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GEOLOGIC REPORT NO. 17

Geology and Geochemistry of the Hollis and Twelvemile Creek Areas, Prince of Wales Island, Southeastern Alaska

By

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GEOLOGY AND GEOCHEMISTRY OF THE HOLLIS AND TWELVEMILE CREEK AREAS, PRINCE OF WALES ISLAND, SOUTHEASTERN ALASKA

by

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ABSTRACT

The Hollis map area is on the east coast of Prince of Wales Island about 40 miles west of Ketchikan. A number of small gold-bearing quartz veins have been mined in the district. Total gold production is estimated at a few hundred thousand dollars. Recent logging operations have made the area much more accessible than previously.

The central part of the map area is underlain by a sequence of graywacke, conglomeratic graywacke, banded siltstone-argillite, and black slate about 10,000 feet thick, overlain by about 2000 feet of andesite agglomerate and flows, and then by more sediments. Several black slate units form distinctive marker beds. Considerable lateral facies change is evident, with conglomerate being more abundant on the south side of the area, and the black slate units thickening northward. The sediments can be dated only as lower Paleozoic(?).

A small granodiorite stock with a narrow aureole of contact metamorphism is present east of Harris Peak, and a large granodiorite to quartz diorite pluton is present along the north side of the map area.

Bedding in the main part of the area dips 20-50° west and southwest, with a possible gentle northwest-trending anticline near the east edge of the area. In the northern part of the map area, an ill-defined zone of shearing separates this sequence from more steeply-dipping rocks similar to those in the lower part of the section. The rocks of the northern area appear to be folded into a sharp northwest-trending anticline.

The known ore deposits consist of quartz and quartz-carbonate veins containing pyrite, chalcopyrite, galena, sphalerite, gold, and silver, and are of value chiefly for their gold content. The veins are in fault zones, usually in, or along the margins of, altered dikes. The most productive veins are in or near the lowest black slate unit of the section, but others occur in a variety of rock types.

About half the stream sediment samples from the area are anomalous in zinc, with values up to 4000 ppm (0.4%). A smaller proportion of samples are anomalous in copper, lead, and molybdenum. Five anomaly groups are distinguished, three of which are in areas of known mines and prospects. The strongest anomaly group, in which samples are strongly anomalous for all four metals, is in an area with no known prospects or mines and is on the projection of a zone of shearing. Further prospecting is suggested for this area and several others.

The Twelvemile Creek area is about 10 miles south of Hollis. Pre-Devonian greenstone, schist, metagraywacke, black phyllite, and marble of the Wales group and Devonian(?) sediments and volcanics are exposed in the map area. Thin

quartz-tetrahedrite-chalcopyrite veins cut marble in one locality, and minor amounts of chalcopyrite are present in some greenstone, schist and limestone. Nine stream sediment samples are weakly to moderately anomalous in zinc, copper, lead, and/or molybdenum.

INTRODUCTION

The gold quartz deposits of the Hollis area have been the subject of many brief reports and descriptions, but the geology of the area has never been mapped. In 1964 several strong geochemical stream sediment anomalies were found in the Harris Creek and Maybeso Creek drainages by Herbert and Race (1964). As a result of this work, the authors, assisted by Kent Smith, geologically mapped the area in 1965 and did some additional geochemical sampling. The main part of the field work was done from May 16-31. Snow cover above 1500 feet made it necessary to return to the area during October 8-11 to map the high country

Thanks are due to Hollis residents Jack Cassell for generous assistance and information which greatly facilitated the work; to Everett Joins for rental of his truck; and to the U. S. Forest Service for use of their cabin at Hollis.

Previous Investigations

The Hollis area is mentioned in numerous U. S. Geological Survey reports. Brooks (1902) first described some of the deposits in the area on the basis of a three-day examination in 1901. F. E. and C. W. Wright (1908) visited the area in 1904 and 1905 and gave locations and descriptions of the prospects. They described essentially all the prospects that have been found to the present time. The annual Alaska mineral resources reports of the U. S. Geological Survey record activities from 1904 until 1931, when a gap occurred until 1939. The culmination of the early geologic mapping by the U. S. Geological Survey was the comprehensive report by Buddington and Chapin (1930) which shows all the rocks on the authors' map area, except the Granite Mountain intrusive, as Middle Devonian sediments and volcanics.

J. C. Roehm (see bibliography) in a number of reports described the prospects and development work during the period 1936 to 1947 in considerable detail. A photogeologic study of lineaments has also been published (Pillmore and McQueen, 1956). The most recent report on the area is a literature compilation supplemented by photogeology (Condon, 1961) which shows the bedded rocks of the map area as one unit of undifferentiated Devonian sediments and volcanics. Sainsbury (1961) mapped the area immediately to the north on a scale of 1:63,360, and part of his mapping is used to extend the coverage north to the Granite Mountain intrusive.

Geography

Hollis lies 40 miles west of Ketchikan. There is a protected harbor with several houses on the west shore near the old site of Hollis and several U. S. Forest Service cabins and a float at the northeast end. The population in 1965 was 3 persons. A system of logging roads extends from Hollis Bay up Harris and Maybeso valleys. The logging roads greatly facilitate travel in the area and provide many exposures of bedrock in road cuts and road metal quarries. The logged-over areas are generally more difficult for walking than unlogged areas. Unfortunately, the Forest Service has pulled up many bridges and culverts on the logging roads so that the upper areas and the more distant areas are not accessible by truck. The State plans to complete the road from Hollis to Craig, utilizing the road up the Harris River.

The map area has been about two-thirds logged. Except in the steeper areas, travel in the unlogged sections is relatively easy due to lack of unberbrush. Exposures are not abundant except on steep hillsides.

GEOLOGY

Regional Setting

The map area lies in a large region of lower Paleozoic eugeosynclinal rocks which consist mainly of andesite, andesitic graywacke, dark siltstones, and black slate and limestone. The general distribution of major rock types is known, but the structural geology has been almost completely unknown, mainly because of the small amount of detailed geologic mapping, complexity of structure, difficult access, and the lack of distinctive horizons of known age.

Sedimentary and Volcanic Rocks

Sedimentary rocks between Harris River and Maybeso Creek

A sequence of gray to green rocks, consisting of graywacke, conglomeratic graywacke, conglomerate, siltstone, and argillite, including several interlayered black slate and argillite units, is exposed on the ridge between the Harris River and Maybeso Creek (see cross section, figure 1). The thickness of this sequence is approximately 10,000 feet. It is overlain by about 2000 feet of andesite agglomerate; which in turn is overlain by clastic sediments. As far as could be determined, most of the thick clastic section is essentially monoclinal with moderate dips to the west and southwest, but locally the rocks are extremely contorted. No unconformities were noted, although disconformities and minor angular discordances could well be present.

The rocks on Cat Island are more highly sheared and foliated than the rocks of the section to the west, but seem to be interbedded with the lower part of it. Basalt flows on the shore between Cat Island and the mainland are interbedded with gray phyllite like that present in the lower part of the section. Pillow basalt was also found interbedded with rocks of unit 12 along the Maybeso Creek road. An alternative explanation is that the Cat Island rocks are considerably older than the rest of the section. Because of the lack of an obvious break at the bottom of the section, these deformed rocks are shown on the map and section as a more sheared and metamorphosed part of the same sedimentary sequence. This treatment is consistent with the fact that foliation, shearing, and slaty cleavage in the main sedimentary sequence are more prevalent near Hollis Bay and on the north side of Maybeso Creek than farther to the west and south.

The stratigraphic section is summarized in table 1. In general, the black slate and argillite bands are the only units that can be readily traced. In units 6b, 8, 10, and 12, conglomerate and pebbly graywacke are widespread along with graywacke, siltstone, and argillite, which are commonly banded.

The graywacke of the area is dark to light gray and greenish gray, containing pebbles and cobbles in some zones. Clasts are predominantly andesite in the lower units but black slate, black argillite, and white siltstone are also common, and predominate in the middle and upper units. Amphibole laths are common in the cementing material of the lower units. In many cases it is difficult to determine whether the rock is graywacke or a volcanic rock, although in a majority of exposures some bedding is visible. Graded bedding and banding from graywacke to siltstone are present in some units. In some siltstone and argillite the bedding shows as contorted thin streaky bands.

In thin section the grains consist mainly of subhedral albite, with a scattering of hornblende, actinolite, or pyroxene. Quartz grains are rare. The groundmass varies from a fine-grained feldspathic material to recrystallized mafic silt consisting of a felted mass of actinolite needles plus chlorite, epidote, and carbonate grains. Veinlets of epidote and carbonate are common. Small amounts of pyrite, magnetite, ilmenite and associated leucoxene, apatite, and sphene are commonly present. The original rock is inferred to have consisted largely of plagioclase and hornblende grains in varying amounts of fine matrix. Metamorphism of greenschist grade resulted in development of albite, epidote, calcite, chlorite, actinolite and other minerals.

Thicknesses approximate, numbers refer to map and cross section, figure

1. Conglomeratic graywacke, tan to brown, with pebbles of argillite, slate, and other rocks; some dark brown to black siltstone and argillite. 500 + feet.

2. Andesite agglomerate, flows, and flow-breccia; most andesite has phenocrysts of hornblende and/or plagioclase in aphanitic light to dark greenish-gray matrix. Basal part locally includes banded andesitic to rhyolitic tuffs. About 2000 feet.

3. Dark gray to black siltstone and argillite, locally slaty, with distinct bedding. 0-400 feet.

4. Light to medium gray graywacke and siltstone, commonly with sporadic chips of black argillite, some units thin bedded and banded, coarser units more massive. 400-1000 feet.

5. Medium gray to black argillite and siltstone, mostly siliceous, bedding usually visible; toward north includes minor graywacke in beds up to 20 feet thick. Andesite and fine-grained diorite present locally. 700-2500 feet.

6a. Upper part of unit is banded light to medium green-gray siltstone and argillite with minor graywacke, bands are one-half to two inches thick, forms resistant cliff-forming unit on north side of Harris River; in Maybeso Creek drainage contains more graywacke and is gray to greenish. 500-700 feet.

6b. Lower part of unit is medium gray graywacke in units up to 100 feet thick interlayered with light to medium gray banded siltstone and argillite plus local conglomeratic units. 1000 feet.

7. Black slaty argillite. 200-400 feet.

8. Conglomeratic graywacke and conglomerate, cobbles and pebbles include slate, argillite, andesite, and rhyolite, some units may be agglomerate; matrix includes much feldspar. In Maybeso drainage includes more graywacke and some siltstone, color gray to gray-green. 500-2000 feet.

9. Dark gray slaty argillite. 00 feet.

10. Banded greenish gray to dark gray siltstone, graywacke, a little pebble conglomerate. 000 feet.

11. Black argillite and slate, interbedded with graywacke beds up to several feet thick in places. 400 feet.

12. Greenish medium gray graywacke beds up to 100 feet thick, but generally less; local conglomerate lenses with andesitic, black slate or siltstone pebbles, locally calcareous. In two places graywacke seems to grade northward into slate. Fine-grained clastic rocks, argillite, siltstone, phyllite, are often banded and usually medium to dark gray. Brownish banded phyllite-argillite, locally has a few feet of black or green slate. Minor gray limestone. Graywacke, andesite clast graywacke conglomerate, vesicular basalt, pillow basalt. 2500 + feet.

The black argillite or slate units commonly consist of hard black siltstone layers interbedded with softer black slate. Individual beds range from 1/4 inch to several inches in thickness. Deformation has been sufficient in most places to cause foliation of the slate and small scale thrusting and boudinage of the siltstone, which commonly makes it impossible to determine bedding tops. Some very dark greenish gray graywacke layers present in the black slate units contain thin black slate or black siltstone layers. The black colors usually allow clear separation from the greenish gray to gray graywacke-siltstone-argillite units.

Along the Harris Creek road below and east of the Dawson Mine, black or dark gray slate is interbedded with graywacke. The beds show graded bedding (top up), lensing beds a few feet long, and load casts of siltstone into graywacke. These beds were probably deposited in a near shore environment.

In some exposures the graywacke grades laterally into green or black slate. Where this was seen the gradation was from graywacke northward into slate. Over a larger area the rocks seem to grade from mainly graywacke in the southern part of the map area along Harris River to mainly black slate in the north along Maybeso Creek, and the black slate units thicken northward at the expense of graywacke and siltstone. Unit 5 (fig. 1) is a good example of northward thickening of a black slate and argillite unit. A considerable proportion of black siltstone and some graywacke is present in this thickened portion.

The presence of tuffs and tuffaceous graywacke and siltstone is suspected in a number of localities, based on the angular shape of plagioclase, pyroxene, and amphibole grains, and the presence of a hard, siliceous green to gray matrix in the banded siltstone and argillite. However, no proof of pyroclastic origin was found.

The rocks of unit 1 appear less consolidated than the lower units, and could be much younger.

The source of clastic material and possibly of volcanic material apparently was south of the area, because conglomerates and possible volcanic material seem more abundant in this direction. The larger proportion of black slate in the northern part of the area indicates that a basin of restricted circulation was often present in that area and expanded southward across the area during periods of low clastic influx. The presence of conglomerate combined with the thickness of the section suggests deposition in a rapidly-subsiding basin adjacent to a tectonically active positive area, with andesitic to rhyolitic volcanoes intermittently active. The presence of argillite pebbles, in some cases flattened, may indicate some uplift and erosion of recently deposited sediments in the source area.

Andesite agglomerate (unit 2 of stratigraphic section)

Porphyritic andesite with plagioclase, pyroxene, and/or hornblende phenocrysts in a gray green aphanitic matrix makes up most of this unit. In many exposures the rock is an agglomerate or flow breccia, with fragments up to a foot or more in diameter in a matrix of very similar-appearing material. In other zones no fragmental character is evident. The andesite unit is very resistant and forms cliffs and steep slopes. Plagioclase phenocrysts are almost completely altered to greenish sericite in all four thin sections that were made of the andesite. Groundmass plagioclase is sodic oligoclase with a felty trachytic texture.

Rocks north of Maybeso Creek

The slate unit adjacent to the Granite Mountain intrusive is similar to the black slate-argillite units mapped elsewhere in the area.

Rock types present in the belt southwest of this slate include dark green graywacke, porphyritic andesite (including one vesicular zone), green phyllite, greenstone, andesite clast conglomerate, and conglomeratic graywacke, locally with a limy matrix. In the sheared zone just northeast of Maybeso Creek, these rocks are converted to green schist and greenstone schist. In general, the rocks of this area tend to be more mafic rich than rocks between the Harris River and Maybeso Creek, and a dark green color is typical in comparison to gray or gray-green colors of the central part of the map area. If these rocks correlate with those in the main part of the section, it is with units near the base of the section, possibly with those around Hollis Bay.

Age and correlation of sedimentary and volcanic rocks

Black slate just south of Granite Mountain was tentatively considered as Middle Ordovician-Lower Silurian by Sainsbury (1961) on the basis of lithologic correlations with fossil-bearing rocks about 10 miles to the north.

No fossils were found in rocks of the Hollis area, although many pieces of black slate were examined for this purpose. In many parts of the area shearing may have obliterated any traces of fossils. The rocks of unit 12 and those on Cat Island and north of Maybeso Creek are similar to those described by Sainsbury (1961), but the higher units differ from the rocks described by Sainsbury in having a much higher proportion of banded graywacke-siltstone-argillite, by a relatively low proportion of dark minerals compared to the 40% pyroxene reported in "volcanic graywacke" to the north, and by a relatively small proportion of andesite clasts in the conglomerates. However, in view of the rapid facies changes across the map area, a correlation with rocks to the north cannot be ruled out.

Until a more definite correlation can be established by fossils or geologic mapping, the rocks of the Hollis area seem best considered as lower Paleozoic(?). The thick section, relatively good exposures, and easy access recommend the area for further stratigraphic studies. No uninterrupted section approaching 10,000 feet in thickness has previously been reported on Prince of Wales Island and vicinity.

Igneous Rocks

Dikes

Dikes and sills are common in the Hollis area. Although no concerted effort was made to study them, the following types were recognized: porphyritic andesite containing plagioclase, hornblende, and/or pyroxene phenocrysts, dacite(?), diabase, porphyritic gabbro, basalt, and gray aphanitic dikes.

Compositional and textural characteristics of a few dikes examined in thin section are listed in Table 2. The porphyritic andesite dikes are most common, with the dacite(?) type being noted only in the Crackerjack-Dawson Mine area. Diabase dikes are present sparingly throughout the area. Northwesterly trends appear most common among the andesite dikes. Crosscutting relations seen in only a few places, indicate that hornblende and pyroxene andesite dikes cut plagioclase andesite dikes, diabase intrudes andesite agglomerate and probably the small granodiorite plug, and andesite dikes in the andesite agglomerate cut off small quartz veins. Sainsbury notes that diabase dikes cut the Granite Mountain intrusive. At least some of the andesite dikes are later than crumpling of the slate because they cut across small folds and crumples.

Some andesite dikes and sills are probably related to the andesite agglomerate. The dacite dikes may be related to intrusion of the Mesozoic(?) granitic stocks, although there is no compelling evidence for this.

Table 2. Characteristics of dike rocks

	5H169B	5H169A	5H93	5H65	5H91	5E82
Quartz				g, p	g, a	
Plagioclase	p, g	g	p, g	p, g	p, g	49%
% An	albite	albite	albite	albite		70
Hornblende		p		p		
Pyroxene	g					30*
Biotite						5a
Chlorite	a		a			10a
Sericite					a	
Epidote			a			
Carbonate	a		low		a†	3a
Pyrite	a	a	a	a		tr
Opaque oxides			g	g		3g
Leucoxene	a			a		
Sphene			g			
Apatite			g			
Texture of groundmass	inter-granular	sub-ophitic	sub-ophitic	cloudy altered	cloudy altered	diabasic
Color	dark blue-gray	greenish-gray		yellowish-med. gray	light gray	dark gray
Name	feldspar andesite porphyry	hornblende andesite porphyry	feldspar andesite porphyry	dacite(?)	dacite(?)	diabase
Grain size						0.2 mm

p phenocryst
g groundmass
a alteration product
* titanangite
† dolomite

5H169 A&B Roadside quarry 3/4 mile ENE of Dawson Mine. Hornblende porphyry cuts feldspar porphyry
5H93 Elev. 630, Creek at Dawson Mine
5H65 Logging road above Dawson Mine
5H91 Dawson Mine
5E82 Elev. 2000 feet, cutting andesite agglomerate above stream sediment sample 182

Granite Mountain intrusive

From the data available, this intrusive varies considerably in composition. Where sampled by Sainsbury (1961) this intrusive is quartz diorite but containing plagioclase of about An_{30}. A sample collected near the end of the logging road northeast of Hollis was determined to be granodiorite (Table 3). Twenhofel, Reed, and Gates (1949) report that gabbro and diorite form the exposures in the Flagstaff Mine area on Granite Mountain.

Cascade granodiorite

Two specimens of this small plug about a mile southwest of the Crackerjack mine have a composition of granodiorite (Table 3), but observations in the field indicate some variations. The texture is medium-grained subhedral granular. The graywacke adjacent to the intrusive is cut by aplitic and granitic dikes and is contact metamorphosed to black epidote-bearing hornfels or to rock containing epidote, hedenbergite, brown garnet, and pyrite. A dark diabase(?) dike and a mineralized quartz vein were observed to cut the granodiorite.

Glacial Deposits

On many hillside areas, bedrock is overlain by glacial till composed of local boulders and gravel "floating" in a matrix of blue to tan clay and small rock fragments. In places, the creeks flow on the till, while elsewhere they cut through it to bedrock. No doubt much of the area covered by vegetation is underlain by such material. This creates difficulties in geochemical soil sampling, tracing float, and mapping bedrock by float.

Table 3 Composition of plutonic rocks

	5H175	5E143H	5H821
Quartz	27.6	15.5	10
Plagioclase	43.5(An 45)	42.5(An 40*)	60 (An_7)
Orthoclase	9.3	21.1 (perthitic)	15 (perthitic)
Biotite	1.2		tr
Hornblende	5.9	10.0	10
Sericite	3.4	1.	
Chlorite	0.9	2.	
Calcite		1.3	tr
Epidote	2.5	4.7	
Apatite	0.6	tr	tr
Sphene	1.6	tr	1
Zircon		tr	
Leucoxene	2.2		
Opaque oxides	1.2	0.5	
Pyrite		1.	1
Texture	Subhedral granular	Subhedral granular	
Grain size	2-3 mm	1/2-3 mm	
Name	Granodiorite	Granodiorite	Altered granodiorite

*Zoned, considerable alteration to albite
5H 175 Granite Mountain intrusive near end of logging road. 500 points counted.
5E143H Cascade intrusive southwest of Crackerjack mines. 470 points counted.
5H821 Cascade intrusive southwest of Crackerjack mines. Estimate.

STRUCTURE

The area between Maybeso Creek and Harris River has a relatively simple monoclinal structure. Figure 1 shows general WSW dips but with a wide variation of individual attitudes. The outcrop pattern is consistent with a generally monoclinal structure and indicates that the variation is not due to large scale folding. Observations of graded bedding indicate that essentially all beds are right side up.

The outcrop pattern of the black slate north of the Dawson Mine is apparently the result of both folding and faulting. Attempts to trace black slate farther up the hill were unsuccessful, and the black slate extending down the hill from the ridge thins and is cut off by a fault. Roehm (1938) reports that veins in the Dawson Mine are cut off at shallow depths by a flat fault. He attributes this to a combination of thrusting subparallel to bedding and later gravity sliding of blocks. A fault trending N40W through the gap in the slate unit would also explain the abrupt appearance of the slate unit about a mile west of the Puyallup Mine, but no evidence of a fault could be found at the contact of this slate body. The details of structure in the vicinity of the Dawson Mine thus remain uncertain.

Minor folds and measurable lineations are not common but most of those observed have gentle southeasterly plunges. There is no sign of foliation in most of the graywackes and slaty cleavage is not consistently well developed in the black slate and argillite.

North of Maybeso Creek zones of shearing are present in the graywacke over an area one-half mile wide extending northwest along the north side of Maybeso Creek. Interspersed with the sheared rocks are areas of unsheared graywacke and banded siltstone. Sainsbury (1961) notes faulting, shearing and thrusting along the south contact of the Granite Mountain intrusive. The diverse attitudes of foliation along the shear zone could be an indication of wrench (strike slip) faulting. However, the apparent swing of the sheared zone south to Cat Island may be an indication that a large sinuous thrust is present. Although a major structural feature is evidently present along this zone, information is not adequate to determine the nature of the feature or its attitude.

The outcrop pattern revealed by this mapping and that of Sainsbury could indicate that an anticline exists north of Maybeso Creek with the black slate along the north edge of the map swinging south into the Harris Peak area. If so, the shearing may be located in the axial zone of the fold with origin of the shearing a result of folding. However, more detailed mapping along the north edge of the map and farther to the northwest will be required to determine the reality of the anticline and the extent of the shear zone.

Rocks on the south side of the Harris River for about two miles west of the Harris River Mine are almost entirely dark green conglomerate and graywacke, and do not appear to correlate with those on the north side of the river. An east-west fault along or just south of the river is possible.

ECONOMIC GEOLOGY

Most of the ore deposits known in the map area are gold-quartz veins which lie along a band of black slate extending from Harris River to Maybeso Creek. Mines in or near this black slate band include the Crackerjack, Puyallup, Dawson, and Harris River mines. These have been known since the early 1900's or before. In addition, there are at least two minor gold-quartz deposits (Cascade and Snowdrift) near the Harris Peak granodiorite, and a precious metal-sulfide-quartz vein in the headwaters of Maybeso Creek (Lucky Nell Mine). Minor gold-quartz deposits shown by Sainsbury (1961) and Pillmore and McQueen (1956a, 1956b) on the south slopes of Granite Mountain are shown on the map but were not visited.

No concerted effort was made to study the detailed geology of the known mines. However, because of the large amount of information scattered through reports of the U. S. Geological Survey and the Division of Mines and Minerals, the data has been summarized on the following pages, and on figures 2, 3, and 4.

Crackerjack Group

Mining and development on the Crackerjack group were underway when first described by Brooks (1902), and later descriptions have been given by Wright and Wright (1908, 1904), Roehm (1938a), and others. The following summary is based on their descriptions. The property, which includes claims referred to as the Hollis group, consists of ten claims patented in 1926 by Maurice McMicken of Seattle, (figures 1 and 2). It lies along the outcrop of the lowest black slate unit, in the drainage of Maybeso Creek. In 1938 Roehm reported eight tunnels with a total length of over 2560 feet, plus numerous open cuts and a tramway. Most of the work was apparently done before 1909. Only the two large workings at 800 and 1000 feet elevation were seen in 1965, but considerable snow was still present. Ore was treated in a five-stamp mill at the Puyallup Mine, with an average value of $15 per ton reported. The largest underground working is at about 900 feet elevation on a western branch of Crackerjack Creek, with other large workings at about 1000 and 1500 feet. A resident of Hollis was active in 1965 on a prospect located in black slate near Maybeso Creek north of the Puyallup Mine.

Mineralization on the Crackerjack claims occurs in two persistent quartz veins, 100 feet apart, which closely follow two porphyry dikes for over a mile or almost the entire length of the claim group. The veins and dikes strike about N20-30W and dip from 20 to 48° southwest, generally parallel to the bedding and foliation in the slates. Strong alteration to quartz, pyrite, calcite, chlorite, and epidote has affected the dikes adjacent to the veins. The dikes have been called gray porphyritic diorite, green porphyry, greenstone, and dacite porphyrite by various observers. The veins and dike margins show evidence of considerable shearing before and during mineralization, and in most localities the quartz is described as "banded". Previous workers have suggested that the veins of the Dawson and Harris River mine areas may be continuations of the Crackerjack veins, but our mapping indicates that structural complications are present in the intervening ground.

The quartz veins are coarsely banded and vary from 1 to 5 feet wide. They contain gold and (in order of abundance) pyrite, chalcopyrite, galena, sphalerite, and silver, with tetrahedrite and a sulf-antimony or bismuth mineral reported. Gangue includes chlorite, epidote, calcite, graphite and altered slate and dikes, along with the abundant quartz. Gold is most abundant with the sulfides, and is

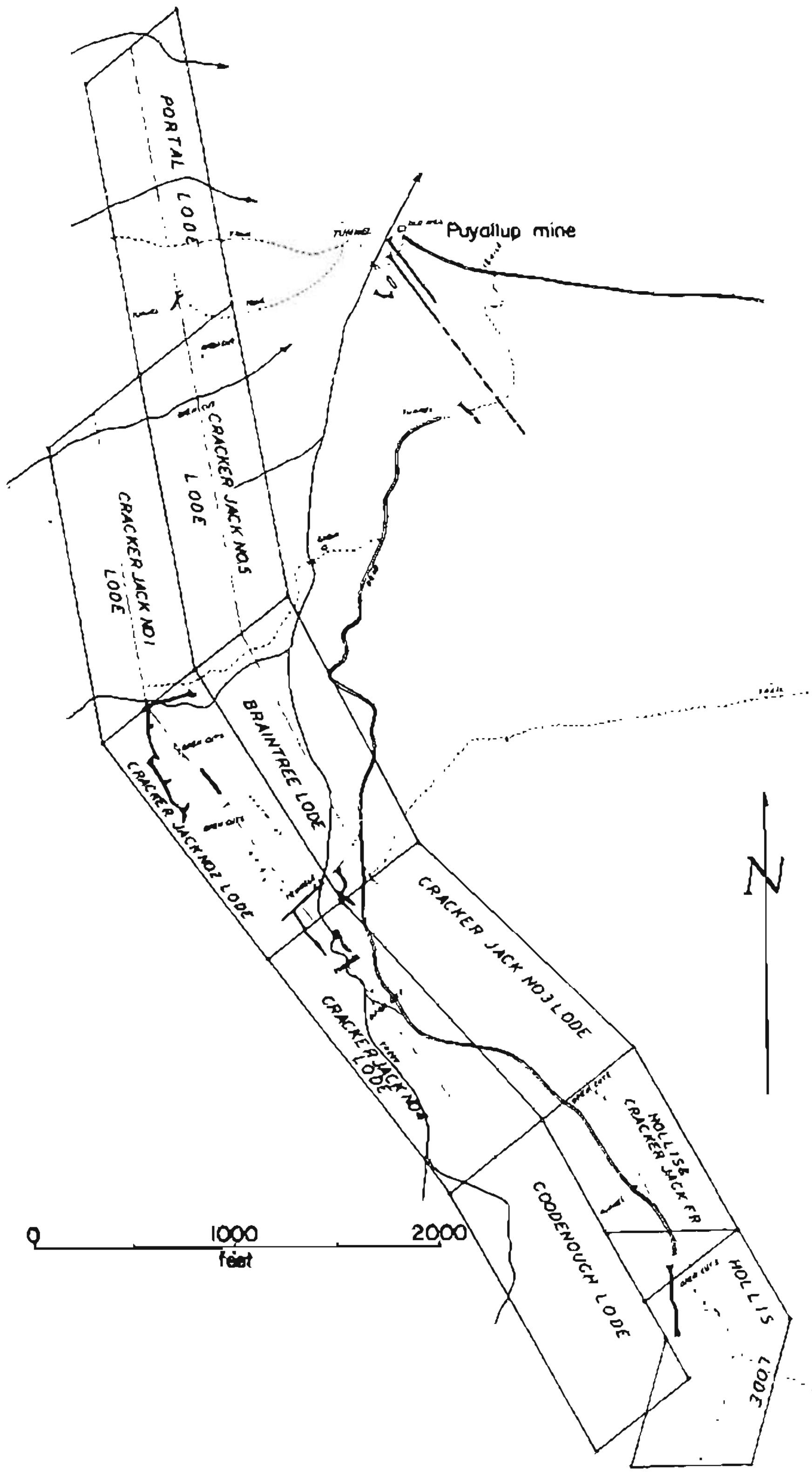


Figure 2. Crackerjack and Puyallup mine workings and claims.

concentrated in shoots along the veins. Roehm suggests that these shoots have a shallow rake to the west, and were developed along rolls or irregularities in the plane of shearing followed by the vein. He also suggests that the shearing was a thrust movement along the bedding of the slate. Relatively high grade and wide ore is also reported where the veins cut across the dikes.

Dawson Mine and Vicinity

This area has also been referred to as the Hardy claims, the George group, the Free Gold and Humbolt veins, and the northern part of the Kasaan Gold Company claims (see Harris River Mine). Wright and Wright (1908)show the Keokuk group between the above claims and the Hollis and Crackerjack groups. The Dawson property has been described by Roehm (1936, 1938b) and is mentioned in several U. S. Geological Survey Bulletins. The geology and underground workings are shown on figure 3 after Fowler.

Claims were reported in the area in 1908 by the Wrights, but apparently little work was done until 1930, when the claims were explored by the Kasaan Gold Company. In 1933 the property was leased to Dawson and Wooton, who first worked mill tailings at the Harris River Mine, and later mined the Free Gold (Dawson) vein. Dawson's operations continued at least through 1948, and a production of at least $20,000 is recorded (including the tailings). No recent work is apparent.

Both the Free Gold and Humbolt veins are very similar to the veins of the Crackerjack group, and Roehm suggests that they are probably faulted extensions of the same vein. However, the fact that the black slate is not continuous from the Crackerjack area (figure 1) casts some doubt on this correlation. Both the Free Gold and Humbolt veins occur along margins of dikes and follow the bedding and foliation in the slate. The dikes are described as light gray to bluish gray porphyritic greenstone or dacite(?) containing albite phenocrysts in an aphanitic groundmass of quartz, dolomite, greenish sericite, chlorite, and pyrite (specimen 5H91, table 2; Roehm, 1936). An olivine diabase dike is also described by Roehm about 500 feet above the Free Gold vein. The veins consist of banded quartz with small amounts of pyrite, chalcopyrite, arsenopyrite, galena, sphalerite, and gold. The latter is reported to have a fineness of 650. Ore from the Free Gold vein ran $20-30 per ton, and sampling of the Humbolt vein indicated a grade of $7-8 for the footwall portion, which was lower grade than the hanging wall in the Free Gold.

The main difference from the Crackerjack group is that the Free Gold vein strikes about N75W and dips 45-75°N, and is cut off by a low angle fault (striking N19W, dipping 26°SW) at a depth of about 40 feet below the surface. Thrust faulting and/or recent gravity sliding down the slope, with rotation during the sliding, are suggested by Roehm as an explanation of the anomalous attitude and the relatively flat faulting. Vertical cross-faults of approximately north-south trend also cut the vein and the slate. The Free Gold vein is cut off at the east and west ends by faults that are apparently of this type.

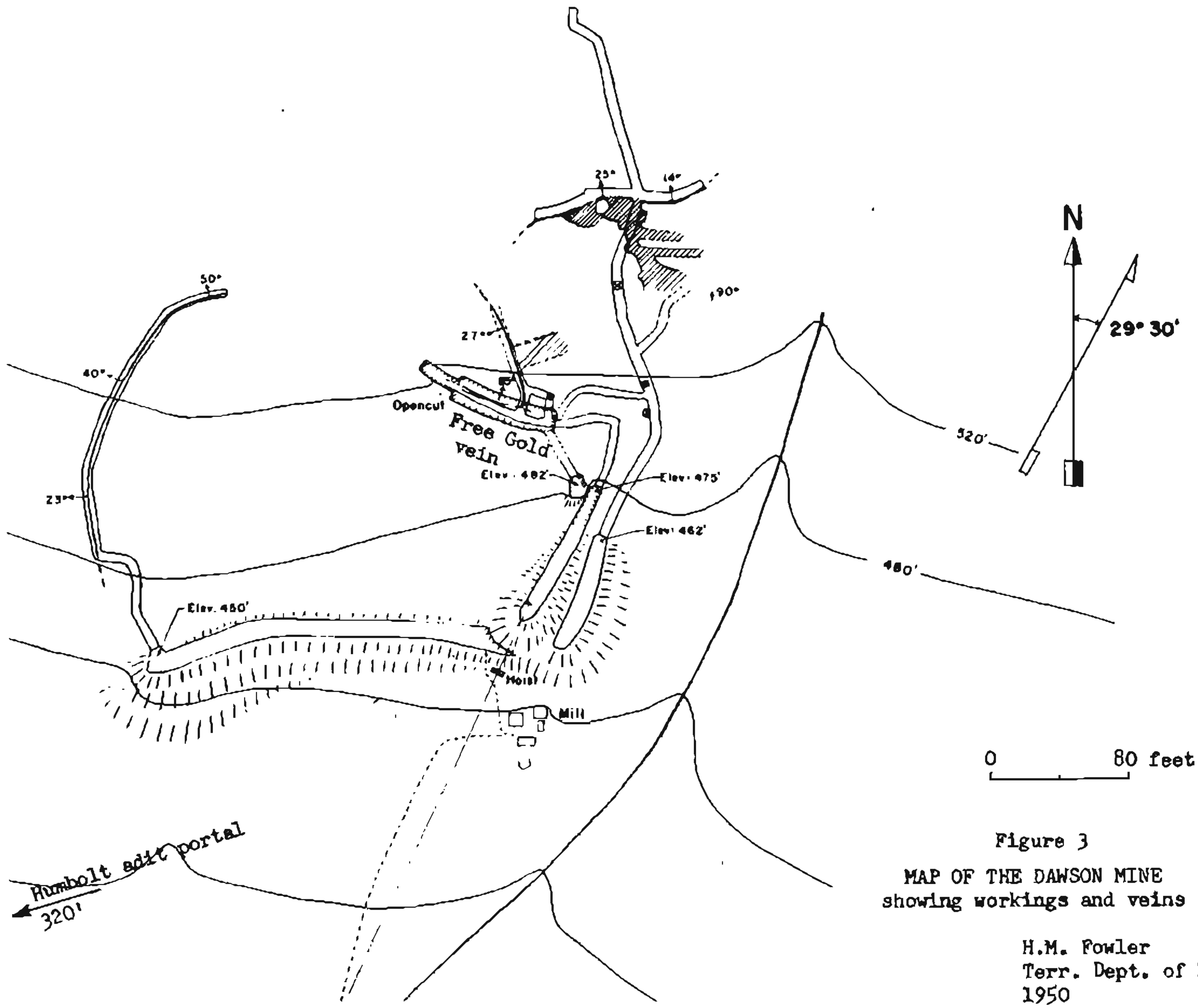


Figure 3

MAP OF THE DAWSON MINE
showing workings and veins

H.M. Fowler
Terr. Dept. of Mines
1950

Harris River Mine

This property has been known as the Julia, Rogers, Dunton, Kasaan Gold, and Harris Creek mine at various times. Available reports on the mine are by Wright (1907), Wright and Wright (1908), Mertie (1921) and Roehm (1936a, 1936b), plus numerous notes on activity in U. S. Geological Bulletins. The mine was first mentioned by Wright (1907). At this time there was a 100 foot inclined shaft on a quartz vein system exposed next to the Harris River. By 1918, when a 12 ton per day mill and a dam had been built, the incline had been extended to a length of 364 feet and workings were on several levels. Two claims were patented in 1920. In 1936 the incline was down 700 feet on a 26° slope and 2600 feet of drifts and raises had been driven. Production was recorded in 1914, 1918-21, 1923-24, and 1927-28, plus recovery from tailings by Dawson in the mid-1930's. A production of $160,000 was reported by the Kasaan Gold Company between 1920 and 1936, and a considerable proportion of the $20,000 recovered by Dawson was probably from tailings of the Harris River Mine. Eight claims were staked by residents of Hollis in 1964 and 1965 on the Harris River near the Harris River Mine.

The best description of the mine is by Mertie (1921). "The country rock at the mine is a graphitic slate, which ranges in strike from east to N. 30° W., averaging perhaps N. 30° E., and dips 12°-35° SE*. The slate is much faulted and slickensided, but the displacements are for the most part parallel with the rock structure. The highly graphitic character of the slate is particularly evident along the slickensided surfaces. Fine-grained dike rocks, in places porphyritic, also intrude the country rock, more commonly parallel with the structure of the slate than otherwise.

"The Dunton lode consists of a number of quartz stringers which form a mineralized zone in and conformable with the slate. The thickness averages about 7 feet, though increasing locally to 12 feet. The individual quartz stringers range in thickness from a few inches up to 1 or 2 feet. Much faulting has taken place parallel with the vein, crushing and slickensiding the ore and country rock but causing no apparent displacement. Dikes run parallel with the vein, more commonly on the hanging than on the footwall side, but here and there cutting across the lode. Many of these dikes are mineralized with pyrite, but they do not constitute minable ore. They have been greatly altered to secondary products, and the original petrographic character could not be inferred. The vein pitches on the average 28° SE.

"The quartz is mineralized by auriferous pyrite, gold, and a little galena. Good ore occurs in shoots, which appear to be localized in parts of the vein where the dip is lowest. The ore is best where pyrite is most abundant. Locally the slaty country rock carries some gold, particularly where it is pyritized. About 75% of the gold is free, and the concentrates consist almost wholly of pyrite. Taken as a whole, the quartz and mineralized country rock, which together form the ore, would be classed as low-grade gold ore, but only ore from the richer shoots is mined. This gives a higher-grade ore but limits the available tonnage."

* Mertie gives SE, but all other observers and the patent plat indicate a westerly dip.

Wright and Wright (1908) state that "pyrite, galena, and zinc blende, with occasional free-gold particles, constitute the metallic minerals, and quartz and calcite the gangue minerals". A small amount of lead was recovered from gold-rich concentrates obtained by gravity and flotation methods.

Puyallup Mine

This property has also been known as the Ready Bullion, the Lucky Jack, and the Hope. It was first described by Brooks (1902) and more recently has been reported on by Wright and Wright (1908), Chapin (1916), and Roehm (1936b, 1936c), plus numerous mentions in annual mining reviews of the U. S. Geological Survey. Production is reported for 1901, 1904, 1905, 1915, 1916, 1933, and 1938, with most of the production being prior to 1916. Workings consist of five tunnels (four of which are shown on figure 2), one short shaft, considerable stoping in the lower tunnels, and several open cuts. In 1965, the two lower tunnels were caved at about 50 feet and 100 feet from their portals. A trench-like zone was present above and southeast of the mine and was followed several hundred yards to another caved tunnel and large overgrown dump at about 560 feet elevation near the end of a logging road.

The country rock at the property is gray-green graywacke and conglomerate with local slate units striking NW and dipping 20-40SW. The main vein cuts across the bedding at N25W, dipping about 35°NE. The width of the vein varies from a few inches to three feet, but is generally quite narrow. It follows the hanging wall of a gray porphyritic dacite(?) dike one to two feet thick. The lowest tunnel, at about 120 foot elevation, has a length of 420 feet along the vein, with stopes up to the upper tunnel (elevation about 160 feet) for most of the first few hundred feet. The richest and widest section is reported at 300-450 feet from the portal. This second tunnel is 1100 to 1200 feet long, according to the early reports. Apparently a poorer-grade vein also occurred on the footwall of the dike. In a third tunnel (about elevation 190 feet) on the creek, a barren quartz vein striking N12W and dipping 45°E was explored for a short distance. Two other caved adits about 900 feet southeast of the main workings are reported to have worked faulted segments of the same vein.

According to Roehm (1936b) "the quartz vein is of a banded nature. The mineralization consists of free gold, pyrite, galena and a little sphalerite in a gangue of quartz, calcite, and pieces of altered dike and rock." Chalcopyrite, bornite and tellurides are reported by Brooks (1901), with assays of $20 to $1100 in gold and up to 3 ounces of silver per ton. The gold is mostly free and occurs in spots, pockets, and shoots along the vein. A sample of vein material collected in 1965 contained 0.1% copper, 0.2% lead, and 0.5% zinc by spectrographic estimate, along with 0.58 ounces of gold and 2.04 ounces of silver per ton.

Cascade and Snowdrift Mines

The exact locations of these mines are not known, but the approximate location of the Cascade is shown on figure 1.* The Snowdrift is presumably nearby. Reports by Wright and Wright (1908) and Roehm (1939) are the basis

*According to a letter in the Division of Mines and Minerals files, the Cascade mine is "at the falls on Cascade Creek".

of the following description. The workings of the Cascade Mine are at an elevation of 1300 and 1500 feet about two miles west of the Puyallup Mine by trail. This location is near the small granodiorite stock. The Snowdrift is at an elevation of 1650 feet.

The Cascade was discovered by R. Knuckolls in 1900. Two tunnels were driven in 1901, and a large quartz boulder, found just above the upper tunnel and containing considerable free gold, was broken up and shipped. J. LeBrandt and Charles Redlenloe produced minor amounts of gold in 1914 and 1915. Minor work was done in 1932, and in 1938 the mine was restaked by J. J. Matuska, who worked the veins in a small way for several years. A trail, constructed of logs in wet areas and including numerous bridges, led from the Puyallup to the valley bottom below the mine. Part of this trail was located in 1965, but the workings were not.

Wright and Wright (1908) say of the Cascade: "The vein averages two feet in width and fills an old fracture crack in an altered basic intrusive. The lower tunnel, which was driven to undercut the vein, is 300 feet in length and crosscuts intrusive rocks and dikes of several different types, but does not expose the vein. The original sedimentary rocks in this area have been profoundly altered by the intrusives, and epidotization is widespread. The vein strikes N53W and dips 70°SW, and has been followed for about 175 feet in the upper tunnel. Its metallic minerals are pyrite, zinc blende, galena, and gold, with quartz and calcite gangue. The values in this vein are very unevenly distributed and the average content is probably not high, although fragments of exceedingly rich ore have been found."

When visited by Roehm in 1939, the lower tunnel was caved at the portal and in the upper tunnel a 12 foot cross-cut in hard clastic greenstone had been driven 21 feet from the face. Most of the vein is described as mineralized shears, some of which are filled with quartz veins up to a few inches in width. A quartz lens up to two feet thick and 36 feet long is exposed near the face of the tunnel. The ore that was milled was taken from surface cuts and from a small lens of heavy sulfide ore located in the creek bed 30 feet west of the upper tunnel portal. This lens is reported to be 15 feet long, averages 8 to 10 inches wide, and contains values averaging $100 per ton. Chalcopyrite is present along with the sulfides mentioned above, according to Roehm, and pyrite penetrates the walls of the vein but is mostly confined to the walls of the shears. Samples from the quartz lens near the face of the upper tunnel contained 0.24 to 0.50 ounces of gold and 0.4 to 0.7 ounces of silver per ton.

The Snowdrift vein is reported to be two feet wide, striking N60E and dipping steeply southeast (Chapin, 1916).

A caved adit found in the vicinity of the Cascade during the mapping does not correspond to any of the adits described above. The adit is located on a steep creek bed at an elevation of 1430 feet near the north end of the Cascade granodiorite plug. (see figure 1). It is driven in granodiorite along a quartz vein one-half to three inches wide, striking N50W, and dipping 80SW. The vein contains visible galena, sphalerite, chalcopyrite and pyrite. An assay of vein material from the dump gave 0.88 ounces per ton gold, 5.88 ounces per ton silver, trace copper, 0.70% lead, and no zinc. The adit is located about 50 feet south of the granodiorite-graywacke contact and is caved eight feet from the portal.

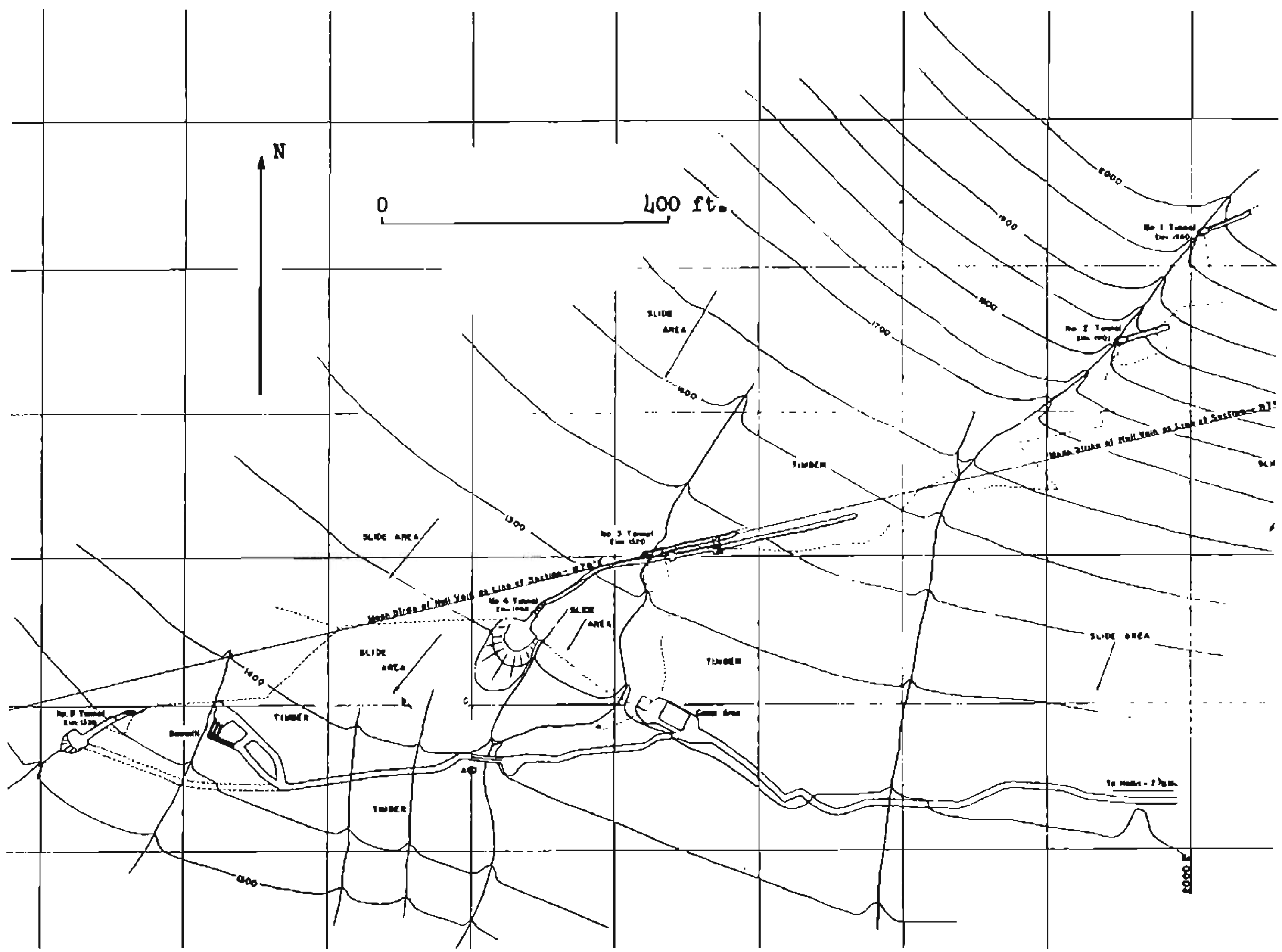


Figure 4. Lucky Nell mine workings, Hollis area (after H.M. Fowler, 1948).

Parts of the granodiorite intrusive are highly pyritized, but a sample contained only 140 parts per million copper and background contents of other metals. A sample of pyritized hornfels from the northwest contact contained 0.09% copper, trace lead, no zinc, 0.02 ounces per ton gold and no silver.

The Lucky Nell Mine and Vicinity

Workings in this area are shown on figure 4, after Fowler (1948), and were reported on by Roehm (1938d, 1947). Other claim and prospect names for this area are Flora, Nellie, Commander group, Gervis group, Summit, Red Jacket, President, Rose, and Dewdrop. The original claims were staked about 1900, with development work reported in 1904, 1905, 1912, and 1913. Ore shipments totaling 38 tons were made in 1905 and 1912. Five tunnels with total length of 740 feet have been driven on the vein. Transportation to and from the mine has always been a problem; in 1947, the road up Maybeso Valley was recorded as passable for caterpiller tractors only in dry weather despite three years of road construction. Access is potentially much better now, although the nearest logging road is still over a mile away.

Mineralization consists of pyrite, galena, sphalerite, chalcopyrite, and gold, in a gangue of quartz with minor chlorite and calcite. Bands of massive sulfides and quartz are well-developed, and sulfides apparently form more than half the vein in many places. The vein, which strikes N68E and dips 60 SE, has a thickness of one to four feet. Gouge, sheared rocks, and slickensides indicate movement along the vein, apparently at a low angle to the horizontal. The country rock is reported as "diorite porphyrite" and may correspond to the andesite agglomerate unit in the Harris Peak area. Assays and ore shipment returns indicate values of $20-$50 per ton, but it is not clear whether any copper, lead, or zinc are included in these figures. The ratio of base metals to gold is apparently higher here than at the mines near Hollis.

The Rose and Dewdrop claims were located above and to the north of the Lucky Nell group and extend across the ridge. A vein with values in gold and silver, striking N60W and dipping 85SW in basic intrusive rock, is reported.

Copper Hill or Copperplate Prospect

A network of chalcopyrite veins bearing some gold, with a N70W strike, is reported for this prospect in greenstone near the Puyallup mine (Brooks,1902, Chapin, 1918).

Burke and Lang (Burked Lang) Prospect

A quartz vein about 20 feet wide trending N70W parallel to the enclosing greenstone tuff is reported at this prospect north of Hollis (Chapin, 1918).

Monday and Stella Prospects

The Monday prospect consists of a vein and shear zone containing galena and pyrite in a gangue of quartz and vesuvianite which cuts black slate near the Granite Mountain intrusive. Values of $5-8 in gold and 15 to 40 ounces of silver are reported (Brooks, 1902).

The Stella claim is apparently in the same area. A quartz vein along the contact of a diorite-porphyrite dike in black slate has been explored by a 130 foot tunnel at an elevation of 540 feet. The vein averages three feet in width, strikes N40W and dips 80NE. Metallic minerals are pyrite, galena, and sphalerite, in a quartz and calcite gangue. Values in precious metals are low.

Mines in the Granite Mountain Area

The largest mine in this group is the Flagstaff mine, northeast of the peak of Granite Mountain just off the map. Others include the Clipper, Cutter, Buckhorn, Lucky Find, and Lucky Jim. The deposits have been discussed by Wright and Wright (1908), Twenhofel, Reed, and Gates (1949)and Sainsbury (1961). Most of these prospects consist of quartz veins in the "granite" gabbro and diorite at the Flagstaff) trending N25-55W and dipping northeast. The veins follow sheared and altered diabase dikes and contain pyrite, galena, chalcopyrite and gold. They are valuable principally for their gold content.

Discussion of Ore Deposits

The ore deposits of the area are quite similar. They have the same mineralogy, are in fault zones, and are closely associated with altered dikes, often with the quartz veins following one or both walls of the dikes. The gold is associated with pyrite, sphalerite, galena, and chalcopyrite, with the richest ore shoots in the quartz veins tending to occur in proximity to concentrations of sulfides in the veins or wall rocks. At least some, and possibly all, the dikes associated with ore have undergone strong quartz, sericite, carbonate, and epidote alteration. (Quartz and sericite are not common alteration minerals in the greenschist facies metamorphism in the district).

The veins cross cut and evidently formed later than the granitoid intrusive at Granite Mountain and east of Harris Peak. Veins follow margins of diabase dikes cutting the Granite Mountain intrusive. These diabase dikes are considered to be Tertiary by Sainsbury (1961). Some andesite dikes of the area are later than crumpling of the slate, and the mineralization is probably later than these dikes. It thus appears doubtful that the ore is related to the granitic intrusives, which are considered to be Mesozoic in age, possibly as young as Cretaceous.

GEOCHEMISTRY

Stream sediment samples were collected during both the 1964 and 1965 field seasons. Analyses of these samples are listed on Table 4 and locations are shown on figure 5. Samples prefixed "R" were collected in 1964 by W. H. Race, who used the University of Alaska heavy metal method for the field test (Mukherjee and Mark Anthony, 1957, see also Table 5). The total metal analyses are a combination of analyses by the U. S. Bureau of Mines in Juneau, A. E. Gooch and D. R. Stein of the Division of Mines and Minerals, Rocky Mountain Geochemical Laboratories, and the U. S. Geological Survey. All 1964 samples were analyzed by the U. S. Bureau of Mines and by Gooch, and the results are an average of their values, along with results from at least one other lab in most cases. These samples have been previously discussed by Herbert and Race (1964).

Samples prefixed 5C, 5E, and 5L were collected in 1965 and analyzed in the field by a modification of the method of Hawkes (1963). The heavy metal extractant was used without the five-times dilution recommended by Hawkes, and xylene was used as the organic phase (Table 5). After the samples had been dried and sieved, analyses were made in the lab using the same method but with diluted extractant. All samples collected in 1965 were analyzed also for total copper, lead, zinc, and molybdenum by Rocky Mountain Geochemical Laboratories of Salt Lake City, Utah.

Histograms of the total metal values are plotted in figure 6. Separation of background values from anomalies is not obvious on the histograms for copper and zinc. To assist in determining background, 38 rock chip samples were analyzed, with results as shown in Table 6.

Table 4. - Analyses of stream sediments, Hollis area

Map No.	Field Sample No.	Copper (ppm)	Zinc (ppm)	Lead (ppm)	Molybdenum (ppm)	Readily extractable Field (milliliters dithizone)	Readily extractable Lab (milliliters dithizone)
1	5C837	60	195	10	4		5
2	5C838	40	160	10	2		4
3	5C835	25	95	10	2		5
4	5C836	60	355	10	3		15
5	5C839	100	525	10	9		>20
6	5C833	140	>1000	85	13		9
7	5C757	100	275	25	6		8
8	R1	50	80	5	1	6	
9	R2	45	95	5	1	7	
10	R3					6	
11	R4					10	
12	R5	100	120	25	1	5	
13	R6	50	50	5	1	4	
14	R7	115	270	25	1	16	
15	5L7	50	280	15	4	6	
16	5E67	60	170	20	3	0	4
17	R8	70	150	8	14	10	
18	R9	150	450	8	16	>20	
19	R10	70	145	8	1	12	
20	R11	135	230	40	1	20	
21	R12	95	315	15	10	20	
22	R13	20	26	4	2	10	
23	R14	125	325	30	1	20	
24	R15	190	325	4	1	20	
25	5E74	80	220	15	5	8	5
26	R16	80	290	5	2	2	
27	5E735	75	210	5	4		6
28	5E144	185	320	45	12	0	15
29	5E143	220	465	45	17	16	>20
30	5E142	225	380	60	14	12	12
31	5E141	175	165	30	8	15	7
32	5L72	65	235	20	4	7	7
	R18	55	195	5	1	6	
33	5L8	80	465	10	3	9	16
34	R19	140	285	45	1	12	
35	R20	100	550	50	2	>20	
36	R21	190	220	40	2	10	
37	R22	200	590	8	1	>20	
38	5L9	80	465	10	5	8	
39	R23	180	975	40	1	>20	
40	R24	85	450	8	1	>20	

Table 4. - continued

Map No.	Field Sample No.	Copper (ppm)	Zinc (ppm)	Lead (ppm)	Molybdenum (ppm)	Readily extractable Field (milliliters dithizone)	Lab
41	5L60					>20	
42	5L10	110	1000*	20	6	>30	
43	5L11	145	>1000	20	10	>25	>4
44	5L61	95	340	10	6	3	7
45	5L62	90	290	15	4	7	15
46	5L73	340	2800*	130	40	>20	
47	R25	420	2500	50	4	4	
48	5L75	510	>1000	80	43	>20	
49	5L74	450	>1000	180	46	>20	
50	5L63	290	>1000	80	32	>20	
51	5L64	225	4000*	60	16	>20	20
52	R26	75	610	40	3	>20	
	5L12	65	>1000	20	12	25	
53	R27	195	1270	105	1	>20	
54	5L13	130	280	15	4	6	7
	R28	135	170	75	1	15	
55	R29	150	200	45	1	18	
56	R30	120	105	30	1	5	
57	R31	130	220	25	1	14	
	5L14	155	425	25	4	7	14
58	5C845	105	360	20	2		14
59	R32	100	145	30	1	7	10
	5C44°	145	410	20	4		>20
60	5L80	115	90	10	3		3
61	5L77	130	120	15	2		2
62	5L6	70	100	5	2	11	1
	R33	80	95	30	1	2	
63	5L15	100	135	5	3	7	2
64	R34	80	65	20	1	4	
	5L16	70	110	5	2	0	1
65	R35	95	80	5	1	4	
66	R36	85	80	8	1	2	
67	R37	90	95	18	1	2	
68	R38	90	95	8	8	2	
69	R39	95	310	15	1	17	
70	R40	110	150	12	1	>20	
71	R41	150	110	25	1	6	
72	R42	75	130	8	1	5	
73	R43	120	120	18	1	5	
74	R44					2	
75	R45	60	110	13	1	6	
76	R46	60	145	10	1	7	
77	R47	70	200	4	3	3	
78	R48	80	130	4		2	
79	R49	90	430	5	1	12	
80	R50	105	365	20	1	10	
81	R51	75	170	20	1	8	
82	R52	35	130	4	1	4	

Table 4. - continued

Map No.	Field Sample No.	Copper (ppm)	Zinc (ppm)	Lead (ppm)	Molybdenum (ppm)	Readily extractable Field (milliliters	Lab dithizone)
83	R53	40	85	20	2	7	
84	R54'	70	270	20	1	7	
85	5L71	30	130	15	3	0	7
86	R17	90	530	10	4	>20	
87	5L70	35	175	15	4	3	5
88	5L69					4	
89	5L68					0	
90	5L67	20	165	15	4	4	6
91	5L66	35	290	30	4	4	6
92	5L65	25	205	15	9	3	5
93	R58	125	790	40	1	>20	
94	5L5	140	750	55	9	14	
95	5L57	125	530	45	8	4	17
96	R55	40	100	20	1	>20	
97	5L58					3	
98	R56	40	115	20	1	>20	
98a	5C75	110	260	25	4	5	4
99	5L56	65	220	25	5	6	6
100	5L59	60	205	15	4	10	5
101	5L55					6	
102	R57	60	220	20	1	20	
103	5L54	80	165	10	3	6	4
104	R59	90	270	8	1	10	
105	5L53	60	175	10	3	6	4
106	R60	70	300	25	1	>20	
107	R111	50	195	10	1	15	
108	5L52	65	235	15	3	8	9
109	R110	50	310	45	1	10	
110	5L50	50	220	15	3	16	10
110a	5L49	90	465	10	3	>20	20
111	5L51	55	350	25	4	4	6
112	5L48	25	85	15	3	9	3
113	5L47	75	260	15	4	11	8
114	5L45	80	1100*	25	14		
115	5L44	290	1200*	30	17		>20
116	5L46	65	185	20	5	11	7
117	5L38	50	300	5	5	15	7
118	5L37	105	505	45	9	>25	>20
119	5L43	120	1300*	50	16		
120	5L42	85	410	20	7		>20
121	5L40	45	210	10	10		5
122	5L41	35	85	15	3		1
123	5L33	35	140	10	4	>25	4
124	5L39	80	395	20	4		8
125	5L36	50	280	10	3	9	13
126	5L32	100	410	30	4	>25	12
127°	5L35	50	55	10	4	3	2
128°	5L34	60	105	15	4	0	1
129	R109	45	815	25	2	>20	
130	R108	150	675	25	2	>20	
131	R107	75	430	20	1	>15	

Table 4. - continued

Map No.	Field Sample No.	Copper (ppm)	Zinc (ppm)	Lead (ppm)	Molybdenum (ppm)	Readily extractable Field (milliliters dithizone)	Readily extractable Lab (milliliters dithizone)
132	5L25	50	150	5	3		4
133	5L24	85	210	5	3	4	4
134	R106	65	170	10	1	10	
134a	5C64	95	250	45	5	0	2
135	R118	140	155	10	1	20	
136	R117	35	30	20	1	16	
137	R116	30	40	25	1	15	
138	R115	60	50	15	1	15	
139	R114	30	55	10	1	15	
140	R113	60	65	15	1	10	
141	R112	60	90	20	1	>22	
142	5L26	110	225	10	2	2	
143	5L27	50	125	10	2	6	3
144	5L28	60	135	10	3	4	3
145	5L31	105	130	10	3	0	2
146	5L29	60	110	10	3	3	3
147	5L30	45	105	10	4	0	2
148	R105	85	270	10	1		
149	R104	75	320	10	1	15	
150	R103	65	100	25	1	5	
151	R102	40	220	15	1	5	
152	R101					>15	
153	R100	60	265	20	1	4	
154	5L23	55	250	5	3	4	5
155	5L22	75	320	10	5	8	4
156	R99	40	95	25	1	10	
157	R98	90	360	30	1	>15	
158	R97	70	160	10	1	15	
159	R96	80	200	15	1	8	
160	R95	50	170	15	1	>15	
161	R94	180	1025	40	1	>15	
162	R93	30	280	35	1	15	
163	5L21	60	245	5	5	4	14
164	5L20	110	600	15	8	9	15
165	R92	125	885	25	1	>20	
166	R91	80	765	40	1	>20	
167	R127	40	110	25	1	20	
	5L17	60	250	10	4	5	1
168	5L19	70	175	10	3	5	4
169	5L18	50	185	5	3	4	2
170	R119	40	110	25	1	>20	
171	5L93	40	110	15	5	4	2
172	R126	65	260	25	1	>20	
173	R120	40	55	15	1	>20	
174	R121	30	130	10	1	>20	
175	R125	40	60	15	1	20	
176	R122	60	475	20	1	>20	
177	R123	30	65	10	4	>20	
178	R124	20	110	10	1	10	
179	R90	85	705	40	1	>20	

Table 4. - continued

Map No.	Field Sample No.	Copper (ppm)	Zinc (ppm)	Lead (ppm)	Molybdenum (ppm)	Readily extractable Field (milliliters dithizone)	Readily extractable Lab (milliliters dithizone)
180	R89	55	450	40	1	13	
181	R88	60	365	25	1	>20	
182	R87	135	515	60	1	15	
183	R86	55	160	30	1	>20	
184	R85	85	270	32	1	>20	
185	R84	95	665	20	1	13	
186	R83	75	200	10	1	5	
187	R82	40	170	12	1	5	
188	R81	75	175	14	1	0	
189	5L94	15	65	10	4	3	2
190	5L95	65	95	10	3	0	
191	5L96	55	95	10	3	2	2
192	5L97	50	120	5	3	2	2
193	5L98	110	135	15	5	0	2
194	5L99	70	160	15	4	6	2
195	R80	45	110	9	1	4	
196	R79	140	100	11	1	0	
197	R78	50	70	10	1	3	
198	R77	100	135	20	4	2	
199	R76	165	150	20	1	4	
200	R75	60	95	15	1	5	
201	R74	180	142	25	1	2	
202	R73	90	135	20	2	8	
203	R61	370	330	20	1	>20	
204	R62	260	320	10	1	20	
205	R63					6	
206	R64	100	180	55	1	13	
207	R65	185	550	715	5	>20	
208	R66					9	
209	R67	90	410	60	1	>20	
210	R72	80	205	12	8	6	
211	R71	210	260	30	2	15	
212	R68	240	1010	50	1	>20	
213	R69	240	235	20	4	16	
214	R70	310	120	4	13	6	

* Analysis by x-ray fluorescence
° Soil sample
> Greater than

Figure 6

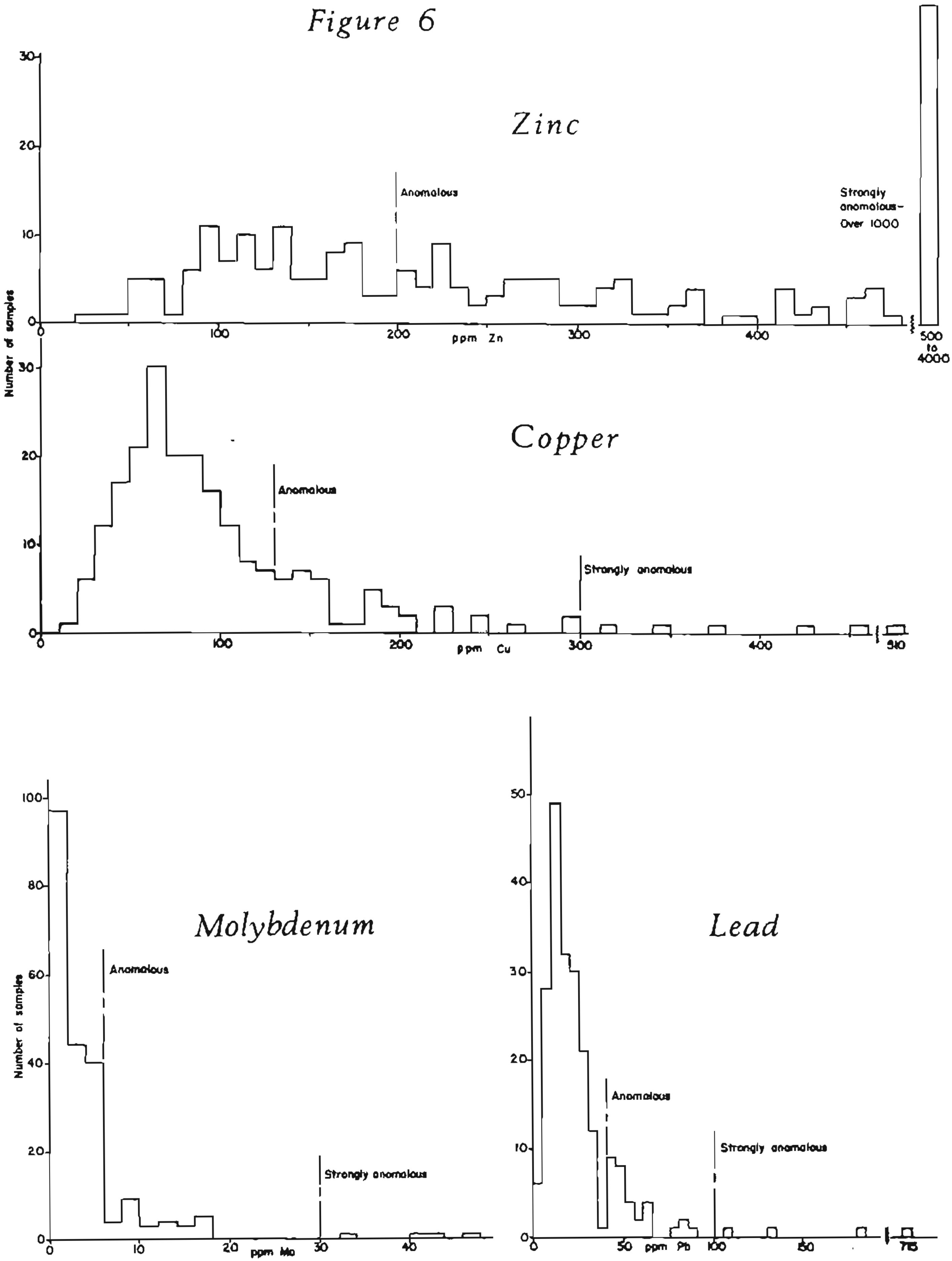

Zinc
Anomalous
Strongly anomalous– Over 1000
Number of samples
ppm Zn
500 to 4000
Copper
Anomalous
Strongly anomalous
ppm Cu
Molybdenum
Anomalous
Strongly anomalous
Number of samples
ppm Mo
Lead
Anomalous
Strongly anomalous
ppm Pb

Table 5. - Conditions for three types of readily extractable heavy metal tests used on samples from Hollis

	University of Alaska	Concentrated, Hawkes	Diluted, Hawkes
Location of test	Field	Field	Lab
Sample condition	Wet, unsieved	Wet, unsieved	Dry, sieved
Sample size	0.2 cc scoop	0.2 cc scoop	0.2 cc scoop
Extractant	NaCl solution	Conc. citrate buffer*	Diluted citrate buffer*
Organic phase	White gasoline	Xylene	Xylene
Dithizone concentration	Saturated	10 mg/l	10 mg/l
Field Sample prefix in Table 4	R	5	5
Location of analysis, Table 4	Field column	Field column	Lab column

* 200 g. ammonium citrate/liter in concentrated buffer, 40 g/l in diluted buffer.

Table 6. Total metal content (in parts per million) of rock samples from the Hollis area. Locations refer to numbers or letters on figure 5.

Black slate, argillite and siltstone

Location	Sample No.		Cu	Zn	Pb	Mo	As
At 117	5C67	Black slate	65	210	10	6	
Near 111	5C68	Black slate	65	110	10	4	
Near 110a	5C73	Black argillite	60	125	5	5	
At F	5C111	Black argillite	130	100	15	3	
At G	5C165A	Unmineralized black slate	60	620	70	21	30
At G	5C165B	Black slate with quartz veins	65	590	10	17	30
At K	5C800	Siliceous black argillite	30	45	5	7	
Near 17	5E68	Black siltstone	45	60	5	3	
Near 150	5E118	Black slaty argillite	60	250	5	10	10
At C	5E164	Black slaty argillite	80	65	<5	9	5
Near 166	5E186	Black argillite and graywacke	25	20	5	3	<5
Near 27	5E736	Black slaty siltstone	50	195	10	3	
Near 49	5E760	Fe-stained black slate	90	100	25	6	
		Average (except 5C165A and 5C165B)	64	116	8.6	5.4	

Table 6. Continued on next page

Table 6. - Continued

Location	Sample No.		Cu	Zn	Pb	Mo	As
Graywacke and gray to green siltstone-argillite							
Near 123	5C65	Banded green siltstone	90	135	15	3	
At G	5C90	Graywacke	45	115	10	4	
Near 96	5C123	Banded siltstone-graywacke	90	90	10	4	
At 105	5C199	Conglomeratic graywacke	70	90	5	3	
At E	5C203	Sheared conglomeratic graywacke	15	90	10	4	
At J	5C814	Graywacke	135	100	10	3	
At H	5C823	Banded graywacke	55	55	10	3	
At A	5C844	Graywacke	125	110	10	3	
At P	5E78	Banded siltstone	95	70	5	3	
At R	5E90	Gray argillite	10	35	5	3	
At 165	5E91	Green banded siltstone-argillite	70	160	10	3	
At Q	5E94	Dark gray graywacke	55	65	5	2	
At L	5E716	Dark graywacke	15	70	10	3	
At B	5E759	Pyritic siltstone-argillite	55	70	10	3	
		Average	66	90	8.9		3.1
Volcanic rocks and dikes							
At 6	5C834	Pyritic andesite dike	85	75	15	3	
At N	5E83	Andesite agglomerate	45	60	15	3	
At O	5E84	Andesite agglomerate	45	75	10	2	
Near 153	5E120	Andesite dike or sill	40	90	10	3	
Near 184	5E165	Andesite agglomerate	15	40	5	4	
At D	5E188	Andesite dike	50	115	20	3	
At M	5E714	Diabase	70	65	5	3	
		Average	50	73	11.4		3.0
Other rocks							
At I	5E156	Pyritized granodiorite	140	30	5	8	
Near 66	5E173	Greenstone schist	95	55	10	3	
At G	5E135	Pyrite lens in black slate	90	950	70	21	
At 8	5E136	Pyrite lens in black slate	80	110	100	13	

All analyses by Rocky Mountain Geochemical Laboratory, except Zn in sample 5E135 by M. Mitchell, Alaska Division of Mines and Minerals, using X-ray fluorescence.

Table 7. - Content of arsenic in stream sediments

Map No.	Field No.	Arsenic (ppm)
49	5L74	115
110a	5L49	25
115	5L44	90
117	5L38	10
121	5L40	20
123	5L33	20

Analyses by Rocky Mountain Geochemical Labs

Using these data, plus log cumulative distribution plots (Tennant and White, 1959) and information from the literature, threshold values were selected as follows: copper 130 ppm, zinc 200 ppm, lead 40 ppm and molybdenum 6 ppm. A sample is arbitrarily considered strongly anomalous if copper exceeds 300 ppm, zinc exceeds 1000 ppm, lead exceeds 100 ppm, or molybdenum exceeds 30 ppm. The Hollis area is clearly unusual in the large proportion of anomalous samples; for instance, using the above threshold values, over half the samples are anomalous in zinc, about 15% are anomalous in copper, and/or lead, and about 12% are anomalous in molybdenum. The large proportion of relatively high values could also indicate a high background for the district, but in view of the relatively normal base metal content in most rock samples, and the fact that other parts of southeastern Alaska show normal background, the writers have elected to consider the high values as anomalous. The wide extent of mineralization in the district may be an indication that it contains one or more commercial ore bodies.

Because of the widespread anomalies, only selected groups of anomalous samples will be discussed here. These five groups of anomalies are outlined in figure 5.

Anomaly Group 1

Anomaly group 1 lies along the trend of the slate unit with which the Puyallup, Crackerjack, Dawson, and Harris River mines are associated. Stream sediments in this group are mainly anomalous in zinc, with a few lead and molybdenum anomalies. As noted under economic geology, ore from the mines in this zone was valuable for its gold content, but pyrite, galena, chalcopyrite, and sphalerite are noted to occur in the veins. An analysis of apparently unmineralized black slate about 200 feet from the Humbolt Mine (Sample 5C165A, Table 6) contained 620 ppm zinc, 70 ppm lead,and 21 ppm molybdenum, all much greater than background, indicating that the rock itself at least locally contains anomalous amounts of either introduced or syngenetic base metal. Lenses of pyrite, containing anomalous amounts of heavy metals, were found in black slate at two localities, one in a logging road quarry on the south side of the Harris River about 2-1/2 miles above the Harris River Mine, and the other, a piece of slate road material from the road about a mile west of the Dawson Mine. In both cases the evidence suggests the pyrite lenses are most likely syngenetic, possibly with some recrystallization. The analyses (samples 5E135 and 136) show strongly anomalous zinc, lead, and molybdenum in one sample and lead and molybdenum in the other. The evidence is thus not clear as to whether the anomalies of group 1 are caused by base metals introduced as veins into the black slate, by local syngenetic concentrations of base metals in pyrite lenses or by some combination of these. Although additional veins are probably present in this zone, prospecting of this area has probably been thorough enough that no new deposits appreciably larger than the known deposits will be found.

Anomaly Group 2

Samples in this anomaly group are characterized by moderate anomalies in copper, zinc, lead, and molybdenum. They occur just below the reported location of the Cascade mine, and in the vicinity of the small granodiorite intrusive. Soil and vegetation conceal much of the bedrock up to about 2000 feet in elevation. Pyritization and silicification characterize the intrusive and parts of its contact zone. As noted under economic geology, copper, lead, and zinc sulfides are present in prospects in this area. A lack of extensive black slate distinguishes the mineralization of this area from the area of anomaly group 1. The presence of disseminated pyrite in the granodiorite suggests the possibility of ore bodies differing from the vein type that has been mined to date in the district. Additional prospecting and geochemical sampling in this vicinity seems warranted.

Anomaly Group 3

This area contains the strongest anomalies found in the area. Samples are very strongly anomalous in zinc, and most are moderately to strongly anomalous in copper, lead, and molybdenum. Zinc values up to 4000 ppm (0.4%) are found in the stream sediments. No prospects are known in the area, although a zone about 100 feet wide near sample 7 contained numerous lenses of pyrite and quartz and occasional thin veins containing pyrrhotite, chalcopyrite, and galena in a quartz-carbonate gangue. No copper, lead, zinc, molybdenum, gold or silver were detected in the one sample of a pyrite lens analyzed. This anomalous area lies within or near the projection of the shear zone identified farther east on the north side of Maybeso Creek. Black slate and argillite crop out in much of the area, but mapping is incomplete, and some gray siltstone and graywacke are known to be present within the black slate.

Further exploration by prospecting, geologic mapping, and geochemical soil sampling is strongly recommended for this area. It may contain a base metal sulfide ore body, possibly with important gold values.

Anomaly Group 4

These moderate to strong anomalies in copper, zinc, and lead come from the vicinity of the Lucky Nell mine. The strong anomalies from the hillside southwest of the Lucky Nell suggest that mineralization may be more extensive in that direction than previously recognized. Access to this area was difficult in the past, but is now much better with the construction of the logging roads. This area deserves further prospecting.

Anomaly Group 5

Samples in this area are moderately anomalous in copper and zinc, with one lead and one molybdenum anomaly. No prospects are known in the vicinity. According to Condon (1961) a large intrusive, possibly gabbroic, is present in the area just to the north. Because of inaccessibility and elevation, it is likely that prospecting has not been very thorough. Prospecting and further stream sediment sampling are justified in this area.

Other Anomalies

Mapping did not disclose any sources of the remaining widespread anomalies, which are mainly in zinc. According to the Forest Service, ammonium sulfate has been spread in some logged areas, but it does not appear likely that this substance would contain appreciable base metals. The anomalies are apparently coming either from small but widespread veins that are not well exposed, or the metal is present in the rocks in a form that is not easily recognized. Sphalerite could go unrecognized, or could be leached from outcrops, but it is surprising that none of the rock samples contained anomalous amounts if the metal is widely distributed. In summary, the anomalies seem real and of natural origin, but their source is unknown.

Readily Extractable Heavy Metal Content

In a general way, the anomalous areas shown by the total metal values are also detected by the field methods for readily (cold) extractable metal. Unfortunately, because three different methods for readily extractable metal have been used, no complete comparison is possible (see Table 5).

Because the readily extractable methods are more sensitive to zinc than to lead or copper, and because zinc is the most strongly anomalous metal in the district, the readily extractable results should be dependent mainly on the zinc content. A plot of total zinc content against readily extractable metal using the diluted Hawkes extractant on sieved samples shows a general correlation of the two measurements, but with considerable scatter. Most of the scatter on this plot is presumably due to the variable proportion of the total metal that is readily extractable, plus some scatter caused by readily extractable lead and copper. Calibration of the Hawkes method shows that for the 0.1 gram samples used, one milliliter of dithizone solution is equivalent to about two parts per million of zinc, and about five parts per million of lead and copper. In most of the samples the readily extractable metal (as zinc) amounts to between three and ten percent of the total zinc.

Similar plots for readily extractable base metal using data from the other two methods (concentrated Hawkes extractant and University of Alaska method) also show a statistical correlation with total zinc, but with much more scatter. For the University of Alaska method a high proportion of very high readily extractable values were found for samples with low total zinc (and lead and copper) contents.

The differences between the readily extractable values for concentrated extractant (measured in the field) and the values for diluted extractant (measured on sieved samples in the lab) are probably due to the following factors:

1. The readily extractable metal is usually higher in the -80 mesh fraction, so the values for sieved samples would be expected to be higher than the unsieved samples.

2. Drying the sample may have strengthened the bonding of some base metals so they are no longer available to the extractant.

3. The higher content of ions in the concentrated extractant may release more heavy metal by base exchange processes.

4. The pH of the concentrated and dilute extractants may differ slightly, so the extent of extraction of base metals into the organic phase will differ slightly.

5. Errors may have been made in the field tests, or there were differences in determining the end point of the reaction.

Probably factors 1, 2 and 5 are the main sources of the differences.

For the University of Alaska method, additional factors causing a lack of correlation with the total zinc content are:

1. The amount of dithizone soluble in white gasoline, and the rate of solution of the dithizone in gasoline, are quite sensitive to temperature, so that different batches of dithizone solution tend to differ in strength.

2. The pH is not buffered, so the heavy metal extraction may vary in rate and extent. This is not likely to be a serious problem with most stream sediments, but may be with soils.

The diluted Hawkes extractant was not tested on the unsieved samples in the field, but the results seem to show that in the Hollis area this field method will detect most of the anomalies found by the total metal analyses, and will produce a minimum number of spurious anomalies.

Arsenic

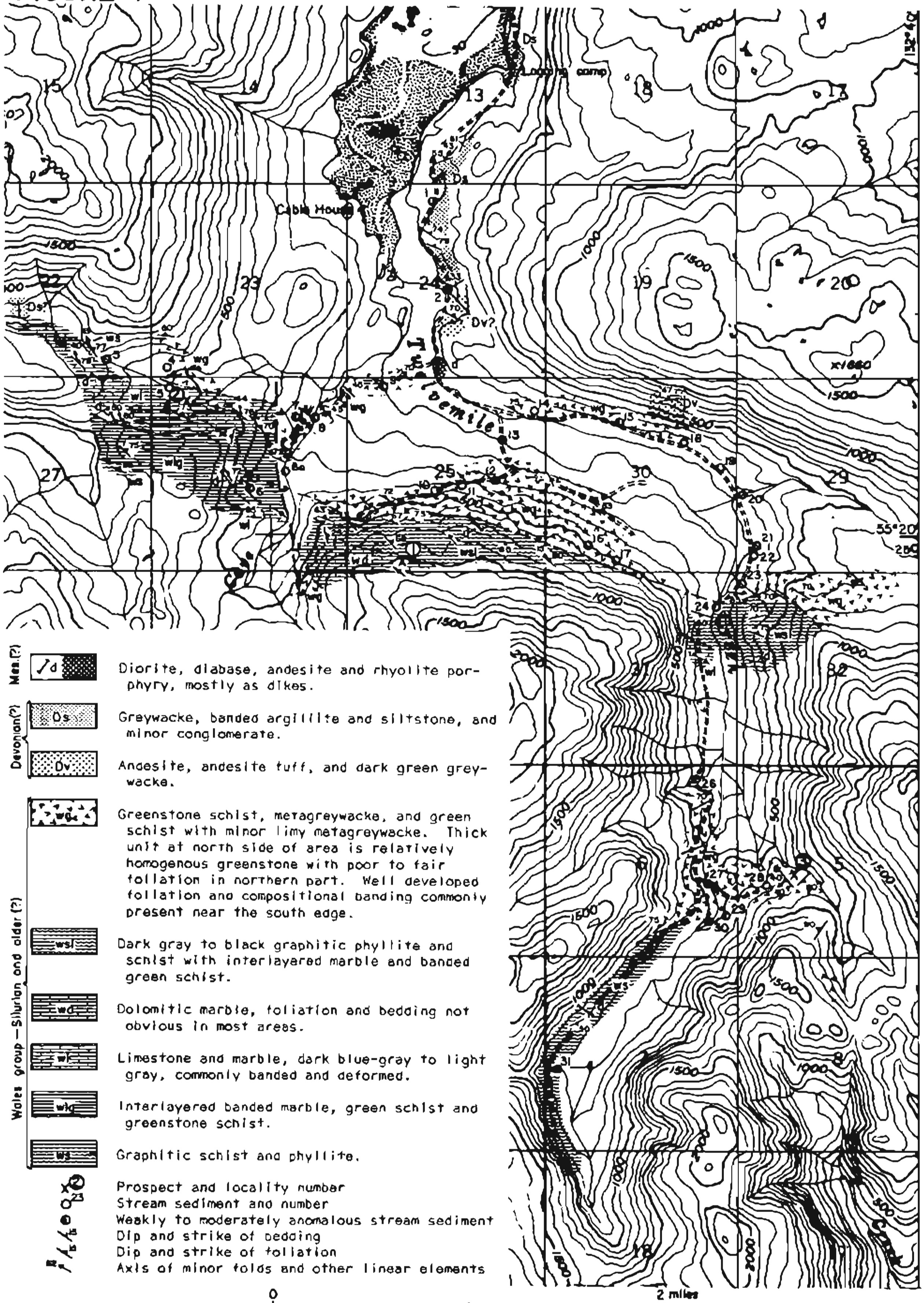
In other regions, arsenic has been found useful as a pathfinder element for gold deposits. Arsenopyrite is present at the Dawson Mine. In order to test the applicability of arsenic analyses in the Hollis area, six stream sediments and five rock samples were analyzed for arsenic (Tables 6 and 7). The analyses of black slate away from mineralization (samples 5E18, 5E164, and 5E186 in Table 6) indicate a background of 5-10 ppm, in approximate agreement with data in the literature. Compared to this, slate near the Dawson Mine (samples 5E165A and B, Table 6) and several of the stream sediment samples from anomaly groups 1 and 3 (Table 7) are distinctly to strongly anomalous. Sample 49, from the strongest part of anomaly group 3, is the most strongly anomalous, suggesting that more gold may be present in this area than at the known mines.

TWELVEMILE CREEK AREA

Four days were spent in geological mapping by a three-man party at the head of Twelvemile Arm about ten miles south of Hollis. This work was done to follow up weak to moderate geochemical anomalies and occurrences of chalcopyrite reported by Herbert and Race (1964). Most of the mapping was done along logging roads, but a few traverses off the roads were made.

The rocks of the area are summarized and described in Figure 7. Metamorphic rocks of the Wales Group (Condon, 1961) are present in the southern part of the area. Condon gives the age of these rocks as "probably pre-Ordovician to Devonian". Homogeneous greenstone and graywacke of the Wales group, with poor to fair foliation, are exposed along the east-west portion of Twelvemile Creek valley. Foliation and compositional banding becomes more obvious toward the south edge of this unit. The marble, banded green schist, and black phyllite and schist to the south are mostly thinly interlayered, highly folded and sheared. Individual beds typically do not persist along strike because of close folding and shearing out of fold limbs. The majority of the Wales group, including much of the greenstone schist, is believed to be of sedimentary origin. This conclusion is based on the presence of marble and phyllite interlayered with the greenschist, and apparent sedimentary textures. However, some greenstone schist contains streaked amygdules and appears to be of igneous origin. Other massive homogeneous greenstone may also be of igneous origin.

FIGURE 7



GEOLOGICAL MAP OF TWELVEMILE CREEK AREA

Younger unfoliated or weakly foliated graywacke, siltstone, argillite, and slate are exposed north of the Wales group. These rocks are similar to the rocks west of Hollis. Unfoliated andesite probably belonging to this younger group of rocks is exposed at one locality north of Twelvemile Creek, and appears to be in fault contact with greenstone schist of the Wales group. Farther west, dark graywacke lies between the Wales group and the lighter-colored sediments farther north.

Dikes of diabase, andesite, and diorite cut the Wales group in various places. These dikes are unfoliated except locally along their margins, and are apparently later than the major deformation of the Wales group. A large diorite pluton is shown by Condon (1961) immediately northwest of the map area. A few small patches of diorite probably related to this mass were noted in the most northwesterly exposures on the map, and a poorly exposed mass of diorite is present at the intersection of the Cave Creek and Twelvemile Creek roads.

The Wales group has been strongly folded and deformed along axes plunging northwesterly at a shallow angle. A northerly fault is postulated as the simplest explanation for the apparent discontinuity of rock units across Cave Creek, but complicated folding combined with shearing out of some units is an alternative explanation. In at least one location, the contact of the Wales group with the younger volcanics and sediments to the north is a fault with an approximately east-west trend.

Two old prospects were examined during the work, and traces of chalcopyrite were observed in a number of places. At locality 1 (Figure 7), a series of discontinuous quartz veins trending N10E and dipping 80°NW contains small amounts of chalcopyrite and tetrahedrite-tennantite. A sample of selected vein material contained 0.06 ounces per ton gold and 8.64 ounces per ton silver. Some pyrite is present in and near the veins. The country rock is massive light gray dolomite. These showings have been prospected by an adit 110 feet long and by several pits. It is likely that this is the Dolly Varden deposit described by Wright and Wright (1908, p. 162). The exposed mineralization appears too spotty to be of interest by itself.

At locality 2, an 18-foot adit and an 8-foot winze were driven on a calcite vein with no obvious sulfide mineralization. The country rock at this prospect is marble. The loggers mentioned other pits and adits in this vicinity, but apparently none are of any size. The Marble Heart lead prospect mentioned by Brooks (1902) lies a short distance south of the map area and was not visited by the writers.

At locality 3, chalcopyrite occurs in a planar quartz vein about one inch thick. The rock at this point is strongly deformed amygdaloidal lava, with ptygmatically-folded quartz-calcite veins. The undeformed quartz-chalcopyrite vein is evidently later than the major deformation. A short distance west of locality 3, Herbert and Race (1964) reported chalcopyrite in limestone and obtained an assay of 0.3% copper on a sample of the mineralization. Traces of chalcopyrite were noted in a quartz vein cutting greenstone near the extreme northeast corner of the mapped area. Narrow zones of disseminated pyrite in calcareous greenstone, in dikes, and adjacent to small quartz veins are present at several places in the western part of the area.

Table 8. Analyses of stream sediment samples, Twelvemile Creek area
All analyses in ppm except field test in milliliters of dithizone solution.

Map No.	Sample No.	Cu	Zn	Pb	Mo	Field test
1	R8	40	115	0	4	4
2	R9	45	100	0	0	6
3	5E14	80	95	10	2	3
4	5C41	30	100	15	3	3 (3*)
5	5C42	80	120	10	3	14 (11*)
6	5E32	50	185	35	5	
6a	R13	45	145	5	5	6
7	(R12	40	325	20	0	13
	(5E35	55	160	25	3	8*
8	(R11	50	190	20	4	8
	(5E36	55	120	15	4	3*
9	R10	30	140	0	6	>20
10	R14	45	90	0	0	9
11	R15	65	130	10	0	6
12	R16	35	90	0	0	9
13	5E66	55	140	15	4	3 (6*)
14	5E62	25	80	10	2	10 (1*)
15	R19	120	115	0	0	6
16	R17	100	145	20	0	10
17	R18	90	140	5	4	>20
18	R20	60	120	0	0	4
19	R21	25	85	0	4	7
20	R22	20	60	5	0	10
21	R23	50	150	10	4	10
22	R24	70	120	10	0	6
23	R25	90	145	5	5	3
24	R27	25	130	0	0	10
25	R26	80	100	5	0	
26	R28	70	125	5	7	10
27	(R29	75	150	20	0	18
	(5L2	40	220	10	5	0*
28	R32	95	130	0	4	17
29	R31	110	225	15	4	20
30	R30	70	275	10	0	25
31	5L1	70	380	10	10	7 (9*)

* Analyzed after drying and sieving

Samples prefixed 5L, 5E and 5C analyzed by Rocky Mountain Geochemical Laboratories. Analyses of samples prefixed R from Herbert and Race (1964).

Specular hematite-coated fractures are present sporadically throughout the area, especially in and near marble.

Table 8 lists the geochemical data on stream sediments, including samples previously reported by Herbert and Race (1964). Zinc is moderately anomalous in the southeastern part of the map area (samples 27, 29, 30, 31). Weak to moderate lead anomalies have been detected in tributaries to Cave Creek (6, 7, 8) and several samples are slightly anomalous in molybdenum (9, 26, 31) and copper (15, 16. 29).

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