ORE DEPOSITS OF THE NORTHWESTERN PART OF THE GARNET RANGE, MONTANA.

By J. T. Pardee.

LOCATION AND ROUTES OF ACCESS.

The area described in this report is in Missoula, Granite, and Powell counties, Mont., about 30 miles southeast of Missoula. It extends from Clinton eastward beyond Bearmouth and from Clark Fork northward into the drainage basin of Blackfoot River, covering in all about 400 square miles. Its southern part is traversed by the Northern Pacific and the Chicago, Milwaukee & St. Paul railways, from which the different mining camps are reached by wagon roads from 3 to 10 miles in length. The most convenient points of departure from the railways are Bearmouth for Garnet, Coloma, and Top o' Deep; Bonita for Copper Cliff; and Clinton for the mines of the Clinton district. Many of the mining camps may be reached also from Potomac, a farming and logging town on the road from Missoula to Ovando. As a whole, the area is but sparsely inhabited, and its chief industries in addition to mining are agriculture and lumbering. (See fig. 16.)

FIELD WORK AND ACKNOWLEDGMENTS.

Felan and Tenmile creeks, a part of the Clinton district, and a few tracts elsewhere were examined by E. L. Jones, jr., in 1911, and some geologic mapping northwest of Bearmouth was done by T. H. Rosenkranz in 1913. A reconnaissance of the remainder of the field, chiefly in August and September, 1916, was made by the writer, who received from the mining men cheerful and unstinted responses to practically all requests for information. Among those to whom special acknowledgment is due are Messrs. J. L. Templeman and H. G. Klenze, of Butte, and F. A. Davey and Ludwig Mussigbrod, of Garnet. The writer is also indebted to W. T. Schaller, of the Geological Survey, for the determination of several minerals, and to

F. C. Calkins, also of the Survey, for the microscopic examination of some of the rocks.

Although brief descriptions of some of the mines have appeared from time to time in the mining journals, no reports covering all of the area here described have hitherto been published.

SUMMARY.

Bear Creek, an affluent of Clark Fork east of Missoula, was a large and early contributor to the placer production of Montana. The character of the deposits was discovered in 1865, and gold to

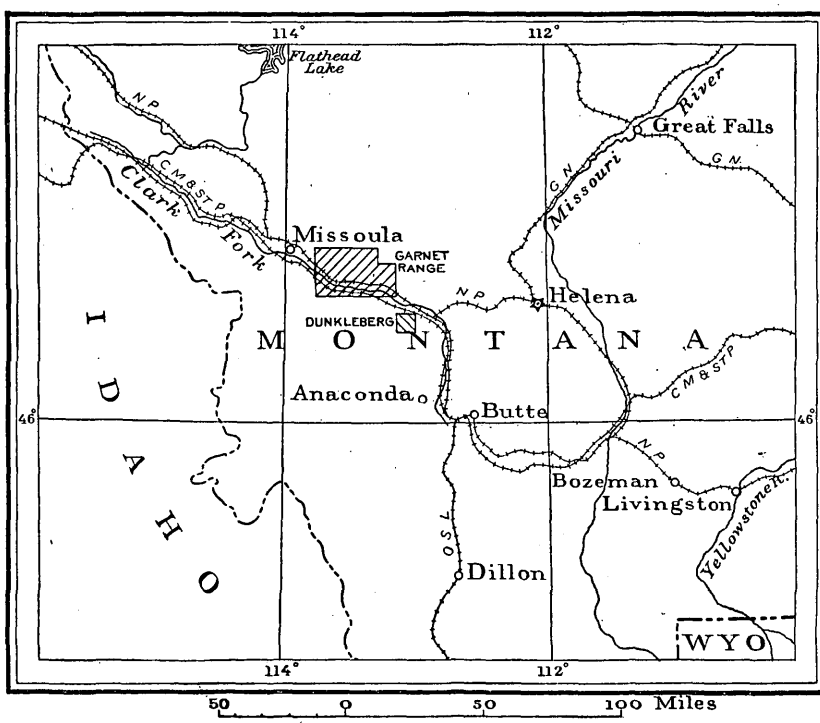


FIGURE 16.—Index map showing location of northwestern part of Garnet Range and Dunkleberg mining district, Mont.

the value of $5,000,000 or more was washed out within a few years. Elk Creek also yielded abundantly, and the total placer production of the area is estimated to be between $6,000,000 and $10,000,000. Quartz lodes around Garnet worked at different times, chiefly since 1896, have yielded $1,500,000 in gold and considerable copper and silver. In addition, moderate amounts of copper, lead, and silver have been produced by lodes in neighboring areas, mainly in the Clinton district.

The gold-bearing veins at Garnet and vicinity occur in granodiorite and in the adjoining quartzite and schist. Generally the

veins are narrow and rich, containing auriferous pyrite and chalcopyrite, with some tetrahedrite and galena that were introduced later. At Copper Cliff enargite and abundant silica were introduced to form the cement in a quartzite breccia. In the Clinton district chalcopyrite is the primary ore mineral in lodes formed in granodiorite, and here and there in the general region bodies of silver-bearing galena occur in limestone.

The ores were deposited by solutions believed to have been given off by granodiorite bodies which came to place in late Cretaceous or early Tertiary time. Most of the mines show no evidence of being exhausted, and new discoveries and increased mining activity are looked for throughout the region.

GEOGRAPHY.

The area described herein is in the drainage basin of Clark Fork about 50 miles west of the Continental Divide. It includes the northwestern part of the Garnet Range, Camas Prairie, and part of Hellgate Canyon, as the gorge of Clark Fork between Missoula and Drummond is locally called. Clark Fork crosses the southern part of the area, following a nearly westward course to its junction with Rock Creek, where it turns sharply northward. Blackfoot River, for the most part north of the area, touches its northwest corner and joins Clark Fork at Bonner, 10 miles farther west.

A somewhat irregular watershed that has a general easterly direction and forms the main summit of the Garnet Range divides the area into two nearly equal parts. The drainage of the northern part is mostly collected by Elk and Union creeks, affluents of Blackfoot River, and that of the southern part flows directly into Clark Fork. Because of irregularities in many of the numerous small streams the drainage plan appears complex in detail. Most of the streams are perennial, and Clark Fork and Blackfoot River are fairly large and swift, their combined flow being used at Bonner to generate considerable power. Both rivers are subject to heavy annual freshets, and during an unusual flood in 1908 Clark Fork ruined many farms and destroyed practically all the railroads in Hellgate Canyon.

Timber is generally abundant, the highlands being thickly covered with the smaller conifers and the lower slopes containing groves of yellow pine. Lumbering, which has been carried on extensively during the last 30 years, has stripped the timber from most of the Clark Fork valley and the slopes about Camas Prairie.

The bottom lands in Hellgate Canyon and Camas Prairie and the adjoining bench lands are fertile and are cultivated chiefly for hay and grain. Apples, cherries, and other equally hardy fruits grow also, and the more gradual slopes afford pasture for considerable

stock. In the higher areas the winters are rather long, there is considerable snow, and frost is likely to occur any summer night.

PHYSIOGRAPHY.

The most obvious characteristic of the area described as viewed from the main traveled route along Clark Fork is its roughness. No smooth or level ground except a narrow flood plain can be seen. The valley sides rise abruptly to imposing heights, the slopes commonly showing cliffs and crags and generally being as steep as soil or loose rock can lie. As far as the view extends up the V-shaped side valleys that branch out right and left at short intervals a similar ruggedness prevails.

In a general view, however, such as that from an elevated point like Baldy Mountain, the region appears very different. The valleys that roughen it so extensively can not be seen, except those near at hand, and what appears to be a smoothly undulating or slightly hilly plain, above which isolated mountains or groups of mountains rise here and there, stretches away on all sides. Evidently the area as a whole is a rather flat but extensively dissected upland.

The origin of this upland and the valleys that almost destroy it is an interesting subject, not only from the viewpoint of the geologist but for the bearing it has upon the mineral deposits, particularly the distribution of the placer gravel.

The highest point in the area is a peak 7,093 feet above the sea, 4 miles northeast of Garnet, and the lowest is the town of Clinton, whose altitude is 2,467 feet. The main valleys, however, are about 2,000 feet deep, and the relief generally does not exceed 2,500 feet.

The steep slopes occupy about three-fourths of the area, the remainder being in part flat lowlands along the streams and in part flat or undulating surfaces on the divides. Practically all the lowland flats are confined to the Clark Fork valley and Camas Prairie. The former contains a flood plain from a quarter of a mile to a mile in width, and Camas Prairie is a somewhat larger flat composed of the flood plains of Union Creek and several tributary streams.

Camas Prairie and the slopes that adjoin it form a large flaring basin that, except for a narrow drainage outlet at the west, is completely inclosed. Camas Basin, as this feature may be called, is about 2,000 feet deep, 6 miles wide, and 10 miles long, and its major axis trends northwest. In strong contrast to the other valleys the sides of Camas Basin, viewed without regard to the gulches and ravines that channel them, slope gradually and curve smoothly into the central lowland.

The flats or undulating surfaces on the divides are worthy of more than passing notice. Most of them lie between elevations of 6,000 and 6,500 feet, and they surmount practically every divide that

reaches those heights. Although perhaps more extensive and continuous along the main watershed, they are common on the lateral spurs out to points that look down on Clark Fork or the other principal streams. As already mentioned, a general view shows that the summit flats fall in place like the surface of an undulating plain, and in fact the flats are remnants of a formerly unbroken surface that was nearly a plain—in other words, a peneplain. The general relief of the peneplain is not more than a few hundred feet, but here and there is a higher isolated summit like Baldy Mountain or Anderson Hill. Some of these summits, as for example a high point east of the head of Deep Creek, are remnants of lava flows poured out on the peneplain; others, like Anderson Hill, are the parts of some older upland not completely reduced when the peneplain was formed.

Less noticeable but equally significant physiographic features are some broad passes in the main divides and flat shoulders or benches on the sides of the valleys. Viewed together, these are remnants of surfaces parallel to the peneplain and slightly below it, or, in other words, remnants of broad valleys in the peneplain. The pass at the head of Elk Creek, at an elevation of 5,840 feet, and the basin drained by Gambler Creek are the remnants of one shallow valley nearly a mile wide, which had a northwest course, and whose stream probably flowed in the same direction and was the ancestor of Elk Creek. A similar valley crossed the main divide a little west of Coloma, and another crossed from the head of Tenmile Creek to the basin of Union Creek, passing a mile west of Copper Cliff. Stones Flat, on the main divide, at an altitude of about 6,200 feet, is a remnant of another ancient valley and is especially interesting because it contains a deposit of gold-bearing stream gravel. The course of this valley is about north, but the stream that deposited the gravel has been diverted and its identity lost.

That the peneplain and its valleys were formed by erosion is plainly shown by the occurrence of their remnants on different kinds of rocks and without regard to the structure. In one locality they occur on granodiorite, in another on quartzite or limestone, and whether the rocks are tilted or not makes no difference. East of the area described the peneplain was developed throughout the Garnet Range, and its remnants are very abundant also in the Sapphire Mountains, which occupy the region between Clark Fork and Bitterroot River. Across the Bitterroot and Missoula valleys it is found extending over a large part of central and northern Idaho.[1]

[1] Lindgren, Waldemar, A geological reconnaissance * * * in Montana and Idaho: U. S. Geol. Survey Prof. Paper 27, p. 14, 1904. Ransome, F. L., and Calkins, F. C., The geology and ore deposits of the Coeur d'Alene district, Idaho: U. S. Geol. Survey Prof. Paper 62, p. 21, 1908. Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho: U. S. Geol. Survey Bull. 528, pp. 23–30, 1913.

Most observers consider the peneplain to have been formed in early Tertiary time. In the Garnet Range no facts are known that determine its age within narrow limits. Lava beds that lie upon it in the eastern part of the area described are in turn overlain by Oligocene sediments farther east, and in the eastern part of the Garnet Range the peneplain cuts across tilted rocks of Cretaceous (Colorado) age. Therefore it was formed after late Cretaceous rocks had been folded and before Oligocene beds were laid down.

Except for differences in magnitude the other surface features of the wide region mentioned in the foregoing paragraph are generally similar to those of the area particularly considered in this report. Narrow steep-sided valleys occur without number, the general monotony being relieved in places by wide, smooth depressions similar to Camas Basin, or by isolated peaks and ranges that rise above the general summit level. All parts of the region have apparently had the same general history, the main events in which are as follows: In early Tertiary time, during a period in which this part of the earth's crust was free of mountain-building or other movements—in other words, during a period of crustal stability—the area generally was reduced to a low elevation, the surface approaching a plain, or at least being without strong relief. Afterward a general uplift of several thousand feet occurred, as a result of which the streams cut deeply into the uplifted region, producing its present ruggedness.

The details of this uplift and erosion, however, were by no means as simple as the foregoing brief statement might imply. The upward movement was neither continuous nor everywhere the same, the result being a more or less widespread and extensive warping, by which features like Camas Basin were formed. In addition to warping, lavas were extruded here and there both before and during the dissection of the peneplain, all of which caused many changes in the drainage plan. For example, at an early date Clark Fork, or rather a stream occupying the present latitude of that river, probably flowed east from a point near Nimrod, a conclusion suggested by the fact that some tributaries, Harvey Creek and Bear Creek among them, incline to the east or opposite to the present course of the main stream. From Nimrod westward, however, there is no evidence of a reversal, and the stream gathered between that point and Rock Creek was merely a small tributary of Rock Creek, a conclusion supported by the fact that Clark Fork now turns sharply north at the junction, abandoning its own general direction for that of its present tributary. Doubtless the warping early caused the waters east of Nimrod to turn to their present direction, but Rock Creek, having become intrenched, has preserved the evidence of its former dominat-

ing rank. Significant features in the valleys of the main streams are numerous bends and, along the Clark Fork valley in particular, low terraces or benches and small transverse spurs, of which Beaver Tail Hill and Medicine Tree Hill are examples. In places the bends give the valleys rather serpentine courses, and for the most part they are thought to be inherited from meanders followed by the streams when they flowed near the surface of the peneplain. The benches and flat spurs are of more recent origin. Apparently, when within 200 feet of its present level, Clark Fork ceased down cutting, probably because of a temporary dam farther down, as suggested in the next paragraph, long enough to widen its valley somewhat and floor it with gravel. When the stream was rejuvenated, probably through destruction of the dam, down cutting was resumed, and parts of the graveled floor were left high and dry as benches and flat spurs, the spurs being formed between meanders through which the stream had traveled from side to side within the limits of its valley.

Clark Fork is now again widening its valley and covering it with gravel, because of a dam of late glacial outwash thrown across it by Blackfoot River at Bonner. Whether the former widening and gravel deposit were due to a similar cause is not known, but it is thought probable that they were, in view of the well-known fact that an earlier Pleistocene glaciation occurred in this general region.

GEOLOGY.

STRATIGRAPHY.

GENERAL FEATURES.

The area described herein is part of the borderland between the great pre-Cambrian shale and quartzite area of northwestern Montana and a province of Paleozoic and later sediments deposited along the main axis of the Rocky Mountains. In its southeast corner Cretaceous shale and sandstone are exposed. Toward the northwest older beds, including at least 4,000 feet of Paleozoic limestones, succeed one another in descending order before the Algonkian shales and quartzites are reached. The latter occupy at least two-thirds of the area described, are 5,000 feet or more in thickness, and belong to the upper part of the Belt series. In common with many other parts of the general region this area does not show angular discordances between any of the rocks mentioned, all the beds having apparently remained undisturbed until the last was laid down. Therefore breaks in the sedimentation are not readily detected, and a great gap between the Cambrian and Belt rocks would hardly be suspected in a

casual examination. So far as the observations go, however, the Flathead quartzite, the oldest Cambrian formation known in the general region, is not present everywhere in the area described.

In several localities intrusive igneous rocks, chiefly granodiorite, have broken through the sedimentary beds mentioned, some of the bodies at least not having come to place until after sediments of Colorado age had been folded. The areal outlines of the granodiorite commonly advance up the gulches and retreat around the intervening spurs, showing that the intrusive bodies are only partly uncovered, and the exposures are so much alike that it seems not unreasonable to regard them all as parts of a single huge deeply buried mass. It does not follow, however, that all the offshoots of this mass arose at the same time. In fact, the body along Clark Fork near Willis, which occupies a lower position than the others, is so much finer grained that it probably crystallized under a very thin cover, a condition that could have been brought about only by considerable erosion after the earlier eruptions. No metalliferous lodes or strongly metamorphosed rocks are known about the granodiorite at Willis, a possible explanation being that rapid solidification of the intrusive body did not give time for mineralizing solutions to collect or escape.

Small dikes of a light-gray granodiorite porphyry are moderately abundant in the metamorphic sediments and in the granodiorite of the Garnet and Clinton mining districts. Pegmatite and aplite are uncommon. Lavas extruded upon eroded surfaces of granodiorite and the Cretaceous and older sediments occupy large areas east of Top o' Deep, in and near Bearmouth, and form small patches elsewhere. Most of these lavas are andesite or related rocks. Rhyolite is fairly abundant and basalt uncommon. Beginning with the oldest, their general order of extrusion seems to be rhyolite, andesite, and basalt. The main bodies of andesite and rhyolite are continuous with masses farther east that underlie sediments of Oligocene age. Surficial deposits consisting of Tertiary light-colored silts containing volcanic ash and gravels of later age are not areally important except in Camas Prairie and the Clark Fork valley.

LITHOLOGY.

Notes on the lithology are given in condensed form in the following table, in which the subdivisions indicate probable correlations with the rocks of the Philipsburg quadrangle:[1]

[1] Calkins, F. C., and Emmons, W. H., U. S. Geol. Survey Geol. Atlas, Philipsburg folio (No. 196), 1915.

Partial sections of rocks in the northwestern part of the Garnet Range, Mont.

Sedimentary rocks.

System.	Series.	Formation.	Character.
Quaternary.	Recent.	Alluvium.	Silt, sand, and gravel that form flats along the streams and are locally gold bearing.
	Pleistocene.	Terrace gravels.	Moderately thick deposits of subangular to smoothly washed gravel that covers the terraces or bench lands around Camas Prairie and Sunset Valley. Small patches of river gravel on terraces or bars along Clark Fork about 100 feet above the stream. Locally gold bearing.
Tertiary.	Oligocene or Miocene.	Lake beds.	Fine light-colored massive silts underlying the bench lands in Camas Prairie, Sunset Valley, and small tracts in the extreme southeastern part of the mapped area. Generally concealed by superficial material and to be seen only in road cuts or other artificial exposures. As a rule the material is sharp and gritty, owing to particles of volcanic glass that glint when specimens are turned in the sunlight. At the southeast corner of the mapped area the lake beds contain a 5-foot bed of subbituminous coal.[a]
Cretaceous.	Upper Cretaceous.	Colorado formation.	Fissile black shale, poorly exposed at the southeast corner of the mapped area.
	Lower Cretaceous.	Kootenai formation.	1,000 feet or more of variegated shales, chiefly purple and maroon, together with some thin beds of limestone. Subdued exposures along Clark Fork in the vicinity of Hellgate and eastward. In the railroad cut at Hellgate the maroon shale shows concretionary forms as large as a cart wheel.
Jurassic.	Upper Jurassic.	Ellis formation.	100 feet or more of flaggy cross-bedded gray sandstone and some buff-weathering shale and limestone, rather poorly exposed along Clark Fork above and below Hellgate.
Carboniferous.	Pennsylvanian.	Quadrant formation.	300 feet or more of grayish-brown and yellow quartzite and red shale overlies the Madison limestone in a narrow area extending from Tenmile Creek southeastward, also west of Little Bear Creek. Outcrops of the quartzite are bold; in places the rock looks like flint and commonly is crushed to a breccia superficially stained red or brown. The red shale is poorly exposed. A little phosphatic sandstone overlies the quartzite in the extreme southeastern part of the area surveyed, but it dies out to the northwest. This phosphatic sandstone probably represents the Phosphoria formation.
	Mississippian.	Madison limestone.	1,000 feet or more of light-gray and blue limestone, fossiliferous, cherty, and otherwise similar to the Madison of the general region. Forms picturesque cliffs and crags along Clark Fork east of Bearmouth and along Bear Creek generally from Tenmile Creek down. Also extensively exposed along the East Fork of Cramer Creek and the upper courses of streams that enter Clark Fork from the north between Nimrod and Willis. Some of the outcrops east of Bearmouth are superficially stained pink with ocher from the red shale member of the overlying Quadrant.
Devonian.	Middle Devonian.	Jefferson limestone.	Crags of gray and brown limestone along Bear Creek near Packer Gulch. Several hundred feet of gray to black limestone along North Fork of Cramer Creek near the Chloride mine.
Silurian (?).		Maywood formation.	A bed of calcareous quartzite about 100 feet thick.

[a] Pardee, J. T., Coal in the Tertiary lake beds of southwestern Montana: U. S. Geol. Survey Bull. 531, pp. 242-243, pl. 14, 1913.

Partial sections of rocks in the northwestern part of the Garnet Range, Mont.—Continued.

Sedimentary rocks—Continued.

System.	Series.	Formation.	Character.
Cambrian.	Middle and Upper Cambrian.	Red Lion formation.	About 300 feet of siliceous limestone measured above the Hasmark at the Cramer Creek section. Composed of thin layers of buff to pink shale and chert alternating with dove-gray limestone. Similar beds are exposed also at a point about two-thirds of the way to the Chloride mine along the trail that follows the divide westward from Copper Cliff.
		Hasmark formation.	Fine-grained dull-blue or lead-gray limestone; weathered surface a dirty white or dove-gray. Some beds have a concretionary structure, and some that are black show light-colored irregular branching or twiglike forms. A section 570 feet thick measured along Cramer Creek at Parent's ranch is made up of dove-gray limestone beds with a few thin, yellow and pink siliceous laminae. Some specimens of the limestone effervesce freely with cold dilute acid and others do not; weathered surfaces feel gritty. Near the granodiorite contacts at Garnet and elsewhere the Hasmark is changed to a white crystalline rock resembling coarse-grained marble that breaks down under the influence of weathering to a carbonate sand. Adjoining the contact the metamorphosed rock is commonly stained green with chlorite, and considerable portions of it are replaced by brown garnet. At moderate distances the original blue and gray colors of the limestone are not destroyed, but as a rule slender needles of white tremolite are developed.
		Silver Hill formation.	Gray and white banded calcareous shale at Garnet and along Bear Creek above First Chance Gulch. Also lead-gray shales along road above the Dandy and Haparanda mines east of Garnet and in some of the workings at the Copper Cliff mine. A section along Ryan Creek about a mile above its mouth shows about 100 feet of siliceous laminated limestone and calcareous white or pale-yellow quartzite below the Hasmark formation and above a yellowish-brown quartzite that in turn rests upon undoubted Belt beds. In the middle of the siliceous limestone is a 6-foot bed of conglomerate made up of well-rounded quartzite cobbles firmly cemented in a sandy, limy matrix. At Garnet portions of the Silver Hill formation are changed by metamorphism to a garnet-epidote hornstone.
		Flathead quartzite.	Rather pure buff to gray banded quartzite on the summit of Anderson Hill east of Garnet; reddish-brown brecciated quartzite along Ryan and Marcella creeks north of Willis. Evidently not very thick, and apparently not developed over the whole region.
Algonkian.	Belt.		Deep-red to grayish-green indurated shales and interbedded quartzitic sandstones that generally show small flakes of mica and form bold exposures along both sides of the Clark Fork valley below Bearmouth and in the canyons of tributary streams. A typical section, 4,000 feet thick, measured along Cramer Creek below the mouth of its west fork, shows chiefly deep-red shale below and red or purple shale interleaved with pale-yellow or gray sandstone above. Many of the upper purple beds show light-colored spots and streaks. Near the large intrusive bodies contact metamorphism has altered the more sandy layers to mica schists, and others to argillite or hornstone. Specimens from the upper beds, which crop out in the vicinity of Garnet, commonly show abundant dark-gray spots or knots that under the microscope prove to be either aggregates of fine biotite or crystals of cordierite. Generally the cordierite crystals show the outlines of short thick prisms a quarter of an inch in diameter and inclose a multitude of fine mica flakes and quartz grains. In addition some of the rock specimens contain a little secondary zoisite and feldspar. Shaly beds in contact with the granodiorite near Clinton are changed to dense purple and green hornstone.

Partial sections of rocks in the northwestern part of the Garnet Range, Mont.—Continued.

Igneous rocks.

Geologic age.	Formation.	Character.
Middle Tertiary.	Basalt.	Small patches of dense fine-grained black lava near Bearmouth. Under the microscope a specimen from an outcrop 2 miles up Lannen Creek is a typical olivine basalt showing plagioclase laths in a cryptocrystalline groundmass. It appears to be later than the hypersthene andesite.
	Dacite.	A medium-grained gray porphyritic lava that looks not unlike granodiorite from a distance occurs along Clark Fork between Willis and Nimrod. The phenocrysts are plagioclase, and in addition there are flakes of biotite and grains of quartz in a fine-grained vitreous groundmass. This lava lies on a surface eroded almost as deeply in the Belt shale as the bed of Clark Fork and it is therefore thought to be comparatively recent.
	Hornblende and augite andesite.	Prominent outcrops along Union Creek above Camas Prairie and a few localities near by of medium-gray, strikingly porphyritic lava. An exposure halfway along the road from Union Creek to Coloma is crowded with distinctly zoned plagioclase feldspars, some of them as large as an inch in diameter. Under the microscope the fine-grained groundmass is seen to be composed of plagioclase biotite and augite, and the zones in the phenocrysts to be made up of biotite flakes. A specimen from a small mass near Shipler's cabin at Copper Cliff is less strongly porphyritic and contains hornblende and augite in about equal amounts. These rocks lie upon an eroded surface of Paleozoic and older rocks and are covered by Tertiary lake beds but were not observed in contact with the other lavas.
	Hypersthene andesite (?).	Large areas of grayish or purplish-brown fine-textured lavas exposed east of Top o' Deep and southeast of Bearmouth. Not examined microscopically, but these bodies are similar in occurrence and practically continuous with areas of hypersthene andesite in the Garnet Range farther east.
	Rhyolite (?).	Exposures south of Felan Creek and along Wood Creek and other places south and east of Bearmouth of light-gray to pink or red fine-grained dense lavas that show small quartz phenocrysts.
Late Cretaceous or Early Tertiary.	Pegmatite and aplite dikes.	Not abundant. Small dikes in the granodiorite at Garnet consist chiefly of pale-pink feldspar and quartz in coarse graphic intergrowths. A specimen from one exposed in the Dewey mine shows both orthoclase and plagioclase, the latter almost wholly altered to sericite, chlorite, and calcite. Small aplite veins were observed in granodiorite at the Pearl mine near Top o' Deep. A dike, 14 feet wide, that cuts the gabbro sill near Tyler Creek is closely related to a quartz vein and carries a little chalcopyrite. A specimen examined under the microscope is composed of albite and quartz with accessory rutile, zircon, and apatite.
	Porphyry dikes.	Small dikes of gray and greenish-gray rock showing porphyritic feldspars and biotite in a fine-grained groundmass are fairly abundant in the Garnet and Clinton districts. In a specimen from a dike near the Red Cloud mill, at Garnet, the phenocrysts are small hypidiomorphic plagioclases and the groundmass consists of feldspars, quartz, and biotite. A dike at the head of Weasel Gulch, near Top o' Deep, shows sharply outlined phenocrysts of plagioclase and orthoclase in a similar groundmass. Both dikes contain accessory iron ore and apatite.
	Granodiorite.	Light-gray granular crystalline intrusive rock exposed extensively in the vicinity of Garnet, in the Clinton mining district, and in small areas elsewhere. Except those along Clark Fork near Willis, all the exposures are very much alike in general appearance, texture, and composition. They show prisms of black hornblende, commonly one-eighth inch or more in length, and flakes of dark mica in a granular mass of medium-textured milk-white feldspars and quartz. The exposures near Willis are very much finer grained and somewhat lighter colored. Porphyritic feldspars half an inch or less in length were observed in the Garnet and Clinton exposures, especially at Clinton, but they are not common. Marginal portions of the exposed masses are generally somewhat darker with ferromagnesian minerals than other portions. A few representative specimens from the Garnet and Clinton bodies are shown by the microscope to be composed chiefly of andesine-oligoclase, quartz, orthoclase, hornblende, and biotite, with accessory iron ore (ilmenite or magnetite) and apatite. A specimen of the fine-textured body at Willis from an exposure north of the river shows the same minerals as the other bodies, but the ferromagnesian silicates are less abundant.
Pre-Tertiary.	Gabbro.	A sill 300 feet or more thick of dense, heavy dark grayish-green crystalline rock intrusive in the Belt rock south of Clark Fork between Nimrod and Bonita. Under the microscope specimens from the locality of Tyler Creek show feldspar (sodic labradorite or albite) and augite as the chief constituents, with minor amounts of hornblende, biotite, and quartz and accessory ilmenite, titanite, and apatite. Some of the original rock minerals are altered to calcite, uralite, and chlorite.

STRUCTURE.

FOLDS.

Several large folds that involve all the sedimentary rocks older than Tertiary cross the area described from southeast to northwest. In the southeastern part, along Clark Fork, the folds are tightly compressed and commonly overturned, causing the rocks to have vertical or very steep dips. A large syncline that is followed by Clark Fork for some distance above and below Hellgate and another which appears just below Bearmouth have tightly squeezed Cretaceous and Jurassic rocks and Carboniferous (Quadrant) quartzite in their cores. Toward the northwest the troughs are more open. They also rise in this direction, so that the younger formations, in consequence of the relation of this inclination to the present erosion surface, thin out, one by one, until only Belt rocks remain. The intervening anticlines carry the Belt rocks southeastward, and most of them plunge in that direction and become very tightly compressed. The gradual opening of the folds toward the northwest marks the transition from the intense deformation of the Rocky Mountain Paleozoic province to the relatively broad and simple structure that characterizes the great pre-Cambrian area of the Northwest.

FAULTS.

One of the chief structural features of this area is a large overthrust fault on a fissure that comes to the surface along the Clark Fork valley from Bearmouth to Bonita. In this locality its general course is about N. 20° W. and its dip 20°–30° SW. West of Bonita this fissure has not been traced, and east of Bearmouth its course is concealed by superficial formations, but there is some reason to think it is continuous with that of the Philipsburg fault,[1] about 20 miles to the southeast. Each fault has carried a great mass of Belt rocks from the west over Paleozoic and younger formations, and a line joining the two falls in an area underlain by Tertiary and other superficial formations that continues to separate the Belt and Paleozoic. Along the Clark Fork valley the trace of the fault is generally accompanied by as much as 100 feet of crushed or disturbed rocks, and where it crosses some low spurs north of the river it is marked by small notches. In places movement is shown along several fractures, as if one had become clogged, causing another to form behind it, and so on. The Gipsy prospect, on the west fork of Cramer Creek, is on a parallel fault that is probably a related thrust if not a branch of the main fault.

[1] Calkins, F. C., and Emmons, W. H., U. S. Geol. Survey Geol. Atlas, Philipsburg folio (No. 196), p. 18, 1915.

There is evidence of northeasterly faulting along steeply inclined or vertical planes in the mines at Garnet, along First Chance Gulch, and elsewhere, but the displacements on these faults are generally small. Along Cramer Creek and its north fork, especially at Copper Cliff, there has been extensive crushing along a northeast plane. In addition to the normal displacements shown at Copper Cliff, the large block on the southwest side of the plane appears to have been shoved forward, or to the northeast, relative to the other block.

ORE DEPOSITS.

CLASSIFICATION.

The ore deposits of the area comprise lodes that are valuable for gold, copper, silver, and lead, and gold placers. The lodes include contact-metamorphic deposits in limestone, simple and multiple quartz veins, filled fissures, replacement veins in granodiorite and schist, and replacement deposits in limestone not directly related to igneous contacts. The lodes are most conveniently described as natural groups about certain localities, and the terms Garnet district, Coloma district, etc., as used in this report include only the mines near those places.

LODES.

GARNET DISTRICT.

HISTORY AND PRODUCTION.

The bulk of the mineral wealth, except placer gold, produced by the region considered in this report has been taken from a small area surrounding the town of Garnet. In 1867, while placer mining was at its height, the Lead King, Grant & Hartford, and Shamrock veins were discovered, and about 1873 S. I. Ritchey located the Nancy Hanks. Except that small lots of ore were worked from time to time in an arrastre down Bear Creek, the productive period of the camp did not begin until 1896. In that year the rich "red-ore" body of the Nancy Hanks was discovered; soon other important mines were opened, and a variable but continuous production has been maintained ever since. Although Garnet as a mining center is less widely known than it deserves, this is partly because its history happily has been free from questionable stock promotion. For the most part the mines have been made to pay their own expenses from the start, a policy that has been possible because rich ore generally extends to the surface.

Records of production since 1897 show a total of about $950,000, of which at least 95 per cent was gold and the remainder copper and silver. Considerable ore for which no records are available was

mined, however, and estimates made by persons familiar with the mining history of the region bring the total up to $1,400,000 or more.

MINING CONDITIONS.

In 1916 the Dewey mine made fairly regular ore shipments. For various reasons, of which litigation was one, the other mines were closed, but none of them is thought to be worked out. Part of the ore produced in the past was milled on the ground, but most of it was shipped to smelters or sampling works at Butte and Helena. An extraction of 80 to 90 per cent of the gold and silver was obtained from oxidized ore worked in the Red Cloud mill by amalgamation and concentration. The shipping ore is hauled down grade 10 miles to Bearmouth and delivered to the Northern Pacific Railway or the Chicago, Milwaukee & St. Paul Railway for transporting to the smelters. In 1916 the cost of the wagon haul was $1.50 a ton and the railroad and smelter charges averaged about $6 additional. Nearly everywhere the district contains sufficient wood and water for ordinary mining and milling, and although snow usually accumulates to depths of 3 or 4 feet during the rather long winters, mining operations are seldom interrupted.

GEOGRAPHY AND GEOLOGY.

Most of the mines around Garnet are within a mile of the town, being distributed along a rather narrow northwesterly belt that lies mostly along the watershed between Clark Fork and Blackfoot River. First Chance Gulch, noted for its large yield of placer gold, heads within the belt and leads out to the southwest. A branch of Kearns Gulch drains the northwestern part, and gulches that lead to Elk Creek head along the north. All these gulches contained rich placer gravels. Except for the southeastern part, which includes the steep slopes south of Anderson or Bear Mountain, the mineralized belt has a plateau-like surface 6,000 feet above the sea. In detail this surface is made up of low hills and flat, shallow valleys, the landscape being a sample of that which the whole region once presented. It is the record of a time long before the many deep, rugged valleys that to-day dominate the region had been made. A short distance from the divide the streams begin to flow rapidly, and soon descend into gulches 1,000 feet or more deep.

The area about Garnet is underlain by very ancient (Belt and Cambrian) sedimentary rocks, intruded by granodiorite. The oldest of these rocks, which occupy the surface from First Chance Gulch eastward, are quartzite and shale, both noticeably micaceous and schistose. Many of the layers show small dark spots or knots, and are sometimes referred to by the prospectors as "bird's-eye porphyry."

MINES AND PROSPECTS

T. 13 N., R. 14 W.
Sec. 28
1. Olympiad (Comet)
Sec. 33
2. Clemantha
3. Mammoth
4. Cato
T. 12 N., R. 13 W.
Sec. 5
5. Boston
6. Hartford
7. Pearl
8. Gold Leaf
Sec. 8
9. Mountain
10. Red Rock
Sec. 19
11. Baker & Sullivan
T. 12 N., R. 14 W.
Sec. 3
12. Shamrock
13. Dewey
14. Nancy Hanks
15. Cascade
16. Lowery
17. Grant & Hartford
18. Magone & Anderson
19. Lead King
20. Red Cloud
Sec. 11
21. Fairview
22. Lynx
Sec. 12
23. Dandy
24. Haparanda
T. 12 N., R. 15 W.
Sec. 11
25. Copper Cliff
26. Leonard
Sec. 20
27. Chloride
T. 12 N., R. 16 W.
Sec. 6
28. Gowrie
Sec. 8
29. Sumpter (Blackhawk)
Sec. 10
30. Charcoal
31. Adaline
32. Daisy
33. Nellie
Sec. 18
34. Grass Widow
35. Triangle
36. Copper Bell
37. Aladdin
38. Cape Nome
Sec. 19
39. Jack Pot
40. Hidden Treasure
41. Senate

GEOLOGIC MAP AND SECTION OF THE NORTHWESTERN PART OF THE GARNET RANGE, MONTANA

Scale 1/125,000

1 ½ 0 1 2 3 4 Miles

1917

Base from Bonner and Drummond topographic maps, profile survey of Clark Fork, and General Land Office township plats

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

Geology by J. T. Pardee

LEGEND

SEDIMENTARY ROCKS

Recent and Pleistocene — QUATERNARY
- Qal — Alluvium

Early Pleistocene — QUATERNARY
- Qt — Terrace gravel *(Also covers Tertiary light-colored silts)*

Miocene or Oligocene — TERTIARY
- Ts — Light-colored silt composed in part of volcanic ash *(Largely overlain by terrace gravels)*

Upper and Lower Cretaceous — CRETACEOUS
- Ks — Chiefly sandstone and shale, some limestone *(Colorado and Kootenai formations)*

Upper Jurassic — JURASSIC
- J — Sandstone, shale, and limestone *(Ellis formation)*

Pennsylvanian — CARBONIFEROUS
- C — Chiefly quartzite *(Quadrant formation)*

CAMBRIAN, SILURIAN, DEVONIAN, AND EARLY CARBONIFEROUS
- ε — Chiefly limestones *(Madison, Jefferson, Maywood, Red Lion, and Hasmark formations)*

ALGONKIAN AND CAMBRIAN
- Aε — Indurated shale and quartzitic sandstone, more or less micaceous *(Silver Hill and Flathead formations (Middle Cambrian) and Belt series (Algonkian))*

IGNEOUS ROCKS

MIDDLE TERTIARY
- Tl — Lavas Chiefly andesite and rhyolite, some dacite and basalt
- grd — Intrusive granodiorite
- ds — Diabase sill

EARLY TERTIARY OR LATE CRETACEOUS

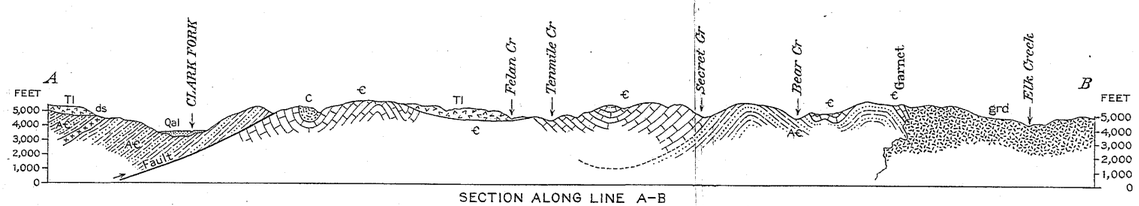
ECONOMIC DATA

Lode deposits
- 20 — Gold predominant
- 25 — Copper predominant
- 30 — Lead-silver predominant *(Numbers refer to list of mines and prospects)*

Placer deposits
- Gold-bearing gravels, mined
- Gold-bearing gravels, not mined
- Placers operated, 1916

- 30° — Strike and dip
- Strike and vertical dip
- 70° — Strike and dip of overturned bed
- a / b, D — Faults
  a, Known fault showing downthrown or overridden side (D)
  b, Concealed fault (covered by later deposits)

SECTION ALONG LINE A–B



In a few specimens that were examined under the microscope the knots proved to be either aggregates of mica or crystals of cordierite, a silicate of alumina, magnesia, and iron. In addition, there are some other secondary minerals, all going to show that the granodiorite has altered the rocks it broke through. Above the quartzite and shale lie thick and extensive beds of limestone, in which metamorphism is also shown near the granodiorite contact. Large portions of the limestone have been changed by the heat and vapors given off by the intrusive body to brown garnet rock, the most prominent outcrop of which is on the hill north of the Garnet schoolhouse. At Top o' Deep and some other localities similar garnet deposits contain copper, but those at Garnet do not, so far as known. Generally the limestone next to the contact is changed to a white marble which under the process of weathering breaks down to a sand that looks like granulated sugar. At moderate distances from the contact the rock retains its original fine texture and blue and gray colors but shows small white needles of tremolite and spots of mica. In general the evidences of contact metamorphism are noticeable for half a mile or more from the contact.

Although locally the contact plane dips toward the granodiorite, the outline of the exposed granodiorite body and its relation to other similar bodies (Pl. VI) suggest that it is larger in depth and probably is but one of several knobs on a mass that underlies a large part of the region. Small dikes of light-gray porphyry have cut the sedimentary rocks or have been forced in along their bedding planes.

The quartzite, shale, and limestone are folded together in an arch that has a northwest direction and crosses First Chance Gulch transversely, its axis lying below the Red Cloud mill. (See fig. 21, p. 191.) North of the axis there are some smaller flexures, but the general pitch of the beds is downward all the way to the granodiorite.

Faults are found in all the mines, but they can not be easily traced on the surface. Most of them have either a northeast or northwest direction, and they cause no very great displacement.

ORE DEPOSITS.

Character and distribution.—The ore bodies at Garnet are veins that in part have filled open spaces along fractures or bedding planes and in part have made room for themselves by replacing the country rock. There are three principal veins or vein systems, spaced about a quarter of a mile apart. The northernmost is a composite vein or zone of veins in granodiorite, on which are the Shamrock, Dewey, Nancy Hanks, and Cascade mines, named in order from east to west. In addition the Spokane vein is probably in the westward continuation of the zone, and the veins in the International and possibly also the Sierra seem to be parts of a fringe into which it splits on the east.

The whole zone, which for convenience is referred to as the Nancy Hanks zone of veins, is 1½ miles long. In the middle part of its course, on which are the Dewey and Nancy Hanks mines, the zone strikes about east; toward the ends it curves to the north, most strongly in that part east of the Dewey. So far as known the zone is relatively narrow, and few of the larger veins within it depart far from a dip of 30° N.

As a rule the individual veins that compose the zone do not persist in length or depth more than a few hundred feet. Each one either ends at a fault or splits into "stringers," to be succeeded by another vein a few feet to one side or the other. These characteristics are well shown in the Dewey and Shamrock workings. (See Pl. VIII and fig. 20, p. 186.) The width of the individual veins ranges from that of a mere seam to 3 or 4 feet, but most of their workable portions are from 1 to 3 feet wide.

South of the Nancy Hanks, in order, are the Magone & Anderson and Red Cloud veins, each following a bedding plane in schist or quartzite that strikes northwest and dips about 30° N. These veins are not composite like the Nancy Hanks zone, and, although as a rule not over 2 or 3 feet wide, each persists, except for interruptions by faults, a distance of half a mile or more. Two profitable mines have been opened on the Magone & Anderson vein, and the Red Cloud contains the principal ore bodies that have been worked in the First Chance Co.'s property.

Deformation.—Doubtless the fractures of the Nancy Hanks zone were originally faults and there is no apparent reason why the veins in the schist and quartzite should have selected any particular bedding planes unless those planes had been opened by faulting or similar movements. After the fracture openings were filled movements were renewed between their walls in the Nancy Hanks zone, severely crushing the ore in many places. The veins of this zone are also cut by transverse and strike faults, few of which, however, have caused displacements of more than a few feet. Available evidence indicates that the fault movements were normal—that is, the hanging wall has gone down relatively, but the scratches on the walls show that the movement was generally oblique.

Faults are less numerous in the Magone & Anderson and Red Cloud veins than in the Nancy Hanks zone, but, as a rule, the displacement on each one is greater. All the larger faults observed strike northeast, and most of them dip steeply to the northwest. One has dropped the Magone & Anderson vein 200 feet or more between the workings of the Magone & Anderson mine and those of the Grant & Hartford. Likewise, the Fourth of July vein appears to be a portion of the Red Cloud vein that was faulted down several hundred feet. Small northeast faults are numerous locally, but certain parts

of the veins several hundred feet in length are practically undisturbed.

Ore shoots.—Few parts of the veins wide enough to be workable are barren. This is especially true of the middle part of the Nancy Hanks zone, where practically all the flat lenslike bodies (fig. 19) that make up the veins may be regarded as ore shoots. These bodies are generally 2 or 3 feet wide or thick and from 25 to 50 feet in breadth and length. The largest one reported, the "red-ore" shoot of the Nancy Hanks mine, is about 150 feet in stope and pitch lengths and 2 or 3 feet wide. Most of the shoots pitch slightly westward. The pinched portions which occupy about as much of the fracture openings as the swelled portions, or lenses, generally contain an inch or less of gouge or crushed ore.

As a rule, the wider parts of the Magone & Anderson and Red Cloud veins are rich enough to be considered ore.

Tenor.—Most of the ore from Garnet is rich—a condition that allows it to be shipped profitably and compensates generally for the relative narrowness of the veins. One carload of oxidized ore from the Tiger mine yielded at the rate of nearly $500 a ton, a large amount of $200 ore was produced by the Nancy Hanks, and rich shipments are reported from the Crescent and Fairview mines. The general run of the ore, however, averages much less, the lots mentioned being exceptional and obtained mainly from the oxidized zone. Sulphide ores from the Nancy Hanks zone generally run about $80 a ton, of which 80 to 90 per cent is in gold and the remainder in copper and silver. Information concerning the relative tenor of the oxidized and sulphide ores of the Magone & Anderson vein is not available. Most of the ore produced was oxidized, and the average of all the ore shipped is said to be about $60 a ton. Not including some exceptionally rich lots, the oxidized ore mined from the Red Cloud vein averaged $20 to $35 a ton, and the sulphide ore remaining is estimated by competent engineers to average between $15 and $25 a ton. In both the Magone & Anderson and the Red Cloud veins copper and silver are proportionately less abundant than in the Nancy Hanks, although this statement may not hold strictly true for the lower levels in the Red Cloud, from which some specimens rich in tetrahedrite are said to have come. Thus from north to south there appears a progressive general decrease in the richness of the ore, but the Magone & Anderson and Red Cloud veins are perhaps as profitably exploited as the Nancy Hanks, because their ore bodies are larger and more favorably situated for mining through adit levels.

Mineralogy.—Quartz generally forms 50 to 90 per cent or more of the vein material, though exceptionally it may be less in amount than the other minerals combined. Barite is widely but irregularly

distributed and is generally coarse textured, showing characteristic large cleavage faces. A carbonate of calcium, magnesium, and iron, apparently the mineral ankerite, is found in many of the veins, particularly those in quartzite and schist, but it ranges in color from white to pale yellow or brown and doubtless is not of uniform composition. Calcite occurs in subordinate amounts associated with the ankerite.

The principal ore minerals are pyrite, tetrahedrite (gray copper), chalcopyrite, and galena or their oxidation products. All are widely distributed, and pyrite, as usual, is found everywhere in the veins and is generally the most abundant of the sulphide minerals. It occurs as massive, rather coarse textured aggregates and disseminated crystals and grains of various sizes. Tetrahedrite is not uniformly distributed, commonly occurring in irregular bunches, and it is rather more abundant in the Nancy Hanks zone than in the other lodes. Galena and chalcopyrite are less common than tetrahedrite and are likewise of irregular distribution.

Of somewhat rare and exceptional occurrence are tellurides of gold, silver, and bismuth, found in the Fairview mine, and molybdenite, observed in some of the mines as thin films on seams in the wall rocks.

In the oxidized zone native gold is commonly embedded in grains of limonite that were derived from pyrite. Gold inclosed in pure quartz was seen in a few specimens, one of which contained the tellurium minerals mentioned above. By far the most of the gold and part of the silver appears to have been brought into the veins and deposited with the pyrite and probably also with the chalcopyrite. The sulphides later deposited, particularly the tetrahedrite, have added some silver but practically no gold. As would be expected from the abundance of pyrite in the sulphide zone, the oxidized portions of the veins contain much limonite. Copper stains appear here and there, a little antimony ocher occurs in places, and rarely manganese stains may be seen.

Some interesting and important relations of the vein minerals to one another are very plainly shown. The first minerals that came into the veins were quartz, barite, and pyrite, all of which crystallized at the same time. Calcite and ankerite were then deposited, filling such spaces as were left by the other minerals and also making additional room for themselves by replacing the wall rocks. Chalcopyrite and a little pyrite seem to have come in later, and the tetrahedrite and galena, accompanied by new quartz, clearly were introduced last, filling small cracks in the older minerals and replacing them, particularly the pyrite. Although tetrahedrite and galena occur in the same veins, they were not seen in actual contact, and their order of deposition was not made out.

Oxidation and enrichment.—For the most part oxidation is partial or complete down to a surface that rises gradually away from the natural drainage lines. In the immediate vicinity of Garnet the greatest depth of oxidized ore is about 75 feet. Farther away, where the gulches are deeper, oxidation may descend 200 or 300 feet. As usual, however, grains of the sulphides completely surrounded by quartz may be found anywhere, even at the surface. The oxidized ore is porous, generally consisting of "honeycomb" quartz and earthy iron oxides. As a rule it is two or three times as rich in gold as the corresponding sulphide ore below, a condition brought about by the solution and removal of valueless material. On the other hand, it has lost more or less of the copper, lead, and silver, which have been leached out and either scattered or carried below. No downward enrichment of any importance seems to have taken place, however.

Genesis and conclusions.—The veins as described are similar to those generally regarded as the effects of granitic intrusion. Their mineralogy and geologic relations suggest that they were formed at moderate to shallow depths by heated solutions given off from the granodiorite. The later generation of minerals, which includes the tetrahedrite, is doubtless related to a younger variety of the granodiorite or possibly to some other intrusive body not exposed at the surface. In any event the minerals came from below—a fact that warrants belief in the persistence of good ore below the limits of the present workings. At Coloma, 2½ miles away, there is some evidence to indicate that veins situated similarly to the Nancy Hanks become lean in gold at a depth of about 700 feet below the general summit level. Whether or not the veins at both places were formed under exactly the same conditions can not be said, but the localities are near together and doubtless their histories are not very dissimilar. These veins are in granodiorite. The veins in quartzite and schist were probably formed under different conditions, being apparently farther away from the source of their minerals and probably not subject to the same limitations. These considerations do not apply to the tetrahedrite and the other minerals of a late generation, which for all that could be learned may continue downward indefinitely.

Whether or not copper will become more abundant in depth is an interesting speculation. In the mines that have the most complete records slight increases in copper are generally shown in ore from the lower levels, but this may be due to the fact that shipments from the higher levels contained oxidized ore.

Although the veins at Garnet are too small to warrant large capitalization or heavy investments in advance explorations, new work on a larger scale than heretofore may be undertaken with reasonable confidence. Considerable parts of the veins within the general area

of rich mineralization, particularly the Nancy Hanks zone, are unexplored beyond shallow depths. Several claims at Garnet that were not examined are in or near the mineral-bearing area, and some of them will doubtless be developed into productive mines in the future. In the light of all that was learned the opinion is ventured that the Garnet district will continue to be productive for a long time.

MINES AND PROSPECTS.

J. L. TEMPLEMAN CO.

A group of mines that includes the Dewey, Tiger, Nancy Hanks, Cascade, and Spokane is (September, 1916) under bond and lease to J. L. Templeman and others, who have operated the Dewey continuously since February, 1915. Except the Tiger, the mines named are along the Nancy Hanks zone or vein system, a single vein or zone of closely related veins that extends from the town of Garnet westward a mile or more.

Dewey.

The Dewey mine is on the gentle slope west of Williams Gulch, about a quarter of a mile northwest of the main part of the town of Garnet. During 1915 and 1916 it was operated under the direction of J. G. Klenze and produced, in round figures, $100,000 gross. Gold contributed slightly more than nine-tenths of this sum, and copper and silver about equal portions of the remainder. The ore was shipped to the Washoe sampler at Butte, and yielded an average of $74 a ton.

Prior to 1915 the Dewey was worked by S. I. Ritchey and others, and contributed largely to the prosperity of the camp. The amount of this early production, whatever it may be, is included in the total given for the Nancy Hanks.

The principal workings are an incline 400 feet deep that slopes northward at an average angle of 47°, and several levels that aggregate 1,000 feet or more (Pl. VIII, p. 186); the lowest, or "400 level," is about 275 feet vertically below the surface. Underground connections are made with a shaft 200 feet to the east and with the Nancy Hanks workings, about an equal distance to the west.

The Dewey vein has an average strike of N. 75° E. and a dip of about 35° N. It shows no signs of failing at a depth on the slope of 400 feet and probably extends a long distance along the strike. Owing to displacements by faults and the limits of the development workings the vein is difficult to identify as an individual fracture for more than 200 feet east of the incline. To the west, however, it is said to be identical with the Nancy Hanks vein. In width the vein ranges from a mere seam to 3 or 4 feet. It consists of a series of

connected irregular, flat lenses, of which the principal ones are from 25 to 50 feet in diameter and average 2 or 3 feet in thickness. The walls are well defined and lined with a soft gouge that permits the vein rock to be readily separated from them. On the 400 level 90 feet east of the incline the vein splits into several stringers and becomes lean.

Fault movements since the vein was formed have been widespread and severe, but most of them have taken place parallel to the plane of the vein and have therefore not shifted it. Nearly everywhere the vein shows some effects of squeezing; in places it is crushed to a fine sand and its component minerals ground together. (See fig. 17.) Apparently the pinched or narrowed portions are largely the result of movement of the walls under pressure. To a considerable distance from the vein the wall rocks themselves are more or less crushed or schistose and cut by networks of curved fractures and slips. There

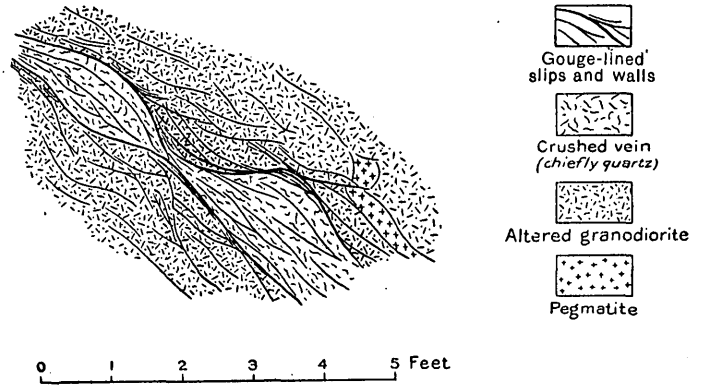


FIGURE 17.—Vein in 400 level west, Dewey mine, Garnet Range, Mont.

are also some larger faults and fault zones, the principal ones of which strike about parallel with the vein but dip more steeply. Those that cut the vein, however, displace it but a few feet, and the fault movement appears to have varied from place to place or to have been shifted from one fracture to another. Other faults that show a wider range in strike and dip cross the vein, but the dislocations they have caused are generally trifling.

Next to the vein the walls have been altered to a greenish-gray rock softer than the fresh granodiorite and scantily sprinkled with fine grains of pyrite. Under the microscope the lime-soda feldspars are seen to be almost wholly changed to sericite, chlorite, and calcite, parts of the rims only remaining fresh. The orthoclase is also partly decomposed, and the hornblende is completely changed to a fine-grained material in which chlorite is abundant.

The gouge that lines the vein walls is generally less than an inch thick and is composed chiefly of sericite and finely crushed ore. It ranges from light gray to dark greenish gray in color, a dark shade generally indicating a considerable amount of ground-up sulphides.

Where the vein has not lost its original features it shows a banded structure rather plainly (fig. 18), being commonly made up of two or more layers separated by thin dark partings that in places swell into small lenses or "horses" of country rock. The texture of the vein minerals is rather coarse, crystal faces or cleavage planes an inch or two across being common. In places the crystalline structure is at right angles to the walls, showing that open spaces have been filled. Commonly, however, the structure shows no definite arrangement except the faint outlines of masses of wall rock that have been replaced by the vein minerals. The gangue and ore minerals are all more or less intermingled, but usually the sulphides are concentrated in the middle of the vein or in one of its layers (fig. 18).

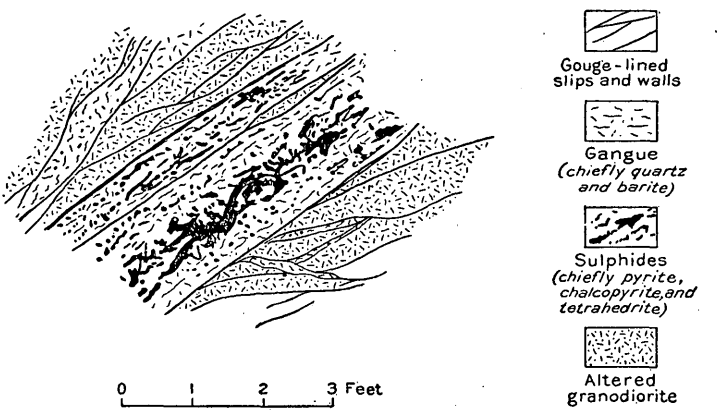


FIGURE 18.—Vein in 400 level east, Dewey mine, Garnet Range, Mont.

In the lower levels the vein consists of quartz and barite (heavy spar), together with the ore minerals pyrite, tetrahedrite (gray copper), and chalcopyrite, named in the general order of abundance. The quartz, barite, and pyrite are intergrown and are the first minerals that formed in the vein. Quartz is the most abundant, making up generally about nine-tenths of the vein and in few places less than half. The barite forms coarse tabular crystals but is irregular in distribution, being absent for considerable distances. The pyrite is widely distributed as grains and "cubes" of various sizes, the largest an inch across, some of which are completely inclosed by quartz crystals. Chalcopyrite was introduced later; it replaces pyrite in part, fills small cracks in the barite, and is of sparse and irregular distribution. Tetrahedrite, which is of wide but irregular occurrence, replaces both pyrite and chalcopyrite and with

the possible exception of galena was the last mineral that came into the vein. Galena was seen in ore from the Nancy Hanks workings and is said to have been found in the Dewey also. In ore from the Red Cloud mine it was observed to have replaced chalcopyrite, but nowhere was its age relation to tetrahedrite discovered. Molybdenite was seen as thin films on slips in the wall rock along the side of the vein but not within the vein itself.

Above the 100 level the Dewey vein is partly or wholly oxidized. Limonite (hydrated iron oxide) is, as usual, the most abundant of the secondary products, copper stains are rather scanty, and manganese occurs in traces only.

Practically all of the vein that is exposed in the Dewey workings has proved to be ore, but the lenses are generally richer than the pinches. Considered together the lenses that have been worked in the Dewey form an irregular ore shoot that extends from a point near the surface down 400 feet and to an unknown distance farther. It ranges from 80 to 130 feet in width and has a slight general westward pitch.

The ore extracted so far has contained on the average a little more than 3½ ounces of gold and 6½ ounces of silver to the ton and 2 per cent of copper. In the different carload lots the gold ranges from 1½ to nearly 5 ounces to the ton, but these extremes are not common. Silver likewise holds rather steadily to the average, rarely showing as much variation as 6 ounces to the ton. Taken in the order of shipment, which is said to correspond with the progress of mining from higher to lower levels, the ore shows steady and strong increases in gold and silver down about halfway, beyond which there is little or no change—certainly no diminution. There is close correspondence between the variations in gold and silver content, an increase or decrease in one being followed by a proportionate change in the other.

Copper ranges between 0.5 and 4 per cent, being somewhat erratic locally but showing a general increase with depth. There is absolutely no relation between the variation in tenor of copper and gold, but the records of the adjoining Nancy Hanks mine and assays of specimens from the Dewey that are especially rich in tetrahedrite show that marked increases in the amount of copper are promptly followed by an increase in silver. Neither gold nor silver in the free state is visible in the sulphide ore, but in the oxidized ore, particularly that of the Nancy Hanks and Cascade mines, native gold occurs in iron oxides that were derived at least in part from the oxidation of pyrite. The conclusion is plain that the gold and part of the silver, together with the pyrite, were introduced into the vein before the tetrahedrite.

Whether or not the replacement of pyrite by tetrahedrite has been accompanied by a migration of gold to some other part of the vein is an interesting question that can not be answered at present. If this has happened, however, a decrease in gold may occur in depth should the tetrahedrite increase, but the value of the additional copper would doubtless offset the decrease in gold and the ore would continue to be at least as valuable as it was before.

Nancy Hanks.

The town of Garnet was first brought into prominence by the discovery of a rich ore shoot in the Nancy Hanks vein in the workings known as the "old shaft," about a third of a mile northwest of the town. Uncommonly rich placer deposits in Williams Gulch were mined clear up to the inconspicuous outcrop of the vein, which is said to have been discovered and located by S. I. Ritchey in 1874. No great amount of development work was done, however, until 1896, the year of the "rich strike" of ore. During the next three years the mine produced shipping ore continuously, and thereafter it yielded intermittently until 1907. Except for a little gouging here and there by lessees, the mine has been idle for the last 8 or 10 years, and the workings are out of repair.

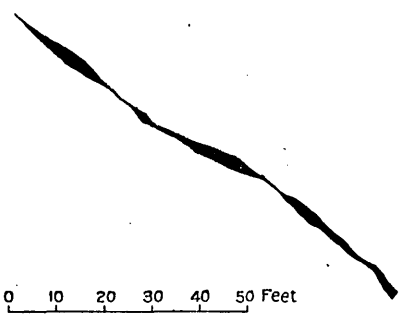
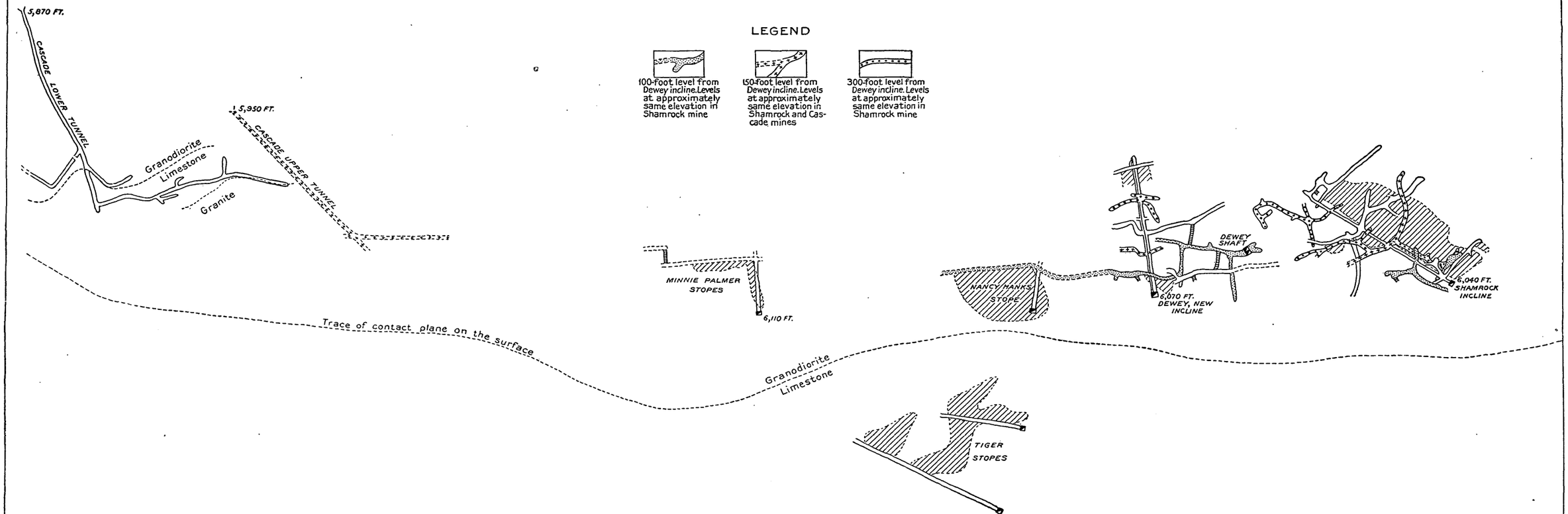


FIGURE 19.—Diagrammatic section of Nancy Hanks vein, Garnet Range, Mont.

Incomplete records of production, which include some ore taken from the Dewey prior to 1915, aggregate nearly $300,000. Nine-tenths or more of this sum was in gold and the remainder in copper and silver. The value of the ore ranged from about $40 to $200 or more a ton, but most of the shipments did not vary greatly from $92, the average.

Shafts were sunk 100 feet deep or more at two points. One, the "old shaft," is about 200 feet west of the Dewey incline and penetrates the same or a very closely related vein. The other, the Minnie Palmer shaft, is 500 feet farther west, on the projected continuation of the vein worked in the old shaft. Between the shafts there are several surface workings, all more or less caved, and at a depth of about 100 feet drifts were run east and west from the old shaft and west from the Minnie Palmer shaft, the principal stopes being above these levels. (See Pl. VII and fig. 19.)

Most of the Nancy Hanks production came from stopes west of the old shaft. The locally celebrated "red ore" shoot extended from a



WORKINGS IN THE NANCY HANKS ZONE, GARNET RANGE, MONT.

Scale 200 feet to 1 inch.

point near the surface to the 65-foot level on a slope of 25° and is said to have yielded gold at the rate of $200 or more to the ton. At least half of the total production of the mine is estimated to have come from this shoot, which is described as a tabular body 165 feet long and from 1 to 3 feet thick, pitching slightly westward. It pinched out below, and explorations are said to have ceased a few feet beyond its point of disappearance. From the west drift at the Minnie Palmer shaft a rich ore body 1 to 3 feet thick was stoped for a length of 50 feet and a height of 13 feet.

The dimensions of other ore bodies worked from the old shaft were not ascertained. The operators are said to have been discouraged from deeper explorations by the idea prevalent at the time that the ore bodies were superficial and that the first pinch ended the vein. Recent developments in the Dewey, however, give strong encouragement for deeper exploration along the whole vein system.

Although there was no opportunity to study the Nancy Hanks ore in place, much of interest was learned from the dumps and the smelter records. Ore fragments on the dump of the old shaft are similar to ore from various levels of the Dewey. Quartz is the most abundant gangue mineral. Barite is generally present, and some of the oxidized ore shows tabular cavities from which calcite or ankerite was leached. In general the oxidized ore shows abundant limonite, both as earth masses and as "cubes" after pyrite. There are also some green and blue copper carbonates, a little antimony ocher, and rarely a little manganese stain. In the sulphide ore pyrite and tetrahedrite are abundant and chalcopyrite subordinate. Galena occurs in some specimens, filling cracks and cavities in the quartz and replacing pyrite. The tetrahedrite of the Nancy Hanks ore, like that in the Dewey, replaces the other sulphides except galena, to which its relations could not be made out. Some of the ore is distinctly banded, showing a replacement of the wall rocks.

Except local bunches of limestone that occur as inclusions, the wall rock of the Nancy Hanks vein is granodiorite, altered similarly to that of the Dewey. The limestone inclusions are dolomitic, have been recrystallized, and are streaked green with chlorite. They are also cut by veinlets of secondary calcite which contain a little pyrite and galena. Ore from the Minnie Palmer shaft shows pyrite, chalcopyrite, and tetrahedrite, named in the order of their genesis. Fine particles of gold are visible in the limonite of the oxidized ore, particularly the cubelike grains derived from pyrite.

Smelter returns from carload lots of the Nancy Hanks ore give the history of the mine in a general way from 1897 to 1903. For a time the ore ran about 8 ounces of gold to a ton and but a trace of copper. This represents the bonanza "red ore" shoot. As is to be expected

in oxidized ores, the silver was variable, ranging from 4 to 28 ounces a ton. Then followed a few rather lean shipments that doubtless represent gleanings from the dumps and stopes, succeeded by shipments, probably in part from the Dewey, that show the gold reduced by half but some copper always present and the silver less variable than before. In general the copper was 3 or 4 per cent, the silver about 10 ounces to the ton, and the gold about 4 ounces. Some of the lots contained from 5 to 12 per cent of copper. Invariably these lots show increases in silver that range from 4 to 18 ounces to the ton, and many but not all of them show a marked falling off in gold. After 1899 there were intermittent shipments that show many fluctuations in value and are said to be made up of the ore searched out here and there from the dumps and stopes by lessees. No separate record of ore taken from the Minnie Palmer shaft is available, but some of it is said to have been of very high grade. Ton for ton there was about twice as much gold in the red ore as in the sulphide ore, a condition doubtless caused by the oxidation of the heavy sulphide minerals and the leaching away of valueless material. There is no evidence to suggest that the gold was increased by downward enrichment.

Little or no exploration is understood to have been done in the Nancy Hanks below a depth of 100 feet, and some portions of the vein are hardly opened below the surface. That other ore shoots are to be found is but a reasonable inference, considering the persistence of the vein or zone, the large part of it that is unexplored, especially in depth, and the fact, as shown by the Dewey, that deep as well as superficial ore bodies exist.

Cascade.

The Cascade mine is in a basin at the head of Kearns Gulch about three-quarters of a mile west-northwest of Garnet and half a mile west of the Nancy Hanks. About $6,000 worth of ore is said to have been produced from stopes above the upper tunnel and pits along the outcrop. In 1916, under a lease, some development work was being done by S. I. Ritchey in an east drift from the lower tunnel. The principal workings are two adit levels (Pl. VII), at elevations of 5,870 and 5,950 feet above the sea, that correspond respectively in height with the 300 and 150 foot levels in the Dewey. The lower adit is driven southward 400 feet in granodiorite, and 50 feet in limestone and after crossing a dike of granodiorite ends in shale. An east drift 300 feet long in part follows the dike, and a west drift leaves the adit 100 feet nearer the portal, goes through granodiorite, and ends in limestone. On the surface, above, granodiorite only is exposed, therefore the limestone and shale penetrated below are regarded as

fragments suspended in the intrusive body. The limestone is coarsely recrystallized and streaked and stained green with chlorite.

Along the west drift there is a vein from 2 to 18 inches in width that has yielded a little rather lean ore but is not persistent and is for the most part filled with barren-looking quartz. The vein strikes N. 65° W. and dips 30°–40° N., and the quartz is badly crushed in places by postmineral movement.

At the face of the east drift in granodiorite there is a vein that strikes N. 75° W., pitches steeply north, and carries 18 inches of good-looking ore. The footwall is well defined, but the north or hanging wall is so extensively altered and cut by quartz stringers that it is difficult to separate country rock from the vein. The granitic texture of the altered rock is faintly preserved, but its original minerals have been largely replaced by sericite and quartz, and it contains a little pyrite and iron oxides and a greenish-yellow stain that is probably copiapite, a hydrated sulphate of iron. At a distance of 4 feet limestone comes in beyond a slip that is parallel with the vein.

The ore consists of rather coarse vein quartz that contains scattered grains of pyrite, chalcopyrite, and tetrahedrite, most of which are partly or wholly oxidized. The tetrahedrite fills cracks and cavities in quartz and penetrates chalcopyrite in a network of veinlets. Fine particles of gold can be seen in the oxidized pyrite or "cube iron," and the ore is evidently of good grade. Small amounts of malachite and chrysocolla occur in cracks and cavities.

The upper tunnel was not entered. Its dump and those of some shallow workings along the outcrop show fragments of ore similar to that in the lower tunnel except that it is completely oxidized. Many of the limonite pseudomorphs, or grains of "cube iron," as they are generally known, preserve perfectly the crystal form of pyrite, even showing fine striations. The fact that gold occurs rather generally in these pseudomorphs and is rarely seen in other associations is strong evidence that it was brought into the vein with the pyrite. "Cube iron" is generally considered a trustworthy indication of good ore in the Garnet district.

Spokane.

The Spokane mine is in a shallow basin at the head of Kearns Gulch, about a mile northwest of Garnet and half a mile beyond the Cascade. A small production of rich ore similar to that of the Cascade and estimated to have yielded $3,000 is reported. The workings were not accessible for examination in 1916, but the vein is said to strike a little west of north and to dip 60° N. Its position and alignment suggest it to be a part of the Nancy Hanks vein system.

SHAMROCK.

The Shamrock mine is on the east side of Williams Gulch opposite the Dewey and about 600 feet distant. It was closed in 1916 and had not been operated for two or three years, the last work having been done by lessees. No certificates of ore shipments were seen, but a production of more than $100,000 is reported. The workings were not entered, but their details, including the geology, are shown by some excellent maps made for former operators by Billingsley & Grimes. The entry is an incline 350 feet deep on a slope of 32°, and the levels aggregate 1,200 feet or more in length. (See Pl. VIII.) A branching vein with an average northeast strike has produced ore similar to that of the Dewey. It is clearly a continuation of the same belt of fractures to which the Dewey belongs, although the particular vein worked in each is probably not the same. To the northeast the Shamrock vein, like the Dewey, on the 400 level east, shows

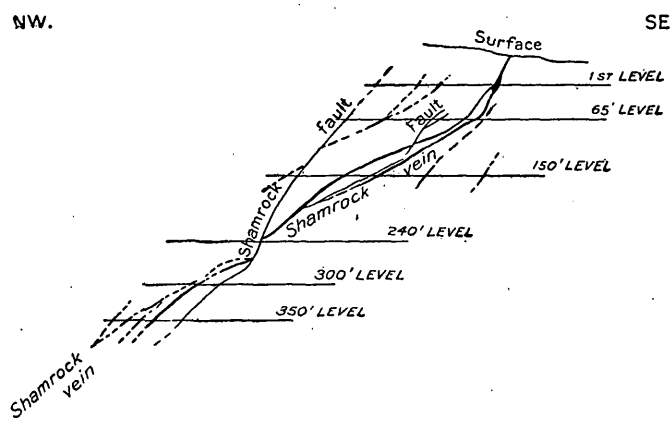


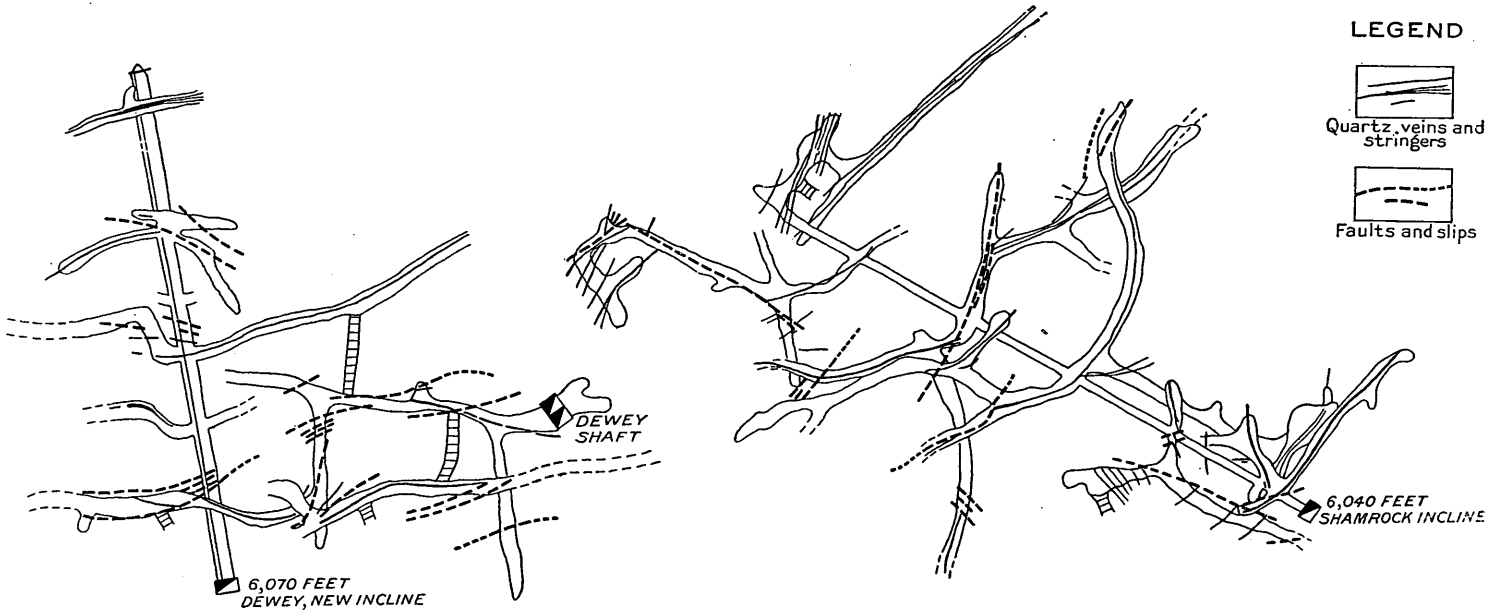
FIGURE 20.—Cross section of Shamrock mine, Garnet Range, Mont.

a tendency to "stringer out." Faults, the largest of which is nearly parallel to the vein in strike but pitches more steeply, displace the vein a few feet. (See fig. 20.)

INTERNATIONAL.

The International mine is about a quarter of a mile north of the center of Garnet and adjoins the Shamrock on the east. It is developed by a shaft reported to be 100 feet deep and by levels that were not accessible for examination in August, 1916.

Two or more small veins that have a northeast strike parallel with the Shamrock are reported to have been developed and to have yielded rich oxidized ore. Smelter certificates of intermittent shipments during the period 1910–1914 amount to about $9,000. The gold content ranged generally from 4 to 8 ounces and the silver from



STRUCTURE IN THE SHAMROCK AND DEWEY MINES, GARNET RANGE, MONT.

Scale 100 feet to 1 inch.

5 to 10 ounces a ton. Copper was absent from some shipments and present in very small amounts only in the others.

A specimen of ore from the International shows flake or leaf gold embedded in limonite.

TIGER.

The Tiger mine, a quarter of a mile west of Garnet and a short distance south of the Nancy Hanks, is developed by several short inclines and open cuts, only portions of which were examined. The formation is limestone, that has been recrystallized to a rather coarse white marble and in places changed to garnet rock and hornstone by the heat and vapors given off by the adjacent granodiorite body. Smelter returns, said to be incomplete, show a production of $23,000. One carload that averaged 22½ ounces of gold and 25 ounces of silver a ton was the richest single shipment made from the camp. Persons familiar with the mine estimate its total production at $40,000.

The ore bodies occur along a fracture that strikes north-northeast, dips west at a low angle, and is not known to continue beyond the contact into the granodiorite. The owners' maps show the outlines of the stopes (Pl. VII, p. 182), which are said to have been irregular in width but generally narrow. No specimens of the ore were seen, but it is said to be oxidized and similar in appearance to that from the "red ore" shoot of the Nancy Hanks. At a depth of about 90 feet the ore is said to have ended at a broken zone or fault having a northeast trend.

SIERRA.

A small production of medium-grade ore is reported from the Sierra mine, half a mile north of Garnet, in the granodiorite area. The workings consist of two adits and an incline, said to be 280 feet deep, only the upper portion of which was accessible in 1916. The vein strikes north, dips 30° W., is 1 to 2 feet wide, and extends at least 500 feet horizontally but is said to be pinched out in depth. Oxidized ore only was seen in the upper workings, but considerable sulphide ore that probably came from the deeper levels is scattered over the dumps. In general, this ore consists of coarse-textured quartz, calcite, and either ankerite or a similar mixture of the carbonates of calcium, magnesium, and iron, together with pyrite and tetrahedrite. As is usual in the district, the tetrahedrite replaces the pyrite in part and is the youngest of the vein minerals that were introduced from below. The oxidized ore contains much limonite and a little copper stain.

GRANT & HARTFORD.

The Grant & Hartford mine is a quarter of a mile south of Garnet, the stage road down First Chance Gulch passing under the trestle that supports the car track between the main adit level and its dump. In addition to this working, which extends eastward into the Magone & Anderson ground (Pl. IX), there is a winze, with short levels, said to be sunk 200 feet on the vein, and an adit level on the west side of the gulch, none of which was accessible for examination in 1916. Most of this work was done prior to 1910, and a production estimated at $30,000 is said to have come mainly from the winze levels. During 1912 and 1913 the main adit was used for extracting ore from the Magone & Anderson mine.

The country rock is quartzite and schist that strike about east, have an average dip of 30° N., and show abundant fine mica and small knots that under the microscope prove to be cordierite. Except where it cuts across a small dike of granodiorite the vein occupies a bedding plane and ranges from 6 inches to 2 feet in width. Beyond 200 feet from the portal of the main adit the vein is lost in a northeasterly fault zone, but it reappears farther east in the Magone & Anderson zone.

In the main adit level the vein is composed of quartz, barite, ankerite, calcite, and pyrite, or its oxidation products. The pyrite is disseminated irregularly but in places is massed in the middle or on one side of the vein to a thickness of several inches.

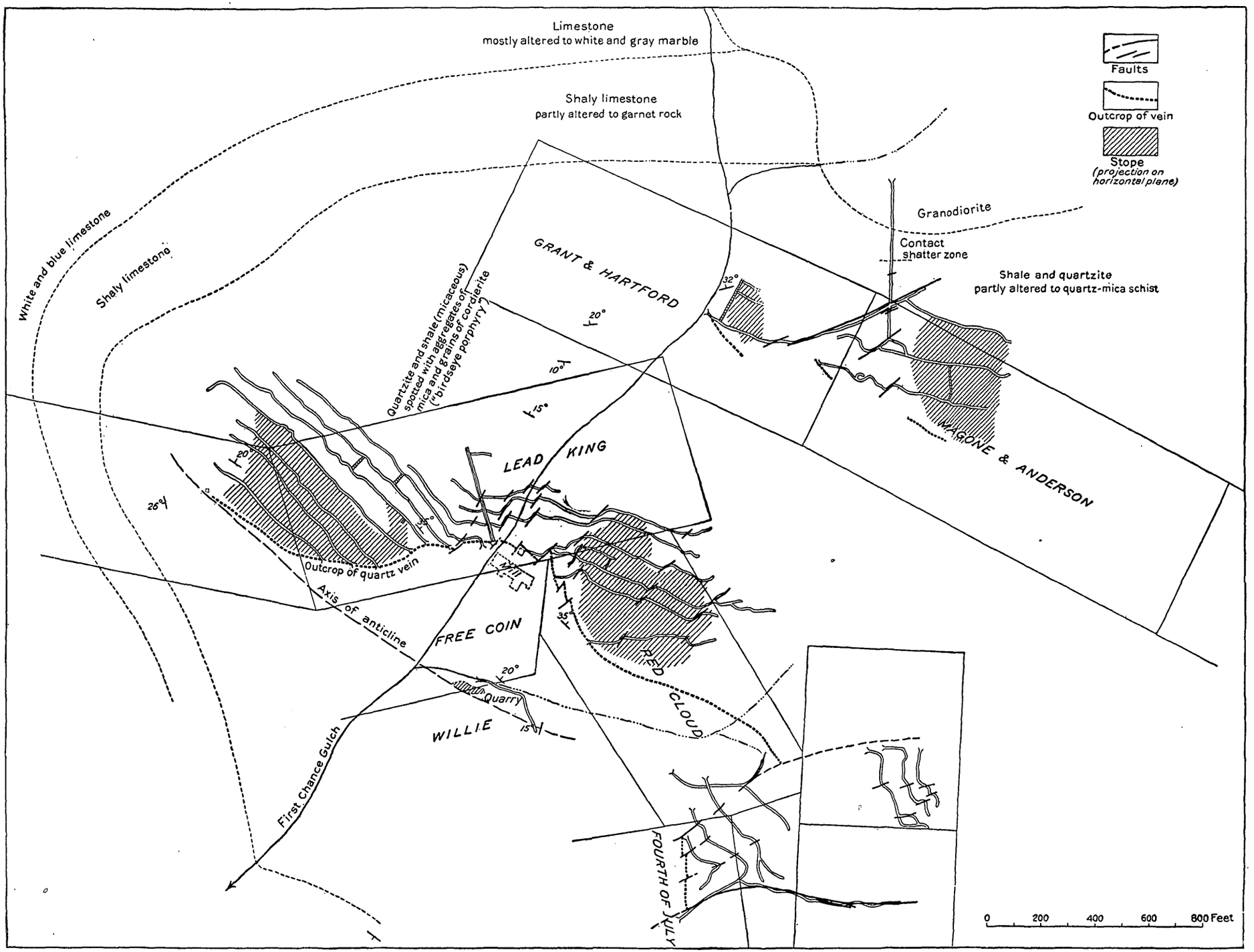
Oxidized ore from small stopes above the main level is said to have contained from 1½ to 5 ounces of gold and about an equal amount of silver to the ton. From the winze levels sulphide ore of about the same tenor is said to have been obtained, the shape of the ore bodies being that of small flat lenses 3 feet in maximum thickness.

Locally the wall rock is replaced by ankerite and calcite, and fine grains of pyrite are generally distributed through it.

MAGONE & ANDERSON.

The Magone & Anderson mine is east of the Grant & Hartford and about a quarter of a mile southeast of Garnet. Considerable work was done on this property before 1910, but its most productive period was the three years following.

Incomplete records show about 2,600 tons of ore are shipped that is said to have averaged $60 a ton, making a total of over $150,000. In addition about $15,000 worth of ore, said to have been mainly sorted from the dumps, was shipped in 1914, and persons familiar with the mine estimate its total yield at $300,000 or more. Smelter certificates for the 1914 shipments show from half an ounce to 5½



WORKINGS OF THE RED CLOUD AND ADJACENT MINES, GARNET RANGE, MONT.

ounces of gold and one-tenth of an ounce to 6½ ounces of silver to the ton. Most of the lots contained a little copper, generally less than 1 per cent.

The main adit level of the Grant & Hartford mine extends east into the Magone & Anderson ground 1,000 feet or more and was used as the main working entry for that property during its later period of activity. At a level about 80 feet higher there is a cross cut known as the Magone & Anderson tunnel No. 5, driven south 600 feet to the vein. There are drifts from No. 5, and the vein has also been worked through several higher adit levels.

The country rock is of the same character and structure as in the Grant & Hartford. Tunnel No. 5 begins in granodiorite and passes through a contact shatter zone 100 feet wide, in which the schist is broken into angular blocks of various sizes wedged apart by dikes of the intrusive rock. To a considerable distance beyond this zone the rocks are intensely metamorphosed, but their sedimentary origin is plainly evident.

Throughout the Magone & Anderson ground the vein lies in a bedding plane which strikes, in general, a little north of west and dips about 30° N. Except that its continuity is interrupted by a fault zone near the west end of the Magone & Anderson claim, the vein is known to persist for a horizontal distance of at least 1,500 feet. The lowest working in the vein is the Grant & Hartford winze, 200 feet below the creek. Levels carried into the Magone & Anderson ground from the Grant & Hartford tunnel reach a depth, measured on the dip of the vein, of 500 feet below the surface.

The fault zone, which has a width of 100 feet or more, crosses the vein obliquely from southwest to northeast and shifts it to the north. The principal slip planes pitch from 35° to 75° NW. and are lined with thick layers of gouge, and altogether the horizontal displacement of the vein at any given level amounts to about 200 feet.

East of the fault zone is a series of stopes on lenses that are connected by narrow or lean portions of the vein; considered together the lenses form a thin tabular body from 100 to 300 feet in stope length and 500 feet in pitch length.

The vein filling normally consists of quartz, barite, ankerite, and calcite in varying proportions, through which grains and masses of sulphide minerals are scattered. A banded structure is common, showing partial or complete replacement of schist by the vein minerals. Pyrite, which occurs as crystals and irregular grains intergrown with the quartz, is the most abundant sulphide. Tetrahedrite is rather sparingly and irregularly distributed, and without exception has replaced pyrite or some other vein mineral.

The lower limit of oxidation rises very slowly eastward, the bulk of the ore above the creek level being partly or wholly oxidized.

FIRST CHANCE MINING CO.

Several claims about half a mile south of Garnet that have been worked by the First Chance Mining Co. are generally known as the Mitchell & Mussigbrod mines. The most extensive workings are on the Red Cloud and Lead King claims, situated, respectively, on the east and west sides of First Chance Gulch. A large amount of work has also been done on the Crescent, Fairview, Fourth of July, and several other claims.

On the stage road from Bearmouth to Garnet the Lead King is the first quartz mine to be seen, the dumps from its several adit levels forming conspicuous long slides on the slope above the stream.

As early as 1867, when placer mining yet dominated all activity in this district, the Lead King-Red Cloud vein is said to have been discovered, but for several years thereafter little work was done upon it. During a period of 8 or 10 years, beginning in 1897, the vein was energetically developed under the direction of Dr. Peter S. Mussigbrod, and a large quantity of ore was produced, part of which was milled on the ground and the remainder shipped to smelters. Because of litigation the property has been idle the last few years.

Mill and smelter records for the period 1898–1907 show a production of $350,000, 97 per cent of which represents the value of the gold and the remainder the silver. In addition a large amount of ore for which no records are available is said to have been extracted by lessees from the Crescent and other claims, and the owners estimate a total yield of $500,000. The company's mill in First Chance Gulch close to the mouth of the Red Cloud incline is equipped with 10 stamps, plates, vanners, and concentrating tables.

Red Cloud.

The Crescent, Lead King, and Red Cloud mines are on a single vein which for convenience is referred to as the Red Cloud vein. This vein has been more extensively and systematically developed than others in the district and has produced at least five-sixths of the total accredited to the First Chance Mining Co. First Chance Creek has cut a deep notch across the vein, exposing a considerable portion of it to mining through adit levels. On the west slope of the gulch, in the Lead King and Crescent claims, there are seven adit levels (Pl. IX) that range from 600 to 1,000 feet in length and are distributed through a vertical distance of 300 feet measured from the stream bed. On the east slope in the Red Cloud claim there are four long adits and in addition several levels run from an incline sunk 250 feet below the stream.

The country rock consists of quartzite and schist that commonly show small dark oval spots caused by groups of mica flakes or crystals of cordierite. Small dikes of a fine-grained gray porphyry have intruded the schist here and there; one in the hanging wall parallel to the vein is exposed in Lead King mine. Under the microscope specimens from some of these dikes show the composition of granodiorite porphyry, and to the unaided eye all appear much the same. The quartzite and schist are folded in an arch (fig. 21), the axis of which crosses First Chance Gulch about 500 feet south of the mill.

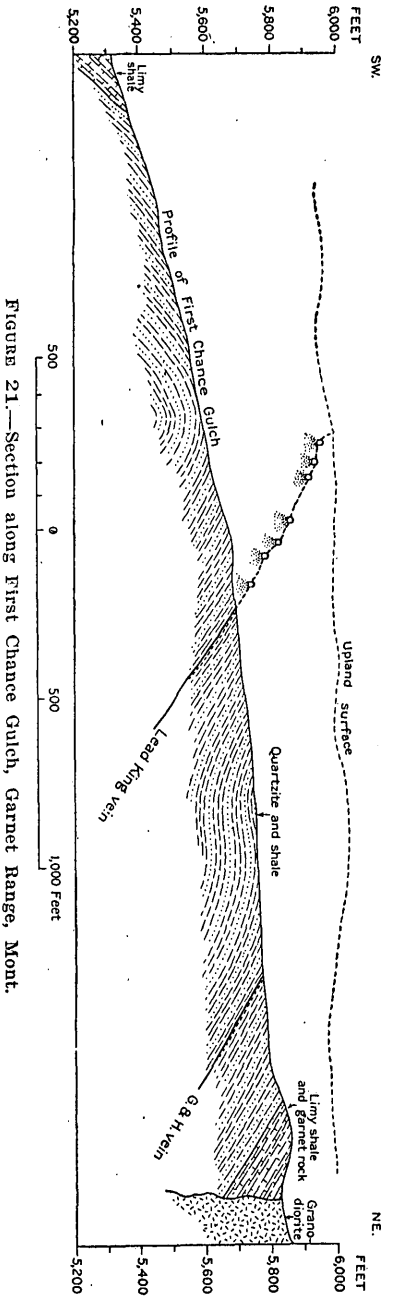


FIGURE 21.—Section along First Chance Gulch, Garnet Range, Mont.

The Red Cloud vein lies along a bedding plane and except for slight interruptions by faults is known to persist half a mile along the strike and at least 800 feet on the dip. In the Lead King workings its average strike is about N. 50° W., and in the Red Cloud about N. 70° W., and the dip ranges from 25° to 35° NE. Its thickness ranges from that of a mere seam to 3 or 4 feet, considerable portions averaging 2 feet or more.

There are two main ore shoots or groups of ore shoots about 700 feet apart, one on each side of the creek, the intervening portion of the vein being either pinched and lean or broken by faults. The shoot on the west claims has a stope length of 500 to 700 feet or more and comes to the surface west of the mouth in the Lead King and Crescent of adit No. 4 (Pl. IX). In the adits that were accessible for examination, namely, Nos. 1 and 2 and part of No. 3, the ore body

in few places is less than a foot wide and for the most part ranges between 1 and 3 feet. Levels below adit No. 1 have not been driven far enough to reach this ore shoot. In the Red Cloud claim, east of the creek, the vein swells to another large composite ore shoot that for the most part is worked out above level No. 2 east from the incline. Only parts of the workings on the east side of the gulch were entered. In Red Cloud adit No. 3, which is at about the same elevation as No. 4 of the Lead King, the vein is generally from 1 to 3 feet wide but in places is pinched to a stringer. Several stopes are carried almost to the surface, and the ore body considered in detail is made up of several flat lenslike masses and small fault blocks.

Three northeasterly faults were seen in the Red Cloud workings (Pl. IX). They dip steeply northwest, and each has shifted the vein northward from 20 to 40 feet. In adit No. 3 the first fault is 100 feet from the portal, and for the next 30 feet the rocks are more or less crushed. The principal plane in this zone strikes N. 45° E., dips 80° NW., and carries 1 foot of gouge and breccia. Another plane has a strike of N. 50° E. and a dip of 75° SE. As the movement was normal on both—that is, the hanging wall dropped—the vein was shifted first to the left and then to the right. At about 400 and 600 feet from the portal of No. 3 the vein is cut by other northeast faults that pitch steeply northwest and shift the vein to the north. Several faults parallel to those mentioned are reported to occur in the levels east from the incline, where they collectively form a fault zone 200 feet wide.

Oxidation is practically complete in the Red Cloud adit levels and above No. 4 of the Lead King. Partial oxidation is shown in the outer portions of Nos. 2 and 3, the lower limit rising slowly from the creek level as the hill is entered.

Most of the Red Cloud vein seen is composed of two or more layers separated by thin greenish-gray partings, and each layer commonly has a banded structure caused by a parallel arrangement of its minerals. In places the partings swell into small horses of country rock, and in general the vein appears to have replaced the schist rather than to have filled open spaces. Under the microscope replacement by quartz is clearly shown, fine flakes of mica arranged in parallel bands that represent bedding planes being all that remains of the original schist.

The walls are smooth and well defined and generally bear a thin soft gouge composed of very fine mica and crushed ore mixed together. Postmineral movements in the plane of the vein have not been extensive.

The vein filling normally consists of quartz with varying amounts of irregularly distributed barite, ankerite, and the ore minerals

pyrite, chalcopyrite, tetrahedrite, and galena. In the oxidized zone iron oxides replace the sulphide minerals, and free gold is present. Quartz, barite, and pyrite were first introduced in the vein, followed by ankerite, or calcite, chalcopyrite, and galena or tetrahedrite in the order given. The relations of galena and tetrahedrite to each other were not made out, but both replace the other vein minerals, particularly pyrite and chalcopyrite. Except in the completely oxidized portions of the vein, pyrite occurs everywhere as disseminated grains and crystals, inclosed in the quartz or carbonate. Chalcopyrite was seen only in specimens from the lowest levels. In most of the levels tetrahedrite and galena are rather sparingly and irregularly distributed, but locally they are abundant.

In specimens of oxidized ore from the Crescent mine gold is inclosed in both quartz and limonite, occurring as flakes and ragged rough particles, some of which are fairly coarse. Flakes of gold were also seen in iron-stained ore from the upper levels in the Red Cloud claim. In the Red Cloud, as in the Nancy Hanks vein, the distribution of the gold appears to be independent of tetrahedrite or galena but closely related to pyrite. Molybdenite was seen as thin films on cleavage planes in the walls but not within the vein itself. In addition to a widespread stain and masses of earthy texture, limonite forms cubes after pyrite, the oxidized ore closely resembling that from the Cascade mine. Manganese appears to be very rare. In a few places only recent stains of manganese oxide were seen on seams in the walls.

Near the vein the wall rocks contain fine grains of pyrite and are generally bleached, showing pale-green tints. Microscopic examination of a few specimens shows their original constituents to have been partly replaced by calcite and sericite. In the granodiorite porphyry dike that parallels the vein in the Lead King adits the feldspar is almost wholly altered to sericite.

Most of the ore stoped from the Red Cloud levels was worked in the company's mill and a saving of 80 to 90 per cent effected by plates and concentrators. On the average the ore contained about 90 per cent of silica, 4 per cent of iron in the forms of pyrite and limonite, 3 per cent of sulphur, small amounts of copper and lead, and 1 ounce of gold and 1½ ounces of silver to the ton. The concentrates, which were chiefly pyrite, generally assayed from 4 to 8 ounces of gold to the ton, and half again as much silver. The bullion from the plates varied considerably in fineness, owing to the presence of copper, but some of the retorts were composed of gold and silver only in proportions that averaged about 850 and 150, respectively. The ore taken from the Lead King workings is reported to have been somewhat richer than that milled from the Red Cloud. Above adit

No. 4 was a shoot of oxidized ore 250 feet long, said to have yielded $35 a ton and in places near the surface much more.

A large amount of ore is blocked out below the Lead King adit No. 4, and from all that could be learned there is no reason to think that the lower limits of the ore shoots have been reached in either the Lead King or the Red Cloud.

Fourth of July.

The Fourth of July vein crops out along a slope about a quarter of a mile southeast of the Red Cloud mill and from 300 to 400 feet higher. It is developed by four adit levels (Pl. IX, p. 188) to a horizontal distance of 300 feet and a depth of 450 feet on the dip.

The Fourth of July is roughly parallel to the Red Cloud vein and is inclosed by similar rocks. On the northwest and southeast it is cut off by transverse faults that bound a wedge-shaped block pointing southwest. The most probable interpretation of the faulting is that the block has moved relatively southwest and downward. If this is true the Fourth of July vein may be a shifted portion of the Red Cloud, a conclusion supported by the similarity of the two and the fact that the continuation of neither has been found. Both faults dip steeply and are accompanied by abundant gouge and breccia, and the ground between them has been broken by some smaller parallel fractures.

Practically all of the vein so far developed is from 1 to 4 feet in width and is reported to be of about the same richness as the Red Cloud. A small portion only of the vein has been stoped, and the ore produced averaged 1.8 ounces of silver and 1.18 ounces of gold to the ton.

The vein shows a banded structure and is normally composed of quartz and pyrite or its oxidation products. In places there are cavities from which tabular minerals, either ankerite or calcite, have been dissolved.

Robert Emmet.

The Robert Emmet vein crops out about 1,000 feet northeast of the Fourth of July, lies parallel to it, and is within the same fault block. It is opened by adit levels and an incline to a length and depth of 200 feet. The workings were not entered, but they are reported to show a vein similar in general to the Red Cloud. Records of ore shipments made from the Robert Emmet in 1906–7 show a total of $6,000 from ore that averaged 1 ounce of silver and 0.89 ounce of gold to the ton.

Fairview.

The Fairview vein crops out on the steep slope west of Cave Gulch, about three-quarters of a mile southeast of the Red Cloud mine. A tabular ore body from 6 inches to 3 feet wide and 400 feet long was

mined from the surface to a depth of 200 feet. Its general direction is east and its dip 30° N., and it is inclosed in schist and quartzite. Records covering the period 1898–1907 show a production of over $50,000. Assays were not seen except for the latest shipments, which averaged 0.77 ounce of silver and 1.1 ounces of gold to the ton. No ore was obtained from the workings in 1916, but specimens in the possession of Dr. Mussigbrod show the ore to be similar in general to that of the Red Cloud. Some of the specimens, however, are unlike any seen in any other mine in the district. In addition to coarse, ragged grains of native gold they contain tellurides of gold, silver, and bismuth inclosed in clear quartz.

Willie.

From a quarry on the east side of First Chance Gulch about 500 feet below the Red Cloud mill a large quantity of ore is said to have been taken that yielded from $4 to $11 a ton in gold. The lode, which is chiefly brecciated and iron-stained schist and quartzite, is known as the Willie lode. To a width of 40 feet or more it is reported to average $2 a ton. An adit level that starts in the bed of a ravine near the quarry penetrates the lode, which has a northwesterly direction, and occupies the core of the anticline previously mentioned as crossing First Chance Gulch below the mill. The folding squeezed and crushed the rocks, opening them for mineralizing solutions which partly replaced them with silica and introduced a little gold-bearing pyrite. Near its face the adit penetrates a vertical northeast fault that is about in line with the second fault met in the Red Cloud adit levels.

COLOMA DISTRICT.

GENERAL FEATURES.

Several mines are grouped closely around Coloma (fig. 22), a mining camp 2 miles northwest of Garnet. During 1897 and the next few years, while the Mammoth and Comet mines were in operation, the camp was lively, but since then it has become almost deserted. In 1916 the only important work in progress was a tunnel being driven by the Montana Gold Mines Co. at a point half a mile north of Coloma and 600 feet lower. Rather extensive development work was formerly done on both the Mammoth and Comet mines, and mills were installed, but from all that could be learned neither mine yielded a profit. Although rich in places, the veins are small, and the work seems to have been planned on a scale out of proportion to them. No records of production were seen, but persons familiar with the mines estimate that more than $200,000 worth of gold ore

was extracted from the Mammoth. Some of this ore was shipped to smelters, but most of it is said to have been milled, and all but a little of the gold was lost in the tailings. In the absence of smelter and mill records it is obviously difficult to estimate the production. The Comet is reported to have yielded a few thousand dollars, and the other mines, of which the Clemantha was the most productive, shipped gold ore worth $40,000 or more to smelters.

Coloma is reached by fairly good wagon roads either from Bearmouth by way of Garnet or from Potomac, a town 12 miles to the west on a logging spur of the Chicago, Milwaukee & St. Paul Railway. The mining area lies chiefly upon the summit plateau, which is continuous with and of the same description as that about Garnet. Most of the drainage goes northward through McGinnis Creek, a stream that has yielded much placer gold.

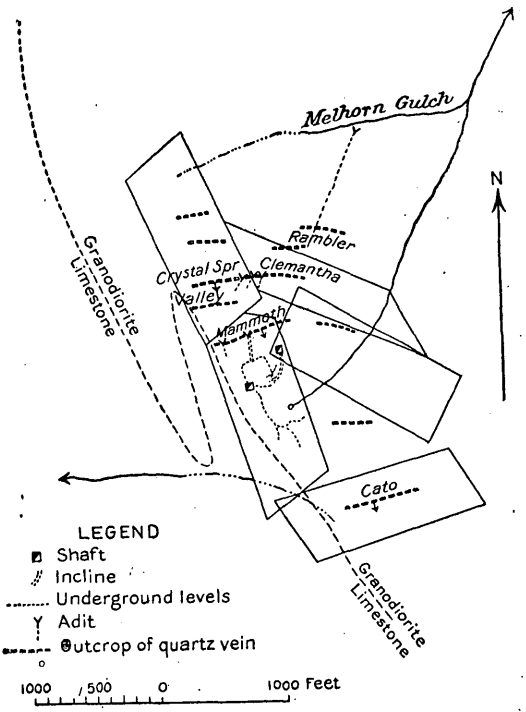


FIGURE 22.—Veins at Coloma, Garnet Range, Mont.

The rocks at Coloma are limestone and granodiorite, both of which are continuous, with similar bodies exposed at Garnet. The veins occupy fractures in the granodiorite that do not depart far from an east-northeast strike and a 30° S. dip. Most of them crop out very near the contact and within a space of half a mile from north to south. Except locally, they are not more than a foot or two in width, but some of them have been proved by explorations to extend 500 feet or more in length and depth.

None of the old workings were accessible at the time of visit, and information concerning the ore bodies is rather meager. Maps of the Mammoth mine show one stope above the 150-foot level that is 200 feet in stope length and 300 feet on the pitch. Most of this body is said to have been oxidized and rich in gold. There are several smaller stopes, and on the lowest level, which is 270 feet vertically below the surface and also below the limit of oxidation, the general

run of the ore is said to be worth from $20 to $30 a ton. Most of the other veins have produced ore near the surface worth $100 a ton, but none except the Comet are developed below the oxidized zone. Little was learned about the Comet beyond the fact that exploration has shown the vein to be generally very lean below a depth of 100 feet or less.

Specimens of sulphide ore from the Mammoth and Comet veins are rather similar in structure and mineralogy to the ores from the veins in the granodiorite at Garnet. Banding due to a replacement of the wall rock is common, and pyrite, chalcopyrite, and tetrahedrite, together with quartz, compose the ore. Tetrahedrite is notably abundant in the Comet ore, and in this mine and the Mammoth also it cuts and replaces the other sulphides. Specimens from the lower levels of the Comet show considerable white mica, and the quartz is rather coarse textured, suggesting a pegmatite. The oxidized ore consists, as usual, of porous quartz and iron oxides in earthy masses and as pseudomorphs after pyrite.

The texture and comparative poverty of the Comet vein, together with the fact that its outcrop is 700 feet lower than the Mammoth and also that much deeper in the granodiorite body, other things being equal, suggest that it may lie near the lower limit of the zone in which the gold-bearing pyrite was deposited. This being true, the depth of 700 feet in the Mammoth, or corresponding levels in other mines, may be a lower limit for good ore, the whole area being so small that the conditions surrounding the formation of all the veins were probably much the same. The tetrahedrite is of a later generation and apparently wholly independent of the gold-bearing pyrite and is probably not subject to the above limitations. In fact, there is nothing to indicate that this copper mineral does not persist in the veins to considerable depths, or even increase downward. In view of these considerations the completion of the tunnel now being driven by the Montana Gold Mines Co. to intersect the Mammoth vein at a depth of approximately 600 feet is awaited with interest.

MINES AND PROSPECTS.

MONTANA GOLD MINES CO.

From a point in Melhorn Gulch about 5,350 feet above the sea a tunnel is being driven southwestward to crosscut the Mammoth and other veins that crop out at Coloma. In September, 1916, about 1,000 feet of large, straight, and well-constructed tunnel had been completed under the supervision of Andrew Ryan, and about an equal distance remained to be run before a point directly beneath the shaft house on the Mammoth and about 600 feet below the surface would be reached. The tunnel penetrates granodiorite and has

crosscut a few small easterly quartz veins or stringers that dip 30°–40° S. Some of them show a little pyrite, and some are crushed by postmineral faulting in the plane of the vein. Generally the country rock is solid, but here and there it is slightly crushed and faulted.

The Mammoth vein is developed by a shaft reported to be 270 feet deep and several levels and stopes, none of which could be entered in September, 1916. The shaft and hoist were in an advanced stage of dilapidation and evidently had not been in use for several years. From 1896 to 1899 the mine was developed on a rather ambitious scale, and a mill was built in Washoe Gulch, about a mile to the west. Ore worth $200,000 or more in gold is said to have been mined and worked in the mill. No records of ore production or mill runs were seen, but the mill extraction is said to have been unsatisfactory, most of the gold having remained in the tailings.

The vein strikes about east and dips 30° S., and a large part of it is said to be from 1 to 3 feet or more in width. It cuts granodiorite adjacent to limestone, but does not cross the contact. Another similar vein follows the contact, which strikes southeast and dips steeply east. In the upper levels the ore in both veins was oxidized and reported to have been of high grade. Sulphide ore at a depth of 270 feet is said to average from $20 to $30 a ton in gold. The few specimens seen are similar in appearance to ore from Garnet, showing pyrite and tetrahedrite in a quartz gangue. The tetrahedrite was, as usual, the last mineral to be introduced into the vein.

Several veins parallel to the Mammoth crop out within a quarter of a mile north and south from it. Their value will doubtless be determined by the crosscut tunnel now being constructed. Named in order, those on the north, which have been the most extensively worked, are the Valley, Crystal Spring, Clemantha, and Rambler. None of these could be seen underground in September, 1916, but they are described by persons familiar with them as narrow veins similar in character to the Mammoth and are reported to have produced rich oxidized ore from their rather superficial workings. The Clemantha is said to have yielded $30,000, and the others smaller amounts.

South of the Mammoth is the Cato, which is one of the first of the veins to be exploited in this locality and for which a small production is reported.

COMET (OLYMPIAD).

The Comet mine, now partly included within the Olympiad claim of B. W. Champe, is three-quarters of a mile north of Coloma, near the head of Bivins Gulch, a tributary of Elk Creek. About 1905 a corporation known as the Quantock Mining & Milling Co. spent a large sum in development work and installed a 15-ton Huntington

mill. But a very small production of gold is said to have been made, however, and the company has to all appearances abandoned the ground.

A two-compartment shaft, with its collar about 5,250 feet above the sea, is said to have been sunk 500 feet on the vein, and several levels were run, one of them a crosscut 1,000 feet to the south. In September, 1916, the shaft was caved within a few feet of the collar. The vein is narrow, strikes N. 60° E., dips 30° S., and cuts granodiorite. Near the surface there were a few bunches of oxidized ore worth $100 a ton in gold. Below this a few small shoots of sulphide ore were found, specimens of which are fairly rich in tetrahedrite. The other sulphides present are pyrite and chalcopyrite, named in the order of their genesis, and both of them are replaced by the tetrahedrite. The gangue is quartz, which ordinarily forms 90 per cent or more of the vein. The long crosscut is understood to have been run in an unsuccessful search for a vein that crops out a short distance south of the Comet. Specimens from the lower workings show considerable white mica, and the quartz is rather coarse textured, features that suggest pegmatite.

HEAD OF ELK CREEK.

GENERAL FEATURES.

Several mines are located along the main divide and the adjacent slopes near the head of Elk Creek and about 2 miles east-southeast of Garnet (fig. 23). Since 1886, when the first one was opened, they have been worked now and then, producing in the aggregate $40,000 to $50,000 in gold. The district is reached from Garnet by an excellent road around the south of Anderson Hill, and, in addition, a road goes from the pass at the head of Elk Creek down Deep Gulch to the highway between Garnet and Bearmouth.

Most of the area drains northward to Elk Creek, chiefly through Day Gulch, a stream that has yielded much placer gold, but a small part is drained by Cayuse Gulch, a tributary of Deep Creek. The area is thickly timbered and abundantly supplied with water.

The surface is similar to that at Garnet. The main divide is an undulating flat that averages a little more than 6,000 feet in elevation and has been deeply scalloped along the borders by gulches from either side. Stones Flat, now a part of the divide, is the remnant of an ancient valley through which a good-sized stream once flowed and deposited placer gravels. The broad pass at the head of Elk Creek is a remnant of another old valley. A short distance away from the divide the surface becomes rugged and steeply sloping.

Beds of quartzite, shale, and schist continuous with those at Garnet occupy most of the surface. They likewise pass beneath lime-

stone and are invaded by granodiorite, of which the principal exposure occupies the basin of Day Gulch. In general the beds are bent into a broad arch, which is a continuation of the one developed at Garnet. Locally, however, there are many variations in the strike and dip, the mine workings commonly disclose faults, and the structure is evidently complex in detail.

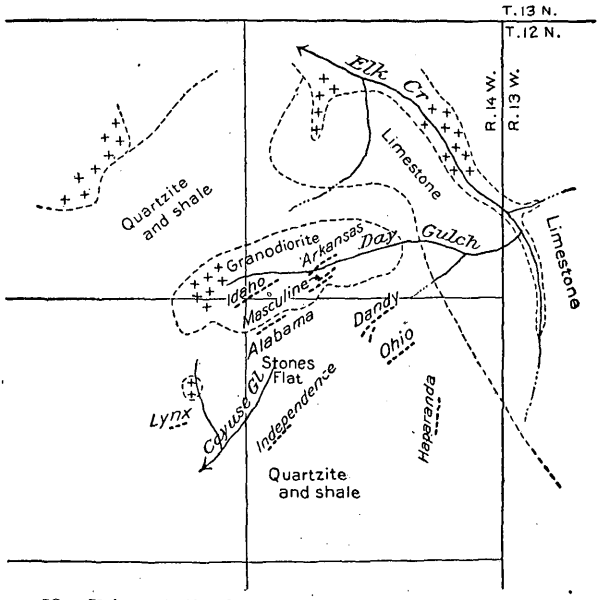


FIGURE 23.—Veins at the head of Elk Creek, Garnet Range, Mont.

LODES.

The lodes at the head of Elk Creek may be all classified as quartz-pyrite veins valuable for gold. They have been formed along fractures that cut the sedimentary rocks and the granodiorite, and, except the Haparanda, which trends north, they have a northeast direction. Most of them dip steeply northwest and all are fairly persistent though narrow. The most extensively developed of these veins, the Dandy, is shown to extend 1,000 feet or more along the strike and 500 feet on the dip without any indications that its lower limit is near. It varies in width but averages 2 feet for considerable distances.

Most of the other veins are narrow, and few of them have been explored more than 100 feet in depth or 200 feet in length. In most of the mines faults have been met that cut off the veins abruptly, but the amount of dislocation is known only for one or two of them. A fault that cuts the Dandy vein, between adits Nos. 1 and 2, has dropped one part relatively about 150 feet, measured on the fault plane, resulting in a horizontal shift of the vein at any given level

of about 200 feet. Most of the other faults carry as abundant gouge and breccia as this one, and their dislocations may well have been equally great.

The lower limit of oxidation has been reached in only one or two mines, in which it is about 200 feet below the surface. Unoxidized pyrite is found at less depths, but as a rule only where the vein is tight and admits little water.

In the veins which have so far proved to be the most profitable, and of which the Dandy is an example, the pyrite or the iron oxides derived from it are more or less concentrated in a middle streak that contains most of the gold. As a rule, however, this streak can not be separated in mining from the leaner quartz on either side, and the whole must be taken out and averaged together. In the other veins most of the pyrite occurs in small veinlets irregularly distributed through the quartz. Ore shoots, or portions of the veins that average sufficiently rich to repay working, range from a few to perhaps several hundred feet in length and depth. A fact that seems well established is the limitation of rich ore—that is, ore worth about $100 a ton—in most of the veins to depths within 50 feet or so of the surface. Except in spots the ore is leaner below, although still in the oxidized zone, and the sulphide ore farther down is of still lower grade. The decrease in tenor experienced in crossing the lower boundary of the oxidized zone, which in the Dandy amounts to the difference between ore worth $30 a ton and ore worth $20 a ton, is explained by the loss of valueless material in the course of oxidation and leaching, but the localization of richer ore just below the surface is not so easily accounted for. There is no evidence of downward enrichment in the sulphide zone.

The close association of these veins with intrusive granodiorite strongly suggests that they are a consequence of the intrusion of that rock, their minerals being formed from solutions given off when the magma cooled. Most of the veins are too small to warrant plans for very deep exploration, although there is no reason to think that the depth limit of ore has been reached.

MINES AND PROSPECTS.

DANDY.

The Dandy mine, on the slope west of Elk Creek about 2 miles east-southeast of Garnet, has been operated in recent years by the Ohio Mining & Development Co. There is a newly constructed building on the property equipped with a Lane mill, amalgamating plates, and concentrators, but it was idle in September, 1916, and the results of previous runs were not learned. A moderate-sized stope above adit

No. 2, the yield of which is not known, and a smaller stope in adit No. 1 that produced $13,000 in gold, are reported to have been made by predecessors of the present company.

Three adit levels have been driven southwest, wholly or in part following a vein in the Dandy claim. The lowest adit, No. 3, is 1,000 feet long and lies about 5,800 feet above the sea. Levels 2 and 1 are about 175 and 350 feet higher, respectively, and 850 and 200 feet in length. At their farther ends levels 3 and 2 are about 400 feet deep in the vein. In addition there are several crosscuts and raises, and altogether about 3,000 feet of underground work has been done.

The formation consists of slaty mica schist and quartzite similar to many of the beds at Garnet, and in addition there is considerable

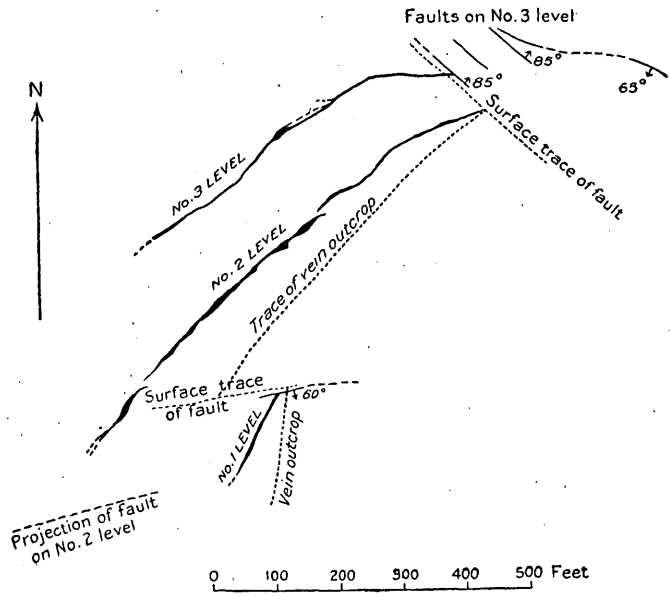


FIGURE 24.—Plan of Dandy vein, Garnet Range, Mont.

very dark shale. A short distance to the east these rocks are overlain by limestone, and to the north they give place to granodiorite. A granodiorite dike is also met in adit No. 3 about 300 feet from its mouth. In general the sedimentary rocks strike northwest and dip at moderate angles northeast, but they show many local variations in attitude and the structure is complex in detail.

The vein dips 55°–75° NW. and cuts the quartzite, schist, and shale at right angles to their general direction. It is exposed by adits Nos. 2 and 3 to a length of nearly 1,000 feet, in which its continuity is practically unbroken, although there are two or three small interruptions where the vein leaves one plane for another parallel fracture a few feet away. There are some extensive pinches (fig. 24), but over

most of the course described the vein averages at least 2 feet in width and in places reaches 3 or 4 feet.

A fault that strikes nearly east and dips 60° south has shifted that portion of the vein exposed in adit No. 1 about 200 feet to the south. The vein is again cut off near the mouth of adit No. 2 and at a point below in adit No. 3 by a northwesterly fault zone, the planes of which are vertical or dip very steeply northeast. Farther east there is a fault that strikes a little north of west and dips southwest. The vein itself lies in a fault fissure and has been slightly crushed by post-mineral movement.

Generally the vein shows a banded structure, in places containing thin partings and horses of country rock, and is composed wholly of quartz and pyrite or the oxidation products of pyrite. As a rule most of the pyrite is gathered along the middle of the vein, forming a streak locally as much as a foot thick. In the oxidized ore the pyrite streak is represented by a porous or "honeycomb" quartz partly filled with limonite. Most of the quartz is rather fine grained, milk-white, and dense, but in places there is a coarser transparent variety that, together with some of the pyrite, seems to be of a later generation.

Oxidation is practically complete above and for short distances below level No. 2, its lower limit lying about 150 to 250 feet below the surface and sloping in the same direction.

Adits Nos. 2 and 3 are unconnected, but there are some raises and small stopes that extend part way between them and afford means for a tolerably comprehensive sampling of the vein. As indicated by the results obtained by several engineers, all of whom estimate a large tonnage in sight, considerable portions of the vein above No. 2 appear to average about $30 a ton in gold, and the corresponding sulphide ore on No. 3 level about $20 a ton. The assay plats suggest that there are two or more persistent ore shoots that pitch slightly westward in the plane of the vein, and in addition some rich spots between.

OHIO AND BUCKEYE.

About 800 feet south of the Dandy a vein has been opened on the Ohio and Buckeye claims. This vein strikes southwest, stands vertical, ranges from 2 to 5 feet in width, and is composed of dense white quartz. Here and there it contains specks of pyrite, and samples from it are said to have assayed $2 or $3 a ton in gold.

HAPARANDA.

The Haparanda mine is on the slope west of Elk Creek about half a mile southeast of the Dandy. It was opened in 1886 by B. A. C. Stone, who built a small mill and extracted about $10,000 in gold.

The property has lain idle many years, and the workings are caved. Mr. Stone describes the vein as having a nearly due north trend and a dip of 85° E. Near the surface there was a rich ore shoot 2 feet thick and 30 feet in stope length that pitched 20°–30° N., parallel to the mountain slope. Beyond this shoot the vein was explored for some distance but proved to be lean. The formation is quartzite and schist, and the vein minerals are quartz and pyrite or iron oxides derived from it.

MASCULINE AND ARKANSAW.

The Masculine and Arkansaw mines, neither of which was being worked in 1916, are in Day Gulch a quarter of a mile northwest of the Dandy. Both veins strike N. 65° E., dip 75°–80° NW., and cut granodiorite. The Masculine, which is from 1 to 2 feet wide, is developed by a short tunnel and a shaft said to be 175 feet deep. At the bottom of the shaft the vein is cut off by a fault that dips north. Ore scattered about the dump is a fine-grained flinty quartz that contains abundant fine pyrite in secondary fractures. Near the surface the ore contains a large amount of iron oxides and is said to assay from $20 to $40 a ton in gold.

The Arkansaw is a foot or less in width and of similar composition to the Masculine. It is said to be developed to a depth of 65 feet and to assay from $40 to $80 a ton.

IDAHO AND ALABAMA.

The Idaho and Alabama mines are in the upper part of Day Gulch, just north of Stones Flat. The veins in both strike northeast, dip 25°–30° SE., and are a foot or less in width. The Idaho vein is in granodiorite and has been developed by an adit level several hundred feet long. From an ore shoot 50 feet long, it is said, about 100 tons of ore that averaged $100 a ton in gold was shipped by way of Bearmouth to smelters. The vein minerals are quartz and pyrite or its oxidation products.

The Alabama vein is in schist, very near the granodiorite contact, but has not been extensively developed. It is similar mineralogically to the Idaho.

INDEPENDENCE.

The Independence is a prospect on the slope east of Cayuse Gulch and near the Elk watershed, developed by an adit level at an elevation of 5,950 feet above the sea, driven northeastward 150 feet. For the last 30 feet the adit follows a N. 55° E. vein that dips 75° NW., ranges from 1 foot to 4 feet in width, and is composed of a dense milk-white, rather flinty quartz, through which fine-grained pyrite or iron oxides derived from it are distributed along a network of small cracks.

LYNX.

The Lynx mine is about a quarter of a mile southwest of Stones Flat, in a ravine tributary to Cayuse Gulch. An adit level 240 feet long follows in part a S. 80° W. vein that dips 75° S. and cuts quartzite. At 165 feet from the portal the vein is cut off by a N. 25° W. fault which dips 85° W., and along which there is a short drift to the north. The fault movement has apparently been normal, and has probably shifted the vein a considerable distance to the north. Beyond the fault the adit continues into a zone of broken and disturbed rocks.

The vein ranges from 1 foot to 3 feet in width and is composed of quartz and iron oxides derived most probably from pyrite. As a rule the iron oxides, which constitute the valuable portion, form a streak in the middle of the vein that ranges from a few inches to a foot or two in width. At 80 feet from the portal a stope 30 feet long begins that extends nearly to the surface and is said to have yielded a moderate quantity of ore worth about $80 a ton in gold.

A short distance north of the Lynx tunnel a small working exposes 25 feet of soft material that is rich in earthy iron oxides and is said to contain fragments of copper ore. This deposit adjoins a small body of intrusive granodiorite and has the appearance of decomposed garnet rock like that of the contact-metamorphic deposits at Top o' Deep.

TOP O' DEEP DISTRICT.

HISTORY AND PRODUCTION.

In the basin at the head of Deep Creek small gold-bearing quartz veins were uncovered by placer mining as early as 1866. At different times since then some of them have been mined to shallow depths, and work was done also on the copper-bearing contact-metamorphic bodies in the hills around the basin. In the summer of 1916 only one mine—the Mountain—was being worked. Most of the claims in the district are patented, and the idleness of some of them is said to be caused by litigation. Altogether the lodes have yielded about $50,000, of which much the greater part was in gold and the remainder in copper.

GEOGRAPHY AND GEOLOGY.

Deep Creek heads in a small basin about 6,000 feet above the sea. Slopes that border it on the east, north, and west rise gently 500 feet or more to a rather broad, undulating divide, beyond which the drainage goes to Weasel Gulch on one side and Elk Creek on the other. The summit north of the basin has an average elevation of

6,650 feet, and one point to the east reaches 6,826 feet. A short distance away from the divide the streams descend into deep, narrow valleys, and the surface in general becomes steep and rugged.

The Deep Creek basin is almost wholly occupied by an intrusive body of granodiorite that has come up through limestone. The exposed portion of this body has a roughly circular form, is about a mile across, and extends northward over the divide into Weasel Gulch. Field evidence shows the exposure to be the top of a mass that expands in depth and is probably connected beneath the surface with the main granitic body exposed at Garnet. There is reason to believe that before it was uncovered by erosion the granodiorite mass projected but little higher than the present rim of the basin. Deep Creek has cut down into it 700 feet or more.

As a rule, to a distance of several hundred feet from the contact the limestone is changed to a white marble, and portions on the top and upper slopes of the intrusive body are replaced by a rock composed of garnet, magnetite, and other contact-metamorphic minerals. North and east of the Deep Creek basin is an area of andesite lava, a formation not known to contain valuable mineral deposits in this region.

LODES.

CLASSIFICATION.

The lodes in the Top o' Deep district form two groups that are distinct in age, origin, and character. The older deposits, of which the Mountain is an example, are masses of garnet and other metamorphic substances that contain copper minerals and occur in limestone next to the intrusive granodiorite. Quartz veins formed by replacement along fractures that cut the granite and the metamorphic bodies also form a later group, chiefly valuable for gold.

CONTACT-METAMORPHIC DEPOSITS.

General character.—The metamorphic bodies are most abundant in high situations and rather significantly absent along Deep Creek and Weasel Gulch at the lowest exposed portions of the contact. From the Red Rock mine they extend northward about a mile, and they also form a shorter chain along the west side of the granodiorite at the Mountain mine.

In detail the metamorphic bodies are irregular, but as a rule their greatest dimensions are parallel with the contact. The body on which the Boston mine is located is bent in the form of a crescent and is almost completely surrounded by the granodiorite. It is 3,000 feet or more in length and about 500 feet in extreme width, and the rather meager information afforded by underground workings shows

it to taper downward like a blunt wedge. The body at the Pearl mine is from 10 to 50 feet wide and at least 300 feet deep. Its length is not shown, but it doubtless extends with some breaks as far south as the Red Rock, a distance of half a mile. Although very irregular in detail, the boundaries of these metamorphic bodies appear to be generally sharp and distinct. No gradual change from the rock that is chiefly garnet and magnetite to granodiorite on one hand or limestone on the other was observed. A flinty quartz that is commonly red or brown with iron oxides forms bodies closely associated with the metamorphic mass and rather indefinitely separated from the limestone. In places the metamorphic bodies faintly show a banded structure caused by a partial segregation of the minerals in layers.

Ore shoots.—Copper minerals appear to be rather generally but sparingly distributed through the metamorphic bodies. An average sample from a pit on an outcrop in the Red Rock claim is reported to have assayed 1.5 per cent copper, and a 2-foot streak in the Mountain mine is reported to contain from 5 to 8 per cent copper. The streak in the Mountain mine, however, is not sharply separated from the leaner portions of the mass, and not enough work has been done to show its limits.

The gold-copper ore shoots worked in the Pearl mine, although inclosed in a metamorphic body, belong mainly to a later quartz vein and are described in succeeding pages.

Mineralogy.—In the following list the minerals of the metamorphic deposits are classified as primary and secondary, according to whether they were deposited originally in the lodes or were formed later:

PRIMARY MINERALS.

Pyrite	Sparingly disseminated grains inclosed by garnet and magnetite.
Chalcopyrite	Irregularly distributed grains intergrown with garnet and magnetite.
Quartz	Locally abundant and flinty, replacing limestone.
Magnetite	Next to garnet the most abundant mineral of the deposits. For the most part it has a rather fine granular texture, but in places it forms good-sized tabular crystals.
Calcite	Absent from the lodes generally but occurs in places as rather large crystals inclosing green hornblende and other minerals. The marbleized limestone is made up chiefly of rather coarse calcite grains.
Garnet	Forms the bulk of the deposits and is chiefly the brown lime-iron variety, andradite. Occurs in compact granular masses but also shows well-developed crystal faces, some of which are an inch across.

Epidote	Abundant and generally fine grained. Occurs throughout the deposits, and also in parts of the adjacent limestone.
Actinolite (green hornblende)	Observed in one place only where it is intergrown with epidote. Occurs in parts of the adjacent limestone.
Tremolite (white hornblende)	Locally abundant as radial aggregates in limestone near the contact.

SECONDARY MINERALS.

Native gold	In cavities in boulders of metamorphic rocks found in Bilk Gulch. Adheres lightly to the faces of garnet crystals and is associated with chrysocolla. Is thought to have been introduced into the metamorphic body by the later quartz veins and to have migrated when the veins were oxidized.
Chalcocite	Fills small cracks in chalcopyrite from the Pearl mine. Apparently produced by downward enrichment.
Chalcedony	Lines small cavities and is abundant in the limestone adjacent to the metamorphic bodies.
Iron oxides	Abundant in the weathered portions of the lodes. Produced by the decomposition of magnetite and iron-bearing silicates and sulphides.
Copper oxides	A black oxide (tenorite?) stains specimens from the Pearl mine.
Malachite	Forms thin coatings and crusts in the upper portion of the lodes. Observed in places to be forming from chrysocolla.
Chrysocolla	Valuable as an ore mineral. Fills seams and small cavities in the upper portions of the lodes. Produced by the weathering of chalcopyrite and the accompanying silicate minerals.

Alteration and genesis.—Some of the metamorphic bodies are considerably decomposed at the surface, the garnet and other silicates having broken down to an ocherous clayey mass and even the magnetite appearing to have changed to limonite. These changes, however, do not extend downward more than a few feet. Most of the metamorphic bodies show rather fresh garnet and other silicates as well as magnetite at the surface. As a rule, oxidation of the copper-bearing sulphides is well in advance of any extensive disintegration of the other minerals but appears to be accompanied by a partial destruction of the garnet. Chrysocolla appears everywhere to be the chief oxidation product and to have migrated from its places of origin to the crystal-lined vugs or other cavities that are numerous in

the deposits. Locally native gold is so intimately associated with chrysocolla that the two appear to have been carried by the same solution. At the surface the chrysocolla appears to be unstable, for it is commonly observed passing directly into malachite. In places the chrysocolla has been carried down below the unoxidized chalcopyrite. At a depth of 40 feet in the Mountain mine the two minerals overlap, forming an enriched zone, the extent of which, however, is not known. Doubtless similar zones have been formed in the other lodes.

A significant fact concerning the metamorphic bodies is their grouping around the higher portions of the granodiorite body. The Boston, Hartford, and others of the largest outcrops are at the very summit of the intrusive mass, and the Mountain, Pearl, and the remaining deposits of any considerable size are very near the top. At low situations, however, as where Deep Creek and Weasel Gulch leave the granodiorite area, hardly a trace of a metamorphic body such as the deposits under consideration is to be seen.

The metamorphic bodies were evidently derived from the granodiorite by heated vapors that carried large quantities of iron and silica and a little copper into the limestone. The pressure being less at the top of the intrusive mass than elsewhere, the vapors with their mineral burden escaped there the most freely.

Conclusions.—Although it appears that none of these lodes are more than a few hundred feet deep, many are extensive enough in other directions to be of value if any considerable portions of them are of workable grade. As the distribution of the copper minerals is irregular, the exploration of these lodes has to be carried on more or less blindly, but the most probable situations for ore are the zone in which the chalcopyrite and chrysocolla overlap and the limestone side of the metamorphic body. Wherever present this enriched zone is probably within 50 feet of the surface. In several other mining districts ore is found most abundantly on the limestone side of garnetiferous deposits, although, so far as the writer is aware, no adequate explanation of this has been advanced. Development work is not extensive enough to determine whether or not this rule applies at Top o' Deep, but nevertheless it is thought advisable to explore the limestone side carefully.

Concentration of this ore would be difficult because of the heaviness of the gangue minerals, but the large percentage of iron may be generally counted upon to procure favorable smelter rates.

QUARTZ VEINS.

Many small quartz veins cut the granodiorite body at the head of Deep Creek and occur also in the metamorphic rocks on the divide between that stream and Bilk Gulch. Most of them are but an inch

or two wide, and they show a variety of strikes and dips. A few attain widths of a foot or more and contain small but rich bodies of gold ore. In part the quartz has replaced the wall rock along fractures or shear zones, and in part it has filled open spaces, as is shown by the growth of free crystals outward from the walls.

Ore bodies from a few inches to a foot or more in thickness and 30 to 40 feet in length and depth have been worked in the upper portions of these veins, most of which have not been explored more than 40 or 50 feet below the surface. In the Pearl several small irregular ore shoots occur between the surface and a depth of 200 feet, the largest one above the 100-foot level. On the Red Rock and Gold Leaf ore extended from the surface down about 40 feet.

Oxidation is complete at least 40 or 50 feet below the surface at the Red Rock and to a somewhat less depth at the Pearl.

The mineralogy of the veins is simple. Grains and small masses of pyrite and chalcopyrite, both presumably gold bearing, together with small amounts of native gold, were introduced with the quartz. In the oxidized ore limonite has replaced the sulphides and commonly retains the crystal form of pyrite. Particles of native gold are embedded in the limonite but in some specimens are inclosed in quartz without any accompanying iron minerals. Chalcopyrite is rather abundant in the Pearl and the other veins that cut metamorphic rocks but apparently is not plentiful in the veins in granodiorite, as suggested by the scarcity of copper stains in these veins. A little enrichment by chalcocite, copper oxides, and chrysocolla has occurred in the Pearl. It may have been caused, however, by the oxidation of copper minerals introduced with the metamorphic deposit as well as from the later quartz vein.

Though smaller and differing somewhat in mineralogy, the quartz veins are similar in general character to those associated with granodiorite near the town of Garnet. They are thought to be of essentially the same age and likewise an effect of the intrusive magma. Because of their small size these veins do not encourage deep exploration, although they are doubtless rich to considerable depths. Their importance collectively as a source of placer gold is shown by the extensive and rich gravels in the gulches below.

MINES AND PROSPECTS.

MOUNTAIN.

The Mountain mine, operated in 1916 by H. P. Hanifin, is on the western rim of the basin at the head of Deep Creek, at an elevation of 6,400 feet. The production by former operators of a carload of ore that yielded 16 per cent of copper but little or no gold and silver is reported, and ore for shipment was being taken out by Mr. Hanifin in September, 1916.

A shaft sunk at the contact between intrusive granodiorite and limestone penetrates a mass composed mainly of garnet, magnetite, and epidote. At a depth of 40 feet drifts aggregating 50 feet in length extend north and south from the shaft and show the metamorphic body, which may be regarded as the lode, to be at least 10 feet wide. A few workings along the outcrop indicate the probable length of the lode to be several hundred feet.

The most abundant ore minerals are chalcopyrite and chrysocolla. Malachite, mainly derived from the alteration of chrysocolla, forms coatings in cracks and seams but is not abundant. Chrysocolla fills seams and cavities, some of which are the size of a hickory nut, and is widely but irregularly distributed through the lode. At the depth of 40 feet most of the chrysocolla is fresh, compact, and of a fine turquoise-blue color—qualities that may give it some value as a gem stone. The chrysocolla is clearly of later origin than the chalcopyrite and the silicates composing the gangue, and was probably derived from the weathering of those minerals. Grains of chalcopyrite appear here and there at the 40-foot level and are more abundant than elsewhere in an irregular ill-defined streak about 2 feet wide that is not far from the limestone. Samples of this portion of the lode are said to assay from 5 to 8 per cent of copper. The chalcopyrite is intergrown with the garnet and magnetite and apparently came into the lode with them. Pyrite occurs also as a primary mineral intergrown with magnetite.

The brown lime-iron variety of garnet known as andradite forms the bulk of the lode. Most of it is coarsely granular and massive, but well-formed crystal faces are shown in the numerous small cavities in the rock. The magnetite and epidote are finer grained, and the three are partly intergrown and partly segregated in rather indistinct bands. Locally a little quartz is associated with them.

PEARL.

The Pearl mine, on the divide between Deep Creek and Bilk Gulch, is reported to have produced about $20,000 worth of gold-copper ore. It is developed by a vertical shaft 300 feet deep from which levels have been run at depths of 100, 150, 200, and 300 feet. No work was being done in August, 1916, and the mine evidently had been idle for several years.

Open pits expose a deposit of garnet-magnetite-epidote rock, at the contact of granodiorite and limestone. The garnet is the brown lime-iron variety andradite and is rather coarse grained. The epidote and magnetite are finer, and the three are intimately intergrown in some places and partly segregated in others. Here and there the rock contains a little quartz sand. Chrysocolla and mala-

chite fill cracks, seams, and small cavities, and a few grains of unoxidized chalcopyrite remain. Irregular bodies of flinty quartz, clouded with iron oxides, occur here and there in the limestone next to the metamorphic body. The underground workings were not entered by the writer, but from a miner familiar with them the following facts were learned: The contact plane is very irregular and has an average nearly vertical dip under the limestone. The metamorphic body ranges from 10 to 50 feet in thickness. At the 100-foot level a steeply inclined ore shoot from 2 to 10 inches thick and 20 feet long was stoped to a height of 40 feet, yielding about $15,000, chiefly in gold. The 150-foot level cut a narrow vertical pipe of ore, worth from $20 to $200 a ton in gold and copper, and a little below 200 feet the shaft went through a small flat-lying shoot of good ore. All the ore bodies are in the garnet, but at no regular distance from either the granite or the limestone. A level at the bottom of the shaft (300 feet) explored the granite but found no ore of consequence.

Specimens of ore said to have come from the shoots mentioned are portions of small quartz veins cutting the garnet rock. Two kinds of quartz occur—a coarsely crystalline kind that incloses sulphides and a compact flinty kind that contains chrysocolla, malachite, and copper oxides. The flinty quartz is the later of the two and is doubtless secondary, but the more coarsely crystalline quartz resembles that of the gold-bearing veinlets in the granodiorite. It incloses grains of pyrite and chalcopyrite, and in one specimen fine particles of gold were observed adhering to a partly oxidized grain of chalcopyrite. In addition chalcocite fills small cracks and seams in the ore. The Pearl lode is evidently a metamorphic deposit similar to the Mountain, but in addition it is cut by some later gold-bearing quartz veinlets. A little enrichment in copper and possibly also in gold has occurred. In Bilk Gulch below the Pearl float boulders, described on page 237, in which gold and chrysocolla are found together in cavities, indicate that a secondary transfer of the gold has taken place in the lode from which these boulders came.

BOSTON, HARTFORD, AND GOLDEN ANGEL (KLONDIKE).

A short distance northwest of the Pearl mine, on the hill at the head of Deep Creek, is an outcrop of garnet-magnetite-epidote rock shaped like a crescent open to the west. This body is about 3,000 feet long and 500 feet across at its widest part, and except on the east, where a neck joins it to the limestone, it is entirely surrounded by granite. Prospect pits here and there show copper-stained rock similar to that at the Pearl and Mountain mines. No work was being done on this deposit in August, 1916, and no ore shipments are reported. Some open pits and a shaft on the Boston claim are along

the middle part of the crescentic mass. Here a copper-stained outcrop 50 feet across stands rather prominently above the general surface. As shown by the natural exposures, the open pits, and the shaft dump the body is composed mainly of rather coarse-textured brown garnet (andradite), magnetite, and epidote, named in their relative order of abundance. The garnet and magnetite are intimately intergrown, and the epidote appears generally to fill interstitial spaces. Cavities are lined with well-formed garnet crystals covered with crusts of chrysocolla, which in the more weathered specimens may be seen with the aid of a hand lens altering directly into malachite.

Here and there the mass is cut by irregular quartz veins an inch or two in width that contain a little pyrite and chalcopyrite. In addition a flinty red and brown quartz locally replaces the garnet rock. Oxidized portions of these veinlets are coated with chrysocolla and malachite, and some specimens contain small particles of native gold. In addition the metamorphic rock is commonly copper stained, though no unoxidized chalcopyrite was seen in it. The shaft is said to be 100 feet deep and to have ended in granite.

On the Hartford and Golden Angel claims, on the northern and southern horns of the crescent, respectively, the workings show the results of mineralization similar to that at the Boston. At the Golden Angel green hornblende (actinolite) occurs in addition to the other metamorphic minerals, and the contact plane, as shown by a shaft 100 feet deep, is said to dip steeply under the metamorphic body.

No assays showing the amounts of copper and gold in any of these deposits are available, but some of the rock looks rich enough to justify careful sampling.

RED ROCK.

The most extensively developed quartz vein in this district is the Red Rock, near the eastern edge of the granodiorite, about a quarter of a mile above the old mining camp of Top o' Deep. Ore from the Red Rock worked in an arrastre is said to have yielded between $10,000 and $12,000 in gold. The workings consist of open cuts, tunnels, and drifts, most of which are caved and which explored the vein along the outcrop for 500 feet or more. The vein has a nearly flat dip and is about a foot in average width, and its quartz is not unlike that of the Cascade vein, near Garnet. Limonite is abundant as earthy masses, stains, and scattered grains, some of which still preserve the crystal form (cube) of the pyrite from which they were derived. In specimens broken from the vein small particles of gold were seen embedded in the limonite, particularly in the cubelike grains. The gold is said to be more or less concentrated in spots or pockets, some of which were very rich. The wall rock is largely

altered to a felty mass of very fine mica (sericite), and is deeply stained with oxides of iron.

Along the contact near the center of the Red Rock claim pits show 6 feet or more of soft earthy limonite that is plainly decomposed garnet-magnetite rock. Farther north along the contact other pits expose a copper-stained body of garnet rock and silicified limestone that is said to assay 1.5 per cent of copper.

Much of the silicified limestone resembles vein quartz to the unaided eye, and has been excavated in the expectation of finding gold but without success. Under the microscope it is seen to be composed of very fine grained quartz and opal, thickly clouded in places with iron oxides. It is much finer textured than the gold-bearing vein quartz, and was apparently formed by replacement of the limestone when the garnet rock was introduced.

GOLD LEAF.

The Gold Leaf mine is in granodiorite about a quarter of a mile north of the Red Rock or half a mile north of Top o' Deep. Several open cuts and an incline said to be 40 feet deep are made on a quartz vein that ranges from a few inches to a foot in width and is similar in composition and texture to the Red Rock vein. "Cubes" and irregular masses of limonite containing fine particles of free gold occur in it, and some of them show unoxidized kernels of pyrite and, rarely, of chalcopyrite. An open cut 100 feet long made on the outcrop is said to have yielded $7,000 from ore worked in an arrastre. The wall rock is extensively sheared, altered, and rusty, and is said to assay $2 or $3 a ton in gold.

COPPER CLIFF DISTRICT.

HISTORY AND PRODUCTION.

A small but very interesting district known by the name of its principal mine, the Copper Cliff, lies along the main divide about 6 miles in an air line west-southwest of Garnet. It is reached from Bonita station on the Northern Pacific and Chicago, Milwaukee & St. Paul railways by a good road, 10 miles long, up Cramer Creek. There are also less-traveled roads to Copper Cliff from Bearmouth, another station on the railways mentioned, and from Potomac, a town on the main highway, up the Blackfoot Valley.

Since the discovery of the Copper Cliff lode in 1891, which caused a mild excitement at the time, mining has been rather spasmodic. The total production is about 150,000 pounds of copper and very small amounts of gold and silver.

GEOGRAPHY.

The general surface features at Copper Cliff are similar to those at Garnet, Coloma, and other places along the summit of the Garnet Range. The main divide and its most prominent spurs are remnants of an ancient flat or gently hilly surface into which the streams have cut deep gulches from either side. The general summit level at Copper Cliff, however, is about 5,500 feet, or 500 to 1,000 feet lower than is usual in the Garnet Range—a difference that is significant of warping or other structural deformation of the ancient surface. The mining area lies just north of the watershed, extending from the summit level down a short gulch that empties into Union Creek not far below its head. Below the Copper Cliff the gulch is steep, narrow, and straight, having a course of N. 50° E., but the small portion above the mine is crooked, flat, and open toward the head. The noticeable feature of this gulch is the Cliff, a huge upright slab of rock at the foot of the slope on the left and about a third of the way downstream from the head. From a viewpoint across the gulch its nearly vertical front is seen to be criss-crossed and deeply scored by joints and fractures and pitted with small caves. Its general tone is a somber gray, but here and there are patches and streaks of bright yellow and turquoise-blue, and the whole, framed by evergreen trees, forms a striking and beautiful picture. The North Fork of Cramer Creek heads just across the divide from Copper Cliff Gulch and flows in the opposite direction, the two valleys falling in line, a fact thought to be of importance in the interpretation of the structure. (See p. 217.)

GEOLOGY.

The rocks of the Copper Cliff district are a group of ancient sandstones and shales (Algonkian Belt series) and limestone (Cambrian) that normally overlies them. There are also a few small bodies of porphyry, but no other igneous rocks are known nearer than the head of Tenmile Creek, 2 miles away, where there is an outcrop of granodiorite. The sandstone is generally fine grained, thin bedded, and pale brown, drab, or red and shows a little fine white mica. It grades into shale on one hand and quartzite on the other. The limestone is fine grained, compact, and lead-gray, but weathers to lighter shades.

In general the sedimentary rocks of the Copper Cliff locality dip gently southwestward, for they lie well up on the southwest limb of an anticline that may be traced several miles in a northwesterly direction. At the Copper Cliff mine and in its immediate vicinity, however, all other structural features are subordinate to faults, of which the most prominent are within a belt 1,000 feet or more wide that

trends northeast, coinciding with the courses of Copper Cliff Gulch and the North Fork of Cramer Creek. It is to be regretted that only the larger features of the faults can be described, because successful development of the mines depends more than anything else upon a detailed knowledge of the faults.

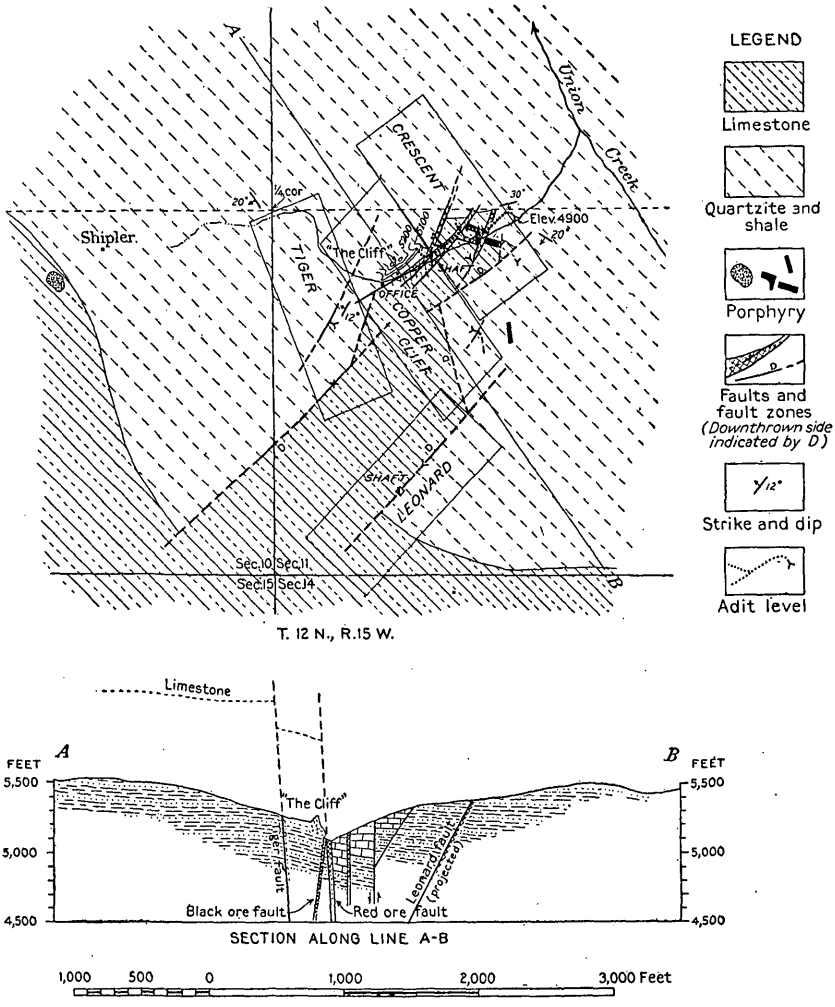


FIGURE 25.—Geologic map and section of the vicinity of Copper Cliff, Garnet Range, Mont

The structure at Copper Cliff is shown in generalized fashion by figure 25. A large block of limestone is now wedged between opposing masses of the sandstone and shale that it formerly rested upon. Some parts of the limestone block are at least 1,000 feet below their original positions, others less, but all have been dislocated extensively. Most of the dislocation has been along fractures that strike N. 50° E.

and dip steeply to one side or the other, but movements have occurred along fractures of other directions, and as a result the limestone mass has an irregular zigzag outline. Apparently fractures are so numerous within the belt mentioned that the whole may be broadly viewed as a fault breccia. So far as the downthrow is concerned, the faulting appears to have been normal—that is, the hanging wall was dropped relatively. The rocks have been so severely crushed, however, that the mere dropping of a wedge-shaped block seems hardly adequate to account for their condition. Great pressure, such as may be conceived would be developed by a strong thrust causing extensive horizontal movements, is suggested by the general relations of the rocks. That this fault belt is a persistent structural feature is indicated by such evidence as the presence of breccia, the alignment of the North Fork of Cramer Creek and Copper Cliff Gulch, and a break in the continuity of the rocks for a considerable distance down the North fork of Cramer Creek. Apparently the most severe faulting has been in a relatively narrow zone on the northwest side of the limestone wedge and parallel to the face of the Cliff. Here underground workings expose at least three large fault fissures that contain from 10 to 20 feet or more of gouge and fine breccia. The principal slip planes in them have an average northeasterly direction and dip steeply one way or the other. As a rule none of them have well-defined walls, owing to cross fractures and the more or less crushed condition of all the rocks. One of them, however, appears to dip 80° NW. and the others at about the same angle in the opposite direction. On the southeast side of the limestone wedge a similar fault that dips 60° NW. and carries 10 feet or more of crushed material is shown at the Leonard mine. Other faults are less well exposed to examination, but unmistakable evidence of them is shown by practically all the numerous prospect pits. The Cliff itself is a mass of brecciated rock, which, unlike that of the faults just described, has been so tightly cemented that it is more resistant than even the quartzitic sandstone near by. Smaller masses of similar breccia occur at the Leonard and Tiger mines and elsewhere, all of which appear to have been shifted by fault movements. Workings that extend partly under the Cliff, although not carried far enough to prove that the brecciated mass is completely cut off, show plainly that it does not extend vertically downward, and that it is in all probability shifted greatly.

The evidence is clear that these cemented breccias are older than the open faults described and were doubtless produced by extensive earlier faulting or similar deformative movements. As distributed at present they do not trend in any particular direction, and the former course of the fault or faults that produced them is not known.

LODES.

CHARACTER AND COMPOSITION.

The fault breccias, both loose and consolidated, contain ore minerals and may be regarded as the lodes. So far as is known, the mineral-bearing portions of them are within an area not over half a mile long from southwest to northeast and a quarter of a mile wide.

The consolidated breccias are made up of angular fragments of fine-grained quartzite or silicified shale and a very abundant cement of quartz carrying more or less sulphides. The quartz appears more like flint or chert than that which ordinarily fills the veins of the region. The microscope shows it to be crystalline but extremely fine grained and containing shadowy outlines of rock fragments that it has replaced. Here and there are indistinct forms of radiated crystals suggesting that the quartz has gradually changed from the amorphous or opaline to the chalcedonic form. A large volume of this fine quartz was introduced throughout the mineralized area, but it did not invade the unbroken quartzite or limestone extensively.

Of the sulphides pyrite is as usual the most widely distributed and abundant. Part of it is of moderately coarse texture, and after it came into place it was broken and penetrated by veinlets of the flinty quartz and the minerals that came with it.

Enargite (arsenical sulphide of copper), an antimonial mineral that is probably famatinite (antimonial sulphide of copper), and pyrite, all generally occurring in microscopic grains, are intimately associated with the flinty quartz. Some crystals of enargite are coarse enough to be recognized with a hand lens, and here and there the mixture is rich enough in sulphides to be scratched with a knife, but commonly the material appears to the unaided eye as nothing more than a cloudy-black chalcedony. Even under the microscope the sulphides in some specimens appear as a dust clouding the quartz, the particles being so fine that their nature is determinable by chemical tests only. A little chalcocite was recognized in some specimens, but it does not seem to occur generally or abundantly in the deposits, and whether it is primary or secondary was not made out.

Oxidation has penetrated the consolidated breccias only a slight distance. Weathered surfaces show the usual iron and copper stains, and on the Cliff there are crusts of a bright-blue phosphate of copper. Some of the partly oxidized ore shows a little arsenate of copper, the mineral species of which was not determined, and crystals of pharmacosiderite (iron arsenate) were detected in vugs.

The metallic content of the deposits is irregular, and no very definnite ore shoots have been located. A quarry face at the north end of the Cliff is said to average 2.5 per cent of copper, and selected small portions are evidently much richer. A carload of ore that averaged

22 per cent of copper is said to have come from a large boulder or detached mass found by drifting on the "black vein" 50 feet below the surface. As a whole, the Cliff probably does not contain more than 1 per cent of copper. At the Leonard and Tiger mines there is a consolidated breccia ore of a similar range in composition.

The loose or unconsolidated breccias are made up of soft, finely crushed material derived in part from the hard breccias and in part from the country rock. The principal workings in the Copper Cliff and Leonard mines are in oxidized loose breccias that contain abundant earthy iron oxides, malachite, and azurite. These bodies are large, but the limits and positions of the parts that may be regarded as ore are not known. Selected shipments have yielded 10 per cent or more of copper. In the red-ore vein at the Copper Cliff mine oxidation extends at least 150 feet below the bed of the gulch, but the adjacent black-ore vein, though fully as permeable as the other, is not oxidized even above the natural drainage level. Evidently these anomalous conditions were produced by recent faulting.

GENESIS.

From the foregoing data the history of the deposits is interpreted as follows:

Movements, probably faulting, crushed the rocks locally, making them open and easily traversed by water. Mineral-bearing solutions entering from below healed the fractures, cementing them with opaline quartz and at the same time introducing the sulphides. After the breccias had been tightly closed and cemented they were broken by strong northeasterly faults and subordinate fractures of other directions, repeated movements on which have extensively shifted the breccias and the country rocks and jumbled them all together. Oxidation commenced with this faulting and has continued to the present time, recent faulting having occurred also, as shown by downthrown oxidized material.

Enargite is not known as a mineral deposited from cold sulphate solutions, and nothing in its occurrence at Copper Cliff suggests that it has other than a deep-seated origin. In the mineralogy, and particularly in the texture of the quartz, the deposits at Copper Cliff are similar to certain ore bodies at Tintic, Utah, regarded by Lindgren[1] as replacements by "colloidal silica" that later crystallized to chalcedony and quartz. Enargite and other sulphides accompanied the silica, and these fine-textured bodies are at the outer end of a series of deposits clearly derived from intrusive granitic rock. Therefore it is thought that the Copper Cliff deposits have not been deeply cut

[1] Lindgren, Waldemar, Processes of mineralization and enrichment in the Tintic mining district, Utah: Econ. Geology, vol. 10, pp. 225–249, 1915.

away by erosion and may be reasonably expected to continue to a considerable depth, subject, of course, to shifting by faults. Furthermore, enriched ore is ordinarily to be expected below gossans such as the red-ore body at the Copper Cliff mine, subject again to having been moved or destroyed by faults. In fact, it appears that faulting is the chief drawback of these deposits, which otherwise show encouraging features. Doubtless in depth the rocks are less shattered and the faulting more uniform than in the loose superficial zone so far explored. An exhaustive study of the structure in the mineral-bearing area and adjoining territory, made hand in hand with the underground work, is absolutely necessary to the successful development of these somewhat unusual and promising deposits.

MINES AND PROSPECTS.

COPPER CLIFF.

The Copper Cliff mine is in the upper part of a short, steep gulch tributary to Union Creek from the southwest. In the bed of the gulch, at an elevation of about 5,100 feet, a shaft has been sunk 150 feet, and adit levels have been run toward it from points 300 and 700 feet downstream and respectively 80 and 200 feet lower. In addition a short adit is run northward from the gulch at a point 40 feet lower than the shaft collar, and there are several drifts and crosscuts, making in all about 1,500 feet of underground workings. The adits described as 40, 80, and 200 feet lower than the shaft collar are known, respectively, as Nos. 1, 2, and 3. The shaft and adit No. 2 are connected, but in September, 1916, adit No. 3, which was being driven toward the shaft, still lacked 300 feet of reaching a point directly beneath it.

The Copper Cliff lode was discovered about 1890 by W. P. Shipler and later purchased by an English company that did most of the development work described above. In recent years it has been idle most of the time, but in 1916 it was being further developed by Bielenberg & Higgins under lease and bond. Smelter certificates for the period 1905–1910 show a total of 310 tons of ore shipped to Tacoma, Wash., that yielded about 77,000 pounds of copper and a little gold and silver.

The formation is quartzite, shale, and limestone that have been faulted together, the limestone forming a downthrown block in which most of the mine workings have been made. In the lower adit and at some other places near by there are small blocks of porphyry, apparently broken from a dike or other intrusive body.

For a width of at least 1,000 feet the rocks bear evidence of repeated intense fault movements along northeasterly fractures. Locally the crushing and dislocations have been the most severe in

narrow zones in which the rocks are ground almost to a pulp. Faults and slips of other directions are numerous but apparently not so extensive as the northeast ones. They show no general arrangement or grouping but serve to complicate the structure in no small degree. In addition there were older faults that became healed or cemented before the younger ones were made. They have been so obscured, however, by the later deformation that their courses and dimensions were not made out. The principal evidences of their existence are detached masses of breccia, of which the Cliff is the most prominent example. This interesting outcrop is situated on the west side of the gulch between the shaft and the company's office. It has a length of about 300 feet and rises 150 feet from the gulch channel. Its front, which has an average slope of 70°, faces the southeast. Other smaller masses of cemented breccia are found here and there, all apparently detached and shifted from their original positions by fault movements.

Most of the bodies of breccia and gouge, whether consolidated or not, contain more or less ore minerals and are regarded as the lode or lodes.

An open cut and a short adit made in the north end of the Cliff expose its structure very clearly. Angular fragments of pale-yellow and brown quartzite of different sizes are jumbled together and so firmly bound with an abundant tough fine-grained cement that the mass breaks more readily through the fragments than around them. Generally the cement is dark gray or black, affording a color contrast that makes the angular outlines of the quartzite fragments appear very distinctly. The cement is chiefly fine-grained quartz, and its color is due to very fine sulphides intimately mixed through it. Except that grains of pyrite can be easily recognized, the sulphide minerals are generally too fine or too thinly disseminated to be determined by ordinary methods. In places, however, they form rather pure masses the size of a hickory nut or larger, and in these enargite and probably famatinite can be identified. The same or similar minerals are doubtless present throughout the cement, because chemical tests show that it generally contains arsenic and antimony as well as copper.

Neither from the surface nor from joints and fractures has oxidation entered the mass more than a few feet, the rock being unusually compact and impervious. Where oxidation has occurred the usual iron oxides and green copper stains are seen. In addition there is a bright turquoise-blue mineral that forms crusts on weathered surfaces and gives the Cliff one of its striking color effects. Chemical tests show these crusts to be a phosphate of copper, the mineral species of which is not known. In places the face of the Cliff bears also a white incrustation that is one of the many phosphates of alumina.

The phosphorus is doubtless of animal origin, the cracks and caves in the Cliff being inhabited by the bushy-tailed wood rat, pack rat, or mountain rat, as it is variously known. The bright-yellow patches that contrast so vividly with the blues and grays on the face of the Cliff are not mineral, but growths of a lichen that is common in the general region.

Under the microscope the quartzite fragments are seen to be made up of sedimentary quartz grains, recrystallized and enlarged. The cement is a much finer textured crystalline quartz crowded with fine grains and specks of pyrite and the black sulphides mentioned. A small adit a short distance south of the Cliff, on the opposite side of the gulch, penetrates a mass of similar breccia, specimens of which contain broken pyrite, in which the fractures are filled with fine quartz-sulphide cement. In adit No. 3 there is a narrow body or vein of cemented breccia that strikes N. 20° W., dips 75° W., and cuts quartzite. It had been opened by a drift for a few feet, and so far as could be seen may not have been shifted greatly from its original position. In structure and composition it is similar to the rock of the Cliff but poorer in ore minerals. But little pyrite is present, and the copper minerals form a very light cloud in the cement.

The shaft and connected workings are in one of the zones of more recent intense faulting, 50 feet or more in width, that lies at the foot of the Cliff. At the shaft on the 80-foot level 20 or 30 feet of the zone is occupied by a rather soft earthy mass, chiefly oxides of iron in which films, flakes, and nuggets of native copper are scattered. Copper nuggets the size of walnuts are not uncommon, and one the size of a man's head is said to have been found. In addition, the red ore body, as the oxidized fault gouge is called, contains a few grains of unoxidized sulphide ore, quartz or quartzite, slight stains of copper carbonates, and a little gypsum that forms crusts in cavities. The body appears to have a southward pitch due to cross fractures or slips within the fault zone. A winze from the 80-foot level is said to have been sunk 70 feet without showing any notable change in the composition of the material. Here and there in adit No. 2 similar oxidized material is exposed. A crosscut that extends west from the shaft at a depth of 80 feet penetrates at a distance of 40 feet another intensely crushed zone, parallel to the red ore body, known as the "black ore." This body is simply a fault gouge 10 feet or more thick composed of finely ground country rock and sulphide ore, and its unoxidized condition is remarkable in view of the fact that it is freely open to the surface waters. Between the two ore zones there is crushed limestone, and beyond the black body a lead-gray shale also greatly broken by slips. The level ends at 120 feet in quartzite that is only slightly crushed and not at all mineralized, conditions that are surprising, because the huge mass of sulphide-bearing breccia

known as the Cliff is directly overhead. Adit No. 1, which is parallel to the crosscut just described, penetrates a similar but wider body of black ore which is said to have yielded a larger boulder of rich sulphide ore. The dip of this black ore body or fault, as determined from its relative position in the two levels, is about 80° W. On the hillside opposite adit No. 2 workings have penetrated a small ore body that occurs near the surface in limestone and is chiefly a spongy mass of chrysocolla, partly altered to malachite and azurite. At the time of examination adit No. 3 had not reached a point beneath the red ore body. It passes from quartzite through a thick mass of crushed limestone and gouge, then through crushed porphyry, and ends in lime.

The different ore shipments from the Copper Cliff mine contained from 9.5 to 22 per cent of copper and from 0.5 to 1 ounce of silver and 25 cents to $2.30 a ton in gold. The richest shipment, 15 tons of 22 per cent copper ore, is said to have come chiefly from the large boulder of sulphide ore found in the black ore body about 50 feet below the surface. The other lots were selected chiefly from the red ore body but do not represent any large portion of it, and the average value of neither ore body is known. A large amount of material was recently quarried from the north end of the Cliff, average samples of which are said to assay about 2.5 per cent of copper. The Cliff as a whole, however, appears to be somewhat poorer, probably containing not more than 1 per cent of copper.

An attempt to hand pick or "cob" the material quarried from the Cliff proved that it can not be graded in this manner by any reasonable expenditure of labor. The rock is so tough and the sulphides are so irregularly and widely scattered through it, so fine, and so intimately mixed with quartz that anything like a clean separation of ore and waste is practically impossible. Because of the fine division of the sulphides, concentration by ordinary mechanical methods is also likely to be impracticable, but the material might yield to flotation.

LEONARD.

The Leonard mine, which lies about a third of a mile due south of the Copper Cliff and 400 feet higher, has been operated intermittently in recent years but was closed in September, 1916. It is said that 21 carloads of ore that assayed from 7 to 10 per cent in copper have been shipped from this mine to smelters. The principal workings are a shaft said to be 100 feet deep and, about 350 feet northeast of it, an incline. The lode occupies a northeasterly fault fissure that dips about 60° NW. and brings quartzite or shale and limestone into contact out of their normal sequence (fig. 25, p. 216). The fissure has a width of 10 feet or more and is filled with fragments of silicified

breccia and earthy material like the red ore of the Copper Cliff mine. According to W. P. Shipler, one of the owners, the shaft passes through the lode at a depth of 50 feet, and the ore shipments were taken out above this level. The ore on the dump consists chiefly of compact and earthy iron oxides, through which stains and crusts of copper carbonates are scattered. Some small but beautifully developed crystals of malachite and azurite were seen, some specimens showing needles of azurite partly changed into malachite without a break in the continuity of the crystals.

At the incline, in addition to the soft ore described, there is several feet of partly oxidized breccia that contains enargite, famatinite, and pyrite and is otherwise similar to the material of the Cliff, at the Copper Cliff mine. In a collection owned by Mr. Shipler is a small but beautifully formed stalactite of green copper carbonate, one of several that were found in a cavity in the red ore at the shaft.

CLINTON DISTRICT.

HISTORY AND PRODUCTION.

The Clinton district is in the Garnet Range, a few miles northeast of Clinton, a town in the Clark Fork valley on the Northern Pacific and Chicago, Milwaukee & St. Paul railways. Most of the mines are within an area 5 or 6 miles long and 1 or 2 miles wide that begins 2 miles east of Clinton and extends northeastward across the divide and part way down the Blackfoot River slope.

About 1889 ore deposits were discovered in the northeastern part of the mineral-bearing area and several mines were opened that have produced a little ore from time to time. One of them, the Charcoal mine, is said to have yielded $15,000 in lead and silver. Between 1905 and 1912 considerable work was done on several groups of claims near Clinton, and some copper ore was shipped. From 1912 to 1916 the district was practically inactive, but according to reports received early in 1917 steps were either contemplated or being taken to reopen most of the mines. Estimates that include the principal mines only show a production prior to 1913 of about $25,000 worth of copper, lead, and silver.

Some of the mines and prospects were examined in 1911 by E. L. Jones, jr., to whom the writer is indebted for information about the northeastern part of the mineral area. Parts of the workings on three of the mines near Clinton were entered by the writer in November, 1912, and some additional facts were learned from the miners, but altogether the information at hand is not sufficient to allow a description of the district except in very general terms.

Timber and water are abundant in the Clinton district, the topography is such that many of the lodes can be worked through adit levels, and the wagon haul to the railroads is from 3 to 8 miles.

GEOGRAPHY.

The surface of the Clinton district is similar in general to the other portions of the Garnet Range described in this report. The general summit level ranges in height from 6,000 to 6,500 feet above the sea. Along both the main watershed and the prominent spurs from it there are flats or gently hilly surfaces at the elevations given. The rest of the land surface is steep and rugged because of the many deep, narrow valleys and gulches leading to the main drainage channels, which lie 2,500 feet or more below the general summit level. Part of the mineral-bearing area is drained southward by Wallace Creek, a tributary of Clark Fork, and the remainder is in the basin of Ashby Creek, which discharges into Blackfoot River. Between Ashby Creek and a branch of Wallace Creek there is a rather narrow pass at an elevation of 5,400 feet, through which the road goes from Clinton to Potomac.

GEOLOGY.

Most of the mineral-bearing area is occupied by an exposure of granodiorite 5 miles long and from half a mile to a mile or more wide. That this intrusive body is uncovered only in part is shown by its outline, which commonly expands where crossed by gulches and contracts on the intervening spurs. In general appearance and composition the granodiorite is similar to that exposed at Garnet and elsewhere in the general area under consideration. As a rule the rock is light gray and even grained, showing feldspar, quartz, hornblende, and mica, but in places near the margin of the mass it shows porphyritic feldspars in a groundmass somewhat darker than usual.

In the granodiorite area and that of the metamorphic rocks around it there are loose fragments of a dike rock similar to the granodiorite porphyry observed at Garnet.

Quartzite, shale, and limestone of the same age and general character as those at Garnet, Copper Cliff, and elsewhere surround the granodiorite and have been metamorphosed by it. Generally the quartzite shows abundant mica, and in places the rock is mottled in pale green or brown, owing to very fine micas being gathered in clusters. Some of the shale is changed to a tough green-banded hornstone, and the limestone is crystalline, resembling a coarse-grained marble. As a rule the evidences of contact metamorphism are very plain to a distance of 500 feet from the contact, and may be detected here and there as far away as half a mile.

The principal structural feature is a large trough or syncline that involves the sedimentary rocks and has lowered a belt of limestone across the northeastern part of the district. On both sides of this fold the quartzite and shale are steeply inclined and are probably deformed by other parallel folds also. Faults are seen in some of the mines, but nothing is known of their structural importance.

LODES.

Lodes are found throughout the granodiorite body and in the metamorphic rocks around it. Most of those in the granodiorite are valuable chiefly for copper and subordinately for silver and gold, and those in the sedimentary rocks, particularly the limestone, contain lead and silver. Considerable amounts of lead are known also in some of the lodes in granodiorite, and copper is generally present in the lodes in the other rocks, particularly near the contact.

The most extensively developed lodes are along Wallace Creek and its tributaries Trail and Woodville creeks, about 2½ miles east-northeast of Clinton. Within a square mile there are 50 or more mines and prospects, on some of which the workings reach a depth of 500 feet vertically below the surface. Another numerous group is in the northeastern part of the mineral-bearing area in the basin of Ashby Creek, and although prospects are by no means scarce in the rest of the area few of them have been worked to any extent.

Most of the lodes in granodiorite, and doubtless some of those in the other rocks, are composite veins or shear zones, each of which is made up of several parallel fractures, together forming a sheared or broken zone from 1 foot to 20 feet or more in width. Commonly the fractures are closely spaced and the intervening rock more or less crushed. The lodes or zones apparently do not depart far from a N. 40° E. strike, and most of them dip steeply northwest. Some are cut and displaced by transverse faults. Many of the individual fractures contain ore seams or veinlets that are generally less than an inch thick but locally may be a foot or more thick for distances of several feet. The most valuable ore bodies, however, are those portions of the sheared zones in which the small ore seams are so numerous and close together that the whole is rich enough to mine. The dimensions and richness of these stringer lodes are known in part only, carload shipments and samples that are said to represent widths of several feet having contained from 1.5 to 6 per cent or more of copper and $2 to $10 a ton in gold and silver. As far as the rather meager available information shows, ore from levels above a depth of 300 feet is partly or wholly oxidized and generally twice as rich as that from lower levels.

The primary minerals are chalcopyrite, bornite, specularite, ankerite, calcite, quartz, and possibly also chalcocite, all of which were

introduced from below, filling the fractures and replacing the wall rock. In addition barite, strontianite, and a bismuth mineral are reported. In the oxidized zone the usual copper carbonates and iron oxides occur.

In the northeastern part of the mineral belt there are composite veins similar to those described, and also lodes of irregular form developed at the contact or in the metamorphic rocks adjoining it. So far as known, the lodes in granodiorite are similar in composition to those nearer Clinton, except that some of them contain noteworthy amounts of silver-bearing galena and a little zinc blende. As a rule the lodes in the sedimentary rocks, particularly the limestone, are valuable chiefly for lead and silver, their most abundant metalliferous minerals being galena and cerusite. Zinc blende was observed in some of them, and calcite and quartz are the chief gangue minerals.

The geologic relations and composition of the lodes, particularly the occurrence of chalcopyrite and specularite together, suggest that they were formed by hot solutions from either a deep-seated portion of the granodiorite body or a later intrusive rock not yet exposed.

Lead and copper appear for the most part to be arranged in zones one above the other. Galena is most abundant in high situations, either in the top of the granodiorite body or in the rocks that inclose it. A thousand feet down in the intrusive mass, which is about the relative position of the workings in the Triangle and other mines near by, chalcopyrite is the most abundant ore mineral and galena or other ores of lead are absent. The fracture zones appear to be strong and persistent, there is no reason to think that the copper minerals do not continue to considerable depths, and in view of all the information available the prospect seems bright, at least as long as the metals maintain their present (1917) high prices, for the development of large ore bodies.

MINES AND PROSPECTS.

In addition to the mines described farther on, there are in the district a large number of claims or groups of claims which are not described in this report but which from all accounts are worth exploring. Among those near Clinton are the Hidden Treasure, Senate, Aladdin, and Crawford groups, on each of which considerable work has already been done. In the northeastern part of the mineral belt are the Charcoal, Gowrie, Adaline, Sumpter, Daisy, and Nellie, most of which have produced some shipping ore.

CAPE NOME.

The Cape Nome mine is on the east side of Trail Creek, about 3 miles east of Clinton. Prior to 1912 the mine was extensively de-

veloped, and ore shipments that yielded about 19,000 pounds of copper, 2,000 ounces of silver, and $100 in gold are reported by the owners.

The workings, which are in granodiorite, are said to consist of two adit levels and a shaft 500 feet deep from which several drifts and crosscuts are run, aggregating in all more than 4,000 feet of underground work. Two lodes have been explored that strike about north, dip 60° or more to the west, and are cut and displaced by vertical northeasterly faults. They are described as composite veins or shear zones 4 to 10 feet wide, in which there are lenslike bodies 2 feet in greatest thickness composed of quartz, barite, chalcopyrite, tetrahedrite, and chalcocite. Oxidation is partial or complete to depths that range from 100 to 300 feet.

Smelter certificates for the shipments mentioned above, which are said to have been made up of mixed sulphide and oxidized ore from different parts of the mine above the 300 level, show that the copper content ranged from 1.6 to 12.7 per cent, the gold from 20 cents to $4.50 a ton, and the silver from 5 to 20 ounces a ton. On the average the ore contained 63 per cent of silica and 12 or 15 per cent of ferric oxide or its equivalent. On the 500 level the vein for a width of several feet is said to average 2.5 per cent of copper and 6 ounces of silver to the ton, the silica and iron contents being 55 and 15 per cent, respectively.

TRIANGLE AND GRASS WIDOW.

The Triangle and Grass Widow mines are about 2½ miles east-northeast of Clinton, on Woodville Creek, a small west branch of Wallace Creek. In 1912 the Triangle had been developed by an adit level driven 540 feet on a N. 40° E. course into a steeply rising granodiorite hill. This working follows a composite vein or zone of parallel fractures that is 10 feet or more in width and dips 75° NW. Ore shipments, in which copper was the most valuable constituent, are reported to have yielded about $3,500.

Most of the fractures that make up the zone contain ore seams that are generally less than an inch in width and in places are rather numerous and closely spaced. The intervening granodiorite is moderately crushed and extensively bleached and sericitized. Near the face of the adit, where several branch fractures lead off to the north, there is a fairly rich looking ore body 14 inches wide and 40 or 50 feet long. The vein filling consists of specularite, chalcopyrite, ankerite, calcite, and quartz, all intergrown. In the oxidized zone penetrated by the first part of the adit there are the usual carbonates of copper and oxides of iron. Smelter certificates for the shipments mentioned show from 3.5 to 6.75 per cent of copper and 7 to 13 ounces of silver and $1.50 to $2.50 in gold to the ton.

The Grass Widow lode is parallel to the Triangle and about 600 feet to the northwest. It is explored at a depth of about 500 feet by drifts reached through a crosscut from the Triangle adit level. There are two main seams about 40 feet apart containing ore similar to that in the Triangle.

JACK POT.

The Jack Pot mine is on the west side of Trail Creek near its junction with Wallace Creek, 2 miles east of Clinton. In 1912 an adit had been driven N. 40° E. for 300 feet in granodiorite, following a composite vein or shear zone that dips about 75° NW. A small dike of granodiorite porphyry, which together with the granodiorite is bleached and sericitized, has been intruded along the shear zone. The fractures contain thin seams of chalcopyrite, specularite, ankerite, and quartz, or minerals derived from them by oxidation, and the zone is otherwise similar to those in the Triangle and Grass Widow claims. In places a little chalcocite fills cracks and also partly replaces the chalcopyrite.

OUTLYING MINES AND PROSPECTS.

Outside of the districts described in this report there are isolated mines and prospects more or less worthy of notice, in particular near Garnet, Coloma, and the head of Elk Creek. Most of them are quartz veins in granodiorite or quartzite and are presumably valuable for gold. One on a knob half a mile south of Coloma shows a little galena and tetrahedrite in silicified limestone.

Here and there along the limestone summits from Mulky Creek to Clinton are scattered deposits of silver-lead ore, of the irregular or pockety form usual to ore bodies in limestone, from some of which ore has been shipped. In addition to those described below, a prospect of Otto McQueston, on the divide north of Tenmile Creek, has made a small production.

Copper prospects, none of which, however, show any great promise, occur at wide intervals. One on the West Fork of Cramer Creek, known as the Gypsy, is on a loose fault breccia of quartzite stained with copper carbonates at the surface and showing a little chalcopyrite below. Another, the Ophir, situated on Tyler Creek a mile south of Clark Fork, occurs in an intrusive sheet or sill of gabbro and is a sheared zone containing nodules of chalcopyrite.

CHLORIDE.

The Chloride mine, on the main divide, 3 miles southwest of Copper Cliff, is a lead-silver deposit from which a few ore shipments are reported. The country rock is a dark-gray or blue limestone (De-

vonian Jefferson limestone), much higher in the sequence than the limestone at Garnet and Copper Cliff. Along one or more zones of a general northwesterly direction, in which the rocks were fractured or crushed, the limestone has been extensively replaced by silica, being converted into a yellow or brown jasper. Within the area of a quarter section several ore bodies have been found, most of which have a pipelike form, stand vertically or inclined, and are 3 or 4 feet in diameter and 20 feet or more in length. All are closely associated with fracture or joint planes and surrounded by the jaspery quartz. The ore is a fine-grained galena, more or less altered to carbonate.

Loose boulders of similar ore are shown in a prospect pit in limestone about a mile west of Copper Cliff.

BAKER & SULLIVAN.

About $11,000 worth of lead-silver ore is reported to have been shipped by Baker & Sullivan from a mine at the head of Mulky Creek, about 4½ miles in an air line southeast of Garnet. This mine has been idle for a number of years. Several open pits and shafts are made on a ridge near the head of Mulky Creek canyon, at an elevation of 6,600 feet. The country rock is limestone of the same age (Cambrian) as that at Garnet and Copper Cliff and is exposed along the summit of a northwesterly anticline.

Along a fractured zone caused apparently by the folding of the beds silica has replaced the limestone extensively and ore pockets have formed. The principal ore body mined has the cross section of a lens 3 or 4 feet thick and 30 feet or more in diameter. The ore is chiefly ocherous material containing galena and its oxidized products, among which cerusite and massicot were identified. There is also a little copper stain. Under the microscope a thin section of the silicified limestone, a yellow or brown jaspery rock, showed a dust of iron oxides and some small crystals of garnet distributed through fine-grained quartz.

MORSE & KENNEDY.

A small ore shipment is reported from a mine formerly worked by Morse & Kennedy, half a mile north of the junction of Elk Creek and its north fork. An open cut at an elevation of 4,650 feet is made at the contact between granodiorite and limestone, and about 50 feet lower an adit level is driven 200 feet or more through granodiorite into the limestone. The contact plane, which is very uneven in detail but is on the whole nearly vertical, bears an irregular deposit consisting of coarse-grained brown garnet, epidote, calcite, and quartz. There are also flakes of specularite and scattered grains and nodules of chalcopyrite inclosed in calcite and intergrown with the silicates mentioned. The deposit is partly oxidized, showing limonite, mala-

chite, and chrysocolla. The copper minerals are mostly confined to a layer that is 3 or 4 feet thick in the open cut but apparently pinches out in the adit below. This deposit is similar in character and origin to the contact-metamorphic bodies at Top o' Deep, but it lies relatively farther down on the sides of the intrusive body, a condition that is thought unfavorable to its downward persistence.

Farther south along the contact in a prospect near Elk Creek there are small seams and pockets in limestone containing chalcopyrite and gray copper.

PLACER DEPOSITS.

HISTORY OF MINING.

Bear and Elk creeks are among the more productive localities of early placer mining in Montana. Gold was discovered here in 1865, the usual rush to the new diggings took place, and, as claims were then restricted to a length of 200 feet, the gulches were soon alive with miners. The pay streak was narrow but rich and favorably situated for drifting, and when the individual workings became connected it is said that one could walk 8 or 10 miles underground up Bear Creek and its main tributary, Deep Creek, without once coming to the surface. At the mouth of Deep Creek, Beartown, celebrated as one of the wildest of the wild early-day mining camps, became the trading center for a population estimated at 5,000 or more. Other thriving camps were Springtown, farther up Deep Creek, and Reynolds City, near the head of Elk Creek. An idea of the cost of supplies at the time is shown by a Reynolds City storekeeper's account which is among the relics preserved by Larabie Bros., bankers, at Deer Lodge. Under the date May 4, 1866, potatoes are charged at the rate of 12½ cents, salt 50 cents, sugar 75 cents, nails 25 cents, and bacon 80 cents a pound. Wages were correspondingly high, and most of the ground that would pay to work under such conditions was exhausted in three or four years and the miners went almost as suddenly as they came. Only a few abandoned cabins remain at Beartown, and the other camps are almost completely obliterated. Since the mining activity declined some of the claims have been reworked from time to time, and new ground that was too lean or otherwise unsuited to early-day methods has been opened. In 1916 open-cut or hydraulic mining was done in a rather small way in about half a dozen places on Bear and Elk creeks.

PRODUCTION.

During the period of greatest activity few of the miners kept records of production, and as gold dust was in general use for currency, that from Bear Creek soon became mingled with gold from other

sources, all traveling many devious paths before reaching the banks or the mint. That the total, however, runs well into millions is generally believed and strongly supported by the data available. The linear extent of the ground mined along Bear Creek and its tributaries, together with that in Bilk and Weasel gulches, is at least 20 miles. According to trustworthy reports, one claim below Top o' Deep yielded $240,000, or at the rate of $1,200 a running foot. Comparably rich also were a claim at the mouth of Cayuse Gulch and portions of First Chance Gulch and its tributary, Williams Gulch. Other claims here and there yielded smaller amounts down to $10 a foot, which was doubtless about the limit for profitable mining at that time. Exclusive of the exceptionally rich spots mentioned, the general average is about $50 a running foot, equivalent to $250,000 a mile, or a total of $5,000,000, which is thought to be a safe minimum for the drainage basin of Bear Creek. Probably $7,000,000 or more, the estimate made by persons living in the district, is nearer the true total. For Elk Creek even less definite data are available, but the extent of the old workings shows that the production must have been large. Estimates by persons familiar with the mining history of this stream range from $1,000,000 to $2,000,000 or more, and the total placer production of the whole area is doubtless somewhere between $6,000,000 and $10,000,000.

DISTRIBUTION AND CHARACTER.

Placer deposits are distributed along Bear and Elk creeks and all their tributary gulches which head in the area between Top o' Deep and Coloma. Bilk and Weasel gulches, which discharge eastward from Top o' Deep, and Washoe Gulch, leading west from Coloma, are also gold bearing, but their deposits do not extend very far downstream. In addition, there are less extensive deposits on a bar at Bearmouth and in Felan and Tenmile creeks. A very little gold is found all along Clark Fork, and small amounts are doubtless present in most of the other streams, but except those enumerated above no workable deposits are known in the region covered by this report.

The bulk of the gold taken from Bear Creek is in particles smaller than wheat grains, and of various shapes from flakes to shot. Nuggets are fairly numerous and of various weights; the heaviest reported weighed 32 ounces. Some of the nuggets are intergrown with quartz, and most of the larger ones were found near the heads of the gulches, where also much of the gold is rough or ragged. Farther downstream the particles average smaller and are generally smoothed, though still irregular in shape. Most of the Elk Creek gold is flat, almost flaky, and the particles average somewhat smalier than in Bear Creek.

Except in the bar at Bearmouth the gold along Clark Fork is sparsely but widely distributed as flakes, some of them as broad as a pin head but so thin and light that the largest will hardly turn the most delicate balance. Doubtless several hundred of them would be required to make 1 cent.

The gold of Bear and Elk creeks is deep yellow and its surface varies from bright to rusty, the shade being significant chiefly of the length of time the particles may have lain in the gravel undisturbed.

The fineness or purity of the gold does not range far from 0.900—that is, of 1,000 parts by weight 900 are pure gold and the remainder alloy, chiefly silver. Records kept by the late E. S. Larabie, of Deer Lodge, show an average of 0.906 for both Bear and Elk creeks, but the data are insufficient to determine whether, as in many placer deposits elsewhere, there is a gradual increase in fineness downstream.

Part of the gold is found in joints and cracks a foot or two deep in the bedrock, and the remainder is distributed through a thin layer of gravel above, the gravel and gold-bearing bedrock together forming the "pay streak." The main pay streak in Bear Creek is in the channel or lowest portion of the bedrock surface and, although 50 feet or more wide in places, generally is not over 10 or 15 feet wide. On top of it is 20 to 50 feet of overburden that consists largely of detritus from the hillsides above, the separation between the pay streak and the valueless material being as a rule rather clean and sharp. Along the smaller tributaries the overburden is less and the pay streak not so well defined, particularly near the heads of the gulches, where it commonly widens and grades into the hill talus or surface mantle on each side. Another pay streak similar to that described except that it is not continuous is found in bars along both sides of Bear Creek 50 to 100 feet above the stream. The Elk Creek pay streak is similar to that in Bear Creek except that it is less deeply buried and not so well defined. Bars are extensive along the west side of the stream in the vicinity of Sunset, but are not known upstream. For the most part the gravel of the pay streaks does not contain large boulders, is but moderately waterworn, and is rather firmly packed. The amount of sand is rather small in Bear Creek and large along Elk Creek, where also particles of magnetite, ilmenite, and other dark heavy minerals collectively known as black sand are abundant. In the mine of B. A. C. Stone a gravel of unusual type, which contains waterworn cobbles completely softened by decay, occurs at the summit of the mountains.

Along Bear Creek few lean spots were found in the pay streaks, and in places the gravel yielded as much as $1,000 a cubic yard, according to all reports. A general average based upon the rather meager available data is $30 a yard. Elk Creek is not so rich on the average, but there are places, particularly in its tributary gulches, comparable to Bear Creek. The bars near Sunset were fairly rich, and a body of workable gravel is thought to lie beneath the flat valley of Elk Creek opposite.

Unsuccessful attempts to mine the scale or leaf gold along Clark Fork have been made on a bar below Nimrod and elsewhere.

Placer deposits occur along the stream beds and in low bars in Tenmile and Felan creeks, but they are not comparable in extent or richness to the deposits of Bear Creek. Along these streams the most extensive mining has been done in a small basin about a mile up Felan Creek and in gulches from a low divide between that stream and Tenmile Creek. The gold produced is said to be of the same quality but less waterworn than that from Bear Creek.

ORIGIN.

The distribution of the gold leaves no room for doubt, except as to Felan and Tenmile creeks, that the placer gold came from the quartz lodes in the Garnet and adjoining districts. After the quartz lodes had been formed erosion reduced the land to a generally flat surface, the peneplain described under the heading "Physiography" (pp. 162–165), which doubtless was low with reference to the sea at the time. The lodes were exposed, their upper portions were worn away, and the gold was incorporated in stream gravel, of which that at Stones Flat and probably in part that in Williams Gulch and other high, flat valleys are remnants. Owing to the flatness of the land the streams of that period were sluggish and unable to shift the gold very far from its place of origin. The great changes that have taken place since then, both in the form of land and in the distribution of the gold, are due primarily to a general uplift of the region, as a consequence of which the multitude of deep gulches and narrow valleys of to-day were excavated, and the gold carried down the narrow channels far from its source. The uplift, however, was somewhat complicated by warping of the surface and the outpouring of lavas, as more fully described in the section on physiography. Necessarily the drainage system underwent many changes. Some of the streams, such as the one which built the gravel bed at Stones Flat, were cut off, their water becoming parceled among other streams and their identity lost. When Bear and Elk creeks had sunk their valleys within short distances of their present depths they ceased downcutting long enough to widen their valleys slightly and deposit con-

siderable gravel. Remnants of this deposit left here and there when the streams had cut to their present depth form bars, such as Archers and Simpsons bars on Bear Creek and the bar along Elk Creek near Sunset. The bars along Bear Creek correlated with some low bars or terraces along Clark Fork, described in the section on physiography, were probably caused by a temporary damming of the drainage farther down. At present Clark Fork is temporarily (in a geologic sense) interrupted in its down-cutting by a dam of glacial outwash at Bonner, and its valley has become deeply floored with gravel. Necessarily most of its tributaries have ceased to deepen along their lower courses, and considerable loose material, such as the overburden of the pay streak in Bear Creek, has accumulated.

CONCLUSIONS.

Placer mining along Bear Creek and its branches has declined to a comparatively insignificant stage, although there is a possibility that it may be revived somewhat by hydraulic or open-cut mining. On Elk Creek some open-cut mining is done, there is considerable unworked ground remaining, and along the flat part of this stream near Sunset a fairly large area may prove to be worth dredging.

MINES.

STONE.

A gravel deposit mined by B. A. C. Stone at Stones Flat on the divide between Cayuse and Day gulches presents some unusually interesting features. At this locality the main divide is a level flat 1,500 feet wide having an elevation of 6,250 feet. On the east and west it merges with rather gentle slopes that rise a few hundred feet, but to the north and south it is rather abruptly terminated by steep descents. An open cut at the south side exposes a bed of compact red sandy clay 30 feet deep to bedrock. Mingled with the clay are small fragments of a rather impure micaceous quartzite, many of which are so thoroughly decomposed that they fall to pieces at a touch. The lowest layer of the deposits contains smooth waterworn cobbles of soft quartzite as much as 6 inches in diameter. The bedrock, which slopes gently southward, is of similar quartzite, smoothed and waterworn and likewise softened to the depth of a foot or more. Evidently the deposit is very old, the stream that made it was long ago diverted to other channels, and the topography of that time has been greatly changed.

Owing to the scantiness of the water supply mining operations are conducted on a small scale, but nevertheless the ground is said to repay working. At the face of the cut the pay streak is 50 feet wide,

and presumably it extends across the flat. The gold occurs mostly in small particles, that do not differ in appearance from the placer gold elsewhere in the district. The erosion of quartz veins that crop out around the flat doubtless supplied the gold.

LEHSOU (HICKEY).

Placer mining, restricted by the water supply to small operations, was done in 1916 by Patrick Hickey on the Lehsou mine, at the head of Deep Creek, just above the old placer camp known as Top o' Deep. Deep Creek rises in a small, rather shallow basin at an average elevation of 6,200 feet. In the center of the basin a pit about 600 feet in diameter forms one end of the more or less connected chain of workings that extends throughout Deep and Bear creeks. The bank surrounding this pit ranges from 5 to 20 feet in height and is composed of material loosened from the underlying rocks by weathering and moved downhill slightly by gravity. No stream-washed fragments were observed, although the deposit has been slightly channeled and doubtless helped in its downward movement by rain and snow water. The bedrock is granodiorite, containing many outcrops of small gold-bearing quartz veins and broad zones of a rusty material that is said to be gold bearing also. The gravel contains irregularly distributed but appreciable amounts of placer gold, although mining with the scanty supply of water is hardly profitable. Doubtless much of the ground surrounding the pit, particularly the slopes to the east and north, would pay to work if water were readily available.

The gold is rough but not ragged and ranges in size from dust and small particles to nuggets weighing several ounces. Vein quartz adheres to most of the nuggets, one recently found being a quartz fragment the size of a hickory nut, in which an irregular mass of gold weighing an ounce or more is embedded. This quartz is fine grained, compact, and rather dull milky white in color, similar to the quartz of many veinlets exposed in the bedrock.

BILK GULCH.

Although Bilk Gulch has ceased to be productive, its later history and some of its natural features are of more than ordinary interest. To wash the gold-bearing material, which extended practically to the divide between Bilk and Deep gulches, at an elevation of 6,550 feet, a pumping plant was installed by King, Allen & Preston, on Weasel Creek, somewhat more than a mile to the east and about 800 feet lower. Water was pumped through a pipe to an elevated point and conveyed by a flume to a large planked reservoir above the ground

to be worked. The total cost of the pump, pipe line, and tank is said to have been nearly $70,000. The gravel was washed, and proved to be rich, yielding a large amount of gold, but financially the venture was a failure, because the deposit was exhausted before production had equaled the cost of the plant.

Gravel mined along the lower course of Bilk Gulch at an earlier date by G. W. Morse was rich, and several nuggets were found, one of which weighed 32 ounces, equivalent to a value of about $600. Large boulders of brown garnet rock are abundant among the débris of the old mine workings, especially along the upper part of the gulch. When broken, some of them show small particles of gold associated with chrysocolla. The boulders are evidently residual from contact-metamorphic bodies, of which several crop out conspicuously near the head of the gulch.

WARNER (ELK CREEK HYDRAULIC MINING CO.).

A placer mine on Elk Creek, 2 or 3 miles southeast of the locality known as Sunset, is owned by the Elk Creek Hydraulic Mining Co. and operated by W. W. Warner. At the mine the valley of Elk Creek is a narrow V-shaped trough with steep slopes about 700 feet high. A short distance upstream the valley flares somewhat, and about a mile downstream it opens into Sunset Valley, a wide basin crossed by Blackfoot River.

Below the North Fork of Elk Creek quartzite and indurated shale (Belt series) crop out on the slopes and evidently form the bedrock beneath the stream gravel. At the North Fork the quartzite and shale are cut off by a granodiorite body that extends up the main stream to its head.

The principal working is an open cut dug upstream 1,000 feet or more and equipped with a 30-inch flume and a steam derrick for moving boulders. In September, 1916, ground sluicing was in progress and the face of the cut was about a quarter of a mile below the North Fork. Owing to the slight average fall of the creek, about 6 inches to a rod, at this locality, the flume could not be given sufficient grade to carry any but the smaller rocks or prevent the sand from packing. From the writer's experience it is suggested that a wider flume would work better, but it is always difficult, if not impossible, to prevent sand from packing in a flume of slight grade. Formerly a hydraulic elevator was used at this mine for lifting tailings, but it was abandoned because of the excessive cost of its operation and upkeep.

At the face the cut is said to be within 2 feet of the bedrock. Here the bank is made up of a 4-foot layer of rather loosely packed stream gravel containing numerous boulders 2 feet or more in

diameter. Above this are 5 or 6 feet of fine gravel and silt and a top layer of tailings, mostly sand, washed from the old mines above. A considerable portion of the sand that collects in the flume consists of magnetite, ilmenite, and particles of hornblende and other dark minerals derived from the granite.

The gold occurs mainly as dust and small flat particles, few of which are more than one-sixteenth of an inch in diameter, and most of it is confined to a foot or two of gravel next the bedrock. The cut is said to have repaid working expenses so far, but the yield was not learned. The deposit no doubt is valuable, because Elk Creek has yielded richly farther up, and gold is known below. The unworked ground extends 2 miles or more above the workings described.

POWERS.

Mining in a small way is done by Patrick Powers on Elk Creek at the mouth of Jonathan Gulch. Here some comparatively small blocks of unworked ground remain, situated mainly on the sides of the main pay streak, which was worked out in former years. The gravel is 8 feet deep and contains a moderate number of boulders, and the gold is found mostly as rather fine, flat particles on the granite bedrock.

M'KEVITT & IVERSON.

A block of new ground on Elk Creek at the mouth of McManus Gulch was being opened by McKevitt & Iverson in 1916. An open cut, worked by ground sluicing through a 16-inch flume, has been made to bedrock. The bank is from 10 to 18 feet deep and is mostly sand and medium-textured gravel. There are a few large granite boulders.

WILLIAMS ESTATE.

Stretches of several miles of the main channel along Bear and Deep creeks are covered by patented claims, owned by the Williams estate, that were inactive in 1916 but were formerly worked by drifting. Although the pay streak is generally narrow and sharply separate from barren material, this ground may repay hydraulicking in places, for the early-day drift miners commonly left more or less gold behind them.

LANNEN.

Bear Creek has not been drifted for a distance of half a mile above its mouth owing to difficulties in the way of drainage. The rich pay streak worked farther up presumably continues down to Clark Fork, buried by 100 feet or more of valueless gravel. So far as known no recent attempts have been made to work this ground, but conceivably it might be drained by pumping.

A bar at Bearmouth, south of Clark Fork and 100 feet above it, was profitably mined several years ago by John Lannen. The deposit is mostly river gravel, but it also contains rather large boulders, which, together with the gold, apparently came from Bear Creek, and it is thought to be correlated with the bars of that stream. Some patches of unworked gravel remain.

TENMILE.

Near the junction of Tenmile and Bear creeks there is considerable new ground which is thought to be valuable, which was being opened for hydraulic or open-cut mining in 1916.