NOTES ON THE PROMONTORY DISTRICT, UTAH.

By B. S. Butler and V. C. Heikes.

INTRODUCTION.

The following notes on the Promontory district are the result of a visit by the writers in August, 1915. Through the courtesy and with the guidance of Mr. S. S. Arentz, manager of the Lake View Mining Co., a much better idea of the geology was obtained than would otherwise have been possible in the time available. Mr. Arentz has described the Lake View Mining Co.'s property in a report to that company,[1] and in the following pages free use has been made of his descriptions, as well as of other data furnished by him.

GEOGRAPHY.

The Promontory district is in Boxelder County, Utah, near the south end of the Promontory Mountains, a range that forms a long promontory on the north shore of Great Salt Lake. (See fig. 1.) The south end of the promontory is crossed by the Lucin cut-off of the Southern Pacific Railroad. Promontory Point station is on the east side and Saline station on the west side of the promontory. Saline serves the portion of the range in which ore deposits have been developed. The camp is about 25 miles south of Promontory station on the old line of the Southern Pacific Railroad.

The area in which ore has been produced is 3 to 4 miles north of the railroad and at an elevation about 1,000 to 1,500 feet higher. The wagon road has a moderate grade for most of the distance but is rather steep near the camp. Wagons and a motor truck were used in hauling ore to the railroad and supplies to the camp. The haul from the camp is almost entirely down grade.

The range supports a rather scanty growth of cedar and other scrubby trees which are available as a fuel supply.

There are some springs on the south end of the promontory but none near the camp. At the time of visit water was brought in on the railroad for the section crew at Saline and the Lake View mining camp. An attempt will doubtless soon be made to develop a supply of water near by.

[1] Salt Lake Min. Rev., vol. 17, pp. 12–15, 1915.

The camp of the Lake View Mining Co., owners of the only producing claims of the district, is located on a beach of Lake Bonneville, the predecessor of the present Great Salt Lake. This old beach forms a bench on the mountain side and affords a level and very beautiful camp site overlooking Great Salt Lake.

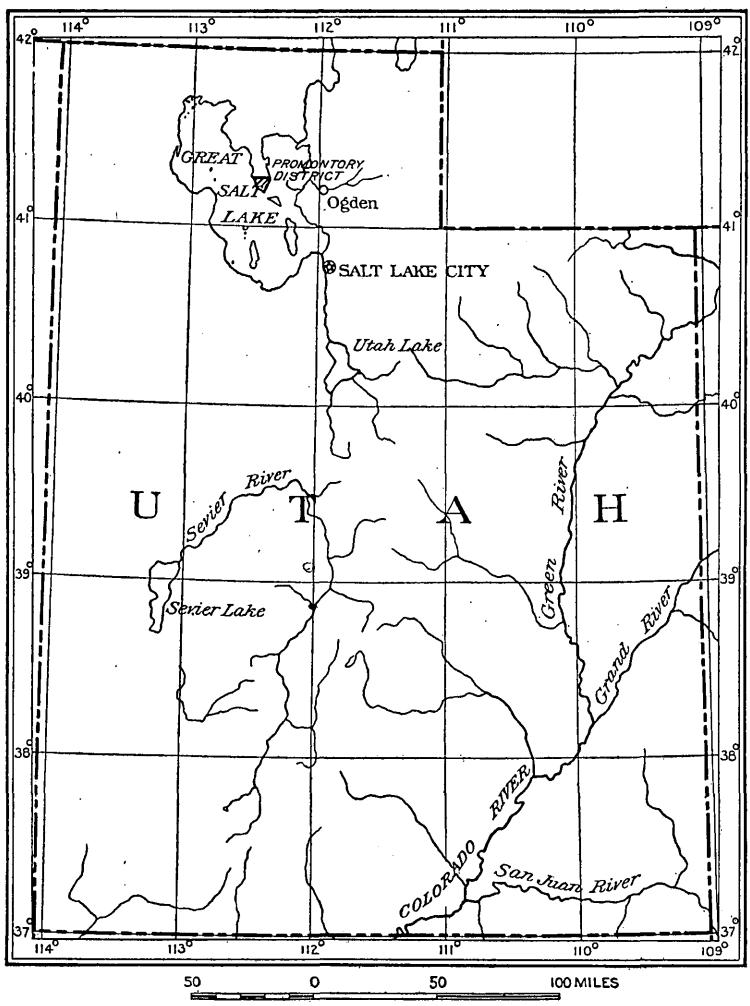

FIGURE 1.—Index map showing location of the Promontory district, Utah.

GEOLOGY.

No detailed description of the geology of the Promontory Range has been published. The range lies within the area covered by the Fortieth Parallel Survey and was examined by Hague, from whose description the following quotation is taken:[1]

This range extends from the northern limit of the map about 45 miles to the southward, forming a rocky promontory, which divides the two northern arms

[1] Hague, Arnold, U. S. Geol. Expl. 40th Par., vol. 2, pp. 420–423, 1877.

of Salt Lake, with a varying width from 4 to 7 miles and reaching in its highest point 3,000 feet above the level of the lake. North of the railroad the range is comparatively low, with rounded outlines, the greater part of its surface being covered with loose soil and grass and showing but few outcrops. The underlying formation, however, belongs to the Wahsatch limestone and is evidently a continuation to the northward of the same beds which characterize the more important portions of the range projecting into the lake. The railroad passes through a low depression in the range, which on the summit attains an altitude 4,943 feet above sea level, or over 700 feet above the level of Salt Lake. The old Pliocene Lake, at its highest elevation, unquestionably occupied this pass, isolating the main portion of the Promontory Mountains, which formed an island of greater extent than either Stansbury or Antelope Island. This gap in the range at its widest expanse measures about 3 miles in a north and south direction and everywhere shows the rounded forms and broad, level benches produced by recent erosion and former occupation by the lake waters. On both the north and south sides of the gap the upper terrace lines of the old lake are quite marked, but perhaps less continuous than at other localities. All along the east and west sides of the Promontory Mountains these old terraces and beach lines may be traced with more or less distinctness, indicated by loose deposits of sand and gravel or by benches cut in the hard mass of limestone. The elevation of the highest of these terraces is approximately 940 feet above the present level of the lake. To the south and west of the railroad, at Promontory station, the range, which is quite narrow, consists of a series of limestones of a prevailing gray color, in the lower part of which are dark, heavy beds of nearly black limestone, all dipping to the westward at an angle of 38°. About 4 miles south of Promontory station the range widens rapidly to the westward, attaining a width of 6 to 7 miles, of which the western third is occupied by the same series of limestones, which here rise with an easterly dip and overlie a limited outcrop of Archean schists.

These Archean rocks are exposed on the southwest corner of this projection of the range and consist of quartzites and mica-bearing schists, closely resembling those described in the Archean bodies of the Wahsatch. The main crest to the east of this western projection is occupied by conformable strata dipping, as already mentioned, about 38° to the west. They are much contorted and show more or less faulting, so that their thickness can not be accurately determined. It is, however, not less than 3,800 feet. About the middle of the series there is an included zone of yellowish-brown sandstone, more or less calcareous, within which are several beds of gray limestone. Its lower portion is sharply defined from the underlying limestone, but 300 feet above, where it passes again into the limestones, it shades off gradually through shaly beds. The general strike of this portion of the range is N. 28° E.

Along the extreme eastern foothills, on the edge of the lower Quaternary plain, which borders the lake shore, are outcrops of easterly dipping beds, which evidently show a portion of the eastern half of an anticlinal fold, of which the main mass just spoken of is the western member. This anticlinal fold appears very distinctly in the group of hills about 8 miles south of Promontory station, of which Benada Peak is the culminating point. Here a distinct northern axis cuts the range, and south of that point the rocks dip to the eastward. Through the pass, about 1½ miles north of Benada Peak, passes a synclinal axis quite parallel to the anticlinal, which lies 1 or 1½ miles to the west of it. Here the easterly dipping members of the western anticlinal and the westerly dipping parts of the eastern or second anticlinal meet. The second anticlinal passes through Benada Peak itself, and, as has been said, to

the south of that point, for about 12 miles down the range the greater part of the limestones dip uniformly to the east at angles varying from 20° to 40°. At Flat Rock Point, on the west side of the range, are found portions of the western members of this anticlinal fold, dipping at a gentle angle into the lake and consisting for the most part of gray and drab limestones, among which are intercalated bands of yellowish-brown sandstone similar to that described in the westerly dipping mass south of Promontory station.

From the westerly dipping limestones about 5 miles south of Promontory station, near Antelope Springs, were obtained the following fossils: *Productus prattenianus, Spirifer opimus, Athyris subtilita,* Streptorhynchus (fragments); while the limestones farther south afforded *Zaphrentis stansburyi, Productus semireticulatus.* These fossils are all clearly of Carboniferous age, though of themselves not distinctly characteristic, either of the Upper or Lower Coal-Measure limestones. The thickness of the series and its relation to the underlying Archeans, however, as well as its general lithological character, all serve to ally it rather to the latter division.

About 14 miles south of Benada Peak the Carboniferous limestones are found to abut unconformably upon a series of Archean schists, which occupy the whole lower 7 or 8 miles of the range, with a strike N. 30°–35° W. and a dip to the northeast. The Archean strata consist largely of siliceous schists and imperfectly bedded hornblendic and micaceous gneisses, together with thick beds of quartzite and more or less interspersed argillaceous schists. Just west of the southernmost extremity of the range the Archean rocks come nearly down to the water's edge, presenting a cliff, some 50 feet in height, of dark argillaceous schist, which has apparently a dip of 25° to the west.

The above description of the south end of the promontory was apparently based on an examination along the western base, for in the central and eastern parts limestone is the most abundant rock.

Only the rocks forming the central portion of the series exposed were examined by the writers. The sedimentary rocks show the general stratigraphic succession discussed below.

According to Hague the basal formation of the range is made up of Archean schists. This formation is overlain by a great series of quartzites whose thickness has not been determined but is at least several thousand feet. The quartzite series is believed to be the equivalent of the Cambrian and Algonkian quartzites and shales in the Wasatch Range, which vary in thickness but in Big Cottonwood Canyon exceed 10,000 feet. Above the quartzite comes a succession of shales, impure limestones, and sandstones, with some beds of rather pure limestone toward the top of the series. This group attains a thickness of 700 to 800 feet. The accompanying section (fig. 2), based on data furnished by Mr. Arentz, shows the character of the sediments in this group. Above this series there are heavy-bedded limestones which attain a thickness of several thousand feet. These limestones were not examined.

Fossils were collected from the shale series overlying the quartzite and from the shale above the "middle bed," as the limestone in which the ore deposits have been developed is locally called. These were

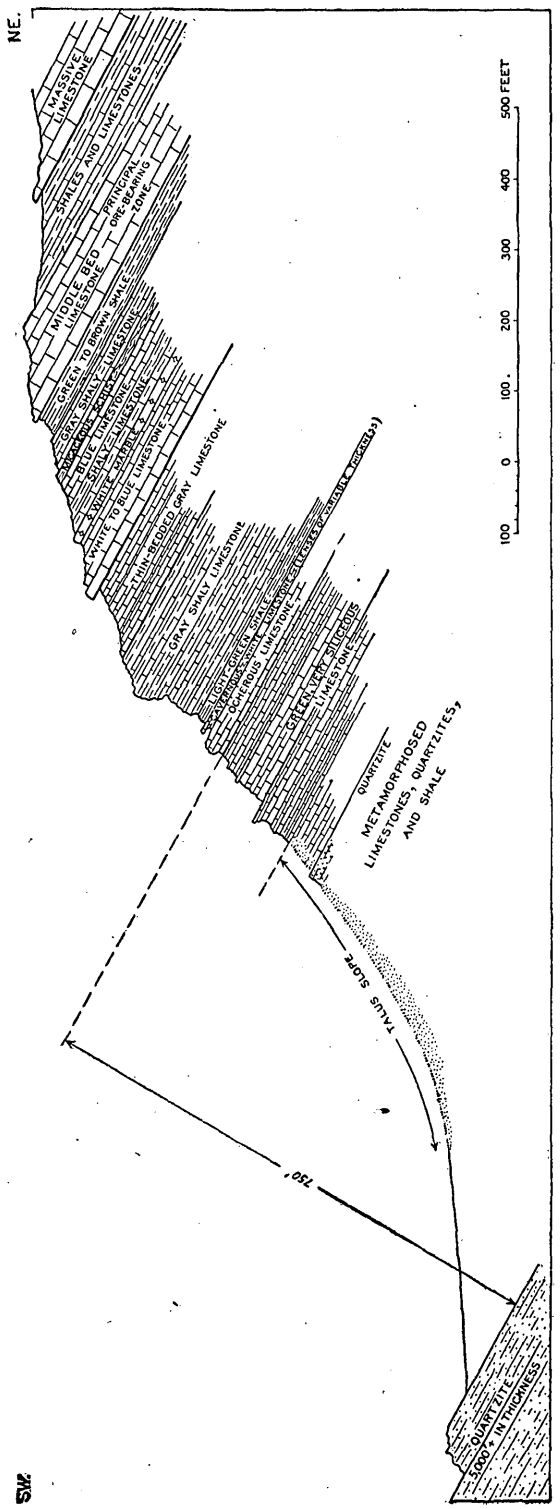

FIGURE 2.—Section showing stratigraphic succession of the sedimentary rocks in a portion of the Promontory district, Utah.

examined by Edwin Kirk, of the United States Geological Survey, who made the following report:

The fossils are not in a very satisfactory state of preservation, but approximate determinations are possible. All the evidence points to the lower Middle Cambrian age of the fossils.

Lot No. 1. Shale, 100 to 400 feet above lower "big" quartzite, about a quarter of a mile north of Lake View camp:
Ptychoparia sp.
Bathyuriscus sp.

Lot No. 2. South of Lake View camp, in shale above "ore limestone":
Micromitra (Iphidella) pannula (White).

Lot No. 3. In shale above (?) ore bed; collected by S. S. Arentz:
Zacanthoides sp.

Lot No. 4. Float from shale above quartzite:
Neolenus cf. N. superbus Walcott.
Bathyuriscus cf. B. productus Hall and Whitfield.

Lot No. 5. Shale above "ore limestone" south of Lake View camp:
Ptychoparia sp.
Algæ.

Lithologically and paleontologically the rocks between the quartzite and the upper limestone series rather closely resemble the series of shales and limestones occurring at a similar horizon in the Wasatch, Oquirrh, Tintic, and other ranges, though both the shales and the limestones are more abundant in the Promontory Mountains than in any of the other ranges mentioned. Limestone is, however, even more abundant at this horizon in northeastern Utah.

The age of the beds has been determined from the fossil evidence and correlation with other areas. The upper part of the quartzite series is doubtless of Cambrian age, and the lower part may be Algonkian, though this has not been determined. The limestone and shale series overlying the quartzite is of Cambrian age, as determined by the paleontologic evidence. The age of the upper limestone probably ranges from Cambrian to Carboniferous.

No igneous rocks were observed in the vicinity of the mineralized area. Mr. Arentz states that a dike 4 feet in width and traceable for about 150 feet cuts the heavy-bedded limestones east of the Lake View property. In the hand specimen this is a dark-green rock apparently having the composition of a rather basic diorite or possibly diabase. Similar rocks are said to cut the quartzite west of the Lake View property.

The general structure of the range at the south end is monoclinal. The beds strike about N. 40° W. and dip 30°–40° N. As indicated by Hague's description of the part of the range farther north, this apparent monocline may be the eastern limb of an anticline from which the western portion has been removed by erosion. Some indication that such is the case is given by a small area of westward-dipping sediments near the south end of the promontory. Minor

faulting in northerly and easterly directions has taken place, but so far as observed the displacement is at most but a few feet. About 6 or 7 miles north of the south end of the range there is apparently a strong east-west break along which the portion to the south has been relatively depressed. This feature was observed only from a distance, and no details concerning it are known. Fissures striking about due north, with a steep westerly dip, are rather abundant through the area where prospecting has been carried on.

ORE DEPOSITS.

HISTORY OF PRODUCTION.

Prospecting in the range up to the time of visit had been largely confined to two localities, both near the southwest side of the promontory. There has been some prospecting of copper deposits in the quartzite series on the west side of the promontory about 1½ miles northwest of Saline over a period of several years. In 1907 14 tons of hand-sorted ore, averaging 3.85 per cent of copper and 1 ounce of silver to the ton, 'was shipped. The present activity is confined largely to the zinc-lead deposits. The history of these deposits is given by Mr. Arentz as follows:[1]

For several years previous to 1915 a coterie of Ogden men, headed by Mr. James Wortherspoon, Lorenzo Farr, John Farr, and Mr. Carlson, held two groups of placer claims covering a bed of marbleized limestone, and also a large portion of what is now the Lake View Mining Co.'s property. This placer property was held by location over a period of some five years; the amount of work done was almost negligible. December, 1914, several men, headed by I. F. Farr, were employed to work on this placer property on the marble outcrop, about 1 mile north of the Judge Henderson wheat field. During noons and Sundays the workmen walked up the wash to the limestone beds outcropping above. Bowlders of lead-zinc carbonate were discovered in the talus and traced to the outcrop of ore in place found at the top of the 100-foot bed of limestone, forming the so-called middle bed in contact with shale. Four locations were then made by Charles Johnson, I. F. Farr, and Lorenzo Farr. Charles Johnson sold out his interest to Mr. P. A. Mattson, who was then superintendent of the Henderson ranch. A few holes were dug on the outcrop by these men. Early in January Mr. W. A. Perkins, of Ogden, joined as a fourth partner, and a total of four 4-foot holes and open cuts were opened up and some ore piled for shipment.

After an examination made in February of this year [1915] by Samuel S. Arentz, of Salt Lake, a fifth interest was negotiated for and obtained on March 9. Mr. Arentz began operations as one-fifth owner and under contract to manage the mine for one year.

The Lake View Mining Co. was then incorporated for 500,000 shares, par value 5 cents, and the following board elected: Lorenzo Farr, president; P. A. Mattson, treasurer; I. F. Farr, secretary; W. A. Perkins and S. S. Arentz, directors.

[1] Salt Lake Min. Rev., vol. 17, p. 12, 1915.

Your company has sold no stock, began operations without money in the treasury, all expenditures made by the original owners have been returned to them, and from the first of May, less than sixty days after beginning of operations, it has been self-supporting.

The net weight of ore shipped to August 1, 1915, was 1,961,900 pounds, averaging as follows:

Content of ore shipped from Lake View Mine.

	Per cent.		Per cent.
Lead	7.7	Zinc	32.75
Iron	1.1	Sulphur	.2
Silver	.2	Moisture	1.9
Gold	Trace.	Insoluble	16.0

The gross returns for 21 cars were $35,636.75.[1] The company reported that it had paid dividends of $8,119.75 to August 1 and had a net balance of $7,180.14.

ZINC AND LEAD DEPOSITS.

Prospecting of zinc and lead deposits at the time of visit had been confined almost entirely to the "middle" limestone bed. (See fig. 2.) As noted in the discussion of the geology, this is a limestone bed 50 to 75 feet in thickness included in members composed prevailingly of shale. The ores have been formed by replacement of this limestone near the north-south fissures. The largest deposits thus far disclosed occur just beneath the overlying shale, though developments have shown that considerable mineralization has taken place at lower horizons in the ore-bearing limestone. The ores are entirely oxidized, consisting of zinc and lead carbonates and a little hydrous iron oxide and manganese oxide. The gangue consists mainly of unreplaced limestone with some quartz.

As the writers' observations were confined to very shallow developments, it is not possible to make any generalizations concerning the relations of the ores. The carbonate ores were undoubtedly derived from the alteration of sulphides, though no sulphide was observed.

It has been found a pretty general rule that in the oxidation of mixed lead and zinc sulphides in limestone the oxidized lead ores occupy essentially the position of the original sulphides and the zinc ores have formed beneath the original sulphide bodies.[2] The zinc sulphate produced by the oxidation of the sulphides has passed into the underlying limestone, with which it has reacted to form the

[1] It is reported that to the end of 1915 the Lake View Mining Co. had produced ore for which $138,737 was received. Of this amount $65,000 was paid in dividends and $16,000 remained in the company's treasury.

[2] Butler, G. M., Some recent developments at Leadville; the oxidized zinc ores: Econ. Geology, vol. 8, p. 1, 1913. Knopf, Adolph, Mineral resources of the Inyo and White mountains, Cal.: U. S. Geol. Survey Bull. 540, p. 81, 1914. Loughlin, G. F., The oxidized zinc ores of the Tintic district, Utah: Econ. Geology, vol. 9, pp. 1–19, 1914.

zinc carbonate. The chemistry of this process has been discussed in the papers cited and need not be set forth here.

In the Promontory district, so far as developments show, zinc is far more abundant than lead, and it is possible that this was true in the sulphide bodies. The relation of the zinc and lead ores in some places corresponds to that found in other districts, namely, the zinc lies below the lead; but there are other places where this does not appear to be the case. A determination of the general relations must await further developments. Mr. Arentz[1] has pointed out that from the crests of the spurs, through which the ore bed passes, toward the canyon bottoms there is a progressive decrease in the content of zinc and an increase in lead.

Prospecting has been carried on along the outcrop of the "middle bed" for a distance of about 4,500 feet, and bodies of ore are shown in numerous openings. In the development of the property the managers seem to have followed the conservative policy of determining the amount and character of the mineralization along the outcrop before beginning extensive developments at depth, and at the time of visit the ore zone had nowhere been exposed more than a few feet below the surface. Sufficient data concerning the mineralization had been obtained, however, to warrant the planning of deeper development work. The region is one of considerable relief and suited to the development of the ore bed for several hundred feet below its highest outcrop by means of tunnels. Practically no work has been done on the lower limestone, though it is said to contain as much as 3½ per cent of zinc on the outcrop.

COPPER DEPOSITS.[2]

The copper prospects of the Promontory district are about 1½ miles northwest of Saline station. The deposits crop out on the crest of a ridge near the shore of the lake. The country rock is the quartzite near the base of the exposed sedimentary rocks of the south end of the range. The beds at this point strike N. 45°–50° E. and dip 16°–20° SE. The ore is disseminated in the quartzite. The primary mineralization formed chalcopyrite and possibly bornite, but at the surface the sulphides have been altered to carbonates.

The developments consist of two shafts about 200 yards apart, sunk from the crest of the ridge. One of these has a depth of about 50 feet, the other of 120 feet. At a lower point an inclined shaft was sunk on a westerly pitch nearly at right angles to the dip of the beds to a depth of 80 feet. Near the same point a tunnel has been driven eastward for about 100 feet. At a point near the shore of Great

[1] Salt Lake Min. Rev., vol. 17, p. 13, 1915.

[2] The statements concerning the copper deposits are based on observations by Mr. Heikes and information furnished by Mr. C. A. Redfield, of Ogden, Utah.

Salt Lake and about 200 feet vertically below this tunnel another tunnel has been driven eastward for 452 feet. This was projected to intersect the downward extension of the ledge that crops out on the ridge.

Some mineralized rock was observed in the prospect openings, and it is said that more valuable ore was encountered at some points which were not accessible at the time of visit. The ore shipped was obtained from large blocks of mineralized quartzite at the surface. These blocks measured from 15 to 50 feet in thickness.