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STRATIFORM MASSIVE SULFIDE DEPOSITS OF THE MT. HENRY CLAY AREA, SOUTHEAST ALASKA

by Jan C. Still, Alaska Field Operations Center, Juneau, Alaska

* Open File Report 118-84

UNITED STATES DEPARTMENT OF THE INTERIOR

William P. Clark, Secretary

BUREAU OF MINES

Robert C. Horton, Director

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THIS IS A DRAFT REPORT
NOT CHECKED, CORRECTED, OR EDITED
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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cu ft	-	cubic foot
ft	-	foot
in	-	inch
lb	-	pound
oz/ton	-	ounces per ton
%	-	percent
ppm	-	parts per million

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CONTENTS

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CONTENTS--Continued

ILLUSTRATIONS

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By Jan C. Still[1]

ABSTRACT

The Bureau of Mines in 1983 examined the Skagway B-4 Quadrangle in southeast Alaska for volcanic host rocks similar to those that host the stratiform world class Windy Craggy copper-cobalt-gold deposit located across the U.S.-Canadian border 50 miles to the northwest. Such rocks were found between the Jarvis and Boundary Glaciers in what is now called the Mt. Henry Clay area. This area was mapped and investigated for etratiform deposits similar to the Windy Craggy deposit. Investigations indicate the Mt. Henry Clay area massive sulfide occurrences are stratiform, have a similar mineralogy, and are in a geologic setting similar to that of the Windy Craggy deposit. However, the Windy Craggy ore zone consists predominately of pyrrhotite- pyrite-chalcopyrite while the occurrences in the Mt. Henry Clay area consist predominately of barite-sphalerite-pyrite. During 1983 the Jarvis Glacier occurrences which contain small amounts of cobalt were discovered in the area by Bureau personnel; ALYU mining personnel discovered the important Mt. Henry Clay zinc-copper-silver-gold deposit. Investigations indicate that the Mt. Henry Clay area is highly mineralized and a target for the discovery of stratiform massive sulfide deposits.

INTRODUCTION

The investigation of the Mt. Henry Clay area near the city of Haines in southeast Alaska (fig. 1) for stratiform massive sulfide deposits started in 1982 as part of the Bureau of Mines critical and strategic minerals program. To characterize mineralization that might occur within the Mt. Henry Clay area the world class Windy Craggy copper-cobalt-gold deposit was briefly examined. This deposit is located 50 miles northwest of the Mt. Henry Clay area in British Columbia. Figure 2 shows the extent of the Mt. Henry Clay area while figure 3 shows the location of the Windy Craggy deposit in British Columbia. For the purpose of this report, the Mt. Henry Clay area is roughly defined as that area east of the British Columbia-Alaska border between Jarvis and Boundary Glaciers and extending to the ridge separating Glacier Creek from Porcupine Creek.

This investigation started in 1982 when John Gammon of Falconbridge, Limited, operator of the Windy Craggy property, offered Bureau personnel an opportunity to examine the deposit. A brief examination and study of the area geology revealed the potential for similar host rocks on the Aleskan side of the border in what is now called the Mt. Henry Clay area. In the spring of 1983, R.B. Campbell (1)[2] of the Geological Survey of Canada (GSC) published a 1:250,000 scale geology map that covered the area between

[1] Mining engineer, Alaska Field Operations Center, Bureau of Mines, Juneau, Alaska.

[2] Underlined numbers in parentheses refer to items in the list of references at the end of this report.

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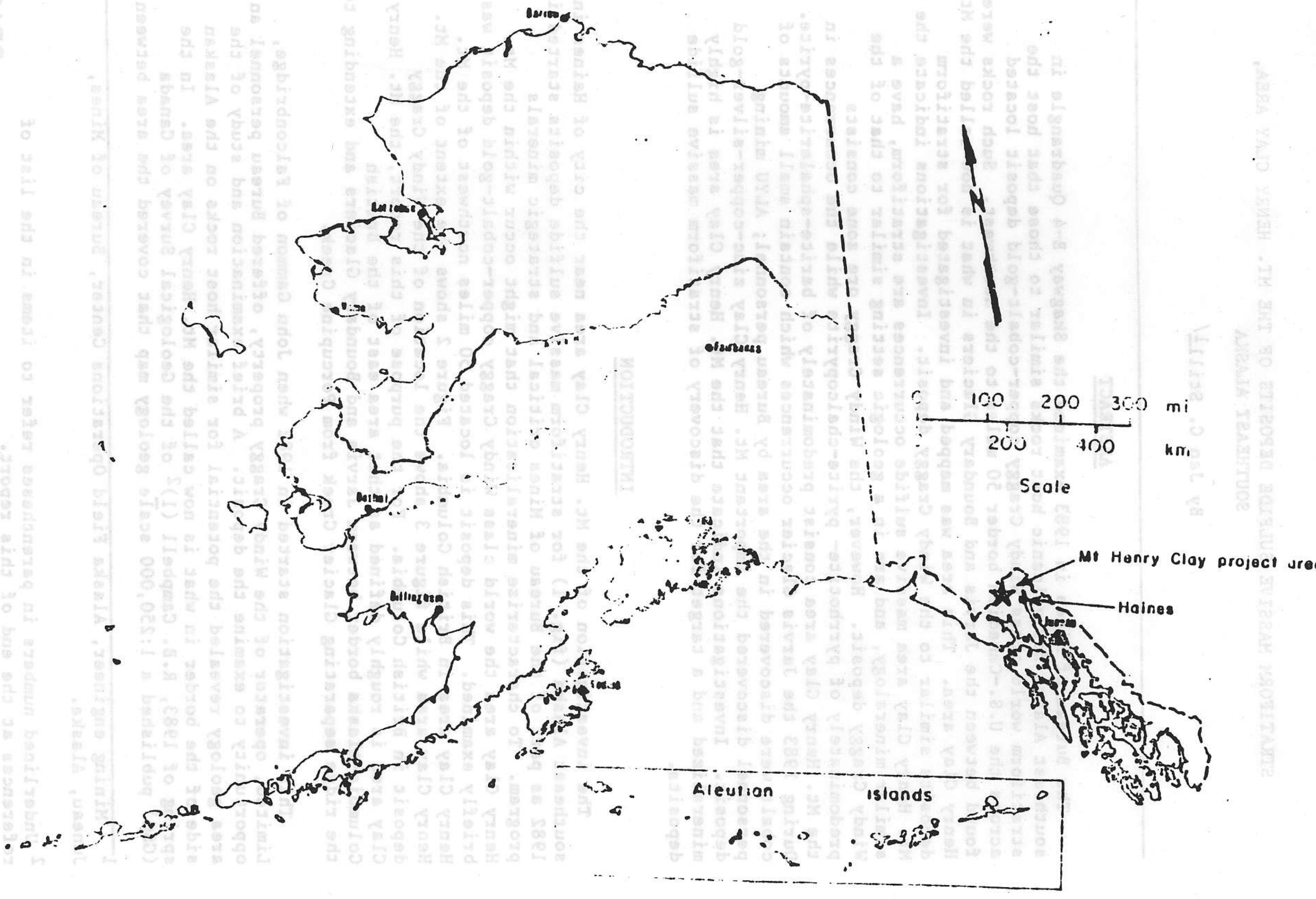

Figure 1.- Location of project area.

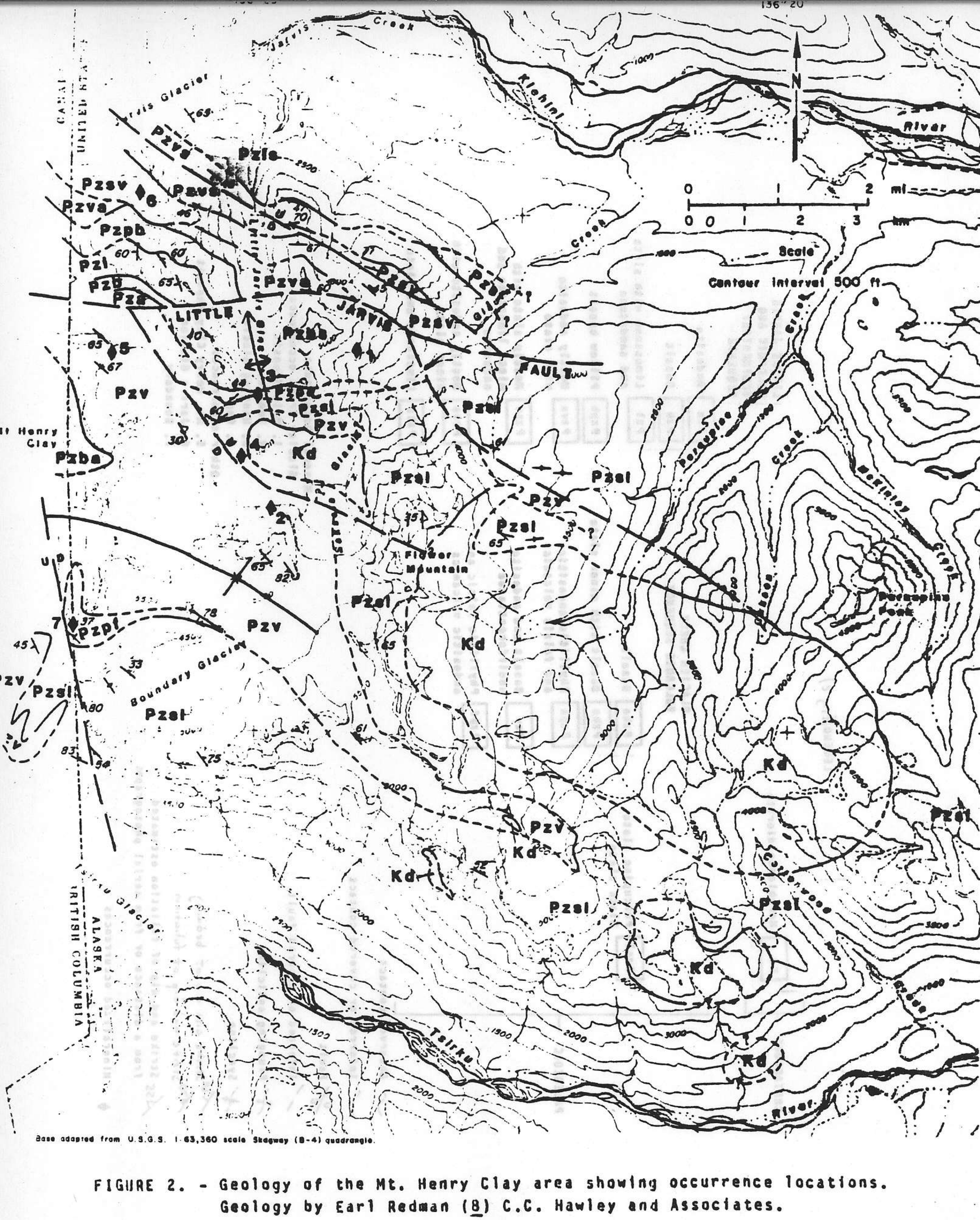

FIGURE 2. - Geology of the Mt. Henry Clay area showing occurrence locations. Geology by Earl Redman (8) C.C. Hawley and Associates.

LEGEND (fig 2)

CRETACEOUS

Kd Hornblende diorite

PALEOZOIC

Pzsl Porcupine slate
Black slate

GLACIER CREEK VOLCANIC SEQUENCE

Pzba Basalt

Pzbs Basalt with minor slate

Pzpa Phyllitic andesitic and felsic volcanics

Pzv Basalt and andesite undifferentiated

Pzpf Phyllitic felsic and andesitic volcanics

LITTLE JARVIS VOLCANIC AND SEDIMENTARY SEQUENCE

Pza Andesite

Pzb Basalt

Pzl Limestone with slate and sandstone

Pzpb Pillow basalt

Pzva Mostly andesite with slate

Pzsv Mostly slate with minor limestone and andesite

Pzvs Mostly andesite with minor slate

Pzls Limestone and slate

Observed contact

Inferred or covered contact

U/D Fault

Inferred or covered fault

Plunging anticline

Syncline

60 Strike and dip of bedding

70 Strike and dip of foliation

55 Strike and dip of foliation estimated from a distance or from aerial photographs

Mineralized occurrences

Mineral Occurrence
Glacier Creek occurrences
1. Main deposit
2. Nunatak
3. Hanging Glacier
4. Cap
Other occurrences
5. Mt. Henry Clay deposit
6. Jarvis Glacier
7. Boundary

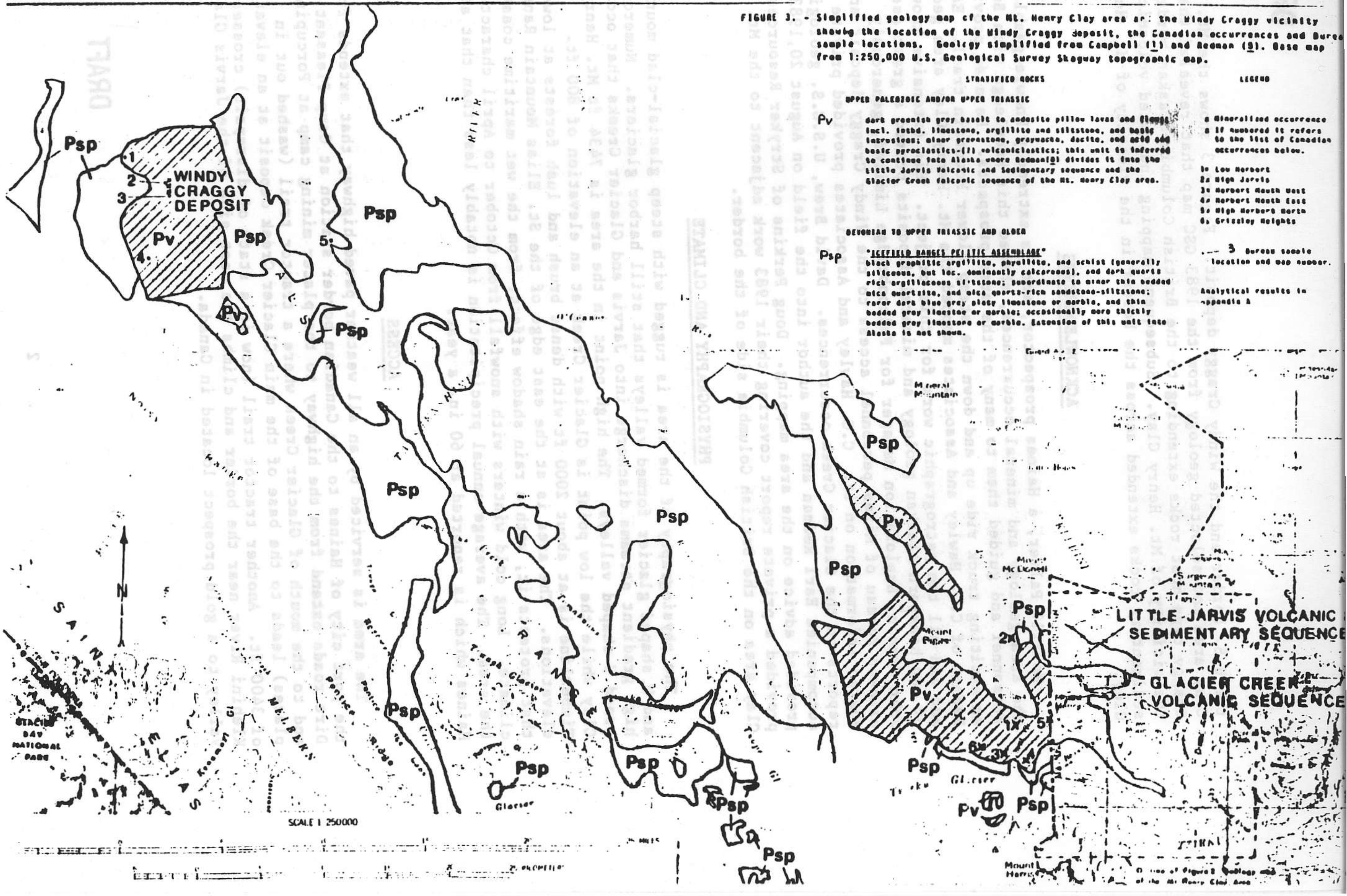

FIGURE 3. - Simplified geology map of the Mt. Henry Clay area and the Windy Craggy vicinity showing the location of the Windy Craggy deposit, the Canadian occurrences and Bureau sample locations. Geology simplified from Campbell (1) and Redman (9). Base map from 1:250,000 U.S. Geological Survey Skagway topographic map.

the U.S. border and the Windy Craggy deposit. Figure 3 shows the Mt. Henry Clay area and selected geology from the 1983 GSC map that revealed the Windy Craggy type host rocks extending to the British Columbia-Alaskan border in the vicinity of Mt. Henry Clay. Subsequent mapping indicated volcanic and sedimentary rocks extended across the border in the vicinity of Mt. Henry Clay.

ACKNOWLEDGMENTS

Merrill Palmer, a Haines prospector, who is extremely knowledgeable of the area geology and mineral occurrences, shared this knowledge with Bureau personnel and guided them to many of the area prospects. He also provided an exciting truck ride up and down the steep Flower Mountain trail. Earl Redman of C.C. Hawley and Associates mapped the Mt. Henry Clay area geology and did all the petrographic work for this project. His extensive knowledge of southeastern Alaskan geology and mineral deposits proved a great asset. John Gammon, Exploration Manager for Falconbridge Limited, generously allowed Bureau of Mines personnel access to the Windy Craggy deposit and shared information on it. C.C. Hawley and Associates provided private reports on the Glacier Creek occurrences. David Brew, U.S.G.S. geologist, accompanied Earl Redman and the author into the field on August 20,1983 and provided advice on the area mapping. Doug Perkins of Stryker Resources provided a private report covering their 1983 work adjacent to the Mt. Henry Clay area on the British Columbia side of the border.

PHYSIOGRAPHY AND CLIMATE

The physiography of the area is rugged with steep glacial-clad mountains and U shaped glacier formed valleys that still harbor glaciers. Numerous high gradient streams discharge into Jarvis and Glacier Creeks that occupy broad U shaped valleys. The high point in the area is 7434 ft Mt. Henry Clay while the low point is Glacier Creek at an elevation of 800 ft. Timberline is at about 2000 ft with dense brush and lush forests at lower elevations. The area is at the east edge of the St. Elias Mountain Ranga that protects it, with a rain shadow effect, from the wet maritime coastal climate. Long cold winters with snowfall from October to April characterize the area. The average annual precipitation is notably less than that at Haines which is reported at 60 in. a year.

ACCESS

The area is serviced by an all weathar paved highway that extends from the port city of Haines to the Canadian border station at Camp Pleasant. Dirt roads extend from the highway to the placer mining camp at Porcupine and to the mouth of Glacier Creek where a tractor trail (washed out in places) leads to the base of the main Glacier Creek deposit at an elevation of 3400 ft. Another tractor trail (now in a state of disrepair) crosses the Klehini River near the border and climbs the west side of the Jarvis Glacier Valley to a gold prospect located in Canada.

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LAND STATUS

Most of the Mt. Henry Clay area is administered by the Bureau of Land Management and is open to mineral entry under Federal law. A small portion of the area in the vicinity of the Klehini River is state land open to mineral entry under State law.

PREVIOUS WORK

Reported mining interest in the vicinity of the Mt. Henry Clay area began in 1899 with the discovery of gold placers in the Porcupine Mining area along Porcupine Creek (3) in 1899. Shortly thereafter, gold placers were discovered elsewhere in the district along Glacier Creek in the eastern part of the Mt. Henry Clay area. From 1899 to 1969 geologic mapping and prospecting in the vicinity centered on the Porcupine placers.

The first reported exploration for massive sulfide deposits within the Mt. Henry Clay area was the 1969 and 1971 discoveries of the Glacier Creek occurrences by Merrill Palmer of Haines, Alaska. In 1969 to 1971 MacKevett (2) of the U.S. Geological Survey (U.S.G.S.) mapped the geology of the Skagway B-3 and B-4 Quadrangles and in 1971 briefy examined the Glacier Creek occurrences. From 1971 to 1982 all of the activity in the area was concentrated on the Glacier Creek occurrences. In 1977, Phil Holdsworth (4) examined the occurrences as did Inspiration Development Company in 1979 and Anaconda Copper Corporation in 1980. Anaconda drilled three holes, one of which intercepted the Main Glacier Creek deposit. In 1981, B. Peterson (5) of Coronado Mining Corporation mapped the Main Glacier Creek deposit in detail. With the exception of the work on the Glacier Creek occurrences, the Mt. Henry Clay area has largely remained unexplored.

Although discovered in 1958 by James McDougall of Falconbridge Limited the significance of the Windy Craggy deposit was not realized until it was drilled by Falconbridge in 1981 to 1982 (6). The geology of the area in Canada between the Windy Craggy deposit and the Mt. Henry Clay area was mapped by the Geological Survey of Canada (GSC) and published in 1979 at a scale of 1:950,000 (7). With additional field work in 1980 to 1982, Campbell and Dodds (1) of the GSC published a 1:125,000 scale map of the area. Selected geology from this map is shown on figure 3.

PRESENT STUDY

The first Bureau task was to determine the extent of volcanic rocks similar to those that host the Windy Craggy deposit in the Skagway B-3 and B-4 Quadrangles. Earl Redman (8), under contract from C.C. Hawley and Associates, mapped the Mt. Henry Clay area and did the petrographic work. Redman's reports covering the area geology and petrographic work are in appendix B while His geology

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map is figure 2. The Bureau of Mines investigated, sampled, and mapped occurrences in the Mt. Henry Clay area and collected rock and stream sediment samples from selected areas in the Skagway B-3 and B-4 Quadrangles. Over 400 rock and stream sediment samples were collected for this project. About 200 of these were rock samples collected from the Mt. Henry Clay area occurrences. The sample location maps and analytical results for the latter work outside of the Mt. Henry Clay area will be released as an open-file report when the analytical results become available.

Field work in the area was conducted by foot, by truck, and by helicopter intermittently from June 23 to September 17, 1983. Two persons spent 29 days in the field; of these 14 days were helicopter supported. Early in the field season work was conducted out of a tent camp located on the Porcupine Creek road at Herman Creek; later work was out of the city of Haines via a helicopter shared with a State of Alaska crew working in the area. Most of the helicopter supported time was spent in the Mt. Henry Clay area while most of the work by truck and foot was spent in other portions of the Skagway B-3 and B-4 Quadrangles collecting rock and stream sediment samples and investigating occurrences.

DESCRIPTIONS OF AREAS, DEPOSITS, PROSPECTS, AND OCCURRENCES

WINDY CRAGGY DEPOSIT

The Windy Craggy deposit is located 50 miles west by northwest from the Mt. Henry Clay area in the rugged St. Elias Mountains of British Columbia (fig. 3). A large area of iron-stained rock (color anomaly) and gossan led to its staking in 1958; however, its significance was not realized until 1981 and 1982 when extensive diamond drilling revealed a world class massive sulfide deposit. Falconbridge Limited operates the property and Geddes Resources Limited holds the majority interest. Because of the implied potential for the discovery of deposits similar to Windy Craggy in Alaska, the Windy Craggy deposit is briefly discribed below.

Regional Geologic Setting

The Windy Craggy deposit and the Mt. Henry Clay area are located within the Alexander tectonostratigraphic terrane. Detailed geologic maps of the area between the Windy Craggy deposit and the Mt. Henry Clay area were first published by the GSC in 1983 (fig. 3). The deposit is located near the contact between the Psp pelitic assemblage and the Pv unit that consists of a thick sequance of basaltic to andesitic pillow lavas and flows (1). These units outcrop between the Jarvie and the Tsirku Glaciers in the vicinity of the British Columbia-Alaska border. Age dates of the rock units are uncertain but the Pv unit is considered upper Paleozoic and/or upper Triassic while the Psp unit is considered Devonian to upper Triassic and older.

Deposit Description

The only published description of the Windy Craggy deposit is contained in an 1983 report by D.G. Macintyre (9) of the Province of British Columbia

Department of Energy, Mines, and Petroleum Resources. Following is a quote from this report:

> "Surface geology and drill hole locations are shown on Figure 54. Drilling to date on the Windy-Craggy property has defined a concordant, tabular, steeply northeast-dipping pyrrhotite-chalcopyrite ± pyrite massive sulphide body over 1,000 metres long and averaging approximately 100 metres in thickness. There are unknown extensions along strike and down dip. Copper grades are variable, ranging from less then 1 per cent up to 14 per cent in narrow high-grade supergene enriched intersections. The drill-indicated reserves of the best grade part of the massive sulphide zone are reported to be over 85 million tonnes averaging 3.04 per cent copper and 0.09 per cent cobalt within an overall inferred tonnage for the deposit of 300 million tonnes averaging 1.52 per cent copper and 0.08 per cent cobalt (Northern Miner, January 13, 1983)."

Figure 54, a map of the Windy Craggy deposit, is reproduced from the above report and is figure 4 of this report.

According to a report in the November 13, 1983 Northern Miner (10), a 1983 drill hole in an untested portion of the Windy Craggy ore body averaged 10.97 ppm gold along a drill intersection distance of 200 ft. Seventy-eight ft of this 200 ft averages 19.89 ppm gold.

According to studies by Falconbridge Limited, the stratigraphic hanging wall of the deposit consists predominately of pillow basalts while the footwall consists of calcareous siltstone, argillite, tuff, and volcanic flows. However, the stratigraphic relationships in the area have not been definitely established. Large zones with stringers and disseminations of pyrrhotite and chalcopyrite occur in chlorite-epidote-serpentine altered pillow basalts, cherts, and argillites along both sides of the massive sulfide body. Age dating of five conodont fauna from a thin limestone debris flow located in the wall of the deposit gave four upper Triassic dates and one Devonian date (9).

On August 13, 1982, Bureau personnel briefly examined the northern portion of the deposit. Samples were collected from what were reportedly the better surface exposures of sulfides. Sample locations are shown on figure 3 (map nos. 2 and 3) while analytical results are in appendix A. Sulfide veins up to 4 in thick in altered basalt were sampled and analysis indicated up to 6.5% copper, 0.07% cobalt, 0.27 ppm gold, and 11 ppm silver. A representative sample across a 10 ft thick zone of iron-stained volcanics containing sulfides assayed 1.08% zinc, 1.18% copper, 11 ppm silver, and 0.10 ppm gold. Massive sulfide boulders up to 4 ft thick are found on the glacier beneath the north side of the deposit (fig. 3 map no.1). These consist mostly of pyrrhotite, pyrite, and chalcopyrite.

About 10 miles to the west of the Windy Craggy deposit, banded pyrite-pyrrhotite boulders up to 6 ft thick are found below the snout of a 8 mile long valley glacier (fig. 3 map no. 5). A sample collected from one of these boulders contained 1.9% copper, 0.47% zinc, and 0.05% cobalt.

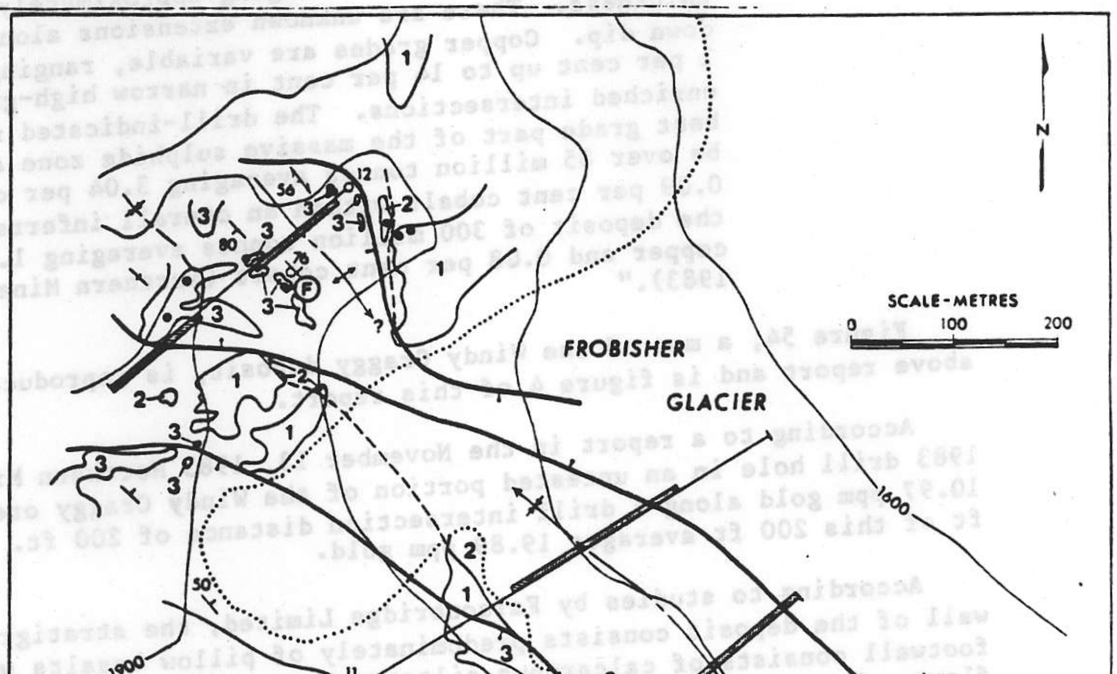

FIGURE 4. - Geology and drill hold locations, Windy Craggy deposit. A copy of figure 54 Macintyre (9).

Falconbridge supplied the Bureau with a Windy Craggy drill hole composite bulk sample for cobalt extraction metallurgical testing that assayed 0.46% copper, 0.21% cobalt, 0.03% zinc, 55.3% iron, and 35.1% sulfur. Two tests were conducted. The first, at the Bureau Albany Research Center indicated that the cobalt was mostly contained in the pyrite-pyrrhotite and did not concentrate with the copper in flotation tests. A cursory chlorine-oxygen leach test was then conducted at the Bureau Reno Research Center. Although 85% of the cobalt and 95% of the copper reported to filtrate and wash solutions, the low grade of the material as compared to the cost of the reagents may maka this process uneconomical. More details of the test are found in appendix C (11). Bureau tests on the recovery of cobalt from pyrite-pyrrhotite sulfides are continuing.

MT. HENRY CLAY AREA

The Mt. Henry Clay area is roughly defined as that area east of the British Columbia-Alaska border between Jarvis Glacier and Boundary Glacier and extending to the ridge separating Glacier Creek from Porcupine Creek. It consists of the Glacier Creek volcanic sequence and the Little Jarvis volcanic and sedimentary sequence mapped by Redman (8) and is bounded on the south and east by the Porcupine slate (fig. 3). These sequences continue to the west into British Columbia where the GSC (1) has mapped them as the Pv and Psp sequences (fig 3). While the division of the area rocks into sequences by the G S C and Redman are similar there are differences. Tha most important is that the Psp sequence includes the Porcupine slate.

Although the Mt. Henry Clay area is formed by the largest area of volcanic rocks in the Skagway B-4 Quadrangle, similar volcanic rocks were observed at other locations in the Quadrangle. In an area of timber at a location 2 miles west of the mouth of Glacier Creek, outcrops of basalt and jasper were observed and on the north side of the Tsirku River, at elevations from 1200 to 1500 ft, andesite and basalt wene observed. More detailed mapping will probably indicate the areas of volcanic rock shown in figure 2 are more extensive.

The Mt. Henry Clay deposit, the four Glacier Creek occurrences (Main, Nunatak, Hanging Glacier, and Cap), and Jarvis Glacier occurrences are all located within the Mt. Henry Clay area and are discussed below.

Mt. Henry Clay Deposit

The Mt. Henry Clay deposit is located near the Alaska-British Columbia border on the rugged glacier clad north side of Mt. Henry Clay about 5 miles southwest of the Pleasant Camp border station on the Haines Highway (fig.2). It was discovered in August 1983 by ALYU Mining Corporation and consists of massive sulfide boulders deposited by glacial action for a distance of 1/2 mile below the snout of a small hanging glacier.

Regional Geologic Setting

The Mt. Henry Clay deposit is located in the Glacier Creek sequence of rocks that consists predominantly of northwesterly striking basalts and andesites which also host all the Glacier Creek occurrences located several miles to the southeast and may host the Windy Craggy deposit located 50 miles to the northwest (fig. 2 and 3). Locally, the basalts show pillow structure and the andesites consist of flows and tuffs with minor sedimentary rocks. The andesites and tuffs in the vicinity of the Mt. Henry Clay deposit are mostly altered to chloritic phyllites. Redman (appendix B) reports that this alteration is found throughout the Glacier Creek sequence and is regional in nature.

In general, the geologic setting is somewhat similar to that of the Windy Craggy deposit with pillow basalts apparently overlying the andesites that host the deposit. Appendix B contains Redman's geological and petrographic reports covering the Mt. Henry Clay area.

Deposit Description

The deposit consists of sphalerite-barite-pyrite-chalcopyrite massive sulfide boulders up to 6 ft thick that are found along a sliver of rock for a distance of 1/2 mile beneath the snout of a small triangular shaped hanging glacier. This sliver of rock consists of meraine and talus with occasional bedrock exposures. Both the bedrock and float consist of andesites altered to chloritic phyllites. In place, ore grade mineralization was not found. (The term ore grade is used here in a general sense indicating metal values high enough to constitute ore under favorable conditions.) Figures 5A and 5B are photographs of the deposit showing detailed sample locations and terrain and gully numbers while figure 6 is a geology and topographic map of the deposit. The gullies that traverse the sliver of rock are numbered from east to west from 1 to 12. Analytical results are in appendix A.

While ore grade mineralization was not found in place, it was found in boulders located below the snout of the glacier. Most of these boulders have rounded edges and appear to have been carried underneath the glacier to near their present location. The greatest abundance of massive sulfide boulders was located between gullies 2 and 4 where the largest, highest grade boulders were also found. Samples collected here indicated most of the sulfide boulders between 1 and 6 ft thick contain from 20% to 44% zinc, about 5% Barium and several percent of copper. A 6 ft chip sample (figure 5A, map no. 32) across the largest boulder found assayed 33% zinc, 2.5 % copper, 5% barium, 65 ppm silver, and a trace of gold. Sulfide boulders between gullies 1 and 2 and between gullies 4 and 12 were mostly smaller, lower grade, and much less abundant. There were a few exceptions; however, at gully 1, a boulder (fig. 5A map no. 14) assayed 8% copper and 4.6% zinc; at gully 8, a boulder (fig. 5B map no. 41) assayed 35% zinc and 16.8% barium; and at gully 12, a 0.3 ft thick band of sphalerite in phyllite float (fig. 5B, map no. 61) assayed 18% zinc. The latter sample was collected from angular float located on the glacier and its likely source is the rock arete immediately to the west.

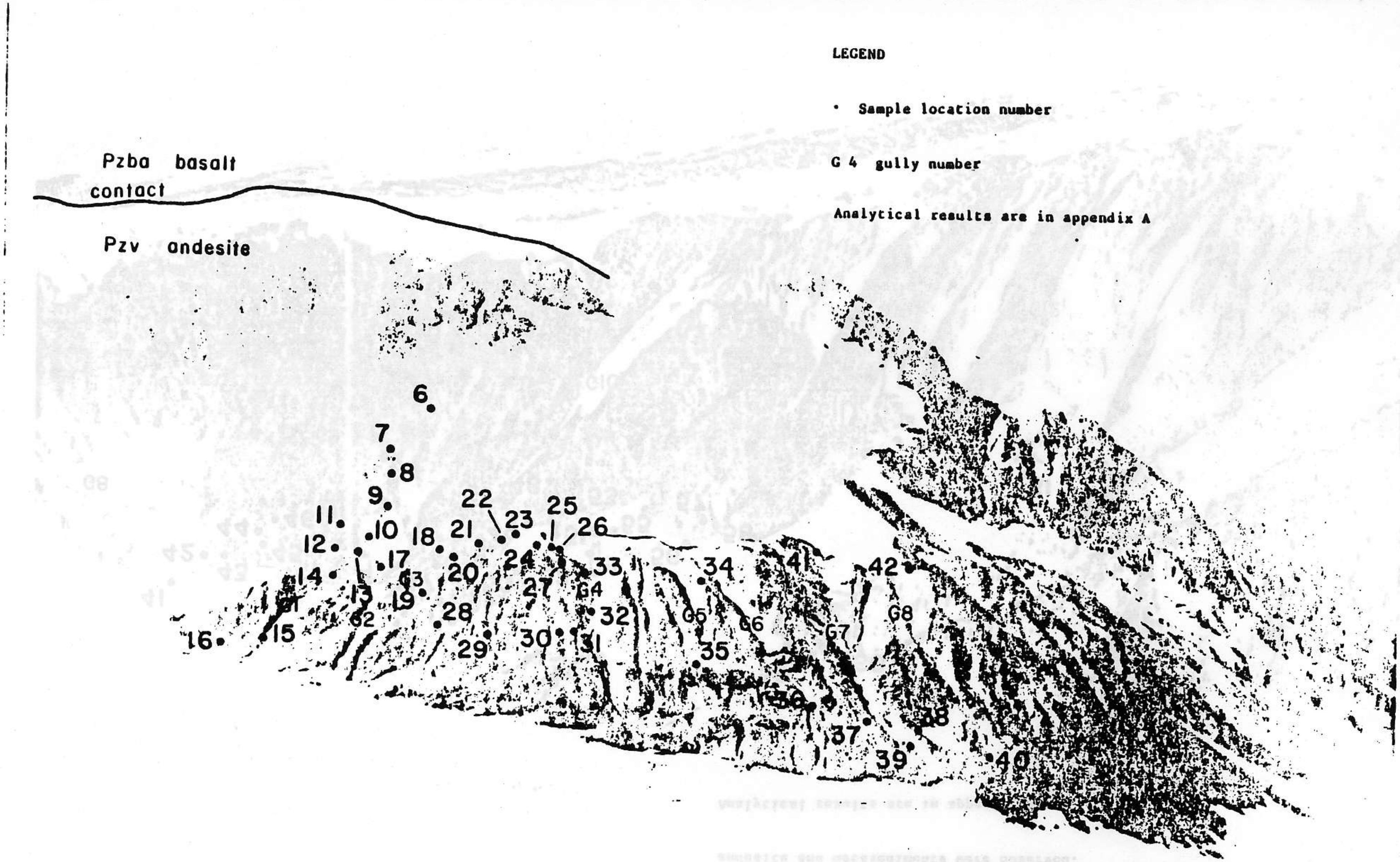

FIGURE 5A. - Photograph of the eastern portion of the Mt. Henry Clay deposit showing detailed sample loctions, geology and gully numbers.

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• Sample location number

G 9 gully number

In the vicinity of the sample locations andesite is the rock type except at the far west rock rib (sample location numbers 59 and 60) where mixed basalt, andesite and metasediments were observed.

Analytical results are in appendix A

FIGURE 5B. - Photograph of the western portion of the Mt. Henry Clay deposit showing detailed sample locations, geology, and gully numbers.

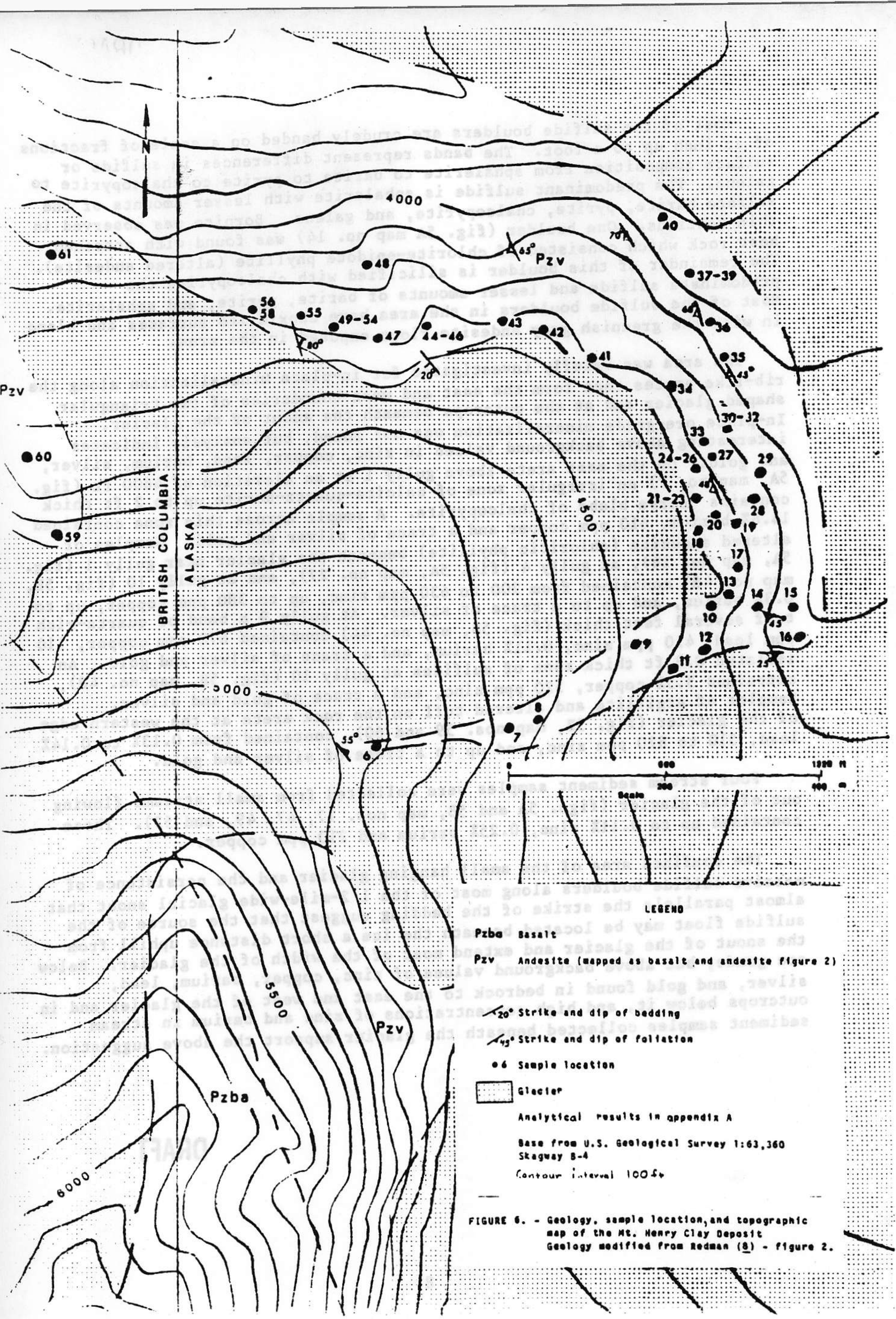

FIGURE 6. - Geology, sample location, and topographic map of the Mt. Henry Clay Deposit
Geology modified from Redman (8) - figure 2.

Most of the sulfide boulders are crudely banded on a scale of fractions of an inch up to a foot. The bands represent differences in sulfide or sulfate composition from sphalerite to barite to pyrite to chalcopyrite to galena. The predominant sulfide is sphalerite with lesser amounts of the sulfate barite, pyrite, chalcopyrite, and galena. Bornite was observed in thin sections. One boulder (fig. 5A map no. 14) was found with attached host rock which consisted of chlorite-epidote phyllite (altered andesite). The remainder of this boulder is silicified with chalcopyrite the predominate sulfide and lesser amounts of barite, pyrite, and sphalerite. Most of the sulfide boulders in the area have unoxidized surfaces and blend in with the greenish gray andesite float exposed in the area.

The area was briefly investigated for in-place mineralization along the rib-like aretes that form the east and west boundaries of the trieegular shaped glacier and at the outcrops beneath the snout of the glacier. In-place ore-grade mineralization was not found, but analysis indicates interesting above background values in zinc, copper, lead, barium, silver, and gold. On the east arete above gully 1 at an elevation of 4600 ft (fig. 5A, map no. 7) an irregular zone of calcite-quartz-barite up to 2 ft thick contains sparse blebs of chalcopyrite. A sample across this zone contained 14.6% barium, 610 ppm copper and a trace of silver and gold. Samples of altered andesite (chloritic phyllite) beneath the glacier near gully 1 (fig. 5A, map no. 16), at gully 4 (fig. 5A, map no. 27), and at gully 10 (fig. 5B, map no. 48) contained from 200 to 630 ppm zinc, up to 380 ppm copper, up to 0.3% barium, and up to a trace of silver. At gully 9 a band of quartz-rich tuff several feet thick (fig. 5B, map no. 44) contained 670 ppm copper, 110 ppm lead, 410 ppm zinc, 0.11% barium, and a trace of silver and gold. An isolated 0.3 ft thick zone of sulfides at gully 10 (fig. 5B, map no. 48), contained 3.5% copper, 520 ppm zinc, and a trace of gold and silver. Samples of argillite and altered tuff on the rock arete at the western edge of the glacier (fig. 5B, map nos. 59 and 60), contained from 0.13% to 0.14% lead, 510 to 620 ppm zinc, and up to a trace of silver and gold.

Four stream sediment samples were collected from small streams flowing out of the glacier (figs. 5A and 5B, map nos. 17, 47, 49, and 53). These contained up to 0.11% zinc, 0.25% barium and 210 ppm copper.

The confined area of the small hanging glacier and the persistence of massive sulfide boulders along most of the 1/2-mile-wide glacial snout that almost parallels the strike of the bedding suggest that the source of the sulfide float may be located beneath the ice a short distance uphill from the snout of the glacier and extend most of the width of the glacier. Below ore grade, but above background values of zinc, copper, barium, lead, silver, and gold found in bedrock to the east and west of the glacier and in outcrops below it, and high concentrations of zinc and barium in stream sediment samples collected beneath the glacier support the above suggestion.

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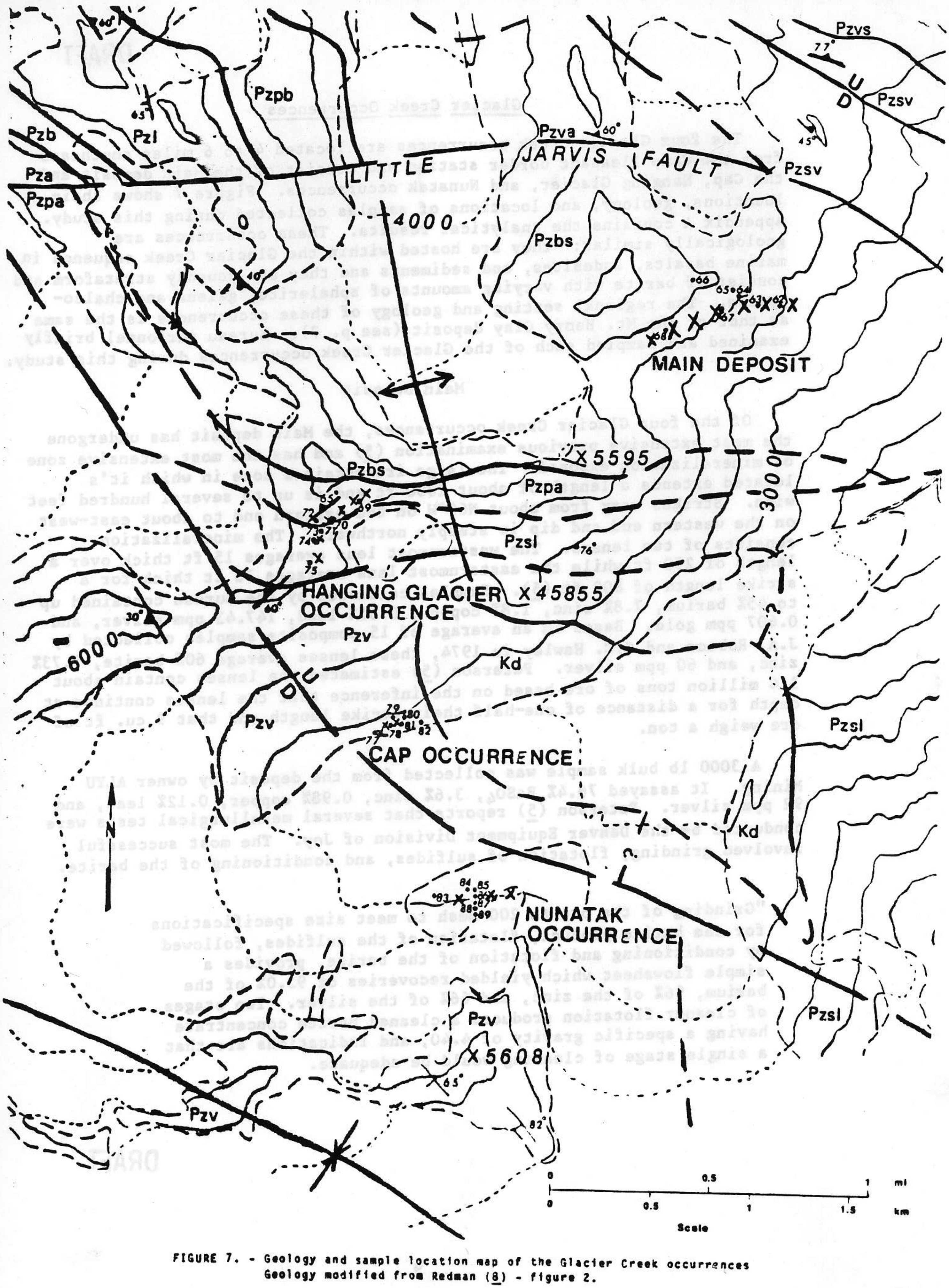

FIGURE 7. - Geology and sample location map of the Glacier Creek occurrences
Geology modified from Redman (8) - figure 2.

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Glacier Creek Occurrences

The four Glacier Creek occurrences are located 4 to 6 miles southeast from the Camp Pleasant border station and consist of the Main deposit and the Cap, Hanging Glacier, and Nunatak occurrences. Figure 7 shows their locations, geology, and locations of samples collected during this study. Appendix A contains the analytical results. These occurrences are geologically similar: they are hosted within the Glacier Creek sequence in marine basalts, andesites, and sediments and they are roughly strataform and consist of barite with varying amounts of sphalerite, galena and chalcopyrite. The regional setting and geology of these occurrences is the same as that of the Mt. Henry Clay deposit (see p. 7). Bureau personnel briefly examined and sampled each of the Glacier Creek occurrences during this study.

Main Deposit

Of the four Glacier Creek occurrences, the Main deposit has undergone the most extensive previous examination (5) and has the most extensive zone of mineralization exposed. The large iron-stained zone in which it's located extends a length of about 2000 ft and is up to several hundred feet wide. Strikes vary from about N60°W on the eastern end to about east-west on the western end and dip is steeply northward. The mineralization consists of two lenses. The westernmost lens averages 15 ft thick over a length of 250 ft while the easternmost lens averages 70 ft thick for a strike length of 800 ft (5). Samples collected by the Bureau contained up to 45% barium, 7.8% zinc, 1.8% copper, 0.52% lead, 147.43 ppm silver, and 0.607 ppm gold. Based on an average of 15 composite samples collected by J.A. Robson and C.C. Hawley in 1974, these lenses average 60% barite, 1.73% zinc, and 60 ppm silver. Peterson (5) estimates the lenses contain about 3/4 million tons of ore based on the inference that the lenses continue at depth for a distance of one-half their strike length and that 9 cu. ft of ore weigh a ton.

A 3000 lb bulk sample was collected from the deposit by owner ALYU Mining. It assayed 76.4% $BaSO_4$, 3.6% zinc, 0.98% copper, 0.12% lead, and 92 ppm silver. Peterson (5) reports that several metallurgical tests were conducted by the Denver Equipment Division of Joy. The most successful involved grinding, flotation of sulfides, and conditioning of the barite.

> "Grinding of the ore to 200 mesh to meet size specifications for the barite product, flotation of the sulfides, followed by conditioning and flotation of the barite, provides a simple flowsheet which yielded recoveries of 93.0% of the barium, 96% of the zinc, and 66% of the silver. Two stages of cleaner flotation produced a cleaned barite concentrate having a specific gravity of 4.40, and indications are that a single stage of cleaning would be adequate.

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LEGEND (fig. 7)

Kd	Hornblende Diorite Cretaceous	
Pzsl	Porcupine Slate Black Slate Paleozoic	

Relative ages of the remaining sequences may be similar

Pzbs	Basalt w/minor slate	Glacier Creek Volcanic Sequence
Pzpa	Phyullitic andesitic and felsic volcanics	Glacier Creek Volcanic Sequence
Pzv	Basalt and andesite undifferentiated	Glacier Creek Volcanic Sequence
Pza	Andesite	Little Jarvis Volcanic and Sedimentary Sequence
Pzb	Basalt	Little Jarvis Volcanic and Sedimentary Sequence
Pzl	Limestone w/slate and sandstone	Little Jarvis Volcanic and Sedimentary Sequence
Pzpb	Pillow Basalt	Little Jarvis Volcanic and Sedimentary Sequence
Pzva	Mostly andesite w/slate	Little Jarvis Volcanic and Sedimentary Sequence
Pzsv	Mostly slate w/minor limestone and andesite	Little Jarvis Volcanic and Sedimentary Sequence
Pavs	Mostly andesite w/minor slate	Little Jarvis Volcanic and Sedimentary Sequence

xxxx Barium-zinc mineralized zone

.--- Sample location

Observed contact

Inferred or covered contact

U/D Fault

Inferred or covered fault

Plunging anticline

Syncline

60° Strike and dip of foliation

82° Strike and dip of Bedding

Glacier

Analytical results in appendix A

Base from U.S. Geological Survey 1:63,360 Skagway B-4

On the basis that the bulk sulfide concentrate is marketable as produced, little work was done on separation of the various sulfide minerals. The bulk concentrate produced contained about 24% zinc, 5.5% copper, and 11.5 ounces per ton of silver as the principal values. The remainder of the concentrate is primarily pyrite which may carry a significant portion of the silver values. The zinc minerals present are highly activated for flotation due to the presence of copper salts, and indications are that any further separation of the sulfide minerals would be very difficult and would probably involve high losses in the copper and silver values." (5)

Hanging Glacier Occurrence

The Hanging Glacier occurrence occupies a pillow basalt capped iron-stained zone several hundred feet thick and about 2000 ft long, that strikes northeast and dips steeply north. Ore consists of barite lenses up to several feet thick and quartz calcite ladder veins up to 0.5 ft thick. Both the lenses and ladder veins contain pyrite, sphalerite, galena, and chalcopyrite. Samples from the lenses and veins contain up to 54 % barium, 14.1% zinc, 0.36% copper, 2.3% lead, 16.01 ppm silver and 1.575 ppm gold.

Nunatak Occurrence

The Nunatak occurrence is located on the north face of a mostly scree-covered nunatak composed mostly of andesite and basalt. MacKevett (2) reported barite lenses up to 20 ft thick. The largest barite lens found by this study was 3 ft thick, northwest striking, and steeply southwest dipping. However, cover prevented determination of the extent of mineralization. Samples collected from this occurrence contain up to 50 % barium, 0.22% zinc, 0.035% copper, 0.37% lead, 19.36 ppm silver, and 0.244 ppm gold.

Cap Occurrence

The Cap occurrence consists of an iron-stained zone about 50 ft thick capped by volcanics that outcrop just above the Saksaia Glacier and whose extent is hidden by the glacier and cover. Barite lenses up to 8 ft thick occur in this zone. Pyrite, sphalerite, galena, and tetrahedrite are found in the barite. Samples collected from this occurrence contained up to 50 % barium, 1.1% zinc, 0.33% lead, 277.7 ppm silver, 1.371 ppm gold, and 100 ppm cobalt.

Jarvis Glacier Occurrences

The Jarvis Glacier occurrences are located on the south side of the Jarvis Glacier in a steep walled canyon about 4 miles east by southeast from the Pleasant Camp border station on the Haines highway (fig. 2). Figure 8 is a detailed geological and sample location map of the area and appendix A

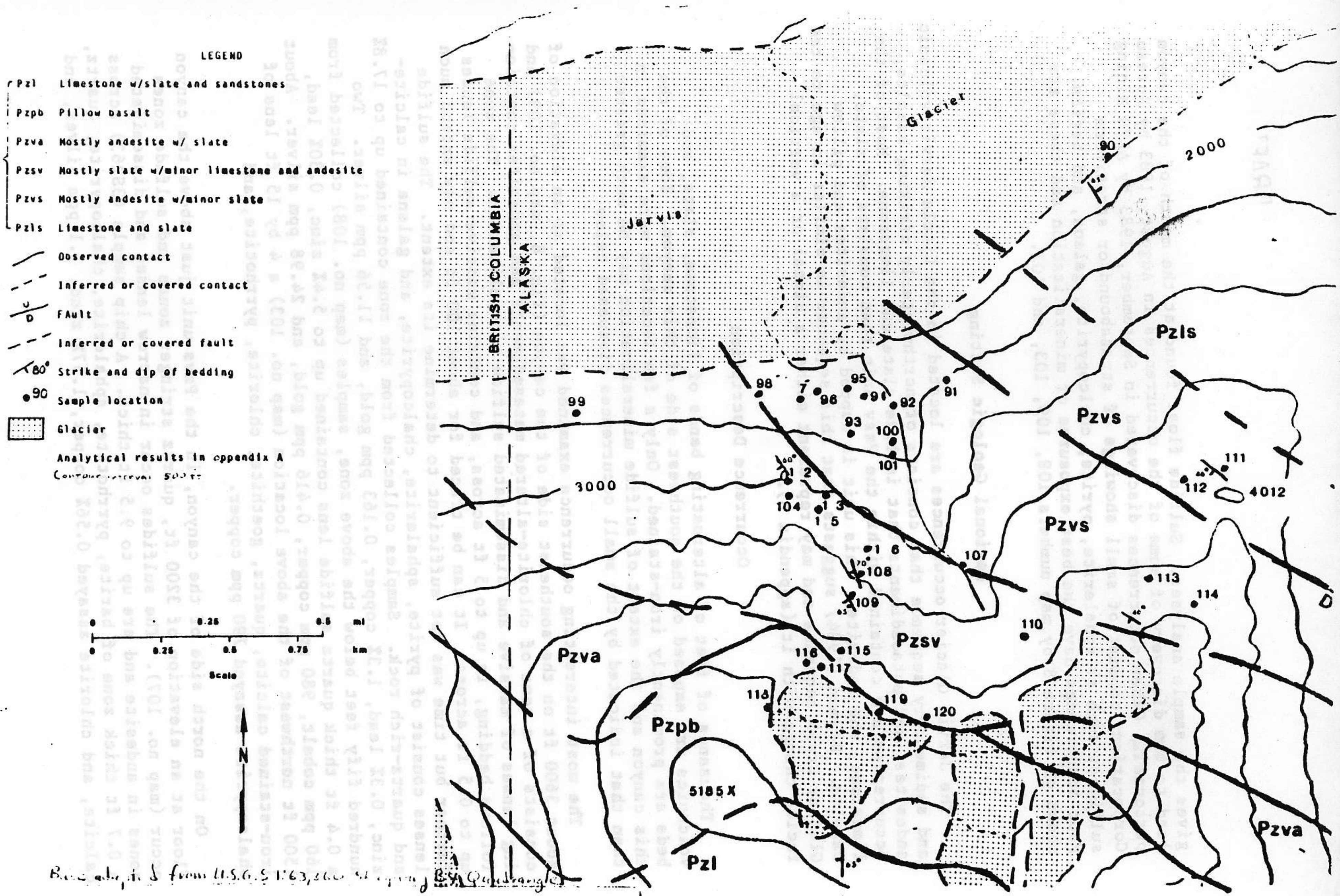

FIGURE 8. - Geology and sample location map of the Jarvis Glacier area. Geology modified from Redman (8) - figure 2.

gives the sample analyses. Sulfide float found at the mouth of the canyon lead to the discovery of some of the occurrences in August, 1983 by Bureau personnel. Other occurrences discovered in September, 1983 by ALYU Mining Corporation, consist of small showings of stratabound or stratiform sulfides, such as sphalerite, pyrite, chalcopyrite, galena, and barite. Four occurrences have the best exposures of mineralization and these are shown on figure 8 by map numbers 108, 109, 103, and 107.

Regional Geologic Setting

The Jarvis Glacier occurrences are located in the Little Jarvis volcanic and sedimentary sequence that consists of northwesterly striking basalts, andesites, and metasediments that include slate and limestone. Most of the occurrences are contained within the Pzsv unit that consists of slate, limestone, and andesite. This unit is capped by andesites and pillow basalts. Redman (1984) suggests that this sequence is similar in age to the Glacier Creek sequence and may represent either a distal or a vertical facies change with it (appendix B).

Oocurrence Description

Thousands of feet of alternating bands of limestone, slate, and volcanics are exposed on the southwest side of this canyon. Some of the beds are prominently iron-stained. Only a few locations were examined in this canyon and the extent of sulfide mineralization may be much greater than that indicated by the small occurrences discussed below.

The most interesting occurrence examined was located at an elevation of about 3600 ft on the southeast side of the canyon (fig. 8, map no. 109) and consists of a zone of chlorite-altered metasediments and andesites containing lenses of massive and disseminated sulfide mineralization. The zone follows bedding, is up to 5 ft across, and contains massive sulfide lenses up to 0.5 ft across. It can be traced for about 100 ft and may extend much farther but time was not sufficient to determine its extent. The sulfide lenses consist of pyrite, sphalerite, chalcopyrite, and galena in calcite- and quartz-rich rock. Samples collected from the zone contained up to 17.8% zinc, 0.3% lead, 1.3% copper, 0.163 ppm gold, and 11.56 ppm silver. Two hundred fify feet below the above zone, samples (map no. 108) collected from a 0.4 ft thick quartz sulfide lens contained up to 5.4% zinc, 0.30% lead, 160 ppm cobalt, 980 ppm copper, 0.416 ppm gold, and 24.98 ppm silver. About 1500 ft northwest of the above location (map no. 103) a 4 by 15 ft lens of iron-stained calcite, quartz, goethite, chlorite, pyrrhotite, and chalcopyrite assayed 790 ppm copper.

On the north side of the canyon, in the Pzvs unit just above the canyon floor at an elevation of 3200 ft, quartz stringer zones and sulfide zones occur (map no. 107). The sulfides occur in narrow lenses and disseminated zones in andesite and are up to 9.5 ft thick. A chip sample (3S263) across a 0.7 ft thick zone of barite, pyrrhotite, sphalerite, chalcopyrite, quartz, calcite, and chlorite assayed 0.56% copper, 1.57% zinc, 1.1 ppm silver, and

122 ppm cobalt. Other samples of sulfide zones taken at this locality contained up to 6.1% zinc, 0.76% copper, 110 ppm cobalt, 0.127 ppm gold and 4.63 ppm silver. The quartz stringer zones contain veins up to 0.5 ft thick that contain sparse knots of pyrrhotite and chalcopyrite.

Samples collected elsewhere in the canyon showed interesting velues. A float sample collected at an elevation of 4400 ft (map no.120) assayed 0.05% copper, 0.103 ppm gold, and 0.59 ppm silver, while another float sample collected at an elevation of 3700 ft (map no. 110) assayed 1.2% zinc and 0.1 % lead. A float sample collected at an elevation of 2400 ft on the west side of the canyon (map no. 93) assayed 660 ppm copper, 330 ppm lead, and 200 ppm cobalt.

ADJACENT CANADIAN OCCURRENCES

The Mt. Henry Clay area volcanic rocks extend across the British Columbia - Alaska border and outcrop over a large area in Canada adjacent to the Mt. Henry Clay area (fig. 3). Stryker Resources investigated the Canadian area in 1983 with a small crew. Doug Perkins, crew chief for the investigation, reported that the area was previously unprospected. Several stratiform sulfide occurrences were discovered near the base of pillow basalts or in the immediate underlying sedimentary rocks (12) as a result of these Stryker investigations. These occurrences are all located within 3 miles of the Mt. Henry Clay area. Their location is shown on figure 3 (locations 1X-6X) and the text of their descriptions from a 1983 Stryker Resources report is contained in appendix D.

Samples from these occurrences are reported to contain up to 7.64 % zinc, 2.15% copper, 0.129% cobalt, 15.97 ppm gold, and 144.4 ppm silver. Of particular interest are figure 3 localities 3X, 4X, and 6X named "Herbert Mouth West," "Herbert Mouth East," and "Grizzly Heights" in the Stryker report. At locality 3X, a sample of massive pyrrhotite float assayed 15.7 ppm gold and 0.129% cobalt while at locality 4X a sample from andesitic volcaniclastic rock assayed 0.017% cobalt. At locality 6X samples from massive pyrite-pyrrhotite boulders assayed less than 1% copper and averaged 0.016% cobalt.

Redman (8) reports a 0.7 ft thick layer of barite hosted in phyllite 1 mile south of Canadian occurrence "Herbert Mouth West" (fig. 3, location 5X). This is the Boundary occurrence (location 7) shown on figure 2. A sample across the barite layer contained 51.1% barium and 64 ppm lead.

CONCLUSIONS

The Mt. Henry Clay area occurrences have a similar ore zone mineralogy and geologic setting. They consist of barite-sphalerite-pyrite stratiformly hosted in a volcanic-sedimentary sequence overlain by basalt or pillow basalt. The main commodities in the ore zones are barium, zinc, copper, silver, and gold. The Windy Craggy deposit with a setting similar to the Mt. Henry Clay occurrences may be hosted in the same sequence but has an ore zone consisting of pyrrhotite-pyrite-chalcopyrite with copper, cobalt, and gold. The similarity of the occurrences within the Mt. Henry Clay area suggests that they may be related to a common geologic event or series of events and that they may bear some relationship to the Windy Craggy deposit. The thick Windy Craggy ore zone, consisting predominately of pyrrhotite, probably represents a proximal volcanogenic type deposit while the thinner barite-bearing Mt. Henry Clay area zones may represent distal volcanogenic type deposits.

Small amounts of the critical and strategic metal cobalt were found in the Jarvis Glacier occurrences and are reported in mineralized zones located in Canada adjacent to the Mt. Henry Clay area.

Prior to 1983, exploration in the Mt. Henry Clay area was concentrated on the Glacier Creek occurrences discovered in the late 1960's. The remainder of the area has received little attention. Sparked by reports of the world class Windy Craggy deposit located 50 miles to the northwest in Canada, 1983 investigations of the area resulted in the discovery of the Mt. Henry Clay deposit and the Jarvis Glacier occurrences. Stryker Resources reports the 1983 discovery of 6 showings of stratiform massive sulfide mineralization in Canada just across the border from the Mt. Henry Clay area. All the Glacier Creek and Jarvis Glacier occurrences are indicated by substantial areas of iron-stained rock visible for many miles. While the Mt. Henry Clay deposit has no visible associated iron-stain, it is indicated by massive sulfide boulders scattered across a distance of 2500 ft. Indications are that the Mt. Henry Clay area has been little explored. Limited exploration from 1969 to 1983 indicates the area contains significant stratiform massive sulfide mineralization and is a target for future exploration.

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APPENDIX A

ASSAY DATA TABLES

see footnotes at the end of appendix A for list of abbreviations

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Map number	Sample field number	Sample type[1]	Sample length ft	Analyses[2] units ppm unless marked %				Analyses[3] X-Ray %	Analyses[4] Fire assay-ICP ppm		Comments
				Zn	Cu	Pb	Co	Ba	Au	Ag	
				Windy Craggy Deposit and vicinity (Figure 3)							
1	35408x	Float grab	—	Sample collected for petrographic work							massive sulfide py, po, cp and sl
	3E038	" "	—	100	93	<30	33	0.08			andesite with 0.5% disseminated po
	3E039	" "	—	82	100	82	11	L .01			black argillite with py cubes
2	25366	grab	—	860	1620	420	6		0.27	7.0	gossan in andesite
	25367	float grab	—	37	G 2%	9	373		<0.014	2.4	po, py, and cp
	25368	chip	0.4 ft	54	G 2%	3	290		<0.014	2.9	massive po, py and cp stringer in pillow basalt
	25369	grab	-	197	233	77	5		<0.014	2.5	black shale
	25370	grab	—	249	378	36	L 1		0.034	3.5	gossan in andesite
	25371	grab	—	555	78	L 2	18		<0.014	0.2	andesite
	18764	Rd. chip	—	44	6.5%	7	690		.21	2	sulfide stringer zones in pillow basalt
	18765	Rd. chip	10-15 ft	1.08%	1.18%	535	291		.10	11	Iron stained outcrop 10-15 ft thick with po, cp and sl
	18766	soil	—	237	1200	222	12		<0.007	7.2	gossan
3	25372	float grab	—								andesite with po and cp
	18767	grab	-	71	1.58%	7	835		<0.007	.9	massive sulfide zone with po and cp
4	35408	grab		68	160	L 30	33	.03	Nil	0.7	pillow basalt
5	35409	float grab		.47%	1.9%	380	510	L .01	Tr	3.4	banded massive sulfide boulder with py, po and cp from the Mus showing

See footnote at end of appendix A

Map number	Sample field number	Sample type[1]	Sample length ft.	Analyses[2] units ppm unless marked % Zn	Cu	Pb	Co	Analyses[3] X-Ray % Ba	Analyses[4] Fire assay-ICP ppm Au	Ag	Comments
			Mt Henry Clay Deposit (Figure 5A+B)								
					east rib						
6	35410	grab	—	190	26	66*	21	0.03	Tr	Tr	chloritic phyllite
7	35272	Rep grab	2 ft	170	610	L 30	10	14.6	Tr	Tr	irregular calc-qz-ba lens with cp and ml
	35272A	float grab		130	140	L 30	35	.32	Nil	6.9	chloritic phyllite with py
8	35411	float grab		190	2.1 %	47	17	.12	Tr	1.0	chloritic phyllite with qz, py and cp
	35412	float grab		130	290	L 30	L0.9	49	Tr	Tr	ba
9	35274	float grab		12	570	L 30	L0.9	14	Nil	Nil	qz+ba with cp and ml
10	35275	float grab		240	2.2 %	L 30	L0.9	.16	Tr	171	silicified tuff with cp
11	35337	float grab		4.6 %	.13 %	74*	30	26	Nil	Tr	banded ba boulder with sl, cp, ml and mag
12	35338	float grab		.10 %	690	L 30	L 0.9	10.9	Tr	3.4	ba boulder with sl and cp
					gully #1						
13	35276	float grab		2050	2.5 %		3.2				altered tuff with cp, sl and ml
	35277	float grab		380	210	L 30	L0.9	45	Tr	Tr	ba boulder with py
14	35336	float grab		4.6 %	8 %	74*	17	.09	Tr	65	chloritic phyllite boulder with silicified bands of cp and sl up to 0.1 ft thick
15	35225	float grab		130	.17 %	L 30	L 0.9	34	Nil	3.4	ba boulder with cp and mag
16	35224	rep. grab		360	33	43*	24	.01	Nil	Tr	chloritic phyllite with mag
					gully #2						
17	35270ss	stream sediment		.11 %	210	42*	31	.06	0.023	L0.7	
					[illegible] #3 - gully #4						
18	35220	float grab		0.54 %	1.8 %	990	35	1.68	Tr	24	chloritic phyllite with ba and disseminated cp, py and ml stain
	35286	float grab		980	80	120	19	.79	Tr	Tr	chloritic phyllite with disseminated py
19	35294	float grab		670	83	L 30	15	.02	Tr	3.4	chloritic phyllite with py and mag
20	35305	float grab		91	1.4 %	L 30	L 0.9	5.6	.023	5.303	ba+calc. boulder with cp, py and ml

See footnote at end of appendix

Map number	Sample field number	Sample type[1]	Sample length ft.	Analyses[2] units ppm unless marked %				Analyses[3] X-Ray %	Analyses[4] Fire assay-ICP ppm		Comments
				Zn	Cu	Pb	Co	Ba	Au	Ag	
				Hanging Glacier Occurrence							
69	35157	float grab		L1	45	81	43	0.21	L0.007	0.963	qz, epidote altered andesite with py
	35158	float grab		L1	35	<30	42	0.30	L0.007	0.720*	iron stained chloritic phyllite with py
70	35154	chip	2.5 ft	9.5%	0.36%	2.3%	14	8.4			qz, calc with ba, sl, gn, cp and py
	35155	chip	2.0 ft	14.1%	0.13%	0.16%	22	7.0	1.575	15.07	brown schist with sl, cp, gn, ba and py
	35156	chip	3.0 ft	2.1%	140	0.90%	18	2.7	L0.007	16.01	purble massive rock laced with ba, qz, calc veins with sl gn and py
71	35149	rep. grab	3.0 ft	0.21%	7.7	1.2%	<0.9	54	L0.007	15.23	ba with gn and sl
72	35153	chip	2.0 ft	5.4	4.8 *	33 *	<0.9	0.01	L0.007	0.770*	iron stained qz vein with chlorite inclusions
73	35150	high grade grab		0.61%	9.8	1.5%	<0.9	0.61			qz with gn and sl
	35151	grab		—	—	—	—	—	—	—	schist with py and ml
	35152	grab		0.24%	33	120	22	0.74			chlorite epidote altered andesite with sl, ml and ba
74	35146	grab		0.52%	120	0.69%	21	9.2			phyllite with ba, sl and gn
	35147	grab		48	57	120	62	0.07	L0.007	L0.3	phyllite with py
	35148	grab		0.21%	110	0.65%	25	42			ba with sl and gn
75	35144	rep. grab		6.2	25	450	15	0.71	L0.007	12.08	silisified tuff
	35145	rep. grab		110	130	380	97	0.04	L0.007	L0.3	chlorite altered andesite
76	35159	float rep. grab		L1	8.7	<30	1.7 *	<0.01	L0.007	L0.3	jasper
	35160	float rep. grab		L1	14	33 *	40	0.01	L0.007	L0.3	chlorite, epidote, calcite altered andesite

Map number	Sample field number	Sample type[1]	Sample length ft.	Analyses[2] units ppm unless marked %				Analyses[3] X-Ray %	Analyses[4] Fire assay-ICP ppm		Comments
				Zn	Cu	Pb	Co	Ba	Au	Ag	
				Cap occurrence							
77	35127	chip	8.0	25	5.3	40 *	19	20	L0.007	8.14	phyllite with py
	35128	rand. grab	5.0	530	12	150	16	8.9	0.007	16.25	iron stained schist with py
78	35125A	chip	0.75	0.11%	65	180	77	1.3	L0.007	15.08	phyllite with sulfides
	35125B	grab		L1	30	<30	10	0.97	Tr	13.71	phyllite with py
79	35121	chip	8.0	0.18%	9.5	700	L0.9	50	1.371	277.72	ba, qz with sulfides
	35122	high grade grab		0.20%	53	390	L0.9	39	—	82.[illegible]	ba, qz, py and sl
	35123	chip	1.5	590	89	270	41	10	0.093	23.28	altered tuff with py
	35124	high grade grab		1.1%	150	0.33%	<0.9	37	0.686	157.725	ba with td, sl, and gn
80	35126	rand. grab		L1	66	120	100	0.24	L0.007	0.550 *	basalt
81	35129	chip	5.0	0.11%	79	[illegible]20	7.8	24	Tr	27.43	ba with sulfides
82	35120	rand chip		—	—	—	—	—	—	—	andesite with disseminated py and sl
				Nunatak occurrence							
83	3E004	grab		200	350	560	20	0.31	L0.007	1.54	tuff with py
84	3E008	grab		0.22%	79	0.37%	<0.4	20	0.244	19.36	silicified rock with py and gn
85	3E001	grab		710	45	220	77	1.1	L0.007	1.40	basalt
86	3E002	grab		180	18	170	[illegible]	0.48	L0.007	4.63	altered tuff
87	3E003	grab		L1	L2	L30	[illegible]	50	L0.007	L0.3	ba
88	3E005	grab		0.19%	59	110	22	0.31	L0.007	L0.3	phyllite with py
89	3E007	grab		300	46 *	65	21	0.23	L0.007	L0.3	phyllite with py

Map number	Sample field number	Sample type[1]	Sample length ft.	Analyses[2] units ppm unless marked %				Analyses[3] X-Ray %	Analyses[4] Fire assay-ICP ppm		Comments
				Zn	Cu	Pb	Co	Ba	Au	Ag	
				Jarvis Glacier area (fig. 8)							
90	3E022	grab		L1	120	*48	110	0.54	L0.007	0.630*	basalt
91	3E016	grab		—	—	—	—	L0.01	—	—	andesite with py
92	3S199	SS		L1	170	170	91	0.02	L0.007	L0.3	
93	3S229	float grab		L1	660	330	200	L0.01	L0.007	0.670*	metased with sulfides
	3S230	float grab		L1	320	*51	110	0.02	L0.007	0.430*	calc qz phyllite cut by calc and qz stringers with py
94	3S197	float grab		L1	720	*51	230	L0.01	L0.007	1.16	qz vein po and cp
95	3S195	float grab		6.5%	0.34%	77	56	0.03	L0.007	2.15	qz breccia with sl, cp and po
	3S196	float grab		L1	320	*39	53	L0.01	L0.007	L0.3	qz vein with cp
96	3S193	SS		L1	140	100	78	0.02	L0.007	L0.3	
	3S194	SS		L1	130	120	82	0.03	L0.007	L0.3	calc breccia
97	3S190	float grab		L1	50	<30	38	0.02	0.034	L0.3	
	3S191	SS		L1	98	*55	53	0.02	L0.007	L0.3	
	3S192	float grab		L1	210	*45	73	L0.01	L0.007	L0.3	qz vein with py
98	3S189	float grab		360	94	*40	44	0.05	[illegible]	L0.3	tuff with py
99	3S188	float grab		L1	160	*49	25	0.26	L0.007	0.70	altered andesite with py
100	3S198	float grab		7.9%	4.6%	710	130	0.17	0.024	20.22	gossan with massive sulfide core sl and cp
101	3S200	float grab		L1	130	85	71	L0.01	L0.007	L0.3	jasper
	3S201	float grab		1.5%	500	110	20	L0.01	[illegible]	0.15	gossan with qz and sulfides
	3S202	float grab		L1	210	140	120	L0.01	L0.007	L0.3	limey andesite with py+cp

Map number	Sample field number	Sample type[1]	Sample length ft.	Analyses[2] units ppm unless marked %				Analyses[3] X-Ray %	Analyses[4] Fire assay-ICP ppm		Comments
				Zn	Cu	Pb	Co	Ba	Au	Ag	
102	35227	grab		L1	59	<30	2.4	L0.01	0.014*	L0.3	qz, calc vein
	35228	grab		L1	65	*44	16	L0.01	0.030	L0.3	altered rock with py
103	35218	rep. chip	0.4×2 ft	L1	790	110	50	L0.01	L0.007	1.027	qz gossan with py and cp
	35219	rep. chip.	0.5×2 ft	46	700	13	11	L0.01	L0.007	L0.3	calc qz breccia with po and cp
	35220	float grab		L1	330	<30	41	L0.01	—	—	qz vein with cp
	35221	random grab		L1	46	130	86	L0.01	0.024	L0.3	chlorite altered andesite
	35223	grab		L1	52	*50	13	L0.01	L0.007	1.15	calc with py
104	35224	grab		L1	26	<30	3.2	L0.01	L0.007	L0.3	graphitic gossan with calc
	35225	grab		L1	190	80	60	L0.01	0.032	L0.3	qz, calc altered sediment with geothite
	35226	grab		L1	140	*56	50	L0.01	L0.007	L0.3	calcite
105	35222	grab		L1	40	34 *	21	L0.01	0.037	L0.3	metased
106	35204	grab		250	870	170	84	L0.01	L0.007	0.620 *	gossan in chlorite epidote altered andesite
107	35257	chip	0.2	44	74	7	12	—	—	0.5	qz vein with py
	35260A	chip	0.5	6.1 %	0.76 %	160	110	L0.01	L0.03	4.33	massive po with sl and cp hosted in chlorite altered andesite
	35260B	chip	2.5	0.27 %	570	89	29	L0.01	L0.007	0.850 *	schistose tuff with sulfides
	35261A	chip	0.5	2.0 %	0.33 %	150	110	L0.01	L0.03	2.000 *	qz rich phyllite with po, geothite, sl and cp.
	35261B	chip	2.0	0.93 %	0.10 %	130	52	L0.01	L0.007	1.180	Altered tuff and gossan with sulfides
	35262A	grab		0.31 %	58	*65	45	L0.01	L0.007	L0.3	chloritic phyllite with sulfides
	35262B	chip	0.0	0.16 %	490	120	49	L0.01	L0.007	L0.3	chloritic phyllite with sulfides

Map number	Sample field number	Sample type[1]	Sample length ft.	Analyses[2] units ppm unless marked % Zn	Cu	Pb	Co	Analyses[3] X-Ray % Ba	Analyses[4] Fire assay-ICP ppm Au	Ag	Comments
107	3S262C	chip	1.5	0.40%	920	100	62	L0.01	L0.007	0.480 *	limey andesite with py
	3S262D	chip	1.0	0.19%	810	100	9.6	L0.01	0.127	3.49	gossan, qz and sulfides
	3S262E	grab		890	510	110	38	L0.01	L0.007	0.410 *	chlorite altered andesite
	3S263	float rep.	3.7	1.57%	5600	11	122	—	—	1.1	ba with qz, po, sl and cp
108	3S205	grab		L1	980	120	160	L0.01	0.416	24.98	qz with sulfides
	3S206	chip	0.4	5.4%	470	0.30%	49	L0.01	0.077	18.51	qz sulfide zone with py, sl, and gn hosted in metased
109	3S207	rep. grab	0.5	17.8%	0.57%	230	110	L0.01	0.163	11.56	calc, qz zone with sl, cp and py
	3S208	chip	0.5	0.64%	0.20%	90	31	L0.01	0.027	3.48	calc, qz zone with sl, cp and py
	3S209	grab		5200	3100	—	35	—	—	—	gossan zone hosted in chlorite altered andesite
	3S210	chip	0.3	0.20%	1.3%	140	41	0.18	0.011 *	2.53	chloritic phyllite with cp
110	3S269	float grab		1.2%	240	0.10%	23	0.10	L0.007	0.400 *	metased with sp and py
111	3E013	grab		L1	81	240	75	L0.01	L0.007	L0.3	andesite with py
112	3E012	grab		L1	680	170	81	L0.01	L0.007	.390	andesite with py
113	3E015	grab		L1	54	85	74	L0.01	L0.007	L0.3	chlorite altered andesite with py
114	3E014	grab		L1	59	74	44	L0.01	L0.007	L0.3	chlorite altered andesite with py
115	3S265	grab		L1	72	160	41	L0.01	L0.007	L0.3	metased
116	3S211	grab		47	[illegible]	[illegible]	[illegible]	—	—	[illegible]	py lenses up to 0.2 ft across hosted in chloritic phyllite
117	3S264	grab		L1	270	[illegible]	[illegible]	0.04	[illegible] *	[illegible] *	altered tuff
	3S266	grab		L1	47	97	65	0.07	L0.007	L0.3	andesite

Map number	Sample field number	Sample type[1]	Sample length ft.	Analyses[2] units ppm unless marked %				Analyses[3] X-Ray %	Analyses[4] Fire assay-ICP ppm		Comments
				Zn	Cu	Pb	Co	Ba	Au	Ag	
118	35212	float grab		L1	180	270	150	L0.01	L0.007	0.770 *	andesite with mag and sulfides
119	35267	float grab		L1	13	* 49	L0.9	L0.01	L0.007	L0.3	qz breccia with py
120	35268	float grab	0.5	L1	510	* 49	15	L0.01	0.103	0.590 *	qz vein with sp and po

Map number	Sample field number	Sample type[1]	Sample length ft.	Analyses[2] units ppm unless marked %				Analyses[3] X-Ray %	Analyses[4] Fire assay-ICP ppm		Comments
				Zn	Cu	Pb	Co	Ba	Au	Ag	
21	35282	float grab	1.2 ft	44 %	1.5 %	0.16 %	L 0.9	2.9	0.34	44	banded massive sulfide boulder with sl and cp
22	35283	float grab		4.4 %	.14 %	90	L 0.9	16.3	Tr	17	banded massive sulfide-sulfate boulder ba, sl, py and cp
23	35284	float grab		31 %	.48 %	.17 %	L 0.9	8.9	Tr	51	banded massive sulfide boulder with sl, ba, py, gn and cp
24	35329	float rep. grab	1.5 ft	37 %	.28 %	.30 %	L 0.9	4.8	Tr	62	banded massive sulfide boulder with sl, cp and py
25	35278	float chip	2.4 ft	30 %	3.1 %	.14 %	L 0.9	4.5	.69	34	banded massive sulfide boulder with sl, cp, and py
	35333	float bulk		To	Albany						collected from massive sulfide boulder with sl, cp, py and ba
26	35340	float rep chip	2.4 ft	29 %	1.6 %	.25 %	L 0.9	12.8	Tr	45	banded massive sulfide boulder with sl, py, cp and ba
27	35280	rep. grab		630	250	32#	15	.3	Nil	Nil	chloritic phyllite with hematite
28	35293	float grab		28 %	3.2 %	660	L 0.9	12.7	Tr	48	banded massive sulfide-sulfate boulder with sl, ba and cp
29	35287	float grab		26	L 2	L 30	L 0.9	49	Tr	Tr	ba boulder
	35288	float rep. chip	1 ft	38 %	.87 %	530	L 0.9	5.9	Tr	45	banded massive sulfide boulder with sl, ba, cp and py
30	35289	float rep. chip	1 ft	30 %	.98 %	940	L 0.9	4.3	Tr	24	same as above
31	35290	float rep. chip	1 ft	20 %	.70 %	160	100	.65	Tr	21	same as above
32	35281	float rep. chip	6 ft	33 %	2.5 %	.11 %	L 0.9	5.0	Tr	65	banded massive sulfide boulder with sl, cp, gn, and py
33	35279	float grab		1.5 %	7.4 %	61#	L 0.9	.06	Tr	38	high grade of cp lens in qz calc vein
				guild 5 - cully 8							
34	35308	float grab	0.8 ft	.5 %	.53 %	36#	L 0.9	3.3	.34	14	calc boulder with ba, cp and sl ... pyritic phyllite inclusions
35	35291	float rep. chip	2 ft	8.3 %	1.1 %	.37 %	L 0.9	34	Tr	21	chlorite phyllite boulder with ba, sl, cp and py showing some banding
	35292	float rep. chip	1 ft	21 %	.87 %	.15 %	L 0.9	20.9	Tr	24	banded massive sulfide-sulfate boulder with sl, ba, py and cp
36	35309	float grab		8 %	.54 %	.84 %	L 0.9	44	Tr	27	banded ba boulder with sl, cp and gn
37	35310	float grab	.6 ft	10.9 %	1.1 %	.27 %	L 0.9	40	Tr	27	banded ba boulder with sl, cp and gn

38	35312	float grab	0.8 ft	10.0 %	400	0.61%	L 0.9	41	Tr	27	banded massive sulfide-sulfate boulder with ba, sl, gn and py
39	35311	float rep. grab	1.3 ft	260	33	31*	L 0.9	.10	Nil	3.4	altered tuff with banded py
40	35313	float grab		450	31	89	L 0.9	.13	Tr	3.4	altered silicified andesite with py
	35314	float grab		3.3%	840	1.2%	L 0.9	45	Nil	27	ba boulder with sl and gn
41	35319	float rep grab	.25 ft	29	160	490	20	.18	0.17	Tr	andesitic tuff + py
	35320	float grab		7.6 %	.53%	.65%	L 0.9	41	4.11	62	massive sulfate-sulfide boulder with ba, sl gn, cp and py showing some banding
	35321	float grab		35%	.36%	.16%	L 0.9	16.8	L 0.17	21	massive sulfide boulder with sl, ba, cp and py
					gully 9 - gully 10						
42	35315	float grab	.6 ft	850	2.1%	210	53	.09	Tr	34	banded massive sulfide boulder with cp and py
	35322	float grab		660	46	L 30	L 0.9	.07	Nil	3.4	chloritic phyllite with py
	35383	float grab	0.8 ft	.16%	.80%	200	64	.02	Tr	10	massive py boulder with cp + calc
43	35316	float grab		8.1%	.35%	.92%	L 0.9	40	.17	Tr	ba boulder with sl, cp, gn and py
44	35317	grab		410	670	110	L 0.9	.11	Tr	Tr	silicified tuff with ml and cp
45	35361	float grab	.05 ft	470	5.2%	49*	48	.03	Tr	17	chloritic phyllite boulder with 0.05 ft band of cp and ml
	35[illegible]	float rep chip	3 ft	360	.22%	40*	46	.04	Tr	Tr	above boulder with disseminated py + cp
46	[illegible]	float grab		1.3 %	700	0.50%	L 0.9	49	Tr	14	massive sulfide-sulfate boulder with ba, sl, gn and py
47	35[illegible]71ss	stream sediment	—	910	240	47*	47	.25	L 0.007	L 0.3	
					gully 10 + 11						
48	35379	grab	.3 ft	520	3.5%	52*	76	.07	Tr	Tr	cp, py, qz and calc [illegible] hosted in chloritic phyllite
	3[illegible]80	random chip		200	380	41*	50	.01	Nil	Nil	chloritic phyllite with py and mag, host rock for above sample
49	35[illegible]		—	...	—	—	—				

Map number	Sample field number	Sample type[1]	Sample length ft.	Analyses[2] units ppm unless marked %				Analyses[3] X-Ray %	Analyses[4] Fire assay-ICP ppm		Comments
				Zn	Cu	Pb	Co	Ba	Au	Ag	
50	35341	rep chip		280	170	43*	15	0.02	Nil	3.4	py schist with iron stain
51	35346	float grab		check 5.7	140	L 30	13	.07	Tr	3.4	muscovite phyllite with py
52	35342	float grab		L1	19	30*	18	11.4	Tr	Tr	muscovite schist with ba +py
	35343	float grab		64	1.1	L 30	23	.16	Tr	24	qz and phyllite
53	35345ss	stream sediment		300	170	54*	34	.14			
54	35344	grab		L1	51	39*	26	.02	Tr	Tr	phyllite with mag
55	35347	float grab		.96%	600	.37%	L0.9	38	.68	82	banded ba boulder with sl and gn
56	35350	float grab		.34%	220	.33%	L0.9	47	.34	.27	ba boulder with sl, gn and py
57	35351	float grab		L1	.57%	51	15	.40	Tr	Tr	qz calc vein with cp in phyllite
58	35349	float grab		L1	12	160	18	1.25	Tr	Tr	sericite phyllite with py
59	35377	random grab		west rib 620	33	.14%	29	.07	Tr	Tr	argillite with sulfides
60	35378	grab		510	65	0.13%	22	.03	Nil	Nil	altered tuff with mag and sulfides
61	35352	float grab	.3 ft	gully 18%	12 .36%	97	66	.40	Tr	6.9	chloritic phyllite boulder with band of disseminated and massive sl and cp
	35353	float grab		.30%	550	60	33	.34	Tr	Tr	chloritic phyllite with qz, sl, cp and py

Map number	Sample field number	Sample type[1]	Sample length ft.	Analuses[2] units ppm unless marked % Zn	Cu	Pb	Co	Analyses[3] X-Ray % Ba	Analyses[4] Fire assay-ICP ppm Au	Ag	Comments
				Glacier Creek Occurrences (fig 7) Main Deposit							
62	35106	grab	0.2	7.8%	0.89%	0.46%	8.4	45	L 0.007	6.118	ba with disseminated sl, cp, gn and py
	35107	chip	3.0	3.7%	1.2%	0.47%	17	22	0.607	14.12	ba with disseminated sl, cp, gn and py
	35107B	chip	2.0	0.19%	0.11%	0.22%	4.1	40	0.043	17.06	gossan
	35107C	chip	5.0	2.1%	0.65%	0.52%	6.1	38	Tr	116.6	ba with sl, cp, gn and py
	35108	high grade grab	0.4	3.0%	1.8%	0.18%	7.0	42	0.043	147.43	ba with sl, cp and ml
63	35109	grab		–	–	–	–	–	–	–	pyritic schist
	35110	grab		–	–	–	–	–	–	–	pyritic phyllite
	35111	grab		380	110	59 *	49	0.24%	L 0.007	L 0.3	
	35258	bulk		–	–	–	–	–	–	–	barite with sl, gn, cp, and py
64	35113	grab		L 1	180	L 30	69	0.68	L 0.007	L 0.3	sericite altered andesite with py
65	35114	grab		L 1	350	66 *	79	0.47	L 0.007	L 0.3	chlorite altered phyllite with py
	35115	grab		93	66	39 *	10	0.08	L 0.007	L 0.3	calc qz zone with py
66	35119	chip	0.3	L 1	120	L 30	16	0.01	L 0.007	L 0.3	iron stained qz vein hosted in andesite
	35119A	grab		L 1	61	34 *	49	0.06	L 0.007	L 0.3	chlorite epidote, altered pillow basalt with py
67	35112	chip bulk		–	–	–	–	–	–	–	Sandy ba
	35116	grab		1.9%	0.29%	52 *	56	0.12	L 0.007	0.560 *	metased. with sl, cp and smithsonite
68	35117	grab		–	–	–	–	–	–	–	calc with py and ml
	35118	chip bulk		–	–	–	–	–	–	–	ba with qz, ml and gn

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1. SS - Stream sediment sample
   PC - Panned concentrate sample
   Rep - Representative
   Rd - Random
   Chip means continuous chip

2. Zn, Cu, Pb, and Co analysis were by Inductively Coupled Plasma Analysis (ICP).

3. Ba analysis was by x-ray

4. Au, Ag analysis was by fire assay - ICP or by fire assay

Sample analyses were by the Bureau of Mines Research Center in Reno, Nevada and Bondar-Clegg Inc. of Lakewood, Colorado.

Units of measure abbreviation used:

ppm - parts per million
L - less than
G - greater than
nil - not detected
Tr - trace
% - percent

Mineral abbreviations used:

az	- azurite	gn	- galena
ba	- barite	hem	- hemitite
bn	- bornite	mag	- magnetite
calc	- calcite	ml	- malachite
chl	- chlorite	po	- pyrrhotite
cp	- chalcopyrite	py	- pyrite
cv	- covellite	qz	- quartz
ep	- epidote	sl	- sphalerite
		td	- tetrahedirite

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APPENDIX B

Reconnaissance geology of the Mt. Henry Clay area, Skagway B-4 Quadrangle, Alaska

Comments on the petrography of the Mt. Henry Clay, Windy Craggy, and Glacier Bay areas

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RECONNAISSANCE GEOLOGY

OF THE MT. HENRY CLAY AREA

SKAGWAY B-4 QUADRANGLE, ALASKA

Earl Redman

C.C. Hawley & Assoc.

SUMMARY

During 1983, the U.S. Bureau of Mines Alaska Field Office, initiated a program to explore the Mt. Henry Clay area (Figure 2) of the Skagway B-4 quadrangle for potential Windy Craggy-type cobalt mineralization associated with stratiform massive sulfide deposits in mafic volcanic rocks. Regional mapping completed for this program identified three volcanic and sedimentary sequences that have informally been called the Little Jarvis volcanic and sedimentary sequence, the Glacier Creek volcanic sequence and the Porcupine slate.

Rocks in the area are primarily basalt, andesite, slate, and limestone. The Little Jarvis sequence contains eight mappable units that include sections of limestone, slate, pillow basalt, and andesite. The Glacier Creek volcanics are composed primarily of basalt and andesite while the Porcupine slate forms a thick section of black slate that interfingers into both the Glacier Creek volcanic rocks and the Little Jarvis sequence. All layered rocks have been intruded by mid-Cretaceous diorite.

Stratiform barite/zinc-copper-lead mineralization is common and widespread within the Little Jarvis and Glacier Creek sequences. Volcanogenic mineral deposits are hosted in different units including basalt, andesite, felsite, and slate mixed with andesite.

INTRODUCTION

Development of the Windy Craggy stratiform copper/cobalt deposit in northwestern British Columbia has focused attention on a possible southeasterly continuation of the stratiform terrane in the Mt. Henry Clay area of Alaska. In 1983, Jan Still, of the U.S. Bureau of Mines, Alaska Field Office, initiated a program to explore the Mt. Henry Clay area for the strategic mineral cobalt using the Windy Craggy model. This report describes regional reconnaissance geologic mapping of the Mt. Henry Clay area done in association with Still's work.

Mapping by the Canadian Geological Survey (1) suggests that the Paleozoic sequences of pillow basalts and limey sediments at Windy Craggy and at Mt. Henry Clay are part of the same time-stratigraphic terrane and, therefore, that mineralization in both areas could be genetically related. Previous mapping on the Alaskan side of the border (2) is only partially correlative with the Canadian work but similar lithologies are associated with known mineral deposits in both countries.

This report and map were done to eliminate discrepancies in geology across the border and, in the Mt. Henry Clay area, to define the extent of the volcanic/limestone terrane containing stratiform deposits. Seven days of field work during a two month period covered approximately 55 square miles from the head of McKinley Creek west to the Canadian Border (Figure 2). Geology shown on Figure 2 should be considered to be of reconnaissance nature because of the short amount of time spent covering a relatively large area.

GEOLOGY

Geology of the Mt. Henry Clay area basically consists of three layered and sedimentary sequences intruded by several small bodies of diorite. The three layered sequences are herein informally called the Little Jarvis volcanic and sedimentary sequence, the Glacier Creek volcanic sequence, and the Porcupine slate. The Glacier Creek volcanics and the Porcupine slate have both been intruded by bodies of hornblende diorite. MacKevett and others (2) have called the rocks on the Alaskan side of the border Silurian to Permian while Campbell and Dodds (1) classify rocks on the Canadian side simply as Paleozoic. Rocks in the Mt. Henry Clay area are assumed to be from the mid to late Paleozoic. Age relations between the Glacier Creek volcanics and the Little Jarvis sequence are not certain but lithologic similarities, the widespread occurrence of stratiform barite, copper, lead, zinc mineralization, and the unifying effect of the intertonguing Porcupine slate, strongly support similar age for all units.

Strike of both bedding and foliation throughout the Mt. Henry Clay area is relatively parallel overall and average 110 degrees to 120 degrees. Dip of foliation, however, usually cross-cuts bedding. In the Little Jarvis area, for example, bedding dips variably to the south while foliation dips to the north.

ROCK TYPES

Little Jarvis Volcanic and Sedimentary Sequence

The Little Jarvis volcanic and sedimentary sequence underlies the area between Glacier Creek and the Jarvis Glacier north of the Little Jarvis fault (Figure 1). This sequence of eight mappable units, in apparent depositional contact with each other, dips moderately to steeply to the south. The units strike approximately 115 degrees with dips increasing from 45 degrees on the north to near vertical on the south. The individual units within the sequence, from bottom to top (north to south), are composed of: 1) limestone and slate (Pzls), 2) mostly andesitic volcanic rocks with minor black slate (Pzvs), 3) mostly black slate with minor limestone and andesitic volcanic rocks

(Pzsv), 4) mostly andesitic volcanic rocks with minor black slate (Pzva), 5) pillow basalt (Pzpb), 6) limestone with minor black slate (Pzl), 7) basalt (Pzba), and 8) andesite (Pza). The section is described as being upright but the only evidence supporting this idea is one graded bed in a conglomerate layer in the upper limestone unit (Pzl).

The lowest unit (Pzsl) is composed of massive to medium-bedded gray to black limestone and abundant to uncommon black slate. A few thin pale green fuchsite-bearing phyllites are associated with the limestones. Pyrite is locally present as discrete layers within the limestone.

The Pzvs and Pzva units are both dominantly andesitic volcanic rocks with sporadic interbeds of black slate and, rarely, limestone. A few layers of pillow basalt may also occur. The andesites are dark to medium green and usually contain pyrite cubes that can be as large as 0.5 inches. Stratiform areas of disseminated pyrite and pyrrhotite are oftaen common and form bright red and orange stained zones.

The Pzsv unit is composed of black slate with locally common gray to black limestone and andesite. Andesite may form up to 25% of the unit in some areas and frequently contain pyrite cubes. At the western end of this unit is the Jarvis Glacier Gulch mineral occurrence (~~number~~ mineral occurrence 6), where layers of stratiform and massive sulfides have been found ~~(number 6)~~. Pyrite is the most common mineral but sphalerite and galena are also present. Mineralization has been found over an area 0.4 miles along strike and 1000 feet across the unit.

Pillow basalts form the bulk of Pzpb but a few rare limestone beds are scattered throughout the section. The basalts are black, amygdaloidal or vesicular and form very conspicuous pillow structures.

Pillows are usually 1 to 3 feet across. Tops of flows are commonly scoriaceous and bottoms contain fragments of the underlying beds.

Limestone is the most common rock type in the Pzl unit although black slate, calcareous sandstone, and conglomerate also occur. The limestones are usually gray to buff but black and reddish beds are present locally. Fossils, usually as a mass of fragments, are abundant in some layers. A conglomerate layer near Point 5185 (Figure 2), which overlooks the Jarvis Glacier, contains graded beds that go from cobble conglomerate on the bottom to sandstone on the top. If this grading is a normal upward decrease in grain size then the whole Little Jarvis sequence is upright.

Basalt flows (Pzb) and andesite layers (Pza)outcrop just above the east branch of the Jarvis Glacier and cap the Little Jarvis sequence. The basalts locally form pillows.

The relationship of the Little Jarvis sequence to the Glacier Creek sequence is not well defined since the only identified contact is across the Little Jarvis fault. The Little Jarvis sequence may represent either a distal or a vertical facies change of the Glacier Creek volcanic sequence which contains similar volcanic rock types. The Porcupine slate apparently intertongues with the Little Jarvis sequence on the west side of Glacier Creek.

<u>Glacier Creek Volcanic Sequence</u>

The Glacier Creek volcanic sequence, as mapped, consists of five mappable units which, however, may be partially correlative with each other. The largest portion of this section is undivided and may contain parts of any or all of the remaining units. The defined units consist of 1) phyllitic felsic and andesitic volcanic rocks (Pzpf), 2) undivided basalt and andesite with minor sediments (Pzv), 3) phyllitic andesite and felsite (Pzpa), 4) basalt with minor black slate (Pzbs), and 5) basalt (Pzba). All observed contacts within this sequence appear to be depositional.

The Glacier Creek sequence is split by a southeast-trending fault. Rocks to the north of the fault form a broad anticline that plunges steeply northward. The rocks dip from 45 degrees to 65 degrees north to northwest. South of the fault the rocks form an open syncline with the north limb dipping about 25 degrees south and the southerly limb dipping 35 degrees to 40 degrees north. While the gross lithologic units dip moderately, their internal structure is much more chaotic with areas of strongly folded beds and cross-cutting foliation.

The Glacier Creek volcanic sequence interfingers to the south and east into the Porcupine slate. This interfingering can be notably abrupt and is vividly displayed in cliffs west of lower Boundary Glacier (on the Canadian side of the border). Long fingers of basalt also extend for several miles into the slates in the upper and middle reaches of Porcupine Creek.

The medium green to white phyllitic felsic and andesitic volcanic flows of the Pzpf unit outcrop west of Boundary Glacier. About 75% of the unit is made of phyllitic rocks and the remainder are more massive flows. The lower half of the unit consists of pale green to white phyllites in which a thin (1 foot thick) layer of barite containing rare, scattered sulfides was found (mineral occurrence 7). The Pzpf unit pinches and swells rapidly along strike and is apparently conformable above the Porcupine slate and below the undivided basalt and andesite unit. The Pzpa unit is similar lithologically and occupies a similar stratigraphic position, immediately below a thick series of basalt flows, as the Pzpf unit and may be correlative.

The large undivided basalt and andesite unit (Pzv) is composed primarily of basalt but also contains a large section of andesite in the upper Jarvis Glacier area below Mt. Henry Clay. Basaltic areas contain flows, pillow basalts and basaltic breccias and agglomerates as well as a few scattered limestone and chert beds. Vesicular and amygdaloidal rocks are common. The andesitic section is composed of medium to dark green flows and tuffaceous rocks. Contacts between the basalts and the andesite were not found in the field but are probably either gradational or interfingering.

The Pzv unit contains three known strataform sulfide deposits, the Nunatak prospect (mineral occurrence 2), the Hanging Glacier prospect on the north side of the Saksaia Glacier (minera occurrence 3),and the newly discovered Mt. Henry Clay deposit (mineral occurrence 5). The Nunatak deposit consists of massive stratabound barite layers and sparse sulfide mineralization in siliceous rocks within basalt and andesite. The Hanging Glacier lode is similar. The deposit near Mt. Henry Clay is a stratiform massive sulfide body up to 6 feet thick that contains up to 75% sphalerite and 15% chalcopyrite with some barite. The deposit lies within a thick andesitic section that dips at about 25 or 30 degrees to the south.

The phyllitic andesitic and felsic volcanic unit (Pzpa) outcrops north of the Saksaia Glacier and consists of green phyllite, a few massive green flows and occasional black slate. This unit contains the Cap deposit (mineral occurrence 4), a small stratiform, sulfide-bearing barite section. Like the Pzpf unit , the Pzpa unit overlies black slate and conformably underlies basalt.

The Pzbs unit consists primarily of amydaloidal or vesicular pillow basalts and basalt flows with occasional limestone and minor black slate. A siliceous portion of this unit hosts the Glacier Creek deposit (mineral occurrence 1) which is the richest part of a large stratiform barite, silver, lead, zinc, copper zone that can be readily traced for over a mile around the 6700 feet peak that separates Glacier Creek from the Little Jarvis Glacier. This basaltic unit may be correlative with part of the basaltic secton in the Pzv unit.

Unit 5 is a basaltic section that lies above a conspicuous contact that crosses the north face of Mt. Henry Clay and is easily traceable around the peak's east side to the head of the Herbert Glacier in Canada. The unit is probably conformable above the andesitic portion of the Pzv unit.

<u>Porcupine Slate</u>

The Porcupine slate is a thick sequence of black slate that extends eastward into the Skagway B-3 quadrangle (<u>2</u>). The unit is a monotonous section of thin-bedded and laminated slate (<u>2</u>). Limestone occurs within the slate to the east of the Mt. Henry Clay area (<u>2</u>) as and below Flower Mtn. In upper Porcupine Creek, the slate has been intruded by a diorite stock which has hornfelsed the slate to a dense, brittle rock with poor cleavage and widespread iron-staining. Hornfelsing extends as much as 1500 feet out from the stock.

<u>Hornblende Diorite</u>

A small stock of hornblende diorite with several satellite bodies outcrops in the Glacier Creek, Porcupine Creek, McKinley Creek area. Most of the diorite intrudes the slate but two small bodies intrude the Glacier Creek volcanic sequence. The rock is medium-grained and consists of about 20% to 25% hornblende, locally replaced in part by epidote, and 75% to 80% plagioclase. Contacts with the hornfelsed slate are sharp and can be observed readily from a distance because of the distinct color contrast, light gray for the diorite and black with red iron-stain for the hornfelsed slates. MacKevett and others (2) dated the diorite as being of mid-Cretaceous age (119 m.y.).

STRUCTURE

Five faults, most probably normal, were mapped in the Mt. Henry Clay area. All but one of the faults trend to the west or west northwest. Foliation and bedding are roughly parallel to the westnorthwest trend.

The Little Jarvis fault is the most significant in the area. It trends east-west and juxtaposes the Little Jarvis volcanic and sedimentary sequence against the Glacier Creek volcanic sequence. The fault appears to dip steeply north and the north side has probably been dropped down relative to the south. The Glacier Creek prospect is truncated by the fault above Glacier Creek. Magnitude of offset on the fault can only be speculative but is probably at least 2000 feet.

Other faults in the area may have significant offset but they occur within units and do not juxtapose differing lithologies. The fault that cuts through rocks of the Little Jarvis sequence is a reverse fault that dips steeply north and has dropped rock units on the south by about 600 feet.

The east-west trending fault under the Jarvis and Saskaia Glaciers appears to be downdropped to the north because the phyllitic and felsic volcanic unit (Pzpa) is juxtaposed against the andesite and basalt of the Pzv unit. Offset is probably at least 2000 feet.

Two faults, including the Jarvis/Saskaia Glacier structure above, appear to be truncated by the diorite pluton. In both cases, however, the intersection of the fault with the diorite was examined only briefly and the relationship is uncertain, although there was no obvious offset of the plutonic margin.

Two large folds, an anticline and a syncline, were identified in the Glacier Creek volcanic sequence. The anticline is little more than a broad warp in the volcanics that plunges steeply northwest. The syncline at the head of the Saksaia Glacier has an uncertain plunge but has limbs that steepen toward the axis of the fold.

While foliation and bedding of all rocks have roughly parallel strike, dips are distinctly different. In many areas of all units, foliation was seen to cross-cut obvious bedding in the rocks. For the most part, foliation dipped steeply either to the north or to the south while bedding dipped moderately in the same directions. Foliation at the Henry Clay prospect forms a deep, tight syncline with limbs dipping about 65 degrees north and south respectively while the general bedding in the area dipped about 30 degrees to the south. At another location above Boundary Glacier well-bedded phyllites dipped 37 degrees to the north but foliation dipped 74 degrees to the north.

COMMENTS ON THE PETROGRAPHY OF THE MT. HENRY CLAY REGION, WINDY CRAGGY AND GLACIER BAY

Earl Redman

Mt. Henry Clay Region

Rock of the Mt. Henry Clay region are strongly altered in the greenschist facies. Most of the rocks examined were, based on hand sample idenification, of probable andesitic and basaltic composition. These rocks included pillow basalts, basaltic agglomerate, basaltic tuff, andesitic flows and andesitic tuffs. Locally, felsic volcanic rocks and a variety of clastic (in part volcaniclastic) and chemical sediments were also present.

Regionally, the intermediate to mafic volcanic rocks are presently composed of plagioclase and chlorite with lesser epidote. The feldspars commonly form euhedral laths and display a diabasic texture. Chlorite and epidote usually occur within the plagioclase crystals. Calcite is not uncommon. No hornblende or augite were seen anywhere within the volcanic sequence. All mafic minerals have been converted to chlorite and epidote.

Felsic volcanic rocks have been metamorphosed to rocks consisting of quartz and sericite with highly variable plagioclase content.

All rocks display a good microscopic foliation formed by chlorite an epidote although this foliation is not always obvious in outcrop. Quartz grains may also be elongated parallel to foliation.

Mineral deposits throughout the Mt. Henry Clay region have a common sequence of crystallization. Barite, quartz and pyrite crystallized first. Pyrrhotite, if present, crystallized next followed by chalcopyrite. Galena and, locally, bornite were the next minerals to form. Sphalerite was the final primary ore mineral to form although secondary covellite locally formed later.

Barite, quartz and pyrite all crystallized at about the same time. Barite, however, was commonly more abundant in the system and engulfed the euhedral grains of quartz and pyite. Pyrite almost always has euhedral crystals scattered amoung anhedral masses. It is not uncommon for the corners on pyrite cubes to be rounded.

Pyrrhotite was identified only at the Jarvis Glacier Gulch occurence where it crystallized after pyrite and before chalcopyrite.

Chalcopyrite was the first ore mineral to crystallize. It is commonly found in fractures in pyrite and as interstital grains within the barite.

Galena and bornite crystallized at about the same time, although bornite may be slightly younger. Galena can occur both by the replacement of chalcopyrite and as an interstitial filling. Bornite, found only at the Glacier Creek deposit, forms primarily as interstitial grains and is usually surrounded by secondary covellite.

Sphalerite was the final primary ore mineral to form. It can be found replacing sphalerite and galena, and as irregular masses and interstitial fillings. Sphalerite may also replace barite in some areas.

In most of the thin sections examined, the sulfide minerals are interstitial to barite and quartz. As mentioned above, sphalerite was seen to replace barite and quartz in a few areas. At least one sample of massive sulfide from the Mt. Henry Clay deposit exhibits large scale replacement of the gangue minerals. In this sample the barite/quartz occurs as small bits and pieces with the rounded and curved boundaries indicative of replacement..

Oxidation of the sulfide minerals varies from nil to nearly total. Most of the bornite has been altered to covellite. In samples with bornite, galena and sphalerite have also been partially altered to covellite. Chalcopyrite in some samples has also been converted to covellite on its margins.

Iron oxides (primarily goethite) are well developed in some areas but poorly developed in others. Most samples from Jarvis Glacier Gulch and half of those from Glacier Creek show significant goethite developement. At Jarvis Glacier Gulch, sphalerite has been extensively replaced by geothite. At the other mineral localities, goethite occurs mainly as thin coatings on the margins of sulfide grains or as replacement along fractures and cleavage.

Windy Craggy

The Windy Craggy area is different from the Mt. Henry Clay region. Metamorphism is not as pervasive or as strong in the Windy Craggy area. Rocks are now composed of altered plagioclase, relict hornblende, chlorite and some edidote. Hornblende, although present, is strongly altered to chlorite and actinolite.

The primary sulfide minerals at Windy Craggy are pyrite and pyrrhotite with minor chalcopyrite and uncommon sphalerite. Pyrite is the oldest sulfide and forms large, anhedral masses with abundant open spaces that are bordered by pyrite cubes. These open spaces were later filled with pyrrhotite. Chalcopyrite may have crystallized both before and after the pyrrhotite. In some sections pyrrhotite seems to have replaced chalcopyrite and in other sections the reverse appears to be true. Sphalerite was always the last sulfide mineral to form and occurs as interstitial grains.

Glacier Bay

Volcanic rocks in the Glacier Bay area exhibit similar metamorphic grade and mineralogy to those in the Mt. Henry Clay region, Basalts have been altered to plagioclase, epidote and chlorite with none of the original mafic minerals remaining. Epidote pods and stingers were common in outcrop. Amygdals within the basalt are filled with chlorite and the zeolite thompsonite.

The area examined at Glacier Bay contained several breccia zones that were probably associated with deposition of the basalt flows. These breccias consist of silicified fragments cemented by silica or calcite. Locally, pyrite is common in the breccia matrix.

A general comment on the Glacier Bay area. Most of the mineralization observed occurred in a thick limestone sequence a few hundred feet from the main basalt contact. About a hundred feet of basaltic flows were interbedded with the limestone along this horizon and mineralization is probably associated with this volcanism. If the beds in the area are upright, then this thin zone of volcanic rock may be the precursor to the main volcanic event. The White Glacier mineral occurrence lies along this same horizon.

DRAFT

APPENDIX C

Metallurgical Testing of a Windy Craggy deposit test sample

DRAFT

United States Department of the Interior
BUREAU OF MINES
P. O. BOX 70
ALBANY, OREGON 97321

May 18, 1983

Memorandum

To: Jan Still, Geologist, Alaska Field Operations Center

From: Metallurgist, Minerals Engineering, Albany Research Center

Subject: Results of tests on Klukwan and Falconbridge Windy-Craggy sulfide samples

The results of bulk sulfide flotation tests on two samples from sulfide-enriched zones in the Klukwan titaniferous magnetite deposit are shown below. In each test, the sample was ground to minus 150 mesh, and a rougher and a scavenger bulk sulfide float was done with potassium amyl xanthate collector and a frother. As the results indicate, the precious metals concentrated with the sulfide minerals.

Product	Wt pct	Analysis, pct		Analysis, oz/ton				Distribution, pct	
		Cu	S	Pt	Pd	Au	Ag	Cu	S
AFOC No. 2S193-2S194-2S195									
Rougher concentrate	1.0	23.8	17.4	0.055	0.056	0.037	0.89	70.0	87.5
Scavenger concentrate	2.6	.81	.45	.009	.005	.003	.12	6.2	6.0
Tailings	96.4	.084	.013	.006	.023	.000	<.02	23.8	6.5
Calculated head	100.0	.34	.20					100.0	100.0
AFOC No. 2S222									
Rougher concentrate	1.0	6.60	6.34	0.150	0.279	0.078	0.91	54.6	81.8
Scavenger concentrate	1.7	.47	.25	.007	.006	.007	.06	6.6	5.2
Tailings	97.3	.048	.010	<.0006	.003	<.0004	<.02	38.8	13.0
Calculated head	100.0	.12	.08					100.0	100.0

A copy of a memorandum from Tom Carnahan to Larry Brown concerning the results of a cursory chlorine-oxygen leach test on the Windy-Craggy complex sulfide is enclosed. As we have said earlier, attempts at concentration by flotation have been unsuccessful, and this test was done to investigate the amenability of the sample to the process devised at Reno Research Center under the project, "Chemical Treatment of Complex Sulfides." Although 85 pct of the cobalt and 95 pct of the copper reported to the filtrate and wash solutions, the low grade of the material would make the process uneconomical according to Carnahan.

David C. Dahlin
D. C. Dahlin

Enclosure

United States Department of the Interior
BUREAU OF MINES
RENO RESEARCH CENTER
1605 EVANS AVENUE
RENO, NEVADA 89512

May 11, 1983

Memorandum

To: Lawrence L. Brown, Group Supervisor/Geologist, Albany Research center

From: Research Supervisor, Reno Research Center

Subject: Falconbridge Windy-Craggy complex sulfide, Albany Sample Number ME-1463

A cursory chlorine-oxygen leach on the subject Alaskan sample, which contained 0.46 pct Cu, 0.21 pct Co, 0.03 pct Zn, 55.3 pct Fe, and 35.1 pct S, was conducted. Analysis of the test products are shown in table 1. Table 2 shows the metals distribution. The chlorine-oxygen test was conducted at 110° C and 50 psig with O_2. The chlorine source was HCl and $CaCl_2$. An excess of hydrochloric acid was used and oxidation of iron sulfide to sulfate resulted in 20 pct of the iron going into solution. With additional tests, good copper and cobalt extractions could be achieved without leaving iron in solution. Methods for recovering copper and cobalt from solution could be developed. However, in view of the low grade nature of this ore, I do not believe any hydrometallurgical approach for recovering values from this ore would be economical. Working out a process for this material would be primarily for academic interest.

T. G. Carnahan

T. G. Carnahan

Enclosure

TABLE 1. - Analysis, percent

	Cu	Co	Zn	Fe	$SO_4^=$	S°	$S^=$	Ca
Filtrate, g/l	2.3	0.80	5.1	61	45	-	-	1.4
Wash, g/l	.34	.12	10	11	11	-	-	1.0
Residue, pct	.024	.028	<.001	43.3	14.8	17.0	2.79	5.0

TABLE 2. - Distribution, pct

	Cu	Co	Zn	Fe	$SO_4^=$	S_{total}	Ca
Filtrate	46.5	40.8	>6	10.3	15.8	4.9	2.2
Wash	49.1	43.7	87	10.6	27.6	8.4	11.3
Residue	4.4	15.5	<7	79.1	56.6	86.7	86.5

APPENDIX D

Portions of a report supplied by Stryker Resources (<u>12</u>)
concerning 1983 discoveries of stratiform mineralization
in Canada adjacent to the Mt. Henry Clay area

DRAFT

DESCRIPTION OF SHOWINGS, TSIRKU AREA

1X Low Herbert

A prominent gossan occurs on the west side of the Herbert Glacier just at and above the ice level four kilometres from the glacier's mouth. The light colored gossan, with a maximum thickness of one hundred metres, appears interfingered with and overlain by dark green pillow basalts. The showing,which was trenched, is ice covered two hundred metres south of the main exposure, but is traceable for at least five hundred metres to the north before being covered by ice. At this latter point the valley and glacier trend west and small portions (windows) of the gossanous horizon appear above the ice for over one kilometre further up the valley. These extensions have not been examined to date.

The main part of the showing is brightly marked by yellow, red and orange ferricrete which, together with a strong sulfur odor, suggests a high sulfide content. Disseminated chalcopyrite, barite and galena were observed in trenched portions of the showing. The distribution of these sulfides in not homogeneous nor do they necessarily occur together. Fine grained pyrite is ubiquitous.

The host rock consists of a grey, very siliceous, highly pyritic talc-sericite schist. Small siliceous clasts up to five centimetres in diameter are abundant and weather in relief from a matrix that contains as much as eighty per cent fine grained pyrite. The textures and the composition of the rock suggest that this showing represents an environment of deposition close to a vent or hydrothermal flue.

A seventeen metre trench was blasted above and in the ferricrete at the top of the showing approximately perpendicular to strike. The average assay over seventeen metres for silver was 0.34 ounce per ton, gold 0.01 ounce per ton and cobalt 0.004 per cent. Other metal values were erratic with zinc attaining a high of 2.08 per cent. A five metre chip sample of pyritic andesite adjacent to the gossan assayed 2.15 per cent copper and 0.33 ounce per ton silver. This interesting zone has been inadequately explored and requires a far more detailed examination.

To gain future access to the Low Herbert showing it should be a relatively inexpensive project to construct a glacier-supported road up the Tsirku and Herbert Glaciers as the gradient of the ice is relatively gentle with few small cracks or crevasses developed. Alluvium in the Tsirku river drainage would provide excellent roadbuilding material for an access route that would join the Haines Highway thirty-five kilometres away.

Water for drilling purposes would be readily available at the foot of the showing in crevasses which have ponded, or, under extreme conditions, may be flown in by helicopter.

2x HIGH JARVIS SHOWING

A stratiform band of massive pyrite and sphalerite was discovered near a peak south of the junction of the Jarvis Glacier and its second southern tributary.

A mineralized calcareous bed was traced for thirty metres being interupted by a gabbro instrusive to the southeast and disappearing under talus to the northwest where it may be displaced by a steep fault. The mineralized band attains a maximum width of two metres and was emplaced in well bedded limestone, silty limestone, siltstone, and a light colored tuffaceous material. Although the mineralization occurs in close proximity to a large, coarse grained gabbro intrusive, the emplacement of the sulfides is apparently not a replacement phenomena if the lack of accompanying alterstion is a guide.

A seventeen metre chip sample was taken, ane metre of which assayed 7.64 per cent zinc. The average assay across seven metres was 0.20 ounce per ton silver and 0.010 ounce per ton gold.

3X HERBERT MOUTH WEST

On the west side of Herbert Glacier, near its mouth, a near vertical zone of light colored, rusty weathering acidic or intermediate volcaniclastics was explored. The zone extends from beneath Herbert Glacier to the top of a steep slope and disappears under the ice of a hanging glacier. This unit contains an abundance of disseminated and locally massive pyrite occurring as pods. It is contained within the pillowed basalts not far from the base of the volcanic sequence. The assumed exhalatives occur at roughly the same stratigraphic horizon as the Herbert Mouth East showing. One grab sample of massive pyrrhotite float near the top of the hill just below the ice assayed: 0.466 ounce per ton gold, 0.129 per cent cobalt with 0.32 ounce per ton silver. A grab sample of pyritic siliceous sediment assayed 0.183 ounce per ton gold and 0.35 ounce per ton silver.

4X HERBERT MOUTH EAST

A prospect was discovered about one hundred metres above the ice on the east side of Herbert Glacier near its junction with the Tsirku. It was briefly visited and only two samples were taken. The showing occurs in a large lense of sediments and pyroclastics enclosed within fresh, unaltered pillow basalts. The mineralization occurs in a light green weathering, andesitic volcaniclastic about fifteen metres thick and consists of pyrite, pyrrhotite, minor chalcopyrite and sphalerite. Both samples assayed 0.25 ounce per ton silver. Cobalt values were 0.017 per cent and 0.010 per cent. The lense is traceable for one hundred and fifty metres pinching out to the south and apparently downfaulted under the Herbert Glacier to the north. The mineralized andesite is overlain by a continuous bed of siliceous massive pyrite and pyrrhotite forty seven centimetres wide and assaying 0.25 ounce per ton silver. This mineralized rock is overlain in turn by about fifteen metres of black, carbonaceous shale. A unit of rusty weathering pillow basalt overlies the shale and is succeeded by fresh pillow basalts to the top of the cliff.

5X HIGH HERBERT NORTH

Shaley sediments overlain by interbedded rhyolite, dacite and andesite pyroclastics occur in a saddle to the south of Mount Henry Clay. This sequence is succeeded by pillowed basalts. Mineralized volcaniclastics form a large, white, rusty weathering gossan which is a minimum of thirty-five metres thick. The mineralized strata disappear under the ice on strike both east and west of the showing. Other mineralization consists of galena in quartz veinlets and stringers in chert beds above the bergschrund. Two chip samples yielded high background silver values of 0.20 ounce per ton. Lead values were measurable but less than one per cent.

In the saddle, a ten metre thick bed of light green andesite tuff is stained on the surface with small patches of malachite. It contained disseminated pyribe and chalcopyrite along with a profusion of pyritic microfractures. A grab sample of this rock assayed 1.36 per cent copper, 0.40 ounce per ton silver and 0.033 ounce per ton gold. The values for lead and zinc are negligible. An outcrop of malachite-stained talc schist contained no visible sulfides but assayed 3.11 per cent zinc and 0.25 ounce per ton silver.

In the overlying basalts an inaccessible rusty weathering zone with malachite stain was noted.

6X GRIZZLY HEIGHTS

The south facing slope between Herbert and Buckwell Glaciers is referred to as Grizzly Heights. The lower slopes consist of well bedded, east-west striking sediments. A number of small hanging glaciers lie on the upper slopes, concealing the geology at the base of the basalts. Knife edged, inter-cirque ridges have exposed the outcrop. These exposures indicate that the vertical gossan of Herbert Mouth West extends all the way to the Buckwell Glacier, a distance of six kilometres.

Sediment sampling of the streams which drain the hanging glaciers and descend the south-facing slope have yielded anomalous copper values coincident with the occurrence of massive pyrite and pyrrhotite boulders. Values for copper in these boulders were less than one per cent. Cobalt values averaged 0.016 per cent. A twenty centimetre wide vein of quartz and pyrrhotite assayed 0.344 ounce per ton gold and 0.42 ounce per ton of silver.