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THE ATLANTIC GOLD DISTRICT AND THE NORTH LARAMIE MOUNTAINS

FREMONT, CONVERSE, AND ALBANY COUNTIES, WYOMING

PAPERS BY

ARTHUR C. SPENCER

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By F. L. RANSOME.

In response to numerous requests from persons interested in the development of the mineral resources of Wyoming and desirous that reliable information concerning them should be published, A. C. Spencer, geologist, was detailed in 1914 to make an economic reconnaissance of the region adjacent to South Pass City, Miners Delight, and Atlantic City, in Fremont County, and of parts of the North Laramie Mountains, in Converse and Albany counties. The two areas examined by Mr. Spencer lie about 125 miles apart, the Atlantic gold district being in west-central Wyoming about 20 miles south of Lander, and the North Laramie Mountains in the southeastern part of the State, south of Douglas and Casper.

The Atlantic district has produced considerable gold, estimated by Mr. Spencer at about $1,500,000, although other estimates vary up to nearly $6,000,000. No large mine has been developed in the district, however, and of late years mining activity has declined. In the North Laramie Mountains mining development remains in the prospecting stage. In both regions the lode deposits occur in schists of pre-Cambrian age, partly with quartz in distinct fissures and partly as tabular or lenticular bodies of rock through which the sulphides are distributed. These bodies are aligned in more or less definite belts in the schist. The chief metal in the prospects of the North Laramie Mountains is copper, although other metals are also present in most of the lodes.

The area shown on the geologic map of the North Laramie Mountains (Pl. IV), which is based largely on the work of N. H. Darton, overlaps to the south an area previously mapped geologically on the same scale by Darton and Siebenthal [1] and to the north the area covered by Darton's geologic map of the central Great Plains.[2] Adjacent to it on the west is an area that will be covered by a map to accompany a report now in preparation by C. J. Hares. The work on which

[1] Darton, N. H., and Siebenthal, C. E., Geology and mineral resources of the Laramie Basin, Wyo.: U. S. Geol. Survey Bull. 364, 1909.

[2] Darton, N. H., Preliminary report on the geology and underground water resources of the central Great Plains: U. S. Geol. Survey Prof. Paper 32, pl. 35, 1905.

the present report is based, while of course not of detailed character, has distinct general value in connecting other areas where geologic work has been or is being carried on.

Regarding the mines and prospects in the two districts described, the report presents reliable statements of facts and conditions which it is hoped may be of use to those specially interested in these deposits.

THE ATLANTIC GOLD DISTRICT, FREMONT COUNTY, WYOMING.

By ARTHUR C. SPENCER.

INTRODUCTION.

In September, 1914, the writer spent three weeks in the vicinity of Atlantic City, in southern Fremont County, Wyo. Although only a short time could be devoted to the study the writer was confronted by the problem of adding to information contained in two excellent reports, one by the late W. C. Knight and the other by L. W. Trumbull, the present State geologist of Wyoming. Prof. Knight has given not only a very adequate description of the general geologic features of the Sweetwater district, which includes the Atlantic district and the Lewiston district (formerly known as the Overland district), lying to the east, but also the results of his own laboratory tests in order to determine the amenability of the gold ores to amalgamation, to chlorination, and to cyanidation. From his observations he was led to make specific suggestions which are of great practical significance. Prof. Trumbull has provided a sketch map upon which the principal geologic features of the Atlantic district are shown.

As it appeared to be impracticable, under the circumstances of inactivity existing, to add materially to the technical data given in Knight's report, the writer decided to turn his attention to making a geologic map of the Atlantic district that should be more detailed than the one presented by Trumbull. In making certain practical suggestions the influence of conclusions drawn by the geologists already referred to is acknowledged.

SITUATION AND GENERAL FEATURES.

Atlantic City is in Fremont County, Wyo., 23 miles due south of Lander, or about 28 miles by wagon road. Lander is the terminus of the Wyoming & Northwestern Railway which connects with the Chicago & Northwestern Railway at Casper. The elevation at Lander is 5,360 feet; at Atlantic City, 7,683 feet; at South Pass City, 7,803 feet. The name Atlantic district is used in this report for the region about Atlantic City, including the environs of South Pass City, 4 miles southwest, and of Miners Delight, 3½ miles northeast.

The Atlantic district and the larger Sweetwater gold country, of which it forms a part geologically, lies entirely within the Missouri River basin, South Pass, on the Continental Divide, being about 10 miles southwest of South Pass City. (See figs. 1 and 2.) A small part of the district northeast of Atlantic City is drained by Beaver Creek, a tributary of Popo Agie River. The Popo Agie joins Wind River near Riverton to form the northward-flowing Bighorn River, whose waters, collected on the northeast side of the Wind River Range, join those of the Yellowstone in Montana. The remainder of the drainage goes by way of Rock Creek and Willow Creek to Sweetwater

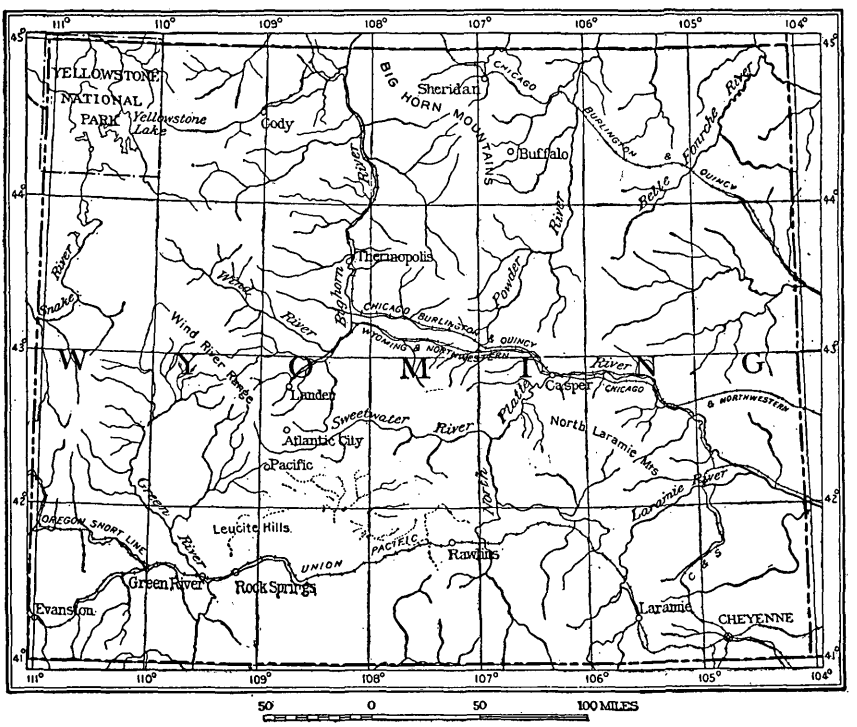


FIGURE 1.—Drainage and railroad map of Wyoming.

River. The upper tributaries of the Sweetwater drain the west side of the Wind River Range as far as a point opposite Lander and the head of the Middle Fork of Popo Agie River, a tributary of the Bighorn system. The Sweetwater flows parallel with the southeastward-trending axis of the Wind River uplift to a point about 10 miles south of South Pass City, where it assumes a more easterly course on its way to join the North Platte. The Sweetwater and Popo Agie headwaters drain the high mountains at the southeast end of the lofty and rugged Wind River Range, which extends for nearly 100 miles to the northwest. Toward the southeast the structural axis of the range may be recognized for a distance of 20 miles, but in this

direction the general elevation gradually decreases and the country becomes less and less rugged. The Atlantic district lies about midway between the high mountains and Sweetwater Valley. Here

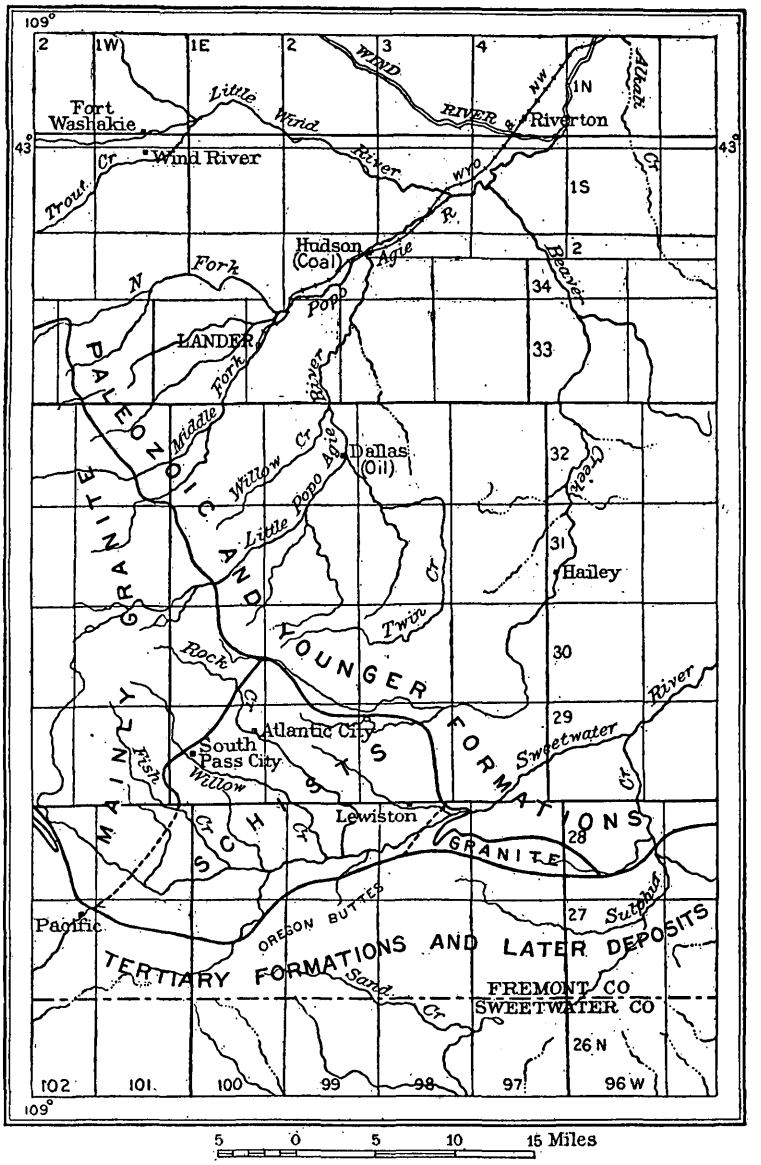


FIGURE 2.—Map of part of Fremont County, Wyo., showing situation of the Atlantic gold district and general geologic features of the region.

Rock Creek has cut a gorge 500 to 600 feet below the height of land on either side, and Willow Creek has excavated a valley from 200 to 500 feet deep. Through erosion along tributary drainage channels the region has come to have a markedly rolling character, but the

impression of a southward-sloping plain, of which the interstream areas form parts, is strikingly presented from points of view south of Atlantic City or from the edge of Willow Creek canyon below South Pass City. Consonant with the southerly slope of the region as a whole nearly all the tributaries both of Rock Creek and of Willow Creek come in from the north. Below Atlantic City the Willow Creek tributaries head practically at the edge of the Rock Creek Canyon.

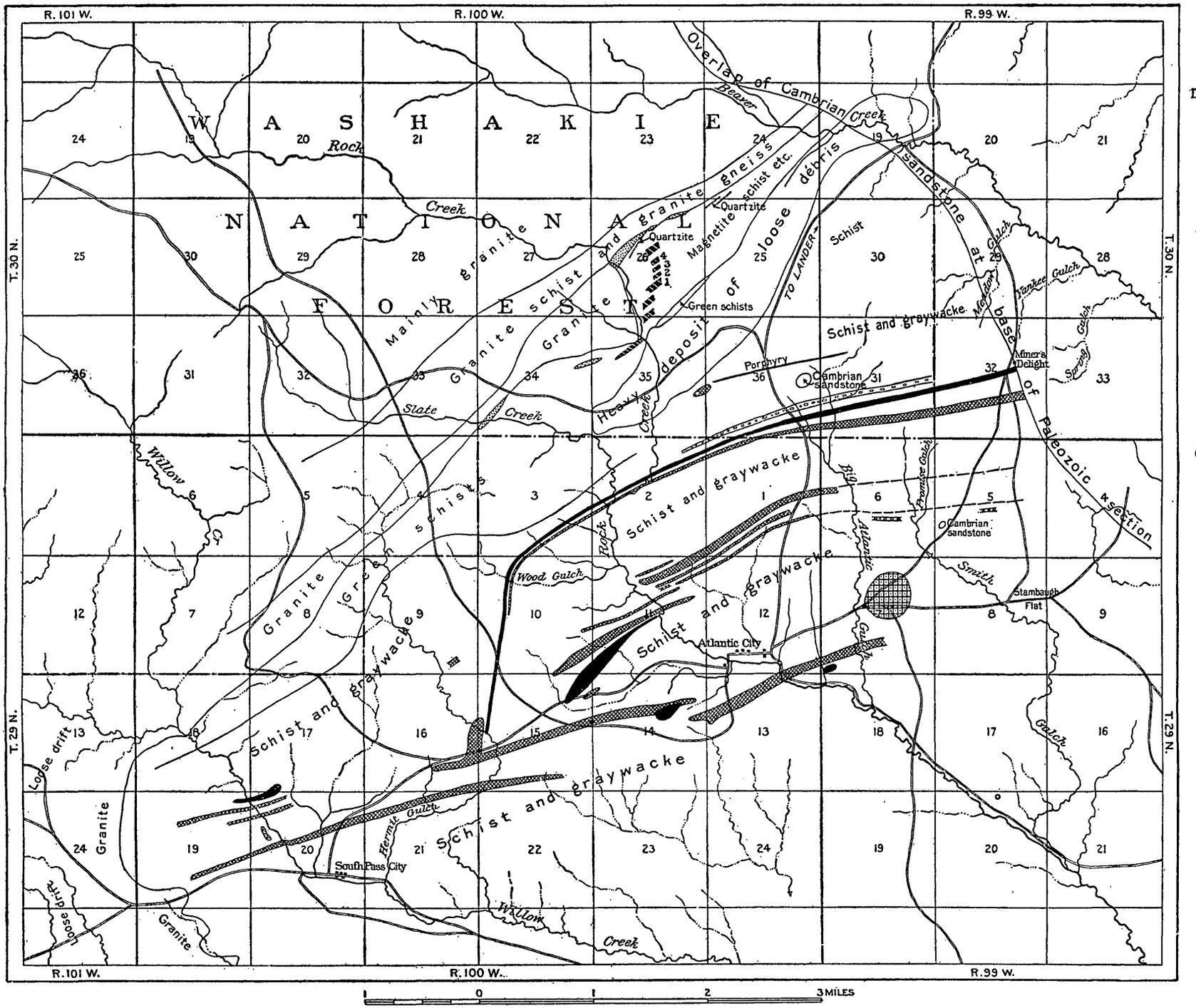
Though the district is one of considerable relief, the slopes are commonly smooth except locally along some of the principal canyons, and almost any point may be easily reached by wagons.

The three principal creeks of the district are perennial streams, the waters of which have been used in a small way for sluice mining and to furnish power for stamp mills. They are not, however, of sufficient volume to be considered alone as of importance in the future development of the district, though if reinforced by waters from Popo Agie River, Rock Creek offers some possibilities.

There is no saw timber in the district, and mine timber is practically lacking, excepting in very small areas, mainly within the Washakie National Forest. Both may be obtained, however, should the need arise, from localities within the national forest 10 to 15 miles to the north. Wood for fuel is hauled from 8 to 12 miles, but only dead wood is obtainable for this purpose, at a cost of $3.50 to $5 a cord. Such sparse tree growth as the immediate region originally supported has been greatly depleted, but firewood for prospectors' camps is furnished by aspen, nut pine, and jack pine growing in favored localities. Throughout this foothill region there is an abundant growth of dry-land grasses affording summer range for beef cattle and for sheep. Several hay ranches are profitably operated in irrigable valleys within 10 or 15 miles of Atlantic City, and along the Sweetwater this industry could undoubtedly be extended.

GEOLOGY OF THE GENERAL REGION.

The Wind River range is reported by geologists who have visited it to be composed of granite, granitic gneiss, and hornblende schist. The central line of the range coincides with the northwestward-trending axis of a broad arch along which for more than 100 miles the ancient crystalline rocks have been upthrust and, through the erosion of overlying formations, exposed throughout a zone from 20 to 30 miles wide. (See Pl. I.) Along the southwest side of this zone the crystalline rocks are overlapped by glacial deposits and by formations of Tertiary age that were deposited long after the upthrusting of the arch and after the greater part of the erosion had taken place. Here the flanks of the fold are not generally exposed, but the anticlinal structure is adequately exhibited by the presence of



LEGEND

- Deposits of Tertiary age
- Agglomerate
- Granite and porphyry
- Diorite
- Serpentine
- Magnetite schist (Numbers are referred to in text)

MAP OF ATLANTIC GOLD DISTRICT, WYO., SHOWING PRINCIPAL GEOLOGIC FEATURES.

Paleozoic rocks where Green River emerges from the mountains, and again at Pacific, about 14 miles southwest of South Pass City. On the northeast stratified rocks ranging in age from Cambrian to late Cretaceous are found tilting away from the high mountains, the harder and more resistant formations forming long hogbacks parallel with the range, and the softer formations appearing along intervening valleys. The Cambrian and younger rocks are in an essentially unmetamorphosed condition. Parallel with the Wind River arch there is a line of elongated domes passing east of Lander. These domes have been prospected for oil with some success.

The manner in which the lower formations of the stratified series rise along the side of the Wind River arch may be seen from Lander. On the way from Lander to Atlantic City, in cliffs on the northeast side of Red Canyon, are seen the basset edges of the red Chugwater formation, and across the valley is a grassy incline which is essentially a dip slope formed by the resistant upper beds of the Embar formation. By climbing to the divide between Red Canyon and Twin Creek and looking back the traveler may see the structure of this side of the arch in diagrammatic clearness. Along the road to the head of Twin Creek lower and lower formations are exposed, and the Cambrian sandstone at the base of the series of noncrystalline formations crops out at Beaver Creek crossing.

Midway between Beaver Creek and Atlantic City, to the east of the mail road, rises Peabody Hill. From the top of this elevation one may look east and see the bold escarpment formed by massive Paleozoic limestones, trending northwest to the divide between Beaver Creek and the Little Popo Agie and southeastward in the direction of Lewiston. To the west are high granite peaks rising above a general platform. This platform, though greatly dissected, appears to merge with the general surface reached by the interstream areas in the foothill region west and southwest from Peabody Hill. As already noted, the surface slopes in a general southerly direction as far as Sweetwater Valley, beyond which the pre-Cambrian rocks are covered by Tertiary formations.

The marked lowering and disappearance of the range between Atlantic Peak and the Sweetwater is, with little doubt, the result of a gentle plunging of the broad anticlinal fold toward the southeast, and the sloping platform that has been described is probably not far below the surface on which the lowest Paleozoic formations were deposited.

From a northeastward-trending line that meets the Paleozoic escarpment north of Beaver Creek southeastward to Lewiston and beyond there are highly metamorphosed rocks, mainly derived from old sediments, that may be grouped under the general term schist. (See fig. 2.) Northwest of this area granite is the principal rock,

and between Lewiston and the point where the Sweetwater breaks through the northeastward-dipping Paleozoic beds granites again appear. A short distance west of South Pass City the schists are broken by coarse red granite, and beyond, near Sweetwater crossing, there are gneisses interlayered with coarse granite or pegmatite.[1]

Knight[2] indicates the existence of two synclinal folds within the sedimentary area, their axes trending somewhat north of east. One of these folds, the axis of which passes north of Atlantic City, has been recognized by the present writer. The axis of the other fold lies about 2 miles north of Lewiston. Except in a very few places the strata are everywhere highly inclined and as a rule they stand nearly vertical. All the prominent folds in the pre-Cambrian rocks trend northeast, or almost directly across the axis of the Wind River anticline.

The occurrence of gold in this region in amounts that have stimulated mining activity appears to be definitely related to the presence of igneous rocks that cut the schists, such intrusions being present both in the Atlantic City and South Pass belt and in the Lewiston district.

GEOLOGY OF THE ATLANTIC DISTRICT.

ROCKS PRESENT.

The rocks occurring in the Atlantic district are crystalline schists derived largely from ancient stratified formations, serpentine, amphibolites representing diorites that have been strongly metamorphosed, quartz porphyry, and granite. The layering in the schists shows persistent northeasterly strikes and steep dips, and bodies of invading igneous rocks conform with this general structure. (See Pl. I.)

SCHISTS.

SCHISTS OF THE CENTRAL ATLANTIC BELT.

The rocks here grouped under the class name schist are in the main strongly metamorphosed sediments, but with these are included certain strongly sheared green rocks, occurring in the northwestern part of the district, that are supposed to have been derived from basic igneous rocks. In the definitely sedimentary portion of the metamorphic complex the rocks appear to have been mainly shales, sandy shales, and fine-grained sandstones, the first two greatly predominating. In places the beds are somewhat calcareous, but no limestone layers have been noted. At several places in the vicinity

[1] Hayden, F. V., U. S. Geol. Survey Terr. Fourth Ann. Rept., p. 38, 1871.

[2] Knight, W. C., The Sweetwater mining district, Fremont County, Wyo.: Wyoming Univ. Geol. Survey Bull., June, 1901.

of Atlantic City and to the north and northeast there are exposures of graphite schist. Near the Rose mine and on the west side of Rock Creek, 1 mile north of Atlantic City, there are sandy beds that carry knots of chiastolite about the size and shape of almond kernels. This rock is known locally as peanut rock.

In addition to the fine-grained sediments, conglomerate occurs along two lines of exposure. Though here called conglomerate this rock may have been originally a volcanic agglomerate or breccia.

The sediments are everywhere in a thoroughly metamorphosed condition. Most of them contain mica as the principal mineral of secondary derivation. In some places a marked cleavage or schistosity is to be noted, but elsewhere the rocks are not greatly sheared, and it is perhaps proper to call such rocks graywackes rather than schists. The conglomerates mentioned above are everywhere greatly mashed, the original rock fragments being flattened so that they form lenses or thin layers that are separated by a felt of hornblende.

STRUCTURE OF THE SCHISTS.

Throughout the schist area the stratification is almost everywhere readily discernible, and in general the sediments are thinly bedded. So far as observed where schistosity is present the secondary structure is parallel with the original bedding.

In the greater part of the district the rock layers stand nearly on edge and the strike ranges from about N. 15° E. to N. 30° E. However, west of South Pass, near the locality where the schists give place to granite, low dips toward the east and northeast were observed, and both on Willow Creek below South Pass City and on Rock Creek below Atlantic City the strata dip to the southeast.

In the area that was most carefully studied the fine-grained sediments, exclusive of the graphite-bearing layers, are all very similar in appearance, and so far as the graywackes are concerned there are no beds or groups of beds that can be followed far enough to make them of any aid in the working out of folds. Below South Pass City, near the mouth of Hermit Gulch, there are massive beds of fine-grained micaceous sandstone that might serve this purpose, but these layers were not traced and corresponding strata were not noted along the canyon of Rock Creek.

Clues that have been found to indicate the structure within the district are, first, a curving boundary convex to the west between the schist area and the granite country northwest, west, and southwest of South Pass City, and low easterly dips in the vicinity of this boundary; second, the two bands of conglomerate occurring north of Atlantic City on the east side of Rock Creek; third, southerly

dips of the rock layers along Willow Creek near the mouth of Hermit Creek and along Rock Creek 2 miles below Atlantic City.

The structure near Atlantic City is essentially isoclinal, in that the rock layers lie nearly parallel among themselves, but the two bands of conglomerate afford very good evidence that the beds are here repeated and that two sides of a fold are represented. The axis of this fold crosses Rock Creek about 1½ miles above Atlantic City and can be traced eastward to the Paleozoic overlap half a mile south of Miners Delight. Toward the west the conglomerate bands have not been identified, and though in this direction the fold is obscure the continuation of its axis would strike the locality west of South Pass City, where the low easterly dips and the curving boundary of the schists against granite indicate the existence of a trough or syncline plunging toward the east. From this correspondence the closely appressed Atlantic fold is regarded as a syncline. The southerly dips observed farther south do not conform with the requirements of a simple syncline but could be explained as the result of a strike fault by which the north side of an adjacent anticline had been cut out. There is a strong presumption that such a fault exists a short distance south of Atlantic City.

If in future studies the conglomerate layer is found south of the Atlantic district, it seems that eventually it will be possible to work out the structure within the area of altered sediments in some detail.

SCHISTS DERIVED FROM IGNEOUS ROCKS.

Northwest of the main area of sedimentary rocks there is a zone occupied principally by green chlorite schists, which, though they have not been closely studied, have probably been derived from some basic igneous rock. Southwestward from the point where it crosses Rock Creek the southern boundary of these schists has been located in a general way, but to the northeast the boundary between the sediments and the green schists was not traced. Southwest of Rock Creek the far boundary of the green schists is against granite that occurs in a band from one-fourth to one-half mile wide. Beyond this granite there is a zone perhaps half a mile wide in which granites and hornblende schists occur in alternation, and to the northwest is massive granite.

From Slate Creek to Beaver Creek the green schists are partly hidden by a deposit of loose rock débris that may be of glacial origin. The covered area is about half a mile in width.

MAGNETITE SCHISTS IN THE NORTHERN PART OF THE DISTRICT.

Distribution and general character.—Northwest of the covered area just referred to is a zone occupied mainly by magnetite, mica, and chlorite schists. These schists are almost completely cut out by

granite west of Rock Creek, but they extend from this place northeastward to and beyond Beaver Creek. Near Rock Creek canyon the zone is about half a mile wide, but toward the Beaver Creek end fully three-fourths of its width is covered by the débris deposits. The schists and accompanying bodies of intrusive diorite stand nearly vertical or dip steeply to the southeast, and the strikes are everywhere northeast. Northwestward across the schists the ferruginous members are succeeded by several hundred feet of shining mica schists. Where exposures are favorable a bed of quartzite from 25 to 50 feet thick is found, and not far beyond this bed there are interlayered schists, granite gneisses, and granite, occupying a zone about 1,000 feet wide.

As only one day could be devoted to a study of this belt it was impossible to map the magnetite schists completely, but from the occurrences that have been plotted on Plate I the conclusion may be fairly drawn that they are distributed throughout a zone about 2,500 feet wide and 2½ miles long. The outcrops north of Beaver Creek were observed only from a distance, but the inference that the iron schists are present in two prominent knolls was confirmed by statements of prospectors familiar with the ground. Here the deposits are capped by the Cambrian sandstone which forms the base of the Paleozoic succession in this region.

In the NW. ¼ sec. 25, T. 30 N., R. 100 W., the more southerly exposures show platy magnetite schists that are more than commonly siliceous, and these rocks are interlayered with mica schists. Between these iron-bearing beds and others forming a prominent ridge nearly 1,000 feet to the northwest there are soft mica and chlorite schists. Very prominent exposures of the iron-bearing rock are to be seen along the east rim of Rock Creek canyon in sec. 26 and on the west side of the creek in sec. 35.

The conclusion is reached that here the aggregate width of the magnetite bands is not less than 1,500 feet. Individual layers of iron-bearing rock from 40 to 250 feet wide are separated either by bodies of granular diorite or by chloritic schists which are probably strongly sheared diorites. All the magnetite-bearing rock is very schistose or slaty.

The magnetite schists considered as iron ore.—The occurrence of iron-bearing rock raises the question of the possible economic value of the deposits. Chemical analyses were made of general samples from four of the magnetite bodies that crop out on the ridge east of Rock Creek (marked 1 to 4 on the map, Pl. I). Essentially continuous exposures were found, and samples weighing from 5 to 7 pounds were taken by chipping across the ledges at intervals of about 2 feet. Sample 1 represents about 180 feet of rock; sample 2, 150 feet; sam-

ple 3, 180 feet; and sample 4, 250 feet. The results of the analyses are as follows:

Partial chemical analyses of magnetite schists, Atlantic district, Wyo.

	1	2	3	4
Iron	42	43	38.6	37
Insoluble	42	40	45.8	47
Phosphorus	.037	.030	.020	.031

Rock carrying from 37 to 43 per cent of iron and from 40 to 47 per cent of insoluble matter can not be profitably smelted, and the conclusion is drawn that material of this grade could be utilized only by submitting it to some process of concentration. In general the magnetite rock is very fine grained, dense, and hard. Crushing would be expensive, as extremely fine crushing would be necessary in order to free the grains of magnetite from those of the siliceous minerals. It therefore seems that the rock would not be readily amenable to concentration.

The siliceous impurities in specimens of the best appearance are pyroxene, hornblende, or chlorite, and in lower-grade materials jaspery silica was noted. In some of the rock the jasper occurs in layers, no more than a few hundredths of an inch thick, but elsewhere the layers of siliceous matter may be as wide as one's finger. Minute seams of limonite, which are of rather common occurrence, indicate the former presence of pyrite, so that the unweathered rock will doubtless contain a small amount of sulphur.

The fact that in taking the samples mentioned above there was no selection as between materials of better or poorer appearance leaves room for the possibility that there may be layers of the iron-bearing rock which contain 50 per cent or more of iron and which could be separately mined. It is believed that this point is worthy of further investigation. If the existence of no more than 5,000,000 or 6,000,000 tons [1] of iron ore fit for the blast furnace without preliminary treatment could be established, the district would be placed in a very favorable situation with respect to proposed railroad extensions.

SERPENTINE AND ASBESTOS.

Four bodies of serpentine are shown on the accompanying map (Pl. I). The serpentine body occurring in the southwest corner of sec. 34, T. 30 N., R. 100 W., has not been prospected, or at least no pits have been dug in it, but along the other bodies asbestos claims have been located and some prospecting has been done. Nothing of any promise was noted either at pits near the east side of sec. 34

[1] Allowing for a specific density of 4, a body of 50 per cent iron ore 10 feet wide and 1,000 feet long would contain 125,000 tons for each 100 feet in depth.

or at others in the NE. ¼ NE. ¼ sec. 26. In the fourth and largest mass of serpentine pits have been opened at several points, and during the summer of 1914 prospecting by William Brice, of Lander, disclosed some very good asbestos. The workings are still very shallow, so that much of the material shows deterioration due to weathering. This is particularly true at one locality where fiber more than 1 inch in length occurs in considerable amounts. Both the altered and the entirely fresh mineral has the softness which is a characteristic of high-grade asbestos and if worked up between the teeth forms a felt free from grit. The greater part of the asbestos thus far found shows fibers less than half an inch long, and commonly seams of such material are closely spaced so that they form veins from 1 to 2 inches wide. A favorable feature of this locality is the fact that immediately to the north there are intrusive masses of granite [1] younger than the serpentine.

INTRUSIVE ROCKS.

DIORITE.

The most abundant intrusive rocks occurring within the general area of the metamorphosed sediments now appear as amphibolite. This name is commonly used to include hornblende-bearing rocks in which the hornblende (and in many rocks other essential mineral constituents) has been formed as the result of a thorough metamorphism of basic igneous rocks. It is often impossible to determine whether the original rock was gabbro, diabase, or diorite. The mineral composition of rocks of this sort occurring in the Atlantic district is like that of diorite, and it will be convenient to use this name for them. These diorites occur as relatively long and narrow dikes following the general structure of the rocks which they invade. Several of these dikes occur in the magnetite schist area 3 miles north of Atlantic City, and they are prominently developed in the strip of country, about 2 miles wide, which contains the principal gold deposits of the Atlantic district. Precisely similar rocks occur also in the Lewiston district.

In the Atlantic gold belt a beginning has been made in mapping the diorite intrusions, with the result shown on the sketch map appearing as Plate I. It is probably correct to assume that all the rock was originally essentially alike, but as a result of differing degrees and kinds of alteration it now presents many varieties. Some of it is entirely massive, the hornblende appearing in irregular but compact individuals. From such material there is a gradation through essentially even-granular rock carrying sheaf-like forms of hornblende

[1] Diller, J. S., The types, modes of occurrence, and important deposits of asbestos in the United States: U. S. Geol. Survey Bull. 470, p. 515, 1910.

to schist in which the hornblende is all fibrous. Locally the rock is still further altered to chlorite schist, and in places where metamorphism has been extreme all semblance to an ordinary igneous rock is lost. The chloritic phases usually have a bright-green color, especially where the rock is eminently schistose; the various hornblende phases range in color from dark green to nearly black.

The dikes that have been mapped range from 50 to more than 400 feet in width. Some of them have been followed individually for distances of a mile or more, and one was found to be continuous throughout a length of 5 miles.

The longest dike of diorite lies about 1,500 feet north of the axis of the Atlantic syncline, and in a nearly symmetrical position to the south there are multiple dikes throughout a zone from 1,000 to 1,500 feet wide that extends in a direction east and somewhat north from Rock Creek to the Paleozoic overlap near the head of little Beaver Creek. The approximate symmetry of these intrusions with respect to the axis of the fold is established by the presence of the conglomerate beds at several points along a line north of and nearly parallel with the northern dike and along the south side of the southern dike zone. The northern dike, which may be called the Gold Dollar dike, from the circumstance that it crosses the group of mining claims bearing that name, has a width of 300 feet or more toward the east, but west of Big Atlantic Gulch it is nowhere more than 100 feet wide. Near the point where it crosses Wood Gulch its course changes from west-southwest to nearly south. Though it appears to terminate in the high hill 2 miles west of Atlantic City, it may continue farther south, but in that direction there are very few rock exposures. The curving of this dike and of the parallel porphyry dike just to the north suggests a corresponding bending of the inclosing strata, but in its long southerly extensions the porphyry dike probably breaks across the stratified rocks. The southern dike zone does not continue directly across the Rock Creek valley but here is offset as if displaced by a nearly east-west fault having a horizontal thrust eastward on the south side. Fairly good evidence that such a fault exists is found in the occurrence of chiastolite graywacke, or "peanut rock," north of the dike zone near the Rose shaft, and in a corresponding position with reference to the diorite dikes that cross Rock Creek. If the conglomerate beds could be found along the south side of the westerly offset part of the dike zone the presence of the supposed fault would be fully established. Because the dikes in the two parts of the zone do not match, the break is believed to have occurred before the intrusion of the igneous rock.

A third zone of diorite intrusions lies just south of Atlantic City and extends westward and southward to and beyond South Pass

City. In this zone there are three principal dikes arranged in overlapping positions. The dike that crosses Rock Creek below Atlantic City may be called the St. Louis dike. It was traced to the northeast only as far as Big Atlantic Gulch. Southwest of Atlantic City and just west of the St. Louis claim it terminates. A short distance to the north, on the Tabor Grand claim, is the eastern end of the Duncan dike, which has an average width of nearly 500 feet and was traced westward to Little Hermit Creek, a distance somewhat greater than 2 miles. West of the point where the mail road crosses Big Hermit Creek there is a large body of diorite that is believed to be connected with the Duncan dike. South of and overlapping the Duncan dike for at least 1 mile is the Carissa dike, which was traced for a distance of 3 miles. It probably extends farther east than is indicated on the map. Where this dike crosses Willow Creek it is about 140 feet wide. Its south wall lies 130 feet north of the Carissa shaft, and here it is more than 150 feet wide. In this vicinity the rock of the dike is a greatly contorted chlorite schist. Farther east parts of the dike are green and schistose and other parts black and massive. The country lying north and northeast of South Pass City was not studied in detail, but two diorite dikes that cross Willow Creek above the Carissa dike have been shown on the map.

DIKES OF PORPHYRY.

In addition to the basic intrusives of the district there are several dikes and small masses of more siliceous igneous rocks, three general types that have been noted being quartz-oligoclase porphyry, orthoclase porphyry, and soda granite.

About 2 miles north of Atlantic City, on the Rustler group of claims, a vertical dike of quartz-oligoclase porphyry is exposed. Its course is a little north of east, parallel with the strike of the inclosing schists. Unweathered specimens obtained from prospect pits show a gray, rather fine grained, apparently even-granular rock, specked with minute grains and small crystals of arsenopyrite and containing pyrrhotite. Under the microscope the texture is seen to be distinctly porphyritic, small crystals of quartz and slightly larger crystals of the oligoclase feldspar being set in a matrix composed of felty sericite. Apparently this sericite replaces an originally glassy groundmass. The same secondary mineral occurs also in some of the feldspar. The introduction of the arsenopyrite and pyrrhotite was obviously contemporaneous with the formation of the sericite. This dike has been traced for about 1 mile, and prospecting at five localities indicates that the rock is everywhere mineralized in the same way. At the outcrop the rock contains cavities

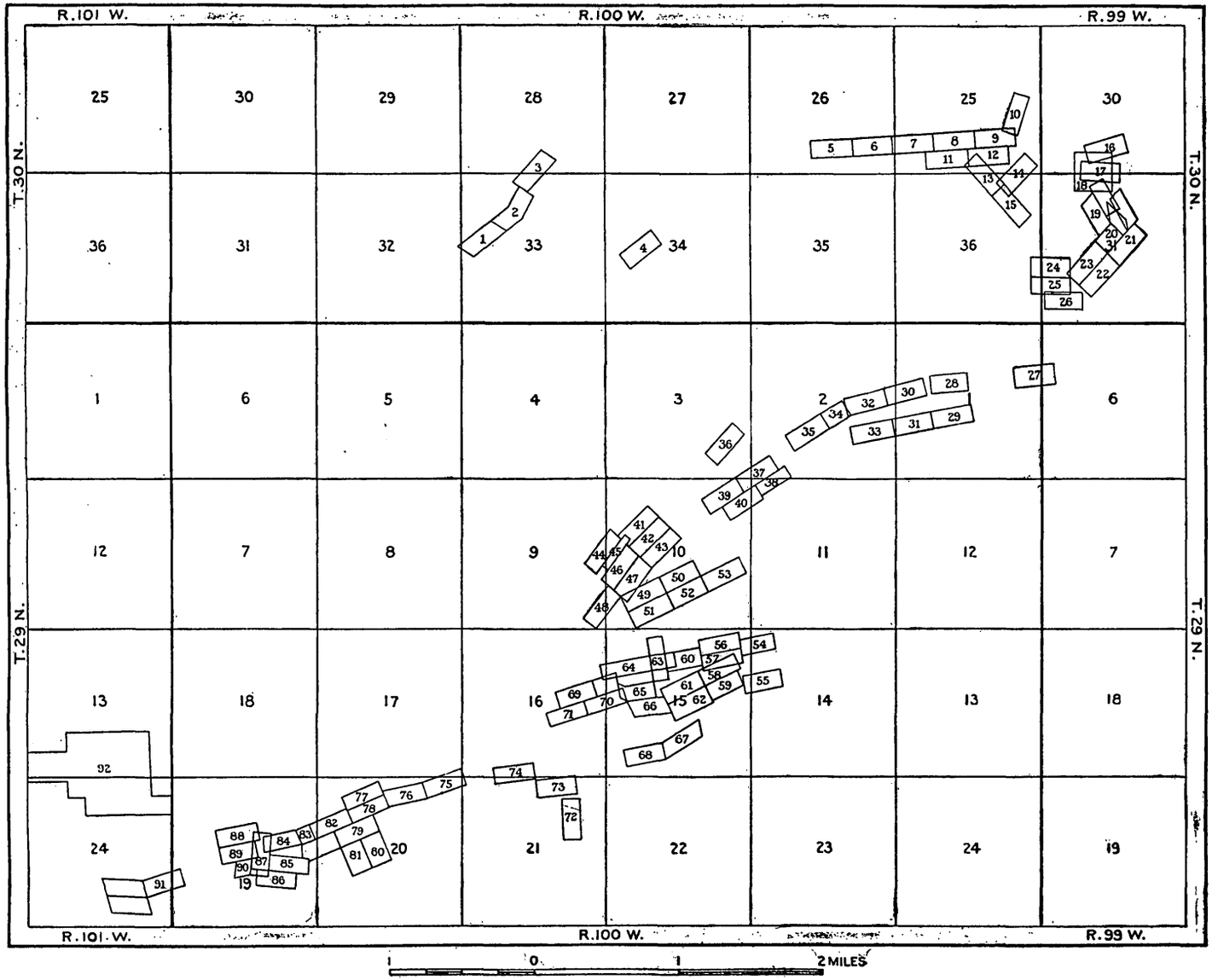
partly filled with limonite, evidently derived mainly from arsenopyrite, and weathered material of this sort is said to carry gold that can be separated by panning.

Near Miners Delight there are prominent exposures of a dark blue-gray rock, which, though presenting a general dense appearance, contains abundant lath-shaped crystals of orthoclase. This orthoclase porphyry is known locally as "spotted rock." It occurs in the form of a dike, which has a width of 50 to 150 feet, may be traced 5 miles, and is probably continuous for 6 miles. From Miners Delight its course is at first west-southwest, parallel with a conglomerate bed to the north and with a diorite dike to the south. West of Rock Creek the conglomerate was not recognized. At a point about 1½ miles northwest of Atlantic City the dike curves and assumes a nearly southerly course. Variations in the mineralogic character of the rock are evidently related to differences in the degree of schistosity. At Miners Delight it is distinctly laminated, the groundmass being composed of needles and rods of hornblende. The lath-shaped feldspar crystals lie parallel with the walls of the dike and conformable with the general lamination, but they are not crushed.

Rock similar in general appearance to that of the Miners Delight dike occurs within the south zone of diorite intrusions east of Big Atlantic Gulch and in a larger body west of Atlantic City. In all these occurrences the presence of lath-shaped feldspars is a feature of marked resemblance, but the alterations of the groundmass are different. The rock from the Big Atlantic Gulch locality is schistose, it carries brown mica in the groundmass instead of hornblende, and the feldspar crystals are partly altered to sericite. Rock collected from a point south of the mail road 1½ miles west of Atlantic City shows no marked schistosity, but the groundmass is composed of a felt of hornblende, part of which is altered to chlorite.

MINOR INTRUSIONS OF GRANITE.

Four small masses of granite occur in the zone of diorite dikes that extends south of Atlantic City and north of South Pass City. Three of these granite masses are in or near diorite dikes, as is indicated on the geologic map (Pl. I), and the field relations show that the granite is the younger of the two rocks. The granite is a fine-grained, even-granular gray rock, composed of quartz, oligoclase, and mica. The presence of oligoclase instead of the ordinary orthoclase or microcline of true granite makes the name soda granite appropriate for this rock. In specimens from the Mary Ellen mine the oligoclase is partly altered to sericite.



1. Dorothy J.
2. Washakie.
3. Arcada.
4. Lone Star.
5. Summit.
6. Peacock.
7. Signal.
8. Central.
9. King.
10. Crown.
11. Paymaster.
12. Minnie B.
13. Fairview.
14. Satila.
15. Oswega.
16. Bonanza 1.
17. Bonanza.
18. Placer.
19. Chicago.
20. Miners Delight.
21. Preserver.
22. Gold Dollar.
23. Milan.
24–26. Gold Dollar group.
27. Ruby Quartz.
28. Snow Bird.
29. Black Bird.
30. Pennsylvania.
31. Augusta C.
32. New York.
33. Blanche May.
34. Cariboo.
35. Arthur.
36. W.J.Bryan(Rose).
37. Garfield.
38. Diana.
39. Lucky Boy.
40. Britannia.
41. Humboldt.
42. Yellowstone.
43. Vulture.
44. West Dip.
45. War Eagle.
46. Ground Hog.
47. Revenue.
48. Cumberland.
49. Hennepin.
50. Ramsay.
51. Rand.
52. Gold Coin.
53. Minneapolis.
54. Denver.
55. St. Louis.
56. Clarissa B.
57. Tabor Grand.
58. Little Nell.
59. Prince Henry.
60. Fair View.
61. Mary Ellen.
62. Cecil Rhodes.
63. Victoria.
64. Duncan Placer.
65. Duncan.
66. Wasp.
67, 68. Silent Friend.
69. Exchange.
70. Dexter 1.
71. Dexter 2.
72. Empire State.
73. Philistine.
74. Rocky Barr.
75. Mars.
76. Mars Pensance.
77. Sampson.
78. Cleveland.
79. Homestake.
80. Lucky Placer.
81. Hermit Placer.
82. Carissa.
83. Mono 2.
84. Jeanette.
85. Lucky Boy.
86. Wolverine.
87. Charles Dickens.
88. Ben Hur.
89. Alpine.
90. J. C. S.
91. Franklin.
92. Wyoming Copper Co.

MAP SHOWING PART OF THE MINING CLAIMS IN THE ATLANTIC GOLD DISTRICT, WYO.

INLIERS OF CAMBRIAN SANDSTONE.

Two small patches of sandstone capping the crystalline rocks were noted—one 2 miles north of Atlantic City in the SE. ¼ sec. 36, T. 30 N., R. 100 W., and the other 2 miles northeast of the town, in the SW. ¼ sec. 5, T. 29 N., R. 99 W. Each of these occurrences is in a swale 50 feet or more below the general hilltop level in the vicinity, and this fact can hardly be interpreted otherwise than as an indication that the basal member of the Paleozoic sedimentary series was deposited on a surface having considerable local relief. The overlap of the Cambrian sandstone along the main outcrop has not been studied.

TERTIARY DEPOSITS.

East of Big Atlantic Gulch, on a broad ridge that separates it from Smith Gulch, there is a deposit of white marly clay. This deposit is regarded as a remnant of the White River formation, of Tertiary age, which is known to occur south of the Sweetwater and which probably was originally deposited over all of the region between that river and the Atlantic district. The deposit consists mainly of a white to yellowish claylike substance that contains only a small amount of carbonate of lime. Such material, though blocky when first excavated, disintegrates or slacks on exposure and is very plastic when wet. Some of the material that carries more calcium carbonate does not disintegrate so readily.

Friable sandstone occurring in the bluffs on the west side of Willow Creek half a mile above South Pass City may also be regarded as a remnant of the White River formation, which in general comprises materials of widely different character.

HISTORICAL NOTES.

The history of gold mining in the Sweetwater district has been related in some detail by Knight,[1] and this account is reprinted in a report by Trumbull.[2] The following summary is based mainly on these reports and on data contained in the reports of Raymond.[3] Plate II shows in part the mining claims in the district.

The discovery of placer gold in the Sweetwater district is said to have been made in 1842. In 1855 a party of 40 men, led by the original discoverer, prospected the region and did some sluicing along Sweetwater River. The leader of the first party returned with eight companions in 1860 and began mining on Strawberry Creek. In the fall of 1861 fifty men had collected at South Pass City with the object

[1] Knight, W. C., The Sweetwater mining district, Fremont County, Wyo.: Wyoming Univ. Geol. Survey Bull., June, 1901.

[2] Trumbull, L. W., The Atlantic City gold-mining district, Wyoming Geologist's Office Bull. 7, 1914.

[3] Raymond, R. W., Statistics of mines and mining in the States and Territories west of the Rocky Mountains for 1869, pp. 327–338, 1870; idem for 1871, pp. 374–376, 1873; idem for 1872, p. 306, 1873.

of mining in the following spring, but this party was driven out by Indians and it was not until 1866 that the same leader again returned with a company, which began operations in 1867. On June 8 of that year the Carissa lode was discovered by H. S. Reedall. This third party was driven away by Indians with the loss of three men, but the survivors came back and wintered. By crushing quartz from the lode in a hand mortar and by washing the detritus from the lode they extracted nearly $9,000 in gold. The news of this success spread rapidly, there was a rush to the district, and 500 men went to work. In July, 1869, there were 2,000 people in the district.

The first stamp mill, of six stamps, driven by an overshot water wheel, was erected on Hermit Gulch. It was started July 20, 1868, and up to November 1 had crushed 1,040 tons of ore, yielding an average of $36 currency to the ton. Between April 20 and July 1, 1869, 480 tons of ore, averaging $47 a ton, was treated. The rock crushed came mainly from the Carissa lode, but ore was also hauled from Atlantic City. The second mill, of 10 stamps, driven by a 40-horsepower steam engine, was installed at Miners Delight and between January and July, 1869, is estimated to have extracted more than $60,000 worth of gold from ore taken from the Miners Delight lode. The ore averaged about $40 a ton. The third mill, of 10 stamps, was a steam-power mill at Atlantic City that began operation June 25, 1869. It treated 75 tons of ore from the Soules & Perkins lode at Atlantic City, yielding about $30 a ton.

The principal veins of the district as they are now known were nearly all discovered before 1871, and by that time 12 mills, with a total of 161 stamps, had been erected. Placer work had been done in many places, mainly on Carissa Gulch, a tributary to Willow Creek; on Big Atlantic, Smith, and Promise gulches, tributaries of Rock Creek; along Rock Creek near Atlantic City and on Spring, Yankee, and Meadow gulches, across the Beaver Creek divide. Up to the end of 1873 the gold production of the district appears to have amounted to about $550,000.

In 1872 South Pass City was nearly deserted. The Cariboo and Buckeye mines, near Atlantic City, were being worked, and at Miners Delight three mines were active, but in 1875 the mines of the Sweetwater district were reported as being essentially idle.

After South Pass City, Atlantic City, and Miners Delight had experienced booms and had dwindled to small villages, a fourth camp, Lewiston, was opened, the Burr lode having been discovered in 1879. This camp had a similar experience to that of the others. Knight[1] says:

> Lewiston, like the others, had rich veins of quartz and placer grounds, but the mills have not stamped much ore and the camp is sorely in need of good mining men who

[1] Knight, W. C., op. cit., p. 81.

are willing to develop a mine before they expect it to yield a dividend. * * * The surface ores were quite free and rich, but with depth they rapidly became base and contained iron pyrites and arsenopyrite. The ores extracted near the surface milled easily, but long before the water level was reached the amount of free gold had diminished so that tailings were assaying $35 and $40.

In 1886 the placers on Spring Gulch at Miners Delight were still being worked, though operations were confined to a short season during the spring when water was available.[1]

In 1884 [2] a French company managed by Émile Granier purchased placer claims on Willow, Rock, and Strawberry creeks and began the construction of a canal or ditch to lead the waters of Rock Creek to several points where they could be utilized in hydraulic mining. Before the completion of this ditch, in 1886, plans were made for diverting the water of Christina Lake at the head of Little Popo Agie River, and this project was carried out. The water thus made available was rated at 8,000 miner's inches. A hydraulic elevator, installed on Rock Creek, below Atlantic City, was operated during the three seasons, 1890 to 1892. The total value of the gold recovered is said to have been about $200,000. About 1893 the company became financially embarrassed, and some time afterward its interests were taken over by the Dexter Mining & Milling Co.

The Dexter Co. purchased several undeveloped and partly developed lode claims in addition to the placer ground and water rights of the Granier company. In 1905 the construction of the Dexter Mill at Atlantic City was begun. The Rose tunnel was driven 1,100 feet, but no ore bodies had been developed on any of the company's property in 1914. Trumbull [3] says:

> After the completion of the mill, ore was hauled in wagons from various prospects in the district. Twelve thousand tons of $5 to $30 ore were milled and the clean-up gave $6,000 off the plates and absolutely nothing from the cyanide plant.

This administrative and technical failure was followed by bankruptcy and by reorganization as the Timba Bah Mining Co. The affairs of the new company were under the management of a receiver in 1914.

Aside from the activities of the two companies mentioned, interest in the Atlantic district has been maintained largely through recurring attempts to reopen certain of the mines that were most productive during the years 1868 to 1872. Individual prospectors and small associations have been continually at work. Up to about 1906 one or more stamp mills were kept in shape for the use of miners in the treatment of small lots of ore. The advantage of such conditions is obvious, and as there has been lately no reduction plant

[1] Aughey, Samuel, Wyoming Terr. Geologist Ann. Rept., 1886, p. 12.
[2] Ricketts, L. D., Wyoming Terr. Geologist Ann. Rept., 1888, p. 72.
[3] Trumbull, L. W., op. cit., p. 86.

conveniently available, assessment work has been even more perfunctory than formerly. Among mines that have been taken up at different times, with the idea of systematic development, the most prominent are the Carissa, at South Pass City; the Miners Delight, at the east end of the district; and the Garfield, near Atlantic City.

The Carissa appears to have been idle from about 1873 until 1900 or 1901, when it was acquired by the Federal Gold Mining Co. In 1901 the shaft was sunk to 300 feet and somewhat later to 387 feet, but the depth of the lowest level at present is 360 feet. The recorded production during the period 1902 to 1906 is about 2,800 tons of ore that returned a total in gold and silver of somewhat more than $25,000. The bullion produced was about 0.845 fine. Since 1906 no mining has been done. For several years the mine has been kept free from water, so that the workings might be available for examination. The shaft is 387 feet deep and the workings extend along the vein for about 750 feet. There are five levels, with horizontal workings below the first level amounting to nearly 2,600 feet.

The Miners Delight property appears to have been worked from the time of discovery in 1868 until 1874. It was then idle until about 1880, when the mine was reopened and operated until 1882. In 1893 the property was sold to satisfy a claim of $28,500.[1] A company was formed to begin mining and in 1894 the workings were pumped out. Though a large sum of money is said to have been spent, this attempted revival was not successful. Failure likewise followed work done in 1910 and again in 1913. In both of these attempts comparatively small amounts were expended.

The Garfield claim is supposed by the writer to be the same as an early location known as the Buckeye State. The Buckeye shaft is said to have been 140 feet deep in 1870 and the production at that time was at the rate of $50,000 a year. Several attempts were made to rehabilitate this mine; the most important one in 1891–1894. Two Tremaine stamps and a small hydroelectric plant were installed, but although some gold was produced the returns appear not to have been sufficient to pay for the mine developments that would have been necessary for a financial success. In 1905 the mine, it is reported, yielded $5,000 from 1,000 tons of ore.

The Mary Ellen mine has been another occasional producer, though between 1902 and 1915 the property was involved in litigation.

A recent undertaking has been the development by the Beck Mining Co. of the Duncan mine, 1 mile west of Atlantic City. After an exploration of the Duncan vein by about 1,500 feet of workings four Nissen stamps and amalgamating devices were installed in 1911. The saving of the gold contained in the ore is reported to have been

[1] Eng. and Min. Jour., Dec. 23, 1893.

about 60 per cent, and in 1912 a system of all sliming followed by cyanidation was adopted, with results that are said to have been very satisfactory. Power for the mine and mill and for an electric plant is furnished by internal-combustion engines adapted for burning gasoline or distillate. Mine developments in 1913 and 1914 appear to have been not very encouraging, and it may be that the financial success of this company will depend upon securing control of other mines than the one for which the technically successful extraction process has been worked out.

About 1908 the X. L. Dredging Co. purchased several groups of placer claims in Big Atlantic, Smith, Promise, and Little Beaver gulches and on Stambaugh Flat. In 1912 a ditch and siphon to carry water from upper Rock Creek was completed and some ground was washed on Promise and Smith gulches. In 1914 operations of this company were confined to properties on Beaver Creek.

The Wyoming Copper Co., organized about 1909, obtained a group of claims situated west of Willow Creek about 1 mile above South Pass City and carried on operations at intervals until the summer of 1914. During this period a shaft was opened to a depth of 500 feet and some drifting was done. Small amounts of rich copper minerals were found near the surface, but nothing of value was discovered in the shaft workings, and the project appears to have been finally abandoned in the fall of 1914.

ESTIMATED GOLD PRODUCTION.

Inasmuch as a large part of the gold output of Wyoming has come from the Atlantic and near-by districts, accurate statistics of the gold production of the State, if available, would furnish a very good idea of the progress of mining in the region under consideration. Unfortunately reliable data are not at hand, but figures indicating the gold and silver output have been compiled by the United States Geological Survey,[1] estimates having been made where no definite figures are available.

The value of gold produced in the Atlantic district from 1867 to 1875 is given at $736,100, on the basis of reports by R. W. Raymond. For the years 1876 to 1895, inclusive, the output of the State is estimated at $165,000, and part of this amount was derived from placers in northeastern Wyoming and in the Douglas Creek district. For the years 1896 to 1913 the gold output of the State is given at $290,000, and it is known that a large proportion of the actual output after 1899 came from copper ores.

If the foregoing figures indicating for Wyoming a total gold production of $1,191,178 could be accepted, it would seem probable that the Atlantic district should be credited with an output valued at

[1] Henderson, C. W., U. S. Geol. Survey Mineral Resources, 1913, pt. 1, p. 50, 1914.

less than $1,000,000. Estimates have been published, however, indicating that the production of the district has amounted to more than $5,000,000.

In a footnote Henderson says:

> The source of the generally quoted figures ($5,050,000) is W. C. Knight (The mining districts of Wyoming: Wyoming Univ. Agr. College Dept. Bull. 14, October, 1893, pp. 123–124), but Knight says: "The only estimate of the output of this region is one that has been generally circulated, but upon what basis the estimate is made or who is the author I am unable to find out."

The estimate of the gold output of the Atlantic district which is given below is taken from a report on Fremont County published in 1911:[1]

Estimate of gold production of Atlantic district.

LODE MINES.		PLACERS.	
Miners Delight	$1,200,000	Meadow Gulch	$1,000,000
Carissa	1,000,000	Yankee Gulch	500,000
Caribou	500,000	Spring Gulch	30,000
Garfield	400,000	Promise Gulch	30,000
Victoria Regina	350,000	Smith Gulch	20,000
Franklin	300,000	Red Canyon	20,000
Mary Ellen	125,000	Atlantic Gulch	15,000
Lone Star	40,000	Beaver Creek	10,000
Carrie Shields	35,000	Others	150,000
Other quartz mines	187,000		1,725,000
	4,137,000		5,862,000

The present writer is inclined to believe that the gold production of the district may have been greater than the indicated total output of the State as given by the Geological Survey figures cited, though it can hardly have been as great as the figure given by Jamison. Possibly the lode mines and placers may have produced as much gold since 1875 as before that year, and if so, a fairly reasonable guess would place the value of the total output at $1,500,000.

VEINS.

PREVIOUS DESCRIPTIONS.

Gold has been found in the bedrock formations mainly in veinlike bodies of quartz which, below the zone of oxidation, carry pyrite or arsenopyrite and in a few places chalcopyrite or galena. The veins have been classified by Knight[2] under four heads—(1) fissure veins that occur in bodies of igneous diorite or granite; (2) contact veins that occur between intrusive rocks and metamorphosed sedimentary

[1] Jamison, C. E., The geology and mineral resources of a portion of Fremont County, Wyo.: Wyoming State Geologist Bull. 2, p. 80, 1911.

[2] Knight, W. C., op. cit., p. 17.

rocks; (3) bedded veins that conform with the dip and strike of the metamorphic schists; and (4) gash veins. Knight says:

The veinstone is quartz. Near the surface is the usual oxidized zone in which the gold is comparatively free. Below this sulphides appear and are of three types—pyrite, arsenopyrite, and galena. Arsenopyrite or pyrite containing a small percentage of arsenic seems to predominate. Occasionally realgar and orpiment are found in minute quantities. No banded structure was found in any of the veins. The quartz is usually massive and varies in color from white to semitransparent with a bluish cast. In the oxidized zone the cavities are filled with limonite. Quartz associated with some of the sulphides usually contains the most of the values. In many instances, however, the schists are especially rich. This condition was especially marked at the Carissa. In the ore stoped it was the rule that the schist clinging to the quartz was gold-bearing, and often there were wires and pellets of gold scattered through the mass. During the last ten years I have assayed schists from this district that contained from 2 to 10 ounces of gold per ton.

Besides the veins, from a foot to 8 or 10 feet wide, that have been opened, there are some mammoth veins of quartz that have been but slightly protected. One of these known as the Mammoth vein is a short distance northeast of Atlantic. It contains some gold, but mines have not been able so far to make it pay. Others of this type are known.

Taken as a whole the veins are of average size, are very persistent, containing good shoots of ore which continue with depth. The relation of the gold contents of these veins with depth could not be worked out.

Trumbull [1] says:

The veins are all quartz filled, and the dip and strike of those carrying workable values show no relation to the strike or dip of the schists. The Big Atlantic and Mammoth veins are heavy wide bands of what seems to be vein quartz, running for miles across the district, following the schists in both dip and strike. But neither of these have shown shoots of pay ore, the gold values being a dollar or less per ton. These leads have been well prospected, for one can follow their course with the eye for miles by the prospect holes dug on them. Their great length and uniform width, also their parallelism with the inclosing schists, make one certain that they are of sedimentary origin.

The gold-bearing veins are found in the schists, diorite, the andesite [called feldspar porphyry in this report], and, in one case, in granite. There is no uniformity of strike. It has been stated that the strike of the veins was in general parallel to that of the schists. In some cases this is true, but apparently it is only a coincidence. The Miners Delight vein, for a part of its length, runs parallel to the strike of the schists, but in other places it strikes nearly across the schists, and the part parallel to the schists has both foot and hanging wall of andesite. Again, the Mary Ellen is a fissure in granite, the strike of which is nearly at right angles to the strike of the schists surrounding the granite intrusion. The veins of the Gold Dollar group and of the Rose strike across the formation, the first in diorite, the second in schist. The Carissa, it is true, does strike parallel to the schists. So also do the several veins of the Garfield. But on the whole there is not evidence to prove that the structure of the schists has controlled the strike or dip of the veins.

The following quotations are taken from a report by Raymond: [2]

The main belt of lodes follows a general northeast and southwest course, but within this limit there is considerable variation in the strike and dip of the veins. Some of

[1] Trumbull, L. W., op. cit., p. 85.

[2] Raymond, R. W., Statistics of mines and mining in the States and Territories west of the Rocky Mountains for 1869, pp. 329 et seq., 1870.

these ran parallel with the stratification of the country rock; others traverse it at a small angle. The dip of the lodes varies from 50° to 90° and is mostly toward the northwest. Their width varies from 1 to 25 feet. At least one of the walls is generally smooth and well defined, especially when the strike and dip of the vein corresponds with that of the country rock. The walls of the cross veins are mostly imperfectly defined.

The ore of the district is mainly quartz, in which oxide and silicate of iron are finely divided. The dark shade thus imparted to it has caused the miners to call it black iron. Some of the quartz, however, is white and transparent, like that of California. The dark kind of quartz is most common; yellow and red stained varieties are frequently so decomposed that they can be easily crushed between the thumb and forefinger. The miners call this kind sandy quartz and consider it richer than the harder ore.

The bullion is about 0.850 fine in gold on an average.

Base metals, such as lead, zinc, antimony, tellurium, copper, etc., are very rare, and to all appearances the percentage of iron pyrites will be very small, even at greater depth. In a few lodes only, malachite and copper pyrites are found interspersed in the quartz.

The average yield of several thousand tons of ore from different lodes has been from $30 to $40 per ton. The richest ore, yielding $100 and over to the ton, is taken from small lodes with an ore streak of 1 to 2 feet wide; lodes of from 4 to 5 feet wide contain a medium quality of ore, and the long veins of 10 to 25 feet contain a vast amount of low-grade ores. The latter will undoubtedly constitute the main strength and most reliable basis for the mining enterprises of the future.

CLASSIFICATION OF THE VEINS AND OTHER GOLD DEPOSITS.

To the classes of veins enumerated by Knight the present writer adds stringer lodes and certain deposits that are not veins in any strict use of the term but bodies of rock that carry gold associated with disseminated sulphides or arsenopyrite. A convenient classification, which resembles but does not fully conform with the one proposed by Knight, is given in the following paragraphs:

Cross veins.—The class of cross veins is intended to include all veins that strike across or oblique to the general trend of the country rock. It is represented by veins in metamorphosed sedimentary rocks, as at the Rose shaft, on Peabody Hill, and north of Miners Delight; also by veins in igneous rocks, illustrated by the Mary Ellen vein, which occurs in a small body of granite, probably by the Duncan vein, in diorite, and by a vein on the Gold Dollar group of claims, also in diorite.

Strike veins.—The strike veins conform in trend with the strike of the schists, or with the course of inclosing dikes that follow the layers of the schists. The Miners Delight vein occurs in a dike of feldspar porphyry and throughout part of its course is in a general way parallel with the walls of the dike and with a notable though not prominent schistosity of the intrusive rock. Along its outcrop the vein makes a sharp bend from a northeast to a nearly north course, and north of this bend it has the characteristics of a cross vein. Other prominent examples of strike veins are the Lone Star,

Big Atlantic, Mammoth, Cariboo, St. Louis, Tabor Grand, Carrie Shields, and Carissa, and probably the Garfield.

Contrary to the statement of Trumbull quoted on a preceding page, the present writer's observation is that strike veins instead of being rather uncommon are numerous throughout the district.

Stringer lodes.—A group of small quartz bodies interleaved with a schist or reticulating through a massive rock and traceable along a definite course may be called a stringer lode. Typical examples of stringer lodes in schist can not be cited, but in several places and to a noteworthy degree along the Carissa lode it was observed that strike veins show a tendency to lose their solidity and to be continued by a set of multiple veinlets.

Four miles north by west of Atlantic City, about a quarter of a mile north of a point between the two serpentine bodies that flank the magnetite schists, a stringer lode in granite shows a network of veinlets composed mainly of quartz but containing also flesh-colored or reddish orthoclase. Material from shallow prospects on this lode is slightly stained by green copper minerals. Other examples of stringer lodes in granite were noted near the head of Big Hermit Creek. In all these places the lodes have been prospected in a small way, but there are no indications that they contain anything of value.

Gash veins.—The term gash vein is used for quartz fillings that are of very slight extent. In the Atlantic district a few veins of this sort have been found to be very rich in gold.

Mineralized rock masses.—A class which in the Atlantic district may or may not prove to comprise deposits of commercial value is that of rock masses which carry disseminated iron sulphide or arsenide. The most definite illustration of this class that can be cited is a dike of quartz porphyry that is crossed by the mail road about 2 miles north of Atlantic City. This dike traverses the Rustler or Lander Belle group of claims. It is 10 to 20 feet wide and has been traced for a distance of more than a mile. The original rock was a dense rock containing definite crystals of quartz and oligoclase feldspar in an extremely fine grained groundmass. As a result of metamorphism that appears to have affected all parts of the dike, large amounts of sericite have been developed in the groundmass, and the same secondary mineral occurs in some of the feldspar. This sericitization is definite evidence that the alteration of the porphyry was effected by the action of penetrating hot solutions, and these solutions also deposited arsenopyrite and pyrrhotite, which are sparsely but generally disseminated through the mass of the altered rock. In surface exposures the arsenopyrite and pyrrhotite are represented by cavities containing cellular iron oxide and, as such material commonly contains free gold, it is supposed that all the

mineralized rock carries some gold. It is claimed that assays have shown gold to a value of $2.50 to $5 a ton.

An example of altered diorite carrying disseminated pyrite and arsenopyrite was noted in workings on the Ground Hog group of claims, and it is very likely that other deposits of this kind occur in the district.

MINERALOGY OF THE VEINS.

The veins of the district are composed mainly of quartz. At the surface the quartz is likely to be more or less iron-stained, and some of it is cellular and the cavities usually contain yellow, brown, or red limonitic material. As depth increases the amount of limonite diminishes and it becomes evident that this material is derived from pyrite or arsenopyrite. An intermediate product in the decomposition of arsenopyrite is scorodite ($FeAs_4.2H_2O$), which was noted in ore specimens from the Carissa mine.

In addition to the common iron sulphide pyrite, the magnetic sulphide pyrrhotite also occurs, but in general both of these minerals are subordinate in amount to arsenopyrite. A few veins carry chalcopyrite. Galena was observed by the writer only in quartz from the Mary Ellen mine, which also carries a little arsenopyrite.

That the gold contained in the veins is usually associated with the sulphide minerals, including arsenopyrite, is evident from the fact that with increasing depth the ores have proved to be less amenable to amalgamation as a rule.

So-called black quartz, which is of rather common occurrence, carries brown or black tourmaline.

The mineralogy of the veins is in accord with the view held by the writer that the veins are of deep-seated origin, and this view is also supported by the fact that none of the veins show layering or banding, as it is commonly called, parallel with the walls.

GOLD CONTENT OF THE ORES.

Very little definite information can be given concerning the amounts of gold carried by the ores that have been mined from the veins of the district. Notes in Raymond's reports indicate that the ores mined prior to 1872 returned as a rule from $20 to $40 a ton under treatment by stamp milling and simple amalgamation. Some ores were worked that yielded only $15 a ton, and occasional lots yielded as high as $200 a ton. "The average yield of several thousand tons of ore from different lodes has been from $30 to $40 per ton."[1] Among the mines mentioned by Raymond in 1870 are the Carrie Shields, Young America, Carissa, Golden Gate, Wild Irishman, Gold

[1] Raymond, R. W., Statistics of mines and mining in the States and Territories west of the Rocky Mountains for 1869, p. 330, 1870.

Hunter, Calhoun, Duncan, Mary Ellen, Barnaba, Buckeye State, Soules & Perkins, Cariboo, Miners Delight, and Bennet Line.

Between July 20 and November 1, 1868, the original Hermit mill, near South Pass City, treated 1,040 tons of ore yielding an average of $36 a ton; and between April 20 and July 1, 1869, it crushed 480 tons of ore, averaging $47 a ton.[1]

Ore from the Miners Delight vein is said to have yielded from $16 to $200 a ton, the average having been about $40.

Perusal of old reports relating to the district leaves an impression that many of the lodes occurring in the district might be expected to yield ores carrying on the average as much as $20 a ton. It is believed, however, that as a general rule this expectation will not be realized, though with little doubt shoots of rich ore will be found. It is more likely that assays will show averages of $6 to, say, $15 a ton.

The records of production in possession of the Geological Survey, which are held as confidential with respect to individual mines, indicate that 11,105 tons of ore produced by eight mines since 1902 yielded an average of $8.15 a ton. (See list of assays, p. 40.) On the face of the returns, if a few tons of exceptionally high-grade ore are left out of consideration, the yield appears to have ranged from $5 to $9.18 a ton. The figures given represent the metal recovered, and there is no way of ascertaining the actual gold content of the ores as mined. In so far as gold and silver yields are both given the ratio of gold to silver is found to vary from 5.03 to 10.02, the weighted mean ratio for 8,958 tons of ore being 6.79, which corresponds to a fineness in gold of 0.871.

PROBABLE PERSISTENCE OF THE VEINS.

From a practical man's point of view the first importance naturally attaches to the question whether or not the veins and other gold-bearing deposits of the district will be found to persist to great depth, and if so whether they will continue to carry about the same amounts of gold as near the surface.

In regard to physical persistence, the conclusions may be drawn that these deposits are of deep-seated origin, that the present topographic surface is a chance surface due to erosion, without significant relation to the ore deposits, and that on the whole the deposits must be as abundant at any depth that might be chosen for consideration as they are at the existing surface. Although these general conclusions are fully warranted by the geologic features of the district, they should not be taken as a guaranty that all the veins of the district will be found to be continuous to indefinite depths. It is probable that the lodes showing long outcrops, like the Carissa and Miners Delight,

[1] Raymond, R. W., op. cit., p. 331.

persist to great depths, whereas it would not be surprising if lodes that can be traced at the surface for very short distances are found to pinch out at correspondingly moderate depths. On the whole the writer is inclined to believe that in this district strike veins, if well defined, are likely to prove more persistent than cross veins.

As to the downward continuance of gold content, though it is likely that there has been some enrichment through solution and redeposition in the oxidized portions of the lodes, it is not believed that any really large proportion of the gold in the upper parts of the veins has been secondarily precipitated from surface solutions; and no hesitation is felt in stating the conclusion that the occurrence of valuable ores is not limited to a shallow zone. It may be expected that here, as is the rule in other districts, different parts of the same lode will be found to carry varying amounts of gold, or, in other words, that in any vein the best ore will be found in the form of shoots.

The foregoing conclusions and suggestions indicate the writer's belief that the district is worthy of further development.

FUTURE DEVELOPMENT.

GENERAL OUTLOOK FOR LODE MINING.

In view of the history of the district and its situation 25 miles from railroad transportation the immediate outlook for a general revival of the gold-mining industry is not very encouraging. Nevertheless the writer shares the opinion which has been expressed by several geologists who have made reports on the district, that the early promise of the region may yet be fulfilled. This opinion rests on the belief that the stronger gold-bearing veins of the district persist in depth, with about the same characteristics as they show near the surface. The whole problem, however, involves more than this and requires a consideration of the planning and execution of development work, methods of ore treatment, transportation, and the cost of power. These questions are discussed in the following paragraphs.

PLANNING OF DEVELOPMENT WORK.

In reviewing attempts that have been made either to rework the old mines or to open new ones the fact becomes apparent that the usual procedure has been to install metallurgic plants before they were warranted by developed ore reserves. A plausible justification for this method of attack is that by means of it ore removed during exploratory work can be treated and the proceeds applied to current expenses, thus decreasing the amount of capital required to place an enterprise upon a profitable basis. But this reasoning has proved to be unsound in thousands of instances throughout the gold-mining districts of the United States, and for the Atlantic district the policy

has been ruinous. An important advantage of the method of applying all expenditures at the start to exploration underground is that the enterprise may be abandoned at any stage without incurring what might otherwise become a double or even a quadruple loss. The conclusion can not be too strongly urged that except under unusual circumstances mine development must precede the erection of ore-treating plants if lode mining is ever to be revived in the Atlantic district.

One element of the general problem is that in addition to several gold-bearing lodes which are traceable for long distances there are others that show only short outcrops. Suppose that a quartz vein averaging 3 feet in width shows an outcrop 300 feet long, and that a short vein of the kind may pinch out at a depth of 300 feet. The cubic content of the vein then corresponds with about 20,000 tons of rock. Allow 12,000 tons of ore that could be won and an average yield of about $8 a ton, or say $100,000, and the expense of mine development and mill installation and the cost of mining and treatment might very well consume all the possible proceeds. But if two veins of this kind could be developed so as to be served by one mill the venture might be made to show a profit. The foregoing example is introduced as a basis for the suggestion that multiple development might lead to favorable results where the exploration of a single vein might fail.

It is hoped and expected that the placer ground held by the Timba Bah Co. will be developed at an early date, and if this undertaking is carried out with good results the company should be placed in a position to take up a systematic exploration of lodes on the properties which it controls. The plan of developing several lodes simultaneously could be adopted with advantage by this company.

If several active companies were present in the field a demand for power would arise, and, under some cooperative arrangement, it might prove economically feasible to install a hydroelectric plant that would furnish power for preliminary mine developments.

OUTLOOK FOR RAILROAD TRANSPORTATION.

The district has been at a disadvantage because of its remoteness from a railroad. Supplies were formerly hauled 70 miles or more from stations on the Union Pacific Railroad, but since 1906, when the Wyoming & Northwestern Railway was completed to Lander, about 28 miles from Atlantic City, nearly all the traffic has been with that point. Only 10 miles south of the district is the now abandoned route of the Overland Telegraph and of the Emigrant or Overland Trail, which led from Casper to the Sweetwater, up this valley to South Pass, and thence across the Green River basin on the way to Great Salt Lake or to the Oregon country. When the Union Pacific

Railroad was planned many engineers regarded the Sweetwater route as more favorable than the more southerly route that was adopted, and it is probable that within 10 years either the Northwestern or the Burlington system will seek an entrance to the Green River basin by way of South Pass. With the extension of either of these lines the situation of the Atlantic and Lewiston districts with respect to transportation will be greatly improved. Atlantic City and South Pass City will then be within 12 miles and possibly within 6 miles of the railroad, depending on whether the location is north or south of Sweetwater River. Lewiston will be still nearer. Whatever alignment is chosen for the railroad, good connecting wagon roads with easy and favorably distributed grades can be cheaply constructed and maintained.

COST OF POWER.

If a railroad is constructed through the upper Sweetwater Valley coal will be made available, and at points along the line should not cost more than $3 to $3.50 a ton. If the smaller figure is taken and if the cost of hauling is assumed to be 35 cents a ton-mile, the estimated cost of coal at points 10 miles from the prospective railroad will be $6.50 a ton. For the present the power problem resolves itself into the use of wood for raising steam; the use of gasoline, distillate, or crude oil in engines of the internal-combustion type; and the development of electric energy in small hydroelectric plants.

Wood for fuel can be obtained from the Washakie National Forest by a haul of 5 to 12 miles, at prices of $3.50 to $5 a cord. Under the regulations of the Forest Service only dead timber is available, the use of which is said to be rather unsatisfactory.

The cost of gasoline delivered has been from 17 to 24 cents a gallon and that of distillate somewhat less. When used in small internal-combustion engines, distillate at 20 cents may be compared with good bituminous coal, burned under a boiler, at about $16 a long ton.

With little doubt engines of the Diesel type could be adapted to use the crude oil produced in the Dallas field, which is situated about 16 miles north of Atlantic City. Since 1911 this oil has been going by a pipe line to Lander, but probably its value for developing power in the Atlantic district would be greater than its value for locomotive fuel, which is reported to be 75 cents a barrel. The possibilities of this oil are suggested by a rough calculation which indicates that, allowing for a cost of $1.40 a barrel at the well and a charge of $1 a barrel for transportation, the cost of crude-oil power would correspond approximately with the cost of steam power if coal could be laid down at $5 a long ton. This calculation is based upon 50-horsepower units. The character of the Dallas oil is shown in the following table:[1]

[1] Woodruff, E. G., The Lander oil field, Fremont County, Wyo.: U. S. Geol. Survey Bull. 452, p. 29, 1911.

Analyses of oils from Lander field, Fremont County, Wyo.

Serial No.	Well No.	Depth of well.	Physical properties.			Distillation by Engler's method.							Paraffin.	Asphalt.	Unsaturated hydrocarbons.	
			Gravity at 60° F.		Color.	Begins to boil.	By volume.									
			Specific.	Baumé.			To 150° C. (cubic centimeters).	150–300° C.		Residuum.		Total (cubic centimeters).			Crude.	150–300° C.
								Cubic centimeters.	Specific gravity.	Cubic centimeters.	Specific gravity.					
		Feet.		°		° *C.*							*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Wyo. 3.....	3	750	0.9198	22.2	Dark brown...	93	2.5	22.0	(a)	(a)	(a)	(a)	(a)	(a)	50.4	(a)
Wyo. 4.....	2	400	.9126	23.4	.....do.....	120	2.0	23.5	0.8041	69.9	0.9543	95.4	0.91	4.02	16.4	4
Wyo. 5.....	10	825	.9121	23.5	.....do.....	93	2.0	21.0	.8067	75.2	.9589	98.2	1.27	5.69	50.8	4
Wyo. 6.....	11	965	.9126	23.4	.....do.....	105	1.5	24.0	.8018	73.9	.9605	99.4	.90	11.04	58.0	4
Wyo. 7.....	13	697	.9091	24.0	.....do.....	108	2.5	23.0	.8047	73.1	.9589	98.6	.62	15.26	50.8	9

a Flask broke during distillation. Water in the oil.

The erection of an electric power plant in the Dallas oil field has been proposed. This project is technically feasible, and the cost of installation would be less than that of a hydroelectric plant on Little Popo Agie River. The transmission line to Atlantic City would be about 17 miles long.

The development of water power at points along Rock Creek would be feasible for about seven months during the year, but from November to March not only is the stream flow small but it is doubtful whether it could be utilized because of troubles due to freezing in the diversion canals. From April to November the minimum flow including the natural waters of Rock Creek and those diverted from Christina Lake would probably not fall below 20 second-feet. With this flow of water approximately 280 horsepower could be developed at each of two sites, one 3 miles above Atlantic City and the other near that place. The upper site is under the ditch of the X. L. Dredging Co. The first right to water is claimed by the Timba Bah Co., but as the stream would be returned to Rock Creek above the headgate of the lower canal of that company it is not evident that these rights would interfere with each other.

The lower power site near Atlantic City is under the main ditch of the Timba Bah Co., which was planned to deliver water for placer mining along Rock Creek. Although this ditch is now in bad condition it must be repaired in order to work the placers, and either in connection with this work or after its completion a power plant could be built.

About half a mile above the headgate of the lower Timba Bah Canal a small hydroelectric plant was installed about 1895 in connection with an attempt to operate the Garfield mine. By means of a ditch approximately 1 mile long a head of about 50 feet is secured. Under this head, with a flow of 20 second-feet, a turbine would develop about 80 horsepower. The estimated minimum flow is based on the inclusion of water diverted from Christina Lake.

So far as the writer is informed those mentioned above comprise all the water powers that could be economically developed within the district. Although, as already intimated, it is not likely that continuous power could be depended on throughout the year, the fact that no expense would be incurred for diversion canals in the two larger schemes may make them worthy of consideration in the planning of the exploration work that must be done if the mines of the district are to be put upon a producing basis.

The installation of a hydroelectric plant on Little Popo Agie River 10 miles north of Atlantic City is regarded as technically feasible. A preliminary permit for the utilization of this power was granted in 1912 to the Beck Mining Co., but the right has since been abandoned. A diversion canal 2½ miles long was planned to deliver water at a point where an effective head of 750 feet would be attained. This

project lies within the Washakie National Forest, and through the courtesy of the Forest Service, the writer has had access to the application of the Beck Mining Co. leading to the permit referred to above. In this application figures are given representing the net horsepower calculated for average discharge per calendar month for parts of 1907 and 1908. For August, 1907, the calculated horsepower was 4,230. There was a gradual decrease until, for December, 1907, the figure was 1,698. For April, 1908, the horsepower figure given was 4,014, for June 17,760, for September 2,970, and for November 3,810. On January 26, 1912, the flow was calculated as capable of furnishing 1,110 horsepower. According to the formula horsepower = head flow × 0.08, these figures indicate that the minimum flow between August and December, 1907, was about 28 second-feet in December, and between April and November, 1908, was about 49 second-feet in September. The indicated flow for January 26, 1912, is 18.5 second-feet.

In 1915 the district engineer of the Forest Service included in a report on certain water-power projects situated on Popo Agie River records of stream gaging in 1914 on Little Popo Agie River at Young's orchard, west of Dallas. These records show in April, 1914, a flow of 62 second-feet, and in the following October 54 second-feet, the latter being the minimum for the seven months, April to November, during which records were kept.

In consideration of the figures given it seems safe to assume for the Little Popo Agie a minimum flow during seven consecutive months of each year of 40 second-feet, corresponding to 2,400 horsepower; during ten months of 25 second-feet, or 1,500 horsepower; and an extreme minimum of 15 second-feet, or 900 horsepower.

In the foregoing calculations no account is taken of any diversion of water from Christina Lake to Rock Creek.

MILLING OF THE ORES.

In general the ores of the Atlantic and Lewiston districts must be treated on the ground, though lots of exceptional value may be shipped to a smelter. Thus far, aside from the operations of the Beck Mining Co. at the Duncan mine, there has been no systematic endeavor in milling to save gold otherwise than by amalgamation. On the whole the percentages of extraction have been low, in the milling of both unoxidized and oxidized ores, and in future operations better though less simple methods will be in general required.

The problems of ore treatment have been discussed by Knight,[1] from whose valuable report the following quotation is made:

> As soon as the quartz ledges in the Sweetwater district had been opened to a depth varying from 10 to 25 feet, stamp mills were ordered. They were large and small,

[1] Knight, W. C., op. cit., pp. 24 et seq.

and early in 1870 there were 10 or 15 mills in operation or nearly completed. On the very outset there were serious complaints as to the refractory nature of the ore, and in one case at least the stamp mill was abandoned and two arrastres erected in its place. The scouring process of the arrastre brightened the gold and made amalgamation more perfect. The bulk of the milling has always been done with stamps of various patterns and weights, but the saving has been very unsatisfactory. For many years I have assayed the tailings from these camps, and they have never carried less than $5 per ton in gold and in the majority of cases they have assayed from $8 to $20 per ton. The early mill men did not save the tailings, or there would have been many valuable dumps to be worked by some of the modern methods. For years stamp mills were condemned in this district and many other contrivances were brought in to take their place. With the exception of the Huntington mill, every other device has utterly failed. At the present time the stamp mill has been reinstated, it having been proven to be the most effectual crushing device, although as a matter of fact there have been serious complications in the free-milling process, owing to the gold being coated and not amalgamating. This has, beyond question, been the source of the greatest loss, but coarse crushing has always claimed more or less of the values.

The results of amalgamation, cyanidation, and chlorination tests made by Knight on samples of ore from the mines of the region are summarized in the appended table:

Results of tests of ore from Atlantic and Lewiston districts.

Mine.	Sample.	Gold.	Amalgamation saving.	Sands assay.	Cyanide tails.	Chlorination saving.
Atlantic City.		*Ounces per ton.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Rose	10 pounds	2.16	0.95	0.108	Trace.	.....
Diana	1 sack	1.5	.82	.027	Trace.	65
Garfield	do	.99	.92	.072	None.	95
Mars	10 pounds	.92	.94	.955	Trace.	99
Victoria Regia	1 sack	.65	.81	.120	0.025	77
Cariboo	do	.61	.78	.130	None.	71
Jim Dyre	8 pounds	.36	.83	.060	Trace.	99
Rustler	1 sack	.171	.94	.012	None.	.....
King Solomon	do	.162	.62	.060	.01	74
South Pass.						
Carissa	5 pounds	1.24	.80	.250	.041	56
Lewiston.						
Spotted Horse	1 sack	1.86	.79	.400	.180	Poor.
Midget	do	.977	.58	.284	.200	13
Mint	do	.612	.57	.260	.140	51
Little Bee	do	.252	.68	.080	Trace.	99

The following comments on the results obtained in the investigation are made by Knight:

The ore from the Mint mine is typical of the Lewiston ores and shows clearly what the miners have been struggling with. In the ordinary stamp mill the saving has been very much less than in the tests, since the ore was not crushed as fine and there was no scouring device to aid amalgamation. When a quantity of this ore was treated with warm, concentrated hydrochloric acid, then washed and treated by the free-milling process, the tailings assayed only a trace of gold. It is certain that the poor savings made by chlorination and cyanide were due to the coated condition of the gold.

The ore from the Midget mine resembles that from the Mint. Here ordinary amalgamation would mean a saving of less than 40 per cent of the gold, though some scouring device would assist in making a better recovery. It is probable that, after roasting, chlorination would make a better saving than is indicated by any of the tests applied. Ores of this type should be tested by various chlorination processes. If any of them will extract 90 per cent of the gold it would surpass any process that has been applied to these ores thus far.

Crush the ores as fine as you can consistently. This you will have to decide by milling tests. Occasionally capacity must be sacrificed to secure high recovery, but this must not be carried to the extreme. Utilize concentration wherever possible and treat the concentrates with cyanide or chlorination, roasting if necessary. Utilize the cyanide process to handle tailings. Do not store the sands, as any contained sulphides will oxidize and form soluble compounds that must be washed out or neutralized to prevent cyanide losses.

The tests summarized in the table given on page 40 were made for the most part on oxidized ores, but in the main the suggestions offered are applicable to the treatment of unoxidized ores as well. Naturally the amalgamation tests show extractions that are greater than could be obtained in practice with economical working. A relatively low extraction for sulphide ores is indicated by current statements that amalgamation recoveries at the Carissa and Duncan mills have been between 60 and 75 per cent on ores carrying from 0.50 to 0.75 ounce of gold to the ton. Such results are not greatly inferior to those that have been attained in the treatment of unoxidized gold ores in the stamp mills of Clear Creek and Gilpin counties, Colo. In the Colorado mills the sulphides are concentrated and are shipped out and smelted, transportation and smelting charges being both very low. Obviously concentrates valued at $30 or even $60 a ton could not be shipped from the Atlantic district under present conditions, but in planning the treatment of ore consideration might be given to the possible advantage of amalgamation, plus concentration, plus regrinding of concentrate, followed either by amalgamation or by cyanidation. Where the gold occurs mainly in the sulphides the suggested treatment would obviate fine crushing of the ore as a whole.

To one like the present writer, having only a very general knowledge of gold milling, amalgamation supplemented by cyanidation would seem to be as a rule the most satisfactory procedure, but it is of interest to note that in the treatment of unoxidized ore at the Duncan mill in 1913 amalgamation had been entirely abandoned. This mill[1] is equipped with four Nissen stamps. The original plan was to save the gold by inside and outside amalgamation. With clear water and careful working 75 per cent extraction was possible, but the water supply is scanty and when exhaust water from a steam pump was admitted very careful work was required to keep

[1] Trumbull, L. W., op. cit., pp. 98–100 (description of Duncan mill by D. C. Kelso).

the extraction above 60 per cent. Experiments were made with the idea of crushing in cyanide solution and amalgamating on plates, but the method of all sliming and cyanidation without amalgamation was finally adopted. The capacity of the mill is about 30 tons a day. For February, 1913, the cost of treatment is given as $2.70 a ton, and of this amount $1.19 is charged against gasoline and distillate used for raising power.

The Dexter or Timba Bah mill at Atlantic City is equipped with 20 stamps of 1,050 pounds each and is provided with apparatus for cyanide treatment. The mill was erected in 1908 but has never been in regular operation.

The Carissa mill, with 10 stamps of 550 pounds, is provided with amalgamating devices and Wilfley concentration tables.

At the Mary Ellen mine there is a 5-foot Huntington mill equipped with amalgamating plates.

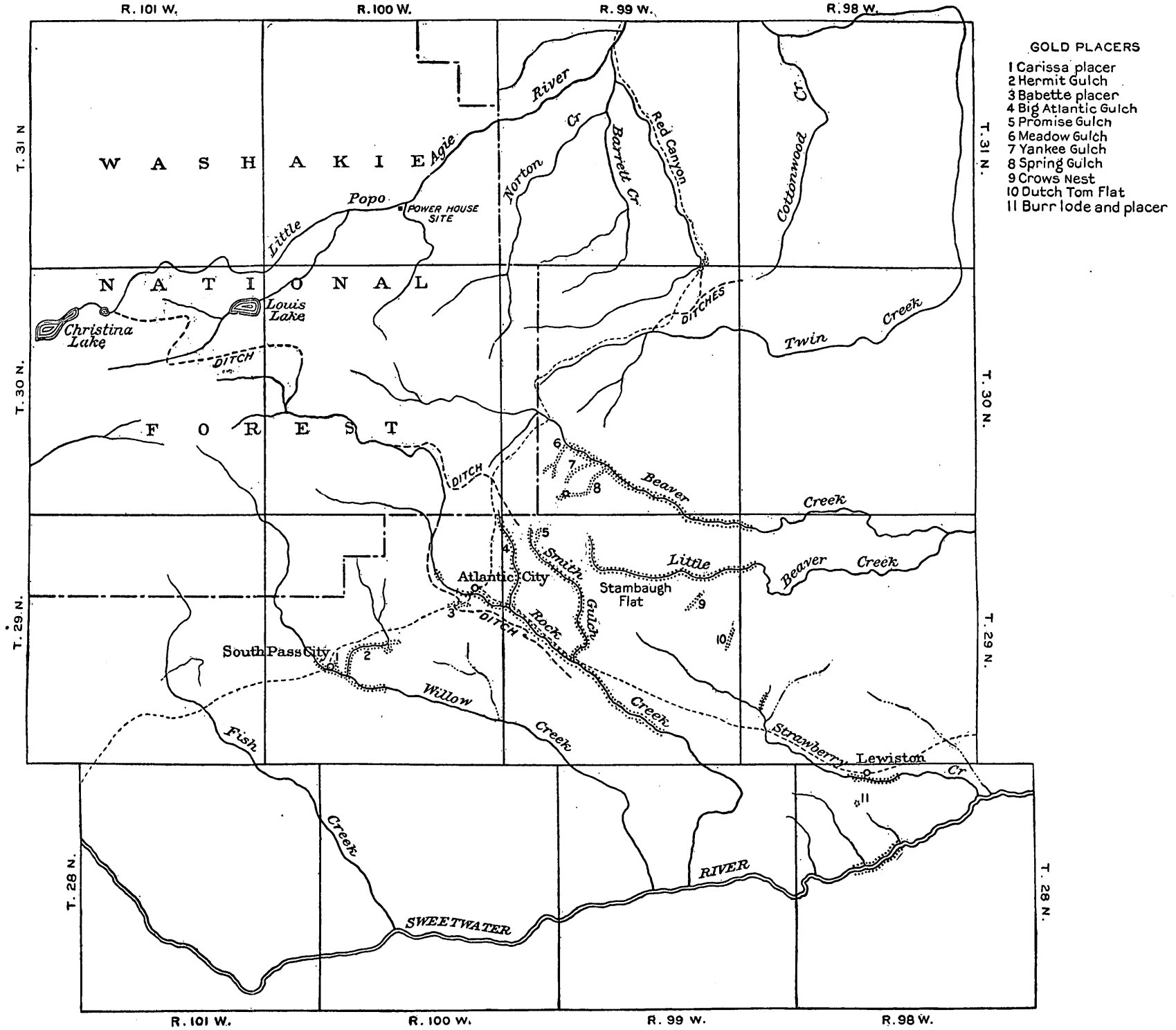
PLACER DEPOSITS.

The alluvial deposits of the Atlantic and Lewiston districts have not been studied in a systematic way, so that only a very brief discussion of this subject can be presented. On Plate III the distribution of the gold-bearing gravels is shown in part.

The greater proportion of the alluvial gold thus far produced has been won by means of the pan or rocker or by sluicing in a small way. The richer gravels occurred in shallow drains heading in ground traversed by gold-bearing lodes. Placers in such situations were usually of very small extent, but as a rule the gravels were thin and therefore readily worked. The small streams in several gulches were diverted by ditches, some of them a mile or more long, but operations were mainly limited to the spring months because of insufficient water at other seasons. Among the small placers that were worked to advantage within the period 1867 to 1872 were those derived from the Carissa lode, near South Pass City; those of Big Atlantic, Smith, and Promise gulches, east of Atlantic City; of Meadow, Yankee, and Spring gulches, near Miners Delight; of the Crows Nest and Dutch Tom flats, to the southeast; and of several localities in the vicinity of Lewiston. The typical gold from these placers was rough and rather coarse, and nuggets weighing as much as 2 ounces were occasionally found.

During recent years there has been a small and sporadic production by individual miners, but in the main the small placers may be regarded as offering little promise for the future.

A small but steady production of gold has been made for several years from gravels occurring in a ravine on the south side of Rock Creek near Atlantic City. The principal workings are on the Babette



SKETCH MAP OF ATLANTIC AND ADJACENT DISTRICTS, WYO., SHOWING DISTRIBUTION OF GOLD PLACERS IN PART.

property. Here loose material fills the valley to a depth of 10 to 20 feet, forming a deposit from 50 to perhaps 150 feet wide. Apparently the best dirt occurs in bedrock along a definite channel, and the deposit is worked by means of a drift. The stream is small, but a sufficient volume of water for sluicing is made intermittently available by means of a dam.

Although the larger part of the alluvial gold produced during the early years of activity came from small placers occurring in headwater drains, stream placers were also worked in several places. These deposits occur in all the gulches that receive drainage from the mineralized areas, and downstream from these areas gravels occurring along the principal creeks carry more or less gold. Gulches having grades steep enough to permit ready disposal of waste are Hermit Gulch, near South Pass City, and Big Atlantic and Smith gulches, east of Atlantic City. Of these the two last appear to have been the most productive, though because of diminished slope the lower part of Smith Gulch was never worked extensively.

In 1914 the X. L. Dredging Co. completed a ditch to deliver Rock Creek waters into the upper part of Smith Gulch, and here hydraulic operations were carried on for a few weeks. Whether or not the results of this work were satisfactory is unknown to the writer. During the late part of summer and the autumn this company was reported to be washing gravels at a locality on Little Beaver Creek several miles east of Smith Gulch.

The following quotation is taken from a report by Jamison,[1] former State geologist:

> The X. L. Dredging Co. owns 1,680 acres of placer ground on Little Beaver, Smith, Promise, and Big Atlantic gulches and Stambaugh Flat. The company has constructed a ditch from Rock Creek, 7 miles above Atlantic City, to the placers. A large part of the Stambaugh Flat ground is reported to have a gold tenor of $1.40 per cubic yard, while that in the gulches yields $0.50 per yard.

The gravels along Beaver Creek are reported to carry gold all the way to the junction with Popo Agie River northeast of Hudson. A sample representing 3 feet of gravel on a bar half a mile above the mouth of the creek was found by Schrader [2] to contain gold to the amount of six colors to the pan, corresponding to a value of about 33 cents to the cubic yard.

Placer deposits on Willow Creek near South Pass City and on Rock Creek near Atlantic City were worked for the most part before 1876. In both places the valley floors are from 200 to 1,000 feet wide, and in general the gravels are said to be from 5 to 20 feet deep. The Rock Creek operations seem to have been more extensive than those on Wil-

[1] Jamison, C. E., Geology and mineral resources of Fremont County, Wyo., p. 79, Cheyenne, 1911.

[2] Schrader, F. C., Gold placers on Wind and Bighorn rivers, Wyo.: U. S. Geol. Survey Bull. 580, p. 142, 1914.

low Creek. Because the gravel flat is broad, the stream grade slight, and the gravel bed rather deep, groundsluicing was not generally practicable and the deposits were worked mainly by means of pits sunk to bedrock. Placer workings below Atlantic City are reported to have yielded in 1869 from $3.50 to $12 a day [1] to the man.

After 1876 and until about 1884 little interest was manifested in the Rock Creek placers. In 1884 French capital was brought into the district through the efforts of an engineer named Émile Granier. The following letter from Granier to L. D. Ricketts is quoted from the report of the Wyoming Territorial Geologist for 1886:

In 1884 I bought from the original locators some placer claims on Willow Creek, Rock Creek, Strawberry Creek, and Sweetwater River, and the next year I commenced digging ditches for the proposed working by those creeks. The ditch is 10.5 miles [2] long, 3 feet wide at the bottom, 6.75 feet wide at the top, 2.5 feet deep, with 10 feet grade to the mile, and can carry 40 feet of water per second. I expected that the ditch would be filled up with water of Rock Creek alone long enough to wash during the whole summer; but Rock Creek was not sufficient, and I had to finish the big ditch that will carry the water of Christina Lake to the head of Rock Creek. This ditch is 6 miles long, 5 feet wide at the bottom, 11 feet wide at water line, and 3 feet deep and 16 feet grade per mile, and can carry 144 feet of water per second. It was cut through solid granite rock for more than half of the way. It has a flume, on trestles 70 feet high and 500 feet long, 6 feet wide and 4 feet high.

Christina Lake is about 1½ miles long, and it is situated at the foot of Atlantic Peak, at 10,000 feet above the level of the sea.

I intend to wash the Rock Creek bottom with one of Joshua Hendy's hydraulic elevators, because the grade of the creek is so small that it is impossible to wash off the tailings. It is not yet quite certain that this machine will work well.

This plant was operated during the three seasons 1890 to 1892 at a point about 2 miles below Atlantic City. A large amount of gravel was moved, but although the value of the gold produced is reported to have been about $200,000, the operations of the Christina Lake Co. ceased in 1892.

The following is quoted from Knight: [3]

Special mention should be made of Rock Creek, from Atlantic for a distance of 4 miles below. The gulch is quite narrow, the fall slight, bedrock rough and covered with 5 to 10 feet of gravel. The gold is coarse and is found upon bedrock. This ground lies just below the gold-bearing zone and has been prospected by pits and found to be very rich. Originally a Hendy hydraulic elevator was put in to handle the tailings, but for some reason it failed. Only a couple of years ago [that is, about 1899] a steam shovel was put in to handle the gravel, and on this occasion the failure was due to lack of water. I do not know of any absolute figures relating to the value of the property per cubic yard, but I am convinced that it is sufficiently rich to warrant the installation of a modern plant that will handle the gravel successfully and pay handsome dividend upon the investment.

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[1] Raymond, R. W., Statistics of mines and mining in the States and Territories west of the Rocky Mountains for 1869, p. 337, 1870.

[2] Actually constructed, about 5 miles.—A. C. S.

[3] Knight, W. C., The Sweetwater mining district, Fremont County, Wyo.: Wyoming Univ. Geol. Survey Bull., June, 1901, p. 23.

The only locality on Sweetwater River that was visited by the writer lies immediately south of Lewiston. Here a gravel deposit forms a flat half a mile or more long. Gold in the form of minute flakes was found in nearly all of several lots of dirt that were panned. These samples were taken practically at the surface. The deposit is about 6 miles below the mouth of Rock Creek and by its position must have received wash from both the Atlantic and the Lewiston lode zones.

It is considered that systematic sampling of this placer is warranted and the suggestion is made that this could best be done by means of churn drills. An adequate number of test shafts would be very expensive, work already done having shown that in sinking to bedrock pumps of large capacity are required.

The occurrence of placer gold along Red Canyon (see Pl. III) is worthy of passing mention because at one time the deposits were made the basis of a rather remarkable promoting exploit. Certain capitalists were induced to form a company and to buy up all the lands along the creek bottom, most of which were owned by prosperous ranchers. Although the ground is commonly regarded as valueless for mining, the ranches are all tenanted, garden truck, fruit, and alfalfa are raised, sheep are wintered, and the venture appears to have been financially successful. The uppermost farm, known as the Tweed ranch, is served by a ditch from Twin Creek. Adjacent to this ditch and visible from the wagon road there are old placer workings at several points. A general cover of gravel appears on the broad ridge that forms the divide between Red Canyon and Twin Creek, and it is obvious that the locally concentrated gold has been derived from this deposit. The bedrock formations are limestone and sandstones, but the gravel is composed almost entirely of crystalline rocks which must have come from the Wind River Range, a considerable distance west of the present headwaters of Red Canyon and Twin creeks. Perched high above the beds of the nearest streams and separated as they now are from the area of pre-Cambrian crystalline rocks by intervening canyons, these gravel beds point to marked drainage changes in recent geologic time—changes whose interpretation can not be attempted until the erosional history of the general region has been studied in detail.

ECONOMIC GEOLOGY OF THE NORTH LARAMIE MOUNTAINS, CONVERSE AND ALBANY COUNTIES, WYOMING.

By ARTHUR C. SPENCER.

INTRODUCTION.

During August, 1914, the writer visited all the better-known localities in southern Converse County and the northern tier of townships in Albany County, Wyo., where prospecting for metalliferous ores has been carried on at various times during the last 30 or 40 years. Most of the work has been done in the search for copper, but at one locality lead ores have been opened, at another chromic iron ore, and at another magnetic iron ore. With one exception all the mineral occurrences that were examined are associated with rocks of pre-Cambrian age. which constitute the core of the Laramie Mountains.

The writer was fortunate in having as guide and companion Mr. W. F. Mecum, of Douglas, Wyo., whose familiarity with the region made it possible to visit many widely separated localities in the comparatively short space of three weeks.

NORTH LARAMIE MOUNTAINS.

Definition.—The Laramie Mountains are the continuation into Wyoming of the Front Range of Colorado. Lying between the Great Plains on the east and the Laramie Basin on the west the range, from 10 to 25 miles wide, trends north from the State boundary to Laramie Peak, a distance of 85 miles, thence northwest for about 50 miles, where its characteristic features are lost in the vicinity of Casper. Parts of the range near Casper have received distinctive names, being known as the Casper, Haystack, and Deer Creek ranges. The following notes relate only to the northern part of the range.

Configuration.—The topography of the range is in general rugged, but the upper valleys of some of the streams are rather broad, and there are many interstream areas that are fairly smooth. Locally along the water parting such areas merge to form rolling uplands of considerable extent. Above these comparatively smooth areas rise the higher mountains and below them, along the lower courses of the

streams, deep and steep-walled gorges have been excavated. The height of land, as determined both by the principal summits and by the mountain passes, lies well to the southwest of the axis of the range.

Laramie Peak, the culminating summit, reaches an elevation above 10,000 feet, other mountains to the northwest ranging from about 9,000 down to 8,000 feet in height, and near the end of the range down to about 7,000 feet. The principal defiles are at elevations of 7,000 to 8,000 feet. Except in the vicinity of Laramie Peak the roughest part of this northern section of the range is along a zone lying a short distance back of the curving edge of the area of crystalline rocks which faces northeast and north. Here the streams commonly flow in narrow canyons from 500 to 700 feet or more in depth; and as the gorges are rather closely spaced the topography is extremely rough.

Drainage.—North Platte River flows nearly due north from its source west of the Medicine Bow Mountains in North Park, Colo., for about 100 miles to the mouth of Sweetwater River, where it turns to sweep in a great curve around the northwest end of the Laramie Range to Casper, thence flows east to Douglas and southeastward across the High Plains of Wyoming and Nebraska. Thus the northern part of the Laramie Range is drained on both sides by tributaries of the North Platte—on the southwest by headwater streams of Medicine Bow River and on the west, north, and east by creeks that flow directly to the master stream.

The drainage pattern is distinctly asymmetric, the divide between streams that flow south or southwest and those that flow north, northeast, or east being situated southeast of the axis of the mountainous belt.

Climate.—The average yearly precipitation within the northern part of the Laramie Range is probably about 20 inches, or perhaps somewhat more than 50 per cent above that on the plains to the east and double that on the Laramie Plains. This figure is an estimate based on the general character of vegetation and on the distribution of floral assemblages. At Lusk, on the high plains in southeastern Converse County, the annual precipitation is about 13 inches; at Fort Laramie, 50 miles south of Lusk, about 11 inches; and at Laramie about 10 inches. Meteorologic records relating to the stations named show that the spring and summer precipitation is materially greater than that of autumn and winter; but as in the mountains the winter snows commonly accumulate to depths of 2 feet or more it is evident that here the precipitation is more evenly distributed throughout the seasons.

The mean annual temperature at elevations below 6,000 feet is probably about 42° F., the extreme range being from −35° to +100°.

Above 6,000 feet the temperatures are of course lower, especially in summer, and frosts may occur during any month in localities at about 7,000 feet.

Vegetation, stock raising, and agriculture.—Like the Great Plains, the foothills and middle slopes of the Laramie Mountains are clothed with grasses, growth of which is especially luxuriant between elevations of 5,000 and 7,000 feet, or locally even up to 8,000 feet. Grass and sagebrush grow together on ridge slopes up to 6,500 feet and locally at higher elevations, but ridges and many extensive areas above this level are covered by grass alone. This region, in common with Wyoming as a whole, supports an extensive grazing industry. Horses, beef cattle, and sheep range through the mountains from May until late in September, when they are moved to valley ranches or to winter ranges on the surrounding plains.

Dry-land farming is carried on, though perhaps in general not with signal success, in smooth areas up to elevations of 7,000 feet, where wheat, oats, and potatoes usually mature during a short growing season and where many garden plants may be successfully grown.

In the broader valleys of the principal creeks, usually below 6,000 feet in elevation, oats, wheat, and forage crops, including alfalfa and timothy, are grown on irrigated ranches. Some of these operations carried on in connection with sheep or cattle raising are on a large scale. Apples, small fruits, and garden truck are also raised. Some of the irrigated lands of the foothill belt utilizing the natural flow of the mountain streams have been under cultivation since about 1880.

On La Prele Creek, about 10 miles east of Douglas, a great dam of concrete now stores the winter waters of this stream for use during the growing season. These works have greatly extended the amount of land irrigable from La Prele Creek, and the dam is so placed that the water may be used for generating electric energy, the use of which is contemplated for pumping water to irrigate lands along the north side of North Platte River west of Douglas. Other projects of the same sort in this region are probably feasible.

A large part of the mountainous area lying above an elevation of 7,000 feet supports a forest growth comprising white and yellow pines suitable for high-class lumber and the less valuable lodgepole and jack pines. Spruce and balsam fir occur but are not abundant, excepting on the slopes of Laramie Peak. Aspen is the principal deciduous tree in the mountains. Cottonwood and the maple-leaved ash or box elder grow along the lower valleys.

At a number of places sawmills have been operated, their product having been sold to ranchers and even at railroad points in competition with lumber from distant points. The better or more accessi-

ble forests have been cut over, so that this industry has greatly declined in recent years.

Railroads.—The region in which the North Laramie Mountains lie is served by four railroads. The southern part of the range is best reached from Medicine Bow station, on the Union Pacific Railroad. East of the mountains is the line of the Colorado & Southern Railway, running north from Cheyenne to Hartville Junction, southeast of Orin. North of the range are the Chicago & Northwestern Railway and the Chicago, Burlington & Quincy Railroad, which run parallel with North Platte River westward from Orin as far as Casper.

Wagon roads.—There are several easy routes north and south or northeast and southwest across the range, along any one of which a good road could be maintained with a moderate expenditure. Formerly there was a stage line from Medicine Bow and Rock Creek stations, on the Union Pacific Railroad, directly north to Fort Fetterman. At present most of the transmountain roads are out of repair, but a fairly good road is maintained through Cold Spring Pass, at the head of La Prele Creek. Routes parallel with the principal creeks are comparatively easy, but travel parallel with the mountain axis is everywhere difficult and in the main impracticable. Still nearly all parts of the region are accessible, though many localities can be reached only by making long detours from the main lines of travel.

From Glendo there is a good road into the district north of Laramie Peak, and this country is also readily accessible from Douglas. Mining prospects in the upper drainage basins of La Bonte and La Prele creeks are most directly reached from Douglas, and localities farther west in Converse County either from Glenrock or from Casper.

GEOLOGY.

GENERAL STRATIGRAPHY AND STRUCTURE.

The Laramie Range as a whole comprises a central belt of pre-Cambrian crystalline rocks flanked on both sides by areas of stratified rocks that range in age from Carboniferous to late Cretaceous and early Tertiary. Later Tertiary formations are also prominent locally, and Quaternary deposits may be recognized at several places just outside of the mountainous belt.

The structure of the range is anticlinal. The older crystalline rocks have been, as it were, pushed up along the axial belt, so that the younger sedimentary rocks dip away from the core on both sides. The nature of the contact between the crystalline rocks and the lowest sedimentary beds shows that the sediments were deposited on a nearly smooth suface. There is no doubt that the Paleozoic and Mesozoic formations, now seen in uptilted positions, once extended

across the area occupied by the mountains, having been since removed by erosion.

On the east and north side of the mountains the sedimentary formations almost everywhere have steep dips, and locally there are strong faults parallel with the general strike. In a few places there are cross faults which produce sharp irregularities in the boundary between sedimentary and crystalline rocks. On the side of the range next to the Laramie Plains the dips are more gentle, so that the profile of the uplift, if restored, would be that of an asymmetric arch with its crest well over toward the convex side of the belt of crystalline rocks. This belt is from 10 to 25 miles wide.

South of Laramie Peak the structure appears to be simple, but toward the northwest the main arch is flanked on the north by a series of minor flexures, almost the whole of the sedimentary series being here sharply but irregularly corrugated, within a zone about 10 miles wide, now characterized by considerable topographic relief. Subsequent to the uplift, which is assigned to the Laramide revolution, erosion was active during a long period, and the general topography of the region came to be very much what it is at present. Toward the end of this erosional period the downstream parts of the main river valleys to the east became clogged with débris, and gradually the deposition of materials derived from the mountains progressed upstream. The stream channels shifted from side to side, so that their deposits eventually merged to form extensive mantles of sedimentary material that covered the former foothills of the range and extended in many places well up on the mountain ridges and along some of the wider valleys quite to the main divide.

In this general region several Tertiary formations ranging in age from Eocene to Miocene have been recognized. The deposits of the Laramie Mountains belong mainly, if not entirely, to the Oligocene White River formation.

After the accumulation of the White River beds the region was one of "buried mountains," all the deeper valleys having been partly filled. Next came a renewal of active erosion. Within the mountains much of the débris was carried away and the streams cut their present valleys. One result of the deep infilling in Tertiary time was the diversion of the larger creeks from their previous courses. When erosion was renewed the new channels were maintained, and where bedrock was encountered narrow canyons were excavated. In places, therefore, the topography is now rougher than it was before the deposition of the White River formation.

The crystalline rocks that form the core of the mountains comprise coarse granite, serpentine, dark schists, and numerous nearly black dikes of diabase. The structural lines in this crystalline area generally trend southwest or transverse to the axis of the range.

THE GEOLOGIC MAP.

The topography of the North Laramie Mountains and the general distribution of the crystalline rocks and sedimentary formations along the range are shown on the accompanying map (Pl. IV). This map is mainly the result of field work done by N. H. Darton and assistants in 1906 and 1907, but in its compilation a map of the Douglas oil field by V. H. Barnett has been used and observations by C. J. Hares and by the present writer have been incorporated.

The short descriptions of the sedimentary formations occurring within the area discussed in this report are written by N. H. Darton, who has previously mapped the area on a smaller scale and parts of it on the same scale. (See pp. 53–56.) The time spent in the region by the writer was very short, and no attempt was made to separate the different crystalline rocks, so that in this connection the map is useful only in showing the general extent of the pre-Cambrian complex.

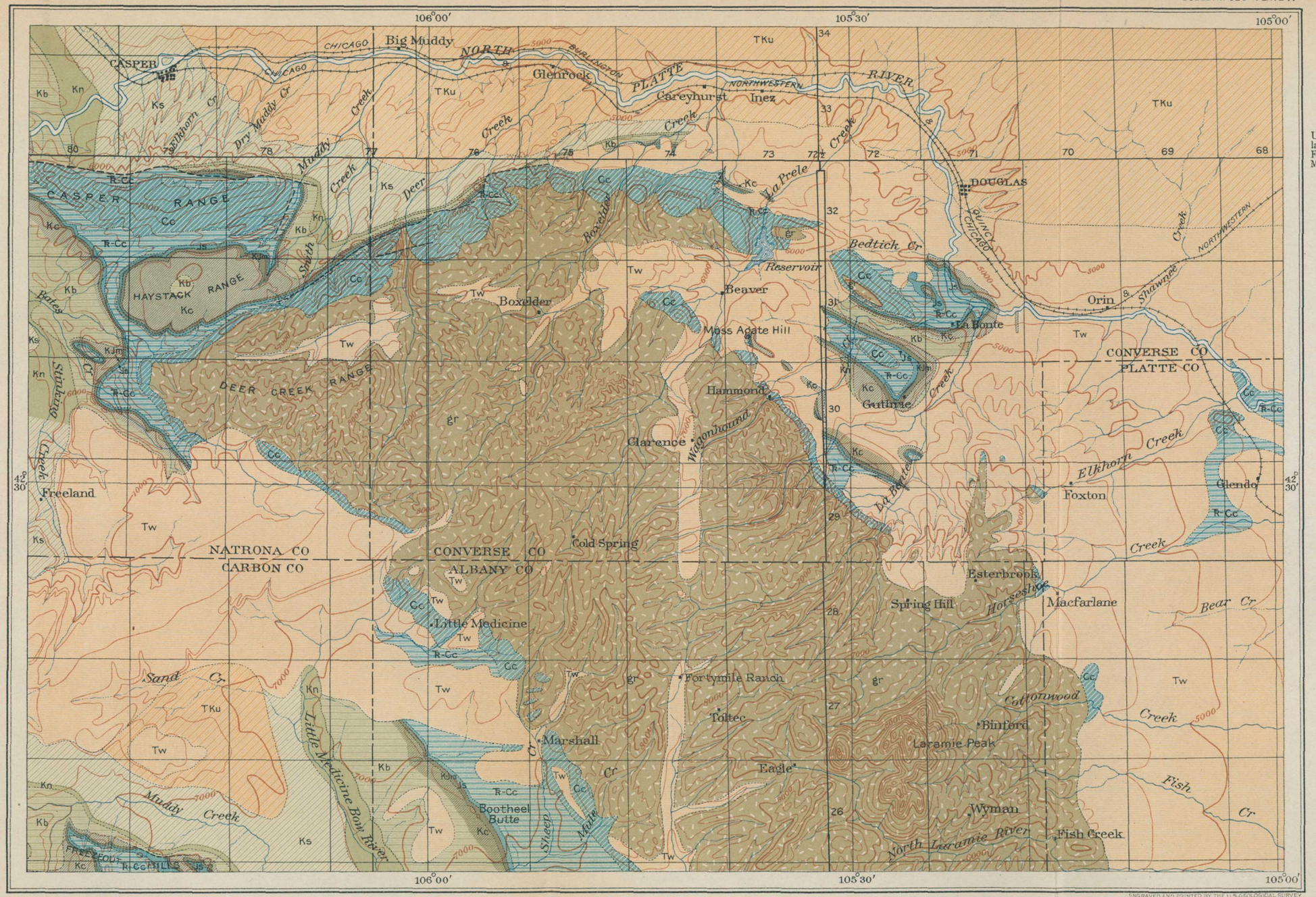
PRE-CAMBRIAN ROCKS.

The complex of crystalline rocks which constitutes the core of the North Laramie Mountains has not been studied in detail, but observations along routes traveled by the writer are sufficient to show the general resemblance of the pre-Cambrian complex here and in other districts to the south and west. The rocks of the Sherman quadrangle,[1] the northern edge of which is about 25 miles south of Laramie Peak, comprise schists and gneisses, which are regarded as in part of sedimentary and in part of igneous origin, and these rocks are interrupted by intrusive bodies of gabbro, syenite, anorthosite, granite, and granite porphyry. There are many narrow dikes of diabase and diorite which cut all the rocks named above. The contacts between the different sorts of rocks commonly trend southwest.

West of the termination of the Laramie Range, in the lower Sweetwater country, the principal rocks of the pre-Cambrian areas are red and gray granites, but there are also bodies of schist, as well as many narrow black or greenish dikes that run in northeast courses.

As in the neighboring regions that have been mentioned, coarse-grained granites are the most abundant rocks in the nucleus or core of the North Laramie Mountains. North of Laramie Peak, in the headwater region of Horseshoe and Elkhorn creeks, there are considerable areas of dark schistose rocks, more or less broken from place to place by intruded masses of granite. The schists trend southwest and the contacts between schists and intrusive rocks are

[1] U. S. Geol. Survey Geol. Atlas, Laramie-Sherman folio (No. 173), 1910.



LEGEND

- Tw — White River formation (Oligocene) — TERTIARY
- TKu — Undifferentiated Eocene and later Cretaceous, including Fort Union formation at top and Mesaverde formation at base — CRETACEOUS
- Ks — Steele shale — CRETACEOUS
- Kn — Niobrara shale — CRETACEOUS
- Kb — Benton shale — CRETACEOUS
- Kc — Cloverly (?) sandstone — CRETACEOUS
- K-Jm — Morrison formation — JURASSIC OR CRETACEOUS
- Js — Sundance formation — JURASSIC
- R-Cc — Chugwater formation (Triassic ?) including in places Forelle (?) limestone and Satanka (?) shale, of Pennsylvanian age — TRIASSIC (?) AND CARBONIFEROUS
- Cc — Casper formation (chiefly Pennsylvanian) — CARBONIFEROUS
- gr — Granite, gneiss, etc. — PRE-CAMBRIAN
- Fault

Area along north side of Casper Range shown as Chugwater formation (R-Cc) should be shown as granite, gneiss, etc.

GEOLOGIC MAP OF THE NORTH LARAMIE MOUNTAINS AND ADJACENT REGION, WYOMING

By N. H. Darton and others, 1907

Base map by N. H. Darton
Topography approximated from barometer readings, controlled by level lines, railroad profiles, etc.
Township base mostly from General Land Office plats

5 0 5 10 15 Miles

Contour interval 250 feet
Datum is mean sea level

1916

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

as a rule steeply inclined or nearly vertical. The writer's impression of these highly metamorphosed rocks is that they represent a series of interlayered sediments and volcanic rocks. Schists like those occurring in the eastern part of the region were not noted in traveling by a circuitous route from Spring Hill post office centrally along the range to Boxelder Creek. Hornblende schist was seen, however, on the south side of the range along the Converse-Albany line in R. 76 W., and the same rock is reported to occur in the high mountains at the head of Boxelder Creek. Throughout the middle section of the range coarse grained gray and red granites abound, and in the main they are interrupted only by narrow dikes of diabase.

Pegmatites, which are particularly coarse grained phases of the granite, occur in relatively small masses in all parts of the district.

In the western part of the range the granites predominate to a less degree and dark schists occur in many places. Locally these rocks inclose masses of serpentine, a metamorphic igneous rock older than the granites. In Natrona County, west of the area visited, the serpentine contains asbestos deposits which have been under development for several years and which it is hoped will prove to be of industrial importance.

SEDIMENTARY ROCKS.

By N. H. Darton.

GENERAL FEATURES.

The sedimentary rocks [1] on the north slope of the Laramie Mountains comprise strata from Carboniferous to early Tertiary in age. The succession appears to be conformable, but not all the geologic epochs are fully represented. The principal gaps are part of the Jurassic and probably much, if not all, of the Triassic. The Tertiary is represented by some of its earlier deposits in conformable sequence and also by the White River formation, which overlaps the other formations and in places lies on the granites and schists.

CARBONIFEROUS SYSTEM.

Casper formation.—The granites, schists, and other crystalline rocks of the Laramie Mountains are overlain by the sandstones and limestones of the Casper formation, whose thickness ranges from 400 to 700 feet. The maximum thickness is shown on La Bonte Creek a mile northwest of Spring Hill. A basal sandstone or quartzite, in most places conglomeratic, is 60 to 100 feet thick in the western

[1] These rocks are described by N. H. Darton (Paleozoic and Mesozoic of central Wyoming: Geol. Soc. America Bull., vol. 19, pp. 403–470, pls. 21–30, 1908), and the upper beds also by V. H. Barnett (Possibilities of oil in the Big Muddy dome: U. S. Geol. Survey Bull. 581, pp. 105–117, 1914; The Douglas oil and gas field: U. S. Geol. Survey Bull. 541, pp. 49–88, pl. 4, 1914).

part of the region but thins toward the east, so that in slopes west and south of Douglas the limestones are not far above the crystalline rocks. These limestones are light gray and from 200 to 500 feet thick. They are overlain by a hard gray massive sandstone which constitutes most of the mountain slopes. Extensive exposures occur in Muddy, Deer, Boxelder, and La Prele canyons. In La Prele Canyon the strata are flexed in a fine arch and the upper sandstone constitutes a well-known natural bridge. The sandstone is massive, coarse grained, and usually light colored, but in some of the ridges west of Douglas it weathers dark brown. It probably represents the Tensleep sandstone of the region farther north.

Fossils are not often found in the Casper beds, but those obtained indicate that while the formation belongs mainly in the Pennsylvanian series possibly the basal beds may be Mississippian.

Satanka (?) shale and Forelle (?) limestone.—The sandstone at the top of the Casper formation is overlain by 50 to 80 feet of red shale and this in turn by 20 to 30 feet of limestone. These beds are supposed to represent the Satanka shale and Forelle limestone of the Laramie Basin or the Opeche formation and Minnekahta limestone of the Black Hills in South Dakota. They crop out along the south side of the Casper Range, on the north slope of the Deer Creek Range, on La Prele Creek south of Inez, in the uplifts east and southeast of Beaver, and on the west side of the Laramie Mountains. A small outcrop of the limestone lying on 50 feet of shale appears in the bank of North Platte River 7 miles south of Douglas.

TRIASSIC (?) SYSTEM.

Chugwater formation.—The red shales and sandstones of the Chugwater formation crop out on the south side of the Casper Range, on both slopes of the Haystack Range, on the north side of the Deer Creek Range, in the several small uplifts south of Douglas, in the ridge east of Freeland, and along the west side of the Laramie Range near Marshall and Little Medicine. They probably underlie the White River formation in part of the valley about Beaver and southwest of Inez. The thickness of the formation averages about 1,200 feet, but on La Prele Creek it has been estimated at 1,500 feet. Thin beds of limestone and gypsum are included at some localities, notably at the east end of the Casper Range and north of Freeland.

JURASSIC SYSTEM.

Sundance formation.—The Sundance formation is exposed in narrow zones of outcrop adjoining those of the Chugwater formation mentioned above. The most extensive exposures are in the uplifts south of Douglas and near Freeland. The thickness of the formation

ranges from 200 to 300 feet. The basal beds consist largely of buff to reddish sandstones, and the upper beds are made up of 150 to 200 feet of gray shale with thin layers of limestone filled with characteristic fossils of Jurassic age. The shales are mostly dark gray and fissile, and therefore differ in character from the Morrison deposits.

JURASSIC OR CRETACEOUS SYSTEM.

Morrison formation.—The gray clay of the Morrison formation overlies the Sundance formation, and is exposed at many places from the Haystack Range eastward to the fault south of Glenrock and in the ridges south of Douglas.

The thickness of the formation averages about 150 feet, and its upper and lower limits are clearly defined. White and pale greenish-gray clay or massive shale predominates, but some portions weather pink, buff, or maroon. Thin beds of sandstone and limy concretions are included in the formation. Bones of characteristic dinosaurs occur in some places, notably in Como Bluff and the Freezeout Hills, a short distance southwest of the area treated in this report.

CRETACEOUS AND TERTIARY SYSTEMS.

Cloverly (?) sandstone.—The prominent sandstone series overlying the Morrison is for the present known as the Cloverly (?) sandstone, but it may here include beds having a greater range of age than in the type locality. It constitutes a large part of the Haystack Range, and its outcrop extends as a hogback ridge along the south side of the Deer Creek valley to the fault south of Glenrock. It appears again in the numerous ridges south of Douglas and also in a small area south of Inez. The thickness of the Cloverly (?) beds ranges from 90 to 140 feet. The rock is mainly gray massive sandstone in two members, separated by 20 to 40 feet of clay or shale of buff to maroon color similar to the Fuson formation of the Black Hills. The basal portion is conglomeratic at most places. The upper sandstone is thin bedded and rusty in color. South of Douglas there are three sandstone members.

Benton shale.—In the Benton shale begin the thick deposits of black shale, which constitute a large part of the Upper Cretaceous section. The formation occupies an area of considerable extent in the syncline of Muddy Creek and in the valley of Little Medicine Bow River. Its outcrop also extends along part of the valley of Bates Creek, the north slope of the Casper Range, and the foot of the mountain south of Glenrock. The Benton shale is about 1,500 feet thick. About 225 feet above its base it includes the Mowry shale member of light-gray hard shale containing large numbers of fish scales. This member is about 175 feet thick and is succeeded by dark shale containing a 100-foot sandstone member about 300 feet below its top.

Niobrara shale.—The dark shales at the top of the Benton give place within a short distance to the Niobrara shale, which crops out almost continuously along the north foot of the mountains from a point south of Casper to Boxelder Creek. It also crops out in the valleys of Bates Creek, Little Medicine Bow River, and Wagonhound Creek. The formation is about 250 feet thick, and the shales are in large part of light color, owing to the admixture of calcium carbonate. They weather to a pale-yellow tint, which is very characteristic. Some of the beds contain *Ostrea congesta*, mostly in small masses or thin layers.

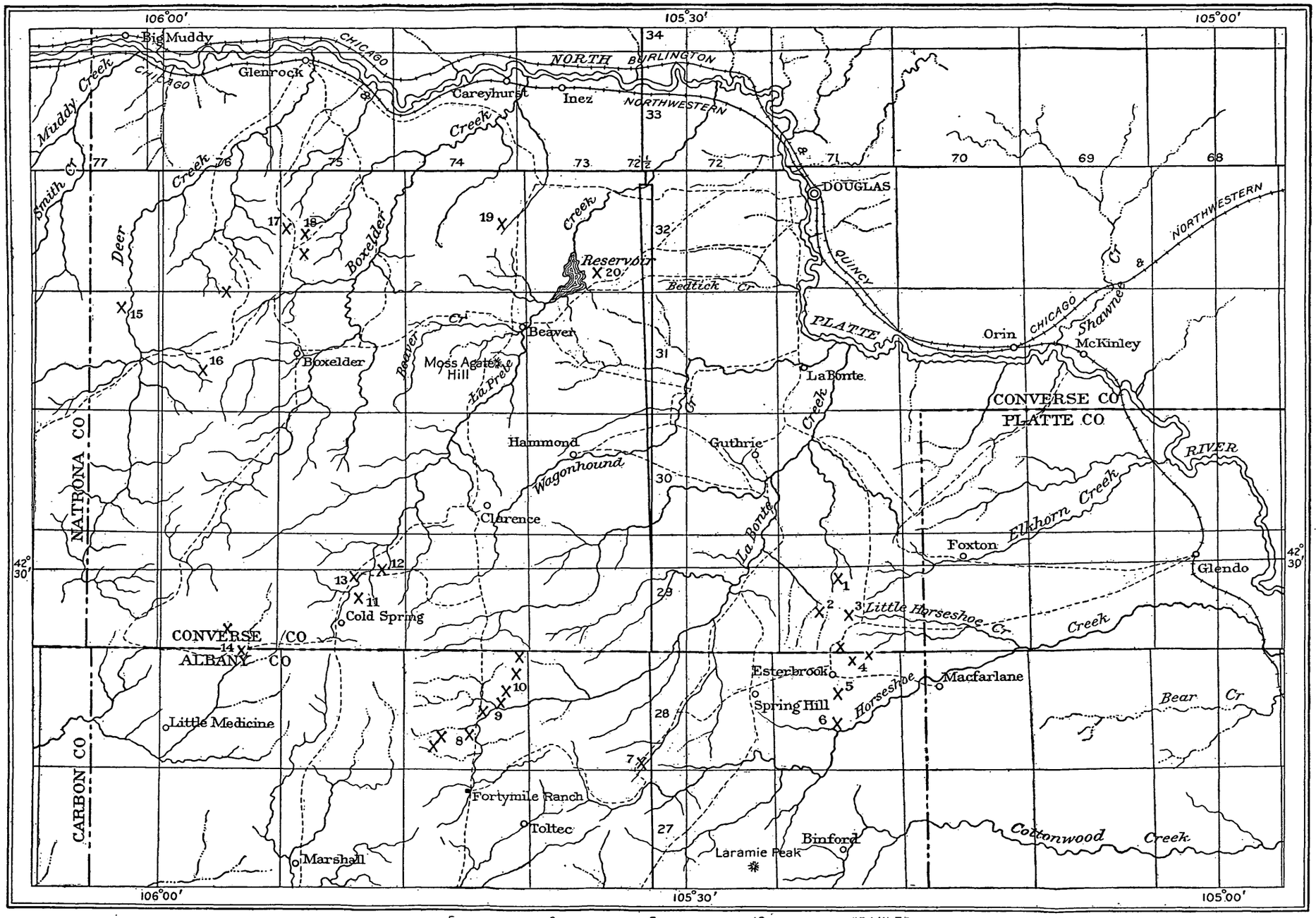
Later Cretaceous and early Tertiary formations.—Above the Niobrara shale in parts of this area are more than 9,100 feet of shales with interbedded sandstones and a few coal beds which represent the Steele shale, the Mesaverde, and higher Cretaceous formations; the Lance formation, classified as Tertiary (?); and the Fort Union formation, of Tertiary (Eocene) age.

White River formation.—The white clay and fine sand of the White River formation occur in many places on the northern slopes of the Laramie Mountains and adjoining ranges. Originally the formation covered all but the higher portions of the region, and much of it has been removed by erosion. Bodies of considerable size occur in the La Prele Valley about Beaver, and smaller outliers remain in the valleys south of the Deer Creek Range. A large area extends along the north slope of the mountains southwest of Douglas, and most of the La Bonte Valley as far south as Spring Hill is in White River beds. In many places these deposits contain bones which indicate that they are of Oligocene age.

MINERAL DEPOSITS IN THE NORTH LARAMIE MOUNTAINS.

DEVELOPMENT.

Evidences of prospecting, assigned by local tradition to the period immediately following the discovery of gold in the Cherry Creek and Pikes Peak districts in Colorado, are to be noted from place to place within the area of crystalline rocks lying northwest of Laramie Peak. Stories of gold having been won by individuals and of lost mines are current, but no printed records are known to justify the belief that there has ever been any production worthy of mention. A discovery of gold in the vicinity of War Bonnet Peak, 15 or 20 years ago, caused a short-lived interest in the country at the head of La Prele and La Bonte creeks. Though a promising vein was discovered the ore proved to be a mere pocket, and systematic work was soon abandoned. Since about 1875 more or less prospecting has been going on in one place or another, during more recent years mainly in the search for copper ores.



LIST OF PROSPECTS

1 TRAIL CREEK
2 SNOWBIRD
3 SAUL'S CAMP
4 KREISLEY PROSPECTS
5 THREE CRIPPLES
6 MAGGIE MURPHY
7 HOOSIER BOY
8 MAMMOTH
9 PYRAMID
10 LA BONTE CLAIMS
11 MAGNETITE LOCALITY
12 COPPER KING
13 ORIOLE
14 BRENNING
15 CHROMITE
16 SWEDE BOY
17 MORMON CANYON (copper and asbestos)
18 SMITH PROSPECT
19 MEWIS PROSPECT
20 HAZENVILLE

X⁴ Prospect (Number refers to list)

SKETCH MAP OF THE NORTH LARAMIE MOUNTAINS, WYO., SHOWING LOCATION OF PRINCIPAL MINERAL PROSPECTS.

The results of work thus far have been disappointing, and after having visited nearly all the principal prospects the writer concludes that there is little or no chance that really extensive copper deposits will ever be developed. It may be that some small deposits will be mined, but even for these the outlook is not very encouraging.

Several occurrences of magnetite were noted, but though some of the material is rich in iron, there are no indications that large deposits exist.

Chromite occurs in western Converse County but is remote from railroad transportation, and the writer's observations indicate that the deposit is not of sufficient size to warrant the undertaking of mining operations.

Deposits of asbestos in Natrona County, south of Casper, were not studied in connection with the present report, as they have been described by Diller.[1] There has been some prospecting for this mineral in western Converse County, but there has been no production, and if workable deposits exist, it is not likely that they will have any value, unless efforts to place the more fully developed deposits, referred to above, on a profitable industrial basis are successful.

Although no mining districts have been organized, the country immediately tributary to Esterbrook post office has been called the Spring Hill or preferably the North Laramie Peak district; the headwater region of La Prele and La Bonte creeks has been called the War Bonnet district, and part of the country drained by Deer Creek the Deer Creek district. Mining claims in Converse County must be registered in the United States land office at Douglas and those in Albany County at Laramie.

The accompanying sketch map (Pl. V) shows the approximate locations of the mining prospects that are mentioned in the following pages.

NORTH LARAMIE PEAK DISTRICT.

LOCATION AND GEOLOGY.

Esterbrook post office, near the center of the North Laramie Peak district, is about 25 miles south of Douglas and 20 miles west and somewhat south of Glendo. The district may be regarded as comprising an area measuring about 15 miles from east to west and 12 miles from north to south, the northern half lying in Converse County and the southern half in the northeast corner of Albany County.

Prospecting for mineral deposits has been carried on principally in the eastern part of the district. Here the gravel and sand deposits of

[1] Diller, J. S., The types, modes of occurrence, and important deposits of asbestos in the United States: U. S. Geol. Survey Bull. 470, pp. 505–524, 1911.

the White River formation overlap the crystalline rocks both from the north and from the east, but in such a manner as to leave an irregular area of the crystalline rocks extending about 7 miles northward from Esterbrook. The general distribution of the crystalline and younger rocks is shown on figure 3.

The crystalline rocks comprise dark schists that are usually rich in hornblende and locally contain mica, dikes of basic rock intrusive in these schists, and granites that are regarded as older than most of the basic dikes. The platy structure in the schists, most of the granite boundaries, and the dikes strike southwest. Beginning about 1½ miles north of Esterbrook, where the wagon road crosses Little Horseshoe Creek, there is a belt of country about 2 miles wide in which the hornblende schists and accompanying basic dikes are not interrupted by any large bodies of granite, but on the northwest and the southeast this belt is flanked by areas showing alternating bands of granite and schist. Observations in the main area indicate that the schists have been derived in large part from a complex set of volcanic lavas and tuffs interbedded with some ordinary sediments. That the sediments included limy layers is shown by the presence of epidote and garnet in some of the schists. Though some of the dikes are not laminated, the minerals of others have yielded to pressure, so that it is not everywhere possible to distinguish the dike rocks from those which they invade. Outside of the main schist area the same difficulty is encountered, and though in the wider bands the schists are regarded as forming a matrix for the granite, in the narrower ones the dark rock is probably as a rule intrusive with respect to the granite.

GENERAL CHARACTER AND OCCURRENCE OF THE MINERAL DEPOSITS.

There has been more prospecting in the older schists than in those that are supposed to be metamorphosed dikes, but the latter show some mineralization in several localities. Exploration work has consisted mainly in the prospecting of rock masses that are more or less thoroughly charged with one or both of the iron sulphides pyrite and pyrrhotite, but in several places there are veinlike bodies of quartz that carry metallic sulphides. Perhaps as a rule pyrite and pyrrhotite are accompanied by some chalcopyrite, though usually the proportion of this copper mineral is small and in places it is not visibly present in the sulphide-bearing material. Pyrrhotite deposits resembling those found near Esterbrook occur in the Hartville district, in eastern Wyoming, and have been prospected for copper. Galena occurs with pyrite and chalcopyrite in the Esterbrook lode but was not noted elsewhere.

As a rule the lodes and country rocks are very tight and dense, so that they are not readily penetrated by surface waters. In con-

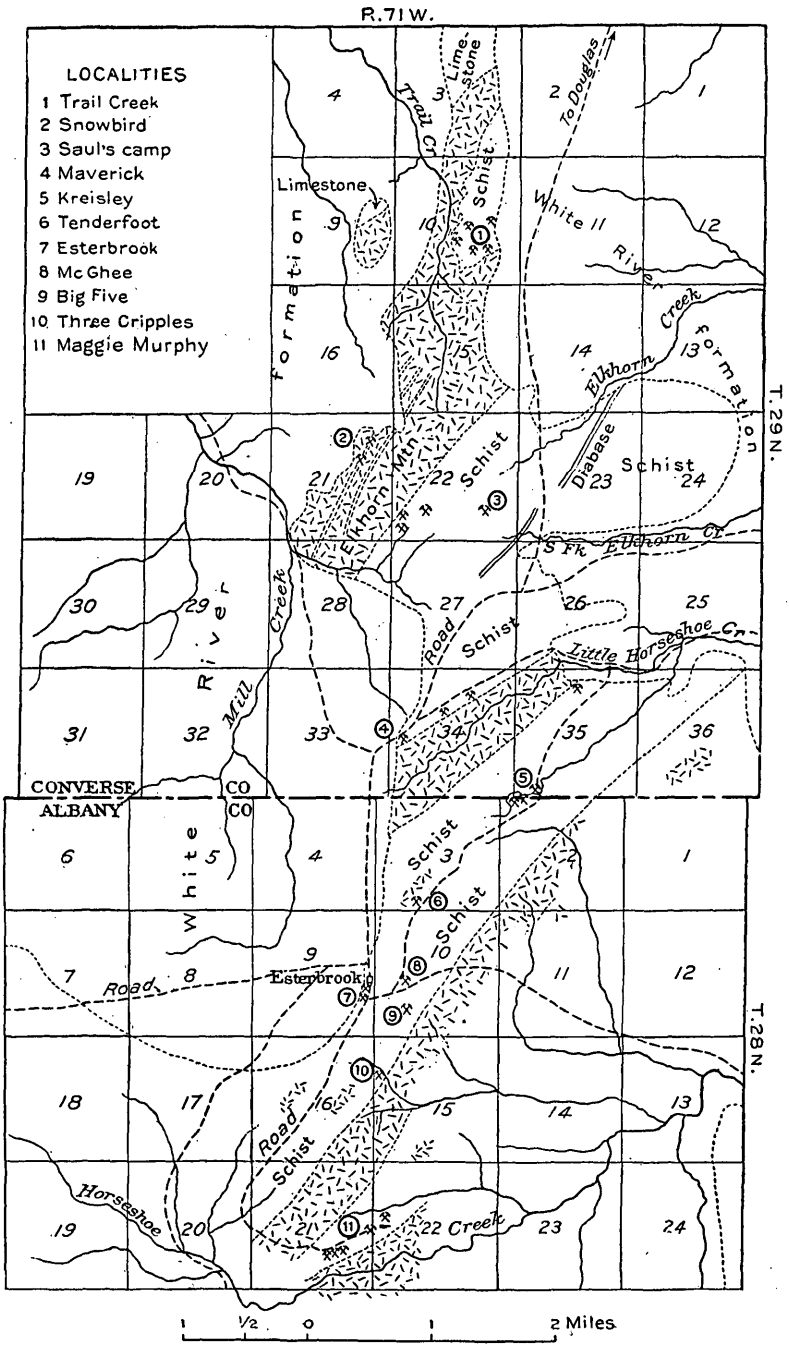


FIGURE 3.—Geologic sketch map of part of North Laramie Peak district. Areas indicated by the rock pattern are mainly granite.

sequence the lodes are not deeply weathered, sulphides may appear within a few feet of the surface, and there has been very little sulphide enrichment. However, in a few places pockets of chalcocite have been found near the surface, and green or blue copper carbonates are present here and there in the limonite caps. Usually water stands at depths less than 60 feet.

The sulphide deposits are tabular bodies or thin lenses that have been formed probably through partial replacement of preexisting rock. They occur in overlapping arrangement in more or less definite belts. The separate bodies and the belts as a whole strike southwest, parallel with the structure of the country rocks. So far as noted the dips are nearly vertical or to the northwest at rather steep angles. A line from Horseshoe Creek canyon northward through Esterbrook crosses the schist and granite belts diagonally and in a distance of about 9 miles intersects eight or nine fairly distinct sulphide belts. Nearly all the prospecting has been done within a north-south zone nowhere much more than 2 miles wide. Because only parts of this zone were traversed and outlying localities were not visited, no general statement can be made concerning the full extent of mineralization along the strike of the several sulphide belts. However, men familiar with the region report that mineralization like that in the vicinity of Esterbrook occurs from place to place as far southwest as Eagle Peak, which is a prominent landmark situated west of Laramie Peak.

MAGGIE MURPHY BELT.

The mining claims known as the Maggie Murphy group are about 3 miles south of Esterbrook, on the north side of Horseshoe Creek. The gorge of this stream is here about 700 feet deep, and its course is a little north of east. About half a mile farther south is a line of high rugged hills composed of coarse reddish granite, and the same rock forms the steep but flaring walls of the gorge. North of the canyon rim is a terrace or bench where hornblende schists are interlayered with minor masses of granite, and less than half a mile to the north rises another line of prominent granite hills. Here as elsewhere in the district the general trend of structural lines is southwest, but the strikes are somewhat more easterly than in the country to the north.

About 1900 the attention of prospectors was attracted to this locality by several outcrops of rusty schist showing small amounts of green copper minerals. This material was rightly judged to be the oxidized capping of sulphide deposits, and subsequent exploration by means of a shaft revealed the presence of a heavy body of the magnetic iron sulphide pyrrhotite. The iron cap is said to have been

very shallow. The shaft was sunk to a depth of 107 feet, and several minor openings were made, showing that sulphide mineralization extends at least half a mile toward the southwest and for some distance northeast of the main workings.

In one of the southwestern openings a layer of graphite-pyrrhotite schist from 1 to 2 feet thick was found to carry some chalcopyrite. Several hundred pounds of rock taken from the shallow shaft may have contained 3 or 4 per cent of copper, but samples that show no visible chalcopyrite were found by laboratory tests to contain no copper. In another opening in the southwestern section massive pyrrhotite was found.

The material from the deep shaft is principally schist composed of hornblende or hornblende and quartz mixed with pyrrhotite. Some of the rock is composed mainly of pyrrhotite, the hornblende and quartz being distributed as isolated grains or small bunches. Most of the material on the dump contains no visible chalcopyrite. It is not difficult to find specimens that contain chalcopyrite in considerable quantity, but apparently it occurs only in rock that contains also a greenish feldspar (oligoclase), which is usually rather coarsely intercrystallized with quartz. This feldspar-quartz material is present in relatively small amounts, and its relation to the mass of sulphide is not clear. So far as seen it does not occur in clean-walled veins or dikes, still its general appearance suggests that it has been injected into the pyrrhotite-bearing rock. Bunches of pyrrhotite that are found in it may be inclusions broken from the matrix. The chalcopyrite is mainly contemporaneous in crystallization with the feldspar and quartz, but it also occurs with the iron carbonate siderite in minute veinlets cutting these minerals. Rusty outcrops 300 to 400 feet southwest of the shaft and pits in limonitic material northeast of the shaft indicate that there is here a body of the pyrrhotitic rock from 10 to perhaps 40 feet wide and several hundred feet long, but the material seen on the dump does not suggest the presence of any valuable body of copper minerals. A possibility worthy of some consideration, however, is that there may be interlayered shoots of copper ore in the pyrrhotitic rock. Indications of such shoots might be sought by means of surface trenches or by shallow tunnels driven across the lode. Deep exploration should not be undertaken unless encouraging results are first obtained by prospecting near the surface.

At the time this property was being prospected several buildings were erected which are still in good condition. The wagon road from Esterbrook, though now in rather poor shape, could be repaired with slight expense.

THREE CRIPPLES AND TENDERFOOT BELTS.

Just northwest of the schists of the Maggie Murphy locality is a belt about 2,000 feet wide occupied mainly by granite but showing also thin layers of dark schist which are regarded as metamorphosed diabase dikes. About a mile southeast of Esterbrook prospecting in schists belonging to this belt has revealed the presence of disseminated pyrite, but nothing that can be regarded as of practical importance has been discovered.

Beyond the granite belt there is a belt occupied mainly by hornblende schists but containing some intercalated bodies of pink granite and locally dikes of white pegmatite. Southwest and west of Esterbrook the full width of this belt is not seen, because here the crystalline rocks are hidden by White River deposits, but to the northeast it is nearly a mile wide. Within this belt near Esterbrook and for 3 miles to the northeast there are many shallow pits showing ferruginous material evidently derived from sulphide-bearing rock, and in several places pyrrhotite or pyrite bodies have been found. From a rather cursory study it seems that the whole belt may comprise two or perhaps three fairly distinct minor belts of sulphide deposits. With respect to the possible occurrence of copper deposits, the results of prospecting thus far are not regarded as encouraging.

About half a mile south of Esterbrook post office is the Three Cripples shaft, said to have been opened to a depth of 96 feet in 1905. The immediate country rock is black schist, but a short distance southeast of the shaft there is a contact between this rock and coarse pink granite. The dump shows a large amount of massive pyrrhotite rock in every way like that from the Maggie Murphy shaft. A sample consisting of 25 chips taken from different parts of the dump was analyzed in the chemical laboratory of the Geological Survey by R. C. Wells with the following result:

Analysis of Three Cripples pyrrhotite rock.

Insoluble	28.38
Iron	41.80
Copper	.23
Cobalt	Trace.

Nickel, platinum, gold, and silver were not detectable in this material.

Here, as at the Maggie Murphy, portions of the rock that carry visible chalcopyrite also contain feldspar-quartz aggregates or bunches of quartz. The proportion of such material in the rock that has been mined is small. The surface improvements comprise a shaft house and a cabin, both in good repair. Part of the machinery has been taken away.

Though there are practically no outcrops along the Three Cripples lode it is possibly represented by iron caps disclosed in pits about 1,000 feet southwest and 1,800 feet northeast of the shaft.

Somewhat to the northwest of the supposed northeastward extension of the Three Cripples lode iron cap has been found in several pits whose positions suggest the presence of two other lines of sulphide bodies, making three in all within a band 600 feet wide bounded on the southeast by granite. Sulphides have been reached only at a shaft known as the Big Five, which is on the northwesternmost of these lodes, about 2,500 feet north-northeast of the Three Cripples shaft. This opening is probably about 50 feet deep. The material on the dump is mainly pyrrhotite rock, and here again chalcopyrite is seen only where bunches of quartz or feldspar and quartz are present.

About 1,200 feet north of the Big Five is an opening known as the McGhee shaft. Here there are gray schists more or less thoroughly charged with pyrite, but nothing of practical significance was found. This deposit may be regarded as belonging to the Three Cripples sulphide belt. Probably this belt extends for some distance northeast from the Big Five shaft, but it was not traced in this direction by the writer.

If the Big Five location is taken as being near the axis of the Three Cripples belt, the medial line of the Tenderfoot belt (p. 65) lies 1,800 or 2,000 feet to the northwest. Prospecting at several points along this belt has extended from Esterbrook northeastward for about 3 miles.

At Esterbrook a tabular body of quartz and calcite carrying lead carbonate at the outcrop and galena below the surface has been prospected, mainly by the Boston-Wyoming Copper Co. Though but poorly exposed the country rock appears to be mainly hornblende schist, but the principal outcrops are white pegmatite dikes from a few feet to 50 feet wide. Some of these dikes are greatly curved, as if they had been injected into contorted schists, but no direct evidence of structure of this sort was seen.

Along the outcrop siliceous lead carbonate occurs as a nearly vertical layer from a few inches to perhaps 3 feet thick, flanked on the west by 1 to 3 feet of finely crystalline calcite. The strike of these layers, as seen in a trench 100 feet long, ranges from N. 30° E. near the south end to N. 15° E. toward the north. From several workings it is seen that the main outcrop is not less than 500 feet long. Toward the south the lode appears to fork, and though it is not continuously exposed, what may be the easterly spur is seen in a pit situated nearly 400 feet from the main shaft on the east side of the wagon road.

There are three shafts on the strike of the lode. The Newell shaft, to the north, between two outcrops of white pegmatite, appears not

to have disclosed either lead minerals or the calcite layer which has been mentioned. About 270 feet south of the Newell shaft is an opening 60 feet deep, now used as a well, from which some ore has been taken, and 270 feet farther south is the principal shaft, 350 feet deep. On the main level at 335 feet drifts are said to have been opened in 1909 and 1910, 300 feet toward the south and 100 feet toward the north.

The material on the main dump consists principally of black schist but includes some rock having a massive appearance, which has been found by examination with the microscope to be a somewhat altered diabase. With the schist and diabase there are considerable amounts of calcite rock, and so far as seen the ore minerals occur only in association with this material. Presumably the relation is generally like that at the surface, where the ore layer lies parallel with the calcite layer. Chunks of the calcite rock contain thin layers of dense quartz and other layers containing disseminated grains and bunches of galena and of chalcopyrite, and at least locally such material appears to have formed the immediate wall of the galena streak. It is thought that the quartz and the sulphide minerals were deposited in partial replacement of the calcite. The course of the main lode corresponds with the strike of the hornblende schists in the neighborhood, but if the vein forks, as is suggested above, one of the spurs probably breaks across the country structure.

Though nothing that can be regarded as ore remains on the dump, it is reported that shoots of nearly solid galena 6 feet wide were found in the mine workings and that shipments of such ore were made. As already noted, chalcopyrite occurs in some of the lode stuff, but it is not present in any considerable amount. Persons directly concerned in this development were not interviewed, so that no statement can be made concerning the amount of ore that has been taken from the mine. However, about 17 tons of carbonate ore shipped prior to 1904 is reported to have given the following returns:[1]

Assay of Esterbrook lead ore.

Silver	ounces per ton	1.4
Gold	do	.035
Lead	per cent	34.65
Iron	do	7.00
Silica	do	34.00

The underground workings of this property were not accessible in 1914. Although, as shown above, the surface ore is very siliceous, it is sufficiently evident from the character of the material on the dump that oxidation does not extend to any great depth, and if shoots of galena are found this mineral could be readily and cheaply freed from

[1] Beeler, H. C., The North Laramie Peak copper district, p. 10, Cheyenne, 1904.

associated quartz or calcite. The boilers and hoist are well housed and appear to be in good condition.

Somewhat more than half a mile northeast of Esterbrook mining explorations were made about 1900 on claims known as the Tenderfoot group. In this section the belt of sulphide deposits is not less than 2,000 feet wide, as shown by pits and shafts in bodies of iron capping. Near the west side of the belt, about 200 feet west of a line of iron-stained croppings, a shaft 150 feet deep was put down, but a crosscut directed toward the southeast was abandoned before reaching the lode. The lode is probably made up of pyrrhotite.

Beyond the Tenderfoot location several openings were noted in iron cap, and doubtless there are others, which were not seen, to prove the continuance of this sulphide belt toward the northeast. About a mile from the Tenderfoot shaft is the Kreisley group of claims, where prospecting during the last two or three years has disclosed large bodies of pyrrhotite. Here, as usual, there are several parallel lodes. One of them is readily traceable for more than 600 feet and in places is certainly not less than 50 feet wide. Material from two shafts shows pyrrhotite mixed with hornblende and quartz, and similar rock essentially unoxidized crops out in the bed of a small creek.

When this property was visited in August, 1914, the owners were unwatering a shaft about 100 feet southeast of the pyrrhotite lode mentioned above. Here neither pyrrhotite nor pyrite had been encountered at a depth of 60 feet, the material from the shaft being yellow to red oxidized schist in which minor bunches and stringers of secondary copper minerals were found.

The northwestern edge of the schist zone that comprises the Three Cripples and Tenderfoot sulphide belts lies about 2,500 feet from the Kreisley workings. Near this edge and north of the Kreisley camp another line of pits in red and yellow jaspery iron cap was noted but not examined in detail.

MAVERICK PROSPECTS.

Northwest of the belt of schists that passes through Esterbrook there is a belt of granite about 2,000 feet wide, and beyond this lies what has been called on page 58 the main body of schists. The granite belt contains some schist, but the main schist area is sharply defined along a southwest-northeast contact with granite. Close to and parallel with this boundary there is a line of prospects about 4,000 feet long. The Maverick location is at the southwest end of this line just north of Little Horseshoe Creek. The type of mineralization here is different from that along the sulphide belts that have been described. Irregular veins of quartz from 3 to 10 feet wide follow a

general line parallel with the strike of the schists and trend from N. 45° W. to N. 55° W. There are several narrow dikes of pegmatite, and in one place a quartz vein grades into rock of this sort. On the Maverick claim there are two vertical quartz veins, both iron stained and rather vuggy, as seen at the surface. One of these veins 3 to 4 feet wide crops out for a distance of 60 feet. The other vein, 6 feet wide, lying to the southeast, has been opened by a 50-foot shaft. The rock on the dump is quartz containing irregular bunches of pyrite. No copper minerals were seen.

About 2,000 feet northeast of the Maverick shaft is a quartz vein 2 to 10 feet wide that forms a continuation of a pegmatite dike. There is no indication that the pegmatite carries pyrite, but the quartz is very ferruginous throughout the 300 feet of exposure. Along the strike of this vein 500 and 800 feet to the northeast there are pits in light-colored schists that seem to have contained pyrite.

SAUL'S CAMP.

The Maverick line of prospects noted in the preceding paragraphs lies along the southeast side of a belt of hornblende rocks nearly 2 miles wide, which is not broken by any large bodies of granite. In the central part of this belt, in the SE. ¼ sec. 22, T. 29 N., R. 72 W. (see fig. 3), is Saul's camp, where a group of 29 mining claims was located several years ago and surveyed for patent in 1914. Many prospect shafts have been opened, and in several of them copper minerals were found. The country rocks are mainly hornblende schists that the writer believes to be metamorphosed volcanic rocks. Locally there are layers that contain epidote or garnet, suggesting that the rocks from which the schists were derived contained thin beds of limestone. Several dikes of black basic rock like diabase cut the schists, and toward the northwest side of the schist belt there are several minor intrusions of granite. The layering in the schists strikes in general about N. 45° E., and the intrusive dikes trend in the same direction. The principal workings are on the Tarsus No. 1 claim, on the southeast slope of a prominent hill and the shaft is formed by ledges of black diabasic hornblendite.

A rather inconspicuous outcrop of gossan contained copper carbonate, and chalcocite was found in the first shaft only a few feet below the surface. This shaft was carried to a depth of 60 feet, and as the lower part showed nothing of particular promise, at a depth of 30 feet a northeast drift was started to follow a streak containing copper minerals. About 25 feet from the shaft a mass of chalcocite ore was cut. This ore proved to be a saddle-like body forming a crest or cap over a chimney of white clay. A raise was opened to the surface, and the clay was found to continue 15 feet below the

drift, or to a point about 45 feet from the surface. At that depth the first water was encountered, and near the water level small amounts of metallic copper were noted. The shaft was carried down to 98 feet, and at 85 feet a layer or lens of chalcopyrite-bearing rock 12 inches thick was found 12 feet southeast of the shaft. The schist lying between this lens and the shaft is reported to carry about 2 per cent of copper.[1]

The material on the dump consists mainly of hornblende schist but includes a large amount of pyritic rock, portions of which carry visible chalcopyrite. No pyrrhotite was noted, but nearly solid magnetite occurs as a layer about 8 inches thick. Samples of the richer ore have shown as much as 30 per cent of copper and from 6 to 8 ounces of silver and 0.03 ounce of gold to the ton. About 100 tons of ore said to carry about 9 per cent of copper was taken out during the development work, and most of this ore remains in the bins.

About 200 feet northeast of the main shaft limonite carrying small amounts of chalcocite and malachite has been opened by a 20-foot shaft. Outcrops near by show iron-stained rock containing small crystals of epidote.

About 400 feet east of the main shaft an opening 35 feet deep shows weathered hornblende schist that is strongly limonitic. In this vicinity, mainly toward the southeast, the compass needle is greatly disturbed, and the inference may be drawn that within an area perhaps 300 feet wide there are rocks carrying considerable amounts of pyrrhotite or of magnetite. Mr. H. C. Saul stated to the writer that a zone of magnetic disturbance can be traced for 1,000 feet or more toward the southeast.

At the 35-foot shaft two diamond-drill holes were bored. One, nearly vertical, is 256 feet deep; the other, inclined about 42° NW., is 250 feet on the incline. The cores from these holes show greenish schist with here and there a little pyrite or pyrrhotite and some minor showings of chalcopyrite. The amount of pyrrhotite contained in the rocks penetrated can not be regarded as sufficient to account for the observed deflection of the compass needle in this locality, and it is suggested that a body of magnetic iron sulphide may be present southeast of the shaft.

The equipment of the property includes a steam boiler, a hoist, and a diamond-drill outfit. There is an adequate shaft house and several other buildings.

From the foregoing notes it will be understood that the prospecting at and near the Tarsus shaft is not extensive. The work has been done in an intelligent way, and the results at the main shaft may be

[1] Saul, H. C., Mining operations in the North Laramie Peak mining district, Wyo.: Min. and Eng. World, vol. 40, p. 738, 1914.

regarded as somewhat encouraging. It appears to the writer that if additional explorations are made, one of the first steps should be to follow the chalcopyrite-bearing layers found in the shaft along their strike. Although results of prospecting the deposits of pyrrhotite that occur to the south have been discouraging, this can not be urged as an adequate reason against undertaking explorations in the zone of magnetic disturbance at Saul's camp.

About 2,500 feet from the Tarsus shaft, in a direction slightly north of west, a small body of chalcocite ore was found practically at the surface. Examination of the pit, which is situated on a high ridge, indicates that the ore occurred as a layer striking northeast, but the work done is insufficient to give any clear impression of the relations.

In a valley northwest of the locality just mentioned some prospecting has been done along a belt of pyritic hornblende-mica schist. Copper minerals are present, but nothing was seen that the writer would regard as warranting further development.

Approximately 3,000 feet northwest of the Tarsus shaft is the northeastward-striking boundary of the main schist area against granites that form a high ridge known as Elkhorn Mountain. (See fig. 3, p. 59.) In several places along this boundary for a distance of nearly 5,000 feet there are outcrops of dense white or greenish quartz. Although locally hidden and perhaps absent in places, this quartz appears to be a rather definite layer and where exposed is from 20 to 130 feet thick. It has not been prospected except at a point due west of the Tarsus shaft, where material from an 8-foot pit carries small amounts of pyrite and chalcopyrite.

SNOWBIRD GROUP.

The five patented mining claims known as the Snowbird group are about 1 mile from Saul's camp (see figs. 3 and 4), on the northwest side of Elkhorn Mountain. Granite is the principal country rock in this neighborhood, but there are two narrow bands of greenish schist that is regarded as sheared diabase, and just to the west is an extensive area underlain by partly consolidated sands and gravels belonging to the White River formation. The claims, which extend from northeast to southwest for a distance of nearly 7,500 feet, were evidently located with the object of covering a body of schist from 60 to 150 feet wide which is flanked by granite on both sides. Aside from shallow pits which show nothing of interest, the development work consists of two shafts—one, said to be 40 feet deep, and the other, 80 feet deep, about 2,500 and 3,800 feet, respectively, from the northeast end of the property. Northeast of the 40-foot shaft there are no bedrock outcrops, but at this place the dark schist appears, and a short distance to the southwest there are exposures of coarse

granite or pegmatite about midway between the sides of the schist belt. This pegmatite continues, apparently as a dike from a few feet to 15 feet in width, for several hundred feet, but at the 80-foot shaft its place is occupied by a strong vein of quartz. The granitic rock and the quartz body probably grade one into the other, but the exposures are not adequate to prove it. Material from the northeasterly shaft includes pegmatite and vein quartz and considerable

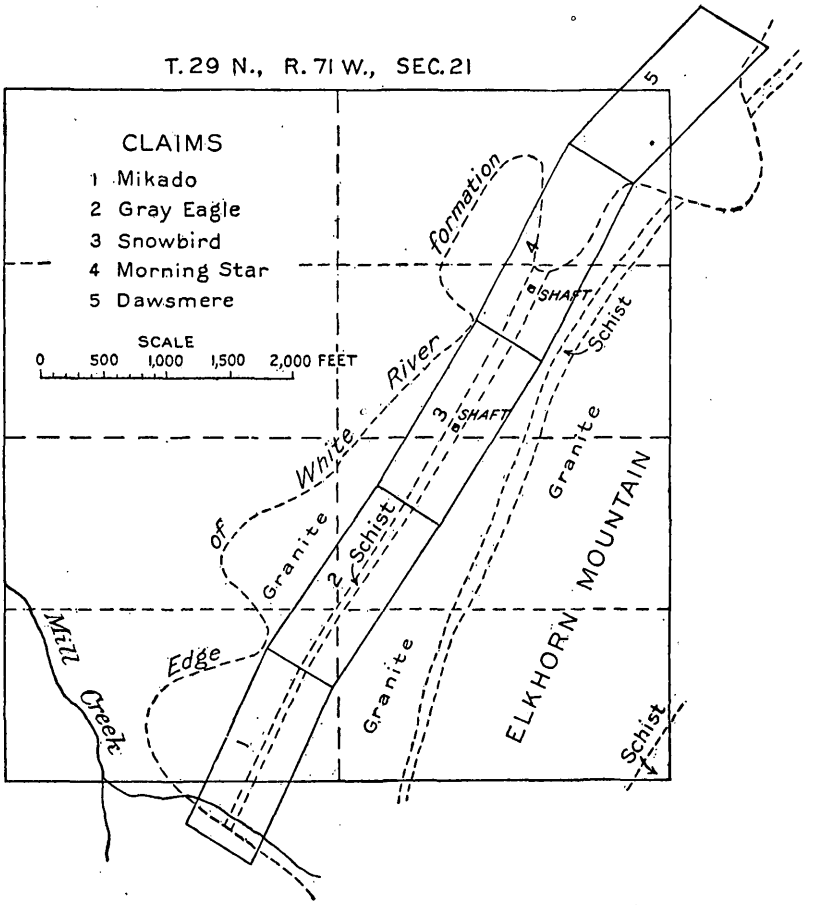


FIGURE 4.—Sketch map of Snowbird group, showing schist bands in granite.

iron-stained dirt. Specular hematite was noted, and there are minor showings of copper minerals. As seen at the surface near the southeasterly or main shaft the quartz vein is not less than 10 feet wide. The rock on the dump includes schist and quartz containing chalcopyrite, and small amounts of chalcocite and other secondary copper minerals were noted. From a study of the surface it is thought that the quartz vein may have a total length of 500 to 600 feet.

TRAIL CREEK GROUP.

About 2 miles north of Saul's camp is a group of mineral locations known as the Trail Creek claims. These claims cover a group of schist hills lying between two sharp canyons near the head of Trail Creek, a tributary of La Bonte Creek. In this vicinity (see figs. 3 and 5) the crystalline rocks appear in a band hardly more than half a mile wide with White River beds on both sides. The Elkhorn Mountain mass of granite extends along the southeast side of the schists of the Trail Creek group of claims, and the same rock cuts

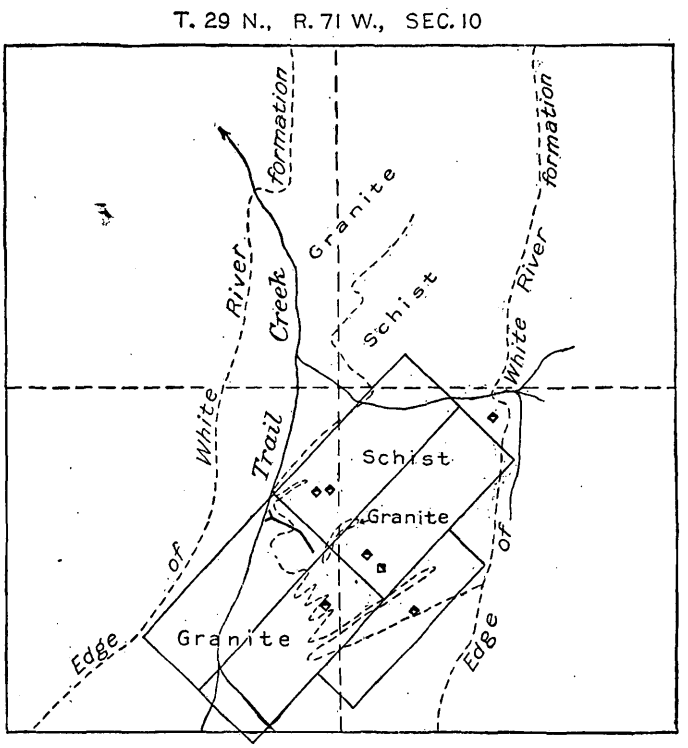


FIGURE 5.—Sketch map of Trail Creek group, showing local geology.

out these schists along their strike toward the southwest and flanks them again upon the northwest. Thus the general relations show that the schists are intruded by the granite, and this is shown also by narrow shoots of the igneous rock that penetrate the schists along the southwest side of the area. The invaded rocks are mainly hornblende schists striking southwest, but there are several large and many small irregular masses of iron-stained jasper. In one place a narrow jaspery vein carries considerable epidote. Evidences of sulphide mineralization are seen at many points where openings have been made in weathered iron caps.

The principal workings are a 75-foot shaft and a tunnel nearly 500 feet long near the west side of the schist area. The shaft is in coarse granite a few feet away from its contact with the schists. Here the rock is fractured, and in the breaks malachite and chalcocite occur in noteworthy but not large amounts. The level of the tunnel is 8 or 10 feet above the creek bed and more than 100 feet below the collar of the shaft. For the first 30 feet it is in granite, beyond which almost completely weathered hornblende schists are exposed. The presence of unoxidized remnants in several places and the generally ferruginous nature of the weathered material show that the rock was all very pyritic. About 75 feet from the tunnel portal a winze was sunk 25 feet on a body of ferruginous quartz which is said to have contained small amounts of copper minerals. Massive quartz from the lower part of the winze contains irregular bunches of pyrite, but no chalcopyrite was found. In August, 1914, after an unusually dry season, water was standing 10 feet below the tunnel floor. About 50 feet beyond the winze water was trickling down the sides of the tunnel, and here a slight deposition of copper salts was noted. No other copper signs were observed in the tunnel, and nothing regarded as encouraging was seen on the dump.

HOOSIER BOY GROUP.

About 1904 some prospecting was done on two groups of mining claims, known as the Hoosier Boy and Kentucky Belle properties, situated about 10 miles southwest of Esterbrook and 8 miles northwest of Laramie Peak. (See Pl. V.) The principal country rock is granite, but there are narrow dikes of schistose diabase which trend about N. 70° E., and it is along one of thesee dikes that the six Hoosier Boy claims and the two Kentucky Belle claims were located, their aggregate length being 12,000 feet. The Hoosier Boy claims lie mainly in a high grassy valley at the head of a tributary of La Bonte Creek, and the Kentucky Belle claims to the southwest, beyond a divide between La Bonte and Horseshoe Creek waters. Systematic prospecting, by means of shafts, was done at two points about a mile apart. In both places there are quartz veins that have the same strike as the dike of schistose rock in which they occur. These veins pinch and swell but are continuous or at least recurrent for distances of several hundred feet. At a point about 400 feet northeast of the Hoosier Boy shaft vein quartz grades into a mixture of quartz and feldspar. Some of the material from the shaft, which is said to be about 80 feet deep, contains small amounts of chalcopyrite.

The Kentucky Belle shaft is about 40 feet deep. The somewhat irregular quartz vein, which has a maximum width of perhaps 2 feet, carries considerable chalcopyrite and some chalcocite, the latter evidently of secondary origin.

WAR BONNET DISTRICT.

LOCATION AND GEOLOGY.

The War Bonnet district, bearing the name of a prominent peak situated near the southern edge of Converse County, may be regarded as comprising the country drained on the north by the headwater tributaries of La Prele Creek and the west fork of La Bonte Creek and on the south by some of the sources of Sheep Creek and Little Medicine Bow River. The country rock is mainly granite, but, as elsewhere throughout the North Laramie Mountains, this rock is cut by dikes of diabase, and the invading rocks have been rather generally converted into schist. The common trend of these dikes is about N. 50° E. In a few places schists were seen which may belong to a series of rocks that is older than the granite.

PROSPECTS NORTH OF FORTYMILE RANCH.

The Fortymile ranch, a station on the now abandoned stage road from Rock Creek north to Fort Fetterman, is situated near the head of West Fork of La Bonte Creek, in sec. 3, T. 27 N., R. 74 W. sixth principal meridian. From this place the stream flows nearly north through a rather open valley for about 3 miles and then turning east soon enters a deep and narrow gorge called La Bonte Canyon. Near the head of the canyon and also toward the west are dikes of diabase along and near which there has been considerable prospecting for copper. The most extensive work was done by incorporated companies known as the Pyramid Copper Co., the La Bonté Mining Co., and the Mammoth Mining & Milling Co. (See Pl. V.)

The property of the Pyramid Co. appears to have been taken over by the La Bonté Co., which held adjacent ground and which is said to have secured patents to five mining claims. Two lodes or veins were explored. One of these, the Pyramid vein, takes its name from a column of quartz-seamed granite about 25 feet high known as The Pyramid. The vein crops out at the base of this column and as exposed for a distance of about 75 feet has a width of about 20 feet. The vein strikes about N. 53° E. and is nearly vertical. Toward the southwest it is covered by gravel deposits in the creek valley.

Near The Pyramid is a shaft 30 feet deep, on the dump of which lies several tons of rock estimated to carry 5 per cent of copper. About 70 feet northeast of this shaft, just within the side valley, is the principal shaft, which was equipped with a steam hoist. The depth of this shaft may be as much as 100 feet. It was started at a point north of the vein, and as the rock on the dump is mainly granite the lode was probably not extensively explored. About 300 feet to the northeast a short tunnel has exposed a quartz body 3

feet wide which carries limonite at the outcrop and which is probably the continuation of the Pyramid vein. No attempt was made by the writer to trace this lode up the steep hill slope, but perhaps half a mile northeast of the Pyramid vein and approximately on its strike there are other exposures of quartz that carries copper minerals.

A short distance northwest of the Pyramid prospects hornblende schist crosses the side valley mentioned above and, trending northeast, appears as a dikelike body in a steep bluff on the east side of the stream about a mile above its mouth. Beyond the bluff the schist forms a prominent ridge, along which prospect pits have disclosed recurring lenses of quartz constituting an interrupted vein. Some of the quartz carries copper minerals. In order to prospect this ground a crosscut was opened from a point perhaps 250 feet below the crest of the schist ridge. The first granite and schist contact was cut 615 feet from the portal, and the far contact at 790 feet, showing the dike to be 175 feet wide. No considerable bodies of quartz were found in the crosscut, and a drift 200 feet to the northeast, 70 feet beyond the northwest wall, shows nothing but schist. Some of the rock on the dump contains disseminated pyrite, but copper minerals were not noted. This schist band was followed by the writer toward the northeast for more than a mile and is said to be traceable for several miles. It has been prospected at points approximately 1 and 2 miles northeast of The Pyramid.

About a mile southwest of The Pyramid a schist dike approximately on the strike of the one mentioned above has been prospected by a tunnel situated near the wagon road in the valley of the main creek.

The Mammoth vein is a body of dense quartz 50 feet or more in width which is traceable by scattered outcrops along a northeast course for a distance of perhaps 2,000 feet. This vein lies northwest of the tunnel referred to in the preceding paragraph. (See Pl. V.) Its outcrops are not generally rusty, but a single shaft has disclosed iron-stained material, showing that sulphide minerals are locally present.

About a mile northwest of the schist dike that traverses the La Bonté group there is another dike of the same sort of rock along which prospecting has been done at intervals for a distance of fully 2 miles. From place to place the schist forms the matrix of quartz bodies that conform with its northeast strike. Where work has been done pyrite is usually found, and in a few places copper minerals are present. It is said that 12 or 15 years ago rich gold ore was found in quartz occurring in this body of schist, on a claim situated a short distance beyond the La Bonte-Sheep Creek divide. This find led to nothing of value, though it is reported that the property was examined by men familiar with gold mining in South Dakota.

COPPER KING BELT.

About 30 miles southwest of Douglas, on a small tributary of La Prele Creek called Crazy Horse Creek, a quartz mass carrying chalcopyrite was systematically prospected at various times between 1902 and 1906 by the Douglas Mining & Milling Co. This company held five claims, including the Copper King, where most of the work was done, and other interests located and prospected claims in the neighborhood, mainly along the supposed extension of the Copper King lode.

The general country rock is granite, but the quartz vein occurs in one of the diabase dikes that are characteristic of the region. This and other dikes in the vicinity trend between N. 30° E. and N. 40° E. Some of them are readily traceable for a mile or more, and probably detailed study would show much greater continuity than could be made out from the writer's hurried observations. The Copper King claim lies within a northeast-southwest zone a few hundred feet wide along which vein fillings and other indications of mineral deposition were noted by the writer from place to place throughout a distance of 6 miles and which is said to have been followed and prospected for an additional distance of 10 miles toward the southwest.

About 2½ miles southwest of Crazy Horse Creek two schist bands separated by about 250 feet of granite were noted. The average width of these bands is perhaps 80 or 100 feet. From place to place along them quartz may be seen, and in several prospect pits quartz occurring in narrow seams carries magnetite. In one place magnetite and a little chalcopyrite were noted.

About 2 miles southwest of the Copper King claim there is a small deposit of nearly clean massive magnetite. The outcrop is hidden, but an area nearly 100 feet square is covered by bowlders of iron ore, some of which measure 2 by 3 by 3 feet. From the appearance of these bowlders they may be supposed to have come from a layer at least 2 feet thick. The small area covered by the float suggests that the deposit has the form of a lens. The magnetite is accompanied by a little quartz. Exposures near by show a band of green diabase schist about 80 feet wide, flanked by coarse granite. The magnetite layer probably occurs in the schist.

About three-fourths of a mile southwest of Crazy Horse Creek a 2-foot layer of magnetite schist was noted in a 10-foot prospect pit.

At several places both southwest and northeast of the Copper King claim prospectors have disclosed small bodies of quartz, but it occurs characteristically in stringers or in separated bunches rather than as continuous veins. There are signs of copper in different places outside of the Copper King claim, but nothing was seen upon which a prudent miner would spend time or money.

On the Copper King claim a shaft about 30 feet deep was opened in a large body of quartz carrying oxidized copper minerals in abundance at a depth of a few feet. A study of the surface shows that the quartz occurs as a series of lenticular bodies lying in schist near the southeast contact of a large horse of granite. Together these lenses form an interrupted vein that can be recognized for nearly 300 feet and may actually have a greater length. The discovery shaft is on a hill slope possibly 175 feet above the creek bottom. The development work consists of two tunnels, each said to be about 600 feet long.

The level of the upper tunnel is about 75 feet below the outcrop. Following the same general course as the dike, this tunnel cuts a narrow quartz vein about 140 feet from the portal. The vein gradually widens to 6 feet, then pinches and widens again to 12 feet, all in a distance of about 100 feet. Where the vein has its greatest width it contains a large proportion of chalcopyrite. This ore shoot is probably the same as the one opened at the discovery shaft. Near the portal of the tunnel a crosscut to the northwest reached the schist and granite contact, but no vein was found. A lot of perhaps 50 tons of ore was taken from the tunnel and from a winze 12 feet deep. Ore remaining on the dump is estimated to carry more than 15 per cent of copper, and it is reported that assays have showed as much as 0.35 ounce of gold to the ton. The tunnel was not accessible beyond the winze.

The portal of the lower tunnel is about 100 feet below that of the other and only a few feet above the creek. These workings were not accessible in 1914. The material on the dump consists almost entirely of dark-green schist but contains some vein matter consisting of quartz and siderite carrying a little feldspar. Vein stuff of this sort which carries small amounts of chalcopyrite is said to have come from the farther part of the tunnel.

Although the writer can form no satisfactory judgment concerning the possibilities of the deposit, he is of the opinion that the known ore shoot is worthy of being more fully prospected. A plan of the workings and a cross section through the shaft and the winze in the upper tunnel would aid in laying out future work, by indicating the position of the lower tunnel with reference to the probable position of the vein as projected downward from the winze in the upper tunnel. If the indicated position would carry it over the lower tunnel the vein should be sought by raising or by crosscutting to the northwest, whereas if the indicated position is to the southeast the vein should be sought by a crosscut in that direction.

ORIOLE BELT.

In the valley of upper La Prele Creek (see Pl. V), approximately 1 mile northwest of the Copper King line of prospects, is a parallel mineralized belt along which old workings were noted for a mile or more.

Here again diabase schist occurs in a granite country rock, and the general relations are similar to those along the Copper King belt. The only serious prospecting here was done about 10 years ago on the Oriole claim. On this claim a body of dense quartz from 20 to 30 feet wide crops out at intervals for nearly 1,000 feet along the edge of a steep bluff on the northwest side of La Prele Creek. The vein dips steeply toward the creek, and a few exposures are adequate to show that it has black or green schist on both sides. The development consists of two shallow shafts about 800 feet apart, both showing small amounts of copper minerals, and workings said to be 250 feet deep, about 300 feet southwest of the northeasterly opening. In the vertical shaft copper-bearing material is said to have been found only a few feet from the surface and to have continued to a depth of 175 feet, where the shaft passed out of the vein into the footwall. Next to this wall there was about 8 feet of rock that carried considerably more than the average amount of copper. No drifts were opened, but it is reported that the vein was crosscut at the 175-foot level and that another crosscut was started from a point 240 feet deep. In the upper crosscut, which is supposed to have reached the hanging wall of the vein, a flow of water was encountered which was too great for the capacity of the pump provided for sinking. The workings were thus flooded, and the operations have never been resumed.

Although it is apparent that the Oriole vein was not adequately prospected, the advisability of further exploration is open to question. Favorable to the property is the fact that several hundred tons of rock which may carry as much as 3 per cent of copper was taken out during the development work already done. On the other hand, the character of the vein stuff as seen in several exposures suggests that the vein does not carry copper minerals throughout. The only project that the writer would regard as at all promising would be the exploration of the footwall ore shoot that was cut by the shaft. This search might be made by means of a crosscut above the water level, followed by drifts along the footwall.

The Oriole property comprises several good houses. It is accessible by a good wagon road either from the north or from the south.

BRENNING COPPER PROSPECT.

The cross-mountain road by way of the upper valley of La Prele Creek passes the Oriole claim, crosses the divide at an elevation of about 8,000 feet, and by a choice of routes gives access to all adjacent parts of the high plains along the north side of Laramie Basin. About 4 miles west of the pass and just south of the Converse-Albany county line prospecting has been done on the Brenning claim. (See Pl. V.) The workings consist of two shafts in which large pieces of massive

chalcocite have been found. There are very few rock outcrops in the vicinity, but at the prospect hornblende schists are exposed. The chalcocite or copper glance is associated with bright-green, fairly well crystallized epidote. The epidote is present in large amounts, but the relation of the occurrence to the hornblende schist was not determined.

Similar epidote rock carrying rich copper ore is reported to occur at the Olin prospect, in the mountains at the head of Boxelder Creek, 4 or 5 miles north of the Brenning claim.

PERRY CLAIMS.

About 2 miles northwest of the Brenning prospect is a group of eight mining claims, here called the Perry group after one of the owners. These claims are arranged end to end and consequently they cover a strip of ground 12,000 feet long. The middle of the group is near the northeast corner of sec. 33, T. 29 N., R. 76 W. The country rock is mainly granite, but schistose dikes are present. The work done has disclosed several small veinlike bodies of quartz but no workable metalliferous deposits.

DEER CREEK DISTRICT.

LOCATION AND GEOLOGY.

Though the Deer Creek district is undefined it may be regarded as comprising the country between Boxelder Creek and the western boundary of Converse County. It is adjoined on the west by the Smith Creek asbestos district, in Natrona County.

The geology of the Deer Creek district appears from a cursory examination to be somewhat more complex than that of the War Bonnet district. Schists are present in greater abundance, and the granite intrusions are more irregular. Serpentine, which was not noted farther east, here occurs in many places.

SWEDE BOY VEIN.

The mining claim known as the Swede Boy is situated between Boxelder and Deer creeks about 16 miles south of Glenrock and somewhat less than 4 miles southwest of Boxelder post office. (See Pl. V.) Here a well-defined quartz vein in granite has been opened by an inclined shaft, and some copper ore is said to have been shipped. From the size of the dump it seems that the workings may aggregate 200 feet. Near the shaft the vein does not actually crop out, but from the alignment of several openings its course appears to be about N. 5° W. At the shaft mouth the vein is about 6 feet thick and its apparent dip is about 60° E. North of the main shaft and for 400

feet to the south the ground is covered by débris from near-by hills, but farther south float appears, and at minor shafts, 600 and 800 feet distant from the main workings, the vein is not less than 4 feet thick and shows the same easterly dip. Rock from all the openings shows some copper, but there is much barren quartz on the dumps, especially at the south workings.

Since the last work was done, about three years ago, the shaft house and mining plant have been destroyed by fire.

CHROMITE IN DEER CREEK CANYON.

About 16 miles southwest of Glenrock and 13 miles due south of Big Muddy (see Pl. V), there is a deposit of chromite from which several lots of ore have been shipped. The locality is on the west side of Deer Creek about 400 feet above the bottom of the steep-walled canyon, here about 1,000 feet deep. This district is one characterized by hornblende schists, coarse granites, and scattered masses of serpentine. The chromite is associated with a small serpentine body. It is said that there are several separate masses of the ore, but this the writer did not observe, as because of the steepness of the slope he was able to examine only the upper or western edge of the serpentine area. Along this edge the serpentine is flanked by schist, the wall striking nearly north and dipping steeply to the east. Near the wall and in a general way parallel with it is a layer of ore, which, as shown by a series of pits, has a thickness of 2 to 5 feet and seems to be continuous for a distance of perhaps 150 feet. The ore is dense and fine grained, the chromite being rather evenly intermixed with a scaly silicate mineral that is probably talc. Near the principal chrome-ore pit a layer of gray talc rock has been exposed. Analyses of the ore are here given through the courtesy of Mr. E. W. Merritt, president of the Chromium Mines Co., and of Mr. J. S. Diller, in charge of chromite statistics for the United States Geological Survey.

Analyses of chrome ore from Deer Creek.

	1	2	3
Chromic oxide	42.36	35.16	44.81
Iron	.....	20.29	20.87
Alumina	17.16	11.20	.....
Lime	.....	1.68	.....
Magnesia	12.67	13.52	.....
Silica	5.72	8.64	3.7

1, 2, Samples sent to Illinois Steel Co.; 3, concentrates furnished by Colorado Fuel & Iron Co.

Carload lots of the Deer Creek ore are reported to have carried 35 per cent of chromic oxide. The freight rate on ore of this class from Glenrock to Chicago is stated by Mr. Merritt to be $4 a ton.

ASBESTOS PROSPECTS EAST OF DEER CREEK.

For several years there has been considerable interest in the development of asbestos deposits on the Casper Range, 8 miles south, and on Smith Creek, 20 miles south of Casper. These districts lie west of Deer Creek.[1] The Smith Creek area extends across Deer Creek, where serpentine rocks are irregularly distributed in masses of small or moderate size over a northeastward-trending area about 8 miles long and 4 miles wide. Although the serpentine areas have been prospected and asbestos has been found in several places, such explorations as were visited are thought to offer little promise. Further developments are not likely to be undertaken until the Smith Creek and Casper Mountain enterprises have been put on a basis of profitable operation.

MORMON CANYON PROSPECTS.

Asbestos and copper locations made by C. J. Wells and associates in Mormon Canyon, at the head of Dry Creek, about 8 miles south of Glenrock, were under development during the summer of 1914. The locality was visited during the temporary absence of Mr. Wells, and the writer was not successful in an attempt to find the copper locations. Samples of the ore that were seen at Douglas show chalcocite and chalcopyrite in white quartz and resemble ore from the Copper King mine.

MARTIN SMITH COPPER PROSPECT.

A mining claim known as the Martin Smith is about 9 miles due south of Glenrock (see Pl. V), in a narrow canyon near the head of a tributary of Hunton Creek. The rocks in the vicinity are hornblende schist, granite, and serpentine. At a point about 100 feet above the bottom of the canyon copper carbonate was discovered. A shaft about 30 feet deep was sunk, and though nothing of practical significance was disclosed a tunnel was run through hornblende schist to a point approximately under the shaft.

LA PRELE DISTRICT.

LOCATION AND GEOLOGY.

The section here called the La Prele district is named for convenience to include mining prospects in the vicinity of the La Prele reservoir, which lies about 12 miles southwest of Douglas. The region is one in which hornblende schists are rather more abundant

[1] Diller, J. S., The types, modes of occurrence, and important deposits of asbestos in the United States: U. S. Geol. Survey Bull. 470, pp. 512-516, 1911.

than granite. In general it is limited on the north by the Paleozoic sedimentary formations, though locally these are overlapped by the Tertiary White River beds. Prospecting has been done in several places, but only two localities were visited.

COPPER PROSPECTS ON COTTONWOOD CREEK.

A group of mining claims 8 miles due south of Careyhurst station, formerly known as the Spring Canyon or Devoe group, is now called

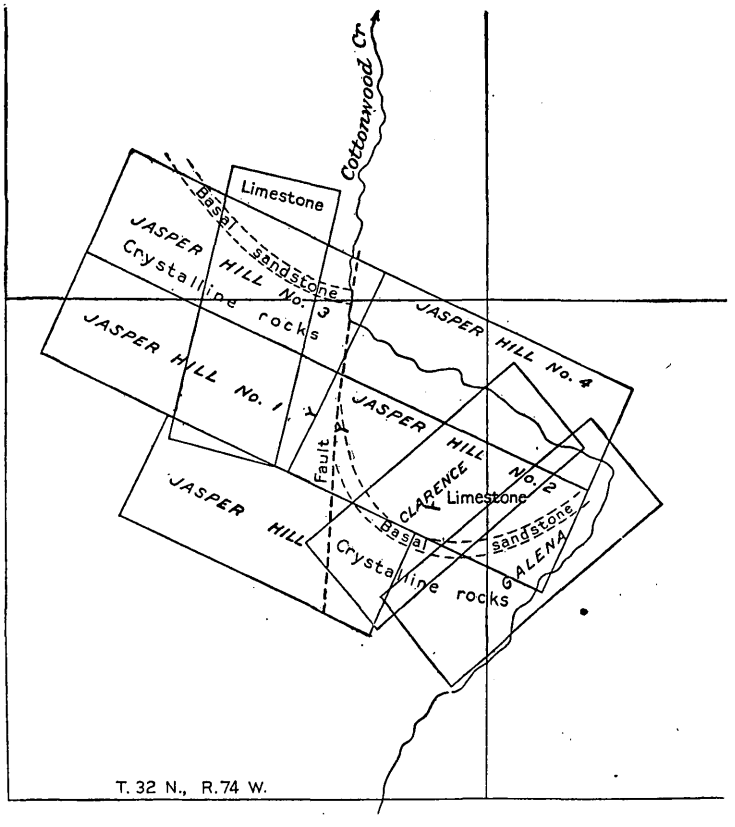


FIGURE 6.—Sketch map of Mewis property, showing location of claims and local geology.

the Mewis property. (See Pl. V.) A plat of these claims made available through the courtesy of Mr. Mewis, of Douglas, shows the principal geologic features of the locality (fig. 6).

The Carboniferous Casper formation here overlaps the pre-Cambrian rocks and is so tilted that its beds dip north-northeast. Immediately overlying black and green schists is a bed of sandstone from 20 to 40 feet thick, and above this are layers of massive limestone. These beds are broken by a strong fault that trends almost directly across their strike and has essentially the same course as the

channel of Cottonwood Creek beyond the mountain front. The vertical displacement along this fault is probably more than 100 feet, and the downthrown block is on the east. Because of the northerly dip of the stratified rocks and the manner in which they have been eroded the horizontal offset of the basal sandstone member is about 800 feet. The sandstone is so indurated that it is properly called quartzite. Away from the fault it is nearly white, but as the break is approached from the east the quartzite takes on a deep-red color. This color change is accompanied by a markedly greater induration, and next to the fault the rock presents a vitreous appearance. The ore mined, which contained carbonate minerals and chalcocite, came from shallow workings that extend at least 50 feet away from the fault break, though the fault can not be accurately located at this place. From a point west of the fault and about 60 feet below the level of the surface workings a tunnel was run in with the evident intention of getting beneath the ore, but apparently it did not lead to the discovery of anything of value.

This occurrence of copper is to be distinguished from all that have been described on foregoing pages in that the metalliferous minerals are here segregated in sandstone of Carboniferous age, whereas not only are most of the other deposits in pre-Cambrian rocks, but their nature is such that they can only be regarded as having been formed in pre-Cambrian time. Copper deposits occur in the Hartville district, in eastern Wyoming,[1] in limestones that correspond in age with the Casper formation.

The influence of the fault in localizing the segregation is obvious. If further prospecting is done, the writer's suggestion would be that the quartzite bed is probably the most favorable place for ore. A tunnel driven in a southwesterly direction from a point in the canyon near the big bend would strike the fault, and by following this break to the south the northward-dipping quartzite would be encountered. The limestone near the fault would be partly explored by the tunnel, and if ore were to be found in the quartzite an extension of the tunnel would show whether the fissure is mineralized below the point where it is met by the quartzite layer.

HAZENVILLE PROSPECTS.

About 1900 some widely advertised prospecting was in progress about 2 miles east of the present La Prele reservoir, at a locality still known as Hazenville. The work, consisting of the opening of a shaft and a tunnel, was undertaken because of a small copper-bearing quartz vein occurring in black schist.

[1] Smith, W. S. T., U. S. Geol. Survey Geol. Atlas, Hartville folio (No. 91), 1903.

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