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PRELIMINARY GEOLOGIC AND MINERAL RESOURCES MAP OF THE MORMON BASIN 7.5′ QUADRANGLE, BAKER AND MALHEUR COUNTIES, OREGON

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NOTICE

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TABLE OF CONTENTS

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INTRODUCTION

The Mormon Basin 7.5 minute quadrangle, Baker and Malheur Counties, Oregon is centered about 25 miles southeast of Baker City, Oregon in the southeastern part of the Blue Mountains. Gravel and dirt roads enter the quadrangle from the north, east, and south. The historic Mormon Basin gold mining district in the west central part of the quadrangle was noted by early writers for the richness of its placer gold deposits. Records of placer production are scarce. Lode mines later produced more than 180,500 ounces of gold and a nearly equal amount of silver, most of it prior to 1920. There has been very little mine production for many decades. The quadrangle is in a mountainous region where Cenozoic volcanic and sedimentary rocks flank a highland cored by Pre-Tertiary metamorphic and plutonic rocks. Elevations range from about 3,550 feet on Basin Creek at the south edge of the quadrangle to 6,455 feet at the top of Pedro Mountain in the northeastern part. The land supports mainly rangeland grasses and brush and scattered patches of pine and fir trees. Industries in the region are chiefly cattle ranching and occasional timber production and placer gold mining. Mormon Basin is centered in a small south-sloping sediment-filled depression along the high divide between Willow Creek, a tributary of the Malheur River to the south and Burnt River to the north and east.

PREVIOUS WORK

Gold deposits in the Mormon Basin district were described by Raymond (1870) and Lindgren (1901). These reports also mentioned silver deposits on Pedro Mountain. Swartley (1914) and Gilluly, Reed, and Park (1933) further described mineral occurrences in the Mormon Basin mining district. The latter report contains a geologic map of the district. Brooks and Ramp (1968) summarize information contained in the earlier reports. Wolff's (1965) 1:62,500 scale map of the north half of the Caviness 30' quadrangle covers the Mormon Basin quadrangle. Modified versions of Wolff’s map are included in larger scale maps by Brooks and others (1976), Walker (1977), and Walker and MacLeod (1991).

GEOLOGY AND REGIONAL RELATIONSHIPS

The Mormon Basin quadrangle is in the southeastern part of the Blue Mountains geomorphic province of northeastern Oregon where metamorphic rocks of Paleozoic to Late Jurassic age are widely exposed. These rocks have been divided into terranes believed to represent fragments of an island arc and associated oceanic crust and basins that were accreted to North America in the Late Mesozoic (Brooks and others, 1976; Vallier and others, 1977; Brooks and Vallier, 1978; Dickinson and Thayer, 1978; Dickinson, 1979; Brooks, 1979; Silberling and others, 1987; Vallier, 1995. Younger non-metamorphosed rocks include Late Jurassic-Early Cretaceous granitic batholiths and stocks and Cenozoic continental volcanic and sedimentary rocks. About 60 percent of the Mormon Basin quadrangle is underlain by accreted rocks, 30 percent by granitic rocks that intruded the accreted rocks, and the remainder by remnants of Cenozoic volcanic and sedimentary deposits that once covered most if not all of the older rocks. The accreted rocks in the quadrangle comprise parts of the Baker and Izee terranes (Silberling and others, 1987), which are separated by the Connor Creek fault that extends northeasterly across the quadrangle – Baker terrane north of the fault, Izee terrane to the south.

Regionally, the Baker terrane is a structurally complex and metamorphosed assemblage including Paleozoic and Triassic ultramafic to silicic igneous rocks, chert, argillite, limestone, and bodies of serpentinite matrix melange containing blocks of all other rock types in the assemblage. The terrane has been interpreted as part of a subduction melange-forearc basin complex (Dickinson, 1979 and Mullen, 1985). Permian (Leonardian and Guadalupian) and Late Triassic (early Karnian to late Norian) ages for Baker Terrane sedimentary units are based on fossil data (Blome and others, 1986; Pessagno and Blome 1986). Devonian (Morris and Wardlaw, 1986) and Pennsylvanian (Bostwick in Brooks and others, 1976 and Morris and Wardlaw, 1986) fossils have also been reported from the Baker Terrane. Crystalization ages of plutonic rocks in the terrane presented by Walker (1995) range from 279 to 215 ma. This range overlaps the fossil age of Permian to Late Triassic sedimentation in the terrane.

Rock units of the Baker terrane exposed in the Mormon Basin quadrangle are (1) the Burnt River Schist (Gilluly, 1937) a regionally extensive sequence of greenschist facies sedimentary and volcanic rocks here divided into units TRPbs, TRPbg, and TRPbl and (2) a highly deformed complex of metamorphosed ultramafic and mafic rocks (TRPum, TRPsp, and TRPam). The latter complex is compositionally similar to mixed rock complexes exposed elsewhere in northeast Oregon that have been interpreted as disrupted ophiolite, including the Canyon Mountain complex (Ave Lallement, 1976; Thayer, 1977; Mullen, 1983) the serpentinite matrix melanges of Ferns and others (1983) and Brooks and others (1984), the "peridotite and associated rocks" of Evans (1989); and the ophiolitic rocks of the Ironside Mountain inlier (Hooper and others, 1995). The metamorphosed ophiolitic rocks in the Mormon Basin quadrangle are interpreted as exposures of the ocean floor on which the volcanic and sedimentary rocks of the Burnt River Schist were deposited. The scattered exposures of metamorphosed chert and silicic argillite (TRPbs) and volcanic rocks (TRPam) incased in the altered ultramafic rocks are interpreted as blocks of the sedimentary and volcanic rocks that became engulfed in serpentinite as the latter formed via expansive hydration of the ultramafic rocks and was intruded diapirically along fractures in the overlying supracrustal rocks during ophiolite disruption.

The Early and Middle Jurassic Weatherby Formation (Jw) (Brooks, 1979a), made up mainly of volcanic wacke and siltstone has been interpreted as the eastward extension of the Izee terrane of Silberling and others (1987) rather than part of their Olds Ferry Terrane. Island arc volcanic and volcaniclastic rocks of the Upper Triassic Huntington Formation unconformably underlie the Weatherby along Snake River to the east in the Huntington and Olds Ferry quadrangles (Brooks, 1979a).

The Huntington and similar rocks believed to extend westward beneath Tertiary cover are interpreted as the main source of the volcaniclastic sedimentary debris found in the Weatherby Formation (Brooks, 1979a; Dickinson, 1979; Hooper and others, 1995). The Weatherby Formation also contains detritus from siliceous sedimentary rocks and olistostromal and/or diapiric blocks of serpentinite matrix melange probably derived from the Baker terrane and, therefore, the Weatherby is believed to have been deposited across the contact between the Huntington Formation and the Baker terrane (Brooks and others, 1976, Brooks and Vallier, 1978, Dickinson, 1979, and Hooper and others, 1995). C. H. Blome (personal communication, 1995) identified Permian and Upper Triassic radiolaria in separated siliceous argillite fragments that are part of a small diapiric(?) block of serpentinite matrix melange exposed on Becker Creek in the Birch Creek Meadow quadrangle about 1/2 mile southeast of the southeast corner of the Mormon Basin quadrangle. The mélange block is structurally enclosed in rocks of the Weatherby Formation. In addition to the fossiliferous argillite, it contains small blocks of metavolcanic rocks, metagabbro, metachert, and marble (Brooks, mapping in progress)..

Small, Late Jurassic-Early Cretaceous granitic stocks intrude the accreted terranes. The largest exposure in the quadrangle underlies Pedro Mountain; most of it within the quadrangle. The small exposure in the west central part of the map is part of a tonalitic body referred to here as the Amelia stock, which extends over an area of about four square miles in the Bridgeport quadrangle to the west (Brooks, mapping in progress). Both intrusions are part of a northeasterly aligned group of Late Jurassic-Early Cretaceous plutons about 55 km long extending from Cow Valley Butte on the southwest to Big Lookout Mountain on the northeast (Brooks and others, 1976). Regionally, these plutons correlate with the Wallowa and Bald Mountain batholiths and many smaller unnamed plutons of similar age and composition that are widely scattered in northeastern Oregon and locally are associated with gold mineralization.

The Cenozoic volcanic rock units include a swarm of Middle Miocene Columbia River Basalt dikes (Tbd) that invaded the Pedro Mountain stock and older units, widely scattered exposures of Miocene and Pliocene basalt (Tb and Tob) and rhyolitic welded tuff (Twt), and basanite (Tba). Pliocene lake and stream deposits are exposed in Mormon Basin (Tsg) and in the southwestern corner of the quadrangle (Tbs). Pleistocene and Holocene units include colluvium, alluvial fan deposits, and stream-bed alluvium.

Ages of the various Tertiary and younger units presented here are largely guesswork based on their stratigraphic relationships to units Tbs and Tsg which are traceable eastward and thus interpreted as representing the northwestward extension of sedimentary deposits included in the Late Miocene-Early Pliocene Idaho Group (Ferns and others, 1993).

METAMORPHISM AND STRUCTURE

Baker terrane units have undergone regional greenschist facies metamorphism and at least two stages of penetrative Pre-Cenozoic deformation, Late Triassic – Early Jurassic and Late Jurassic (Avé Lallemant and others, 1980). Fold features and faults in the Burnt River Schist typically trend east and northeast (Ashley, 1966 and 1995). In the central part of the quadrangle, metamorphic foliation in the Burnt River Schist is strongly deflected around the western and southern perimeter of the Pedro Mountain stock, the foliation dips steeply toward the intrusion, and the southwest margin of the stock appears to dip steeply southwest, all of which may be due to forceful emplacement of the stock (Gilluly, Reed, and Park, 1934; Wolff, 1965; Ashley, 1995). The foliation is locally visible in air photos. Wall-rock foliation trends along the irregularly shaped northern margin of the stock do not follow the contact (Ashley, 1995).

The altered ultramafic rocks (TRPum), assumed here to be older than and therefore deformed with the foliated rocks of the Burnt River Schist are much fractured (most contacts between different rock types probably are faults) but except for the black carbonaceous schists are mostly non-foliated. A poorly developed cleavage generally trends northeasterly and dips steeply north or south.

The Weatherby Formation is much less intensely folded and metamorphosed than the Burnt River Schist. It was deformed in the Late Jurassic during the second major stage of deformation of the Baker terrane (Avé Lallemant and others, 1980) and before the granitic rocks of Kji were emplaced. Structurally, the Weatherby is characterized by a well-developed penetrative axial plane cleavage (Brooks and others, 1976; Avé Lallemant, 1983, Hooper and others, 1995) Fold hinges and primary bedding are difficult to find, partly because they are obscured by the cleavage, but more importantly, outcrops are scarce. Wherever folds have been observed the fold axes and the cleavage are approximately parallel. In the Mormon Basin quadrangle the cleavage generally strikes northeast and dips steeply north or south. On the south slope of California Mountain and south of Dixie Creek the cleavage is locally visible in air photos and roughly parallels the Connor Creek fault. In places, especially near the Connor Creek fault, small blocks and slivers of altered ultramafic and mafic intrusive rocks are structurally intercalated with rocks of the Weatherby Formation. Talc schist slivers occur along cleavage planes in the Weatherby in several places along the top of California Mountain.

Regionally, the cleavage in the Weatherby and the late Jurassic fold features in the Burnt River Schist strike northeasterly, roughly paralleling the Connor Creek fault (Avé Lallemant and others, 1980; Ashley, 1966, 1995).

Metamorphism related to emplacement of the Pedro Mountain and Amelia stocks has overprinted the regional metamorphic mineral assemblages of both terranes for distances up to one mile, perhaps more locally, from exposed margins of the stocks. No attempt was made to map the limits of the contact aureol. The volcanic and volcaniclastic rocks of the Burnt River Schist were amphibolitized (metamorphosed to the hornblende hornfels facies. Turner and Verhoogen, 1960) and the silicic sedimentary rocks were converted from phyllites and metacherts to quartz mica schists and quartz schists. Although most of unit TRPum appears to lie within the thermal aureoles of the Pedro Mountain and Amelia stocks, no consistent metamorphic mineral zonation is apparent. Paragenesis of the ultramafic rocks is uncertain but may have included at least three progressive stages: 1) serpentinization of original harzburgite during regional metamorphism; 2) regrowth of olivine and orthopyroxene minerals and accompanying introduction of amphibole minerals during the contact metamorphism; and 3) partial conversion of the olivine and pyroxene to serpentine and talc by circulating hydrothermal fluids during and after emplacement of the stocks.

The contact between rocks of the Baker terrane and the Weatherby Formation was first mapped by Wolff (1965). It has been traced for about 40 miles from near Ironside Mountain in Oregon, eastward to the Cuddy Mountain area in Idaho (Brooks and Vallier, 1978). The eastern extension of the contact including the Mormon Basin area has been mapped as a high angle reverse fault (Brooks and others, 1976), referred to later as the Connor Creek Fault (Brooks and Vallier, 1978). It is vertical or steeply dipping where it crosses the Mormon Basin quadrangle. West of the quadrangle the contact is much less steep and more irregular (Wolff, 1965) but evidence of faulting was noted in all investigated exposures. (Evans, unpublished mapping, 1993; Hooper and others, 1995).

Outside of the Mormon Basin quadrangle, regional Cenozoic structural features are mainly north and northwest-trending faults and broad northwest trending folds that involve rocks as young as Pliocene (Walker and MacLeod, 1991).

The north-northwest trending swarm of basalt dikes cutting the Pedro Mountain stock suggests that the Mormon Basin area was under predominantly east-west directed tension during the middle Miocene. Although northwest-trending faults have not been located clearly enough to map, the northwest trending contacts between Tertiary and Pre-Tertiary units in the southwestern part of the map very likely are fault-controlled. Mormon Basin itself is a northwest-trending, probably fault-bounded depression that is partially filled with Tertiary sedimentary and volcanic rocks.

MINERAL DEPOSITS

Gold and silver have been the principal mineral products of the Mormon Basin quadrangle. Chief sources of these metals were lode and placer mines in Mormon Basin and placer mines along Basin Creek below Mormon Basin and in gulches near the former site of Amelia in the southwest corner of the map. The placer deposits were formed by the erosion of gold-bearing quartz veins and deposition of the gold in streambeds. Placer production is unknown even as an estimate. Lode production totals about $2.6 million. Tungsten has been produced from a small mine on Pedro Mountain. Silver and gold bearing veins on Pedro Mountain have been prospected. A small amount of lump chromite has been produced at the Mule Shoe prospect. Data on lode mines and prospects are summarized in Table 1.

Placer Mines

Rich gold placer deposits were discovered in Mormon Basin (also known as Humboldt Basin in the early days) in 1862 and for two or three decades the district was well known as an important placer mining camp (Raymond, 1870; Lindgren, 1901). Raymond (1870) said that a nugget weighing 40 ounces worth $640 was found in 1866 and that men using crudely built rockers "realized as much as $70 to $90 per day of eight hours….Mining is carried on with iron and canvas hydraulic pipes, or with ground sluices….A pocket vein, the Niagra in Humboldt Basin, furnished in 1863 some remarkable specimens of quartz studded with gold". Although none of the early writers offered an estimate of production, Swartley (1914) said "the amount is quite large". The placer camps in Mormon Basin and at Amelia likely produced most of the gold credited to Malheur County (Lindgren, 1901). Partial records credit placer mines in Mormon Basin with slightly over 3,000 oz of gold valued at $75,200 during operations in 1882 and 1883 (Lindgren, 1901).

Gold-bearing gravels covered parts of the floor and west margin of Mormon Basin and extended along the 5-miles long channel of Basin Creek south of Mormon Basin. Hand and hydraulic placer mining in the 1860s -1890s left extensive hillside cuts and hand stacked boulder piles along the western margin of Mormon Basin and the west-facing slope of lower Basin Creek. Mechanized equipment, including draglines and washing plants, were used in later years to work gravel deposits of units Tsg and Qal in the central part of Mormon Basin, gravel deposits in unit Qal in parts of the flood plain of Basin Creek, and coarse bench gravels (QTg) on the east side of Basin Creek. The placer pit in the central part of Mormon Basin is a mile long and from 700 to 1000 feet wide. Much of the pit is floored by a layer, thickness unknown, of moderately indurated lake sediments (unit Tsg) composed mostly of clay, silt, and sand with some gravel locally. Miners called the material “webfoot” or “false bedrock”. Similar, though less indurated deposits are exposed along the pit’s margins. Evidently the latter, mostly fine- grained, deposits were not economically mineable. Thickness of the gold-bearing gravel and sand overlying the false bedrock is said to have averaged about 16 feet (Wagner, 1946).

Scarcity of water and the shallow gradient of the basin floor made mining difficult. Basin Creek carries little water except during spring runoff. Some of the water used for placer mining operations was pumped from the shaft of the Humboldt mine. Gravel found in tailings from placer mine operations is composed of rock types from local sources. Most is no more than a foot, some is more than two feet, in diameter and generally well rounded. The placers formed in part by the reconcentration of gold-bearing Tertiary gravel beds by present day streams (Swartley (1914).

The sedimentary deposits (Tsg) in the pit area are estimated to be as much as 100 ft thick (Swartley, 1914). Records of minor drill-testing of the sub-surface in a small area of the pit are not available, but are said to indicate the existence of a gold bearing gravel layer at depth of about 18 feet (Wagner, 1946). It seems likely that other gravel beds or lenses containing gold could be found interbedded with silt and sand deposits beneath the pit floor but whether any could be exploited profitably remains to be determined by exploration and would require solution of mining problems relating to scarcity of water and the shallow gradient of the basin.

Swartley (1914) said that locally on the slopes above Mormon Basin, gold-bearing quartz fragments were found in coarse sand deposits of unit Tsg that so closely resembled decomposed granitic rocks that early day prospectors drove adits into the material in anticipation of finding gold-bearing veins.

Placer excavations extend along the eastern bench of the narrow canyon of lower Basin Creek in Sec. 32, T. 13 S., R. 42 E. and Secs. 5 and 8, T. 14 S., R. 42 E. The bench is about 150 feet above creek level. Development includes several small pits and trenches and an open cut about 1,500 feet long, 100 to 500 feet wide, and up to 15 feet deep. The latest gold production was from periodic operations of a 60-yards per hour washing plant in the larger pit during 1974 – 1983. Water for the washing plant was pumped from Basin Creek, which is limited except during spring runoff. The gravel is a poorly sorted mix of silt, sand, and pebble- to boulder-size gravel most of which is under a foot in diameter. Some boulders exceed 4 feet. Bedrock, consisting of sandstone and siltstone of the Weatherby Formation, has been exposed in several places (unpublished reports in DOGAMI files).

Lode Gold and Silver Mines

The recorded gold and silver production from the quadrangle came mainly from lode mines in the Mormon Basin district. The Rainbow Mine (for locations of mines and prospects discussed here see Table 1) was the largest mine. Smaller producers included the Humboldt and Sunday Hill mines. All three mines were underground operations; the Rainbow and Humboldt were developed by shafts reaching depths of about 500 feet. The following information about the mines is largely from published reports by Swartley (1914), Parks and Swartley (1916), Gilluly, Reed, and Park (1933), Brooks and Ramp (1968), and unpublished reports by W. W. Elmer and G. C. Hogg.

The productive gold and silver lode deposits in the Mormon Basin district are associated with quartz veins and mineralized shear zones in or near diorite dikes in the contact aureole of the Pedro Mountain stock. Several small, less productive silver- and gold-bearing quartz veins occur within the Pedro Mountain stock.

Nonmetallic gangue minerals are chiefly quartz and a small amount of ankerite and locally fuchsite. The host rocks are partly altered to clay minerals, pyrite and arsenopyrite are the main metallic minerals, sphalerite and galena occur locally (Swartley, 1914). Meager records indicate that bullion from the mines averaged about 700 fine. The veins probably formed from fluids generated during emplacement of the Pedro Mountain stock and related dikes.

The Rainbow Mine produced $2,323,092.46 in gold and silver (equivalent to112,389 ounces of gold) between 1901 and 1919 and 1,222 ounces of gold in 1934. The 1910 - 1915 production was $1,083,360 (gold equivalent: 52,412 ounces) from 95,747 tons of ore. Recovery averaged about 94 percent (0.48 ounce per ton of ore treated). The mine workings extended along two nearly parallel quartz veins, one on each wall of a northeast trending shear zone that varies from a few feet to 50 feet wide in dark colored quartz mica schist and phyllite and ultramafic rocks. The shear zone is made up largely of fractured country rock cemented by quartz. It includes a felsic dike 4 to 6 feet wide that was altered during mineralization. Alteration minerals include uralitic hornblende, some actinolite and a little sericite and chlorite. The most productive vein, along the footwall of the shear zone, strikes N 60^0 E and dips 55^0 to 65^0 NW. The ore zone had strike length of 1,500 feet and dip depth of 500 feet. Ore shoots ranged up to 350 ft long. The gold was largely free, although small amounts of arsenopyrite and pyrite containing some gold were found locally. Underground development consists of 7,000 feet of workings, accessed by a shaft about 500 ft deep.

The Humboldt deposit was discovered in 1880. The mine produced about $225,000 in gold and silver between 1909 and 1915 (Swartley, 1914). The production was from quartz veins in an east trending fault zone up to 40 feet wide cutting amphibolite, ultramafic rocks, quartz mica schist and phyllite, and a diorite dike. Dip of the fault zone was about 75^o N. The main vein is in phyllite, strikes N 45^o W, and dips 50^o N. Average mining width was 2 1\2 feet. Gangue includes quartz and fault gouge, pyrite, and lesser arsenopyrite, galena, and sphalerite. Development includes a 500 ft shaft and 3,500 feet of underground workings.

The Sunday Hill mine was first operated in 1868. Total production has been about $100,000 mostly prior to 1940. Development includes about 2,000 ft of underground workings from an adit and shaft all within a sub-surface depth of about 200 ft. Recent activity includes seven diamond drill holes drilled in 1984 and a large surface cut dug in 1995-96. Country rocks are foliated sedimentary rocks of the Burnt River Schist and a quartz diorite dike intruding the schist. The underground workings and the surface cut expose several narrow veins consisting chiefly of quartz and fault gouge associated mainly with the dike. Metallic minerals found in small amount include pyrite and lesser arsenopyrite, galena, and sphalerite.

Lindgren (1901), relying partly on earlier reports by Raymond (1869 - 1877) noted that: "A number of quartz veins containing silver have been found on Pedro Mountain and attracted great attention between 1870 and 1880. The Monumental, Green Discovery, Washington, and Rising Sun veins were known in 1872; all were very rich in wire silver, chloride, and silver glance, besides containing a little gold. In 1875 a 5-stamp mill was erected on the Lafayette, a gold-silver vein, and a similar pan-amalgamation plant on the Green Discovery. In 1880 the New England and Oregon Mining Company erected a large pan-amalgamation mill, spending $50,000 on the property, evidently with unfavorable results. All these veins are situated high up on Pedro Mountain. Green Discovery is said to strike northwest and dip 70^0 SW." During the present study none of the prospects mentioned by Lindgren were identified specifically. Numerous small and discontinuous quartz veins ranging from a few inches to 3 feet thick and from vertical to horizontal were found cutting intrusive rocks of the stock. Several veins (see Table 1) had been prospected by shallow underground workings, open cuts, and bulldozer trenches. Rock on some of the dumps contains small amounts of sulfide minerals, mostly pyrite.

Tungsten

Scheelite is a minor constituent of two small pyrite-rich zones in quartz diorite on the southeast slope of Pedro Mountain stock: the Broken Pick (locality D in Table 1) and Frisco (F) mines. About $20,000 worth of scheelite concentrate was produced and sold from the Frisco mine during the mid-1970s. The pyritic zone exposed in a large dozer cut about 100 yards long in a northeasterly direction, ranges from 0 to 25 feet wide. Its' north and south contacts with less altered quartz diorite dip steeply south. The ore zone is said to have been about 6 feet thick along the north contact and to have yielded about 100 tons of ore averaging about two percent WO_3. Many quartz seams less than an inch wide cut the altered rock. A small lens of interlayered limestone and quartz phyllite about 100 feet across and a Tertiary basalt dike are exposed nearby. The limestone has been recrystallized but appears otherwise unaltered by intrusion of the younger quartz diorite. Some of the dozer exploration work was done in 1957. Development of the Broken Pick mine includes a 250 ft adit, two shorter adits and a shallow shaft. A scheelite bearing pyritic zone similar to that at the Frisco mine is exposed at the collar of the shaft adjacent to the road. There is no record of production.

Chromite

The Mule Shoe prospect, referred to as the Buckhorn Mine on the Mormon Basin topographic base map shipped 17.2798 long tons of lump chromite ore to the U. S. Government buying depot in Grants Pass, Oregon in 1956.The ore averaged 48.04 percent Cr_2O_3, 13.4 percent Fe, and 4.3 percent SiO_2 (unpublished report, Oregon Department of Geology, Baker Field Office). Workings include an open cut and caved adit in altered ultramafic rock consisting mainly of serpentine, olivine, dolomite, and talc. The chromite is said to occur as small pods and lenses in the altered rock. A few hundred pounds of chromite-bearing rock is piled near the adit portal.

Talc

Talc is an almost ubiquitous component of the ultramafic rocks within the contact metamorphic aureoles of the Pedro Mountain stock and satellite bodies. The talc probably formed during prograde metamorphism of serpentinized ultramafic rocks following emplacement of the intrusives (Ferns and Ramp, 1988). Some of the best exposures of talc-bearing rock occur on the south slope of Spirit Hill, the western part of California Mountain, and the ridge southeast and east of the Rainbow mine. Many exposures were estimated to contain 10 to 25 percent (maximum 40 percent) talc. Potential for future development of the talc as an industrial mineral is limited due to its association with small amounts of asbestiform amphibole minerals in the host rock.

DESCRIPTION OF MAP UNITS

Qal **Alluvium (Holocene and Pleistocene)** — Unconsolidated and unsorted to well-sorted deposits of gravel, sand, and silt comprising floodplains of present streams. Includes reworked gold-bearing gravels locally.

Qf **Alluvial Fan Deposits (Holocene and Pleistocene)** — Coalescing fan and slope-wash deposits of unconsolidated coarse to fine gravel, sand, and silt. Mapped only in the southwest corner of the quadrangle where bedrock identity is obscured.

Qbc **Colluvium (Holocene – Late Pleistocene)** — Bedrock-obscuring accumulation consisting largely of basalt fragments and silty sediment derived from pre-basalt or interflow soft sediment deposits. Includes small amounts of gravel locally. Unit typically girdles small basalt-capped topographic highs.

QTg **Gravel deposits (Pleistocene and Pliocene)** — Gravel-rich horizons on ridge tops and benches south of Mormon Basin; chiefly lag and reworked gravels in the upper part of unit Tbs. Includes auriferous bench gravels along Basin Creek and Discovery Gulch where boulders to 4 ft across were observed.

Tob **Olivine basalt (Pliocene?)** — Dark gray, olivine phyric alkalic basalt. Weathers reddish brown. Flows contain 5 to 20 percent olivine phenocrysts up to 2 mm across in a fine-grained groundmass of devitrified glass, plagioclase (45 to 60 percent), clinopyroxene and 5 to 10 percent iron oxide minerals. Olivine crystals are partly altered to iddingsite in some samples. Tob flows in Mormon Basin and on the south slope of Spirit Hill overlie sedimentary deposits of unit Tsg. Some remnants of the unit south of California Mountain appear to overlie Tertiary lake and stream deposits of unit Tbs, although the contact is somewhat obscured by Qbc deposits. Six samples from different exposures are alkalic basalts chemically (Table 2) with SiO_2 ranging from 47.26 to 50.71 per cent, K_2O from 1.18 to 2.38 per cent, and Na_2O from 3.00 to 4.73. A seventh sample (B-93-34) included in this unit is chemically low silica basanite but it is mineralogically more like the other samples of Tob flows than the basanite of Tba.

Twt **Rhyolitic tuff (Pliocene or Late Miocene)** — Chiefly light gray to white, some purplish, welded ash-flow tuff. Weathers reddish brown and gray. Locally vesicular, particularly near the base where some vesicles are as much as 2 inches long and commonly flattened parallel to flow layering. Typical rocks contain sanidine, plagioclase, and quartz phenocrysts. Locally contains pumice fragments to 1 1/2 inches and black to gray translucent glass clots, some roundish, some flattened. Locally spherulitic. In a small exposure in the northwestern part of the placer pit in Mormon Basin (south central part of Sec. 17, T. 13 S., R. 42 E) a layer of welded tuff 5 to10 feet thick overlies a layer of air-fall tuff about 30 ft. thick, base not exposed. Twt exposures are small and widely separated. Gilluly, Reed, and Park (1933) observed that flows of this unit are interlayered with the gravels of unit Tsg. In this study rounded fragments of rock similar to Twt were noted in sedimentary deposits in the upper part of unit Tsg beneath basalt flows of unit Tob. Thus it appears that rocks of unit Twt were deposited and then partly eroded during deposition of Tsg. Greatest exposed thickness, about 40 ft, is near sample site 42 in Sec. 32, T. 13 S., R. 42 E. Although described as trachyte by Swartley (1914) and dacite by Gilluly, Reed, and Park (1933), analyses (no. 42 and 44, Table 2) are typical of rhyolitic ash-flow tuffs. The rocks were mapped as part of the middle Miocene Dinner Creek Tuff by Wolff (1965), which would make Tsg older than herein interpreted to be.

Tba **Basanite (Pliocene?)** — Gray to black, fine to medium grained, locally vesicular, pyroxene-phyric rock composed of weakly pleochroic pale green clinopyroxene, colorless orthopyroxene and lath shaped pleochroic brown to pale brown phlogopite phenocrysts in a fine grained groundmass of granular pyroxene and ophitic nepheline and olivine. Norms are approximately: clinopyroxene, (40-50 percent), nepheline (40 percent), phlogopite, (5-10 percent), plagioclase (3-5 percent), orthopyroxene (3-5 percent) and smaller amounts of olivine and opaque minerals including magnetite and chromite. Phenocrysts range up to 2 cm. Some vesicles are rimmed by zeolite. The exposure on Basin Creek in Sec. 32, T. 13 S., R. 42 E. lies on rocks of the Jurassic Weatherby Formation (Jw) and is overlain by Pliocene? welded tuff (Twt). The presence of the Tba occurrence mapped in Sec. 4, T14 S., R. 42 E is indicated by angular float scattered along the slope beneath a basalt flow (Tob). Two analyses from the Basin Creek exposure (Table 2) show low SiO_2 (41.51 - 43.11 per cent), Al_2O_3 (1.26 -11.36 per cent) and moderate K_2O (1.00 -1.71 per cent). Although the rocks are olivine poor, they are regarded on the basis of geochemistry and apparent stratigraphic position to be related to the alkalic lavas of unit Tob.

Tbs **Lake and stream deposits (Pliocene)** — Mostly poorly bedded, weakly consolidated, brownish, clay-rich silt, sand, and small-gravel deposits. Upper part of unit contains lenses and sheets of coarse gravel, and boulders as large as 4 ft in diameter. Most boulders are under 12 inches across. Brown to yellow palagonite deposits occur locally. Light colored silicic tuffaceous sedimentary deposits are included in the unit south of the quadrangle boundary (Brooks, unpublished mapping). The gravels appear locally derived, as they contain rounded clasts of basalt, welded tuff, and all Pre-Tertiary units that are exposed to the north. Faint layering generally dips gently (5-10 degrees) southward. Unit locally contains lenses of reworked gravels and grades upward into unit QTg. Deposits of this unit underlie lava flows of Tob in Sec. 31, T. 13 S., R. 42 E. and

Sec. 4, T. 14 S., R. 42 E. and include rounded clasts of rocks similar to Tob south of the quadrangle. These relations indicate that Tbs deposition preceded and continued after the Tob flows were emplaced.

Tsg **Lake and stream deposits (Pliocene and late Miocene)** — Mostly reddish- to yellowish-brown poorly sorted and poorly to moderately indurated deposits consisting mostly of clay, silt, and sand with local layers and lenses of pebble to small boulder-size gravel. Exposures in the main placer pit in Mormon Basin are estimated to average about 80-90 percent sand and silt and 10-20 percent gravel and boulders ranging to 12 inches in diameter. Mineral components of the sand are chiefly feldspar, quartz, amphibole minerals, and up to 2 or 3 per cent biotite and opaque minerals including magnetite. Rock fragments include recrystallized argillite and chert, amphibolite, and meta-ultramafic rocks similar to those found in unit TRPum. Coarser gravels concentrated along the south margin of the basin have been mined for placer gold. Basalt flows of unit Tob overlie the sand-rich lower part of the unit. Basalt and dacite clasts up to 3 ft in diameter are included in the gravel-rich upper part of the unit. Most of the placer mines in the central and west side of the basin worked gravel and sand deposits in the upper exposures of the unit. Units Tsg and Tbs are regarded as partly equivalent in age but differ lithologically in that Tsg deposits are much more arkosic, having been formed largely of debris from the Pedro Mountain and Amelia stocks.

Tb **Basalt (Miocene)** — Three very small remnants of massive gray flows overlying metamorphic rocks in the northwest corner of the map. The rock lithologically resembles basalt flows north of the quadrangle which were mapped as Miocene by Ashley (1966). No other evidence of age.

Tbd **Columbia River basalt dikes (middle Miocene)** — Holocrystalline, aphyric, dark gray, reddish brown weathering basalt dikes. Composed mostly of plagioclase, clinopyroxene, and opaque minerals including magnetite and ilmenite. Most abundant in the Pedro Mountain stock where they range up to 200 feet wide and 1.7 miles long. There is a mall cluster of smaller dikes cuttting Jurassic sedimentary rocks of unit Jw near the east edge of the quadrangle. Most of the mapped dikes are visible on air photos; some smaller, poorly exposed dikes that are not obvious on air photos were not mapped. The dikes seem to vary little in texture or composition. Analyses of samples from 14 different dikes (Table 2) range from ferro basaltic andesite to ferroandesite. They are similar chemically and petrographically to typical Grande Ronde Basalt (Peter Hooper, personal communication, 1995) and the Birch Creek flows of the Malheur Group of Lees (1994).

Kji **Plutonic rocks (Early Cretaceous and Late Jurassic?)** — Includes exposures of the Pedro Mountain stock, Amelia stock, and several dikes cutting the metamorphosed rocks of the quadrangle. The Pedro Mtn stock is largely coarse to medium grained, hypidiomorphic-granular, hornblende-biotite tonalite but includes zones ranging from hornblende-rich diorite to trondhjemite. The largest hornblende and biotite crystals are about 1 cm long in the typical tonalite, which contains 40 to 50 percent plagioclase (probably andesine) 5 to 25 percent quartz, 10 to 30 percent blue green to olive green to pale brown hornblende, and 5 to 15 percent brown biotite. Accessories include up to 5 percent potassium feldspar plus magnetite, apatite, sphene, zircon and secondary calcite and epidote. Diorite forms a mafic border phase along the southeast margin of the pluton, e.g, sample 62 (Table 2). Fine-grained, mafic mineral-poor trondhjemite (e.g. samples 68 and 87, Table 2) occurs as ill-defined dikes. Such dikes are rare. Xenoliths up to a foot across are widely scattered but make up far less than one percent of the stock's surface area. In Kji along the west edge of the stock, biotite is oriented roughly parallel to the wall rock contact. The Kji exposure on the west slope of Spirit Hill (southwest edge of map) is a small part of an intrusive referred to here as the Amelia stock that underlies about 4 square miles to the west in the Bridgeport quadrangle (Brooks, in progress). The Spirit Hill exposure includes porphyritic diorite (Analysis 37, Table 2). Rock types found farther west in the Amelia stock closely resemble those of the Pedro Mountain stock. Small quartz diorite dikes including those exposed in the Sunday and Rainbow mine areas appear compositionally similar to the stocks and are assumed to be about the same age. N.W. Walker (1986) obtained U-Pb ages of 119+-1, 120+-1 and 122+-1 Ma (mid-Early Cretaceous) on three zircon fractions from a tonalite sample collected from the south side of the Pedro Mountain stock.

Jw **Weatherby Formation (Early and Middle Jurassic)** — Chiefly interlayered massive to thin bedded volcanic wacke and siltstone, minor phyllite, rare conglomerate and limestone lenses. Mostly greenish gray to brown but dark gray and black locally. Wacke beds are poorly sorted dirty sandstones. Major components are volcanic rock fragments and quartz and feldspar grains in a fine grained silt- and clay-rich matrix, which makes up more than 15 percent of the rock. Calcite detritus and veinlets are abundant in some rocks. Small amounts of chlorite, stilpnomelane, and albite are present as evidence of low grade regional metamorphism. The phyllitic rocks are similar compositionally but finer grained. Cleavage surfaces of some phyllites exhibit a faint sheen produced by concentrations of microcrystalline quartz, sericite, chlorite, and clay minerals. The limestone lenses are a few inches to a few feet thick, and interbedded with the detrital rocks. Conglomerate beds are made up mainly of small rounded to angular wacke and siltstone clasts derived from slumping or another form of gravity induced disruption of older beds of the formation. Secondary biotite, epidote, and quartz crystals occur in the rocks within the contact metamorphic aureole of the Pedro Mountain and Amelia stocks. Structurally the Weatherby Formation is characterized by a well-developed penetrative cleavage (Avé Lallemant, 1983) that in the Mormon Basin quadrangle generally strikes northeast and dips steeply south. In the area south of California Mountain and Dixie Creek the cleavage is visible in air photos and roughly parallels the Connor Creek fault. Fold hinges and primary bedding are rarely seen, partly because they are obscured by the cleavage, but more importantly, outcrops are scarce. Age based on fossil ammonite identifications by Ralph W. Imlay (1986 and earlier reports listed therein) of fossils collected from the formation in the Huntington and Olds Ferry quadrangles (Brooks, 1979) to the east. Fossil ages range from early Sinemurian to early Callovian (Early to Middle Jurassic). No fossils have been identified in the northern part of the Weatherby Formation near the Connor Creek fault.

Burnt River Schist (Late Triassic and Permian?) — Southward extension of metamorphic rocks included in the Burnt River Schist, first mapped by Gilluly (1937). Burnt River schist units in the map area are part of the (informal) Campbell Gulch phyllite unit of the Burnt River Schist (Ashley 1966, 1995). Age of the Burnt River Schist is not closely bracketed. All identified fossils are from sites in marble exposures along Burnt River north and northeast of the Mormon Basin quadrangle: a pentacrinid columnal identified as "probably Late Triassic" by David Bostwick (Brooks and others, 1976) and conodonts from two sites reported and identified by Morris and Wardlaw (1986) as Middle and Late Triassic. A metamorphosed intrusive body in the Burnt River Schist on the north side of Burnt River (Ashley, 1966) yielded a Pb/U age of 233 to 230 ma (Late Middle Triassic) (N.W. Walker, 1995), a bryozoan identified as "questionably Permian" by Helen Duncan (Ashley, 1966), Burnt River Schist map units in the Mormon Basin quadrangle are herein divided into the following three units: TRPbl, TRPbs, and TRPbg.

TRPbl **Marble** — Typically bluish gray, locally white to mottled gray and white, coarse-crystalline rock composed mainly of calcite and lesser dolomite with local interlayers of phyllite and/or greenstone. Outcrops are small and widely separated, the largest mapped, measuring about 1,000 feet by 200 feet, is in Sec. 31, T. 13 S., R. 32 E.

TRPbs **Metamorphosed sedimentary and volcanic rocks** — Mainly metamorphosed clay-rich, tuffaceous argillite and chert, basaltic and andesitic lava flows, and tuffaceous sedimentary rocks. Unit consists of phyllite, quartz phyllite, and quartzite (metachert), with intercalated greenstones and minor marble. Typical phyllite consists of fine grained quartz-rich layers several millimeters to several centimeters thick separated by generally thinner but locally thicker layers consisting mostly of micaceous minerals, mainly muscovite with some biotite. In places the phyllite contain spots composed of thin scaly masses of sub-microscopic high birefringent mineral, probably muscovite or sericite, and opaque material, probably organic matter. Greenstones are made up mostly of albite, actinolite, chlorite and pumpellyite, other mineral constituents include leucoxene, quartz, and muscovite. Within several hundred yards of the Pedro Mountain stock the greenstones are generally altered to dense dark green hornblende hornfels. A belt of such rocks extends across the head of Devils canyon and along the west side of the North Fork of Dixie Creek

TRPbg **Metamorphosed volcanic rocks** — Chiefly greenstone and greenschist derived from mafic to intermediate lava flows, breccias, and tuffs. Includes small amount of quartz phyllite, pelitic phyllite and metachert similar to rocks making up the bulk of unit TRPbs. Mapped only in the northwestern part of the map area where exposures are continuous with greenstones mapped by Ashley (1966, 1995) north of the quadrangle boundary. Major components of the greenstones are actinolite, albite, chlorite and pumpellyite. Minor constituents include leucoxene, quartz, and muscovite. Relict subhedral clinopyroxene phenocrysts as much as 1 mm long, locally form as much as 20 percent of the rock. Analyses by Ashley (1966, 1995) suggest that most of the greenstones are derived from basaltic andesite. Pillow structures locally associated with some flows indicate that the volcanic rocks are subaqueous. The rocks typically form bold outcrops and thus are distinguishable in map scale from rocks of similar composition that are interlayered with sedimentary rocks in unit TRPgs.

TRPam **Amphibolite (Triassic or Permian)** — Dark gray to greenish gray, generally massive, both phyric and aphyric rocks composed largely of crystalloblastic hornblende and plagioclase. In thin section, hornblende is highly colored, mostly green but ranges from emerald green to yellow green and pale brown and tends to occur as stubby prisms with ragged terminations. Cream-colored plagioclase generally occurs as equidimensional, some twinned, xenoblastic grains; crystals ranging to 1/4 inch commonly are visible in outcrop. In thin section and in some outcrops, plagioclase crystals are seen to enclose tiny hornblende crystals. Minor constituents include epidote, sphene and granular quartz. The rocks are much fractured and locally foliated. Some, presumedly derived from volcanic flow rocks, are fine-grained and locally vesicular. Coarse-grained rocks probably were gabbro or diorite originally.

TRPum **Ultramafic rocks (Triassic or Permian)** — Mostly dark green to greenish gray, commonly brownish weathering metaserpentinite and serpentinite made up largely of altered orthopyroxene, olivine, serpentine, talc, and amphibole minerals. Some specimens contain small amounts of carbonate minerals, probably mostly magnesite. Accessory minerals include magnetite, chromite and other unidentified opaque minerals, limonite, and sphene that names traditionally applied to ultramafic rocks are not applicable. Mineral assemblages range from olivine and . Although the original rocks probably were harzburgite composed largely of orthopyroxene and olivine, the unit's current mineralogy varies so greatly over short distances orthopyroxene-rich rocks to serpentine and talc- or amphibole-rich rocks. Olivine crystals typically are divided into a multitude of small grains by serpentine-filled fractures. Optical continuity of grains indicates that some of the now altered crystals were as large as 15 mm in diameter. Orthopyroxene crystals range up to 10 mm across, appear relatively less altered than the olivine, and show a silvery gray birefringence. Where serpentinization of these minerals is far advanced, the serpentine replacing olivine exhibits a mesh-like texture and serpentine psuedomorphs orthopyroxene and parts of amphibole porphyroblasts. Talc is almost ubiquitous, although it was not observed in anthophyllite-tremolite-rich rocks. Many outcrops contain between 10 and 25 percent and locally as much as 40 percent talc. Outcrops containing more than 40 percent talc are small (no more than a few tens of feet in longest dimension) and widely separated. The talc typically occurs as small veins less than a cm across and as disseminated clots of white to colorless, locally pink or pale green, tabular crystals that are prominent on weathered surfaces. Some tabular talc crystals up to 0.5 cm across yield flexible lamellae. In some thin sections parts of some orthopyroxenes are visibly altered to talc. In others talc crystals appear pseudomorphic after orthopyroxene and amphibole minerals.

Porphyroblasts of anthophyllite or tremolite or both, occur in small amounts in most ultramafic rocks. Generally they occur as small equidimensional grains embedded in the other major minerals. They also form elongated prismatic porphyroblasts as much 4 mm long crossing earlier crystals. Some sections show at least two generations of amphibole, the younger crossing microcrenulations involving the older. Rocks composed mainly of colorless to white amphibole minerals form small widely separated outcrops. The largest outcrop observed is several hundred feet long and up to 40 ft. wide, composed largely of well-formed prismatic crystals up to three cm long. The rock at sample sites B-95-185 and B-95-72 is composed almost entirely of a colorless near-equigranular mix of both ortho- and clinoamphiboles. Hand specimens are white to cream colored with a defuse mottling of pale green and pink and a few small clusters of magnetite.

Foliated black carbonaceous(?) rocks occur in narrow linear zones that may mark small shear zones throughout the ultramafic rock exposure belt. Such zones are especially well exposed on the southern slopes of Spirit Hill. They commonly but not always separate different rock types. They are discontinuous, en echelon, and individually range up to a few 10's of ft wide and a few hundreds of ft long and approximately parallel shear surfaces in the associated ultramafic rocks. The rocks are composed largely of black, microscopically opaque, nonmagnetic material presumed to be a form of carbon interlayered and mixed with talc and lesser amphibole minerals. Typical rock specimens scratch easily with a penny and have a greasy feel. A few chromite grains were noted. Intricate micro-folding of interlayered talc and black material between foliation planes and around clots of talc is common. Some thin sections show discontinuous veinlets and clots of very fine grained quartz. Tremolite porphyroblasts crosscut foliation.

TRPsp **Serpentinite (Triassic or Permian)** — This unit forms an easterly trending belt along the southwestern margin of the ultramafic rock unit TRPum. Thin sections show both mesh textured and fibrous varieties of serpenitine, mostly antigorite, and minor magnesite or dolomite. The unit includes small blocks of amphibolite similar to rocks in TRPam. A block of foliated amphibolite about 50 feet wide is cut by the Basin Creek road about midway across the TRPsp exposure belt. The rock is composed largely of alternating layers of hornblende and plagioclase. Hornblende crystals are oriented parallel to the foliation. The rock also contains minor epidote or clinozoisite, chlorite, zircon and opaque minerals.

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APPENDIX: TABLE LOCATIONS

Table 1. Mines and Prospects in Mormon Basin quadrangle – following pages
Table 2. Chemical analyses of rock samples – The data that accompany this report on CD are located in the “more” folder on the CD. The table is in Microsoft Excel format.

Table 1. Mines and Prospects in the Mormon Basin Quadrangle

Map Location	Mine or Prospect Name	Commodity	Quarter Section	Section	Township (South)	Range (East)	Elevation (feet)	Map Rock Unit	Geologic Description	Surface and/or Underground Workings	Past Production	Reference
A	Silver Queen ???	Silver	NE, NW	2, 1	13, 13	42, 42	5,400	KJi	Quartz veins in quartz diorite	Several short?? adits and surface cuts	Small	8, 5
B	No Name	Silver	SW	1	13	42	4,800	KJi	Quartz veins in quartz diorite	Several short ?? adits and surface cuts	Small	8, 5
C	Silver Spur	Silver	NE	11	13	42	5,080	KJi	Quartz veins in quartz diorite	Several adits and open cuts	No record	
D	Broken Pick	Tungsten	SW	7	13	43	4,360	KJi	Pyrite/scheelite bearing shear zone in quartz diorite	250 ft adit, shallow shaft, and small opencuts	No record	Mike Dolan
E	Golden Reef	Gold	SE	11	13	42	5,360	KJi	Pyrite and free gold in small quartz veins in quartz diorite	Opencut and short adit	Small; in 1914-16	Gene Potter
F	Frisco	Tungsten	SW	7	13	43	4,640	KJi	Partly oxidized pyrite/scheelite bearing shear zone 6 feet wide in quartz diorite	Opencut and short adit	$20,000 in mid-1970's	Mike Dolan
G	Sunday Hill	Gold	NE	17	13	42	5,200	KJi	Quartz veins in quartz diorite dike in meta-argillite	About 2,000 ft of workings from an adit and surface shaft	$100,000	1, 3, 4, 6
H	Overshot Group	Gold	NE	18	13	42	5,320	TrPbg	Gold bearing quartz seams in quartz diorite and meta-argillite; minor sulfides	Adits; longest about 300 ft	No record	1, 3, 6

Map Lo-catio n	Mine or Prospect Name	Commod-ity	Quarter Section	Sec-tion	Town-ship (South)	Range (East)	Eleva-tion (feet)	Map Rock Unit	Geologic Description	Surface and/or Underground Workings	Past Produc-tion	Refer-ence
I	Randall		SE	17	13	42	5,040	KJi TRPbs	2 quartz veins 2 to 8 ft thick in quartz diorite	2 adits 24 ft apart totalling 1200 ft and several open-cuts	No record	1, 3, 6
J	Monohon Tunnel	Gold	SW	17	13	42	5,200	TRPbs	Adit dump is mostly meta-argillite and amphibolite	300?? ft adit	No record	
K	Morton	Gold	SE	18	13	42	5,400	Tsg	gold-bearing quartz frag-ments in arkosic sandstone	Includes 96 ft shaft	No record	1, 3, 6
L	Golden Gate	Gold	SE	14	13	42	4,200	KJi	Quartz-bearing fracture zones in quartz diorite	Several short adits and open-cuts. Three stamp mill was idle in 1900	No record	5
M	Potter cabin	Gold							Caved adit col-lared in meta-argillite	200 ft adit. Failed attempt to intersect small quartz body exposed on slope above.	None	
N	Summit (lower)	Gold	NW	22	13	42	4,600	TRPbs	Adit collared in meta-argillite	Adit said to be 1,400 ft long	No record	1, 3, 6
O	Summit (upper)		NW	22	13	42	4,900	TRPbs	Altered zone along at meta-argillite - quartz diorite contact, 1 to 5 ft wide, strikes NE. Sparse pyrite, galena, and free gold	750 ft adit	Small pro-duction in 1914-1915	1, 3, 6

Map Location	Mine or Prospect Name	Commodity	Quarter Section	Section	Township (South)	Range (East)	Elevation (feet)	Map Rock Unit	Geologic Description	Surface and/or Underground Workings	Past Production	Reference
P	Humboldt	Gold	NE	20	13	42	4,980	TRPam	Quartz veins in east trending fracture zone up to 40 ft wide in amphibolite, ultramafic rock. Zone includes a diorite dike.	500-ft shaft with 3,500 ft of workings connected to it	$225,000 in 1909-1915	1, 3, 6, 7, 9
Q	No name	Gold??	NW	22	13	42	5,090	KJi, TRPbs	Iron oxide stained shear zone in quartz diorite and meta- argillite	Opencut and short adit	No record	
R	Rainbow	Gold	C	22	13	42	5,060	TRPbs, KJi??	Quartz veins along walls of fault zone up to 50 ft wide in phyllite and ultramafic rocks. Zone contains felsic dike	500-ft shaft with several levels and upper level adit; 7,000 ft of drift	$2,323,092 in 1901-1919	1, 2, 3, 6, 7, 9
S	Blue Mud	Gold	E 1/2	20	13	42	4,900	TRPum, TRPam	Rocks on dumps mostly talc schist, amphibolite, and meta- argillite. Little evidence of metallic ore mineralization	Two or more short adits, a 200 ft shaft, and several opencuts	No record	1, 3, 6
T	Hice		E 1/2	20	13	42	5,120	TRPum	Many quartz seams under 4-in thick in altered ultramafic rocks	250 ft adit with branches; total 400 ft	No record	1, 3, 6,

Map Location	Mine or Prospect Name	Commodity	Quarter Section	Section	Township (South)	Range (East)	Elevation (feet)	Map Rock Unit	Geologic Description	Surface and/or Underground Workings	Past Production	Reference
U	Cleveland	Gold	SW	21	13	42			Quartz seams in porphyry dike cutting schistose rocks beneath lake sediments	2 short adits and several pits	No record	1, 3, 6, 9
V	Buckhorn (Muleshoe)	Chromite	SW	20	13	42	5,080	TRPum	Minor chromite in massive rocks composed mostly of serpentine, orthopyroxene, and calcite	2 short adits and shaft	17.3 long tons chromite ore,1956	10
W	No Name	Gold???	SW	22	13	42	5,060	TRPum	Shear zone in ultramafic rocks; no evidence of mineralization	200 ft adit	No record	
Y	No Name	Gold	NW	28	13	42	4,900	TRPam	Mineralized shear zone in amphibolite; near vertical, strikes N 35 E. Minor pyritization and silicification	2 short drift adits	No record	