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GEOLOGICAL SURVEY

Mineral Resources of the Alpine Lakes Study Area, Chelan, King, and Kittitas Counties, Washington

By

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STUDIES RELATED TO WILDERNESS

WILDERNESS AREAS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, Sept. 3, 1964) and the Conference Report on Senate bill 4, 88th Congress, the U.S. Geological Survey and the U.S. Bureau of Mines are making mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System. The act provided that areas under consideration for Wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. This report discusses the results of a mineral survey of some national forest lands in the Alpine Lakes study area, Washington, that may be considered for wilderness designation. The area studied is on the crest of the Cascade Range in west-central Washington.

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MINERAL RESOURCES OF THE ALPINE LAKES STUDY AREA, CHELAN, KING, AND KITTITAS COUNTIES, WASHINGTON

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SUMMARY

The Alpine Lakes area, about 324 square miles (839 km^2), is rugged terrain on the crest of the central Cascade Range of Washington State. It includes the proposed Enchantment Lakes Wilderness of about 54 square miles (140 km^2), the proposed Alpine Lakes Wilderness of about 196 square miles (508 km^2), the area between the two proposed wildernesses, and a small area southwest of the proposed Alpine Lakes Wilderness, in parts of the Snoqualmie and Wenatchee National Forests.

The study included reconnaissance geologic mapping, an aeromagnetic survey, geochemical sampling, and examination of mines, prospects, and claims. County records show that about 435 lode and placer claims, 60 of which are patented, have been located in the study area since the 1880's. Most mining claims lie near the edges of granitic intrusive masses along the west and south sides of the area. Although no established mining districts exist, mining claims are mostly in groups, and the study of mines and prospects was divided into nine areas containing most of the claims.

A total of 23 tons of ore has been produced from three small mines in the area. Probably additional small production resulted from exploratory work in other areas but no records are available.

U.S. Geological Survey personnel collected a total of 2,986 samples for analysis: 1,853 stream-sediment samples, 1,127 rock samples, and 6 panned concentrates. The entire area was systematically sampled and rocks were sampled in detail; areas in which anomalous amounts of metal were detected were examined to determine the source of the metals.

U.S. Bureau of Mines personnel collected about 300 samples from prospected veins, shear zones, and areas of mineralized breccia. The samples were analyzed by fire assay and chemical methods. More than 35 samples from placer claims and gravel deposits were analyzed to determine recoverable gold and heavy mineral content.

The Deception Creek fault zone divides the Alpine Lakes area into an eastern block characterized by dominantly pre-Cretaceous metamorphic, granitic, and ultramafic rocks, and a western block characterized by dominantly Mesozoic and Tertiary sedimentary volcanic and granitic rocks. The Deception Creek fault zone is a group of anastomosing northwest-trending vertical faults, part of which forms a shear zone in the Ingalls peridotite.

Intensely altered and mineralized volcanic and granitic rock containing anomalous amounts of copper occurs in several places in the Alpine Lakes area; for example, the drainage basins of Gold, Mineral, Van Epps, and Lemah Creeks and the Middle Fork of the Snoqualmie River. Aureoles of slightly altered and mineralized rock in places surround the intensely altered areas. Major structural features such as high-angle and vertical faults that may have controlled the emplacement of the deposits occur in only a few of the mineralized areas.

The part of the Clipper-Crawford Creek area along the Middle Fork-Snoqualmie River has a potential as a low-grade copper resource. The Three Brothers zone of mineralized granodiorite and quartz monzonite may contain as much as 2 million tons of rock averaging 0.9 percent copper. The Red Face zone in the same area contains low-grade disseminated copper minerals and may be a potential resource.

Disseminated sulfides, mainly chalcopyrite and molybdenite, in granitic rock in the Gold Creek valley are a potential resource. Two drill holes by Phelps Dodge Co. contained 300-foot intervals that assayed 0.11 and 0.12 percent copper.

Of the several vein-type mineral deposits in the Alpine Lakes area, the Dutch Miller mine in the Chain Lakes basin near La Bohn Gap is the most promising. One vein is exposed at surface and two veins are reported in the subsurface. They may be genetically related to the emplacement of a young stock of the composite Snoqualmie batholith. The veins are located on shear zones that are not known to have been explored at depth. The Dutch Miller mine contains a small, high-grade deposit estimated to contain 3,500 tons of copper ore averaging over 11 percent copper and has potential for discovery of additional ore. With suitable access, this deposit may be a minable copper deposit. Other veins may be present in the subsurface in the Chain Lakes basin and possibly other areas surrounding the stock.

Several small base metal deposits and small patches of hydrothermally altered rock containing disseminated sulfides occur in the Van Epps Pass area. The deposits are located in shear zones in ultramafic rock, or are associated with intermediate to mafic dikes. Rock and stream-sediment samples taken in the area suggest a possible zonation from relatively high-copper low-zinc concentrations near the contact of the Mount Stuart batholith and ultramafic rock, to relatively high-zinc low-copper away from the contact. Low-grade mineralized rock in the Van Epps adit and in another zone explored by drilling may represent a potential copper resource. The weighted average of samples taken 242 feet along the adit was 0.33 percent copper. Mineralized rock containing 0.10-0.46 percent copper was disclosed in 226 feet of drill hole about 3,500 feet from the adit. The zones are not evident on the surface.

Silver was detected in samples from the main mineralized areas and, in some localities, would contribute substantially to the total value of the resources. Samples indicate that the most consistent silver values are in the arsenopyrite veins in the Sprite Lake area. They contained as much as 6.8 ounces silver per ton. The silver and gold in the deposits are a potential resource. Samples from the Transit, Giant, Silver King, and Silver Queen claims, all in the Gold Creek area, contained as much as 22.40 ounces silver per ton. The deposits are not minable, but represent a small potential silver resource. Samples from the Dutch Miller mine contain about 2-10 ounces silver per ton. Copper would be the primary metal produced but silver would be a significant added value.

Gold occurs in detectable amounts in many places in the study area but only the Sprite Lake area contains significant concentrations. One vein in the Sprite Lake area is estimated to contain over 2,000 tons of mineralized rock containing about 1.78 ounces gold per ton. Only very minor amounts of recoverable gold were found in placer samples from all areas.

An iron-stained, altered area of granitic rock located in the eastern part of the Alpine Lakes area on French Ridge near Turquoise Lake shows anomalies in zinc, copper, silver, and tin. Because sparse grains of sulfide minerals are in the altered rocks, the area is considered to have mineral potential.

The Swauk Formation near Summit Chief Mountain, which is structurally similar to the Swauk which contains the L-D gold deposit near Wenatchee, may have mineral potential.

The study area has no potential for combustible fuels. Granitic rock and sandstone, possibly suitable for construction and decorative stone, and sand and gravel could be produced from the area but these commodities are more readily accessible at other localities that are closer to markets.

The Snoqualmie batholith is of late Miocene age and may retain sufficient heat to be considered a source of geothermal energy. Surficial indications of geothermal activity, such as hot springs, however, were not observed in the study area.

INTRODUCTION

By J. L. Gualtieri and George C. Simmons
U.S. Geological Survey

A mineral survey of the proposed Enchantment Lakes and Alpine Lakes Wildernesses, an intervening area, and an area adjacent to the Alpine Lakes area, was undertaken to appraise the suitability of incorporating these areas into the Wilderness system. About 54 square miles (140 km^2) is in the proposed Enchantment Lakes Wilderness (area 2, pl. 1), about 196 square miles (508 km^2) in the proposed Alpine Lakes Wilderness (area 1, pl. 1), about 63 square miles (163 km^2) in the intervening area (area 3, pl. 1), and about 11 square miles (28 km^2) adjacent to the western part of the Alpine Lakes Wilderness (area 4, pl. 1). All areas are referred to in this report as the Alpine Lakes area, and total about 324 square miles (839 km^2).

Location and geography

The Alpine Lakes area is on the crest of the central part of the Cascade Range of Washington (fig. 1) and is roughly bounded by Interstate Highway 90 on the southwest, U.S. Highway 2 on the northwest, and U.S. Highway 97 on the southeast. On the west, south, and east the boundary lies well back from the main highways and follows such natural features as ridge crests and canyon floors, or is located along section lines. The southeastern extremity of the area is about 3 miles (5 km) southwest of Leavenworth, Wash., the southwestern extremity is about 1 1/2 miles (2.5 km) from the Snoqualmie Pass recreation area, and the northwestern boundary is about 2 miles (3 km) from the Stevens Pass recreation area.

The area is rugged and is characterized by deeply glaciated canyons and serrate ridges. In only a few small highland areas does relatively flat rolling topography exist. Major streams draining the area are Icicle and Ingalls Creeks on the east; the Cle Elum, Waptus, and Cooper Rivers on the south; the Middle Fork of the Snoqualmie River on the west; and the East and West Forks of the Foss River, and Deception Creek on the north. Mount Stuart, the highest peak in the area, at an altitude of 9,415 feet (2,871 m), is located in the south-central part of the study area. It is one of several peaks in the Stuart Range with summits above 8,000 feet (2,440 m). In the western part of the study area the highest peaks exceed 7,000 feet (2,135 m), and in the northeastern part they reach almost 8,000 feet (2,440 m); in both parts the lower peaks and ridges average 6,000-7,000 feet (1,830-2,135 m).

Little of the scenery of the Alpine Lakes area is visible to the road-bound viewer either because of obstruction by intervening terrain or because of steep relief which permits only upward oblique views. Locally, however, parts of the Alpine Lakes area can be seen from certain vantage points: the Stuart Range is visible from places along Interstate 90 between Ellensburg and Cle Elum and from along U.S. Highway 2 between Wenatchee and Leavenworth, as well as from secondary roads southeast of the Alpine Lakes area; the south-western part of the area, including the south face of Chimney Rock, is visible from a secondary road in the Cooper Lake area about 15 miles (24 km) north of Cle Elum. The southeastern ridge and peak of Cashmere Mountain are visible from the Icicle Creek road at a point about 5 miles (8 km) from Leavenworth.

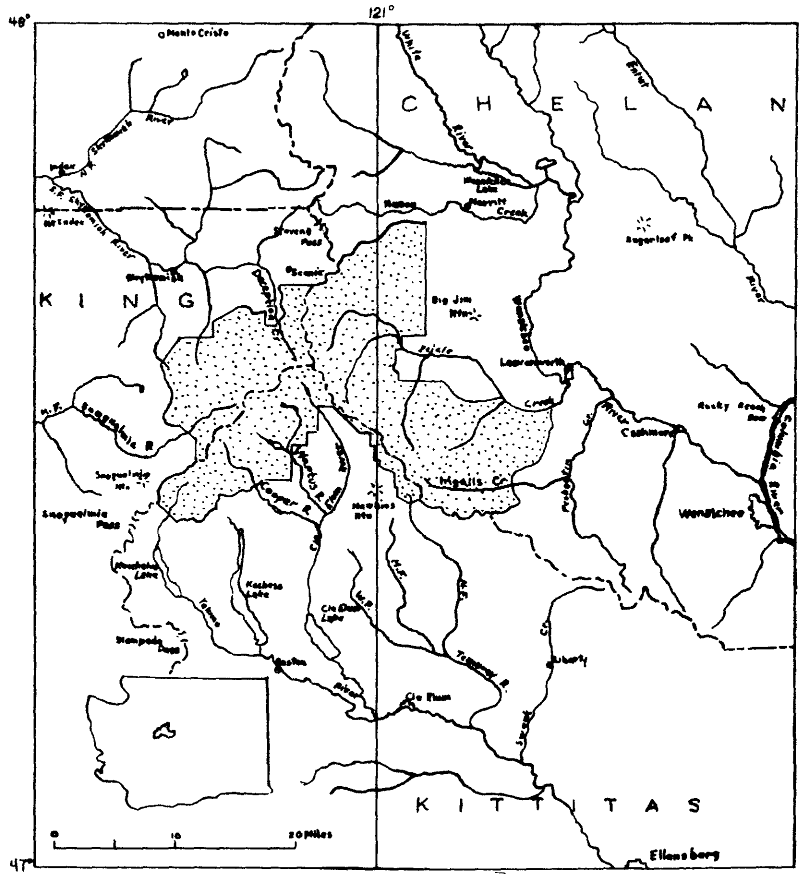

Figure 1.--Location of the area considered in this report (stippled).

In the Alpine Lakes area a secondary road starts in Icicle Creek canyon and runs a few miles up Mountaineer Creek to a point a short distance above its confluence with Pioneer Creek. Another road, which requires a four-wheel-drive vehicle, starts in the canyon of Cle Elum River about 5 miles (8 km) above Salmon La Sac Guard Station and runs up Fortune Creek to a point a few miles inside the Alpine Lakes area at Van Epps Pass from which the southeast-central part of the area can be seen.

Numerous Forest Service trails traverse the area. The Cascade Crest Trail, perhaps the best known, enters the area along the Middle Fork of the Snoqualmie River, crosses the Cascade crest at three places, and leaves the area about 2 miles (3 km) southeast of Stevens Pass. Snow Lakes Trail is the most used. It starts in Icicle Creek canyon about 4 miles (6.5 km) west of Leavenworth, passes between the main Stuart Range and The Temple by way of Snow Lakes and Lower Enchantment Lakes, and ends near Upper Enchantment Lakes. In this distance of about 7 miles (11 km) there is a vertical rise of about 6,500 feet (1,980 m).

The Alpine Lakes area has been glaciated and is estimated to contain about 30 remnant glaciers and more than 600 small lakes. Glacial features such as cirques and hanging valleys are common throughout the area, and near the toes of some of the glaciers small morainal deposits of the 19th century advance are evident. The area is mostly below timberline which is about 6,000 feet (1,830 m). Dense stands of Douglas fir with minor pine and other types cover most of the area. In the southeastern part, which is appreciably drier than the rest of the area, open stands of ponderosa pine grow on the lower south-facing slopes. Tamarack, spruce, and white pine grow locally in areas near timberline. In areas where fire or snow slides have destroyed the trees, bush alder and vine maple have taken over and form dense thickets which are penetrated only with great difficulty. Above timberline is mostly bare rock, talus, and snowfields. Grasses, wild flowers, and broad-leafed plants grow in areas where soils have developed.

Little industrial activity is underway in the area at present. No mineral deposits are being mined, and the only mineral activity appears to be annual assessment work on claims. Logging is not permitted because of the area's defacto wilderness status. Highland meadows permit limited sheep grazing. The area is an important source of water. Streams which flow eastward, notably Icicle Creek, supply fruit orchards in the Wenatchee River valley below Leavenworth. Other streams flow into Kachess and Cle Elum Lakes, both of which are dammed and serve as reservoirs to conserve the spring runoff which is drawn from the Yakima River to irrigate the hayfields of Kittitas valley and the orchards of Yakima valley.

Previous studies

Geologic studies of the Alpine Lakes area have been concerned mainly with the areal geology and the petrography and petrology of the rock units; however, a few unpublished reports have been made of the mineral deposits in the area.

Russell (1900) sketchily reported on the geology of the Cascade Range of northern Washington, and made the earliest known mention of the geologic character of the Alpine Lakes area; he recognized granitic rocks and serpentinite in the southeastern part of the area.

Smith (1904) mapped the Mount Stuart 30-minute quadrangle which includes the southeastern part of the Alpine Lakes area. Smith and Calkins (1906) later mapped the adjoining Snoqualmie 30-minute quadrangle which includes the south-central and southwestern part of the Alpine Lakes area. The work of these men, although subsequently modified, has remained a primary source of knowledge of the geology of the central Cascade Range of Washington.

Later work in the area includes several unpublished theses or published work based on theses by graduate students of the University of Washington and other schools. Pratt (1954, 1958) made a reconnaissance of most of the Alpine Lakes area east of Cle Elum River and Deception Creek, where he mapped pre-Tertiary schist, ultramafic rock, and the Mount Stuart batholith. Foster (1955) studied Tertiary sedimentary and volcanic rocks in the extreme south-western part of the area near Snoqualmie Pass. Galster (1956) studied the area south of the Skykomish River and west of Deception Creek covering part of the ground along the northwestern boundary of the Alpine Lakes area. He mapped parts of several rock units including pre-Tertiary schist, Cretaceous-Tertiary sedimentary and Tertiary volcanic rock units, and batholithic rock. Ellis (1959) worked in the southwestern and south-central parts of the study area where he mapped extensions of most of the same rock units previously mapped by Galster to the north.

Erikson (1965) studied the eastern part of the Snoqualmie batholith. He mapped detailed numerous textural and mineralogic facies of the body, demonstrating the composite nature of the batholith. Plummer (1969) studied the pre-Tertiary schist, ultramafic bodies, and the Mount Stuart batholith in the northeastern part of the area. Southwick (1962) studied the mafic and ultramafic rocks in the Peshastin area and a small part of the southeast corner of the Alpine Lakes area. Grant's (1969) study of ore deposition and related alteration in the central Cascade Range included the western parts of the study area.

Recently, graduate students at Washington University (1972) reported on the environmental aspects of the geology in the central Cascades which included the Alpine Lakes area.

Several mines and mineral deposits in the study area were examined by U.S. Bureau of Mines engineers and U.S. Geological Survey personnel in connection with the Strategic Minerals program in the 1940's, and the Bureau made a study of copper resources in the Cascade Mountains in the 1950's. The reports briefly describe the workings and mineral occurrences at the mines examined. Between 1951 and 1957 two exploration projects were conducted at the Pickwick mine in the Van Epps area by U.S. Bureau of Mines and U.S. Geological Survey personnel under the Defense Minerals Exploration Administration program. Mining engineers of the U.S. Forest Service have made mineral appraisal examinations in various parts of the study area, notably in the Gold Creek and Mineral Creek areas and at various prospects on the Middle Fork of the Snoqualmie River. Most of these mineral appraisal reports are unpublished, but were available to the writers.

Numerous geologic studies have been made of mineral deposits in the Alpine Lakes area by mining engineers and geologists either in a consulting capacity or in the employ of mining companies. The reports, mostly unpublished, are the property of private citizens or mining companies. Some of them were available to the writers.

Present studies and acknowledgments

Geologic fieldwork began in the summer of 1971 by J. L. Gualtieri and G. C. Simmons assisted by F. Michael Krautkramer and Ronald J. Tucker. The work consisted mainly of geochemical sampling and geologic reconnaissance. Fieldwork was resumed by the writers in the summer of 1972. That year additional geochemical samples were taken, but the main effort was reconnaissance geologic mapping with special attention being paid to the geologic environments of mineral deposits. Approximately 12 1/2 man-months were spent by U.S. Geological Survey personnel in field investigations.

Samples of stream sediments were taken along all the major and medium-sized stream drainages. Samples of rock were taken along the crests and flanks of most ridges, especially in areas of mineral deposits and hydrothermally altered rock, to check them for metal content.

The analytical work was performed in the field by U.S. Geological Survey personnel, under the immediate supervision of C. L. Whittington. Semiquantitative spectrographic analyses of all samples were made by C. L. Forn with the assistance of E. F. Cooley and R. N. Babcock.

U.S. Bureau of Mines personnel did fieldwork in the mining districts and mineralized zones in and near the study area during the summers of 1971 and 1972. Investigations were made by H. K. Thurber and Michael S. Miller assisted by Michael B. Walen, John Roswell Hill, Guy W. Curtis, and Thomas L. Hamilton. Approximately 26 man-months were spent by Bureau personnel in field investigations.

The investigations made by the U.S. Bureau of Mines were concerned mainly with the economic aspect of the mineral resources in and adjacent to the study area. Information was obtained from the records of the U.S. Forest Service. The records of Chelan, King, and Kittitas Counties were examined at their respective county seats for the location of patented and unpatented mining claims. Data on production and history of former operations were compiled from U.S. Bureau of Mines records and from various reports of the Washington Division of Mines and Geology.

The computer storage and retrieval program work was completed under the direction of Lamont O. Wilch with the assistance of Steven K. McDanal, both with U.S. Geological Survey.

An airborne magnetometer survey was flown in the summer of 1972 by Scintrex Mineral Surveys, Inc. The data were interpreted by W. E. Davis of the U.S. Geological Survey.

Because of the rugged, precipitous character of the area, geologic studies were carried out by helicopter; foot traverses were run between dropoff and pickup points. In low-lying areas where there are roads, work was carried out by truck and foot traverses. Reconnaissance of mines and mine properties was carried out with fixed-wing aircraft. Access to mine properties was by helicopter and by foot.

Acknowledgment is due U.S. Forest Service personnel, without whose cooperation the wilderness study could not have proceeded, particularly Donald R. Campbell, Forest Supervisor, Snoqualmie National Forest, and Andrew C. Wright, Forest Supervisor, Wenatchee National Forest. Also special acknowledgment is made to John Sargentson, Lands and Recreation Officer, Charles R. Garrett, Mining Engineer, Bert Toler and Ellis Gross, District Forest Rangers, all of Snoqualmie National Forest, and to Pat Int-hout, Fire Control Officer and Charles S. Banko, District Forest Ranger, Wenatchee National Forest. Thanks are also due the personnel of the Leavenworth National Fish Hatchery, notably Henry S. Hosking, Manager, who made available a hatchery building for the use of field laboratory personnel, and an area of the hatchery grounds for use as a heliport.

Alan Robert Grant, consulting geologist, supplied valuable detailed information on results of exploration in the Snoqualmie River-Middle Fork-Gold Creek-Mineral Creek mineralized areas. Permission to use much of the information was kindly given by Grant and Gregg C. McDonald, President, Natural Resources Development Corp. Grant supplied additional data on the Gold Creek-Mineral Creek zone.

GEOLOGY

By J. L. Gualtieri and George C. Simmons
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Geologic setting

The Alpine Lakes area is underlain by metamorphosed rocks which have been intruded by granitic plutons and which are overlain by sedimentary and volcanic rocks. A regional northwest-trending fault divides the area into two blocks of contrasting geology. To the east are mostly metamorphic, ultramafic plutonic, and mafic volcanic and related sedimentary rocks that have been intruded by a Mesozoic batholith. To the west are mostly metamorphic, arkosic sedimentary, and intermediate volcanic rocks that have been intruded by a Tertiary batholith.

The oldest rock in the area is schist that probably was metamorphosed in Mesozoic time in response to orogenic forces. Schist crops out in the eastern and the western parts of the study area and, because of slightly different lithologic characteristics, is treated in this report as two formations (Chiwaukum Schist and Easton Schist). Similar rock is exposed at numerous places along the axis of the central and north Cascade Range in Washington.

Greenstone, argillite, metagraywacke, and tuffaceous rock of the Peshastin and Hawkins Formations crop out in a structurally complex area in the southeastern and south-central parts of the Alpine Lakes area. These rocks are isolated from similar rocks in the Cascade Range; therefore, the stratigraphic sequences cannot be correlated with confidence.

Peridotite and associated gabbroic bodies that may be genetically related intrude metamorphic rocks in the southeastern and south-central parts of the study area, and occur as roof pendants in batholithic rock in the northeastern part. The peridotite is similar to several other ultramafic bodies in the Washington Cascade Range and, although it cannot be confidently correlated with them, it is assumed to occupy the same position in the geologic history of the Cascade Range. A period of erosion followed emplacement of the peridotite and iron-rich deposits and formed a weathered surface, which was subsequently buried beneath younger sediments.

In the eastern part of the Alpine Lakes area a Late Cretaceous granitic pluton, the Mount Stuart batholith, intrudes the schist and peridotite. This body extends eastward and northward beyond the study area, and is the southwesternmost occurrence of a series of Mesozoic plutons extending into northeastern Washington and southern British Columbia.

During latest Mesozoic and earliest Tertiary time, contemporaneous with and immediately following intrusion of the pluton, a thick blanket of stream-deposited, arkosic sandstone, the Swauk Formation, was deposited over all or most of the Alpine Lakes area, but today it is preserved only in the western part. At several places north of the study area and south and southeast of it, occurrences of similar sandstone are known.

Following deposition of the arkosic beds the rocks were folded, and were offset by thrust faults and some normal faults. Shortly thereafter, in early Tertiary time, the first rocks (the Naches Formation) were deposited from several volcanic episodes that were to span most of the rest of the Tertiary period. Rocks deposited during two or more of these episodes are in the Alpine Lakes area, but, either because of structural complexities of the rocks or because they have not been mapped in adequate detail, their relative stratigraphic positions are uncertain. The volcanic rocks are present only in the western part of the study area but may once have overlapped the eastern part. Two layered sequences are distinguishable: basalt flows interbedded with arkosic sandstone, and andesite flows interlayered with andesite pyroclastic units. They are part of an extensively exposed belt that lies to the north and south of the Alpine Lakes area, and correlative units may be present in the Puget Sound lowland.

One orogenic event, and possibly more, took place during the period of volcanic activity and produced the major vertical faults that cut the area.

The orogenic events that shaped the structure of the layered rocks in the western part of the Alpine Lakes area had far less effect in the eastern part. Only along the southeastern boundary, where there is a west-trending zone of sheared and deformed serpentinized peridotite with inclusions of greenstone and gabbro, is such activity evident. The zone is known to have been active at least once during Tertiary time and may have been active repeatedly during that period.

In middle Tertiary time granitic rock (the Snoqualmie batholith) intruded the western part of the study area. It is an eastward-projecting lobe of a batholith that is extensively exposed to the west. Some deformation and uplift accompanied and followed the emplacement of the batholith. A drainage pattern with gently rolling hills and broad valleys was established at this time, and parts of this old topography are still preserved at a few high places in the study area.

Uplift of the Cascade Range on a north-trending, southward-plunging axis concluded the tectonic activity in the region. Streams became entrenched to form the deep canyons that give the Alpine Lakes area its steep rugged topography.

With the onset of the Quaternary Period, developing glaciers followed the already existing valley and canyon courses, deepening and broadening them. Three major advances and retreats are recorded in the deposits of glacial debris, most of which are located at canyon mouths outside the Alpine Lakes area. Very minor advances and retreats are recorded as late as the middle of the 19th century.

Rocks

Chiwaukum Schist

The Chiwaukum Schist together with the Easton Schist constitute the two oldest rock formations in the Alpine Lakes area. The Chiwaukum Schist was first studied and named by Page (1939) and was later studied by Southwick (1962) and Plummer (1969).

The Chiwaukum Schist is best exposed in the Chiwaukum Mountains which are located in the extreme northeastern part of the Alpine Lakes area. The rock is mostly quartz-biotite schist and phyllite with minor amphibolite. Garnet, which can be seen in felsic foliae in grains 1-2 mm across, gives the weathered rock a wart-studded appearance. Minerals visible under the microscope include staurolite, sillimanite, and kyanite. The rock is brownish gray to greenish gray where it is biotite-rich and is very light gray where it is quartz-rich. The foliae are about 1 mm thick and in most places are undulose or intricately folded. The rock is ribbed with limonite-stained lenses of white quartz a few inches thick and a few feet long that both parallel and cut across the foliae. The thickness of the unit in the Alpine Lakes area is not known for it occurs only as roof pendants in the Mount Stuart batholith.

The Chiwaukum Schist was affected by two episodes of metamorphism; an early regional and later thermal metamorphism. The thermal metamorphism is restricted to a narrow zone near the contact of the Mount Stuart batholith and is characterized by the development of andalusite and cordierite. The Chiwaukum is believed to be derived from high aluminum Paleozoic sedimentary and volcanic rocks.

Easton Schist

The Easton Schist was named by Smith (1903), who with Calkins (Smith and Calkins, 1906) mapped and described extensive outcrops in the Snoqualmie 30-minute quadrangle. The formation was later mapped and described by Foster (1957), and subsequently by Ellis (1959) who demonstrated that the formation extended northward to the crest of the Cascade Range. The formation, whose thickness in the Alpine Lakes area is not known, is exposed in a fault-bounded belt about 6 miles (10 km) long and 1/2-2 miles (0.8-3 km) wide. The character of the rock differs along the belt; in the northern part the rock is quartz-graphite phyllite and in the southern part, according to Ellis, it is amphibolite schist.

The quartz-graphite schist is brownish gray and finely crystalline with undulous to contorted foliae less than 1 mm thick. Graphite occurs as wispy films together with sericite, chlorite, quartz, and feldspar. Quartz lenses, commonly a few inches thick and a few feet long, parallel the enclosing foliae.

The amphibolite schist is composed of actinolite schist interlayered with sodic-amphibole schist and with minor amounts of quartz-graphite phyllite. Ellis also recognized epidote, chlorite, quartz, feldspar, stilpnomelane, and sphene in the schist. The rock is greenish gray to dark green. It is thinly foliated with the foliae locally contorted or crenulated and contains quartz lenses and pods, several centimeters thick and several centimeters to a meter long, parallel to the foliation.

The Easton Schist is altered in places along its margins. Hornfels, characterized by the development of biotite, occurs in a zone several hundred meters wide at the north end of the belt where schist had been intruded by granite. In places along its western margin the schist is intensely silicified in a zone several meters to several tens of meters wide. The rock is bleached white to very light gray and its constituent minerals were apparently unselectively replaced by silica.

Peshastin Formation

The Peshastin Formation was named by Smith (1903) for beds of black slate, chert, and conglomerate along Peshastin Creek. He mapped (1904) isolated bodies of the formation in a belt across the northern part of the Mount Stuart 30-minute quadrangle, and later he and Calkins (Smith and Calkins, 1906) mapped it in the Snoqualmie 30-minute quadrangle. Subsequently the Peshastin was remapped in the Mount Stuart area by Pratt (1958), and studied in detail in its type area by Southwick (1962). The formation crops out just outside the southeastern boundary of the Alpine Lakes area, where numerous isolated bodies of it occur in an ultramafic intrusion. Its true thickness is not known but may be several tens or even a thousand meters.

The Peshastin Formation (Southwick, 1962) is mostly argillite with lesser amounts of metagraywacke, and minor amounts of metaconglomerate and metavolcanic rocks, which include flows and breccias of intermediate composition, and siliceous tuffs. The rocks are foliated and have developed imperfect slaty cleavage. They weather various shades of gray, green, brown, and black.

The metasedimentary rocks are mostly finely crystalline. The argillite contains sparse megascopic pyrite and graphite and microscopic biotite, quartz, and feldspar (Southwick, 1962). The metagraywacke contains megascopic rock fragments, quartz and feldspar interbedded in a microscopic matrix of biotite, graphite, chlorite, and quartz. The conglomerate contains mostly pebble-sized angular rock fragments in a matrix similar to the graywacke.

Hawkins Formation

Rocks of the Hawkins Formation were first observed and reported by Russell (1900) and 4 years later the formation was named by Smith (1904). The formation was subsequently identified by Smith and Calkins (1906). Pratt (1958) remapped the formation in the Mount Stuart area, and Southwick (1962) studied it in detail near the southeastern boundary of the Alpine Lakes area. The formation has been intruded and broken into several large and many smaller bodies; for this reason and because internal stratigraphy is obscure or lacking, its total thickness is not known.

The Hawkins Formation is composed dominantly of altered volcanic breccias and flows with sparse feldspar phenocrysts and some fine-grained clastic rocks, all of which have been altered to greenstone. It is commonly dark grayish green weathering somewhat lighter. Those flow rocks which are recognizable have amygdaloidal fillings of calcite and chlorite and are commonly a few tens of feet thick. Volcanic breccia units range in thickness from several feet to more than 100 feet (2-30 m), and contain rock fragments that range in diameter from one-fourth inch to more than a foot (6 mm-30 cm). The original mineral constitutents in some of the altered volcanic rocks remain relatively intact, whereas in others they are completely destroyed and replaced by a new mineral suite. Microscopic relic minerals are feldspar, augite, epidote, chlorite, sphene, and magnetite. The alteration minerals are albite, chlorite, clinozoisite, and epidote. Numerous small, isolated bodies of the Hawkins Formation that occur in ultramafic rocks, as shown by Pratt (1958), were not mapped in this study.

Mafic rock

Mafic rock of uncertain formational affiliation occurs in two areas. At Deception Pass near the head of Deception Creek is a sliver of mafic rock in the easternmost fault slice of the Deception Creek fault zone. The rock can be divided into a lower and upper unit. The upper unit is a distinctly thin-layered siliceous sequence 10-20 feet (3-6 m) thick that resembles the siliceous tuff in the Peshastin Formation described by Southwick (1962, p. 67), except that this unit contains a dark micaceous mineral which gives the rock a foliated character. The lower unit is dominantly a dark-gray to dark-greenish-gray, aphanitic, mafic or ultramafic rock which is intensely sheared near the fault. This lower unit may be the volcanic flow or breccia that Southwick (1962, p. 66-67) described in the Peshastin, or it may correspond to the Trico Peridotite that Pratt (1954) mapped in this area.

The second mafic body is near the head of Snowall Creek between Highchair Mountain and The Cradle. It is about one-half mile (0.8 km) wide and occurs as a xenolith in a yellowish-orange-weathering ultramafic rock. The contact between the two rock types is distinct and sharp. The mafic body is crudely layered and is cut by sills of ultramafic rock. This body may be an inclusion of Hawkins Formation, as similar small inclusions were interpreted by Pratt in this area.

Ingalls Peridotite

A body of serpentine south and southwest of the Mount Stuart area was sketched and described by Russell (1900, p. 109-111), and later described and mapped by Smith (1904) and Smith and Calkins (1906). Subsequently Pratt (1958) named it Ingalls Peridotite and mapped a northwestward extension of the main body as well as numerous roof pendants. More recently Southwick (1962) made an extensive study of the formation in the southeastern margin of the Alpine Lakes area; he concluded that the body is essentially serpentinite.

Ingalls Peridotite crops out along the southeastern boundary of the Alpine Lakes area, along the ridge just east of the Cle Elum River to a point about as far north as Hyas Lake. Peridotite forms a large roof pendant in the Mount

Stuart pluton in the east-central part of the study area and other small roof pendants are present in the northeastern part. The Ingalls intrudes the Chiwaukum Schist, Hawkins Greenstone, and Peshastin Formation.

The peridotite is massive, finely crystalline, medium dark gray to greenish black where unsheared, and weathers dark yellowish orange to moderate brown. Where sheared, the rock is mottled greenish black and light olive or grayish olive and it is cleaved into angular blocks of unequal dimensions ranging from a few inches to more than a foot (10-30 cm) in maximum dimension. In detail it weathers to an irregular, crenulated surface an eighth of an inch (3 mm) or more in relief. Outcrops form ridge crests and peaks which are rugged but which are more subdued than those developed in adjacent granitic rock.

The proportion of mineral constituents differs from place to place apparently reflecting different degrees of serpentinization. In the Wenatchee Mountains a typical specimen of Ingalls Peridotite is composed of 60-80 percent olivine and about 10 percent enstatite with minor clinopyroxene and chrome-magnetite. The other 10-20 percent of the rock is composed of serpentine minerals (Pratt, 1958, p. 101). Serpentinization developed by stages from initial replacement along fractures in olivine grains to more advanced replacement, wherein a serpentine matrix developed containing numerous partially replaced bodies of olivine, to near complete replacement in which only sparse, minute bodies of olivine remain. In the lower Ingalls Creek area the peridotite is thoroughly serpentinized and commonly contains less than 3 percent olivine (Southwick, 1962, p. 137). In addition to serpentine minerals, small amounts of picotite, talc, carbonate, and chlorite are present, as is minor tremolite, which occurs most abundantly in the peripheral zones of the peridotite. Evidently the serpentinization process generally advanced further in the tectonically active area along Ingalls Creek.

Metagabbro

Bodies of gabbro along lower Ingalls Creek and on the ridges south of the creek were mapped by Smith (1904), who considered the gabbro correlative with the Camas Land sill, which intrudes the Swauk Formation and therefore is of Tertiary age. Southwick (1962) remapped part of the Ingalls Creek area, and concluded from geologic relations and the presence of pronounced alteration that the gabbro is not correlative with the Camas Land sill and is pre-Tertiary in age.

The metagabbro occurs as dikelike bodies which crop out as steep-sided ridges and locally form knobs and subordinate spurs. The rock is medium to coarsely crystalline, and contains relic ophitic and hypidiomorphic igneous textures which have been overprinted by metamorphic textures (Southwick, 1962, p. 162). It is mostly dark grayish green, very dark gray, or black, but locally it is very light gray or white and mottled with dark mafic minerals. The light-colored bodies are anorthositic and are gradational with mafic metagabbro.

Relic minerals include plagioclase, which has been partially replaced by sodic oligoclase and clinozoisite, and diallage, which has been partially replaced by uralitic amphibole (Southwick, 1962, p. 163). To a lesser extent plagioclase is replaced by zoisite and epidote and in places serpentine minerals and chlorite are present. Accessory minerals include magnetite, ilmenite, sphene, leucoxene, prehnite, and carbonate.

Granitic rocks of the Mount Stuart batholith

Granitic rocks of the Mount Stuart batholith were first noted by Russell (1900, p. 105-107) who sketch-mapped the body in the Mount Stuart-Leavenworth area, and called the rock granite. Smith (1904) mapped the southern part of the body in the Mount Stuart quadrangle and gave it its name. Various parts of the pluton were subsequently mapped or remapped by Page (1939), Oles (1951, 1956), Pratt (1954, 1958), Galster (1956), and Southwick (1962), whose collective efforts essentially outlined the body. The batholith is about 40 miles (65 km) long and as much as 15 miles (24 km) wide. The southern and southwestern limits lie within the Alpine Lakes area where about 200 square miles (520 km^2) of the body, including roof pendants, is exposed. Many bodies of granitic and intermediate composition, too small to be mapped at this scale, occur peripheral to the batholith. Yeats and McLaughlin (1969) reported a Cretaceous age for the stock based on radiometric determination.

A steep, rugged topography is developed on Mount Stuart granitic rocks. Dogtooth peaks and serrate ridges steepled with spines characterize the Stuart Range. Other areas underlain by the batholith are less rugged. Sheeting and jointing are common.

In some parts of the stock, foliation is caused by subparallel orientation of mafic minerals and in a few places by the alinement of elongate, lozenge-shaped mafic inclusions. E. H. Erikson (oral commun., 1972) believes that the sculpturing of one of the lesser ranges may have been affected in part by the foliation.

Xenoliths occur sparsely to abundantly in many parts of the stock; they are commonly mafic-rich and stand out in sharp contrast to the enclosing felsic rock. Most xenoliths occur as discrete rounded bodies that are in such an advanced state of reconstitution as to obscure their original lithology, but locally abundant unreconstituted xenoliths occur near the border of the stock (Pratt, 1958, p. 178).

Dikes of aplite and alaskite, too small to be mapped at this scale, are sparse in the study area; pegmatites are even less abundant. Some of the pegmatites contain considerable pink orthoclase. The dikes range in size from a few inches (10 cm) wide and a few tens of feet (10 m) long, to many feet (3-4 m) wide and hundreds of feet long (60-90 m). They display distinct, abrupt contacts and are thought to be late differentiates of the granitic rocks. They were probably emplaced shortly after solidification of the batholith.

The rock is medium crystalline and mottled very light gray and black. Megascopic minerals are subhedral feldspar, anhedral quartz which is not everywhere discernible, black biotite in books and clots, and more rarely subhedral hornblende. In thin section, rocks of the Mount Stuart batholith generally have a hypidiomorphic crystalline texture. Crystal faces are common on plagioclase and somewhat less so on hornblende. Biotite occurs in ragged bodies, and quartz is invariably anhedral.

Metasomatic rock

A small body of granitoid rock occurs on the crest of the Chiwaukum Mountains near the northeastern corner of the Alpine Lakes area. It overlies granitic rock of the Mount Stuart batholith, and is in contact with Chiwaukum Schist along its southwestern boundary and with coarsely crystalline amphibolite along its northeastern boundary. It is banded, finely to coarsely crystalline, and although texturally different from layer to layer has an overall texture of granitic rock. The mineralogic composition of the individual layers ranges from dominantly feldspar to dominantly pyroxene or amphibole. In one layer abundant dark-green amphibole metacrysts 1/8 to 1/4 inch (3-6 mm) across and 1-1 1/2 inches (2.5-4 cm) long are embedded in a finely crystalline feldspathic matrix. In places amphibolite schist is interlayered with the felsic-mafic rock and in one place a limy layer 8-10 inches (20-25 cm) thick was noted. It is believed that these layers are relics of Chiwaukum Schist and it is assumed that the mass of granitoid rock is metasomatized Chiwaukum.

Amphibolite

A narrow elongate body of coarsely crystalline amphibolite, which crosses the crest of the Chiwaukum Mountains in the extreme northeastern part of the Alpine Lakes area, is in contact with granitic rock on its southwestern boundary and with Chiwaukum Schist on its northeastern boundary. The rock is composed of equant grains of subhedral, dark-greenish-gray amphibole about 1/2-3/4 inch (12-20 mm) in diameter, and, except for slight differences in grain size, the rock appears uniform. In thin section it appears to be dominantly tremolite, more than 85 percent, which is locally replaced by chlorite. No other minerals were identified.

The relation of the amphibolite to the adjoining rock units is not clear, but it is thought to intrude them. Coarsely crystalline amphibolite identical to that described here occurs as sills in the adjacent layered granitoid rock. The amphibolite may be a reconstituted derivative of peridotite or serpentinite that has been mobilized.

Swauk Formation

Russell (1893, p. 20) included sandstone and shale near Wenatchee with coal, sandstone, and shale near Roslyn, in a single stratigraphic unit. When later it was found that volcanic rock underlies the coal-bearing section, he (1900, p. 118-127) revised the stratigraphic nomenclature. The coal-bearing rocks above the volcanic unit he called the Roslyn Formation; those below, the Swauk Formation. Many workers have subsequently studied and mapped the Swauk over most of its areal extent; those who have mapped it in the Alpine Lakes area include Smith and Calkins (1906), Pratt (1954), Galster (1956), and Ellis (1959).

The Swauk Formation is preserved only in the western part of the Alpine Lakes area where it crops out in a northwest-trending belt as much as 6-8 miles (10-13 km) wide. The formation is folded and faulted and the structures become progressively more pronounced from east to west across the belt.

The Swauk Formation is mostly fluvial arkose with minor feldspathic graywacke, conglomeratic arkose, and siltstone. It is estimated that the Swauk is about 95 percent sandstone, 3-4 percent siltstone, and 1-2 percent conglomerate (Ellis, 1959, p. 18).

The arkose beds are light to medium gray, commonly massive and thick bedded, and well indurated. Sorting is fair to poor. Low-angle crossbeds are prevalent but are not commonly distinct. The light-colored minerals blend in an opaque mass and so mineral types are not easily distinguishable and dark minerals and clasts stand out. Graphitic phyllite in flakes 1-5 mm long are generally present and locally very abundant. Biotite, in light-brown ragged bodies 1-2 mm long, is abundant in places. Where the Swauk Formation is intruded by granitic rock the adjacent arkose beds have been recrystallized to pyroxene hornfels.

Arkose studied microscopically averages about 58 percent quartz, 35 percent plagioclase feldspar, 3 percent biotite, and 3 percent graphitic phyllite with a very small fraction of accessory minerals (Ellis, 1959, p. 21). The clasts are tightly packed with little or no matrix material. The tight packing is evidenced by biotite which is bent around clasts of quartz and feldspar; some biotite bodies display microscale chevron folds.

Conglomeratic beds range in thickness from less than an inch (2.5 cm) to more than 10 feet (3 m). Well-rounded fragments are about 1-12 inches (2.5-30 cm) long and are composed of granitic rock, quartz, schist, and peridotite. The pebble-to-boulder size fragments rarely compose more than 50 percent of the conglomeratic units.

Siltstone beds are very dark gray, well indurated and nonfissile, and are a few inches to several feet thick. Fossil flora is common but not abundant.

Fragmented arkose, in blocks measuring less than a foot (30 cm) to tens of feet (5-10 m) across, occurs locally associated with minor amounts of volcanic rock at the top of the Swauk Formation. The fragmented arkose, because it appears to be genetically related to the volcanic rock, is mapped with the overlying volcanic unit.

The preserved thickness of the Swauk Formation in the study area is not known. Pratt (1954, p. 35) measured about 7,000 feet (2,135 m) near Marmot Lake, north of Mount Daniel. Ellis (1959, p. 97) mapped a thickness of 7,500-10,000 feet (2,290-3,050 m) between Dutch Miller Gap and Summit Chief Mountain, but part of this section may be repeated by faulting. Smith and Calkins (1906, p. 4) mapped a thickness of about 5,000 feet (1,525 m) on Goat Mountain, south of the study area.

Flora collections from the upper part of the formation show the Swauk to be Cretaceous, or Cretaceous and Paleocene in age (F. H. Knowlton, in Smith, 1904, p. 5). Later work has substantiated this determination.

Naches Formation

Smith and Calkins (1906) mapped and described the Naches Formation in the Snoqualmie 30-minute quadrangle. Later Ellis (1959) and Foster (1960) mapped it northward to the Cascade Range crest. The Naches is present in two places in the western part of the Alpine Lakes area; one at the extreme southwestern tip of the study area near Kendall Peak and Rampart Ridge, the other a few miles farther east between Chikamin Ridge and the Lemah Creek drainage. About 3 square miles (8 km^2) of Naches Formation is exposed within the study area near Kendall Peak and from there it extends to the southwest. The strata dip moderately eastward. The Naches between Chikamin Ridge and Lemah Creek crops out in a belt about 5 miles (8 km) long and 1 1/2 miles (2.5 km) wide. Strikes are subparallel to the outcrop belt, dips are vertical to steep, and most strata are overturned. Neither the base nor the top of the formation is exposed in the study area but the base is observable to the west (Foster, 1960, p. 115) and to the south (Smith and Calkins, 1906, p. 4).

The Naches Formation is composed mostly of flow and flow breccia units of basalt and andesite. Flows appear to be more numerous than breccia units, and andesite more abundant than basalt. The basal part of the exposed section contains arkose, siltstone, and shale interbedded with basalt flows.

The arkose is light to dark gray and occurs in lenses several feet to several tens of feet (2-10 m) thick. Grain size ranges from medium to very coarse (2 mm); crossbedding is common. Feldspar is recognizable in some of the arkose but because it is glassy it cannot be distinguished from quartz. Dark-green, grit-sized fragments, possibly peridotite, and sparse white quartz pebbles as much as 1/2 inch (1.3 cm) in diameter occur in arkose beds at the southwestern tip of the study area, whereas flakes of graphitic phyllite are present in the arkose in the eastern part of the area. Ellis (1959, p. 48) identified microscopically minor biotite and a matrix consisting mainly of micaceous minerals.

Siltstone and shale are not abundant and not well exposed. Medium-gray, sandy, and subfissile siltstone occurs in lenticular beds a few feet thick; in places it contains fossil flora. No shale was observed in the Naches Formation in the Alpine Lakes area, although it may be present.

The preserved stratigraphic thickness of the Naches Formation in and just adjacent to the Alpine Lakes area is estimated to be 7,000-9,000 feet (2,000-3,000 m). To the south Foster (1960, p. 116) estimated the Naches to be 5,000 feet (1,500 m) thick. It thus seems likely that the bodies mapped in the study area have stratigraphic sections that are repeated by faulting.

The age of the Naches Formation is not known definitely. Fossil flora led Smith and Calkins (1906, p. 5-6) to correlate the formation with both the Swauk Formation and the Puget Group whose ages range from Late Cretaceous to Eocene. Foster (1960, p. 116) recommended that the Naches be tentatively dated Eocene until diagnostic fossils are found.

The basalt flows are dark gray to dark greenish gray and occur in layers a few inches (20 cm) to many tens of feet (25 m) thick. Locally the flows contain anhedral feldspar phenocrysts 1-3 mm long. In a few flows indistinctly outlined mafic bodies about 1 mm across are present locally. Vesicules and amygdules are common and are less than an inch to several inches (2.5-7 cm) across. The amygdules are composed of quartz, chalcedony, calcite, and possibly zeolite. Ellis (1959, p. 46) noted some amygdules of epidote and chlorite.

Basalt breccias, except for being fragmental, are similar to the flows. Fragments are rounded to subangular and commonly are less than 1 inch (2.5 cm) across.

Naches basalt was studied microscopically by Ellis (1959, p. 45), who noted the presence of euhedral plagioclase phenocrysts embedded in a trachitic or felted matrix of plagioclase microlites. Both phenocrysts and matrix microlites are labradorite. He also identified pigeonite and augite which occur as phenocrysts and in the matrix.

The basalt is cut by thin stringers of quartz and locally it is altered to amphibolite where it has been intruded by granitic rock. Ellis (1959, p. 47) reported the replacement of labradorite by more calcic feldspar, and the replacement of pyroxene minerals by hornblende which makes up 30-50 percent of the hornfelsed rock. Away from the granitic contact the basalt is locally affected by a pervasive low-temperature alteration (Ellis, 1959, p. 46). The alteration is characterized by epidote, sericite, and carbonate and clay minerals which replace plagioclase, and by epidote, chlorite, actinolite, and serpentine minerals which replace pyroxene. Along the northern part of the fault that bounds the Naches belt, the basalt is intensely silicified, probably the result of hydrothermal activity. The normally dark-gray basalt is bleached very light gray but its textures are perfectly preserved.

The andesite is light to medium gray, and greenish and brownish gray, is finely crystalline with a granular texture, and occurs in flows that are commonly tens of feet (5-15 m) thick. Chloritized mafic minerals and mafic clots occur in some flows. Vesicules and amygdules, commonly quartz, are locally abundant.

Dacite dike

A thick dacitic dike which intrudes the Swauk Formation occurs just west of the Waptus River near the south boundary of the Alpine Lakes area. Most of the dike lies south of the study area. It is reddish brown and finely crystalline, and contains anhedral quartz phenocrysts as much as 4-5 mm long. The dike was mapped by Smith and Calkins (1906) as part of the Keechelus Andesite but Ellis (1959, p. 63) later distinguished it from overlying pyroclastic rock which appears to be a small outlier of the Keechelus mapped east of the Waptus River. The dike, because it differs lithologically from the pyroclastic rock and appears not to intrude it, is considered substantially older, as Ellis inferred.

Keechelus Andesite

The Keechelus Andesite was described and mapped by Smith and Calkins (1906), Ellis (1959), and Foster (1960). The formation is present only in the western part of the Alpine Lakes area but very likely it was once present throughout the area.

Rock mapped as Keechelus (Ellis, 1959) in the area between the drainages of the Waptus and Cle Elum Rivers and extending northward to Marmot Lake (pl. 1), although similar to type Keechelus, may be correlative to an older Tertiary volcanic formation (P. E. Hammond, oral commun., 1972). Rock shown as Keechelus in a small area near the West Fork of the Foss River (pl. 1) may likewise be a correlative of some other volcanic unit. Galster (1956) recognized the uncertainties of the correlations and tentatively called the volcanic rock in that area Temple Mountain Andesite. The problem remains unresolved; Ellis's usage has been followed by the writers.

The Keechelus Andesite is comprised of flows, and flow breccias and other pyroclastic rocks, almost all of which are massive and many tens of feet (15-30 m) thick. Locally, thinly layered tuff beds are present. Ellis (1959, p. 68) estimated that about 75 percent of the formation is pyroclastic and the other 25 percent, flow rock.

Some units of the Keechelus are amygdaloidal. The amygdules are commonly an inch or less (1.5-2.5 cm) in diameter but some are as much as 2 inches (5 cm) long. The amygdules are composed of quartz, chlorite, and possibly a zeolite.

The rock is commonly dark greenish gray to dark gray, and rarely reddish gray or maroon. In pyroclastic units the fragments are commonly the same color as the matrix but of a slightly different shade.

Phenocrysts of megascopic feldspar occur as subhedral to euhedral laths <1-5 mm long. The visible feldspar constitutes only a minor part of the rock; Ellis (1959, p. 67) estimated 5-10 percent. Anhedral bodies of a mafic mineral that may be augite occur sparsely in some layers; it appears altered and in at least one place was observed replaced by chlorite. Small, wispy, lenticular bodies of epidote occur sparsely.

The matrix of the rock is finely crystalline whether the rock be flow, flow breccia, or breccia fragment.

Ellis (1959, p. 68) studied the rocks in thin section and noted that the matrix is composed of felty- to trachitic-textured altered placioclase, and chloritic and opaque minerals. The plagioclase, where not replaced by alteration minerals, is andesine. Ellis (1959, p. 65) considered the Keechelus to be deuterically altered.

Breccia fragments are of the same general composition and texture as the matrix rock. The fragments range from a fraction of an inch (1 cm) to several feet (1 m) across and are subangular to subrounded. Swauk fragments are locally numerous in the basal part of the Keechelus. In places they occur as a minor constituent of flow rocks and flow breccias but elsewhere they occur as the sole constituent of breccias which may be fossil talus deposits (Ellis, 1959, p. 66). Elsewhere, angular blocks of Swauk, as much as tens of feet (5-10 m) across, with little or no admixed volcanic material, seem more likely to be the products of diatreme or cryptovolcanic activity.

The Keechelus Andesite is hydrothermally altered in several areas in the southwestern Alpine Lakes area. Where incipiently altered the constituent minerals appear less distinct and they may contain pyrite; where in an advanced state of alteration the rock is silicified and almost invariably contains pyrite. On a freshly broken surface the altered rock is white or light gray with minute, anhedral sulfide grains sparsely scattered through it. Relic feldspar and a mafic mineral can be seen in some of the altered rock. Outcrops of the altered rock are conspicuously iron stained from oxidized pyrite.

The age of the Keechelus Andesite is not accurately known. It is older than the lage Miocene Snoqualmie batholith which intrudes the Keechelus. An oreodont collected from the formation several miles south of the study area is suggestive of an Oligocene-Miocene age (Grant, 1941, p. 590).

Keechelus-related intrusive body

A small, irregular circular body of andesite appears to intrude Keechelus volcanic rocks and the Swauk Formation. The body is west of Hyas Lake and the Cle Elum River and includes Cathedral Rock. The rock is finely crystalline and, except for being nonfragmental, closely resembles Keechelus volcanic rock in color and texture. Several dikes (too small to be shown on the map) radiate into adjacent pyroclastic rock and arkose beds. The contact between the andesite and the surrounding rock is poorly exposed. The character of its outcrop, the similarity between the lithology of the andesite and the Keechelus flow rocks, and the presence of radiating dikes all suggest that the body is a volcanic rock which served as a feeder for at least part of the Keechelus Andesite, as Ellis (1959, p. 70) pointed out.

The Cathedral Rock body is the only Keechelus-related intrusive body of mappable size in the Alpine Lakes area. Dikes of Keechelus-related rock occur locally near the contact of the Keechelus with the Swauk Formation.

Breccia dike

A breccia dike located on the northwest side of Marmot Lake cuts the Swauk Formation from about the level of the lake to the ridge crest and is about 40-50 feet (12-15 m) wide at its widest point. The dike apparently is at the northwest end of a fault which, south of the lake, brings Keechelus Andesite into contact with the Swauk Formation. The dike is composed of angular to subangular arkose fragments ranging in size from a fraction of an inch (1 cm) to as much as 2 feet (60 cm) across, embedded in a comminuted matrix of arkosic material. Some dense fragments, dark green to olive, may be of volcanic origin but are believed more likely to have been derived from siltstone beds of the Swauk Formation.

An unmapped igneous dike 10-25 feet (3-8 m) thick was intruded next to the west wall of the breccia dike. The igneous rock is dark gray, finely crystalline, with small subhedral phenocrysts of feldspar, and may have been an andesite feeder for Keechelus rocks younger than those involved in the fault. If the igneous dike is related to the Keechelus, then the fault was active during early Keechelus time and may have been accompanied by explosive vulcanism which could have produced breccia bodies. In any case the morphology, and the lack of sheared, slicked, or other planar features, negate the likelihood of the breccia being solely fault produced.

Granitic rocks of the Snoqualmie batholith

The Snoqualmie batholith was first described by Smith and Mendenhall (1900), and subsequently was mapped by Smith and Calkins (1906) in the Snoqualmie 30-minute quadrangle. Later Galster (1956) mapped the batholith near the boundary of the northwestern part of the Alpine Lakes area and more recently Erikson (1965) studied and mapped an eastern lobe of the body which lies within the study area.

The Snoqualmie batholith ranges in composition from granodiorite to quartz monzonite and is exposed in the western part of the Alpine Lakes area where it crops out in an east-west trending lobe more than 40 square miles (100 km^2) in extent. The tip of a large apophysis, which extends southeastward from the main body and into the study area, is exposed along the north side of Gold Creek. An isolated exposure, possibly a separate intrusive phase of the Snoqualmie, is located on Chikamin Ridge and extends southward beyond the study area.

A steep, precipitous topography is developed on Snoqualmie granitic rocks but it is less rugged than that developed on granitic rocks of the Mount Stuart batholith. The rock is almost everywhere jointed, and forms copious talus that mantles the flanks of peaks and ridges.

Snoqualmie granitic rocks are mostly medium crystalline but textures vary with the compositional phases. The rock for the most part is mottled light gray and black; the quartz monzonite is mottled light pinkish gray and black.

Erikson (1965, 1968, 1969) studied the batholith in detail and divided it into several intrusive phases. In the Alpine Lakes area these include, in the order of emplacement, pyroxene granodiorite, granodiorite, and quartz monzonite. The intrusive phases were not mapped as separate units in this study. Most of the following rock and alteration descriptions are from Erikson's work.

The most abundant phase of the Snoqualmie batholith is granodiorite. It is composed of plagioclase (An 100 to An 14), potassium feldspar and quartz in microperthitic intergrowths, hornblende, hypersthene, augitic clinopyroxene, and biotite (Erikson, 1965, p. 18-23). Quartz monzonite, where it is intruded by granodiorite, locally is altered to hornfels; plagioclase is altered to amphibole minerals and biotite. In addition, the granodiorite has undergone a low-grade, possibly hydrothermal alteration in which hornblende is replaced by actinolite, chlorite-pistacite, and biotite-pistacite.

In the pyroxene granodiorite phase, primary minerals include euhedral to anhedral zoned plagioclase (An 100 to An 10), potassium feldspar, hypersthene, augitic pyroxene, brown biotite, quartz, and minor quantities of other minerals (Erikson, 1965, p. 8). The rock was thermally metamorphosed later by the emplacement of main-phase granodiorite; mafic minerals recrystallized into finely crystalline aggregates. Later an intense, low-grade alteration, which Erikson (1965, p. 10) attributed to either hydrothermal activity or the contact metamorphism caused by the quartz monzonite, changed clinopyroxene to actinolite, actinolitic hornblende, and biotite; and hypersthene to cummingtonite, grunerite, and biotite.

The quartz monzonite contains strongly to moderately zoned plagioclase (An 80 to An 10), microperthitic alkali feldspar, quartz, hornblende, augitic clinopyroxene, biotite, and accessory minerals (Erikson, 1965, p. 29-40). The plagioclase reflects in some places one, and in other places two stages of resorption and regrowth, and is variously replaced by clinozoisite-chlorite and by quartz. The mafic minerals have been deuterically altered and original mafic minerals have survived only along the margin of the quartz monzonite. Hornblende and pyroxene are replaced by fibrous actinolite and actinolitic hornblende, cummingtonite, and magnetite; brown biotite is replaced by green biotite. The alteration products are further altered to chlorite minerals, owing possibly to an inward enrichment of volatiles. This last alteration is best indicated by the replacement of plagioclase and potassium feldspar by tourmaline, and by quartz-tourmaline veins which emanate from the quartz monzonite and which in one place are associated with a base-metal deposit.

In addition to the major intrusive phases mentioned above, Erikson (1965, p. 42-44) described small pluglike bodies and aplite dikes in the Alpine Lakes area. Aplite, alaskite, and other felsic dikes are sparse, and are commonly less than a foot (30 cm) in width. They may be genetically related to the igneous host in which they occur, although Erikson (1965, p. 17, 42) believes that some are derived from a separate, younger aplitic phase.

Inclusions are generally sparse but are abundant locally at points along the peripheral zones of the batholith. They are commonly rounded, a foot (30 cm) or less in diameter, and most appear mafic-rich and in advanced states of reconstitution. Some inclusions may be cognate, and none of them are oriented.

The Snoqualmie batholith is the youngest rock in the area and intrudes the Swauk Formation and Tertiary volcanic rocks. It is late Miocene in age (Baadsgaard and others, 1961; Curtis and others, 1961; and Erikson, 1969).

Other rocks

Northeast- to east-trending dikes of Teanaway Basalt, too small to be mapped at this scale, occur sparsely in the southeastern and west-central parts of the Alpine Lakes area. Some are as thick as a few tens of feet (5-10 m) and are traceable for several hundreds of feet (100-300 m).

Alluvium and other surficial deposits

Alluvium and other unconsolidated deposits occur throughout the Alpine Lakes area; only the significantly extensive alluvial deposits have been mapped. Thin mantles of silt, sand, and gravel occur locally on the floors of valleys and canyons, where they have been overdeepened by glaciers.

Two, and possibly three, ages of glaciation are recognized in the Alpine Lakes area (Page, 1939, p. 141-180); the principal deposits lie at the canyon mouths, outside the area boundaries. Numerous glacial deposits, mostly preserved remnants of lateral moraines, occur sporadically along the walls of some of the canyons. Small terminal moraines, products of the 19th-century advance, lie at short distances below existing glaciers.

Colluvial deposits, mostly talus but also including a few rock slides and a rock glacier, occur generally throughout the area.

Structure

The structure of the Alpine Lakes area is part of a regional belt of thrust faults which lie west of high-angle faults that extends southward from the northern Cascade Range. The continuity of the structures has been locally broken by the intrusion of the Snoqualmie batholith.

The Deception Creek fault zone

The Deception Creek fault zone (pl. 1), first mapped and described by Pratt (1958, p. 59-61), divides the Alpine Lakes area into two blocks of diverse geology. The fault crops out in only a few places, elsewhere its existence is inferred from the juxtaposition of unlike rocks and from topography. Segments of the zone vary from a single fault to several faults to multiple faults, which form a braided pattern. South from the Hyas Lake area the eastern fault, as described by Pratt (1958, p. 60-61), is a zone of sheared serpentinite and gouge that separates relatively unaltered peridotite from serpentinized rock.

Total displacement on the structure is unknown but may measure in thousands of feet (several hundreds of meters), and part of the movement may be lateral, as Pratt (1958, p. 61) noted. The structure may have been active over a considerable span of time, but the available evidence indicates movement only in early or middle Tertiary.

Area east of Deception Creek fault zone

Pronounced foliation is developed in the Chiwaukum Schist. The foliae strike mostly northwestward and dip northeastward, and in many places they are intricately folded into tight structures a few inches (15 cm) to a few feet (3 m) in amplitude and length. The axes of the folds, in the few places they were measured, plunge southeast. Presumably the rock has been isoclinally folded for there is no evidence of large-scale, open folds. Marginal to the Mount Stuart batholith a second foliation developed in the Chiwaukum as a result of the intrusion of the batholith (Plummer, 1969, p. 57). The two mapped bodies of mafic rock are foliated and sheared, but the Peshastin and

Hawkins Formations appear undeformed, probably because deformation has been obscured by metamorphic effects related to the intrusion of the Ingalls Peridotite.

Two separate zones of intensely fractured, serpentinized rock, are developed in the Ingalls Creek Peridotite, subparallel to the southwestern contact of the Mount Stuart batholith. One zone, which extends from the Huckleberry Mountain-Hawkins Mountain area eastward beyond Alpine Lakes area, was first described by Pratt (1958, p. 60-70) who observed serpentine breccia fragments of greenstone and gabbro that range in size from 1 foot (30 cm) to several thousand feet (few thousand meters). A second zone lies between the crest of the Wenatchee Mountains and the Cle Elum River extending from near the study area boundary southeastward to the Huckleberry Mountain area. The outline of the zones is irregular and the contact with relatively unaltered rock to the east and north is gradational whereas to the west and south it is more abrupt. Contact with inclusions of greenstone and gabbro is likewise abrupt. The zones apparently developed in response to uplift of the Mount Stuart block for they are only located in areas where beds of the Swauk Formation dip moderately to steeply away from the block. As uplift proceeded, peridotite in the zones was sheared, hydrolyzed, and reconstituted as serpentine, and the mass effect was that of a plastic body (Southwick, 1962, p. 130). The inclusions of greenstone and gabbro, in contrast, generally resisted deformation, although locally they were fragmented. As a result, the more mobile serpentinized rock flowed by and around the resistant inclusions.

The cumulative movement in the deformed zones is unknown but could amount to thousands of feet (hundreds of meters). Movement in the zones is believed to postdate the deposition of the Swauk Formation and to have occurred in Tertiary time; deformed Teanaway dikes engulfed in serpentinized peridotite were recognized by Southwick (1962, p. 131). The deformed zones, however, are older than some of the movement on the Deception Creek fault zone, as shown by the fact that a branch of the structure separates unaltered peridotite from serpentinized rock (Pratt, 1958, p. 60-61).

Foliation in the granitic rocks of the Mount Stuart batholith is evident in the areas of lower Eightmile Creek, the Lower Enchantment Lakes, and upper Ingalls Creek. The foliation in the Eightmile Creek and Enchantment Lakes areas is purely a magmatic feature and is characterized by the alinement of mafic minerals, and locally by lensoidal xenoliths. It trends easterly to northeasterly and dips steeply. The foliation in the Ingalls Creek area occurs in mylontinized peridotite at the margin of the Mount Stuart batholith. The strike parallels the contact--roughly due north. The dip is nearly vertical.

Jointing in the Mount Stuart granitic rock and nearby rocks was not studied systematically but was noted in the vicinity of mineral deposits. The dominant joint system strikes northwest; a second system striking northeast is indicated by the alinement of Teanaway dikes.

Area west of the Deception Creek fault zone

Foliation is well developed in the Easton Schist. The foliae are mostly north striking with steep dips to the east and west, but locally, as on Chikamin Ridge east of the Three Queens, the foliae are west striking with low to moderate dips to the north and south. In many places the foliae are folded into tight structures a few feet (0.5-2 m) in amplitude and length. The trend of the axial traces is north.

Several folds, most of them of little known extent, occur in several places in the Swauk Formation. The folds appear to have formed both previous to and concurrent with high-angle faults. The folds are open and plunge moderately to the southeast (pl. 1). The flank of a typical trough is conspicuous on the southeastern face of Bears Breast Mountain.

Many of the southeast-trending synclines, similar to the one lying along the east side of the high-angle fault on Summit Chief Mountain, are believed to be a drag fold formed concurrently with the fault, whereas others located in the area between Escondido Lake and lower Lemah Creek are inferred to be truncated by the high-angle fault cutting Summit Chief Mountain.

Numerous northwest-trending steep-dipping to vertical faults are known or inferred to cut the Swauk Formation. The faults are commonly a few miles long but their full extent is not known, either because they extend outside the Alpine Lakes area or because they were cut by the intrusion of the Snoqualmie batholith, and the respective segments, if part of the same fault, cannot be confidently correlated.

The amount of displacement on the faults is unknown because of the absence of marker beds, but on many of the more extensive faults the displacement is assumed to be hundreds (tens of meters) and perhaps as much as thousands of feet (hundreds of meters). Ellis (1959, p. 104) estimated that at least 4,000 feet (1,220 m) of Swauk section has been eliminated on the west side of the high angle that cuts Summit Chief Mountain. The age of faulting is considered early Tertiary; the fault in the area of Deep Lake appears to predate Tertiary volcanic rock, and several other faults are cut by the Snoqualmie batholith.

Layered rocks of the Naches Formation in the area of Lemah and Delate Creeks strike roughly north to northwest and have steep to vertical dips, but are mostly steeply overturned to the west. The Naches there is inferred to be cut by several high-angle faults.

A northwest-trending, high-angle fault forms the eastern boundary of the Naches. The fault places Easton Schist on steeply dipping layers of the Naches Formation. The structure was first mapped by Ellis (1959, p. 101-104) who called it the Easton-Naches fault. It appears to be a continuation of a fault mapped by Smith and Calkins (1906) in the area of Kachess Lake. Although brecciated or sheared rock was not evident, the rocks along either side of the fault plane are silicified and bleached in a zone as much as several hundred feet (100 m) wide and which extends from the area of Chimney Rock southward for about 1 1/2 miles (2.5 km).

The Naches is assumed to be displaced downward relative to the Easton Schist, as it is to the south outside the Alpine Lakes area where younger formations locally are in contact on opposite sides of the fault (Foster, 1960). Ellis (1959, p. 103-104) estimated a minimum movement of 2 miles (3,200 m).

The fault does not cut, and therefore does not predate, the emplacement of late Miocene Snoqualmie batholith. The silicified zone developed along the fault is considered the result of hydrothermal activity related to the batholith.

Jointing in the Snoqualmie batholith and the other rocks was not studied systematically but was noted only in the near vicinity of mineral deposits. The dominant joint sets strike northwest, parallel to the regional structural grains, and northeast dips are commonly steep to vertical.

Several thrust faults cut the Swauk Formation in the areas of Summit Chief Mountain and Chief Creek. A major thrust forms the western edge of the Swauk Formation along Lemah Creek and one of its tributaries.

The upper plates of the thrust faults have apparently moved westward; this is best shown by the configuration of the traces of the thrusts east of Summit Chief Mountain. There, Swauk is thrust upon itself, and beds in the upper plates rest with pronounced angular discordance on beds of the lower plates; in places upper plate beds are vertical to steeply dipping in contrast to lower plate beds which are locally only slightly inclined. The rock adjacent to the thrust planes is apparently undisturbed.

The thrust fault along Lemah Creek and its tributary places Swauk on Easton Schist. The thrust is traceable for 2 1/2 miles (4 km) and is inferred to extend southward about another 3 miles (5 km). Superficially the contact appears to be depositional; bedding planes of the Swauk are more or less parallel to the plane of the thrust. A zone of deformed or reconstituted rock, however, is developed along the thrust plane. Dark, basaltic-appearing pseudotachylite as much as several feet (1-3 m) thick has formed along the zone, and in places lenses of Swauk, many feet (2-3 m) thick and tens of feet (10 m) long, have been torn from the sole of the upper plate and driven into the adjacent underlying Easton Schist. Locally the Swauk Formation has been altered adjacent to the thrust plane. A roughly circular area just west of Summit Chief Mountain is underlain by hydrothermally altered arkosic sandstone, in part silicified and kaolinized, that extends from the thrust plane upward through several hundreds of feet (100-150 m) of section. The alteration was probably an effect of the intrusion of the nearby Snoqualmie batholith. Neither the amount of westward movement nor the amount of section missing from the base is known.

Aeromagnetic interpretation

By W. E. Davis, U.S. Geological Survey

An aeromagnetic survey of the region between lat 47°24' N. and 47°45' N. and long 120°40' W. and 121°24' W., which includes the Alpine Lakes area, was made by the Scintrex Mineral Surveys, Inc., under contract for the U.S. Geological Survey. Total intensity magnetic data were obtained along east-west lines flown about 1 mile (1.6 km) apart at an average barometric altitude of 9,500 feet (2,900 m) above sea level. The data were compiled at a scale of 1:62,500 and contoured at intervals of 20 and 100 gammas (pl. 1). No laboratory study of the magnetic properties of the rocks was made. The magnetic features, which were interpreted from the geology of the area, are discussed briefly on the following pages.

The magnetic map is dominated by a broad high over rocks of the Ingalls Peridotite and Hawkins Formation along the south-central margin of the area. Although the southern flank of the feature was not completely flown, magnetic gradients indicate that the high reaches a maximum relief of more than 1,000 gammas over the greenstone near Hawkins Mountain. The northwest part of the anomaly has a maximum difference of about 600 gammas near the head of Silver Creek and seems to be associated mainly with peridotite. Steep magnetic gradients on the northeastern flank of the broad high correspond with the contact between Mount Stuart granitic rock and the ultrabasic rocks. These gradients suggest that the contact is sharp and may be fairly steep in most places. The magnetic low over the Mount Stuart granodiorite northeast of its contact with peridotite indicates that the direction of magnetization in the greenstone and peridotite formations is similar to that of the earth's present magnetic field. Very likely the main high represents a thick mass of greenstone and peridotite.

General low magnetic relief and intensity occur over the Mount Stuart batholith and older rocks in the northeastern part of the area. Undulations in the contours indicate that a weak magnetic low is associated with the schist, but there seems to be no magnetic indication of the peridotite in the southern part of the large roof pendant. Perhaps the magnetic response of the peridotite is marked by the bordering dipolar low. The lack of more prominent magnetic relief suggests that the roof pendant does not extend to great depth.

On the east margin of the area, a small, partly mapped high is indicated by a contour closure over Icicle Ridge. This feature is probably caused by rocks near the crest of the ridge.

In the western part of the area, a narrow magnetic high lies over Chikamin Ridge and the headwaters of Cooper River and the Middle Fork of Snoqualmie River. The southern part of the feature is associated with volcanic rocks, but includes granitic rock exposed at the southeastern end of the ridge and southwest of Huckleberry Mountain. Maximums of about 100 gammas that are probably enhanced by topography occur near Chikamin Peak and over the southern part of the ridge. Northward the anomaly has a maximum of about 80 gammas and appears to reflect the Snoqualmie batholith. Topography also contributes to the magnetic expression of these rocks. The anomaly indicates that the pluton extends southward beneath volcanic rocks along the ridge to connect with the granitic outcrops in the southwestern part of the area. High magnetic gradients along the eastern flank of the anomaly may represent a steep wall of the pluton. Small variations in the magnetic pattern probably are related to intense deformation in the bordering basaltic and arkosic rocks.

A partly mapped magnetic high occurs on the northwest margin of the map. The apparent maximum of this feature may be the magnetic expression of plutonic rocks in the southern part of Maloney Ridge.

Intensity variations in the magnetic pattern are probably caused mostly by magnetic contrasts in materials near the surface of the ground. None of the anomalies are considered to be of the type commonly associated with large deposits of magnetite or with metalliferous lodes that occur in extensive zones of alteration in country rock.

Mineral deposits

The study of the Alpine Lakes area had as its principal object the evaluation of mineral deposits and for geologic environments that suggest the presence of mineral deposits. Mining claims and evidence of prospecting and mining were looked for and the geologic, geochemical, and geophysical characteristics of the area were investigated.

Setting

The central Cascade Range is part of a metallogenic belt characterized by the presence of porphyry copper and low-grade molybdenum deposits (Little and others, 1968, p. 504). The belt extends from British Columbia southward through the central Cascade Range of Washington where it becomes obscured by an extensive cover of Tertiary volcanic rocks. The mineral deposits are associated with quartz-biotite, calcic-alkalic differentiates of late Mesozoic-Tertiary granitic intrusive complexes (Little and others, 1968, p. 504; Grant, 1969, p. 24-27), and with transverse shear zones (Grant, 1969, p. 39-46). According to Grant (1969, p. 23, 39) at least 18 major plutonic masses and 6 known or inferred large shear zones are present in the Cascade Range of Washington. The shear zones are east- to northeast-trending structures and their intersections with older northwest-trending folds or other structures in the vicinity of favorable plutonic rock are the loci of many mining districts (Grant, 1969, p. 45). The copper deposit at Holden and the gold deposit at Monte Cristo, the newly developed copper bodies at Glacier Peak and Sultan basin, and a mineralized area currently being explored along the Middle Fork of the Snoqualmie River are all examples of mineral deposits along transverse shear zones.

Several types of wallrock alteration occur in mineralized areas. Important types are propylitic, quartz-sericitic, potassium silicic, and silicic (Grant, 1969, p. 49-50). In places alteration halos have developed around mineralized cores. Altered areas shown on the geologic map (pl. 1) are conspicuously sericitized or silicified and commonly they contain pyrite and possibly other sulfide minerals. Where oxidized, the sulfides have stained rock surfaces with limonite.

The Alpine Lakes area contains numerous occurrences of copper, and other base and precious metals, and although many of the deposits have been prospected and explored, few have produced ore. The area is overlapped by five mining districts (Washington Div. Mines and Geology, 1971, fig. 2) which are of past or current importance: Blewett (southeast), Cle Elum (south-central), Leavenworth (northeast), Miller River (northwest), and Snoqualmie (southwest). (See pl. 2.)

Lode deposits

Significant amounts of gold were produced from the Blewett district, which lies adjacent to the southeastern part of the Alpine Lakes area. Most production took place in the period around the turn of the century; the district is essentially idle now. Gold was produced from ore shoots located along discontinuous, northwest- to west-trending quartz-carbonate veins in mafic and ultramafic rock (Weaver, 1911, p. 72-73). The ore shoots, according to Weaver, are irregular, lensoidal bodies a few feet to more than 10 feet (1-3 m) wide, as much as several hundred feet long and a few tens to hundreds of feet in vertical extent. The ore is oxidized near surface and contains free gold; at depth the ore minerals are arsenopyrite and pyrite. In addition to gold the ore bodies contain very minor amounts of silver, copper, and lead.

Numerous other deposits of precious and base metals occur in an arcuate belt that extends westward from the Blewett district through the Swauk district and northwestward into the Cle Elum and Leavenworth districts. The belt roughly parallels the boundary of the Mount Stuart batholith and in most places lies some distance away. Many of the gold deposits, like those of the Blewett district, occur in sulfide-bearing quartz or quartz-carbonate veins in ultramafic rock (Huntting, 1955, p. 64, 66-67). The veins are apparently located along planar structural features such as shears or faults. Other auriferous deposits are located near the contact between granitic and ultramafic rock where locally silicified-carbonatized rock has developed as a product of contact alteration and metasomatism with the subsequent introduction of sulfide minerals (Purdy, 1951, p. 62-66).

Base metal deposits, which are mostly copper-rich and contain other base and precious metals, are most numerous in the Van Epps Pass area and they overlap the gold belt. Most deposits occur as disseminated sulfide minerals deposited along weakly developed shear planes in peridotite or serpentinized peridotite. In some prospect pits only copper carbonate stain is visible. Other copper-bearing deposits appear syngenetic and consist of sulfide minerals sparsely disseminated through dikes of intermediate composition.

Locally along the mineral belt that parallels the Mount Stuart batholith, nickeliferous veins occur in ultramafic rocks. The deposits of nickel and allied metals were apparently liberated from ultramafic rock through either weathering, serpentinization, or hydrothermal activity and were picked up and incorporated in the vein-forming solutions (Vhay, 1966, p. 122). Deposits of this type are oriented east-west (Lupher, 1944, p. 10).

Nickeliferous laterite deposits are exposed in an arcuate belt that extends from the Blewett mining district through the Swauk and into the Cle Elum mining district. The deposits are thin, discontinuous lenslike bodies developed in a zone lying between ultramafic intrusive rock and sandstone of the Swauk Formation (Lupher, 1944). The deposits formed through the weathering of ultrabasic rock, apparently in a warm, wet climate and apparently were modified by colluvial processes. The more soluble constituents of the source rock were removed during weathering leaving a relatively insoluble iron-rich residue rich in nickel, aluminum, and chromium.

Gold was mined in the Liberty area (fig. 1) of the Swauk district around the turn of the 19th century (Smith, 1904, p. 9). It occurs in or is associated with quartz-carbonate veins in narrow, brecciated fissures cutting sandstone or shale beds of the Swauk Formation. In places the veins are distinct but elsewhere they grade into shattered wallrock. The gold commonly occurs in vein quartz and in silicified wallrock. Most of it is native gold that contains appreciable silver. Sulfide minerals are rare. The veins trend northeastward more or less parallel to the Teanaway dikes, but the veins are younger than the dikes.

Gold, silver, copper, and other base metals have been produced in significant quantities from the Miller River district, but at present (1971-72) mining activity is at a low ebb. Part of the mining district is in the northwestern part of the Alpine Lakes area, but most of the mines and workings are located several miles outside the study area.

Most mineral deposits are in granitic rock (Purdy, 1951, p. 78-87) and some are in andesite (Livingston, 1971, p. 144). The deposits are in veins in faults and shear zones that strike northwest and dip steeply southwest. Most of the developed veins have replaced the wallrock. Ore minerals differ in type and proportion across the district and include pyrite, arsenopyrite, chalcopyrite, galena, tetrahedrite, sphalerite, and jamesonite (Livingston, 1971, p. 137-147). The wallrock adjoining the deposits is variably altered; in places only the mafic minerals are affected but commonly the rock is kaolinized or sericitized.

Other deposits, dominantly copper with little molybdenite and sparse silver and gold, occur in the Quartz Creek area of the Miller River mining district (the Snowqualmie mining district of Livingston, 1971, p. 149-152). The district is on a large east-trending transverse shear zone (Grant, 1969, p. 40) which in mineralized areas is recognizable as sets of small east-trending shears. The deposits are in elliptical, steep-sided breccia pipes in granitic rock (Grant, 1969, p. 79-81). Outcrops of the pipes are hundreds of feet (100-200 m) across. Angular granitic fragments within the pipes are inches to feet (10 cm-1 m) long and are cemented with quartz and sulfide minerals.

The principal sulfide minerals are pyrite, pyrrhotite, chalcopyrite, and arsenopyrite that occur as disseminations, veinlets, and lenticular replacement pods. The host rock in areas of mineralization is intensely altered (Grant, 1969, p. 81). Chlorite and sericite are developed at the expense of mafic minerals and feldspar around areas of abundant sulfide mineralization. This alteration was superposed on an earlier biotite alteration which more commonly affected the brecciated structures.

Additional copper deposits, similar in mineralogy and structure to those of the Quartz Creek area, occur in the Snoqualmie mining district along the Middle Fork of the Snoqualmie River above Burntboot Creek. The deposits are in breccia pipes, shatter zones, and shears which transect granitic rock. They are alined along a northeast-trending zone measuring more than 6 miles (10 km) long and 400-2,500 feet (120-750 m) wide (Grant, 1969, p. 81-88). The mineralized zone may have once been continuous but subsequently was cut by a series of northwest-trending faults that subdivided it into several separate mineralized bodies (Grant, 1969, p. 85).

Sulfide minerals, principally chalcopyrite, molybdenite, pyrite, and pyrrhotite, occur in veins and fracture fillings and as disseminations in the host rock. Mineralization occurred in two or more stages: an earlier one which took place at an upper level and a later, richer one which took place at a deeper level. Biotite-potassium feldspar and quartz-sericite alteration is associated with the mineralization. Pyropylitic alteration also developed during the periods of mineralization but is associated with barren pyritic rocks surrounding the areas mineralized with copper and molybdenum.

The mineralized ground along the Middle Fork of the Snoqualmie River extends into the western part of the Alpine Lakes area. It lies along a transverse shear zone (Grant, 1969, p. 40) which may extend several miles (5 km) into the study area.

Evidence of other possible mineralization occurs in the Mineral Creek area of the Snoqualmie mining district. The area is thought to have structural, alteration, and mineralogic characteristics which suggest that it is a high-level equivalent of the copper deposits along the Middle Fork of the Snoqualmie River (Grant, 1969, p. 87). Mineralization and accompanying alteration has occurred in the upper parts of granitic intrusive rock and in adjoining volcanic rock, and more nearly corresponds to the pyrite-propylite zones of the Middle Fork area. Where the Mineral Creek area has been explored by drilling, copper sulfides accompanied by alteration have been found.

The mineralized zone of Mineral Creek area is on a northeast-trending transverse shear zone which may extend into the Alpine Lakes area.

The geologic setting in the study area is very similar to that of the L-D gold mine 40 miles (64 km) east near Wenatchee, Wash. According to Patton and Cheney (1971) mineralization at the L-D mine is in an imbricate, northwest-trending thrust zone in the Swauk Formation along which small bodies of intermediate and mafic rock were intruded. The mineralization was accompanied by repeated episodes of silicification. Along the ridge of Summit Chief Mountain in the study area is a similar zone of northwest-trending imbricate thrust faults, as well as a major vertical fault, cutting the Swauk Formation. The Snoqualmie batholith intrudes the Swauk a short distance north of the ridge, and a small satellitic body of the Snoqualmie intrudes the Swauk near the thrust structures. An elliptical zone of silicified, iron-stained Swauk occurs in the upper plate of the westernmost thrust near a vertical fault. In other ways, however, the two areas differ: rocks of the Snoqualmie batholith are more felsic than the intrusive bodies associated with the L-D deposit. The Snoqualmie batholith appears most likely to have intruded the Swauk after the period of faulting, whereas the intrusive rocks of the L-D deposit appear to have been emplaced penecontemporaneously with folding and faulting; and mineralization in and adjacent to the Snoqualmie batholith was mostly conducive to base metals, whereas that near Wenatchee was conducive solely to precious metals.

Placer deposits

Placer deposits of gold occur in those areas where significant lode gold deposits exist as, for example, along Peshastin Creek in the Blewett district and along Swauk Creek (fig. 1) in the Swauk district. The gold is mostly in stream-level gravels but along Swauk Creek it also occurs in older terrace gravels (Smith, 1904, p. 9). Placers are not reported from other districts around the Alpine Lakes area.

Geochemical exploration

A geochemical survey was made concurrently with the geologic reconnaissance of the Alpine Lakes area. A total of 2,986 samples was collected for analysis: 1,853 stream-sediment samples, 6 panned concentrates, and 1,127 rock samples. Sample localities are shown on plate 2 and analytical data on table 10. The samples are numbered and where two or more specimens were taken at the same sample site, the additional samples are indicated by letter suffixes in the table. Underlined numbers on plate 2 indicate anomalous samples. Anomalous areas are outlined on plate 2 and the anomalous samples occurring in them are so categorized in table 10. The type of sample or samples taken at the respective sample sites are indicated by symbol on plate 2. Also indicated on plate 2 are stream-sediment samples containing copper and zinc detected by atomic absorption, and molybdenum detected by colorimetry, and rock and panned-concentrate samples containing gold detected by atomic absorption.

Stream-sediment samples consist of the finer fraction of alluvial material in active streams or dry stream beds. The collected samples were analyzed for various metallic and other elements by several methods. The metals are adsorbed on clay- and silt-size particles in the stream sediments. Stream sediments with anomalously high metal content indicate mineralized rock somewhere in the drainage basin. The magnitude of the anomaly may reflect the volume and concentration of metal in the source area, but the magnitude can be affected by such factors as availability of the contained metals to solution, the distance from the source area, and the volume of the stream. Tributary streams at the head of Van Epps Creek drain nearby mineralized rock, some of it opened by prospecting and mining operations. Stream sediment samples from the tributaries are high in metals, but about 1 mile (1.5 km) down stream near the mouth of Van Epps Creek no anomalous concentrations of metals were detected.

Stream-sediment samples were collected from most small tributary streams, usually just above their confluence with medium or large streams. The samples were taken from the finest material available but where fine grained sediment could not be obtained, material from underwater bank sediment was taken instead. In some steep-gradient streams it was not possible to obtain sufficient fine sediment for certain types of analyses.

The samples were sieved and the minus 80-mesh fraction used for analyses. Sediment samples containing sufficient fine material were analyzed by the citrate-soluble heavy metals (cxHM) colorimetric test for combined zinc, cobalt, copper, and lead (Ward and others, 1963). Samples in which 3 ppm or more of metals was detected by the citrate-soluble method were also analyzed for copper and zinc by atomic absorption. A selected number of these samples were analyzed for antimony and molybdenum by colorimetric methods. Some samples in which high concentrations of copper and zinc were detected by atomic absorption were further analyzed for gold using the same method.

All stream-sediment samples, including those in which the fine fraction was insufficient for citrate-soluble analysis, were analyzed by 6-step semiquantitative spectrographic analysis for a group of 30 elements (Grimes and Marranzino, 1968). Samples containing more than normal amounts of copper, lead, or zinc were further analyzed for copper and zinc by atomic absorption (Ward and others, 1969). Further testing was necessary because the limit of detection of zinc by 6-step semiquantitative spectrographic analysis is 200 ppm, which in the Alpine Lakes area is an anomalous value.

Panned concentrates of stream sediments were taken along a few of the larger streams and analyzed for gold by atomic absorption and for platinum and platinum group metals by fire assay, and for other elements by semiquantitative spectrographic analysis. The results were essentially negative.

Grab samples of rock were taken throughout the study area. Where stream sediments contained anomalous amounts of metal, rock samples were taken in the drainage basin in an attempt to locate the source of the metal. Others were taken from areas of hydrothermal alteration or in the vicinity of geologic structures that might contain mineral deposits. Some were taken near mines and prospects to determine not only the amount of metal in the visible ore minerals, but also to determine other elements which occur in trace amounts and which might serve as indicators of as yet undiscovered mineral deposits. Most grab samples, however, were taken to check for possible metal anomalies or anomalous trends, and to establish the normal amounts of metal in the different rock formations. The samples were tested by 6-step semiquantitative analysis and selected samples were further checked by atomic absorption for gold and copper.

Selected typical samples of ultramafic rock were assayed for platinum and platinum-group metals, mainly to establish background levels for these metals, and they were further checked by atomic absorption for cobalt, copper, nickel, and silver. Also, selected samples of arkosic sandstone were tested for uranium by paper chromatography. The results were negative.

Review of the analytical data, especially data from areas of known mineralization and hydrothermal alteration, indicates that minimum values for anomalous amounts of elements, regardless of rock type or stream sediment source, are as follows:

Method and element	Value (ppm)
Stream sediment samples	
cxHM	10
Atomic absorption:	
Cu	100
Zn	100
Colorimetric analysis:	
Mo	25
6-step semiquantitative spectrographic analysis:	
Ag	0.5
Cu	100
Zn	200
Pb	50
Mo	5
Sn	10
W	50
Rock samples	
Atomic absorption:	
Ag	1
Au	1
Cu	100
Colorimetric analysis:	
Mo	5
6-step semiquantitative spectrographic analysis:	
Ag	0.5
Cu	100
Zn	200
Pb	50
Mo	5
Sn	10
W	50
As	200
Sb	100

All of the data for the above elements are shown in table 10 for each sample in which one of the elements was detected at or above the miminum values considered anomalous.

The 100-ppm level for copper may be close to the background level of that metal in intermediate and mafic dikes, although where dikes were found to contain copper at this level, they were observed to contain sulfide or other ore minerals.

The relatively high chromium and nickel content found in samples of ultramafic rock is considered to be normal background. On the basis of 6-step semiquantitative spectrographic analysis of 30 representative grab samples, the chromium content is found to average about 2,000 ppm with highs ranging to 3,000 ppm, and the nickel content is found to average about 1,400 ppm with highs ranging to 3,000 ppm. In samples from streams draining areas solely or mostly underlain by ultramafic rock, the chromium and nickel contents average 3,000 and 400 ppm respectively and are considered to reflect the high averages of these metals in the source rocks.

Only the analytical data for samples regarded as anomalous are shown in table 1. Computer tape with all U.S. Geological Survey analytical data from the Alpine Lakes study area can be obtained from the National Technical Information Service, Department of Commerce, Springfield, Va., 22151 (USGS 73-031).

Anomalous areas

Areas designated anomalous were judged so from the abundance and areal concentration of anomalous samples occurring therein, and also on the character of the geology. Included in the anomalous areas are areas known to have been prospected or mined, and for which there is supporting analytical data. The areas are discussed in order from east to west.

In the following discussion of anomalous areas, many samples were analyzed by more than one method and many were anomalous in more than one metal.

Bulls Tooth area (pl. 2, area 1)

A grab sample (EG-1144) (table 10) containing 10 ppm tin detected by spectroanalysis was collected from near the nose of a ridge lying just north of Icicle Creek and west of Doughgod Creek. The sample is limonite-stained granitic rock which otherwise appears unaltered. The stained rock underlies an area about 100 feet (30 m) wide and a few hundred feet (100 m) long. An aplitic dike and a quartz vein which cut the stained rock were sampled, but no anomalous amounts of metal were found.

The Bulls Tooth area is considered anomalous, and similar to the French Ridge area where several samples of iron-stained granitic rock contain anomalous amounts of several metals, including tin.

French Ridge area (pl. 2, area 2)

Three stream-sediment samples and eight rock samples anomalous in metals were collected from French Ridge west of Turquoise Lake. The eight rock samples are from an oval area of iron-stained, slightly altered, granitic rock about 1,500 feet (460 m) across that straddles the ridge crest. Two of the stream-sediment samples are from a stream draining the northwestern part of the altered area.

In the altered area the granitic rock is slightly more finely crystalline than the surrounding rocks. Biotite and feldspar have been partly altered to sericite. Dikes of intermediate composition and at least one quartz vein cut the granitic rock and all contain anomalously high amounts of metal. Sparse, minute grains of sulfide minerals and traces of malachite were noted in some of the fine-grained granitic rock.

The rock samples contain as much as 500 ppm copper, 1.5 ppm silver, and 15 ppm tin, all determined by semiquantitative spectrographic analysis (table 10). The maximum amounts of copper occur in intermediate dike rock, but copper is also present in anomalous amounts in altered and in some relatively fresh-appearing granitic rock. Silver occurs in anomalous amounts in both intermediate dike rock and altered granitic rock; tin is present in the quartz vein.

The stream-sediment samples contain 18-70 ppm heavy metals; the heavy metals component apparently is mostly zinc for as much as 500 ppm zinc was determined by atomic absorption. Silver in one sample is 0.7 ppm, as determined by semiquantitative spectrographic analysis.

This area is clearly anomalous; the contained metals probably occur in sulfide minerals disseminated through the rock in minute grains. The area is considered to have a mineral potential and is worthy of further investigation.

Leland Creek (pl. 2, area 3)

Thirteen stream-sediment samples that contained anomalous amounts of metals were collected from tributary streams along the course of Leland Creek from a point just above Lake Leland to near its confluence with Prospect Creek. Most of the samples are concentrated in an area just below the lake.

Nine samples contain anomalous amounts of molybdenum which range from 5 to 20 ppm and average 8 ppm, determined by spectroanalysis (table 10). All but one of the samples came from the right bank of Leland Creek. Two samples, EG-0270 and ES-0002, contain 10 and 16 ppm heavy metals, respectively. Atomic absorption analysis of samples ES-0002 showed 100 ppm copper and 120 ppm zinc. Another sample, ES-0004, contained 110 ppm zinc and some copper.

Two samples from near the head of Lake Leland, EG-0258 and EG-0260, are barely anomalous in lead. They may be genetically unrelated to the other anomalous samples.

The areas drained by the streams containing anomalous stream-sediment samples were examined for evidence of hydrothermal alteration, the presence of veins, and other evidences of mineralization. Analyzed rock samples from these areas showed no anomalous or near-anomalous amounts of molybdenum or other metals. All but one of the areas are underlain by unaltered granitic rock that is texturally similar to that of the adjoining areas. The one exception is an area of limonite-stained granitic rock about 200-300 feet (60-90 m) across that lies near the crest of French Ridge, southwest of Todd Lake and north of Klonaqua Lakes. There biotite books are partly altered but otherwise the rock appears fresh. Analyses of a sample of the limonite-stained rock and a stream-sediment sample from the outlet of Todd Lake do not show anomalous contents of metals. Nevertheless, this area is considered the likely source of the copper and zinc anomalies found in stream-sediment samples ES-0002 and ES-0004.

The Cradle (pl. 2, area 4)

Thirty-nine stream-sediment samples and 11 rock samples that contain anomalous amounts of metals were collected from The Cradle area (table 10). The stream-sediment samples were taken from small streams tributary to Meadow, the upper part of French, and Snowall Creeks, and from Cradle Lake, and most of them came from an area at the heads of Meadow and French Creeks. Most rock samples are from veins and country rock in a narrow isthmuslike body of the Mount Stuart batholith that intrudes peridotite near The Cradle.

Thirty-one stream-sediment samples analyzed by semiquantitative spectrographic methods contain 5-20 ppm molybdenum and average about 7 ppm. An additional stream-sediment sample analyzed by a colorimetric method contains 25 ppm molybdenum.

Four sediment samples, all from Meadow Creek, contain 18-25 ppm heavy metals. Of the several sediment samples checked by atomic absorption for copper and zinc, four were found anomalous in copper; and none in zinc; the copper content averages about 120 ppm.

Two sediment samples, ES-0018 from near the head of Snowall Creek and EK-0172 on French Creek, contain 50-100 ppm tungsten as determined spectrographically. U.S. Bureau of Mines personnel recognized scheelite in panned concentrate samples collected on upper Meadow Creek which contained 0.015-0.018 percent tungsten.

The search for the source of the anomalous metals in the stream-sediment samples was concentrated on The Cradle, a northwest-trending ridge that is bounded by Meadow, French, and Snowall Creeks. Seven rock samples collected along the ridge contain anomalous amounts of metals. Four of them, which are from barren-appearing quartz veins 3-15 inches (8-38 cm) wide, contained, by spectrographic analysis, 300 ppm arsenic, 70-300 ppm tungsten, 10-15 ppm molybdenum, and 0.5-0.7 ppm silver. Not all the elements cited are common to each of the vein samples. Other similar quartz veins were sampled, but were not found to contain anomalous amounts of metals.

Three samples of granitic rock collected on The Cradle are anomalous. Two of the samples, EG-0840 and EG-0840-A, are from a small limonite-stained area, the only such area observed on the ridge. Sample EG-0840 contains 70 ppm tungsten and sample EG-0840-A contains 150 ppm copper.

Metal anomalies occurring in other rock samples in The Cradle area do not appear to be genetically related to those occurring in the quartz veins or granitic rock. Two samples from near the contact of granitic and ultramafic rock are anomalous in lead and tin; two other samples from along the crest of Sixtysix Hundred Ridge are anomalous in copper. One of the latter samples, EG-0417, is from a vein of asbestiform amphibole about 1 inch (2.5 cm) thick that occurs near a shear zone.

Paddy-Go-Easy Pass area (pl. 2, area 5)

Gossan and copper-stained outcrops in the Paddy-Go-Easy Pass area were prospected before the turn of the century, and the area was studied principally to learn the character of the mineralization and geology. The properties and workings are discussed at length in the section dealing with mines and prospects.

One anomalous stream-sediment sample (table 10) and 15 anomalous rock samples were collected from the Paddy-Go-Easy Pass area. The stream-sediment sample, from the outlet of Sprite Lake, is anomalous only in lead and was detected by spectrographic analysis. Stream-sediment samples from along French Creek and the Cle Elum River and from streams draining the Paddy-Go-Easy Pass area are anomalous in metals but the sample sites may be so remote from the source area as to be affected by dilution.

The rock samples collected from prospect pits and dumps are mostly of sulfide minerals, vein and wallrock; the metal content is expectably high and is not necessarily representative of the overall tenor of the deposits. Of the 15 anomalous samples detection was by 6-step semiquantitative spectrographic analysis, 9 are anomalous in silver, 0.7-150 ppm and averaging about 24 ppm; 4 in gold, 10-70 ppm and averaging 30 ppm; 12 in copper, 150-20,000 ppm averaging about 440 ppm; 8 in arsenic, 300-10,000 ppm averaging about 4,400 ppm; also 2 samples are anomalous in lead, 2 in molybdenum, 2 in antimony, and 1 in tungsten. Gold was detected in eight samples by atomic absorption in amounts ranging from 1 to 70 ppm and averaging about 20 ppm.

The occurrence of arsenic in most of the Paddy-Go-Easy Pass samples reflects the presence of arsenopyrite in the deposits; only two of the deposits sampled were rich in pyrite. The association of gold with arsenopyrite is common in many mineral deposits. The presence of silver and base metals and the location of the area near the Mount Stuart batholith give the Paddy-Go-Easy Pass deposits characteristics in common with those in the Blewett mining district. But unlike those of the Blewett district, the Paddy-Go-Easy Pass deposits are located around small granitic plugs, and the known veins are narrow, a few inches (10 cm) wide at most, and discontinuous. Although they have similar mineral assemblages, the deposits in the Paddy-Go-Easy Pass area appear to have neither the tenor nor the volume of those in the Blewett district.

Van Epps Pass area (pl. 2, area 6)

The Van Epps Pass area has been extensively prospected over a period dating from before the turn of the century, but only minor production is recorded. Areas known to be hydrothermally altered are shown on the geologic map (pl. 1). Properties and workings are discussed in the section dealing with mines and prospects.

Fourteen stream-sediment samples and 25 rock samples collected from the Van Epps Pass area are anomalous in various metals. The stream-sediment samples were collected from Solomon, Van Epps, and Fortune Creeks.

Three stream-sediment samples collected from tributaries at the head of Solomon Creek were found anomalous in molybdenum by spectrographic analysis but they averaged only 5 ppm. No other metals were detected.

Five anomalous sediment samples were collected from the head of Van Epps Creek, four of which contain anomalous copper ranging from 200 to 1,000 ppm and averaging 600 ppm detected by spectrographic analysis. The high copper content is expectable in most of these samples because they are from streams draining areas in which there are workings in copper-bearing rock. The highest copper anomaly, however, was detected in a sample from a stream draining an iron-stained, hydrothermally altered area located on the south and southwestern part of the headwall of Van Epps Creek where there is little evidence of prospecting activity. In addition, the Van Epps Creek samples contain molybdenum ranging from 10 to 30 ppm and averaging about 18 ppm; only a few of these samples also contained silver and zinc.

Anomalies of heavy metals in the Van Epps Creek samples are similar to those detected by spectrographic analysis. Copper, checked by atomic absorption, likewise parallels that detected by spectrographic analysis. It ranges from 110 to 1,300 ppm and averages 500 ppm. Zinc was detected in only three of the anomalous Van Epps Creek sediment samples by this method.

Six anomalous sediment samples are from tributary streams draining the areas north and east of Fortune Creek. Four of the six are anomalous in zinc, 200 to 300 ppm and averaging 225 ppm, detected by spectrographic analysis. Three samples from along the bottom of the canyon of Fortune Creek, EK-0358, ET-0304 and ET-0306 are anomalous in silver whereas the samples from high on the side of the canyon of Fortune Creek, EG-1097, EG-1100, and EG-1107 show no silver. Evidently the source or the sources of metal lies some place between the groups of sample sites.

The rock samples collected in the Van Epps Pass area are mostly from dumps and workings and most are mineralized; the high metal content in the analyses is expectable and does not necessarily reflect the average tenor of the deposits.

Of the several metals detected in anomalous quantities, copper, silver, zinc, and molybdenum are the most commonly anomalous, and tin, lead, arsenic, and antimony are anomalous locally. Copper and zinc are the most abundant metals; copper ranges from 100 to 20,000 ppm and zinc from 200 to 10,000 ppm by spectrographic analysis. Molybdenum ranges from 15 to 500 ppm and silver from 0.5 to 100 ppm. Selected samples were checked for gold by atomic absorption but only one, containing 2 ppm, was found anomalous.

The metallic minerals are mostly pyrite, chalcopyrite, and sphalerite, and malachite bloom is evident in many samples. Minerals of silver and molybdenum may be present but were not identified. Silver, on the basis of the analytical results, appears to be more closely associated with copper than with zinc. The content of silver and arsenic in the samples does not correlate well and apparently the source of the arsenic is in some mineral other than an arsenic-bearing silver sulphosalt.

The mineral deposits are along shear zones or joints in ultramafic rock. The rock in and adjoining the structures is silicified or otherwise altered and commonly iron stained. The metallic minerals occur disseminated or in veinlets in the sheared rock, and in quartz veins. The shears and veins strike northwest to west and dip steeply to the north. Some deposits are closely associated with intermediate or mafic dikes.

The most intensely mineralized part of the Van Epps Pass area is located within 2,000-3,000 feet (600-900 m) of the contact zone between Ingalls Peridotite and the Mount Stuart batholith and appears to be dominantly copper bearing and subordinately zinc bearing. Westward, in the Fortune Creek area, the abundance of both metals diminishes, but zinc dominates over copper. This zonation, if real, implies that the mineralization process was extensive, and may have produced other deposits in the area. The area is considered to have mineral potential which is yet unexplored.

Esmeralda Peaks area (pl. 2, area 7)

The area around Esmeralda Peaks and Gallagher Head, where at least two copper-bearing mineral deposits are known, was examined for possible unknown extensions of mineralized ground.

The two anomalous stream-sediment samples from tributary streams in the headwaters area of the North Fork of the Teanaway River apparently reflect the presence of a known mineral deposit in that area. One of the sediment samples, EG-1071, is anomalous only in zinc, showing 200 ppm; the other sediment sample, EK-0119, contains 12 ppm heavy metals; by atomic absorption it contained 120 ppm zinc.

Two anomalous rock samples are from mine dumps in the upper Teanaway area. Sample EG-1070 is an iron-stained, silicified, sulfide-bearing ultramafic rock with a disseminated green mineral; sample EG-1070-A is similar but contains less sulfides and no visible copper minerals. Spectrographic analysis shows sample EG-1070 to contain 3 ppm silver, 15 ppm gold, 300 ppm zinc, and 1,000 ppm arsenic, and sample EG-1070-A to contain 500 ppm copper and 3,000 ppm zinc. Atomic absorption method shows the two samples to contain 16 and 2.5 ppm gold, respectively. The high arsenic in EG-1070 indicates that the sulfide mineral is arsenopyrite which may account for the relatively high gold content.

Sample EK-0114-D, collected from gravel about 2,000 feet (600 m) downstream from the dumps, is composed of limonite-stained quartz. It is anomalous in silver and copper and may have been carried downstream from dumps that contain vein quartz.

Samples EG-1081, EG-1081-A, and EG-1081-B are from workings near Gallagher Head. Although outside the study area, the deposit was briefly examined because it may be located on a structure related to that in the Teanaway drainage. The samples are from malachite-stained silicified and pyritized rock occurring in shear zones that cut greenstone. In addition to copper, the samples contain some zinc and minor molybdenum and silver.

The mineralized shear zone in the Gallagher Head area trends N. 70° E., but its extension was not recognized east of the pass. The mineralized structure in the upper basin of the North Fork of the Teanaway River may be similarly oriented although this could not be verified because the workings are inaccessible. In both areas the deposits appear to be confined to the structures.

Gold Creek-Delate Creek area (pl. 2, area 8)

Parts of the Gold Creek-Delate Creek area have been prospected and explored from before the turn of the century to the present. A dogleg-shaped area along Gold Creek, about 15,000 feet (4,600 m) long and 1,000-3,000 feet (300-900 m) wide, is hydrothermally altered and mineralized. The area is at the distal tip of a lobe of the Snoqualmie batholith, and both granitic and volcanic rocks are affected. Several other altered and mineralized areas are located southeast of Gold Creek but they are smaller and are within volcanic rock (pl. 1).

The granitic rock appears to have undergone quartz-sericite alteration with the attendant destruction of mafic minerals and the development of quartz and sericite at the expense of feldspar. The character of the alteration in the volcanic rocks is less clear, however. In many areas alteration did not go beyond the propylitic stage and is not readily recognizable in the field. Only where the alteration process reached advanced stages are its effects on the rocks easily recognized and mapped. In these places the rock is silicified, and where not iron-stained, appears bleached.

Sulfide minerals are common throughout the altered areas and commonly occur as disseminated grains, elsewhere they occur in veinlets. Pyrite was the only sulfide mineral recognized but evidently copper sulfide minerals are also present.

Forty-eight stream-sediment samples containing anomalous amounts of metals are from the Gold Creek-Delate Creek area. Twenty-five samples are anomalous in silver, 0.5-2 ppm; 23 in copper, 100-200 ppm; 10 in molybdenum, 5-20 ppm; and 18 in lead, 50-100 ppm, detected by spectrographic analysis. These and several additional sediment samples were checked by atomic absorption for copper and zinc. Twenty-four are anomalous in copper and 24, not all the same ones, are anomalous in zinc. Copper values range from 100 to 440 ppm, averaging about 180 ppm. Zinc values range from 100 to 350 ppm, averaging about 180 ppm.

Only 12 of the stream-sediment samples are anomalous in heavy metals, and correspond fairly well with the samples known to be anomalous in copper and zinc from atomic absorption analysis.

Most of the stream-sediment samples anomalous in metals are from along Gold, Mineral, Delate, and Box Canyon Creeks. Some of 28 samples from along Gold Creek, especially those in the upper part of the drainage basin, reflect the presence of the altered and mineralized area. Other samples from tributary streams west of the altered area may reflect either slightly altered and mineralized rock that was not recognized, or possibly a body of mineralized rock in the subsurface.

The anomalous metal content of sediment samples from near Mineral and Delate Creeks and the outlet of Three Queens Lake appears to be derived from a source or sources centered around the Three Queens granitic stock. The rock there, although locally iron stained, does not appear to be intensely altered.

The few anomalous stream-sediment samples from Box Canyon Creek appear unrelated to known areas of altered and mineralized rock; possibly they reflect in the subsurface or an unidentified surface source.

Rock samples were collected throughout the Gold Creek-Delate Creek area and especially from areas recognized to be altered or mineralized. Thirty rock samples are anomalous. Excluding those from vein deposits, the samples most commonly contain silver, 0.5-1.5 ppm; copper, 100-1,000 ppm; molybdenum, 5-50 ppm; and zinc, 200-7,000 ppm; and rarely lead, tin, and tungsten. With the exception of lead, which commonly occurs in less than anomalous amounts, the abundance of the metals in the anomalous rock samples is generally similar to that in the anomalous stream-sediment samples.

Samples EG-1396, -A, and -B, and ES-1097, -A, -B, -C, and -D were collected from the workings and dumps of two vein deposits on the southeast headwall of the canyon of Gold Creek. The veins are confined to shear zones and are composed of quartz, pyrite, and ore minerals of base metals, and, unlike the pervasive altered and mineralized rock, they contain proportionally more lead and zinc and less copper. In addition, traces of tin, tungsten, antimony, and gold were also detected in vein samples. The assemblages of metals and their relative abundances are very similar in the two veins, with the exception of arsenic, which was found only in samples from the lower vein (EG-1396, -A, and -B).

Parts of the area are anomalous in several metals and, although some of them have been previously explored without productive results, they have a fair potential for the discovery of low-grade economic deposits of copper and molybdenum.

Lemah Creek-Snoqualmie River-Gold Lake area (pl. 2, area 9)

The Lemah Creek-Snoqualmie River-Gold Lake area straddles the contact between granitic rocks of the Snoqualmie batholith and the older mafic volcanic and arkosic rocks. The volcanic rocks are extensively altered by low- to high-temperature thermal metamorphism, and the arkosic rocks are similarly affected but to a lesser degree. Several areas of propylitic alteration, sericitization, and silicification are known, and over the last 90 years a number of them have been prospected and explored. Only the altered areas that are easily recognizable in the field are shown on the geologic map (pl. 1).

Forty-three stream-sediment samples from the area were found anomalous in metals by spectrographic analysis. Four of the samples are from Lemah Creek and its tributaries, one from a small stream on the north side of Summit Chief Mountain, 28 from tributaries of the Middle Fork of the Snoqualmie River, and 10 from the Hardscrabble Lakes-Gold Lake-Crawford Lake area.

Of the total, 17 samples contain anomalous silver ranging from 0.5 to 3 ppm and averaging about 1 ppm; 16 contain anomalous copper ranging from 100 to 300 ppm and averaging about 190 ppm; 20 contain anomalous molybdenum ranging from 5 to 20 ppm and averaging about 10 ppm; and 17 contain anomalous lead ranging from 50 to 150 ppm and averaging about 75 ppm.

Fifteen samples, most from along the Middle Fork of the Snoqualmie River, contain anomalous amounts of heavy metals ranging from 10 to 50 ppm and averaging about 20 ppm. These and several other samples were checked by atomic absorption for copper and zinc; 14 contain anomalous copper ranging from 100 to 440 ppm and averaging about 200 ppm, and 18 contain anomalous zinc ranging from 100 to 460 ppm and averaging about 185 ppm.

Three stream-sediment samples, EG-0637, EG-0638, and ES-0200 are from streams located along or near known or inferred faults. Two of the samples, EG-0637 and EG-0638 collected near silicified schist and volcanic rock along a high-angle reverse fault, are anomalous in copper.

Sediment sample EG-1324, from a small, northeastward-flowing stream on the north side of Summit Chief Mountain, contains anomalous amounts of silver, base metals, tin, and arsenic.

Fourteen anomalous sediment samples taken along the Middle Fork of the Snoqualmie River from Williams Lake to a point about 2 miles (3 km) downstream cannot be related to a known mineralized or altered area. Because the samples were collected from tributary streams on both sides of the river, the source of the metals is assumed to be of considerable areal extent. Possibly finely disseminated sulfides associated with unrecognized low-grade propylitic alteration are the source. Most samples are anomalous in copper and molybdenum, a few are also anomalous in lead and zinc, and very few in tin.

The anomalous samples collected along the north side of the Snoqualmie River from near the mouth of Crawford Creek to the study area boundary probably derive their metals from an area of hydrothermally altered granitic rock centered along the ridge just north of the Snoqualmie near Hardscrabble Lakes. Several samples from tributary streams south of the Snoqualmie and from the Gold Lake area are also anomalous. These samples indicated that a low-grade altered and mineralized halo surrounds the more intensely altered area. Most samples are anomalous in copper and molybdenum and some are also anomalous in silver and zinc.

Forty anomalous rock samples, including several samples taken from some of the more intensely altered or mineralized areas, are from the Lemah Creek-Snoqualmie River-Gold Lake area. The anomalous metals are commonly silver, 0.5-300 ppm; copper, 100-20,000 ppm; and zinc, 200-10,000 ppm. Lead and molybdenum are anomalous in a few samples, and tungsten, antimony, and arsenic in very few. All but one of the visibly altered areas are anomalous in copper or in copper and zinc. The one altered area is on the west side of Summit Chief Mountain and it is anomalous in silver, 0.5-2 ppm; lead, 150 ppm; and tin, 15 ppm. The abundance of metals in the anomalous rock samples is generally similar to that in the anomalous sediment samples.

Samples EG-1322 and ES-1100 are from an altered and mineralized area north of Summit Chief Mountain and on the inferred projection of a high angle fault. The samples are anomalous in silver, copper, and lead.

Parts of the area are hydrothermally altered and mineralized and, although explored without productive results to date, the possibility of discovering economic deposits remains, and several of the altered areas, which are the sources of some anomalies, have not been explored in depth. A fair potential remains for the discovery of low-grade economic deposits of copper.

Chain Lakes area (pl. 2, area 10)

In the Chain Lakes area, a massive sulfide vein in a northwest-trending shear zone cutting granitic rock has been mined for base and precious metals. Two other veins, which do not crop out at the surface, were reached through underground workings that are now caved. During the 1971 and 1972 field seasons only a small part of the vein that crops out was free of snow. It is 15-20 feet (4.5-6 m) thick and could be followed on the surface only a few tens of feet (10-15 m). The properties, workings, and reserves are discussed at length in the section dealing with mines and prospects.

Nine samples, from the exposed vein, include unaltered-appearing granitic rock, tourmaline-rich rock with quartz, and massive aggregates of pyrite that also contain chalcopyrite, covellite, sphalerite, arsenopyrite, cerussite, and malachite. The samples were analyzed spectrographically and analyzed for gold by atomic absorption. Samples were selected to determine the relative abundance of metals present and are not necessarily representative of the average tenor of the vein. The samples commonly contain lead, 100-7,000 ppm; arsenic, 200-10,000 ppm; silver, 0.5-300 ppm; molybdenum, 5-150 ppm; and tin, 15-30 ppm. They commonly contain copper, 150-20,000 ppm; antimony, 1,000-10,000 ppm; tungsten, 50-300 ppm; and zinc, 2,000-10,000 ppm. Small amounts of gold are in four samples which are high in arsenic.

The assemblage of metals in the vein is similar to that in veins in the Gold Creek-Delate Creek area, but the relative abundance of the metals differs somewhat; it seems unlikely that the veins in the two areas are genetically related. The veins in the Chain Lakes area may be related to late-stage hydrothermal activity around a young stock in the Mount Hinman area (Erikson, 1965, p. 39-40), whereas the veins in the Gold Creek-Delate Creek area are probably related to older rock of the Snoqualmie batholith.

There is no record of exploration drilling in the area. There may be other blind veins in the Chain Lakes area or possibly in other areas peripheral to the Mount Hinman stock.

Camp Robber Creek-Foss River area (pl. 2, area 11)

In the Camp Robber Creek-Foss River area, 35 anomalous stream-sediment samples and 2 anomalous rock samples were collected--the sediment samples from small tributary streams along the course of the two main streams and the rock samples from near ridge crests.

Of the 35 anomalous sediment samples, 32 were analyzed spectrographically. Of these, 14 are anomalous in lead, 50-150 ppm and averaging about 70 ppm; 12 in molybdenum, 5-30 ppm and averaging about 10 ppm; and 11 in copper, 100-150 ppm and averaging about 130 ppm. Another four samples are anomalous in silver. One sample, ET-0344 from the outlet of Lake Malachite, is anomalous only in tin and may be contaminated. Only 9 of the 31 samples that are anomalous by spectrographic analysis are anomalous in more than one metal.

Of the sediment samples checked by atomic absorption, 13 are anomalous, 12 in copper and 1 in zinc. Copper in the samples ranges from 100 to 270 ppm and averages 155 ppm. Two of the stream-sediment samples are anomalous in heavy metals.

The two anomalous rock samples, collected from medium-crystalline granitic rock that shows no evidence of alteration, contain 100 ppm copper.

The Camp Robber Creek-Foss River area, because it contains weak and sparse anomalies and is underlain by unaltered or little altered rock, is considered to have a low potential for future discovery of economic mineral deposits.

Necklace Valley area (pl. 2, area 12)

Ten anomalous stream-sediment samples and two anomalous rock samples were collected from the Necklace Valley area. The sediment samples are from tributary streams around the lakes and from the lake outlets; both rock samples are from near the south end of Locket Lake.

Nine of the sediment samples are anomalous in metals by spectrographic analysis, five in molybdenum and four in lead. Molybdenum in the anomalous samples ranges from 5 to 15 ppm and averages 10 ppm, and lead ranges from 50 to 100 ppm and averages about 60 ppm. Another sample is anomalous in zinc, 110 ppm, as analyzed by atomic absorption. None of the samples are anomalous in more than one metal.

The rock samples from apparently unaltered granitic rock are anomalous in copper. Sample EG-0470-A, from an alaskite dike, contains 150 ppm copper, and sample EG-470-B, from mafic-rich rock associated with the dike, contains 100 ppm copper.

The Necklace Valley area is considered to have a low potential for the discovery of ore deposits.

Other anomalous samples

Scattered and isolated anomalous samples that occur outside anomalous areas are shown separately in table 1. A few are commented on briefly below.

Several sediment samples collected from streams draining the schistose-granitic terrane of the Chiwaukum Mountains have low but anomalous amounts of molybdenum. About 12 from the same area contain low but anomalous amounts of copper and zinc.

Numerous sediment samples collected along Icicle Creek, and some of the major streams tributary to it, contain low anomalous amounts of lead. An exception is a group of three samples, EG-0335, EG-0338, and EG-0339, taken from the upper part of Eightmile Creek. They contain anomalous amounts of molybdenum. Two other sediment samples, ET-0035 from the upper part of Icicle Creek and EK-0058 from the lower part of Mountaineer Creek, appear to be contaminated. Both were collected from terranes of unaltered granitic rock and both contain 1,500 ppm copper and 200 ppm tin. The source of the anomalies is unknown. Samples of stained orthoclase pegmatite dike, quartz vein, and schist from along the crest and flank of the ridge southeast, southwest, and northwest of Cashmere Mountain, contain 100-300 ppm copper.

A malachite-encrusted, sheared, and serpentinized sample of peridotite, EG-1044, collected from a shallow prospect pit between Ingalls Creek and the North Fork of the Teanaway River contained 3 ppm silver and 10,000 ppm copper. The prospect and the surrounding area were examined for the presence of sulfide minerals, but none were found. The copper anomaly probably is solely attributable to the malachite; the source of the copper is unknown.

A few scattered anomalous stream-sediment and rock samples were collected from along the periphery of the Snoqualmie batholith in the areas southwest of Mount Hinman and north of Mount Daniels. The sediment samples contain low to moderate anomalous amounts of lead and copper. The rock samples, which include granitic rock, arkosic sandstone, and volcanic rock, contain low to moderate anomalous amounts of zinc, molybdenum, and silver.

Other commodities investigated

Potential resources of a group of mineral, fuel, and rock products which are or might be present in the Alpine Lakes area were also investigated.

Because of the known association of platinum and platinum group metals with ultramafic rocks, 23 peridotite samples, 5 mineralized rock samples, and 6 panned concentrate samples were analyzed by fire assay for these metals. Twenty-two rock samples showed detectable traces of platinum and (or) palladium. The highest analytical value in platinum (0.010 ppm) was detected in a sample of sheared, talcose peridotite, and the highest in palladium (0.008 ppm) was detected in serpentinized peridotite. No other platinum group metals were detected. None of the panned concentrate samples contained detectable amounts of any of the platinum group metals. From these data, and from what is known about the structure and configuration of the peridotite body, and the character of the mineral deposits associated with it, the potential for finding economic deposits of platinum and platinum group metals in the study area is considered low.

The Swauk Formation was examined for uranium deposits. Arkosic sandstone elsewhere in the United States contains roll-type uranium deposits. The deposits are commonly oxidized and contain a conspicuous suite of yellow minerals. Nothing observed indicated the presence or likely presence of uranium deposits. All samples were scanned by a scintillometer in the laboratory; 35 samples were analyzed by chromatographic method; no uranium was detected.

Nickeliferous iron deposits occur outside the southeastern part of the Alpine Lakes study area and are present in the canyon of the Cle Elum River as far north as Camp Creek (Lamey and Hotz, 1952). The deposits are lenticular, are rarely more than 1,000 feet (300 m) long, and commonly no thicker than a few tens of feet (10 m). They occur in a weathered zone on the Ingalls Peridotite where it is unconformably overlain by Swauk Formation. In the area of the upper part of the Cle Elum River, Swauk adjoins Ingalls Peridotite along a major vertical fault that roughly parallels the course of the river. The weathered zone is assumed to be present beneath the Swauk on the west side of the fault and extends into the Alpine Lakes area.

Pegmatite dikes occur in parts of the Mount Stuart batholith but they do not contain workable quantities of muscovite, valuable feldspar, or other minerals.

A fibrous, asbestoslike mineral occurs in veins a few inches to about 1 foot (8-30 cm) thick in the areas of Sixty-six Hundred Ridge and Windy Pass. The mineral, however, is an amphibole and therefore too brittle to be used as asbestos fibers.

Although coal occurs in the Bellingham area of the State in a formation equivalent to the Swauk, no coal is known to occur in the Alpine Lakes area. The Swauk has a very high sandstone-to-shale ratio and was deposited under conditions unfavorable for the formation of coal. Only sparse carbonized fragments and imprints of fossil flora were observed in the Swauk.

Granitic rocks, like those in both the eastern and western parts of the study area, are crushed and used as road metal and railroad ballast and in large blocks are used as riprap. Neither of the granitic bodies within the study area can be considered an economic resource because they are not accessible to the main routes of transportation.

The arkosic sandstone of the Swauk possibly may be suitable as building stone to veneer small buildings, domestic dwellings, and fireplaces. The esthetic attractiveness of the rock as a building stone is, however, questionable, and because the sandstone is in thick to massive beds, it probably cannot be easily cleaved into blocks of specified sizes. Other more accessible deposits of the sandstone are outside the study area.

A possible source of geothermal energy in the Alpine Lakes area could be the Snoqualmie batholith. It was emplaced in late Miocene time and may retain enough of its heat to have a geothermal gradient greater than is normal for crustal rocks. A hot spring associated with the batholith occurs about 6 miles (10 km) west of the study area. The batholith is, however, extensively exposed outside the Alpine Lakes area and potential development would probably occur outside the area.

Geologic appraisal of mineral resources

Most of the known mineral deposits in the Alpine Lakes area appear to be genetically related to the Mount Stuart and Snoqualmie batholiths. The areas with the greatest potential for mineral resources, therefore, are near borders of granitic plutons, especially in the western part of the area.

Along the southwestern and southern part of the Mount Stuart batholith a discontinuous mineralized belt is indicated by gold deposits in the Paddy-Go-Easy Pass and Peshastin Creek areas and by copper deposits near Van Epps Pass and along the ridge south of Ingalls Creek. Most gold and some copper occur in veins. The Van Epps Pass area contains a disseminated copper deposit. The deposits occur along the border of the batholith; some are as much as 4 miles from it. Two mineralized areas are within the Mount Stuart batholith; they may be near the borders of individual plutons that make up the batholith.

Numerous disseminated copper deposits and a few base and precious metal veins occur along the border of the Snoqualmie batholith and in the adjacent rock. Their irregular pattern of distribution may be due to concealed apophyses and outlying stocks related to the batholith.

The most extensively explored disseminated copper deposit is in granitic rock and lies just outside the study area on the southeastern side of the Middle Fork of the Snoqualmie River. Similar potential deposits may be present in the extensive areas of hydrothermally altered rock in the Alpines Lake area. A deposit is on the ridge between Hardscrabble Lakes and the Middle Fork of the Snoqualmie River. It is in granitic rock less than 2 miles (3 km) from the edge of the batholith. Other deposits are in the upper part of Gold Creek in the area near Alaska and Joe Lakes and on the opposite side of the canyon, and in the upper part of Mineral Creek opposite Park Lakes. The Gold Creek deposit is in granitic and volcanic rock, whereas the Mineral Creek deposit is in volcanic rock about 1 mile (1.6 km) from the Three Queens stock.

Copper-bearing vein deposits containing other base and precious metals occur in the Chain Lakes area near La Bohn Gap. They are in granitic rock near the border of the Mount Hinman stock, a young pluton of the Snoqualmie batholith. Other veins, mostly with zinc and lead, some copper, and minor amounts of gold occur in the upper part of Gold Creek on the southeastern wall of the canyon. They are in volcanic rock near the border of a granitic pluton.

Other veins containing copper, lead, and zinc occur near the batholith border in the Miller River mining district, about 4-10 miles (6-16 km) northwest of the Alpine Lakes area.

Copper deposits are more numerous and of greater size near the Snoqualmie batholith, whereas gold is more copiously associated with the Mount Stuart batholith. This difference is thought to be due to differences in the character of the magmas which formed the two batholiths rather than to differences in the wallrocks.

ECONOMIC APPRAISAL

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U.S. Bureau of Mines

History and production

Mining activity in areas adjacent to the study area began with the discovery and mining of placer gold in Peshastin Creek in 1860. Similar deposits were discovered along Swauk Creek (fig. 1) in 1868. Claims on the lode sources of the Peshastin placers were first located in 1873 and vein deposits of gold in the Swauk district were discovered in 1881 (Patty, 1921, p. 267-268). The value of combined production from the Peshastin and Swauk districts exceeded $2 million before 1901 (Smith, 1904, p. 8).

The discovery of lode deposits and the staking of the first claims in the Index district in 1874 stimulated prospecting northwest of the study area. Claims were staked in the Miller River drainage a few miles northwest from the study area in 1892 (Hodges, 1897, p. 36). The most significant development was from 1893 into the 1920's but sporadic small production from the Miller River drainage has continued to recent times.

A section of the Cle Elum River canyon (the Camp Creek drainage) adjacent to the south-central part of the study area was first prospected mainly for iron-ore deposits in 1881 (Hodges, 1897, p. 61). Prospecting for iron extended eastward along an iron-enriched zone extending roughly through Iron Peak, Earl Peak, Navaho Peak, Iron Mountain, to the Blewett district. Exploration of some of the properties on the west end of the zone was done between 1889 and 1892 (Shedd, 1902, p. 7). The deposits were first studied systematically in 1892 (Bethune, 1892). The U.S. Bureau of Mines conducted a drilling program in 1942 on deposits near the Cle Elum River. Although many claims have been located on the deposits, no production, except small tonnages for smelter tests, has been reported.

The iron deposits of the Snoqualmie Pass area, a short distance southwest of the study area, were first discovered in 1869 on Denny Mountain. No work was done until 1883, when development adits were driven (Hodges, 1897, p. 40-41). The Guye iron deposits, approximately 2 miles (3.2 km) northeast of Denny Mountain, were discovered in 1881 (Shedd, 1902, p. 7). The only production from the iron deposits in the Snoqualmie Pass area has been small tonnages mined for metallurgical testing.

The mineralized areas in the study area were prospected during the same upsurge of mining activity that resulted in the staking of claims in surrounding areas. The mineral deposits in the Van Epps Creek-Solomon Creek area (fig. 2) were discovered in the 1880's. Little significant work was done on the deposits until 1896 when existing properties were obtained by the Pickwick Mining and Development Co. Patents were granted October 31, 1904, on 18 lode claims covering much of the mineralized area. Sporadic exploration on the property continued until the 1950's. Production of 13 tons of ore is recorded (E. A. Magill and W. P. Puffett, written commun., 1955).

Arsenopyrite veins in the Sprite Lake area (fig. 2) were discovered in the mid-1880's. By 1896 a number of workings had been completed on both the Aurora group of claims and the American Eagle group of claims, and a small stamp mill had been erected near Tucquala Lake on the Cle Elum River to treat ores from the various properties (Hodges, 1897, p. 61-62). Later prospecting resulted in the discovery of deposits nearer to French Creek. Although there are numerous scattered workings, no production has been recorded from the Sprite Lake area.

The deposits near Gold Creek (fig. 2) were first prospected in 1890. The first claims were staked mainly in the higher elevations near the head of the drainage. By 1896 a number of exploration workings had been opened. In the same year the Esther and Louisa mine shipped 10 tons (9 tonnes) of sorted ore, valued at $100 per ton, to the Tacoma smelter (Hodges, 1897, p. 61).

The copper deposits in the Mineral Creek area (fig. 2) were prospected a few years later. Several workings were noted in 1899 when the area was mapped by the U.S. Geological Survey (Smith and Calkins, 1906, p. 14). Development work continued and a mill of 25-tons-per-day capacity (23 tonnes) was built in the area in 1920. Production from the district has been minor (Patty, 1921, p. 267-287).

The mineral deposits in the Clipper-Crawford Creek and Dutch Miller Gap-La Bohn Gap areas were discovered by prospectors in the late 1890's. The copper deposit on the Dutch Miller claim group was located in 1896, and by 1901 several small shipments of ore had been made (Landes and others, 1902, p. 86). Exploration activity by a succession of owners and lessees has continued to the present time, but little additional production has resulted. Copper-molybdenum deposits on the Clipper group of claims and the Pedro zone were discovered around the turn of the century and claims were located in 1902. A number of claims on the Clipper and Pedro mineralized zones were surveyed for patent in 1908 and some patents subsequently granted. Although minor copper ore production probably resulted from development of the major workings, none is recorded.

The Trout Lake area (fig. 2) was prospected in the late 1890's and by 1902 claims covered most of the area surrounding Trout Lake, Copper Lake, and Lake Malachite. A significant amount of exploration had been done by 1906 (McIntyre, 1907, p. 238-250). Six claims and a millsite were patented after 1918 but there has been no recorded production from any claims in the Trout Lake area.

Claims were located outside the main mineralized areas throughout the study area. Most are on altered, iron oxide-stained zones but some were located on quartz-rich zones or other outcrops. Dates of location range from the beginning of the century to recent years. Only a few have even minor development and no production has been recorded.

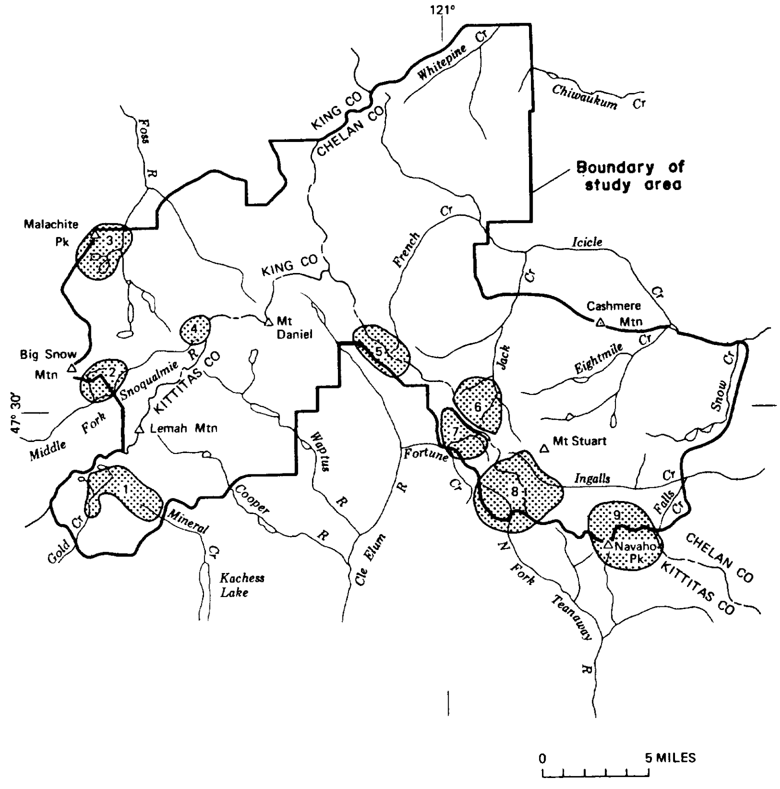


Figure 2.--Areas containing numerous prospects, Alpine Lakes area: 1, Gold Creek-Mineral Creek; 2, Clipper-Crawford Creek; 3, Trout Lake; 4, Dutch Miller Gap-La Bohn Gap; 5, Sprite Lake; 6, Van Epps Creek-Solomon Creek; 7, Fortune Creek; 8, Teanaway River-Ingalls Creek; 9, Navaho Peak.

Mineral commodities

The search for gold and silver brought prospectors to the study area. Some small deposits were found. Discovery of iron deposits adjacent to the south boundary stimulated prospecting for iron inside the study area but none was found. Prospecting for copper, the most significant mineral commodity within the study area, continues to the present time. National and world data for the following section on economic considerations are from the U.S. Bureau of Mines (1973); and Engineering and Mining Journal (1973).

Copper

Copper consumed in the United States exceeds production from mines and secondary sources. Copper in various forms is imported to meet consumer needs. About one-eighth of a year's supply at the 1972 rate of consumption (258,700 short tons) was in the General Services Administration stockpile at the end of 1972. Most copper is used as refined metal for electrical applications; some is used in alloys. Barring technological changes, demand is expected to increase at an annual rate of about 4 percent. Price of copper was 59 cents a pound in April 1973. Large disseminated deposits as low as 0.6 percent copper are now being mined by surface methods.

Two areas (Dutch Miller mine and Clipper-Crawford Creek area) containing potential copper resources are along the west side of the study area within or near the east edge of the granitic rocks of the Snoqualmie batholith. The Gold Creek drainage, Mineral Creek drainage, and Van Epps Creek-Solomon Creek area have a potential for discovery of copper resources.

Estimates based upon incomplete data (B. Thomas, written commun., 1907) indicate that over 800,000 pounds of copper is contained in approximately 3,500 tons of high-grade copper ore on the dumps and in limited underground workings at the Dutch Miller mine. Small shipments were made during early exploration and development work.

The Clipper-Crawford Creek area is on the northwest side of the Middle Fork Snoqualmie River in and adjacent to the study area. Copper-rich rock occurs in a series of brecciated or shattered areas in a wide zone. One of the breccias (the Clipper breccia) is near the study area and has been explored by core drilling and adits. A. R. Grant (written commun., 1971) estimated that the zone may contain 250,000 tons of mineralized rock containing 0.9 percent copper and significant molybdenum values. Geologic conditions suggest that an additional 5 million tons of rock of the same grade may be present in the Clipper zone.

The Three Brothers mineralized zone is also in the Clipper-Crawford Creek area and within the study area. The intensity of the brecciation and mineralization (some more intense than observed in the Clipper workings) suggests that the copper content in this area is of grade similar to that in the Clipper area. The Three Brothers zone could contain between 0.8 and 2 million tons of copper-bearing rock averaging between 0.7 and 0.9 percent copper.

Exploratory work, including core drilling by a major copper mining company and recent geologic mapping by A. R. Grant (written commun., 1971) indicates that the granitic rocks exposed at lower elevations in the Gold Creek basin have an environment favorable for discovery of porphyry copper resources. More than 1.5 square miles of the surface exposure of the granitic stock exhibits copper-bearing rock.

The Mineral Creek drainage, adjacent to Gold Creek (fig. 2) has been explored for copper since late in the last century. A small production has come from mines outside the study area. The main mineralized area lies outside the study area but the geology is similar in the study area and it probably contains similar mineral deposits.

Sporadic exploration and mining in the Van Epps Creek-Solomon Creek area (fig. 2) since aound 1890 has outlined an area with potential for discovery of low-grade copper resources. Some copper ore was shipped from an enriched shear zone in the peridotite country rock, but no additional minable material has been found by subsequent exploration. The area probably will continue to attract prospectors.

Samples from other prospects widely distributed throughout the study area contained copper but the size of the deposits at each location precludes their consideration as potential copper resources.

Gold

Domestic gold mine production in 1972 was about one-fifth of consumption (7.5 million troy ounces, or 233.25 million grams). Most U.S. gold imports come from Canada. Jewelry manufacturers are the principal gold consumers. Gold price averaged \$84.62 per ounce (\$2.71/g) during April 1973. Gold could be produced as a byproduct or coproduct from lode deposits in the study area.

Gold occurs in minor amounts in most of the mineralized areas within the study area, but only in the Sprite Lake area are the values significant. The workings examined are too limited in extent to allow the calculation of an ore reserve, but samples suggest that parts of the Sprite Lake area have a limited potential as a small-scale gold producer. There are no significant gold placer deposits in the study area.

Silver

Domestic silver consumption (137.1 million troy ounces) in 1972 was about four times domestic mine production. Most imported silver is from Canada. Sufficient silver to supply 1 year's demand is in the General Services Administration stockpile. Primary uses of silver are for photographic materials, electrical equipment, and silverware. About two-thirds of the supply is a byproduct of base-metal mining. Price of silver averaged \$2.31 per ounce during April 1973. The silver in the study area is mostly associated with base metals.

Silver in significant amounts was detected in samples from the main mineralized areas in the study area but in none of them is the value great enough to allow the mining of the rock for the silver alone. In some localities the silver would contribute substantially to the total value of the ore. Samples show that the most consistent silver values are in the arsenopyrite veins in the Sprite Lake area. Samples from the Transit claim, Giant claim, Silver King and Silver Queen claims, all in the Gold Creek area, contained as much as 22.40 ounces silver per ton (766 g per tonne). The deposits are not minable because of the small size and discontinuity of the veins. Samples from the Dutch Miller mine contain from 2.0 to over 10.0 ounces silver per ton (60-340 g per tonne). Copper would be the primary metal produced but silver could be a significant added value.

Mining claims

The location of patented and unpatented mining claims in and adjacent to the study area was determined by a search of the records of Chelan, King, and Kittitas Counties and records of the U.S. Forest Service. Published reports by various Washington State agencies provided the location of some old workings. Many claims recorded could not be found in the field because their location was poorly described. More than 435 unpatented lode and placer claims within and adjacent to the study area were recorded in county records but only a small percentage of these are currently held. The majority of unpatented claims are in the mineralized areas outlined on figure 2; the remainder are scattered throughout the study area. Some claimed areas exhibited no evidence of economic mineral deposition.

Approximately 60 patented claims are within or immediately adjacent to the study area. Nearly all were patented in the period 1902-1912. The largest group of patented claims (18 claims) is mostly in the Van Epps basin but extends into the Fortune Creek drainage. Fifteen patented claims cover most of the workings in the Sprite Lake area and a similar size group is contiguous to the study area in the Clipper-Crawford Creek area (fig. 2). The remaining patented claims are in the Dutch Miller Gap-La Bohn Gap area, the Teanaway River-Ingalls Creek area, and the Trout Lake area.

There are no Federal oil and gas leases in or near the study area and resources of leasable minerals that occur in the study area are more accessible elsewhere at localities closer to markets.

Gold Creek-Mineral Creek area

The rocks, structural relationships, and mineral deposits of the Gold Creek-Mineral Creek area (fig. 2) have been described by Smith and Calkins (1906), Hammond (1961), Stout (1964), Erikson (1969), and A. R. Grant (written commun., 1971).

Granitic rocks of the Snoqualmie batholith intruded volcanic and sedimentary rocks in the Gold Creek area. A. R. Grant (written commun., 1971) reported strong northwest-trending shear zones in the Gold Creek area and complimentary northeast-trending en echelon shears and sheet joints. Some shear zones contain quartz, pyrite, chalcopyrite, pyrrhotite, tetrahedrite, galena, sphalerite, and silver minerals. Extensive hydrothermally altered areas, especially in granodiorite, contain disseminated quartz, pyrite, pyrrhotite, chalcopyrite, molybdenite, and mica minerals. Phelps Dodge Co. (written commun., 1972) has drilled five holes totaling 3,171 feet (966 m) in Gold Creek basin (fig. 3). Two holes contained 300-foot (91 m) intervals that assayed 0.11 and 0.12 percent copper. In the summer of 1973 geologic mapping was done by Grant, who reported that additional work was scheduled for 1974.

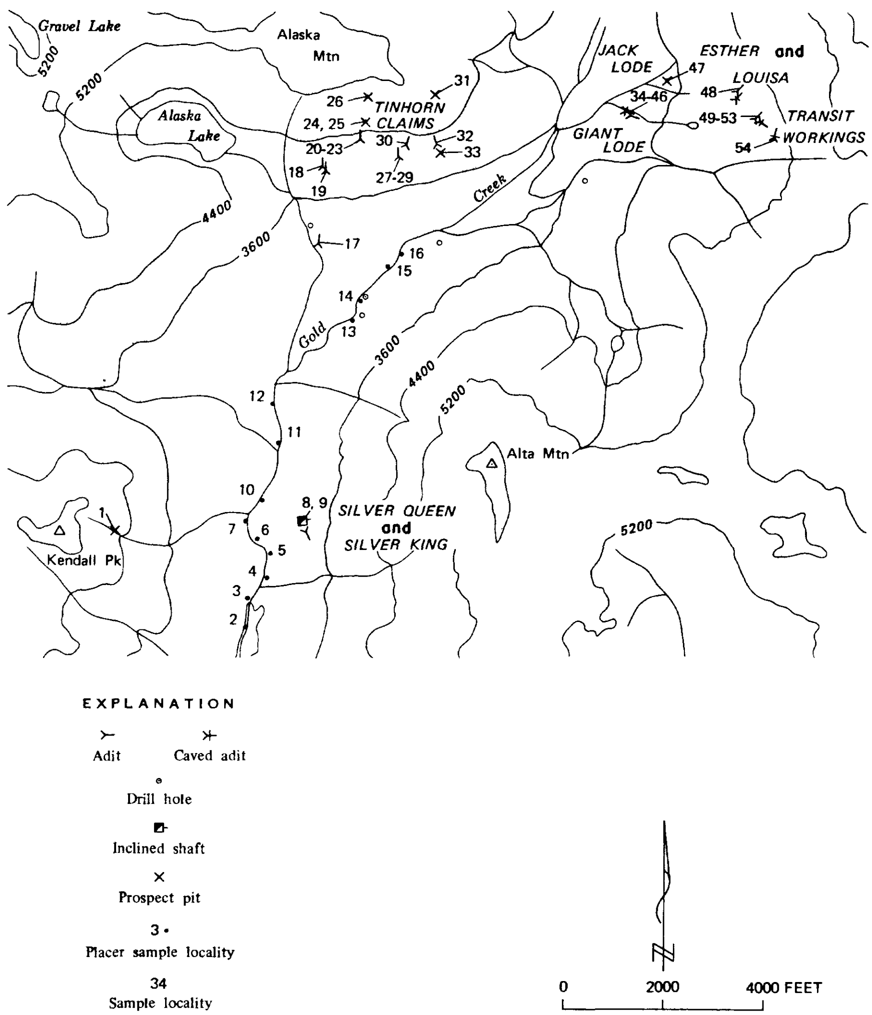


Figure 3.--Prospects in the Gold Creek area.

Data for samples shown on figure 3

[Tr, trace; N, none detected; --, not analyzed; < less than shown; NA, not applicable]

Sample			Gold				
No.	Type	Length (feet)	(cents per cubic yard) 1/	(ounces per ton)	Silver (ounces per ton)	Copper (percent)	Lead (percent)
1	Chip	3.0	--	Tr	0.1	0.018	0.01
2	Channel	2.0	1.0		--	--	--
3	do	1.8	1.0		--	--	--
4	do	2.0	4.0		--	--	--
5	do	2.1	3.0		--	--	--
6	do	2.5	0.5		--	--	--
7	do	2.0	23.0		--	--	--
8	Grab	NA	--	0.07	22.4	.063	.62
9	Select grab	NA	--	.08	2.6	<.006	.22
10	Channel	2.5	Tr		--	--	--
11	do	3.5	.5		--	--	--
12	do	1.5	.5		--	--	--
13	do	2.0	.5		--	--	--
14	do	2.0	Tr		--	--	--
15	do	1.5	2.0		--	--	--
16	do	1.5	.5		--	--	--
17	Select grab	NA	--	N	N	--	--
18	Chip	30.0	--	N	.3	.33	.004
19	Select grab	NA	--	N	.8	.39	.01
20	Grab	NA	--	N	Tr	--	--
21	do	NA	--	N	.1	--	--
22	Chip	1.2	--	N	1.9	--	--
23	Grab	--	--	N	Tr	--	--
24	Chip	2.6	--	N	.1	--	--
25	do	2.0	--	N	.6	--	--
26	do	7.0	--	N	3.6	.03	.25
27	Grab	NA	--	N	11.1	7.7	.008
28	Chip	1.1	--	N	.2	.13	.007
29	do	1.1	--	N	.2	--	--
30	do	1.5	--	.02	4.5	1.3	--
31	Grab	NA	--	N	.01	.04	--
32	Select grab	NA	--	.01	1.2	1.9	--
33	Chip	3.5	--	N	N	.02	.02
34	Select grab	NA	--	.08	6.2	.31	2.1
35	Grab	NA	--	.08	12.4	--	--
36	do	NA	--	.20	8.04	--	--
37	do	NA	--	.20	1.04	--	--
38	Random chip	NA	--	N	N	.03	--
39	Chip	.5	--	.14	14.96	--	
40	Random chip	1.0	--	N	8.9	--	--
41	do	100.0	--	N	1.2	--	--
42	Chip	.7	--	N	.14	.04	N
43	Random chip	1.5	--	N	.3	.08	.16
44	Chip	1.-	--	.08	1.46	--	--
45	do	2.0	--	.12	2.34	--	--
46	do	1.0	--	.02	2.14	--	--
47	Random chip	3.0	--	N	.1	--	--
48	Chip	3.2	--	N	.2	--	--
49	do	2.2	--	N	3.2	.13	.58
50	do	.9	--	N	.3	--	--
51	do	2.6	--	N	Tr	--	--
52	Chip	.8	--	N	.4	.23	--
53	do	.5	--	.08	10.70	.56	--
54	do	1.9	--	.05	2.90	.52	--

1/ Calculated using a gold price of $84.62 per ounce.

In the Gold Creek drainage, numerous short adits and pits on the south face of Alaska Mountain have been driven along mineralized shear zones (fig. 3). The steeply dipping shear zones on the Tinhorn claims strike approximately N. 30° E., subparallel to a possible major fault along Gold Creek (Foster, 1960; Hammond, 1963). A dump of an adit (sample 17, fig. 3) is nearly on line with the shear zones at the Tinhorn Nos. 3 and 4 workings. They have a difference in elevation of about 1,000 feet (305 m) and are one-half mile (800 m) apart. The intervening distance is covered by talus and brush but it is probable that the workings are on the same structure. Linear features on aerial photographs suggest that the strongest zone at the Tinhorn workings extends at least to the ridge of Alaska Mountain (fig. 3).

Lode samples from a few prospects in Gold Creek basin contain values that represent small potential resources of copper and silver.

Most prospecting in the Mineral Creek drainage has been along the lower 2 miles (3 km) of the drainage, outside the study area boundary. An early U.S. Geological Survey map shows five adits and seven buildings along Mineral Creek (Smith and Calkins, 1906). Investigators reported active prospecting and exploration work by large companies during the early and mid-1960's.

An intrusive, believed to be related to the Snoqualmie granodiorite and termed the Mineral Creek stock (A. R. Grant, written commun., 1971), intrudes volcanic flows, tuffs, andesite, rhyolite, and basalt in the Mineral Creek area. Pyrite is abundant in many of the rocks. The Durrwachter workings, outside the study area, expose a 20- to 40-foot-wide (6-12 m) breccia zone in the Mineral Creek stock and a 500-foot-wide (150 m) breccia zone along the contact between basalt and rhyolite. Pyrite, chalcopyrite, bornite, chalcocite, and covellite are the dominant sulfides; pyrrhotite and molybdenite are accessory sulfides. The property reportedly produced 20 tons (18 tonnes) of 6-percent copper ore before 1920.

In 1922, the Mineral Creek Copper Co., also outside the study area, produced about 125 dry tons (113 tonnes) of ore containing 25 ounces (777.5 g) silver and 3,582 pounds (1.63 tonnes) copper (U.S. Bureau of Mines production records). Mineral exploration will probably continue in the Mineral Creek area both within and outside the present study area.

Tinhorn Nos. 3 and 4 claims

The Tinhorn Nos. 3 and 4 workings are at about 4,300 feet (1,310 m) altitude and are the major workings open on Alaska Mountain (samples 20-26, fig. 3). The country rock in the area of the portal (fig. 4) is altered granodiorite with less than 5 percent sulfide minerals disseminated through the rock and concentrated along fractures. The workings were driven along two intensely altered, wet, gouge zones. The adit first was driven along a 1- to 3-foot-thick (30-90 cm) shear zone composed of 0.5- to 2.0-foot-thick (15-60 cm) lenses of granitic wallrock with 5- to 25-percent gouge. The shear zone strikes approximately N. 23° E. and dips from 40° NW. to vertical. Grab samples from the zone contained no gold and 0.1 ounce or less silver per ton (3.4 g per tonne).

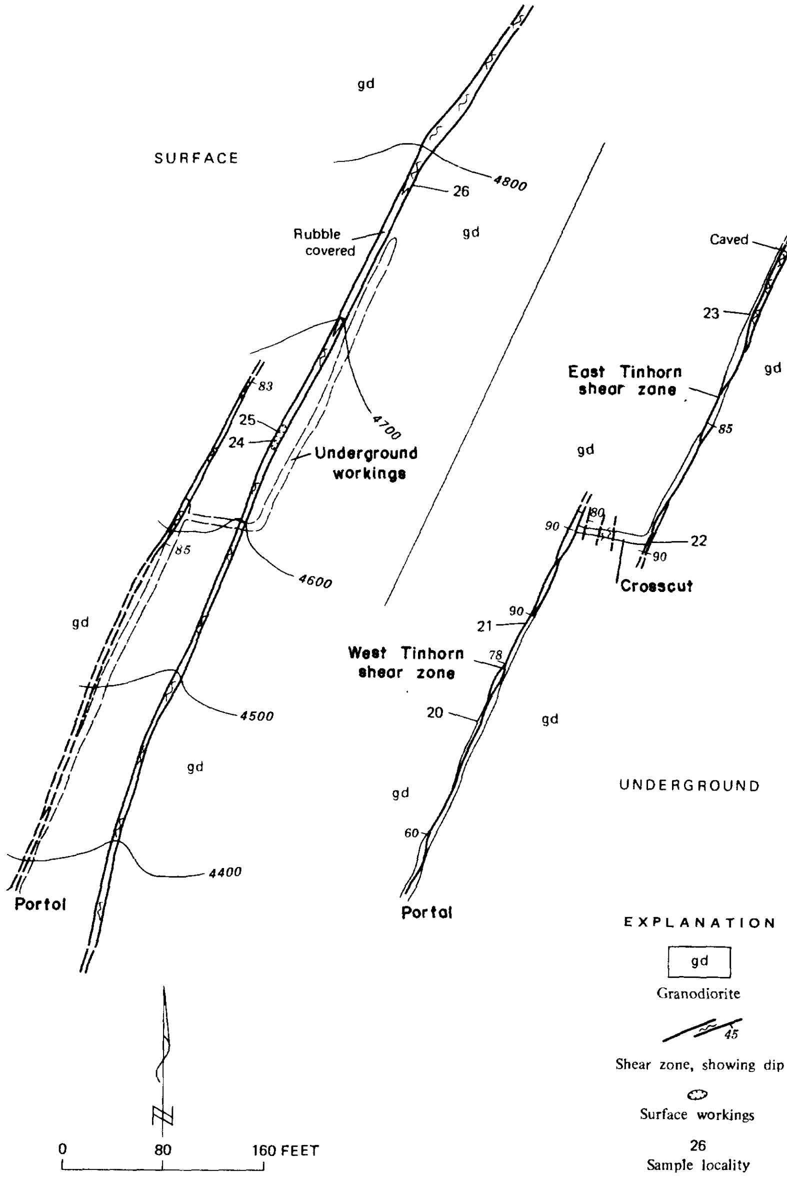


Figure 4.--Tinhorn Nos. 3 and 4 claims.

Data for samples shown on figure 4

[NA, not applicable; N, none detected; Tr, trace; --, not analyzed]

Sample No.	Sample Type	Length (feet)	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)	Lead (percent)
20	Grab	NA	N	Tr	--	--
21	do	NA	N	0.1	--	--
22	Chip	1.2	N	1.9	--	--
23	Grab	NA	N	Tr	--	--
24	Chip	2.6	N	.1	--	--
25	do	2.0	N	.6	--	--
26	do	7.0	N	3.6	.03	.25

About 320 feet (97 m) from the portal a crosscut was driven eastward to a second shear zone which strikes N. 24° E. and dips nearly vertical. The zone is 0.5-2.0 feet (15-60 cm) thick and contains 5-10 percent sulfide-enriched stringers averaging 0.08 foot (24 mm) thick. The zone contains quartz lenses that average 0.5 foot in thickness (15 cm), but is mostly fragments of wallrock. On the shear zone a pit 2.4 feet wide (73 cm) (sample 24, fig. 4) has been dug about 280 feet (85 m) vertically above the main adit. A second pit (sample 26, fig. 4) about 400 feet (122 m) vertically above the main adit exposes the zone which is about 6 feet (1.8 m) wide and nearly vertical. The best sample from the zone contained 3.6 ounces silver per ton (123 g per tonne), 0.03 percent copper, and 0.25 percent lead.

The workings in the two shear zones expose only highly oxidized, weathered sections of the veins which contain only low-grade material. No potential resource exists above the workings. The persistence of the veins, the oxidized, weathered surface material, and the low assay values indicate a possible zone of secondary enrichment at lower levels in the shear zones and a possible zone of unaltered sulfides at greater depths.

East Tinhorn zone

Two adits are driven on another smaller shear zone (samples 27-30, fig. 3) about 900 feet east from the zones on Tinhorn Nos. 3 and 4 claims. The lower adit (samples 27-29, fig. 3) was driven for a total distance of 330 feet on a zone consisting of two closely spaced, roughly parallel faults which diverge near the face. Where observed in the adit and on the surface near the portal the zones are tight. A random grab sample from a stockpile near the portal assayed 11.1 ounces silver per ton, no gold, 7.7 percent copper, and 0.008 percent lead. It is not evident where the ore came from in the workings. Two chip samples taken across the zone assayed no gold and at best 0.2 ounce silver.

The upper adit, probably along the same shear zone (sample 30, fig. 3) was driven for 20 feet (6 m) on a bearing of N. 20° E. The country rock is jointed to slightly brecciated granodiorite. In the adit the shear zone is 0.5-1.5 feet (15-46 cm) wide and is composed of 50 percent intensely fractured country rock, 30 percent quartz, and about 20 percent sulfides. Of the sulfides, about 75 percent is pyrite, 20 percent chalcopyrite, and 5 percent tetrahedrite. The granodiorite between shears intersecting the main shear zone near the portal is iron oxide-stained and contains about 5 percent small, irregular masses and stringers of sulfides. A sample (No. 30, fig. 3) taken across the main shear zone at the portal contained 0.02 ounce (0.7 g per tonne) gold and 4.5 ounces (154 g per tonne) silver per ton, and 1.3 percent copper.

Giant and Jack lodes

The Giant and Jack lode patented claims are east of Gold Creek. The lower Giant adit portal is caved, but a map of the workings (fig. 5) was obtained from E. A. Magill (written commun., 1971).

The Giant workings are in granitic rock near the contact with volcanic rocks. Disseminated pyrite, chalcopyrite, and galena (less than 5 percent) occur in the granitic rock. The sulfides, however, are concentrated in north-striking, steeply dipping shear zones.

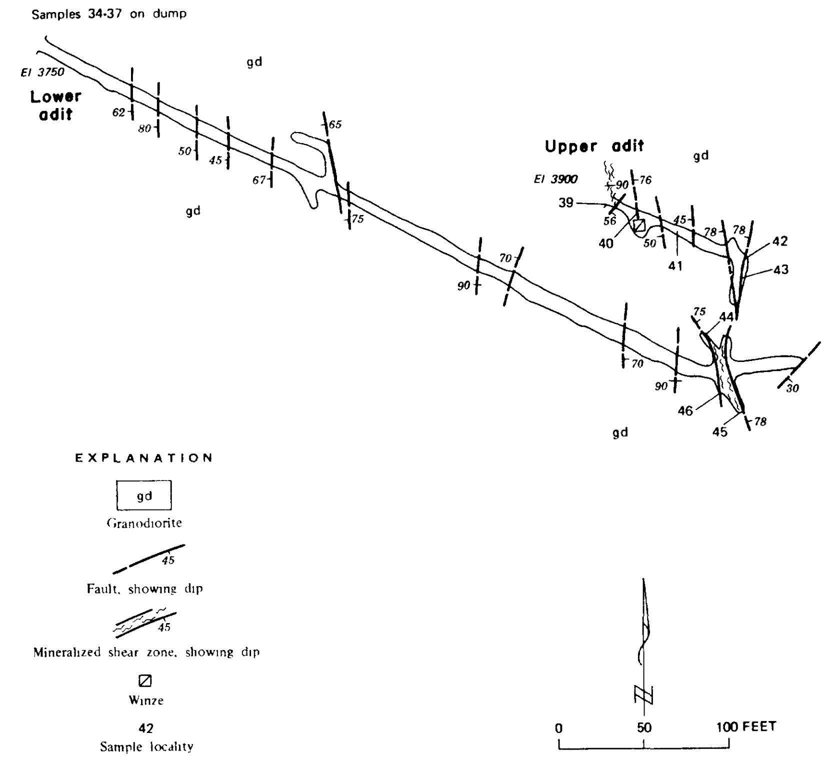


Figure 5.--Underground workings, Giant lode claim. Modified from E. A. Magill (written commun., 1971).

Data for samples shown on figure 5

[NA, not applicable; N, none detected; --, not analyzed]

Sample No.	Sample Type	Length (feet)	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)	Lead (percent)
34	Select grab	NA	0.08	6.2	0.31	2.1
35	Grab	NA	.08	12.40	--	--
36	do	NA	.20	8.04	--	--
37	do	NA	.02	1.04	--	--
39	Chip	0.5	.14	14.96	--	--
40	do	1.0	N	8.9	--	--
41	do	100.0	N	1.2	--	0.1
42	do	0.7	--	.14	.04	--
43	do	1.5	N	.3	.08	.16
44	do	1.0	.08	1.46	--	--
45	do	2.0	.12	2.34	--	--
46	do	1.0	.02	2.14	--	--

The upper Giant adit was driven easterly in the granitic rock, and short drifts were driven north and south along minor shears. A flooded winze close to the portal is reported to be more than 32 feet (9.75 m) deep. The adit was begun in an iron oxide-stained, altered shear zone about 6 feet (1.8 m) wide. The winze was sunk on an intensely altered 0.5-foot-thick (15 cm) shear zone which strikes N. 8° W. and dips 76° NE. The shear zone consists of 10-25 percent pyrite and siliceous minerals. At about 27 feet (8.2 m) from the portal, the adit crosses an iron oxide-stained 0.5- to 1.0-foot-thick (15-30 cm) pyritic fault that strikes N. 15° W. and dips 50° SW. to vertical. The north, 8-foot-long (2.4 m) drift of the upper Giant workings is along a 0.1-foot-wide (3 cm) altered fault which strikes north and dips 82° SE. The south drift was driven on an 0.5- to 1.0-foot-wide (15-30 cm) fault that strikes N. 10° W. and dips 72° to 82° NW. The fault zone is composed mostly of quartz with 5-10 percent pyrite.

Selected samples (fig. 5) from the lower Giant dump contained highs of 12.40 ounces silver per ton, 0.20 ounce gold per ton, 0.3 percent copper, and 2.1 percent lead. Samples from the upper Giant workings contained maximums of 14.96 ounces silver per ton, 0.14 ounce gold per ton, 0.08 percent copper, and 0.16 percent lead. A random chip sample from granitic rock in the streambed containing disseminated sulfides assayed no gold or silver, and 0.03 percent copper. The extent of the disseminated sulfides in the granitic rock on the surface could not be seen because of overburden.

The Jack lode workings are about 1,000 feet northeast of the upper Giant adit. The Jack workings are on the north and south sides of a small creek which cuts gray granitic rock. A 3-foot-long pit undercutting the north bank and a caved adit about 30 feet away on the south bank are in a 4-foot-wide shear zone. The zone is nearly vertical and strikes about N. 27° E. The zone is about 90 percent granitic fragments, 5 percent gouge, and 5 percent pyrite.

Transit workings

The main workings on the patented Transit claim (fig. 3) are on the east side of upper Gold Creek valley. The crosscut adit (fig. 6) on the north side of a steep-sided gulch was driven through mineralized faults that bound a fractured zone in blocky andesite. A drift was turned from the adit N. 48° E. along the zone. The faults converge at a point about 58 feet (18 m) from the intersection of the adit and drift, and a winze of undetermined depth was sunk on the dip 14 feet (4 m) from the face of the drift.

The northernmost of the two faults consists of a 0.5-foot-wide (15 m) zone of gouge and a 0.5-foot-wide (15 cm) vein of pyrite-rich quartz. The southernmost fault is narrower and consists of gouge but no quartz stringers. The intervening andesite is dark, fine grained, intensely fractured, and stained with iron oxides.

No minable ore was found on the Transit claim. One 0.5-foot-wide sample (No. 53, fig. 6) from across a mineralized fault contained 10.70 ounces silver per ton (366 g per tonne), 0.08 ounce gold per ton (2.7 g per tonne), and 0.56 percent copper.

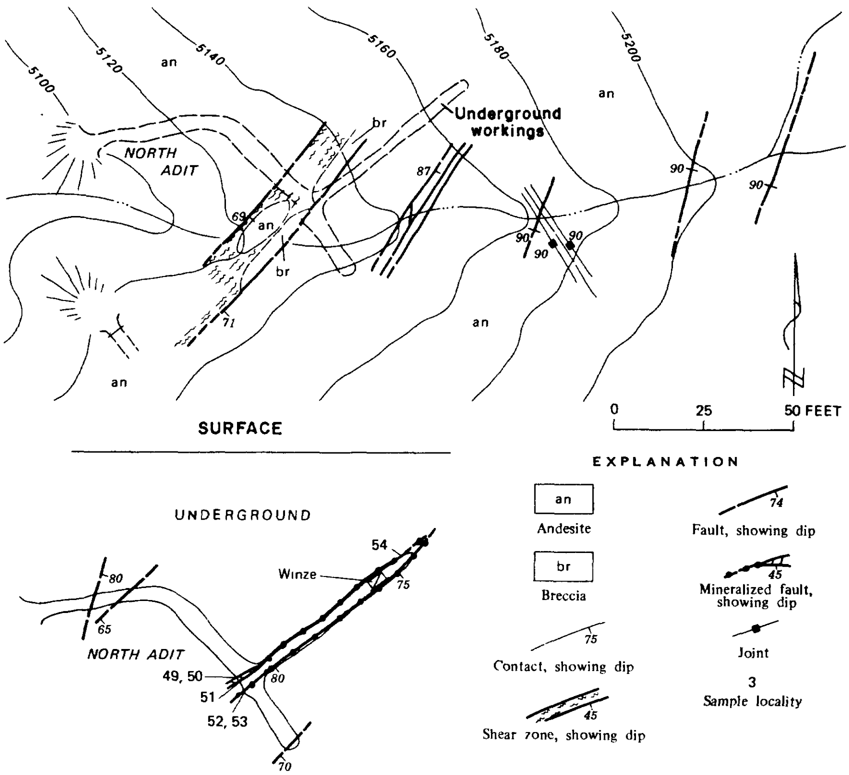


Figure 6.--Transit workings.

Data for samples shown on figure 6

[Tr, trace; N, none detected]

Sample No.	Sample Type	Length (feet)	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)
49	Chip	1.0	0.04	2.86	0.37
50	do	2.2	N	3.20	.30
51	do	2.6	N	Tr	.04
52	do	.8	N	.40	.23
53	do	.5	.08	10.70	.56

Silver King and Silver Queen claims

The Silver King and Silver Queen patented claims (fig. 3) are east of Gold Creek and on the west side of Alta Mountain. The intersection of a fault and an irregular quartz-filled fracture in massive andesite occurs on the property (fig. 12). The fault strikes N. 60° E., dips 46° NW. and is evidenced by a straight, very steep gully. The quartz-filled fracture crops out at the portal of an inaccessible adit south of the gully and near a caved inclined shaft north of the gully. North of the shaft the fracture splits and appears to pinch out. The vein was traced a few hundred feet south.

A random grab sample (No. 8, fig. 7) from a stockpile on a lower dump appeared to be from the inclined shaft. The sample contained 0.07 ounce gold per ton, 22.4 ounces silver per ton, and 0.063 percent copper. A second random grab sample (No. 9) of a stockpile near the shaft collar contained much less.

The intersection of the fault and the vein on the surface is covered by debris. The moderate dip of the two structures indicates an intersection having a relatively flat rake to the northeast that may have localized the emplacement of sulfides. The inclined shaft would penetrate this zone a few tens of feet from the collar.

Miscellaneous prospects

Other lode and placer prospects in the Gold Creek area have no potential or are not well exposed (table 1). Placer samples from carefully selected sites along Gold Creek contained only very minor amounts of gold.

Clipper-Crawford Creek area

The northeast end of a 4 1/2-mile-long, copper-rich zone extends into the study area along the north side of the Middle Fork of the Snoqualmie River (area 2, fig. 2). The section of the zone inside the study area lies between Katie Belle Gulch and Crawford Creek (fig. 8) and includes the Three Brothers, the Red Face, the Hawk, the Alps (not shown), and the Crawford Creek zones.

The Clipper zone workings are on patented claims near the study area and was the site of significant underground exploratory work done by the Snoqualmie Copper Co. between 1908 and 1912. Various lessees explored the zone by geophysical methods and by diamond core drilling intermittently between 1963 and 1969 (A. R. Grant, written commun., 1971). On the basis of results of sampling of the underground workings and assays of the samples from drilling, Grant (written commun., 1971) has estimated an inferred resource of 250,000 tons of mineralized rock containing an average of 0.85 percent copper in a relatively small area. Significant molybdenum values exist in parts of the zone. The zone on the whole has not been adequately explored to project additional resources.

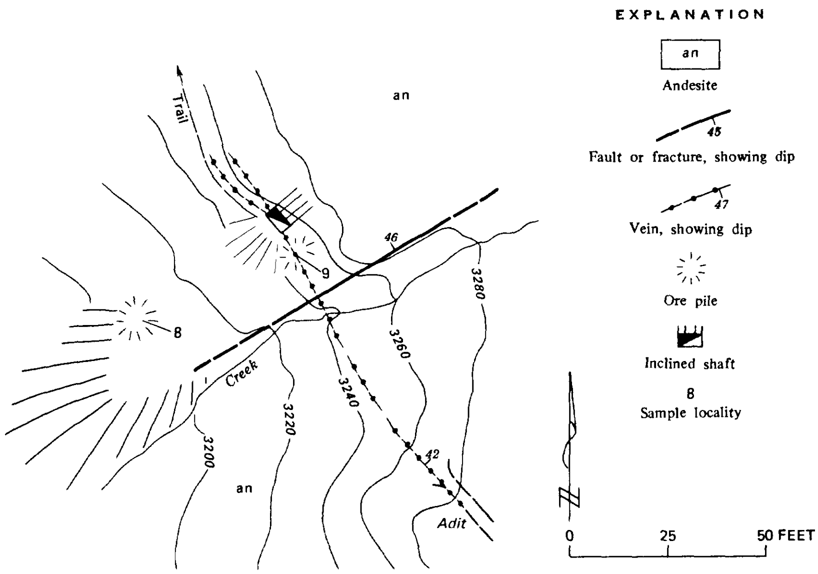


Figure 7.--Silver King and Silver Queen claims.

TABLE 1. - Miscellaneous prospects in the Gold Creek-Mineral Creek area

Map No. (fig. 3)	Prospect name	Summary	Sample data
1	Kendall Peak	Iron-oxide-stained shear zone 0.5 to 3.0 feet thick in altered volcanic rock.	Random chip sample; trace gold, 0.1 ounce silver per ton, 0.02 percent copper.
2-16	Placer locations	Panned samples from bedrock exposures and favorable gravel deposits in and near Gold Creek.	Thirteen samples tested for recoverable gold. One sample, 18 cents per cubic yard. Others less than 1 cent to 5 cents per cubic yard.
17	Granite King	Caved adit, estimated 500 feet long, in porphyritic granodiorite.	Random grab sample from dump; no gold, no silver.
18-19	Tinhorn Nos. 1 and 2	Eighteen and 34-foot adits in granodiorite. Some silicified, pyritized and micaceous country rock.	One chip sample and one grab sample. Maximum 0.8 ounce silver per ton, 0.39 percent copper. No gold in either sample.
31	Ridge breccia	Pyritized breccia zone in granodiorite.	One sample; no gold, 0.01 ounce silver per ton, 0.05 percent copper.
32	Adit	Brecciated granodiorite containing less than 1 percent disseminated pyrite. One 11-foot long adit.	One sample; 0.01 ounce gold per ton, 1.2 ounces silver per ton, and 1.9 percent copper.
33	Pit	A pit in 4-foot wide pyritized shear zone in silicified breccia.	One chip sample; no gold or silver, 0.02 percent copper.
48	Esther and Louisa	Open adit 200 feet long and one caved adit in andesite porphyry. Pyrite in fractures and disseminated in porphyry.	One sample; no gold, 0.2 ounce silver per ton.
	Park Lakes trail	A 9-foot-long adit at trail crossing from lower Park Lake is in metavolcanic breccia.	One 56-foot-long chip sample; trace gold, 0.2 ounce silver per ton, 0.06 percent copper, 0.01 percent lead.

The Pedro and Katie Belle zones are a few thousand feet outside the study area (fig. 8). A. R. Grant (written commun., 1971) described the Pedro zone as an elliptical breccia pipe about 300 feet (120 m) wide and 600 feet (240 m) long with a highly mineralized central zone. The breccia contains 5-10 percent sulfides, mostly pyrite, and at least 10 percent quartz. Less than 20 percent of the sulfides is chalcopyrite with minor amounts of sphalerite, galena, and rare molybdenite.

The Katie Belle zone is considered by Grant (written commun., 1971) to be a stockwork (fig. 8). There are no underground workings, but two drill holes were completed in the zone in 1963 and 1965. Steep dipping, north-trending shears cut the center of the zone. Sulfides appear to be localized along the shear zones. Grant suggested that the strike length of individual mineralized zones may be as long as 1,200 feet (365 m) but widths are not determined. In some zones, 5 percent of the rock consists of sulfides; about 20 percent of the sulfides is chalcopyrite. Grant noted that "relatively massive molybdenite lenses occur in tensional fractures adjacent to the north-trending Katie Belle fault." Samples (Nos. 12 and 13, fig. 8) from the Katie Belle zone contained highs of 0.01 ounce gold per ton (0.3 g per tonne), 0.2 ounce silver per ton (7 g per tonne), and 0.39 percent copper.

Because of intense localized copper enrichment of the brecciated and altered zones and the pervasive nature and volume of the mineralized rock, the Clipper-Crawford Creek area contains a potential mineral resource. The area will likely be the site of additional exploration activity in the future. The Three Brothers and possibly the Red Face zones have potential resources of copper. The Hawk, Crawford Creek, and Alps zones are breccia or shatter zones apparently too low in grade to be a resource. Potential resources in the Three Brothers zone cannot be reliably estimated but exploration data obtained from present lessees indicate that resources are between 0.8 and 2 million tons averaging between 0.7 and 0.9 percent copper.

Three Brothers zone

The Three Brothers zone is mineralized granodiorite and quartz monzonite lying between two steeply dipping faults (fig. 8). It is bounded on the east by a mass of quartz diorite porphyry and is covered by talus to the west. The faults strike N. 75° W. and N. 80° E. in contrast to the major faults mapped in the Pedro and Katie Belle zones (fig. 8). The zone has been explored by a drill hole (drilled in 1963), a short adit, and three shallow pits.

The brecciated and altered quartz monzonite in a shallow surface cut (No. 16, fig. 8) contains stringers of vuggy quartz. Magnetite, hematite, and quartz crystals fill some of the vugs. Chalcopyrite occurs in the vugs and is disseminated near fractures and quartz veinlets. The shallow cut is probably near the south edge of the Three Brothers zone.

An adit (Nos. 17 and 18, fig. 8) was driven to crosscut three steeply dipping shear zones with parallel strikes of N. 5° W. The adit, driven through altered granodiorite with disseminated pyrite on a bearing of N. 83° W. for about 30 feet (9.1 m), ends in a 6-foot-deep (1.8 m) winze on the footwall of a 5-foot-wide shear zone. The shear zone is highly brecciated, with irregular walls and horses of altered granodiorite. Gouge material is common.

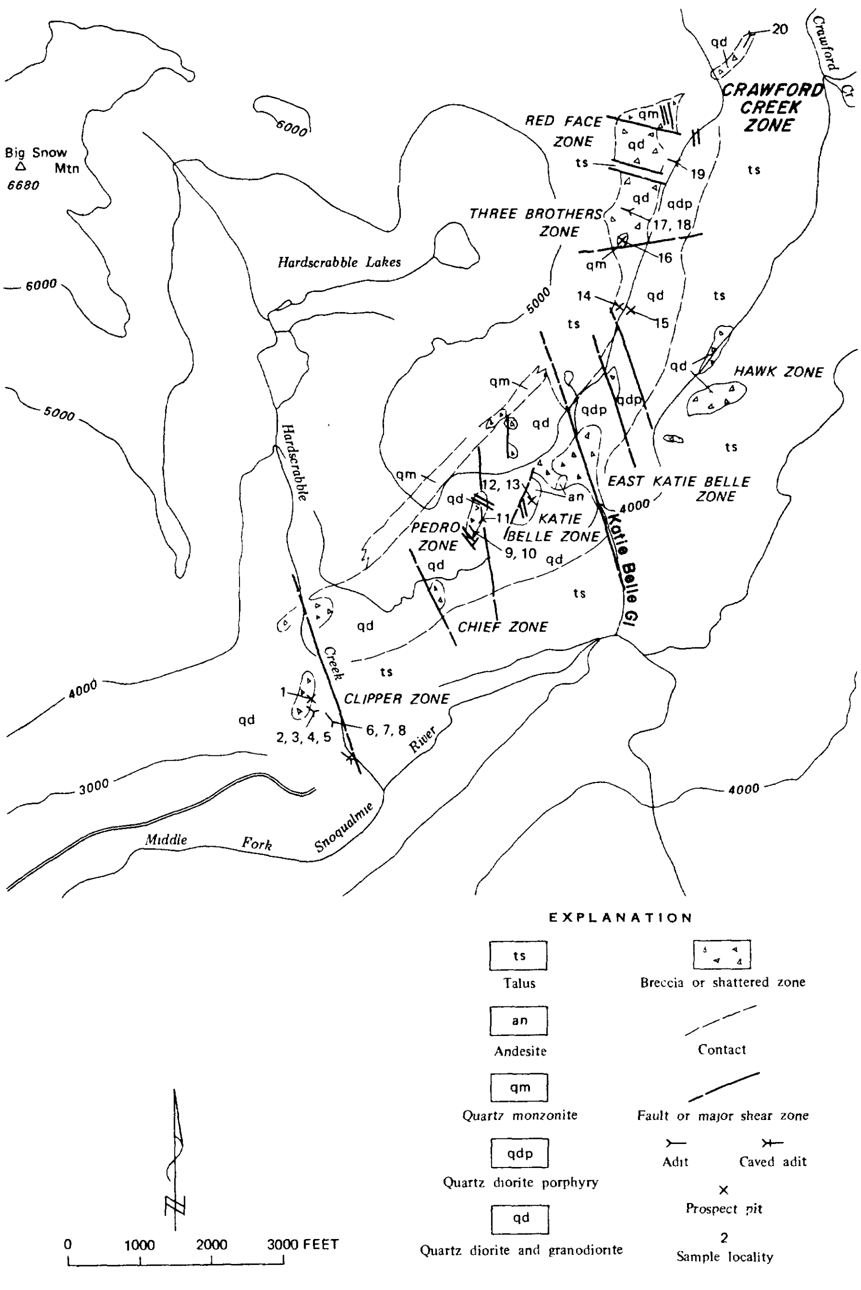


Figure 8.--Prospects in the Clipper-Crawford Creek area. Modified from A. R. Grant (written commun., 1971).

Data for samples shown on figure 8

[Tr, trace; N, none detected; --, not analyzed; NA, not applicable]

Sample		Length	Gold	Silver	Copper
No.	Type	(feet)	(ounces per ton)	(ounces per ton)	(percent)
1	Chip	8	Tr	0.1	0.24
2	do	54	Tr	.2	.37
3	Grab	NA	Tr	.2	.19
4	Chip	4.5	Tr	.1	.05
5	do	0.8	Tr	Tr	.04
6	do	8	Tr	.1	.36
7	Grab	NA	Tr	.6	.44
8	do	NA			.50
9	Chip	8	Tr	--	.02
10	do	60	Tr	--	.01
11	do	20	Tr	2.2	.86
12	do	550	0.01	.2	.06
13	do	17	Tr	.1	.39
14	Grab	NA	Tr	N	.02
15	Chip	5.5	Tr	N	.02
16	Grab	NA	--	--	.07
17	Chip	8.2	Tr	.5	.50
18	Grab	NA	Tr	.2	.40
19	Chip	4	Tr	N	.03
20	Grab	NA	Tr	.1	.03

Pyrite in blebs and fine disseminations occurs throughout the brecciated rock and the horses across the full width of the shear. The smaller shear zones, 2-3 feet wide (61-91 cm), are similar in character to the major zone. They can be traced for about 250 feet (71 m) on the surface.

Samples (Nos. 16-18, fig. 8) from the Three Brothers zone assayed a maximum of a trace gold, 0.5 ounce silver per ton (17 g per tonne), and 0.5 percent copper. Sparse data suggest the possibility of 0.8 to 2 million tons (1.81 million tonnes) containing between 0.7 and 0.9 percent copper.

Red Face zone

The Red Face zone is composed of pyrite-rich, closely jointed or brecciated granodiorite. Near the portal of an adit in the zone (No. 19, fig. 8) a flat-lying fracture with many blebs of pyrite, arsenopyrite, and marcasite was noted. A sample cut over a length of 4 feet (1.2 m) along a flat-lying fracture contained a trace of gold, no silver, and 0.03 percent copper.

North of the Red Face zone, a large zone 500 by 1,000 feet of leached rock with minor Cu_2S (secondary) exhibits a significant I. P. anomaly. In addition, soil samples with values greater than 1,000 ppm copper delineate the downslope geochemical reflection from the area. No drilling has been done here.

Trout Lake area

A group of patented lode mining claims, surveyed in 1918, covered most of the east slope of Malachite Peak and the area around Trout Lake (fig. 2). Other unpatented lode claims have, at various times, covered additional areas around Lake Malachite, Copper Lake, and the surrounding ridges. Granitic rocks of the Snoqualmie batholith have intruded metamorphic, volcanic, and sedimentary rocks near Trout Lake. The shear zones, which are mostly weakly mineralized at the surface, are extensive in the volcanic and sedimentary rocks but smaller and less abundant in the granitic rocks. Quartz and carbonates are the main vein materials in the zones. Weathering has removed metallic minerals from many surface exposures, but pyrite, chalcopyrite, arsenopyrite, galena, and sphalerite may be more plentiful at depth.

Figure 9 shows the locality of samples taken in the Trout Lake area. Table 2 summarizes the geologic conditions at the sample localities and tabulates the sample results.

No potential mineral resource is known in the Trout Lake area; however, a shear zone containing sulfides is partially exposed at the Copper Lake "A" workings and at other scattered locations in the area. Weathering probably has decreased the tenor of many of the surficial outcrops.

Dutch Miller Gap-La Bohn Gap area

The Dutch Miller mine and nearby prospects are near La Bohn Gap at the head of the Middle Fork of the Snoqualmie River (fig. 10). The mine and outlying prospects are in rugged cirques and on sharp ridges at elevations from 4,800 to 6,000 feet at the crest of the Cascade Range. The terrain is snow covered for a large part of the year.

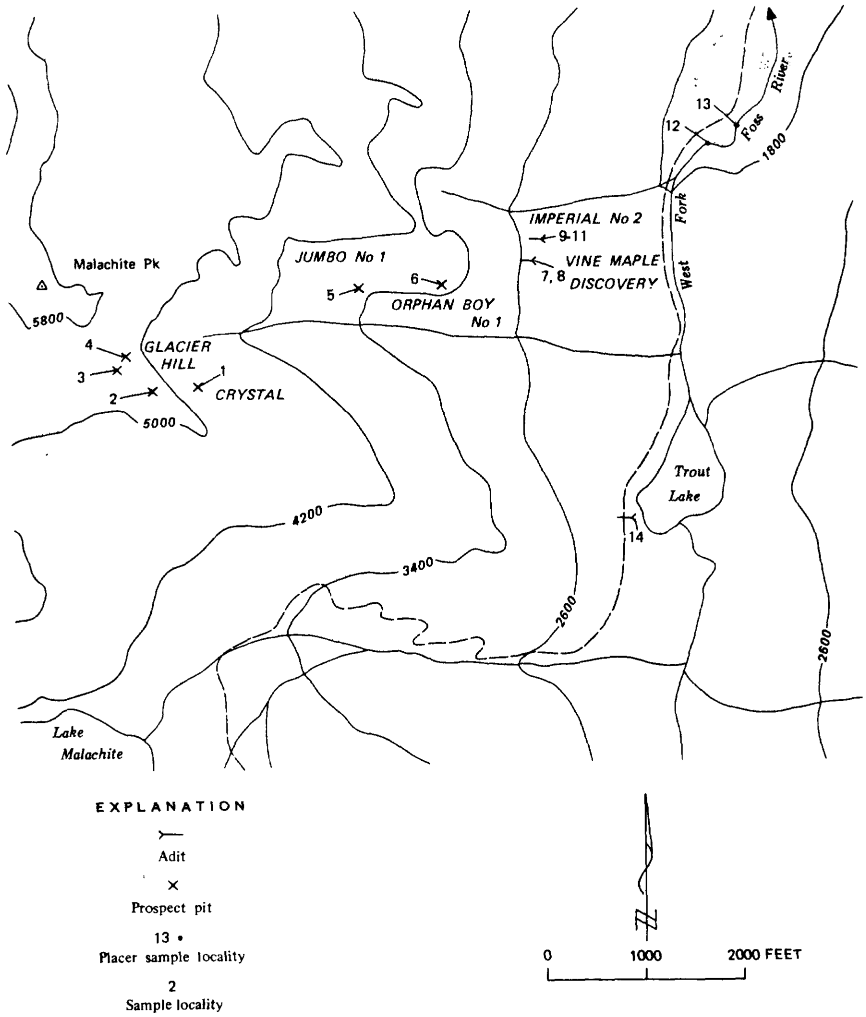


Figure 9.--Prospects in the Trout Lake area.

Data for samples shown on figure 9

[NA, not applicable; N, none detected; Tr, trace; --, not analyzed]

No.	Type	Length (feet)	Gold (cents per cubic yard) 1/	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)
1	Grab	NA		Tr	0.1	0.007
2	Random chip	30		Tr	Tr	.006
3	do	NA		Tr	.1	.008
4	do	4.0		Tr		.01
5	do	1.0		N	.3	--
6	do	3.0		Tr	.2	--
7	do	4.0		Tr	.1	.01
8	do	0.5		Tr	.2	.08
9	do	7.0		0.01	.1	.008
10	do	2.0		Tr	.2	.01
11	do	1.5		.01	Tr	.01
12	Placer channel	1.5	1			
13	do	1.5	N			
14	Random chip	.7		Tr	.2	--

1/ Calculated using a gold price of $84.65 per ounce.

TABLE 2. - Miscellaneous prospects in the Trout Lake area

Map No. (fig. 9)	Prospect name	Summary	Sample data
1-4	Glacier Hill and Crystal	Pits and outcrops on 1- to 50-foot-thick mineralized shear zones in metavolcanic and sedimentary rocks.	Four grab or chip samples. Maximum value; 0.01 percent copper, no gold, and 0.1 ounce silver per ton.
5	Jumbo No. 1	1- to 3-foot-thick mineralized shear zone in metavolcanic rock.	Chip sample across zone; no gold, 0.3 ounce silver per ton.
6	Orphan Boy No. 1	1- to 5-foot-wide mineralized shear zone in metavolcanic rock.	Chip sample across shear zone; trace gold, 0.2 ounce silver per ton.
7-8	Vine Maple Discovery	A 112-foot-long adit driven along a 4- to 5-foot-wide mineralized shear zone in metasedimentary and metavolcanic rocks.	Two chip samples, one from the face of adit, one from adit walls; no gold, maximum 0.2 ounce silver per ton, maximum 0.08 percent copper.
9-11	Imperial No. 2	A 772-foot-long adit in metavolcanic and metasedimentary rock with numerous mineralized crosscutting shear zones.	Samples from shear zones at 142, 390, and 570 feet from the portal. Maximum values; 0.1 ounce gold per ton, 0.2 ounce silver per ton, and 0.001 percent copper.
12	West Fork Placer No. 1	From fine gravel downstream from 10-foot-diameter boulder.	Value in recoverable gold: less than 1 cent per cubic yard.
13	West Fork Placer No. 2	Coarse, iron-oxide-stained, bouldery gravel.	No recoverable gold.
14	Southwest Trout Lake	A 456-foot-long adit in schist, gneiss, and granodiorite. Adit started on 0.05- to 0.7-foot-wide mineralized shear zone which terminated in a zone of crosscutting shears.	Chip sample across shear zone 20 feet from portal; trace gold, 0.2 ounce silver per ton.
----	Copper Lake "A"	One mile south of Lake Malachite on ridge west of Copper Lake. One caved pit and a caved adit in a 10-foot to 15-foot-wide tourmalinized shear zone in granodiorite.	One random grab and two select grab samples from dumps; trace gold, maximum 3.3 ounces silver per ton, maximum 5.85 percent copper, and maximum 0.76 percent lead.

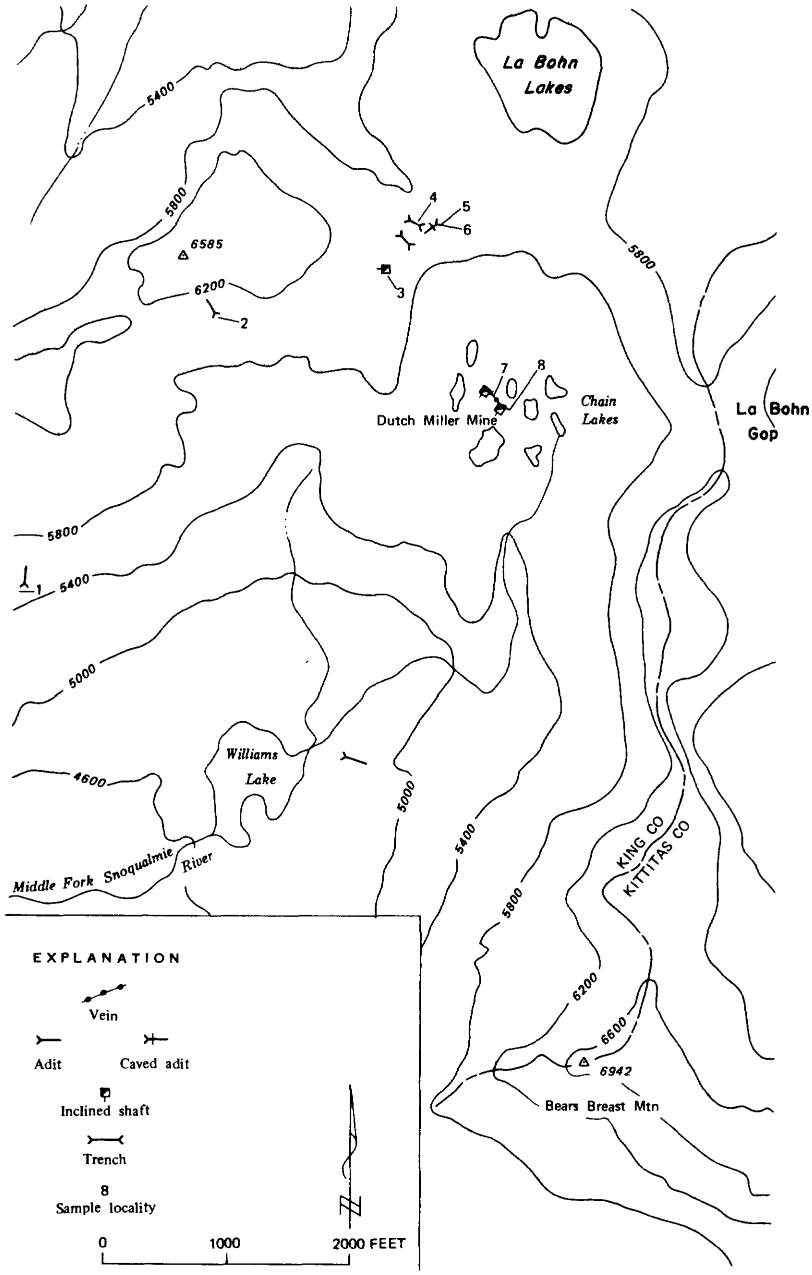


Figure 10.--Mines and prospects in the Dutch Miller Gap-La Bohn Gap area.

Data for samples shown on figure 10

[NA, not applicable; N, none detected; Tr, trace]

Sample No.	Sample Type	Sample Length (feet)	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)	Lead (percent)
1	Grab	NA	N	N	N	N
2	Chip	3.9	N	N	0.03	N
3	do	1.9	Tr	N	.02	N
4	Grab	NA	Tr	0.10	.007	N
5	Chip	5.5	Tr	.10	.01	N
6	do	1.5	Tr	.02	.03	N
7	do	12	0	.80	.30	0.6
8	Grab	NA	Tr	12.00	13.40	1.97

Sulfides occur in quartz-tourmaline veins in granodiorite in the area. The Dutch Miller mine is the only property believed to have potential mineral resources. The mine is estimated to have 3,500 tons of ore exposed in the workings and a good potential for discovery of additional ore.

Dutch Miller mine

The small, high-grade copper deposit, mainly of chalcopyrite, tetrahedrite, and arsenopyrite, has been the impetus for a number of mining ventures since the discovery of the outcrop in 1896 (Landes and others, 1902, p. 123). Mineralization occurs as shoots in lenticular masses of quartz with tourmaline banding and minor pink dumortierite. The shoots are wide parts of narrow, discontinuous branching veins in the jointed granodiorite. The main vein strikes N. 40° W. and dips 74° to 80° SW.; it is over 150 feet long and has a maximum width of 18 feet (fig. 11). A 12-foot chip sample (No. 8, fig. 11) taken across a relatively barren section of the vein contained no gold, 0.8 ounce silver (10 g per tonne), 0.3 percent copper, and 0.6 percent lead. A grab sample (No. 8) from a stockpile assayed a trace gold, 12 ounces silver per ton (400 g per tonne), 13.40 percent copper, and 1.97 percent lead.

The major workings on the property are three adits and two inclined shafts not accessible because of water and snow. The two 100-foot-deep inclined shafts were sunk in the plane of the main vein (fig. 11). One was collared near the portal of the adit. The other, sunk near the northwest termination of the main section of the vein, evidently did not penetrate mineralized rock. One adit was driven from an open pit N. 40° W., about 70 feet through mineralized rock. A 25-foot-long adit was driven on a slightly mineralized vein northwest of the northernmost shaft but no ore was found. A recent lessee began a long, low-level adit from the vicinity of Williams Lake (fig. 10) planned to extend 2,800 feet to the downward projection of the known ore zone at a point about 750 feet below the collar of the shaft. Work was stopped at 88 feet.

The southernmost shaft penetrated intensely mineralized rock.

In a 1907 mine examination report, B. Thomas (written commun., 1907) reported that two levels were opened from the shaft. On the 50-foot level, a 74-foot-long drift was driven southeast on the main vein to intersect the extension of the ore shoot found near the collar of the shaft. The drift exposed copper mineralization between 43 feet and its face as did a 9-foot winze sunk near the end of the drift. Two 16-foot-long crosscuts driven into the footwall exposed only soft, decomposed granodiorite.

B. Thomas (written commun., 1907) reported that on the 100-foot level of the shaft a 50-foot-long crosscut along a sulfide stringer into the hanging wall encountered copper mineralization 30 feet from the shaft in a shear zone possibly parallel to the main vein. Drifts driven 25 feet southeast and 35 feet northwest on the shear zone exposed mineralization 1-4 feet wide containing a reported 14-25 percent copper and as much as 11.4 ounces silver per ton. Near the face of the crosscut a 0.8-foot-wide vein containing chalcopyrite assayed 24 percent copper. Thomas also reported that copper mineralization was found in samples of the brecciated, altered granodiorite.

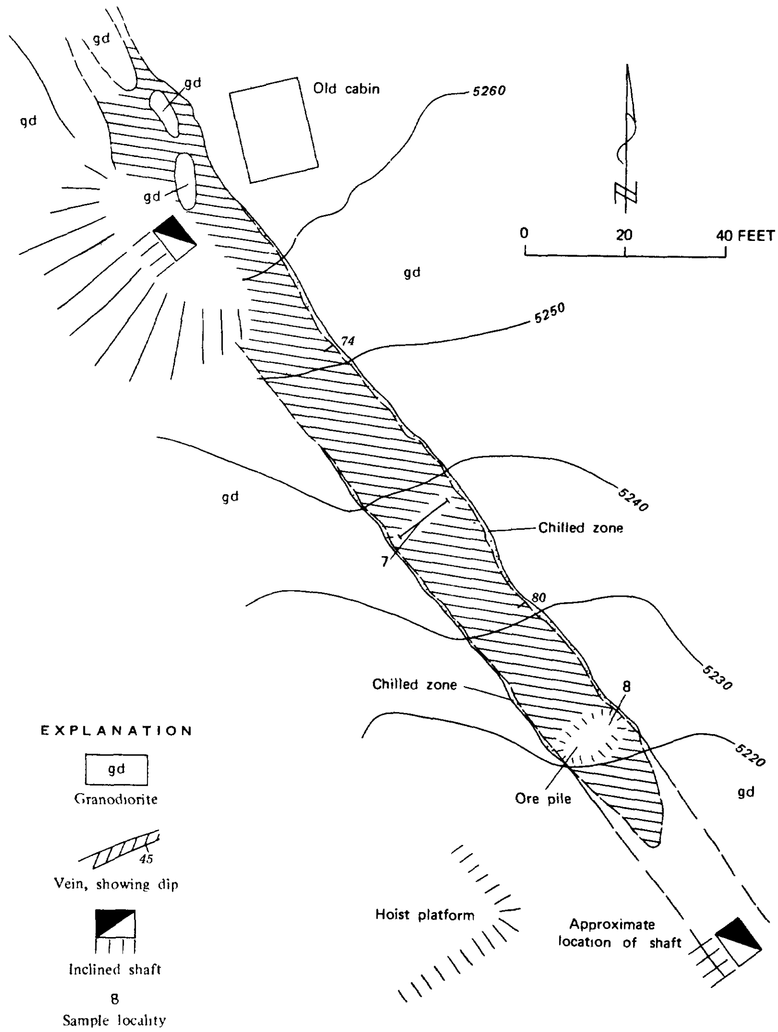


Figure 11.--Dutch Miller mine.

Two distinct assemblages of sulfide minerals were observed by Melrose and Carithers (written commun., 1942), one from surface exposures and one from the underground workings. Sample 8 (fig. 11) is from an ore pile which is believed to represent the ore exposed on the surface. This material is predominantly massive chalcopyrite with minor pyrite, arsenopyrite, and little tetrahedrite. The ore from the underground workings is reported to be largely tetrahedrite and arsenopyrite in quartz and tourmaline gangue but with some galena, sphalerite, and minor chalcopyrite, pyrite, and siderite.

The main vein and its ore shoot are probably terminated by a zone of cross fracturing marked by a well-defined ravine (Melrose and Carithers, written commun., 1942). No evidence of the vein can be seen in a granodiorite outcrop on the southeast side of the ravine. This suggests to Melrose and Carithers (written commun., 1942) that the ore shoot formed a pipelike structure along the zone of cross fracturing and in the adjacent vein. The northwest limits of the ore shoot can be seen on the surface and in the adit driven northwest along the strike of the vein.

Small shipments of ore are reported to have been made during early development of the mine (Landes and others, 1902, p. 123). A 1,100-pound shipment for metallurgical testing was made in October 1960 from ore in a surface stockpile. About 3,500 tons of indicated ore was estimated by B. Thomas (written commun., 1907) when mapping and sampling during the time of underground exploration to contain from 800,000 to 850,000 pounds of copper. The grade of the reserves ranges from 4 to more than 20 percent copper, and more than 5 ounces silver per ton. The probability of developing additional reserves is good because the full extent of the shoots has not been delimited. With suitable access the deposit may be minable.

Miscellaneous prospects

Other minor workings are on the unpatented claims of the Dutch Miller group and adjacent area (table 3). These are mainly on quartz-tourmaline veins in granodiorite. None contained visible sulfide and probably do not contain potential resources.

Sprite Lake area

The Sprite Lake area is along the ridge dividing the drainage of the Cle Elum River and the French Creek drainage (fig. 2). The workings are distributed over a wide area and mainly on veins and shear zones (fig. 12). Most of the workings in the southern part of the area are probably on patented claims.

The arsenopyrite-rich vein deposits of the Lake adit, the Snow workings, the North Area workings, and the Skeeter Creek workings are similar. Most are on mineralized fracture zones in small bodies of granitic rock or along contact zones between the granitic rock and peridotite (the predominant rock of the area). Assays of samples taken from both underground workings and from stockpiles on the surface show gold to be the predominant valuable metal along with significant silver values in some samples and minor amounts of copper.

TABLE 3. - Miscellaneous prospects in the Dutch Miller Gap-La Bohn Gap area

Map No. (fig. 10)	Prospect name	Summary	Sample data
1	Harry's adit	Adit, 6 feet long, driven N. 20° W. from 10-foot-long cut. Flat-lying, limonite stained joints in granodiorite zone cut by 0.05-foot-wide limonite stained vertical joints.	Muck pile grab; no gold, silver, or copper.
2	West adit	Adit, 8.5 feet long driven N. 65° W. along strike of two parallel quartz-tourmaline veins, 1.5 and 2.0 feet wide) dipping 70° to 72° SW.	3.9-foot-long chip across zone at portal; no gold, silver, or lead, 0.03 percent copper.
3	Copper King shaft	Water filled inclined shaft sunk S. 35° W. on wide section of quartz-tourmaline vein 5 to 2.0 feet wide which strikes N. 55° W., dips 56° SW. Alteration 4 feet into granodiorite hanging wall along cross fractures. Vein traceable for 150 feet.	Chip across vein; trace gold, no silver, or lead, 0.02 percent copper.
4-6	Copper King adit and trenches	Group of minor workings in area of narrow, irregular fractures in granodiorite. Some fractures filled with quartz and tourmaline; others narrow aplite dikes.	Three samples; 5.5-foot-long chip at adit portal: trace gold, 0.1 ounce silver per ton, 0.01 percent copper. 0.2-foot-long chip at adit portal; trace gold, 0.2 ounce silver per ton, 0.003 percent copper. Random grab at upper trench: trace gold, 0.1 ounce silver per ton, trace copper.

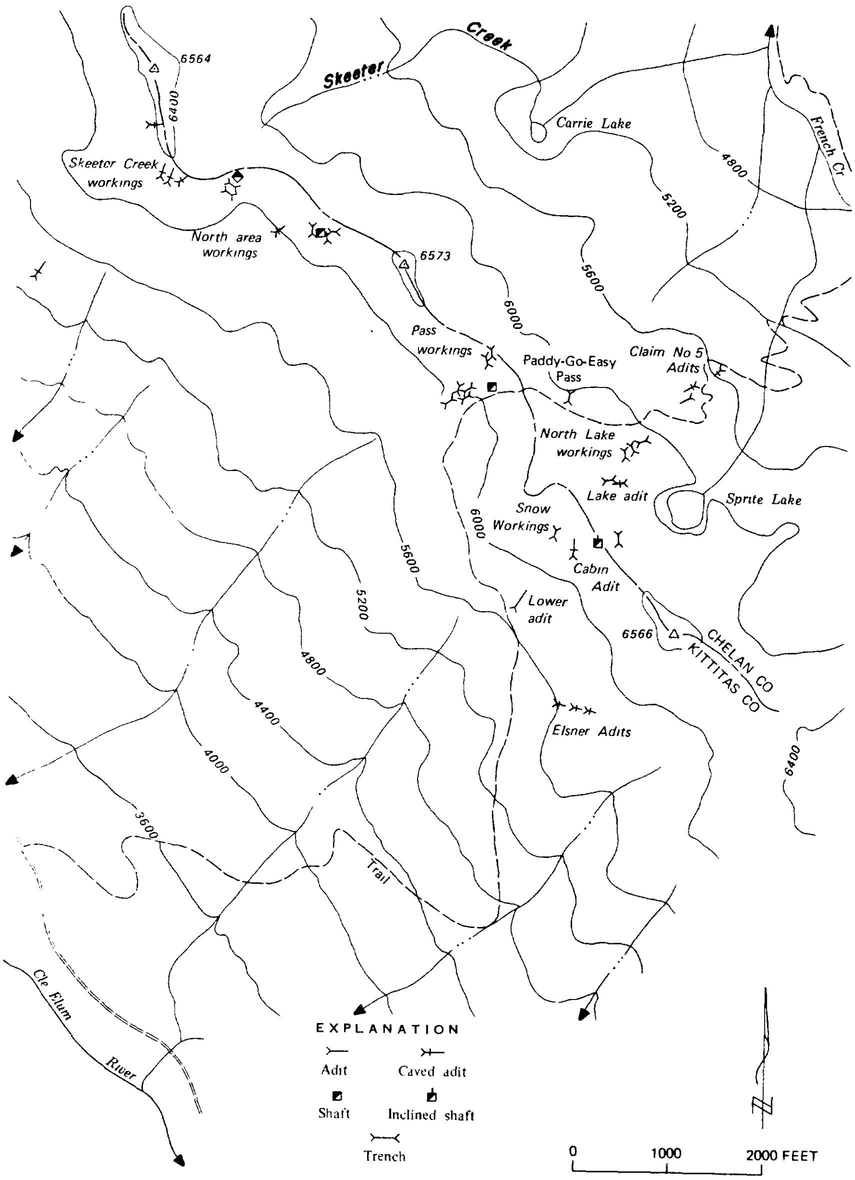


Figure 12.--Prospects in the Sprite Lake area.

Gold values in samples from some veins of the Sprite Lake area may represent economically interesting ore; other veins are probably too narrow to be workable. The workings examined, however, are too limited in extent and too widely separated to establish sufficient horizontal continuity or vertical extent to allow calculation of an ore reserve.

A lineation with a fairly constant strike, as shown on aerial photographs, extends between the major workings in the Skeeter Creek area and the North Area workings and about 1,000 feet east and west beyond both groups of workings. The lineation probably represents a fracture containing widely spaced deposits of auriferous arsenopyrite, but only the obvious and easily found outcrops have been prospected.

Claim No. 5 adits

The middle and upper adits on Claim No. 5 (fig. 12) were driven on a 2.8- to 3.0-foot-wide fault filled with vuggy quartz containing some sulfides (arsenopyrite?) in the most deformed zones (fig. 13). This vein, which can be traced between the workings, strikes N. 70° to 80° E. and dips 60° to 80° NW.

Samples from the adits (fig. 13) indicate that the gold values probably exist sporadically in the vuggy quartz rather than in the gouge, which is less than 1 foot thick on the hanging wall. Sample data are not sufficient to allow a valid calculation of grade, however, possibly 2,000 tons with a weighted average of 1.78 ounces of gold and 0.16 ounces of silver per ton might be selectively mined.

Snow workings and Cabin adit

The Snow workings and the Cabin adit (fig. 12) are southwest of Sprite Lake on the south edge of a small mass of granodiorite near a contact with peridotite (fig. 14). A steeply inclined shaft on the Snow workings was sunk along vuggy, limonite-stained quartz filling a fracture paralleling the contact but within the granodiorite. The vein is about 2 feet wide in the area of the caved shaft but narrows to a stringer westward. A 2.4-foot chip sample (No. 1, fig. 14) across the width of the quartz vein assayed 0.8 ounce gold per ton, a trace silver, and 0.03 percent copper.

A vein, 0.5- to 0.8-foot-thick, in the Cabin adit (fig. 14) consists of quartz with minor pods and stringers of arsenopyrite. A winze, now inaccessible, was driven along the vein hanging wall. A selected sample from a stockpile near the portal contained 1.02 ounce gold per ton, a trace silver, and 0.02 percent copper. The material on the stockpile is more massive than observed in the adit and is probably from the winze.

Lake adit

The Lake adit (fig. 12) and associated open cuts (fig. 15) are at the north edge of the small granodiorite intrusive about 450 feet west of Sprite Lake. The adit is caved but was driven in a shattered and altered zone parallel to a narrow but persistent diorite dike. The pits above the adit were excavated along the strike of the shattered zone. No sulfide mineralization was observed; however, small piles of rock containing arsenopyrite are

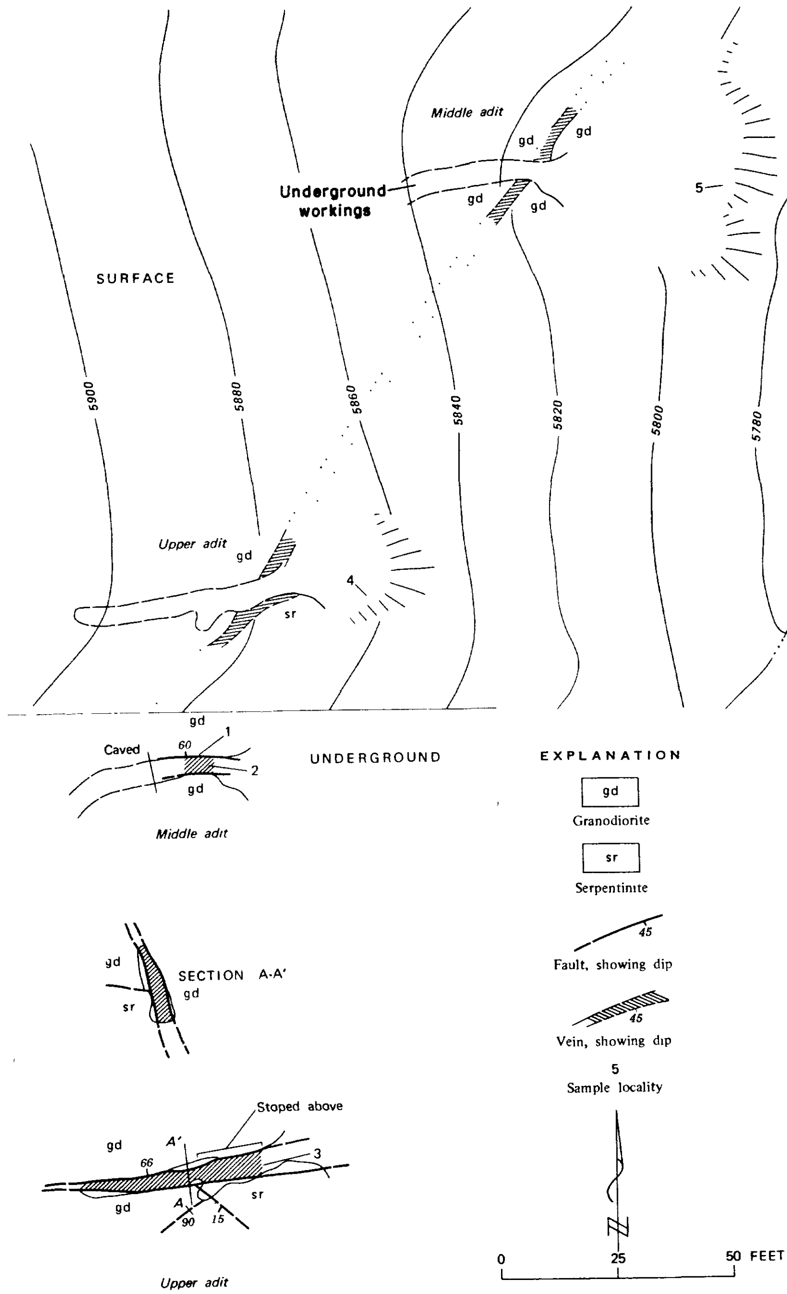


Figure 13.--Claim No. 5 adits.

Data for samples shown on figure 13

[Tr, trace; NA, not applicable]

Sample No.	Sample Type	Length (feet)	Gold (ounces per ton)	Silver (ounces per ton)
1	Chip	2.8	2.71	0.30
2	do	.8	.29	Tr
3	do	1.6	.91	Tr
4	Grab	NA	3.01	.50
5	do	NA	Tr	Tr

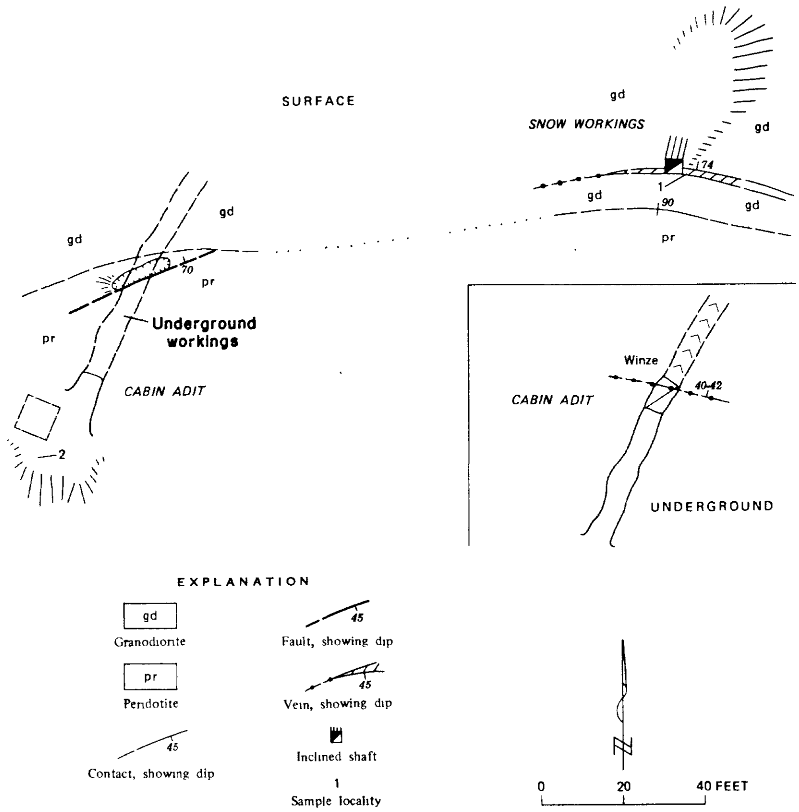


Figure 14.--Snow workings and Cabin adit.

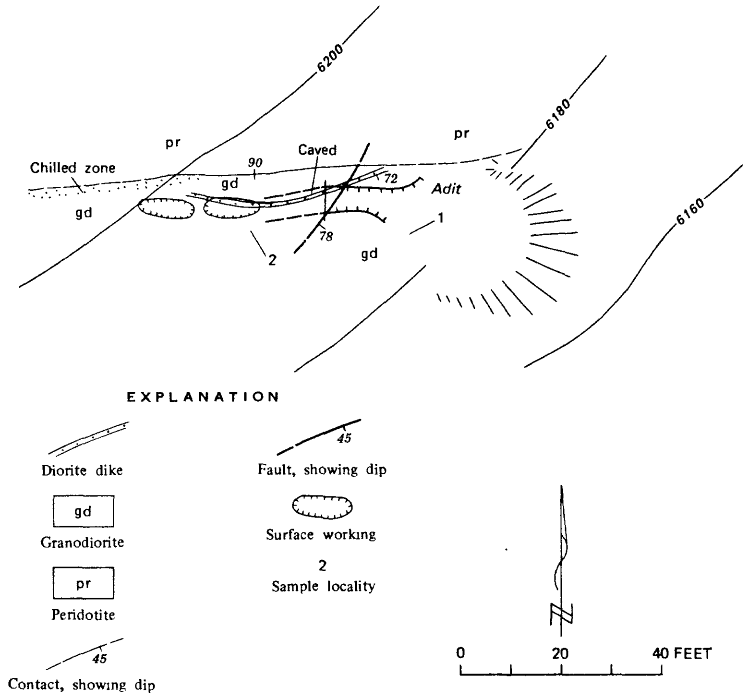


Figure 15.--Map of Lake adit area.

near the lower pit and on the adit dump. The arsenopyrite-rich rock may be from pods or stringers in the shattered zone. The arsenopyrite is similar to that near the south edge of the small intrusive mass at the Cabin adit. Grab samples (Nos. 1 and 2, fig. 15) from the stockpile contained 0.5 and 0.96 ounce gold per ton and 0.1 ounce silver per ton.

Lower adit

The Lower adit (fig. 12) was probably driven to encounter downward extensions of veins exposed in the Snow workings and the Lake adit. The adit is about 1,700 feet long in barren peridotite and probably did not reach the objective. A mineralized fault zone (vein) striking N. 85° to 89° E. and dipping from 39° to 70° NW. crosses the adit about 1,090 feet from the portal (fig. 16). A drift was driven eastward along the fault for approximately 160 feet. The fault zone narrows along the drift and becomes a hairline fracture at the end of the drift. Two samples (Nos. 1 and 2, fig. 16) taken across the vein near the intersection of the main adit and the drift contained 0.37 and 0.02 ounce gold per ton and one contained 0.2 ounce silver per ton.

Elsner adits

Three adits (Elsner adits, fig. 12), now caved, were driven into a persistent fault zone which strikes N. 80° W. and dips vertically. The fault zone is filled with shattered, limonite-stained serpentinite wallrock and narrow, widely separated quartz pods. The fault trace is very evident below the workings, where a ravine has formed in the shattered zone, and above the workings, where a well-defined trench across a saddle extends for a few hundred yards. The only mineralized rock observed was a pile of vuggy, quartz-rich material on the dump of the uppermost adit. No sulfides were observed in the rock. A random grab sample from this pile contained 0.20 ounce gold per ton, 0.80 ounce silver per ton, and 0.50 percent copper. The sporadic nature of the quartz pods apparently discouraged additional work.

Pass workings

The Pass workings (fig. 12) are on and near the contact of peridotite and granodiorite. A vertical shaft, estimated to be 150 feet deep, was sunk in peridotite about 100 feet from the contact. Seven shallow pits and trenches were dug on or close to the contact, mainly on limonite-stained fractures. Maximum values in three selected samples from the area were 0.21 ounce gold per ton and 0.10 ounce silver per ton.

North Lake workings

The North Lake workings (fig. 12) are five pits and trenches in a wide granodiorite dike cutting peridotite. The major trench is about 40 feet long on a limonite-stained fracture. The other pits were probably dug in unsuccessful attempts to find an extension of the fracture. A single selected sample from a pile of limonite-stained rock near the trench contained 3.2 ounces silver per ton and 4 percent copper. Because of the small size of the mineralized fracture, no resource of gold or silver is estimated to exist.

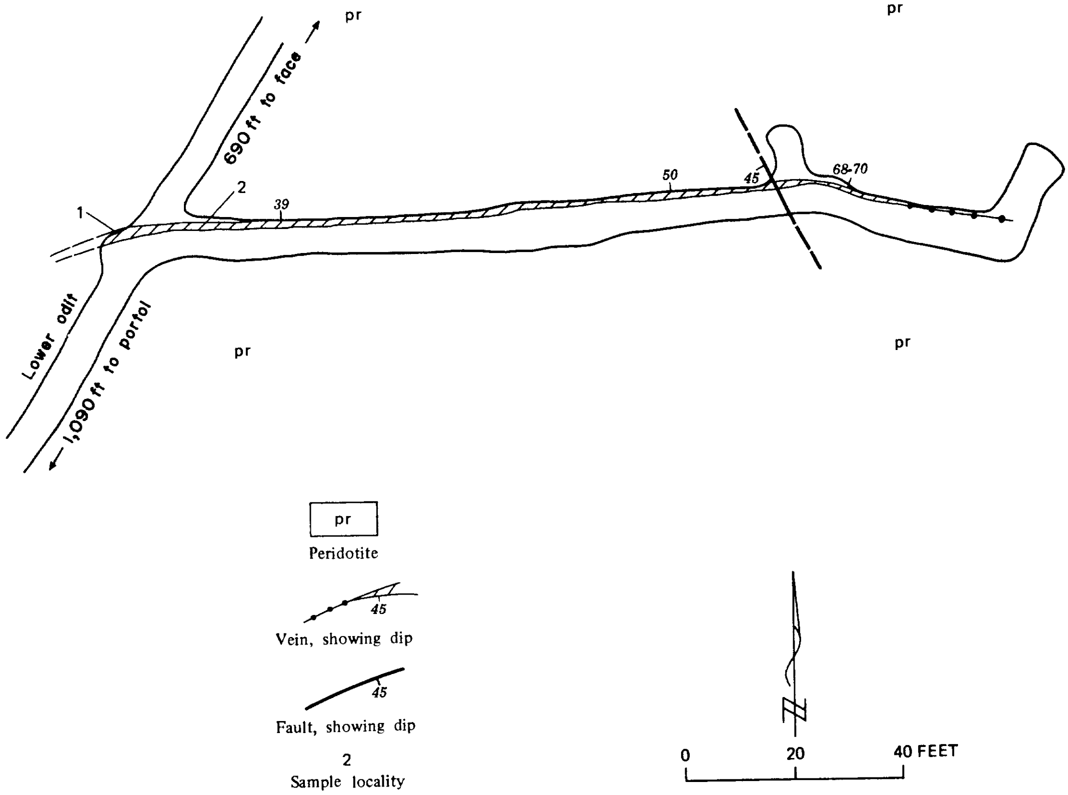


Figure 16.--Map of part of Lower adit workings.

North Area workings

The North Area workings (fig. 12) are along vein outcrops and mineralized zones, mostly in peridotite but closely associated with small, irregular bodies and dikelike masses of intrusive granitic and porphyritic rocks.

Sulfide veins exposed in the southernmost of the workings (fig. 17) are nearly identical to those in the Lake adit and the Snow workings. A selected sample contained 0.12 ounce gold per ton and 6.80 ounces silver per ton. A 3.5-foot chip sample taken across one vein contained no gold and 0.1 ounce silver per ton.

Skeeter Creek workings

The Skeeter Creek workings, consisting of four caved adits, are near the head of Skeeter Creek (fig. 12). The major workings are along quartz-talc veins containing sulfide minerals, mainly arsenopyrite, or along limonite-stained shear zones exhibiting no sulfide minerals. The veins range from 1 to 5 feet in thickness. Six samples were taken from the workings. A 1-foot-long chip sample containing 0.39 ounce gold and 3.5 ounces silver per ton showed the highest grade.

Van Epps Creek-Solomon Creek area

Granodiorite intrudes metasedimentary rocks, metavolcanic rocks, and ultramafic rocks in the Van Epps Creek-Solomon Creek area (fig. 2). Most shear zones parallel the contacts of the granodiorite; other shear zones cross the formations. Quartz, talc, and carbonate minerals are especially plentiful in these shear zones. Sulfides occur mostly as accessory minerals in the country rock, although pyrite, pyrrhotite, arsenopyrite, chalcopyrite, sphalerite, stibnite, and galena fill some pores, fractures, and short shears distributed throughout the rock. Magnetite and chromite are also accessory minerals in the rocks.

Prospectors have worked in the Van Epps Creek-Solomon Creek area from the late 1880's. R. Klessatel (written commun., 1911) studied the economic geology of the Van Epps Creek-Solomon Creek area. A report (E. A. Magill and W. P. Puffett, written commun., 1955) on a Defense Minerals Exploration Administration (DMEA) contract on the Van Epps area was freely used in this report.

The mine workings in the area are distributed mainly in the basin at the head of the Van Epps Creek and the headwaters of Solomon Creek (fig. 18).

Some of the samples from the Van Epps Creek-Solomon Creek area, particularly from disseminated material, represent a large enough volume and contain copper values that are high enough to represent potential resources, particularly in view of the fact that small production has been recorded from the Pickwick shaft and the Van Epps adit and possibly from the Ellen mine area. Samples from rock containing disseminated sulfides, taken along 242 feet of the Van Epps adit, averaged 0.33 percent copper. U.S. Bureau of Mines DMEA drill hole No. 2, about 3,500 feet west of the adit, in another zone, penetrated 226 feet of mineralization containing 0.10-0.46 percent copper (R. N. Appling, written commun., 1955). Samples of leached rock from the surface near the drill hole contained lower values.

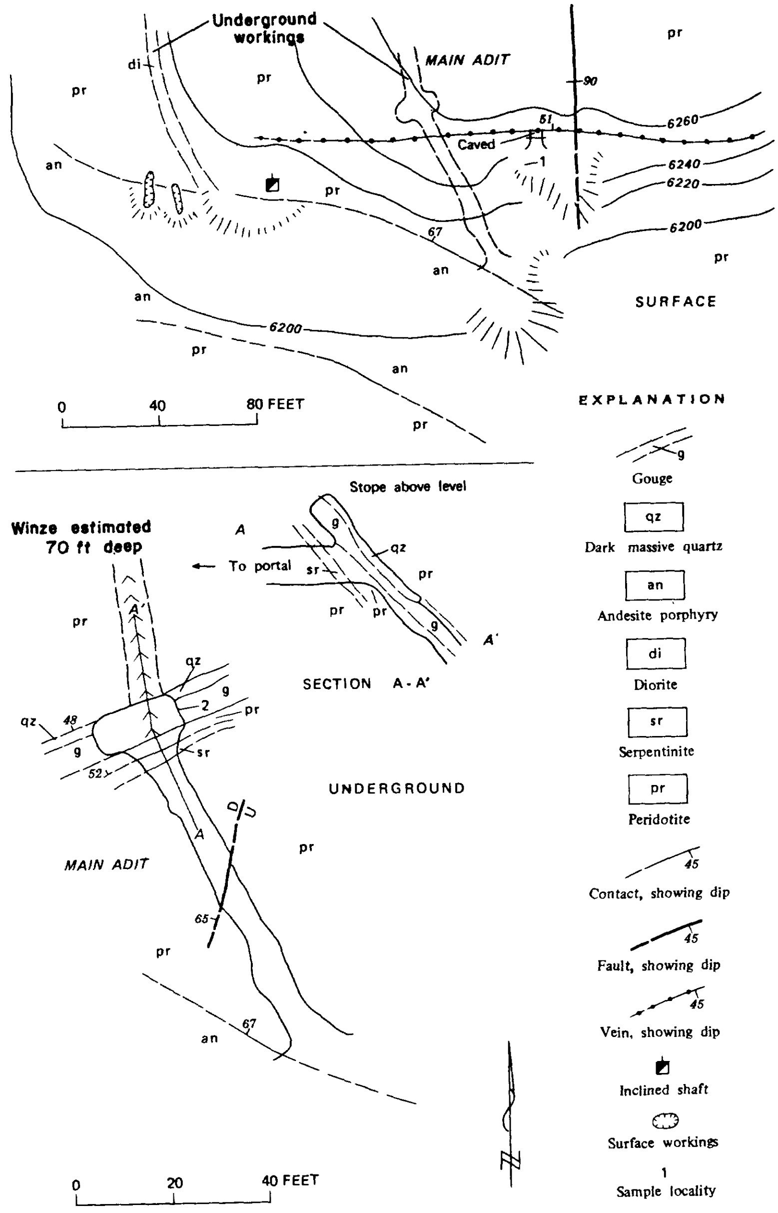


Figure 17.--North Area workings.

Van Epps adit

The major working in the area is the Van Epps adit (fig. 19). The portal of the crosscut adit is near the north fork of Van Epps Creek at about 5,070 feet altitude.

The Van Epps adit, which was excavated about 1900, connects with the Pickwick shaft. The adit is driven through glacial deposits, which obscure much of the bedrock geology, and through diorite and peridotite. Several shear zones are exposed in the adit. Sections of the adit in the glacial deposits are timbered but most have stood well.

Disseminated sulfides occur throughout the adit walls but are more abundant in the first 700 feet from the portal. The weighted average of samples taken for 242 feet along this section of the adit was 0.33 percent copper. Samples selected from the dump of the Van Epps adit (Nos. 32-34, fig. 19) contained highs of 0.01 ounce gold per ton, 0.42 ounce silver per ton, and 3.85 percent copper.

Pickwick shaft

The DMEA reports (E. A. Magill and W. P. Puffett, written commun., 1955) describe much of the Pickwick shaft (fig. 19). The shaft cuts serpentinitic peridotite, diorite, and several shear zones. Slumping overburden and exploratory trenching obscure much of the early work near the shaft. The shaft was sunk in 1897 to a depth of at least 110 feet with drifts at depths of 50, 80, and 110 feet. A raise, completed about 1924, connected the Van Epps adit to the bottom of the shaft. Workings on the 50-foot level of the shaft extended to the surface (fig. 19). Minor stoping was done on the 110-foot level, near the shaft. Most of the lenticular sulfide concentrations along the shear zones near the shaft had been mined out before 1957. By 1957, operators of the Van Epps property had drilled three vertical exploratory diamond drill holes near the shaft.

Two samples (Nos. 16-17, fig. 19) from the drift at the 110-foot level of the shaft contained low values, but a sample (No. 18, fig. 19) from material thought to represent stoped ore from the 80-foot level contained 0.02 ounce gold per ton, 3.10 ounces silver per ton, and 4.62 percent copper.

Meadow adit

Another larger working in the Van Epps area is the Meadow adit (fig. 18). The adit was driven through peridotite, felsite, and felsite porphyry for more than 1,500 feet (fig. 20). It was apparently intended to intersect the downward extension of gossans cropping out on the surface. A brecciated fault zone with gouge is about 1,180 feet from the portal. Broken material from the zone has caved into the adit damming a flow of water and filling the adit upward from the caved area to a depth of 4-5 feet, making it inaccessible. Only one of the ten samples from the adit (Nos. 41-50, fig. 20) contained any values.

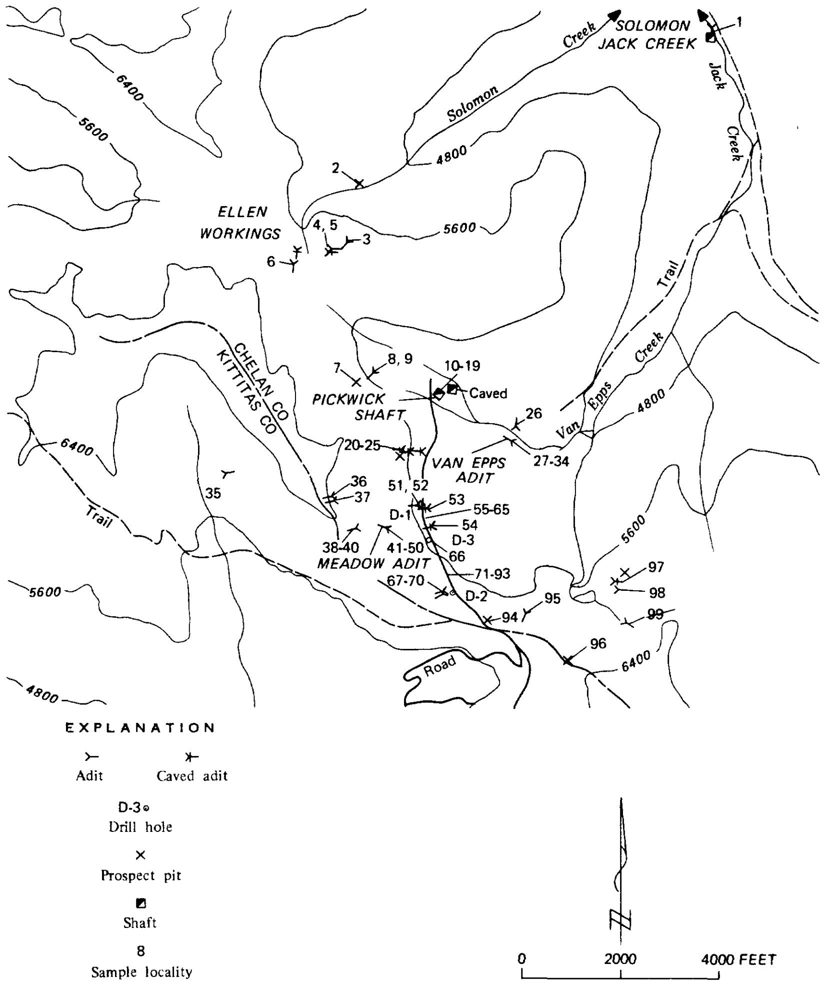


Figure 18.--Mines and prospects in the Van Epps Creek-Solomon Creek area.

Data for samples shown on figure 18

[Tr, trace; N, none detected; --, not analyzed; NA, not applicable]

Sample No.	Sample Type	Sample Length (feet)	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)
1	Grab	7	Tr	N	--
2	do	10	0.13	1.5	--
3	Chip	4	N	N	--
4	do	2	.74	3.2	--
5	Grab	30	N	.9	--
6	Chip	4	N	.2	--
7	do	1.5	N	.3	0.04
8	Grab	NA	N	N	--
9	do	NA	N	N	--
10	Chip	15.0	Tr	.16	.42
11	do	2.0	.02	.16	1.2
12	do	3.0	Tr	.16	.25
13	do	18.0	Tr	.34	.23
14	do	4.0	.04	1.4	7.09
15	Grab	NA	.01	.1	1.11
16	do	NA	Tr	Tr	.34
17	Chip	20.0	.02	Tr	.19
18	Grab	NA	.02	3.10	4.62
19	Select grab	NA	Tr	1.0	--
20	do	15	N	N	--
21	do	15	N	2.10	--
22	do	15	N	1.0	--
23	Grab	40	Tr	.5	--
24	do	40	N	1.3	--
25	do	NA	N	.36	.67
26	Chip	61	N	<.02	.02
27	do	3	N	.02	.10
28	do	20	.01	.02	.26
29	do	39	N	.12	.71
30	do	100	Tr	Tr	.18
31	do	80	.02	.3	.36
32	Grab	NA	N	.08	.04
33	do	NA	.01	.42	3.85
34	do	NA	N	.18	.19
35	do	NA	Tr	1.0	1.5
36	Chip	25	Tr	Tr	--
37	do	20	Tr	.1	--
38	do	5	N	N	--
39	Grab	1.8	Tr	N	--
40	do	0.8	N	.1	--
41	Chip	1.3	N	N	--
42	do	3.2	Tr	.1	--
43	Grab	NA	.01	.27	.58
44	do	NA	Tr	.1	--
45	Chip	8.0	N	N	--
46	do	4.5	Tr	Tr	--
47	do	100	N	N	
48	do	NA	N	0.02	.04
49	do	3.2	N	Tr	--
50	do	50	Tr	.2	--
51	Grab	NA	N	<.02	.02
52	Chip	2	--	--	.03
53	Select grab	5	Tr	.2	.85
54	do	5	Tr	N	.02
55	Chip	22	--	--	<.02
56	do	25	--	--	.02
57	do	25	--	--	<.02
58	do	25	--	--	.02
59	do	24	--	--	.06
60	do	20	--	--	<.02
61	do	13	--	--	.08
62	do	19	--	--	.10
63	do	15	--	--	<.02
64	do	25	--	--	.05
65	do	25	--	--	.07
66	do	33	N	.06	.07
67	Grab	NA	N	<.02	.03
68	Chip	3	Tr	.2	--
69	do	4	N	.3	--
70	do	15	N	.36	.08
71	do	16	--	--	<.02
72	do	34	--	--	.03
73	do	34	--	--	<.02
74	do	40	--	--	.02
75	do	25	--	--	.02
76	do	25	--	--	.03
77	do	25	--	--	.03
78	do	25	--	--	<.02
79	do	25	--	--	.06
80	do	14	--	--	.03
81	do	25	--	--	.02
82	do	25	--	--	.12
83	do	25	--	--	.02
84	do	27	--	--	.03
85	do	14	--	--	.02
86	do	12	--	--	.02
87	Chip	25	--	--	<.02
88	do	30	--	--	.02
89	do	25	--	--	<.02
90	do	25	--	--	.02
91	do	25	--	--	.02
92	do	19	--	--	.03
93	do	37	--	--	.04
94	do	27	N	<.02	.04
95	do	3	N	.4	--
96	do	5	N	.1	.05
97	Select grab	5	Tr	.7	--
98	Grab	20	N	N	--
99	Chip	10	Tr	.4	.54

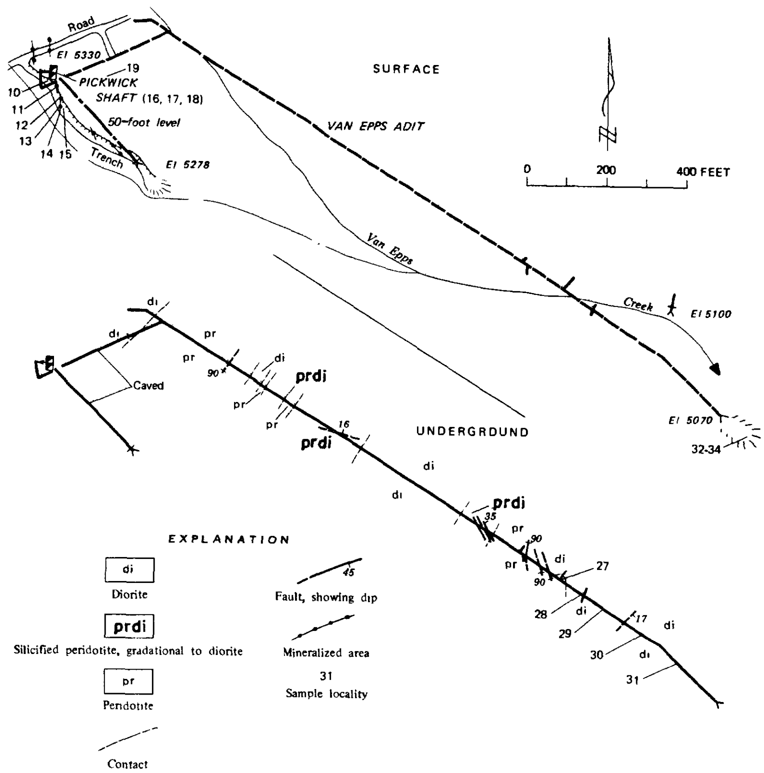
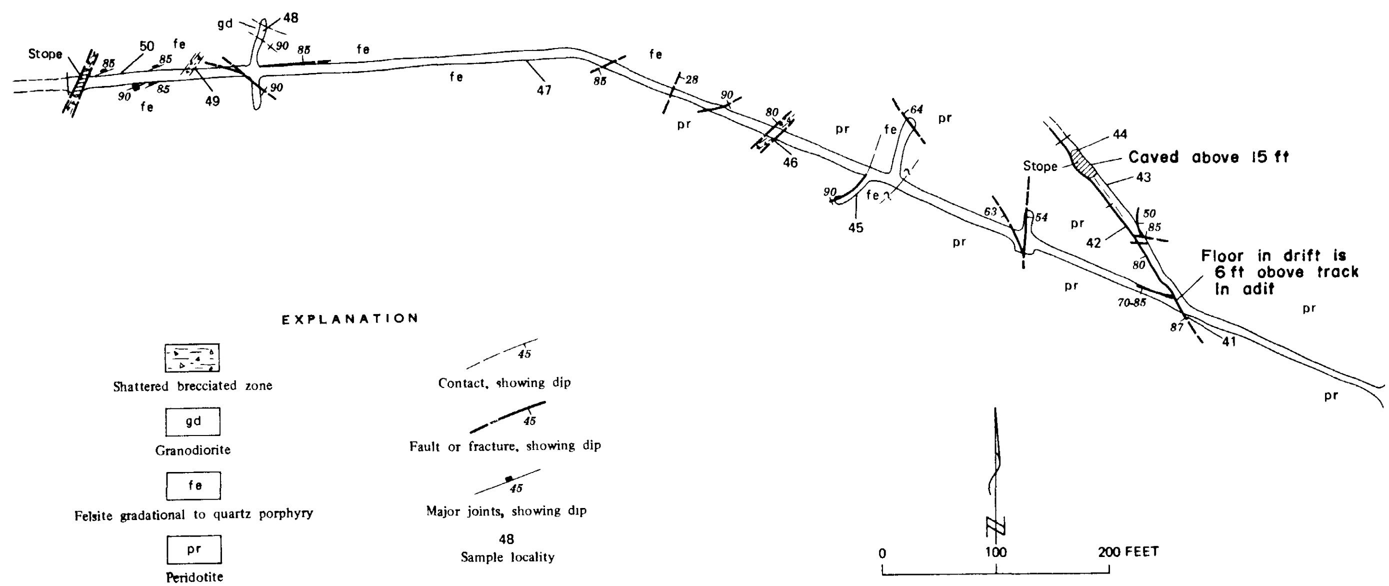


Figure 19.--Van Epps adit and Pickwick shaft. Modified from E. A. Magill and W. P. Puffett (written commun., 1955).

Data for samples shown on figure 19
[Tr, trace; N, none detected; --, not analyzed; NA, not applicable]

Sample No.	Sample Type	Sample Length (feet)	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)
10	Chip	15	Tr	0.16	0.42
11	do	2	0.02	.16	1.2
12	do	3	Tr	.16	.25
13	do	18	Tr	.34	.23
14	do	4	.04	1.4	7.69
15	Grab	NA	.01	.1	1.11
16	do	NA	Tr	Tr	.34
17	Chip	20	.02	Tr	.19
18	Grab	NA	.02	3.10	4.62
19	do	NA	Tr	1.0	--
27	Chip	3	N	.02	.10
28	do	20	.01	.02	.26
29	do	39	N	.12	.71
30	do	100	Tr	Tr	.18
31	do	80	.02	.30	.36
32	Grab	NA	N	.08	.04
33	do	NA	.01	.42	3.85
34	do	NA	N	.18	.19



Data for samples shown on figure 20

[Tr, trace; N, none detected; --, not analyzed; NA, not applicable]

Sample No.	Sample Type	Sample Length (feet)	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)
41	Chip	1.3	N	N	--
42	do	3.2	Tr	0.1	--
43	Grab	NA	0.01	.27	.58
44	do	NA	Tr	.1	--
45	Chip	8.0	N	N	--
46	do	4.5	Tr	Tr	--
47	do	100	N	N	--
48	do	NA	N	.02	.04
49	do	3.2	N	Tr	--
50	do	50	Tr	.2	--

Figure 20.--Meadow adit.

Van Epps No. 3 workings

Two small pits at the base of a cliff above the Van Epps No. 3 adit are in a sulfide-rich vein in peridotite (No. 7, fig. 18). The vein is 1 foot wide, strikes N. 65° E., and dips nearly vertically. The vein is more than 90 percent massive, fine-grained, gray sulfides. A chip sample across the sulfide lens at the upper workings (No. 7, fig. 18) contained no gold, 0.3 ounce silver per ton, and 0.04 percent copper.

The Van Epps No. 3 adit (Nos. 8-9, fig. 18) did not intersect the sulfide vein exposed in the pits or any mineralized structure. Samples 8 and 9 from the dumps assayed no gold or silver and only a trace copper.

Ellen workings

The Ellen workings are near the head of the Solomon Creek drainage (fig. 18). The Chinook, Silver Fiend, Humbug, and White Star were early claims in the same area (Hodges, 1897; Huntting, 1943; Purdy, 1951). A collapsed cabin, millsite, and traces of several foundations are evidence of old surface development near the head of Solomon Creek.

The Ellen adits at sample localities 3, 4, and 5 (fig. 18) are on or near a shear complex at the contact of ultramafic and granitic rocks. Purdy (1951) described the geology in detail. The shear zone, 10-15 feet thick, strikes about N. 60° E. and dips about 80° NW. The zone crops out for about 150 feet horizontally and about 100 feet upward to a ridge crest, and an estimated additional 130 feet to the adit on the east side of the ridge (sample No. 3). Beyond this adit the mineralized zone thins, splits, and is offset by cross faults but may extend approximately 800 feet horizontally and 600 feet downward toward the pit at sample locality 2 before being obscured under slope wash and talus.

Ultramafic rocks, silicified altered rock, and granitic rock intertongue along the Ellen shear zone. The outcrops are limonite stained, leached, and vuggy. Minor vein minerals in the shear zones, mainly the workings at sample localities 4 and 5, are galena, sphalerite, tetrahedrite, chalcopyrite, pyrite, and arsenopyrite. The major workings on the Ellen shear zone (Nos. 4-5, fig. 19) are a 12-foot-long adit and a caved adit which Purdy (1951) reported to be 210 feet long with five crosscuts driven to explore the width of the zone (fig. 21). The shear zone in the vicinity of the workings consists of coarse-grained quartz with carbonate minerals, feldspar stringers, minor veinlets, and inclusions of sulfides. The sulfides, galena, tetrahedrite, chalcopyrite, pyrite, and arsenopyrite, were seen. The hanging wall of the shear zone is granodiorite, the footwall, peridotite (fig. 21). Samples contained highs of 0.74 ounce gold per ton, 3.2 ounces silver per ton, and 1.4 percent copper. Purdy (1951, p. 64) reported that a grab sample of a quartz vein (from the workings at sample localities 4 and 5) contained 0.12 ounce gold per ton and 5.98 percent lead.

A 27-foot-long adit (sample No. 3, fig. 18) was excavated through granitic rock, a lamprophyre dike, limy rock, and into about 8 feet of the shear zone. The zone is estimated to be 20 feet thick at this point. It is composed of about

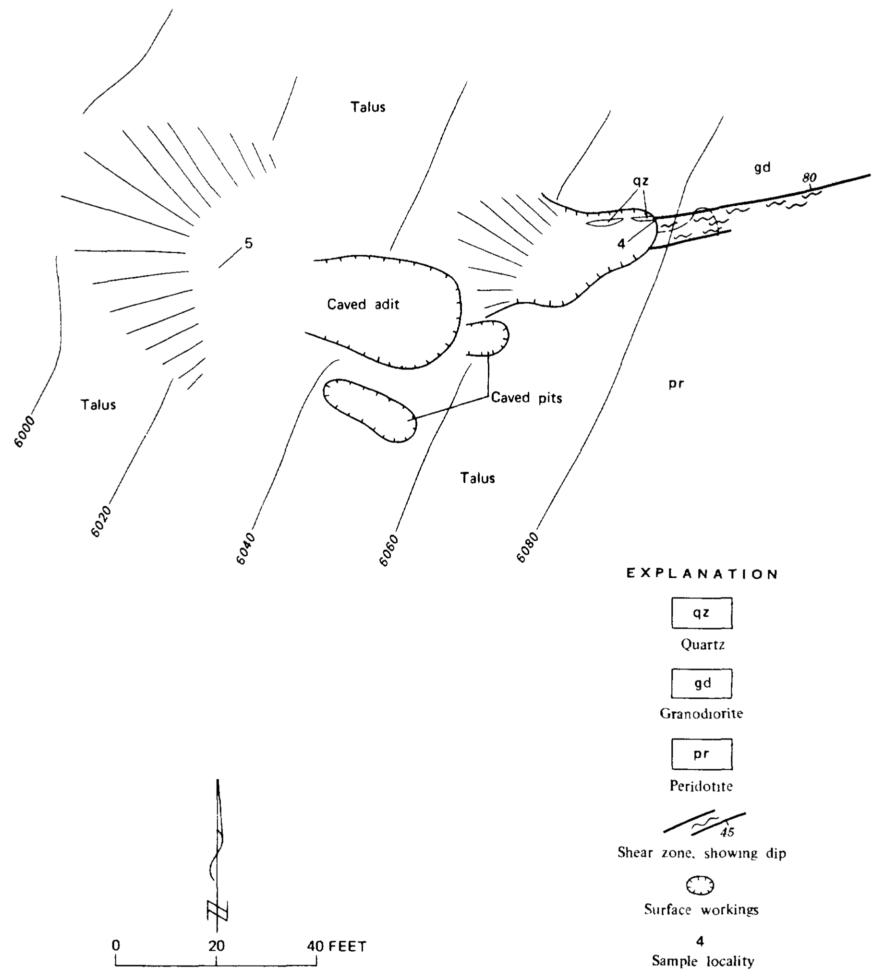


Figure 21.--Ellen workings.

5 percent gouge, 10-20 percent quartz lenses, and 75-85 percent lenticular wallrock inclusions as much as 3 feet thick. Fine-grained gray metallic minerals occur in layers, mostly less than 0.3 foot thick.

Several caved excavations and cuts (sample No. 2, fig. 18) are in granitic slope wash in Solomon Creek valley. Granitic rock crops out in large exposures nearby. Fire bricks and some slag may be the remains of a small smelter.

Two caved adits (sample No. 6, fig. 18) are probably both on the same mineralized zone which may be an extension of the major Ellen shear zone. The adit, caved at 18 feet, is along sheared, weathered, serpentinite and decomposed granitic rock. The shear zone is 1-6 feet wide, strikes N. 30° to 45°, and dips 55° to 65° NW. Weathering has probably leached and removed surficial metallic minerals at the two workings. A 4-foot-long chip sample across the zone assayed no gold and 0.2 ounce silver per ton. Spectrographic analysis indicates less than 0.01 percent copper and lead.

Miscellaneous prospects

Minor workings in the Van Epps area, listed in table 4, probably have no potential or are not well enough exposed to estimate potential.

Fortune Creek area

Scattered prospects (fig. 22) are at the head of Fortune Creek in an area underlain by serpentinitic peridotite and intrusive granodiorite. Much of the rock is sheared and some serpentinitic peridotite is intensely slickensided. Most significant mineralization occurred in sheared zones. Quartz, carbonates, and talc are the most abundant vein minerals; pyrite and arsenopyrite fill some of the fractures in shear zones. Chalcopyrite, the principal economic mineral, occurs in some veins.

HHY prospect

The HHY prospect (Nos. 1-8, fig. 22) were dug in fractured, weakly mineralized area in peridotite (fig. 23). Narrow dikelike masses of dacite intrude the peridotite at widely spaced intervals and subparallel to the major fractures. Pyrite is disseminated in country rock along a few fractures. Most fractures are tight and only slightly mineralized.

A 0.7-foot-long sample taken across a vein above the adit (fig. 23) contained 2.9 ounces silver per ton and 4.2 percent copper. The vein is exposed 24 feet along the strike. It pinches out to the east and is covered by debris to the west. The area of the HHY prospect has a small potential for discovery of silver-copper resources.

Benita claims

The prospect workings on the Benita claims (sample localities 9-22, fig. 22) are nearly alined along a silicified sulfide-enriched zone, the Benita shear zone, which strikes N. 45° to 55° W., and dips 65°-85° NE. The known length of

TABLE 4. - Miscellaneous prospects and mineralized zones in the Van Epps Creek-Solomon Creek area

Map No. (fig. 18)	Prospect name	Summary	Sample data
1	Solomon-Jack Creek	Adit and caved shaft in weathered banded dolomitized serpentinite and peridotite.	Select dump sample; 0.01 percent copper, trace lead, and 0.02 percent vanadium.
8-9	Unnamed adit	Fifty-three-foot-long adit into felsite, peridotite, and serpentinite.	Two dump grab samples; average 0.006 percent copper.
20-25	Blackhawk	Four caved adits, total length probably more than 1,000 feet, serpentinitic peridotite and felsite. Disseminated pyrite, arsenopyrite, galena, chalcopyrite, and sphalerite; some in masses 0.8 feet thick.	Six select dump samples; as much as trace gold, and 2.10 ounces silver per ton. Spectrographic analysis indicates as much as 1 percent lead.
26	Porcupine	Adit extends 71 feet into serpentinitic peridotite.	One sample; 0.02 ounce silver per ton, 0.02 percent copper.
36-37	Unnamed workings	Adits extend 32 and 56 feet into serpentinitic peridotite with 0.1 to 1.0 feet thick magnetite-chromite and cuprite veins.	Two chip samples; trace gold and as much as 0.1 ounce silver per ton.
38-40	Unnamed adit	A 20-foot adit into pyritized, silicified felsite and mafic rock.	Three chip samples; maximum trace gold, and 0.1 ounce silver per ton.
54	do	Caved adit along near-vertical vein containing pyrite, arsenopyrite, and magnetite. Vein approximately 1 foot thick in serpentinitic peridotite and felsite.	Select grab; trace gold, no silver, and 0.02 percent copper.
51-53	Unnamed adit	Adit 47 feet long in sheared contact between silicic felsite and serpentinitic peridotite. A caved adit below road with veins at least 0.5 feet thick containing arsenopyrite and pyrite.	Select grab from adit below the road; 0.2 ounce silver per ton, 0.85 percent copper, trace gold. Chip sample from upper adit; 0.03 percent copper. Grab sample from same area; 0.02 percent copper.
55-58	Roadcut	One-hundred-foot-long zone of mafic rock, felsites, and mineralized shears.	Four chip samples; maximum 0.02 percent copper.
59-65	do	Mafic rock and shears 141 feet along road.	Seven chip samples; maximum 0.1 percent copper.
66	do	Thirty-three-foot-long zone of mafic rocks and shears.	One sample; 0.06 ounce silver per ton and less than 0.07 percent copper.
67-70	The Goldie	Two adits, 68 and 37 feet long into felsite, serpentinitic peridotite and diorite with scattered pyrite and pyritized shears one-fourth inch to 1 foot thick.	Average of 4 chip samples; 0.2 ounce silver per ton, maximum 0.8 percent copper.
71-93	Roadcut	Five hundred-fifty feet of mafic rocks and shears.	Twenty samples; average less than 0.03 percent copper.
95	Unnamed workings	Aplitic. porphyritic granodiorite with two crosscutting shears, less than 0.5-foot-thick.	One chip sample; no gold and 0.4 ounce silver per ton.
96	do	Pit 2 to 4 feet deep in silicic felsite containing scattered sulfides.	One chip sample; no gold, 0.1 ounce silver per ton and 0.05 percent copper.
97	Unnamed adit	Adit about 20 feet long into ultramafic rock and along 0.3- to 0.8-foot-thick shear. Pyrite along shear.	One select sample; trace gold, 0.7 ounce silver per ton.
98	do	Partly caved adit in serpentinite. Vein containing pyrite and arsenopyrite, at least 1.5 feet thick.	One select grab; no gold or silver.
99	do	Twenty-five-foot-long adit along 0.1- to 0.5-foot-thick shear in serpentinitic peridotite with chalcopyrite and pyrite.	One sample along shear; 0.4 ounce silver per ton, 0.54 percent copper.
D1	USBM drill hole	Drilled in 250 feet of mafic rock and shears.	Maximum copper rich rock containing 0.12 to 0.24 percent copper.
D2	do	Drilled in 226 feet of mineralized rock.	Assay values ranged from 0.10 to 0.46 percent copper.
D3	do	Hole encountered mafic rocks and shears for total depth of 186 feet. Rock mineralized with copper encountered between 138.8 and 146.0 feet.	Copper values ranged from 0.10 to 0.20 percent and a maximum of 0.05 percent WO_3.

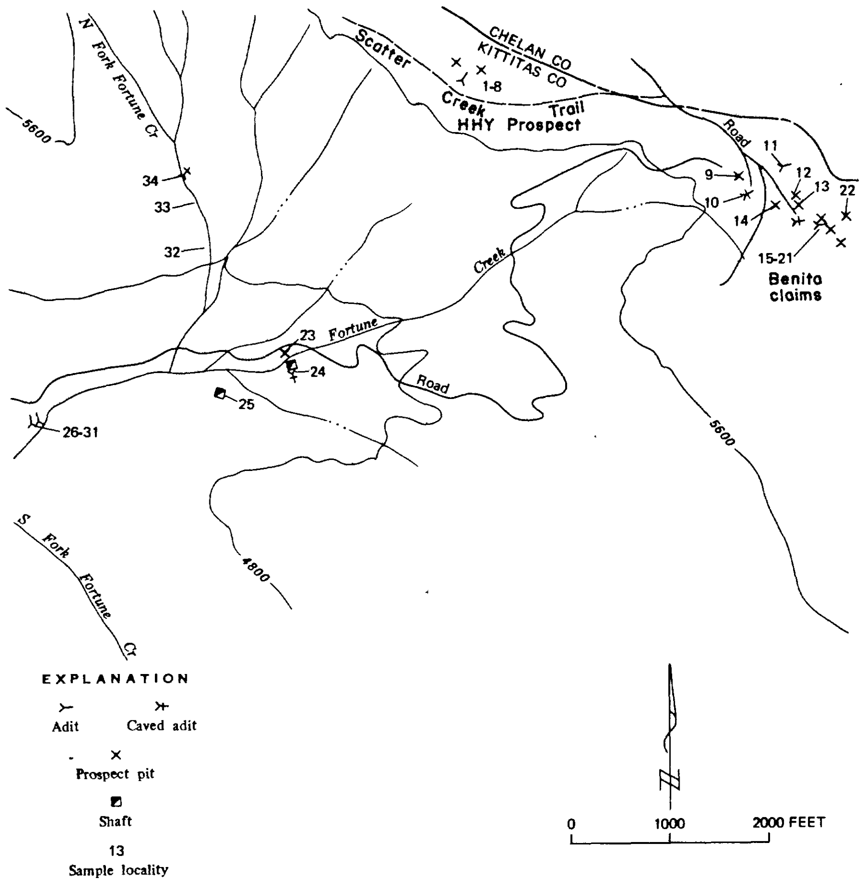


Figure 22.--Prospects in the Fortune Creek area.

[Tr, trace; N, none detected; --, not analyzed; NA, not applicable]

Sample		Length	Gold	Silver	Copper
No.	Type	(feet)	(ounces per ton)	(ounces per ton)	(percent)
1	Grab	NA	N	0.10	0.02
2	Chip	0.7	N	2.90	4.20
3	Grab	NA	N	N	.30
4	Chip	4.0	Tr	N	--
5	do	0.7	Tr	N	N
6	do	3.8	N	N	N
7	do	1.2	N	.10	--
8	do	1.5	N	Tr	N
9	Grab	170	Tr	N	.04
10	do	50	N	N	--
11	Chip	40	Tr	N	--
12	do	.5	Tr	N	--
13	do	25	N	N	--
14	do	15	Tr	.2	--
15	Grab	NA	N	1.10	2.80
16	Chip	1.5	Tr	1.00	.35
17	do	2.9	N	.3	.05
18	do	3.0	Tr	1.10	.003
19	do	0.8	N	.20	--
20	Grab	NA	Tr	.50	--
21	Chip	2.5	Tr	.10	--
22	Grab	NA	Tr	.10	--
23	Chip	1.8	Tr	Tr	.006
24	do	1.6	Tr	.30	Tr
25	Grab	NA	N	N	--
26	Chip	0.7	N	.10	.02
27	do	1.3	.31	.10	1.00
28	do	1.7	.18	.20	.10
29	do	1.5	N	.10	.003
30	do	1.7	N	.30	.001
31	Grab	14.3	N	Tr	.006
32	do	NA	N	N	--
33	Chip	6.0	N	N	--
34	Grab	NA	Tr	.4	.07

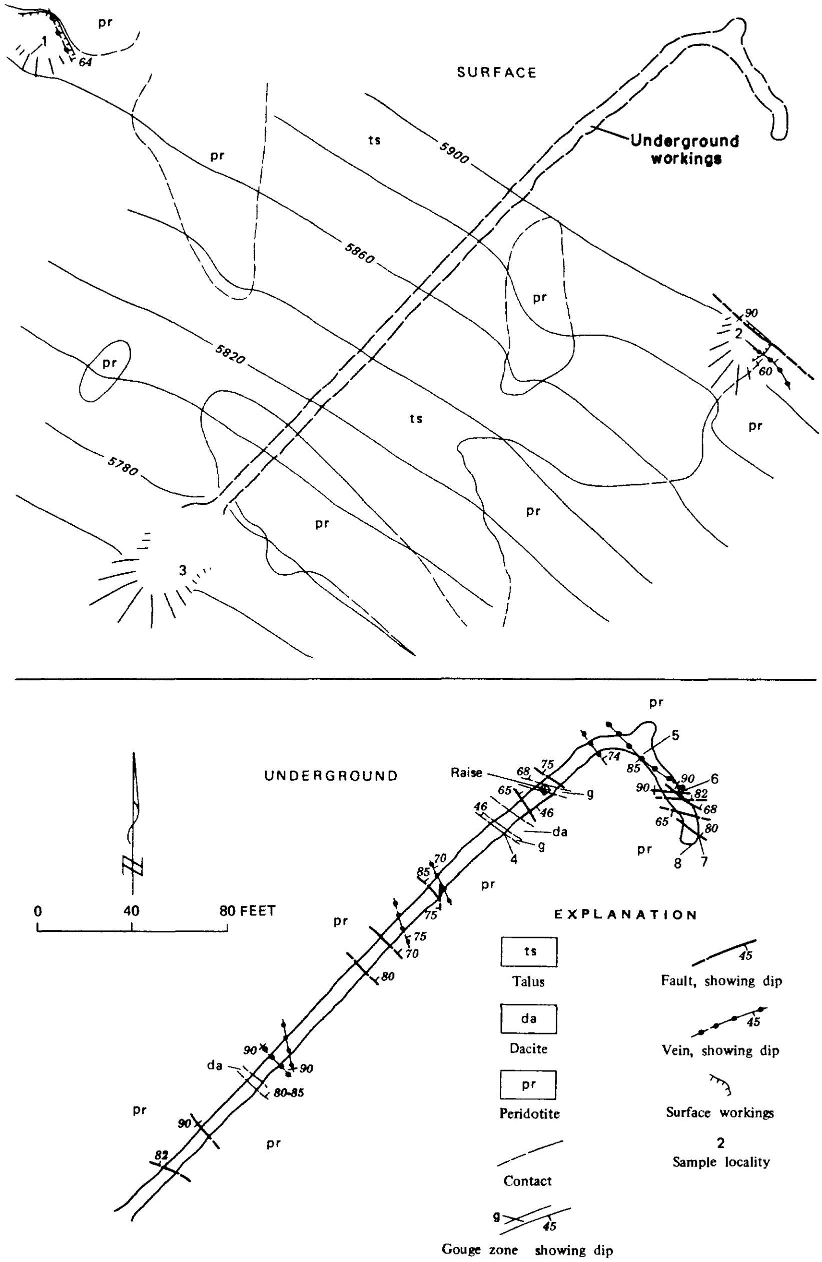


Figure 23.--HHY workings.

Data for samples shown on figure 23

[Tr, trace; N, none detected; --, not analyzed; NA, not applicable]

Sample					
No.	Type	Length (feet)	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)
1	Grab	NA	N	0.10	0.02
2	Chip	0.7	N	2.90	4.20
3	Grab	NA		N	.30
4	Chip	4.0	Tr	N	--
5	do	0.7	Tr	N	N
6	do	3.8	N	N	N
7	do	1.2	N	.10	--
8	do	1.5	N	Tr	N

the Benita shear zone is 1,500 feet, but it can be projected for an additional few hundred feet to the northwest and southeast. Some short adits and pits are along a brecciated and mineralized zone northeast of the main Benita zone.

The main Benita workings are an adit, two trenches, and a caved inclined shaft (fig. 24). The shear zone in the workings is about 8-15 feet wide between walls of serpentinite and peridotite. An irregular quartz vein in the center section of the zone averages 0.3 foot wide and contains 5-10 percent pyrite, chalcopyrite, and galena. Near the bounding faults are massive, pyrite-rich, elongate sulfide lenses about 0.5 foot thick and as much as 6 feet long.

Debris from the Van Epps road covers the portal of an adit (sample 10, fig. 23). Peridotite and serpentinite on the dump of the adit contain less than 5 percent small, disseminated pyrite grains. Masses of pyrite, arsenopyrite, and chalcopyrite with quartz and talc as much as 0.5 foot wide are in some of the broken material.

Samples containing highs of 1.10 ounce silver per ton and 2.8 percent copper and the persistence of the Benita shear indicate some potential for the discovery of small low-grade silver and copper deposits.

Miscellaneous prospects

Other prospects in the Fortune Creek area, listed in table 5, have no potential or are not well enough exposed for a potential to be estimated.

Teanaway River-Ingalls Creek area

Prospects in the Teanaway River-Ingalls Creek area (fig. 2) are in two widely separated sections and are described as the east and west sections.

The west section (fig. 25) covers the headwaters of the North Fork of the Teanaway River, De Roux Creek, headwaters of Ingalls Creek, and the upper Turnpike Creek basin. Except for a small area of volcanic rock in the southwest section of the map area, the entire area is underlain by peridotite and serpentinized peridotite. With one exception, the prospects within the map area explore structures with very low grade mineralized material and probably have no potential resources. Only at the Tip Top prospect (sample localities 2-7, fig. 25) was development work of consequence done. At this location, an adit and a shaft were driven in a pyritized fracture zone in dacite porphyry which has intruded the peridotite. A small primitive mill was constructed on the claims to process the mineralized material. Tailings from the mill indicate that some production has been made. Table 6 summarizes pertinent geologic information and sample results for the west section of the Teanaway River-Ingalls Creek area.

Two copper prospects are on the flanks of the ridge dividing Fourth Creek and Hardscrabble Creek (fig. 26) in the east section of the Teanaway River-Ingalls Creek area. Although several adits and pits are on the Grandview prospect, sample values indicate no resource potential. The Copper Glance-Clean Sweep adit is on one of two patented claims. A shear zone along the adit

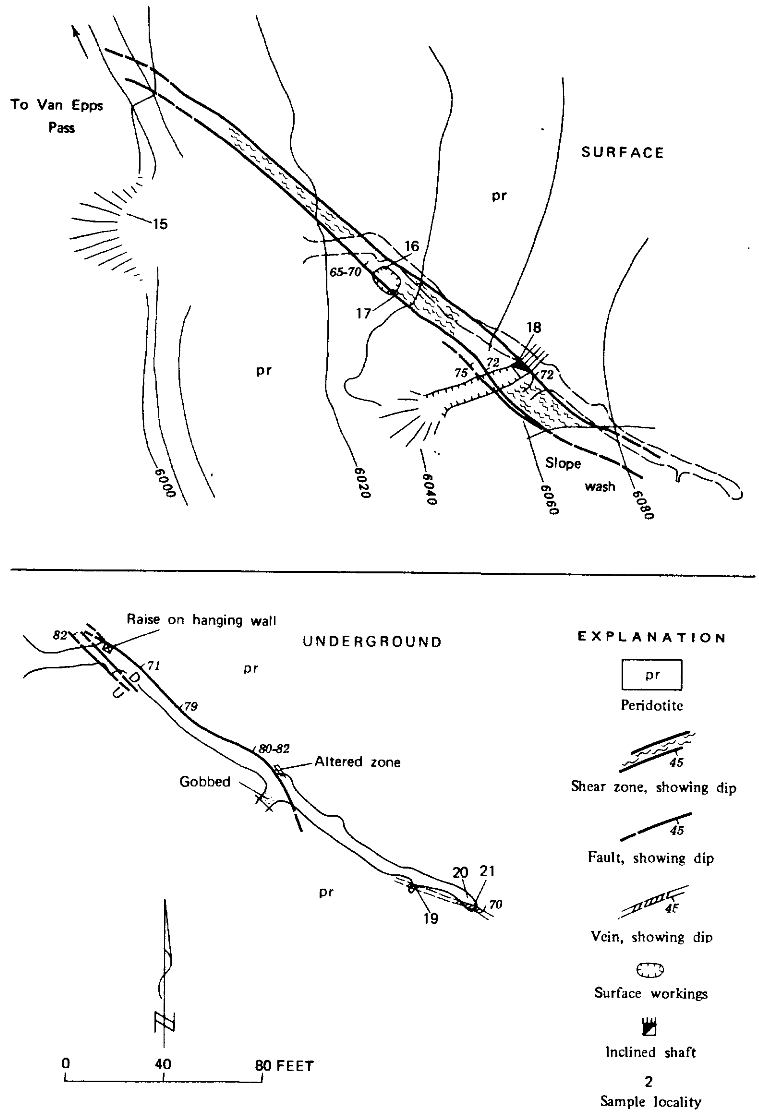


Figure 24.--Benita workings.

Data for samples shown on figure 24

[Tr, trace; N, none detected; --, not analyzed; NA, not applicable]

Sample No.	Sample Type	Length (feet)	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)
15	Grab	NA	N	1.10	2.80
16	Chip	1.5	Tr	1.00	--
17	do	2.9	N	.3	--
18	do	3.0	Tr	1.10	.003
19	do	0.8	N	.20	--
20	Grab	NA	Tr	.50	--
21	Chip	2.5	Tr	.10	--

TABLE 5. - Prospects in the Fortune Creek area

Map No. (fig. 22)	Prospect name	Summary	Sample data
11	Adit	Forty-two-foot-long adit into silicic felsite containing scattered sulfides.	A single chip sample 40 feet along the wall of the adit contained a trace gold, trace of silver and 0.02 percent copper.
12-13	Pits	Pits in peridotite with magnetite dispersions and pyritized shear zones up to 1.0 feet thick.	Three samples contained a maximum of 0.02 percent copper.
14	Pit	Pit in slope wash.	A select grab from debris around pit contained 0.2 ounce silver per ton and 0.02 percent copper.
22	do	Caved pit in silicic felsite.	A random grab sample contained 0.1 ounce silver per ton and 0.01 percent copper.
23-24	Silver Bowl prospect	Caved adit, two trenches, one caved shaft in serpentinitic peridotite which is cut by a dolomite-gypsum-quartz healed shear zone. Evidence of placer mining near adit.	Two chip samples; one contained 0.30 ounce silver per ton.
25	Silver Treasury	Crib bed shaft in peridotite with very minor iron-oxide stained fractures.	Very minor values of metallic minerals.
26-31	Black Bear	Altered shear zone as much as 1.7 feet thick in peridotite.	Five chip samples; maximum 0.31 ounce gold per ton, 0.10 ounces silver per ton and 1.00 percent copper.
32-33	North Fork Trail	Small pits at trail crossings. Peridotite country rock.	Samples contained no metallic values.
34	Jacobson Cabin	Pits and one caved adit on 60-foot-wide iron-oxide stained shear zone in serpentinitized peridotite. Zone strikes N. 11° E., dips vertically. Pyrite and marcasite occur in 15-foot-wide talcose zone on southeast wall of shear zone.	Grab sample of dump from pit; trace gold, 0.4 ounce silver per ton, 0.07 percent copper.

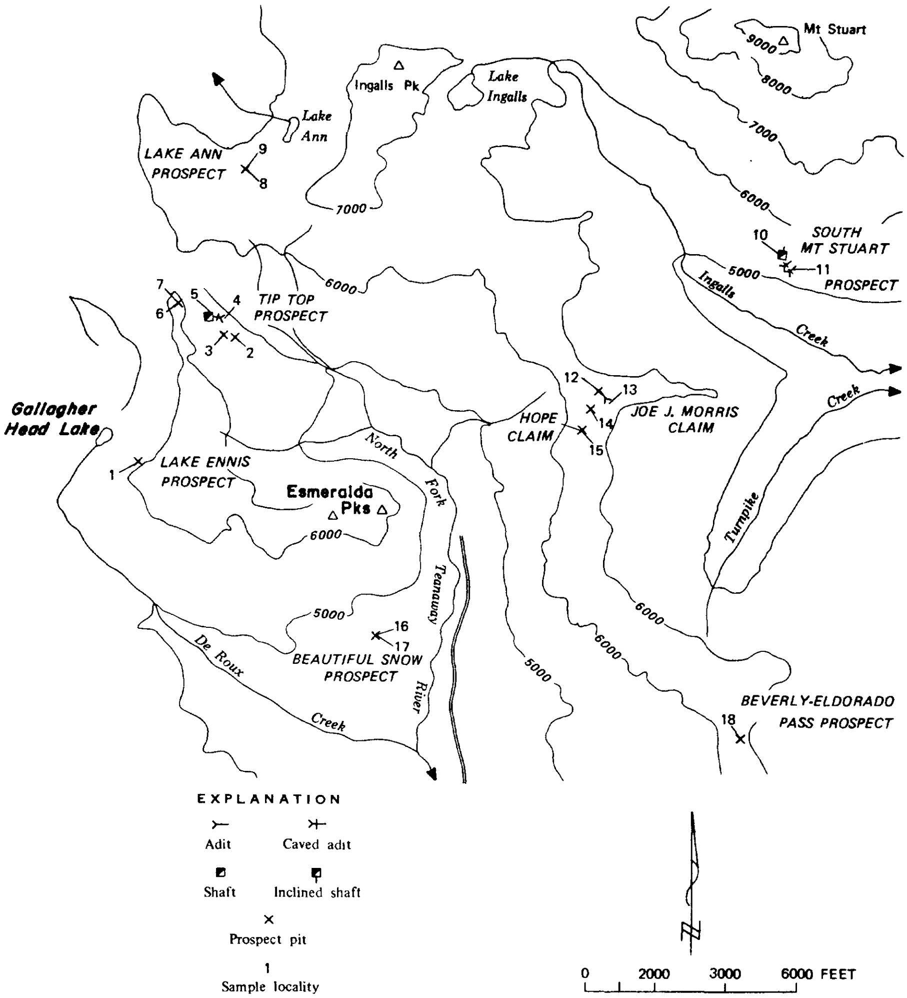


Figure 25.--Prospects in west section of Teanaway River-Ingalls Creek area.

Data for samples shown on figure 25

[Tr, trace; N, none detected; --, not analyzed; NA, not applicable]

Sample No.	Sample Type	Length (feet)	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)
1	Grab	NA	Tr	1.7	2.2
2	do	NA	Tr	0.2	--
3	do	NA	0.34	Tr	--
4	do	NA	.2	.05	--
5	do	NA	N	.02	--
6	Chip	0.5	.04	1.0	.02
7	do	0.7	N	.1	.005
8	Grab	2.0	N	.003	.001
9	do	20.0	N	.2	.0005
10	Chip	9.0	Tr	.1	--
11	do	1.0	N	.1	--
12	Grab	NA	N	N	--
13	Chip	4.0	N	N	--
14	Grab	NA	N	N	--
15	do	NA	N	.1	--
16	Chip	20.0	Tr	Tr	--
17	do	10.0	N	N	--
18	do	10.0	N	N	--

TABLE 6. - Prospects in west section of Teanaway River-Ingalls Creek area

Map No. (fig. 25)	Prospect name	Summary	Sample data
1	Lake Ennis	Open cut on narrow irregular iron-oxide stained zones in peridotite on hillside.	One select grab from a stockpile; trace gold, 1.7 ounces silver per ton, 2.2 percent copper, 0.1 percent lead.
2-7	Tip Top	Pyritized fracture zone in dacite porphyry.	Six samples; as much as 0.34 ounce gold per ton, 1.0 ounce silver per ton, 0.02 percent copper.
8-9	Lake Ann	Small shallow pit in shattered zone striking N. 25° W. and dipping 60° SW. at ridge top. Irregular, discontinuous quartz and barite veinlets in highly altered serpentinite. Grades to greenish-black serpentinite on west edge; east edge is sharp contact with unaltered serpentinite.	Two samples; no gold, maximum 0.2 ounce silver per ton and 0.001 percent copper.
10-11	South Mount Stuart	Caved shafts and pits intensely weathered contact of granodiorite and ultramafic rocks.	Two chip samples; maximum trace gold, 0.1 ounce silver per ton.
12-13	Joe J. Morris	Shallow pit on ridge and short adit 150 feet east of ridge in serpentinite country rock. No continuous structure observed. No economic minerals observed.	Two samples; no gold or silver.
14-15	Hope Lode	Altered area and area of calcite and quartz veins in serpentinite and peridotite. No economic minerals observed.	Two samples; no gold, maximum 0.1 ounce silver per ton.
16-17	Beautiful Snow	Discovery pit in serpentinite. Irregular veins of highly altered, fine-grained white rock, 0.3 to 0.7 feet wide, strikes N. 50° W. and dips 75° SW. Vein parallels foliation of sheared serpentinite.	Two samples; maximum trace gold and silver.
18	Beverly-Eldorado Pass	Fifty-foot-long caved trench along altered peridotite.	One chip sample; no gold or silver.

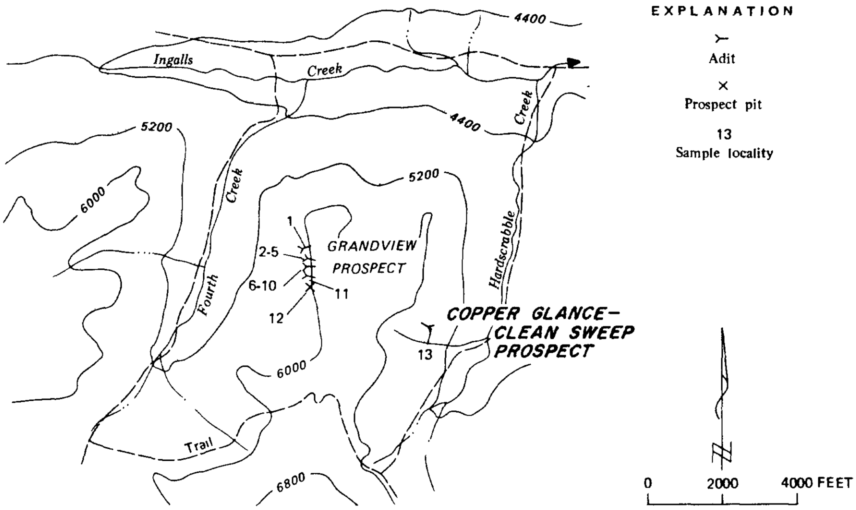


Figure 26.--Prospects in east section of Teanaway River-Ingalls Creek area.

Data for samples shown on figure 26

[Tr, trace; N, none detected; --, not analyzed; NA, not applicable]

Sample No.	Sample Type	Length (feet)	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)
1	Chip	2.0	N	N	--
2	do	5.0	N	N	--
3	do	2.0	N	N	--
4	do	10.0	N	0.1	1.52
5	Select chip	NA	Tr	.7	11.6
6	Chip	7.0	N	N	--
7	do	NA	0.01	Tr	
8	do	2.5	N	N	--
9			.01	Tr	Tr
10	do	15.0	N	.1	4.2
11	do	7.0	N	N	--
12	do	3.0	N	N	--
13	Select grab	NA	N	.70	13.20

contained only sporadic pods and stringers of sulfide minerals. Because of the discontinuous nature and limited length of the structures, the deposits are probably of no importance. Details of the workings and sample results are in table 7.

Navaho Peak area

Serpentinitic peridotite, metavolcanic rock, and anorthositic gabbro are the predominant rock types in the Navaho Peak area (fig. 2). Shears, pervading most of the rock, are subparallel to the contact of the diorite. Most highly mineralized rock is in shear zones or associated with rock contacts. Quartz, talc, and carbonates with minor chalcopyrite, bornite, magnetite, and pyrite occur in veins at most contacts and along most shear zones. The prospects are mostly south and southeast of the peak (fig. 27).

South Navaho Peak workings

The South Navaho Peak workings consist of seven pits or caved adits along a copper-bearing shear zone and a pit in black sheared serpentinite (fig. 28). The workings are outside the study area but the zone or similar zones may extend into the study area. A pit (sample locality 4) exposes an irregular limonite- and malachite-stained zone, mostly serpentinite with an average thickness of 0.3 foot. The zone, striking N. 75° W. and dipping 50° NE., can be traced only 20 feet. Fine-grained magnetite layers about one-half inch thick comprise 10-40 percent of the shear zone. A sample (No. 4, fig. 28) selected from along 4 feet of the zone contained a trace gold, 0.1 ounce silver per ton, 2.24 percent copper, 0.13 percent nickel, and 0.19 percent chromium.

A caved adit (No. 5, fig. 28) and the workings to the east are along a highly irregular sulfide-rich shear zone near and partly along the contact between altered diorite and serpentinitic peridotite. The zone strikes N. 65° W. and dips 55° to 60° NE. The thickness averages about 1.5 feet. About 10-20 percent of lenticular quartz masses, 0.05-1.0 foot thick in the vein, contain arsenopyrite and pyrite as grains less than one-fourth inch diameter. Some massive layers of arsenopyrite and pyrite, however, are at least 0.25 foot wide. Sulfides are about 5-10 percent of the shear zone and chalcopyrite is less than 25 percent of the sulfides. Weathering of the sulfides produces malachite and azurite in the dump debris.

A sample (No. 5, fig. 28) of stained quartz and massive sulfide from the pit contained a trace gold, 0.1 ounce silver per ton, and 0.48 percent copper. A sample (No. 6, fig. 28) selected from malachite-stained material on a dump contained a trace of gold, the equivalent of 0.2 ounce silver per ton, and 1.24 percent copper.

The persistence of the shear zone and the amount of copper in the samples indicate a few thousand tons of potential resources in this area. Similar deposits may exist inside the study area.

Miscellaneous prospects

Miscellaneous properties in the Navaho Peak area (table 8) are all minor and the results of sampling indicate little mineralization in any; some are outside the study area.

TABLE 7. - Prospects in east section of Teanaway River-Ingalls Creek area

Map No. (fig. 26)	Prospect name	Summary	Sample data
1-12	Grandview prospect	Adits and pits in serpentinitic peridotite with a few felsite lenses. Subparallel branching shears 0.5 to 6 feet thick with less than 5 percent cuprite, chalcopyrite, magnetite, chromite, and pyrite. Workings consist of a 40-foot-long trench and adits ranging in length from 13 to 113 feet long.	Twelve samples. Maximum gold, 0.1 ounce per ton; maximum copper, 11.6 percent (specimen taken by an early investigation. Other chip samples contained a maximum of 4.2 percent copper and 0.1 ounce gold and silver per ton. Underground samples contained a maximum of 0.03 percent copper.
13	Copper Glance-Clean Sweep prospect	Mineralized shear zone about 5 feet wide in serpentinitic peridotite. One adit 47 feet long. Pyrite, magnetite, cuprite and chalcopyrite in lenticular pods, constituting about 10 percent of the sheared zone.	Select grab of stockpile; no gold, 0.70 ounce silver per ton, 13.20 percent copper.

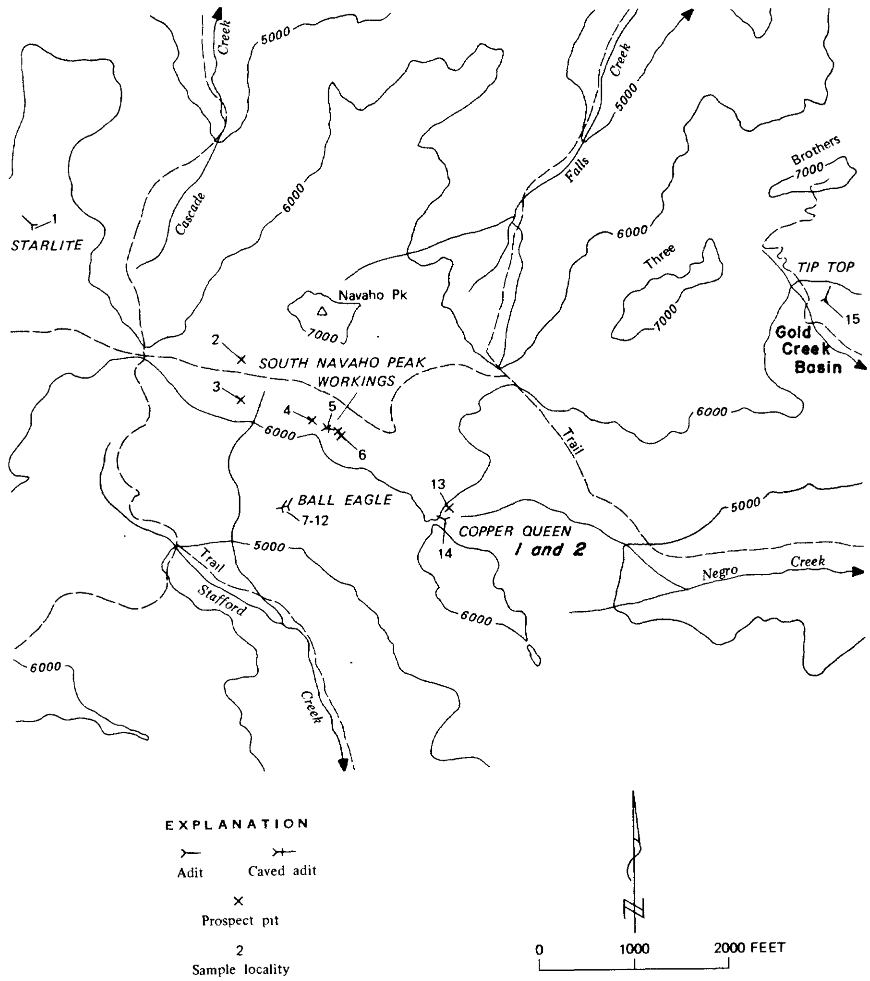


Figure 27.--Navaho Peak area.

Data for samples shown on figure 27

[Tr, trace; N, none detected; --, not analyzed; NA, not applicable]

Sample No.	Type	Length (feet)	Gold (ounces per ton)	Silver (ounces per ton)	Copper (percent)
1	Chip	4	N	N	0.02
2	Grab	NA	Tr	0.1	.35
3	Chip	15	N	N	--
4	do	4	Tr	.1	2.24
5	Grab	NA	Tr	.1	.48
6	do	NA	Tr	.2	1.24
7	do	NA	Tr	.3	<.02
8	Chip	NA	Tr	.1	N
9	do	10	Tr	<.05	<.02
10	do	10	Tr	<.05	.09
11	do	4	Tr	.2	.04
12	Grab	NA	Tr	.1	<.02
13	Chip	3	Tr	.1	--
14	do	4	.02	.1	--
15	Grab	NA	Tr	.1	--

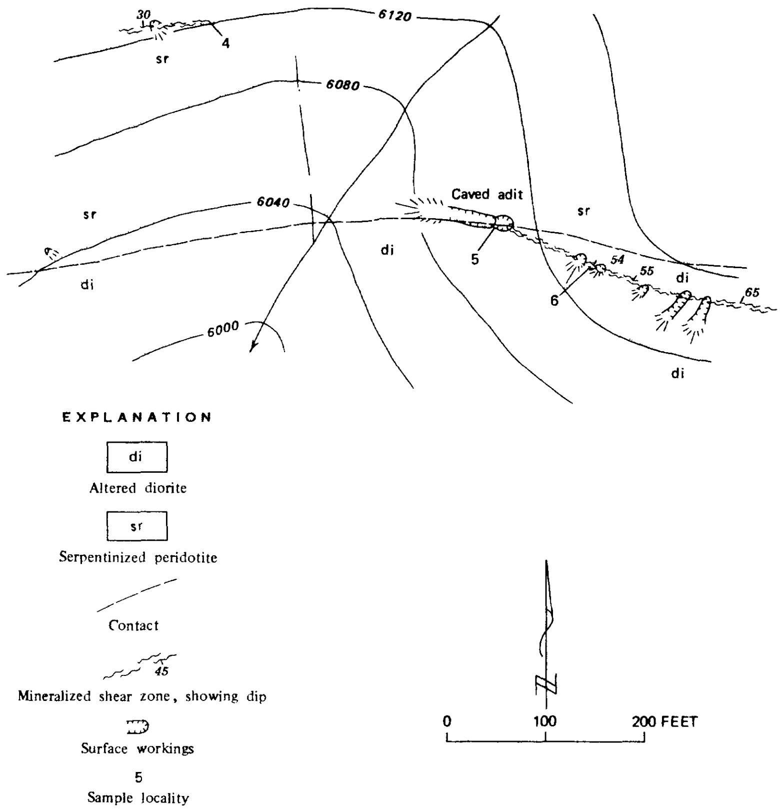


Figure 28.--South Navaho Peak workings.

TABLE 8. - Prospects in the Navaho Peak area

Map No. (fig. 27)	Prospect name	Summary	Sample data
1	Starlite	Adit in slightly sheared serpentinitic peridotite and altered granodiorite dikes (probably outside the study area)	One sample; trace gold and silver, 0.02 percent copper.
2	Navaho Pass	Two caved pits in foliated granodiorite with sheared calcite-quartz veins 1 to 2.5 feet thick and 5 to 15 feet long containing less than 5 percent pyrite, chalcopyrite, chalcocite, and bornite.	One sample; trace gold, 0.1 ounce silver per ton, 0.35 percent copper.
3	Southwest Navaho Peak	Two caved pits in sheared serpentinitic peridotite and fine-grained granodiorite dike (probably outside the study area).	One sample; no gold or silver.
7-12	Ball Eagle	Irregular quartz stringers and lenses of pyrite and chalcopyrite in peridotite dike (outside the tudy area).	Six samples: maximum values; trace gold, 0.3 ounce silver per ton, 0.09 percent copper.
13-14	Copper Queen 1 and 2	Two adits (about 3 and 14 feet long) in sheared serpentinitic peridotite, granodiorite. Sheared quartz-carbonate veins less than 5 feet thick with less than 5 percent sulfides.are exposed.	Two samples; maximum 0.1 ounce gold and 0.2 ounce silver per ton.
15	Tip Top	Adit 570 feet long in altered peridotitic rock.	One sample; no gold, 0.1 ounce silver per ton.

Isolated, outlying prospects

Seven individual lode or placer prospects are outside the areas of figure 2. The prospects have no potential or deposits are not sufficiently exposed to estimate potential. The location description and assay data from samples of these prospects are listed in table 9.

TABLE 9. - Isolated, outlying lode and placer prospects

Prospect name	Location	Summary	Sample data
Galena group	Near the head of Miles Creek, a tributary of Middle Fork Snoqualmie River, near Williams Lake. Property is 2.7 miles S. 32° W. from Dutch Miller mine.	Main working is a 75-foot-long adit in a quartz and pyrite filled breccia zone in schist. Other workings are two short adits and one open cut in the felsite dike in the schist. The portal of another now inaccessible adit driven in an altered zone is on the north slope of Summit Chief Mountain.	Five samples; maximum 0.03 ounce gold per ton, 3.4 ounces silver per ton, and 1.02 percent copper.
Chiwaukum Ridge workings	On the west side of Ewing Basin at the head of Chiwaukum Creek.	A lower adit is 87 feet long in a shear zone in granodiorite near and intertonging mass of schist. The shear contains pyrite. An upper prospect cut is in schist near the contact with an apophysis of granodiorite. Graphite is in fractures and small (15 cm long) pods parallel to the schistosity of the rock.	Assays show no economic minerals.
Elvira claim	On the ridge north of French Creek and approximately three-fourths mile from junction with Icicle Creek.	An open cut and possibly caved adit in a 20-foot-wide, 120-foot-long quartz lens which strikes N. 74° W., dips 80° NE. roughly parallel to the schistosity of the enclosing schist. Sparse sulfide blebs observed in the quartz.	Two samples; no gold, trace silver and less than 0.1 percent copper.
Skookum group	In a draw on the north side of Ben Creek, one-half mile from junction with Jack Creek.	Caved adit and ruins of a cabin. The dump of the caved adit indicates a 300-foot-long working in a vuggy, limonite-stained quartz vein. Vein strikes N. 20° E. and dips vertically. Vein estimated to be approximately 3 feet wide in peridotite country rock.	Select grab sample from quartz on dump contained 0.04 percent copper.
Meadow Creek placers	Three claims on Meadow Creek beginning 2 miles upstream from the confluence with Jack Creek.	Gravel deposits in present stream. Stream gradient uniform and low with no bedrock exposures in the length of stream sampled. Boulders up to 2 feet in diameter.	Six pan samples; less than 1 cent per cubic yard. All samples contained anomalous amounts of scheelite (calcium tungstate).
Addie and Pau Hana placer claims (Icicle Creek placers)	Two placer gold claims on the south side of Icicle Creek downstream from the mouth of Eightmile Creek.	One gravel bar approximately 16 acres and 1 gravel bar 26 acres in area plus smaller gravel deposits along Icicle Creek. Edges of the bars were sampled at seven favorable exposures near the creek.	Seven samples; 3 cents per cubic yard. All samples contained anomalous amounts of garnet.
June Bug-Washika group	Vicinity of Windy Pass, approximately 2 miles southwest of Cashmere Mountain.	Subparallel, irregular quartz veins and masses striking about N. 10° E. and dipping nearly vertical. Veins are 5 to 50 feet wide in schist and serpentinite. No sulfide minerals observed in the quartz. Minor, narrow pods of asbestos (chrysotile) in the serpentinite. Fibers are coarse, brittle, and short.	No significant values.

Table 10.--Analytical results of anomalous samples from the Alpine Lakes area

[The analytical data in the table are separated into three categories on the basis of the type of sample taken: rock, panned concentrate, and stream sediment. The data are further classified on the basis of 12 areas containing anomalous amounts of metal with an additional group that includes all anomalous samples taken from outside the anomalous areas.

The letter symbols shown at the head of the columns of analytical data indicate as follows: S, 6-step semiquantitative spectrographic analysis; AA, atomic absorption; P, partial digestion; CM-CX-HM, citrate soluble heavy metals colorimetric test; and CM, colorimetric test (where shown with SB, antimony, or MO, molybdenum), or paper chromatography (where shown with U, uranium). The letter symbols at the right of the analytical data indicate as follows: N, looked for but not detected; L, detected but below limit of determination value shown; and G, detected in quantities greater than value shown; OB indicates not determined.

All elements and citrate soluble heavy metals are reported in parts per million]

TABLE 10. ANALYTICAL RESULTS OF ANOMALOUS SAMPLES FROM THE ALPINE LAKES AREA

SAMPLE	S-AG	S-AS	S-CU	S-MO	S-PB	S-SB	S-SN	S-W	S-ZN	AA-AU-P	AA-CU-P	AA-ZN-P	CM-CX-HM	CM-MO
ROCK SAMPLE BULLS TOOTH AREA														
EG1144	0.5N	200N	70	5N	15	100N	10	50N	200L	0.05N	0B	0B	0B	0B
ROCK SAMPLES FRENCH RIDGE AREA														
EG1166A	0.5	200N	500	5N	10L	100N	10N	50N	200N	0.05N	0B	0B	0B	0B
EG1167	0.7	200N	500	5N	10	100N	10N	50N	200N	0.05N	0B	0B	0B	0B
EG1167A	0.7	200N	50	5N	10L	100N	15	50N	200N	0.05N	0B	0B	0B	0B
EG1167B	1.5	200N	100	5N	10	100N	10N	50N	200L	0.05N	0B	0B	0B	0B
EG1168	0.7	200N	200	5	10	100N	10N	50N	200N	0.05N	0B	0B	0B	0B
EG1169	0.5N	200N	200	5N	10	100N	10N	50N	200N	0.0 B	0B	0B	0B	0B
EG1169A	0.5N	200N	100	5N	10L	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG1169B	0.5N	200N	100	5N	10L	100N	10N	50N	200N	0.0 B	0B	0B	0B	0B
STREAM SEDIMENT SAMPLES FRENCH RIDGE AREA														
ES0002	0.5N	200N	70	5N	10	100N	10N	50N	200N	0.0 B	100	120	16	0B
ES0004	0.5N	200N	30	5N	15	100N	10N	50N	200N	0.0 B	25	110	3	0B
ES0005	0.5N	200N	30	5L	15	100N	10N	50N	200N	0.0 B	20	180	18	0B
ES0006	0.5N	200N	50	5L	30	100N	10N	50N	300	0.0 B	35	400	40	0B
ES1172	0.7	200N	10	5N	15	100N	10N	50N	200	0.0 B	45	0B	70	0B
STREAM SEDIMENT SAMPLES LELAND CREEK AREA														
EG0178	0.5N	200N	100	5N	10	100N	10N	50N	200N	0.0 B	100	25	18	0B
EG0258	0.5N	200N	7	5N	70	100N	10N	50N	200N	0.0 B	5L	35	1L	0B
EG0260	0.5N	200N	15	5N	50	100N	10N	50N	200N	0.0 B	0B	0B	2	0B
EG0267	0.5N	200N	15	10	15	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
EG0268	0.5N	200N	15	5	15	100N	10N	50N	200N	0.0 B	15	60	3	0B
EG0270	0.5N	200N	15	20	15	100N	10N	50N	200N	0.0 B	10	55	10	0B
EG0273	0.5N	200N	15	7	15	100N	10N	50N	200N	0.0 B	10	30	3	0B
EG0274	0.5N	200N	20	10	50	100N	10N	50N	200N	0.0 B	10	35	2	0B
EG0276	0.5N	200N	15	5	10	100N	10N	50N	200N	0.0 B	20	40	5	0B
EG0289	0.5N	200N	15	5	15	100N	10N	50N	200N	0.0 B	0B	0B	1	0B
EG0290	0.5N	200N	20	5	20	100N	10N	50N	200N	0.0 B	15	30	5	0B
EG0783	0.5N	200N	20	15	10	100N	10N	50N	200L	0.0 B	15	45	1	20
EK0129	0.5N	200N	20	15	10L	100N	10N	50N	200N	0.0 B	10	35	2	15
ES0003	0.5N	200N	15	5	15	100N	10N	50N	200N	0.0 B	10	50	6	0B
ROCK SAMPLES THE CRADLE AREA														
EG0326	0.5N	200N	150	5N	10N	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG0417	0.5N	200N	300	5N	10N	100N	10N	50N	200N	0.02N	270	0B	0B	2L
EG0840	0.5N	200N	50	5N	10	100N	10N	70	200L	0.0 B	0B	0B	0B	0B

TABLE 10. ANALYTICAL RESULTS OF ANOMALOUS SAMPLES FROM THE ALPINE LAKES AREA - CONTINUED

SAMPLE	S-AG	S-AS	S-CU	S-MO	S-PB	S-SB	S-SN	S-W	S-ZN	AA-AU-P	AA-CU-P	AA-ZN-P	CM-CX-HM	CM-MO
ROCK SAMPLES THE CRADLE AREA-CON.														
EG0840A	0.5N	200N	150	15	10L	100N	10N	50N	200L	0.05N	0B	0B	0B	0B
EG1117	0.5N	200N	50	5N	10N	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG1125	0.5N	200N	20	5N	10L	100N	10N	70	200N	0.05N	0B	0B	0B	0B
EG1127	0.5N	300	30	5N	10L	100N	10N	300	200N	0.05N	0B	0B	0B	0B
EG1128	0.7	300	70	5N	10	100N	10N	50N	200N	0.05N	0B	0B	0B	0B
EG1131	0.5	200N	100	10	10	100N	10N	300	200N	0.05N	0B	0B	0B	0B
EG1136	0.5N	200N	150	5N	15	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG1141	0.5N	200N	7	5N	10N	100N	20	50N	200N	0.05N	0B	0B	0B	0B
ES1047	0.5N	200N	100	5N	10	100N	10N	50N	200L	0.05N	0B	0B	0B	0B
STREAM SEDIMENT SAMPLES THE CRADLE AREA														
EG0181	0.5N	200N	7	15	10L	100N	10N	50N	200N	0.0 B	10	20	2	30
EG0190	0.5N	200N	10	7	10L	100N	10N	50N	200N	0.0 B	10	25	1L	0B
EG0191	0.5N	200N	20	10	10L	100N	10N	50N	200N	0.0 B	10	30	2	0B
EG0192	0.5N	200N	10	5	10L	100N	10N	50N	200N	0.0 B	5	25	2	0B
EG0197	0.5N	200N	50	10	10	100N	10N	50N	200N	0.0 B	20	20	1L	0B
EG0202	0.5N	200N	30	20	10L	100N	10N	50N	200N	0.0 B	25	45	2	20
EG0203	0.5N	200N	70	7	20	100N	10N	50N	200N	0.0 B	50	40	25	0B
EG0216	0.5N	200N	50	5N	15	100N	10N	50N	200N	0.0 B	45	45	18	0B
EG0237	0.5N	200N	20	5	15	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
EG0299	0.5N	200N	50	10	10	100N	10N	50N	200N	0.0 B	0B	0B	2	0B
EG0300	0.5N	200N	70	7	50	100N	10N	50N	200N	0.0 B	55	55	1L	0B
EG0314	0.5N	200N	50	5N	10L	100N	10N	50N	200N	0.0 B	30	40	18	0B
EK0124	0.5N	200N	15	5	10L	100N	10N	50N	200N	0.0 B	0B	0B	2	0B
EK0125	0.5N	200N	30	15	10L	100N	10N	50N	200N	0.0 B	15	40	1	25
EK0126	0.5N	200N	15	15	10L	100N	10N	50N	200N	0.0 B	10	40	2	20
EK0127	0.5N	200N	15	15	10L	100N	10N	50N	200N	0.0 B	10	50	2	25
EK0128	0.5N	200N	20	15	10L	100N	10N	50N	200N	0.0 B	15	45	2	25
EK0130	0.5N	200N	30	10	10L	100N	10N	50N	200N	0.0 B	0B	0B	2	0B
EK0131	0.5N	200N	20	10	10L	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
EK0132	0.5N	200N	30	10	10L	100N	10N	50N	200N	0.0 B	0B	0B	2	0B
EK0134	0.5N	200N	20	5	10	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
EK0138	0.5N	200N	15	5N	10L	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
EK0156	0.5N	200N	30	30	15	100N	10N	50N	200N	0.0 B	20	30	2	15
EK0157	0.5N	200N	30	20	15	100N	10N	50N	200N	0.0 B	15	35	2	15
EK0158	0.5N	200N	30	10	30	100N	10N	50N	200N	0.0 B	15	35	2	10
EK0159	0.5N	200N	20	15	10	100N	10N	50N	200N	0.0 B	15	35	2	15
EK0160	0.5N	200N	30	15	10L	100N	10N	50N	200N	0.0 B	30	40	2	20
EK0161	0.5N	200N	15	10	10L	100N	10N	50N	200N	0.0 B	0B	0B	2	0B

TABLE 10. ANALYTICAL RESULTS OF ANOMALOUS SAMPLES FROM THE ALPINE LAKES AREA - CONTINUED

SAMPLE	S-AG	S-AS	S-CU	S-MO	S-PB	S-SB	S-SN	S-W	S-ZN	AA-AU-P	AA-CU-P	AA-ZN-P	CM-CX-HM	CM-MO
STREAM SEDIMENT SAMPLES THE CRADLE AREA-CON.														
EK0163	0.5N	200N	50	15	10L	100N	10N	50N	200N	0.0 B	20	35	1	15
EK0171	0.5N	200N	150	5N	10	100N	10N	50N	200N	0.0 B	130	50	1	0B
EK0172	0.5N	200N	150	5N	15	100N	10N	50	200N	0.0 B	140	45	2	0B
EK0173	0.5N	200N	100	5N	15	100N	10N	50N	200N	0.0 B	100	35	1	0B
ES0018	0.5N	200N	50	5L	10	100N	10N	100	200N	0.0 B	0B	0B	2	0B
ES0022	0.5N	200N	30	10	15	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
ES0023	0.5N	200N	30	5	10	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
ES0244	0.5N	200N	30	15	20	100N	10N	50N	200N	0.0 B	20	35	1L	25
ROCK SAMPLES PADDY-GO-EASY-PASS AREA														
EG1448	10.0	1500	150	5N	200	100N	15	50N	200L	1.00	0B	0B	0B	0B
EG1448A	15.0	10000G	1500	5N	100	500	10N	50N	200L	30.00	0B	0B	0B	0B
EG1449	0.5N	500	70	5N	10N	100N	10N	50N	200N	0.05	0B	0B	0B	0B
EG1449A	0.5N	300	1500	5N	10N	100N	10N	50N	200L	0.05L	0B	0B	0B	0B
EG1451	15.0	200L	700	5N	15	100N	10N	50N	200N	70.00	0B	0B	0B	0B
EG1451A	0.5N	200N	500	5N	10N	100N	10N	50N	200N	0.10	0B	0B	0B	0B
EG1451C	2.0	200N	5000	5N	10N	100N	10N	200	200L	0.15	0B	0B	0B	0B
EG1451D	15.0	200N	20000	5N	10N	100N	10N	50N	200L	2.00	0B	0B	0B	0B
EG1453	0.5N	10000	15	5N	10N	100N	10N	50N	200N	1.50	0B	0B	0B	0B
EG1453A	0.7	10000G	200	5N	10N	300	10N	50N	200L	9.00	0B	0B	0B	0B
EK0474	0.5N	200N	300	5N	10N	100N	10N	50N	200N	0.0 B	0B	0B	0B	0B
EK0474A	2.0	200N	2000	5N	10N	100N	10N	50N	200N	0.06	200	0B	0B	2L
ES1110	150.0	3000	20000G	7	10N	100L	50	50N	700	2.00	0B	0B	0B	0B
ES1111	5.0	10000G	700	50	10L	300	10N	50N	200L	48.00	0B	0B	0B	0B
STREAM SEDIMENT SAMPLE PADDY-GO-EASY-PASS AREA														
ET0421	0.5N	200N	30	5N	50	100N	10N	50N	200N	0.0 B	35	60	3	0B
ROCK SAMPLES VAN EPPS PASS AREA														
EG1059	5.0	200N	200	5N	15	100N	10N	50N	200	0.05L	0B	0B	0B	0B
EG1059A	20.0	200N	5000	5N	10L	100N	10N	50N	200N	0.10	0B	0B	0B	0B
EG1060	0.7	200N	50	5N	10	100N	10	50N	200N	0.05N	0B	0B	0B	0B
EG1061	100.0	200N	20000G	30	10L	100N	100	50N	1500	0.45	0B	0B	0B	0B
EG1063	15.0	200N	700	30	10N	100N	10N	50N	300	0.05L	0B	0B	0B	0B
EG1063A	70.0	500	5000	5N	5000	100N	10N	50N	10000G	0.10	0B	0B	0B	0B
EG1063B	15.0	200N	7000	150	50	100N	10N	50N	500	0.20	0B	0B	0B	0B
EG1063C	1.5	200N	1500	5N	15	100N	10N	50N	700	0.05L	0B	0B	0B	0B
EG1068	7.0	200N	15000	500	10L	100N	10L	50N	200N	0.30	0B	0B	0B	0B
EG1068A	3.0	200N	10000	50	10N	100N	10N	50N	200N	0.20	0B	0B	0B	0B
EG1096	10.0	300	30	5N	100	100N	10N	50N	200	0.60	0B	0B	0B	0B

TABLE 10. ANALYTICAL RESULTS OF ANOMALOUS SAMPLES FROM THE ALPINE LAKES AREA - CONTINUED

SAMPLE	S-AG	S-AS	S-CU	S-MO	S-PB	S-SB	S-SN	S-W	S-ZN	AA-AU-P	AA-CU-P	AA-ZN-P	CM-CX-HM	CM-MO
ROCK SAMPLES VAN EPPS PASS AREA-CON.														
EG1108	0.5L	200N	10	5N	10N	100N	10N	50N	200	0.05N	0B	0B	0B	0B
EG1109A	0.5N	200N	100	5N	10	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG1114	3.0	200N	20	5N	200	100N	10N	50N	200N	2.00	0B	0B	0B	0B
EG1454	2.0	700	700	5N	10L	100N	10N	50N	200L	0.05L	0B	0B	0B	0B
EG1454A	0.7	200N	100	5N	20	100N	10N	50N	300	0.05N	0B	0B	0B	0B
EG1454B	10.0	200N	5000	20	10N	100N	10N	50N	200	0.20	0B	0B	0B	0B
EG1454C	0.5N	200N	500	5N	10L	100N	10N	50N	200N	0.05N	0B	0B	0B	0B
EG1454D	2.0	200N	30	15	10N	100N	10N	50N	200	0.05N	0B	0B	0B	0B
EG1455	0.5	200N	50	5N	10N	100N	10N	50N	200L	0.05N	0B	0B	0B	0B
EK0153A	0.5N	200N	200	5N	10N	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EK0153D	0.5N	200N	150	5N	10L	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EK0484	20.0	200N	7000	10	10N	100N	70	50N	200	0.15	7900	0B	0B	15
ES1112	0.5N	700	150	5N	10N	300	10N	50N	200L	0.05	0B	0B	0B	0B
ES1113	0.5L	700	200	7	10N	100N	10N	50N	200N	0.05L	0B	0B	0B	0B
STREAM SEDIMENT SAMPLES VAN EPPS PASS AREA														
EG1064	0.5N	200N	700	20	10	100N	10N	50N	200N	0.05N	570	0B	40	0B
EG1065	0.5	200N	1000	30	30	100N	10N	50N	200	0.05N	1300	0B	160	0B
EG1066	0.5N	200N	200	10	15	100N	10N	50N	500	0.05N	150	0B	16	0B
EG1069	0.5N	200N	500	5N	10L	100N	10N	50N	200	0.05L	440	0B	20	0B
EG1097	0.5N	200N	50	5N	50	100N	10N	50N	300	0.05	30	0B	20	0B
EG1100	0.5N	200N	50	5N	10L	100N	10N	50N	200L	0.0 B	15	0B	1	0B
EG1107	0.5N	200N	30	5N	15	100N	10N	50N	200L	0.05N	45	0B	18	0B
EK0153	0.5N	200N	15	5	10	100N	10N	50N	200N	0.0 B	15	40	1	0B
EK0154	0.5N	200N	30	5	10L	100N	10N	50N	200N	0.0 B	20	45	2	0B
EK0155	0.5N	200N	10	5	10L	100N	10N	50N	200N	0.0 B	15	35	3	0B
EK0358	0.5	200N	300	7	30	100N	10N	50N	200	0.15	340	95	6	0B
ET0304	1.0	200N	30	5N	20	100N	10N	50N	200N	0.02L	25	50	2	0B
ET0306	0.5	200N	70	5N	30	100N	10N	50N	200	0.02	50	190	8	0B
ROCK SAMPLES ESMERALDA PEAKS AREA														
EG1070	3.0	1000	3000	5N	15	100N	10N	50N	300	16.0	0B	0B	0B	0B
EG1070A	0.5N	200L	500	5N	10L	100N	10N	50N	3000	2.50	0B	0B	0B	0B
EG1081	0.5N	200N	300	5N	10N	100N	10N	50N	200N	0.0 B	0B	0B	0B	0B
EG1081A	2.0	200N	20000G	30	10N	100N	10N	50N	500	0.05N	0B	0B	0B	0B
EG1081B	0.5N	200N	10000	5N	10N	100N	10N	50N	200	0.05N	0B	0B	0B	0B
EK0114D	1.5	200N	200	5N	10N	100N	10N	50N	200N	0.02N	360	0B	0B	4
STREAM SEDIMENT SAMPLES ESMERALDA PEAKS AREA														
EG1071	0.5N	200N	30	5N	15	100N	10N	50N	200	0.05N	30	0B	3	0B

TABLE 10. ANALYTICAL RESULTS OF ANOMALOUS SAMPLES FROM THE ALPINE LAKES AREA - CONTINUED

SAMPLE	S-AG	S-AS	S-CU	S-MO	S-PB	S-SB	S-SN	S-W	S-ZN	AA-AU-P	AA-CU-P	AA-ZN-P	CM-CX-HM	CM-MO
STREAM SEDIMENT SAMPLES ESMERALDA PEAKS AREA-CON.														
EK0119	0.5N	200N	50	5N	10L	100N	10N	50N	200N	0.0 B	50	120	12	0B
ROCK SAMPLES GOLD CREEK-DELATE CREEK AREA														
EG0537	1.0	200N	150	5N	10L	100N	10N	50N	200N	0.0 B	0B	0B	0B	0B
EG0541	0.5N	200N	150	5N	10L	100N	10N	50N	200N	0.0 B	0B	0B	0B	0B
EG0606	1.5	200N	70	5N	70	100N	10	50N	500	0.02N	120	0B	0B	2L
EG1309	0.5N	200N	30	5N	10N	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG1332	3.0	200L	30	5N	500	100L	10N	50	7030	0.05N	0B	0B	0B	0B
EG1373	0.5N	200N	15	5N	10L	100N	10N	50N	300	0.05N	0B	0B	0B	0B
EG1383	0.5N	200N	100	5N	10N	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG1384	0.5L	200N	50	7	15	100N	10N	50N	200L	0.05N	0B	0B	0B	0B
EG1385	0.5N	200N	100	5N	10L	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG1388	0.5	200N	30	5N	30	100N	10N	50N	200	0.05N	0B	0B	0B	0B
EG1390	0.5L	200N	30	10	30	100N	10N	50N	200N	0.05N	0B	0B	0B	0B
EG1393	0.5N	200N	20	5	10L	100N	10N	50N	200N	0.05N	0B	0B	0B	0B
EG1396	70.0	7000	1500	5	2000	300	15	50N	10000G	2.00	0B	0B	0B	0B
EG1396A	15.0	1000	2000	5N	150	100L	10	70	700	0.45	0B	0B	0B	0B
EG1396B	70.0	2000	700	5L	500	100N	20	50L	10000	0.50	0B	0B	0B	0B
ES0165A	1.0	200N	150	5N	50	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
ES0166	1.5	200N	1000	5N	10	100N	10N	50N	700	0.02N	430	0B	0B	4
ES0166A	0.5N	200N	200	50	10N	100N	10N	50N	200N	0.02N	75	0B	0B	60
ES0166B	1.0	200N	1500	5N	10N	100N	10N	50N	200N	0.02L	1800	0B	0B	6
ES0166C	0.5N	200N	150	15	10N	100N	10	50N	200N	0.02N	300	0B	0B	15
ES0169B	0.5N	200N	200	15	10L	100N	10N	50N	200N	0.0 B	0B	0B	0B	0B
ES0190B	0.5N	200N	70	20	10N	100N	10L	50N	200N	0.02N	40	0B	0B	25
ES1080C	0.5N	200N	50	5N	10N	100N	50	50N	200	0.05L	0B	0B	0B	0B
ES1085	1.5	200N	30	5N	10	100N	10N	50N	200L	0.05N	0B	0B	0B	0B
ES1086	0.7	200N	100	5N	10	100N	10N	50N	200	0.05N	0B	0B	0B	0B
ES1097	1.0	200N	150	5N	10	100N	10N	50N	300	0.05N	0B	0B	0B	0B
ES1097A	30.0	700	150	5N	300	100L	10N	50L	1000	0.20	0B	0B	0B	0B
ES1097B	200.0	1500	300	5N	1000	200	10N	50N	10000G	3.00	0B	0B	0B	0B
ES1097C	700.0	1500	1000	5N	20000G	500	10N	70	10000	0.95	0B	0B	0B	0B
ES1097D	150.0	1000	1000	15	1000	100L	10N	50	10000G	1.00	0B	0B	0B	0B
STREAM SEDIMENT SAMPLES GOLD CREEK-DELATE CREEK AREA														
EG0527	2.0	200N	150	15	70	100N	10N	50N	200N	0.02N	180	180	25	15
EG0528	0.5N	200N	50	5N	20	100N	10N	50N	200N	0.0 B	0B	0B	35	0B
EG0529	1.5	200N	150	10	50	100N	10N	50N	200N	0.0 B	150	90	16	10
EG0530	0.7	200N	150	15	30	100N	10N	50N	200N	0.02L	140	55	6	15

TABLE 10. ANALYTICAL RESULTS OF ANOMALOUS SAMPLES FROM THE ALPINE LAKES AREA - CONTINUED

SAMPLE	S-AG	S-AS	S-CU	S-MO	S-PB	S-SB	S-SN	S-W	S-ZN	AA-AU-P	AA-CU-P	AA-ZN-P	CM-CX-HM	CM-MO
STREAM SEDIMENT SAMPLES GOLD CREEK-DELATE CREEK AREA-CON.														
EG0531	0.5N	200N	150	5	30	100N	10N	50N	200N	0.0 B	100	75	8	4
EG0532	0.5N	200N	100	10	20	100N	10N	50N	200N	0.0 B	140	90	5	8
EG0535	0.7	200N	100	5N	100	100N	10N	50N	200N	0.04N	100	280	14	2
EG0538	0.5	200N	70	5N	15	100N	10N	50N	200N	0.0 B	130	45	6	2
EG0539	0.5L	200N	150	5	50	100N	10N	50N	200N	0.04N	280	110	18	10
EG0540	1.5	200N	70	5N	150	100N	10N	50N	200N	0.0 B	55	160	16	4
EG0545	1.5	200N	100	5	30	100N	10N	50N	200N	0.02L	110	120	2	6
EG0546	0.5	200N	70	5N	20	100N	10N	50N	200N	0.02L	45	30	2	2L
EG0549	0.5N	200N	70	5N	30	100N	10N	50N	200N	0.0 B	55	100	2	2L
EG0555	1.0	200N	100	5N	10	100N	10N	50N	200N	0.0 B	160	75	2	0B
EG0558	0.5N	200N	100	5N	30	100N	10N	50N	200N	0.0 B	100	190	3	0B
EG0566	0.5N	200N	15	5N	50	100N	10N	50N	200N	0.0 B	30	25	3	0B
EG0571	0.5N	200N	100	5N	10	100N	10N	50N	200N	0.0 B	30	45	1L	0B
EG0588	0.5N	200N	30	5N	50	100N	10N	50N	200N	0.0 B	35	75	2	0B
EG0589	0.5N	200N	15	5N	50	100N	10N	50N	200N	0.0 B	20	55	1	0B
EG0600	0.7	200N	30	5N	30	100N	10N	50N	200N	0.0 B	35	95	3	0B
EG0602	0.7	200N	100	5N	20	100N	10N	50N	200N	0.04N	150	100	1L	0B
EG0604	0.5N	200N	15	5N	70	100N	10N	50N	200N	0.0 B	0B	0B	6	0B
EG0641	0.5N	200N	20	5N	50	100N	10N	50N	200N	0.0 B	20	20	3	0B
EG0644	1.0	200N	20	5N	30	100N	10N	50N	200N	0.02N	15	65	1	0B
EG0665	0.5N	200N	15	5N	50	100N	10N	50N	200N	0.0 B	25	80	8	0B
EG1364	0.5N	200N	10	5N	20	100N	10N	50N	200N	0.0 B	20	0B	16	0B
ES0164	1.0	200N	100	5	100	100N	10N	50N	200	0.0 B	120	350	12	6
ES0167	2.0	200N	100	5	50	100N	10N	50N	200N	0.0 B	140	70	2	6
ES0168	0.5N	200N	150	15	20	100N	10N	50N	200N	0.0 B	160	95	3	15
ES0169	0.5N	200N	150	5	30	100N	10N	50N	200N	0.0 B	240	200	10	8
ES0170	0.5N	200N	150	10	50	100N	10N	50N	200L	0.0 B	230	220	2	15
ES0171	0.5N	200N	100	5	30	100N	10N	50N	200L	0.0 B	130	230	6	10
ES0172	0.5	200N	100	10	30	100N	10N	50N	200N	0.0 B	220	95	3	15
ES0173	1.5	200N	200	5	30	100N	10N	50N	200L	0.02L	380	140	20	10
ES0175	1.0	200N	100	5L	30	100N	10N	50N	200N	0.0 B	130	130	6	15
ES0176	0.5	200N	70	5L	30	100N	10N	50N	200N	0.0 B	70	110	2	6
ES0177	1.5	200N	70	5N	70	100N	10N	50N	200N	0.0 B	90	200	5	6
ES0178	0.7	200N	150	5N	30	100N	10N	50N	200L	0.02N	55	110	2	2
ES0182	0.5	200N	30	5N	50	100N	10N	50N	200L	0.04N	60	240	12	0B
ES0183	0.5N	200N	50	5N	50	100N	10N	50N	200L	0.0 B	50	190	3	0B
ES0184	0.7	200N	50	5N	70	100N	10N	50N	200	0.04N	50	210	3	0B
ES0186	0.5N	200N	70	5N	30	100N	10N	50N	200L	0.0 B	85	190	2	0B
ES0187	0.5N	200N	70	5N	30	100N	10N	50N	200N	0.0 B	75	150	3	0B
ES0190	0.5N	200N	70	5N	30	100N	10N	50N	200N	0.0 B	140	20	3	0B

TABLE 10. ANALYTICAL RESULTS OF ANOMALOUS SAMPLES FROM THE ALPINE LAKES AREA - CONTINUED

SAMPLE	S-AG	S-AS	S-CU	S-MO	S-PB	S-SB	S-SN	S-W	S-ZN	AA-AU-P	AA-CU-P	AA-ZN-P	CM-CX-HM	CM-MO
STREAM SEDIMENT SAMPLES GOLD CREEK-DELATE CREEK AREA-CON.														
ES0192	0.5N	200N	200	20	20	100N	10N	50N	200N	0.0 B	440	35	18	60
ES0193	0.5N	200N	50	15	10	100N	10N	50N	200N	0.0 B	55	30	1L	25
ES0194	1.5	200N	150	10	30	100N	10N	50N	200N	0.02L	180	120	3	8
PANNED CONCENTRATE SAMPLE GOLD CREEK-DELATE CREEK AREA														
ES1099	1.5	200N	100	5N	15	100N	10N	50N	200L	0.10	0B	0B	0B	.B
ROCK SAMPLES LEMAH CREEK-SNOQUALMIE RIVER-GOLD LAKE AREA														
EG0655A	0.5N	200N	100	5N	10	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG0657	0.5N	200N	150	5N	10	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG0671	0.5N	200N	50	5N	10	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG0672	0.5N	200N	50	5N	15	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG0672A	0.5N	200N	30	10	10	100N	50	50N	200N	0.02N	10	0B	0B	2
EG0673	1.5	200N	50	5N	10L	100N	10N	50N	200N	0.02N	55	0B	0B	6
EG0674	0.5N	200N	100	5N	15	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG0675	0.5N	200N	7	5N	30	100N	10N	50N	700	0.0 B	0B	0B	0B	0B
EG0675A	2.0	200N	30	5N	70	100N	10N	50N	300	0.0 B	0B	0B	0B	0B
EG1312A	0.5N	200N	50	5N	10N	100N	10N	50N	200	0.05N	0B	0B	0B	0B
EG1321	0.5N	200N	100	5N	10	100N	10N	50N	300	0.05N	0B	0B	0B	0B
EG1321A	0.5N	200N	70	5N	10	100N	10N	50N	200	0.05N	0B	0B	0B	0B
EG1322	3.0	200N	700	10	150	100L	50	50L	500	0.05N	0B	0B	0B	0B
EG1322A	30.0	200N	300	5N	100	100	30	50L	200	0.05N	0B	0B	0B	0B
EG1322B	70.0	300	7000	5N	10N	100	10N	70	700	0.15	0B	0B	0B	0B
EG1322C	0.7	200N	50	5N	20	100N	10N	50N	200L	0.05N	0B	0B	0B	0B
EG1322D	300.0	300	10000	5N	10	1500	10N	50L	10000G	1.00	0B	0B	0B	0B
EG1322E	70.0	200N	20000	5N	10L	200	10N	50N	10000G	0.05	0B	0B	0B	0B
EG1336	0.5N	200N	70	5N	10N	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG1339	0.5N	200N	100	5N	10L	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG1340	0.5N	200N	70	5N	10N	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG1340A	0.5N	200N	70	5N	10N	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG1349	0.5N	200N	20	5N	10L	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG1399	2.0	200N	30	5N	150	100L	15	50N	200	0.05N	0B	0B	0B	0B
EG1400B	0.5	200N	7	5N	10	100N	10N	50N	200N	0.05N	0B	0B	0B	0B
EG1402	0.5N	200N	30	5N	10	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG1403	0.7	200N	15	5N	20	100N	10N	50N	200N	0.05N	0B	0B	0B	0B
EG1408	1.0	200N	500	5N	100	100N	10N	50N	300	0.05N	0B	0B	0B	0B
EG1408A	0.7	200N	30	5N	10L	100N	10N	50N	200N	0.05N	0B	0B	0B	0B
EG1409	7.0	200N	10000	5N	10	100N	10L	50L	300	0.05L	0B	0B	0B	0B
EG1410	15.0	200N	15000	10	10L	100N	15	50L	300	0.05N	0B	0B	0B	0B

TABLE 10. ANALYTICAL RESULTS OF ANOMALOUS SAMPLES FROM THE ALPINE LAKES AREA - CONTINUED

SAMPLE	S-AG	S-AS	S-CU	S-MO	S-PB	S-SB	S-SN	S-W	S-ZN	AA-AU-P	AA-CU-P	AA-ZN-P	CM-CX-HM	CM-MO
ROCK SAMPLES LEMAH CREEK-SNOQUALMIE RIVER-GOLD LAKE AREA-CON.														
EG1410A	2.0	200N	2000	50	10L	100N	15	50L	200	0.05N	0B	0B	0B	0B
EK0392	0.7	200N	70	5N	20	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EK0398	0.5L	200N	70	5N	70	100N	10N	50N	200L	0.0 B	65	0B	0B	0B
EK0398B	7.0	200N	2000	5N	300	100N	10N	70	200L	0.02L	1900	0B	0B	6
ES0140	0.5N	200N	200	5N	10L	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
ES1100	20.0	2000	1500	5N	150	200	10N	50N	10000G	0.15	0B	0B	0B	0B
ES1100A	30.0	7000	2000	5N	10L	2000	10N	50N	1500	0.20	0B	0B	0B	0B
ES1100B	70.0	5000	2000	5N	1500	300	10N	50	10000G	2.00	0B	0B	0B	0B
ES1101A	200.0	200N	1500	30	10000	100N	20	50N	200L	0.40	0B	0B	0B	0B
ES1102	3.0	200N	50	5N	50	100N	10N	50N	200N	0.05N	0B	0B	0B	0B
ET0340	0.5N	200N	100	5N	10L	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
ET0340A	1.0	200N	100	5N	10	100N	30	50N	200N	0.02N	150	0B	0B	6
STREAM SEDIMENT SAMPLES LEMAH CREEK-SNOQUALMIE RIVER-GOLD LAKE AREA														
EG0479	0.5N	200N	500	5N	50	100N	10N	50N	200N	0.0 B	440	45	50	0B
EG0485	1.5	300	100	5L	100	100N	15	50N	300	0.02L	90	290	20	0B
EG0486	1.0	200	70	7	70	100N	10	50N	200	0.02N	85	350	14	0B
EG0487	0.5N	200N	30	10	30	100N	10N	50N	200N	0.0 B	40	75	5	0B
EG0488	0.5N	200N	15	5	20	100N	10N	50N	200N	0.0 B	15	30	3	0B
EG0489	0.5N	200N	7	5	15	100N	10N	50N	200N	0.0 B	10	20	2	0B
EG0497	1.0	200N	100	15	15	100N	10N	50N	200N	0.04L	95	100	16	25
EG0498	1.5	200N	70	5L	50	100N	10N	50N	200	0.02N	90	160	5	0B
EG0499	1.0	200N	70	15	30	100N	10N	50N	200N	0.0 B	130	85	8	15
EG0500	0.5	200N	150	15	30	100N	10N	50N	200L	0.02N	100	100	5	15
EG0501	0.5	200N	70	5N	30	100N	10N	50N	200L	0.02N	95	140	10	0B
EG0502	0.5N	200N	70	5N	50	100N	10N	50N	200L	0.0 B	50	130	6	0B
EG0503	0.5N	200N	50	5N	30	100N	10N	50N	200N	0.0 B	65	120	12	0B
EG0504	0.5N	200N	70	5N	50	100N	10N	50N	200L	0.0 B	45	110	5	0B
EG0505	3.0	200N	70	5N	20	100N	10N	50N	200N	0.04N	140	60	16	0B
EG0507	0.5N	200N	50	5N	30	100N	10N	50N	200N	0.0 B	45	100	14	0B
EG0637	0.5N	200N	150	5N	30	100N	10N	50N	200N	0.0 B	95	85	2	0B
EG0638	0.5N	200N	100	5N	30	100N	10N	50N	200N	0.0 B	95	70	2	0B
EG0646	0.5N	200N	100	5N	50	100N	10N	50N	200N	0.0 B	190	130	5	0B
EG1324	1.0	500	70	5N	150	100N	10	50N	200	0.05N	85	0B	12	0B
EK0388	0.5	200N	30	5	70	100N	10N	50N	200N	0.02N	35	60	2	0B
EK0390	1.5	200N	150	15	100	100N	15	50N	200N	0.04N	140	35	6	25
EK0393	1.0	200N	300	5L	70	100N	10N	50N	200N	0.02L	390	110	10	0B
EK0394	0.5N	200N	50	5N	50	100N	10N	50N	200N	0.0 B	40	60	3	0B
EK0396	0.5N	200N	70	5N	70	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
EK0397	1.5	200N	70	5N	30	100N	10N	50N	200N	0.02N	65	40	1L	0B

TABLE 10. ANALYTICAL RESULTS OF ANOMALOUS SAMPLES FROM THE ALPINE LAKES AREA - CONTINUED

SAMPLE	S-AG	S-AS	S-CU	S-MO	S-PB	S-SB	S-SN	S-W	S-ZN	AA-AU-P	AA-CU-P	AA-ZN-P	CM-CX-HM	CM-MO
STREAM SEDIMENT SAMPLES LEMAH CREEK-SNOQUALMIE RIVER-GOLD LAKE AREA-CON.														
EK0400	0.7	200N	70	5N	70	100N	10N	50N	200N	0.02N	100	150	3	0B
ES0129	0.5N	200N	300	5N	30	100N	10N	50N	200N	0.0 B	460	50	35	0B
ES0130	0.5N	200N	15	5	20	100N	10N	50N	200N	0.0 B	20	40	2	0B
ES0133	0.5N	200N	50	10	15	100N	10N	50N	200N	0.0 B	45	35	1L	0B
ES0137	0.5N	200N	50	5	20	100N	10N	50N	200N	0.0 B	35	60	2	0B
ES0138	1.5	200N	300	20	150	100N	10N	50N	200L	0.0 B	340	190	25	25
ES0139	0.7	200N	200	5N	50	100N	10N	50N	200L	0.02N	190	140	30	0B
ES0141	0.5N	200N	100	15	20	100N	10N	50N	200N	0.0 B	90	55	16	B
ES0142	0.5N	200N	30	5	20	100N	10N	50N	200N	0.0 B	15	20	1	0B
ES0147	0.5N	200N	100	15	20	100N	10N	50N	200N	0.0 B	120	50	6	15
ES0148	0.5N	200N	150	15	20	100N	10N	50N	200N	0.0 B	140	40	6	20
ES0149	0.5	200N	200	10	15	100N	10N	50N	200N	0.02N	280	30	25	0B
ES0151	0.5N	200N	50	5	10	100N	10N	50N	200N	0.0 B	50	25	2	0B
ES0200	0.7	200N	70	5N	30	100N	10N	50N	200N	0.02N	80	120	1	0B
ET0333	0.7	200N	20	5N	50	100N	10N	50N	200N	0.02L	40	40	3	0B
ET0334	0.7	200N	30	10	70	100N	10N	50N	200N	0.02L	50	70	3	0B
ET0341	0.5	200N	70	5L	70	100N	10N	50N	200N	0.02N	110	30	8	0B
ROCK SAMPLES CHAIN LAKES AREA														
EG1229	0.5N	200	30	15	300	100N	30	50	200L	0.05N	0B	0B	0B	0B
EG1229A	0.7	300	30	5L	300	100N	20	50N	200L	0.05N	0B	0B	0B	0B
EG1229B	200.0	10000G	20000G	150	3000	10000G	20	70	10000G	1.50	0B	0B	0B	0B
EG1229C	500.0	10000G	20000G	20	7000	7000	15	50L	10000G	0.35	0B	0B	0B	0B
EG1229D	3.0	700	300	5	300	1000	30	50	200L	0.05N	0B	0B	0B	0B
EG1229E	7.0	10000G	700	20	7000	1500	10L	50	2000	2.0	0B	0B	0B	0B
EG1229F	0.5	700	70	5N	150	100N	10L	50N	200L	0.05N	0B	0B	0B	0B
EG1229G	300.0	10000G	20000G	20	5000	5000	20	50N	10000	0.10	0B	0B	0B	0B
EG1229H	0.7	500	150	15	100	100L	20	300	200L	0.05N	0B	0B	0B	0B
ROCK SAMPLES CAMP ROBBER CREEK-FOSS RIVER AREA														
EG1431	0.5N	200N	100	5N	10	100N	10N	50N	200N	0.0 B	0B	0B	0B	0B
ET0348	0.5N	200N	100	5N	10L	100N	10N	50N	200N	0.0 B	0B	0B	0B	0B
STREAM SEDIMENT SAMPLES CAMP ROBBER CREEK-FOSS RIVER AREA														
EG0647	0.5	200N	70	5N	70	100N	10N	50N	200N	0.04N	0B	0B	2	0B
EG0649	0.5N	200N	150	5N	50	100N	10N	50N	200N	0.0 B	160	35	6	0B
EG0652	0.5N	200N	30	5N	70	100N	10N	50N	200N	0.0 B	0B	0B	3	0B
EG0691	0.5N	200N	100	5N	50	100N	10N	50N	200N	0.0 B	100	75	8	0B
EG0692	1.0	200N	70	5N	30	100N	10N	50N	200N	0.0 B	40	20	2	0B
EK0324	0.5N	200N	10	5	15	100N	10N	50N	200N	0.0 B	0B	0B	1	0B

TABLE 10. ANALYTICAL RESULTS OF ANOMALOUS SAMPLES FROM THE ALPINE LAKES AREA - CONTINUED

SAMPLE	S-AG	S-AS	S-CU	S-MO	S-PB	S-SB	S-SN	S-W	S-ZN	AA-AU-P	AA-CU-P	AA-ZN-P	CM-CX-HM	CM-MO
						STREAM SEDIMENT SAMPLES CAMP ROBBER CREEK-FOSS RIVER AREA-CON.								
EK0326	0.5N	200N	70	30	70	100N	10N	50N	200N	0.0 B	100	30	5	60
EK0327	0.5N	200N	70	5	50	100N	10N	50N	200N	0.0 B	150	85	6	0B
EK0329	0.5N	200N	100	5N	30	100N	10N	50N	200N	0.0 B	160	40	5	0B
EK0330	0.5N	200N	30	10	15	100N	10N	50N	200N	0.0 B	0B	0B	1	0B
EK0331	0.5N	200N	100	10	30	100N	10N	50N	200N	0.0 B	100	45	2	0B
EK0332	0.5N	200N	150	5	30	100N	10N	50N	200N	0.0 B	270	45	3	0B
EK0333	0.5N	200N	100	5L	30	100N	10N	50N	200N	0.0 B	140	30	3	0B
EK0334	0.5N	200N	150	7	20	100N	10N	50N	200N	0.0 B	170	40	3	0B
EK0337	0.5N	200N	50	7	30	100N	10N	50N	200N	0.0 B	0B	0B	1	0B
EK0339	0.5N	200N	30	5	30	100N	10N	50N	200N	0.0 B	0B	0B	2	0B
EK0402	0.5N	200N	70	15	70	100N	10N	50N	200N	0.0 B	95	55	5	15
EK0403	0.5N	200N	70	5N	70	100N	10N	50N	200N	0.0 B	65	40	3	0B
EK0404	0.5N	200N	50	5	50	100N	10N	50N	200N	0.0 B	25	35	1	0B
ES0207	0.5N	200N	70	5N	150	100N	10N	50N	200N	0.0 B	70	45	5	0B
ES0209	0.5N	200N	70	5N	70	100N	10N	50N	200N	0.0 B	70	45	2	0B
ES0210	0.5N	200N	150	5N	30	100N	10N	50N	200N	0.0 B	130	35	3	0B
ES0211	0.7	200N	150	5N	70	100N	10N	50N	200N	0.04	140	60	3	0B
ES0215	0.5N	200N	150	5N	30	100N	10N	50N	200N	0.0 B	170	50	6	0B
ES0216	0.5N	200N	150	5N	50	100N	10N	50N	200N	0.0 B	180	45	5	0B
ET0271	0.5N	200N	30	5N	50	100N	10N	50N	200N	0.0 B	30	70	3	0B
ET0273	0.7	200N	70	5N	30	100N	10N	50N	200N	0.02N	85	40	5	0B
ET0277	0.5N	200N	30	5N	30	100N	10N	50N	200N	0.0 B	40	30	20	0B
ET0279	0.5N	200N	30	5N	70	100N	10N	50N	200N	0.0 B	55	30	2	0B
ET0286	0.5N	200N	50	5N	20	100N	10N	50N	200N	0.0 B	150	25	12	0B
ET0290	0.5N	200N	30	10	20	100N	10N	50N	200N	0.0 B	30	50	2	0B
ET0291	0.5N	200N	50	5N	50	100N	10N	50N	200N	0.0 B	55	95	3	0B
ET0293	0.5N	200N	50	5N	30	100N	10N	50N	200N	0.0 B	65	110	3	0B
ET0344	0.5N	200N	10	5N	30	100N	50	50N	200N	0.0 B	0B	0B	2	0B
ET0349	0.5N	200N	20	5N	50	100N	10N	50N	200N	0.0 B	25	25	3	0B
ET0350	0.5N	200N	50	5N	50	100N	10N	50N	200N	0.0 B	50	35	2	0B
						ROCK SAMPLES NECKLACE VALLEY AREA-CON.								
EG0470A	0.5N	200N	150	5N	20	100N	10N	50N	200N	0.0 B	0B	0B	0B	0B
EG0470B	0.5N	200N	100	5N	10	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
						STREAM SEDIMENT SAMPLES NECKLACE VALLEY AREA-CON.								
EG0464	0.5N	200N	30	10	50	100N	10N	50N	200N	0.0 B	35	65	3	0B
EG0465	0.5N	200N	10	10	20	100N	10N	50N	200N	0.0 B	10	10	1L	0B
EG0468	0.5N	200N	30	5N	50	100N	10N	50N	200N	0.0 B	50	55	8	0B

TABLE 10. ANALYTICAL RESULTS OF ANOMALOUS SAMPLES FROM THE ALPINE LAKES AREA - CONTINUED

SAMPLE	S-AG	S-AS	S-CU	S-MO	S-PB	S-SB	S-SN	S-W	S-ZN	AA-AU-P	AA-CU-P	AA-ZN-P	CM-CX-HM	CM-MO
STREAM SEDIMENT SAMPLES NECKLACE VALLEY AREA-CON.														
EG0478	0.5N	200N	10	5	20	100N	10N	50N	200N	0.0 B	5	10	1	0B
EG0678	0.5N	200N	30	5N	50	100N	10N	50N	200N	0.0 B	30	30	2	0B
EK0407	0.5N	200N	30	5N	50	100N	10N	50N	200N	0.0 B	15	45	1	0B
EK0408	0.5N	200N	50	5N	100	100N	10N	50N	200N	0.0 B	50	30	3	0B
ES0123	0.5N	200N	30	5N	15	100N	10N	50N	200N	0.0 B	55	110	1	0B
ES0125	0.5N	200N	7	10	15	100N	10N	50N	200N	0.0 B	5	30	2	0B
ES0128	0.5N	200N	7	15	10L	100N	10N	50N	200N	0.0 B	20	45	1	35
OTHER ANOMALOUS ROCK SAMPLES														
EG0092A	0.5N	200N	100	5L	10	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG0607	0.5N	200N	100	5N	10L	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG0609	0.5N	200N	50	5N	15	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG0611	0.5N	200N	50	5N	15	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG0614	0.5N	200N	150	5N	15	100N	10N	50N	200N	0.0 B	0B	0B	0B	0B
EG0625A	0.5N	200N	5L	5N	50	100N	10N	50N	200N	0.02N	5	0B	0B	2L
EG0630A	0.5N	200N	200	5N	20	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG0711A	0.5N	200N	70	5N	15	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG0784	0.5N	200N	150	5N	10	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG0785	0.5N	200N	100	5N	10	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG0787A	0.5	200N	300	5N	10L	100N	10	50N	200N	0.02N	10	0B	0B	2L
EG0797	0.5N	200N	100	5N	10N	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG0801	0.5N	200N	150	5	15	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG0842	0.5N	200N	300	5N	10N	100N	10N	50N	200N	0.0 B	22	0B	0B	0B
EG0842B	0.5N	200N	150	5N	10N	100N	10N	50N	200N	0.0 B	0B	0B	0B	0B
EG0842D	0.5N	200N	200	5N	10N	100N	10N	50N	200N	0.0 B	0B	0B	0B	0B
EG1042	0.5N	200N	50	5N	10	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG1044	3.0	200N	10000	5N	10N	100N	10N	50N	200L	0.20	0B	0B	0B	0B
EG1080	0.5N	200N	100	5N	10L	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EG1249B	0.5	200N	50	5N	10L	100N	10N	50N	200N	0.05N	0B	0B	0B	0B
EG1264	0.5N	200N	50	5N	15	100N	10N	50N	200	0.05N	0B	0B	0B	0B
EG1266	0.5N	200N	30	5N	10	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG1284	0.5N	200N	30	5N	15	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EG1302B	0.5N	200N	150	5N	10N	100N	10N	50N	200	0.05N	0B	0B	0B	0B
EG1325	0.7	200N	50	5N	10	100N	10N	50N	500	0.05N	0B	0B	0B	0B
EG1469	0.5N	1000	10	5N	10L	100N	10N	50N	200L	0.05N	0B	0B	0B	0B
EK0077B	0.5N	200N	150	5N	10L	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EK0255	0.5N	200N	100	5N	10	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EK0372	0.5N	200N	100	5N	10	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
EK0386A	0.5N	200N	100	5N	10	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
EK0387	0.5N	200N	150	5N	10L	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B

TABLE 10. ANALYTICAL RESULTS OF ANOMALOUS SAMPLES FROM THE ALPINE LAKES AREA - CONTINUED

SAMPLE	S-AG	S-AS	S-CU	S-MO	S-PB	S-SB	S-SN	S-W	S-ZN	AA-AU-P	AA-CU-P	AA-ZN-P	CM-CX-HM	CM-MO
OTHER ANOMALOUS ROCK SAMPLES-CON.														
EK0428	0.5N	200N	100	5N	15	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
ES0225	0.5N	200N	100	5N	10L	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
ES0302	0.5N	200N	100	5N	30	100N	10N	50N	200N	0.02N	230	0B	0B	2L
ES1071	0.5N	200N	30	10	10L	100N	10N	50N	200L	0.05N	0B	0B	0B	0B
ET0002	0.5N	200N	150	5N	10	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
ET0009	0.5N	200N	150	5N	15	100N	10N	50N	200	0.0 B	0B	0B	0B	0B
ET0009A	0.5N	200N	20	5N	10L	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
ET0095	0.5N	200N	50	5N	15	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
ET0100	0.5N	200N	100	5N	15	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
ET0242	1.0	200N	15	5N	10L	100N	10N	50N	200N	0.02N	15	0B	0B	2
ET0266A	0.5N	200N	100	5N	15	100N	10N	50N	200N	0.0 B	100	0B	0B	0B
ET0328	0.5N	200N	150	5N	10L	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
ET0386	0.5N	200N	100	5N	15	100N	10N	50N	200L	0.0 B	0B	0B	0B	0B
OTHER ANOMALOUS STREAM SEDIMENT SAMPLES														
EG0034	0.5N	200N	7	5N	10	100N	10N	50N	200N	0.0 B	10	45	10	0B
EG0043	0.5N	200N	50	5N	10	100N	10N	50N	200N	0.0 B	20	40	10	0B
EG0064	0.5N	200N	20	5N	100	100N	10N	50N	200N	0.0 B	15	60	5	0B
EG0065	0.5N	200N	10	5N	50	100N	10N	50N	200N	0.0 B	10	45	3	0B
EG0071	0.5N	200N	30	10	15	100N	10N	50N	200N	0.0 B	10	45	3	0B
EG0073	0.5N	200N	70	5N	15	100N	10N	50N	200N	0.0 B	45	135	5	0B
EG0335	0.5N	200N	20	5	15	100N	10N	50N	200N	0.0 B	20	35	3	0B
EG0338	0.5N	200N	15	5	15	100N	10N	50N	200N	0.0 B	0B	0B	2	0B
EG0339	0.5N	200N	30	10	10	100N	10N	50N	200N	0.0 B	0B	0B	2	0B
EG0393	0.5N	200N	20	5	15	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
EG0394	0.5N	200N	30	7	15	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
EG0440	0.5N	200N	30	5	20	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
EG0442	0.5N	200N	7	5	20	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
EG0697	0.5N	200N	70	5N	200	100N	10N	50N	200N	0.0 B	20	55	2	0B
EG0698	0.5N	200N	20	5N	150	100N	10N	50N	200N	0.0 B	25	65	2	0B
EG0705	0.5N	200N	15	5N	50	100N	10N	50N	200N	0.0 B	15	30	2	0B
EG0706	0.5N	200N	100	5N	30	100N	10N	50N	200N	0.0 B	0B	0B	2	0B
EG0708	0.5N	200N	100	5N	15	100N	10N	50N	200N	0.0 B	30	20	1L	0B
EG0717	0.5N	200N	15	5N	50	100N	10N	50N	200N	0.0 B	15	35	3	0B
EG0718	0.5N	200N	15	5N	200	100N	10N	50N	200N	0.0 B	15	100	25	0B
EG0723	0.5N	200N	20	5N	50	100N	10N	50N	200N	0.0 B	20	60	2	0B
EG0740	0.5N	200N	20	5N	70	100N	10N	50N	200N	0.0 B	10	40	1	0B
EG0770	0.5N	200N	30	5N	200	100N	10N	50N	200N	0.0 B	30	55	3	0B
EG0775	0.5N	200N	30	5N	70	100N	10N	50N	200N	0.0 B	0B	0B	6	0B
EG0802	0.5N	200N	50	5N	70	100N	10N	50N	200N	0.0 B	20	35	2	0B

TABLE 10. ANALYTICAL RESULTS OF ANOMALOUS SAMPLES FROM THE ALPINE LAKES AREA - CONTINUED

SAMPLE	S-AG	S-AS	S-CU	S-MO	S-PB	S-SB	S-SN	S-W	S-ZN	AA-AU-P	AA-CU-P	AA-ZN-P	CM-CX-HM	CM-MO
OTHER ANOMALOUS STREAM SEDIMENT SAMPLES-CON.														
EG0810	0.5N	200N	20	5N	50	100N	10N	50N	200N	0.0 B	0B	0B	2	0B
EG0812	0.5N	200N	150	5N	30	100N	10N	50N	200N	0.0 B	20	70	2	0B
EG0820	0.5N	200N	70	10	50	100N	10N	50N	200N	0.0 B	80	110	3	0B
EG0822	0.5N	200N	50	5	30	100N	10N	50N	200N	0.0 B	0B	0B	2	0B
EG0823	0.5N	200N	70	5L	30	100N	10N	50N	200N	0.0 B	120	50	3	0B
EG0825	0.5N	200N	70	5N	50	100N	10N	50N	200N	0.0 B	50	55	2	0B
EG1162	0.5N	200N	30	5N	10	100N	10N	50N	200N	0.0 B	30	0B	2	0B
EK0058	0.5N	200N	1500	5N	10	100N	200	50N	200N	0.0 B	0B	0B	2	0B
EK0220	0.5N	200N	10	5	10	100N	10N	50N	200N	0.0 B	0B	0B	1	0B
EK0282	0.5N	200N	30	5	10	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
EK0285	0.5N	200N	10	5	20	100N	10N	50N	200N	0.0 B	0B	0B	2	0B
EK0312	0.5N	200N	30	5	50	100N	10N	50N	200N	0.0 B	15	55	1	0B
EK0315	0.5N	200N	15	5	20	100N	10N	50N	200N	0.0 B	0B	0B	1	0B
EK0414	0.5N	200N	7	5N	30	100N	10N	50N	200N	0.0 B	15	45	10	0B
EK0444	0.5N	200N	15	5N	70	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
EK0448	0.5N	200N	10	10	50	100N	10N	50N	200N	0.0 B	20	80	2	0B
EK0492	0.5N	200N	15	5N	50	100N	10N	50N	200N	0.0 B	0B	0B	5	0B
ES0080	0.5N	200N	20	5N	10	100N	10N	50N	200N	0.0 B	10	120	12	0B
ES0088	0.5N	200N	20	7	15	100N	10N	50N	200N	0.0 B	10	40	2	0B
ES0241	0.5N	200N	7	5N	70	100N	10N	50N	200N	0.0 B	15	55	3	0B
ES0314	0.5N	200N	70	5N	50	100N	10N	50N	200N	0.0 B	160	130	6	0B
ET0035	0.5N	200N	1500	5N	20	100N	200	50N	200L	0.0 B	0B	0B	3	0B
ET0104	0.5N	200N	30	5	15	100N	10N	50N	200N	0.0 B	0B	0B	1	0B
ET0137	0.5N	200N	15	15	10	100N	10N	50N	200N	0.0 B	10	35	1L	15
ET0169	0.5N	200N	5	5N	15	100N	10N	50N	200N	0.0 B	0B	0B	2	0B
ET0170	0.5N	200N	20	5N	50	100N	10N	50N	200N	0.0 B	15	40	2	0B
ET0171	0.5N	200N	15	5N	50	100N	10N	50N	200N	0.0 B	10	45	3	0B
ET0219	0.5N	200N	30	5N	30	100N	10N	50N	200N	0.0 B	25	140	20	0B
ET0296	0.5N	200N	20	5N	50	100N	10N	50N	200N	0.0 B	20	110	2	0B
ET0302	0.5N	200N	30	5N	50	100N	10N	50N	200N	0.0 B	20	80	1L	0B
ET0371	0.5N	200N	20	5N	100	100N	10N	50N	200N	0.0 B	20	60	6	0B
ET0387	0.5N	200N	10	5N	70	100N	10N	50N	200N	0.0 B	10	20	3	0B
ET0403	0.5N	200N	7	7	20	100N	10N	50N	200N	0.0 B	0B	0B	1L	0B
OTHER ANOMALOUS PANNED CONCENTRATE SAMPLE														
EG1459	0.5N	200N	15	5N	10L	100N	10N	50N	200	0.05N	0B	0B	0B	0B

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