UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

SUMMARY OF ECONOMIC GEOLOGY DATA FOR THE GLACIER PEAK WILDERNESS, CHELAN, SNOHOMISH, AND SKAGIT COUNTIES, WASHINGTON

By

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INTRODUCTION

Initial prospecting in the vicinity of the Glacier Peak Wilderness area (fig. 1) probably began in the late 1880's. The first claims in the Holden Mine area were located in 1892. The first claims in the Glacier Peak (i.e., Miner's Ridge) and Red Mountain (Trinity) areas were located about 1900. During the period from 1890-1900, most of the Pb-Ag vein occurrences in the Cascade Pass district were located and worked with apparent little success.

After this initial flurry of prospecting, most of the activity in the area was confined to exploration and/or development on the Holden, Glacier Peak and Red Mountain properties. Howe Sound Company, in conjunction with their Holden Mine operation, conducted fairly detailed reconnaissance examinations of all exposed mineralized showings within a several mile radius of Holden. The results of this work are summarized in a series of private Howe Sound reports now owned by Bear Creek Mining Company (domestic exploration subsidiary of Kennecott Corporation). As a direct result of their interest in the Glacier Peak deposit, Bear Creek conducted an extensive reconnaissance program of the now Glacier Peak Wilderness area during the period from 1956 through 1963.

The only significant mining venture which took place in the general area of interest (immediately east of the Wilderness boundary in the Railroad Creek drainage) was the Holden Mine. According to Howe Sound records, total production during the period from 1938 through 1955 was 10,148,222 tons with a recoverable production grade of 1.02% Cu, 0.21% Zn (1942-1955 only), 0.058 oz/ton Au and 0.203 oz/ton Ag. The mine closed in 1957. No production figures for the final two years of operation are present in the Bear Creek files.

The Glacier Peak porphyry copper system has been extensively explored but no production has been achieved. Pre-Bear Creek drilling activity is summarized below.

Company	Date	No. of Holes	Total Footage
Minerals Separation Co.	1918	3	1,986
Hanna C. & O. Co.	1937-1941	32	19,036
International S. & R. (Lease from Hanna)	1942-1943	9	6,765

Bear Creek optioned the property in 1954. Title to the property was acquired by Ridge Mining Company (a wholly-owned Kennecott subsidiary formed specifically as a holding and operating entity for the Glacier Peak deposit) in 1959 upon completion of the option payment installment schedule.

From 1954-1956, Bear Creek drilled 18 holes for a total aggregate footage of 13,852'. In 1959, they drilled an additional 13 holes for a total footage of 9,972'. Several additional holes have been drilled during the 1962, 1968 and 1970 field seasons for a total aggregate footage of 5,587'.

In 1956, Bear Creek drilled 5 holes in the Mt. Buckindy area for a total aggregate footage of 2,280.5'.

Immediately south of the Wilderness boundary near the junction of Phelps Creek and the Chiwawa River, the Red Mountain (Trinity) deposit has been

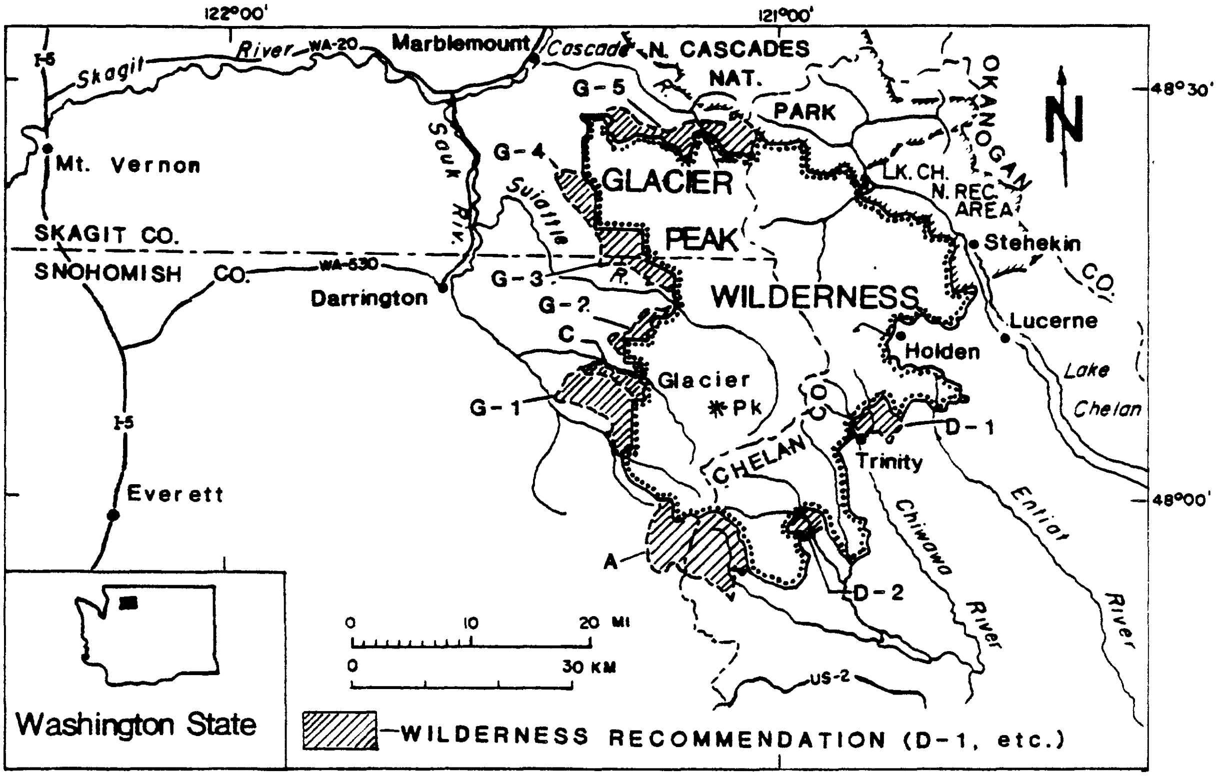

Figure 1.--Index map showing location of Glacier Peak Wilderness.

explored by several companies during the period from 1902 to present. The property has been explored by greater than 12,000' of drift and crosscut and an unknown amount of drilling. Recorded production (1936-1940) is 15,837 tons of unknown grade. Approximately 2,000,000 tons of inferred Cu, Ag ore could be present in several small breccia pipes.

METHOD OF INVESTIGATION

Most of the information presented in this report was obtained directly from the exploration files of Bear Creek Mining Company. During February, 1980, I spent several days in Bear Creek's Spokane office reviewing their data on exploration results at Glacier Peak, Buckindy, Fortress Mountain and elsewhere in the Glacier Peak Wilderness. Arrangements for this review were made by Dr. A. B. Ford of the U.S. Geological Survey. In every aspect of this part of the research investigation, Bear Creek personnel were most cooperative. Special thanks are due Mr. R. C. Babcock, Jr., Vice President, Bear Creek Mining Company; and Mr. Phil Fikkan, Sr. Geologist for Bear Creek. Permission for release of Bear Creek data used in this report was granted by Mr. Babcock (written commun., July 17, 1980).

Other data sources used in the preparation of this report include several private reports written by Howe Sound geologists during the Holden production period and the Washington State Division of Geology and Earth Resources files in Olympia.

During the period from 1959 through 1964, I was employed as an exploration geologist by Bear Creek. My principal responsibility was the direction of base metal exploration projects in the Washington Cascades. Specifically, during the period from 1959 to 1961, the main emphasis of field work was reconnaissance exploration within the Glacier Peak Wilderness in an attempt to discover deposits similar to the Glacier Peak porphyry copper system on Miner's Ridge. Many of my interpretations presented in this report are a direct result of observations made during this period of time. Subsequent to my leaving Bear Creek in 1965, I expanded on the economic geology concepts of the Glacier Peak area (Grant, 1969).

Specific property information, locations of mineralized areas, geochemical data and some geologic background data are shown on the accompanying map. In some instances, prospect locations are approximate due to the imprecise description in the literature. No attempt was made to plot all the background geologic information, as this was outside the scope of my investigation and presentation of economic geology data.

SUMMARY OF BEDROCK AND ECONOMIC GEOLOGY - NORTH CASCADE RANGE

Regional Geologic Relationships

The Cascade Range of Washington can be subdivided into two major geologic provinces; namely, the Northern and South-Central Cascades. This report will deal only with the North Cascade province. The Northern Cascade province consists primarily of a metamorphic-plutonic crystalline core, fault-bounded on both the east and west sides by dominantly pre-Tertiary marine and continental rocks. According to Misch (1966), the crystalline core rocks consist of 1) pre-Middle Devonian crystallines, 2) pre-Cascade Metamorphism intrusive plutons, 3) crystalline rocks produced during the Cascade Metamorphic cycle, and 4) plutonic rocks intruded during the Upper Cretaceous-Tertiary period of granitic evolution. In a recent summary of Cascade radiometric dating, Engels and others (1976) report a wide variety of dates for rocks belonging to each of the above mentioned groups. Of these, the most surprising are those reflecting the age of the pre-Middle Devonian meta-igneous rocks and those reflecting the age of rocks produced during Cascade Metamorphism. Mattinson (1972) determined that the oldest ages were those representing the crystallization of the parent plutonic rocks of the Yellow Aster Complex. There, assignment to Precambrian events is based on dates ranging from 1,452 m.y. to as great as 2,000 m.y. Somewhat concurrently, deposition of the volcaniclastic parent strata of the Swakane Gneiss and possibly the Skagit Gneiss may have occurred >1,650 m.y. ago. Intense regional metamorphism of these rocks occurred about 415-460 m.y. ago. This crystalline complex was uplifted, eroded and buried by middle Paleozoic and younger supracrustal rocks in part derived from the older crystallines. Deposition of these rocks was followed by the emplacement of numerous complex plutons into the Precambrian and Caledonian crystalline core about 220 m.y. ago. Regional metamorphism accompanied by synkinematic igneous activity occurred between 60-90 m.y. ago. This event was responsible for granitization, migmatization and mobilization from pre-existing plutonic and supracrustal rocks. Concurrent with the Cascade Metamorphic event was the beginning of an extended period of granitic evolution resulting in the emplacement of Upper Cretaceous-Tertiary intrusive masses both in the North Cascade and the South-Central Cascade provinces. Because of the direct association between this period of intrusive activity and base metal deposition in the Range, discussion of the Cretaceous and Tertiary plutons will be presented as a separate section in this report.

Both flanks of the crystalline core are predominantly underlain by low-grade to essentially unmetamorphosed sedimentary and volcanic eugeosynclinal strata. The complexities of these flanking sections are further complicated by major structural juxtaposition. Misch (1973), in his paper on The North Cascades in Geotectonic Perspective, summarizes the implications of the large scale structural features. On the west side of the crystalline core, mid-Cretaceous thrusting involves 1) the Shuksan thrust which brought phyllite and greenschist of the Shuksan Metamorphic Suite over Paleozoic rocks, and 2) the Church Mountain thrust which brought Paleozoic rocks over Mesozoic rocks. The root of these great thrust systems is steep, and Misch suggests it may extend down to the upper mantle. The western thrust system does not coincide with the boundary between the oceanic and continental crust but rather lies well west of the boundary. Evidence for this is based on the presence of Precambrian continental basement rocks within the root zone and below the western autochthonous plate.

On the east side of the crystalline core, the complex Ross Lake-Hozomeen fault zone was active up through late Cretaceous. The fault system is hundreds of miles long and is postulated to extend down into the upper mantle based on the presence of serpentinized and tectonized peridotites which appear to have come up along the root zone.

Misch (1973) considers these two principal tectonic systems are major fundamental crustal fractures and not geosutures in the plate-tectonic sense. He does not believe that all the major tectonic, metamorphic and igneous action which has occurred in the Northern Cascades should be related to the oceanic interface with the continental crust. As will be discussed later, however, the association between Cascade transverse linears and the distribution of major sulfide systems is suspect of being related to lower plate discontinuities.

A transitional sub-province separates the North and South-Central provinces. Within this transitional zone, tectonic slices of North Cascade crystallines are juxtaposed into the Tertiary section. Weakly metamorphosed Paleozoic and Mesozoic supracrustal rocks are common in the western transitional zone. On the eastern side of the transitional sub-province, pre-Tertiary ultramafic rocks of nearly batholithic dimension intrude both supracrustal and crystalline core rocks. Continental clastics, in part derived from the northern crystalline terrain, comprise a relatively thick, yet now erratically distributed supracrustal unit unconformably overlying the crystallines and other pre-Tertiary rocks. Widespread Upper Cretaceous and Tertiary intrusive activity has occurred within this sub-province.

Upper Cretaceous-Tertiary Intrusive Activity

Radiometric dating by Mattinson (1972) indicates the pre-existing plutonic and supracrustal rocks were subjected to regional metamorphism approximately 60-90 m.y. ago. Concurrently, this event triggered a period of igneous pulses which have continued until recent times as manifested by historical eruptions and thermal activity on the Quaternary Cascade volcanoes. The magnitude of this extended period of thermal activity is reflected in some radiometric dates of 43-48 m.y. reported by Kulp (1961), Misch (1964), and Richards and White (1970) for biotite, hornblende and apatite in Skagit Gneiss rocks which were produced during the middle to late Cretaceous regional metamorphism. Mattinson (1972) believes these ages suggest that the regionally metamorphosed rocks remained deeply buried at elevated temperatures well into the Tertiary period. This theory is certainly compatible with evidence for anatectic origin of some of the batholiths in the Northern Cascades. I suggest the Tertiary Cascade intrusions are dominantly a product of palingenesis from pre-existing crystallines. As a result, upward migration of North Cascade intrusions, as now exposed, is probably negligible as compared to the South-Central Cascade intrusions where high level emplacement and local breaching to surface has occurred. As will be discussed, these differences in spatial levels are important factors in the interpretation and evaluation of Cascade sulfide systems.

Most of the Cascade intrusions have a composite magmatic history. Typically, the main-phase is calc-alkaline and granodioritic-quartz dioritic in composition. Subordinate dioritic to nearly gabbroic rocks commonly precede the main-phase in some of the batholithic masses. Most of these early rocks were subsequently assimilated in the rising magma front resulting in the ubiquitous presence of mafic fragments in main-phase rocks. Post main-phase elements consist of leucogranites, quartz monzonites and, more rarely, syenites. Increasing evidence suggests that weak compositional zoning from mafic peripheries to felsic cores does exist in many plutons. The deep felsic core zone is considered to be the most probable source for K and Si introduced to upper levels during hydrothermal alteration events associated with the development of Cascade type porphyry copper systems.

In the north part of the Northern Cascades, Misch (1966) has separated the post-regional metamorphism intrusions into two main belts. The eastern belt includes those plutons which rose along the Ross Lake-Hozomeen fault zone. The oldest rocks, those of the granodioritic Black Peak batholith, have been radiometrically dated at 72-88 m.y. (Misch, 1963). The western intrusive belt includes the Chilliwack batholith, the main phase of which has been dated over a range of 31-50 m.y. (Misch, 1963, 1966; and Engels and others, 1976). The eastern Perry Creek phase yields an age range of 22-31 m.y. North of the 49th parallel, Baadsgaard and others (1961) reported K-Ar dates of 18 m.y. for a northwestern lobe of the Chilliwack batholith. South of the Chilliwack batholith, Misch (1963) and Engels and others (1976) report K-Ar dates of 18 m.y. for the Cascade Pass transverse pluton. The southernmost intrusion within the North Cascade province is the Cloudy Pass batholith which has been dated as 20-30 m.y old (Tabor and Crowder, 1969).

Although some significant sulfide systems are associated with the North Cascade core plutons, the majority of the major occurrences are situated either within the transitional sub-province or in the South-Central geologic province. The composite nature of many of the larger intrusive masses within these areas presents some problems in geochronologic correlation. Nevertheless, based on available information, the higher level intrusions appear to be considerably younger than their North Cascade counterparts. This age differential is thought mainly to reflect time lags between palingenetic plutonism within the crystalline core or in subjacent crystallines below the unmetamorphed supracrustal cover and the upward migrating magma front reaching intermediate to high levels in the overlying stratigraphic section.

Figure 2 shows the location of the major plutons in the Washington Cascades.

Evidence suggests that a direct association exists in the Cascade Range between the upper Cretaceous-Tertiary intrusions and major porphyry copper systems. I do not necessarily advocate that subduction tectonics are related to the development of the great period of granitic evolution in the Cascades. At the same time, however, such consideration cannot be ruled out. Sillitoe (1975) summarizes the relationship of subduction tectonics to porphyry copper systems in Southwestern North America. He considers that porphyry copper deposits are generated in stocks beneath cogenetic calc-alkaline volcanic piles. Calc-alkaline magmatic rocks are thought to be characteristic of belts of plate convergence above subduction zones. The SW porphyry copper formation appears to have ended in early Miocene when the subduction activity in that region ceased. Energy transfer to the west and northwest could well have resulted. Certainly in the NW, this time is roughly coincident with the great period of calc-alkaline intrusive events in the Cascades.

Transverse Structural Lineaments

Early workers in the Cascades recognized the importance of vein and fracture systems which are commonly oriented approximatelyt normal to the dominant NNW trending structural fabric of the enclosing rocks. In the Monte Cristo district located immediately southwest of the Glacier Peak Wilderness Area, Spurr (1901) outlined and discussed the economic importance of steeply dipping structures trending approximately N 60-90° E. Later work by Weaver (1912) in the Index district and by Carithers and Guard (1945) in the Sultan Basin indicated that a majority of the mineral prospects occur along structures striking approximately N 50-90° E. Known significant mineral occurrences as plotted on commodity maps confirm the importance of east to northeast trending distributional patterns coinciding with recognized or suspected transverse lineaments.

Until recently, no attempt was made to examine these transverse structures on a regional basis. Grant (1969) summarized available data as well as more detailed observations accumulated over several years of Cascade field work and described the regional aspect of these transverse structures. Although data are still far from complete, evidence now indicates the presence of two definite,

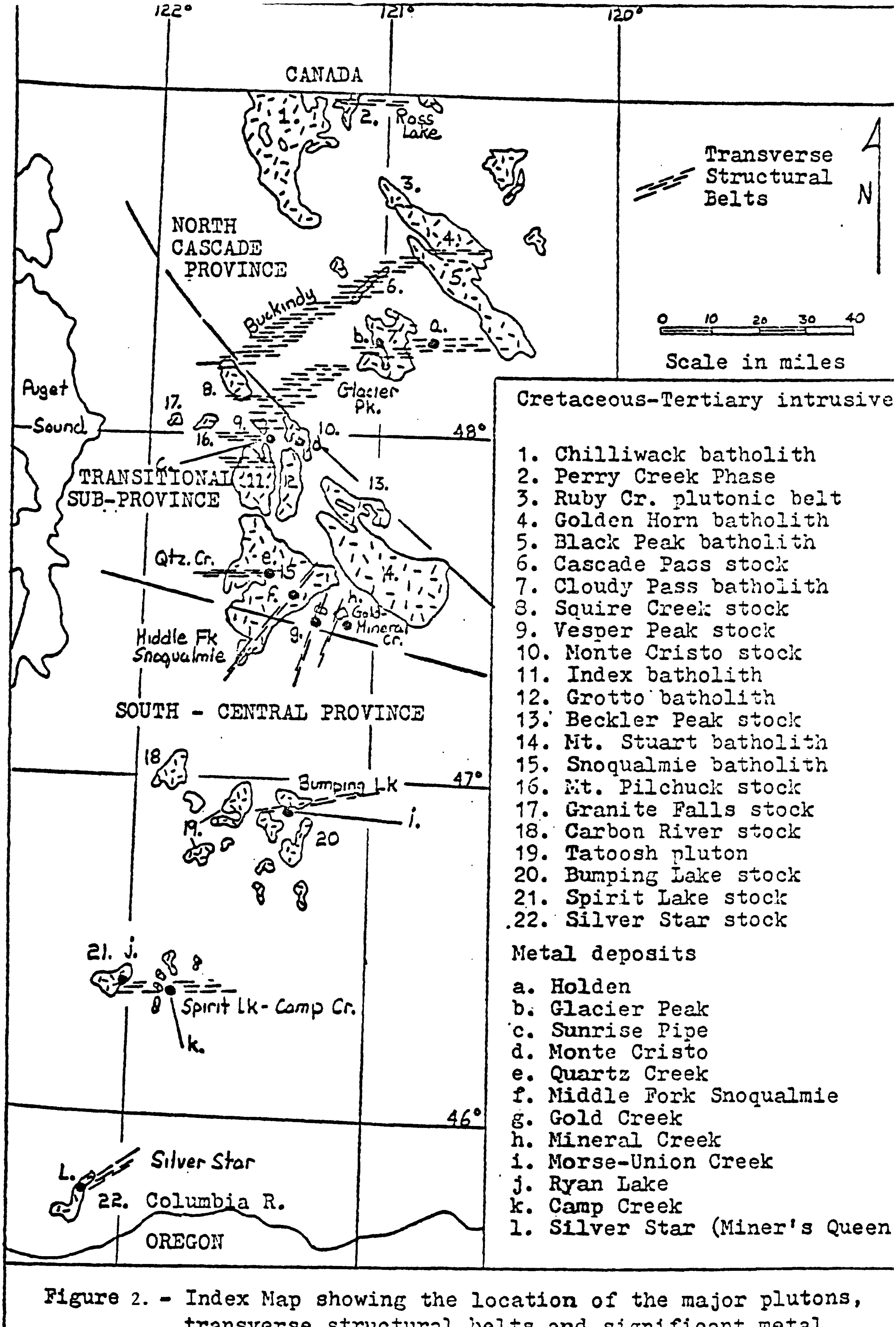

Figure 2. - Index Map showing the location of the major plutons, transverse structural belts and significant metal deposits in the Washington Cascades.

three probable, and four possible transverse structural belts in the Washington Cascades. All of these are directly associated with either important mineral districts or significant metal occurrences. In most cases, the significant sulfide deposits occur within or immediately adjacent to Tertiary and/or, in a few cases, to Late Cretaceous intrusives. Thus, the combination of these intrusives, plus transverse structures, appears to set the stage for the occurrence of all significant sulfide systems in the range.

For purposes of general orientation, the two transverse lineaments crosscutting the Glacier Peak Wilderness Area are discussed briefly below. It must be emphasized that others could exist, particularly where outcrop patterns and detailed mapping are both scattered and disconnected. The two known transverse belts are:

a. Buckindy Belt - a major transverse structural system but only a small segment cuts Tertiary intrusive rocks. Potentially significant sulfide systems along this belt include the northern Squire Creek stock (immediately south of Darrington), Cascade Pass-Horseshoe Basin-Thunder Creek, Mt. Buckindy and a possible ENE projection to Mazama (Goat Creek) east of the Cascade Range in the Methow Graben.

b. Glacier Peak Belt - the largest and best defined of the transverse systems. Cuts several major Tertiary plutons. Important deposits or districts along this belt include Index, Silver Creek, Sultan Basin (Sunrise, Goat Haven), Monte Cristo, Glacier Peak, Holden and Meadow Creek.

Figure 2 illustrates the present known extent of these transverse lineaments in the Washington Cascades and indicates the close association of base metal mineralization with these structures.

The majority of transverse lineaments occur as broad strips or belts within which major fracture-sheeting systems are conspicuous at both the macroscopic and megascopic scale. In the field, these features are characterized mainly by near vertical, closely spaced en echelon fractures and shears. The jointed nature of the transverse fracture zones suggests that these structures are formed at relatively high levels in the crust. However, in an upthrown block of pre-Tertiary metamorphic rocks near Sloan Peak, Grant (1969) has mapped a section of contorted gneiss in which there is considerable irregular, disharmonic folding restricted to a zone along the direct projection of the Glacier Peak lineament. This suggests that early transverse fracture activity was relatively deep-seated and that the deep yielding was plastic rather than brittle. The presence of transverse fracture zones in all pre_Pleistocene rocks in the Northern Cascades and pre-Middle Pliocene rocks in the Southern Cascades indicates an upper age limit on the tectonic activity which produced the lineaments. As yet, there is no definitive evidence to indicate what lower age limits could be expected for these features. However, a few transverse lineaments are known to cut across major northerly trending faults, such as the Strait Creek fault, which display considerable strike-slip movement. Major movements along these faults may be as young as Eocene (Grant, 1969). Hence, the late development of some transverse lineaments may have been initiated early in the Cenozoic. Although major offsets of transverse lineaments are unknown, there is one important exception. The Glacier Peak structure in the vicinity of the Cloudy Pass pluton on the east side of the North Cascades appears to be offset as much as 1 mile by a high-angle post-Miocene fault (Grant, 1969). The eastern extension of this transverse lineament passes through the Holden mine area where the copper mineralization appears to be concentrated in an overfold probably produced during late-Cretaceous metamorphism (DuBois, 1954). Regional mapping in this area (Crowder, 1959; and Cater and Crowder, 1967) has indicated considerable E-W and NE-SW shear activity which may be related to the same pre-Tertiary tectonic and metamorphic events responsible for sulfide deposition at the Holden Mine. This correlation suggests a pre-Tertiary age for the initial development of the Glacier Peak structure with recurrent movement during most of the Tertiary Period.

Cascade Sulfide Systems - General Overview

Although geologic differences do exist between the North and South-Central provinces in the Washington Cascades, similarities of economic geology criteria allow some combination in the establishing of basic environments for sulfide deposition. On the whole, the Cascades must be considered metallogenetically as a copper province with most major sulfide systems being generally categorized as porphyry copper systems. Interpretation of present knowledge and understanding of these systems allows the establishment of three basic types as briefly described below:

Type	Characteristics	Example
Deep level	Depth of formation probable >5 km. Host rock is quartz diorite derived by anatexis from pre-Tertiary migmatitic rocks. The orthoclase-copper core is exposed on surface and grades downward into "grass roots" subeconomic feeder fractures. Tonnage potential is limited because only the lower part of the system remains. Strong transverse structural control in combination with mid-Tertiary plutonic activity establish the favorable environment for ore deposition	Glacier Peak, Snohomish County
Intermediate level	Depth of formation probably 2-3 km. Host rock is K-altered quartz diorite-granodiorite. Deroofing of the intrusion is moderately recent (total or in part). Progressive increase with depth of K-silicate alteration and associated sulfides. Upper level stockwork of less intense alteration and fracture filling sulfides occurs mostly above and weakly lateral to the disseminated sulfide porphyry core. Strong transverse structural control.	Middle Fork Snoqualmie, King County
High level	Depth of formation probably <2 km. High level intrusion commonly breaks to surface. Intrusive breccias common. Ryodacite extrusions represent breached section. These upper level phenomena appear to overlie the intermediate level type deposit. Structural control still transverse but very complex. Alteration and sulfide zoning may occur over a vertical range of 2 km. Least known of the 3 types but being actively explored.	Miner's Queen, Skamania County

In overall geometry, because of the strong transverse structural control, many of the Cascade porphyry systems are linear. Alteration halos appear to be more zoned in the vertical rather than lateral dimension. Certainly this is not true for all the systems, but definitely for a majority based on current data. This linear tabular geometric model has been used with some success in past and current exploration activities.

Figure 3 illustrates the generalized relationships in the various levels of a Cascade type porphyry copper system.

The various spatial levels of porphyry copper development can be equated to the changing geologic environment from the North Cascade core outward to the flanks and southward into the thickening Tertiary cover. The North Cascades represent fairly deep erosion into the crystalline core rocks. Therefore, it can be expected that the "grass roots" of the plutonic systems are exposed. The economic constraint in this type of deposit is that the core system remnants limit the size. Certainly, this is the case at Glacier Peak where only the core remains intact. Tonnage potential is severely restricted in the deep level type.

Along the flanks of the North Cascades and into the Central Cascades, intermediate level types predominate. These systems show considerably more vertical and, to a lesser degree because of their tabular geometry, lateral zoning. Economic potential in these deposits is greater than the deep level types because more of the system is preserved. While no porphyry ore has been delineated in the intermediate type within the Central Cascades, the probability of such a discovery remains high.

While only preliminary data are available, the age of mineralization in the range appears to be contemporaneous with or somewhat later than intrusive emplacement. Data supplied by V. Hollister (oral commun., 1978) show a range of 6.2 m.y. to 24 m.y. for hydrothermal alteration probably associated with mineralization. Hollister reports the following ages:

a. 24.0 m.y. age for secondary biotite associated with chalcopyrite in the Camp Creek stock.

b. 17.3 m.y. for secondary biotite in an intrusive contact zone in Silver Creek (east of Sultan Basin).

c. 16.2 m.y. for secondary biotite in the Ryan Lake deposit (N of St. Helens-Spirit Lake stock).

d. 6.2-6.3 m.y. for sericite in the Mesatchee Creek area (N part of Bumping Lake pluton).

Cascade Porphyry Copper Alteration Systems

Hydrothermal alteration systems in Cascade type porphyry copper deposits exhibit basic similarities to those occurring in the S. W. United States. Beyond this basic similarity, however, the Cascade types become more complex. The principal reason for this complexity is the tight linear structural control in generally poorly reactive calc-alkaline intrusive rocks. Taken as a whole, many of the Cascade porphyry copper deposits can be considered as mega-breccias. The intensity of shattering appears to be directly proportional to the degree of alteration and, in many cases, subsequent mineralization. Within

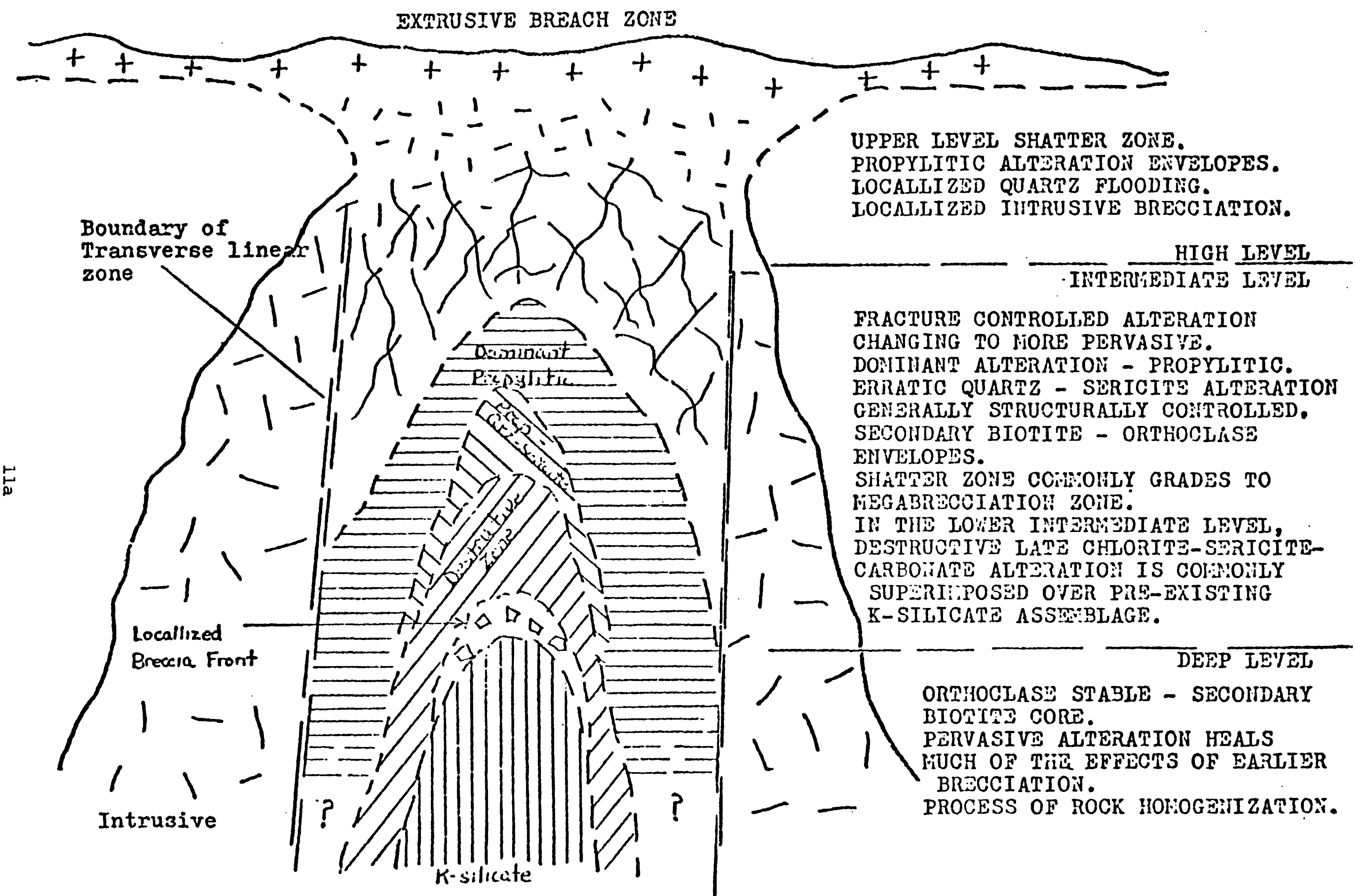

Figure 3.-Diagrammatic cross section of Cascade type porphyry copper system showing distribution of alteration types in deep, intermediate and high level zones.

some intensely altered mineralized sections, large massive barren blocks of virtually unaltered intrusive rock attest to the necessity of structural preparation prior to the introduction of hydrothermal and mineralizing fluids. Tight structural control of the deposit development results in linear shatter zones bounded laterally by relatively massive rocks. The vertical development of this shattering may extend for thousands of feet. Thus, later solutional activity is concentrated mainly within the vertical section and the resultant alteration zoning extends over at least several thousand vertical feet. Conversely, lateral zoning is either very narrow or practically non-existent.

The hydrothermal alteration assemblage characteristic of the porphyry system core is characterized by the presence of K-rich orthoclase and/or secondary biotite. Petrographic studies clearly indicate that the strongly altered K-silicate core rocks are not derived from a separate late stage felsic intrusive event but rather mostly from main-phase calc-alkaline intrusive rocks. Significant gains are generally present in K_2O and FeO while significant losses are registered in SiO_2, Na_2O and CaO.

Rocks at depth within Cascade type porphyry copper systems commonly exhibit polycyclic alteration phases. The intense period of K-feldspathization and/or biotitization was followed by a retrogressive stage of chloritization and sericitization. The resultant alteration assemblage includes relics of the earlier K-silicate phase partly to totally replaced by propylitic stage minerals. In some zones, an intervening, localized stage of quartz-sericite alteration is also superimposed on the deep K-silicate assemblage. The result of these superimposed alteration systems is a vertical and, in part, gradational stacking of later events upon earlier ones. A classic example of the above occurs at Glacier Peak where strong late chloritization-sericitization is directly superimposed over the early K-metasomatically altered rocks.

In many of the cascade alteration systems (particularly in the intermediate or high level types), quartz-sericite alteration is not prevalent. This probably reflects the reduced hydrous nature of the introduced fluids. The reduced presence of quartz-sericite alteration indicates the mobile, highly hydrous volatiles from the magma either were not present in significant amounts or possible surface breaching.

Breccia Pipes

Within or apparently directly associated with many of the complex Cascade porphyry copper systems are breccia pipes which commonly reflect similar multicyclic periods of development. The most common type of pipe in the range is characterized as having a crudely to well-defined elliptical plan and steep sharp contacts, and extending to at least several thousand feet in depth. Most occur within Tertiary intrusive rocks and those which occur in supracrustal rocks are thought to have roots in subjacent Tertiary plutons. Characteristically, the breccias, at least in their upper levels, consist of angular to sub-rounded fragments of country rock (either supracrustal or intrusive) surrounded by a quartz-flooded matrix. Associated sulfide mineralization in these upper levels is confined mostly to the quartz matrix. Quite commonly, hydrothermal alteration, where noted, is restricted to the clast peripheries.

With depth, however, the upper level quartz-cemented breccia unit commonly grades into a more complicated system involving several different periods of breccia resurgence. An excellent example of this multicyclic activity is the

Sunrise deposit, located in eastern Snohomish County, approximately 40 miles east of Everett. The pipe, on its upper levels, is adjacent to the upper Oligocene Vesper Peak stock, a satellite of the Index batholith. Below the 2,000' elevation, however, the pipe appears to be totally enveloped by quartz diorite. Evidence indicates major collapse has occurred dropping metasediment fragments for at least 1,000' into the intrusive mass.

The upper breccia mass, from surface (about 4,500' elevation) to the 3,000' level, consists of two types of breccia, namely an early quartz-cemented breccia with little or no hydrothermal alteration imprint and a later, reshattered breccia with a strong hydrothermal alteration overprint. This later breccia is considered to have formed during a phase of resurgence within the original breccia followed by strong hydrothermal alteration, resorbtion of the early quartz matrix and subsequent sulfide mineralization. The later breccia contains nearly double the copper content but a similar molybdenum content to that in the early breccia.

Below 3,000', however, the quartz-cemented breccia section appears to grade into a breccia unit somewhat but not totally similar to the resurged breccia of the hanging and footwall panels on the 3,000' level. This lower breccia unit is characterized by quartz matrix enclosing totally altered, dominantly argillite fragments. Within this unit, as molybdenite content increases, copper content decreases. Adjacent to the quartz matrix, either coarse-grained chlorite or secondary biotite commonly develops. Relatively coarse-grained molybdenite occurs mostly between the boundary of the quartz and altered clasts. Minor, finer-grained disseminated molybdenite is frequently noted in the altered clasts. Adjacent to the molybdenite-bearing breccia unit at depth, a highly chloritized low-quartz breccia unit generally containing $<0.1\%$ molybdenite appears to occur. It is suspected that this unit represents a fourth type of breccia formation within the complex pipe development. Some of its matrix consists almost entirely of chlorite possibly derived from gouge formed during the breccia formation process. In any event, the complexities encountered at depth support the theory of multi-cyclic breccia activity.

Alteration zoning within the pipe can be delineated over a vertical range of several thousand feet. The upper levels have been subjected to sporadic propylitic alteration within areas of resurgence. At depth, however, approximately 1,500' below surface, potassic alteration becomes more extensive. K_2O analyses run on 50' composites for a 1,500' hole drilled from the 3,000' elevation to the 1,500' elevation (3,000' below surface) indicate an upper background value of 2.5-3.0% increasing to greater than 5% in the interior breccia zone. Griffis (1977) reports gains in K_2O, MgO, FeO, Al_2O_3 and MnO and losses in SiO_2, CaO and Na_2O in K-silicate altered, mineralized tonalite fragments within the pipe on the 3,000' level. Interestingly, within zones of high sulfide content, significant increases occur in Rb and Ba.

The K-silicate alteration phase is mainly reflected by the occurrence of coarse-grained blades of reddish-brown biotite and hydrothermal orthoclase. The biotite commonly rims the breccia clasts in contact with the quartz matrix. This habit is similar to that of the coarse-grained molybdenite occurring in some of the higher grade sections. Orthoclase appears to replace plagioclase and quartz in both meta-sediment and intrusive fragments. The degree of hydrothermal feldspathization is difficult to estimate in many sections because of its fine-grained nature.

Intense propylitic alteration is the dominant hydrothermal signature of the interior breccia at depth. Chlorite, minor sericite and carbonate appear to be the major index minterals of this assemblage. Although iron analyses are not available, most of the iron in the system is thought to be tied up in sulfide. If this is the case, the dominant chlorite is probably an Mg-rich variety.

Propylitic alteration within the Sunrise pipe represents a destructive phase of hydrothermal activity superimposed over the earlier K-silicate phase. As has been shown, this relationship is common in many of the Cascade porphyry copper systems where tight linear structural control exists. At Sunrise, the enclosing silicified, hornfelsed country rock acted as a barrier to lateral migration of hydrothermal solutions and vertical alteration zoning and superposition of one phase over another (i.e., stacking) took place over a minimum range of several thousand feet. In most known cases, the association of breccia pipes with Tertiary plutonic activity, transverse linear structures and adjacent or subjacent porphyry copper systems is striking.

DESCRIPTION OF MINERALIZED AREAS

Introduction

Past exploration work has identified numerous mineralized target zones within the Glacier Peak Wilderness area. Their locations are shown by numbers (see below) on the accompanying map. Of these, the largest and most important is the identified Cu-Mo-W-Ag porphyry copper system on Miner's Ridge. This deposit, known as Glacier Peak, is wholly controlled by Kennecott Corporation through their subsidiary Ridge Mining Corporation. Kennecott's exploration activities at Glacier Peak have been conducted, in their entirety, by Bear Creek Mining Company. During the most active years of Glacier Peak exploration (1955-1962), Bear Creek conducted regional reconnaissance in hopes of discovering additional ore which might complement the limited reserve picture on Miner's Ridge. This reconnaissance effort resulted in core drilling on Mt. Buckindy and Fortress Mountain, geologic mapping, bulk sampling and widespread soil and stream sediment geochemical sampling. A large amount of the following descriptive information is a result of the Bear Creek effort.

Geochemical sample results, as plotted on the accompanying map, represent values for cold extractable (i.e., exchangeable) Cu and heavy metals and ppb Mo in water. The field analytical methods used are the standard Holman (dithizone) test for Cu and heavy metals and the Clark, Jacobson methods (amyl acetate) for Mo in water. Special note should be made that the "top of the tube" maximum Holman values reported for Cu and cxHm during the 1956-1958 seasons were >17-19 ppm. A refinement of the Holman test in 1959 increased the maximum xCu and cxHm values to >44 ppm. Unfortunately, no total values (particularly for Cu) were analysed. In many areas of the Cascades, particularly in the North Cascades, primary copper sulfides are exposed on surface. Little oxidation has occurred and thus exchangeable Cu cations are rare in the downslope wash. In such an area, the resultant exchangeable geochemical profile would probably show a series of low, possible nonanomalous Cu values. The same samples, if analysed for total Cu, could be strongly anomalous.

In the case of the Bear Creek geochemical data, I recommend that all values of 12 ppm Cu or greater be considered anomalous. The exchangeable heavy metal value anomalous threshold is recommended at 16. Mo in water threshold is 0.5 ppb.

It is known that in many areas described below, rock samples were collected by Bear Creek for assay. However, results of these assays were not available during my review of the Bear Creek files.

Prospects and Mineralized Areas

Described in this Report in Order of Presentation

	Name	Location	Quadrangle
1.	Glacier Peak	S. 10, 11, 31N, 15E	Holden
2.	Buckindy	S. 10, 11, 12, 13, 14, 33N, 12E	Downey Mtn.
3.	Fortress Mountain	S. 24, 31N, 15E	Holden
4.	Milt Creek	S. 29, 30, 34N, 13E	Sonny Boy Lks.
5.	Red Mountain Ridge	S. 29, 33, 31N, 16E	Holden
6.	Crown Point	S. 7, 31N, 16E	Holden
7.	Canyon Creek	S. 3, 31N, 14E	Holden
8.	Sitting Bull	S. 26, 32N, 15E	Holden
9.	Bannock Mtn.	S. 14, 15, 32N, 14E	Agnes Mtn.
10.	Pass Creek	S. 29, 33, 33N, 16E	Agnes Mtn.
11.	Company Creek	S. 15, 16, 21, 22, 32N, 16E	Mt. Lyall
12.	S. Cascade Glacier	S. 21, 34N, 13E	Dome Peak
13.	Suiattle River	S. 4, 9, 31N, 14E	Glacier Pk.
14.	West Red Mtn.	S. 22, 30N, 12E	Sloan Peak
15.	Deerfly	S. 11, 31N, 14E	Holden
16.	Martin Peak	S. 26, 35, 32N, 16E	Holden
17.	Riddle Peak	S. 33, 32N, 17E	Lucerne
18.	Nine Mile Creek	S. 4, 31N, 17E	Lucerne
19.	Red Cap	S. 35, 32N, 16E S. 2, 31N, 16E	Holden
20.	Ebbutt's Breccia	S. 2, 31N, 16E	Holden
21.	Buckskin Mountain	S. 20, 31N, 16E	Holden

22.	N. side Dumbell Mtn.	S. 3, 10, 31N, 16E	Holden
23.	W. side Bonanza Pk.	S. 32, 33, 32N, 16E	Holden
24.	Red Mountain-Chiwawa	S. 20, 21, 28, 29, 31N, 16E	Holden
25.	North Star	S. 6, 31N, 16E	Holden
26.	Blankenship	S. 10, 33N, 16E	McGregor Mtn.
27.	Bryan (see Red Mtn. Ridge)	S. 9, 30N, 16E	Holden
28.	Lake Shyall	NW 1/4, S. 16, 34N, 15E	Cascade Pass
29.	Silver Trail	S. 8, 31N, 16E	Holden
30.	Cascade	NW 1/4 S. 7, 34N, 13E	Sonny Boy Lakes
31.	Epoch	S. 10, 34N, 10E	Cascade Pass
32.	Pioneer	S. 2, 11, 34N, 13E	Cascade Pass
33.	Goff	S. 19, 20, 29, 30, 29N, 14E	Bench Mark Mtn.

1. <u>Glacier Peak</u> (Sections 10, 11, T31N, R15E, W.M.)

The Glacier Peak porphyry copper system lies on the south slope of Plummer Mtn. near the east-west trending contact between the Cloudy Pass batholith and the Totem Pass migmatitic gneiss unit. The #1 ore body, as defined by Bear Creek, occurs entirely within the intrusive rocks several hundred feet south of the contact with the migmatites. The #2 ore body occurs mainly in Cloudy Pass rocks but does extend, to a limited degree, into the gneiss.

The structural setting of the main deposit is dominated by an east-northeast trending zone of en echelon fractures and shears which is part of the Glacier Peak transverse structural belt previously described. The en echelon fracture pattern equally affects both the Totem Pass and Cloudy Pass rocks. I suspect that the specific structural setting for the #1 deposit involves the intersection of transverse fracturing with the projection of a northwest trending, tight, overturned anticline in the migmatitic rocks. Axial plane shearing in the fold could have accentuated this intersection as a zone of weakness for later hydrothermal alteration and sulfide mineralization events. Subsequent to my work in the area, Bear Creek mapped the northwest trending axial plane shear zone as a high angle fault which they named the Plummer Mountain fault. In any event, the structural intersection most probably was the cause of the localization of ore.

The #1 ore body is roughly circular in surface outline. With depth, the zone diminishes in size. The overall geometric shape crudely resembles an inverted cone. In 1968, a deep (2,180') probe of the #1 ore body was drilled. Most disseminated chalcopyrite was found to occur in the upper level finer-grained hydrothermally altered quartz-monzonite phase. Also, much of the significant Cu mineralization occurs within and adjacent to transverse fractures. With depth, the altered leuco-quartz monzonite phase grades into lesser altered main phase quartz diorite with submarginal values below 1,000'. The #2 ore body, lying ENE of the #1 zone, consists of a blind, tabular, linear feature paralleling the transverse structural trend.

No breccia pipes appear to be present in the defined ore bodies but several exist in the general target area. Two breccia pipes occur in the Upper Cirque zone about 2,000' ENE of the #2 ore body. The fragments in both pipes consist of angular blocks of gneiss, quartz diorite and quartz monzonite. The pipe matrix is mostly quartz and sericite. The pipes are strongly limonitized and near surface sulfides appear to be mostly leached.

Locally along the intrusive contact, some brecciation has occurred. Most of this appears to be related to emplacement of the Cloudy Pass rocks. Some brecciation of a similar type is present in the #2 ore zone and probably served as a partial control for mineralization.

Hydrothermal alteration in the target area is complex. Intense K-silicate alteration is restricted to a zone extending from a few tens of feet to several hundred feet outside the ore bodies. Weak to moderate superimposed chloritization and sericitization are more widespread and parallel the transverse structural orientation for several thousand feet. In some drill holes, the change from strong to incipient or nil alteration is very abrupt over a few feet. This rapid change is thought to be due to the megabreccia character of the host rock. The well shattered rocks are generally intensely altered and mineralized in the ore zones. Conversely, more massive rocks appear to have been resistant to mineralizing and/or alteration fluids. Glacier Peak is a classical example of the direct relationship between the intensity of fracturing and the intensity of subsequent alteration and sulfide mineralization.

The dominant hydrothermal alteration mineral assemblage in the main ore zones is quartz, orthoclase, sericite and chlorite. Secondary biotite is, at best, a minor constituent. Secondary orthoclase (average of 26 specimens cut for petrographic examination) ranges in content from 0-85%, averaging 37%. Sericite ranges from 0-55%, averaging 19%. Chlorite (mostly pennine) ranges from 0-18%, averaging 11%. Quartz ranges from 10->80%, averaging 40%. A plug of bull quartz, nearly 100' in diameter, is present in the NE corner of the #1 ore body. This plug probably represents a late stage of silica flooding post-dating the major period of sulfide introduction. The quartz plug is a waste block in Kennecott's mining plan study.

Subordinate alteration minerals present in the ore include tourmaline, epidote and carbonate. The carbonate appears to be mainly ankerite and/or siderite.

Sulfide mineralization in the deposit is relatively complex but typical of a porphyry copper system. Chalcopyrite is the dominant sulfide in the higher grade ore. Elsewhere pyrite and pyrrhotite in variable ratios dominate. Molybdenite, scheelite, tennantite, arsenopyrite and marcasite are present in small amounts. Trace amounts of sphalerite, galena and realgar have been identified in the ore zone. Minor chalcocite and covellite are present in the thin (average $<5'$ thick) zone of secondary enrichment beneath the equally thin partially leached cap.

The geochemical halo signature of the ore body is defined by strong positive anomalies for Ag, As, Bi, Cu, Mo, Pb and W. Moderately positive anomalous elements are Au, In, K, Rb, Ti and Zn. Negative elements are Al, Ca, Na, Ni and Sr.

Bear Creek requests that specific tonnage and grade figures for the Glacier Peak deposit be kept confidential. Nevertheless, it is common knowledge that the combined deposits contain >30,000,000 tons grading about 0.7% Cu with significant recoverable credits in Mo, W and Ag and a minor possible recoverable credit in Au. Based on current data, opportunities for expansion of reserves appear limited.

2. Buckindy (Sections 10-14, T33N, R12E, W.M.)

The Mt. Buckindy area was extensively mapped and sampled by Bear Creek in 1956-1957. This work culminated in the drilling of five holes in late 1957. The results of the drilling were not particularly encouraging although some interesting but submarginal Cu and Mo intercepts were encountered. Since 1957, the zone has been remapped on several different occasions in an attempt to generate new drill targets.

East of Mt. Buckindy, the dominant rocks consist of migmatitic, biotite-hornblende gneisses. These rocks exhibit a wide variety of compositional banding, from leuco-trondhjemites to amphibolites. The banding is attributed more to metamorphic differentiation rather than original compositional differences in the parent strata. The migmatites grade northward (about 1 mi. north of Mt. Buckindy) into a directionless to weakly gneissose quartz diorite pluton. This pluton is thought to have been emplaced during a late stage of the Cascade metamorphic cycle as a result of mobilization and anatexis of the migmatites (Grant, 1966). The migmatitic rocks are intruded by several stages of andesite porphyry, dacite porphyry and quartz dacite porphyry dikes. In local zones, the migmatites appear to have been intruded by fine- to-medium-grained granodioritic rocks. It is not clear if these rocks are a product of mobilization or igneous activity. I suspect the latter.

On the south slope of Mt. Buckindy, the host rocks for sulfide mineralization consist of a complex intrusive unit. The dominant lithologies are quartz diorite porphyry, equigranular granodiorite and weakly gneissic quartz diorite. These rocks become somewhat more leucocratic west to northwest of Mt. Buckindy. Dacite and/or andesite porphyry dikes are common. Several small breccia pipes occur in the Buckindy target zone. These pipes contain fragments of all lithologies mapped in the area and have been subjected to intense silica flooding. Most of the pipes contain sulfides and were one of the principal features of exploration interest during the early Bear Creek work.

The dominant structural trends in the Buckindy area are twofold. The foliation in the metamorphic rocks trends E-W and clearly is significantly divergent from the regional NW trends. Superimposed fracturing and shearing trend dominantly NNE to NE. Numerous andesite and dacite dikes and quartz veins are emplaced in the NE trending structures. Hydrothermal alteration is generally most intense in envelopes adjacent to the NE fractures.

Hydrothermal alteration at Buckindy is highly variable both in intensity and distribution. Many rocks, particularly in the relatively unfractured, massive sections exhibit no megascopically detectable effects of a hydrothermal event. Overall, the intensity appears directly related to the degree of NE fracturing. The strongest pervasive (albeit structurally controlled) alteration occurs along the NW to SW slope of Buckindy coincident with the highest concentrations of sulfides. The dominant hydrothermal overprint is weak, structurally controlled propylitization. Quartz-sericite alteration is mostly restricted to envelopes adjacent to NE trending fractures and within the silicified breccia pipes. In the DDH-57-5 area (see Summary of Buckindy Drilling Data), strong, pervasive quartz-sericite alteration occurs in a zone about 300' x 250' within a silica flooded breccia. No occurrence of secondary K-feldspar has been noted.

Many but not all of the andesite and dacite dikes are propylitized and/or secondary biotitized. This indicates the hydrothermal and sulfide phases post-date at least the early period of dike emplacement.

The Mt. Buckindy zone stands out as a strong color anomaly due to intense near surface limonitization. The dominant limonite minerals are goethite and jarosite. Sulfide mineralization consists dominantly of pyrrhotite and pyrite (in ratios ranging from 1:1 to 3:1 respectively) with subordinate chalcopyrite and molybdenite. Traces of scheelite are noted in a few very localized areas. Most of the sulfides occur in NE trending fractures although they are not exclusively confined to these sets. Disseminated chalcopyrite is rare except in the early andesite and dacite dikes. This suggests a relationship between the dike activity and a sulfide mineralization pulse. In the DDH-57-5 area, the pervasive alteration and sulfide mineralization are thought to be possibly associated with a subjacent intrusive mass (see DDH summary). Molybdenite clearly has an affinity to occur within fractures exhibiting intense quartz-sericite alteration. However, the pervasive quartz-sericite alteration encountered in DDH-57-5 is not significantly high in MoS_2 content.

Bear Creek collected over 1,000 stream sediment and soil samples in the Buckindy area for exchangeable Cu analysis. An outline of the Cu geochemical anomaly is shown on the map accompanying this report.

Figure 4 shows the assay results of Bear Creek's surface sampling in the Buckindy target area. In many zones, the assay results for Cu appear high.

2a. Summary of Buckindy Drilling Data

Five holes were drilled in the Mt. Buckindy zone during 1957. Total accumulated footage is 2,280.5'. The purpose of the drill program was to test the principal anomalous sulfide zones as defined by prior geologic mapping and relatively high exchangeable Cu-in soil and silt values. Hole data are summarized from BCMC logs. Grade intercepts represent weighted averages calculated from assay logs. Hole locations are shown in Fig. 4.

(1) DDH 57-1 (T.D.-497.1', vertical)

(a) Rock type: directionless to gneissic quartz diorite with numerous layered mafic and felsic sections. DDH log commonly refers to sections of "leuco-granite" which most probably are trondhjemitic leucogranodioritic gneiss.

(b) Hydrothermal alteration: dominant, weakly pervasive

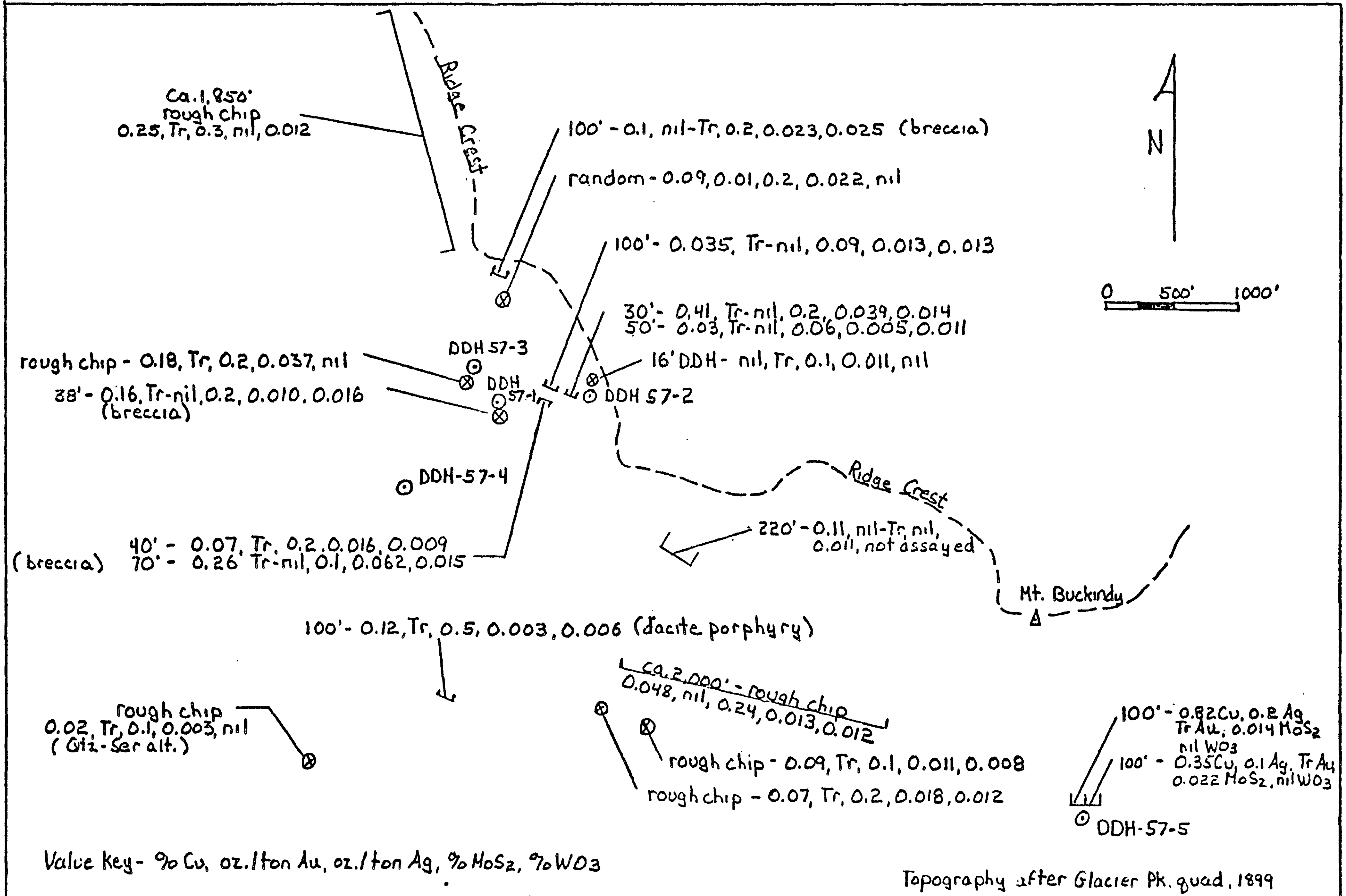

Figure 4. - Surface sample results, Mt. Buckindy area
(Data source - Bear Creek Mining Company)

propylitization. Quartz-sericite envelopes relatively common in and adjacent to MoS_2 veinlets.

(c) Sulfide mineralization: dominant pyrite and pyrrhotite; estimated ratio 1:1 in variable total sulfide amounts from 1% to 5%. Less than 0.3% chalcopyrite occurring mostly with pyrrhotite in veinlets. MoS_2 occurs exclusively in quartz-pyrite veinlets. Significant decrease in total sulfides (<1%) below 235'.

(d) Assay intercepts:

0-90' - 0.085% Cu
90-396' - <0.01% Cu
396'-end - nil Cu
20-110' - 0.108% MoS_2
balance of hole - <0.02% MoS_2
0-195.4' - 0.35 oz/ton Ag
balance of hole - < 0.01 oz/ton Ag
Nil - Tr Au only except two 10' intercepts - 0.01 oz/ton
Nil WO_3

(e) Comments: Hole 57-1 failed to encounter Cu mineralization comparable to surface values. The only values of potential significance are 90' of 0.108% MoS_2 and 195.4' of 0.35 oz/ton Ag. Downhole all values diminish along with the intensity of fracturing and alteration. The sulfide distribution appears to be dominantly fracture controlled.

(2) DDH 57-2 (T.D. 394', vertical)

(a) Rock type: Same as DDH 57-1

(b) Hydrothermal alteration: similar to 57-1 except intensity of fracturing is considerably less. Quartz-sericite envelopes rare; <10% as compared to those noted near the top of 57-1.

(c) Sulfide mineralization: more uniform than 57-1. Total sulfides <25% of total sulfide content in the top 235' of 57-1. Very rare quartz-sericite envelopes adjacent to pyrite-MoS_2 veinlets. Pyrrhotite is the dominant sulfide; approximately 3:1 over pyrite. Traces of chalcopyrite only. Total sulfides estimated to be < 1% for the total hole.

(d) Assay intercepts:

0-end of hole - 0.015% Cu
0-100.7 - 0.015% MoS_2
100.7'-end - <0.01% MoS_2
0-end of hole - <0.01 oz/ton Ag
0-end of hole - <Tr Au

(e) Comments: Failure to encounter any significant mineralization is attributed mostly to the absence of anomalous fracturing intensity.

(3) DDH 57-3 (T.D. 468.2', vertical)

(a) Rock type: Same as 57-1, 57-2

(b) Hydrothermal alteration: Similar to 57-1

(c) Sulfide mineralization: Similar to 57-1 except total sulfides only 50-60% of those in 57-1. Significant decrease in total sulfides below 160'.

(d) Assay intercepts:

0-161.6' - 0.039% Cu
161.6' to end - $<$0.02% Cu
15'-151.4' - 0.13% MoS_2
151.4'-end - $<$ 0.02% MoS_2
0-end of hole - $<$0.05 oz/ton Ag
0-end of hole - Nil-Tr Au except 10.2' of 0.2 oz/ton
Nil - Ni, Co

(e) Comments: The only significant intercept (136' of 0.13% MoS_2) is directly associated with an increase in both fracture controlled quartz-sericite alteration and fracture intensity. In both 57-1 and 57-3, significant values only occur in the upper part of the hole and decrease as fracturing density diminishes. In both holes, the $>$ 0.1% MoS_2 intercepts appear to represent localized zones with no depth potential.

(4) DDH 57-4 (T.D. 496.2', brg. due E, -45°)

(a) Rock type: same as DDH 57-1 - DDH 57-3

(b) Hydrothermal alteration: Similar to but weaker than 57.2.

(c) Sulfide mineralization: Similar to 57.2.

(d) Assay intercepts:

0-138.7' - $<$0.02% Cu
138.7'-407.3' - 0.036% Cu
407.3'-end - $<$ 0.02% Cu
0-101' - 0.018% MoS_2
101-216.5' - $<$ 0.01% MoS_2
216.5-377' - 0.017% MoS_2
377'-end - $<$ 0.01% MoS_2
Total hole - $<$0.05 oz/ton Ag
Total hole - Nil - Tr Au

(e) Comments: Hole was drilled across structure in an attempt to intersect MoS_2 mineralization at depth. In contrast to 57-1 and 57-3, weak but insignificant mineralization was found in deeper intercepts.

(5) DDH 57-5 (T.D. 425', vertical)

(a) Rock type: Weakly brecciated foliated biotite granodiorite with local directionless sections. Several short intercepts of mafic-rich rock described in the log as andesite porphyry. Below 270', intensity of brecciation appears to be increasing. This tendency continues to the bottom of the hole.

(b) Hydrothermal alteration: Pervasive moderate-intense quartz-sericite. Intensity of the quartz-sericite alteration appears to be directly proportional to the degree of brecciation. Local drusy quartz veinlets in either a weakly developed stockwork system or as matrix in the breccia; difficult to determine from the core.

(c) Sulfide mineralization: 2-5% average total sulfides for total hole. Pyrite and pyrrhotite ratio approximately 1:1. Chalcopyrite mostly within or adjacent to fractures. Weak disseminated chalcopyrite in intense quartz-sericite zones. Molybdenite relatively rare and confined to occasional quartz-pyrite veinlets.

(d) Assay intercepts:

0-119' - 0.23% Cu
119-205' - 0.61% Cu
205-229' - 0.05% Cu
229-end - 0.32% Cu
0-end - 0.013% MoS_2
Incomplete Au but probably Tr
Incomplete Ag - best intercepts - 9.5' of 1.07% Cu and 0.3 oz/ton; 9' of 1.02% Cu and 0.7 oz/ton Ag

(e) Comments: DDH 57-5 encountered significant pervasive quartz-sericite alteration in fractured, locally brecciated rock similar in description to my (Grant, 1966) Buckindy intrusive complex. Not having seen the core in recent time, I cannot recall the lithologic detail necessary for comparison. Nevertheless, I suspect that 57-5 penetrated narrowly within or adjacent to a subjacent intrusive mass which could be directly associated with the distribution of hydrothermal alteration and sulfide mineralization in the Buckindy area. In retrospect, considering Bear Creek's expenditures on the Buckindy project, I would have pushed for several additional holes in the 57-5 zone (South Cirque area) to determine either whether a significant porphyry copper target might be present or whether the 57-5 intercepts are localized.

3. Fortress Mountain (Section 24. T31N. R15E. W.M.)

The Fortress Mountain zone is located about 3 miles southeast of the Glacier Peak #1 ore body in the headwaters of Miner's Creek. Topographically, the mineralized area is considerably more rugged than Miner's Ridge; the main showing occurs near the base of the 2,500' high NE face of Fortress Mountain. Snow and/or rockfall hazard represent real objective dangers to anyone examining this particular showing.

The geologic setting for the Fortress zone is similar to that occurring at Glacier Peak except for the absence of significant crosscutting transverse fractures. Sulfide mineralization is present in 2 small plugs of hydrothermally altered quartz-monzonite-granite which occur along the Cloudy Pass-migmatitic gneiss-contact. The possible principal controlling structure for the emplacement of these plugs appears to be a NW trending anticline in the roof pendant metamorphic rocks. This same structure is believed to be the one partly responsible for the emplacement of the Glacier Peak #1 ore body.

The southeast plug, having surface dimensions of about 350' x 400' contains several percent total sulfides. The host rock consists mostly of moderate to intensely sericitized quartz monzonite-granite. The following compositional ranges are based on examination of 17 thin sections of samples collected on the SE plug.

Mineral	Range	Average
Orthoclase	30% - 65%	44.2%
Quartz	15% - 30%	24.1%
Plagioclase	2% - 45%	12.5%
Sericite	5% - 45%	11.0%
Biotite (? secondary)	1% - 5%	2.5%
Chlorite (mostly pennine)	0 - 15%	2.2%
Epidote	0 - 2%	<1.0%

Most of the sericite and chlorite appears to be superimposed over the probable earlier K-silicate alteration.

The dominant sulfides in the SE plug are pyrite, pyrrhotite and chalcopyrite with subordinate molybdenite. Weak secondary enrichment minerals present in variable amounts within a few feet of surface are chalcocite, covellite, malachite and azurite. The plug itself stands out from the surrounding intrusive and metamorphic rocks because of incipient pale surface limonitization (mostly goethite).

Over 150 surface samples were collected by Bear Creek in 1961 from the SE plug. Of these, 61% assayed <0.1% Cu, 23% 0.1%-0.2% Cu and 16% >0.2% Cu. The highest concentrations of chalcopyrite appear to occur near the contact of the plug and the gneiss. There, 9 grab samples (taken in 1960) averaged 0.9% Cu.

Three short packsack holes were drilled by Bear Creek in the SE plug in 1961. DDH 61-2 was drilled near the exposed base of the plug. The hole collared in quartz diorite and encountered a few short intercepts of weakly mineralized quartz monzonite. The 101' hole averaged 0.03% Cu. DDH 61-3 was collared in quartz monzonite at the top NW corner of the plug. Weakly mineralized quartz monzonite was intersected from 0-38', below which propylitized quartz diorite continued to the hole bottom. The 80' hole averaged 0.13% Cu. DDH 61-6 was collared near the top SW corner of the plug. The top 52' of the hole penetrated moderately mineralized quartz monzonite averaging 0.43% Cu. Below 52', the hole encountered 35' of weakly mineralized, propylitized quartz diorite averaging 0.203% Cu. The entire 87' hole averaged 0.344% Cu. No Au, Ag or Mo assays were taken.

The NW plug (about 300' x 900' in outcrop) consists mostly of quartz monzonite without significant superimposed sericitization. Cu values are consistently <<0.1% and total sulfide content is <1%. The low Cu values coupled with the absence of late sericitization suggest a relationship between the superimposed hydrothermal alteration cycle and sulfide mineralization.

The results of the Bear Creek surface sampling and drilling are not encouraging. Nevertheless, Bear Creek decided in 1962 to drill a deep (1,000'-1,500') probe in the SW plug zone to determine if grade improvement might exist at depth. With the advent of the wilderness controversy, however, the drilling attempt was cancelled.

Elsewhere on Fortress Mountain, numerous narrow discontinuous quartz monzonite dikes intrude both the main-phase quartz diorite and the migmatitic rocks. All these dikes contain minor chalcopyrite and traces of molybdenite. It is believed these dikes could have been derived from late stage felsic differentiates of the Cloudy Pass pluton similar to the felsic plugs in the exposed Fortress Mountain target zone.

4. Milt Creek (Sections 29, 30, T34N, R13E, W.M.)

The Milt Creek zone was discovered by Bear Creek in 1956 as a result of regional reconnaissance. The anomalous area straddles the wilderness boundary; part being within the wilderness in the upper Milt Creek drainage and part outside in the headwaters of Sonny Boy Creek.

Most of the western part of the area of interest is underlain by weakly foliated granodiorite of the Snowking complex (Bryant, 1955). Snowking rocks are in contact to the east with a heterogeneous migmatitic gneiss-schist complex which in turn is in fault contact (Le Conte fault) with Marblemount meta-quartz diorite and/or Cascade River Schist (Tabor, 1961). Numerous andesite and dacite porphyry dikes appear to intrude the granitoid rocks. This dike activity probably reflects increased pre-mineral alteration fracturing. One small breccia zone has been mapped near the southern boundary of the geochemical anomalous area. Elsewhere, considerable limonitized brecciated float was found by Bear Creek, particularly in the upper Milt Creek basin. Much of the area is covered by talus, brush and timber and outcrops are scattered and disconnected.

Approximately 2 miles NE of the zone, a small stock of partly propylitized, pyritized quartz diorite is exposed. This stock is thought to be a satellite of the Cascade Pass pluton. Another segment of the NE trending Cascade Pass pluton outcrops on the northeast side of the S. Fork Cascade River. The intrusive rocks are strongly limonitized on surface mainly due to pyrite.

Bear Creek mapping in the Milt Creek area failed to note any significant structural data; particularly the trends of dominant fractures. I have made only one brief examination of a small part of the Milt Creek ground. Within the area examined, the dominant trend of fracturing is NE to ENE. The dominant hydrothermal alteration overprint is fracture controlled, weak to moderate propylitization. Some silicification, quartz veining and very minor quartz-sericite alteration is mentioned in the 1956 and 1957 Bear Creek reconnaissance reports.

The mineralization in the Milt Creek area consists mostly of pyrite and pyrrhotite in varying ratios up to 5% total sulfides. Both pyrite and pyrrhotite appear to occur mostly in hydrothermally altered and/or silicified schist and leucogneiss sections. Pyrrhotite is reported as the dominant sulfide in the south boundary breccia. Chalcopyrite is very sparse, mostly occurring in brecciated or fractured float of propylitized volcanic rocks. South of the geochemical boundary, minor chalcopyrite is reported to occur in a small ultramafic pod.

One hundred twenty-three silt and soil samples were collected in the Milt Creek-Sonny Boy Creek and S.F. Cascade River areas. The largest anomaly (>20 ppm Cu) is about 4,000' x 5,000' in area and occurs in the Upper Milt and Sonny Boy drainages. A linear strip, approximately 8,000' long along both sides of the S. Fk. Cascade River, is also anomalous in Cu (>20 ppm). Part of this anomaly source is attributed to segments of the Cascade Pass pluton (see accompanying map). A small Cu anomaly, about 4,000' downstream from Sonny Boy Lake No. 2 is coincident with a zone of limonitized brecciated quartz diorite.

The Milt Creek zone appears to represent a fairly extensive but weak Cu anomaly. Based on the Bear Creek work, the possibility for the delineation of a potential economic target appears remote. Nevertheless, the weak surface mineralization could be a high level reflection of a possible subjacent SE projection of the Cascade Pass pluton.

5. Red Mountain Ridge (Sections 29, 33, T31N, R16E, W.M.)

Prospecting activity on Red Mountain Ridge, about 5 miles north of Trinity, has centered around the contact between a small satellitic stock of the Cloudy Pass pluton and the Swakane Gneiss. A swarm of probable Cloudy Pass-related dikes intrude the Swakane section within about a one-mile radius of the satellite intrusion contact. The area stands out as a strong limonite anomaly caused by the presence of minor yet pervasive fracture controlled pyrite and pyrrhotite in both the Swakane and Cloudy Pass rocks.

Several old underground workings exist on the west side of the ridge. These workings were known at various times as either the Copper Queen or the Keefer Brothers (Huntting, 1956) prospect. The adits appear to have been driven on narrow, fracture controlled veins in the intrusive rocks. These veins contain minor molybdenite, chalcopyrite, pyrite and arsenopyrite.

Bear Creek conducted reconnaissance mapping in this area because of the presence of several small breccia pipes adjacent to the intrusive contact. Two types of breccia are present. The smaller pipes, with diameters generally less than 100', consist dominantly of relatively small lithic fragments less than 6 in. across in a silica-flooded matrix that averages 25 volume percent of the breccia. A relatively large pipe about 400'-600' in diameter consists of large fragments cemented by 5-10 volume percent quartz. These pipes contain numerous fragments of strongly quartz-sericite altered mineralized quartz monzonite. The dominant sulfide mineralization in these fragments consists of trace to 1% chalcopyrite, <1%-5% pyrite and/or pyrrhotite and very sparse molybdenite. The similarity of these altered and mineralized fragments to rocks in the Glacier Peak #1 ore body gave rise to speculation that the pipes could be an upper level reflection of a blind porphyry copper target. However, other than reconnaissance mapping, no sampling or other physical exploration work was accomplished by Bear Creek in this area. I still consider this zone ultimately should be mapped and sampled in detail to determine if the pipes and/or adjacent intrusive rocks might constitute a potential porphyry copper system.

6. Crown Point (Section 7, T31N, R16E, W.M.)

Descriptive data for this mine was obtained from Ebbutt (1938). The deposit is located about 4 miles east of the #1 Glacier Peak ore body near Crown Point falls on Railroad Creek.

The host rocks for mineralization are massive, Cloudy Pass quartz diorite. Sulfide mineralization is mostly restricted to a series of near horizontal fractures, some of which have been flooded by quartz. The dominant sulfides are molybdenite, pyrite, chalcopyrite and arsenopyrite. The property achieved very minor production (about 22 tons) in 1901-1902. The molybdenite ore was mined from a flat lying quartz lens no greater than 4' thick and 100' across. Some museum quality molybdenite crystals were found in the upper level stope by Bear Creek geologists in 1958.

The mine has 3 levels of underground workings. The lowest level (about 4,920' elevation) consists of a 560' adit, driven mostly in massive unaltered quartz diorite. The adit follows a flat joint plane, locally filled with quartz and very minor chalcopyrite and molybdenite. No assay data are available from this level. The intermediate level (about 5,000' elevation) consists of a 60' adit driven to intersect several steep shear zones which form a fracture stockwork. Very localized sulfide mineralization occurs adjacent to these fractures. A Howe Sound dump grab of selected grade assayed 7.23% Cu, 8.75 oz/ton Ag and 0.03 oz/ton Au. The upper level (about 5,030' elevation) consists of a 160' adit driven along a flat quartz-chalcopyrite-molybdenite filled fracture. It was from this level that the minor production was achieved using room and pillar mining methods. A Howe Sound select sample from this mineralized fracture assayed 3.75% Cu, 2.67 oz/ton Ag and 0.01 oz/ton Au. No analysis was made for molybdenum.

This deposit, while containing some impressive molybdenite and chalcopyrite ore specimens, appears to be very restricted in extent and therefore of little economic interest.

7. Canyon Creek (Section 3, T31N, R14E, W.M.)

The Canyon Creek zone is located adjacent to the contact of the Cloudy Pass and Totem Pass rocks on the north side of Plummer Mountain, about 4,000' NNE of the Glacier Peak #1 ore body.

Sulfide mineralization, consisting mostly of pyrite, arsenopyrite, and sparse chalcopyrite, occurs both in quartz veins and as disseminations adjacent to the veins in weakly altered quartz diorite-granodiorite. The veins occur within a relatively narrow zone of E-W trending en echelon fractures. Several NE-trending post-mineral faults have caused minor offset of the mineralized fractures. Several of the faults have been intruded by lamprophyre dikes.

Assay values of samples taken by Bear Creek range as high as 4.46% Cu over a 25' chip. Unfortunately, this zone is mostly covered by talus and determination of size cannot be accomplished by surface examination.

Bear Creek has speculated that this prospect could represent a mineralized zone satellitic to the Glacier Peak porphyry copper system. Indeed, the best chance for expansion of reserves at Glacier Peak probably lies north to northeast of known ore bodies under the roof pendant of migmatites on Plummer Mountain. Prior to leaving Bear Creek in 1965, I recommended that at least one hole be drilled to test this anomaly. Because of the wilderness controversy, no drilling was ever accomplished.

8. Sitting Bull (Section 26, T32N, R15E, W.M.)

The Sitting Bull prospect is located about 1.5 miles NNE of Plummer Mountain on the east side of Sitting Bull Mountain. The zone was discovered by Bear Creek in 1961. The dominant sulfide mineralization consists of pyrite with very subordinate chalcopyrite and molybdenite occurring in a quartz monzonite plug along the contact of the Cloudy Pass pluton. The plug is thought to represent a late felsic differentiate of the Cloudy Pass cycle and is megascopically similar to the host rocks at the Fortress Mountain prospect (description #3) and at Bannock Mountain (description #9).

The zone of interest is about 1,000 x 800' in area. Total sulfides in the quartz monzonite average <1% but locally increase to 2-3% adjacent to the contact. The Bear Creek interest in this prospect was mainly due to the occurrence of the felsic host rocks. However, the weak distribution of sulfides and absence of a significant hydrothermal alteration overprint discouraged any real exploration effort other than prospecting. No samples were submitted for assay but megascopic estimates suggest maximum values of 0.1% Cu and < 0.02% MoS_2.

It is of interest to note that the roof pendant migmatites adjacent to this prospect are strongly limonitized and contain minor pyrite and chalcopyrite as fracture fillings.

9. Bannock Mountain (Sections 14, 15, T32N, R14E, W.M.)

A small plug of weakly limonitized leuco-granite (about 500' x 300' in surface area) is exposed along the Cloudy Pass contact on the east side of the Bannock Mountain ridge south of Bannock Lake. This plug is megascopically similar to the Fortress Mountain plug and appears to be a late stage felsic differentiate of the Cloudy Pass pluton. The granite locally contains minor (<1%) disseminated chalcopyrite associated with about 1% pyrite. A few flakes of molybdenite were noted on fractures. Although minor, this molybdenite occurrence could be responsible for Bear Creek's Mo-in-water anomaly at the mouth of Spruce Creek.

Several other small pinkish-brown pods of probable leuco-granite were observed from the air along the eastern slope of the Bannock-Sitting Bull ridge. Reconnaissance mapping in the migmatitic gneiss complex on Bannock disclosed the presence of a large, open north-south trending syncline. In all probability, several other folds exist in the roof pendant metamorphics which could provide partial structural control for the emplacement of these pods of granite (see Fortress Mountain discussion).

These leuco rocks, because of their megascopic similarity to Fortress and Glacier Peak rocks, should be studied in more detail. No thin sections were cut but I suspect the granite has been subjected to at least incipient K-silicate hydrothermal alteration.

10. Pass Creek (Sections 29, 33, T33N, R16E, W.M.)

The Pass Creek prospect was brought to Bear Creek's attention by W. G. Libby in 1961 while he was accomplishing his PhD thesis field mapping (Libby, 1964). The zone is underlain by Cascade River Schist about 1/2 mile south of the Cloudy Pass contact in the Pass Creek valley. Libby found float of pyrite, chalcopyrite and molybdenite-bearing quartz monzonite in talus below the east face of Lyall Ridge.

The source of the mineralized float was found to be a few narrow dikes of moderately quartz-sericite altered, leuco-quartz monzonite which have intruded the Cascade River section. These dikes are probably related to the Cloudy Pass intrusive cycle as a late stage felsic differentiate. The distribution of sulfide mineralization is very erratic and the average total sulfides content appears to be $<1\%$. Nevertheless, the Pass Creek zone represents another case where late stage leuco-rocks of Cloudy Pass affinity contain a porphyry copper type sulfide mineral assemblage.

11. Company Creek (Sections 15, 16, 21, 22, T32N, R16E, W.M.)

The Company Creek zone, located about 8 miles NE of Miner's Ridge, was examined in some detail by Bear Creek in 1959 and 1960. At that time, interest was centered mainly on the possible intersection of the NE trending Glacier Peak transverse structure and the NW trending Holden Mine structure. It was determined later that the Glacier Peak structure is offset to the southeast by a high angle fault on the east side of the Cloudy Pass batholith (see Grant, 1969, p. 73) and is not present in the Company Creek drainage.

The Company Creek area of interest is underlain by Cascade River Schist. An orthogneiss unit, probably correlative to the Marblemount meta-quartz diorite, is thrust over the Cascade River Schist in Upper Company Creek south of the target zone. A few quartz diorite (probably Cloudy Pass) and andesite porphyry dikes and plugs intrude the schist unit. Very localized zones of intrusive breccia containing traces to $<0.5\%$ chalcopyrite were mapped adjacent to several of the quartz diorite plugs. The dominant fracture and shear pattern in the mineralized Cascade River section trends WNW with shallow variable dips. These fractures could be parallel to subparallel strends of the above mentioned thrust.

Most of the significant sulfide mineralization occurs in relatively thin layers of quartz-sericite-chlorite altered schist which could have been derived from felsic volcanic rocks. These low-grade metamorphic rocks occur in an otherwise medium-grade metamorphic environment. The low-grade mineral assemblage could be due to selective structural stranding during the period of overthrusting. The most intense zone of sulfide mineralization is confined to a 30' wide section containing about 5% pyrite and $<0.5\%$ chalcopyrite. Due to topographic effect, a greatly enlarged anomalous geochemical fan results. Elsewhere in both the Company and Swamp Creek drainages, localized, mostly fracture controlled occurrences of pyrite, pyrrhotite and rare arsenopyrite have been found. In upper Swamp Creek, galena and sphalerite veinlets occur in a few talus blocks of schist. Minor pyrite (up to 5%) is also common in the plane of the Swamp Creek-Company Creek overthrust.

Overall, it is unlikely that significant Cu mineralization occurs in the Company Creek area. It is of interest to note that the felsic schist host rock can be traced intermittently southeast through the Martin Peak and Redcap zones (see descriptions #16 and 19) to the Holden Mine.

12. South Cascade Glacier (Section 21, T34N, R13E, W.M.)

The South Cascade Glacier zone was discovered during the construction of the USGS observatory hut on a rock rib along the west side of the glacier. The mineralization, consisting of widely spaced chalropyrite-molybdenite-quartz veinlets occurs within NE-trending fractures in the South Cascade quartz diorite stock. While the distribution of sulfides is limited in outcrop, the mineralized zone probably extends some distance to the east under the glacier. A few boulders of Mo-bearing quartz diorite have been found in the morainal debris near South Cascade Lake.

This zone appears to represent a weakly developed Cu-Mo-quartz system and chances for the discovery of significant mineralization are, at best, very remote. The intrusive rock, except immediately adjacent to the stockwork veinlets, is unaltered and unmineralized.

13. Suiattle River (Sections 4, 9, T31N, R14E, W.M.)

One mile west of Canyon Creek on the south side of the Suiattle River, a small zone of altered, pyritized weakly gneissose leuco-trondhjemite is exposed. The sulfide mineralization occurs both within rocks of the Sulfur Mountain pluton and a satellite stock of the Cloudy Pass batholith. It is thought that the mineralization is mainly a contact phenomenon due to the emplacement of Cloudy Pass rocks.

The dominant Sulfur Mountain mineralogy consists of glomeroblastic quartz, plagioclase (An_{20-30}), hornblende, biotite and subordinate perthite. Apparent hydrothermal alteration products are dominantly sericite and penninite. The distribution of sulfides is erratic averaging 1-1.5% pyrite and pyrrhotite. Only trace amounts of chalcopyrite were noted. Locally, very minor ($<0.5\%$) amounts of hematite are disseminated in the altered Sulfur Mtn. rocks. Float of intrusive breccia containing pyrite and pyrrhotite suggest some of the mineralized zone occurs near the Cloudy Pass contact although the actual contact is not exposed. Possible partial structural control for the mineralization could be a series of pre-intrusive NW trending faults mapped by Tabor and others (1966) south of the zone of interest.

The zone of mineralization, as exposed, is 2,000' x 1,500'. Bear Creek collected 16 soil samples within or topographically below the exposed area of interest. The specific Cu-Mo value data for these samples could not be found in the Bear Creek records but my 1961 reconnaissance summary report indicates none of the samples were anomalous in Cu or Mo. The threshold for anomalous soil values in this area is considered to be 100 ppm total Cu and 10 ppm total Mo. This zone was dropped from further Bear Creek interest in early 1962.

14. West Red Mountain (Section 22, T30N, R12E, W.M.)

The West Red Mountain zone stands out as strong color anomaly along the trend of the Glacier Peak transverse structural belt, about 6 miles WSW of Glacier Peak. The occurrence of the limonite zone along a favorable structural projection prompted Bear Creek to examine the area in 1960.

The limonitization is due to the presence of a small stock of propylitized, pyritized diorite-quartz diorite which has intruded a migmatitic gneiss complex. Total sulfides in the intrusive vary from 1-5% and consist of pyrite and pyrrhotite. No chalcopyrite was noted.

The brief 1960 reconnaissance was sufficient to remove the area from further Bear Creek interest. Geochemical stream sediment sampling from creeks draining the color anomaly was recommended but no follow-up was ever made.

15. Deerfly (Section 11, T31N, R14E, W.M.)

This prospect is near the southeastern boundary of the Glacier Peak deposit area of interest. It was worked about 1910 as a separate entity from Glacier Peak even though it is part of the same mineralization system. Approximately 500' of drift and crosscut in several adits were developed but no production was achieved.

The dominant sulfide mineralization is pyrite and chalcopyrite which occurs mostly along silicified, quartz-sericite altered E-W trending sheeting. Significant although localized occurrences of galena and sphalerite suggest the presence of a crude Pb-Zn halo in the Glacier Peak porphyry system.

Massive sulfide veins locally attain widths of 21"-18" which obviously attracted the early prospectors. Bear Creek considers this zone peripheral to their area of interest and it has not been drilled.

16. Martin Peak (Sections 26, 35, T32N, R16E, W.M.)

This zone was examined by Howe Sound and described by Ebbutt (1938 and 1956) and Youngberg (1950). Sulfide mineralization is restricted to a series of relatively thin limonitized quartzite and quartz sericite schist layers. intercalated in isochemical schists (? Cascade River). The quartz-sericite rocks can be traced NW of Martin Peak over the Hilgard Creek-Company Creek divide into upper Company Creek. The exclusive sulfides are pyrite and very minor pyrrhotite. These sulfide-bearing rocks are similar to those occurring in the Company Creek area (description #11).

An adit, named the Mary Green tunnel, was driven into one of the quartz-sericite schist layers. The adit, consisting of 70' of crosscut and 280' of drift, encountered pyritized schist and quartzite along its entire length. A representative dump grab by Howe Sound assayed nil Cu and Au. The zone is exposed for a distance along strike of about 4,600' and is remarkably consistent in sulfide content. However, the apparent absence of copper and/or precious metal values caused Howe Sound to conclude that the probability of economic potential was remote.

17. Riddle Peak (Section 33, T32N, R17E, W.M.)

Several relatively thin layers of limonitized quartzite occur along the Riddle Peak ridge at the head of Nine Mile Creek. These limonitized outcrops were examined by Howe Sound (Ebbutt, 1938). No sulfides were observed in outcrop. However, the depth of leaching on the ridge could be adequate to oxidize all near surface sulfides. Even so, the extent of these particular rocks is so limited that Howe Sound determined further investigation was unjustified.

18. Nine Mile Creek (Section 4, T31N, R17E, W.M.)

The upper basin of Nine Mile Creek was also investigated by Howe Sound (Ebbutt, 1938). In particular, the prospect shown on the Lucerne quadrangle as the Edil Mine was examined. Although this area lies immediately south of the Wilderness boundary, it is briefly described here because of its close proximity to Riddle Peak.

The Edil Mine workings comprise a 20' adit and several open cuts. Mineralization consists mainly of a massive pyrrhotite vein which occurs in amphibolite and/or hornblendite. A select grab of massive pyrrhotite was assayed by Howe Sound. The sample contained 0.25% Cu, 0.01 oz/ton Au and nil Ni.

A short distance below these workings, Howe Sound reports the occurrence of massive, unaltered "granitic" outcrops. They conclude that even if the above described sulfide mineralization was of economic interest, its depth projection would be limited due to the subjacent intrusion.

19. Red Cap (Section 35, T32N, R16E, W.M. and Section 2, T31N, R16E, W.M.)

The Red Cap area can be traced from immediately east of Holden Lake SE for about 9,000'. The mineralized zone consists of a relatively thick layer of silicified, limonitized, quartz-sericite rock which could have been derived from original felsic volcanic rocks. It is thought that the quartz-sericite mineral assemblage is a product of superimposed hydrothermal alteration as the surrounding isochemical schist unit is mostly upper-medium metamorphic grade.

The quartz-sericite rocks have been offset by several NE trending right-lateral high angle faults (Youngberg, 1950). Howe Sound drilled three holes in this zone in 1931 for a total footage of 1,174'. The location of these holes is not known. All of the holes encountered mixed quartz-sericite and quartz biotite schist (Ebbutt, 1938). The exclusive sulfide noted was "whitish to steely gray" pyrite which occurs in amounts up to 5% in the quartz-sericite rock. It is not known if all the core was assayed but Ebbutt reports nil Cu values and only a 1.5' intercept of 0.06 Au. All other Au values are $<$ 0.05 oz/ton with most only a trace.

Just NE of the Holden Lake trail and a short distance west of the first creek crossed by the trail, a 70' adit was driven in early days (? about 1900) into the SE extension of the Red Cap zone. The adit intersects sericitized quartzite (?) with intercalations of quartz biotite schist. Ebbutt (1938) reports both rock types contain minor pale colored pyrite. A dump grab taken by Howe Sound assayed Tr Cu and Tr Au.

Howe Sound considered this zone to have little if any economic potential. Consequently no additional work was accomplished in this area after Youngberg's mapping in 1950.

20. Ebbutt's Breccia (Section 2, T31N, R16E, W.M.)

Ebbutt's breccia (named after Frank Ebbutt of Howe Sound) lies west of the SE end of the Red Cap zone. Whether or not the mineralized area is an actual breccia was a question of considerable debate by Howe Sound geologists. The most widely accepted theory of origin is that the target represents a wide zone of fault breccia caused by the intersection of the Big Creek fault with a silicified segment of the Red Cap section. The breccia fragments, consisting mostly of pyritized quartz-sericite rock, are both angular and rounded. The matrix consists of quartz, calcite and sulfides.

Youngberg (1950) describes the breccia as being crudely elliptical in shape, measuring about 1,000' x 750'. Right lateral faulting which has offset the Red Cap section appears to have offset the breccia as well. The breccia outcrop is leached, with resultant strong limonitization. Ebbutt (1956) reports that the breccia zone was drilled by Howe Sound in 1940 but supplies no details. He does mention that pyrite and hematite with very subordinate "late" sphalerite and chalcopyrite were observed in the core.

Ebbutt (1956) recommended that the breccia zone be studied in more detail and that follow-up drilling be accomplished if necessary. It is not known if Howe Sound performed this recommended work.

21. Buckskin Mountain (Section 20, T31N, R16E, W.M.)

Although this zone as defined lies north of the Wilderness boundary, it is briefly discussed because southeasterly extensions could project into the Wilderness east of Buckskin Mtn. Howe Sound conducted extensive drilling of the target from the southeast drift of the 1,500' level in the Holden Mine. A total of 79 holes for a total aggregate footage of 17,197' was drilled (Ebbutt, 1956). The available Holden reports do not discuss the details of the drill results but only refer to the mineralized zone as a low-grade Cu-Zn target which could have had the potential of ultimately being included in the Holden Mine plan.

On surface, a short 20' adit has been driven into a massive lens of pyrrhotite. A Howe Sound grab sample of massive sulfide assayed trace Au and 1% Cu (Ebbutt, 1938). The total width of the main exposed mineralized zone is 30'. Several parallel to sub-parallel limonitized shear zones were observed in the general area but were inaccessible to the Howe Sound geologists.

The host rock for this occurrence is described as an "early intrusive acid rock" (Ebbutt, 1938). Not having visited the area, I'm not sure what this means. Ebbutt mentions the possible structural linkage of Buckskin with the Red Cap area so the Buckskin host could be some type of quartz-sericite schist derived from felsic volcanic rocks.

Adjacent to the pyrrhotite-chalcopyrite zone, Howe Sound discovered disseminated pyrrhotite in a (?) peridotite. Apparently, the pyrrhotite is nickeliferous (no specific assay data) and Howe Sound considered this an added attraction to the overall economic potential of the Buckskin target.

22. North Side - Dumbell Mountain (Sections 3, 10, T31N, R16E, W.M.)

This area, lying immediately southeast of Hart Lake on the south side of Railroad Creek, stands out as a pronounced limonite zone. The country rock consists of weakly propylitized, pyritized medium-grained, early phase Cloudy Pass diorite. The diorite is cut by numerous lamprophyre dikes which also are weakly pyritized. No chalcopyrite has been noted either in any of the accessible sections or in talus examined below the cliffs. There is no field evidence to suggest the sulfide mineralization would change in type at depth. As a consequence, the economic potential of the zone is rated very poor.

23. West Side - Bonanza Peak (Sections 32, 33, T32N, R16E, W.M.)

A prominent limonite zone is visible on the west face of Bonanza Peak directly east of the pass at the head of Glacier Creek. The zone itself appears quite difficult to reach but the talus below the cliffs can be easily examined. The limonitization is caused by 1-2% disseminated pyrite in weakly gneissose meta-intrusive rock. No chalcopyrite was found in any of the talus blocks examined. The sulfide mineralization could be related to a suspected fault which juxtaposes Cloudy Pass rocks against orthogneiss in the Glacier Creek pass area.

24. Red Mountain - Chiwawa (Sections 20, 21, 28, 29, T31N, R16E, W.M.)

A large prominent limonite zone occurs along the Red Mountain-Chiwawa Peak ridge south of the Lyman Glacier. The limonite appears to be due to the pervasive presence of minor pyrrhotite and pyrite in the Swakane Gneiss along the Cloudy Pass contact. Very minor chalcopyrite also is present in a few localities. The sulfide mineralization is thought to be related to the emplacement of the Cloudy Pass although the specific controls for this occurrence are not known. Bear Creek spent a considerable amount of time mapping this area and concluded that in spite of the widespread weak sulfide mineralization, the probability of discovery of a target of economic potential was remote.

Sediment samples taken from streams draining north from this zone are strongly to moderately anomalous in exchangeable copper (see geochemical data plots on the accompanying map).

25. North Star (Section 6, T31N, R16E, W.M.)

The North Star prospect is located on the north side of the ridge leading from Cloudy Pass towards the summit of North Star Mountain. The country rock is massive, main phase Cloudy Pass quartz diorite.

Sulfide mineralization consists of a 6"-12" wide, gently dipping vein of massive galena. The vein can be traced for <50' on surface although when I examined this locality in 1959, considerable snow was still present on the north facing slope. A grab sample of massive galena assayed 142 oz/ton Ag. It is possible that a few hundred tons of this high-grade ore could be mined. Early miners drove a 20' adit into the vein but apparently did not ship any ore.

Near the Lyman Lake trail due north of Lyman Falls on Railroad Creek, a short adit was driven into a 1" vein of minor galena and sphalerite (Ebbutt, 1938). The country rock is massive, unaltered Cloudy Pass quartz diorite.

26. Blankenship (Section 10, T33N, R16E, W.M.)

Note: Information regarding properties #26-32 in this descriptive section was taken from Huntting (1956). I have not visited any of the prospects and therefore cannot verify the accuracy of data, including location.

The Blankenship prospect lies just east of the Wilderness boundary near the confluence of Agnes Creek and the Stehekin River. In 1930, it consisted of 7 claims and a millsite. The reported metal commodity is Cu but the type of deposit is unknown.

27. Bryan (Section 9, T30N, R16E, W.M.)

The Bryan prospect is situated on Red Mountain Ridge, probably somewhat south of the same area discussed in description #5 of this section. As of 1940, the property consisted of 20 unpatented claims. The reported metal commodities are Cu, Au and Ag but the type of deposit is unknown.

28. Lake Shyall (NW 1/4 Section 16, T34N, R15E, W.M.)

The prospect is described as being located near the south shore of Trapper Lake, about 2,000' north of the Wilderness boundary. Apparently one or more claims were located here in 1897. However, no later activity has been reported. The reported metal commodities are Cu, Au and Ag but the type of deposit is unknown.

29. Silver Trail (Section 8, T31N, R16E, W.M.)

The reported location of the prospect is on Railroad Creek adjacent to the Crown Point Mine. At various times, the property was owned by Aurelia Crown Mines Corp. (1909-1918), Crown Power Molybdenum Co. (1922-1924) and Chemical Products Association (1925-1926), all of which controlled the Crown Point Mine during the same period. The reported metal commodities are Cu, Ag, Pb, Zn and Au. The gold is said to occur mostly in quartz veins.

30. Cascade (NW 1/4 Section 7, T34N, R13E, W.M.)

The approximate location of this prospect is on the ridge between Sonny Boy Creek and the S. Fork Cascade River, about 3/4 mile NW of the Wilderness boundary. The deposit is described as a 5' quartz vein with a 10" paystreak of massive galena. The metal commodities are Pb and Ag. A 100' adit was driven on the vein about 1892. (Note: on basis of information supplied by R. B. Statelmeyer, U.S. Bureau of Mines, this prospect is probably on Pincer Creek, as shown on accompanying map).

31. Epoch (Section 10, T34N, R10E, W.M.)

The approximate location of the claims if 1.5 miles north of the Wilderness boundary on the south slope of Johannesburg Mtn. The deposit is described as a 3' vein of massive galena assaying 38-45% Pb and 39-102 oz/ton Ag. In all probability, the vein is similar to the numerous Pb, Ag veins which trend NE from Johannesburg Mtn. through Boston Basin and into Skagit Queen Creek.

32. Pioneer (Sections 2, 11, T34N, R13E, W.M.)

The location of this prospect is about 3,000' NE of the Epoch claim (description #31), also on the south slope of Johannesburg Mtn. The property consists of 9 patented claims. Mineralization consists of argentiferous galena and minor sphalerite in NE trending veins.

33. Goff (Sections 19, 20, 29, 30, T29N, R14E, W.M.)

Information on this property was obtained from a 1940 Howe Sound report by H. B. Smith which is now in the Bear Creek files. Claim status is not known.

The property is located partly within and partly outside of the Wilderness on the ridges separating the N. Fork Skykomish River, Sauk River and Little Wenatchee River drainages. The mineralized area stands out as a pronounced limonite zone in rocks described by Smith as rhyolites and trachytes. The limonitization is due to oxidation of pervasive pyrite (1%-3%) which occurs in the volcanics over an area of about 1.5 square miles. Smith collected 4 samples of the pyritized volcanic rock within the Wilderness (see Bench Mark Mountain quadrangle). All of the samples assayed Nil-trace Au and trace-0.01 oz/ton Ag. Two samples collected from narrow veins south of the Wilderness boundary assayed 0.01 oz/ton Au, 1.58 oz/ton Ag and 0.1 oz/ton Au, 13.85 oz/ton Ag, 7.3% Cu respectively, The latter sample was cut from a 2' vein.

Smith concluded the prospect had little economic potential and was not of interest to Howe Sound.

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