LODE DEPOSITS OF THE ALLEGHANY DISTRICT, CALIFORNIA.

By Henry G. Ferguson.

TOPOGRAPHY AND LOCATION.

The mines of the Alleghany district, in the southwestern part of Sierra County, Cal. (fig. 47), are of interest not only on account of the extreme richness of the ore, some of which may contain as much as $100,000 a ton in gold, the apparently capricious distribution of the small shoots in which the high-grade ore is found, and the abruptness of the transition from these shoots to nearly barren quartz, but also because of the problems they offer in the study of vein formation. The mines visited by the writer are all within a short distance of the small towns of Alleghany and Forest. The northern boundary of the Colfax quadrangle, within which the district lies, is about a mile north of Forest. The region has the topography that characterizes the central portion of the Sierra, being made up of gently rolling interstream areas cut by deep and sharp river canyons. The canyons of Middle Fork of Yuba River and Kanaka Creek cross the southern and central portions of the Alleghany district. The Middle Fork canyon has an average depth of about 1,500 feet, but Kanaka Creek canyon is somewhat shallower. The northern part of the area is drained by the headwaters of Oregon Creek. The highest point, a little over 5,400 feet in altitude, is about a mile northwest of Forest. Between Forest and Alleghany the lava-covered interstream region has a width of about 2 miles, and south of the Middle Fork of the Yuba is another broad, flat upland area. Between Kanaka Creek and the Middle Fork, however, the ridge is narrow, reaching its greatest width, about a mile, above Chips Flat.

The district lies within the Tahoe National Forest, but the more accessible portions, although once heavily timbered, have been almost completely denuded. Difficulty of access has been a serious handicap to the mining industry. Nevada City, the terminus of the

Nevada County Narrow Gage Railroad and the nearest railroad station, is 25 miles distant in an air line but about 40 miles by stage road. Up to the present time the district has been almost completely isolated during the winter, and all supplies have been of necessity brought in before November. Even in summer the roads are often

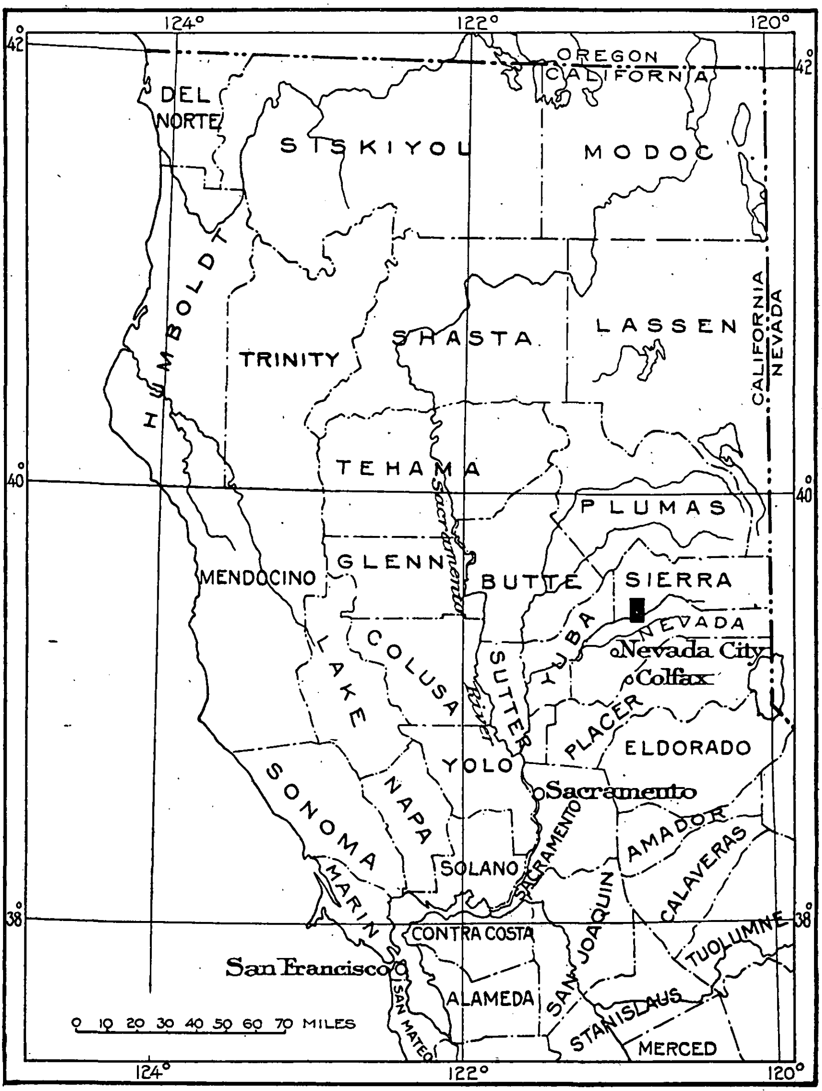

FIGURE 47.—Map of northern California, showing the location of the Alleghany district.

passable only with difficulty, and the freight rate from Nevada City varies with the condition of the roads, the minimum being $20 a ton. In May, 1913, a new road was being built to follow the canyons of Kanaka Creek and Middle Fork of Yuba River instead of crossing the ridges. This road will be passable for the greater part of the winter.

The district is reached by daily stage from Nevada City to Mountain House, where there is connection with another stage line for Alleghany. From June to September an automobile stage reduces the time of transit between Nevada City and Alleghany from 14 to 6 hours.

FIELD WORK AND ACKNOWLEDGMENTS.

The writer spent two weeks in the district in May, 1913, and made short visits to the principal mines then in operation. As the areal geology and the placer deposits have already been fully described by Lindgren, the writer confined his attention almost entirely to the lode mines. He is greatly indebted to all the mining men of the district, particularly to Messrs. A. B. Foote, R. H. Bedford, A. B. Hall, G. O. Scarfe, and W. B. Pierson, for their courtesy, hospitality, and many helpful suggestions. Mr. D. F. Hewett, of the U. S. Geological Survey, who visited the district in 1909, kindly placed his notes and specimens at the writer's disposal.

PREVIOUS DESCRIPTIONS.

Lindgren,[1] in the Colfax folio, has given an excellent description of the general geology of the region, together with a short note on the veins of this district. Turner[2] has discussed the geology of the Sierra Nevada as a whole and has given petrographic descriptions of rocks in the Downieville quadrangle, a short distance to the north. In his comprehensive work on the gravels of the Sierra Nevada Lindgren[3] has summarized the general geology and described the auriferous gravels of the vicinity. That report also contains a list of the more important publications relating to the Tertiary gravels.[4] The only paper dealing directly with the lodes of the Alleghany district is one by A. H. Martin,[5] which gives brief descriptions of the mines in operation in 1909. Another short account of mining in the district has appeared more recently.[6]

GEOLOGY.

The geologic map (fig. 48) of the region surrounding the Alleghany district is taken, with a few minor changes, from that published in the Colfax folio.

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1 Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Colfax folio (No. 66), 1900.
2 Turner, H. W., U. S. Geol. Survey Seventeenth Ann. Rept., pt. 1, pp. 521–762, 1896.
3 U. S. Geol. Survey Prof. Paper 73, 1911.
4 Idem, p. 12.
5 Martin, A. H., Alleghany mining district, Cal.: Min. World, vol. 31, p. 589, 1909.
6 Special correspondence, Allegheny, Cal.: Min. and Sci. Press, July 5, 1913, pp. 22–23.

In the northeastern and southwestern parts of the area are the Carboniferous clay slates of the Calaveras group, represented by the Blue Canyon and Cape Horn formations, respectively, of that group. Separating these is a broad belt composed of gabbro, schistose amphibolite, and serpentine, which are considered by Lindgren[1] to be intrusive into the sedimentary series. Transitions occur between the gabbro and the amphibolite; and the amphibolite appears to have been derived from the gabbro by simple pressure.

Serpentine outcrops as bands bordering the amphibolite area and as strips within the amphibolite parallel to its schistosity. In

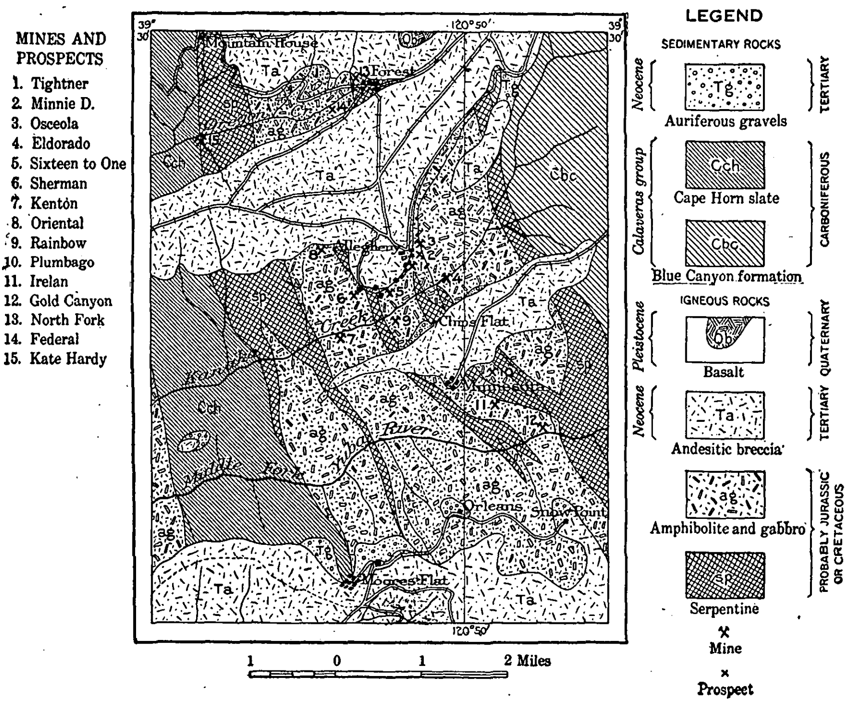

FIGURE 48.—Geologic map of the Alleghany district, Cal., and vicinity. Adapted from U. S. Geol. Survey Geol. Atlas, Colfax folio (No. 66), 1900.

all probability the serpentine is derived from a peridotite which was intruded into the original gabbro and between the gabbro and the sediments.

Throughout the Sierra Nevada there are great masses of silicic igneous rocks—granite, granite porphyries, quartz monzonites, and granodiorites, of which the last are most prominent. The period of ore deposition closely followed the intrusion of these rocks. At only one locality in the Alleghany district, however, does a silicic rock occur near a vein. This is at the Oriental mine, where the

[1] U. S. Geol. Survey Geol. Atlas, Colfax folio (No. 66), p. 3, 1900.

veins, for a short distance, follow the borders of a small mass of much-altered microcline granite. A small area of granite, about 5 miles southwest of Alleghany, is shown on the geologic map accompanying the Colfax folio, and 5 miles east of the town is the western boundary of a great mass of soda granite which extends northward from the South Fork of the Yuba to the North Fork, in the southern part of the adjoining Downieville quadrangle. The nearest outcrop of the large granodiorite mass of the Nevada City and Grass Valley region is close to the Federal Loan mine, about 22 miles southwest of Alleghany. A small area of granite porphyry lies along the northern border of the Colfax quadrangle, about 5 miles northwest of Alleghany.

The "Superjacent series" as represented in this region consists of the Neocene auriferous gravels overlain by andesitic breccia. These deposits cover the upland areas between Forest and Alleghany, between Chips Flat and the Plumbago mine, and south of the Middle Fork of the Yuba. The gravels have been so fully described by Lindgren [1] that it is not necessary to go into detail concerning them here. The Tertiary channel of the Middle Fork paralleled the present course of the river about a mile to the south, and in it were accumulated the placer deposits of Snow Point, Orleans, and Moores Flat. A tributary stream flowed southward from Forest, through Alleghany, Chips Flat, and Minnesota. This stream and its tributaries crossed the outcrops of many of the rich quartz veins of the district, and much of the gravel it laid down was extraordinarily rich. Several of the quartz mines of the region were discovered in drift mining beneath the capping of andesitic breccia.

According to Lindgren [2] no flows of massive andesite are present in the Alleghany area, the ejected material having flowed down the old river valleys as volcanic mud mixed with water. This mud later consolidated to a hard, compact mass.

A small body of basalt of early Pleistocene age caps the andesitic breccia of Table Mountain, about a mile north of Forest. The rock is of normal character, black, and fine grained and generally contains small crystals of olivine. The bedrock tunnel of the Bald Mountain Extension Co. crosses a dike of basalt which cuts the serpentine and the overlying Neocene masses.[3] An interesting occurrence of basalt of a similar type associated with andesitic fragments was observed on the third level of the Plumbago mine. The andesitic fragments are numerous and fairly well rounded. With them are a

[1] U. S. Geol. Survey Prof. Paper 73, pp. 133–159, 1911.

[2] U. S. Geol. Survey Geol. Atlas, Colfax folio (No. 66), p. 6, 1900; U. S. Geol. Survey Prof. Paper 73, p. 137, 1911.

[3] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Colfax folio (No. 66), p. 7, 1900.

number of small angular fragments of vein quartz. The matrix is made up of fragments of augite and feldspar and small grains of vein quartz. The basalt is clearly later than this andesitic breccia and cuts it in a rather irregular dike. The breccia and the dike follow the course of the vein for more than 200 feet on the dip and not quite so far on the strike. Presumably this is the neck of a Neocene volcano, from which came a portion of the andesitic breccia that caps the present divide. The basalt dike corresponds petrographically to the Pleistocene basalt described by Lindgren.

In the more recent gravels of the shifting bars of Kanaka Creek and Middle Fork of Yuba River the gold content has been reconcentrated from the Neocene gravels and furnished extremely rich placers in the early days of mining.

The following summary of the geology of the district is condensed from Lindgren's description[1] in the Colfax folio. The oldest rocks of the region are of Carboniferous age and belong to the Calaveras group. They have the appearance of one conformable series, the thickness of which it is difficult if not impossible to determine with accuracy. They should perhaps be regarded as thrown into many sharply compressed folds, nearly vertical or sharply overturned eastward. After the deposition of the Triassic and Jurassic beds upon the upturned strata of the Calaveras group came a period of mountain building, during which the later beds were folded against the Carboniferous land masses. Probably during latest Jurassic or earliest Cretaceous time the great eruptions of igneous rock occurred. The general sequence of these rocks has not been fully ascertained. The main granitic masses are, in general, more recent than the greenstones and serpentines, and in a given area of granular rocks the darker modifications are nearly always older than the lighter-colored silicic facies. The intrusions were followed by the principal period of ore deposition.

The later history of the region[2] includes the building of a high mountain range and its reduction to a region of very gentle topography. In late Cretaceous time came the beginning of the organic disturbances and faulting which have formed the present Sierra Nevada. A long period of erosion followed, and in Neocene time began the accumulation of the auriferous gravels. Volcanic activity beginning in the Neocene and continuing at intervals into the Pleistocene has left the breccias and lavas which cover the interstream areas.

[1] Op. cit., pp. 4–6.
[2] Lindgren, Waldemar, U. S. Geol. Survey Prof. Paper 73, p. 44, 1911.

HISTORY AND PRODUCTION.

The Alleghany district was one of the early discoveries in California gold mining. At first the rich river bars absorbed the attention of the miners. After the exhaustion of the bars, work was largely confined to the Neocene gravels, and hydraulic mining, followed by drift mining, was at first the principal occupation of the camps. During this period lode mining had been carried on in a desultory way and occasionally masses of rich ore were taken from the veins. The Plumbago, at least, has been worked at intervals since some time before 1860, and several other mines for comparable periods. The history of the camp, as an important producer, begins, however, in 1907 with the rediscovery of the Tightner vein by H. L. Johnson. Apex litigation greatly reduced the output in 1909, but production increased the next year, and in 1912 the shoots of rich ore in the Tightner and other mines gave a production more than double that of any preceding year. Probably the output for 1913 exceeded even that of 1912.

It is impossible to obtain any figures as to the output from the quartz veins of the district, distinct from the placers before 1908. Lindgren[1] estimates that, out of a total production of $150,000,000 up to 1909, the yield from quartz mines in the entire Colfax quadrangle has not exceeded $10,000,000. Probably half of this was derived from the mines in the vicinity of Alleghany. The following table gives the production of the lode mines of the district since 1908:

Deep-mine production of the Alleghany district, Cal., 1908–1912.

[From Mineral Resources of the United States.]

	Ore treated (tons).	Gold.	Silver (ounces).	Producing mines.
1908	13,626	a $173,866	(a)	3
1909	1,514	a 41,379	(a)	8
1910	7,485	110,554	976	3
1911	10,350	113,675	1,121	8
1912	18,389	a 293,561	(a)	5

a Silver production not given separately.

ORE DEPOSITS.

GENERAL FEATURES.

All the lodes visited are well-marked fissure veins, which are confined almost exclusively to the amphibolites. The Kate Hardy vein cuts the Cape Horn slate near the serpentine contact and the Oriental veins follow the contact between amphibolite and microcline

[1] U. S. Geol. Survey Prof. Paper 73, p. 133, 1911.

granite for a short distance, but these are the only exceptions. Where the veins pass from the amphibolite into the serpentine they split into small stringers, which die out within short distances. This is particularly well seen in the Gold Canyon and Oriental mines. The amphibolite on the walls of the veins is usually so intensely crushed as to be altered to a chloritic or talose schist somewhat resembling serpentine. This has led to the belief that all the veins lie along the contacts of serpentine and amphibolite, an idea which has caused a certain amount of barren prospecting. The veins are, for the most part, very persistent in the amphibolite, though they vary greatly in width. Where the quartz pinches out there is generally a well-defined wall, with more or less gouge, which can easily be followed to the point where the quartz reappears. Exceptionally the quartz may attain a width of 30 feet in the so-called swells.

Movement along the veins has been very pronounced, and for the most part the veins, together with a certain amount of crushed country rock, lie between smooth walls. At certain places these walls leave the lode and pass as slips into the country rock, diverging at small angles from the strike and dip of the vein. At such places the lode for a short distance is without a well-defined footwall or hanging wall. It appears that the stress which produced the slickensided walls was exerted in directions that in homogeneous material would have resulted in fissures oblique to the vein. The angle of obliquity, however, was so small that the movement for considerable distances took place along the vein. The grooving and slickensiding on the walls of many of the lodes indicate that the last movement along these surfaces was more nearly horizontal than vertical.

Transverse faults are exceptional. In places, as on the second level of the Gold Canyon mine, the quartz is displaced a few feet by a movement which was earlier than the last movement parallel to the vein, as the present vein walls are not disturbed. The only large transverse fault is that which cuts the Tightner vein. Between the upper and lower workings that vein is displaced by a fault zone, consisting of a group of closely spaced nearly vertical parallel fissures which intersect the vein at a small angle and produce a vertical displacement of 100 feet and an estimated horizontal offset of 300 feet. Probably movement parallel to the vein was in part later than this faulting.

The strike of the veins is almost without exception northwesterly and varies from nearly north to about N. 60° W. A few veins, such as the Oriental, have an east-west strike. The dips of all the veins are low, 40° to 60° being average dips throughout the district. Single veins, however, show great variation, the difference at different levels being not uncommonly as much as 30°.

MINERALOGY.

GANGUE MINERALS.

Quartz is the principal mineral of the veins and is the only host of the rich sulphides and free gold. Lenticular masses of a dark quartz occur in the amphibolite and slates. Except for rare specks of pyrite these quartz lenses contain no metallic minerals and, so far as known, are not gold bearing. In the vein quartz two generations can be distinguished. The quartz of the first generation forms the bulk of the veins and is coarsely crystalline and in places vuggy. The largest vug seen had a maximum diameter of 2 or 3 feet, but most of these cavities do not exceed a few inches. Prismatic crystals, from a fraction of an inch to 6 inches in length, line the vugs. In the uncrushed massive quartz the microscope shows interlocking grains with few definite crystal boundaries. The quartz, seen in the hand specimen, is milky white in color, rather than transparent. By the aid of the microscope this color is seen to be due to reflection from the surfaces of innumerable minute cavities. These are not greater than 0.01 millimeter in diameter and usually much less, but are so closely spaced that thin sections of the quartz have a decidedly cloudy appearance under the microscope. Two kinds of these little bubble-like cavities are present. Those of one kind, where any definite relation can be observed, are arranged in rather shadowy lines, parallel to the prism and pyramid faces of the quartz crystals. A narrow border of clear quartz generally surrounds the cloudy area. These cavities appear to be filled with a liquid, and where they are particularly well developed, as in the large crystals projecting into the vugs, small moving gas bubbles may be seen under the highest power of the microscope. These bubbles move upward as the stage is rotated, but with a slow and rather uncertain movement as if inclosed in a viscous liquid. Most of the liquid-filled cavities are irregular in outline, but a few appear to be fairly definite negative crystals. The cavities of the other kind follow rather more definite lines and tend to lie with their long axes parallel. Their outlines are irregular and the moving bubbles were never observed in them. In many places the lines of these cavities cross from one quartz grain to another without change of direction. It would seem that the cavities of the first kind were formed contemporaneously with the crystallization of the quartz, and that those in which the linear arrangement is marked are the result of shearing and subsequent healing of the already formed grains. As a rule the larger quartz grains do not show the cloudy or wavy extinction attributable to strain, but a few of the smaller grains in the minute veinlets which cross the arsenopyrite crystals show a distinctly wavy extinction.

Many of the larger grains have an indefiniteness of total extinction which is due to reflected light from the surfaces of the minute cavities. Rarely the larger grains show the peculiar "flamboyant" extinction sometimes seen in vein quartz.

The later quartz is an inconspicuous feature of the veins as a whole. Many of the crystals of the vugs are coated with minute transparent quartz crystals. Rarely, as in specimens obtained at the Irelan mine, the large crystals of the older quartz have been coated with successive layers of chalcedonic and finely crystalline quartz until their outlines are almost lost. In many places minute veinlets of clear quartz cross the milk-white quartz of the veins. These are generally not more than a millimeter wide. Under the microscope they are seen to be composed of minute slender crystals, which, in polarized light, give a feathery effect.

Albite is rare in the veins but where present it forms fairly large crystals close to the walls. Most commonly it is in the small stringers branching out into the schists rather than in the larger veins.

Calcite occurs as a replacement mineral in the wall rock rather than in the veins, as much of the wall rock gives a slight effervescence with cold dilute hydrochloric acid. The great mass of the carbonate mineral present is, however, a dolomite. In places the carbonate has evidently migrated from the altered wall rock into the vein as a replacement of the older quartz. It also forms small veinlets in the quartz and rarely between the quartz and arsenopyrite, or crosses the larger arsenopyrite crystals in veinlets less than 0.1 millimeter wide.

Mariposite, a vivid-green chromium-bearing micaceous mineral, is associated with ferriferous dolomite in the altered wall rock. This dolomite-mariposite aggregate, although largely composed of calcite, has a viridian green color due to this disseminated mariposite and is lined with small white veins of later calcite. The brilliant color of this mixture makes it a prominent feature of the veins and has earned for it the local name of "blue jay." Like the dolomite, the mariposite occurs in a few localities as a replacement of the quartz but nowhere far from the altered wall. Under the microscope the "blue jay" is seen to consist largely of the carbonate with shreds of the green mariposite scattered through it in irregular lines. The mariposite, as seen in thin section, is bright green and is faintly pleochroic. It resembles sericite, save that owing to its greater absorption of light, the polarization colors are far less brilliant. Exceptionally the green color is very faint, so that the mineral is hardly distinguishable from sericite. In the veins of the Mother Lode region mariposite is generally found where serpentine is the wall rock. In the Alleghany district, however, the mineral occurs as a replacement of the talcose or chloritic amphibolite.

Sericite occurs in minute veinlets in the quartz, especially in the crushed portion, and also as partial replacements of quartz grains. It is probably present to some extent as an hydrothermal alteration product in the wall rock, but as the amphibolite schist is in part altered to talc along the walls of the veins and as none of the altered material collected appeared to be of sufficient purity to justify microchemical tests, it is uncertain how far the sericite has replaced the wall rock. In specimens of microcline granite collected close to the Oriental vein no sericitization of the feldspars is apparent under the microscope.

Dolomite of a second generation and lime-bearing siderite are among the last minerals formed. In specimens from the Rainbow and Minnie D. mines dolomite appears as bladed semicircular crystals about a centimeter in diameter grown upon the quartz of the later generation, and in specimens from the Minnie D. and Twenty One reddish siderite occurs in a similar association.

METALLIC MINERALS.

Arsenopyrite is the most important sulphide in the veins, both from its gold content and as an indicator of the shoots of rich ore. The mineral is found both in the veins and in the altered wall rock, but its mode of occurrence is somewhat different in the two situations. In the veins it occurs in large bladed crystals and irregular crystalline masses much broken and veined by quartz, and more rarely in minute distinct crystals of octahedral habit. Even in the most completely shattered portions of the larger individuals crystal faces can be found, and in a few specimens crystals 4 to 5 centimeters in length and 5 millimeters in width are distinct and sharp, though cut by minute veinlets of quartz or gold and slightly faulted across, with displacements of a millimeter or less. Where there has been later crushing in the quartz, however, the arsenopyrite is smeared out along the line of movement in dusty bands that give one form of the banded quartz which is regarded as a favorable indication. In some places cleavage fragments of original crystals and more rarely minute perfect crystals of octahedral habit are discernible under the microscope. These crystals are believed to be the result of recrystallization of the dustlike arsenopyrite fragments in the zones of crushing rather than of a second accession of material. In certain localities, particularly in the Gold Canyon mine, much of the arsenopyrite in the quartz is massive crystalline, and these masses are rudely rectangular in outline and have sharp boundaries which suggest the complete replacement of fragments of the wall rock, or possibly fragments of large sulphide masses. In these occurrences, as well as in the crystals, the arsenopyrite is shattered and veined with quartz. In the wall rock, or as a partial replacement of fragments of the wall rock in the vein close to the walls, arsenopyrite has crystallized in minute slender prisms or less commonly as barely visible crystals of octahedral habit.

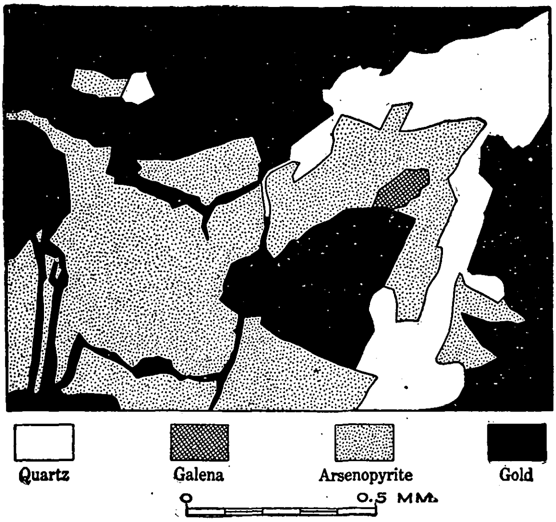

FIGURE 49.—Gold and galena in arsenopyrite. The small veinlets of gold crossing the arsenopyrite appear to be, in part at least, replacements of quartz.

Coarse gold is a notable feature of the veins of the Alleghany district. So far as the writer is aware, the little bunches of exceptionally rich ore have been found only in the quartz and in close connection with the coarsely crystallized arsenopyrite (fig. 49). The gold occurs in the arsenopyrite chiefly as a replacement, but perhaps in part also in solid solution with the sulphide. It is to be noted, however, that the arsenopyrite of the near-by wall rock is almost barren, and that the fine crystalline arsenopyrite found in the veins at a distance from the shoots of high-grade ore carries comparatively small amounts of gold.

D. F. Hewett made some assays on material from the German Bar mine which illustrate this point, and the following table is quoted from his notes:

Assays of material from German Bar mine.

	Gold.		Silver.		Total value.
	Ounces.	Value.	Ounces.	Value.	
1	0.41	$8.47	0.12	$0.06	$8.53
2	4.68	96.73	.47	.23	96.96
3	460.56	9,519.79	42.51	21.25	9,541.02

1. Quartz showing fine arsenopyrite and banding, from raise from lowest tunnel.
2. Concentrate from No. 1. 342 grams of No. 1 concentrate into 29 grams of No. 2 (11.8 into 1). Results show saving of 98 per cent of gold and 32 per cent of silver in operation.
3. Coarse arsenopyrite, not showing free gold. From lower tunnel.

In the rich arsenopyrite the visible gold may occur either as irregular replacements ranging in size from particles at the limit of microscopic observation to patches several millimeters across, as minute threadlike veinlets, or as replacements of the quartz veinlets that cross the arsenopyrite. At the borders of the broken crystal fragments the gold replaces both the quartz and the arsenopyrite (fig. 50). Away from the arsenopyrite the gold cuts the quartz in small irregular fissures, apparently involving but little replacement. In some of the rich ore from the Tightner mine small veinlets of gold cross the zones of broken quartz, but in many specimens the gold is itself polished and slickensided by later movement. The gold in the quartz at a distance from the arsenopyrite is usually associated with galena. A rare but fairly characteristic feature of the rich ores is the presence of gold in octahedral crystals on the quartz crystals of the smaller vugs. In a few of the specimens examined minute specks of a reddish spongy gold were seen upon the plates and crystals of light-yellow gold in the quartz. As the reddish spongy gold is clearly later than the greater part of the gold in the veins it may have been deposited by downward-flowing surface water.

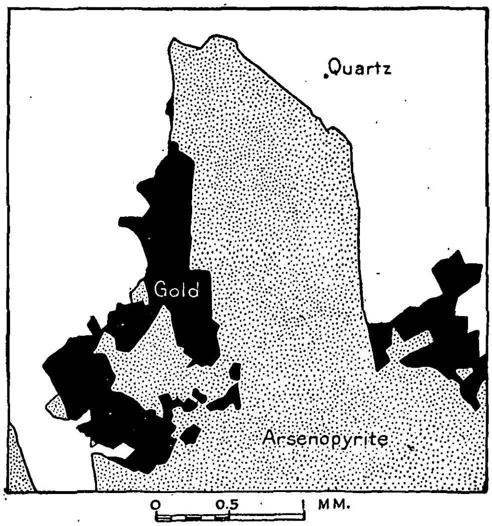

FIGURE 50.—Gold replacing quartz and arsenopyrite.

Galena is not an abundant constituent of the deposits, but is usually found in close association with the gold of the rich ore. Commonly it occurs as a replacement of quartz (fig. 51). There is usually a small nucleus of solid cleavable galena from a fraction of a millimeter to 2 or 3 millimeters in diameter, and from this radiate delicate needles, extremely narrow, and not exceeding 2 millimeters in length, similar to rutile

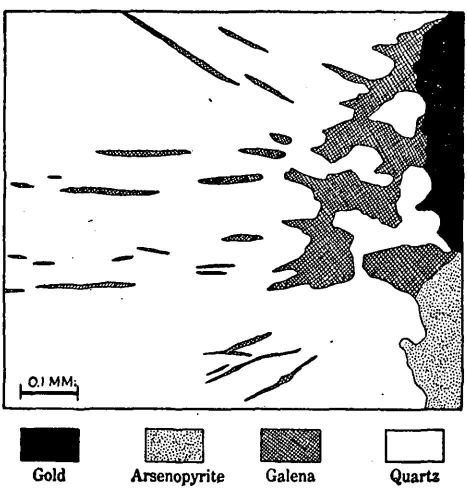

FIGURE 51.—Galena replacing quartz.

needles replacing quartz, but so closely spaced that the clusters resemble minute chestnut burrs. Examination of thin sections of galena in quartz shows that these minute rays in places cross different quartz crystals.

Dark-brown sphalerite, generally in very minute specks, can be seen in the vicinity of the galena in much of the quartz. It is far less abundant than the galena and was never seen in such close association with the gold.

Pyrite is found in several different associations. To some extent it replaces the quartz of the vein. In this situation it is generally associated with the other sulphides and is presumably of the same age as the galena. Rarely pyritohedrons are implanted on the faces of quartz crystals in the vugs. In the mariposite and dolomite replacement of the country rock pyrite is always present and is apparently slightly later than the intergrown mariposite and dolomite and contemporaneous with the later white carbonate which veins the green mass. Pyrite of a distinctly later generation and presumably deposited by circulating surface waters is found in small fissures and in layers of minute octahedral crystals, coating the later quartz. Marcasite has been reported in the same position, and specimens of a very minutely crystalline mineral that appeared to be marcasite were collected for examination in the office. On unpacking the material, however, it was found to have oxidized and lost its crystal outlines.

Tetrahedrite, carrying arsenic as well as antimony, is rare in the Alleghany district, but was noted in specimens from the Tightner, Plumbago, and Kate Hardy mines. In the Tightner it occurs in the same general neighborhood with the other sulphides and free gold, but most closely associated with the pyrite. Rarely small specks of tetrahedrite occur on the faces of crystals of pyrite. In other veins tetrahedrite was found only as small specks in the quartz.

Chalcopyrite was seen in most of the veins. In many places it occurs in isolated specks in the veins, and, although not found in the country rock, it is scattered throughout many of the veins in small irregular masses.

ORDER OF CRYSTALLIZATION.

The microscopic structure of the vein quartz and arsenopyrite shows that the arsenopyrite of the vein crystallized earlier than the quartz. As already explained, the arsenopyrite is seamed and fissured with minute quartz veinlets. (See fig. 52.) This quartz does not, as a rule, belong to a later period of mineralization but is of the same age as the quartz which makes up the body of the vein. This is well shown at the mouths of the little veinlets of quartz which intrude the arsenopyrite. Here the veinlets of quartz, for distances of several hundredths of a millimeter, are portions of the same large crystal which partly surrounds the arsenopyrite. Not only is the optical orientation the same, but the quartz in the veinlet has the same cloudy appearance, due to the presence of minute bubbles, as the quartz in the main mass of the vein, and there is no evidence of any boundary line between the portion of the quartz crystal in the main vein and the portion in the small veinlet. The distinctly later veinlets of quartz, which cross both the earlier quartz and the arsenopyrite, are invariably clear and free from bubbles. Moreover, angular fragments of arsenopyrite separated by distances

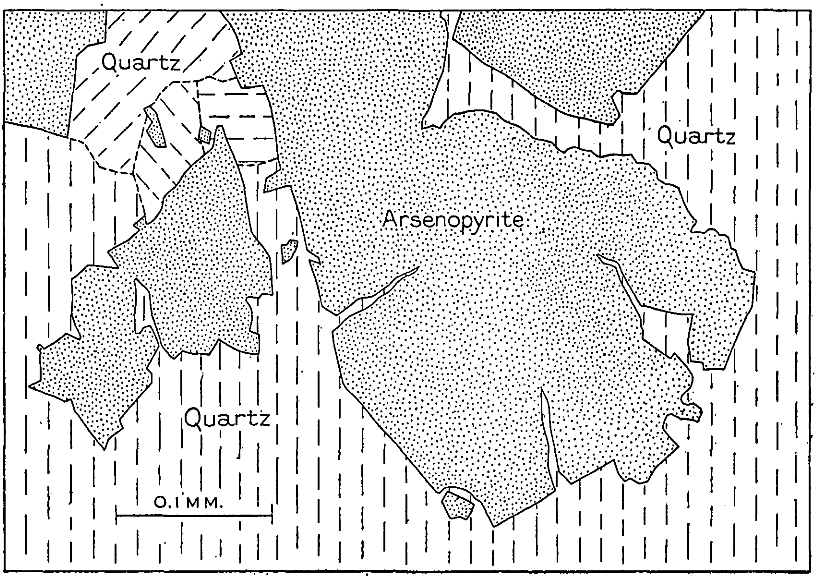

FIGURE 52.—Arsenopyrite veined by a single quartz crystal, seen by polarized light. The different quartz crystals are indicated by the directions of the broken lines.

of a fraction of a millimeter from the large crystal are found entirely inclosed in a single quartz individual. The reentrants of such fragments agree with the angles of the larger arsenopyrite mass and afford evidence of a character similar to that given by the quartz veinlets. It seems most natural to assume that the solution from which the quartz and arsenopyrite crystallized was essentially without motion at the time of the crystallization of the arsenopyrite and, for a short time at least, was sufficiently viscous to allow of small pieces of the wall rock being held without sinking. The arsenopyrite to some extent migrated into and replaced the wall rock but for the most part crystallized in the fissure about whatever nuclei were available, such as the walls themselves and small fragments and specks of the wall rock in the solution. It is supposed that after the crystallization of the arsenopyrite outside motion of some sort stirred the supersaturated quartz solution and caused it to fissure and drag the already crystallized arsenopyrite at the same time that a rapid crystallization of the quartz set in.

Vein formation of an essentially similar nature has been noted by Ransome[1] in the Silverton quadrangle, Colo., by Graton[2] in the auriferous quartz veins of the southern Appalachians, and by Hess[3] in the tin deposits of the Black Hills.

The formation of the dolomite and mariposite mixture in the altered wall rock was clearly later than the crystallization of the quartz, for all three of the members of this aggregate, mariposite, dolomite, and pyrite have been observed as replacements of the quartz. Possibly it is to be correlated with the introduction of the gold and sulphides.

After the crystallization of the quartz there was movement parallel to the walls which crushed the quartz along narrow bands, and in places the arsenopyrite crystals were comminuted and dragged out. This was followed by the introduction of the gold and galena and probably of the other sulphides also. The gold is clearly of later date than the crushing of the quartz, as minute threadlike veins of gold cross the crushed zones. It is probable that the gold is contemporaneous with the galena, as both occur in close association without replacement one by the other and both are younger than the quartz and arsenopyrite. Probably the other sulphides of the vein—pyrite (the earlier series), sphalerite, tetrahedrite, and chalcopyrite—belong to the same period.

It is not intended to imply that any great interval separated these different periods of mineral introduction. The evidence shows that they were distinct, but it is impossible to say whether they are to be considered as separated by intervals of minutes or of years.

Distinctly later action, separated from the earlier periods of vein formation by a long interval, is shown by the fine-grained chalcedonic quartz, the later carbonates and pyrite, and the rare small specks of reddish gold. These, it is thought probable, were deposited from generally downward-flowing atmospheric waters.

ORE SHOOTS.

The extreme localization of the gold is a feature of all the mines of the district and has led to their being referred to as "pocket mines." This is not a fair description, however, for a "pocket"

[1] Ransome, F. L., U. S. Geol. Survey Bull. 182, p. 136, 1901.
[2] Graton, L. C., U. S. Geol. Survey Bull. 293, p. 72, 1906.
[3] Hess, F. L., U. S. Geol. Survey Bull. 380, p. 140, 1909.

in California miners' usage often refers to gold found outside of any well-marked veins. In the deposits of the Alleghany district, on the other hand, the rich ore is in the veins and in small but distinct ore shoots. The great mass of the quartz of the veins is of extremely low tenor. Much of it carries even less than $1 or $2 worth of gold to the ton, and this is largely in the sulphides. The concentrates from portions of the vein outside of the ore shoots carry $50 or less to the ton in gold and form only about 1 per cent by weight of the ore. In the small ore shoots, however, the ore may carry as much as $40 or $50 in gold to the pound, for the most part free gold. Some of these very rich masses have been found immediately adjacent to the nearly barren quartz; more commonly, however, the richest spots grade off into the vein quartz within distances of a few feet. The amount of rich ore in a single shoot may be from a few pounds to several tons. In the several mines different features of the veins are looked upon as indicators—in fact, the so-called indicators are nearly as numerous as the mines themselves. Among such guides are the presence of either more or less "blue jay" than usual, a "hard cabby hanging," rolls in the foot and hanging walls, sharp changes in dip or strike, banding of the quartz, and intersecting veinlets. The writer's conclusions in regard to genesis as given in the following paragraphs are based on a small amount of field work and hence are offered with some hesitation. The explanation presented may not be as fully supported as would be desirable, but it is at least in accord with the facts observed.

The gold, as has already been shown, is distinctly later than the arsenopyrite, but the coarsely crystalline arsenopyrite carries gold visible with the microscope if not always to the unaided eye. Palmer and Bastin [1] have shown that arsenopyrite is an extremely effective precipitant of gold. Hence it appears reasonable to suppose that the later solutions traveling through the crushed quartz of the vein tended to deposit their gold content when they reached the arsenopyrite and to replace a portion of the arsenopyrite and the neighboring quartz. Also in the quartz near the arsenopyrite, though not in direct contact with it, gold and such sulphides as galena, tetrahedrite, and sphalerite were deposited in minute fissures or as replacements in the quartz. Where open spaces, such as vugs, afforded the opportunity, gold crystals were formed. The gold-bearing solutions were confined to the vein, for although arsenopyrite occurs in the country rock the arsenopyrite crystals in the vein alone carry free gold. Hence the formation of the ore shoots depends on two sets of conditions—those which determined the formation of masses of coarsely crystalline arsenopyrite in the veins and

[1] Econ. Geology, vol. 7, pp. 140–170, 1913.

those which determined the paths followed by the later solutions, which carried the greater part of the gold. Of these conditions the first set seems to have been the more influential, for so far as the writer is aware all the coarse arsenopyrite found in the veins has a high gold content and almost invariably is closely associated with coarse gold. It may therefore be assumed that the gold-bearing solutions were fairly ubiquitous within the vein, and that the presence of the arsenopyrite to a great extent determined the ore shoots. (See fig. 53.)

As has already been explained, it is believed that the arsenopyrite crystallized out from a still fluid quartz solution, in a manner comparable to the formation of the large tourmaline crystals along the walls of a pegmatite dike. The most favorable localities for the formation of these large arsenopyrite crystal masses would naturally be those portions of the veins where there was possible a maximum amount of circulation. This condition seems to have been met, in the Tightner and Rainbow mines at least, by the localization of the arsenopyrite along the edges of lenticular swellings in the veins. These enlargements themselves appear to be due to intersections with other veins. In the Plumbago and Oriental mines the general location of the small shoots of high grade has been assigned to intersections of transverse veins with the main vein. In the Tightner mine rich shoots have been found at two points on the lower level. Each of these shoots is near the north end of a marked enlargement in the vein and about 100 feet north of an intersecting vein on the hanging wall. The old stopes of the Rainbow appear to show a similar relation. It is supposed that the opening was wider at the junction of two channels, and, therefore, when movement in the solution ceased there was greater opportunity for differentiation here than elsewhere in the veins, and it was at favorable localities along the edges of these enlargements that the arsenopyrite crystallized. This original concentration of the arsenopyrite determined the locus of deposition of the gold carried up by later solutions.

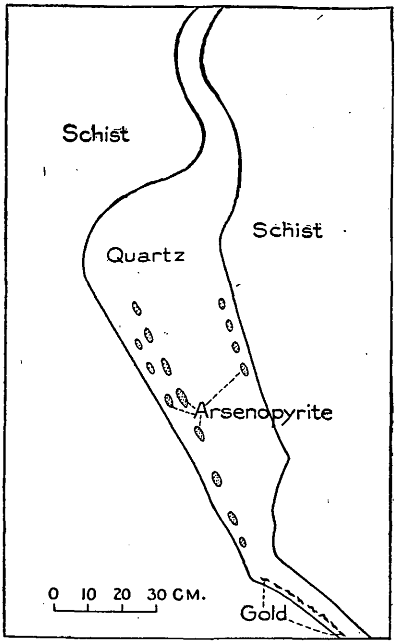

FIGURE 53.—Sketch of Gold Canyon vein, Alleghany district, Cal., showing occurrence of arsenopyrite and free gold.

If the explanation above offered is the correct one, it follows that most of the small ore shoots will be found near the circumferences of the lenticular swellings of the vein, and that these enlargements will in any one mine be found at similar distances from intersecting veins. The distances and directions will vary in different mines according to the magnitude and direction of the movements along the vein walls.

MINES.

TIGHTNER MINE (1).[1]

The Tightner vein, directly beneath the town of Alleghany, was rediscovered by H. L. Johnson in 1907. During the placer operations of the early years of the camp the vein had been cut in a bedrock tunnel, but no attention was then paid to it. The report that a very rich gravel had been found in the neighborhood of the vein led Mr. Johnson to reopen the bedrock tunnel and drift on the vein. He was rewarded by the discovery of a few tons of very rich ore on the first level and several smaller patches elsewhere in the upper workings. He is reported to have taken out more than $400,000 in gold. The present company began operations in 1911 and has developed the vein on the lower level, entered by a long tunnel at an elevation of 4,080 feet. The production under the present management has been about $600,000 to June, 1913. At the time of visit there was a 10-stamp mill on the property. Lately 10 stamps more have been added.

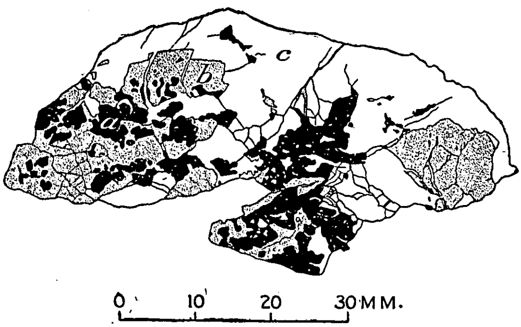

FIGURE 54.—Rich ore from Tightner mine, Alleghany district, Cal. From a photograph. *a*, Gold; *b*, arsenopyrite; *c*, quartz.

The wall rock of the vein is amphibolite schist, which is much altered near the vein. Where the movement has been most intense the rock has been altered to a talcose schist. Hydrothermal alteration is common but irregular. Masses of dolomite and mariposite are irregularly distributed along the walls, and in places there is silicification as well. The vein crosses the steeply dipping laminæ of the schist, but the schist is so sheared and altered near the walls that the difference in dip between the veins and the schist can only rarely be observed. On the first level the crosscut passed through

[1] Numbers refer to map, fig. 48.

a small band of serpentine about 75 feet from the vein. A small vein consisting of quartz, talc, and calcite crosses the serpentine.

The principal vein has been followed for about 1,800 feet. In two places the quartz pinched out but reappeared a short distance beyond. The maximum width is about 20 feet. The strike varies in different parts through an angle of about 45°, and the dip ranges from 30° to 55°. Between the upper and lower workings the vein is cut obliquely by a composite fault of about 100 feet vertical and 300 feet total horizontal displacement. Along the fault planes there is a small amount of crushed quartz which has been recemented by later quartz filling.

The rich ore taken from the lower workings has come from two areas, one just south of the winze connecting the upper and lower workings and the other about 700 feet north of the winze. At each place the vein is wider than the average, its width being about 7 feet at one place and 10 feet at the other. Moreover, they both lie at the north ends of marked enlargements of the vein and at nearly equal distances, about 100 feet, north of intersecting veins.

The writer had the opportunity of observing the rich ore in place in the northern stope. Here, directly beneath a well-marked hanging wall, was 1½ feet of black and gray gougey material, apparently in the main comminuted country rock, containing a few angular fragments of quartz. Below this was a very distinct band, about half an inch wide, of finely comminuted white quartz. Under the microscope this was seen to consist of angular quartz fragments varying in size from pieces a few millimeters across to minute specks barely distinguishable with the highest power. This band was separated from the vein by a narrow streak of black gougey material. The broken material lying between the hanging wall and the vein widened away from the richest ore and reached a maximum width of 12 feet a short distance to the south. For the first 10 inches the quartz of the vein was closely banded, the white quartz being separated by thin black streaks at intervals of 1 to 3 inches. The banding is due to movement and the black streaks consisted of arsenopyrite, crushed to the fineness of dust. Here and there among the dustlike fragments of arsenopyrite were small well-formed crystals that appeared to be the result of recrystallization in place of a part of the crushed and powdered arsenopyrite. Among these streaks was also a certain amount of free gold striated and polished by movement. In the quartz of the upper part of the vein were also shattered and broken crystals of arsenopyrite, with which the greater portion of the free gold was closely associated. In the quartz were small specks of sulphides, principally galena, which showed the peculiar radiate replacement structure characteristic of this mineral in the Alleghany district. Below the 10 inches of banded quartz was 3 feet of massive white quartz. This was rather coarsely crystalline and contained numerous large and small vugs lined with quartz crystals. The long axes of the larger vugs appeared to be generally parallel to the dip of the vein. Specks of gold occurred throughout this quartz but decreased in number toward the footwall. In several of the smaller vugs little crystals of gold had grown on the faces of the projecting quartz crystals. No mariposite was found in the vicinity of the rich chimney. A specimen of the rich ore is shown in figure 54.

MINNIE D. PROSPECT (2).

The Minnie D. prospect, a short distance north of the Tightner, is developed by two tunnels 60 feet apart vertically. The upper tunnel follows the vein for 150 feet and the lower for about 300 feet. The strike varies from N. 80° W. to N. 65° W. and the dip averages 46° NE. On the hanging-wall side the vein is bounded by a well-marked slip which is in places intersected at small angles by fault planes passing off into the hanging wall. On the footwall there has been but little movement and the vein cuts sharply across the schistosity of the amphibolite and is in several places joined by stringers from the footwall side.

The vein varies in thickness from a maximum of 15 inches to practically nothing, but the most usual width is about 2 inches. The quartz is distinctly banded and in places approaches comb structure. Near the walls are rare white crystals of albite. In places the quartz crystals projecting into the vugs are coated with minute crystals of siderite and of semicircular crystals of dolomite. The quartz contains nests of little pyrite crystals, accompanied by specks of sphalerite and galena. In the upper tunnel it is iron stained and in a few places shows black dendritic markings. Free gold is found where the stringers from the footwall intersect the vein. The gold is in the quartz near the sulphides and is very commonly smeared out along slips in the vein. A rare occurrence of gold was seen in the presence of minute specks on the faces of pyrite crystals.

OSCEOLA MINE (3).

The Osceola mine is above the north fork of Kanaka Creek, about half a mile northeast of the town of Alleghany. A large amount of ore has been taken out from this mine, but the production is unknown. Development work was in progress in May, 1913.

The upper tunnel, at an elevation of 4,370 feet, follows the vein for about 40 feet N. 60° W. and then for about the same distance N. 47° W. The dip is here about 55° NE. The vein consists of white quartz and is 6 feet wide at the portal and 2 feet at the face. The lower tunnel, at an elevation of 4,200 feet, has a length of 1,650 feet. The strike of the vein in the outer part of this tunnel is N. 45° W., in the central part between N. 60° W. and N. 70° W., and near the face N. 25° W. The dip shows similar variations; near the portal it is 50° NE.; in the central part it steepens to 70° or more; for the greater part of the course of the vein it is between 50° and 60°, and near the face of the tunnel it flattens to 35°. The vein has a maximum width of 10 feet, but between points 650 and 1,150 feet from the portal the quartz pinches out and the tunnel follows a crushed zone in the schist. From the 1,150-foot point to the face the quartz is continuous. Near the portal there is a split in the vein and a part goes off to the north with a dip of 60° W. but has not been prospected.

The ore, so far as could be seen, is similar to that of the other mines. In the richer patches the quartz contains narrow dark bands of crushed arsenopyrite, and near these free gold is found.

ELDORADO MINE (4).

The Eldorado mine was not in operation at the time of visit. The property is on the south bank of the South Fork of Kanaka Creek, about three-quarters of a mile southeast of Alleghany. The principal workings consist of a tunnel 1,100 feet in length, with stopes above. The country rock is amphibolite, the only notable feature of which is that here the schistosity dips at about 30°, a much lower angle than elsewhere. The vein is fairly continuous throughout the length of the tunnel. At about 500 feet from the portal a well-marked vein branches off on the footwall side. At 800 feet in the vein which up to this point has a northwesterly strike turns sharply, and within a little more than 100 feet it assumes a northeasterly direction. For about 100 feet along the turn quartz is lacking. The slickensides and grooves along the wall, which in the northwesterly course of the vein pitch to the northwest, are vertical at the turn and pitch to the southwest in the portion of the vein with the northeasterly strike.

TWENTY ONE MINE.

The Twenty One mine just south of the Tightner was idle in May, 1913, and its production is unknown. The vein has been followed for about 1,000 feet and pinches and swells greatly, quartz being absent for considerable distances. Although at a lower level than neighboring mines there appears to be more oxidation, and secondary pyrite is prominent.

SIXTEEN TO ONE MINE (5).

The Sixteen to One mine, three-quarters of a mile south of Alleghany, was located in 1908. Its production is estimated to have been between $150,000 and $300,000. The main tunnel is about 900 feet long, and all the work has been done above this level. A winze is now being sunk to develop the ore at greater depth.

The country rock is amphibolite; in places near the vein it is silicified, and along the walls it is everywhere much crushed. The average strike of the vein is northwest. The dip is to the northeast—in the raise above the adit about 30°, at the adit level 50°, and in the winze from 60° to 70°. For about 200 feet along the tunnel there is a well-defined quartz vein. Beyond is a band of gauge, in places 2 feet wide, which carries small lenses of quartz mixed with mariposite and dolomite. The pay ore occurred in a single shoot, about 80 feet in width along the drift and 100 feet up the dip, which had a pitch of 30°–40° NW. Within this shoot the high-grade ore occurred in small zones transverse to the pitch of the shoot.

SHERMAN MINE (6).

The Sherman mine, 1½ miles southwest of Alleghany, is developed by a tunnel about 1,000 feet long. The production is unknown. The vein is sinuous, the strike varying between north and N. 30° W., and the dip averaging about 60° W. At 650 feet from the portal the tunnel encountered a nearly horizontal quartz stringer, which has been followed for 450 feet. The main vein is well defined for the first 700 feet of the tunnel. Beyond this it pinches out and only small discontinuous stringers of quartz are found to a point within about 50 feet of the face, where a vein about a foot wide comes in.

The vein material is white quartz, slightly iron stained. In places it contains small inclusions of schist, and rarely small patches of pyrite associated with a little minutely crystalline arsenopyrite. Parallel to the walls are streaks of gouge containing pyrite.

KENTON MINE (7).

The Kenton is one of the older mines of the district and is supposed to have had a large production. For the last few years, however, practically no gold has been obtained. The equipment consists of a 10-stamp mill and four vanners. The principal workings consist of a tunnel and drift about 300 feet above Kanaka Creek. The crosscut tunnel is about 500 feet in length and the drift follows the vein for about 300 feet.

The country rock is, as usual, amphibolite, and the vein does not differ in type from others of the region. The strike varies between north and N. 10° E. and the dip from 45° to 50° E. The quartz is persistent and, from a minimum of a few inches, in places reaches 6 feet in thickness. No mariposite was seen. Throughout the quartz are patches of pyrite with small crystals of arsenopyrite. These, however, carry but little gold. Near the north end of the drift a marked fissure in the hanging wall coincides with the part of the vein where the best prospects in free gold were obtained. Here a single mass of coarsely crystalline arsenopyrite was found. This is described as being the size of a fist and yielded $30 in gold.

The upper workings are to the southeast of the lower and may be on a different vein, as the strike is here N. 20° W. and the dip 40°–45° NE. In places the quartz here shows dendritic manganese markings. The old stopes appear to have favored portions of the vein where the hanging-wall slip was less marked.

ORIENTAL MINE (8).

The Oriental mine is on the north side of Kanaka Creek, about 1½ miles west of Alleghany. A large amount of work has been done here in the past, but the mine has been idle for some years. On the lower tunnel, at an elevation of 4,050 feet, the vein is reached by a crosscut tunnel 4,150 feet in length. For the most part the tunnel passes through amphibolite schist, but from the 3,600-foot point to the face it is in a much-altered microcline granite, the only silicic intrusive rock seen in any of the mines. On the lower level two veins have been developed. The southern vein cuts the granite but is here small and poorly defined. The northern vein is at the northern contact of the granite and schist and has been developed only on this level. For about 400 feet the northern vein follows the contact very closely, but at the west end it passes first into granite and then into schist, and at the east end directly into schist. Between this level and the outcrop at an elevation of 4,800 feet the southern vein is developed by several levels.

The strike is variable but averages about N. 70° W. The dip, which is 30°–35° N. in the lower levels, steepens to 50° N. in the upper workings. At an elevation of 4,250 feet the southern vein passes out of the granite, and above this level it is entirely in the amphibolite, except at the west end of the 4,340-foot level, where it enters a serpentine band and breaks up into small irregular stringers.

In places the quartz pinches out for short distances, but on the whole it is fairly persistent. The greatest width observed was 10 feet. All the stoping seems to have been done along the footwall; generally the lower 2 feet of the vein has been mined. Small quartz stringers are very common in the schist near the vein. The only sulphide seen was pyrite, which occurs in the quartz in small patches half an inch across. The granite, near the vein, contains pyrite and much carbonate and is said to carry gold. In the rich ore, however, as shown by specimens collected by Mr. Hewett, there is the same association of gold and coarsely crystalline arsenopyrite that occurs in the other mines.

RAINBOW MINE (9).

The Rainbow vein, at Chips Flat, was discovered in 1885 in the course of gravel mining and is said to have produced $1,500,000. The present workings consist of two levels, entered by tunnels at elevations of 3,900 and 4,250 feet. There had been a 10-stamp mill on the property which had burned down just previous to the writer's visit. The immediate country rock of the vein is amphibolite, with a well-marked vertical schistosity which strikes N. 60° W. A crosscut to the south of the vein, however, cuts a band of serpentine about 200 feet wide which contains small tremolite veins. Near the vein the schist is in places altered to dolomite and mariposite and more rarely silicified.

On the lower tunnel the vein is reached by a 1,200-foot crosscut. Two veins have been developed to some extent. The smaller one has an average strike of about N. 15° W. and dips 65° W. This vein has been followed for about 600 feet but not stoped. The other vein has a general strike of about N. 70° W., though varying between west and northwest, and dips 30°–65° N. This vein has furnished the production of the mine. The quartz is generally between 1 and 2 feet wide, but in some places reaches 5 or 6 feet. A short distance southeast of the intersection of the two veins it is a large irregular mass about 30 feet thick. The gouge streak marking the footwall of the main vein is continuous across the minor vein. On the lower level the quartz of the main vein is continuous for about 400 feet.

The quartz is milky white but contains numerous vugs, particularly in the stopes. Some of the projecting quartz crystals in the vugs are as much as 6 inches in length. The quartz in the vugs is in many places coated with finely crystalline or chalcedonic secondary quartz and here and there with pyrite and perhaps marcasite. Bladed semicircular crystals of dolomite also project from the faces of the drusy quartz. Intersecting veins enter from both footwall and hanging wall, but a band of gouge everywhere separates the intersecting vein from the main vein, indicating later movement parallel to the strike.

The ore occurred in small rich shoots, as in the Tightner mine. So much gophering has been done by lessees that it is impossible to deduce any rule covering the occurrence. It is certain, however, that around the edges of the large mass of quartz found near the intersection of the two veins very rich masses of arsenopyrite and free gold have been taken out. The trace of the northerly vein upon the main vein would be a line rising to the east, and it appears from the old workings as if the stopes tend to follow such a line.

PLUMBAGO MINE (10).

The Plumbago mine is situated on the south side of the divide between Kanaka Creek and the Middle Fork of Yuba River. It has been worked at intervals since some time before 1860, and the production is said to have amounted to several millions. Besides the old workings along the outcrop the vein is developed by five tunnels at intervals of 100 feet on the dip of the vein. There is a 20-stamp mill in operation on the property.

The vein lies in a belt of amphibolite between two bands of serpentine. The amphibolite is less altered than usual, and specimens collected near the serpentine contact at the mine clearly show their derivation from gabbro. The amphibolite belt which contains the vein is about 300 feet wide at its widest part. It narrows to the northwest, where it passes under the gravels that cap the ridge, and it wedges out a short distance to the southwest.

The vein strikes northwest and dips 30°–45° NE. The greatest thickness observed was about 6 feet. As in the other mines the quartz forms in lenses. These are about 200 feet along the drifts and somewhat longer down the dip. The rich spots seen are irregular in distribution, but seem to follow poorly marked shoots which have a southeast pitch. The localization is considered to be due to an intersection of two veins.

On the third level and for a short distance below it is a mass of andesitic bowlders and quartz fragments, cut by a basalt dike. Presumably this material represents a Neocene volcanic vent. The basalt dike is probably of Pleistocene age, for it has the same composition as the Pleistocene basalts in the region north of Forest described by Lindgren.[1]

The ore is similar to that of the other mines in the district, small masses of high-grade ore occurring in nearly barren quartz. These patches seem to have been more or less localized along two broad southeastward-pitching shoots. The quartz outside of the high-grade pockets carries irregular amounts of sulphides, principally pyrite but including also galena, sphalerite, and chalcopyrite. The concentrates run about $50 to the ton, and there are sufficient sulphides in the vein to permit stoping the low-grade quartz.

[1] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Colfax folio (No. 66), p. 7, 1900.

IRELAN MINE (11).

The Irelan mine is situated on the top of the ridge between the Plumbago and Gold Canyon mines, and the vein is supposed to be a continuation of the Gold Canyon vein. As in the Plumbago, the outcrop is not covered with gravel, and so the vein was discovered earlier than those of some other mines. The mine was located about 40 years ago and is said to have produced at least $300,000. Besides the old surface workings, a tunnel has been opened on the veins near the top of the hill, at an elevation of about 4,400 feet. A second tunnel is being started about a quarter of a mile to the southeast, 400 feet lower. The country rock is entirely amphibolite, but a belt of serpentine lies between the Irelan and Plumbago mines.

There are two veins here. The eastern vein strikes N. 60° W. and dips 50°–60° NE., and the western one strikes about N. 50° W. and has an average dip of 45° NE. The intersection has not yet been developed. The eastern vein has been followed about 600 feet. It pinches and swells greatly, varying from a 1-foot band of gouge and altered country rock to 6 feet of quartz. Very little mariposite was seen, and this only in close association with the country rock. Most of the quartz is banded, and bands of white quartz averaging about 3 inches in width are separated by thin dark bands which consist of altered country rock and crushed arsenopyrite. Dark transparent cryptocrystalline quartz also occurs in places in these darker bands. The quartz is vuggy and the projecting crystals of the vugs are in places coated with successive layers of minutely crystalline and chalcedonic secondary quartz.

The ore shoots appear to pitch to the southeast and are said to be more regular than in the other mines of the district, though not of such exceptionally high grade. The rich ore consists of gold-bearing arsenopyrite. Free gold is only rarely visible, but when a polished section of the arsenopyrite is examined under the microscope it is seen to be flecked with minute specks of gold. The arsenopyrite occurs in shoots in the wider portions of the veins, either in fairly definite parallel bands in the quartz or in crystalline bunches. The western vein has not yet been developed to any considerable extent. Near the southeast end of the western drift a 3-inch veinlet of quartz, carrying patches of rich arsenopyrite, 1 to 2 inches across, enters from the footwall.

GOLD CANYON MINE (12).

The Gold Canyon mine is on the north bank of the Middle Fork of the Yuba, about a mile southeast of the Plumbago. Its total production is said to be in excess of $1,500,000. There is a 10-stamp mill on the property, and the power for mill and mine is furnished by the power house belonging to the company. The mine is developed by several tunnels, the lowest of which enters a few feet above the level of the river. Below this tunnel the vein has been opened by a winze for about 200 feet along the dip. Drifts have been run from the winze at a point 160 feet down the dip from the lowest tunnel, at the tunnel level, and at the mill level, 125 feet above. The drift at the mill level is about 1,200 feet in length. The vein strikes about N. 50° W. and has an average dip of 50° or 60° NE. On the tunnel level the vein is nearly vertical, but immediately below this level it has a dip of about 50° and on the upper level it is even flatter. The vein pinches and swells to a marked extent, and the lenses appear to be roughly parallel to the slickensides on the walls, which dip about 65° SE. in the plane of the vein.

The country rock is amphibolite, which is much altered near the vein. At the southeast end of the main drift the vein passes from the amphibolite into the serpentine and within a distance of a few feet is broken up into irregular stringers.

The richest shoots appear to have been formed at the edges of enlargement in the vein, but it could not be determined whether or not they were connected with intersecting veinlets. At the time of visit a patch of quartz containing rich arsenopyrite was being stoped. Here the vein was about a foot wide, but it narrowed immediately below. Visible gold was not directly associated with the arsenopyrite, which was said to assay about $1,000 a ton, but coarse gold occurred in the constriction of the vein immediately below. (See fig. 53.) Under the highest power of the microscope, however, a few minute specks of gold, not over 0.003 or 0.004 millimeter in diameter, could be distinguished in the arsenopyrite. The arsenopyrite in the vein appears to be (in part at least) a replacement of included fragments of the country rock, for instead of being present in separate individual crystals, as in the rich ore of the Tightner mine, it occurs in small, compact, coarsely crystalline masses with fairly definite boundaries. At another point the rich arsenopyrite was found close to the footwall, but none occurred on the hanging wall.

NORTH FORK MINE (13).

The North Fork mine, near Forest, has been essentially a gravel mine, but lately exploration has been going on with a view to rediscovering a vein cut by one of the early bedrock tunnels, now caved, from which a pocket carrying $100,000 in gold was obtained. The workings consist of a 13° incline, 1,037 feet in length, and a

1,000-foot crosscut. The incline cuts a belt of serpentine, but the crosscut is entirely in the amphibolite, which is for the most part altered to a chlorite schist. At the time of visit the footwall of the vein had been cut. This wall strikes N. 38° W. and dips about 40° SW. On the wall is about 1 foot of quartz, with broken ground, consisting of crushed and much altered schist and irregular stringers of quartz, above the vein quartz. The southwesterly dip is one of the few exceptions to the general easterly and northeasterly dips which prevail throughout the region. A shaft is being sunk in the footwall, and it is planned to crosscut the vein at a depth of 75 feet.

FEDERAL PROSPECT (14).

The Federal prospect, near Forest, has a tunnel about 1,000 feet long which in a general way follows the contact of amphibolite and serpentine, varying in direction between S. 20° E. and S. 50° E. A few small quartz veins have been cut but none developed.

KATE HARDY MINE (15).

The Kate Hardy mine has a reported production of $225,000 and has been worked at intervals since about 1860. The present equipment consists of a three-stamp mill and one classifier. The vein outcrops in the Cape Horn slate on the south bank of Oregon Creek, about 300 feet west of the serpentine contact. The slate is fine grained and much sheared, and contains small lenses of blue-gray quartz free from any mineralization. Near the vein the slate has a distinctly talcose and in places a graphitic appearance. The outcrop of the vein is much more prominent than is usual in this region and can be traced up the hill to the southeast until it is lost beneath the gravel and lava capping. The vein strikes about N. 20° W. and the dip varies from 80° W. to vertical. The width of the vein is between 10 and 30 feet. Development work has been carried on in four tunnels, the longest of which is about 300 feet in length.

The ore is partly oxidized, but contains considerable quantities of sulphides. Commonly these consist of small patches of finely crystalline pyrite which rarely assays over $10 to the ton. Small specks of chalcopyrite, galena, sphalerite, and tetrahedrite were observed near the rich ore. As usual in these deposits, the pay ore occurs in small patches of extremely rich ore consisting of free gold associated with auriferous arsenopyrite. The visible gold occurs both in the partly oxidized arsenopyrite crystals and in the quartz near by. The gold ranges in value from $16.30 to $16.75 an ounce. The patches of rich ore have been found only along the footwall and were all small. The smallest found carried $9 in gold, and the largest yielded over 500 pounds of rich ore, containing $20,000 worth of gold. Up to the present time the hanging wall has not been prospected.

On the north side of Oregon Creek the vein splits and has not been developed. It is said to be the same vein which has been worked at the Brush Creek mine, near Mountain House.