid Inlet area but probably in quantities too small to be exploited.

Many of the streams throughout the monument undoubtedly contain small concentrations of placer gold, but the likelihood of significant gold production from them is small. The extensive glacial outwash and other fluvioglacial deposits in the monument likewise probably contain widely dispersed gold. Attempts to find concentrations of gold in these deposits were unsuccessful, and it is unlikely that they contain minable placers.

PLATINUM

Platinum is a rare constituent of some of the beach placers near Lituya Bay, especially those south of the bay (Mertie, 1933, p. 134), but no lode sources of platinum are known in the monument. By analogy with known platinum deposits, such as those in the Bushveld Complex and at Sierra Leone in Africa, or in the Stillwater Complex in Montana, the platinum probably is a minor constituent of the mafic and ultramafic layered complex that forms the Crillon-LaPerouse and the Astrolabe-DeLangle stocks in the Fairweather Range. The platinum would most likely be associated with certain ilmenite-rich layers within these rocks or with some of their sulfide deposits. Platinum and several other metals, should be prospected for in the little-explored layered mafic and ultramafic rocks because these rocks are assuredly the source of the placer platinum.

SILVER

Silver is a subordinate metal in many of the gold and base-metal deposits in the monument; in only one prospect, near Rendu Inlet, is silver a major commodity. The known silver minerals in the monument are minor constituents of veins, altered zones, and replacement bodies. They include argentiferous tetrahedrite, jamesonite, and native silver. Besides the Rendu Inlet prospect (pl. 1, loc. 37), silver has been reported from the Reid Inlet gold lodes, the Sandy Cove gold prospect, a prospect in the northwestern part of Willoughby Island, a locality near Blue Mouse Cove on Gilbert Island, and the Nunatak molybdenum prospect. The richest silver values in our samples are 4.377 ounces per ton (150 ppm) from the Alaska Chief prospect, 2.043 ounces per ton (70 ppm) from the Rainbow mine in the Reid Inlet area, 1.46 ounces per ton (50 ppm) from the Sandy Cove prospect, 1.46 ounces per ton (50 ppm) from Francis Island, 0.875 ounce per ton (30 ppm) from the base-metal lodes near Mount Brack, and 0.583 ounce per ton (20 ppm) from the copper deposits north of White Glacier (tables 9, 11). Rossman (1963b, p. K49) states that a quartz-rich sample from a gulley northeast of the Nunatak molybdenum prospect carried 7.07 ounces of silver to the ton, but our samples from the Nunatak molybdenum prospect (table 13) carried only trace amounts of silver.

Small amounts of silver are associated with gold in most of the gold placer deposits in the monument. The high degree of mineral comminution in many of the placers, particularly the recycled and glacially derived ones, inhibits recovering substantial amounts of silver from them.

RENDU INLET PROSPECT

The Rendu Inlet silver prospect, found at an altitude of 30 feet on the west side of Rendu Inlet about 3 miles northwest of the mouth of the inlet (pl. 1, loc. 37), has been known for many years. According to Buddington (unpub. data, 1924), it consists of two claims that were patented about 1892. Its workings consist of a short westward-trending adit that is caved at the portal. Recent slide material that covers most of the outcrops precluded a satisfactory examination of the prospect. The deposits are mainly in an ankeritic carbonate-quartz vein about 6 inches thick and in continguous altered wallrock a few feet thick. The vein and altered zone both strike N. 85° E. and dip 65° SE. White bleached marble forms the hanging wall of the deposit, and the footwall is a dioritic dike that is about 20 feet thick and intrudes marble. A 4-inch-thick quartz-calcite vein occupies a steep northwest-striking fault that offsets the northeast-striking vein by a few inches. The only indication of ore mineralization exposed at the time of our examination was locally intense iron staining. Samples from the prospect were low in grade and lacked silver (table 9, loc. 37). Buddington (unpub. data, 1924) states that argentiferous tetrahedrite occurs on the claims. Rossman (1963b, p. K48, K49) found a specimen that contained tetrahedrite and wire silver along fractures in quartz. It is concluded that these ore minerals are sporadically distributed in the veins. Several similar-appearing veins and altered zones are along the west side of Rendu Inlet near the prospect. Samples from these zones were barren, but possibly diligent prospecting would detect small amounts of silver and copper minerals in them.

IRON AND FERROALLOY METALS

The iron and ferroalloy metals discussed here include iron, chromium, cobalt, manganese, molybdenum, nickel, titanium, tungsten, and vandium. Deposits described include the two that have the best potential for mining in the near future, the Brady Glacier nickel-copper deposit and the Nunatak molybdenum deposit, and a few others that merit exploration.

IRON

Several iron deposits are within the monument, but none of them appear to be large enough or rich enough to be mined currently. The deposits include several magnetite-rich skarns, concentrations of magnetite and ilmenite in the layered mafic rocks of the Fairweather Range, beach placers that contain magnetite and ilmenite, and an alleged hematite deposit of uncertain genesis and type. Although they are locally rich, all the known skarn deposits seemingly contain insufficient amounts of magnetite to be exploited. The layered mafic rocks of the Fairweather Range and the placer deposits northwest and southwest of Lituya Bay constitute a low-grade resource of iron as well as a titanium resource.

DESCRIPTIONS OF DEPOSITS

East of Dundas Bay

Rossman (unpub. data) mentions an iron deposit at an indefinite location east of Dundas Bay and north of Icy Strait (pl. 1, loc. 33). Little is known about the deposit, but on the basis of the local geology, it probably is in skarn near the contact between granodiorite and limestone. A magnetic disturbance reported from the north side of Lemesurier Passage near locality 33 (U.S. Coast and Geod. Survey Chart 8202, 13th ed., 1965) probably is all attributable to a magnetite-rich skarn deposit.

Buddington (unpub. data, 1924) reports claims for hematite at an altitude of 1,700 feet in the mountains between Dundas Bay and the next cove to the east. No additional information is available on these claims, which were probably abandoned many years ago.

West of Rendu Inlet

Magnetite-rich skarn deposits are distributed irregularly in the southern part of the peninsula west of Rendu Inlet (pl. 1, loc. 39). The deposits are in small pods of tactite or skarn near the contact between quartz diorite and marble or within the quartz diorite (fig. 17). The deposits appear to be small, but much of the nearby bedrock is covered by surficial deposits, and the size and distribution of the magnetite deposits cannot be estimated accurately. The skarn and tactite consist of garnet that is rich in grossularite, associated with calcite, quartz, chlorite, epidote, and with concentrations of magnetite. The marble is massive, coarse grained, and calcite rich. The quartz diorite is medium coarse grained and contains abundant hornblende. A few mafic dikes as much as 6 feet thick cut the other rocks; some of them contain small pyrite-rich blebs and pods near their contacts.

Two magnetometer traverses were made across the marble-quartz diorite contact and for several hundred feet into the quartz diorite terrane (fig. 17). These revealed local magnetic anomalies as high as 5,500 gammas (fig. 17). The quartz diorite has a fairly high magnetic background, but the anomalous magnetic values that were detected in it are attributed to pods of magnetite-rich skarn or tactite or possibly to local magnetite-rich segregations. Except for iron, samples of the skarn and tactite lacked significant amounts of ore metals (table 9, loc. 39).

Queen Inlet

Masses of tactite that locally contain sufficient magnetite to be termed "skarn" crop out in sea cliffs along the east shore of Queen Inlet east of Composite Island (pl 1, loc. 40). The tactite bodies are as much as 20 feet thick and intervene between alaskite and coarse white marble (pl. 10). Porphyritic felsic volcanic rocks are associated with some of the alaskite. In addition to magnetite, the tactite contains abundant garnet, quartz, calcite, hornblende, pyroxene, chlorite, and sporadically distributed veins and pods of sulfide minerals, chiefly pyrite. Some of the veins are rich in albite. A few steeply dipping mafic dikes as much as 15 feet thick cut the other rocks. Several steep faults, apparently with minor offsets, are exposed in the sea cliffs.

The alaskite is a hypidiomorphic-granular medium-grained rock that is slightly altered. A light-gray color prevails, but some of the feldspars are altered to milky white masses. The alaskite contains 50–65 percent oligoclase, 20–30 percent quartz, minor potassium-feldspar, and subordinate amounts of magnetite and alteration products, including calcite, epidote, actinolite, and chlorite. Some of the alaskite is cut by veinlets and minute fractures.

The porphyritic volcanic rocks are yellowish white. They contain abundant phenocrysts of plagioclase (sodic andesine) and quartz in a microcrystalline groundmass composed largely of plagioclase microlites, quartz, and albite(?). Minute crystals of pyrite and magnetite are widely dispersed throughout the rock. Calcite veinlets transect some of the volcanic rocks.

The coarse white marble consists predominantly of calcite. The mafic dikes are dark-gray to black altered porphyritic andesites. They contain about 70 percent plagioclase (andesine), which forms phenocrysts between 1 and 2 mm long and is also the dominant mineral in the groundmass. Other minerals in the rock are chlorite, actinolite, magnetite, and pyrite.

A magnetometer traverse along the beach contiguous to the sea cliffs revealed magnetic anomalies greater than 1,000 gammas along projections of the tactite bodies (pl. 10).

The hillsides east and northeast of the sea cliffs are largely covered by glacial deposits. Outcrops on

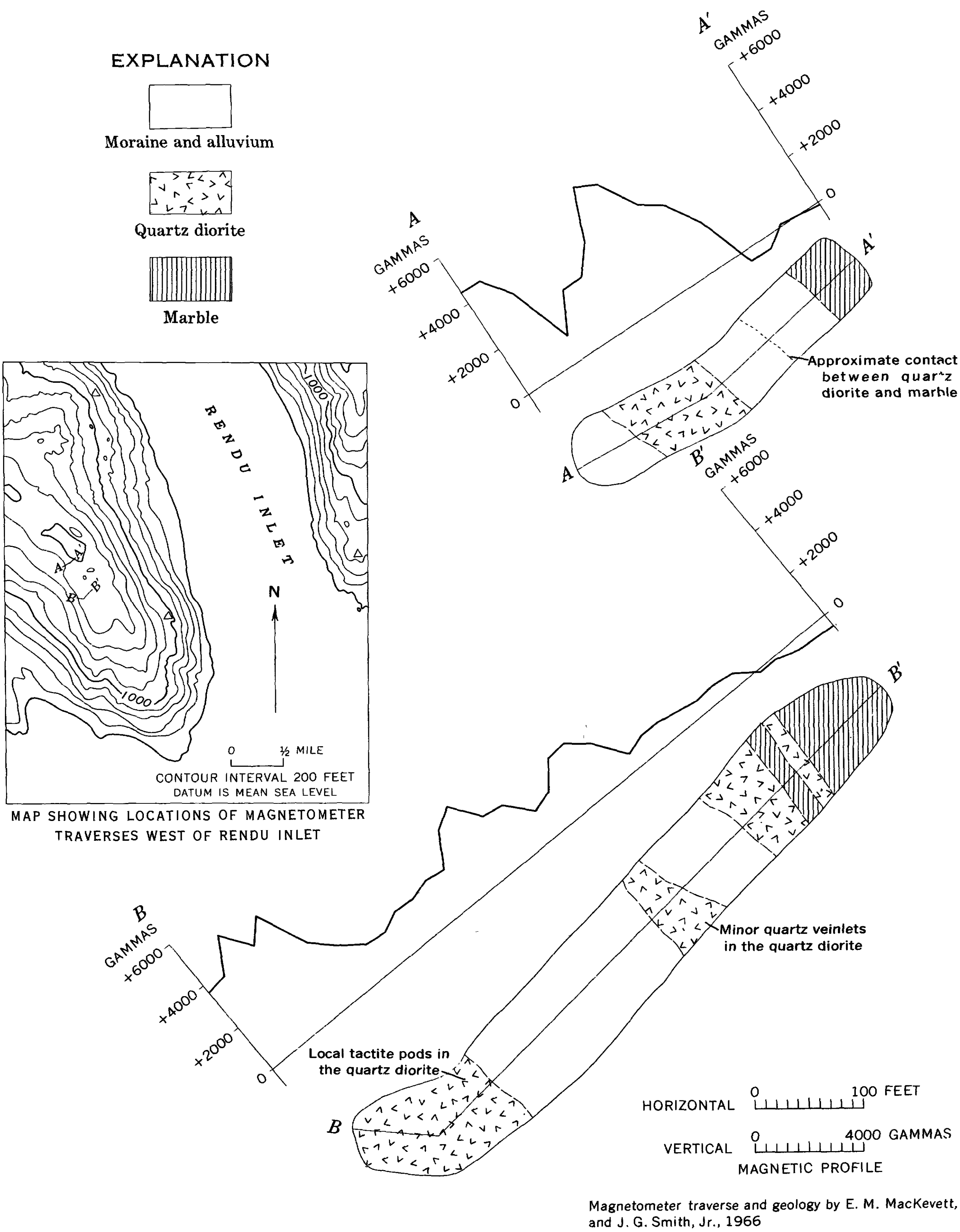


FIGURE 17.—Magnetometer traverses west of Rendu Inlet.

these hillsides consist mainly of felsic siliceous rocks that were mapped as alaskite but which also include some siliceous porphyritic volcanic rocks. The alaskite and the volcanic rocks are cut by steep mafic dikes that contain sparsely distributed pods and thin veins of sulfides, chiefly pyrite. The petrography of these rocks is analogous to their counterparts that are exposed in the sea cliffs. A magnetometer survey along a traverse extending southwestward from an altitude of 1,740 feet to near the beach was made to trace the magnetite deposits inland and to find concealed deposits (pl. 10). This survey revealed anomalous magnetism to 1,300 gammas in some areas that are covered by glacial drift; this probably indicates concealed magnetite-rich lodes similar to those exposed in the sea cliffs.

Semiquantitative spectrographic analyses of the skarns showed major amounts (>10 percent) of iron, as much as 300 ppm copper, 300 ppm cobalt, 30 ppm tin, and traces of molybdenum and nickel (table 9, loc. 40, samples 66AMk–298A, –298B, –299, –303). Similar analyses of pyrite-rich pods, veins, and altered zones contained abundant iron and as much as 300 ppm copper, 70 ppm cobalt, 30 ppm tin, and traces of molybdenum and lead (loc. 40, samples 66AMk–305, –321, –323, –324). Analyses of an 18-foot-long chip sample taken across the richest appearing magnetite deposit in the sea cliffs revealed 23.4 percent total Fe as Fe_2O_3, 38.5 percent SiO_2, 7.0 percent Al_2O_3, 0.11 percent P_2O_5, 1.54 percent S, 0.36 percent TiO_2, and 30 ppm As.[1]

The known iron deposits east of Queen Inlet are too small and too lean to warrant economic interest, but intensive prospecting might lead to the discovery of larger and richer deposits near the known ones.

West of Blackthorn Peak

Seitz (1959, p. 117) reports a magnetic anomaly near the divide of Geikie Glacier west of Blackthorn Peak (pl. 1, loc. 51). The anomaly was detected from an airplaine from an altitude of about 2,500 feet above the ground. Outcrops are poor in the vicinity of the anomaly because of extensive ice and snow. Probably the anomaly indicates a magnetite-rich skarn deposit, but confirmation of the nature of the deposit and its size and grade would require drilling or other physical exploration.

East of Brady Glacier

Magnetite deposits were found in the hills east of the lower part of Brady Glacier about 3¾ miles south of Abyss Lake (pl. 1, loc. 54). The deposits are at an altitude of about 1,350 feet. They consist of several steep lenses of magnetite-rich skarn that strike northwestward. The lenses comprise abundant magnetite and garnet, subordinate quartz and calc-silicate minerals, and minor pyrite and chalcopyrite, and are bordered by marble and small masses of leucocratic granodiorite. They are as large as 30 feet long and 10 feet thick.

Semiquantitative spectrographic analyses showed that samples of the skarn contained major amounts of iron and 1,000 ppm copper (table 9, loc. 54). Magnetometer readings of as much as 5,000 gammas were obtained on some of the skarn outcrops. Although some of the skarn bodies are rich enough to constitute iron ore, they are too small to be exploited. Development of the deposits is contingent upon the unlikely possibility of discovering concealed skarn bodies that contain large tonnages of magnetite.

Fairweather Range

The layered mafic and ultramafic rocks of the Fairweather Range contain a large low-grade iron resource and appreciable amounts of other metals, notably titanium. These rocks form the Crillon-LaPerouse and the Astrolabe-DeLangle stocks of Rossman (1963a) and probably a similar, but unexplored, mass near Mount Fairweather. Four localities where the layered rocks are known to contain concentrations of iron minerals are shown on plate 1 (locs. 73, 79, 80, 83). Undoubtedly, many other localities in the Fairweather Range contain similar deposits, but the range has been only cursorily prospected, chiefly because of its formidable terrain and difficult access.

The iron deposits in the Astrolabe-DeLangle stock are represented in a general way by locality 73 on plate 1. Rossman (1963a, p. F44, F45) reports that some layers in the stock contain concentrations of ilmenite and that other layers contain as much as 20 percent titanium-bearing magnetite. At most places the contact zones of the stock also contain titanium-bearing magnetite. Most of the layers that carry much magnetite or ilmenite crop over a "stratigraphic" thickness of about 1,000 feet near the top of the mountain that forms Astrolabe Penisula. The iron- and titanium-rich layers are at an altitude of 1,100–2,000 feet and appear to persist through the mountain. Rossman (1963a, p. F45, table 8) gives the magnetite and ilmenite contents of some rocks from the Astrolabe-DeLangle stock.

Several iron-stained layers that are signaled by bright red outcrops have been reported from the Crillon-LaPerouse stock (Rossman, 1963a, p. F42,

[1] Fe_2O_3 determined by atomic absorption by W. D. Goss. SiO_2, Al_2O_3, and TiO_2 determined colorimetrically by G. T. Burrow. P_2O_5 determined volumetrically by L. F. Rader. S determined by induction furnace by Dorothy Kouba. As determined colorimetrically by E. J. Fennelly.

F43) (Kennedy and Walton, 1946, p. 71). A few of these are represented on plate 1 (locs. 79, 80, 83). Most of these layers contain fairly abundant ilmenite and subordinate pyrrhotite and chalcopyrite. The layers have not been prospected thoroughly, and probably some of them and some of the other layers in the stock also contain concentrations of magnetite.

The presence of layered mafic intrusive rocks near Mount Fairweather is indicated by float on the moraines of the Fairweather Glacier. Presumably, the magnetite and ilmenite content of these unexplored rocks is similar to that of the Crillon-LaPerouse and the Astrolabe-DeLangle stocks.

Placer Deposits

The beach placers north and south of Lituya Bay which were described under "Gold" contain concentrations of these heavy minerals in the monument are between 2 and 13 miles south of Lituya Bay (Rossman, 1963a, p. F46). Rossman's samples (1957, table 1) from the beach placers contained as much as 10 percent magnetite and 21 percent ilmenite, but their average content of these minerals was considerably less. The probability of iron being recovered from these deposits is remote.

CHROMIUM

No chromium lodes are known to occur in the monument, but chromite float has been reported on glaciers in the Fairweather Range (Goldthwait, in Kennedy and Walton, 1946, p. 71, 72). The largely unexposed ultramafic rocks that are inferred to form the lower parts of the layered intrusive complexes of the Fairweather Range are potential hosts for chromite deposits. Trace amounts of chromium were found in almost all our samples from the monument, and anomalous quantities of chromium were found in a few of the samples (tables 9, 11, 13, 15). The largest amounts of chromium detected in the samples were 1,500 ppm from near Mount Young (table 9, loc. 1), 1,000 ppm from peridotite at the Brady Glacier prospect (table 15, No. CSN–1), and 700 ppm from the Curtis Hills (table 9, loc. 23).

COBALT

Cobalt is a potential byproduct of the nickel-copper deposits at the Brady Glacier prospect, but no discrete cobalt minerals have been identified in the deposits. Samples representative of the richest ore at the prospect contained an average of 0.25 percent cobalt. Cobalt probably is a minor constituent of similar sulfide deposits that may be associated with the layered mafic and ultramafic complexes of the Fairweather Range. Minor amounts of cobalt were detected in almost all our analyzed samples from the monument, and anomalous amounts of cobalt were detected in a few of them (tables 9, 11, 13, 15). The anomalous concentrations of cobalt are as much as 2,000 ppm in massive sulfides from the Brady Glacier prospect (table 15, pl. 1, loc. 72); 700 ppm in samples west of the mouth of Rendu Inlet (table 9, loc. 38); 300 ppm north of Adams Inlet (5), the Queen Inlet magnetite locality (40), and the Alaska Chief prospect (29); and 200 ppm from Shag Cove (49).

MANGANESE

Manganese is widely associated with most of the mineral deposits, but no potentially exploitable manganese deposits are known from the monument, and the likelihood of discovering such deposits is remote. Manganese-stained oxidized zones are conspicuous in outcrops of several deposits, particularly the base-metal replacement lodes and altered zones. Samples from several of the deposits contained between 2,000 and 7,000 ppm manganese (table 9). The most notable of these are from Francis Island (loc. 28, No. HF–183C) and the Alaska Chief prospect (29, No. hk–474).

MOLYBDENUM

DISTRIBUTION

Many mineral deposits that contain molybdenum are known in the monument. They include one important prospect, the Nunatak prospect (pl. 1, loc. 21); a few deposits, such as those in the Bruce Hills (34) and near the southwestern part of Gilbert Island (44, 45), that contain molybdenum and copper of near-equal potential; several small molybdenite deposits; and some deposits whose analyzed samples revealed trace to minor amounts of molybdenum.

Molybdenum is widely distributed throughout much of the eastern and northeastern parts of the monument where widespread, but generally small, molybdenum content characterizes many of the metalliferous deposits. The molybdenum deposits are particularly abundant in parts of the Mount Fairweather D-1 and D-2 quadrangles (pl. 1).

TYPES OF DEPOSITS

The molybdenum deposits are commonly localized in metamorphic rocks near granitic masses or within the granitic rocks themselves. They form stockworks, disseminations, veins, mineralized fault zones and fracture coatings, and at some places are parts of contact-metamorphic zones, dikes, or amygdaloidal lavas. The largest known molybdenum deposits in the monument consist of swarms of closely spaced veins and veinlets that are termed "stockworks." Except for minor amounts of molybdite in the Bruce Hills copper-molybdenum deposit (pl. 1, loc. 34), molybdenite is the only molybdenum mineral in the deposits.

DESCRIPTIONS OF DEPOSITS

Casement Glacier

Molybdenite-bearing float was found on lateral moraines fairly high on Casement Glacier (pl. 1, loc. 9) by members of the Ohio State University field party sponsored by the Institute of Polar Studies (Colin Bull, written commun., 1965). The float reportedly also contained some copper carbonates.

Van Horn Ridge

Numerous claims for molybdenum are on Van Horn Ridge east of the head of Muir Inlet (pl. 1, loc. 11). A few of the claims have been explored by shallow pits and trenches. The deposits are in iron-stained altered zones, both in steeply-dipping north-striking hornfels and in granodiorite. Most of the altered zones are along faults. Typically, they are a few feet wide and do not persist along strike. The altered zones are weakly mineralized. Samples from them contained as much as 200 ppm molybdenum and traces of lead (table 9, loc. 11).

West Side of Tarr Inlet

Many iron-stained altered and brecciated zones are exposed in the cliffs west of Tarr Inlet south of Margerie Glacier (pl. 1, loc. 17). These zones are between 1 and 5 feet thick and cut granodiorite or, less commonly, hornfels. A few of them are near the edges of felsic dikes. The altered zones are lean in ore metals. Samples from them contained as much as 100 ppm molybdenum, 5,000 ppm arsenic, and 1,000 ppm barium (table 9, loc. 17).

Nunatak Prospect

The largest known molybdenum deposits in the monument are at the Nunatak prospect east of Muir Inlet (pl. 1, loc. 21). The deposits are mainly in the northern part of "The Nunatak," an isolated knob about 1,100 feet high which is surrounded by water and periglacial debris. Before regression of the nearby glaciers, "The Nunatak" was surrounded by ice and was a true nunatak. The deposits were located in 1941 (Twenhofel, 1946, p. 12), and since then, they have been explored intermittently. They were investigated and described by a Geological Survey field party under the direction of W. S. Twenhofel (1946) and by the U.S. Bureau of Mines (Sanford and others, 1949). During the summer of 1966, the deposits were explored with three diamond-drill holes by the American Exploration & Mining Co. Our field examination consisted of checking Twenhofel's geologic map and collecting numerous chip samples, soil samples, and a few pertinent rock and mineral specimens.

Deposits at the prospect consist of stockworks of molybdenite-bearing quartz veins, uncommon disseminated molybdenite, and a mineralized fault zone. They are mainly in hornfels, but locally they occur in quartz monzonite porphyry and in silicified zones near the edge of the porphyry (pl. 11).

Geology

The following descriptions of the rocks at the Nunatak prospect are largely from Twenhofel's report (1946). The oldest rocks are dark-blue thin-bedded limestone and subordinate shale that crop out in the southwestern part of "The Nunatak" (pl. 11). These rocks are conformably overlain by a thick sequence of hornfels, which Twenhofel (1946, p. 12) differentiated into three units (pl. 11). The hornfels consists chiefly of orthoclase and clinozoisite with some diopside, garnet, quartz, and oligoclase. The lower hornfels unit is characteristically thin bedded and contains a few limy beds. The middle unit is also thin bedded and contains many beds that are rich in clinozoisite. The upper hornfels unit is thick bedded.

Small discordant masses of quartz monzonite porphyry cut the hornfelses (pl. 11). Numerous post-metallization andesitic dikes cut the hornfels, limestone, and quartz monzonite porphyry. Surficial deposits, chiefly of glacial origin, cover parts of "The Nunatak." Outcrops of the quartz monzonite porphyry are locally bordered by siliceous zones as much as 15 feet thick.

The rock mapped as quartz monzonite porphyry by Twenhofel (1946) consists of phenocrysts of oligoclase and less abundant hornblende, biotite, and quartz in a microcrystalline groundmass that contains potassium feldspar, quartz, and plagioclase. The phenocrysts commonly are euhedral and 3–4 mm long. Accessory minerals in the rock are magnetite and sphene. The alteration products include actinolite and epidote. Numerous quartz-rich veinlets cut the rock. Samples of the porphyry which were studied petrographically contained less potassium-feldspar than a normal quartz monzonite; this fact, along with the characteristic microcrystalline groundmass, indicates that the rock should be classified as rhyodacite porphyry. However, the term "quartz monzonite porphyry" is retained here for consistency with previous usage.

The andesitic dikes are predominantly hornblende andesite porphyry and some dacite porphyry. They are altered porphyritic rocks with pilotaxitic groundmasses. They contain between 50 and 60 percent plagioclase (sodic andesine), the dominant mineral in both their phenocrysts and groundmasses. Hornblende, both a phenocryst and groundmass mineral, forms between 10 and 15 percent of the rock. Other primary minerals that are minor constituents of the andesitic rocks include biotite, pigeonite, magnetite, and apatite. The secondary minerals include actinolite, chlorite, epidote, and calcite.

The dominant structural grain at "The Nunatak" is shown by north-striking beds that dip eastward (pl. 11). In the western part of "The Nunatak," the beds are folded into an open anticline. Bedding is obscure near the rock mapped as quartz monzonite porphyry. Several steep faults, apparently with minor offsets, are exposed at the prospect (pl. 11). These faults commonly strike north or northeast. The myriad fractures that developed in the quartz monzonite porphyry and the hornfels before the intrusion of the andesitic dikes were mineralized to form the stockworks of quartz-molybdenite veins.

Ore deposits

The ore deposits consist of stockworks of closely spaced quartz veins and veinlets that contain almost all the known molybdenum reserves, mineralized fault zones, and less common fracture coatings and disseminations. The stockworks are widely distributed throughout the northern part of "The Nunatak," extending from near the summit westward and northwestward to Muir Inlet (pls. 11, 12). They consist of myriad closely spaced quartz veinlets less than 1 inch thick, and thin quartz veins that are as much as 18 inches thick but commonly are less than 6 inches thick. The stockworks are mainly developed in the hornfels, but they have formed in the quartz monzonite porphyry also, particularly in its partially silicified peripheral zones. The stockworks are best exposed in the cliffs contiguous to the shoreline of Muir Inlet throughout a lateral extent of about 800 feet (pls. 11, 12). There they consist of hundreds of quartz veins and veinlets that strike N. 70° W. to west and dip nearly vertical. The veins and veinlets are cut by many steep northeast-striking fractures that are occupied by clayey gouge as much as 2 inches thick and less common barren quartz and calcite. In places the transecting fractures offset the veins a few inches. Poorly developed near-horizontal fractures also cut some of the quartz veins and veinlets. Many of the quartz veins and veinlets contain molybdenite, generally as selvages or thin films along their borders, but, unusually, as scattered disseminations within the quartz. Molybdenite also forms rare thin films along some joint surfaces near the stockworks. Diamond-drill cores reveal quartz-free molybdenite along fractures in some of the hornfels and as very fine disseminations in some of the quartz monzonite porphyry.

Besides quartz and molybdenite, the veins contain minor to trace amounts of pyrite pyrrhotite, chalcopyrite, tetrahedrite, bornite, enargite, alunite, potassium feldspar, epidote, albite, malachite, and chlorite. The copper minerals occur mainly near the margins of the stockworks, and their distribution indicates a crude lateral zoning of the deposits. Thin altered zones that border some of the veins contain phlogopite, montmorillonite, calcite, and feldspars.

Rossman (1963b, p. K49) reports that a grab sample of mineralized quartz-rich rock that was collected from a gulley on the northeast side of "The Nunatak" contained 0.04 ounce gold per ton and 7.07 ounces silver per ton. Silver was detected in only two of our samples (table 13). Minor amounts of both gold and silver were found in some of the cores from the American Exploration & Mining Co. diamond-drill holes (Robert Garwood, oral commun., 1966).

The fault deposits are largely confined to the steep north-striking fault that extends northward from the lake north of Nunatak Cove (pl. 11), but they are also weakly developed in some of the lesser faults at the prospect. They differ from the stockworks mainly by containing molybdenite deposited along fractures within fault zones.

Stockwork deposits are inherently difficult to sample, and a reliable grade estimate for the Nunatak deposits would require extensive bulk sampling. Adequate estimates of the reserves are contingent upon determining the configuration of the deposits. Indications that the deposits extend to considerable depths are: (1) they are exposed throughout a large vertical range; (2) the richest exposures of ore are in sea cliffs that border Muir Inlet; (3) a company diamond-drill hole was mainly in mineralized rock to its bottom, about 300 feet below sea level; and (4) a Bureau of Mines diamond-drill hole penetrated uniformly mineralized rock continuously to its bottom 158 feet below sea level.

Twenhofel's reserve estimates (1946, p. 17, 18) are based on the results of drilling and sampling by the U.S. Bureau of Mines during 1942 and on his geologic mapping. The Bureau of Mines program consisted of drilling two diamond-drill holes totaling 285 feet and collecting and analyzing a total of 249

TABLE 13.—*Semiquantitative spectrographic analyses and colorimetric analyses for molybdenum of samples from the Nunatak molyodenum prospect*

[Spectrographic analyses by Harriet Neiman. Molybdenum determined colorimetrically by G. T. Burrow and E. J. Fennelly]

Results are reported in parts per million, which for the spectrographic analyses have been converted from percent to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.2, 0.1, . . . , which represent approximate midpoints of group data on a geometric scale. The assigned group for six-step results will include more accurately determined values for about 30 percent of the test results.

Symbols used: 0, looked for, but not detected; <, less than.

The following elements were looked for, but not found: As, Au, Be,[1] Cd, Hg, La, Li, Nb, Pd, Pt, Sb, Tl, W, Zn.

Sample locations and descriptions are shown on pl. 12.

Sample 66A	Mo (colormetric)	Ag	Ba	Bi	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sn	Ti	V	Y
Mk-93	305	0	70	0	7	20	150	50,000	1,000	200	15	0	0	2,000	70	15
94	275	0	100	0	7	15	150	30,000	700	100	10	0	0	1,500	30	0
95	725	0	70	0	10	30	300	70,000	700	500	20	0	0	1,500	50	10
96	700	0	100	0	7	30	100	30,000	700	300	15	0	0	2,000	70	10
97	190	0	150	0	10	50	100	70,000	1,500	200	15	0	0	3,000	70	15
98	370	0	100	0	7	20	200	50,000	1,000	100	15	0	0	2,000	50	10
99	360	0	100	0	7	50	200	50,000	1,000	300	15	0	0	2,000	50	10
100	45	0	150	0	10	50	100	70,000	1,500	30	20	0	0	2,000	70	10
101	55	0	150	0	10	70	100	70,000	1,500	30	20	0	0	3,000	70	10
102A	1,370	0	100	0	7	20	500	70,000	2,000	1,000	10	0	0	1,500	50	0
102B	665	0	150	0	10	70	200	70,000	2,000	20	20	0	0	2,000	70	10
103	60	0	300	0	10	50	200	50,000	1,500	20	20	0	0	2,000	70	10
104	115	0	200	0	10	100	150	70,000	1,500	30	30	0	0	3,000	100	10
105	8	0	500	0	10	150	70	50,000	1,000	7	20	0	0	3,000	100	10
106	55	0	500	0	10	150	50	50,000	1,000	50	30	0	0	2,000	100	10
107	15	0	150	0	10	50	500	70,000	1,500	10	15	0	0	1,500	70	10
108	145	0	150	0	15	30	1,000	70,000	1,000	100	15	0	0	3,000	70	15
109	25	0	150	0	10	70	300	70,000	1,500	150	15	0	0	3,000	100	20
110	45	0	100	0	10	100	300	70,000	2,000	30	20	0	0	2,000	70	15
111	<5	0	200	0	10	30	100	50,000	1,500	5	15	0	0	2,000	70	10
112	<5	0	200	0	7	30	300	50,000	1,500	<5	15	0	10	3,000	100	15
122	110	0	70	0	0	7	150	15,000	500	15	0	0	0	300	15	0
123	40	0	100	0	0	10	100	20,000	700	30	3	0	15	700	20	0
124	40	0	150	0	0	15	200	30,000	500	20	7	0	0	1,500	30	10
125	170	0	200	0	0	3	200	15,000	200	100	0	0	0	500	15	0
126	30	0	700	0	5	15	50	20,000	300	20	7	0	0	1,500	70	10
127	40	0	700	0	0	3	30	10,000	100	30	0	0	0	700	15	0
128	60	0	700	0	0	1	50	10,000	150	50	0	0	0	500	0	0
129	40	0	700	0	0	1	70	15,000	150	15	0	0	0	500	10	0
130	10	0	300	10	0	2	100	10,000	200	7	0	0	0	300	0	0
131	10	0	150	0	0	1.5	50	7,000	200	7	0	0	0	200	0	0
132	10	0	150	0	0	15	70	20,000	7,000	7	5	0	0	1,000	30	0
133	20	0	150	0	0	10	50	20,000	1,000	20	5	0	0	700	30	0
134	160	0	50	0	0	10	50	30,000	1,000	100	5	0	0	1,000	30	0
136	20	0	300	0	10	20	50	50,000	1,000	15	15	0	0	3,000	150	15
137	80	0	300	0	5	15	30	30,000	1,000	70	7	0	0	2,000	50	0
140	20	0	150	0	7	30	70	50,000	1,500	0	10	0	0	1,500	70	10
Re-1	160	0	70	0	15	30	50	70,000	3,000	100	15	0	0	3,000	100	15
2	70	0	100	0	15	50	100	50,000	2,000	30	20	0	0	5,000	150	15
3	815	0	50	10	7	30	50	30,000	2,000	500	10	0	0	2,000	50	10
4	2,480	0	70	0	7	20	30	30,000	1,500	1,500	10	0	0	1,500	70	10
5	900	0	100	0	7	30	50	50,000	1,500	500	20	0	0	1,500	70	10
6	1,290	0	150	0	7	20	50	50,000	2,000	1,000	15	0	0	1,500	70	10
7	810	0	150	0	7	30	100	5,000	1,500	700	20	0	0	1,500	100	10
8	1,665	1	100	0	7	20	200	30,000	1,500	700	15	20	0	1,000	50	0
9	640	0	100	0	7	30	70	30,000	1,000	300	15	10	0	1,500	70	10
10	<5	0	100	0	15	70	15	70,000	1,500	0	30	0	20	2,000	100	15
11	145	0	100	0	10	30	30	50,000	1,500	100	15	0	0	2,000	100	10
12	1,080	0	70	0	10	50	50	50,000	1,500	500	20	0	0	2,000	70	10
13	60	0	150	0	10	30	50	50,000	2,000	50	15	0	0	1,500	70	10
14	735	0	70	0	5	15	50	30,000	2,000	300	10	0	0	1,500	50	0
15	815	0	150	0	7	70	30	50,000	1,500	500	20	0	0	2,000	70	10
16	985	0	200	0	15	100	100	50,000	1,000	700	30	0	0	3,000	100	15
17	415	0	150	0	20	200	50	70,000	1,000	500	100	0	0	3,000	200	15
18	10	0	150	0	10	30	100	50,000	1,500	7	15	0	0	3,000	100	15
20	880	0	50	0	0	3	30	10,000	500	500	0	0	0	300	10	0
21	1,500	0	30	0	0	3	20	10,000	500	700	0	0	0	200	0	0
22	1,500	0	30	0	0	2	100	7,000	200	700	0	0	0	200	0	0
23	3,000	0	30	0	7	15	70	50,000	1,500	1,500	7	10	0	1,500	50	10
24	2,900	1.5	100	0	0	15	700	20,000	1,000	1,000	5	0	0	700	30	0
25	80	0	100	0	15	30	1,000	50,000	1,000	30	15	0	0	1,500	70	10

[1] 2 ppm Be detected in sample 66AMk-102A.

chip, drill-core, and channel samples. Sixteen samples were from the fault zone and 233 from the stockwork (Sanford and others, 1949). The average molybdenum content of 177 samples from the part of the stockwork mapped as containing conspicuous molybdenite was 0.075 percent (Twenhofel, 1946, p. 17). Fifty-six samples that were collected from parts of the stockwork mapped as containing inconspicuous molybdenite contained an average of 0.048 percent molybdenum (Twenhofel, 1946, p. 17). The samples from the fault zone contained an average of 0.12 percent molybdenum (Twenhofel, 1946, p. 17).

A summary of Twenhofel's reserve and grade estimates (1946, p. 17, 18) follows.[2] His grade estimates were based partly on channel samples.

	Surface area (square feet)	*Projected depth (feet)*	*Estimated tons* [1]	*Estimated grade (percent* MoS_2)
Fault deposit	18,000	300	540,000	0.169
Stockworks	2,170,000	500	[2] 8,500,000	.125
			[3] 91,500,000	.080

[1] Based on the assumption that 10 cu ft of ore weighs 1 ton.
[2] Estimated from surface mapping to contain conspicuous molybdenite.
[3] Estimated from surface mapping to contain inconspicuous molybdenite.

Our investigations included collecting 58 chip samples from the stockworks, 3 chip samples from the fault zone, and 98 soil samples (pl. 12). The chip samples were between 20 and 120 feet in length, the sample interval, ½ to 5 feet. All the chip samples were analyzed colorimetrically for molybdenum and by semiquantitative spectrographic methods. Our samples are inadequate for satisfactory grade estimates, but they furnish information on the distribution of molybdenum, copper, and other elements in the rocks and soils at the prospect.

Three diamond-drill holes drilled by the American Exploration & Mining Co. and associates during 1966 explored the lower part of the stockworks to a depth of 313 feet below sea level. The locations of the drill holes are shown on plate 11, but other data from the drilling are considered restricted information by the company and could not be released at the time this report was prepared. In general, the results of the drilling corroborate the size and grade of the stockworks as indicated by the surface exposures.

The Nunatak molybdenum prospect contains a large reserve of low-grade material, and if the current trends in price and demand for molybdenum continue, it may be minable in the future.

Geochemical studies

Ninety-eight soil samples and six water samples were collected at the Nunatak prospect to determine whether geochemical methods could trace the molybdenum mineralization beyond areas known to contain molybdenite. The soil samples were collected from a traverse along the crest of "The Nunatak" and along other traverses in the medial and lower parts of "The Nunatak" (pl. 12). Water samples were collected from two glacial lakes on the west side of "The Nunatak." For comparison, four water samples were collected from creeks in the Glacier Bay area far from known molybdenum mineralization.

Soils from outside the mineralized area are typically azonal, are rich in bedrock fragments, and contain less than 5 ppm molybdenum and less than 30 ppm copper. During the ridge-crest traverse, many anomalous samples that contained between 10 and 29 ppm molybdenum were collected south of the area shown as mineralized on the geologic map (pls. 11, 12) and from sites where close examinations of the rocks revealed no molybdenite. Some of the molybdenum may have been transported by glaciers from north of "The Nunatak"; however, it is believed that much of this molybdenum is of local derivation. Both molybdenum and copper are present in abnormal amounts in azonal soils near the southern end of the crest of "The Nunatak," where minerals containing these metals have not been identified in the nearby bedrock.

Samples collected along the east base of "The Nunatak," except those near the extreme northern tip, have only background molybdenum and copper contents (less than 5 ppm and 30 ppm, respectively). On the west side of "The Nunatak," however, most of the samples contain anomalous values. The highest metal content in this group (910 ppm molybdenum, 270 ppm copper) occurs in sample 64 (pl. 12). The samples indicate that the soils with high molybdenum and copper content extend irregularly southward beyond the area mapped and are mineralized as far south as the eastern tip of the larger lake (pls. 11, 12). These high values confirm the southern extension of the geochemical anomaly and also the presence of copper in the southern part of the anomaly, which was indicated by the ridge-crest sampling.

Several types of azonal soils are present and available for sampling along the base of "The Nunatak." Of these, the oldest is slightly weathered glacial till composed of gray mud and rounded glacial erratics. After deglaciation, a series of alluvial talus cones formed, composed in part of glacial materials and in part of sand and angular pebbles of the local rock. Where talus cones of several different ages are recognizable, the younger ones contain the most

[2] Twenhofel's samples were not analyzed for copper, a possible byproduct.

local rock. The relative ages of the cones can be identified from their physiographic relations, as the older ones are being dissected and the younger ones are still being formed.

For comparison, samples of two different kinds of soil were taken at several sample sites. The results in table 14 show that large differences exist in the

TABLE 14—*Comparison of older and younger soils at the Nunatak molybdenum prospect in terms of molybdenum and copper content*

[Analytical methods described under "Geochemical studies." Semiquantitative-spectrographic analyses by R. G. Havens and Nancy Conklin. See pl. 12 for sample locations]

Sample site		Description	Metal Content (parts per million) Molybdenum	Copper
66AHF				
40	G	Glacial till	5	28
	T	Talus composed of local rock	10	46
41	G	Glacial till	0	29
	T	Talus composed of local rock	13	62
45	G	Outwash sand	7	31
	T	Talus overlying outwash	320	290
51	G	Glacial till	5	30
	T	Talus; some molybdenite visible	10	150
55		Older talus	0	50
	B	Younger talus; some molybdenite visible	20	100
61	G	Older talus	0	100
	T	Younger talus; mostly local rock	5	230
64	B	Older talus	5	31
		Younger talus, 50 percent local rock	910	270

molybdenum and copper contents of these closely related soils and that the younger soil at a given site commonly contains much more of these metals than the associated older soil.

All soil samples from the Nunatak area composed entirely of glacial till have a low metal content. Samples collected along the two traverses that extend westward (pl. 12), except sample 61, are composed entirely of till, and all have low metal contents. Sample 61, which contains 230 ppm copper, is the only sample from these traverses composed in part of local bedrock.

The two samples of lake water from the Nunatak area were dried to a residue and analyzed spectrographically. One sample contains a remarkably high concentration of molybdenum, 7,000 ppm. The other residues contain 700 ppm molybdenum, which is high by comparison with the soil samples. These analyses show that molybdenum is fairly soluble in the surficial envionment. Even though the places in the area where waters could be sampled are limited, the possible use of water analyses in prospecting appears to deserve more study here. Because plants are likely to absorb molybdenum from the ground water, study of the molybdenum content of the local plants seems desirable.

ENTRANCE OF ADAMS INLET

Buddington and Chapin (1929, p. 330) report that molybdenite occurs in fractures in metamorphic rocks on the north side of, and near the entrance to, Adams Inlet (pl. 1, loc. 22). This occurrence was not found, although the general area was examined in some detail. Possibly it is the same locality as the copper-bearing amygdaloid contains trace amounts of molybdenum that crops out about 1½ miles from the entrance to the inlet (5).

WACHUSETT INLET

A molybdenite-bearing quartz vein crops out in recently deglaciated rocks near the head of Wachusett Inlet (pl. 1, loc. 35). It strikes N. 34° E. and dips 85° SE. The vein is between 1 and 12 inches thick and is exposed for about 75 feet along its strike. The vein cuts quartz diorite, which has been intruded by andesitic and pegmatitic dikes and contains quartz, pyrite, molybdenite, chalcopyrite, and secondary iron minerals. A sample from the richest part of the vein carried 7,000 ppm molybdenum, 15,000 ppm copper, 700 ppm zinc, and 0.0045 ounce per ton (15 ppm) silver (table 9, loc. 35). The deposit is too small to be exploited; but it is rich enough to encourage exploration for similar, but larger, deposits in the vicinity, particularly since the nearby terrain was recently exposed and is virtually unprospected.

TRIANGLE ISLAND

Rossman (1963b, p. K49) reports that a few hundred pounds of molybdenite, which constituted the entire deposit, was mined in one day from Triangle Island, in the northern part of Queen Inlet (pl. 1, loc. 36). Examination of the island, which is a seagull rookery, failed to reveal any molybdenite or signs of workings. The island is composed of fine-grained granodiorite that is cut by a few east-striking aplitic dikes that commonly dip north at about 50°.

GEIKIE INLET

Buddington and Chapin (1929, p. 329, 330) report specimens of molybdenite float from near Geikie Inlet. Reed (in Smith, 1942, p. 178) reports claims on molybdenite-bearing tactite at a rather high altitude near the head of Geikie Inlet, probably near locality 50 on plate 1. A brief examination failed to disclose any molybdenite or signs of workings in the general vicinity. Buddington (unpub. data, 1924) reports that molybdenite ore was obtained from near Geikie Inlet in 1918.

Lower Brady Glacier

Float specimens of molybdenite-bearing quartz veins have been reported from Brady Glacier (pl. 1, loc. 56). (See A. F. Buddington, unpub. data, 1924; Buddington and Chapin, 1929, p. 329, 330; Smith, 1942, p. 177.) No specific information is available on the locations of the float specimens, and we were unable to find similar ones. The Brady Glacier moraines contain diverse rocks that were derived from a large and geologically complex area. Among these rocks are felsic-granitic types that are favorable hosts for some molybdenum deposits.

Ridge West of Rendu Inlet

A swarm of thin quartz veins and subordinant thin quartz-rich pegmatite dikes cut granitic rocks on the ridge west of Rendu Inlet (pl. 1, loc. 60); they occupy a zone about 25 feet wide. The veins and dikes have diverse attitudes, but they generally strike northward and dip steeply eastward. The veins commonly are spaced several feet apart and are between ½ and 3 inches thick, commonly less than 1 inch thick. The veins and quartz-rich parts of some of the dikes contain scattered sulfide minerals, including molybdenite, chalcopyrite, pyrite, and pyrrhotite. The deposits appear to be too small and too dispersed to justify exploration.

Other Molybdenum Deposits

Molybdenum is a constituent of many other deposits in the monument, particularly some of those that are noteworthy for their copper contents. Molybdenum occurs in significant amounts in copper deposits in the Bruce Hills (loc. 34) and near the southwestern part of Gilbert Island (44, 45). It occurs in lesser amounts in deposits east of Dundas Bay (32) and southwest of Lamplugh Glacier (67) and in minor to trace amounts in many other deposits that are indicated on plate 1 and in tables 9 and 11.

Molybdenum was detected in trace to minor amounts in several samples that are not particularly noteworthy for their contents of other metals. These samples represent deposits best regarded as occurrences with no economic potential, and they do not merit individual descriptions. Included among them are occurrences east of the head of Charpentier Inlet (loc. 47), on the north shore of Geikie Inlet (48), on the south end of the ridge west of Reid Inlet (70), southeast of the head of Reid Inlet (71), on the south shore of Johns Hopkins Inlet west of Lamplugh Glacier (74), and about a quarter of a mile northwest of the Sandy Cove prospect. (See pl. 1 and table 9.)

NICKEL

Nickel occurs in trace to moderate amounts in many of the sulfide deposits in the monument, and it is the principal commodity in the major deposits at the Brady Glacier nickel-copper prospect. Most of the samples that contained nickel are from deposits described under "Copper." The highest nickel contents in these samples were 1,000 ppm from a pyrite-rich lens west of the mouth of Rendu Inlet (loc. 38) and 500 ppm from soil at the Alaska Chief prospect (29). Many other deposits described under "Copper" contained between 100 and 300 ppm nickel. These include the deposits near Mount Young (1), north of White Glacier (6), north of York Creek (8), in the Curtis Hills (23), on the shore south of Tidal Inlet (41), on South Marble Island (25), and on Francis Island (28). Minor amounts of nickel were detected in samples from two deposits that lack notable concentrations of other metals: a deposit north of Mount Abdallah (16) that consists of iron-stained hornfels and a deposit west of the head of Lamplugh Glacier (68) in altered zones that cut hornfels. (See pl. 1 and table 9.) Probably some of the unsampled pyrrhotite-rich lenses and veins that have been reported from the Fairweather Range are nickeliferous (Kennedy and Walton, 1946, p. 71).

The most favorable hosts for undiscovered nickel deposits are layered mafic and ultramafic complexes of the Fairweather Range, particularly their lower horizons and contact zones. Both of these environments are regarded as geologically favorable sites for nickel-copper sulfide lodes, such as those at the Brady Glacier prospect.

DESCRIPTIONS OF DEPOSITS

Brady Glacier Prospect

By H. R. Cornwall

Massive and disseminated nickel-copper sulfides were discovered in 1958 by the Fremont Mining Co. in three nunataks near the west edge of Brady Glacier in Mount Fairweather C–3 quadrangle (pl. 1, loc. 72). The sulfides occur at the southeast margin of a large lopolithic instrusion of gabbro and peridotite described by Rossman (1963a). The intrusion, called the Crillon-LaPerouse stock by Rossman, is 17 miles long and 8 miles wide and consists mainly of layered gabbro. The nickel-copper deposits occur near the base of the gabbroic intrusive in a zone where ultramafic rocks (peridotite) predominate. The following descriptions of the geology and ore deposits include some material that was graciously supplied by the Newmont Exploration Co.

Geology

This mafic complex is intruded into amphibole and biotite schist that Rossman tentatively correlates with greenstone and graywacke units on Chichagof Island southeast of Brady Glacier. In the area of the Brady Glacier nickel-copper deposits, the mafic complex has intruded garnetiferous biotite schist. The minerals in this schist are quartz, plagioclase, orthoclase, and biotite with sparse prophyroblastic pink garnets.

According to Rossman (1963a), the Crillon-La Perouse gabbroic intrusive has an exposed thickness of about 32,000 feet. The layers range in thickness

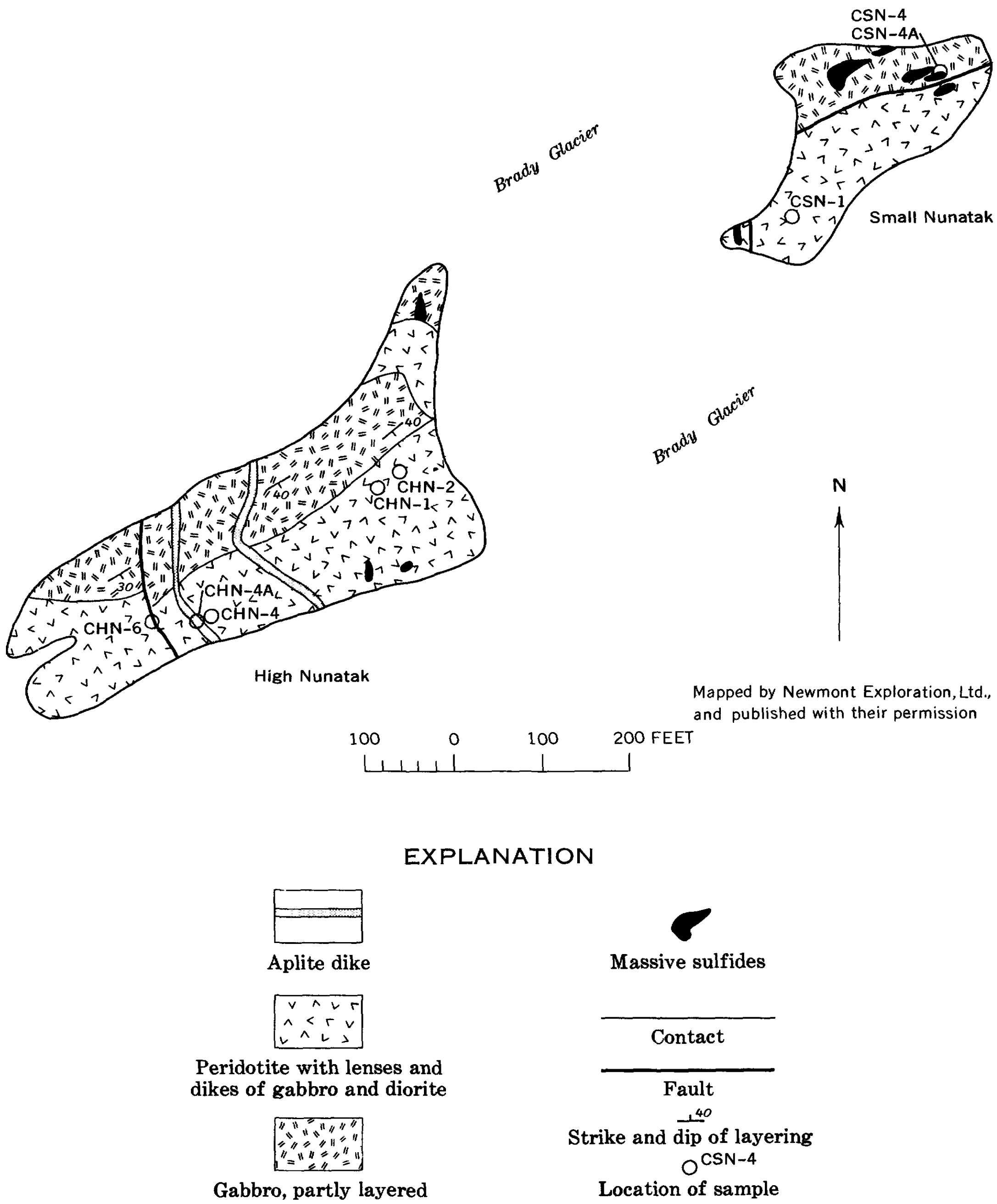


FIGURE 18.—Generalized geologic map of Brady Glacier nunataks showing nickel-copper sulfide lodes.

from less than one inch to tens of feet, which is due to differences in grain size and proportions of the principal minerals, plagioclase, pyroxene, and olivine; the layers dip toward the interior of the complex at angles of 70° or less.

In the nickel-copper-bearing nunataks on Brady Glacier, the structures are much more complex and stratiform relations are less apparent. This is due in part to later intrusions and in part to post-crystallization faulting near the margin of the intrusive. The general relations of the rocks exposed in 1966 are shown in figure 18. Two of the three nunataks described by geologists of Newmont Exploration, Ltd. (written commun., 1961), were exposed in 1966 —the High Nunatak and the Small Nunatak. In these exposures periodotite overlies fine- to medium-grained gabbro, in part layered, and the units dip 20°–50° southeast toward the margin of the intrusive. These rocks are intruded by dikes and irregular bodies of gabbro, diorite, aplite, and possibly peridotite. A prominent shear zone strikes northeast parallel to the axis of the Small Nunatak, and smaller faults run parallel to this shear zone in both nunataks. Several minor faults strike nearly north-south across the High Nunatak. The faults dip moderately to steeply east and southeast.

Peridotite is the predominant host rock for the Brady Glacier deposits. The periodotite most commonly consists of a mixture of forsterite (olivine) and enstatite (orthopyroxene); augite (clinopyroxene) has been found in some specimens. Dunite consisting entirely of olivine is present but not abundant. The olivine crystals in the peridotite are rounded, 0.2–3.0 mm in diameter, and commonly poikilitically enclosed by pyroxene. In most of the peridotite, the pyroxene and, to a lesser extent, the olivine have been partly to completely altered to tremolite (amphibole), serpentine and minor epidote. The peridotite contains small amounts of chrome picotite (green spinel) and pyrrhotite ($Fe_{1-x}S$), pentlandite ($(FE,Ni)_9S_8$), and chalcopyrite ($CuFeS_2$). It also contains lenses or schlieren, as much as 1 foot thick, of coarse gabbro and gabbro pegmatite, elongate parallel to layering where discernible.

Fine- to coarse-grained olivine gabbro is also a common host rock for the nickel-copper sulfide deposits. Plagioclase (An_{45-60}) is commonly fresh in crystals ranging from 0.1 to 2.5 mm. Augite is interstitial to the plagioclase in grains less than 0.5 mm. Some orthopyroxene is present; locally, it is more abundant than augite. The pyroxene is moderately to completely altered to tremolite and serpentine group minerals. Forsterite (olivine) occurs in 0.1–3.0 mm grains and is partly to completely altered to tremolite and serpentine group minerals. A little epidote is present and small amounts of pyrrhotite, pentlandite, and chalcopyrite are disseminated through the rock.

Dikes as much as 5 feet or more wide of fine-grained gabbro, diorite, and aplite are very common and tend to cross the layering of the peridotite and gabbro. The diorite is similar to the fine-grained gabbro but has more sodic plagioclase ($An_{\pm 40}$). The aplite has plagioclase phenocrysts (An_{35}) as much as 2.5 mm long in a groundmass with grains less than 0.3 mm of euhedral biotite and anhedral plagioclase and quartz.

Ore deposits

The sulfides pyrrhotite (Fe_{1-x}), pentlandite ($(Fe,Ni)_9S_8$), and chalcopyrite $CuFeS_2$) occur in the host rocks described above as disseminated grains, veinlets, and lenticular masses as much as 35 feet long and 5 feet in diameter. Most of the masses of solid sulfide are, however, much smaller. Large sulfide masses were mainly observed only near the northeast end of the Small Nunatak. The sulfide veinlets are commonly less than 1 mm thick and occur along fractures and fissures. Small lenticular masses also occur along the more prominent fissures and faults. The grains and small patches of sulfides are scattered through most of the host rock and occur in all types, except the aplite. The disseminated sulfides appear to be most abundant in altered peridotite and gabbro pegmatite. Individual sulfide grains are commonly less than 2 mm in diameter.

The relative order of abundance of the sulfides is pyrrhotite, pentlandite, chalcopyrite. Pyrrhotite grains commonly have smaller peripheral grains of pentlandite and chalcopyrite. Pentlandite also occurs as lenticular blebs, 0.01–0.04 mm in diameter, in the pyrrhotite with nearly parallel orientation. These blebs probably formed by exsolution from the pyrrhotite during cooling of the rock. Chalcopyrite is more erratically distributed than the other sulfides, and textural relations suggest that it may have formed slightly later. Near the surface in the nunataks and upper part of diamond-drill holes the pentlandite has been partly altered by weathering to violarite (Ni_2FeS_4) and polydymite (Ni_3S_4).

Possibilities of commercial ore deposits

The Fremont Mining Co. staked claims covering the Brady Glacier nickel-copper deposits in 1958, and in 1958–59 sampled the nunataks and drilled 32 diamond-drill holes (written commun., 1959). In 1960–61, Newmont Exploration, Ltd. (written commun., 1961), under an agreement with Fremont, drilled 14 more holes and did more mapping and sampling of the nunataks.

Disseminated sulfides are widely distributed throughout the nunataks. The amounts are small, however, and the overall average grade of the nunataks would probably be less than 0.5 percent each of nickel and copper. Several of the sulfide masses in the nunataks have been sampled and assays run 2–3 percent nickel, 1–1.4 percent copper, and 0.25 percent cobalt. Results of semiquantitative spectrographic analyses of Survey ore and rock samples from the prospect are given in table 15. Individual massive sulfide lenses are small; five such bodies on the nunataks, however, have lengths ranging from 15 to 35 feet and average widths of about 6 feet, and the extent in depth is probably comparable to these dimensions.

Diamond drilling thus far has shown that low-grade nickel-copper mineralization is widespread in the gabbro-peridotite complex, but more drilling is needed to establish continuity of the higher grade zones. A large area about 1,000 feet in diameter beneath the glacier 1,000 feet southwest of the nunataks appears to contain 0.3–0.6 percent nickel and 02–0.4 percent copper in gabbro and peridotite; the depth of mineralization has not been determined. By analogy with known commercial deposits of a similar nature elsewhere, it is very possible that, as the basal contact of the ultramafic complex is approached with greater depth, higher grades of nickel and copper mineralization will be found.

Several diamond-drill holes were drilled 200–700 feet south of the nunataks and these revealed mineralization of somewhat higher grade than in the area described above. One hole intersected sulfide mineralization for more than 100 feet with 1 percent nickel and 0.4 percent copper; another intersected more than 100 feet averaging 0.7 percent nickel and 0.4 percent copper. The area surrounding the nunataks appears to offer the greatest promise for commercial ore bodies, but more exploration is needed for a reliable evaluation.

TITANIUM

DISTRIBUTION

Important amounts of titanium are in ilmenite-rich rocks of the layered mafic sequences of the Fairweather Range and, to lesser extents, in ilmenite-bearing beach placers north and south of Lituya Bay (locs. 87, 88). Titanium was detected in quantities of 10,000 ppm in samples from three other deposits examined during our investigations: Curtis Hills (23), South Marble Island (25), and east of Charpentier Inlet (47). It was also found in amounts of 2,000–7,000 ppm in many other deposits. (See pl. 1 and table 9.) These titanium values reflect host rocks that intrinsically have moderate titanium contents but are too lean to be of economic significance.

DESCRIPTIONS OF DEPOSITS

Fairweather Range

The ilmenite-rich gabbros of the layered intrusive complexes of the Fairweather Range constitute a large resource of low-grade titanium ore. The ilmenite deposits have not been studied in detail, and the limited information available is from Rossman (1963a, p. F42–F45) and from Kennedy and Walton (1946, p. 71). The layered intrusive masses of the Fairweather Range are the Crillon-LaPerouse and the Astrolabe-DeLangle stocks of Rossman (1963a)

TABLE 15.—*Semiquantitative spectrographic analyses of rocks and ore from the Brady Glacier nickel-copper prospect*

[Spectrographic analyses by A. L. Sutton, Jr.]

Results are reported in parts per million, which have been converted from percent to the nearest number in the series 100, 70, 50, 30, 20, 15, 10, ... which represent approximate midpoints of group data on a geometric scale. The assigned group for six-step results will include more accurately determined values for about 30 percent of the test results.

Symbols used: M, major constituent—content greater than 100,000 ppm; 0, looked for, but not detected; <, less than.

In addition to the elements shown in the table, the following elements were also sought in all of the analyses: Au, Ag, As, Be, Bi, Cd, Hg, La, Li, Nb, Pb, Pd, Pt, Sb, Sn, Ta, Tl, W, Zn. Reported values for these were always 0.

Sample locations shown in fig. 18.

Field No.	Al	Ba	Ca	Co	Cr	Cu	Fe	Mg	Mn	Mo	Ni	Si	Sr	Ti	V	Y
CHN–1.......	20,000	10	10,000	150	200	2,000	M	M	1,000	<5	3,000	M	30	500	150	0
2.......	30,000	10	10,000	150	150	200	M	M	1,000	<5	300	M	50	150	100	0
4.......	70,000	100	70,000	30	100	700	50,000	M	1,000	0	300	M	150	1,500	200	10
4A.....	M	500	30,000	15	20	50	20,000	10,000	300	0	200	M	200	1,500	70	10
6.......	70,000	100	50,000	30	300	70	70,000	M	1,000	0	200	M	200	500	200	30
CSN–1.......	30,000	15	10,000	70	1,000	1,500	M	M	1,000	<5	1,500	M	20	70	150	0
4.......	200	0	0	2,000	500	20,000	M	200	150	70	15,000	1,500	0	20	50	0
4A......	70	0	0	2,000	700	20,000	M	30	100	20	15,000	100	0	0	50	0

CHN–1 Selected sample of periodite with sulfides.
2 .... do ....
4 Selected sample of gabbro.
4A Selected sample of aplite.
CHN–6 Selected sample of diabase.
CSN–1 Selected sample of periodotite.
4 Grab sample of massive sulfides.
4A .... do ....

and an inferred and undefined stock near Mount Fairweather. These masses have crude troughlike configurations that are shown by northwest-trending axes and inward-dipping layers. In the Crillon-LaPerouse stock, the largest of the layered masses, the layered sequence has a maximum exposed thickness of 32,000 feet and consists largely of gabbro. The ilmenite-rich layers represent magmatic deposits in which ilmenite was concentrated mainly by gravity settling. Four of the ilmenite deposits are shown on plate 1 (locs. 73, 79–80), and similar deposits undoubtedly occur elsewhere in the little-explored range.

Rossman (1963a, p. F42) reports that the contact area of the Crillon-LaPerouse stock, 1½ miles southeast of Mount Lookout, probably contains between 10 and 25 percent ilmenite through a distance of several hundred feet, but that the lateral extent of the ilmenite-rich zone could not be determined because of extremely rough terrain. Rossman noted similar zones in the valley walls south of South Crillon Glacier. Layers of gabbro northwest of North Crillon Glacier contain between 7 and 10 percent ilmenite, and similar concentrations of ilmenite are near the southernmost exposures of the Crillon-LaPerouse stock (Rossman, 1963a, p. F42). Rossman also found a few layers that contain small concentrations of ilmenite and sulfide minerals elsewhere in the Crillon-LaPerouse stock. Rossman (1663a, p. F43, F44) shows tables indicating the ilmenite contents of samples from the Crillon-LaPerouse stock and semiquantitative spectrographic analyses of heavy-mineral concentrates from the stock.

Some layers of the Astrolabe-DeLangle stock contain concentrations of ilmenite, and others contain as much as 20 percent titanium-bearing magnetite (Rossman, 1963a, p. F44). Most of the layers that contain much ilmenite or magnetite crop out through a "stratigraphic" thickness of about 1,000 feet, high in the mountains that form Astrolabe Peninsula. The mineralized layers appear to be continuous throughout the mountains. Rossman (1963a, p. F45, table 8) shows the content of ilmenite- and titanium-bearing magnetite from rocks of the Astrolabe-DeLangle stock.

Kennedy and Walton (1946, p. 71) report that an intrusive layer about 5 feet thick which crops out for several thousand feet along the south wall of the valley of North Crillon Glacier contains as much as 60 percent ilmenite.

On the basis of present knowledge, the layered gabbros of the Fairweather Range are a potentially important resource of titanium and possibly iron and other metals. More accurate evaluations of their economic potential require detailed exploration and sampling. Such investigations would be inhibited by the remote and rugged terrain of the Fairweather Range and would be costly and time consuming.

Placer Deposits Near Lituya Bay

The beach placers north and south of Lituya Bay (pl. 1, locs. 87, 88) have been investigated by Mertie (1933, p. 117–135), Rossman (1957), and Thomas and Berryhill (1962, p. 37–39). The latter two investigations stressed the ilmenite content of the placers. Detailed descriptions of the placers are in the section of this report describing gold placer deposits. The placer deposits have yielded a small production of gold, and they and their probable offshore extensions are potential sources for gold, titanium, and possibly other metals. The largest known placer concentrations of heavy minerals in the monument are along the beaches between 2 and 13 miles south of Lituya Bay. The upper parts of all the bare beaches and most of the tree-covered beaches north and south of Lituya Bay contain between 5 and 40 percent heavy minerals. Some of the deposits are large, extending for more than 2 miles along the beaches with widths of several hundred feet.

Rossman's samples (1957, p. 6, table 1) from the beach deposits between Palma Bay and Dry Bay indicate that these deposits contain 0.25–21.0 percent ilmenite and as much as 10 percent magnetite. The TiO_2 content of the ilmenite from these samples ranges from 46.80 percent to 52.38 percent (Rossman, 1957, p. 8, table 2).

The U.S. Bureau of Mines investigations of the placers north and south of Lituya Bay consisted of sampling 26 auger holes and collecting 11 shovel samples (Thomas and Berryhill, 1962, p. 37–39, table 21, fig. 12). The magnetic fractions of these samples contained 0.1–16.5 pounds of iron per cubic yard; the nonmagnetic fractions, 0.3–89.5 pounds of TiO_2 per cubic yard.

TUNGSTEN

Deposits that contain tungsten in potentially minable quantities are not known in the monument. The one previously reported tungsten occurrence consists of minor amounts of scheelite in a gold-quartz vein east of Reid Inlet (Rossman, 1959, p. 56). Tungsten was detected in samples from only two of the deposits that we examined. This is attributable in part to the low sensitivity for tungsten in the semiquantitative spectrographic analysis, but it is mainly because of the scarcity of tungsten.

A sample of pyrrhotite-rich massive sulfide float from the Margerie copper prospect contained 3,000 ppm tungsten and a sample from a quartz vein at the prospect, 150 ppm (pl. 1 and table 9, loc. 19). A sample representative of a 1-foot-thick sulfide-bearing tactite that has replaced marble in the northern part of Gilbert Island contained 150 ppm (pl. 1 and table 9, loc. 43).

Samples of sediments from streams entering the northern part of Dundas Bay contained as much as 150 ppm tungsten and 30 ppm tin, indicating a geochemical anomaly (table 4). Tracing the anomalous metals to their source might lead to the discovery of a tungsten deposit of interest.

Tactite bodies and, to a lesser extent, gold-quartz veins are generally favorable hosts for scheelite deposits; the fact that many deposits of these types were examined and sampled with negative results presages little support for successful tungsten exploration in the monument. Wolframite and other tungsten minerals are elsewhere associated with leucocratic granitic rocks similar to some rocks that are fairly abundant in the monument. With the possible exception of the geochemical anomaly north of Dundas Bay, no evidence linking tungsten mineralization to these rocks was found during our investigations.

VANADIUM

Vanadium was detected in minor amounts in samples from many deposits in the monument. The highest concentration of vanadium found was 1,500 ppm in a sample of sulfides replacing metavolcanic rocks near Mount Young (pl. 1 and table 9, loc. 1). Vanadium was detected in quantities between 500 and 700 ppm in a few samples and in lesser amounts in many samples (tables 9, 11, 15).

The ilmenite and the titanium-bearing magnetite in layered mafic intrusive rocks of the Fairweather Range contain subordinate amounts of vanadium, and vanadium would possibly be a byproduct from mining deposits of these minerals. Rossman (1963a, p. F44, table 7) indicates that the vanadium content of heavy mineral concentrates of nine samples from the Crillon-LaPerouse stock was less than 1 percent.

By analogy with known deposits, the search for vanadium in the monument should focus on prospecting for concentrations of vanadium-bearing ilmenite and magnetite in the layered intrusive complexes of the Fairweather Range. The Bushveld complex of Africa, which has some similarities with the layered intrusions of the Fairweather Range, contains the largest known reserves of vanadiferous iron ore in the world.

GEOLOGIC INFLUENCES ON LOCALIZATION OF METALLIFEROUS DEPOSITS

Almost all the known deposits in the Glacial Bay National Monument can be related, at least spatially, to magmatic sources. The relationships range from strictly magmatic deposits, such as the titanium and iron deposits in the layered gabbros of the Fairweather Range, through many deposits associated with granitic plutons and dikes that are inferred to be late-stage magmatic derivatives, to a few deposits with only tenuous magmatic affiliations far from exposures of igneous rocks.

Correlations and affinities of specific rocks and geologic settings with specific types of mineral deposits are well documented in the geologic literature. In the monument, such affinities are exemplified by the ilmenite and magnetite deposits in the layered gabbro; the probability of chromite and platinum deposits in ultramafic rocks of the layered intrusive complexes; nickel-copper deposits in the lower and peripheral parts of the layered intrusives; magnetite-rich skarn deposits and base metal deposits in marble near contacts with intrusive rocks; and molybdenite deposits in or near epizonal intrusive rocks. Many of the gold lodes may be inferentially related to felsic granitic rocks.

Structural and tectonic factors have been important in localizing some of the deposits. Disruptive intrusions shattered the wallrock at the Nunatak molybdenum deposit and probably at a few other molybdenum deposits, creating myriad fractures that were sites for subsequent mineralization. An east-trending structural zone in the east-central part of the monument may have influenced the formation of the nearby molybdenum deposits. This zone contains many porphyritic plutons, and some of them are associated with molybdenum deposits.

Carbonate rocks near intrusive masses are favorable sites for a variety of ore deposits, and such associations are known from many places in the monument. Besides the carbonate rocks, hornfels and other rocks near intrusive bodies are potential hosts for metals derived from the magmas. The northwest-trending mixed rocks and hornfels that extend from west of Lamplugh Glacier to near the northern boundary of the monument contain numerous altered zones.

NONMETALLIC COMMODITIES

Deposits of several nonmetallic commodities are known in the monument, but their economic potential is minimal because of their low grade, small size, impurities, poor access, and cheaper availability from other sources. Limestone and marble are distributed widely throughout the central and eastern part of the monument, particularly on islands in the southern part of Glacier Bay and on the nearby mainland. The most extensive limestone and marble deposits are on Willoughby, Drake, Francis, and Marble Islands and on the mainland south of Sandy Cove and near Marble Mountain (pl. 1). Although many of these deposits are large and are accessible to tidewater, our limited examinations indicate that most of them are contaminated with silicate or dolomitic phases or other impurities and that they are also cut locally by numerous dikes and veins.

Most of the dolomite bodies appear to be too small to be of interest. A possible exception is the dolomite that is exposed at a rather remote location on the ridge west of Geikie and Hugh Miller Glaciers (pl. 1; Seitz, 1959, p. 115, 116), but little is known concerning the composition and relative purity of this mass.

Minor amounts of several other nonmetallic commodities are known from the monument. Barium is associated with many of the lode deposits (table 9) but in amounts too small and grades too lean to be significant. A small amount of celestite (strontium sulfate) has been found in the monument (Seitz, 1959, p. 115), but the deposits are too small to be important. Sand and gravel are available at a few places in the monument, but their utilization is negated by the lack of nearby markets and by the widespread occurrence of similar and better deposits closer to potential markets.

PETROLEUM AND COAL

By George Plafker

PETROLEUM

Within Glacier Bay National Monument potentially petroliferous rocks of Tertiary age underlie a coastal lowland-and-foothills belt less than 4 miles wide and about 40 miles long southwest of the Fairweather fault (fig. 19). Tertiary rocks are also presumed to occur over much, if not all, of the adjacent offshore area within the monument. The Tertiary rocks are underlain by regionally metamorphosed and complexly deformed Mesozoic(?) sedimentary and volcanic rocks that represent effective "basement" for traps petroleum in this area.

The part of Glacier Bay National Monument described herein lies within the Lituya district of the Gulf of Alaska Tertiary province. The Gulf of Alaska Tertiary province has been studied by Don J. Miller, who published many reports on the area and summarized its geology (Miller and others, 1959). The descriptions of the structure and stratigraphy of the Tertiary sequence in the Lituya district are based mainly on detailed mapping by Miller and others (Miller, 1953, 1961) and on unpublished U.S. Geological Survey field data obtained by the author during a stratigraphic reconnaissance of part of the area in 1963.

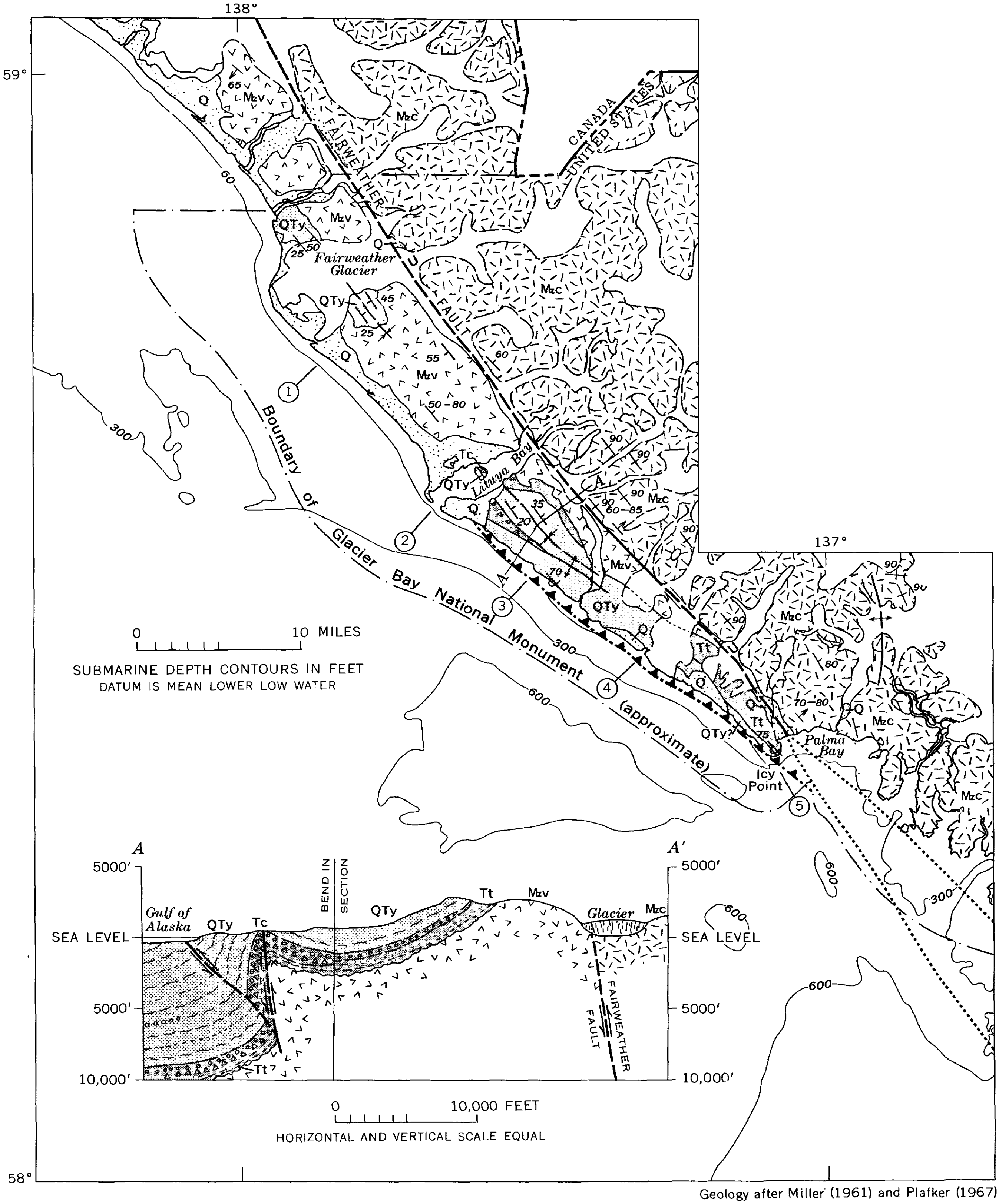
STRATIGRAPHY

Bedded rocks of Tertiary age in the Lituya district include marine and nonmarine clastic and volcanic units totaling at least 12,000 feet which unconformably overlie the Mesozoic basement. The sequence has been subdivided into three formations: the Cenotaph Volcanics and Topsy formation, both of postearly Oligocene(?) to premiddle Miocene age, and the Yakataga Formation of middle Miocene to early Pleistocene age (Plafker, 1967). Relations between the Topsy Formation and Cenotaph Volcanics are obscure; the two units are believed to be at least partly equivalent in age, for the predominantly or wholly nonmarine beds of the Cenotaph Volcanics appear to grade into, and interfinger with, the marine Topsy Formation. Both formations are disconformably overlain by the Yakataga Formation. Generalized stratigraphic sections and tentative correlations of the Tertiary sequence are shown in figure 20.

The Topsy Formation ranges in thickness from about 1,200 feet at the type section along upper Topsy Creek to at least 4,400 feet at Icy Point. It consists of about 75 percent hard calcareous or concretionary siltstone, and 25 percent fine- to medium-grained gray or greenish-gray argillaceous and carbonaceous sandstone. Deposition in a marine environment in premiddle Miocene, probably Oligocene, time is indicated by a sparse molluscan fauna.

At Lituya Bay the Cenotaph Volcanics consist of at least 850 feet of green, red, and purple volcanic breccia and tuff overlain by 400 feet of interbedded green and red tuffaceous siltstone, green glauconitic sandstone, and glauconitic pebble-cobble conglomerate. Andesitic lava flows are present in the basal part of the formation south of Lituya Bay, and lenses and discontinuous beds of low-rank coal occur locally within the uppermost part of the formation. The Cenotaph Volcanics were probably deposited under predominantly nonmarine and nearshore conditions during a period of intermittent volcanic activity.

The Yakataga Formation is the youngest and most widely distributed Tertiary formation; it is as much as 8,400 feet thick. This formation comprises a lower unit, ranging in thickness from 600 to at least 2,400



Geology after Miller (1961) and Plafker (1967)

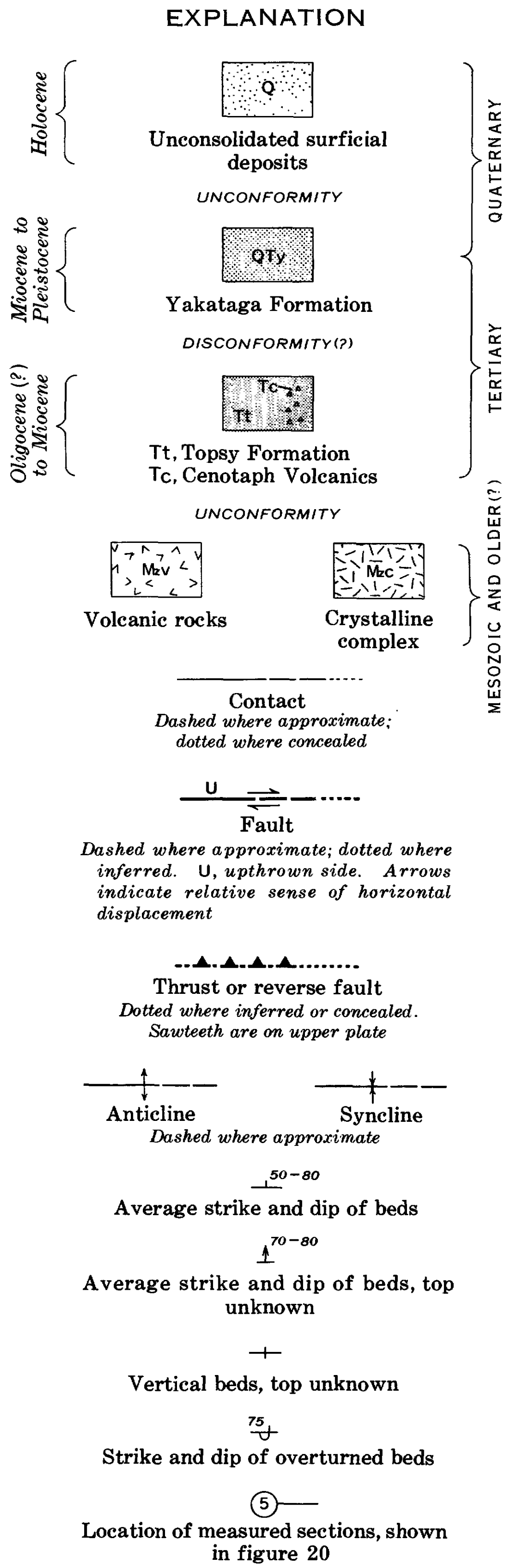


FIGURE 19.—Geologic sketch map and structure section of Tertiary rocks in the Lituya district.

feet, consisting mainly of interbedded siltstone and sandstone containing calcareous lenses or concretions and sparse isolated pebbles, and an overlying upper unit consisting of at least 6,000 feet of sandy mudstone, siltstone, sandstone, and minor conglomerate interbedded with abundant conglomeratic sandy mudstone (marine tillite) which characteristically contains unsorted ice-transported clasts of diverse lithologies. Depositon in a cold-water shallow-marine environment is indicated by an abundant molluscan fauna.

STRUCTURE

The narrow belt of Tertiary rocks south of Lituya Bay is folded into a shallow syncline and a highly asymmetric faulted anticline (fig. 19, section *A–A′*). These folds pass to the southeast into a seaward-facing homocline which is nearly vertical or slightly overturned. The south limb of the anticline is believed to be cut by an unexposed thrust or reverse fault that strikes parallel to the coast. Upper Tertiary rocks in the two small outliers near Fairweather Glacier form a broad northwest-trending syncline unconformably overlying the pre-Tertiary volcanic rocks.

POTENTIAL

The petroleum potential of the Tertiary sequence within Glacier Bay National Monument is poor within the area of outcrop on land. There are no oil or gas seeps such as those which occur abundantly throughout the coastal part of the western part of the Gulf of Alaska Tertiary province. Deformation of the older siltstones and a low organic content in the less deformed younger siltstones limits the source-rock potential. However, the reported occurrence of an oily film and petroliferous odor in sandstone at one locality near the top of the Cenotaph Volcanics (Miller and others, 1959, p. 44) suggests the possibility that at least some hydrocarbons may have been generated in the lower part of the section.

A critical factor for petroleum accumulation is the availability of adequate reservoir beds. Sandstones in all units except the uppermost part of the Yakataga Formation are commonly argillaceous and probably have low permeability and porosity. Some of the stratigraphically highest sandstones in the Yakataga Formation are good potential reservoirs, but they are stratigraphically several thousand feet above the possible source rocks and are separated from them by one or more disconformities or unconformities.

The anticline (fig. 19, section *A–A′*) is a marginal prospect as a structural trap because (1) it probably does not have structural closure; (2) potential reservoir sands in the upper parts of the Cenotaph and

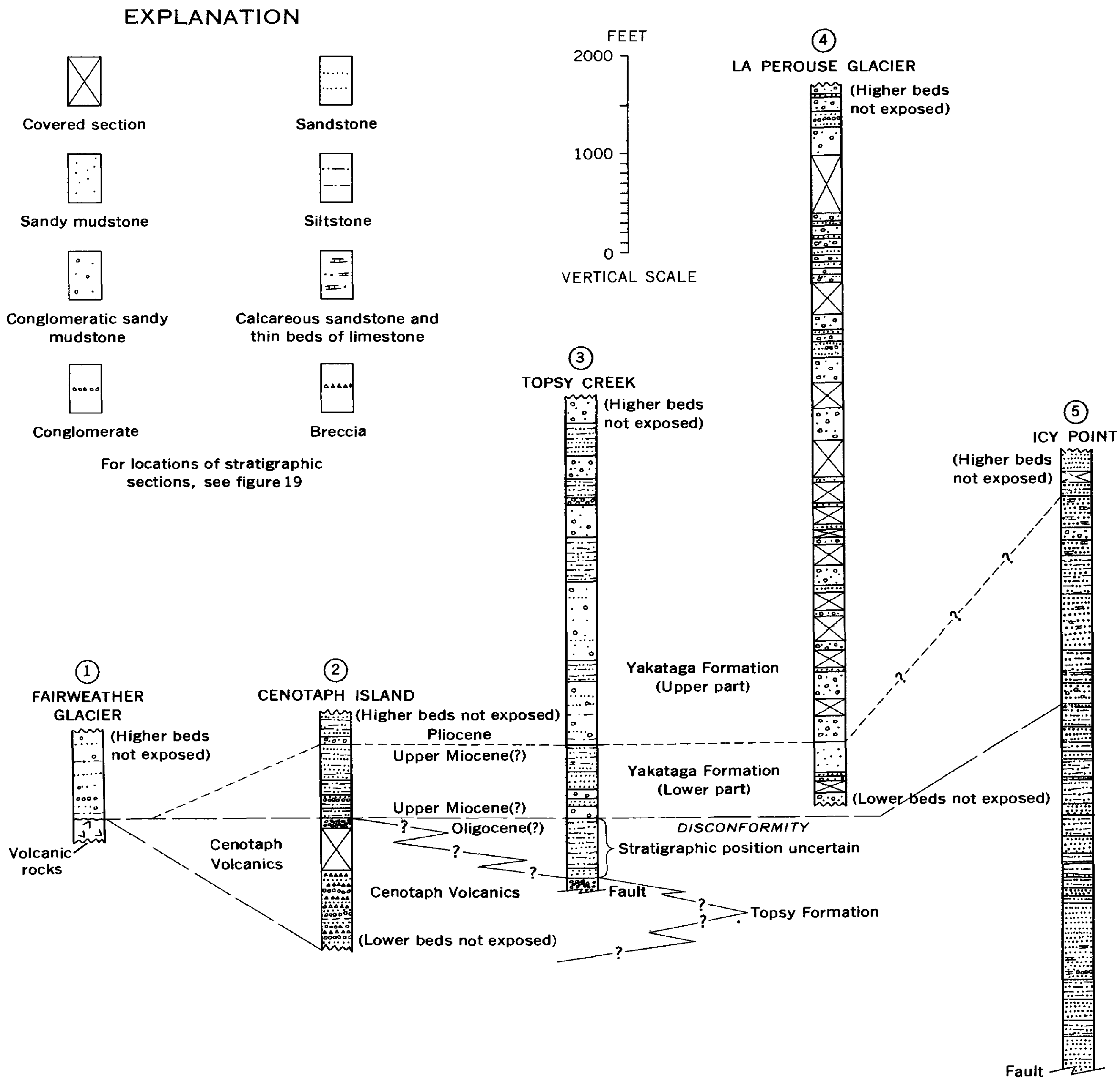


FIGURE 20.—Tentative correlation of stratigraphic sections exposed in the Lituya district.

Topsy Formations are breached by erosion; and (3) the structure is cut by an axial fault and is probably complicated by faulting at depth.

The offshore petroleum possibilities within the monument cannot yet be adequately evaluated, but there is no reason to believe that they will differ significantly from those landward. Structures may be more favorable, and the source-rock potential of the sequence may increase in a seaward direction away from the zone of intense deformation associated with the Fairweather fault. On the other hand, potential reservoir rocks are likely to become scarcer with increasing distance from shore, and drilling depths to objective horizons in the Cenotaph Volcanics and Topsy Formations could rapidly become excessive.

COAL

Reported occurrences of coal in the Glacier Bay National Monument are limited to the sequence of bedded sedimentary and volcanic rocks of Tertiary age exposed in the Lituya district and to a single specimen of float material of unknown origin found near the terminus of the Casement Glacier (E. H. Lathram, oral commun., 1966).

In the Lituya district, coal occurs as thin stringers and beds less than 8 inches thick in conglomerates of the Cenotaph Formation at both the type section on Cenotaph Island and in the valley of Coal Creek just south of Lituya Bay. Thin beds of carbonaceous siltstone and silty coal as much as 3 inches thick are also interbedded with sandstone and siltstone of the Topsy Formation at Clay Point.

The one available analysis of the coal, which was made on a grab sample collected by Don J. Miller, from Coal Creek, indicates that it has a high ash content and is probably of subbituminous rank:

Proximate analysis of coal from the Cenotaph Formation, Coal Creek

[U.S. Bureau of Mines, lab. No. F–47643]

	As received	Moisture free
Moisture	2.4	
Volatile matter	34.6	35.5
Fixed carbon	34.0	34.8
Ash	29.0	29.7
	100.0	100.0
Sulfur	.5	.5

The coal in the Lituya district has little or no commercial potential because of its low rank and its occurrence as thin discontinuous beds and stringers.

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