THE AVAILABILITY OF NICKEL, CHROMIUM AND SILVER IN WASHINGTON

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By

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INTRODUCTION

The following report represents a summary of all the basic information utilized in preparing computer input schedules for entry of selected mineral commodity data into the U.S. Bureau of Mines' Minerals Availability System. The Minerals Availability System or M.A.S. is a process through which mineral resource information, collected and prepared for automatic storage and retrieval, may be rapidly utilized to establish the nation's mineral supply position at any given point in the future. In this particular case, all of the known occurrences of nickel, chromium, and silver in Washington State have been investigated; only those deposits that still contain or may possibly contain recoverable amounts of these commodities have been presented for inclusion in the system.

The majority of the reported occurrences of these three basic commodities have been known for a number of years and most have, at one time or another, received the attention of competent investigators, miners, and prospectors. In most instances the more significant deposits were mined-out or abandoned for one reason or another. Refractory ores, transportation and access difficulties, adverse metal markets, etc. were often reasons for abandonment. In many instances the reasons for abandonment are no longer valid and the properties can therefore be reviewed in the new light of progress.

Nearly all of the properties selected for inclusion in the system require considerable exploration of one sort or another to either confirm or enhance the data used to assemble the Probabilistic Grade-Quantity Matrix. The matrix, which constitutes the heart of the Minerals Availability System, is an orderly accounting of the various resources thought to be available within various levels of probability. Matrices for the deposits of nickel, chromium, and silver in Washington are included in the appendix.

In this report each property selected for M.A.S. input is described in detail as to location and access, history and production, geology and mining. Recommendations and conclusions regarding exploration, utilization, and disposition of the properties have also been prepared.

WASHINGTON NICKEL RESOURCES

Dick Nickel Prospect, Chelan County, Washington

Property Location and Access: 47°46'12" N., 120°12'23" W., sec. 9, T. 26 N., R. 21 E.

The Dick nickel prospect, also known as the Winesap or Chelan deposit, is situated on the north side of Oklahoma Gulch, approximately three-fourths of a mile northwest of Winesap, a siding on the Burlington Northern railroad which parallels U.S. Route 97 between Entiat and Chelan.

History and Production

Gossan material containing secondary nickel and copper minerals in outcrops of peridotite was discovered at the site in 1898. Several short prospect tunnels were subsequently driven into the outcrops but soon abandoned. Interest in the prospect was renewed during the World War II in response to the demand for strategic minerals; several of the original tunnels were extended by prospectors and over 1,000 feet of diamond drilling was performed by the U.S. Bureau of Mines.

Since the end of the war, a number of private companies and individuals have examined the property, and, like the Bureau of Mines, they concluded that the deposit is interesting but unworthy of further expenditures.

With the exception of small quanitites of ore removed for testing purposes, there has been no production from this property.

Ownership

The prospect is within a 60-acre tract of deeded land, which was sold in 1966 to the Washington State Fish and Game Department. The mineral rights on this tract were reserved by L & S Mines, Inc. of Wenatchee, Washington. An officer of the company is Dr. Merle E. Louden, D.D.S., 530 North Main East, Wenatchee, WA, 98801, phone (509) 663-2417.

Geology and Description of the Ore Body

Very little data is available to describe the geology and origin of this prospect. The deposit consists primarily of grains of pyrrhotite, chalcopyrite, and pentlandite disseminated throughout a small lens-shaped mass of peridotite. The peridotite, believed to be of pre-Jurassic age (Hopson, 1955), is contained within a gneissic contact breccia or migmatitic border facies of the younger intrusive Chelan batholith, a large pluton that forms the core of the Chelan Mountains to the west and east. The relationship of the peridotite to the batholith is unclear; field relations suggest that the ultrabasic unit probably represents the remains of an older intrusive mass or xenolith of peridotite. There was apparently little or no obvious metamorphism of this unit during emplacement of the Chelan batholith. Small alpine-type peridotite masses are scattered throughout the Cascades.

The sulfide mineralization, which is apparently restricted to the peridotite, is probably also related to the metamorphism of its host by the intruding batholith.

A large, apparently post-ore, andesite dike cuts off the northwest end of the mineralized ultrabasic unit.

Results of the assays performed on samples obtained from the diamond drilling and tunnel sampling programs showed nickel values ranging from 0.6 to 1.7 percent together with up to 0.7 percent copper. As could be expected, cobalt was also present but in amounts no greater than 0.005 percent, with the average being around 0.002 percent. The maximum tonnage of ore delineated and calculated by the Bureau of Mines was 30,000 tons.

In 1942, beneficiation test were performed on the Dick nickel ore by the Freeport Sulfur Co.; the results of their tests indicated that 41.2 percent recovery of the nickel contained in the ore was the maximum recovery that could be accomplished under contemporary technology.

Due to a lack of adequate reliable data, no attempt was made to construct an elaborate Probabilistic Grade-Quantity Matrix. The grades reported on the record for the various metals present in the deposit represent an average of all

of the available drilling and adit sampling data.

Conclusions

The Dick nickel prospect can at best be classified as a marginal primary nickel resource. In consideration of the favorable geologic environment of this deposit, there would appear to be a moderately high probability of extending the known ore reserves and locating additional mineralized zones through the proper application of advanced modern geophysical techniques combined with additional drilling.

WASHINGTON NICKEL RESOURCES

Blewett Iron-Nickel Deposit, Chelan County, Washington

Property Location and Access: 47°23'45" N., 120°40'00" W., sec. 14, T. 22 N., R. 17 E., within the Wenatchee National Forest.

The iron-nickel deposits described in this report are located on the east side of State Highway 97, approximately 33 miles north of Cle Elum and 8 miles north of Swauk Pass. A jeep trail provides access from the paved highway to the center of the property.

History and Production

The Blewett iron-nickel deposit which outcrops as prominent ridges or "ledges" adjacent to a major north-south thoroughfare has received the attention of numerous investigators since its discovery in 1893. Prospectors from the nearby gold camps of Nigger Creek and Culver Gulch frequently tested the outcrops for precious metals. Between 1904 and 1944 several adits and trenches were developed to test the deposit.

In 1943-44, ten diamond drill holes, totalling 2,395 feet, were drilled by the U.S. Bureau of Mines in conjunction with U.S. Geological Survey's war minerals mapping and investigatory effort.

With the exception of small tonnages extracted for testing purposes, there has been no mineral production from this property.

Ownership

The property containing the iron-nickel deposit lies entirely within patented ground owned by Washington Nickel Mining and Alloys, Inc., c/o Mr. Richard S. Cary, 308 White-Henry-Stuart Building, Seattle, WA, 98101, phone (206) 692-9540.

A number of nearby submarginal occurrences of the same iron-nickel unit are located within the National Forest boundaries.

Geology and Description of the Ore Bodies

The Blewett deposit like those at Cle Elum represents the remnants of a buried nickel-chromium-bearing ferruginous laterite developed on the surface of an intrusive pre-Tertiary peridotite body. Subsequent to its development, the laterite was partially eroded or destroyed, then buried and preserved under the terrestrial sediments of the Eocene Swauk Formation. Burial was followed by folding, faulting, and intrusion.

The higher-grade portions of the iron-nickel units are highly resistant to erosion and form prominent outcrops or "ledges" in areas of exposure. There are a number of these ledges exposed along the 20 or so miles of peridotite-Swauk contact between the Cle Elum River and the Blewett area. Most of these exposures, however, are quite small and inaccessible and do not constitute minable units.

Unlike the Cle Elum deposit, that of the Blewett area consists primarily of peridotite conglomerate containing or surrounding a tabular lens-shaped unit of higher grade ferruginous material. The conglomerate is composed of subangular to well-rounded pebbles, cobbles, and boulders embedded in a ferruginous and serpentinous matrix. Practically all of the larger constituents are composed of serpentine or serpentinized peridotite with a very few well-rounded cobbles of basaltic rock. The iron-rich fine-grained lens is about 25 feet thick and occupies a stratigraphically central position within the conglomeratic mass. This lens

is thought to represent the remains of the upper lateritic surface, which has been buried and preserved by mudsliding or similar torrential deposition of serpentinous laterite from adjacent higher terrain.

Though many small faults are present, the outstanding structural feature is a large reverse fault that places the overlying Swauk in juxtaposition with the southern end of the ore deposit. Intrusive diabase crosscuts the center and cuts off the end of the deposit.

Mineralogically, both the conglomerate matrix and the high-grade lens consist of massive very fine-grained magnetite and hematite, with subordinate amounts of chromite and aluminum silicates. The magnetite occurs primarily as massive material, though thin crosscutting veinlets of magnetite are not uncommon. No individual nickel minerals have been isolated or identified, and it is therefore presumed that the nickel values are contained within the iron atom.

Lamey (1950) points out the strong similarity, both chemical and metallurgical, between the Blewett-Cle Elum deposits and the nickeliferous iron deposits of the Mayari district of Cuba

Description of the Probabilistic Grade-Quantity Matrix (see appendix for Matrix)

Although some of the Bureau of Mines drilling data was available to aid in construction of the matrix, the marginal quality and limited extent of both the data and of the ore itself preclude extending the probability of success above and beyond the 50 percent or the inferred level for the larger or conglomeritic mass. The higher grade unit shown as containing 0.90 percent nickel was calculated at the 50 percent level by utilizing Lamey's average thickness of 25 feet. Expansion to the 75 and 90 percent levels was accomplished by decreasing the thickness to 15 and then 10 feet, respectively.

The volume of the conglomerate was calculated from gross dimensions scaled from the maps and block diagrams provided by Lamey (1950).

Mining and Beneficiation Methods

From a purely economic standpoint, the Blewett deposit appears at this time to be too small to justify any sort of mining operation; however, under a wartime, etc., embargo situation, it would seem reasonable that an attempt would be made to exploit not only the Blewett deposit but possibly some of the smaller related deposits.

Presumably exploitation of the Blewett and related iron-nickel deposits would be contingent upon erection of a smelter at Ronald or elsewhere; primarily to handle the large volume of ore that would be mined from the Cle Elum deposits.

The higher-grade Blewett ores, if selectively mined, could be smelted directly without beneficiation. The larger volume of conglomerate ore, however, would require crushing, sizing and further concentration at the mine site prior to shipment to the smelter. Since the supply of water is somewhat limited in the Blewett area, the amount of concentration possible at the mine site would depend to a large extent on the beneficiation process selected.

Again, as with the Cle Elum ores, it is assumed that the various strategic metals in the Blewett iron-nickel will best be recovered in the form of high-grade nickel-iron alloys and (or) as low-chrome stainless steel.

WASHINGTON NICKEL RESOURCES

Congress Prospect, Ferry County, Washington

Property Location and Access: 48°13'40" N., 118°37'25" W., sec. 35, T. 32 N., R. 33 E.

The Congress mine or prospect is on the north bank of Bridge Creek, a tributary of the Sanpoil River, 3½ miles to the west. The small community of Keller is 11 miles downstream from the river-creek junction.

History and Production

There is no record of any ore (other than small test lots) having been produced from this mine.

After the prospect's discovery around 1890, and between the discovery date and 1904, over 2,000 feet of underground workings were developed by hand on 3 levels. This original work was encouraged by the presence of low-grade base metals sweetened by minor amounts of gold and silver. The prospect has been investigated a number of times since 1904; however, there are no known published or unpublished reports covering the findings of these investigations.

Ownership

The mine lies within the Colville Indian Reservation and is covered by four patented claims, staked originally by the Congress Gold and Copper Mining Co., of Spokane, Washington.

The current owner of the claims is Jean H. Coon, 8035 Southwest Broadmore Terrace, Portland, OR, 97207. No phone number is available.

Geology and Description of the Ore Body

The Congress mine has been partially developed in a series of late Paleozoic(? schists of both sedimentary and igneous origin, which have been intruded by a large body of quartz monzonite porphyry of possible Mesozoic age. The nickel occurs along a shear zone as millerite in pyrite, and as nickeliferous chlorite, both of

which are carried in a gangue of bluish-colored quartz. The mineralized zone strikes northeast and dips steeply to the northwest. Other minerals within this zone include dolomite, magnetite, epidote, and chalcopyrite. The width of the shear zone, as inferred from mineralized float in the overburden, ranges from 6 to 80 feet and has a known vertical depth in excess of 300 feet. The mineralized float has been traced for over 1,200 feet on the surface. Considerable fracturing and faulting has disrupted both the mineralized zone and its host.

Description of the Probabilistic Grade-Quantity Matrix (see appendix for Matrix)

The tonnage-grade data supplied with the matrix were established by Shelton (1956), from dimensions measured in the field and(or) inferred from meager underground data. The grade of 1.2 percent nickel was determined from analyses performed on a bulk sample collected from the mine for metallurgical testing. The dates, locations, and extent of the bulk sampling program are unknown. Bancroft (1914) reported that a high-graded sample of pyrite picked from the underground workings contained 5.71 percent nickel and 0.35 percent cobalt. Generally, the content of the oxidized zone exposed in the mine workings is low; however, the grade is expected to increase substantially below the water table where oxidation is reduced or eliminated.

Mining and Beneficiation Methods

Due to a general lack of reliable data regarding subsurface conditions, width and extent of mineralization and other factors, it is thought that a combined method of underground mining should be proposed. If the results of a developmental drilling program establish that the inferred dimensional characteristics of the ore zone remain essentially unchanged at depth, then both overhand and shrinkage stoping methods supplying ore to one or more horizontal and(or) vertical haulage ways should be sufficient to adequately exploit this deposit. A screen analysis of the crushed ore by Shelton (1956) indicates that there was no significan

concentration of the nickeliferous pyrite in any size fraction. Flotation of the millerite from the pyrite required stage grinding to minus 200 mesh or more before adequate liberation was realized.

Depending upon the results of an exploratory drilling program, on-site milling and refining of the ore may be more practical than transporting the ore for concentration elsewhere.

In the event that a flotation mill cannot be justified, the scanty distribution of the nickel-bearing sulfide within the mineralized quartz vein dictates that the ore be concentrated prior to shipment elsewhere. Egress from the deposit, which is quite isolated, is greatly restricted by both severe winter conditions and the various bridgeless waters and tributaries of the Columbia River system that bracket the area to the south.

Cle Elum Nickel Deposit, Kittitas County, Washington

Property Location and Access: 47°27'02" N., 121°3'05" W., sec. 26, T. 23 N., R. 14 E., within the Wenatchee National Forest.

The area occupied by the principal nickeliferous iron outcrops of the Cle Elum nickel deposit are located along the east bank of the Cle Elum River between Camp and Boulder Creeks. Eighteen miles of gravel road link the prospect with the town of Ronald and State highway 903, which in turn provides paved access to the towns of Roslyn and Cle Elum to the southeast. The Port of Seattle lies approximately 60 miles west of Cle Elum. Altitudes within the outcrop areas range from 2,700 to 3,500 feet. A railroad spur of Burlington Northern Inc. serves several of the Roslyn basin coal mines situated in the vicinity of Ronald.

History and Production

The Cle Elum deposits were first explored between 1890 and 1903. During this period, surface trenches, test pits, several adits, and four diamond drill holes were utilized to examine and sample the deposit. Most of the old workings are now caved and the drill-hole records are reported to have been lost in the San Francisco earthquake and fire of 1906 (Zoldok, 1948).

In response to wartime demand for domestic sources of various strategic minerals including nickel, the U.S. Bureau of Mines drilled and thoroughly explored the Cle Elum and related adjacent nickeliferous iron deposits. During the project, 57 diamond drill holes, amounting to over 1,100 feet, were drilled and sampled, and approximately 32 tons of ore was extracted for metallurgical experiments by various Bureau of Mines laboratories.

Between and after the two major periods of activity outlined above, a number of interested parties have examined and reported on the geology and economic aspects of the deposits; however, their conclusions are that under normal or curre economic and technologic conditions the deposits would be too costly to develop

(Washington Division of Geology and Earth Resources, unpublished data).

Ownership

All of the patented claims which cover the major outcrops, projections, and exposures of the Cle Elum "nickel ledge" are owned by Burlington Northern, Inc., Central Building, Room 358, Seattle, WA 98104, phone (206) 624-1900.

The claims were originally staked and patented by Balfour, Guthrie and Co., Ltd., address unknown.

Geology and Description of the Ore Bodies

The Cle Elum deposit is essentially a thin discontinuous nickel-chromium-bearing ferruginous laterite, which was developed on the surface of an intrusive pre-Tertiary peridotite body. The laterite was subsequently partially eroded or destroyed then buried and preserved under the terrestrial sediments of the Eocene Swauk Formation. The entire area was later folded and faulted and subjected to minor intrusive activity.

The average thickness of the iron deposits drilled by the Bureau of Mines is 15 feet, but the thickness ranges from less than 1 foot to over 48 feet. The deposit are scattered discontinuously along 20 miles of the basal Swauk-peridotite contact; however, they are thick enough to mine only in the patented claim area adjacent to the river and in the vicinity of Blewett Pass to the east. A magnetometer survey was made by the Northern Pacific Railway Co. in 1960 with the intention of extending the ore to the north along the mineralized contact. The overall results of this study led to the conclusion that no minable units existed within the bounds of the area surveyed (Northern Pacific Railway, unpublished data).

The Cle Elum deposit has four petrographically distinct but metallurgically inseparable units; they consist for the most part of magnetite, hydrous aluminum oxides, and minor inclusions of serpentine or rather serpentinized peridotite. Minute grains or crystals of chromite are disseminated throughout the mass and yield

an overall chromium value of 1.64 percent. With the exception of minor secondary millerite (NiS), no distinct nickel minerals have been identified. Lamey and Hotz (1952) conclude that the nickel values must be contained within the iron atom, for the amounts of nickel present tend to vary directly with the content of iron.

Unlike the lateritic nickel deposits near Riddle, Oregon, the Cle Elum deposit was noted by a number of authors to be nearly identical, chemically and metallurgically, to the nickeliferous iron deposits of the Mayari district of Cuba.

Description of the Probabilistic Grade-Quantity Matrix (see appendix for Matrix)

Construction of the probabilistic grade-quantity matrix was based wholly on the results of the U.S. Bureau of Mines drilling program of 1944 as reported by Lamey and Hotz (1952) and Zoldok (1948).

The maximum quantity recorded on the matrix correlates with the maximum available tonnages reported by Lamey and Hotz on page 60 of their report.

Columns 20-24 of the matrix show the quantity of nickel contained in the nickeliferous iron unit, plus the underlying 20 or so feet of nickeliferous serpentinite, which is reported to have an overall value of 0.7 percent nickel. The volume of the serpentinite was calculated by utilizing the drilling logs and analyses included in Zolkok's report (pages 6-8), together with the various dimensions and tonnages reported by Lamey and Hotz (1952).

The tonnages as reported include all of the ore within the area drilled by the Bureau of Mines. It is assumed that all of the major metals present in the ore will be utilized together to produce specialty ferrous alloys.

Mining and Benefication Methods

The report of Lamey and Hotz (1952) recommends that mining be restricted to two thick, individual north and south areas along the eastern edge of the contact. In both areas they note that open-pit methods may be used to mine a maximum of 1 million tons. The balance of the measured tonnage will have to be mined by

underground methods because of the steep attitude of the ore horizon, thickening overburden, and flooding problems which will be encountered as the floor of the pit approaches the level of the river.

Breast stoping was selected as offering the simplest and most practical approach to mining the ore underground. Again flooding, plastic flowage and other water related problems are expected to be encountered especially along several of the more extensive shear zones which cut all of the formations involved. The overlying Swauk Formation is considered competent and, therefore, should provide a fairly strong back requiring a minimum of support.

Various smelting and metallurgical tests run on the ore by USBM (Cremer, 1954; Ravitz, 1947) resulted in the development of an electric smelting process by which the nickel can be recovered as a high-grade nickel-iron alloy and the iron can be recovered as a low-chrome stainless steel. As a result of these tests, performed on the bulk ore samples, it was concluded that beneficiation is not required and that more of the combined nickel and chromium on the Cle Elum ore may be recovered directly as constituents of ferrous alloys than would otherwise be possible. Additionally, the local abundance of timber, coal, and hydroelectric power should enhance the value of the iron deposits if and when they become otherwise economically attractive.

WASHINGTON NICKEL RESOURCES

Mount Vernon Nickel Deposit, Skagit County, Washington

Property Location and Access: 48°22'12" N., 122°16'40" W., secs. 4, 9, 10, and 11, T. 33 N., R. 4 E.

The nickel prospect is located along the crest of Devils Mountain, a prominent local feature 4½ miles southeast of the town of Mount Vernon, Washington. The conspicuous outcropping deposit ranges in elevation from 350 to 1,750 feet. The Burlington Northern railroad and Interstate Highway 5 are approximately 2 miles due west of the property.

History and Production

The presence of nickel on Devils Mountain was recognized in 1936 by the four Scott brothers of Sedro Woolley; this discovery was the direct result of their first efforts following graduation from a course in mineral prospecting. Exploration of the property was undertaken by a group of local businessmen who combined in 1938 to form the Pacific Nickel Co. In the course of the next several years, the company drove about 300 feet of exploration tunnels and completed over 6,375 fee of diamond drilling. The property was examined and mapped in 1937 by geologists of the Works Progress Administration (Washington Division of Geology and Earth Resources files) and again in 1940 by the USGS as part of their pre-World War II Strategic Minerals Investigatory Program. The results of the latter investigation were published as USGS Bull. 931-D (Hobbs and Pecora, 1941). There has been little if any recorded interest in the property since the end of the second world war.

With the exception of small quantities of ore removed for testing purposes, there is no record of any production from this property.

Ownership

The Pacific Nickel Co., though apparently no longer actively engaged in the development of the property, owns or controls 2,300 acres of mineral rights covering the ore deposit. The company also maintains active status as a company registered

to do business within the state. The president of the Pacific Nickel Co. is Mr. Felix Minor, 1315 Harrison Street, Mount Vernon, WA, 98273, phone (206) 336-2535.

According to the Skagit County assessor's office, there is only one other mineral entry reservation posted in the Devils Mountain area. This entry is located in sec. 4 and covers portions of government lots 2 and 3. The applicant is Mr. George Bernhard, 19950 130th S.E., Woodenville, WA, 98072..

Geology and Description of the Ore Body

The Mount Vernon nickel-gold deposit is developed within a shear zone adjacent to a large high-angle northwest-trending reverse fault. Along this fault, pre-Tertiary sedimentary and igneous rocks have been placed in contact with overlyin Eocene sedimentary rocks of the Chuckanut Formation.

The pre-Tertiary unit consists of various thin-bedded metamorphosed sediments, intruded by irregular masses of serpentinized peridotite. A silica-carbonate rock formed by partial alteration of the peridotite adjacent to the fault zone is highly resistant to erosion and forms a prominent outcrop along the crest of Devils Mountain. This rock contains irregular masses and lenses of peridotite and is primarily a mixture of quartz, chalcedony, and carbonates, with small quantities of iron oxide and scattered grains of chromite that may have been derived from the peridotite. The fault zone between the Eocene sandstone of the hanging wall and the silica-carbonate serpentinized peridotite of the footwall contains a wide zone of sulfide-bearing silica-carbonate breccia. The sulfides, which are scattered through out portions of the breccia matrix, are predominately marcasite with subordinate pyrite and bravoite. The nickel values are apparently contained mostly within the nickeliferous marcasite and bravoite and to a lesser extent in some of the carbonate minerals of the silica-carbonate neck. Gold and silver are present in the breccia in varying small quantities. One rock sample of uncertain origin was reported in the company's prospectus as containing 1.30 percent nickel and 0.80 percent cobalt.

Hobbs and Pecora (1941) theorize that the mineralization at Devils Mountain resulted from hydrothermal alteration of the serpentinized peridotite along the fault; however, it would seem reasonable to modify this theory somewhat and postulate that the nickel deposit is simply another example of the same buried or fossil nickeliferous laterite that occurs between Blewett Pass and the Cle Elum River and elsewhere within the coastal ranges. Furthermore, it is thought that there has in fact been little, if any, hydrothermal alteration and that the sulfides and silica-carbonate veining are the direct result of cold leaching, mobilization, and redeposition of the various constituents.

Description of the Probabilistic Grade-Quantity Matrix (see appendix for Matrix)

Most of the available data representing the results of various surface and and subsurface sampling programs were used to construct the matrix. In cases where the core recovery was less than adequate, there apparently developed some conflict between the USGS investigators and representatives of the Pacific Nickel Company regarding the assignment of weighted averages to the affected diamond-drilling results. Core recoveries ranged from 15 to 70 percent, with the average being only about 20 percent (Felix Minor, pres., Pacific Nickel Co., oral communication). Consequently, some of the results were apparently upgraded or projected to compensate for either poor core recovery or the possible mechanical loss of some sulfides from the porous rock during the core extraction process.

In most cases, the tonnage data shown on the matrix were insufficient to permit projection beyond the 50 percent reliability or probability level. The maximum tonnage recorded, at a grade of 0.68 percent nickel and 0.47 grams per metric ton of gold, represents the larger volume of the lower-grade silica-carbonate rock. Conversely, the high-grade low tonnage figure represents the sulfide-bearing breccia, which, because of the uneven tenor and small tonnage, cannot be depended upon to sustain any long-term mining operation.

At best, this deposit should be considered marginal to subeconomic; however, changes in technology, world economics, local industrialization, etc. may improve the chances of the deposit's eventual development at a later date. Hobbs and Pecora (1941) suggest that the deposit would best be considered as a low-grade gold deposit whose value would be enhanced by the presence of recoverable nickel. Careful drilling and adequate recovery of cored material may indicate a higher than suspected quantity of iron and chromium similar to the Blewett-Cle Elum ore, which has considerable potential as a material from which various ferro-nickel products may be produced.

Proposed Mining and Beneficiation Methods

The ore is well exposed for over two miles along the crest of Devils Mountain and would be easily recoverable by surface mining methods. The generous dimensions and steep attitude of the ore indicate that a large quantity could be removed before overburden stripping would be required.

Experimental flotation tests reported by Hobbs and Pecora (1941) and others indicate a high concentration ratio for the sulfide-bearing breccia. The silica-carbonate rock is apparently less amenable to concentration so additional research along these lines would be required before any mining can be considered.

In light of the marginal value of the deposit, trucks would probably be the most practical and initially the least expensive method of mine-to-mill transport. An aerial tramway or conveyor system would be the most practical system over a long period of time, but the high initial cost would probably be difficult to justify.

The water, electrical, and shipping facilities in the area are more than adequate to provide for the requirements of a mill.

WASHINGTON NICKEL RESOURCES

Mackinaw Mine, Snohomish County, Washington

Property Location and Access: 57°31'22" N., 121°26'15" W., sec. 19, T. 29 N., R. 11 E.

The Mackinaw mine is located on the east side of Weden Creek, a tributary of the South Fork of the Sauk River, approximately 19 miles southeast of the of the town of Darrington. The old mining town of Monte Cristo is about 3 miles east of the mine.

History, Production and Ownership

In 1900 shortly after the discovery of mineralization on Weden Creek the Mackinaw Mining and Milling Co. was established to develop and exploit the deposit. Since that time a number of companies and individuals have leased and explored the property.

The current (1975) owner of the property, listed as being in good standing with both the Office of Secretary of State of Washington and with the Snohomish County Auditor is:

The Mackinaw Metals Company

President-Mr. Don Fortner
318 N.E. 58th
Seattle, WA 98105

Sec. Tres.-Mrs. Edwin Wilson
4700 Maryland
Everett, WA 98203 phone (206) 259-16

A small unknown tonnage of ore is reported to have been produced between 1900 and 1910 (Huntting, 1956). Since that time, however, production has been limited to recovery of fractional tonnages for testing purposes only.

Geology and Description of the Ore Bodies

The mine, which consists of four short tunnels with a total length of just over 2,000 feet, is developed in a sheared and partially serpentinized peridotite. The peridotite is believed to be a pre-Tertiary intrusive body similar to other small peridotite bodies scattered throughout the Northern Cascade Mountains.

A large fault, known as the Weden Creek fault, which strikes north-northwest through the deposit area, has intensly sheared the ultrabasic unit and placed it in contact with the overlying terrestrial sediments of the Eocene Swauk Formation. Serpentinization, followed by hydrothermal alteration or steatitization of the peridotite, preceded mineralization. Mineralization was finally introduced into the porous shear zone and formed both massive and disseminated deposits of copper-nickel arsenides and sulfides, together with minor amounts of cobalt, zinc, gold and silver. There are also minor quantities of secondary or supergene forms of some of the elements above.

The assemblage of arsenides present in the Mackinaw ore is unique in Washington and is known to occur elsewhere only in the ore at Alistos, Sinola, Mexico. One other unique aspect of these two occurrences is that pentlandite is present without pyrrhotite.

A number of nearby Tertiary quartz dioritic intrusions are generally considered to have been the sources of both the hydrothermal solutions and the ensuing sulfide-arsenide mineralization (Nichols, 1970).

I suggest that perhaps this deposit, like many of the other nickel deposits in Washington State, owes more of its notable quality to secondary rather than primary or hydrothermal processes. The similarity between this deposit and the so-called "nickel ledge" deposits of the Cle Elum-Blewett Pass, Mount Vernon, etc. areas is notable; in all cases the host peridotite is of similar origin and age and its emplacement was followed by a long period of exposure to lateritic weathering and residual concentration of contained nickel and chromium. The weathering processes were terminated by burial beneath the terrestrial sediments of the Swauk Formation. Chemical analyses of the Mackinaw ores by early investigators (Division of Geology and Earth Resources files) indicated that unusually high concentrations of aluminum posed various problems relating to beneficiation—high aluminum content was also noted to be a problem encountered during studies

on the various "nickel ledge" deposits. It seems reasonable therefore to theorize that perhaps we are dealing with a combination of factors that include most importantly, lateritic concentration and high-grading of nickel, iron, and aluminum values from an impure host peridotite, followed by hydrothermal alteration along porous zones and subsequent introduction of cupriferous arsenides and sulfides. The occurrence of copper sulfides related to Tertiary intermediate intrusives is much more widespread in this area of the Cascades than it is in other "nickel ledge" areas to the south and west. If my theory is correct, the significant nickel values should not be expected to persist to any great depth along the mineralized shear zone such as could be reasonably expected in the case of similar deposits of strictly primary origin.

One major reason for entering this very marginal deposit in the Minerals Availability System is to draw attention to the fact that there are a number of minor, structurally and genetically related occurrences of copper-nickel sulfides in the Monte Cristo-Darrington area. This area, which parallels the regional strike, may contain as yet undiscovered sulfide deposits of economic proportions.

As mentioned earlier, a number of interested parties have investigated this deposit and eventually concluded that the mineralization is restricted to the shear zone and consists only of small discontinuous lenses, stringers, and pockets of marginal economic value. The tonnage figures quoted in the Probabilistic Grade Quantity Matrix are unrealiable and to a large extent apparently based upon questionable data. The smaller tonnage figure was obtained from Vhay (1966).

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WASHINGTON CHROMIUM RESOURCES

Denney Prospect, Kittitas County, Washington

Property Location and Access: 47°26'35" N., 121°01'15" W., sec. 36, T. 23 N., R. 14 E.

Commencing at Roslyn northwest of Cle Elum follow the forest service road numbered 2149 north along the Cle Elum River for approximately 21 miles to Camp Creek. An old road runs east along Camp Creek, then turns south for about 1 mile to Big Boulder Creek. The workings of the Denney prospect lie 1 more mile to the east, at an altitude of 5,500 feet, between the headwaters of Big Boulder and Camp Creeks.

History and Production

The chromite was discovered, prospected and pegged by Richard(?)Denney. A small quantity was mined and shipped during the first World War and an additional small tonnage was produced in 1942 (U.S. Bureau of Mines unpublished data).

Ownership

The deposit was covered by 6 claims during the second period of development in 1942. The land is now within the Wenatchee National Forest and there are no known active claims for chromite in the Boulder Creek areas.

General Geology and Description of the Ore Bodies

The known ore bodies are in the western part of a serpentine area, 3 or 4 miles wide and 20 miles long, that extends from the Cle Elum River eastward around the south side of Mount Stuart (Pardee, 1921). The pre-Tertiary serpentinite (serpentinized peridotite) appears to have intruded both the surrounding Paleozoic Hawkins and Peshastin Formations.

The chromite bodies consist of small isolated lenses of high-grade mineral. They constitute a separate and distinct occurrence of chromite and are not genetically related to the nearby Cle Elum lateritic chrome-nickel-iron or "nickel-ledge" deposits, which ring the eastern margin of the host serpentinite.

These occurrences of chromite as distinct, though subeconomic, masses have been included in the Minerals Availability System to focus attention on large chromite-bearing serpentinite, which may, with properly aimed exploration, yield additional minable quantities of this strategic metal.

WASHINGTON CHROMIUM RESOURCES

Mount Hawkins Prospect, Kittitas County, Washington

Property Location and Access: 47°26'38" N., 120°58'40" W., sec. 33, T. 23 N., R. 15 E. Within the Wenatchee National Forest.

Commencing at Teanaway Junction on Interstate Route 90, east of Cle Elum, proceed northeast on U.S. 97 to Swauk. Turn northwest at Swauk on forest service route 2003 through Casland, then north for 14 miles on forest route 232 to the De Roux Creek campsite. Follow a trail northwest along the creek to Gallagher Head Lake, a distance of about $2\frac{1}{2}$ miles upstream from the campsite. The Mount Hawkins chromite deposits are situated a short distance up hill from the northwest side of the lake.

History and Production

The Mount Hawkins chromite was discovered, prospected, and pegged by Mr. Richard Denney around 1918. That same year Mr. Denney produced 15 tons of chromite averaging around 50 percent Cr_2O_3.

The only other recorded production was in 1942 when the Skipper Chrome Mining Company of Seattle mined and shipped one carload of ore, the value

of which was exceeded by the costs of production (U.S. Bureau of Mines unpublished data).

Ownership

During the production period of 1942, the prospect was covered under 15 claims owned by Mr. Jack Crowe of Cle Elum and leased to the Skipper Chrome Mining Company. The land is now within the Wenatchee National Forest and is believed to be free of any claims or similar incumberances.

General Geology and Description of the Ore Bodies

The known ore bodies are in the western part of a serpentine area, 3 or 4 miles wide and 20 miles long, that extends from the Cle Elum River eastward around the south side of Mount Stuart (Pardee, 1921). The pre-Tertiary serpentinite (serpentinized peridotite) appears to have intruded both the surrounding Paleozoic Hawkins and Pershastin Formations.

The chromite bodies consist of small isolated lenses of high-grade mineral. They constitute a separate and distinct occurrence of chromite, and they are not genetically related to the nearby Cle Elum lateritic chrome-nickel-iron deposits that ring the eastern margin of the host serpentinite.

These occurrences of chromite as distinct, though subeconomic, masses have been included in the Minerals Availability System to focus attention on a large chromite-bearing serpentinite, which may, with proper intensive exploration, yield additional minable quantities of this strategic metal.

WASHINGTON CHROMIUM RESOURCES

Funkhouser (Johnson Creek) Chromite Deposit, Okanogan County, Washington

Property Location and Access: 48°28'40" N., 119°35'05" W., sec. 5, T. 34 N., R. 26 E.

The Funkhouser chromite deposit is located on the southwestern slope of Little Chopaka Mountain approximately 7 miles north of Omak on the Omak-Conconully Road. The property is approximately one-quarter of a mile east of the road, at an elevation of 1,600 feet.

History and Production

The chromite deposit was discovered in 1936 by Mr. Ralph Roberts, a geology student during a student field trip in the Omak area. With the exception of stripping and sampling of the outcrop by various investigators, no developmental work or production has been recorded.

Ownership

The property, consisting of 300 acres of deeded land, is owned by Buck Haberly of Omak, Washington (1955, U.S. Bureau of Mines, unpublished data). In 1955, the property was leased to Chrome Cliffs Mine, Inc. of Conconully, Washington, James E. Dow, Manager.

Geology and Description of the Ore Body

The deposit consists of a singular lens of massive chromite imbedded in serpentinized peridotite. The lens measures approximately 5 feet wide by 10 feet long and is estimated to contain about 25 tons of ore (U.S. Bureau of Mines, unpublished data). Disseminated chromite grains form a thin halo in the serpentinite around the massive lens.

Plane table mapping and exploration of the deposit by the Bureau of

Mines in 1943 failed to reveal any additional significant occurrences of chromite. Samples taken during the investigation yielded favorable chromium to iron ratios but were otherwise of poor quality. The deposit was described as being too small to be of any economic value.

The occurrence of massive isolated lenses or concentrations of chromite are not uncommon in the numerous small alpine-variety serpentinite bodies scattered throughout western Washington and elsewhere along the Pacific Coast ranges. Exploration for chromium concentrations within these serpentinites is at best difficult and limited to physical searching of exposed areas.

In view of the strategic importance of this mineral, it seems that more research could be justified to develop broader and more reliable exploration techniques for chromite. This effort should be directed perhaps toward applying recent advances and techniques in ground and airborne geophysics, remote sensing, trace element detection, etc.

WASHINGTON CHROMIUM RESOURCES

Chopaka Mountain Chromite Deposit, Okanogan County, Washington

Property Location and Access: 48°57'54" N., 119°46'35" W., sec. 13, T. 40 N., R. 24 E.

Commencing at the Coulee Creek road approximately 2 miles north of Loomis on the Loomis-Nighthawk Highway proceed west up Coulee Creek for approximately 9 miles to the North Fork Camp. Follow a jeep trail upstream for one-half mile from the camp, turn north along Ninemile Creek and proceed upstream for 5 miles to Chopaka Mountain and a fork in the trail. Take the north fork of the track and continue up hill for another 3 miles to the Mount Chopaka chromite deposit. The deposit is located on a saddle between Chopaka Mountain and Hurley Peak to the northeast.

History and Production

The occurrence of chromite on Chopaka Mountain was discovered in 1917. Since then a number of prospectors and other interested parties have visited and studied the property and determined that the deposits are at best subeconomic and unworthy of further investigation.

Though mining claims have at one time or another been staked on the property, there is no record of any current activity or production of any sort.

Ownership

The entire area belongs to the State of Washington

Geology and Description of the Ore Bodies

Chromite occurs on Chopaka Mountain as disseminated grains and as bands 3 or 4 inches wide in dunite and serpentinized peridotite. Chromite

is also found as 1/8-inch veinlets along a fault in the dunite. Most of the bands are 1.5 feet or less in length (Huntting, 1956). Very little massive chromite has been observed in situ, though a number of high-grade samples have been collected from nearby talus slopes. Perhaps the elusive high-grade material represents the complete erosional release of massive lenses or it may be the remnants of a latertic cap formed on the surface of the serpentinite.

The occurrence of massive isolated lenses or concentrations of chromite are not uncommon in the numerous small alpine-variety serpentinite bodies scattered throughout western Washington and elsewhere along the Pacific Coast ranges. Exploration for chromium concentrations within these serpentites is at best difficult and limited to physical searching of exposed areas.

In view of the strategic importance of this mineral, it seems that more research could be justified to develop broader and more reliable exploration techniques for chromite. This effort should be directed perhaps toward applying recent advances and techniques in ground and airborne geophysics, remote sensing, trace element detection, etc.

WASHINGTON CHROMIUM RESOURCES

Alamether-Gora and adjacent claims (Three Lakes South area)

Skagit County, Washington

Property Location and Access: 48° 38' 03" N., 121° 53' 15" W., sections 3, 4, T. 36 N., R. 27 E. Within Mount Baker National Forest.

The countryside around Three Lakes is moderately timbered with silver fir and intervening low brush. Exposure of the mineralized dunite is primarily restricted to steep cliff faces, stream cuts and occasional breaks in the overlying glacial till, which ranges from a few feet to 15 to 18 feet in thickness (Shaffer, U.S.B.M. unpublished data, 1942).

Access to the Alamether-Gora and adjacent claims of the Three Lakes South area is gained via secondary and logging roads. Starting at the town of Hamilton on state route 17A, a secondary road goes northwesterly for 6 miles toward Lyman Pass and through Soundview logging camp, thence easterly for approximately 3 miles along the South Fork of the Nooksack River. A logging road, intersecting the main secondary track near the river crossing, continues in an easterly direction parallel to the river for another 9 miles, at which point it turns northward, crosses the river, and terminates at the Alamether claim. Chromiferous olivine is currently being mined on a regular basis at the claim site by Northwest Olivine International, a subsidiary of International Minerals and Chemicals, Skokie, Illinois. The olivine product is marketed as a foundry sand, refractory material, fertilizer, etc. Access to the mine area is believed to be open on a year-round basis. At present there is no known vehicle access to the claims at higher elevation.

History and Production

As with other chromium properties in the Twin Sisters Mountain, the original prospecting and claim staking was performed by Mr. George Peterson of Sedro Woolley. Prospecting commenced in 1918. Of the claims in the Three Lakes South area, the Alamether and the Gora are the most promising.

With the exception of small quantities of ore removed for analytical purposes, there has been no recorded production of chromite from the Three Lakes area. As noted before, however, chromiferous olivine is currently being mined from the Alamether claim.

Ownership

At present (1975), the Three Lakes claims are indirectly maintained by Industrial Mining Company, Myron Nielson, president, Rt. 3, Box 267A, Sedro Woolley, WA 98284, Phone (206) 826-3858. Another organization that is directly interested in the claims of the Three Lakes area is: The Twin Sisters Associated Advisory Council, Cecil F. Henderson, president, 12318 Ninth Drive SE, Everett, WA 98203, Phone (206) 337-7664.

The following statement by Shaffer (1942) sums up the (current?) ownership picture for most of the Twin Sisters dunite: "Numerous transfers and options have been made and cancelled and, in all probability, any start of work would initiate numerous law suits over title."

General Geology

The main mass of dunite that forms the Twin Sisters Mountain is elliptical in configuration and measures 9 miles long and 4 miles across. The mountain is approximately 90 percent dunite (fosterite olivine) and 10 percent saxonite (Gaudette, 1963). A peripheral rind of serpentinized olivine, a few to 1,600 feet thick, is found along the margins of the olivine body. This is believed to be a late stage contact alteration phenomenon (Spanski, 1963).

The Twin Sisters dunite was intruded in a solid, dry state (Gaudette, 1963) along a high angle northwest-trending fault. This feature forms a faulted contact between the upper Paleozoic Chilliwack Group on the east and pre-Jurassic phyllite to the west.

Occurrence of Chromite and Description of Ore Bodies

At eight adjoining claims in the Three Lakes South area only three the Alamether, Gora, and Shaft deposits have warranted attention by various investigators. The Shaft deposit was noted only as being similar in type to the Alamether, but much smaller. Both the Alamether and Gora claims consist of chromite exposures on steep cliff faces, accessible only by-foot trails.

The chromite mineralization in the Three Lakes South area is similar to occurrences elsewhere within the Twin Sisters Mountain; that is, that chromite occurs as both high-grade lens-shaped bodies and as sharply defined lower-grade veins or schlieren in relatively unaltered dunite.

Mineralization on the Alamether claim is of the latter type and contains a large tonnage of low-grade material. Conversely, the Gora claim contains a small tonnage of higher-grade ore. According to Magill (1958) surface mapping and diamond drilling results indicate a high degree of post-mineral faulting in the Alamether-Gora claims area. Drilling also proved that in-depth projection of surface ore exposure is at best an unreliable approach to evaluation when dealing with deposits of this sort.

Probabilistic Grade-Quantity Matrix (see appendix for Matrix)

The figures and diagram used to construct the Probabilistic-Grade Quantity Matrix were obtained from Magill (U.S. Bureau of Mines unpublished data, 1958). Magill's grades, tonnages and estimates were based primarily upon the results of seven diamond drill holes--four holes on the Alamether and

the remaining three on the Gora claim.

> According to Magill, "Tonnage estimates for the Alamether deposit are based on three blocks (Fig. 1-c). Block "A" is a triangular prism 100 feet by 110 feet on the base and 150 feet high. It is estimated to contain 82,000 long tons. DDH's 1 and 2 intersected a corner of this block and were virtually barren; consequently, the estimated tonnage may be too large. Block "B" is a rectangular prism 30 feet by 100 feet by 110 feet containing 33,000 long tons. Block "C" is also a triangular prism 100 feet by 110 feet on the base and 165 feet high. It is estimated to contain 91,000 long tons. A tonnage factor of 10 cubic feet has been used in the computations. The grade of 3.7 percent Cr_2O_3 for the Alamether deposit was based on 29 assays from DDH's 7 and 8 (Fig. 1-b)."

> "Tonnage calculations for the Gora (Begonia) deposit do not take into account structural complexity. They are based on a deposit having a vertical extent of 250 feet, an average width of 15 feet and an approximate length of 115 feet. A tonnage factor of 10 cubic feet per long ton has been used. This gives an inferred tonnage of 43,000 long tons."

Expansion of Magill's basic estimates was accomplished for the 10 and 25 percent probability levels by increasing the length of the triangular ore blocks by 50 feet for the 25 percent level and 100 feet for the 10 percent level. Due to the limited nature of the Gora ore, expansion beyond the base limits set at the 50 percent level is obviously not as reliable as those projected for the Alamether deposits.

Mining and Beneficiation Methods

Open pit quarry mining would appear to be the most practical method of mining the chromite deposits of the Three Lakes South area; consequently, the proposal for underground mining of any sort has been omitted. The steep exposures of the ore combined with relatively good accessibility to transport make the Alamether-Gora deposits the most attractive occurrences of chromite in the Twin Sisters Mountain.

Beneficiation experiments have been conducted on chromite samples obtained from a number of different localities in the Twin Sisters Mountain, including the Alamether and Gora claims. The highest and best separation

and concentration of chromite was obtained by tabling of minus 48 mesh ore, followed by treatment of the table middlings by electrostatic separation. This combination separated 82.7 percent of the chromite at a grade of 46.7 percent Cr_2O_3 (U.S. Bureau of Mines, unpublished data). Flotation of the ore was also tried but proved to be of lesser value. All of the mineral dressing techniques tried by the U.S. Bureau of Mines resulted in an unfavorable reduction in the Cr:Fe ratio between the head and the concentrate (Wells, U.S. Bureau of Mines, unpublished data, 1947). The process feed grade of 9.0 percent shown on the beneficiation record was arrived at by combining the grade percentages shown on the Grade-Quantity Matrix for the two main deposits.

A partial beneficiation record for olivine was prepared; however, this commodity only requires crushing and sizing to be a useful product. Chromium cannot be removed as a byproduct without seriously altering the refractory qualities of the olivine.

As indicated earlier, there is adequate road access to the Alamether-Gora claims. Assuming that a mill can be erected at the site, mine-to-mill transport can be best performed by a conveyor system. Insufficient costing data is available to extend the transportation record away from the mill, etc.

WASHINGTON CHROMIUM RESOURCES

Meadow-Leader and adjacent claims (Three Lakes North Area)

Skagit County, Washington

Property Location and Access: 48° 38' 22" N., 121° 54' 05" W., sections 3, 4, T. 36 N., R. 7 E. Within the Mount Baker National Forest.

The countryside around Three Lakes is moderately timbered with silver fir and intervening low brush. Exposure of the mineralized dunite is primarily restricted to steep cliff faces, stream cuts, and occasional breaks in the overlying glacial till, which ranges from a few feet to 15 to 18 feet in thickness (Shaffer, U.S. Bureau of Mines unpublished data, 1942).

Access to the area is gained via secondary and logging roads. Starting at the town of Hamilton on State Route 17A, a secondary road goes northwesterly for 6 miles toward Lyman Pass and through Soundview logging camp, thence easterly for approximately 3 miles along the South Fork of the Nooksack River. A logging road, intersecting the main secondary track near the river crossing, continues in an easterly direction parallel to the river for another 9 miles, at which point it turns northward, crosses the river, and terminates at the mine of Northwest Olivine International, a subsidiary of International Minerals and Chemicals, Skokie, Illinois. Access to the mine is believed to be open on a year-round basis. At present there is no known vehicle access to the higher elevations in the vicinity of Three Lakes and the Meadow-Leader claims.

If production is started from the Meadow-Leader deposit, the ore can be transported directly to the river valley by aerial tram. The tram would be about 5,500 feet long; the difference in altitude is about 2,000 feet. A good millsite and tailings disposal site is at the lower terminus of

the tram site (Lorain, U.S.B.M. unpublished data, 1949). No costing data is available to extend the transportation record away from the mill site.

History and Production

As with other chromium properties in the Twin Sisters Mountain, the original prospecting and claim staking was performed by Mr. George Peterson of Sedro Woolley. The work was performed in 1918 or later. The Meadow-Leader claims are the most promising of the many claims in the area designated for this inventory as the Three Lakes North area.

With the exception of small quantities of ore removed for analytical purposes, there has been no recorded production of chromite from the Three Lakes North area.

Ownership

The Three Lakes claims are indirectly maintained by the Twin Sisters Associated Advisory Council, Cecil F. Henderson, president, 12318 Ninth Drive S.E., Everett, WA, 98203 (phone (206) 337-7664). TSAAC is an organization of holders of Twin Sisters Mountain chromite claims. Industrial Mining Company, Myron Neilson, president (1975) Rt. 3, Box 267 A, Sedro Woolley, WA 98284 (phone 826-3858) is also believed to hold interests in the area. The following statement by Shaffer (1942) sums up the (current?) ownership picture for most of the Twin Sisters dunite. "Numerous transfers and options have been made and cancelled and, in all probability, any start of work would initiate numerous law suits over title."

General Geology

The main mass of dunite that forms the Twin Sisters Mountain is elliptical in configuration and measures 9 miles long and 4 miles across. The mountain consists of approximately 90 percent dunite (fosterite olivine) and 10 percent saxonite (Gaudette, 1963). A peripheral rind of serpen-

tinized olivine from a few feet to 1,600 feet thick is found along the margins of the olivine body. This is believed to be a late stage contact alteration phenomenon (Spanski, 1963).

It is concluded that the Twin Sisters dunite was intruded in a solid, dry state (Gaudette, 1963) along a high angle northwest-trending fault. This feature forms a faulted contact between the upper Paleozoic Chilliwack Group on the east and pre-Jurassic phyllite to the west.

Occurrence of Chromite and Description of the Ore Bodies

Unlike the majority of the minable claims within the Twin Sisters dunite, the Meadow-Leader claims consist primarily of irregularly spaced bands or linear concentrations of chromite rather than lens-shaped bodies. The bands vary in thickness from knife edge to about 1 foot, and are spaced irregularly across a zone that is about 160 feet wide on the Meadow claim to about 20 feet wide on the Leader claim. The intervening ground between the two exposures, a distance of about 1,200 feet, is covered deeply with soil and glacial debris.

On the Meadow claim, most of the bands strike N. 70° E. and dip 70° SE; on the leader the altitude of the bands is N. 60° E. at 70° SE.

Probabilistic Grade-Quantity Matrix (see appendix for Matrix)

All of the data utilized in the construction of the marginal or partial Grade-Quantity Matrix was obtained from estimates determined by Lorain (1949). The data used by Mr. Lorain was measured and collected from surface exposures only on the Meadow-Leader claims.

Since the primary purpose of Mr. Lorain's report was in ". . . passing judgment on conflicting reports as to the value of the deposit" the figures used to construct the matrix, though minimal, appear to represent the most accurate and unbiased accounting of the ore reserves available. Mr. Lorain's ore reserve estimates and calculations are as follows:

ORE RESERVES

Indicated Ore

The horizontal projection of the outcrop of the Meadow deposit is an irregular polygon whose area is a little more than 20,000 square feet. The vertical range of the Meadow outcrop is 150 feet. Therefore the cubic content of the "indicated" ore is:

$$\frac{20,000}{2} \times 150 = 1,500,000 \text{ cubic feet.}$$

The specific gravity of samples taken by the writer was determined to be about 3.3 which is about the same as the specific gravity of pure olivine. A ton of rock with a specific gravity of 3.3 would have a volume of slightly less than 10 cubic feet.

Therefore the weight of rock contained in the block of "indicated" ore would be:

$$\frac{1,500,000}{10} = 150,000 \text{ short tons.}$$

150,000 short tons 9 percent Cr_2O_3 would contain 13,500 short tons of Cr_2O_3 or the equivalent of slightly more than 25,000 long tons of 48 percent concentrates.

No significant amount of ore is "indicated" on the Leader claim.

Inferred Ore

Because of the well known undependability of chromite ore deposits the writer does not wish to "infer" the existence of any ore at the Meadow—Leader deposit in addition to the "indicated" ore. He prefers to discuss additional reserves under the head of:

Possible Ore

(a) Meadow outcrop area: If the outcrop area is "squared" it will be about 180 feet by 200 feet. Therefore its area will be about 36,000 square feet. It could contain $\frac{36,000}{10} \times 100 = 360,000$ tons of ore in

each 100 feet of depth that it may continue downward. The chromium content would be equivalent to $\frac{360,000 \times 0.09 \times 100}{48}$ = 67,500 short tons or 61,400 long tons of 48 percent concentrates. Hence this area could contain chromite equivalent to 25,000 long tons plus 61,400 long tons; a total of slightly over 86,000 long tons of 48 percent concentrates. Extensions to the northeast would increase the reserves proportionally.

(b) Area between Meadow and Leader outcrops: If it is assumed that the ore zone is continuous between the Meadow and Leader outcrops, that it is 70 feet wide on the northeast and tapers uniformly to a width of 20 feet on the southwest end, and that it is continuous from surface to the altitude of the Meadow and Leader outcrops, it contains:

$$\frac{\frac{70 \text{ plus } 20}{2} \times 1,200 \times 200}{10} = 1,000,000 \text{ tons of ore.}$$

The chromite content would be equivalent to:

$\frac{1,100,000 \times 0.09 \times 100}{48}$ = 187,500 short tons or 170,000 long tons of 48 percent concentrates.

Summary of Ore Reserve Estimates

Class	Area	Tons ore (LT)	Tons Chromium	Long tons equivale Cr_2O_3 concentrat
Measured	——	None	None	None
Indicated	Meadow outcrop	150,000	13,500	25,000
Inferred	——	None	None	None
Possible	Meadow outcrop (to 100 ft. depth)	360,000	32,400	61,400
Possible	Meadow -Leader (surface to depth main outcrops)	1,000,000	90,000	170,000
Totals (in round numbers)		1,500,000	136,000	250,000

The above totals do not include further extensions in length, depth, or width which are possible.

Mining and Beneficiation Methods

Shrinkage mining was selected as being the most applicable method to employ for underground mining of the high-grade zones—especially the buried

ore zone thought to connect exposures on the Meadow and Leader claims.

In light of the rugged terrain and high elevation, especially in the higher grade areas, bench mining is thought to be the most applicable method of surface mining and one which may also be employed on a year-round basis.

Beneficiation experiments have been conducted on chromite samples obtained from a number of different localities in the Twin Sisters Mountain, including the Meadow and the Leader claims. The highest and best separation and concentration of chromite was obtained by tabling of minus 48 mesh ore, followed by treatment of the table middlings by electrostatic separation. This combination separated 82.7 percent of the chromite at a grade of 46.7 percent Cr_2O_3 (U.S. Bureau of Mines written communications). Flotation of the ore was tried, but proved to be of lesser value. All of the mineral dressing techniques tried by the U.S. Bureau of Mines resulted in an unfavorable reduction in the Cr-Fe ratio between the head and the concentrate. (Wells and others, U.S. Bureau of Mines unpublished data, 1947).

A partial beneficiation record for olivine was also prepared; however, this commodity, to be a useful product, requires crushing and sizing only. Chromium cannot be removed as a byproduct without seriously altering the refractory qualities of the olivine.

Meadow-Leader claims

If production is started from the Meadow-Leader deposit, the ore can be transported directly to the river valley by aerial tram. The tram would be about 5,500 feet long; the difference in altitude is about 2,000 feet. A good millsite and tailings disposal site is at the lower terminus of the tram site (Lorain, U.S.B.M. unpublished data, 1949). Insufficient costing data is available to extend the transportation record away from the millsite.

WASHINGTON CHROMIUM RESOURCES

Cypress Island Chromite Deposit, Skagit County, Washington

Property Location and Access: 48° 34' 33" N., 122° 42' 20" W. Sections 29, 30, 33. Cypress Island is a part of the hilly San Juan archipelago, which separates Puget Sound and Juan de Fuca Strait from the waters of Georgia Strait. It is roughly 10 miles due west of the mainland at Samish Bay, 4 miles northwest of Anacortes (the nearest railroad point), and about 80 miles by water from Seattle. The island is about 5 miles long from north to south and 3 miles wide in the middle (Pardee, 1921).

History and Production

Chromite ore was mined on Cypress Island in 1917 by the Bilrowe Alloys Company for use in its smelter at Tacoma. Prior to this no production is reported, but a moderate amount of development work had been done on several claims that were located 15 or 20 years earlier. In 1918 development work was extended, several new ore bodies were found, and a moderate amount of ore (50 tons) was produced by the Cypress Chrome Company (Pardee, 1921). The value and grade of samples tested by the U.S. Bureau of Mines (Wilson, 1942) was deemed unacceptable for purchase by the wartime Metals Reserve Company.

Ownership

The bulk of the land on Cypress Island is under private ownership with a lesser amount being held by the state. There is no evidence to suggest that any of the mining claims staked on the chromite occurrences are still valid.

General Geology and Description of the Ore Bodies

The Cypress Island ultramafic body is an alpine-type complex made up of serpentinite, dunite, and subordinate harzburgite layers, and harzburgite with subordinate dunite layers. The serpentinite has been derived from the harzburgite and is composed of chrysotile, lizardite and minor magnetite (Conway, 1971).

The entire mass exhibits varying degrees of serpentinization and is believed to belong to the pre-Tertiary Fidalgo Formation.

Chromite on Cypress Island occurs in association with dunite dikes, and in no instance was there any notable concentration of chromite in the original stocklike intrusions. No concentrations of chromite were found on the other islands composed of the Fidalgo Formation (McLellan, 1927).

The following description of the Cypress Island ore bodies by Pardee (1921) is the only detailed reference available:

> Distribution and occurrence - Chromite is scattered through the serpentine in many places, in several of which it is sufficiently abundant to form workable ore bodies. The largest body of this description observed by the writer is on the Ready Cash claim, on the steep west slope of the island, about 1,100 feet above sea level and three-quarters of a mile from the shore. It was developed by an open cut 10 feet wide, 15 feet long, and 6 feet deep, from which about 25 tons of ore was mined. The serpentine is traversed by persistent narrow veins or seams that trend No. 25° W. and are filled with a rather soft light-green claylike material, apparently a decomposition product of the rock itself. Locally the seams are accompanied by chromite, which forms irregular veinlets an inch or more thick and bunches or pockets a foot or more in diameter. The surrounding masses of serpentine also contain more or less chromite in the form of scattered grains. On the south side of the cut a face 6 feet high and 6 feet wide was estimated to be about half serpentine and half chromite. On the north a fault that strikes No. 75° E. and dips 60° S. cuts off the ore. In 1918 the Cypress Chrome Co. developed this body further, extending its known limits considerably and mining about 50 tons of ore.
>
> On the southwest side of the island, on one of several claims belonging to the estate of George B. Smith and others, a short distance west of Mexican Bay, a small ore body is exposed by an open cut and short drifts. These workings are made along a fault plane that strikes No. 70° E., dips 80° N., and carries 2 or 3 feet of crushed and mixed serpentine and chromite. Small bunches and stringers of chromite are also scattered through the serpentine in the hanging wall, At a level 70 feet below the open cut an adit is driven No. 65° W. for 60 feet, following prominent joint planes that dip 45° SW. In this working small bunches and streaks of chromite occur sparingly.
>
> At the lake near the center of the island an adit level is driven northward 120 feet into the serpentine without disclosing more than a few grains of chromite, but several small streaks of chromite are said to crop out on the hill above. Several other claims belonging to the Smith estate and reported to contain chromite were not examined.
>
> Bodies made up of chromite grains thickly disseminated in serpentine were discovered a short distance south of the lake by the Cypress Chrome Co. while building a road from Strawberry Bay to the Ready Cash claim. A shipment from one of these bodies was milled at the Faust Concentrating Co.'s plant in Seattle. Other similar bodies are reported to occur short distances west and south of the Ready Cash claim.

Character and composition - Ore from the Ready Cash body consists of rather coarse granular chromite intergrown with small amounts of a micaceous amethystine or rose-red mineral identified as the chrome chlorite kotschubeite. There is a little serpentine between the grains, and the aggregate is cut by veinlets of a rather coarse platy light-green chrome-bearing variety of hornblende. Most of the other deposits consist of serpentine more or less thickly peppered with fine grains of chromite. Ore shipped from the Ready Cash claim by the Cypress Chrome Co. averaged 47.5 per cent of chromic oxide. Ore from the Last Chance claim, south of the lake, that was milled in Seattle carried 25.5 per cent of chromic oxide. The coarse and fine concentrate made from it contained respectively 43.9 per cent and 49.6 per cent of chromic oxide.

Summary

From the descriptions of the Cypress Island chromite deposits by Pardee (1921) and McLellan (1927), and the notable lack of any mention of chromite by subsequent students, it would appear that the deposits, with the exception of a few isolated bodies, constitute little more than a mineralogical curiosity.

However, from a strategic rather than economic standpoint, the Cypress Island chromite should be considered as a large marginally low-grade source of chromite accessible year-round via water transport.

WASHINGTON CHROMIUM RESOURCES

Alma & McMaster Claims, Skagit County, Washington

Property Location and Access: 48° 37' 35" N., 121° 53' 10" W., sec. 10, T. 36 N., R. 7 E. All claims are within the Mount Baker National Forest.

Access to the claim area is gained via secondary and logging roads. Starting at the town of Hamilton on state route 17A, a secondary road goes northwesterly for 6 miles toward Lyman Pass and through Soundview logging camp, thence easterly for approximately 3 miles along the South Fork of the Nooksack River. A logging road, intersecting the main secondary track near the river crossing, continues in an easterly direction parallel to the river for another 9 miles, at which point it turns northward, crosses the river, and terminates at the Northwest Olivine Company Mine, access to which is believed to be maintained on a year-round basis. From the mine site, walk southwesterly along the river to the first large stream that enters the river from the northwest. Follow the stream uphill to the Alma & McMaster claims, at 2,000 feet in elevation.

For text please refer to Twin Sisters Group, Whatcom County.

WASHINGTON CHROMIUM RESOURCES

Bellingham Claims Group, Skagit County, Washington

Property Location and Access: 48° 37' 46" N., 121° 56' 00" W., sec. 5, T. 36 N., R. 7 E. All claims are within the Mount Baker National Forest.

Partial access to the claim area is gained via secondary and logging roads. Starting at the town of Hamilton on state route 17A, a secondary road goes northwesterly for 6 miles toward Lyman Pass and through Soundview logging camp, thence easterly for approximately 3 miles along the South Fork of the Nooksack River. The road then forks to the left (northeast), crosses the river, and continues climbing for about 5 miles along the west side of Howard Creek. In the extreme northeast corner of section 2, the road terminates at its intersection with the bed of an old logging railroad that runs southeasterly along the opposite side of Howard Creek. Follow the course of the railbed for approximately 2 miles to section 7 and (or) the terminus of the road. A trail beginning at the end of the track goes uphill and through the Bellingham claims, which start at an elevation of 3,000 feet.

For text please refer to Twin Sisters Group, Whatcom County.

WASHINGTON CHROMIUM RESOURCES

Twins Claim Group, Skagit County, Washington

Property Location and Access: 48° 37' 37" N., 121° 54' 05" W., sec. 9 & 19, T. 37 N., R. 7 E. All claims are within the Mount Baker National Forest.

Access to the claim area is gained via secondary and logging roads. Starting at the town of Hamilton on state route 17A, a secondary road goes northwesterly for 17 miles toward Lyman Pass and through Soundview logging camp, thence easterly for approximately 3 miles along the South Fork of the Nooksack River. A logging road, intersecting the main secondary track near the river crossing, continues in an easterly direction parallel to the river for another 9 miles, at which point it turns northward, crosses the river and terminates at the Northwest Olivine Company mine, access to which is believed to be maintained on a year-round basis. From the mine site, walk southwesterly for about .7 mile. The southeastern corner of the Twins claim group is located uphill at about the 2,000 foot contour.

For text please refer to Twin Sisters Group, Whatcom County.

WASHINGTON CHROMIUM RESOURCES

Hildebrand Lake Claims, Whatcom County, Washington

Property Location and Access: 48° 42' 2" N., 121° 55' 50" W., sec. 8, T. 37 N., R. 7 E. All claims are within the Mount Baker National Forest.

Commencing at Bellingham, follow state route 542 north northeast for about 15 miles through the town of Deming to the intersection of the Kulshan Road. Follow the Kulshan Road southeasterly along the Middle Fork of the Nooksack River for about 5 miles. Before the road crosses the river, intersect the all-weather road, which parallels the north bank of the river, and continue along it to Heisler's Ranch. From the ranch, follow the road and river for 10 more miles to Green Creek, a south branch of the river. A trail starts at the river-creek intersection and bears due south for 1 mile. Continue on the same bearing past the change in trail direction for another mile. The Hildebrand Lake group of claims are located at about 4,000 feet and approximately one-half of a mile due east of Lake Wiseman.

For test please refer to Twin Sisters Group, Whatcom County.

WASHINGTON CHROMIUM RESOURCES

Lambert Claim Group, Whatcom County, Washington

Property Location and Access: 48° 40' 48" N., 121° 59' 00" W., sec. 23, T. 37 N., R. 6 E. All claims are within the Mount Baker National Forest.

Partial access to the Lambert claim group is gained via secondary and logging roads. Starting at the town of Hamilton on State Route 17A, a secondary road goes northwesterly for 6 miles toward Lyman Pass and through Soundview logging camp, thence easterly for approximately 3 miles along the South Fork of the Nooksack River. The road then forks to the left (northeast), crosses the river, and continues climbing for about 15 miles along the west side of Howard Creek. The road terminates in the extreme northeast corner of section 2. On foot continue to follow Howard Creek to its terminus, then traverse north-northeasterly to Hayden Creek. The Lambert claims are located at an elevation of 4,000 feet, about one-half of a mile north and between the two major headwater branches of Hayden Creek.

For text please refer to Twin Sisters Group, Whatcom County.

WASHINGTON CHROMIUM RESOURCES

Ribbon and Button Claims, Whatcom County, Washington

Property Location and Access: 48° 43" 00" N., 121° 57' 14" W., sec. 6, T. 37 N., R. 7 E. All claims are within the Mount Baker National Forest.

Commencing at Bellingham, follow state route 542 north-northeast for about 15 miles, through the town of Deming to the intersection of the Kulshan Road. Follow the Kulshan Road southeasterly along the Middle Fork of the Nooksack River for about 5 miles. Before the road crosses the river, intersect the all-weather road, which parallels the north bank of the river, and continue along it to Heisler's Ranch. From the ranch, follow the road and river for 10 more miles to Green Creek, a south branch of the river. Follow a trail along the west bank of Green Creek upstream for 2 miles to an abandoned prospector's camp. The Ribbon and Button claims are uphill to the west, starting at an elevation of 3,800 feet.

For text please refer to Twin Sisters Group, Whatcom County.

WASHINGTON CHROMIUM RESOURCES

Sister Creek Claims, Whatcom County, Washington

Property Location and Access: 48° 43' 47" N., 121° 58' 25" W., sec. 31, T. 37 N., R. 6 E. All claims are within the Mount Baker National Forest.

Commencing at Bellingham, follow state route 542 north-northeast for about 15 miles through the town of Deming to the intersection of the Kulshan Road. Follow the Kulshan Road southeasterly along the Middle Fork of the Nooksack River for about 5 miles. Before the road crosses the river, intersect the all-weather road, which parallels the north bank of the river, and continue along it to Heisler's Ranch. From the ranch, follow the road and river for about 4 miles to Sister Creek, a south branch of the river. The Sister Creek claims are located around the top end of Sister Creek, at an elevation of 2,700 feet.

For text please refer to Twin Sisters Group, Whatcom County.

WASHINGTON CHROMIUM RESOURCES

Sumner Claim Group, Whatcom County, Washington

Property Location and Access: 48° 39' 8" N., 121° 57' 12" W., sec. 31, T. 37 N., R. 7 E. All claims are within the Mount Baker National Forest.

Partial access to the claim area is gained via secondary and logging roads. Starting at the town of Hamilton on state route 17A, a secondary road goes northwesterly for 6 miles toward Lyman Pass and through Soundview logging camp, thence easterly for approximately 3 miles along the South Fork of the Nooksack River. The road then forks to the left (northeast), crosses the river, and continues climbing for about 5 miles along the west side of Howard Creek. In the extreme northeast corner of section 2, the road terminates at its intersection with the bed of an old logging railroad, which runs southeasterly along the opposite side of Howard Creek. Follow the railroad bed for approximately one-eighth of a mile to the intersection of an old logging trail and go northwards into the woods and up the hill. The southwest corner of the Sumner group of claims is at 3,000 feet in elevation and approximately one-half of a mile northeast of the termination of the logging trail and near the headwaters of a branch to Howard Creek.

For text please refer to Twin Sisters Group, Whatcom County.

WASHINGTON CHROMIUM RESOURCES

Thunder Mountain Claims, Whatcom County, Washington

Property Location and Access: 48° 42' 42" N., 122° 0' 47" W., sec. 10, T. 37 N., R. 6 E. All claims are within the Mount Baker National Forest.

Commencing at Bellingham, follow state route 542 north-northeast for about 15 miles through the town of Deming to the intersection of the Kulshan Road. Follow the Kulshan Road southeasterly along the Middle Fork of the Nooksack River for about 5 miles. Before the road crosses the river, intersect the all-weather road, which parallels the north bank of the river, and follow it to Heisler's Ranch. At an intersection approximately $2\frac{1}{2}$ miles up the river road, there is a lesser track that crosses the river and bears southward into the mountains. Follow this track in a southeasterly direction for about 2 miles to Galbraith Creek. Follow Galbraith Creek upstream for another 2 miles to Orisino Creek, follow the north fork of Orisino Creek upstream to the 3,800 foot elevation and the Thunder Mountain claims.

For text please refer to Twin Sisters Group, Whatcom County.

WASHINGTON CHROMIUM RESOURCES

Trappers Pride Claims, Whatcom County, Washington

Property Location and Access: 48° 40' 20" N., 122° 00' 8" W., sec. 3, T. 37 N., R. 6 E. All claims are within the Mount Baker National Forest.

Commencing at Bellingham, follow state route 542 north-northeast for about 15 miles through the town of Deming to the intersection of the Kulshan Road. Follow the Kulshan Road southeasterly along the Middle Fork of the Nooksack River for about 5 miles. Before the road crosses the river, intersect the all-weather road, which parallels the north bank of the river, and follow it to Heisler's Ranch. At an intersection approximately $2\frac{1}{2}$ miles up the river road, there is a lesser track that crosses the river and bears southward into the mountains. Follow this track in a southeasterly direction for about 3 miles to its terminus at the next major mountain creek past Seymour Creek. Proceed on foot southward up the creek and toward the prominent cliffs at the head of the valley. The Trappers Pride claims are situated on a ridge, at 4,600 feet in elevation.

For text please refer to Twin Sisters Group, Whatcom County.

WASHINGTON CHROMIUM RESOURCES

Twin Sisters Group (Washington Chromium Company), Whatcom County, Washington

Property Location and Access: 48° 40'40" N., 121° 57' 20" W., secs. 17, 18, 19, 20, 29, 30, T. 37 N., R. 7 E. and portions of east ½ sections 13, 24, 25. All claims are within the Mount Baker National Forest.

The chromiferous Twin Sisters dunite and two smaller dunite bodies to the southeast are located along a N. 40° W. trending zone in the western part of the Northern Cascades, approximately 70 miles north of Seattle and 20 miles east of Bellingham, Washington.

The Twin Sisters Mountain is extremely rugged and difficult to prospect, with the highest peaks ranging in altitude from 5,000 to nearly 7,000 feet. Perpetual snow and small active glaciers cover many of the protected higher valleys and cirques. Heavy snowfalls above 2,000 feet restrict travel and other activities to the summer months of June to September.

A well-maintained forest service road provides almost year-round access to the lower eastern slopes of the mountains. Starting at the town of Concrete on state route 17A, and the Burlington Northern railroad tracks, the road goes north through Lake Shannon Valley and forks to the northwest along Sulfur Creek, then southwest along Wanlick Creek, and thence northwards up the headwaters of the South Fork of the Nooksack River to a dead end at Bench Mark 2122. The total distance from Concrete to the end of the road is approximately 22 miles.

History and Production

With the exception of several thousand pounds of ore removed from various claims for metallurgical and beneficiation tests, there has been no established production of chromite from the Twin Sisters dunite. Of the chromite mined for testing purposes, 20 tons was obtained from high-grade lenses on the Ribbon claim (Washington Chromium Co.) in 1934 (Slater, 1935), and approximately 3,000 pounds was mined from the Dannie claim (Washington Chromium Co.) (Slater, Washington Div. of Geology unpublished data, 1935).

The chromium deposits of the Twin Sisters massif were discovered in 1918 by Mr. George Peterson of Sedro Woolley, Washington. Over the next 12 to 15 years, Mr. Peterson actively prospected, staked, and filed a number of claims in the area, including most of the claims of the Washington Chromium Company.

Other claims or groups of claims included under this blanket report are as follows with the name of the prospect, prospector, and year of discovery:

Twin Sisters Group (Wash. Chromium Co.), Geo. Peterson, 1918
Ribbon and Button, 1934
Twins Group, Geo. Peterson, 1940
Lambert group, S. S. Lambert, 1930
Hildebrand Lake, A. C. Ross, 1934
Sisters Creek, Robert McArthur, 1935
Thunder Mountain, Albert Odmark, 1935
Trappers Pride, L. E. Bradley, 1937
Alma & McMaster, Geo. Peterson, 1940
Bellingham group, L. M. Coffield, and others, 1943
Sumner group, J. N. Brisky, 1943

In most cases the information outlined above constitutes all that is available for this report. All of the claims and properties covered herein are within the Mount Baker National Forest.

Ownership

Organizations holding or primarily involved with chromite claims, valid

or otherwise in the Twin Sisters Mountain (1975) are as follows:

Washington Chromium Company
Cecil Henderson, president
12318 Ninth Drive S.E.
Everett, WA 98204
PH. 337-7664
(Washington Chromium Co. claims)

P & H Mining Company
Dan C. Peterson, president
616 Alexander
Sedro Woolley, WA 98284
PH. 855-0662
(various George Peterson claims)

Current ownership status for other claims on Twin Sisters Mountain is unknown. The last-known owner of individual properties is listed on record 020 of the MAS worksheet.

The validity of most of the claims listed in the MAS records (011) of the above properties is questionable. On many properties the value and currency of the assessment work may not be sufficient to insure ownership. The exact location of some of the claims, their dimensions and extent are also conjectural. The following confidential account by (name withheld) fairly well describes the problem.

Legal

> In consideration of the negligible production record, the organization of the holdings seems extraordinarily complicated. 190 claims have been staked and recorded in the Twin Sisters district by George Peterson of Sedro Woolley and his associates. Some of the claims belong to the partnership of Peterson and Hammer (Mrs. Isabel Hammer of Sedro Woolley); some belong to the Industrial Mining Co., Inc. (interested parties other than Peterson include C. E. Steele, Chas. Thomas, E. Davis, Grant Franklin.)
>
> None of the claims are properly located. Discoveries are not of legal dimensions, and are not on center line. In some cases four claims are staked on one small outcrop of chromite, and no work has been done on that. Many of the claims have been "rediscovered", some of them probably several times. No consequential assessment work has been done on any of the claims I visited, other than rudimentary trail construction, and the building of a cabin at Three Lakes. More work has been done on the Meadow than on any other claim in the Basin, but the present location notice claims "discovery" on July 1, 1942, 2:30 p.m. and "location" on August 27, 1942.
>
> Most of the more promising claims in Three Lakes Basin were jumped in November 1941, or thereabouts. No discernible work

has been done by these locators.
While the validity of the claims is, manifestly, questionable, no more valid location has yet been made and maintained.

A conclusion drawn by Shaffer, U.S.B.M. unpublished data, (1942) summarizes the extent of the ownership picture for much of the area ". . . in all probability, any start of work would initiate numerous lawsuits over title."

General Geology

The main mass of dunite which forms the Twin Sisters Mountain is elliptical in configuration, and measures 9 miles long and 4 miles across. The mountain consists of approximately 90 percent dunite (fosterite-olivine) and 10 percent saxonite (Gaudette, 1963). A peripheral rind of serpentinized olivine from a few feet to 1,600 feet in thickness is found along the margins of the olivine body. This is believed to be a late stage contact alteration phenomenon (Spanski, 1963).

It is concluded that the Twin Sisters dunite was intruded in a solid, dry state (Gaudette, 1963) along a high angle northwest trending fault. This feature forms a faulted contact between the upper Paleozoic Chilliwack Group on the east and pre-Jurassic phyllite to the west.

Occurrence of chromite

The chromite deposits of the Twin Sisters Mountain have been investigated by a number of individuals, companies, state and governmental agencies (see Selected References). Interest in domestic chromium resources has been especially evident during recent world conflicts.

Chromite occurs in the area as lenses, veins, and fine-grained disseminations. The majority of the chromiferous zones strike roughly parallel to the northwest regional strike, others strike east to east-southeast. The dips range from 50° to vertical. Spanski (1963) reported the following observations:

> The chromite veins are generally quite small and are commonly grouped in an en echelon pattern within "zones.". These "zones" are from 1 to 40 feet wide and 10 to 150 feet long and contain from 3 to over 100 small, parallel, discontinuous veins. The veins exhibit a pinch and swell form, with swells rarely exceeding a few inches in thickness and a foot in length, and single veins rarely exceeding 20 feet in length.
>
> Large single veins exist, but they are isolated and rare. Two veins 20 to 50 feet long and 1 to 2 feet wide were examined; both developed into large, elliptical pods of chromite near their midpoints. The pods in cross-section, average 8 feet in thickness and 12 feet in length, and change abruptly into veins 1 to 2 feet thick at either end.

As a part of a strategic mineral investigation (James, 1943) the U.S. Geological Survey examined all reported chromium occurrences on the Twin Sisters Mountain. In addition to a general description of the deposits, the authors emphasized that chromite samples from several of the deposits were richer in chromic oxide than most other deposits in the United States. In many of the analyses of the chromite samples, concentrations of the oxides of chromium and iron approached a very favorable ratio of 3:1, necessary for the production of ferro-chrome oxide, the metallurgical grade product required by the steel industry.

Subsequent investigations of chromite occurrences within most of the claim groups staked on the Three Sisters also conclude that the Twin Sisters chromite is indeed of a high quality, but greatly lacking in quantity. Preparation and/or completion of a Probabilistic Grade-Quantity Matrix for these numerous claims is impossible due to a lack of adequate and (or) reliable data. For the most part, published analytical data has reflected isolated surface or bedrock samples collected from isolated and (or) small subeconomic exposures of the mineral. Many of the samples were collected from exposures along vertical cirque walls, knife-edged ridges, and other areas equally inaccessible to high-grade mining methods.

In light of chromium's growing importance as a strategic and essential metal, combined with the United States' total dependence on embargo-prone imported ores, it would not seem unrealistic at this juncture to view the

Twin Sisters dunite as a valuable national asset worthy of immediate attention. Exploration and delineation of the higher-grade areas should transcend all environmental, legal, and economic obstacles in order to prepare for the inevitable crisis or embargo, or to simply assure that a worthwhile and thoroughly tested "deposit" has been placed in the national mineral bank for use at a later date. Additionally, the immense bulk of refractory and metallurgical grade olivine, a source of magnesium, should be viewed as also constituting a valuable, if not strategic byproduct, of any chromite mining operation.

Concomitant research in the area should be aimed at improving the speed and efficiency of mining disseminated ores such as these, reproducing and improving established beneficiation processes, and development of improved geological, geochemical, and geophysical prospecting techniques for chromite and other strategic minerals.

Sumas Mountain Chromium, Whatcom County, Washington

Property Location and Access: 48°55'33" N., 122° 12'41" W., sec. 30, T. 40 N., R. 5 E., on a tributary to Breckenridge Creek.

The deposit is approximately 5 miles southeast of the town of Sumas situated near the Canadian border in Whatcom County, Washington. Take State Route 1 due east toward Limestone Junction. Five miles from Sumas turn south on the Jacobs Spur-Nooksack Road, and proceed 4 miles southwesterly along the west flank of Sumas Mountain to Breckenridge Creek. The Sumas Mountain chromite prospect is located on the south side of the creek at an elevation of about 2,200 feet.

History and Production

The Sumas Mountain chromium deposit was discovered on the south bank of Breckenridge Creek by hunters in 1930. A 50-foot adit was driven on the discovery outcrop and an undisclosed tonnage of chromite was mined. A number of claims were subsequently filed over the area; however, there is no record of any resultant mining activity. Further development was attempted in 1946 and a very small amount of chromite was mined before the operation was suspended. No further mining has since been attempted. Tabulation of these events is as follows (from Moen, 1962):

1930: Discovery by Elmer Goodwin and John Dahlgreen.

1943: Claims covering most of section 30 filed by J. M. Stine, Fred Shea, Ott (initials unknown), and John Dahlgreen.

1946: Super Chrome Company of Seattle, Washington, headed by Elmer Larsen, attempted development.

1952: Yamated Trading Company of San Francisco, California, obtained a

20-year lease on the property from the State of Washington.

Ownership

The Sumas Mountain serpentinite is held under both state and private ownership.

Geology and Description of the Ore Bodies

The chromite deposits and scattered minor occurrences of chromite on Sumas Mountain are developed in a highly jointed and serpentinized peridotite overlain by late Paleozoic graywacke and argillite. The peridotite forms an elongated, northwesterly striking mass which is believed to have been tectonically emplaced (possibly in a solid state) into the surrounding rocks. The age of the peridotite is thought to be Jurassic-Cretaceous.

Chromite occurs primarily as disseminated particles, small stringers, and as high-grade concentrations in a few scattered lenticular-shaped bodies. The largest lens exposed at the mine workings was 5 feet long by 5 inches wide. The overall maximum tonnage of individual lenses is about 5 tons. Larger deposits of chromium may occur at Sumas Mountain; however, deep overburden and a lack of exposure combine to discourage exploration under current economic and technological conditions.

Analysis of a relatively pure lump of Cr by the U.S. Bureau of Mines (Wilson, 1943) showed 45.1 percent Cr_2O_3 and 17.6 percent FeO. The Cr to Fe ratio was 2.5:1. Samples collected from the mine dump in 1936 by the Washington Div. of Mines & Mining assayed 48.06 percent Cr_2O_3, 19.9 percent FeO; the Crife ratio was 2.4:1.

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Refer to M.A.S. backup file for reports by Magill, Lorain, and Shaffer.

WASHINGTON SILVER RESOURCES

The Apex Mine, King County, Washington

Property Location and Access: 47°41'42" N., 121°30'44" W., sec. 34, T. 26 N., R. 10 E.

From the town of Snohomish, Washington, go east approximately 37 miles on U.S. Route 2 toward Stevens Pass and Wenatchee, to the hamlet of Baring. Continue eastward from Baring on the same highway for another 4.5 miles to the intersection of the highway and the road to Miller River and Skykomish. Turn south on the Skykomish road, cross the Skykomish River and go approximately 1 mile to the intersections of the road with U.S. Forest routes 2601 and 2522. Turn west on route 2601 which parallels Money Creek, and go upstream 5.5 miles to Lake Elizabeth. The Apex mine is located on a bearing of approximately 15° east of south and 1,000 feet above the outlet of the lake. The mine is within the Snoqualmie National Forest and just outside of the proposed Alpine Lakes Wilderness area.

History and Production

According to Hodges (1897), the Apex mine was discovered in 1889 by Alex McCartney. The Apex was both the first discovery and the first mine to ship ore from the Money Creek area. Between the original entry date and closure by the War Production Board under L-208, a variety of companies mined and produced an estimated $300,000 worth of gold and silver from this property.

Development consists of more than 2,240 feet of underground workings on four levels and stopes between the adit levels. Level 2 is the only working presently open (Gualtieri, 1975).

Prior to closure, mined ore was moved and milled on the property by the holding company, Apex Gold Mines, Incorporated.

Ownership

After closure of the mine, the 12 unpatented claims, millsite, railroad, tramway, and adjacent mining properties were acquired by Cleopatra Mines, Inc., of nearby Index, Washington. Though the corporation was dissolved in 1973, the claims are presently being held under possessory title by parties unknown.

Geology and Description of Ore Bodies

The ore bodies of the Apex mine are vein deposits developed along persistent shear zones in granodiorite of the Tertiary Snoqualmie batholith. The mineralized zone strikes approximately N. 75° E. and dips at about 60° to the SE; thickness is from a few inches to over 6 feet, with the average width about 1.2 feet. Mineralization consists of arsenopyrite, pyrite, chalcopyrite, galena, and sphalerite, carried in a gangue of quartz and calcite. Argentiferous galena and gold-bearing arsenopyrite are the principal ore minerals. A number of smaller veins and(or) shear zones of similar character parallel the principal or Apex vein and hold potential for further discovery or development. The mine and several other deposits in the vicinity possess a relatively high concentration of arsenic compounds when compared with similar mines in other districts.

Description of the Probabilistic-Grade-Quantity Matrix (See appendix for matrix)

The maximum available tonnage calculated for the matrix and shown in column one at the 10 percent probability level is 450,000 metric tons of ore, containing an average value of 191.8 g/t of silver and 33.0 g/t of gold. The grade figures, published by Livingston (1971), are an average of the results of 91 samples collected in the workings by W. J. Priestley, a former Apex mine owner.

The base tonnage figure for the 50 percent confidence level was calculated from outcrop and underground dimensions scaled from maps prepared by Mr. Priestley. The total surface outcrop trace of the Apex vein and an undeveloped, mineralized zone to the north measured 1707 meters. The depth from the surface to the 4th level of the mine is approximately 152 meters. Gualtieri's (1975) average thick-

ness of 0.4 meters (1.2 feet) was selected as being probably the most accurate and unbiased figure available. The average thicknesses reported by earlier investigators ranged up to 1.2 meters. Tonnage values for the 10 percent and 25 percent levels were derived by increasing the depth dimension of the veins from 500 to 700 feet and from 700 to 900 feet deep, respectively. Taking into consideration the relatively uniform overall values and strength of the mineralization in the developed portions of the mine, it seems reasonable to assume that the selected values will be maintained over the lengths and depths utilized in construction of the matrix. It should be noted, however, that no reduction in volume was considered for the existing workings that have been almost completely backfilled with an estimated 20,000 short tons of rock, containing up to 0.50 ounce of gold and 9.27 ounce of silver and 0.11 percent lead per ton.

Values used to calculate column two of the matrix represent grades and tonnages established by Gualtieri(1975). The indicated tonnage value of 12,000 tons represents a smaller portion or block within the same structures utilized to establish column one.

Gualtieri and other observers who have had the opportunity to study the mine site and(or) the workings all concluded that the possibilities for finding additional ore along projections of the Apex and related mineralized zones appear to be most favorable.

Mining and Beneficiation

The generally narrow width of the Apex vein combined with the good support characteristics of the surrounding rocks would seem to favor mining by shrinkage stoping methods over all others. It is proposed that the most practical method of exploiting this deposit, following exploratory drilling, of course, would be to extend crosscut number 5 southward to intersect the vein 300 feet below level number 4. Mining should then be directed westward along the shear zone and eventually raise to level number 4 where the lower-grade backfill or gob can be

extracted for combination with the mill feet or shipping ore. It is estimated that with a minimum daily (24 hr.) production rate of 50 metric tons the mine should have a life of 10 or more years and contribute significantly to the local and state economies.

As noted earlier, many of the silver-gold deposits in the area contain a high percentage of arsenic compounds, primarily arsenopyrite, and therefore require specialized treatment. It is proposed that a mill designed to handle arsenical ores be erected to service the Apex mine, the nearby Cleopatra mine, and other related or high arsenic deposits in the vicinity.

A mineral dressing report was prepared in 1941 by the Northwest Testing Labs., Inc. for the purpose of streamlining and improving the efficiency of the Apex mill. The report, prepared by W. H. Marquette (see backup file), showed that the ore after being reduced to minus 48 mesh readily responded to flotation. A final recovery of 93.23 percent with a concentration ratio of 5.4 to 1 was reported by this study.

Lead-time required to open the mine is estimated at approximately 1.5 years to 2.0 years. This estimate assumes that the extension of number 5 tunnel will proceed as soon a preliminary surface drilling verifies the extension and worth of the vein(s) at depth. During the drilling and tunnelling state and prior to justification and erection of the mill, the ore would be trucked to the railroad siding at Miller River, thence freighted to the Tacoma smelter for treatment.

WASHINGTON SILVER RESOURCES

The Cleopatra Mine, King County, Washington

Property Location and Access: 47°38'08' N., 121°27'32' W., sec. 24, T. 25 N., R. 10 E.

From the town of Snohomish, Washington, go east approximately 37 miles on U.S. Route 2 toward Stevens Pass and Wenatchee, to the hamlet of Baring. Continue eastward from Baring on the same highway for another 4.5 miles to the intersection of the highway and the road to Miller River and Skykomish. Turn south on the Skykomish road, cross the Skykomish River and go 1 mile to the intersection of U.S. Forest Service Routes 2601 and 2522. From the intersection take Route 2522 south to the West Fork (Miller River) campground, a distance of about $3\frac{1}{2}$ miles. Near the campground turn southwest on to a jeep trail along the west bank of the West Fork and go 3.6 miles to the remains of the old Cleopatra base camp. A cat road begins near the camp and goes directly to the mine, a distance of about $1\frac{1}{2}$ miles to the west, and at an elevation of about 3,400 feet. The mine is on the south wall of the Cleopatra basin.

The Aces Up mine which is developed on the same vein as the Cleopatra is located about three-fourths of a mile south of the base camp.

History and Production

The Cleopatra was one of the first mines to be located in the Miller River Mining District. Location was made in 1892, and the first shipment of ore was made in 1897 following completion of the Miller River Road, which was constructed by the county to encourage development of the Cleopatra, Aces Up, and other mining properties in the area (Smith, 1915). In 1940, a 4,100-foot tramline was built connecting the mine with the Cleopatra camp on the valley floor. A reported total of $250,000 worth of ore was taken from the property by 1941, at

which time the Cleopatra was classified as a nonessential mine and closed down because of World War II (Livingston, 1971). During the operating years over 2,100 feet of workings were developed. Though efforts have been made from time to time to resume operations, there is no record of any production following the wartime closure.

Ownership

After closure of the mine, the 23 unpatented claims were acquired by the Cleopatra Mines, Inc., of nearby Index, Washington, Joe Cashman, president. The corporation was dissolved in 1973 and the claims are presently being held under possessory title by persons unknown.

Geology and Description of the Ore Bodies

Like many of the mines in the Miller River area the Cleopatra is developed along a shear zone or system of mineralized joints formed in granodiorite of the Tertiary Snoqualmie batholith. The mineralized zone dips steeply toward the south and strikes approximately 60° W. for a distance in excess of 12,000 feet, from the West Fork of the Miller River westward through Bear Lakes basin and possibly as far west as the Paradise Lakes area. The Aces Up mine and the Dawson prospects are also located on this zone; however, the Cleopatra mine is the largest of the three operations. Thickness of the mineralized zone ranges from 6 inches to over 9 feet, with the average being about 2.5 feet.

Mineralization at the Cleopatra consists principally of argentiferous galena, chalcopyrite, tetrahedrite, arsenopyrite, pyrite, jamesonite, and sphalerite. Purdy (1951) reported that a 500-pound shipment of ore from the Aces Up mine to the Tacoma smelter contained too much arsenic to be acceptable, but that the amounts of jamesonite and galena were too small to make a commercial lead-antimony concentrate.

Description of the Probabilistic-Grade-Quantity Matrix (See appendix for matrix)

Two matrices have been developed primarily to focus attention on the resource

potential of the Cleopatra shear zone.

Matrix No. one reflects the resource potential for the mineralized area in the immediate vicinity of the mine. Reserves of 91,000 metric tons of ore with a silver grade of 342 g/t were estimated by Gualtieri (1975) and placed at the 50 percent probability level. Tonnage values were established for the 10 and 25 percent confidence levels by increasing the downdip dimensions of Gualtieri's blocks by 100 (25 percent) and 200 (10 percent) feet. Values used in columns 2 and 3 represent tonnage/grade figures published by the mine owners in their promotional brochure of 1961. The erratic assay values in the brochure represent analyses by a number of different laboratories. The values selected for the matrix were done by the Asarco smelter in Tacoma, Washington, and they represent the approximate median of values reported in the brochure.

The second matrix was prepared to point out the immense quantity of silver that may possibly be recovered should the entire mineralized zone be exploited from the 2,000 foot level of the Aces Up mine to the surface and along the 12,000 foot surface trace. Utilizing the same 2.5 foot thickness as above, the 2,000 foot level-to-surface block tonnage was placed at the 50 percent probability level. Calculation of the 25 and 10 percent levels was accomplished by increasing the depth of the block from the 2,000 to 2,500 foot and 2,500 to 3,000 foot levels, respectively. These calculations are, of course, purely speculative at this juncture and only very extensive and thorough exploration will confirm or deny the existence of economic mineralization at or to the depths proposed.

In situ leaching is included on a separate record as an alternate proposed method of mining the Cleopatra deposit. It may be entirely possible that the bulk of the metallic content of the Cleopatra shear zone could be recovered by leaching, and that a considerable savings could be realized by reducing waste disposal and underground labor requirements. A basic outline of the proposed

system is as follows:

1. Extend the depth of the Aces Up tunnel or drive an alternate nearly horizontal tunnel along the shear zone from its lowest possible outcrop or exposed location.
2. Then, drill a series of parallel large-diameter holes (estimated 12 inch) from the surface through the shear to just above the back of the tunnel. Separate the holes by a predetermined or calculated distance, probably about 30-40 feet. Into every other hole, insert a perforated 4-inch pipe. Pack these pipes solid with a soluble material to prevent collapse of the pipe during blasting. Pack every alternate hole with explosives and seal the collars with cement.
3. Then widen and clean the tunnel to expose the unsheared country rock and carpet the floor of the tunnel with heavy plastic sheeting.
4. Following completion of step 3, fire the charged holes simultaneously. The force of the blast, confined on two sides by the unsheared country rock, should be directed primarily toward open unpacked alternate holes and thereby open the intervening sheared ground to the passage of fluids.
5. Dissolve the protective packing from the perforated pipes and pump an appropriate acid or other chemical into the shattered zone. The pregnant solutions could then be collected at the mine portal via the impermeable plastic trough or the solutions could be retrieved from a sump provided at the head of later tunnels placed below the level of the first tunnel.
6. Precipitate the dissolved metals near the mine portal and return the chemically active solutions to the leach zone.

Mining and Beneficiation

In light of the variable reported thicknesses of the veins within the mineralized zone resuing is proposed as being the best method of developing either the Cleopatra Mine or the entire mineralized zone. Development of the larger zone could be based upon the establishment of a main haulage level collared adjacent to the river bank at an elevation of about 2,400 feet. Secondary haulage levels could then be established at higher elevations and connected to the main level from which the entire haulage operation could be performed by truck via an improved road along the West Fork of the Miller River. A mine-to-mill aerial tramway, however, may prove to be more environmentally acceptable and it would certainly be less vulnerable to avalanche hazards.

It is proposed that an appropriately sized mill be erected at the community of Miller River to process ore from the Cleopatra and the Apex mines as well as any other local deposits that surely would be developed if suitable ore dressing facilities were erected to handle antimonial and arsenical ores. The only beneficiation test results available are those that were performed on a laboratory scale by Mills (1949). The results of this study, performed on genetically similar ores from the nearby Coney Basin, showed that by using flotation over 93 percent of the silver and nearly 87 percent of the gold values could be recovered.

Lead-time estimated to explore and produce ore from the Cleopatra is $1\frac{1}{2}$ years. Two and one-half years work at least will be required to explore and block out enough ore within the larger area to justify both mining and erection of a mill.

In both cases above, lead-time is assumed to begin with actual physical occupation of the property. It includes both exploratory drilling on a year-round basis where possible, test tunneling and pilot beneficiation tests, all of which should be performed concurrently. Drilling at the higher elevations

may be severly restricted during winter and all operations at the lower elevations will be subject to avalanche and occasional winter access problems

Arlington Mine, Okanogan County, Washington

Property Location and Access: 48°28'15" N; 119°43'58" W; sec. 6, T 34 N; R. 25 E.

The Arlington mine is located on Ruby Hill nearly 2 miles south of the old Ruby City townsite on Salmon Creek.

From the town of Okanogan, go 15.5 miles northwest toward Conconully and turn west onto the secondary road leading to Cow Lake, Salmon Creek, and eventually back to Okanogan. After crossing Salmon Creek, follow the road south approximately 0.3 miles to the Ruby City townsite. At Ruby City, turn west off the Salmon Creek Road on to a jeep trail and go another 4 miles around and up the west slope of Ruby Hill. The Arlington mine works are located where a series of switchbacks carry the road up the steep western slope of the hill. The lower adit is about 300 feet south of the first switchback, and the upper tunnel is about 400 feet south of the third switchback or nearly directly above the first tunnel.

History, Production and Ownership

The mineralized vein of the Arlington mine was located by John Oleson in 1887. Shortly thereafter the property was acquired by the newly formed Arlington Mining Company, which operated the mine intermittently until 1937. In 1937 the property was purchased by Arlington Mines, Inc. and a 10-stamp mill was installed at the mine site. Mining and milling operations ceased in 1940, by which time over 4,000 feet of workings had been developed on 3 levels. The total recorded production from the mine between the discovery date and 1940 amounted to $144,650.00, with most of the values being in silver. There is no record of any production or sustained activity on the property following its closure in 1940.

The Arlington property consists of a group of 12 claims, 9 of which are patented. The present owners of the claims are:

Estate of Suzanna Phillips
c/o Mrs. Oscar Pitts
Malott, WA 98829

And

Emma Jean Claridge
5747 West Missouri
Space 34
Glendale, AZ 85301

Geology and Description of the Ore Body

The Arlington vein is a true fissure vein developed across the contact between granodiorite and metamorphic rocks. The metamorphics, consisting predominately of schists and gneisses, were developed during the Jurassic orogeny from Paleozoic sediments and volcanics; together they constitute part of a thick metamorphosed sequence that underlies large areas of central Okanogan County. The granodiorite is part of the post-Jurassic Similkameen batholith of western Okanogan County. The contact between the later intrusive granodiorite and the metamorphic series is generally sharp, though transitional and migmatic zones occasionally intervene. The strike of the contact is about N. 10°W., dipping steeply to the east. The primary vein is a quartz fissure vein, which strikes generally north and dips 70° W. The vein pinches and swells from 1 to 6 feet in thickness and occurs for the most part along the granodiorite-metamorphic contact.

The ore minerals are restricted to within the limits of the vein and occur as layered or banded masses; they consist principally of argentiferous tetrahedrite and galena, chalcopyrite, and minor sphalerite. Ore shoots up to 2 feet thick and 300 feet long, containing as much as 1,000 ounces of silver per ton, were exploited during the early mining operations. Gold and copper are also present, though in minor amounts averaging about 0.02 ounce per ton and 1.15 percent, respectively.

Description of the Probabilistic-Grade-Quantity Matrix (See appendix for matrix)

The data used to prepare the matrix were based primarily upon a few visual

estimations by early investigators combined with gross assays averaged over a period of years. There is no detailed sampling data known to exist. The grade figures shown in column one represent an estimated average grade for the ore shoots based upon early smelter returns.

To the writer's knowledge there has been no attempt to delineate the subsurface lateral extent of the Arlington vein. Moen (1973, p. 10) states that the vertical extent of the ore minerals on Ruby Hill appears to be as much as 1,500 feet. Assuming that the vein will maintain an average thickness of 3 feet, the resources quantity established for the 50-percent level represents extension of a vein 3 feet wide by 1,500 feet deep by 1,000 feet long, or that area occupied by the vein between the present workings and the northern border of the claim. Dimensions for establishing tonnages at the 25-percent level represent projection of the vein lengths for 750 feet north and 750 south of the Arlington claim. An additional projection of 750 feet each way provides the dimensions for the 10-percent level. Both of the areas projected to the north and south of the Arlington claim are covered by the adjoining Missing Link and Pomeroy claims.

There is every reason to speculate that the tenor of the remaining ore will match or possibly exceed that of the mined ore. It is also possible that predevelopmental exploration drilling may reveal additional mineralized veins within the limits of the Arlington group of claims.

Mining and Beneficiation

Since the average thickness of the Arlington vein is only 3 feet, resuing appears to be the most appropriate mining method. Resuing combined with careful attention to waste control and backfilling should minimize the environmental impact on the surface, as well as adequately serve to extract the bulk of the mineralized rock. Assuming a daily production rate of 200 tons of ore and concentrating only on the material inferred to be available at the 50-percent level of

confidence, the Arlington mine should have a minimum productive life span of 7 years.

No recent data are available concerning the degree to which the ore can be concentrated. Jones, (1916, p. 24) reports that in laboratory tests performed in 1915 on ores from Ruby Hill that recovery of about 90 percent of the silver values could be achieved by concentrating the ore using both gravity and flotation methods. Modern mineral dressing techniques should be capable of increasing this percentage significantly.

A 1,000-ton-per-day mill was included in the MAS proposal. It is expected that a mill of at least this capacity will be required to handle the production volume from the Arlington and other mines located on Ruby Hill. The mill could situated near the old Ruby City townsite where adequate water and electricity could be brought in with a minimum of difficulty. Ore from the mines on Ruby Hill and elsewhere could be trucked and/or trammed to the millsite.

Without including the time required to plan and construct a mill or similar facility, the Arlington mine should be able to produce ore with a lead-time of about 9 months.

WASHINGTON SILVER RESOURCES

First Thought Mine, Okanogan County, Washington

Property Location and Access: 48° 29' 34" N; 119° 44' 21" W., sec. 31, T. 35 N, R. 25 E.

The First Thought mine is on the northwest end of Ruby Hill in the Conconully Mining District of north-central Washington.

From the town of Okanogan, go 15.5 miles norhtwest toward Conconully and turn west onto the secondary gravel road heading toward Cow Lake, Salmon Creek, and eventually back to Okanogan. After crossing Salmon Creek, follow the road south approximately 0.3 mile to the abandoned townsite of Ruby City. At Ruby City turn west off the Salmon Creek road onto a jeep trail and proceed up the steep eastern slope of Ruby Hill. On the crest of the hill and about 1.3 miles from Ruby City, turn left or south on the Buzzard Lake Road. Follow the Buzzard Lake Road south, bearing left through several forks, for a distance of about 1.1 miles. The lowest or main adit of the First Thought mine is near the west side of the road and just past the second switchback curve. The portals of two smaller First Thought adits are located uphill to the southeast from the main entrance.

History, Production and Ownership

The First Thought mine was one of the first discoveries made on Ruby Hill and for a while it was one of the richest silver producers in the Conconully district. Bethune (1891) reported that one ore shoot produced 1,926 ounces of silver per ton and that several others ran well over 1,000 ounces per ton. The deposit was discovered in 1886 by Dick Bilderback and his father, Pat McGreel, and Will Chilson (Hodges, 1897); from October 1892 to the beginning of the silver panic in May of 1893, the mine produced ore valued at $66,000. The First Thought mine, like most of the other domestic silver mines, shut down during the

panic, and though small tonnages were produced during the 1920's, the mine was never again fully operational. Over 1,000 feet of workings were developed on 3 levels during the productive years; today the workings are largely inaccessible due to caving and flooding.

The current owner of the patented claims, which include the First Thought mine is:

Last Chance Partnership (Talmo, Inc.)
P. O. Box 401
Gig Harbor, Washington 98335

Geology and Description of the Ore Body

Like other silver mines in the Conconully district and in particular those on Ruby Hill, the First Thought mine is located on mineralized fissure veins. The veins are developed in gneiss adjacent to their contact with a large post-Jurassic intrusive granodiorite body, part of the Similkameen batholith of western Okanogan County. The lens-shaped mineralized quartz veins vary from several inches to more than 90 feet thick along a strike length of up to 700 feet. The lenses have a general strike of N. 10° E. and dip at about 60° to the E. The number of individual veins present on the First Thought and adjoining properties is unknown.

Ore shoots in the mine are commonly developed along the lens walls; some shoots are as much as 5 feet thick. The average value of the quartz between the high-grade margins runs about 6-8 ounces of silver per ton. The principal ore minerals are galena, tetrahedrite, sphalerite, pyrite, and Ruby silver.

The discontinuous nature of the silver-bearing lenses in the north Ruby Hill area, combined with little or no recorded surface or subsurface, detail, leaves nothing with which to construct a Probabilistic-Grade-Quantity Matrix. Although a considerable volume of ore appears to have been removed from the mine since its inception, there is every reason to believe that an even greater quantity of high-grade material remains to be found on the First Thought and

the adjoining patented and unpatented claims.

Estimated lead-time to produce crude ore only is about 9 months.

Fourth of July Mine, Okanogan County, Washington

Property Location and Access: 48°28'37" N., 119°43'40" W., sec. 5, T. 34 N., R. 25 E.

The Fourth of July property is 1 mile north of the summit of Ruby Hill in the Conconully Mining District of Okanogan County.

From the town of Okanogan, go 15.5 miles northwest toward Conconully and turn west onto the secondary road heading toward Cow Lake, Salmon Creek, and eventually back to Okanogan. After crossing Salmon Creek, follow the road south approximately 0.3 mile to the Ruby City townsite. At Ruby City turn west off the Salmon Creek Road onto a jeep trail and go another 4 miles around and up the west slope of Ruby Hill. The two shafts of the mine are about 200 feet north of the last sharp switchback, which the road makes before heading south along the east flank of Ruby Hill toward Buzzard Lake.

History, Production and Ownership

The richest vein on Ruby Hill, the Fourth of July, was discovered in 1887 by Richard Dilderback. A 200-foot shaft was sunk on the vein and the first shipment of ore was made in 1889 to a smelter in Helena, Montana. In 1890 a Montana Syndicate, encouraged by the results of the earlier shipments, acquired the property and sunk a double-compartment shaft to a depth of 500 feet. The silver panic of 1893 resulted in the closure of many mines including the Fourth of July. The mine was reopened in 1958 by Cecil Murray of Okanogan, who operated the mine and produced a limited quantity of hand-sorted ore that ranged in value from 50-80 ounces per ton. Mr. Murray operated the mine until 1964 and one small shipment of ore was made by a leasee in 1967. The patented claim was acquired from Mr. Murray's estate in 1975 by:

William Hommel
Box 86
Nespelem, WA 99155

The underground workings of the mine, in addition to the 500-foot double shaft and a nearby 200-foot shaft, consist of over 850 feet of drifts developed along the vein on 5 levels, ranging from 30 feet to 300 feet below the surface. The 500-foot shaft and the deeper workings developed from it are no longer accessible.

Geology and Description of the Ore Body

The Fourth of July mine, similar to the other mines in the Conconully district, is developed on a mineralized fissure vein. The vein averages 6 feet in thickness, strikes N. 10° W. and dips 70 to 80° E. According to W. S. Moen (1973, p. 13), ". . . the vein is in biotite gneiss and parallels a granodiorite gneiss contact that is several hundred feet west. The metallic minerals are argentiferous tetrahedrite and galena that are almost always accompanied by pyrite. The minerals appear to be concentrated into a 2-foot thick section of the vein that parallels the hanging wall. Parts of the vein are highly sheared by faults that parallel the walls of the vein. Early mining operations were confined to ore shoots that contained from 50 to 80 ounces of silver per ton. Ore that was mined in 1964 contained 50 to 80 ounces."

Description of the Probabilistic-Grade-Quantity Matrix (See appendix for matrix)

There is no detailed sampling data available to date with which to establish a meaningful grade-quantity matrix. According to an unbiased estimation by W. S. Moen, the grade figure of 20 ounces per ton (622 g/mt) represents the minimum grade which should be encountered in the mine. This estimate is based on Moen's study at the mine during an earlier period of operation. The dimensions used to calculate the volume and tonnages of the ore are: the length of the vein exposed on the surface, in the workings, and to the border of the claim is 530 feet; the average width is 6 feet; and the mineralized vein is known to exist to a depth of

500 feet. The inferred tonnage calculated at the 50-percent level is established within the dimensional framework outlined above. Dimensions for establishing tonnage quantities at the 25-percent and 10-percent confidence levels are the same as above but with increases in vein depth to 1,000 feet and 1,500 feet for the two percentage levels, respectively. No deduction or allownaces were made to include the ore thus far removed. Also not included were any increases in tonnage volume due to the inclusion of wallrock waste.

The tonnages established utilizing the known surface traces of the vein are considered to be conservative. According to Moen (oral communication), the Fourth of July vein or one closely related to it is believed to also be present within the southeastern or undeveloped portion of both the Fourth of July claim and the adjoining Keystone claims (8-foot vein with up to 50 ounces of silver/ton, developed with a 150-foot shaft). No estimation of values on both claims is attempted here pending deliniation of the "other" vein. The vein may persist to the north past the northern claim boundary; however, any surface indications have been obscured by alluvium and(or) faulting.

Mining and Beneficiation

In the event that the silver mines on Ruby Hill are reopened, the best possible method of attacking the Fourth of July vein, as well as any adjacent mineralized veins, would be to extend the haulage level of the Arlington mine northeastward to intersect the Fourth of July. The existing shafts on the Fourth of July could then be used as ventilation shafts and both the monetary and energy costs of transporting the ore from the face to the surface would be considerably reduced.

Either resuing or shrinkage stoping with delayed filling could be applied to exploit this deposit. However, the mining method ultimately selected will depend to a large extent upon the results of predevelopmental exploration and whether or not the deposit is to be exploited in conjunction with other Ruby

Hill deposits, notably the Arlington mine.

No recent data is available concerning the degree to which the ore can be concentrated or the values extracted. Jones, (1916, p. 24) reports that in laboratory tests performed in 1915 on ores from Ruby Hill that recovery of about 90 percent of the silver values could be achieved by concentrating the ore by both gravity and flotation methods. Modern mineral dressing techniques should be capable of increasing this percentage significantly.

A 1,000-ton-per-day mill was included in the MAS proposal. It is expected that a mill of at least this capacity will be required to handle the production volume from the Fourth of July and other mines located on Ruby Hill. The mill could be situated near the old Ruby City townsite where adequate water and electricity could be brought in with a minimum of difficulty. Ore from the mines at Ruby Hill and elsewhere could be trucked and(or) trammed to the mill site.

The current owners of the Fourth of July are in the process of reopening the mine so the question of lead-time required to put the mine into operation in the event of a national emergency or shortage crisis will depend to a large extent upon the results of work now in progress. In the event that the mine remains closed, reopening and producing the first ore should not require over 6 months of lead-time.

WASHINGTON SILVER RESOURCES

Ruby Mine, Okanogan County, Washington

Property Location and Access: 48° 56' 08" N; 119° 41' 31" W; sec. 28, T. 42 N; R. 25 E.

The principal adit, the mill, and etc. of the Ruby or Pyrargyrite mines are located at the base of the steep east slope of Mt. Chopaka which is several miles north-northwest of Palmer Lake in north-central Okanogan County. A large well-preserved mill building and several tailings dumps mark the site of the mine, which is within the Nighthawk Mining District. The property is immediately west of the access road, the Burlington Northern railroad, and the West Fork of the Similkameen River.

To locate the mine, proceed north toward Nighthawk on the Loomis-Nighthawk road to an intersection approximately 1 mile north of the northern end of Palmer Lake. Take the left, or west fork, of the road and follow it for approximately 2.5 miles to the mine-mill site. The mill is at an elevation of about 1,200 feet.

History, Production and Ownership

According to Hodges, 1897 (page 103) a mine named the Rush mine was, by 1897, well established on the same(?) vein which was later developed as the Ruby or Pyrargyrite mine. In later reports covering the Ruby mine, however, there is no reference to any pre-Ruby development. E. N. Patty in his 1921 report on the metal mines of Washington noted that there had been over 5,000 feet of underground development at the mine; vertical exploration on the vein amounted to over 770 feet and horizontal development north and south of the main raise was over 800 feet.

Ore valued at a total of $25,000 was reported shipped from the Ruby during the following years of production (Huntting, 1956): 1915-1920, 1922-1923, and 1939. There is no record of any production since the final shipment in 1939.

According to Huntting (p. 309), high-grade ore sampled from the dump assayed 0.01 oz/ton gold and 92.1 oz/ton silver. However, the earlier report by Hodges (1897), covering the Rush mine, states that silver assays on the same(?) vein ran between 20 and 200 ounces/ton, accompanied by as much as one ounce of gold.

The mine property, consisting of five patented claims surrounded by private land, is currently (1975) owned by:

Lester H. Everett
P. O. Box 187
Okanogan, WA 98840
Phone: (509) 422-3540

Geology & Description of the Ore Body

The principal vein at the Ruby mine is developed along a fault in granodiorite of the Lower Jurassic Anderson Creek pluton, which intrudes the large Loomis pluton, Palmer Mountain Greenstone, and the Kobau Formation which lies along the northeastern margin of the Loomis pluton. The mineralized vein pinches and swells and has a thickness of 2 to 12 feet, with the average thickness being about 3 feet. The vein strikes N. 45° W. and dips SW. at about 45°. A foot or more of gouge commonly lines both sides of the vein, and in places there is evidence of post-mineral movement along the fracture zone. The vein crops out poorly on the east slope of Mount Chopaka about 400 feet above the level of the railroad and the main adit. Silver is the predominant metal present in the mine, though patches of gold, copper, lead, and zinc-bearing minerals are scattered irregularly throughout the mineralized portions of the vein. Pyrite, chalcopyrite, arsenopyrite, sphalerite, proustite, argentite, malachite, azurite, and limonite are the principal metallic minerals.

Studies and comparisons of the mines in the Nighthawk-Loomis area by various investigators have demonstrated that in most cases where mineralized veins are present along fault zones both silver and gold values, as well as the strength of the vein, tend to remain fairly constant within the limits of exploration or to

the depths attained by small-scale mining operations. Conversely, many of the smaller rich fissure veins have been found to disappear or become subeconomic a short distance from the surface. The majority of the mineralized veins found in the Nighthawk-Loomis area have been mined out; the Ruby vein, however, which falls into the category of a shear-zone or depth persistent deposit, appears to have been abandoned without further exploration in 1939, possibly due to a combination of economic and world political factors.

The Ruby mine, like many others in the area, is nearly devoid of exploratory, analytical, or projectional data upon which to establish a rudimentary resource evaluation. It does appear however, that the mine possesses a significant potential for renewed production of high-grade silver ore in the area beyond the limits of the present workings. There is also a fairly good possibility that other structurally related mineralized zones will be encountered during the process of deliniating the depth and extent of the mineralization remaining in the Ruby mine.

WASHINGTON SILVER RESOURCES

Johnsburg Mine, Skagit County, Washington

Property Location and Access: 48° 28' 43" N., 121° 06' 54" W., secs. 27, 34, T. 35 N., R. 13 E.

The Johnsburg Mine is situated on the steep, north-facing slope of Johannesburg Mountain within the Mount Baker National Forest. From Burlington, Washington, go 44 miles east on State Highway 20 to the town of Marblemount. At Marblemount take the Cascade River Road east along the river toward Cascade Pass to the Mineral Park Campground. From the campground proceed 4.5 miles northeast along U.S. Forest Route 3528 and the North Fork of the Cascade River toward Cascade Pass. The mine is south across the river at an elevation of 5,100 feet.

History, Production and Ownership

The first claims to be staked in Skagit County were those of the Boston group located on the north side of the North Fork of the Cascade River. Discovery of the Boston led to further prospecting and staking in the area and eventually to the discovery of outcropping argentiferous galena along a steep gully on Johannesburg Mountain. The Johnsburg and three additional claims were located along the gully exposures, and the four claims plus a millsite on the river bank were patented and partially developed by the Silver Queen Mining and Smelting Company. There is no record of any production or continuous activity prior to shipments of about 10 tons made by William Soren in October 1955; later that same year shipments of another 10 tons were made by other parties. There is no record of any production since 1955--nor is there any record in the Skagit County assessor's office indicating current ownership of the patented ground. Over 250 feet of underground workings have thus far been developed to exploit this deposit.

Geology & Description of the Ore Body

The mineralization at the Johnsburg Mine consists principally of veins and lenses of argentiferous galena, with subordinate gold developed along a shear zone in chlorite schist of the pre-Eocene Cascade River schists. A pre-ore lamprophyre dike also occupies the shear zone; and this dike and the mineralization are apparently related to the nearby Tertiary Cascade Pass quartz diorite, which intrudes the older crystalline schists of the area around the headwaters of the North and Middle Forks of the Cascade River. Chalcopyrite, sphalerite, mimetite, anglesite, and cerrusite are also reported to be present in lesser quantities (Huntting, 1956). Gangue minerals are leached and silicified schist and calcite.

According to an investigation of the mine in 1953 by the U.S. Bureau of Mines under D.M.E.A. contract Number 1831, nearly 800 tons of indicated ore reserves containing 8.9 ounces/ton silver, 0.128 ounces/ton gold, and 9.6 percent lead are within the present workings. Another 300 tons are inferred to be present near the portal of the mine.

The tonnages outlined above, which are included for reference only in the Probabilistic grade-quantity matrix, are thought to be too small to serve as a base upon which to develop proposals for mining, beneficiation, and transportation. A considerable amount of exploration, mapping, and drilling will be required to further develop this property and increase the ore reserves to the degree required to justify full-scale production. However, this property and other nearby genetically related deposits, such as the Boston, Eldorado, Midas, etc. offer considerable potential for discovery of additional ore bodies which collectively could become significant producers of both lead and silver. Lead-time required to develop this property to the point where crude ore only can be produced is estimated at at least 3 years.

45 (Magus) Mine, Snohomish County, Washington

Property Location and access: 48° 03' 10" N., 121° 33' S., secs. 29 and 30, T. 30 N., R. 10 E.

The 45 mine is located at the head of Williamson Creek, a northern tributary of the Sultan River in central Snohomish County. Commencing at the community of Startup, on U.S. Route 2 approximately 30 miles east of Everett, Washington, go north on the all-weather highway to the Spada Reservoir and the Sultan Basin. Approximately 1 mile east of the reservoir and the Sultan River the road forks and goes north along the east bank of Williamson Creek. The mine property is at the end of the road, a distance of about 6 miles north of the Sultan River crossing. U.S. Forest Service maps indicate that the final 5 miles of the road is unpaved.

History, Production, and Ownership

The 45 mine was discovered by prospectors in 1891, and by 1896 it became the first mine to produce ore in Snohomish County. The ore was transported by pack horses over Marble Pass to the rail head at Silverton, a distance of about $2\frac{1}{2}$ miles. Heavy rains in 1898 washed out part of the railroad bed and repairs were not completed until 1901. In the meantime, the mine owners constructed a 22-mile-long corduroy haulage road south to another railway near Startup. The cost of constructing this road put the company so far into debt that it never recovered, and the property was subsequently purchased by the Charles H. (Lydia) Pinkham estate of Lynn, Massachusetts. The 25 claims covering the deposit were patented in 1910. Between 1896 and 1901, despite the various transportation difficulties encountered by the original owners, a total of 3,185 tons of hand-sorted ore was delivered to smelters in Tacoma and Everett. The ore contained between 48.0 and 171.0 ounces of silver and between 0.35 and 1.06 ounces of

gold per ton. There has been no production from this mine since the last shipment in 1901. The mine property is within the Snoqualmie National Forest.

The current (1975) owner of the 45 mine is:

Dr. Gerald J. McCarty
2000 NW Blue Ridge Drive
Seattle, WA 98177
Phone (206) 783-9783

Geology and Description of the ore bodies

The ore bodies of the 45 mine property consist of 6 or more fissure veins occupying fractures within a pre-Jurassic series of metamorphic rocks, consisting of slaty argillite, quartzite, and schist. Tertiary intrusive quartz diorite occurs 1½ miles southeast of the mine; the silver, gold, and base metal mineralization at the mine is believed by most investigators to be directly related to the nearby intrusive. The Vesper Peak-Sunrise mine copper-molybdenum deposit currently under development by Brenmac Mines, Inc. is the same quartz diorite described above. This new mine is just a little over 3 miles southeast of the 45 mine property.

The principal vein, the Magus, occurs in a northwest-trending fracture zone in the metamorphic series, and several workings and outcrops indicate that it has a length of at least 3,000 feet. It extends through the Hard to Beat, Deu Pree, and Magus Claims (Carrithers and Guard, 1945). The majority of the mineralized veins strike a few degrees north of west and dip southward at about 80°.

Over 4,000 feet of underground workings were developed by the original miners to follow the Magus and several smaller veins. These veins consist of crushed argillite cemented by quartz and calcite, and contain pyrite, arsenopyrite, sphalerite, chalcopyrite, and galena. These veins appear to converge toward the west, and apparently make up the ore shoot, which is reported to have averaged more than 4 feet in thickness (Carrithers and Guard, 1945). On adjacent 45 group claims, small amounts of marcasite, scheelite, and pyrrhotite

have also been encountered in some of the workings developed to exploit the deeper extensions of the Magus or related veins. A number of other mineralized veins have been recorded and (or) explored on the property; however, none have been developed to the depth or degree of the Magus.

As pointed out by several investigators (papers by Lee, Stoess, and others in backup file) the development and exploration of this deposit was poorly managed and somewhat haphazardly organized and pursued. Remoteness and lack of adequate mine-to-mill transport were primary factors contributing to the termination of mining activities. There is no mention in the available literature of any subsequent attempts to drill or further determine the extent of the mineralization on this property, and it would therefore seem appropriate to speculate that the 45 mine could, with adequate exploration and development, once again become a major producer of silver.

Description of the Probabilistic-Grade-Quantity Matrix (See appendix for matrix)

Reliable data required to support the matrix is at best meager. As is the case with many precious metal deposits, reported assay results should be viewed with some degree of doubt. Unless there has been a proper systematic sampling program performed and reported by an unbiased investigator, any grades and tonages reported otherwise should not be included in the matrix. The grade values reported in the matrix are from Broughton, the resource quantity was obtained from the report by C. F. Lee, 1901, (backup file). Mr. Lee's calculations allowed 25 feet beyond the present mine faces where the shoots are well mineralized and nothing beyond where they are poorly mineralized. A depth of 50 feet below the lowest level was employed, but there is no mention of the average thickness used by Mr. Lee to arrive at the figure of 15,000 (13,608 M.T.) tons of reserves.

Smelter returns on part of the ore shipped from the mine between 1896 and 1901, and published by Carrithers and Guard (p. 43), show an average of 93.0

ounces of silver and 0.74 ounces of gold per ton.

Mining and Beneficiation

The present mine workings are reported to be largely inaccessible due to flooding, caving, etc. Renewed development of the mine would, of course, include dewatering, timbering, ventilation, and extensive sampling. The results of necessary preliminary diamond drilling during the developmental stage would to a large degree dictate the mining method most suitable for exploitation of the deposit. With the data available at present, the resuing method of mining thin veins seems to be most applicable, especially when applied to the continuation of existing workings.

Again there is little or no reliable data available upon which to base the beneficiation record. The early mining operations included, in addition to hand mining methods, hand cobbing and rather careless handling of the resulting handsorted concentrate. In his report, Lee estimated that out of 20,000 tons of total mine production nearly 4,000 tons were lost or scattered at the mine.

It is assumed that if the mine were again brought into production, the ore would be shipped away from the property for milling. The Williamson Creek area is part of the watershed that supplies water to the city of Everett so it seems unlikely that the establishment of a mill at the mine would be allowed. On site crushing and gravity concentration may be possible barring any unusual metallurgical problems which would require custom smelting, and the concentrate may then be transported via truck and rail to the American Smelting and Refining Company's smelter at Tacoma.

At least two years of lead-time will be required to put this property back into production.

Deer Trail Mine, Stevens County, Washington

Property Location and Access: 48° 02' 7" N., 118° 5' 40" W., secs. 1,2 T. 29 N., R 37 E.

The Deer Trail group of mining claims is situated on the west slope of Huckleberry Mountain, at the headwaters of Cedar Canyon and within the Cedar Danyon (Deer Trail) mining district.

Commencing at Fruitland, a small settlement located on State Route 25, which parallels Roosevelt Lake and the Coulee Dam National Recreation Area, take the only paved secondary road east to the community of Turk, a distance of about 5 miles. From Turk, a dirt road goes east through Cedar Canyon and directly to the Deer Trail mine. The distance from Turk to the mine is about 3 miles.

History, Production and Ownership

The veins upon which the Deer Trail claims are developed were discovered in 1894 by the Vanhorn brothers, and between 1894 and the final year of operation (1939), 11 adits, drifts and raises totalling over 4,000 feet underground were developed.

Production figures for the various periods of activity are sketchy and inconsistent. According to Weissenborn (1966) the mines of the Deer Trail group, plus the nearby Queen and Seal mine, produced between 100,000 and 1,000,000 ounces of silver and 100,000 and 10,000,000 pounds of lead and zinc. The references given do not support these figures though all of the properties did, however, produce respectable quantities of the various metals. There is no record of any significant production from these mines following closure in 1939. Over the years following closure, a number of companies leased the mineral rights and performed a limited amount of exploration and developmental work. The Deer

Trail mill was rehabilitated in 1954 for the purpose of reclaiming metals, especially copper, from the waste dumps of mines located elsewhere within the district. The mill has since been dismantled and only the building remains.

The mine property, which consists of 19 unpatented and one patented claim, has been held since 1939 by:

McLennon C. Slate
1110 South Sherman St.
Albany, OR 97321
phone (503) 928-3886

The one patented claim covers the property known as the Elephant claim.

Geology & Description of the Ore Body

The deposit exploited by the numerous mines on the Deer Trail claims is essentially a large mineralized quartz vein contained within a system of joints and fissures developed in metasediments of the Precambrian Deer Trail group.

The rocks exposed in and around the mines are quartzite, argillite, calcareous argillite, slate, limestone, and dolomite. The strike of the various units is about N. 55° E., dipping to the SE at about 60°. The attitude of the principal vein is essentially the same as the enclosing metasediments, though in places the vein crosscuts the bedding following fractures, fissures, and joints. Emplacement of the vein was apparently controlled or confined within the more calcareous horizons of the metasediments. The host rocks are, in many places, overturned toward the west. The area is underlain and intruded by granodiorite and quartz monzonite of the Mesozoic (Cretaceous?) Loon Lake batholith. It is from this batholith that the mineralization is thought to have been derived. Several small basic dikes also intrude the metasediments, the granite, and the mineralized vein; however, they apparently have not had any obvious direct influence on the character of the mineralization.

The ore minerals are argentiferous galena, argentite, cerargyrite, chalcopyrite, sphalerite, azurite, malachite, pyrargyrite and pyrite, carried in a gangue of quartz with subordinate calcite, barite, and silicified argillite. Some

native silver was reported by Bancroft (1914). The quartz vein is in places decomposed and slightly offset by numerous small faults that sharply intersect the main fissure.

A number of other mines and prospects have been located within the metasediments ringing this portion of the Loon Lake granitic batholith. Though most of the known peripheral deposits have now been exhausted or abandoned, it is worth noting that due to the processes of magmatic differentiation the assemblage or ore minerals encountered within the metasediments varies considerably away from the granite contact area: tungsten deposits predominate at or near the contact, a little farther away from the contact and within the metasediments siliceous silver-lead deposits including the Deer Trail mine are prevalent. At yet a greater distance, the arsenopyrite-chalcopyrite deposits of the nearby Togo Mine are associated with basic dikes which cut all of the ore and rock at the intervening Deer Trail mine. The amount of barite present in all of the peripheral deposits also increases away from the contact, culminating in several deposits that have been mined solely for barite.

Description of the Probabilistic Grade-Quantity-Matrix (See appendix for matrix)

The information utilized in assembling the probabilistic matrix was based entirely upon figures and estimates calculated by Poole (1939), from data which he collected at the mine during its final year of operation. Since no data is otherwise available, it must be assumed that Poole's assays and dimensions are accurate. In any event, if the accuracy level was only 50 percent, there still appears to be a significant reserve of silver remaining in this deposit.

As Poole noted in his report, primitive ore transportation methods during the early years of production dictated that only high-grade ore could profitably be shipped from the mine. Rock containing less than 50 ounces of silver per ton was left in the old workings as backfill. Poole (p. 10) indicated that the unmined ore remaining on the property averages 139.6 ounces of silver per ton.

The 6.2 percent grade figure shown to indicate the value of unmined lead was calculated from tonnage-recovery figures published by Fulkerson and Kingston in 1958.

Additional reserves of silver are available on the 9 plus waste dumps. W. S. Moen, of the Washington Division of Geology and Earth Resources, stated (oral communication) that the Sunshine Mining Company leased the Deer Trail claims and thoroughly sampled a number of the larger dumps. Sampling was accomplished by sinking a lagged test shaft through the dump material. The dumps averaged about 15 ounces of silver per ton. Spot silver at the time was just over $1.00 an ounce, so no attempt was made to reclaim the dumps.

A promotional brochure prepared by the Venus Mines Corp. of America indicated that there were 9 dumps containing a total tonnage of 51,500 tons of waste and that the average value of the metals present was 13.38 ounces of silver and 0.58 ounces of gold per ton. The dump reserves have not been included at this time in the matrix.

Mining, beneficiation, and transportation

Again, Poole's recommendations, based on studies of the operating mine, have been followed and horizonatal cut and fill mining was selected as the most efficient mining method.

On-site concentration or beneficiation of the ores would probably be best accomplished by utilizing sink float techniques. It is proposed that the concentrates be trucked north about 50 miles to the railroad at Kettle Falls. From Kettle Falls, the ore would be transported via rail to the smelter at Trail, British Columbia, a distance of roughly 50 miles. An alternate smelter would be the Bunker Hill smelter at Kellogg, Idaho; however, the greater shipping distances and difficult access to the railhead from the mine, especially during the winter months, would make the latter an impractical and expensive choice.

Lead time to produce crude ore from the Deer Trail is estimated at between

3 and 6 months. Serious sophisticated exploration in the general area may well result in the discovery of a number of new deposits, ranging from tungsten through the base metals to barite.

Old Dominion Mine, Stevens County, Washington

Property Location and Access: 48° 30' 42" N., 117° 46' 38" W., sec. 9, T. 35 N., R. 40 E.

The Old Dominion mine is located near the foot of the southwest flank of Old Dominion Mountain, 7 miles east of Colville, Washington.

From Colville go about 2.5 miles east on State Route 20 toward Ione and turn left or north onto County Highway No. 652. Proceed north on the county road for about one-half mile to Prouty Corners. At Prouty Corners turn east onto U.S. Forest Route No. 615 and go approximately 2 miles; the tailings dump below the portal of the main Old Dominion adit should be visible near the north side of the road. Additional workings, consisting of both tunnels and shafts, are located up hill from the main adit on a bearing of about 60° east of north. Stagnant or bad air presents a hazard in some of the deeper workings.

History, Production and Ownership

Silver mineralization was first discovered in the Colville area in 1883 by four local residents while descending the southwest slopes of Old Dominion Mountain. The discovery was soon developed and over $400,000 worth of ore was produced and hauled via packhorse to Spokane, thence via rail to smelters in Tacoma, Washington, and Helena, Montana. Most of these early shipments consisted of very high-grade ore, all of which was mined from within 75 feet of the surface. By 1899 the property was under new ownership, and by 1927 over 8 miles of workings on 11 levels had been completed. Since closure of the underground workings in 1927, some metal values have been recovered by reworking the old tailings. The total recorded production from both the mine and the dumps between 1902 and 1953 was 342,517 ounces of silver, 323 ounces of gold, 4,132 pounds of copper, 744,391 pounds of lead and 148,563 pounds of zinc (Fulkerson

and Kingston, 1958).

Ten patented claims have been established along the mineralized zone; however, according to the Stevens County Assessor's office only three of the claims are known to be on the active tax rolls. These claims are owned by:

Boise Cascade Corporation
Box 310
Kettle Falls, WA 99141
phone (509) 738-4611

Geology and Description of the ore bodies

The silver-lead-zinc ore mined from the Old Dominion was reported by Bancroft (1914) and other observers as occurring in lens-shaped replacement bodies, developed in carbonate rocks adjacent to a granitic batholith. The carbonates in which the ore bodies are found are predominantly limestone, with subordinate dolomite; they are part of a series of Middle Cambrian metasediments, which occur between Colville and Old Dominion Mountain. The granitic intrusive, from which the mineralization is believed to have developed is the Mesozoic Kanisku batholith (formerly called the Loon Lake granite), which outcrops over a large area of both Stevens and Pend Oreille Counties and Northern Idaho. The batholith in the vicinity of the mine varies in composition from quartz monzonite to granodiorite. The faulted contact between the granite and the mineralized limestone is reported by Jenkins (1924) to be well defined and traceable for over 3,000 feet. The fault dips steeply to the SE. and strikes approximately N. 60° E. The limestone in the vicinity of the contact has been highly brecciated and recemented with quartz, calcite, and siderite; it is within this fractured zone that the ore bodies were developed. The size of the ore lenses, many of which are interconnected by a network of silicified joints and fractures, average 300 feet in length, by 30 feet wide, by about 7 feet in thickness; the long axis generally strikes parallel to the faulted limestone-granite contact. The known occurrences of ore were all encountered within 125 feet of the contact and as much as 2,500 feet

apart. Jenkins noted that a granite-aplite dike parallels the faulted surface about 15 feet to the southeast. The significance of the dike's influence on the emplacement of the ore minerals is unknown. There is little evidence of contact metamorphism or post-ore movement along the faulted limestone-granite contact.

The ore minerals of the Old Dominion are principally galena, sphalerite, and pyrite. Secondary enrichment processes acting in the upper portions of the fractured zone contributed significantly towards producing silver values, varying from 100 to 400 ounces per ton.

This mine has been included in the Minerals Availability System inventory for several reasons, not the least of which is the fact that exploration during the developmental stages consisted primarily of drifting from one ore body to the next, by using the various silicified fracture networks as paths. Fulkerson and Kingston (1958) noted that the ore bodies failed some 200 feet below the main tunnel level. Geophysics, geochemistry, and (or) systematic diamond drilling have apparently not been thoroughly applied if ever in the Old Dominion area. The possibility for the discovery of many additional ore bodies seems to still exist, not only in this mineralized zone but within some of the other isolated carbonate bodies scattered around this particular segment of Kanisku batholith contact. In light of the considerable variation in techniques required to explore this type of deposit, a lead-time of at least 2.0 years should be allowed to produce crude ore from the Old Dominion Mine.

WASHINGTON SILVER RESOURCES

The Queen-Seal Mine, Stevens County, Washington

Property Location and Access: 48° 01' 35" N., 118° 7' 18" W., sec. 11. T 29 N., R 37 E.

The Queen-Seal mine is located along the crest of a ridge parallel and west of Huckleberry Mountain in southeast Stevens County.

The entry or access data for this property is essentially the same as that prepared to describe the access to the Deer Trail mine. From the Deer Trail mine, continue along the road uphill and in a southeasterly direction for approximately 1.2 miles to the road intersection on the saddle separating Cedar Canyon from O-Ra-Pak-En Creek. At the intersection, take the road or track that goes toward the west and proceed about 0.8 mile to the Queen-Seal property.

History, Production and Ownership

Silver was first mined from the Queen-Seal deposit in 1896 by the Vanhorn Brothers who, in 1894 discovered and developed the Deer Trail mine. Due to the remote location of this mine, early mining operations, like those at the Deer Trail, relied heavily upon hand sorting at the working face to produce a concentrate suitable to ship out to the railhead by pack horse. According to Huntting (1956), the ore produced during the initial development averaged between 150 and 200 ounces of silver per ton, so if the Vanhorns followed the same mining practices as they used at the Deer Trail, the Queen-Seal mine may be backfilled with high-grade ore. There is no mention, however, in any of the available literature that backfilling was in fact practiced.

The only published production figures are those assembled by Fulkerson and Kingston (1958); the figures indicate a total production of 2,930 tons of ore between 1903 and the final year of recorded production in 1940. From this ore, 285,759 ounces of silver and 17 ounces of gold were recovered. The ore also

yielded 140,821 pounds of copper and 14,148 pounds of lead. These production figures show that the average silver value of the ore from the Queen-Seal amounted to over 97 ounces per ton.

Huntting (p. 324, 331) notes that the total underground development consisted of a 1,370-foot adit, an 80-foot crosscut adit, a 125-foot adit, and an adit caved 100 feet from the portal; a 300-foot shaft with 4 levels, a 206-foot shaft, and a 50-foot shaft. Considerable stoping was also accomplished.

The mine property, consisting of 3 unpatented claims, is currently held by:

Mr. George C. Segal
(address unknown)
Spokane, Washington
Mr. Segal does not have a telephone

Geology and Description of the Ore Bodies

According to the preliminary geologic map of the Hunters quadrangle prepared by Campbell and Raup (MF-276, 1964), the Queen-Seal silver deposit, unlike the nearby Deer Trail, is developed in the Stensgar dolomite, a member of the Precambrian Deer Trail Group. The dolomite host strikes about N. 30° E. and is overturned at a steep angle toward the west. A prominent fault parallels the regional strike and separates the dolomite from the Deer Trail argillite, to the east. It is along this fissure that the ore bodies of the Queen-Seal are developed. The Stensgar dolomite described by Campbell and Loofbourow (1962) is a fine-grained, dense, light-bluish or pinkish-gray, somewhat thinly bedded dolomite. Silicification is a prominent alteration feature within the envelope of mineralization. Both the Queen-Seal and the Deer Trail deposits are believed to have originated as a result of the intrusion of their respective hosts by the Mesozoic (Cretaceous?) Loon Lake batholith. The main body of the batholith is exposed less than one-half mile to the southeast, and there is a small outcrop of granite about one-half mile northeast, or upstrike from the Queen-Seal workings. The batholith ranges in composition from quartz monzonite to granodiorite.

The ore minerals at the Queen-Seal mine are argentite, cerargyrite, galena, and sphalerite, accompanied by pyrite, azurite, malachite, and native silver. The gangue is white quartz, which is often iron stained. According to Weaver (1920), the ore is concentrated into shoots having a predominant northeast pitch. A small amount of scheelite was reported to have been present in some of the early concentrates.

This report accompanies a location-only entry into the Minerals Availability System. Information on this deposit is at best scanty and no reliable data is known to exist with which to prepare a meaningful resource estimate. The deposit is significant from the standpoint that it has not been completely explored, especially at depth. Also its genetic environment is such that the probability for successful exploration elsewhere within the immediate vicinity appears to be good.

Lead-time for the development of this particular deposit depends, of course, to a large extent upon the results of exploration and drilling programs, which should be mounted along the entire length of the Stensgar dolomite from Cedar Canyon south to its contact with the Loon Lake batholith.

United Copper Mine Group, Stevens County, Washington

Property Location and Access: 48° 10' 17" N. 117° 39' 47" W. sec. 32, T. 33 N. R. 41 E.

The United Copper mine and the other mines associated with it are developed on the west flank of Eagle Mountain, northeast of the town of Chewelah, Washington. The group of claims and deeded land securing the mineralized zone is surrounded by lands belonging to the Colville National Forest.

From Chewelah, 38 miles north of Spokane, go north on the Smith Grade, then east on U.S. Forest Route 437, which parallels the east bank of the South Fork of Chewelah Creek. At a point approximately 1.8 miles northeast of the intersection of the Lambert Grade (F.R. 437) and the Smith Grade, a dirt road takes off to the right and goes east, winding 2 miles up the slopes of Eagle Mountain, past several small mines and prospects, and eventually terminates at the United Copper mill and tunnel sites.

History, Production and Ownership

The mine referred to in this report includes the Amazon, Copper King, Copper Queen and Keystone mines, in addition to the United Copper Mine. All of these properties are developed on essentially the same system of veins and all have at one time or another produced moderate amounts of copper, silver, and gold.

According to Bancroft (1914), the principal mine--the United Copper Mine--was acquired by a Mr. Sheppler of Chewelah, about 1891. In 1906 the property was purchased and developed by the United Copper Mining Company, which operated the mine until 1920. Between 1920 and 1959, several companies and individuals mined the property and produced limited quantities of copper, silver, and gold. The history of the adjoining properties is essentially the same as that of the

United Copper; however, none of the other properties have been developed to any extent. The limited development and sporadic operation of the various mines is reflected in the production figures compiled by Fulkerson and Kingston in U.S. Bureau of Mines Information Circular Number 7872. The total recorded production of ore from the United Copper mine and the adjacent group of mines amounts to 355,132 tons and 17,692 tons respectively. These respective tonnages of ore yielded the following quantities of metal: Copper 9,914,204 and 476,419 pounds; silver 1,645,997 and 41,784 ounces; gold 1,222 and 189 ounces.

Despite the moderate production figures for the group, copper and silver from the United Copper mine accounted for 95 and 97 percent of the total production of these metals from the Chewelah district. A total of over 12,000 feet of workings have been developed on the various properties, with the most extensive work completed on the Copper King property. The workings are for the most part accessible though caving and flooding restrict entry to some of the deeper parts. Mining activities on the Amazon vein were reported to have been halted around 1959 due to legal difficulties that were not resolved until about 1970.

With the exception of the Copper Queen property, all of the properties are held under patented claims. The Copper Queen property consists of 80 acres of deeded land owned by Naomi Durkee and Dorothy Alm, both of Chewelah. There is no record of mineral rights ownership on this land; however, the Durkee family earlier held the Copper Queen mining claims and probably still retain some of the rights.

Ten patented claims covering the balance of the property are held by five separate groups of people; and all of the claims, many of which overlap one another, seem to cover the bulk of the mineralized ground. To simplify the owner-operator record entries, a 20-percent share of the ownership was assigned to each of the owners listed therein. The current owners of the patented claims are as follows:

Mine	Owner	Interest
Keystone	Louis Thacker Graessle 1933 Woodmere Drive Jacksonville, FL 32210 (904) 389-3970	50%
	Marie Wilmer Kulzer 4222 Frace Tacoma, WA 98407 (206) 759-5205	50%
United Copper	Phillip P. Skok Chewelah, WA 99109 (206) 759-5205	50%
United Copper	Janet Dickey Emmanuel 350 Bryant Avenue Roslyn, New York 11576 (516) MA1-1754	50%
Copper King	Banner Mining Company Box 65 Sprague, WA 99032	100%
Amazon	Shirley Deitch 16940 S.E. 38th Place Bellevue, WA 98008 (206) 747-0439	100%

Geology and Description of the Ore Bodies

A total of six prominent mineralized veins have been identified and developed within the United Copper group. The veins, which consist primarily of mineralized quartz with subordinate siderite and calcite, follow nearly vertical zones of shearing and partial replacement along the bedding and jointing planes in schists and argillite of the Precambrian Belt series. The mineralization is mostly chalcopyrite, pyrite, and freibergite. It is apparently restricted to the upper or western plate of a shallow westerly dipping, north-northeasterly-striking thrust fault, which roughly parallels the regional strike. The mineralization is believed by Clark and Miller (1968) to be related to the upper Mesozoic(?) Flowery Trail Granodiorite batholith, which outcrops along the Thomson Creek valley less than 2 miles southeast of the mine workings.

According to Patty (1921), there have apparently been two periods of miner-

alization. The first and most extensive mineralization appears to be controlled in part by shearing and fracturing, resulting from the intrusive emplacement of several relatively small cross-cutting lamprophyre dikes. The frequency of small-scale jointing, fracturing, and faulting appears to increase northward from the principal cluster of workings.

A high-grade ore shoot, which assayed from 70-300 ounces of silver per ton, was mined out of the lower United Copper workings. Patty (1921, p. 125), theorizes that the shoot was introduced during a later period of mineralization, since it exhibited both a sharp line of contact with the surrounding lower-grade vein material and because it consisted almost exclusively of freibergite. Silver and gold ores rather then those of copper tend to predominate at the partially explored Copper Queen mine to the north. This fact would seem to support speculation that the number of rich ore shoots in which freibergite predominates, may increase in number toward the Copper Queen mine.

Description of the Probabilistic-Grade-Quantity Matrix (See appendix for matrix)

During the productive years of mining on all six veins in the United Copper Group, a total of over 390,000 tons of ore was reported to have been produced, and as is usually the case, very little factual assay data is available with which to assemble the probabilistic-grade-quantity matrix. The grade figures in columns 1 and 2 of the matrix were determined by utilizing the total recorded production figures compiled by Fulkerson and Kingston to establish weighted average grades for the various metals extracted from the ore. The weighted averages for copper, silver, and gold produced per ton of ore were then upgraded to mill feed standards by utilizing a factor derived from comparisons made between production grades above and the average assay figures of run-of-the-mine ore shipped during 1908 and reported by Bancroft (p. 102).

Column 2 represents the estimated grade and tonnage of the United Copper mine vein alone, which forms the most persistent zone of mineralization through-

out the length of the property. The first column represents the combined grade and tonnage of column 2, plus the amount of ore estimated to be available from the five smaller mineralized veins west of and parallel to the United Copper mine vein.

Tonnages were calculated using an average width of 6 feet for the United vein and 4 feet for each of the 5 lesser veins combined to make a block 20 feet wide. The 5 smaller veins are designated the Amazon Nos. 1 and 2 veins, Copper King Nos. 1 and 2 and the Copper Queen. The mine map compiled by Clark and Miller and included with the property file indicates that the Copper King vein No. 2 was present only in the central or active portion of the property. Blocks representing the developed heart of the property contain the resource quantities available at the inferred or 50 percent level of expectancy.

Tonnage estimates for the 25 percent confidence level represent projection of the mineralized zone north and south of the known mineralized areas. Extension to the south is toward other possibly related copper-silver occurrences, while the extension to the north is somewhat speculative. The tonnages estimated for the 10-percent level represent material which may be present between the lowest level of the United Copper mine and the 1,800 foot level--a vertical distance of about 300 feet. Since the exact location of the thrust fault surface, which separates the mineralized area from possibly barren underlying rock, is unknown. The vertical dimensions of the 10-percent block may or may not be attainable over the entire 6,000-foot horizontal length.

Mining and Beneficiation

Shrinkage stoping with hand-cobbing and backfilling were methods employed during the early exploitation of these deposits. However, both Patty and Bancroft note that shrinkage stoping was complicated and unsatisfactory due to the tendency of the wall rock to slab-off in large blocks, which would clog the ore chutes and delay sorting and extraction of the broken ore. With this fact in mind,

underhand stoping with waste storage on stulls and(or) arch pillars was selected as being possibly the safest and most practical method of attacking narrow vein deposits such as these.

There is no recent information regarding the application of modern beneficiation techniques to the ores produced from these mines. Patty (1921) notes that some difficulty was experienced in attaining satisfactory recovery of the metals with the contemporary technology. It is estimated that, if the mine were to be reopened and if a daily production rate of approximately 800 metric tons per day could be achieved, a mill capable of handling about 650 metric tons per day would be adequate. At this rate of production, the mine should have a life expectancy in excess of 20 years.

In an unpublished report dated 1939(?) Professor F. M. Handy noted the composition of the copper ores from the Chewelah district was such that the ores were self-fluxing and thereby more amenable to direct smelting rather than to milling and flotation. If this is in fact the case, then predevelopmental extractive proceedures will have to be performed and perfected to establish the sort of mill and(or) smelter required to handle these ores. The particulars regarding transportation requirements will also be dependent upon the outcome of these preliminary studies.

According to a clipping from the Chewelah Independent, dated 1/13/55, three diamond drill holes were executed under a Defense Minerals Exploration Administration contract. These holes were designed to test the nearby unexplored Keystone Independent vein at depth. The results of this drilling program are not available for inclusion in this study; consequently, any tonnages attributable to the Keystone vein have not been included in the matrix.

Needless to say, a considerable amount of detailed drilling and exploration will be required to realize even the expectations set forth at the 50-percent confidence level. It does appear however, that both exploration and development

of the mineralized zones at the United Copper Mine group have in the past concentrated primarily on indiscriminate drifting rather than following any set pattern established by exploratory drilling. The chances of proving-up considerable additional tonnages of average-grade ore, sweetened by the occasional ore shoot, appears to be fairly good for both the mines and those possibly related mineralized zones outside of the matrix area.

Lead-time to produce ore is estimated between 6 and 9 months only. Erection of a mill and(or) a transportation facility will depend to a large extent upon the outcome of required pilot beneficiation studies.

WASHINGTON SILVER RESOURCES

Great Excelsior (Wells Creek) Mine, Whatcom County, Washington

Property Location and Access: 48° 54' 01" N., 121° 48' 24" W., sec. 6, T 39 N, R. 8 E.

The Great Excelsior or Wells Creek mine is located on the south side of the Nooksack River one-half of a mile up the west side of Wells Creek. The Wells Creek-Nooksack River junction is about 6 miles east of the town of Glacier, and approximately 52 miles east of Bellingham, Washington on State Route 542, the Mount Baker Highway. The mine property is directly south of and across the river from the U.S. Forest Service's Excelsior campground. Several foot trails and jeep trails provide access to the property from the highway. The property is within the Mount Baker National Forests.

History, Production and Ownership

The Great Excelsior was discovered by W. H. Norton and others in August 1900 (Moen, 1969). The property, which consists of ten unpatented claims, was originally staked as lode gold deposit; however, smelter returns on early shipments of concentrates revealed that silver values far exceeded those of gold. The Great Excelsior Mining Company was established in 1902 and a 20 stamp mill was erected on the property. Milling problems resulting in a 50 percent loss of primary values prompted closure and reorganization of the company in 1905 into the President Group Mining Company. In 1914, the amalgamation mill was replaced by a cyanidation plant, which also proved to be inefficient, and following two years of uneconomical operation, the mill was closed. Several years later the mill was again opened and redesigned to utilize flotation, which in time also proved to be impractical. The original claims were relocated in 1922 by Mr. H. E. Barnes who performed annual assessment work only until abandoning the claims in 1960. The deposit was restaked as the Wells Creek Group in 1966 by the Exploration Division of American Smelting and

Refining Company; they determined that the property was subeconomic under 1971 market conditions and abandoned the claim. The property was immediately restaked and is currently being maintained and explored by Mr. Doug McFarland, Star Route, Coulee Dam, Washington, 99116.

Geology and Description of the Ore Body

The ore minerals at the Great Excelsior Mine occur in fractured andesite, argillite, and slate of Jurassic age. The fracture system occurs over a length of about 4,000 feet and has a width of 200 to 400 feet. The main fractures trend N. 5° E. on the south end of the claims, and N. 15 E. on the north end; secondary fractures trend N. 10°-40° W. The spacing of the fractures is irregular; the average distance between fractures is only several inches. Many of the fractures are filled by thin veinlets of quartz that contain as much as 3 percent pyrite, and smaller amounts of gold and silver; sparsely disseminated grains of chalcopyrite, arsenopyrite, galena, and sphalerite are also present in some of the quartz (Moen, 1969, p. 86). Mineralization is largely restricted to the fractured or brecciated zone within the greenstone and does not occur to any notable extent within the surrounding slates. Stoess and Slater (1935) reported that in the underground workings there are many locations where mineralization has impregnated the greenstone for some distance away from the fractures. Over 1,700 feet of drifts, crosscuts, and open stopes have been developed during the years of mining activity at the Great Excelsior. One stope is 180 feet long by 60 feet wide and has a ceiling over 80 feet high. A number of tunnels have been run from the workings to the surface, though only one, the mill tunnel, connects the heart of the workings directly with the input side of the mill.

The only available production figures is that given by Huntting (1956, p. 177) of 10,000 tons, which netted $20,276. Total production to 1917 amounts to $69,157.

Description of the Probabilistic-Grade-Quantity Matrix (See appendix for matrix)

Mining engineers Stoess and Slater thoroughly and systematically sampled the Great Excelsior mine for the State and reported the results of their findings in an unpublished report dated 1935. Unfortunately, the data, however thorough, does not extend beyond the limits of the underground workings. Stoess and Slater in their conclusions (p. 1) report that since mineralization is moderately uniform throughout the sampled workings and over the surface thereof, there is every reason to expect that the minimum grade of the deposit will at least be maintained over the entire length of the lode line. Therefore, on the strength of this conclusion, the grade figures used in column one of the matrix represent a very optimistic appraisal of the larger mass of brecciated and mineralized greenstone. The grade figures used in column one were reported by Stoess and Slater (p. 11) to be average values recovered from composite ore samples treated by flotation. The grades and tonnage quantities shown in column 2 are from the same source (p. 12) and represent indicated and speculative supradevelopment resource quantities based again on data collected from within the workings. The tonnages in column one represent three double sets of blocks arranged to include a large portion, but not all, of the brecciated greenstone lying between the surface and a horizontal plane established at the elevation of the blacksmith tunnel. Tonnages shown at the 50 percent confidence level are those calculated for blocks A_1 and A_2, which surround the mined or developed area. Blocks B_1 and B_2, followed by Blocks C_1 and C_2, cover the mineralized zone along the strike to the north of the developed area and together represent commulative tonnages at the 25 and 10 percent probability levels.

Mining and Beneficiation

The great extent of the mineralized area, combined with the ability of the rock mass to stand over large areas without support, would seem to favor shrinkage stoping with delayed filling over other underground methods. Underground mining of this deposit, while aesthetically and environmentally more acceptable

than surface methods, would of course add considerably to both the cost and the time required to develop and produce ore from a deposit of this sort. Surface mining, though not proposed in the MAS record, would be a faster, less expensive, and much more practical method of mining this deposit, and perhaps at a later date should strategic or economic considerations take precedent, this type of mining could be considered.

According to tests performed by Stoess and Slater during the course of their investigation, between 80 and 85 percent of the silver and at least 90 percent of the gold values are recoverable using 1934 vintage flotation technology. Due to the compact, siliceous nature of the ore, it did not yield readily to early-day crushing equipment. Early attempts to concentrate the ore, utilizing various water-based media, resulted in sliming losses amounting to over 50 percent; this alone contributed significantly to the ultimate closure of the mine.

It is proposed that should the mine be reactivated as an underground operation a 1,000 TPD mill could be erected nearby to handle the mine output. To avoid environmental problems it may be desirable or indeed necessary to return the mill tailings to the empty stopes for disposal and transport the concentrates to either an onsite or locally established smelter. Bullion from the smelter could then be easily transported to the American Smelting and Refining Company's refinery in Tacoma, Washington, a distance of about 250 km from the minesite.

Exploration, development, design and construction of a mill and completion environmental impact studies is estimated to require at least 2.5 years.

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APPENDIX

Probabilistic Grade-Quantity Matrices of various resource deposits arranged alphabetically.

ALAMETHER-GORA CHROMITE

Reference Number-E

PROBABILISTIC GRADE-QUANTITY MATRIX

U.S. BUREAU OF MINES
MINERALS AVAILABILITY SYSTEM

125

1 2 State: 53 | 3 5 County: 057 | 6 9 Sequence Number: | 10 Record Identification (1st digit): 1

Average Minable Grades (columns) 1 2 3 4 5

Record Identification	Action Code	Commodity	1	2	3	4	5
01		CHROMITE	3.7	25.0			
02							
03							
04							
05							
06							
07							
08							
09							
10							

Resource Quantity (thousands)

Record Identification	Action Code	Probability	1	2	3	4	5
11		P 1 90					
12		P 2 75					
13		P 3 50	211	44			
14		P 4 25	272	48			
15		P 5 10	335	53			

Year of this Evaulation - E 6162 75

A-10

APEX MINE

PROBABILISTIC GRADE-QUANTITY MATRIX

Reference Number-E

1 2 State: 53 | 3 5 County: 033 | 6 9 Sequence Number: | 10 Record Identification (1st digit): 1

U.S. BUREAU OF MINES
MINERALS AVAILABILITY SYSTEM

Average Minable Grades (columns)

Record Identification (11 12)	Action Code (13)	Commodity (14)	1 (15 19)	2 (20 24)	3 (25 29)	4 (30 34)	5 (35 39)
01		SILVER	193.7	222.7			
02		GOLD	35.6	31.1			
03		ARSENIC	21.1	2.6			
04		LEAD	4.5	0.25			
05		COPPER		0.16			
06		ZINC		0.18			
07		ANTIMONY		0.18			
08							
09							
10							

Resource Quantity (thousands)

Record Identification (11 12)	Action Code (13)	Probability	14 15	16 24	25 33	34 42	43 51	52 60
11		P 1	90					
12		P 2	75		121			
13		P 3	50	2574	151			
14		P 4	25	356	236			
15		P 5	10	457	295			

61 62 Year of this Evaulation - E: 75

A-10

ARLINGTON MINE

Reference Number-E

PROBABILISTIC GRADE-QUANTITY MATRIX

U.S. BUREAU OF MINES
MINERALS AVAILABILITY SYSTEM

127

1 2 State: 53 | 3 5 County: 047 | 6 9 Sequence Number: | 10 Record Identification (1st digit):

Average Minable Grades (columns)

Record Identification	Action Code	Commodity	1	2	3	4	5
01		SILVER	622 gm/mt				
02		GOLD	0.62 gm/mt				
03		COPPER	1.15 %				
04							
05							
06							
07							
08							
09							
10							

Resource Quantity (thousands)

Record Identification	Action Code	Probability	16–24	25–33	34–42	43–51	52–60
11		P 1 90					
12		P 2 75					
13		P 3 50	322				
14		P 4 25	830				
15		P 5 10	1327				

Year of this Evaulation - E: 6162

A-10

BLEWETT IRON-NICK

MINERALS AVAILABILITY SYSTEM

PROBABILISTIC GRADE - QUANTITY MATRIX

Reference Number - E

1 2	3 5	6 9	10
53 State	007 County	Sequence Number	1 Record Identification (1st digit)

Average Minable Grades

Record Identification	Action Code	Commodity	14	15 19	20 24	25 29	30 34	35 39
01		NICKEL		.47	.90			
02		CHROMIUM		.64	1.66			
03		IRON		13.34	32.65			
04								
05								
06								

Resource Quantity (thousands)

Record Identification	Action Code	Probability	14 15	16 24	25 33	34 42	43 52	53 60
11		P 1	90		476			
12		P 2	75		715			
13		P 3	50	7218	1192			
14		P 4	25	7218	1192			
15		P 5	10	7218	1192			

61 62 Year of this Evaluation - E 75

CLE ELUM IRON-NI #1

MINERALS AVAILABILITY SYSTEM

PROBABILISTIC GRADE - QUANTITY MATRIX

Reference Number - E

1 2	3 5	6 9	10
53 State	037 County	Sequence Number	1 Record Identification (1st digit)

Average Minable Grades

Record Identification (11 12)	Action Code (13)	Commodity (14)	15 19	20 24	25 29	30 34	35 39
01		NICKEL	0.84				
02		CHROMIUM	2,40				
03		IRON	40.86				
04							
05							
06							

Resource Quantity (thousands)

Record Identification (11 12)	Action Code (13)	Probability (14 15)	16 24	25 33	34 42	43 52	53 60
11		P 1 90	2903				
12		P 2 75	3493				
13		P 3 50	5670				
14		P 4 25	5670				
15		P 5 10	5670				

61 62 Year of this Evaluation - E 75

CLE ELUM IRON-NICK #2

MINERALS AVAILABILITY SYSTEM

PROBABILISTIC GRADE - QUANTITY MATRIX

130

Reference Number - E

1 2	3 5	6 9	10
53 State	037 County	Sequence Number	2 Record Identification (1st digit)

Average Minable Grades

Record Identification	Action Code	Commodity	14	15 19	20 24	25 29	30 34	35 39
01		NICKEL		.77				
02								
03								
04								
05								
06								

Resource Quantity (thousands)

Record Identification	Action Code	Probability	14 15	16 24	25 33	34 42	43 52	53 60
11		P 1	90	3022				
12		P 2	75	3606				
13		P 3	50	5783				
14		P 4	25	5783				
15		P 5	10	5783				

61 62

Year of this Evaluation - E 75

CLEOPATRA MINE #1

Reference Number-E

PROBABILISTIC GRADE-QUANTITY MATRIX

U.S. BUREAU OF MINES
MINERALS AVAILABILITY SYSTEM

1 2	3 5	6 9	10
53 State	033 County	Sequence Number	1 Record Identification (1st digit)

Average Minable Grades (columns)

Record Identification	Action Code	Commodity	14	1 (15 19)	2 (20 24)	3 (25 29)	4 (30 34)	5 (35 39)
01		SILVER		340.9 gm/mT	622.0 gm/mT	.3278 gm/mT		
02		GOLD		.9 gm/mT		3.7 gm/mT		
03		ANTIMONY				2.2 %		
04		ARSENIC				3.6 %		
05		COPPER				0.2 %		
06		ZINC.				1.0 %		
07								
08								
09								
10								

Resource Quantity (thousands)

Record Identification	Action Code	Probability	14 15	16 24	25 33	34 42	43 51	52 60
11		P 1	90	20	18	2		
12		P 2	75	68	18	2		
13		P 3	50	91	18	2		
14		P 4	25	125	18	2		
15		P 5	10	284	18	2		

Year of this Evaulation - E 6162 75

CLEOPATRA MINE #2

Reference Number-E

PROBABILISTIC GRADE-QUANTITY MATRIX

U.S. BUREAU OF MINES
MINERALS AVAILABILITY SYSTEM

132

1 2 State	3 5 County	6 9 Sequence Number	10 Record Identification (1st digit)
53	033		2

Average Minable Grades (columns)

Record Identification	Action Code	Commodity	14	1 (15 19)	2 (20 24)	3 (25 29)	4 (30 34)	5 (35 39)
01		SILVER		310.1				
02		GOLD		2.0				
03								
04								
05								
06								
07								
08								
09								
10								

Resource Quantity (thousands)

Record Identification	Action Code	Probability	14 15	16 24	25 33	34 42	43 51	52 60
11		P 1	90					
12		P 2	75					
13		P 3	50	5437				
14		P 4	25	6719				
15		P 5	10	8084				

Year of this Evaulation - E (61 62): 75

A-10

CONGRESS NICKEL

MINERALS AVAILABILITY SYSTEM

PROBABILISTIC GRADE - QUANTITY MATRIX

Reference Number - E

1 2	3 5	6 9	10
53 State	019 County	Sequence Number	1 Record Identification (1st digit)

Average Minable Grades

11 12 Record Identification	13 Action Code	Commodity	14	15 19	20 24	25 29	30 34	35 39
01		NICKEL		1.2				
02		IRON		5.5				
03		COBALT		0.02				
04		CHROMIUM		0.27				
05								
06								

Resource Quantity (thousands)

11 12 Record Identification	13 Action Code	Probability	14 15	16 24	25 33	34 42	43 52	53 60
11		P 1	90					
12		P 2	75					
13		P 3	50	567				
14		P 4	25	567				
15		P 5	10	567				

61 62 Year of this Evaluation - E: 75

DEER TRAIL MINE

PROBABILISTIC GRADE-QUANTITY MATRIX

U.S. BUREAU OF MINES
MINERALS AVAILABILITY SYSTEM

Reference Number-E

1 2	3 5	6 9	10
53 State	065 County	Sequence Number	1 Record Identification (1st digit)

Average Minable Grades (columns)

Record Identification	Action Code	Commodity	14	1 (15 19)	2 (20 24)	3 (25 29)	4 (30 34)	5 (35 39)
01		SILVER		0432 Gm/MT				
02		LEAD		006·2 %				
03								
04								
05								
06								
07								
08								
09								
10								

Resource Quantity (thousands)

Record Identification	Action Code	Probability	14 15	16 24	25 33	34 42	43 51	52 60
11		P 1	90					
12		P 2	75	432				
13		P 3	50	432				
14		P 4	25	432				
15		P 5	10	432				

Year of this Evaulation - E: 61 62

FORTY FIVE (MAGUS)

Reference Number-E

PROBABILISTIC GRADE-QUANTITY MATRIX

U.S. BUREAU OF MINES
MINERALS AVAILABILITY SYSTEM

1 2 State: 53 | 3 5 County: 061 | 6 9 Sequence Number: | 10 Record Identification (1st digit): 1

Average Minable Grades (columns)

Record Identification	Action Code	Commodity	1 (15–19)	2 (20–24)	3 (25–29)	4 (30–34)	5 (35–39)
01		SILVER	622 gm/mt				
02		GOLD	5 gm/mt				
03		LEAD	5 %				
04		ZINC	4 %				
05							
06							
07							
08							
09							
10							

Resource Quantity (thousands)

Record Identification	Action Code	Probability	14 15	16–24	25–33	34–42	43–51	52–60
11		P 1	90					
12		P 2	75					
13		P 3	50	14				
14		P 4	25	14				
15		P 5	10	14				

61 62 Year of this Evaulation - E: 75

A-10

4TH OF JULY MINE

Reference Number-E

PROBABILISTIC GRADE-QUANTITY MATRIX

U.S. BUREAU OF MINES
MINERALS AVAILABILITY SYSTEM

1 2 State: 53 | 3 5 County: 047 | 6 9 Sequence Number: | 10 Record Identification (1st digit): 1

Average Minable Grades (columns) 1 2 3 4 5

11 12 Record Identification	13 Action Code	Commodity	14	15 19	20 24	25 29	30 34	35 39
01		SILVER		622				
02								
03								
04								
05								
06								
07								
08								
09								
10								

Resource Quantity (thousands)

11 12 Record Identification	13 Action Code	Probability	14 15	16 24	25 33	34 42	43 51	52 60
11		P 1	90					
12		P 2	75					
13		P 3	50	117				
14		P 4	25	235				
15		P 5	10	352				

Year of this Evaluation - E 6162 75

A-10

GREAT EXCELSIOR

Reference Number-E

PROBABILISTIC GRADE-QUANTITY MATRIX

U.S. BUREAU OF MINES
MINERALS AVAILABILITY SYSTEM

1 2	3 5	6 9	10
53 State	073 County	Sequence Number	1 Record Identification (1st digit)

Average Minable Grades (columns)

Record Identification	Action Code	Commodity	14	1 (15 19)	2 (20 24)	3 (25 29)	4 (30 34)	5 (35 39)
01		SILVER		93.3	106.9			
02				.31	2.8			
03								
04								
05								
06								
07								
08								
09								
10								

Resource Quantity (thousands)

Record Identification	Action Code	Probability	14 15	16 24	25 33	34 42	43 51	52 60
11		P 1	90					
12		P 2	75		1134			
13		P 3	50	21251	5103			
14		P 4	25	38063	9072			
15		P 5	10	56752	9072			

Year of this Evaulation - E 61 62 75

A-10

MEADOWS-LEADER CHROM I

Reference Number-E

PROBABILISTIC GRADE-QUANTITY MATRIX

U.S. BUREAU OF MINES
MINERALS AVAILABILITY SYSTEM

1 2	3 5	6 9	10
5 3 State	0 5 7 County	Sequence Number	1 Record Identification (1st digit)

Average Minable Grades (columns)

Record Identification 11 12	Action Code 13	Commodity 14	1 15 19	2 20 24	3 25 29	4 30 34	5 35 39
0 1		CHROMITE	9 - 0				
0 2							
0 3							
0 4							
0 5							
0 6							
0 7							
0 8							
0 9							
1 0							

Resource Quantity (thousands)

Record Identification 11 12	Action Code 13	Probability	14 15	16 24	25 33	34 42	43 51	52 60
1 1		P 1	9 0					
1 2		P 2	7 5	1 2				
1 3		P 3	5 0	2 1				
1 4		P 4	2 5	2 9				
1 5		P 5	1 0	8 2				

Year of this Evaulation - E 61 62: 7 5

MT. VERNON NICKEL

MINERALS AVAILABILITY SYSTEM

PROBABILISTIC GRADE - QUANTITY MATRIX

Reference Number - E

1 2	3 5	6 9	10
53 State	057 County	Sequence Number	1 Record Identification (1st digit)

Average Minable Grades

11 12 Record Identification	13 Action Code	Commodity	14	15 19	20 24	25 29	30 34	35 39
01		NICKEL		.68	.87	1.07		
02		GOLD		.47	.59	.47		
03		SILVER			8.08	8.10		
04								
05								
06								

Resource Quantity (thousands)

11 12 Record Identification	13 Action Code	Probability	14 15	16 24	25 33	34 42	43 52	53 60
11		P 1	90					
12		P 2	75			14		
13		P 3	50	45360	514	45		
14		P 4	25	45360	514	45		
15		P 5	10	45360	514	45		

61 62 Year of this Evaluation - E 75

UNITED COPPER MIN

140

Reference Number-E

PROBABILISTIC GRADE-QUANTITY MATRIX

U.S. BUREAU OF MINES
MINERALS AVAILABILITY SYSTEM

1 2 State: 53 | 3 5 County: 065 | 6 9 Sequence Number: | 10 Record Identification (1st digit): 1

Average Minable Grades (columns)

Record Identification	Action Code	Commodity	14	1 (15–19)	2 (20–24)	3 (25–29)	4 (30–34)	5 (35–39)
01		SILVER		166.5 gm/mt	169.4			
02		GOLD		0.327 gm/mt	00.25			
03		COPPER		002.5 %	02.44			
04								
05								
06								
07								
08								
09								
10								

Resource Quantity (thousands)

Record Identification	Action Code	Probability	14 15	16–24	25–33	34–42	43–51	52–60
11		P 1	90					
12		P 2	75					
13		P 3	50	4289	1056			
14		P 4	25	11804	2718			
15		P 5	10	15314	3528			

61 62 Year of this Evaulation - E: 75

A-10

LOCATION OF NICKEL, CHROMIUM, and SILVER RESOURCES

IN

WASHINGTON

1975

By

JOHN M. LUCAS

Explanation

• Deposit, commodity

10 0 10 20 30 MILES