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BERT L. COLE, Commissioner of Public Lands

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MARSHALL T. HUNTTING, Supervisor

Geologic Map GM-5

GEOLOGY OF THE CHEWELAH MOUNTAIN QUADRANGLE, STEVENS COUNTY, WASHINGTON

By

LORIN D. CLARK and FRED K. MILLER

U. S. GEOLOGICAL SURVEY

Prepared cooperatively by the U. S. Geological Survey

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TO ACCOMPANY GEOLOGIC MAP GM-5

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INTRODUCTION

The Chewelah Mountain quadrangle is in the east-central part of Stevens County about 45 miles north of Spokane (fig. 1). It covers the western half of the mountains dividing the Pend Oreille and Colville River valleys at that latitude. Mapping of the quadrangle was begun in 1963 by the U.S. Geological Survey in cooperation with the Division of Mines and Geology of the Washington State Department of Conservation to further understanding of the geologic setting of copper, silver, and nonmetallic ore deposits in the area. It was found that in many mines little exploration had been attempted below adit level and that the plane of an underlying thrust fault that appears to have been the control for ore deposition has not been tested. A search for ore, particularly near the intersection of this thrust with high-angle faults in the area, might be warranted.

The Chewelah Mountain quadrangle (pl. 1) is underlain by folded, faulted, and regionally metamorphosed sedimentary and volcanic rocks of Precambrian age; folded and faulted Cambrian quartzite and carbonate rocks of Paleozoic(?) age, and intermediate plutonic rocks of Mesozoic(?) age. Generally, bedrock is exposed in upland areas, but in more than half of the quadrangle it is concealed beneath unconsolidated glacial deposits. The scarcity of exposure seriously hinders projection and correlation of some major structural features.

The area now called the Chewelah Mountain quadrangle was included in Weaver's (1920) geologic reconnaissance of Stevens County. Jones (1928), who remapped the area, modified the outcrop pattern, but retained most of Weaver's original units. Bennett (1941), and later, Campbell and Loofbourow (1962) and Campbell and Raup (1964), prepared more detailed geologic maps of the northeastern Washington magnesite belt, which lies immediately to the west of the quadrangle (fig. 1). These geologists all made significant contributions toward unraveling the Precambrian and Cambrian stratigraphy of the region. The greater part of the present investigation was carried out by Clark and Miller during 1963 and 1964; it was completed by Miller, with the assistance of J. C. Moore in 1965.

STRATIFIED ROCKS

PRECAMBRIAN ROCKS

BELT SERIES

Rocks here included with the Belt Series underlie much of the southeastern part of the quadrangle. They consist of argillite units 500 to 1,500 feet thick alternating with units of roughly similar thickness composed of interbedded quartzite and argillaceous quartzite. Argillite in these strata is light green or dark gray to light gray. Most argillite is well stratified, and it commonly contains ¼- to 1-inch-thick beds of very fine grained impure quartz sandstone. Some of these sandy beds are graded. The quartzite is fine grained and contains 2 to 20 percent sericitic material. Bedding thickness is variable, although it is most commonly between ½ foot and 2 feet. White is the most common color except in argillaceous specimens, where light green and gray prevail. Ripple marks and mudcracks occur at some localities, but crossbedding is sparse. Approximate calculations from outcrop width suggest that these rocks are more than 8,000 feet thick in the quadrangle. The base of the unit is not exposed in the map area.

DEER TRAIL GROUP

The Deer Trail Group underlies most of the southern half of the Chewelah Mountain quadrangle. It is of Precambrian age and was named the Deer Trail Argillite by Weaver (1920, p. 59) and redefined as the Deer Trail Group by Bennett (1941, p. 7). In the magnesite belt, the group is chiefly a sequence of argillite, quartzite, and dolomite which Campbell and Loofbourow (1962, p. 8) subdivided into, in ascending order, the Togo Formation, Edna Dolomite, McHale Slate, Stensgar Dolomite, and Buffalo Hump Formation. The Deer Trail Group is unconformably overlain by the Huckleberry Formation. Units of the Deer Trail Group in the Chewelah Mountain quadrangle generally correspond lithologically to units in the type area west of the quadrangle. The Togo Formation, which consists in its type area almost entirely of argillite (Campbell and Loofbourow, 1962, p. 9), has not been recognized in the quadrangle but continuing studies may reveal its presence.

Edna Dolomite.—The Edna Dolomite consists of dolomite, argillite, phyllite, and quartzite. The dolomite, a tan, finely laminated rock, is extremely impure, commonly containing appreciable amounts of argillaceous material and silt-size quartz. The argillite is indistinguishable from that of the Belt Series. The quartzite is vitreous, fairly coarse grained, and thickly bedded. In the Chewelah Mountain quadrangle, the Edna Dolomite is in most places deformed, and in the northern two-thirds of the quadrangle is metamorphosed to calc-silicate rock and schist. The thickest section in the quadrangle that is thought to be homoclinal is about 2,000 feet. Campbell and Loofbourow (1962, p. 10) estimate the thickness to be between 1,500 and 2,500 feet in the magnesite belt to the west, where the lithologies are very similar.

McHale Slate.—The McHale Slate is lithologically quite uniform, unlike other formations comprising the Deer Trail Group. It is almost entirely dark-gray and green argillite interspersed with beds less than 1 inch thick of fine-grained quartzite or quartz siltstone. Alternating argillite and quartz-rich layers, which give many outcrops a striped appearance, form a lithology identical to some of the argillite horizons in the Belt Series. Slump structures and, in places, load casts are abundant. Many quartz-rich beds show graded bedding or cross lamination. Beneath the erosional unconformity at the base of the Addy Quartzite, the McHale Slate in the quadrangle has a maximum thickness of about 2,000 feet.

Stensgar Dolomite.—The Stensgar Dolomite is less heterogeneous than the Edna Dolomite. It does, however, include maroon slate, particularly in the southwest corner of the area. The dolomite is gray to pink, more thickly bedded, and lacks the thin lamination characteristic of the dolomitic parts of the Edna Dolomite. Large magnesite deposits are exploited to the west, but no commercial deposits have been found within the quadrangle. All exposed bodies of the Stensgar Dolomite within the quadrangle are bounded on at least one side by faults. The greatest thickness observed is less than 500 feet. At the northeast end of the magnesite belt, about 2.5 miles west of the quadrangle, the Stensgar Dolomite is about 1,200 feet thick (Campbell and Loofbourow, 1962, pl. 1).

Buffalo Hump(?) Formation.—Dark-gray phyllite about 1,100 feet thick and overlying vitreous quartzite about 400 feet thick, along the western border of the quadrangle, are tentatively correlated with the type Buffalo Hump Formation. Both phyllite and quartzite resemble rocks in the type area of the Buffalo Hump Formation on the west slope of Huckleberry Mountain southwest of the quadrangle, but correlation is uncertain because the rocks in the quadrangle are sheared and their contacts with surrounding rocks are not exposed.

Huckleberry Formation.—The Huckleberry Formation as redefined by Campbell and Loofbourow (1962, p. 21) includes a conglomerate member and an overlying greenstone member. At nearby areas outside the Chewelah Mountain quadrangle, the conglomerate is as thick as 1,600 feet. About 40 miles to the northeast, Park and Cannon (1943, p. 7) report a thickness of 5,000+ feet for the Shedroof Conglomerate, which is probably equivalent to the conglomerate member of the Huckleberry Formation. Within the quadrangle, however, the Huckleberry Formation is entirely greenstone except for a small amount of conglomerate in the southwest corner. Bennett (1941, p. 8) demonstrated that in the magnesite belt, where stratigraphic relations are more readily discernible, the conglomerate rests unconformably on more than one formation of the Deer Trail Group.

The large mass of greenstone along the western edge of the area is composed of flows, flow breccias, debris flows, and minor amounts of tuff and limestone. Chemical analyses, mineralogy, and microscopic textures indicate that the flows are basalt. Stratification is difficult to recognize, being obscured by a cover of lichen. Original igneous textures are well preserved. The Huckleberry Formation is estimated to be at least 1,500 feet thick in the quadrangle, but this is uncertain because it is difficult to determine attitudes of beds. The two small areas of greenstone in the vicinity of Bayley Creek appear to be intrusive.

PRECAMBRIAN OR CAMBRIAN ROCKS

Slate and limestone.—Near the western margin of the quadrangle, the Huckleberry Formation and Addy Quartzite are separated by rocks of Precambrian or Cambrian age having a total thickness of about 500 feet. Bedding attitudes appear concordant from the upper few feet of the Huckleberry Formation through the lower part of the Addy Quartzite, but concealed intervals separate the various lithologies that comprise the intervening unit of uncertain age. At the base of the unit, limestone a few feet thick is in depositional contact with vesicular lavas of the Huckleberry Formation. Above the limestone is deep-red to dark-green thin-bedded slate with interbedded argillaceous carbonate rocks. Near the contact with quartz monzonite immediately west of the boundary, the unit is thermally metamorphosed to marble, calc-silicate hornfels, and fine-grained schist. The unit is possibly part of the Monk Formation (Daly, 1912, p. 147) of Cambrian(?) age (Park and Cannon, 1943, p. 13), which occurs at several localities between Chewelah and British Columbia.

CAMBRIAN SYSTEM

Addy Quartzite.—The Addy Quartzite is chiefly medium- to coarse-grained, medium- to thick-bedded, white to pink, vitreous orthoquartzite. It is commonly crossbedded. Sparse conglomerate lenses in the formation contain rounded pebbles of vein quartz, greenstone, and quartzite. At the base of the formation is about 100 to 200 feet of black-striped purple quartzite, which grades upward through pink quartzites over a stratigraphic distance of about 100 to 200 feet into the white quartzite characterizing most of the formation. The greatest exposed thickness of the Addy Quartzite in the quadrangle, about 1,600 feet, is on Eagle and Quartzite Mountains, but those sections are incomplete, for at both places the formation is truncated by faults. Much greater thicknesses elsewhere in the region have been reported by Campbell and Raup (1964). Trilobites and gastropods of Early Cambrian age (Okulitch, 1951, p. 405) occur in argillaceous and quartzitic beds in the lower part of the Addy Quartzite near the town of Addy, about 8 miles northwest of Chewelah.

The Addy Quartzite rests with angular unconformity on several older formations. About a quarter of a mile west of the quadrangle boundary, near the large area underlain by the Huckleberry Formation, the Addy Quartzite rests, apparently conformably, on the rocks of Precambrian or Cambrian age; on Eagle and Quartzite Mountains, the quartzite was deposited on the McHale Slate; and near the southwest corner of the quadrangle, it overlies the Huckleberry Formation. East of the Colville River valley and about 1 mile south of the quadrangle boundary, the Addy Quartzite overlies the Edna Dolomite. Stratigraphic evidence of the angular unconformity is confirmed by a difference of about 25° in bedding attitudes of the Addy Quartzite and McHale Slate near the south boundary of the quadrangle and by a greater difference in attitudes of the Addy Quartzite and Huckleberry Formation near the southwest corner of the quadrangle.

PALEOZOIC(?) ROCKS

Carbonate rocks, undivided.—Carbonate rocks of Paleozoic(?) age include limestone, dolomite, and about 100 feet of maroon slate. Most of the carbonate rocks are grayish, medium- to fine-grained, medium- to thick-bedded dolomite and limestone, but near contacts with intrusive rocks they are coarsely crystalline, massive, and nearly white. East of Chewelah, carbonate rocks in the western part of the belt are sheared, brecciated, and recemented. Near the line of cross section C–C′, a layer of oolitic limestone and a layer of limestone containing chert nodules are traceable for a few hundred feet. The maroon slate nearby grades upward and downward into laminated carbonate rock. Between faults that bound both sides, the carbonate rocks are about 2,000 feet thick. No fossils were found in this unit, but a late Paleozoic age is consistent with the occurrence of Mississippian fossils (McLaughlin and Simons, 1957, p. 515) in similar rocks about 6 miles south along the projected strike of the carbonate rocks in the quadrangle. Precise correlation between the two areas is precluded by intervening concealed areas and by faults of large displacement.

About 4 miles north of Chewelah, near the western border of the quadrangle, are two small areas of limestone from which Jones (1928) and V. E. Barnes collected trilobite fragments and brachiopods identified by Branson (1931, p. 70) as *Kutorgina cingulata* (Billings) of Early Cambrian age.

TERTIARY(?) SYSTEM

Sedimentary rocks.—In the southwest corner of the quadrangle and on the south flank of Cliff Ridge are several small erosional remnants of indurated, undeformed boulder conglomerates. The conglomerates are poorly sorted and poorly stratified, and contain rounded pebbles and boulders of limestone, dolomite, quartzite, chert, slate, and greenstone of probable nearby origin.

QUATERNARY SYSTEM

Alluvial and glacial deposits.—Alluvial and glacial deposits and lake beds are combined in a single map unit. The alluvial deposits are confined to the immediate vicinity of modern streams; by far the most abundant are sand and gravel in outwash plains and terraces and in mantle deposits on hillsides. Fine-grained lake deposits underlie parts of the Colville River valley and an area between the Paleozoic(?) carbonate rocks and the Addy Quartzite in the southern part of the quadrangle. Small moraines occur in the large glacial area north of Burnt Valley. The glacial ice, as shown by the distribution of striae, glacial erratics, and moraines, covered the western two-thirds of the quadrangle and a lobe moved eastward from the main body of ice in the Burnt Valley. In some other valleys, outwash was transported eastward from the margin. The glacial ice in the Colville River valley must have been more than 2,000 feet thick, as shown by the glacial debris on top of Quartzite Mountain; evidence west of the quadrangle indicates that it was probably more than 4,000 feet thick. Above an altitude of about 5,000 feet, Chewelah Mountain was not glaciated, but bedrock is deeply frost riven. Similarly, rocks at higher elevations in the vicinity of Calispell Peak protruded above the continental glaciers, but two cirques on the north side of Calispell Peak indicate local mountain glaciation.

IGNEOUS INTRUSIVE ROCKS

PLUTONIC ROCKS

Rocks of Calispell Peak.—Diverse igneous and metamorphic rocks, typified by exposures in the vicinity of Calispell Peak, underlie most of the northeastern quarter of the quadrangle; they are here collectively termed an igneous-metamorphic complex. The complex consists of remnants of Precambrian(?) roof rocks engulfed by biotite-muscovite granodiorite, both of which have been intruded by dikes, sills, and cupolas of muscovite quartz monzonite. The attitude of compositional layering and the horizontal and vertical distribution of roof remnants suggests that the top of the biotite-muscovite granodiorite was broad and gently arched in the Chewelah Mountain quadrangle. No roof remnants are delineated separately on the map, as they do not have sharply defined contacts but grade into the plutonic rocks through zones of increasingly numerous dikes and sills. Calc-silicate rock, mica schist, and amphibolite are the most common rock types preserved in the roof remnants.

Almost everywhere the biotite-muscovite granodiorite has a slight foliation that shows no relation to the external form of the mass. The foliation appears to be related, not to emplacement of the body, but to a later structural or metamorphic event. The texture of the granodiorite is unusual in that the muscovite and biotite are interstitial to much larger crystals of feldspar and quartz. Composition of the rocks ranges from quartz diorite to granodiorite (fig. 3, pl. 1). In areas where dikes and sills of the muscovite quartz monzonite are most abundant, the two-mica body has a quartz diorite composition; where least intruded, it is granodiorite. The biotite-muscovite granodiorite is easily distinguished from other plutonic rocks in the area because it contains both biotite and muscovite, has a slight foliation, has large quartz crystals, and is completely lacking in hornblende and sphene.

Some cupolas of muscovite quartz monzonite are about 1 mile in diameter. Tabular intrusions range in thickness from an inch to more than 200 feet, but most are about 20 to 40 feet thick. Although the rock lithologically resembles aplite, the size and number of bodies differ markedly from the thin, localized dikes characteristic of aplite. The rock has a hypidiomorphic granular to xenomorphic granular texture. Most of the rock has some biotite, especially near contacts with the biotite-muscovite granodiorite, where the biotite may result from contamination by the granodiorite.

Flowery Trail Granodiorite.—The Flowery Trail Granodiorite is here named for its type locality, the igneous pluton about 2 miles northeast of Chewelah. Here excellent exposures of this rock are found in roadcuts along the Flowery Trail Road, particularly near the base of the Chewelah Mountain ski lift. It is an apparently tabular body about 7.5 miles long and 2 miles wide. Contacts with the host rock are sharp, and in places dikes extend as much as 100 yards from the main mass of granodiorite. The pluton is chiefly hornblende-biotite granodiorite, although modally its composition ranges from quartz monzonite nearly to the quartz diorite boundary (fig. 2). The color index ranges from 22 to 45. Most of the granodiorite is medium grained and has a hypidiomorphic granular structure, although parts of the border are foliated. In hand specimen, the rock is characterized by more abundant hornblende than biotite, abundant sphene, and white K-feldspar.

Starvation Flat Quartz Monzonite.—About 35 square miles in the northwest corner of the quadrangle is underlain by a plutonic rock here named the Starvation Flat Quartz Monzonite. Its type area includes sporadically occurring, but reasonably unweathered, exposures within 1 mile of Starvation Flat. Rock typical of the mass as a whole may be found where Little Bear Creek intersects the western border of the quadrangle. Contact relations are not exposed in the quadrangle. The rock is a hypidiomorphic granular biotite-hornblende quartz monzonite of uniform texture, appearance, mineralogy, and modal composition (fig. 2, pl. 1). Most of the intrusive is medium- to coarse-grained and nonporphyritic. Immediately north of Starvation Lake, however, the quartz monzonite is porphyritic, contains no hornblende, and may be part of an entirely different plutonic mass. The Starvation Flat Quartz Monzonite is similar enough in appearance to the Flowery Trail Granodiorite that the two can be confused. In the Starvation Flat Quartz Monzonite, however, biotite is more abundant than hornblende and occurs in euhedral pseudohexagonal tablets. In addition, K-feldspar is commonly pink rather than white, as in the Flowery Trail Granodiorite.

Age.—All the plutonic rocks are of probable Mesozoic age. Jaffe and others (1959, p. 97) report a lead-alpha radiometric age of 99 million years for a sample collected near Arden, about 5 miles west of the quadrangle. Although the exact locality is not described, the Starvation Flat Quartz Monzonite extends more than 5 miles in that direction, and is probably the rock collected.

The biotite-muscovite granodiorite would be the oldest intrusive rock in the quadrangle, if, as suggested previously, its foliation results from a structural or metamorphic event not recorded by the other plutonic rocks. It cannot be proved, however, that the foliation did not result from intrusion of the other plutonic rocks. The apparent relation shown by the modes of all plutonic rocks except the biotite-muscovite granodiorite suggests that three of the bodies are part of a differentiation sequence (fig. 3, pl. 1). The two-mica granodiorite does not appear to be genetically related to the other three bodies because its average mode plots so far off the apparent differentiation trend.

The muscovite quartz monzonite is the youngest of the intrusive bodies, for it intrudes the biotite-muscovite quartz monzonite and the Starvation Flat Quartz Monzonite and appears to have mildly metamorphosed part of the Flowery Trail Granodiorite. The relative age of the other three plutonic rocks is not known with any degree of certainty.

HYPABYSSAL INTRUSIVE ROCKS

Mafic dikes.—Mafic dikes, occurring in small outcrops over much of the quadrangle, intrude both metamorphic and plutonic rocks, but are most abundant in and around the plutonic rocks. The majority are composed of euhedral phenocrysts of plagioclase, hornblende, and biotite in a fine matrix of K-feldspar, albite, and minor quartz. The dikes cut all the plutonic bodies, and therefore are of Mesozoic or younger age.

STRUCTURE

The complicated structure of layered rocks in the quadrangle results from successive deformations ranging in age from Precambrian to late Paleozoic, Mesozoic, and, possibly to Cenozoic. The deformations include broad open folding and probably faulting prior to deposition of the Addy Quartzite, movement along a thrust fault, and development of three distinct sets of high-angle faults. Some high-angle faults cut the thrust, but the relations of others to the thrust are undetermined.

The earliest deformation recognized in the quadrangle is indicated by the transgression of the base of the Addy Quartzite from the top of Precambrian or Cambrian rocks in the northwest part of the quadrangle to the Edna Dolomite at the southern end of the quadrangle. If the formations that are successively cut out at the unconformity maintained uniform thickness throughout the area, the total thickness of strata eroded below the Addy Quartzite is more than 5,000 feet. Possibly this erosion results from two separate intervals of uplift, for Campbell and Loofbourow (1962, p. 24) cite evidence that in the magnesite belt the base of the Huckleberry Formation, as well as the base of the Addy Quartzite, marks an unconformity. The small magnitude of angular differences in bedding attitudes at the unconformity indicate that folds formed during the pre-Addy deformation were broad and open.

Of the three sets of high-angle faults in the quadrangle, those that strike nearly north are shown, by crosscutting relations with other faults, to be the oldest. The amount and direction of movement along most of these faults is uncertain, for they intersect bedding at small angles. Northeast of Chewelah, movement was great enough to juxtapose the Edna Dolomite against Paleozoic(?) carbonate rocks. One of these faults can be traced intermittently for at least 10 miles south of the map boundary.

Concealed east-northeast-trending faults in the valleys followed by the Flowery Trail Road and by the North Fork of Chewelah Creek are inferred on the basis of apparently offset contacts. A similar fault possibly underlies Burnt Valley. Structural continuity across the valley south of Quartzite Mountain precludes any but minor high-angle fault movement there. The amount and direction of movement along the east-northeast faults are unknown, but stratigraphic separation on the fault in North Fork of Chewelah Creek valley is about 4,000 feet.

High-angle faults that strike about N. 30° E. are among the most persistent faults in the quadrangle. The fault reaching the northern border of the quadrangle appears to have offset the west border of the biotite-muscovite granodiorite and the muscovite quartz monzonite dikes in an apparent right-lateral sense.

A thrust fault underlies most of the south part of the quadrangle east of the Colville River valley and is probably at depth north of Eagle Mountain. The thrust is cut by a high-angle fault near Quartzite Mountain, but elsewhere the relation of high-angle faults to the thrust is unclear. Sheared rocks with gently dipping planar structures that crop out near Horseshoe Lake are probably in the thrust zone or in an ancillary fault zone. Rocks of the lower plate near the Flowery Trail Road in the eastern part of the area dip consistently northwestward and, according to their sedimentary structures, are right side up. Lower-plate rocks near the Jay Gould mine dip more steeply, but are otherwise little deformed. In contrast, upper-plate rocks, except Paleozoic strata, are complexly deformed and their structure is therefore generalized on section C–C′. Bedding is inferred to be overturned in much of the area south of the Flowery Trail Road, and repeated deformation of some upper-plate rocks is shown by two generations of cleavage and by steeply plunging minor fold axes. At higher altitudes on Chewelah Mountain and Goddards Peak, the existence of schistosity, as well as its diverse orientation, implies a deformational event that is absent or much less pronounced at lower altitudes in the upper plate. The direction of upper-plate movement is not established, but eastward movement is precluded by the abundance of quartzite in the upper plate, as no rocks comparable to those in the upper plate are known to occur in the magnesite to the west.

ECONOMIC GEOLOGY

METALLIC DEPOSITS

INTRODUCTION

Almost all mining activity is confined to the southern third of the Chewelah Mountain quadrangle, and more specifically to areas within 2 miles of the Flowery Trail Granodiorite. The mines and prospects can be roughly subdivided into three groups. The most productive group by far is on the west flank of Eagle Mountain. Copper-silver mines of this group have accounted for over 99 percent of the total recorded production in the quadrangle. Mines in the second group, in the Jay Gould area about 2 miles south of Eagle Mountain, have exploited lead-silver deposits, but recorded ore production is less than 600 tons. Mines in the third group, in the Embrey Hill area, were worked chiefly for copper and silver, although some ore contains molybdenum.

Mines in the quadrangle were most productive between 1902 and 1920; minor production is recorded until 1941, and almost none after that. Total recorded production for all mines in the quadrangle (Fulkerson and Kingston, 1958) is: 9,928,543 pounds of copper, 1,700,841 ounces of silver, 251,341 pounds of lead, 1,426 ounces of gold, 3,000 tons of barite, and 6 tons of beryl.

EAGLE MOUNTAIN AREA

The five largest producing mines in the quadrangle are the United Copper, Copper King, Amazon, Copper Queen, and the Keystone, all on the west slope of Eagle Mountain (pl. 1). Of these, the first two have had by far the greatest reported production. Patty (1921, p. 121) described the veins and mines near the end of their most active period; little development work has been done since. Most buildings and equipment are in ill repair or have been removed; the most productive workings in the Amazon and United Copper No. 2 mines were not accessible in 1964, but many other workings were. Mine maps (pl. 2) are largely taken from company maps, but accessible workings were checked in 1964.

The ore deposits are in shear zones less than 50 feet thick, distributed through a belt about 800 feet wide. Most movement appears to have taken place on the western edge of the belt, and the fault shown on the geologic map is drawn there. All mineralized rocks on the east side of this fault are probably argillite and carbonate of the Edna Dolomite; those on the west are argillite of the Belt Series.

Except in the United Copper No. 2 and Amazon mines, little evidence was found of exploration below adit level, and evidently the lower thrust plate has not been tested. The altitude of the thrust is unknown in this vicinity, but a search for the lower plate, particularly near the intersection of the thrust with the high-angle fault, might be warranted. Similarly, there is little evidence that rocks of the lower thrust plate near the contact of metamorphic rocks with the Flowery Trail Granodiorite on the south and west slopes of Eagle Mountain have been adequately explored.

The ore deposits occur as anastomosing quartz-carbonate veins from less than 10 feet to as much as 25 feet wide within the shear zones. Veins presently exposed in the workings are composed predominantly of milky quartz and carbonate minerals, ranging from calcite to siderite but containing small horses of argillite from the wall rock. Sulfides are sparsely disseminated but locally concentrated; they include: pyrite, chalcopyrite, tetrahedrite, pyrrhotite, covellite, and chalcocite or digenite. Some malachite and hematite are also present. Older reports on the producing mines suggest that most of the ore mined was fairly low grade. Fairly high-grade ore was mined between the 1,000- and 1,300-foot level of the

United Copper mine, and along the Amazon vein in the Copper King No. 2 mine.

United Copper properties.—The United Copper properties are in sections 31 and 32, T. 33 N., R. 41 E. The mine has a total listed production of 9,414,204 pounds of copper, and 1,645,997 ounces of silver (Fulkerson and Kingston, 1958, p. 28) accounting for about 95 and 97 percent, respectively, of copper and silver production in the quadrangle. The productive part of the mine was inaccessible in 1964. Geologic maps of the two tunnels are shown in figures 4 and 6, plate 2. Patty (1921, facing p. 128) shows an excellent cross section of workings in the largest ore bodies, at present inaccessible. As more than 85 percent of the total recorded production had been attained at the time of Patty's report, the section represents at least an approximation of the extent of the workings. Most production after 1919 presumably came from the lower levels of the unmined high-grade ore shown on Patty's cross section.

Copper King and Amazon properties.—Although listed as separate properties, the Copper King and Amazon mines in the northern part of section 32, T. 33 N., R. 41 E., will be treated together here. The mine workings of the Amazon are on a vein about 700 feet west of the northward projection of the vein worked by the United Copper mine (see figs. 1 and 2, pl. 2). The Copper King is in part developed on the upper part of the Amazon vein, but most of the workings are along the northern extension of the United Copper vein. The United vein in this area is composed of a large number of small veins, all in sheared argillite.

Combined total production of the two mines is about 14,000 tons of ore and accounts for most of the production in the quadrangle not accredited to the United Copper mine. Figure 1 on plate 2 is a company map of the workings and geology of the mine, updated during this investigation. Most of the workings in the Copper King mine were accessible in 1964.

Copper Queen.—The Copper Queen, the northernmost mine in the Eagle Mountain area, is located in the southern half of section 29, T. 33 N., R. 41 E. Little data concerning the history of the Copper Queen is available. The mine is reported to have had some production (Huntting, 1956, p. 95), although the figures (Fulkerson and Kingston, 1958, p. 27) appear to have been included in those given for either the Copper King or the United Copper. The major drift is along the probable northward projection of the United Copper vein.

Independent Keystone.—Little is recorded concerning the Keystone. No production is reported by Huntting (1956, p. 97), nor could any be found in mineral resources publications. The small-scale plan of the workings shown in figure 5 on plate 2 is from old company maps. Huntting (1956, p. 97) mentions that development was along a quartz vein parallel to bedding in the argillite, so apparently the geologic setting is similar to that of nearby mines.

Blue Star.—The Blue Star mine, in section 5, T. 32 N., R. 41 E., is in carbonate rock of probable Paleozoic age. Ore is concentrated in small chimneys in fractured white limestone (Weaver, 1920, p. 149). The Flowery Trail Granodiorite is present a few hundred feet from the portal. The easternmost workings terminate in what is probably the Addy Quartzite. Highly sheared argillite separates the quartzite from the carbonate. The mine consists of about 3,000 feet of workings, which were partly accessible in 1964. Latest recorded production was in 1935.

JAY GOULD AREA

Jay Gould.—The Jay Gould mine is located on several large and many smaller quartz veins in section 8, T. 32 N., R. 41 E. The veins are in carbonate rocks, argillite, and calc-silicate hornfels. Dikes of the Flowery Trail Granodiorite are found a few tens of feet from the workings. Latest recorded production was in 1939; none of the workings were accessible in 1964.

Chewelah Silver.—The Chewelah Silver mine, in section 9, T. 32 N., R. 41 E., is developed in the Flowery Trail Granodiorite, carbonate rocks, and calc-silicate hornfels. A few sparsely mineralized quartz veins were observed in 1964. Figure 7 on plate 2 is a geologic map of the mine.

Hecla.—The Hecla mine, in section 4, T. 32 N., R. 41 E., is on a 4-foot-thick quartz vein in the Flowery Trail Granodiorite. All workings were inaccessible in 1964.

High Grade.—The High Grade mine, in section 31, T. 33 N., R. 41 E., is on a network of quartz stringers containing very sparse sulfides. The mode of occurrence appears to be similar to that in the larger mines of this immediate area. The ore is said to have had fair silver values. Huntting (1956, p. 328) reports total development of only a few hundred feet of underground workings, none of which were accessible in 1964. About 100 tons of hand-sorted ore was shipped between 1917 and 1920.

Imperial Copper.—This mine consists of a 106-foot shaft and about 450 feet of crosscuts in schist and carbonate rock. One 4-foot-thick quartz vein is the only mineralization reported. The workings were inaccessible in 1964.

McPherson.—The McPherson mine, on the west flank of Eagle Mountain in section 32, T. 33 N., R. 41 E., was inaccessible in 1964, and no records of its operation were found.

Lead-silver ore, rather than copper-silver ore typical of the west slope of Eagle Mountain, characterizes deposits in the Jay Gould area. These mines and the Blue Star mine near the north side of the pluton are all adjacent to, or within, the Flowery Trail Granodiorite (see fig. 8, pl. 2).

Total recorded production from the mines in this area is entirely from the Blue Star and Jay Gould operations. Together, these mines produced a total of 550 tons of ore, which yielded 4 ounces of gold, 6,042 ounces of silver, 3,963 pounds of copper, and 250,451 pounds of lead (Fulkerson and Kingston, 1958, p. 27).

Payne.—The Payne mine, in section 8, T. 32 N., R. 41 E., is on a quartz vein in altered Flowery Trail Granodiorite. All workings were inaccessible in 1964. No significant mineralization was observed on the dump.

EMBREY HILL AREA

Mineralization on or near Embrey Hill, about 1 mile northeast of Chewelah, differs from that in the Jay Gould area in that the Embrey Hill ore contains less lead and more molybdenum. The Juno-Echo is the only mine in the area reported to have shipped molybdenum concentrate, although the concentrate failed to meet market specifications (Huntting, 1956, p. 88). Total production for all mines is 89 tons of ore yielding 22 ounces of silver and 4,011 pounds of copper. There is no record of production since 1916 except for the molybdenum shipment made in 1941.

June-Echo.—The June-Echo mine, in section 7, T. 32 N., R. 41 E., is reported to be developed by a 292-foot shaft and about 850 feet of drifts (Huntting, 1956, p. 98), but none were accessible in 1964. The workings follow veins near the contact between the Flowery Trail Granodiorite and recrystallized carbonate of probable Paleozoic age. Values of silver and copper from the vein are said to have been variable (Weaver, 1920, p. 153).

Chewelah Standard.—This mine, in section 7, T. 32 N., R. 41 E., was inaccessible in 1964. It is developed on small quartz veins in the Flowery Trail Granodiorite. No production is recorded.

Security Copper.—The Security Copper mine is located on numerous quartz veins in decomposed argillite in section 7, T. 32 N., R. 41 E. All the quartz veins are in argillitic layers of the Edna Dolomite near the contact with the Flowery Trail Granodiorite. Weaver (1920, p. 155) reported that the workings consist of a 552-foot shaft and 635 feet of drifts and crosscuts. These were not accessible in 1964.

OTHER MINES

Of several mines outside the three areas mentioned above, only two have recorded production. These are the Eagle Mountain (Lynx Cat) mine and the Cannon (Merikay, Railway Dike) mine. The former produced barite and the latter beryl.

Copper Cliff (Quartzite Mountain).—This mine, in section 17, T. 32 N., R. 41 E., is on scattered quartz and carbonate veins and slightly mineralized argillite. A 400-foot adit is reported by Huntting (1956, p. 101), but was inaccessible in 1964. No production is recorded.

Windfall.—The Windfall mine, not shown on pl. 1, is in section 17, T. 32 N., R. 41 E., about 1,500 feet east of the Copper Cliff mine, and is developed on a sparsely mineralized quartz vein in calc-silicate rock and micaceous quartzite. Huntting (1956, p. 105) reports about 1,000 feet of workings, but no known production. The workings were inaccessible in 1964.

Mullen mine.—The Mullen mine, in section 16, T. 32 N., R. 41 E., consists of a shaft dug on one mineralized quartz vein near a quartz diorite dike in the pre-Edna rocks. In 1964 the shaft was water filled.

Perry.—The Perry mine, not shown in figure 8 on plate 2, is in section 7, T. 33 N., R. 41 E., considerably north of most of the mines in the quadrangle. A 90-foot shaft and several open cuts explored a zone of sparse sulfide mineralization in argillite and calc-silicate rock. No production is recorded.

Cannon (Merikay, Railway Dike) mine.—The Cannon mine, in section 33, T. 34 N., R. 42 E., developed a beryl-bearing pegmatite in a small pendant of schist. Rocks surrounding the pendant are the biotite-muscovite granodiorite and the muscovite quartz monzonite. Abundant pegmatites occur in these rocks, but only this body appears to contain more than a trace of beryl. The property is developed by a 355-foot adit, two open cuts, and eight trenches. From the available exposure in 1964, most of the beryl crystals appear to be concentrated along the west side of the dike. Even where concentrated, the total percentage of beryl crystals is probably far less than 1 percent. A few scattered crystals of columbite were observed at one locality along the west side of the dike. Huntting (1956, p. 356) reports 6 tons of beryl produced in 1952. The property was idle in 1964.

Prospects on Calispell Peak.—Noncommercial amounts of garnet, beryl, and columbite occur in several small pegmatite prospects in section 21, T. 34 N., R. 42 E., on the ridge north of Calispell Peak.

NONMETALLIC DEPOSITS

INTRODUCTION

Several nonmetallic mining or quarrying operations are active in the Chewelah Mountain quadrangle for at least part of the year. Sand and gravel are mined from the glacial deposits, and carbonate rock, chiefly from quarries within 3 miles of Chewelah, is crushed and used for roofing granules, terrazzo, and decorative stone. Current production of crushed rock from Paleozoic(?) carbonate rocks and the Edna Dolomite is between 10,000 and 20,000 tons per year.

Eagle Mountain (Lynx Cat) mine.—The Eagle Mountain mine in section 33, T. 33 N., R. 41 E., near the crest of Eagle Mountain, consists of an adit, shaft, and open cuts developed on barite veins a few inches to more than 4 feet in thickness. Moen (1964, p. 66), in an excellent summary of the operation, reports that about 3,000 tons of measured, indicated, and inferred ore remain. The calculated average barite content for the shipped ore is about 95 percent.

REFERENCES CITED

Bennett, W. A. G., 1941, Preliminary report on magnesite deposits of Stevens County, Washington: Washington Div. Geology Rept. Inv. 5, 25 p.

Branson, C. C., 1931, New paleontological evidence on the age of the metamorphic series of northeastern Washington: Science, v. 74, no. 1907, p. 70.

Campbell, A. B., and Raup, O. B., 1964, Preliminary geologic map of the Hunters quadrangle, Stevens and Ferry Counties, Washington: U.S. Geol. Survey Mineral Inv. Field Studies Map MF-276, scale 1:48,000.

Campbell, Ian, and Loofbourow, J. S., Jr., 1962, Geology of the magnesite belt of Stevens County, Washington: U.S. Geol. Survey Bull. 1142-F, p. F1-F53.

Daly, R. A., 1912, Geology of the North America Cordillera at the forty-ninth parallel: Canada Geol. Survey Mem. 38, pts. 1-3, 857 p.

Enbysk, B. J., 1954, Additions to the Devonian and Mississippian paleontology of northeastern Washington: Washington State College, Pullman, Master's thesis.

Fulkerson, F. B., and Kingston, G. A., 1958, Mine production of gold, silver, copper, lead, and zinc in Pend Oreille and Stevens Counties, Washington, 1902-1956: U.S. Bur. Mines Inf. Circ. 7872, 45 p.

Huntting, M. T., 1956, Inventory of Washington minerals—Pt. II, Metallic minerals: Washington Div. Mines and Geology Bull. 37, pt. 2, v. 1, 428 p., v. 2, 67 p.

Jaffe, H. W., Gottfried, David, Waring, C. L., and Worthing, N. W., 1959, Lead-alpha age determinations of accessory minerals of igneous rocks (1953-1957): U.S. Geol. Survey Bull. 1097-B, p. 65-148.

Jones, R. H. B., 1928, Notes on the geology of the Chewelah quadrangle, Stevens County, Washington: Northwest Sci., v. 2, p. 111-116.

McLaughlin, K. P., and Simons, M. E., 1951, Upper Paleozoic microfossils from Stevens County, Washington: Jour. Paleontology, v. 25, no. 4, p. 514-519.

Moen, W. S., 1964, Barite in Washington: Washington Div. Mines and Geology Bull. 51, 112 p.

Moore, J .G., 1963, Geology of the Mount Pinchot quadrangle, southern Sierra Nevada, California: U.S. Geol. Survey Bull. 1130, 152 p.

Okulitch, V. J., 1951, A lower Cambrian fossil locality near Addy, Washington: Jour. Paleontology, v. 25, no. 3, p. 405-407.

Park, C. F., Jr., and Cannon, R. S., Jr., 1943, Geology and ore deposits of the Metaline quadrangle, Washington: U.S. Geol. Survey Prof. Paper 202, 81 p.

Patty, E. N., 1921, The metal mines of Washington: Washington Geol. Survey Bull. 23, 366 p.

Weaver, C. E., 1920, The mineral resources of Stevens County: Washington Geol. Survey Bull. 20, 350 p.

WASHINGTON DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES AND GEOLOGY

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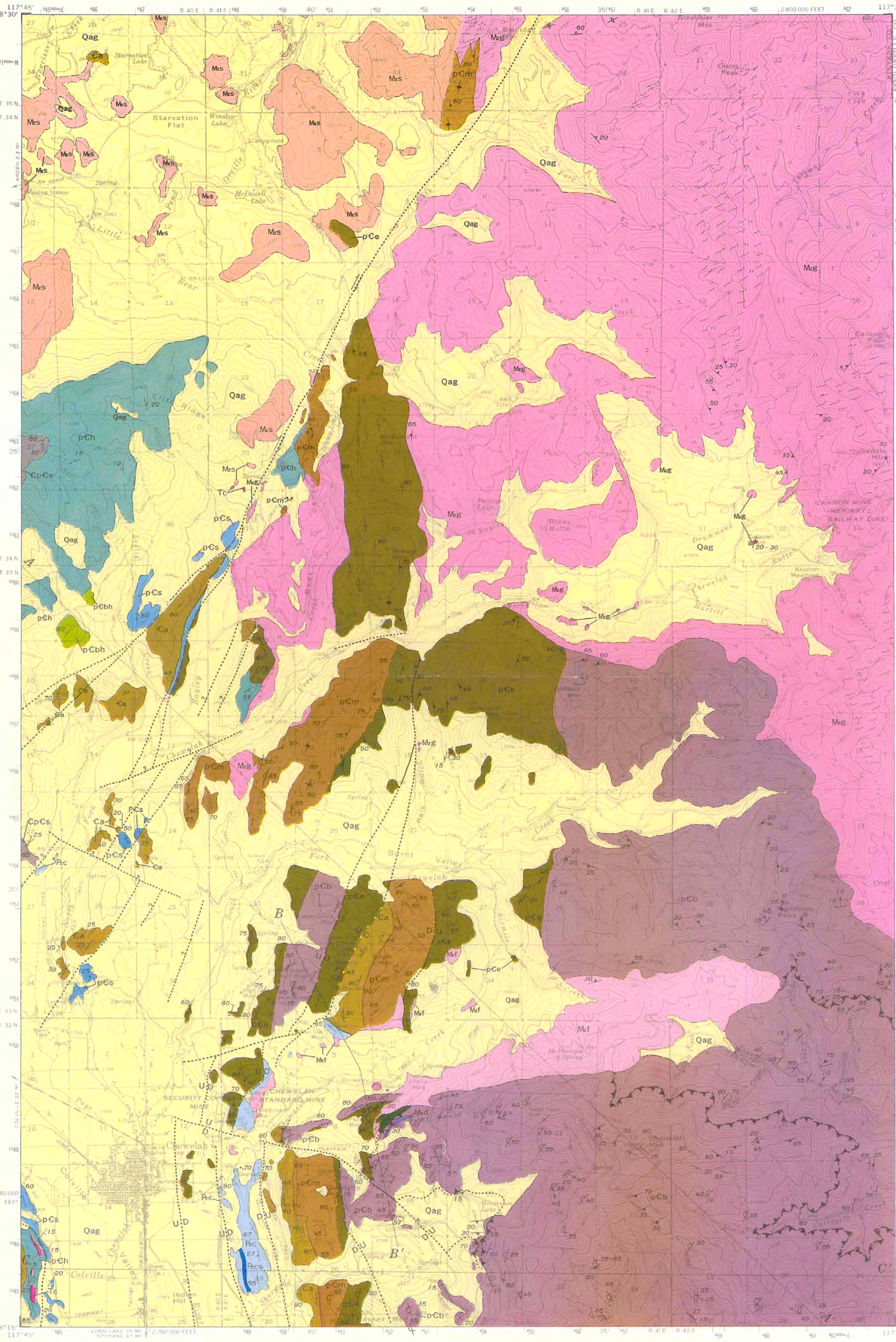


Base from U.S. Geological Survey, 1966

Geology mapped in 1963 and 1964 by L. D. Clark and F. K. Miller, in 1965 by F. K. Miller assisted by J. C. Moore.

SCALE 1:62 500

1 ½ 0 1 2 3 4 5 MILES

1 .5 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 80 FEET
DOTTED LINES REPRESENT 40-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

APPROXIMATE MEAN DECLINATION, 1968

EXPLANATION

QUATERNARY

Qag
Alluvial and glacial deposits
Chiefly unconsolidated gravel, sand, and clay, but includes sparse till and talus

TERTIARY(?)

Tc
Sedimentary rocks
Very thick bedded unsorted boulder-bearing conglomerate with fragments of limestone, Stensgar Dolomite, chert, and sparse greenstone

MESOZOIC OR YOUNGER

Mzd
Mafic dikes
Euhedral phenocrysts of hornblende, biotite, and plagioclase in fine-grained matrix of K-feldspar, plagioclase, and minor quartz

MESOZOIC(?)

Mzf
Flowery Trail Granodiorite
Hornblende-biotite granodiorite. Ranges in composition from diorite to quartz monzonite and in color index from 22 to 45. Age relation to other plutonic rocks unknown

Rocks of Calispell Peak

Mzqm
Aplitic muscovite quartz monzonite
Occurs as a complex of dikes and sills as much as 200 feet thick and cupolas as much as one mile in diameter intrusive into older intrusive and metamorphic rocks. Indicated by overprint pattern on host rock units

Mzg
Biotite-muscovite granodiorite
Slightly foliated in most places. Intrudes metamorphic rocks (Mzm) and is intruded by aplitic muscovite quartz monzonite. Probably oldest intrusive rock in quadrangle

Mzm
Metamorphic rocks
Chiefly schist and calc-silicate rocks of probable Precambrian origin. Occurs as roof remnants. Individual bodies not mapped separately. Indicated by overprint pattern on intrusive rock units

Mzs
Starvation Flat Quartz Monzonite
Medium- to coarse-grained hornblende-biotite quartz monzonite of uniform texture and composition, except porphyritic north of Starvation Lake. Age relation to plutonic rocks other than aplitic muscovite quartz monzonite is unknown

PALEOZOIC(?)

Pzc
Carbonate rocks, undivided
Dark-gray to white dolomite and limestone. In part resembles Mississippian lithologies about 8 miles to the southwest Pzcs, maroon slate

CAMBRIAN

Ca
Addy Quartzite
Thick- to thin-bedded vitreous orthoquartzite; medium- to coarse-grained, white to pink color; about 100 to 200 feet of black-striped purple quartzite at base

PRECAMBRIAN OR CAMBRIAN

CpCs
Slate and limestone
Red slate, in places appears to grade upward into Addy Quartzite. Limestone at base, calcareous throughout. Thickness appears to vary along strike

UNCONFORMITY

PRECAMBRIAN

pCh
Huckleberry Formation
Metamorphosed volcanic rocks (greenstone) and conglomerate. Massive lava-flow breccia, pyroclastic breccia, and some tuff. Conglomerate exposed only in southwest corner of quadrangle. Small intrusive masses in vicinity of Bayley Creek

UNCONFORMITY

Deer Trail Group

pCbh
Buffalo Hump(?) Formation
Phyllite and quartzite. Thick-bedded, vitreous, white orthoquartzite in upper half; dark-gray phyllite in lower half

pCs
Stensgar Dolomite
Pink, tan, or gray dolomite with some interbedded argillite; thick to thin bedded

pCm
McHale Slate
Thin-bedded dark-gray and green argillite, commonly phyllitic or slaty with sparse interbedded fine-grained quartzite and quartz siltstone

pCe
Edna Dolomite
Thick- to thin-bedded dolomite, argillaceous dolomite, argillite, phyllite, and minor quartzite. Mostly metamorphosed to calc-silicate rock. Dolomite is yellow-brown; argillite is similar to McHale argillite

pCb
Belt Series, undifferentiated
Interbedded argillite, slate, phyllite, and orthoquartzite

Contact
Dashed where approximately located

Fault
Dashed where approximately located, dotted where concealed, queried where uncertain; U, upthrown side; D, downthrown side; arrows indicate direction of lateral movement

Thrust fault
Barbs on upper plate, approximately located where dashed, concealed where dotted, uncertain where queried

Inclined — Overturned — Vertical
Strike and dip of beds

Inclined — Vertical
Strike and dip of schistosity

Inclined — Vertical
Strike and dip of parallel beds and schistosity

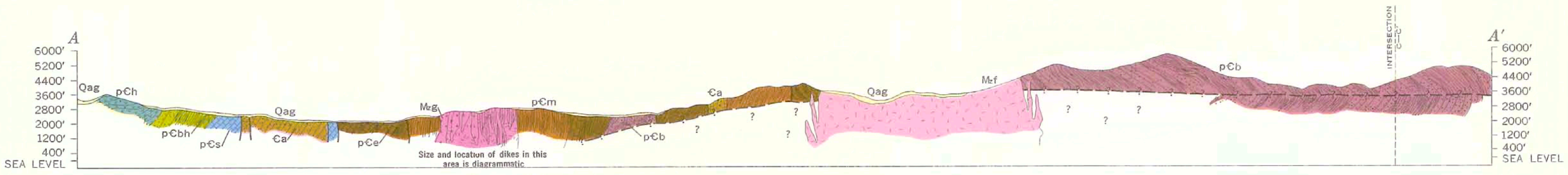
Inclined — Vertical
Strike and dip of slaty cleavage

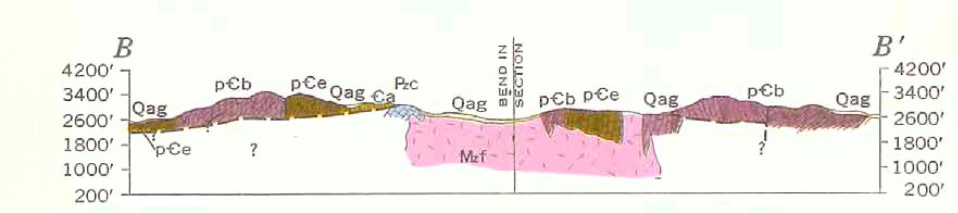
Inclined — Vertical
Strike and dip of primary or secondary foliation in igneous rocks

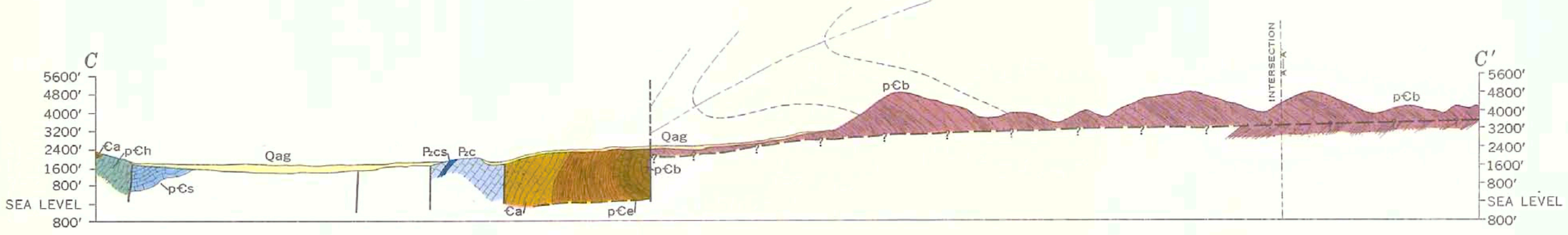
Bearing and plunge of minor fold axes

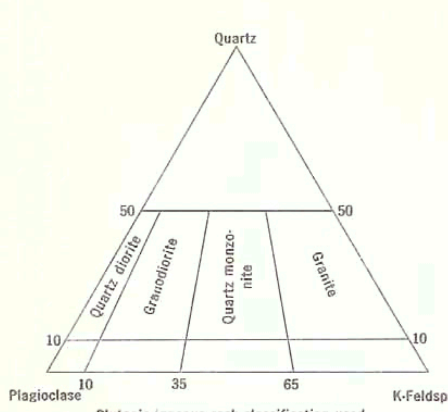
Inclined — Vertical
Strike and dip of parallel beds and cleavage

Strike and dip of slip cleavage









Plutonic igneous rock classification used in this report
Diagram from Moore (1963)

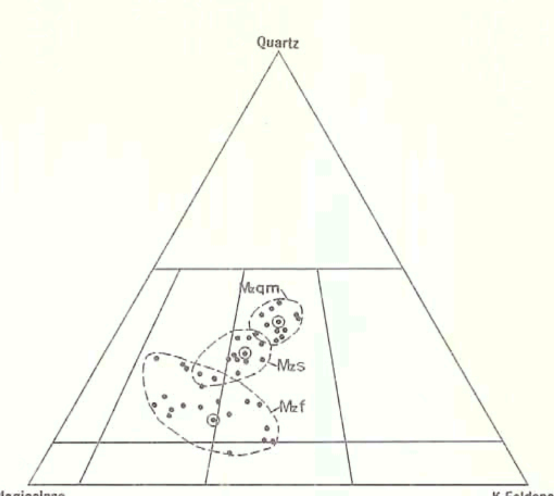
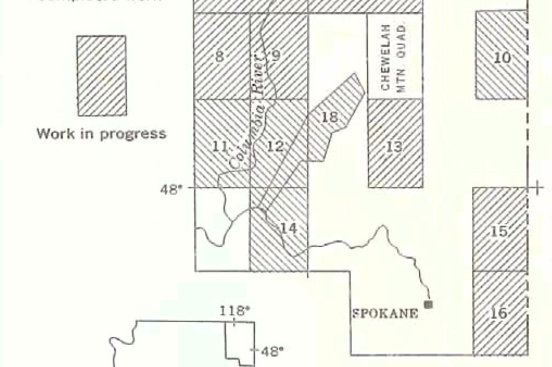


Fig. 2 Modal composition of Flowery Trail Granodiorite (Mzf), Starvation Flat Quartz Monzonite (Mzs), and muscovite quartz monzonite (Mzqm). Circled points are average of all modes for each pluton.



1 Togo Mountain quadrangle—R. C. Pearson
2 Orient quadrangle—E. C. Bowmen
3 Northport area—R. G. Yates
4 Deep Lake area—R. G. Yates
5 Kettle Falls area (west of river)—C. D. Campbell
6 Kettle Falls area (east of river)—J. W. Mills
7 Colville area—W. A. G. Bennett
8 Twin Lakes quadrangle—G. E. Becraft
9 Inchelium quadrangle—A. B. Campbell
10 Bead Lake area—M. C. Schroeder
11 Wilmont Creek quadrangle—G. E. Becraft
12 Hunters quadrangle—A. B. Campbell and O. B. Raup
13 Chewelah No. 4 quadrangle—F. K. Miller
14 Turtle Lake quadrangle—G. E. Becraft and P. L. Weis
15 Mt. Spokane quadrangle—A. E. Weisenborn
16 Greenacres quadrangle—P. L. Weis
17 Metaline area—M. G. Dings and D. H. Whitebread
18 Magnesite belt—Ian Campbell and J. S. Loofbourow

Figure 1. Index map showing location of the Chewelah Mountain quadrangle and surrounding areas in which geologic mapping of a scale of 1:62 500 or larger is available or is in progress.

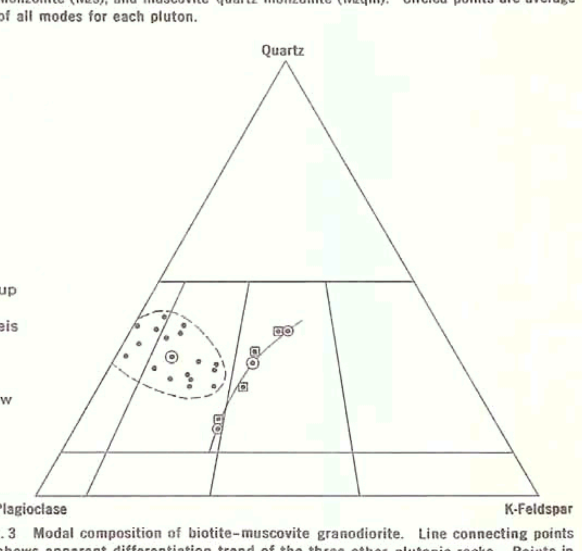
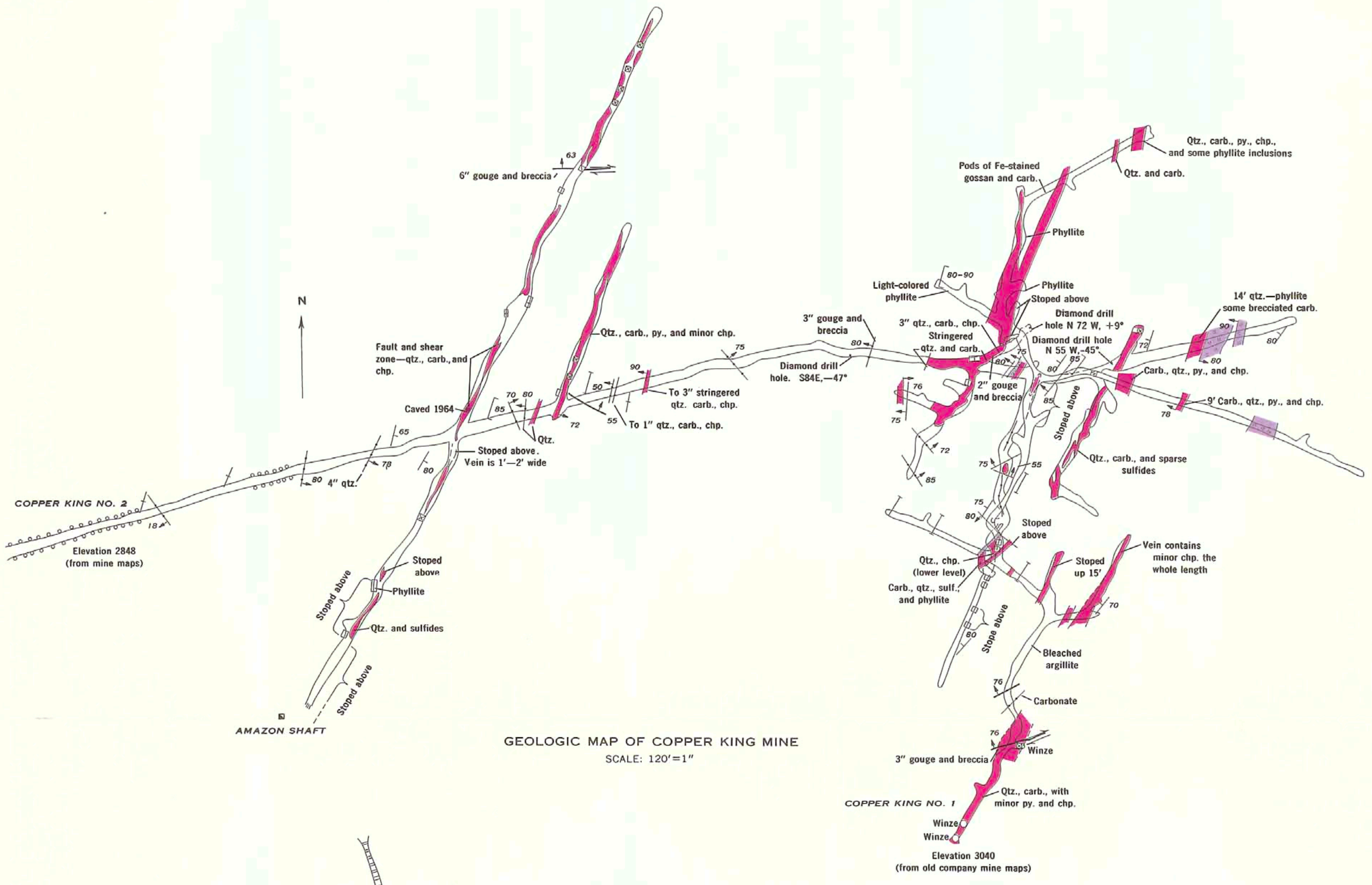


Fig. 3 Modal composition of biotite-muscovite granodiorite. Line connecting points shows apparent differentiation trend of the three other plutonic rocks. Points in squares are average modes of plutons in the quadrangle immediately south.

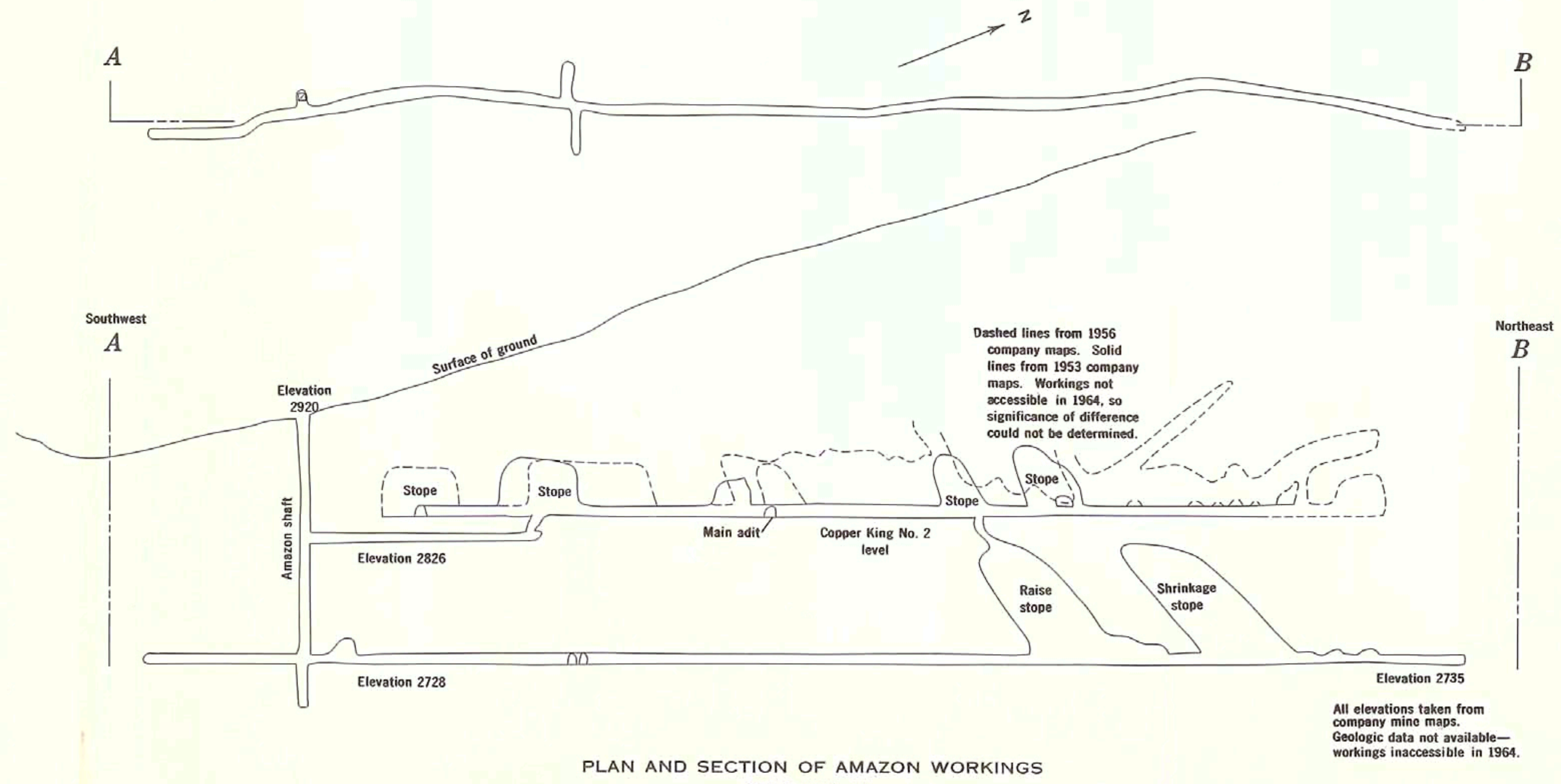
PRELIMINARY GEOLOGIC MAP OF THE CHEWELAH MOUNTAIN QUADRANGLE, STEVENS COUNTY, WASHINGTON

by
Lorin D. Clark and Fred K. Miller
U.S. Geological Survey
1968

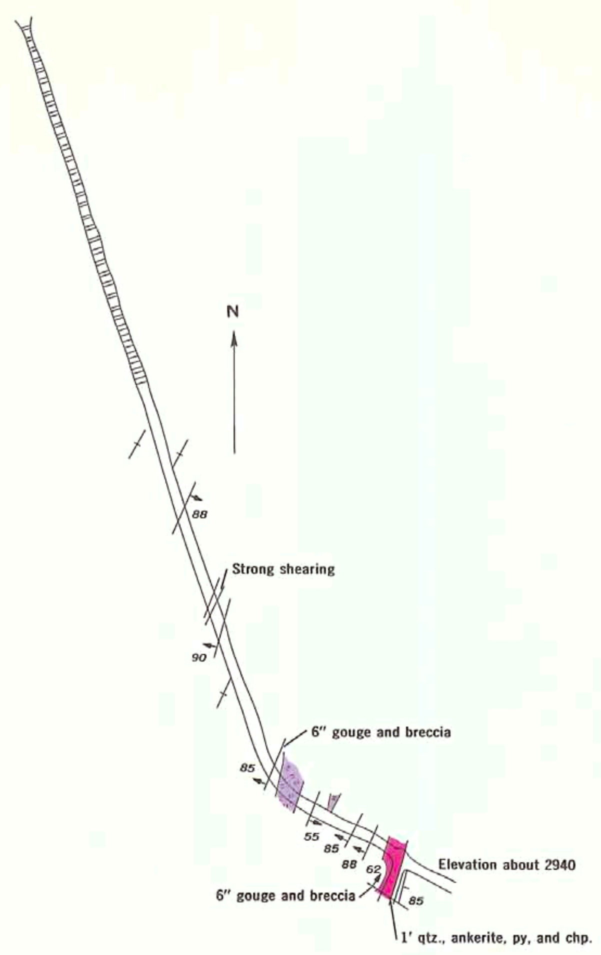
PREPARED COOPERATIVELY BY THE
U.S. GEOLOGICAL SURVEY



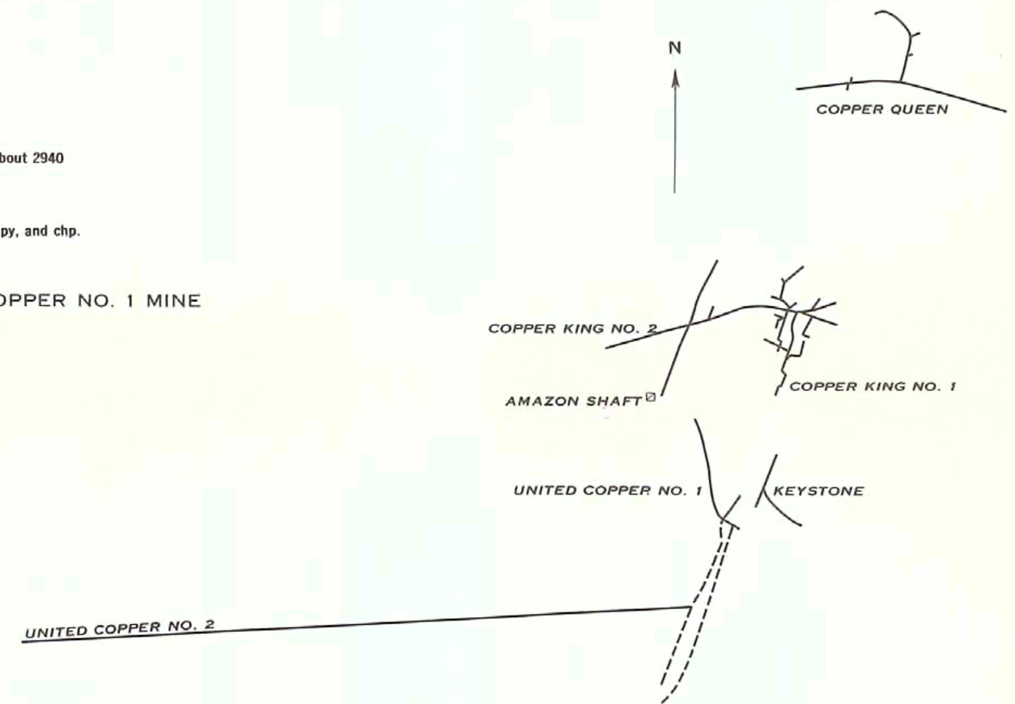
GEOLOGIC MAP OF COPPER KING MINE
SCALE: 120'=1"



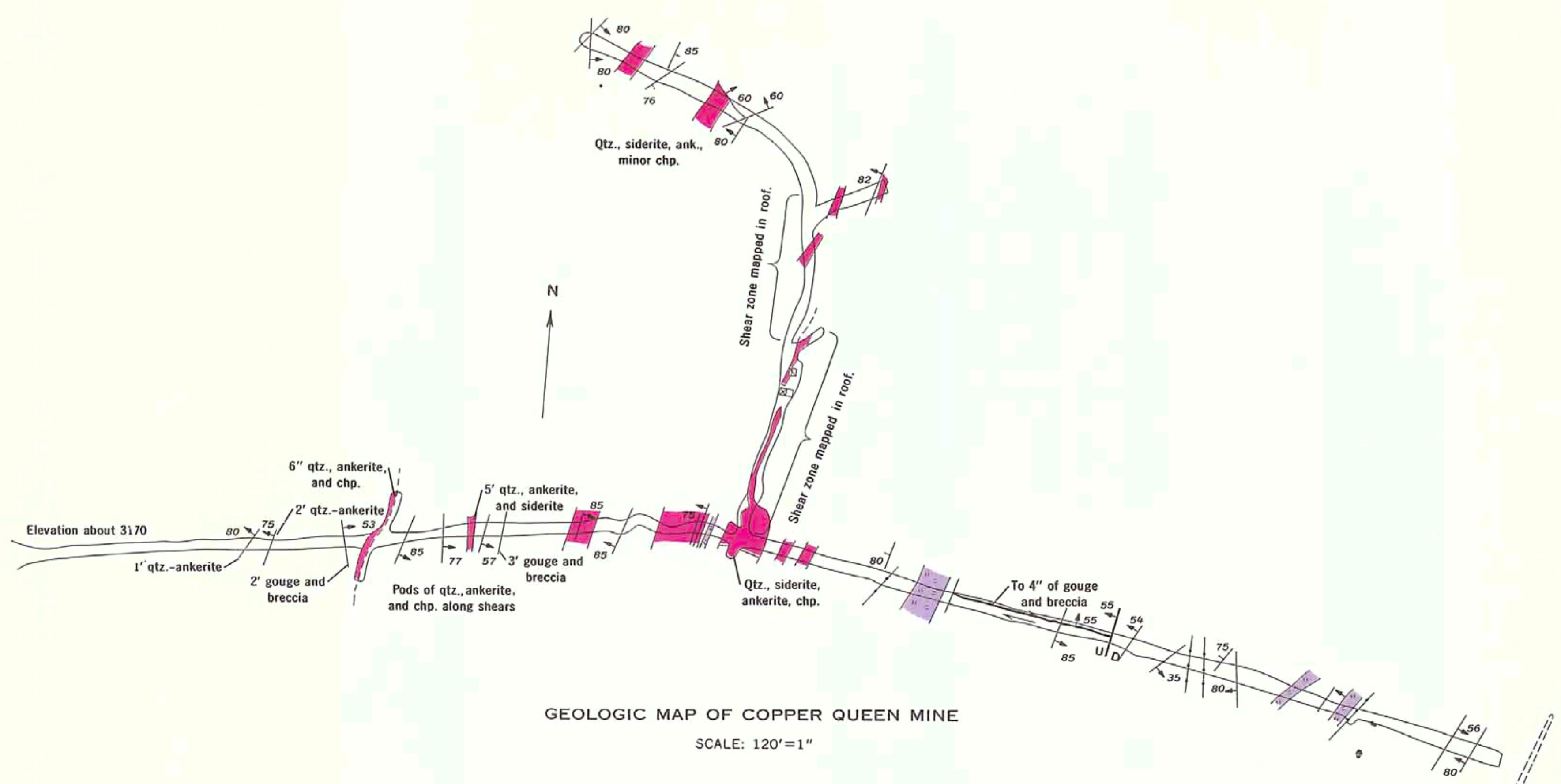
PLAN AND SECTION OF AMAZON WORKINGS
SCALE: 120'=1"



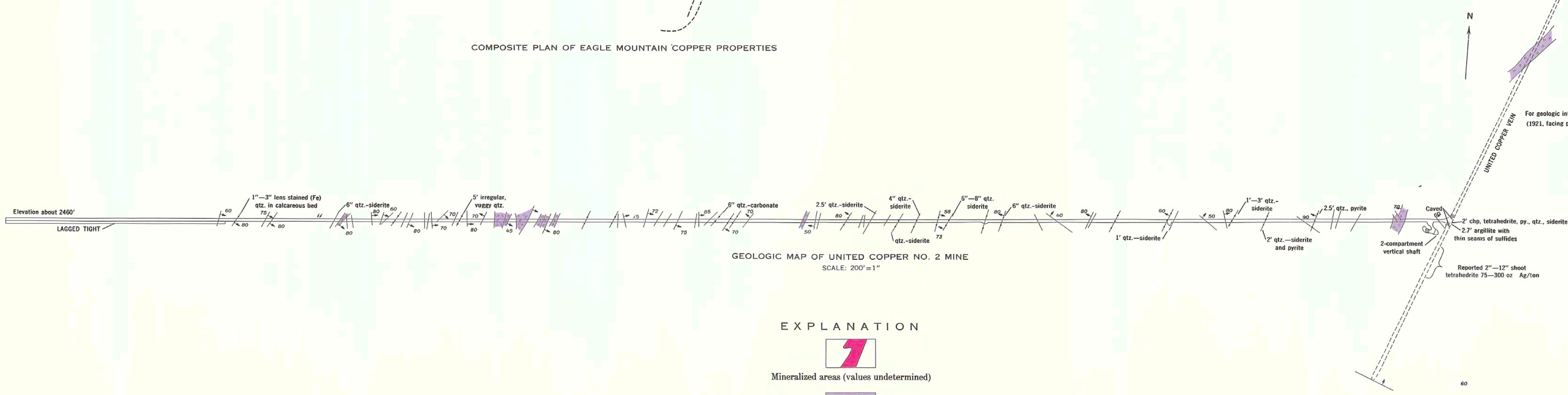
GEOLOGIC MAP OF UNITED COPPER NO. 1 MINE
SCALE: 120'=1"



COMPOSITE PLAN OF EAGLE MOUNTAIN COPPER PROPERTIES



GEOLOGIC MAP OF COPPER QUEEN MINE
SCALE: 120'=1"



GEOLOGIC MAP OF UNITED COPPER NO. 2 MINE
SCALE: 200'=1"

EXPLANATION

Mineralized areas (values undetermined)

Mafic dikes

Flowery Trail Granodiorite

Fault showing apparent strike-slip movement and direction and amount of dip

Shear zone (with or without mineralization)

Inclined / Vertical
Strike and dip of bedding

Inclined / Vertical
Strike and dip of cleavage

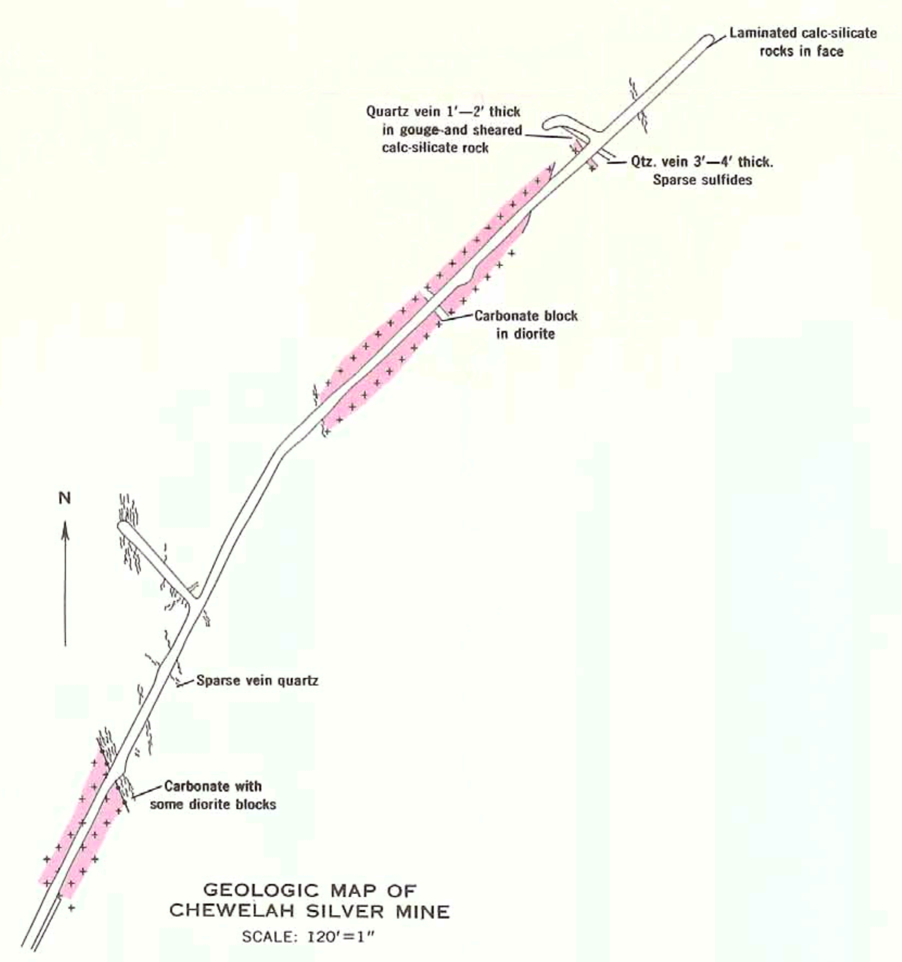
Small veins showing direction and amount of dip

Head of raise or winze / Foot of raise or winze

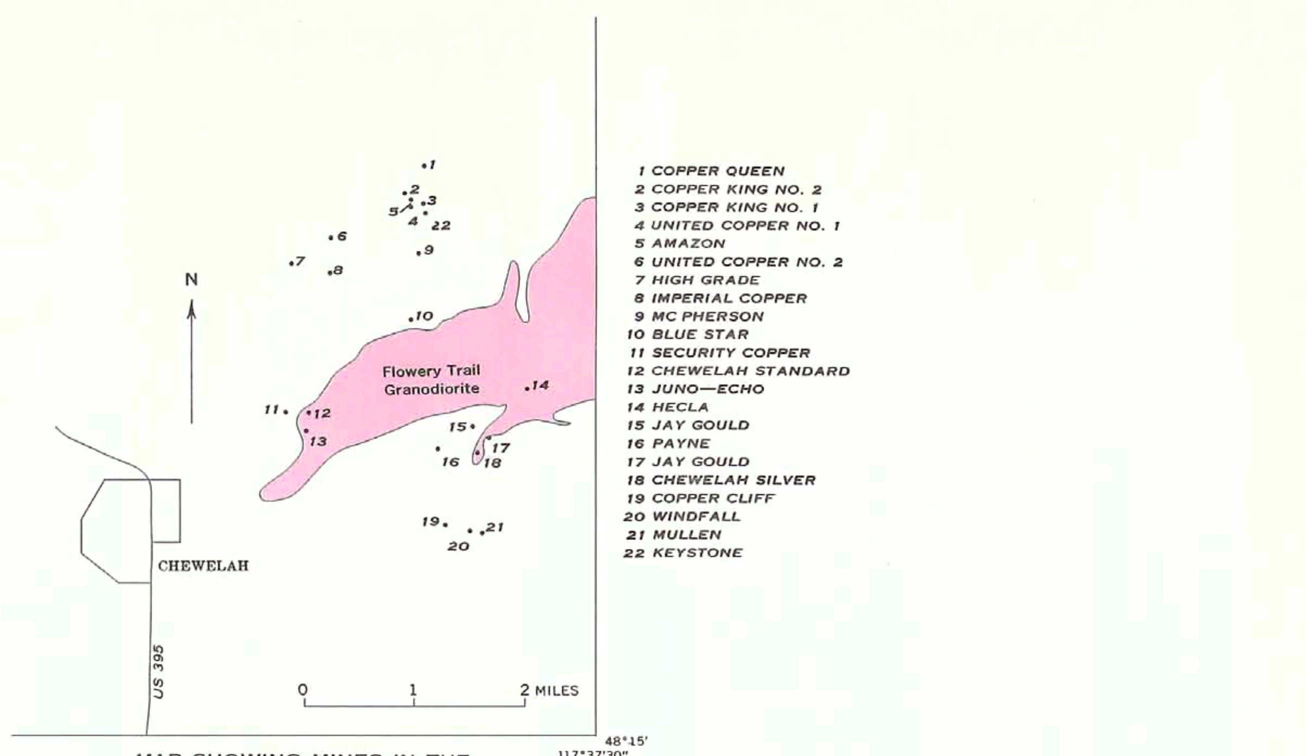
Ore chute / Lagging

Unidentified symbols taken from company mine maps:

Abbreviations:
QTZ.—Quartz
CARB.—Carbonate
CHP.—Chalcopyrite
PY.—Pyrite



GEOLOGIC MAP OF
CHEWELAH SILVER MINE
SCALE: 120'=1"



MAP SHOWING MINES IN THE
CHEWELAH MOUNTAIN QUADRANGLE

GEOLOGIC MAPS OF MINES IN THE EAGLE MOUNTAIN AREA

By
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U.S. Geological Survey
1968