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Eric

L-D Gold Mine, Wenatchee, Wash.: New Structural Interpretation and Its Utilization in Future Exploration

by Thomas C. Patton and Eric S. Cheney

L-D gold mine is 3 miles south of Wenatchee, central Washington. Recognition of locally mappable conglomerates, sandstones, and shales within the Paleocene (?) Swauk formation led to the discovery that the known epithermal gold mineralization is limited to a previously unknown imbricate thrust zone of unknown displacement cutting the open folds of the area. Hypabyssal intrusions also are most numerous along the trace of the thrust faults. Yakima basalt of Miocene age unconformably overlies the Swauk formation, thrust faults, and the intrusions. The L-D mine is in a northwesterly trending imbricate fault block of nearly vertical strata. Microscopic native gold, electrum, and naumannite occur in quartz veins and as low-grade disseminations in the well-silicified portions of arkosic sandstones. Fault gouge on the "footwall fissure" limits ore to the hanging-wall block of the fault. Epithermal mineralization and alteration are spatially related to the nearby intrusions. Right lateral north-south faults offset the ore a maximum of 300-400 ft along any one fault. From 1949 until January 1967, when the L-D mine closed, 1,036,572 dry tons of ore valued at $14,962,305 and averaging 0.396 oz Au per ton and 0.607 oz Ag per ton were mined. Recognition of the structural control of the mineralization and alteration within the Swauk formation suggests several areas within and outside of the mine that warrant further exploration. For example, the high-angle faults, imbricate thrusts, and the intrusions of this area are on strike with similar features along the major Entiat fault zone 10 miles to the northwest.

The L-D gold mine (previously called Squilchuck, Wenatchee, Golden King, Gold King, and Lovitt) is located in Squilchuck Canyon about three miles south of Wenatchee, Chelan County, Wash. (Fig. 1) on the eastern edge of the Cascade Mountains. The major stratigraphic unit in the area is the nonmarine early Tertiary Swauk formation, which is predominantly composed of arkosic sandstone. The lack of laterally persistent units and the paucity of outcrops heretofore have precluded all but the grossest subdivision of the Swauk.[1] As a result, the true significance of the open folds in the Wenatchee area was not recognized, and although the geology within the mine was known,[2] the structural setting of the mine was virtually unknown.

T. C. PATTON and E. S. CHENEY, Member AIME, are with University of Washington, Seattle, Wash. TP 701203. Manuscript, Jan. 19, 1970. Discussion of this paper, submitted in duplicate prior to June 15, 1971, will appear in SME Transactions, September 1971, and in AIME Transactions, 1971, Vol. 250.

During the present investigation, several locally mappable units were discovered within the Swauk which, in conjunction with mine maps, indicate an imbricate thrust zone. The epithermal gold mineralization, most of the hypabyssal intrusions, and the zones of hydrothermal alteration are located within or near this thrust zone. The purpose of this paper is to: (1) to describe this structural setting, rather than the detailed mine geology already presented by Lovitt and Skerl,[3] and (2) to suggest that from an exploration standpoint, this structural setting may be repeated in areas inside and outside of the mine area.

Stratigraphy and Structure of the Swauk Formation

General: The Swauk formation contains three distinct lithologies. Typical Swauk sandstone is gray on fresh surfaces, poorly sorted, weathers tan, and is cross-bedded; it consists of 40-60% quartz, 20-40% feldspar, and up to 10% muscovite and biotite.[4] The typical shale is gray to dark brown, very soft, and interbedded with silty sandstones; sharp contacts exist between the

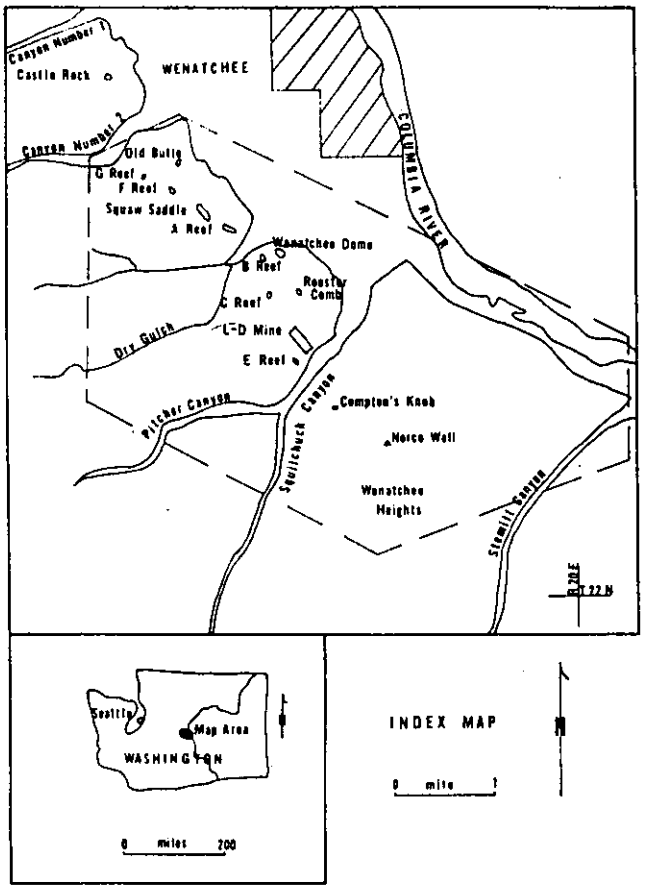


Fig. 1—Index map. Area of Fig. 2 is outlined by dashed lines. Area of Fig. 4 is outlined by the solid rectangle.

sandstone and shale layers. Coarse conglomerates are the least common rock type.

Numerous leaf and wood fragments, thin coal beds, and the absence of marine fossils, together with crossbedding in poorly sorted material, scour and fill, intraformational breccias, lack of laterally persistent beds, and the coarse, angular arkosic sandstones indicate that the Swauk is nonmarine. Fossil leaves from various parts of the formation throughout the Cascade Mountains are reported to range in age from Late Cretaceous to early Eocene.[1,4-6]

Mappable Units: At the confluence of Pitcher and Squilchuck canyons is a distinctive 420-ft stratigraphic sequence within the Swauk (see Fig. 2). Lignite and underlying clay at the base of the exposed beds are overlain by about 100 ft of interbedded purple and gray shale and arkosic sandstone. Gray shales predominate in the lower part of the sequence. Overlying the shale sequence are about 200 ft of medium-grained, massive sandstone containing 90 to 95% quartz; this sandstone is currently being used as a source of foundry sand. Successively above the massive sandstone are 70 ft of purple shale; 20 ft of thin-bedded, brown, arkosic sandstone; and 30 ft of white pebble conglomerate. The pebble conglomerate is composed of subrounded, medium to coarse pebbles of quartz, andesite, and black chert in a sandy arkosic groundmass.

At least 200 ft of distinctive conglomerate are exposed in the main workings of the L-D mine. Here and on the southwestern side of Rooster Comb, the conglomerate consists of large, rusty stained cobbles and small boulders of andesite, quartz, and minor biotitic gneiss. At B Reef,* the number of gneissic clasts is greater and the size of all the clasts is smaller.

About 100 ft of conglomerate crop out along the western side of Stemilt Canyon. Texturally and lithologically, this conglomerate is strikingly similar to the conglomerate at the mine. Because it is unconformably overlain by 75 to 100 ft of sandstone, the original thickness of the conglomerate in Stemilt Canyon cannot be determined. The original thickness of the overlying sandstone cannot be determined because it, in turn, is unconformably overlain by Miocene Yakima basalt.

Structure and Correlation: The distinctive sequence at the junction of Pitcher and Squilchuck Canyons is restricted to the fault-bounded Pitcher syncline (Fig. 2). Steep faults are well-exposed in the workings of the L-D mine.[3,7-9] Crossbedding in associated sandstones demonstrate that the cobble conglomerate in the footwall block is slightly overturned; therefore the easternmost premineralization fault in the mine, the so-called "footwall fissure" (Fig. 4), is a reverse fault. The decrease in dip of this fault with depth suggests that it is part of an imbricate thrust zone (see Fig. 4). The presence of steeply dipping strata as far northwest as Canyon Number Two indicates that the faults continue at least that far.

On the southern side of Dry Gulch, steeply dipping units crop out above a 300-ft covered interval below which are relatively flat lying beds of the southwestern limb of the Pitcher syncline; these dips are suggestive of a second thrust fault within the covered interval. In the divide between the northern and southern forks of Dry Gulch, minor silicification coincides with the termination of the mappable units of the Pitcher syncline. A few steep dips, silicification, and known faulting at G Reef suggest that faults underlie the divide between Dry Gulch and Canyon Number Two.

The angular discordance between the cobble conglomerate and the massive sandstone on the western side of Stemilt Canyon might be interpreted as a southeastward, up-dip extension of the nearly flat basal portion of the imbricate thrust zone. However, crossbedding along the contact, the inclusion of cobbles from the underlying conglomerate in the basal part of the massive sandstone, and the absence of recognizable shearing along most of the contact, support Chappell's contention[9] that this is an angular unconformity.

Correlation of the conglomerates at Stemilt Canyon and the mine is hindered by facies changes and structural complexities. The cobble conglomerate in Stemilt Canyon is on the southwestern limb of the northwesterly plunging Stemilt anticline but is not present on the northeastern limb; the conglomerate may be correlative with pebbly sandstones on the northeastern limb. Because the conglomerate north of the L-D mine is the oldest unit exposed in that area, whereas the conglomerate in Stemilt Canyon is the youngest unit below the unconformity, the presumed correlation of these two strikingly similar conglomerates is difficult to prove. Because the Stemilt anticline plunges to the northwest, the massive sandstone unconformably overlying the conglomerate in Stemilt Canyon need not have been deposited upon either the conglomerate or the overlying strata in the area northeast of the mine.

Couch[10] and Wilson and others[11] noted the lithologic similarity between the massive quartz sandstones in the Pitcher syncline and above the unconformity in Stemilt Canyon. However, sandstone is such a common lithology in the area that correlation of these two units must be regarded as speculative.

Steeply dipping beds on the bluffs above the Columbia River (Fig. 2) may be caused by imbricate thrust faulting or a southeastward extension of the regional high-angle faults of the Entiat fault zone to the north-

* A reef in the local usage, is any silicified portion of the Swauk formation.

west (Fig. 3). In 1933-34, the Northwest Oil Research Corp. (NORCO) drilled a 4903-ft well on Wenatchee Heights through 336 ft of Yakima basalt into the Swauk formation and rhyolitic intrusive rocks.[13] Therefore, south of the above-mentioned high-angle faults, the Swauk could be at least 3000 ft thick, if the section is not repeated by thrust faults. Northeast of the Columbia River, on the northern side of the high-angle fault, the thickness of the Swauk is about 1200 ft.[15]

Post-Swauk Intrusions

General Statement: The hypabyssal intrusions within the Swauk[14] form the aligned, jagged spires northwest of the mine: Squaw Saddle, Old Butte, and the narrow rib adjacent to C Reef (Figs. 1 and 2). Wenatchee Dome and Rooster Comb are ¼ mile northeast of the aligned intrusions. Less conspicuous sills and dikes increase in number toward the center of the Twin Peaks andesitic-gabbroic igneous complex[9,15] northwest of the map area.

Petrology and Petrography: Rooster Comb and the Wenatchee Dome are porphyritic biotitic dacites[9,16] and are more siliceous than the other intrusions in the area. Wenatchee Dome has exfoliation sheets, with flow banding parallel to jointing, dipping 25° to 55° away from a common center. Both Wenatchee Dome and Rooster Comb contain igneous breccias, spherulites, and discontinuous zones of perlite along their contacts.[9,12] "Rhyolite" and perlite were encountered in the NORCO well on Wenatchee Heights between depths of 678 to 940 and 1060 to 1360 ft.[13]

The central part of Squaw Saddle is a porphyritic hypersthene basalt; the glassy, olive-green border phase is a more sodic hornblende-pyroxene andesite.[9] The composition of the narrow intrusion adjacent to C Reef is very similar to the border phase of Squaw Saddle. Old Butte consists of both nonglassy, porphyritic andesite and an "olive-green dull-to resinous-lustered glassy andesite . . . whose percentage of glass appears to be greater than in similar rock at Squaw Saddle."[12]

The igneous rocks intrude the Swauk sandstone but apparently do not intrude the overlying Miocene Yakima basalt. All the foregoing andesitic rocks are within the area bounded by thrust faults. The aligned andesitic intrusions and the intrusion adjacent to C Reef have very prominent, steeply dipping joints parallel to the bedding of the adjacent Swauk sandstone; this suggests that the intrusions within the thrust zone may have been emplaced during the last phases of faulting and associated folding. Because some folding of the Swauk preceded the eruption of the middle Eocene Teanaway basalt south of Mount Stuart,[17] the intrusions may possibly be pre-middle Eocene.

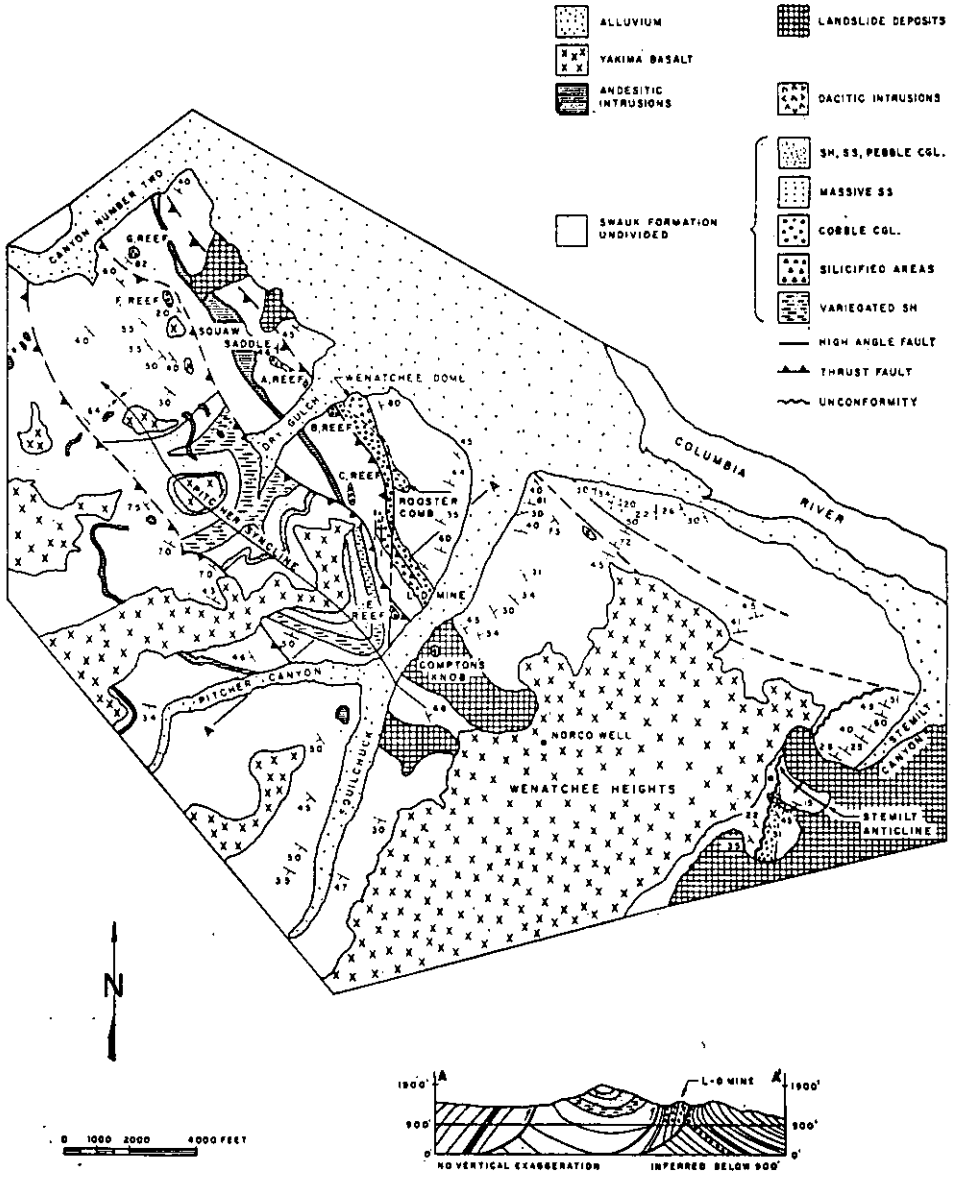


Fig. 2—Geologic map of the L-D mine area.

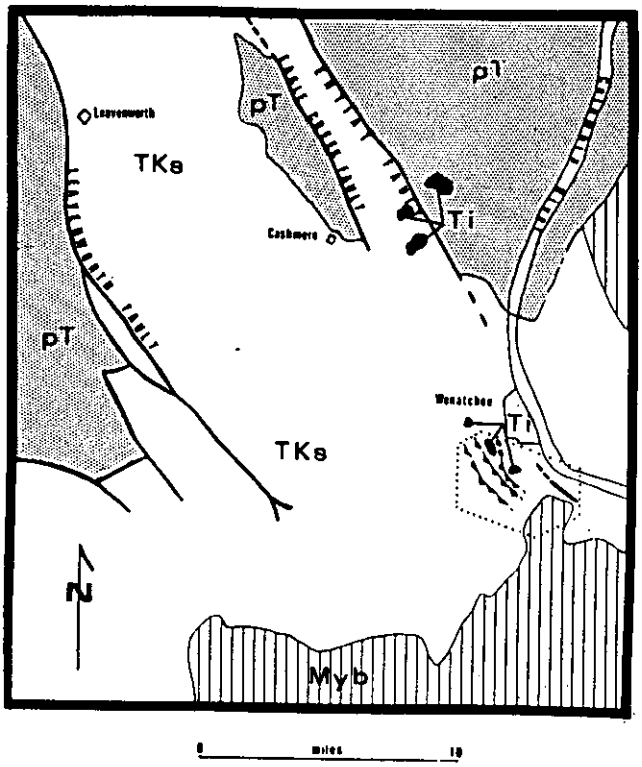


Fig. 3—Regional geologic map. Area of Fig. 2 is outlined by dotted line. After Alexander[6] and Willis.[24] Myb, Yakima basalt; Ti, tertiary intrusions; TKs, Swauk formation; pT, pre-Tertiary igneous and metamorphic rocks. Line with triangles, thrust faults; line without solid triangles, high-angle faults.

ECONOMIC GEOLOGY

History: Lovitt and McDowall[7] point out that prior to 1949, the discouraging economic evaluation of the L-D property was based on the assumption that the ore body was a large, low-grade deposit averaging $3.50-4.00 per ton. With selective underground mining, the ore averaged well over $20 per ton during the last half of 1949 and continued to produce profitably through 1966. As late as 1966, the L-D was the 6th largest gold mine and 13th largest gold producer in the United States. According to E. H. Lovitt,[18] 1,036,572 dry tons of ore valued at $14,962,305 and averaging 0.396 oz. Au per ton and 0.607 oz. Ag per ton were mined from 1949 until the mine closed in January 1967.

Ore has been extracted from the L-D mine between elevations of 850 and 1600 ft, and diamond drilling has shown gold values down to the 750-ft level. Significant development work has been done at B Reef. Exploration adits at Compton's Knob, and A, C, F, and G Reefs did not encounter ore. At E Reef diamond drilling revealed only minor gold values.

Ore Mineralogy and Hydrothermal Alteration: Guilbert's comprehensive study[19] of the fine-grained to microscopic ore minerals revealed gold, electrum, naumannite (Ag_2Se), and minor aguilarite ($Ag_2Se \cdot Ag_2S$), an assemblage which has only been found elsewhere in the United States at Republic, Wash.[20] Guilbert's study showed that: (1) ore minerals are found both in quartz veinlets and silicified arkosic sandstone; (2) the ore minerals usually range in size from 1 to 80μ in diam; and (3) brecciation, absence of mylonite, and breaks around grains indicate that the mineralized fractures were tensional openings.

Guilbert distinguished three periods of silicification: (1) early pervasive silica, (2) milky fine-grained vuggy vein quartz, and (3) late coarse-grained clear coxcomb vein quartz. Other evidence supports Guilbert's identification of three periods of silicification. In the Wenatchee area, Swauk sandstone is normally poorly cemented; therefore, only pervasive silicification could increase the competency sufficiently to permit fracturing and the formation of ore-bearing quartz veins. A third period of silicification produced barren veins that offset ore-bearing veins. On the southwestern side of Canyon Number Two, clear coxcomb vein quartz corresponding to Guilbert's late veins, cuts the andesitic intrusions.

A close spatial relationship exists between areas of hydrothermal alteration, the steeply dipping Swauk sandstones within the thrust zone, and the intrusions aligned northwest of the L-D mine. The most obvious example of hydrothermal alteration is at the L-D mine on the western side of Squilchuck Canyon: a jagged cliff of tan, silicified arkosic rocks[9,19,21] is crisscrossed by quartz veins. Early miners called this "bastard granite." Intense silicification and brecciation occur at Compton's Knob, and A, B, C, E, F, and G Reefs (Fig. 2). Coombs[10] noted hydrothermal alteration at Wenatchee Dome, and Huntting[13] reported silicification at Rooster Comb and in the NORCO well between depths of 715 to 815 ft.

Structural Control of Ore: Lovitt and Skerl[9] inferred that the hydrothermally altered mine rocks were folded, faulted, and subsequently formed a monadnock against which the younger Swauk formation was deposited. However, the dissimilar stratigraphy of each of the antiformal limbs on either side of the mine rocks (Fig. 2), the overturned and vertical beds that decrease in dip north-eastward away from the mine, and high-angle faulting in the mine and elsewhere make this hypothesis untenable. The steeply dipping mine rocks are most probably an imbricate thrust block within the Swauk formation (Fig. 2 and 4).

The chief structural control of ore is the "footwall fissure," a zone of shaly lustrous, soft, black fault gouge (Fig. 4). It dips steeply southwesterly, has eastern and western strands which apparently merge at depth, and contains many angular sandstone fragments. Ore values and silicification are limited to the hanging-wall block of the western strand. The cobble conglomerate on the footwall side of the fault dips steeply to the southwest. The same relationship exists at B Reef: the ore is on the hanging-wall side of the footwall fissure and the conglomerate is on the footwall side. Because the conglomerate is not present at A Reef, both it and the associated eastern strand may have been offset northeast of A Reef by right-lateral faults similar to those in the mine.

Lovitt and Skerl[9] note that the southeastern section of the mine has a "fairly regular pattern of major veins . . . that have been mined as separate entities, but the bulk of the tonnage produced is from zones of veins and veinlets. . . ." They also noted that northward dipping veins, which correspond to the second period of silicification, carried most of the gold. This regular system of fractures and most intense hydrothermal alteration occurs where two imbricate thrust faults converge east of the easternmost north-south fault shown in Figs. 2 and 4.

These steeply dipping north-south faults offset the ore-bearing structures as much as 400 ft to the north, creating several blocks within the mine. Lovitt and Skerl[9] mapped more than ten north-south faults. As one passes northwestward from Block I, through Block II, to Block III, the dips of the strands of the footwall fissure diminish, the northwesterly dip of the major ore-bearing veinlets decrease, and the NE-SW width of the mineralized area on a given level increases; these phenomena could be explained if the western block on each north-south fault was uplifted, so that successively

deeper portions of the imbricate fault block occur on a given level in each successive western block.

Conclusions and Recommendations for Future Exploration

Under more favorable economic conditions, the L-D mine might reopen. Perhaps most of the silicified areas would show appreciable gold values if sufficient money were available to test them extensively. The following geologic environments and areas are worthy of further exploration.

1) Any steeply dipping, silicified sandstone close to an intrusion merits investigation.

2) The presence of gold at A and B Reef suggests that exploration between these two silicified areas might reveal gold mineralization beneath the valley fill.

3) If the blocks west of the main north-south fault were uplifted as suggested, previous exploration in the mine for steeply dipping ore bodies may have missed some ore.

4) Silicification at Compton's Knob on the southeastern side of Squilchuck Canyon and the presence of thrust faults at the L-D mine on the northwestern side of the canyon suggest that mineralization may extend under the Canyon.

5) The structural complexities on each side of the Squilchuck-Stemilt divide (Wenatchee Heights) capped by Yakima Basalt, and the silicification and intrusions encountered beneath the basalt cap by the NORCO well have been noted previously. Pieces of shaly fault gouge occur in the cuttings from the well. It may well be significant that assays of two samples of this material obtained by E. A. Magill of the U.S. Bureau of Mines were 0.697 oz. Ag per ton and no gold at 590 to 600 ft and neither gold nor silver at 653 to 669 ft. Rhyolite at 905 to 923 ft assays 0.016 to 0.048 oz. Au per ton and no silver.

6) The epithermal gold-quartz veins of the Republic district of north-central Washington[20,22] have nearly the same mineralogy and are approximately the same age as the L-D ores. The ores of both districts are spatially, and presumably genetically, related to large regional faults. Therefore, future regional exploration should be directed northwestward along the regional Entiat fault zone shown in Fig. 3, particularly the area around the rhyolitic and andesitic Tertiary intrusions[23] in the Swauk formation east of Cashmere. Southeast of the L-D mine favorable areas may lie beneath the Miocene Yakima basalt.

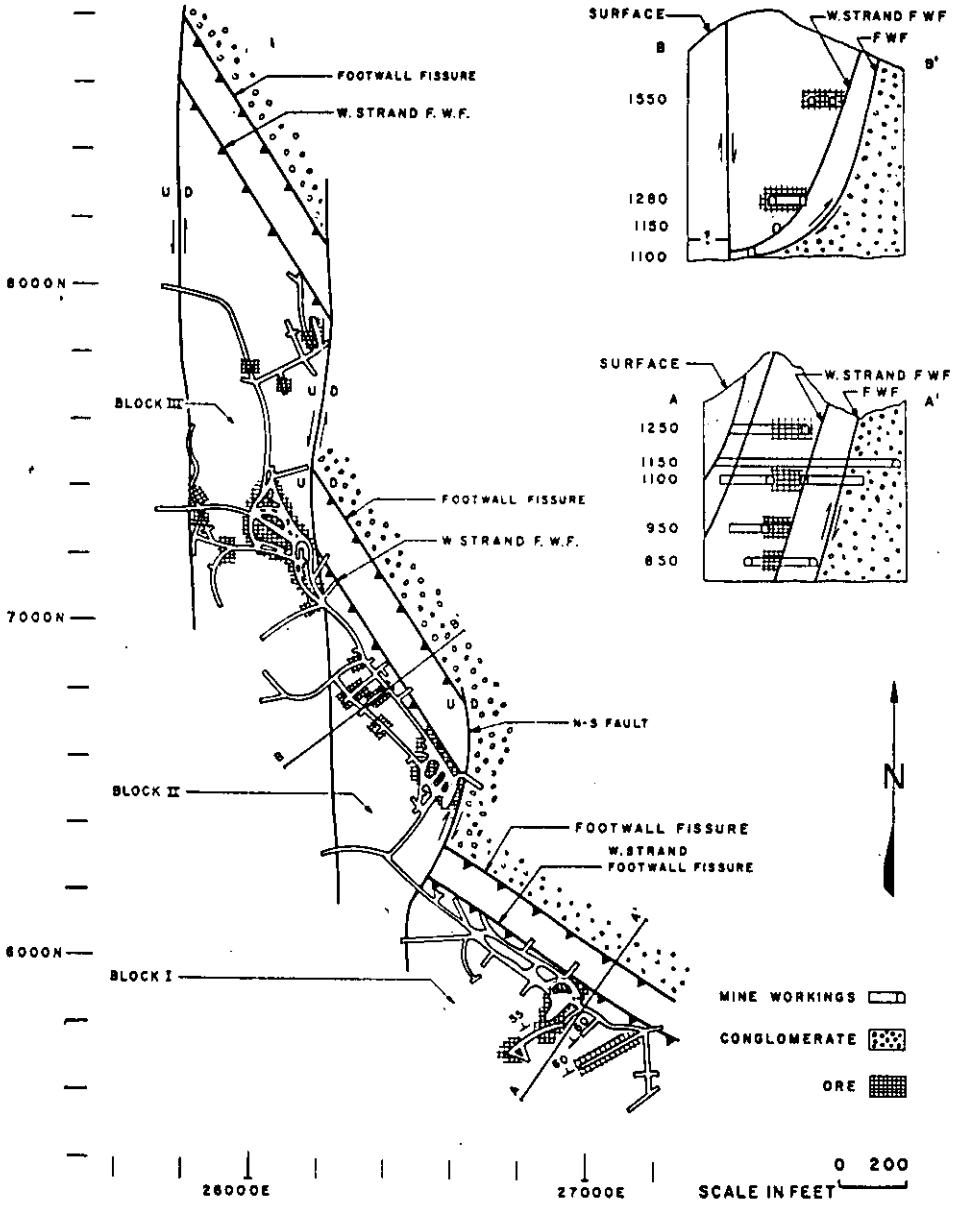


Fig. 4—Generalized geology of the L-D mine: 1250 level and cross sections; see Fig. 1 for location. The northwesterly dipping ores in the crosscuts of Block I and Block II are the veins.

Acknowledgments

We would like to thank E. H. Lovitt, principal owner and general manager of the L-D mine, for financing the investigation, and E. B. McKee, M. T. Huntting, T. V. Livingston, W. S. Moen, C. P. Purdy, and J. W. Trammell for critically reading earlier drafts of this paper

References

[1] Young, R. E., "Geology of the Swauk Formation in the Leavenworth, Washington, Area," Unpublished undergraduate thesis, University of Washington, Seattle, 1963, 45 pp.

[2] Lovitt, E. H., and Skerl, A. C., "Geology of the Lovitt Gold Mine, Wenatchee, Washington," *Mining Engineering*, Vol. 10, No. 9, Sep. 1958, pp. 963-966.

[3] Industrial Consultants, "Economic Feasibility of Silica Sand Processing and Related Manufacturing Operations in Chelan County, Washington," Economic Development Administration, Technical Assistance Project, U.S. Dept. of Commerce, 1966, 103 pp.

[4] Rector, R. J., "Geology of the East Half of the Swauk Creek Mining District," Unpublished M.S. thesis, University of Washington, Seattle, 1962, 73 pp.

[5] LaMotte, R. S., "Preliminary Report on Fossil Collection from the Swauk Formation at the University of California," *Geology of the Wenatchee Quadrangle*, Unpublished Ph.D. thesis by W. M. Chappell, University of Washington, Seattle, 1936, pp. 72-76.

[6] Alexander, F., "Stratigraphic and Structural Geology of the Blewett-Swauk Area, Washington," Unpublished M.S. thesis, University of Washington, Seattle, 1956, 64 pp.

[7] Lovitt, E. H., and McDowall, V., "The Gold King Mine," *Western Miner and Oil Review*, Vol. 27, 1954, pp. 37-39.

[8] MacLaren, D. R., et al., "Gold," *Mineral and Water Resources of Washington*, A. E. Weissenborn, ed., Washington Div. of Mines & Geology, Reprint 9, 1966, pp. 82-92.

[9] Chappel, W. M., "Geology of the Wenatchee Quadrangle," Unpublished Ph.D. thesis, University of Washington, Seattle, 1936, 249 pp.

[10] Couch, A. H., "Silica Sands of Washington," Unpublished M.S. thesis, University of Washington, Seattle, 1935, 98 pp.

[11] Wilson, H., Skinner, K. G., and Couch, A. H., "Silica Sands of Washington," *Engineering Experiment Station Bulletin*, Vol. 108, 1942, 76 pp.

[12] Huntting, M. T., "Perlite and Other Volcanic Glass Occurrences in Washington," *Report of Investigations*, Washington, Div. of Mines & Geology, Vol. 17, 1949, pp. 1-77.

[13] Coombs, H. A., Personal Communication, 1967.

[14] Smith, G. O., and Calkins, F. C., "A Geological Reconnaissance Across the Cascade Range Near the Forty-Ninth Parallel," *Bulletin*, U.S. Geological Survey, Vol. 235, 1904, pp. 3-103.

[15] Bayley, E. P., "Bedrock Geology of Twin Peaks Area, An Intrusive Complex Near Wenatchee, Washington," Unpublished M.S. thesis, University of Washington, Seattle, 1965, 47 pp.

[16] Coombs, H. A., "Spherulitic Breccias in a Dome Near Wenatchee, Washington," *American Mineralogist*, Vol. 37, 1952, pp. 197-206.

[17] Smith, G. O., "Mount Stuart Folio (No. 106)," *Atlas*, U.S. Geological Survey, 1904, 10 pp.

[18] Lovitt, E. H., Personal Communication, 1969.

[19] Guilbert, J. M., "Report on Selected Specimens from the Gold King Mine, Wenatchee, Washington," Unpublished report for Day Mines, Inc., Wallace, Idaho, 1963, 27 pp.

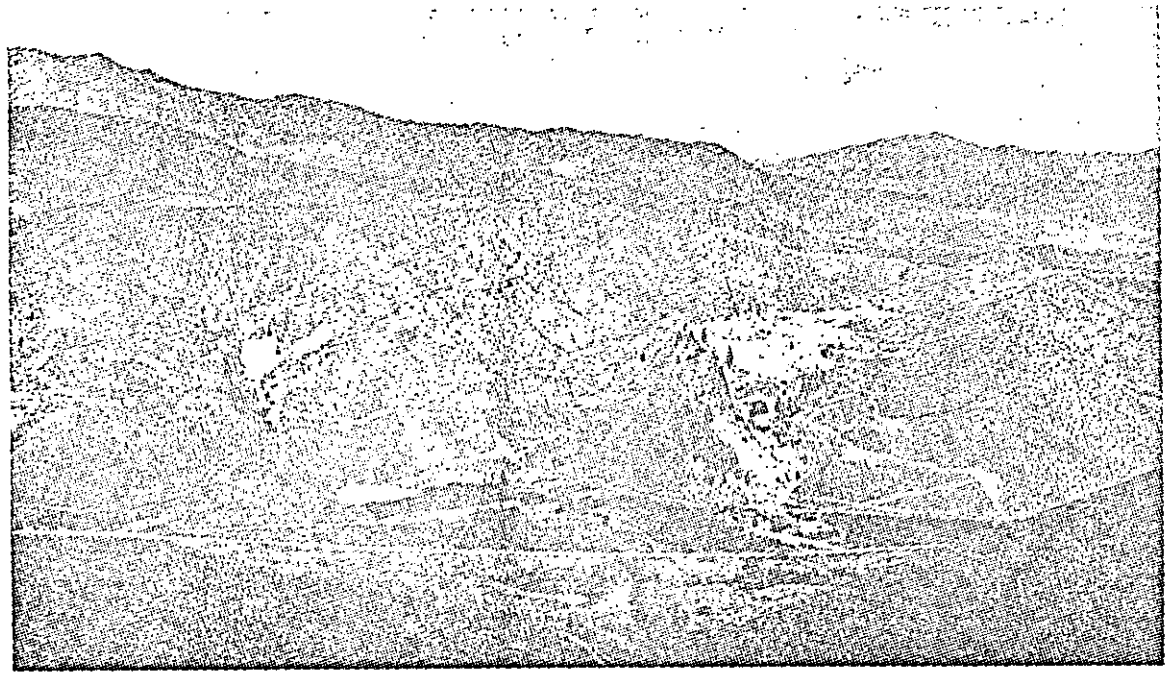
[20] Full, R. P., and Grantham, R. M., "Ore Deposits of the Republic Mining District, Ferry County, Washington," *Ore Deposits of the United States, 1933-1967*, J. D. Ridge, ed., AIME, New York, 1968, pp. 1481-1494.

[21] Coombs, H. A., "Granitization in the Swauk Arkose Near Wenatchee, Washington," *American Journal of Science*, Vol. 248, 1950, pp. 369-377.

[22] Wright, L. D., "Geologic Relations and New Ore Bodies of the Republic District, Washington," *Trans. AIME*, Vol. 178, 1949, pp. 264-282.

[23] Waters, A. C., "A Petrologic and Structural Study of the Swakane Gneiss, Entiat Mountains, Washington," *Journal of Geology*, Vol. 40, 1932, pp. 604-633.

[24] Willis, C. L., "The Chiwaukum Graben, A Major Structure of Central Washington," *American Journal of Science*, Vol. 251, 1953, pp. 789-797.



Prominent ridges mark terrain in area of Lovitt gold mine.

GEOLOGY OF THE LOVITT GOLD MINE, WENATCHEE, WASH.

by E. H. LOVITT and A. C. SKERL

After nine years of continuous operation it is a good idea to take stock of the geological concepts that guide the working of a mine. This is a welcome opportunity to discuss the Lovitt gold mine, which has been a challenge in both the geological and operational fields.

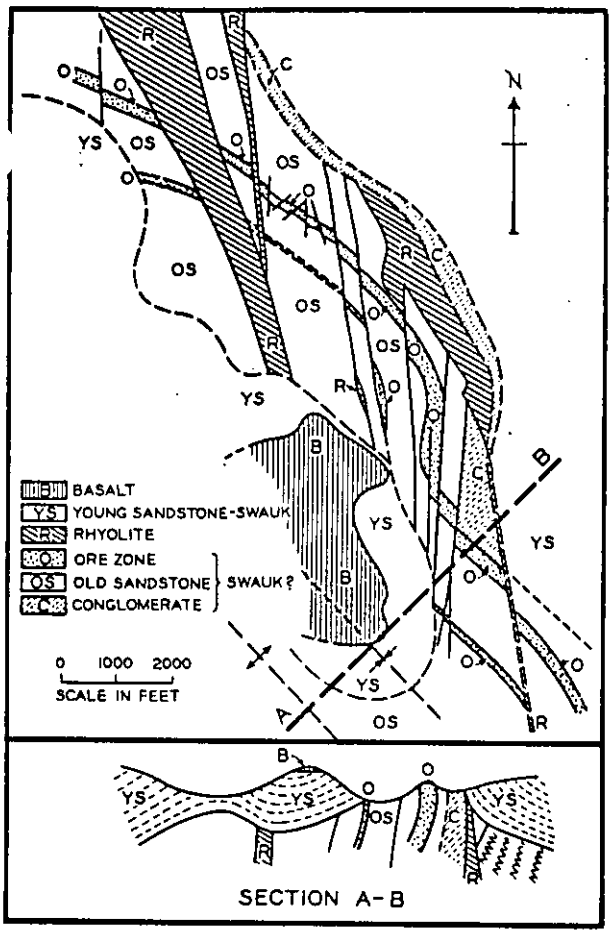
The occurrence belongs to the extensive group of epithermal gold-silver deposits once worked so vigorously in the western states, Hungary, and New Zealand and still producing in Central America and the Philippines. These deposits are characterized by a relatively shallow vertical range up to 2000 ft, and often much less, and by bonanza orebodies of even more limited range. The area in which they oc- is frequently widespread, so that exploration l be directed along and across the strike of wn favorable structures in search of repetitions.

E. H. LOVITT is President and General Manager, Lovitt Mining Co., Wenatchee, Wash. A. C. SKERL is Consulting Geologist.
AIME Pacific Northwest Regional Conf., April 1958, Spokane, Wash.

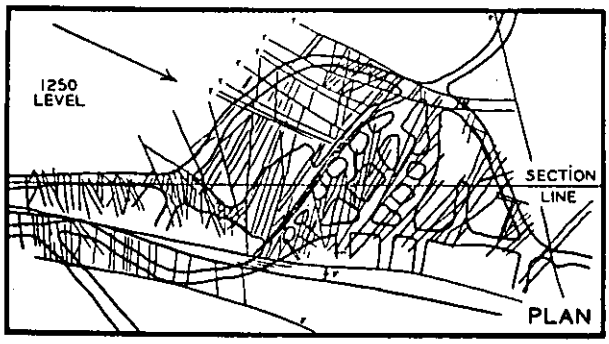
Location: The Lovitt mine is ideally situated near the paved highway that extends up the Squilchuck Valley about three miles from Wenatchee, Wash., and a mile and a half from the Columbia River. Rail transportation, too, is excellent, supplies are plentiful, and repair services close at hand. Electric power is obtained from Chelan County Public Utilities Div., which has an excellent source of energy in the Columbia River. The operation is also fortunate in having experienced miners.

History: The ground was first staked in 1885 as the Gold King mine, and in 1894 a small five-stamp mill was erected. Since recovery was very poor, milling soon stopped and has never been resumed. It is now known that the reason for low recovery was the finely divided state of the gold, which the comparatively coarse grinding by stamps did not liberate for amalgamation to be effective. Cyanidation had only recently been introduced and was probably not appreciated by the operators.

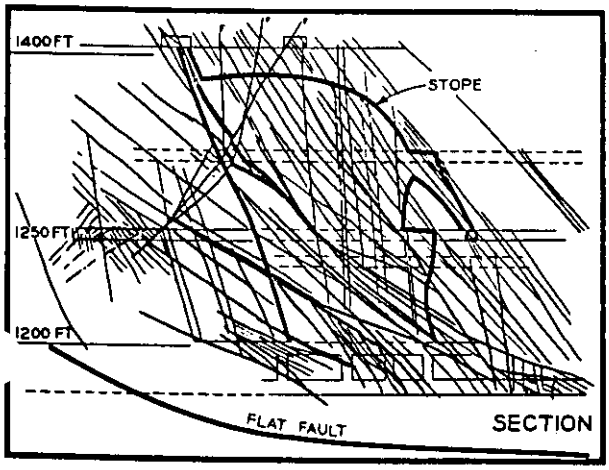
The two key claims were always kept in good standing, and J. Keegan of Wenatchee, obtaining



Distribution of rock types at Lovitt mine.



49 ORE BODY



Detailed cross section of orebody at north end of mine.

an option in 1934, explored the holdings and interested various mining companies in his findings. Considerable tunneling and sampling were carried out, but it was not until 1949 that the operation became a success, under Lovitt Mining Co.'s management.

From initial production in August 1949 to the end of 1957, 446,025 tons have been shipped to the Tacoma smelter, where the highly siliceous ore is found to be an excellent flux. Gross content of this ore—189,404 oz of gold and 217,328 oz of silver—has been valued at $6,612,569 and averages $14.80 per ton.

GEOLOGY

The Wenatchee area is mostly underlain by gently folded continental deposits of Eocene age known as the Swauk Formation, which consists of sandstones, shales, and conglomerates that are often only partially consolidated. Above an elevation of 2000 ft there are flat-lying Miocene volcanics, known as the Columbia River lavas, which must once have covered the entire area.

Sediments of the mine formation, the oldest rocks exposed in the area, resemble the usual Swauk sediments except that they are fractured and better indurated. They were tilted up on edge to form an island chain against which the Swauk sandstones were piled. This relationship suggests the oldest sediments could be cretaceous age.

The accompanying map and section show the distribution of rock types. The belt of mine rocks stands at a steep angle with about 1000 ft of older coarse conglomerate to the east and a sandstone-shale series overlying it in the form of synclines on both sides. In the past, lignite seams have been explored in these younger sediments. They also contain a layer of silica sand that was once exploited.

The area was sliced up by a northerly trending zone of steep faults, probably before the younger sediments were deposited. These faults are believed to be the southern extension of the Entiat fault.

Subsequently both rhyolite with perlitic facies and minor andesite were intruded as dikes along some of these faults. The sediments in the mine belt became pyritized, silicified, and permeated by numerous quartz veins over a distance of two miles and a width of 300 ft.

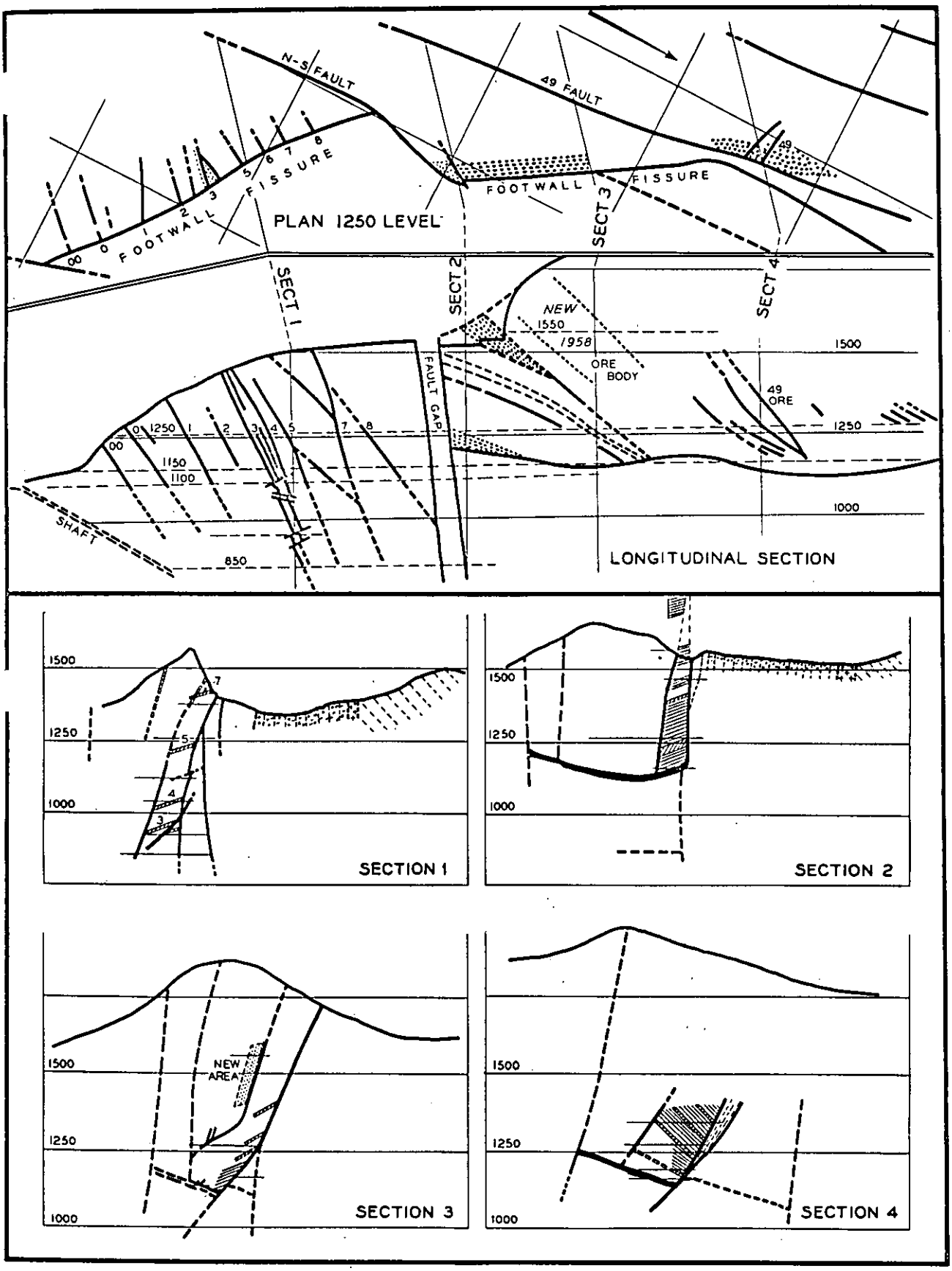
Mine Geology: A typical section from east to west through the mine shows several hundred feet of conglomerates with mostly vertical dips. There are then about 100 ft of feldspathic sandstones with minor clay seams. Next there is the important footwall fissure, a clay bed with associated argillaceous sandstone up to 50 ft wide and dipping steeply west. This is followed by more feldspathic sandstone with some pebbly layers for a few hundred feet—the sandstone is usually pyritized and often highly silicified. Clay partings and thin argillaceous beds often show signs of movement.

Completely carbonized plant material such as leaves, twigs, and small logs are common in the sandstones, especially near the footwall fissure.

Cross-bedding, both large and small-scale, is typical in these sandstones, which are of lacustrine origin.

The only intrusive found in the mine workings is some perlitic rhyolite in the conglomerate horizon near the portal of the main haulage tunnel on the 1150 level.

At times a fine-textured dark arkose with scat-



Above: Simplified plan of faults and veins on 1250 level, with corresponding longitudinal section. Section 1: Cross section of veins in southwest area. Section 2: Location of orebody in angle between footwall fissure and flat-lying fault. Section 3: New area recently located along secondary faulted clay bed. Section 4: Generalized cross section of principal orebody at present north end of the mine known as the "Forty-Nine." See opposite page for detailed section.

tered feldspar grains simulates a bedded dike rock.

Structure: The major fault zone in which the mine is situated consists of more than ten parallel tear faults in a width of 1½ miles, as shown on the geological map of the surface. The movement was apparently such that the east side of the area moved a half mile south relative to the west side. The weak clay beds and seams took up some of the movement.

Between two of the main faults a block some 1000 ft wide has moved south on a flat-lying fault. The amount of movement is not yet known and ore has only recently been found below this fault. Where it has cut obliquely across the weak clay with interbedded sandstones it has produced a zone of lustrous shale fragments with blocks of broken sandstone.

As mentioned above, a shale horizon near the base of the older sandstones became a strong fault known as the *footwall fissure*. The sandstone beds adjacent to it were severely dislocated in several directions to produce fractures that were subsequently filled with quartz to form veins and systems of veinlets.

Veins: The mine is divided into two areas by a strong north-trending fault. In the southwest area the auriferous veins always dip 60° to 80° to the north and in the northeast area 30° to 50°. The northeast area is underlain by the flat fault described above.

In the southwest area there are later south-dipping and vertical barren veins that offset the auriferous veins. In the northeast area a series of north-trending vertical veins also offsets the ore-bearing veins.

There is a fairly regular pattern of major veins, especially in the southwest area, that have been mined as separate entities, but the bulk of the tonnage produced is from zones of veins and veinlets that extend as much as 300 ft along the footwall fissure on the level, for a vertical range of 200 ft, and an average of 50 ft out from the fissure. Much of this ore is mined *en masse* by rings of long holes. Where the average grade is too low it is sometimes possible to stope out a high grade vein selectively.

Significant gold values have been found on the surface up to an elevation of 1800 ft and underground down to the lowest exploration drillhole at 750 ft—a vertical range of a least 1050 ft for occurrence of ore.

So far stoping has been done from an elevation of 850 ft up to 1600 ft.

Mineralogy: The vein quartz is cherty and usually pure white, with vague patches and banding that are slightly grey in color. Sometimes a vein consists partly or wholly of black chert, often a sign of good ore. In some areas large masses of sandstone have been irregularly replaced by black chert that may or may not be auriferous. As much as 30 pct of a vein may be calcite.

Usually the ore contains gold and silver in about equal parts by weight. No visible gold is present and the vein quartz is almost free of sulfides, so it is suspected that electrum is the valuable mineral.

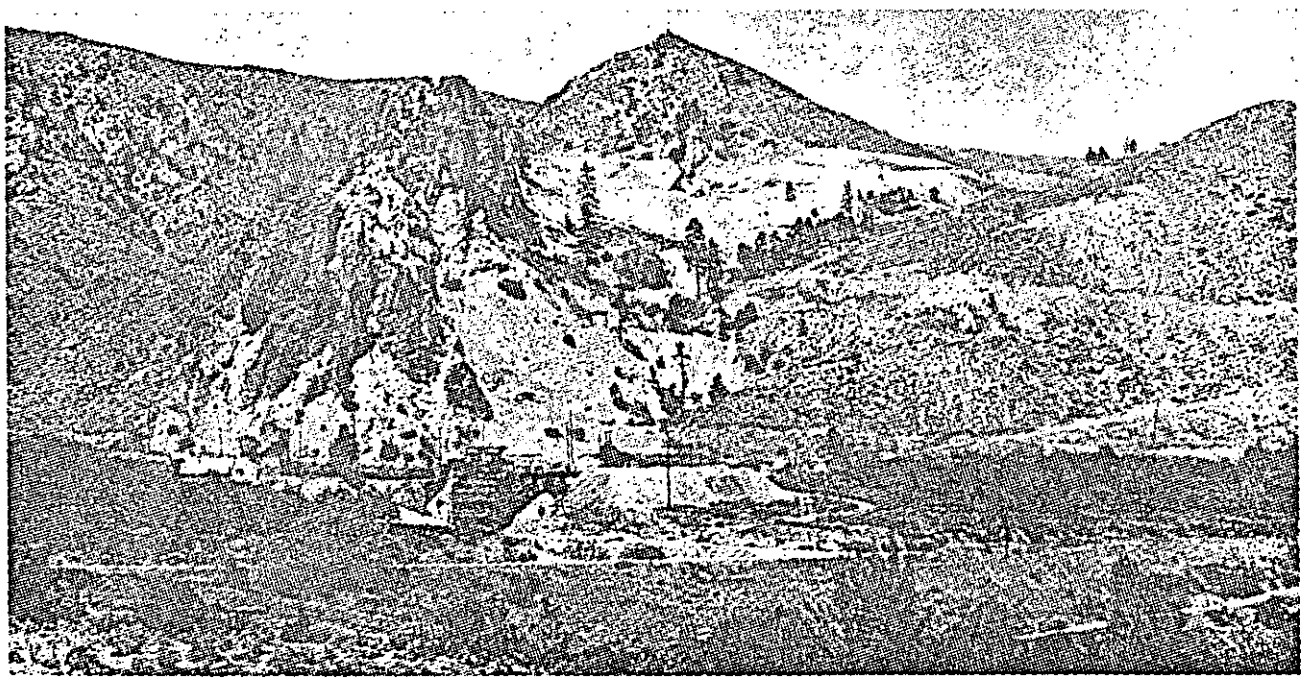
One small vein in the mine assays about 25 oz of silver and only 0.20 oz of gold per ton. Tiny nests of a silvery mineral that could be argentite can be distinguished through a lens.

The oxidized ore near the surface usually carries two to three times as much silver as gold by weight. This may be due to secondary enrichment or to an original conditions near the top of the orebodies.

The sandstone country rock, particularly near the veins, is normally impregnated with fine pyrite that could amount to 3 pct by weight. Oxidation of the pyrite gives the sandstone outcrops a pronounced brown yellow stain.

CONCLUSION

This mine is still responding to development, and the geological picture suggests that it could continue to do so for many years. But the life of the mine may well be shortened if the non-controllable costs continue to mount with no compensatory increase in the price paid—a situation that has been strangling gold mining for the past 12 years.



Pinnacled mine formation of original workings is shown at center left. Younger sandstones dip away on each side.

Ted Livingston

L D Mines

WASHINGTON STATE
DEPARTMENT OF WATER RESOURCES
OLYMPIA

August 9, 1967

Board of County Commissioners
Chelan County
Courthouse
Wenatchee, Washington 98801

Gentlemen:

Re: L-D Mines' Tailings Ponds

Pursuant to your letter of June 19, this office made an inspection of the referenced channel change on Squillchuck Creek on June 28 and on July 11. The July 11 inspection was made by Mr. Gregory M. Hastings of the Department of Water Resources, Mr. Ted Livingston, Department of Natural Resources (Division of Mines and Geology), and Mr. Joreen Sommerseth, engineer for the Seattle District Corps of Engineers, and myself. Our findings are as follows:

1. The creek is diverted around the tailings ponds in a concrete lined flume, with dimensions as shown on the enclosed sketches. Also, there is a floodway provided between the tailings ponds and the creek as shown on the enclosed photographs.

2. There is a low spot in the lower tailings ponds approximately 180 feet upstream from the face of the dam. This low spot is approximately 5 feet below the crest of the dam.

3. As evidenced by the photographs and the aerial photographs, the creek channel does not come within 75 feet of the face of the dam.

4. The channel restriction on Squillchuck Creek is the highway crossing 1.2 miles above the tailings ponds.

This is an 8' x 10' box culvert, 70 feet long, with a limited capacity.

Following this inspection, we conclude that the tailings ponds per se do not constitute a threat to the community and no remedial action is indicated. Mr. Livingston pointed out to us that the surface of these tailings ponds is highly oxidized and no surfaces showed the effects of any erosion.

The professional engineers of our office have never viewed a tailings pond in the Pacific Northwest that was better maintained than the one under question and posed less of a threat to public safety.

Very truly yours,

Milton J. Westin, Chief Engineer
Department of Water Resources

MJW:kf
Enc.

cc: Corps of Engineers, Seattle

Mr. Ted Livingston

C O P Y

Boston and Colorado Smelting Company, Argo, Colorado
October 17, 1895

Dear Sir:

The samples of ore, referred to in your letter of the 26th came duly to hand by express, and after careful crushing and sampling, we found the following results. The white quartz assayed 2/10 of an oz. of gold per ton. The gray rock, which you call porphery 4/100 of an oz. of gold per ton. A sample of the white quartz was treated with 1/4% solution of cyanide of potassium extending over a period of 56 hours. After treatment the residue or tailings contained 0.035 ozs. of gold, which indicates an extraction equal to 82½% of the total quantity of gold present. This shows that the gold is sufficiently finely divided to be acted upon by the cyanide solution.

A search was made for tellurium and other elements usually associated with gold but nothing of importance was obtained.

The grey rock contains a good deal of iron pyrites finely disseminated throughout the massof the material.

A concentration experiment was made with the view of determining approximately the proportion of iron pyrites present with the following results: 100 parts of the rock gave 2.55 parts iron pyrites which equals a concentration of nearly 34 tons into; the concentrated product producing iron pyrites assayed, 1.18 ozs. ($24.39) gold per ton, which indicates a saving of 87% of the gold, and proves conclusively that the pyrites itself contains the gold. This may be of no practical value to you, but I thought it might perhaps be interesting to know just how the gold occurs.

The samples were billed to us by express, with kindest regards.

Yours very truly

Richard Pearce,
Manager

October 17, 1938

Mr. J. J. Keegan
Mission Court
Wenatchee, Washington

Dear Mr. Keegan:

I saw by a news item in the Spokesman-Review of Sunday, October 16th, that you have begun shipment of ore from your property near Wenatchee.

Will you please send me the exact information so that we can incorporate it in our report on mining operations that is now almost ready for publication? I hope the report in the paper is true, and that you are shipping substantial quantities of ore on a profitable basis.

Sincerely,

Thomas B. Hill,
Supervisor

TBH:A

TheKeegan Mining & Dev Company.

Wenatchee Washington.

October.22nd.1938.

Mr. Thomas B. Hill.
Supervisor.
Division Of Mines.
Olympia Washington.

RECEIVED

Dear Mr. Hill:

I have your letter of enquirey under date of Oct. 17th. relative to the shipment of Ore from the Gold Mine near Wenatchee,

We have entered into an agreement with the American Smelting and Refining Companys, Tacoma Smelter. to supply their requirements with our Silicious Gold and Silver Bearing Ores, the present Contract calls for 10.000 Tons with option on additional Tonnage,

Contract was let for Mining and Hawling to one of the local Contractors, the Mining operations is carried on by Open Quarrying, over an area of 200ft, this will be extended as work progresses which will embrace the entire Cliff or Dike. providing everything is satisfactory,

Mining by open quarrying can be done remarkably cheap especially on this particular property, as the Cliffs now being Mined raises from an Elevation of 1000ft to 1500ft, the Rock drills and breaks very easy there is no expence connected with getting the material down to the lower loading levels, at present Bulldozers are used to push the ore into the Bins as it slides down the side of the hill. a Chute is used to hold the ore where it is loaded by Gravity, so we have an open quarrying gravity Mining Proposition.

Large Trucks [3 MILES over Paved Roads made from this Material Called] are used in transporting the material to the G.N R.R. where it is loaded over a ramp and dumped into the Ore Cars. and shipped to the Smelter at Tacoma, so far the values are very satisfactory, and checks very close to our previous Assays,

[Margin: Roads of Gold your Esteemed Tenant Rufus Woods paper.]

I am checking up on some Molybdenumite Cobalt and Nickel. and Tungeston Ores, also Insolating Materials. the State Dept of Mines at Pullman states it is Molybdenumite, if it is and runs high enough there is some People in New York that buys it I have sent them a small Sample, I would like to interest someone in our Lime and Clays, and Cement and Insolating Materials,

Sincierly Yours. [signature]

October 24, 1938

Mr. J. J. Keegan
Keegan Mining & Development Co.,
Wenatchee, Washington

Dear Mr. Keegan:

Thank you sincerely for your letter of October 22nd, telling of the operations in connection with your mining property. We are pleased to know that this is developing satisfactorily, and would like to be kept informed as the work progresses, and also with respect to other mining properties that you may develop.

If at any time we can be of service, please advise us.

Sincerely,

Thomas B. Hill,
Supervisor

TBH:A

...ORE PAYROLL

Lovitt Mine Building Mill

Construction has started on a flotation mill at the ...old King Mine, three miles south of Wenatchee.

The project is a joint venture ...r, the Lovitt Mining Co. and the ...ay Mines Inc. of Wallace, Idaho, ...d Lovitt said today. The mill is ...xpected to be in operation July 1.

Ore from ther Lovitt mine has ...een shipped to a Tacoma smel...er. After July 1 the mine will be ...hipping concentrates rather than ...ulk ore.

The mill is designed to handle ...0 tons of ore per day. Produc...on now is about 250 tons daily.

Primary purpose of the mill is ... prolong the life of the mine ...y permitting a lower grade ore ... be processed economically, ...ovitt said. "It's difficult to pre...ict the life of a mine but this ...ill should add many years to ...e Gold King," Lovitt said.

The work force at the mine ...ill be upped from 25 to 35 or ...0 men, including the mill crew ...nd perhaps additional men in ...e mine.

The mill will go right into pro... when its finished. "We ... have sufficient tonnage ...n ...and to justify construction of ...e mill," Lovitt said.

To reflect the joint Lovitt Min...g Co. and Day Mines Inc. ven...re, the mining and milling oper...tion will be known as L-D Mines. ...ovitt will remain in charge of ...roduction.

The Gold King Mine — which ...as yielded some $10,000,000 worth ...f gold ore — is the state's larg...st gold producer. The number ...e producer at Republic is oper...ted by Day Mines in asociation ...ith Knob Hill Mines.

Lovitt, a Vancouver, B. C. ...ining engineer, purchased the ...old King Mine July 15, 1959 and ...as been the only owner to make ...e mine operate profitably since ... was discovered in the late ...880s.

ED LOVITT

Day Mines — The 300-ton mill which Day Mines built at the Gold King mine near Wenatchee has started up and results are said to justify adding a second shift soon. The new mill is an exact duplication, although only one-half the size, of Lucky Friday's modern concentrator. The Gold King is Washington's second largest gold producer. Previous shipments have been high-silica gold ore direct to the Tacoma smelter. The mill will cut costs and up profits. Day Mines' new interest in this mine, together with its Gold Dollar mine at Republic (state's No. 1 producer), will further enhance the position of this company as one of the top gold producers in the United States. Both mines also produce silver in substantial amounts. Day Mines also has a one-fourth interest in the Galena mine, the country's second largest silver mine, near here.

NEW MILLING PLANT STARTS AT L-D MINE

Operating on Two-Shift Basis At Wenatchee; 32 Employed

The new 300-ton flotation concentrator of L-D Mines at Wenatchee, Wash., was placed in operation Monday of this week and a two-shift operation is under way this week.

Henry L. Day, president of Day Mines, Inc., made this announcement Tuesday. E. H. Lovitt, Wenatchee, is manager of the new L-D Mines, a joint venture of Lovitt Mining Co. of Wenatchee, owner of the Gold King mine there, and Day Mines, which built the concentrator.

Testing of the mill began a week ago and was completed last weekend.

Ore being put through the mill is coming from broken ore reserves underground in the adjacent Gold King mine, Day said, and it is planned to run the mill at capacity five days a week. This will require a one-third increase in mine output.

A pyritic gold concentrate with minor silver values is being made for shipment to the Tacoma smelter.

Thirty-two men are employed in the mine and mill, he said. The mill superintendent is Al J. Almquist, who formerly was employed in a similar capacity by Day Mines near Wallace.

Lovitt has operated the mine profitably for a decade by shipping mine-run ore directly to the smelter.

Gold King's Yield Is 270 Tons Daily

The Gold King Mine at Wenatchee is yielding 270 tons of gold-silver ore daily, according to a Spokane report attributed to E. H. Lovitt, president, L-D Mines, Inc.

The 300-ton flotation concentrator put into operation at the property last summer by Day Mines, Inc., is recovering 95 per cent of the metal values, he said.

Forty-five men are employed in mining operations and in developing new ore, he said.

The mine has been developed over a vertical range of 800 feet so far, he said. The deepest level, the 850, is only 250 feet below the lowest adit level.

Anaconda Mining Company is driving a third exploratory tunnel on the Keegan ground adjacent to the E. H. Lovitt Company operations at the Golden King mine three miles south of Wenatchee, Washington. The Golden King is yielding more than 200 tons of gold-silver ore daily. (MINING WORLD, December, '51)

ANACONDA SINKS GOLD KING SHAFT

Wenatchee Property Is Second Taken On in State

Anaconda Copper Mining company, which last Friday bought the Bonanza mine at Bossburg, Wash., is sinking an exploration shaft on the Gold King on the outskirts of Wenatchee, on which it holds an option.

This was confirmed yesterday by E. C. Stephens, geologist in charge of Anaconda's exploration department office in Spokane.

The shaft, started near the tunnel, is now down about 30 feet, Stephens indicated.

Option Exceeds $1,000,000

Lovett Mining company, backed by Vancouver, B. C., capital, has been operating under lease from Wenatchee Mining company. An option has been taken in the name of A. M. McDonald, Salt Lake City, exploration manager for ACM.

e Bonanza option exceeds),000; that on the Gold King ore than $1,000,000.

The Gold King is not only the second property optioned to Anaconda in its current expansion program in eastern Washington. It became, in 1950, the second mine in gold production in the state, close behind Howe Sound's Chelan mine at Holden, Wash.

Washington's increased gold production, which exceeded $3,000,000 in 1950, was principally due to the Gold King, as Holden output declined 22 per cent. The Gold King passed the Knob Hill at Republic, which dropped to third place.

The property was originally opened as a silica deposit by J. J. Keegan of Wenatchee. Gold was recognized several years ago, but commercial development has come only in the last three years.

Stephens Complimented

State Representative Elmer E. Johnston, at yesterday's mining luncheon at the Spokane hotel, complimented Stephens, who is president of Northwest Mining association, for his major part in bringing the big Anaconda company into the state.

"This morning's front page news story in The Spokesman-Review," he said, "gives me some much needed ammunition to take back to Olympia in the effort to convince West Side lawmakers that we really have some mines and some potential mines, other than coal.

"I was thrilled by the news that Anaconda had concluded the F za deal, and I know it will ate other companies to g er efforts in development."

Johnston is president of Silver Dollar Mining company of the Coeur d'Alenes, whose affiliate, Mines Management, is opening the Iroquois and Advance mines in Stevens county, distant about 20 miles from the Bonanza.

R 2-15-52

JOE MONIGER (left), diamond driller for Ed Lovitt's Gold King Mine up the Squilchuck, and his helper, Charles Kalma, study core samples from their drill inside the mine. Part of the Gold King c

Wenatchee Daily World March 4, 1952

Part of the 50-man mining crew of the Gold King Mine up the Squilchuck were transferred this week to the payroll of Anaconda Copper company.

The transfer was a bookkeeping transaction. "During an intensive development period for Anaconda, part of our crew is going on their payroll," according to Ed Lovitt, owner of the Gold King property from which $2 million has been taken in the more-than-two-years of its operation.

The transfer means that exploratory work which Ana-

mine crew is now on Anaconda's payroll as Anaconda Copper Company's exploration at Squilchuck continues.

—(Daily World Photo).

conda has been carrying on at Squilchuck under an option arrangement with Lovitt will be intensified. Anaconda is still only exploring, not commercially mining ore, however.

Lovitt's own operation will be temporarily curtailed, although some mine activity will continue.

Anaconda has been probing the inside of the big hill between Squilchuck and the end of Miller street for almost a year now. One series of shafts were tunnelled into the hillside near the old brickyard at the end of Miller. Main scene of operation nearly adjoins the Lovitt mine out Methow St.

Anaconda Drops Option on Gold King Property

WM 3-26-53

Anaconda Copper Mining company has relinquished its option to buy the Gold King mine five miles southwest of Wenatchee, Wash., from Lovitt Mining Company, Inc., according to Ed Lovitt, head of the latter firm.

Plans for developing the property have been dropped by the ACM firm after more than two years of exploratory work.

The mine now reverts to the Lovitt company. Operations will be continued at the rate of about 150 tons of ore a day, Lovitt said. About 80 per cent of the mine output is silica, with a gold content of about $20 per ton, he stated.

Cyprus Mines Continues Exploration Of L.D. Mine

WMN 5/21/76

Cyprus Mines Corp. will continue exploration work at the LD gold mine south of Wenatchee, Wa. to evaluate encountered mineralization and determine whether the mine will once again be of commercial value.

Gene Allen, vice-president of technical operations, said, "It will take another four or five months of work before we'll know if the LD is commercial." He said the exploration work began in mid 1975 and, "we are about on our planned schedule."

According to Allen, there is mineralization in the LD, sometimes known as the Lovitt-Day Mine, and the grade of ore encountered so far has been consistent with previous analysis.

Day Mines Inc. last operated the LD in 1967 and mined ores which assayed .25 ounces of gold per ton and lesser amounts of silver.

Allen would not say if Cyprus has prepared designs for additional facilities but said that after the exploration work is complete at summer's end, consideration of a metallurgical facility would be a logical step.

The LD is one of two domestic gold prospects which Cyprus and AZCON Corp. are studying under a joint venture agreement.

Zinc Price Up

The Bunker Hill Co. announced last week a one cent per pound increase for all zinc die-casting alloy products.

The new price for No. 3 and No. 7 alloys will be 45½ cents per pound.

...watus, whom the government has pledged to protect from such exploitation," the department said.

WM 6/3/76

Wenatchee's LD Mine To Be Re-Evaluated

Cyprus Mines Corp. will continue exploration work at the LD gold mine south of Wenatchee to evaluate encountered mineralization and determine whether the mine will once again be of commercial value, according to a Spokane report.

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The LD is one of two domestic gold prospects which Cyprus and AZCON Corp. are studying under a joint-venture agreement.

Late in 1975, the Los Angeles-based Cyprus closed its Spokane exploration office to concentrate its exploration efforts in other parts of the West.

Allen said Cyprus and AZCON are spending "substantial sums" on investigation of the two gold prospects.

Engineering and Mining Journal, December 1965, page 134

EMJ—Volume 166, No. 12

L-D Mines is undertaking a $133,260 exploration project at its "B-Reef" gold-silver ore deposit near Wenatchee, Chelan County, under a 50% Office of Minerals Exploration loan. The contract provides for shaft sinking, drifting, crosscutting and long-hole drilling.

Washington's second-largest gold producer, L-D Mines is a joint venture of Lovitt Mining Co., of Wenatchee, and Day Mines Inc., of Wallace, Idaho.