Quicksilver Deposits Near Weiser, Washington County, Idaho

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QUICKSILVER DEPOSITS NEAR WEISER, WASHINGTON COUNTY, IDAHO

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ABSTRACT

The quicksilver deposits in the general vicinity of Weiser, Washington County, Idaho, were first recognized about 1936. They are in an agricultural community with almost no previously known evidence of the presence of metallic lodes. A deposit opened in 1939 became by the following year one of the leading quicksilver producers in the United States. The mine was operated by the Idaho Almaden Mines Co. through December 1942. As yet none of the other quicksilver deposits in the district has become productive and there has been little mining activity since 1943.

All of the deposits are of the opalitic type, and are in sedimentary rocks of Tertiary age, which have been altered along fractures and in zones of tension by hydrothermal solutions. The principal shoots, which have been mined, are under a cover of relatively impermeable rock. Silica and clay minerals were formed in several pulses of mineralization, during which the grains composing the sedimentary rocks were dissolved and contributed their constituents to the minerals of the opalite. The opalite is finely brecciated, apparently in part because of swelling and contraction of colloidal gels. Cinnabar was introduced during each of the pulses of mineralization, but principally in the last one.

The district has promise for the future, as the mining and prospecting already done have not exhausted the possibilities. When economic conditions warrant, it will be worthwhile to search for cinnabar in areas of sedimentary rock that show evidence of opalitization. In 1942 at the close of productive activity much low-grade material was known to have been left unmined, but there may remain ore as rich as that already mined.

INTRODUCTION

The quicksilver deposits near Weiser, Washington County, Idaho, (fig. 7) appear to have been first discovered about 1936. Soon thereafter one mine became, for a few years, one of the country's leading quicksilver producers; it still has possibilities of future production. The delay in recognizing the quicksilver lodes resulted largely from the fact that the mineralized outcrops are inconspicuous and have few features commonly regarded as characteristic of metallic mineral deposits. The deposits occur in an agricultural community, but metal-mining districts are close by. Experienced mining men would not

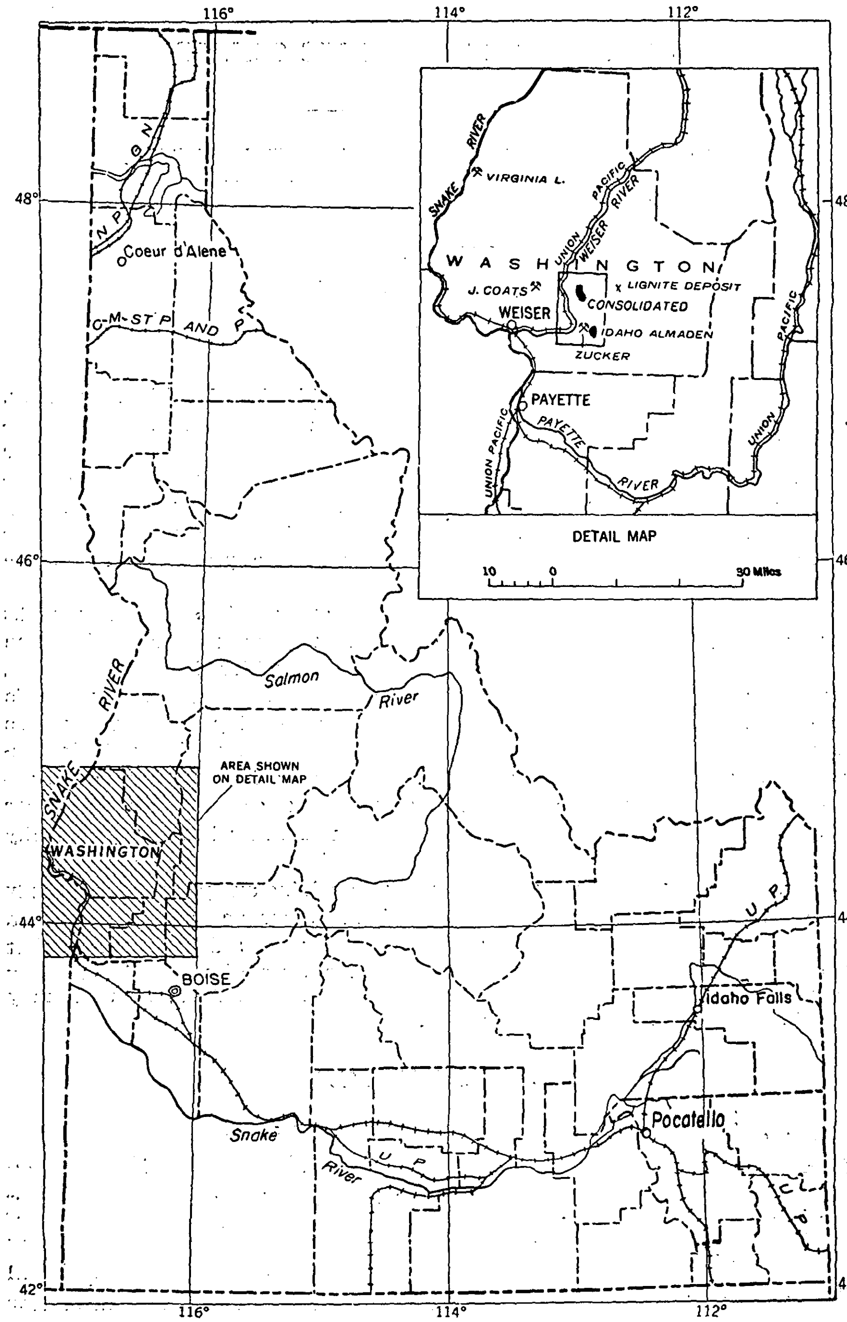


FIGURE 7.—Index map showing location of the principal quicksilver deposits near Weiser, Washington County, Idaho.

have expected to find ore deposits in the lava flows and soft sedimentary beds of the area.

LOCATION

The principal quicksilver deposits are immediately east of the Weiser River, which here flows south near the common boundary of T. 11 N., R. 3 and 4 W. (pl. 4). This area is served by the New Meadows branch of the Oregon Short Line (Union Pacific System), which joins the main line at Weiser. County roads near Weiser have recently been paved, others are gravel-surfaced with many dirt roads leading from them. The Idaho Almaden mine, the only significantly productive mine in the district, is at the south end of this area and 15 miles by road from Weiser.

Plate 4 shows the topography of this area and the position of the principal mines and prospects. This map is compiled from the map of Weiser Cove quadrangle published by the U. S. Geological Survey in 1952 and from manuscript copies of parts of adjacent maps. The township lines shown on plate 4 are projected from data on the map of the Weiser Cove quadrangle.

Cinnabar has been reported also from prospects (fig. 9) in the southeastern part of T. 12 N., R. 5 W. along U. S. Highway 95 about 8 miles north of Weiser (fig. 7). Some of these prospects were originally opened in search for gold. Quicksilver has also been found in a prospect in T. 15 N., R. 6 W. near the Snake River (fig. 7).

SCOPE OF THE REPORT

The studies here summarized were carried out mainly in 1941 as a part of the strategic minerals investigations of the U. S. Geological Survey. The data were used in exploration made by the U. S. Bureau of Mines and are of interest in connection with any future explorations for the metal in southwestern Idaho. Quicksilver lodes somewhat similar to those near Weiser are widespread in northern Nevada and southeastern Oregon, and some, without present known commercial value, have been noted by the writer also in parts of Owyhee County, Idaho.

During the summer of 1941 an area that includes the principal quicksilver deposits east of Weiser was studied by C. H. Dane, Jr., assisted by R. P. Full; they also visited the prospects in T. 12 N., R. 5 W. and T. 15 N., R. 6 W. At the same time the writer mapped and studied the properties then held by the Idaho Almaden Mines Co. and the Consolidated Quicksilver Mining Corporation, and visited nearby prospects. The writer was assisted by R. P. Full in the planetable surveying; Full also participated in the underground work.

Since 1941 the area has been revisited several times. In June 1943, the writer, assisted by N. W. Balcom, mapped the then-existing workings at and near the Idaho Almaden mine. At that time work was in progress at the Zucker group, northwest of the main workings of the Idaho Almaden mine;[1] therefore the planetable map was extended to include that part of the Zucker group in which there was activity. In June 1954, the writer, assisted by Jack Terry, visited other parts of the district and further extended the map.

ACKNOWLEDGMENTS

Cooperation was received throughout the investigations from the Idaho Almaden Mines Co., represented by its president, L. K. Requa, and superintendent, Reginald Lee. Dr. J. C. Bartlett, who represented the owners of the Idaho Almaden property, was most cooperative. Dr. F. L. Richardson, president of the Consolidated Quicksilver Mining Corporation, and those interested in the other properties visited were likewise cordial and helpful. Data on production and assay values given in the present report are based on the records of the Idaho Almaden Mines Co., released through the courtesy of the present owners.

Clarence S. Ross of the Geological Survey identified the constituent minerals of the clay aggregates and aided in evaluating their significance. K. E. Lohman, F. S. MacNeil, R. W. Brown and D. W. Taylor furnished paleontologic information. C. A. Ecklund made the compilation of plate 4 possible by furnishing data in advance of publication.

PREVIOUS WORK

Several valuable geologic reconnaissances have been made in this part of Idaho, notably that by Lindgren in 1897 (Lindgren, 1900, 1901) and those by Washburne (1911) and Buwalda (1923). Kirkham's work on water supply at Weiser (Kirkham, 1928) added details. Kirkham (1930; 1931a, b, c; 1935) later mapped and described a large area that includes all the cinnabar deposits here described. His work constituted a distinct advance in the study of the Tertiary and Quaternary history of the region. However, the present studies, which are more detailed and cover a much smaller area, differ from Kirkham's in enough respects to emphasize the need for further structural and stratigraphic work.

In addition to the general papers just cited, three that summarize the early work at the Idaho Almaden mine are available. These are a news note written soon after production started (Mining World, 1939), followed soon by an account of operations written by the president of the company (Requa, 1940), and somewhat later a geo-

[1] Mining at the Idaho Almaden mines is reported to have been resumed in 1955 and 1956 by the Rare Metals Corporation of America.

logic study made for the Idaho Bureau of Mines and Geology (Anderson, 1941). Reference should also be made to notations in the annual reports of the Idaho Inspector of Mines for 1939 through 1943 (Campbell, 1942 and 1944).

GEOGRAPHY

The quicksilver deposits here described are in the low hills north of the west end of the Snake River plain. These hills are drained by the Weiser River and its tributaries. The Weiser River enters the Snake River near the city of Weiser at an altitude of about 2,110 feet above sea level. Some of the hills are flat topped and steep sided but many have gentle slopes. On the whole, the topography is far more subdued than that of most areas in central Idaho. Nutmeg Mountain (altitude 3,735 feet) is one of the highest hills in the vicinity of the quicksilver deposits. Farther east and north, mostly beyond the limits of the area shown in plate 4, some summits rise over 4,000 feet above sea level. The upper reaches of the Weiser River flow through canyons but within the area (pl. 4) the river valley broadens sufficiently to permit some farming and west of that area, toward Weiser, the valley is even wider and more intensively cultivated.

As the mean annual precipitation is little more than 11 inches, uncultivated land has a somewhat scanty cover of grasses and sagebrush, with trees only in favored spots. However, the soil of the large valleys responds so readily to cultivation under irrigation that favorably situated parts of Washington County contain many ranches, dairy farms, and orchards. The county, with an area of 1,479 square miles, had a population of 8,853 according to the 1940 census and 8,576 according to the 1950 census. Weiser, the county seat, had a population of 3,663 people in 1940 and 3,961 in 1950, and is a center of trade for a wide area that stretches beyond the county limits.

GEOLOGY

STRATIGRAPHY AND LITHOLOGY

The most abundant rocks near Weiser are moderately consolidated sandstone and siltstone or shale with subordinate conglomerate. Basalt flows are intercalated in these, and a few small dark dikes have been noted. The bedrock is masked by alluvium in the valleys and by landslide debris on some slopes.

The sedimentary rocks are largely arkosic, but locally include some tuffaceous material and a few diatomaceous beds. They are stream, fan, and pediment deposits broadly similar to those forming in modern valleys. Beds of lignitic coal crop out along Crane Creek several miles to the east (fig. 7). The coal beds have little economic value under present conditions. They indicate that the Tertiary valley fill included some swamps. Ponds or lakes may also have been present locally. The arkosic material was probably derived from the Idaho batholith, whose west border is exposed along the North Fork of the Payette River about 35 miles east of Weiser (fig. 7).

Plant fossils were collected by Dane in 1941 in sec. 31, T. 11 N., R. 3 W. and were reported by R. W. Brown to include *Zelkova oregoniana* (Knowlton) Brown, *Quercus columbiana* Chaney, and *Salix inquirenda* Knowlton. Brown noted that "These species are common Miocene elements in Idaho and Washington," probably middle or upper Miocene in age. Paleobotanists are inclined to believe that the flora to which these plants belong indicates a climate more humid than the present one in the region (Axelrod, 1950).

Fossil shells collected by Dane were examined by F. S. MacNeil. He found that a collection from near the Idaho Almaden mine on Nutmeg Mountain contained

Goniobasis sp. aff. *G. taylori* (Gabb) and *Goniabasis* sp.?, a gigantic form of nearly four inches in length and lacking the axial structure characterizing *G. taylori* with which the smaller specimens are compared.

The second collection came from about 4 miles north of the Idaho Almaden mine, south of Crane Creek and at an altitude of roughly 2,500 feet; in it MacNeil found *Campeloma* sp., *Vorticifex* cf. *binneyi* (Meek) and *Sphaerium* cf. *idahoense* Meek. MacNeil, whose communication was dated January 12, 1942, was not then in a position to assign an age to the fossils he listed. D. W. Taylor had recently made studies pertinent to the problem so the list was sent to him for comment. His reply, dated October 8, 1954, suggested a Pliocene age.

Dane collected diatomaceous material close to the spot where he got the second collection of fossil leaves referred to above. K. E. Lohman (written communication, February 1955) stated that he recognized 64 kinds of diatoms. He commented that the assemblage of fresh-water diatoms he identified is characteristic of a large, cool, and fairly deep lake. The diatoms are mixed with volcanic ash in about equal proportions, which suggests light but continuous ash fall during the time interval represented by the collection. Many of the larger diatoms are broken, with sharp, jagged edges. Lohman suggested that they might have been broken during compaction of the material into rock or that the broken diatoms might have been derived from some older diatomaceous sediment.

With reference to the age of the deposit Lohman commented as follows—

This assemblage is unusually diverse in character, as it contains a few species which in other localities are restricted to fairly short periods of geologic time, coupled with many long ranging species that range from Miocene to Recent. The most diagnostic extinct species, and also the most abundant in this assemblage is *Melosira solida*, which reached its heyday in early to middle Pliocene time and has never been found in Pleistocene rocks. *Gomphonema grovei* is another species with a similar history and which occurs frequently in this assemblage. Several of the un-named species are ones which I have found in rocks of Pliocene age in other localities. The unusual preponderance of long ranging species makes an age assignment of this collection dependent upon the small proportion of species considered to be definitive and reduces the certainty with which such an assignment may be made. With these uncertainties expressed, the most probable age assignment is early to middle Pliocene.

Kirkham (1930) assembled data on the Tertiary strata in this part of Idaho. He said the Payette formation (Miocene of Kirkham) is interbedded with the Columbia River basalt and in most places it underlies the upper flows of the Columbia River basalt. On this basis his generalized map shows the sedimentary rocks east of that part of the Weiser River shown in plate 4 of this report as belonging to the Payette formation, whereas it shows those to the west of the river as belonging to the Idaho formation which he regarded as Pliocene(?). In this report the sedimentary rocks are assigned simply to the Tertiary, leaving more precise subdivision and age assignment to future work.

The only other pre-Quaternary rock extensively exposed is the basaltic lava. Kirkham's map shows this as part of the Columbia River basalt. The lava generally resembles that formation and Kirkham's assignment is assumed to be broadly correct for the region he mapped. However, the correlation of the flows within the area (pl. 4) is subject to the same uncertainties as the enclosing sedimentary beds. Like the enclosing rocks, the flows are, of course, Tertiary in age. A few dark fine-grained dikes have been noted.

Large areas are covered by alluvium and hill wash. Landslide debris is fairly plentiful.

STRUCTURE

Kirkham (1931a, b, c) concluded that Tertiary rocks near Weiser are flexed into subparallel irregular folds that trend northwestward. He mapped four anticlines, with their corresponding synclines, from Weiser past the east border of the area (pl. 4), but showed no faults. In an earlier paper Kirkham (1928) reported more than 10 nearly parallel folds in the vicinity of Weiser. He said these strike N. 45° W. and plunge southeast. In contrast, Dane believed that normal faulting dominates the structure. He believed faults trending northwestward are closely spaced in the area (pl. 4). These faults are variable but most strike N. 20°–30° W.; some are inferred to dip northeast, others southwest. The rather ill-defined folds on Nutmeg Mountain strike northeast, presumably a local feature. Buwalda

(1923) referred to folds near Weiser and in other localities in the general region but emphasized that they are irregular and discontinuous, commonly with low dips. Washburne (1911) similarly suggested that the folds are poorly defined and agreed with the results obtained on Nutmeg Mountain during the present investigation.

QUICKSILVER DEPOSITS

Cinnabar was apparently first recognized in this area in 1936 on Nutmeg Mountain, although the mineral is reported to have been noted by placer prospectors in the surrounding region much earlier. The Idaho Almaden Mines Co. at Nutmeg Mountain was among the leading quicksilver producers in the United States from 1939 through 1942; it had a total output of nearly 4,000 flasks of quicksilver derived from nearly 53,000 tons of ore. This company closed down at the end of 1942 and no other has yet produced. From 1943 through 1954 mining was confined to sporadic prospecting, mostly on and near Nutmeg Mountain, where in 1954 the only work was being done.

Most of the quicksilver lodes are in zones in the sedimentary rocks that, through introduction of silica and clay minerals, have been converted into the material commonly called opalite, which is an aggregate formed by replacement; it consists largely of chalcedony and other silica minerals, and is so fine grained as to have an opaline appearance. The distribution of these zones is indicated in plate 4. Within the opalitized rocks relatively small portions, mostly roughly accordant with the bedding, contain cinnabar. In and near these are a few irregular steep fracture zones that contain high-grade cinnabar veinlets. These fractures have not yet yielded any large quantities of ore.

MINERALOGY

The deposits contain cinnabar, pyrite, opal, chalcedony, and clay minerals, mingled with unreplaced constituents of the original sedimentary rock. Locally, a little limonite is present.

The cinnabar is everywhere fine grained, and is exceptionally so in some of the high-grade stringers; but it is still coarse enough so that individual grains, some with crystal faces, can be discerned with a hand lens. Throughout the district most of the cinnabar has rounded grains and dendritic, incipient crystals with maximum dimensions of 0.1 to 0.001 millimeter. Although the microscope shows that many, if not all, of these tiny grains line cracks and coat different kinds of surfaces, the grains are so fine and so scattered that much of the opalite has a faint vermilion tint that results from cinnabar particles not visible at low magnifications.

Pyrite is the only other metallic mineral detected. It occurs in minute grains that are generally partly altered, and is visible in only a few places, mainly in the more veinlike lodes. Assays show that much of the cinnabar ore contains about 0.01 ounce of gold to the ton; one small sample assayed 0.16 ounce to the ton. These small quantities of gold, too small to be of commercial interest, may be associated with the pyrite. North of Weiser are quicksilver prospects that were originally opened for gold, which may have occurred likewise in pyrite. The local limonite stains in the opalite are derived in part from altered pyrite.

Opal in rounded to irregular aggregates, locally with colloform banding, is fairly abundant. Probably much of the clay contains opal so finely dispersed that it cannot be recognized with certainty. Most of the clear opaline aggregates, comparatively free from other minerals, show dessication cracks. It is doubtful if any of the opalitized rock now contains as much as 50 percent opal. However, much of the silica may have been originally deposited as opal, followed by partial crystallization later.

Chalcedony is widespread and locally may be the most abundant constituent of the opalite. The walls of cavities are coated with chalcedony, which forms small irregular commonly radiate masses that appear to invade and replace the mixtures of opal and clay. Possibly the chalcedony was formed in part by recrystallization of preexisting opal. Chalcedony is the principal gangue mineral in the steep stringers in fracture zones.

The part of the opalitized rock that contains cinnabar also contains clay minerals, locally well over 50 percent. Close to the surface the altered rock is so dried and hardened that its clay content is not perceptible on casual inspection. Perhaps this accounts for the apparent paucity of clay minerals in opalite not exposed in prospect cuts. In underground workings, such as the main workings of the Idaho Almaden, the abundance of soft moist clay is obvious.

The most abundant clay mineral is beidellite. This mineral when pure has the formula $Al_2O_3 \cdot 3SiO_2 \cdot nH_2O$, but here, as in many other places, that molecule is isomorphously mixed with variable proportions of the nontronite molecule, $Fe_2O_3 \cdot 3SiO_2 \cdot nH_2O$. Some of the beidellite contains enough ferric iron to make it a distinct greenish-yellow. Kaolinite ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) is present in some of the opalitic rock, particularly that which is soft, nearly white, and obviously claylike. Halloysite, which is similar in composition to kaolinite but is isotropic, has been noted in a few places.

The minerals above enumerated probably include all those formed in significant quantities during mineralization. Quartz, feldspar, and mica remain in varying amounts in the opalitized sandstones. Small sparse grains of zircon and tourmaline in the opalite are probably also residual from the original sandstone. Similarly, tuffaceous and shaly rocks that are now opalitized retain some of their original constituents.

OPALITE

CHARACTER

The cinnabar deposits are all within parts of the sedimentary rocks that have been more or less completely altered to opalite. The altered rock in this area (pl. 4) contains, at least locally, more clay than most of those deposits called opalite in other quicksilver districts. Opalite is a more appropriate name for the rocks of this area than it is for rocks of many other areas, including those of the type locality (Yates, 1942, p. 323–339), the Opalite district in Oregon. Near Weiser much of the opal remains unaltered, whereas, in the Opalite district the silica is mainly chalcedony, perhaps originally deposited as opal.

The opalitized masses are irregular, both in form and in degree of alteration. Most are thought to be near faults but they are rarely bounded by fracture planes or other definite limiting features. The larger and more intensely altered masses are mostly in flat or gently inclined beds. They constitute blanketlike bodies that conform roughly with the bedding of the host rock and pass gradually into unaltered material at the borders. Where the beds are steeply inclined, however, the opalitic material tends to remain nearly horizontal rather than to reach out far down the dip of the beds. (See plate 5.) On the other hand, where the rocks have not been extensively opalitized, small masses of intensely opalitized rock are steep and accord with fractures rather than with bedding planes. This is illustrated at the principal prospect in T. 12 N., R. 5 W., where a fracture zone in slightly opalized shale is followed by opalite that widens upward. Similarly, the elongate opalite bodies (pl. 8) may be controlled by fractures or joints. Their shapes do not appear to correspond to the bedding.

In other places, notably in and near the upper quarry and the eastern part of the underground workings of the Idaho Almaden mine, all sides of joint blocks are altered, leaving the rock in the core of the blocks comparatively unaffected. The alteration here simulates the effects of weathering in producing curved exfoliation shells. Where the effects of this process are conspicuous the rock superficially resembles a conglomerate with boulders of arkose embedded in altered material.

The character and degree of opalitization change from place to place. In slightly altered rock, generally outside the ore zones, the cement of the sandstone has been replaced by opalitic material; which in some places is mainly opal, and in other places is mainly chalcedony. Clay minerals where present are not conspicuous. The material added is more voluminous than the original cement so that the detrital grains are moved and broken. In moderately altered rock the original constituents, other than quartz, have begun to be destroyed. Even the quartz grains are rounded and embayed, and many are broken into sharply angular fragments. In more highly altered rock the feldspar and most of the mica are gone and the formerly abundant quartz grains are reduced to tiny splinters scattered through a medley of opal, chalcedony, and clay minerals. This aggregate was irregularly broken and converted into a complex breccia.

Apparently, as Anderson (1941, p. 6) had suggested, some opal consolidated early and is now represented by comparatively clear rounded to irregular bodies 1 to 2 millimeters in maximum dimensions; these are embedded in a mixture of opal, clay, and chalcedony and have highly irregular textures that are in part distinctly colloform. This mixture is also brecciated and the component fragments of different shapes and sizes are embedded in and tend to merge into surrounding material of similar composition. In the fragments of supposedly early opal other minerals are comparatively rare; thereby they differ from other fragments. Dessication cracks are more conspicuous in the clear, early opal than in the surrounding mixtures. Much of the chalcedony in the opalitized rock coats the walls of openings. This mineral is a major constituent of the filling of many of the mineralized fractures that are at a distance from the opalitic ore bodies.

Cinnabar is distributed unevenly through the opalitized rock. In most of this rock it is far too sparse to be visible; and only those portions of the opalite that contain visible cinnabar have proved rich enough to be mined. Opalite with less readily detectable cinnabar may be mineable under different economic conditions. In the ore bodies cinnabar is present in the fragments of supposedly early opal, though in such minute and sparsely distributed grains as to be difficult to find even under the miscroscope. It is somewhat more abundant in the embedding mixtures—mainly on grain boundaries, the surfaces between colloform bands, and as linings of other openings. A large part, probably more than half, of the cinnabar in the ore fills cracks that formed during and following the consolidation of the opalitic gangue minerals. Anderson (1941, p. 7, pl. 3) noted that the cinnabar appears to have entered the cracks by replacement. In some localities the spaces between exfoliation shells surrounding residual joint blocks are filled with cinnabar. In veins in the fracture zones outside the opalitic ore bodies cinnabar forms layers several millimeters wide.

Many of these are approximately parallel to the vein walls and tend to be more abundant close to the walls than in the center of individual veinlets. Some of these cinnabar layers have pronounced colloform texture.

DISTRIBUTION

The principal masses of opalitized material in the area that contains most of the lodes are indicated in plate 4. In addition small areas in the sedimentary rocks in T. 12 N., R. 5 W. and in other localities in the region around Weiser are partially opalitized. So far as known, however, these are neither as large nor as thoroughly altered as those within this area (pl. 4). Within the mapped area the opalitized masses are so distributed as to suggest that faults served as channels along which the mineralizing solutions rose, a suggestion that is in harmony with Dane's work. Support for this concept is furnished by the fact that tests by means of the ultraviolet lamp and willemite screen show that traces of quicksilver are present along fault fractures and breccias, which were noted by Dane; although, similar rocks remote from faults react negatively to this exceedingly delicate test for quicksilver. A number of the rocks that react positively to this test are not visibly opalitized. Exceptionally, fault breccias at a distance from known ore bodies contain enough cinnabar to be visible; of these some are in basalt, although no ore is known in basalt anywhere in the region.

The known opalitic masses that contain enough cinnabar to be of commercial interest contain fractured, sheeted, and brecciated zones. The impression that they are more broken than lower grade masses may be deceptive; perhaps it is only that mine openings give better exposures. Further, and more significantly, part of the fracturing in the more intensely opalitized areas results from structural instability there. Changes related to conversion of opal into chalcedony and volume changes in the clays would produce late-stage fractures. Both would be more plentiful in and near ore bodies than elsewhere. Such changes began long before mineralization ceased and relatively abundant fractures, irrespective of origin, contributed to the concentration of cinnabar in the fractured areas. On the other hand, none of the known ore bodies is on a major fault as is evidenced by the absence of large faults. (See plates 5 and 8 and figure 9.) The walls of such faults may have been tightly pressed together and any openings that remained were filled with gangue so as to be comparatively impermeable before the cinnabar solutions circulated.

The only quicksilver ore bodies so far profitably mined in the region are along the crest of the transverse uplift that underlies Nutmeg Mountain. Plate 5 shows the uplift to be poorly defined. Several short synclines are plotted but in large parts of the uplifted areas

MAIN QUARRY OF THE IDAHO ALMADEN MINE

View taken from the ore bin on west border of quarry. Man is tramming toward portal of drift 102; portal of drift 103 is to his right rear, and broad opening on lower level leads into stope A. Some of the fractures (f) above stope A are visible, which illustrates the fact that displacements are small. The dark bed at the top of the quarry wall, in the middle distance, is the cap rock. Above cap rock is sandstone (ss). Photograph was taken on August 22, 1941.

between the synclines the beds remain flat or nearly so. Nevertheless, the rocks of the crest of Nutmeg Mountain were put under tension by the uplift so that whatever fractures existed tended to be open, facilitating passage of solutions through them. The mountain has a complex fracture system whose components are clearly visible only in fresh mine openings. (See plates 5 and 6.) Most of the faults (pl. 5) have no apparent relation to the large northwestward-trending faults that Dane regarded as dominant in the regional structure. From the eastern part of Sly Park No. 5 claim to about the center of Weiser Cove No. 1 claim, exposures of sheeted and slickensided sandstone are thought to mark the positions of faults (pl. 5). Attention was first called to these by a series of nearly straight bluffs a few feet high, too small to be reflected in the contours on the map. The displacements along the faults were not large enough to bring unlike units against each other or to produce major shear or breccia zones. As the structure sections show, they are thought to be similar in magnitude to the fractures exposed underground, most of which have small, almost undetectable, offsets. The bluffs result from especially intensive silicification along the faults; this has made the sandstone along the faults more resistant to erosion than the sandstone at a distance from faults, even though the latter is also altered. Such features may well be independent of amount of displacement.

In the area occupied by the main mine workings, fractures or faults that trend about N. 60° W. and have vertical displacements of a few inches to a few feet are plentiful though apparently discontinuous. Those visible in the summer of 1941 are shown in plate 6 and in a much more generalized fashion in plate 5. A fault, or possibly several closely associated fractures, of this group bounds the main Idaho Almaden ore body on the north. On and near the Missouri and Ibex claims farther north, discontinuous fractures of similar trend are exposed.

A less prominent and abundant group of faults has a trend of about N. 15° W. These are clearly recognizable only in mine workings (pl. 6) and only a few have been mapped even there. The topographic break that passes east of the upper quarry and west of the high ridge that begins in the northeast corner of the Rimrock claim may mark the presence of a fault of this group. Such a fault (pl. 5) would help to account for the fact that an isolated body of cap rock is exposed at the site of the water tank nearly 50 feet higher than the nearest exposure of the large cap rock body near the main workings. On the other hand, no evidence of such a fault has been found in the exposures along the steep flanks of Nutmeg Mountain. The faults of N. 60° W. trend and those of N. 15° W. trend contain cinnabar in enough places to show clearly that they are of premineral origin although they also show abundant evidence of postmineral movements.

Minor fractures of other trends, most of which are so small that they are not mapped, cut the opalite. These include the cinnabar-lined cracks in the ore bodies. In the underground workings of the Idaho Almaden the more systematic of these trend northeasterly, almost normal to the long axes of the ill-defined masses that make up the ore body.

In addition to the fractures, the thin somewhat opalitized shale bed, called cap rock by the operators, that overlies the main Idaho Almaden ore body (pls. 5 and 7) may have been a potent factor in localizing the cinnabar. This bed forms a sharp upper limit of the ore body, whereas the lower limit is determined solely by decreases in the cinnabar content of the opalite (Requa, 1940, p. 8). Thus, the local conditions correspond closely to the "structural traps" which Schuette (1931, p. 406) regarded as essential to the formation of commercially valuable quicksilver ore shoots. While the shale cap rock probably did aid in concentration of the cinnabar in the only ore body so far successfully mined in the area, it should be emphasized that this does not imply that prospecting in the general area should be confined to places where a cap rock is thought to exist. So far, the main Idaho Almaden ore body is the only one known to have a cap rock above it, yet cinnabar in significant quantities is known in other parts of Nutmeg Mountain and in several other places in the district. In general, cinnabar ore shoots may form under many conditions. The one condition that seems essential is that at the time of mineralization ready passage of solutions into the rock being mineralized was possible (Ross, 1942, p. 454–459).

ORIGIN

The opalite and its contained ore bodies result from the effects of mineralizing solutions on the sedimentary rocks. The solutions rose along faults and fractures and the attack on the rocks was at an unknown but probably shallow depth. There were several pulses of the mineralizing solutions in which differences in composition and in the conditions governing precipitation were such that silica minerals, mainly opal, may have predominated in a poorly defined early stage, mixtures of silica and clay minerals in intermediate stages, and cinnabar with or without silica in the final stages. Some cinnabar accompanied each pulse of mineralization; and in each stage it tended to consolidate after the gangue minerals. Variations in the different factors involved produced diversity in details. Special structural conditions, such as zones of tension and traps produced by impermeable beds, appear to have resulted in especially thorough alteration in a few places. Presumably ore shoots were formed wherever openings suitable for the free passage of solutions were available during the late stages in the sequence of mineralization, during which cinnabar could be deposited in relative abundance. As only a single mine has been opened, and even there most of the exploration was very shallow, the factors that may have influenced the formation of ore shoots cannot be satisfactorily evaluated. Any body of opalitized sedimentary rock that shows evidence of fracturing would be worthy of prospecting.

The prevalence of opal and of clay minerals among the products and the abundance of colloform textures indicate that colloidal conditions prevailed during mineralization. These conditions may account in part for the repeated brecciation that has occurred in blanket or mantolike deposits which do not appear to have suffered major deformation during mineralization. Colloid gels may swell by imbibition of water and exert marked pressure in doing so (Ware, 1930, p. 250–255). Apparently, opal would not contribute markedly to volume changes related to imbibition as silica gel is reported to hold only one H_2O to one SiO_2 and to be one of the "rigid" gels that swell only slightly when immersed in liquid (McBain, 1950, p. 168–170). Clays, however, would be expected to swell markedly in water (McBain, 1950, p. 394; Marshall, 1949, p. 162–164).

It seems probable that volume changes in the colloids may have occurred several times and in different ways in the course of the intermittent mineralization. The water taken up by the gels may have come in part from rising hydrothermal solutions and in part from surficial sources. Changes in chemical and physical conditions that result from variations in composition, quantities, temperatures, and other factors which affect the water from different sources contributed to the complexities.

Although imbibition produces gel swelling the net result is a decrease in the total volume of the mixture of gels, liquid, and crystalline matter. Consequently movements of adjustment along fractures and subsidence in weakened areas took place. Later, when the water drained off, the gels dried and shrunk. Silica gel shrinks markedly when water is removed from it (Herman, 1949, p. 529–536). It appears from Herman's discussion that sorption and swelling effects in gels are complex and imperfectly understood. Under the conditions connected with the process of opalization they may well have been adequate to cause or contribute to the origin of shallow structural basins like those at the Idaho Almaden mine. This concept implies that a basin within an area of opalitization may be caused by particularly intense mineralization and hence, deserves prospecting.

The beidellite in the opalite may have formed concomitantly with the silica minerals and the cinnabar, but the locally conspicuous kaolinite probably formed in a more acid environment. Most deposits of kaolinite are thought to result from weathering rather than hydrothermal agencies. The opalitic lodes, like many other quicksilver lodes, were formed at such shallow depths that acid vadose water may have mingled with the hydrothermal solutions in the course of the original mineralizations; therefore sharp distinctions between hypogene and supergene effects cannot be drawn.

OUTLOOK

Quicksilver mining in the general vicinity of Weiser had come to an end by the summer of 1943, except for minor prospecting in part by bulldozing. The latter has continued intermittently but late in 1954 had not yet resulted in new production of record. In the sole productive mine, the Idaho Almaden, known ore bodies of a tenor regarded by the operators as profitable have been exhausted and all equipment removed. Small but rich veinlets on and near the Sly Park No. 5 claim have been mined. Other broadly similar veins on and near Nutmeg Mountain probably remain unmined and some of these might repay operation by a few men, using retorts. The ground bordering the main Idaho Almaden excavations on the southeast is known to contain cinnabar. On the basis of drill holes, shafts, and trenches, the Idaho Almaden Mines Co. estimated that this ground contains about 100,000 tons of opalite with a content of between 2 and 3 pounds of quicksilver to the ton. A test run of 200 tons of this material through the furnace yielded 2 to 6 pounds to the ton. An area west of the main workings has so many geologic features similar to those of the ore body mined by the Idaho Almaden Mines Co. as to warrant more investigation than it has yet received. The characteristics on which this suggestion are founded are outlined in the description of the mine.

Exploration by bulldozer cuts and shallow drill holes on Sly Park Nos. 2, 3, 4, and 5 claims on the northern part of Nutmeg Mountain was carried out from 1952 through 1954 by Dr. J. C. Bartlett and associates with results reported by him to be encouraging (Bartlett, written communication, October 1954). Thus, there is enough cinnabar in that area to warrant consideration.

Other localities are known to contain cinnabar and the possibility of new discoveries remains. Prospecting in the district has been by no means exhaustive. Many of the cinnabar-bearing masses that remain are low grade but resumption of quicksilver mining in the district might well result in significant production. Quicksilver mining in general is subject to fluctuations in price and demand but should the high prices obtained in the fall of 1954 persist this district may well have a revival.

MINES AND PROSPECTS

IDAHO ALMADEN (OSA ANNA) MINE

The property known as the Idaho Almaden mine is on Nutmeg Mountain about 13 miles east of Weiser. The common corner of secs. 4 and 5, T. 10 N., R. 3 W., and secs. 32 and 33, T. 11 N., R. 3 W., is near the center of the property. Its approximate position is indicated on plate 5 but the corner was not found during the surveying on which that map is based.

The first definitely established discovery of cinnabar in place in this part of Idaho was made on Nutmeg Mountain in the summer of 1936 by Harry Brown. During 1937 and 1938 claims were staked and the propery came under the control of Ethel Bartlett and Osa Anna Brown of Ontario, Oreg. They named it the Osa Anna. The property was leased in 1938 by L. K. Requa, and later the Idaho Almaden Mines Co., with Mr. Requa as president and general manager, was organized. The original group of 17 claims was gradually added to so that in 1941 the property included 30 claims, one of which was patented, and a little deeded land. Plate 5 shows only that part of the group on which mining has been done. The claim boundaries on this map should be regarded as approximate as not all corners were found.

A 50-ton Gould rotary furnace and other necessary equipment were installed. Production began May 18, 1939 and was essentially continuous until the mine shut down in December 1942. Development was so rapid that by the end of 1939 the mine was the seventh largest producer in the United States and in 1940 it was one of a group of 29 leading producers that together yielded 85 percent of the total quicksilver produced in the United States (Meyer and Mitchell, 1940, p. 669, and 1941, p. 656).

The total production obtained throughout the operation by the Idaho Almaden Mines Co. is given in the table below and is published with permission of Dr. J. C. Bartlett, who represents the owners.

Production of the Idaho Almaden mine

[Data from records of the U. S. Bureau of Mines, 1943]

Year	Tons treated	Flasks of quicksilver	Pounds recovered per ton
1939	8,457	1,040	9.36
1940	14,491	1,097	5.75
1941	15,748	991	4.78
1942	14,154	830	4.45
Total	52,850	3,958	
Weighted mean			6.27

The steady decline in the average tenor of the ore mined, coupled with the fact that extensive exploration by drill holes and shafts had failed to disclose much ore of satisfactory grade beyond the limits already mined induced the company to suspend operations at the end of 1942 and return the property to the original owners. In June 1943 the furnace and most of the buildings had been removed and the workings had begun to cave. At that time representatives of the owners were prospecting by means of shallow pits, mainly along the northern part of the crest of Nutmeg Mountain, where small veins conspicuously banded with cinnabar had been exposed. Veinlets on Sly Park No. 3 claim are reported to have yielded 20 pounds to the ton of quicksilver on assay. For some years after this little appears to have been done. A little work may have been carried on at the main workings as a map prepared about 1952 by Edgar Bailey of the U. S. Geological Survey shows some excavations not shown on previous maps. According to Dr. J. C. Bartlett (written communication, October 1954) he and G. N. Brown had a bulldozer working on Sly Park Nos. 2, 3, 4, and 5 claims from 1952 through 1954. The trenches on these claims (pl. 5) represent such of this work as had been accomplished prior to June 1954. The presence of cinnabar in several spots in these trenches is shown in plate 5.

When the mine was originally opened, the ore that cropped out at the surface was mined in a quarry or open cut which finally attained a length of about 270 feet with a maximum breadth of about 135 feet and a maximum depth of 30 feet (pl. 7). In addition there was a scraped and trenched area south of the quarry from which no ore was mined except for a sample lot of 204 tons which yielded 2.6 pounds of quicksilver to the ton. Prospecting was mainly by shafts and drill holes which served satisfactorily to indicate the material of mineable grade. Most of the shafts and holes were stopped less than 30 feet from the surface. One shaft was sunk 165 feet in the crushed rock of the fault zone near the west end of the northern margin of the quarry but disclosed only one slab of ore, 6 feet long, at a depth of 100 feet. A sample from this slab yielded 27 pounds to the ton on assay.

It was soon found desirable to undertake underground mining both because the overburden east of the quarry was too deep to remove economically and because of the protection from the weather thus given the miners. As the ore body was irregular, defined by assay limits, and had its greatest dimensions in the horizontal plane, the workings were necessarily unsystematic. In some of the underground work done the ore mined was two sets or more high. Where this was required (stope *A*, pl. 6) square sets were used. Elsewhere only such stulls and other timbers as were essential for safety were employed. Pillars were left in early stages and removed as mining progressed.

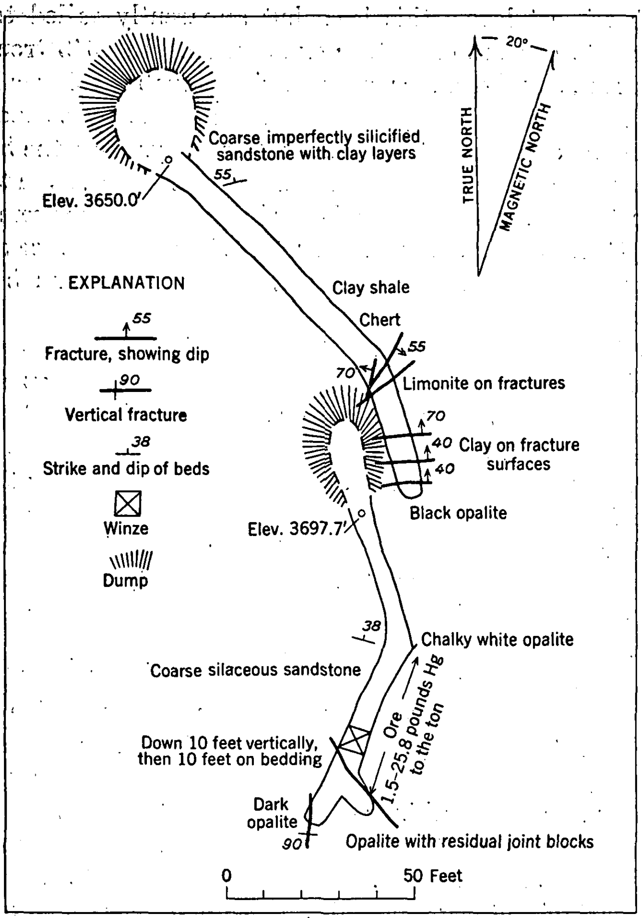


FIGURE 8.—Geologic map of the tunnels on the Sly Park No. 5 claim, Idaho Almaden mine.

In so far as possible mining was selective but eventually so large a portion of the material was removed that the ground above the entire area of underground workings collapsed. Caving is now so complete that any cinnabar that may remain would be difficult or impossible to obtain.

In addition to the main quarry and workings leading therefrom, some ore was taken from an excavation on the Rimrock claim known as the upper quarry, and from two short tunnels on the Sly Park No. 5 claim (fig. 8). The upper tunnel has now been converted into a narrow caved open cut perhaps in part by collapse of stopes above it. A shallow quarry has been excavated south of this cut, but no data as to the recovery from it, if any, are available.

Late in the summer of 1941 a shaft, called the North Shaft, was started in the hanging wall of the fault that bounds the main workings. During 1942 ore was mined at a depth of 75 feet below the collar of this shaft, about 40 feet below the bottom of the main quarry. A winze was sunk 67 feet below this level but apparently failed to reveal enough ore to encourage further exploration. In 1943 trenches on Sly Park Nos. 3 and 4 claims revealed rich cinnabar veinlets in a few spots. More recently this area has been explored by bulldozer cuts (pl. 5) and by drilling. It is reported that assays from the bulldozer cuts run as high as 20 and 34 pounds to the ton. Here, as in the main workings, the richest samples doubtless include cinnabar from narrow veinlets. So far as could be seen in June 1954 much of the rock exposed in the cuts is not markedly opalitized. Much of the cinnabar noted at that time was in the western parts of the cuts. (See pl. 5.)

Plates 5 and 6 are composite. Together they record all available data on the geology of Nutmeg Mountain and the workings accessible to the present writer. The geologic observations incorporated in both maps are those of the writer but the mine workings shown in them and also in figure 8 are based largely on maps furnished by the Idaho Almaden Mines Co., and represent conditions existing in 1941 and 1943 rather than those of the present. As plate 5 represents three separate planetable surveys without sufficient control points to tie the three together with a high degree of precision minor errors of adjustment between the three parts presumably exist.

All of the cinnabar in the Idaho Almaden is in shoots within masses of opalitized sandstone, the opalite being far more extensive than the mineable ore. The principal ore body is the irregular, roughly horizontal mass, or assemblage of interconnected ore shoots, mined in the main quarry and workings connected thereto. This body is in a shallow structural and topographic depression on the crest of the poorly defined anticline of northeasterly trend that occupies the southern part of Nutmeg Mountain. The ore is beneath an opalitized shale bed, which is termed caprock by the operators. The anticline is cut by fractures or faults of slight displacement that are difficult to trace except in mine workings. For example, plate 7 shows several exposed faults in the wall of the quarry above the entrance to a stope but the displacements are so small that most cannot be identified as such in the photograph. The principal ones are indicated by arrows. The faults or fractures are mainly premineral and have influenced the shape of the ore shoots. They do not, however, delimit the ore.

In the main workings work stopped on the north against fairly well defined fault walls, but the workings from the North Shaft later found ore north of this fault zone. The limits of stoping in the main workings were set solely by the tenor of the material found. The mined material had an average content of close to 6 pounds of quicksilver per ton and few of the closely spaced samples taken during the operation of the main workings yielded more than 20 pounds to the ton on assay. Mining was stopped when the samples on the periphery of the workings showed an average grade close to 3 pounds to the ton.

On the east and south, particularly, the only limits to the ore body are those imposed by décrease in the cinnabar content. Beyond these limits the tenor decreases, but not uniformly. Plate 6 has a dashed line corresponding to the limit of the low-grade zone as estimated by the Idaho Almaden Mines Co. but some cinnabar is known to extend into the opalite far beyond this line. The upper quarry, where some material rich enough to mine was found, is 300 feet southeast of the border of the low-grade zone mentioned above. Thus, that border by no means sets a limit on prospecting.

Within the area of the main workings fractures lined with cinnabar locally raised the average grade. Similar rich veinlets have been mined in other parts of the property.

All the opalitized rock on Nutmeg Mountain not already mined is worthy of exploration. Attention is directed to the southern part of the Red Rose and northern part of the Sandstone claim. This area appears to have been little prospected but has features in common with the area that contains the main workings. The cap rock so prominent in the main workings is present in much and probably most of this area. Hence, it could have had much the same effect in checking the ascent of solutions there as it is supposed to have had at the site of the main workings. Likewise in both localities there appear to be structural sags, which are reflected in the topography. Around the periphery of the main workings the opalitized sandstone beds dip inward toward the quarry at angles of 5° to 35°. In the area under discussion the dips are so slight that most of the beds are represented (pl. 5) as flat. However, from the gentle ridge (crest at about 3,540 feet) within the 3,525-foot contour to the low point near the southeast corner of the Red Rose claim (altitude about 3,528 feet) the beds are thought to dip in approximate conformity to the topographic surface, as is indicated in section *A–A′* plate 5. If this sag and that at the main working are, as suggested above, genetically related to changes in the colloids introduced during opalitization, their presence implies thorough and presumably relatively deep opalitization, a favorable feature. The dips bordering the unmined area are much less than those on the borders of the mined ground. In so far as this may reflect less intense or deep opalitization in the unmined area it agrees with the fact that such test holes as have been put down there have not had results sufficiently encouraging to have led to mining. Even so, it is felt that exploration so far done is not adequate to rule out the area as a possible source of ore.

ZUCKER PROPERTY (PARKER GROUP)

The property formerly held by Zucker Mines, Inc., of Spokane, Wash., adjoins the Idaho Almaden mine on the northwest. It is reported to center around the northwest corner of sec. 32, T. 11 N.,

R. 3 W., and in 1943 according to the State Mine Inspector (Campbell, 1944, p. 228) consisted of 6 unpatented claims. This property was originally known as the Parker group. Work began here in August 1941 and continued into the spring of 1942, with a little additional activity in 1943. Several pits, shallow shafts, and short tunnels were driven. A bulldozer was used to drain a stagnant pool on the top of a hillock and to clean small surface areas. The principal workings visible in 1943 are shown on plate 5. At that time a special kind of retort designed to permit agitation of the ore during roasting had been installed but apparently little used. When the property was revisited in 1954 the retort and all buildings had been removed and there appeared to have been no activity for years.

Much of the surface of the property is mantled with landslide material and hill wash, derived from Nutmeg Mountain and spread rather thinly through solifluction and related processes. Some of this, particularly the larger blocks of landslide debris, consists of opalitized sandstone which here and there contains visible cinnabar. As the landslides came from the west and northwest flanks of Nutmeg Mountain, they did not involve rock close to that which the Idaho Almaden Mines Co. found rich enough to be profitably mined. Small amounts of sandstone, in place, are exposed at the surface and in the shallow workings on the Zucker property. None of the sandstone seen shows much evidence of mineralization although some is cut by minor faults.

PROSPECTS NEAR NUTMEG MOUNTAIN

Claims have been staked by several different prospectors on the lower slopes of Nutmeg Mountain and in nearby areas. The shallow shaft (pl. 5) south of the Rose claim was started in 1941 on a group of 13 claims then held by Peter and Robert March. Cinnabar was found in shale at a depth of 12 feet in this shaft. Other claim groups south of the Idaho Almaden property are reported to have been located by C. W. and R. M. Curl and by H. Midland. In addition, prospect holes east of Nutmeg Mountain were noted during the study in 1941. Some of these showed cinnabar in fractures. No activity was seen at any of the prospects here referred to during the visits in 1943 and later.

CONSOLIDATED QUICKSILVER MINING CORPORATION

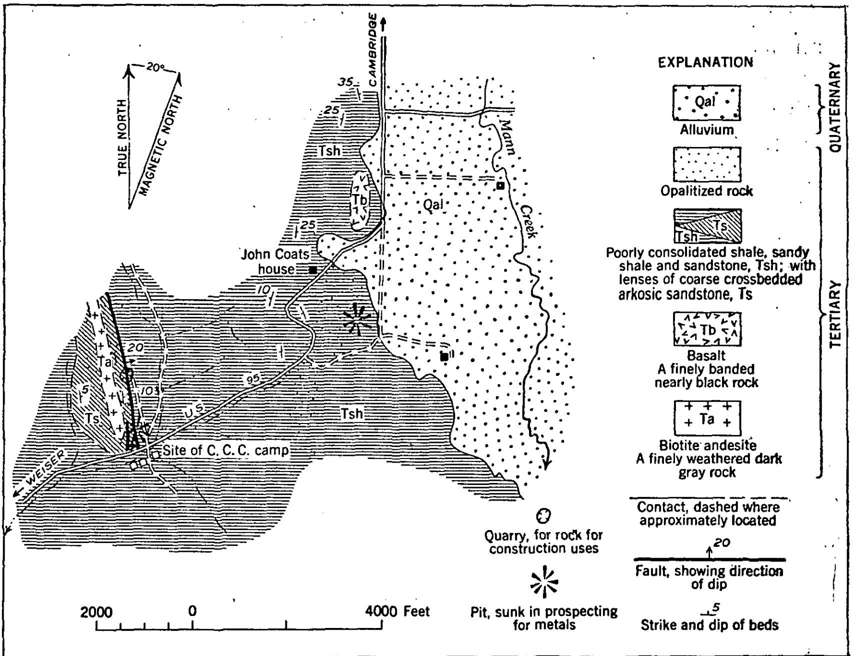
The Consolidated Quicksilver Mining Corp., formerly the Hoover Consolidated Quicksilver Mining Corp., held 69 unpatented claims in 1941 (Campbell, 1942, p. 245). The property is in and south of sec. 36, T. 12 N., R. 4 W. In 1940 and 1941 the company explored its claims by means of trenches, shafts, a tunnel, and drill holes, but since August 1941, the company appears to have been inactive.

The part of the Consolidated property where most of the exploration has been done is shown in plate 8, which is based on a planetable survey by C. P. Ross and R. P. Full. In this area arkosic sandstone with some conglomerate beds and a little shale is interbedded with basalt. The shale is not shown separately in plate 8. The rocks are inclined to the northeast and east at angles that range from horizontal on the hilltop up to 30° at the south edge of the area mapped. The sandstone is somewhat opalitized but most of it is much less intensely so than at Nutmeg Mountain. Only the more thoroughly opalitized bodies are distinguished in plate 8. There are conspicuous joints of northwesterly trend and some of the more intensely opalitized material follows these. Fracture zones in the tunnel are lined with clay. They range in strike from N. 60° W. to N. 15° W., and dip both northeast and southwest. The only quicksilver seen by the writer was in the patch of marked opalitization in the southern part of the area (pl. 8) but jointed and opalitized rock in several places on the property is reported to yield cinnabar when panned.

PROSPECTS IN T. 12 N., R. 5 W.

In 1941 prospects close to U. S. Highway 95 about 8 miles northeast of Weiser and almost as far due west of the property of the Consolidated Quicksilver Mining Corp. were being explored for quicksilver. These were visited by C. H. Dane and R. P. Full. Cinnabar was discovered here early in June 1941 by Frank Coats, mainly on land southeast of the highway in sec. 25, T. 12 N., R. 5 W., then owned by John Coats. The land was leased to Chester Lackey, Ontario, Oreg., for exploration. This was done by means of shallow pits and bulldozer cuts starting 1,800 feet southeast of the John Coats house and extending 500 feet farther southeast. The largest pit, in 1941, was 20 feet long and 20 feet deep, and was at the south end of the explored area.

Other small workings on land that in 1954 was being ranched by Line Brothers were dug about a mile to the southwest and immediately north of the highway. One of these, when seen in 1954, was a trench about 90 feet long. Farther north there is a small quarry in sandstone, which is used for construction. Much earlier prospecting for gold is reported to have been carried on at this place, evidently without sufficient success to induce exploration at depth. Apparently almost no prospecting for quicksilver has been done since 1941. When the locality was revisited in 1954 no evidence of more recent mining was noted and the ground was being used as a ranch by Line Brothers. However, at the more southerly of the two localities just mentioned a notice was found indicating that Glenn and Gary Erharde had claimed the ground as the "Tip Top Mine," under



Base from air photograph, U. S. Bureau of Reclamation

Geology by C. H. Dane and R. P. Full, 1941

FIGURE 9.—Geologic map of prospects in T. 12 N., R. 5 W.

date of February 10, 1954. Varley (Varley, and others, 1919, p. 51) mentions a gold mining district, called the Monroe Creek or Weiser district, about 10 miles north of Weiser. The prospects here described would be within that district. Monroe Creek, not shown on maps in the present report, passes just west of the prospects and enters the Snake River at Weiser.

The geology of the area that includes the two groups of prospect holes is shown in figure 9. This figure shows that each group is in an area where the shaly and sandy country rock has been opalitized, within the vicinity of small mafic intrusive bodies. Near the John Coats house the opalitized rock trends roughly N. 20° E. but small, more thoroughly silicified shoots within it trend N. 10°–55° W. These latter (not shown on fig. 9) are rudely tabular and dip steeply eastward. They are not conformable with the bedding where that can be determined. Figure 9 shows that most beds nearby dip westward. The silicified rock has been crumpled and broken. In 1941 in the largest pit near the house cinnabar was visible in irregular clay-filled fractures between the small angular fragments of the brecciated opalite. At the openings a mile farther south mineralization effects are even more scanty. The trench mentioned above exposes a fault that strikes west of north and dips east, between sandstone and shale.

The offset is probably small. A poorly exposed dike of biotite andesite lies west of the fault. The igneous rock north of the John Coats house is a finely banded basaltic rock, whose presence is shown by abundant fragments but no actual exposures.

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