TIN ORE IN NORTHERN LANDER COUNTY, NEVADA.

By Adolph Knopf.

LOCATION AND DISCOVERY.

Tin ore has recently been found in northern Lander County, Nev., in an unnamed short range of hills lying 20 miles north of Battle Mountain, a town on the Southern Pacific system. The discovery was made by employees of the cattle ranch in which the range is situated. Near the base of the range is the old Izenhood ranch, which had been established at a large spring, known as Warm Spring, whose waters are used for irrigation. This ranch is now a part of the extensive cattle ranch held by Mr. George Russell, sr., of Elko, Nev.

The range in which the tin occurs trends northeastward. It rises steeply from a broad, flat valley and attains an extreme elevation of 6,000 feet, which is about 1,500 feet higher than the valley. A few miles northeast of Warm Springs the range is separated by a low, broad pass from the northern extension of the Shoshone Mesa, as it is called on the map of the Fortieth Parallel Survey, though this name appears not to be locally known. Some float wood tin has been found at the north end of Shoshone Mesa. As seen from Battle Mountain, Shoshone Mesa is a prominent feature consisting of a high, broad table-land and capped by a great thickness of black basalt, but to the north the basalt capping is absent and the mesa becomes a sharp crested ridge. The topography of the region is roughly shown in figure 17, which is reproduced, with some changes and additions, from a part of Plate IV of the atlas of the Fortieth Parallel Survey. The region is readily accessible by level roads.

Tin ore in the form of a nugget of wood tin was found on the wash at the base of the range in April, 1914, by an employee of the Russell cattle ranch. What the substance was, however, remained unknown until the fall of that year, when it was taken to Battle Mountain, where an engineer, Mr. M. G. Thurston, who had prospected a tin-bearing vein in Mexico, chanced to see it and recognized it as wood tin. The specimen was then sent to the University of California for further examination, and late in the year the report came back that the mineral was high-grade tin ore. The subsequent discovery of wood tin in its bedrock source at a number of localities

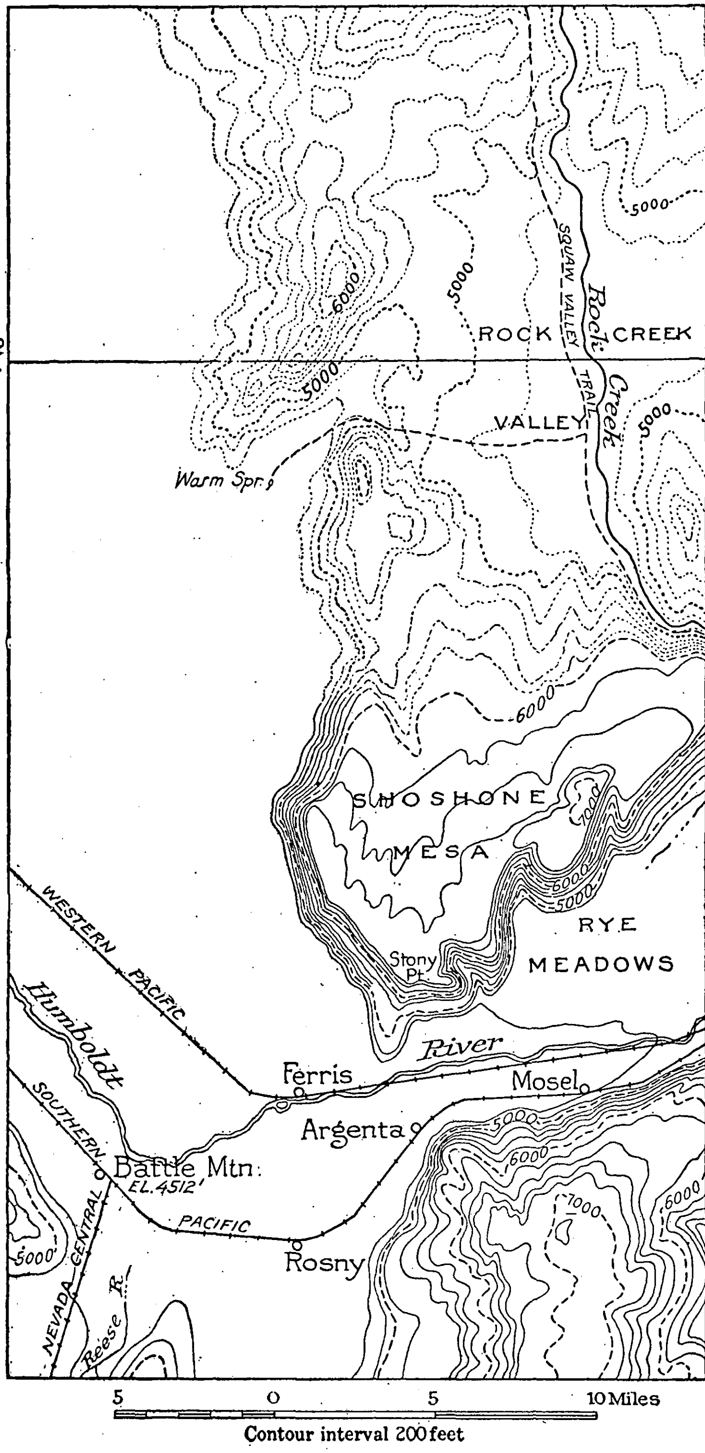

FIGURE 17.—Map of the tin-bearing area in northern Lander County, Nev., and vicinity.

was made by Edward Larson, who has also done most of the development work so far undertaken.

The prospects were examined by me early in June, 1916, and it gives me much pleasure to acknowledge my indebtedness to Mr. George Russell, sr., and Mr. George Russell, jr., for their hospitality, and to Mr. Edward Larson, whose intimate familiarity with the region greatly aided this examination.

GENERAL GEOLOGY.

Rhyolite consisting of a series of superposed lava flows is the main rock of the tin-bearing area. Basalt appears in small quantities at the west end of the belt and becomes increasingly prominent farther west. Alluvial washes, so characteristic of the Nevada region, are amassed along the base of the range, and in places they carry wood tin.

RHYOLITE.

Rhyolite is the predominant rock of the region. It makes up nearly all the main tin-bearing range, as well as the northern extension of Shoshone Mesa, and, as shown by King,[1] is part of one of the largest areas of rhyolite found by the Fortieth Parallel Survey, an area aggregating nearly 1,500 square miles. The thickness of the rhyolite series is thought by W. H. Emmons[2] to exceed 2,000 feet.

The rhyolites are monotonously alike. They are highly porphyritic lavas, light gray on fresh surfaces but rather dark on weathered surfaces, so that their rhyolitic character is not obvious in distant views. They have a strongly marked flow layering, which commonly gives them a stratified appearance. As a rule the layering stands at high angles, yet in places it changes from horizontal to vertical within short distances. This feature gives the ranges, when seen from a distance, the aspect of having an irregular and confused internal structure, and, taken in connection with the petrographic uniformity of the rocks, makes it impossible without close study to determine how much the rhyolites have been faulted and tilted since they were erupted. According to Emmons[3] the rhyolites are the oldest Tertiary lavas in this part of Nevada, and their eruption probably began early in Miocene time.

The rhyolites as a rule are massive porphyries crowded with phenocrysts of quartz, generally smoky, and of glassy feldspar, consisting predominantly of sanidine. The phenocrysts make up nearly one-half the bulk of the rocks, and their abundance gives the

[1] King, Clarence, Systematic geology: U. S. Geol. Expl. 40th Par. Rept., vol. 1, p. 624, 1878.

[2] Emmons, W. H., A reconnaissance of some mining camps in Elko, Lander, and Eureka counties, Nev.: U. S. Geol. Survey Bull. 408, p. 31, 1910.

[3] Idem, p. 35.

rhyolites on casual examination somewhat the appearance of granites. Biotite and hornblende are notably absent. In texture the rhyolites are rather porous. Lithophysal structure is not uncommon, but the lithophysæ are not large. In a rhyolite of this kind that was especially examined the groundmass is composed wholly of delicate, extremely thin-walled lithophysæ averaging one-fourth inch in diameter. Flow breccias also occur in the region. In short, the rhyolites bear abundant evidence that they consist of a superposed succession of lava flows.

Under the microscope the dominant porphyritic component of the rhyolite is found to be quartz, which generally contains dihexahedral inclusions of glass, each inclosing a gas bubble. The feldspar, as is apparent to the unaided eye, proves to be mainly sanidine, whose optic axial angle is practically zero. Some oligoclase, however, averaging near $Ab_{70}An_{30}$ in composition, occurs and in some rocks is abundant enough to show that they have affinities with the group called in recent years quartz latite. The microscope shows further that, although biotite and hornblende are not recognizable in hand specimens, hornblende at least was originally present, but has been pseudomorphously altered to specular hematite. The accessory minerals apatite, titanite, and zircon are extremely rare, but specular hematite is common, although it is evidently not wholly a pyrogenic mineral. The groundmass is generally cryptocrystalline and partly spherulitic; tridymite is locally abundant.

Rhyolite from the Modoc No. 6 claim has been analyzed in part by Mr. A. A. Chambers in the laboratory of the Geological Survey.

Partial analysis of rhyolite from Lander County, Nev.

SiO_2	76.25
CaO	.44
Na_2O	4.05
K_2O	5.18

The chemical analysis amply confirms the microscopic determination and shows that the rhyolite is a variety high in potassa, soda, and silica.

BASALT.

Basalt occurs at the extreme west end of the tin-bearing belt, where it forms a small patch over the rhyolite. It is a fine-grained, highly vesicular variety. Farther west basalt becomes more prominent. To the south, in the Shoshone Mesa, it attains a great thickness—as much as 1,500 feet. As shown by S. F. Emmons in the Fortieth Parallel Survey, the basalt flowed over and buried a surface of very irregular relief eroded in the rhyolite.

ALLUVIUM.

Alluvial washes skirt the base of the range, extending to elevations 300 to 400 feet above the valley bottom. They consist of rhyolite detritus and are rather bowldery, containing many blocks 3 to 4 feet in diameter. In places the alluvium has been channeled by storm waters to depths of 15 to 20 feet.

THE TIN-BEARING VEINS.

OCCURRENCE AND CHARACTER.

Veins carrying wood tin have been found along the south side of the range in an area that forms, roughly, an eastward-trending belt 10,000 feet long and 2,000 feet wide. The known veins are at altitudes between 5,500 and 5,700 feet. They are inclosed in rhyolite, which is petrographically alike at all the occurrences.

The veins are narrow, ranging in width from a fraction of an inch to 18 inches. They occur typically as stringers an inch or so wide, carrying wood tin and specular hematite in a gangue of chalcedony, lussatite (a form of silica resembling chalcedony), tridymite, and opal. At some places enough veinlets traverse the rhyolite to constitute stringer lodes, whose greatest thickness is 8 feet. The veins or stringers of tin ore, however, are widely spaced in these lodes, and the large quantity of barren rhyolite lying between the stringers will necessarily reduce the average tenor of the stringer lodes, if mined as a whole, to a low figure. It is doubtful whether any of the lodes now exposed will average 1 per cent of metallic tin. Not much is known concerning the linear extent or persistence of the lodes. Information on this point is most pressingly needed before the deposits can be exploited. It is clear that individual stringers are likely to prove disappointingly short.

Some brecciation accompanied the fissuring of the rhyolite, as is shown by the occurrence of angular fragments of rhyolite cemented by opal or incrusted with micaceous hematite, but it appears not to have been extensive. The minerals filling the veinlets are strictly contemporaneous, as is proved by their intergrowth and association. The wood tin was probably somewhat more copiously deposited during the early stages of vein formation. It is in places manifestly brecciated, angular particles of it being inclosed in a cement of hematite, chalcedony, and opal. This brecciation was probably not produced by movement along the fissures, but appears to be more reasonably interpreted as due to the setting of colloidal silica or to the bursting of colloidal membranes by osmotic forces, as in the classic example of the bursting of copper ferrocyanide membranes when immersed in a dilute solution of potassium ferrocyanide.

A notable feature of the deposits is the comparatively small amount of alteration of the rhyolites near the veinlets. The microscope shows that the groundmass of the rhyolite close to the ore has been wholly replaced by an aggregate of hematite, chalcedony, and other forms of silica, but the sanidine and oligoclase phenocrysts have remained intact.

From the foregoing description it appears that the deposits resemble the tin-bearing veins of Durango, Zacatecas, Guanajuato, and other Mexican States in their association with extrusive rhyolites, in that the tin-bearing mineral is exclusively wood tin, in the presence of abundant specular hematite in the ore, and in the character of the gangue, which consists chiefly of chalcedony. There are some differences, but the resemblance is close. Deposits of this type differ very widely from all other kinds of tin-bearing lodes, which are invariably associated with intrusive granite and occur either in the granite itself or in the adjacent rocks invaded by the granite. It is to be noted, however, that rhyolite has essentially the same chemical composition as granite but was erupted upon the earth's surface and has cooled under conditions widely different from those that prevailed where granites have cooled, and in consequence the rhyolite has assumed a texture widely different from that of granite.

DEVELOPMENTS.

Tin ore has been found in the rhyolite at many places along the belt. Some work has been done at eight of these places at least, and the more extensive developments are described in the following paragraphs.

The most work has been done on the Modoc No. 6 claim, which is at the west end of the tin-bearing belt, so far as it is now known. An incline, sloping 60° N., has been sunk here to a depth of 45 feet, following a stringer zone or lode about 8 feet thick. The zone has been cut off near the bottom of the incline by an irregular ill-defined fault dipping 45° S. It is apparently a normal fault, in which the hanging wall has slipped down relatively to the footwall, and the lode therefore would probably be recovered by drifting to the north. An open cut a few hundred feet east of the shaft is possibly on the eastward extension of the lode shown in the shaft, but no work has yet been done to test this possibility. Another cut has been opened about 100 feet north of the shaft on what is possibly a parallel vein. The prospects on these claims are more favorably situated topographically than any others in the tin-bearing belt, for considerable depth can be attained under the outcrops by means of tunnels.

On the Black Nugget No. 6 claim a tunnel 20 feet long, sloping into the hill at a low angle, has been driven on an irregular ledge ranging in thickness from 3 to 18 inches. This prospect is at an elevation of about 5,700 feet and is 6,000 feet east of Modoc No. 6. The vein is mineralogically noteworthy on account of its content of coarse tridymite, which forms granular aggregates as much as an inch in diameter. Specular hematite is particularly common, considerably more abundant than the associated wood tin, and fragments of rhyolite are completely incrusted by spherulitic micaceous hematite.

An open cut on the Mayflower claim, 4,000 feet east of the Black Nugget No. 6 tunnel, attains a depth of 10 feet. Here a zone 8 feet wide, showing a number of narrow, irregular stringers carrying wood tin and abundant platy hematite, is exposed. In this zone there are some angular fragments of rhyolite cemented by white opal, proving that a certain amount of brecciation accompanied the opening of the veinlets.

Although no tin ore has yet been found in place in the range southeast of the main tin-bearing belt, nevertheless evidence of mineralization of the same general character has been discovered. An open cut at an elevation of 5,600 feet in this range exposes an irregular vein, 6 inches wide at most, which stands vertical and trends at right angles to the flow structure of the inclosing rhyolites. The vein consists of specular hematite in a gangue of chalcedony, quartz, and opal.

MINERALOGY OF THE VEINS.

The wood tin in the veinlets in the rhyolites of northern Lander County, Nev., is the first recorded occurrence of this mineral in place in the United States. Of further interest is the association of the tin ore with abundant tridymite—an association apparently not heretofore observed elsewhere.

No topaz, tourmaline, or other fluorine or boron minerals were noted in these tin deposits. The minerals found in them are described in alphabetic order in the following paragraphs.

Chalcedony.—Chalcedony is a finely fibrous variety of silica that commonly occurs in spherulitic masses. To the unaided eye it appears to be the dominant gangue mineral associated with the wood tin; but under the microscope part of the fibrous silica corresponds closely to the mineral called lussatite by Mallard. The chalcedony (and probably the associated lussatite) is of distinctly bluish tinge.

Hematite.—Specular hematite is a common constituent of the tin ore, occurring intergrown with all the other minerals. It is embedded in the wood tin in amounts ranging from microscopic particles to masses that make up the larger part of the nuggets. The banding of the wood tin invariably wraps around the inclosed plates of hematite. The specular hematite forms also solid layers, as much as an inch thick, of roughly radial structure. Single crystals, or the free ends of crystals embedded in other minerals, show complex crystalline habits and are splendently lustrous.

Lussatite.—The name lussatite was given by Mallard[1] to a fibrous variety of silica whose average refractive index is 1.446, whose birefringence is somewhat less than that of quartz, and whose fibers are optically positive—properties that serve to distinguish it readily from chalcedony. A mineral having these properties is associated in some abundance with the tin ore at the Modoc No. 6 prospect. As seen under the microscope it is globular and is in places molded around plates of tridymite. In parallel light it resembles the opal that occurs with it; it has a well-marked concentric structure, and its refractive index is distinctly lower than that of the associated tridymite. Between crossed nicols it shows a finely fibrous spherulitic structure like chalcedony, but its elongation is optically positive; its birefringence, as determined by means of the interference color chart, is about 0.006. The mineral is therefore identified as lussatite. It occurs molded upon wood tin also and incloses specular hematite.

Opal.—Opal is the amorphous hydrated form of silica, carrying from 3 to 10 per cent of water. It is abundantly associated with the other silica minerals that form the gangue of the tin ore.

At one locality in the range an open cut has been made on a zone of highly opalized rhyolite. No tin ore, however, has been found in it. The opalized rhyolite consists essentially of milk-white opal with numerous quartz crystals scattered through it. So thoroughly was the original rhyolite altered that only the quartz phenocrysts remained intact and the remainder of the rock was transformed to opal, though the sanidine phenocrysts were in part changed to a mixture of opal and chalcedony.

Quartz.—Quartz does not occur in the tin-bearing veinlets as a constituent recognizable by the unaided eye, and it is present only in minute amount as shown by the microscope. As the most abundant porphyritic component of the rhyolites, however, it is a prominent constituent of the ore.

Sanidine.—Like the quartz, sanidine is abundantly associated with the ore as one of the prominent porphyritic constituents of the rhyolites. It resembles the quartz closely, from which, however, it is distinguished by its perfect cleavage. The sanidine, although it may occur in the ore or in close proximity to ore, shows no trace of chemical alteration.

[1] Mallard, E., Sur la lussatite, nouvelle variété minérale cristallisée de silice: Soc. franç. minéralogie Bull., vol. 13, pp. 63–66, 1890.

Tridymite.—Tridymite is a common constituent of the tin ore, but as a rule is only recognizable microscopically. It is most abundant in the Black Nugget No. 6 prospect, where it occurs in plates aggregated in radial or fan-shaped masses as much as an inch in diameter. In places it is well crystallized, showing the characteristic hexagonal plates; some of it incloses plates of hematite. To establish beyond question the identity of the mineral as tridymite, W. T. Schaller has carefully measured the refractive indices of material from the Black Nugget vein. He found that $\gamma = 1.477 \pm 0.001$ and $\alpha = 1.472 \pm 0.003$—values that agree closely with those determined for tridymite by Mallard.

A determination of silica in the coarse platy aggregates was made by A. A. Chambers in the laboratory of the Geological Survey. He found that they contained 96.68 per cent of silica, a figure that, although determined on a mineral aggregate, compares closely with the figures listed by Hintze under analyses of tridymite, which range from 95.5 to 99.21 per cent silica. Under the microscope such tridymite aggregates are feebly birefringent and show a narrow polysynthetic lamellation like albite; a little quartz is present, which has probably inverted from the tridymite, as it has inherited the parting or twinning seams of the tridymite.

Plates of tridymite are embedded in the opal associated with the wood tin, lussatite, and chalcedony at the Modoc No. 6 claim. Long ago Rose[1] found that the opal of many localities is commonly filled with microscopic crystals of tridymite. This was proved true of opal from Silesia, Iceland, Carinthia, Hungary, and Mexico, and clearly shows the possibility of the hydrothermal origin of tridymite. These observations appear not to have been often repeated, but it is clear that tridymite is abundantly associated with opal and other forms of silica in the tin-bearing deposits of northern Nevada.

Wood tin.—The tin-bearing mineral is exclusively in the form of wood tin and invariably shows the characteristic concentric banding resembling the annual growth rings of wood. In color it ranges from dark reddish to brown. It is generally in globular masses or in the different modifications of this form that are designated botryoidal, mammillary, and reniform. These forms are, of course, best displayed in the material recovered from the gravels, where masses or nuggets weighing as much as 2 and 3 pounds have been found. As seen on polished surfaces and in thin sections, the particles of wood tin commonly contain nuclei of hematite. Some of these nuclei are surrounded by opal, then by hematite, and then by wood tin.

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[1] Rose, G., Ueber das Vorkommen des Tridymits in der Natur: K.-preuss. Akad. Wiss. Berlin Monatsher, 1869, pp. 461–462, 1870.

Some angular particles of wood tin occur in the veinlets, and these appear to have originated from the bursting of colloidal membranes by osmotic forces in the manner shown by Liesegang[1] that certain seemingly brecciated agates were produced.

Under the microscope it is found that one of the causes of the banding of the wood tin is the alternation of opaque or nearly opaque bands with fairly translucent bands. The translucent bands react on polarized light, giving a shadowy extinction, suggestive of a radial fibrous structure. The ultimate origin of the banding is most probably due to rhythmic precipitation effected in colloidal stannic oxide.

A nugget of wood tin was analyzed in the laboratory of the Geological Survey, and the analysis probably represents the purest wood tin of this region. The specimen analyzed was dark red, homogeneous, and showed only faint banding; the powdered material was opaque, even the smallest particles being opaque when immersed in a liquid of refractive index 1.89. It was selected because of its freedom from inclusions of hematite.

Analysis of wood tin from Lander County, Nev.

[A. A. Chambers, analyst.]

SnO_2	85.14
SiO_2	1.03
Fe_2O_3	13.42
MnO	.02
H_2O-	.20
H_2O+	.05
	99.86

The analysis shows that the wood tin is highly ferriferous, comparable in this respect to the Mexican wood tin, and contains 67.06 per cent of metallic tin. The ferric oxide is surely an integral part of the mineral. The analysis shows further that the wood tin contains no deleterious constituents, such as arsenic or antimony.

The only previously recorded occurrence of a tin mineral in Nevada is that by Hoffman,[2] who briefly mentions that "small crystals of cassiterite" are occasionally found in the Tuscarora placer mines. Tuscarora is 45 miles northeast of the tin-bearing area recently found, and as similar rhyolites of the same age occur there it is possible that the stream tin was derived from veinlets like those described in this report.

The simplest test for wood tin, or for cassiterite, which is the commoner form of the oxide of tin occurring in nature, is to place

[1] Liesegang, R. E., Ein Membrantrümmer-Achat: Centralbl. Mineralogie, 1912, pp. 65–67.

[2] Hoffman, W. J., On the mineralogy of Nevada: U. S. Geol. and Geog. Surv. Terr. Bull., vol. 4, p. 734, 1878.

the mineral in hydrochloric or sulphuric acid with zinc, preferably granulated zinc, for it is necessary that the mineral and the zinc should be in contact while the acid is acting on them. Immersion for a few minutes is ample, and if the mineral tested is wood tin or cassiterite it will be coated with tin, whose characteristic metallic appearance can be brought out by rubbing with a soft cloth or with the fingers.

ORIGIN OF THE VEINS.

Wood tin has been generally regarded as of secondary origin ever since Stelzner[1] showed that its abundance in the Bolivian deposits is due to the action of descending solutions, whose tin was derived from the oxidation of stannite or other tin-bearing sulphide. This explanation is doubtless correct in so far as it applies to the Bolivian deposits. Those who have described the Mexican deposits, in which the ore mineral is wood tin, do not explicitly consider the question whether the wood tin has been deposited from ascending thermal solutions or from descending oxidizing waters. The wood tin in the Nevada deposits, however, is clearly of hydrothermal origin, as is definitely shown by the intimate intergrowth of tridymite with the opal and hematite associated with it. Tridymite has been repeatedly synthesized in aqueous solutions at temperatures between 300° and 400° C. On the other hand, the lowest known temperature at which it forms in nature is 73° C., the temperature of the hot springs at Plombieres, where Daubrée[2] found tridymite plates inclosed in the hyalite that had formed in the pores of the Roman bricks altered by the hot waters. Experiment and observation thus combine to prove that tridymite may be of hydrothermal origin, and as it occurs together with opal, lussatite, and chalcedony in the tin-bearing veinlets it affords evidence that they were all deposited from hot waters. The wood tin was deposited in the colloidal condition, like the associated chalcedony and opal, and its deposition in this form is doubtless the geologic expression of the strong chemical analogy between tin and silicon.

The fissures in which the wood tin occurs were opened by stresses that were accompanied by movement sufficient to brecciate slightly the adjoining rhyolite; at least this is true of some of the fissures, and from this it follows that the veins occupying such fissures are not merely fillings of joints or shrinkage cracks.

It is concluded, therefore, that the veins were formed by ascending hot waters soon after the eruption of the rhyolites; that these

[1] Stelzner, A. W., Die Silber-Zinnerzlagerstätten Bolivias: Deutsche geol. Gesell. Zeitschr., Band 49, p. 122, 1897.

[2] Daubrée, A., Sur la présence de la tridymite dans les briques zéolithiques de Plombières: Soc. géol. France Bull., 3d ser., vol. 4, p. 523, 1876; Études synthétiques de géologie expérimentale, p. 195, 1879.

waters deposited the wood tin and associated minerals in channels formed by dynamic action; and that it is reasonable to expect that along the more strongly fissured zones the ore will persist in depth.

PLACER TIN.

The examination of the occurrence of the wood tin in place in the rhyolites leaves a strong impression that the range is an ample source for placer tin. Certainly the relatively small amount of prospecting already done has disclosed more deposits in bedrock than have been discovered, for example, in the drainage area of Buck Creek, Alaska, whose placers are now being profitably worked; but this abundance, although highly favorable to the accumulation of workable placers, is only one of several conditions necessary for their formation. Large amounts of alluvium lie on the south flank of the range and should be carefully examined as to their content to the cubic yard and the quantity available. The placers will be difficult to work on account of the coarse gravels, bowlders 3 and 4 feet in diameter being common, and because of the lack of water supply. It may be necessary to work them by dry placering.

A small attempt at placer mining was made in the spring of this year by the use of the very scant supply of water available from melting snow. A short sluice box was set up in a steep gulch only a few yards below the cliffs against which it heads—obviously a place unsuitable for commercial operations—and considerable wood tin, mixed with perfectly faceted hematite, was recovered, sufficient to show that the gravel here is richly tin bearing.

Some float wood tin has also been found in the range west of Warm Spring, in the northern extension of Shoshone Mesa. It has not yet been traced to its source in bedrock.

PRACTICAL CONSIDERATIONS.

That the tin ore occurs in narrow veins inclosed in rhyolite lavas of Tertiary age stamps the deposits immediately, as already pointed out, as belonging to a type heretofore only known from Mexico. Unfortunately, the Mexican deposits have not yielded largely or steadily, because they are bunchy and discontinuous. The greatest depth to which any vein has been worked is 200 feet. The placers, however, according to the most recent description,[1] hold promise of economic value. The resemblance of the Nevadan to the Mexican tin veins will therefore, it must be recognized, create a presumption against their value and will doubtless compel the discoverers to develop the deposits more extensively than is generally necessary.

[1] Wittich, E., Zinnerze in der Sierra von Guanajuato, Mexico: Zeitschr. prakt. Geologie, Jahrg. 18, pp. 121–123, 1910.

In view of the scant knowledge of the Mexican veins, especially of matters that are essential to the valuation of similar deposits occurring elsewhere, it would be idle to draw too heavily upon mere resemblance. The Nevada deposits should be prospected and developed on their own merit. What appears necessary to be done now is to concentrate development at a few of the most favorable outcrops. The prospecting so far done proves that tin ore occurs in bedrock at many places but has not been of the kind adequately to determine the continuity of any one deposit along its strike; in fact, the number of openings at widely separated points is likely to create the adverse impression that the tin ore invariably occurs in small discontinuous veinlets. It is necessary, therefore, to determine whether some, at least, of the stringer zones or lodes persist along the strike and whether they continue in depth; in short, it must be shown that ore is available in commercial quantities.

As the price of tin fluctuates rather abruptly and widely, it will be advisable to base all estimates of the value of tin ore on the possible minimum price of the metal, namely 30 cents a pound, as indicated by the average annual prices since 1905, which have ranged from 29.54 to 46.43 cents. It is probable that only ore carrying in excess of 1 per cent of metallic tin can be worked profitably.

The known tin-bearing belt is a small fraction of the great area of 1,500 square miles or more underlain by rhyolites similar to those associated with the tin ore in northern Lander County. This rhyolitic area extends at least as far north as the Nevada-Idaho State line. Clearly it is a region that merits further attention from the prospector, especially such parts as have been but superficially examined because barren of precious-metal deposits.

SUMMARY.

The tin ore of northern Lander County, Nev., occurs in a series of rhyolite flows of middle Tertiary age. The stanniferous mineral is exclusively wood tin, which is inclosed in narrow veinlets together with specular hematite, chalcedony, lussatite, tridymite, and opal. The veinlets are sufficiently numerous in places to form low-grade lodes, but because of the small development so far done not much is known of the persistence and tenor of these lodes. The deposits are clearly of hydrothermal origin, and consequently the deposition of the tin ore in the veinlets is in nowise due to the action of descending surface waters.

The deposits resemble closely those of the Mexican States of Durango, Zacatecas, and Guanajuato, and with the exception of these they are wholly unlike all other tin deposits, which are generally associated with intrusive granites. Tin ore has been found

in place at a number of localities over a considerable area, and, furthermore, placer tin ore has been found not only in all the gulches heading in this area but also in some of those in the northern end of Shoshone Mesa.

In conclusion, it is believed that the indications of the stronger lodes, taken in connection with their geology, are such as to justify further exploration; that the rhyolite area, of which the known tin belt forms but a small part, deserves further prospecting; and that the placers should be carefully examined to determine their economic possibilities.