THE YELLOW PINE MINING DISTRICT, CLARK COUNTY, NEVADA.

By James M. Hill.

INTRODUCTION.

FIELD WORK.

During the summer of 1912 the writer was detailed to visit a number of widely separated mining districts in Nevada and northeastern California. The work was entirely of a reconnaissance nature, and the results are far from complete. The last nine days of September were spent in the Yellow Pine district, Nevada's new and largest zinc camp. This report is based on a hasty inspection of most of the mines in an area of approximately 384 square miles.

The writer was fortunate in obtaining the services of Mr. Richard Feaster, whose acquaintance with the mines, roads, water holes, and people of the district did much to expedite the work. The mining men of the district extended many courtesies. Their open hospitality was much appreciated, and their interest in the work was such that all of them gave generously of their time and information. Particular thanks are due to Messrs. Fred A. Hale, C. D. Coates, George A. Fayle, John Frederickson, and Harvey Hardy.

In the preparation of this report the writer received assistance from a number of his colleagues in the Geological Survey and wishes here to express his thanks to them, particularly to Messrs. W. T. Schaller, E. S. Larsen, and J. B. Umpleby for mineralogic and petrologic determinations, to Mr. George H. Girty for the determination of the fossils, and to Messrs. Adolph Knopf and C. E. Siebenthal for criticism.

LOCATION AND ACCESSIBILITY.

The Yellow Pine mining district, sometimes called the Good Springs district, is in the southwestern part of Clark County, Nev., near the California line. It covers the southern part of the Spring Mountain Range. The mines lie on both sides of the ridge over an area 24 miles north and south by 16 miles east and west. This region is in the northern part of the Ivanpah and the southern part of the

Las Vegas quadrangles as mapped by the United States Geological Survey. (See Pl. IV.) The center of the district is 35 miles southwest of Las Vegas, the supply point for the greater part of southern Nevada.

The San Pedro, Los Angeles & Salt Lake Railroad, commonly called the Clark road, runs along the east side of the district, affording excellent transportation facilities for the mines on that side of the mountains. Jean is the principal shipping point, though the Potosi mine hauls its ore to Arden and some of the ore from the mines at the south end of the district goes to Roach. Good Springs, the principal town in this region, about 8 miles northwest of Jean, is now connected with the main line by the narrow-gage "ore road" belonging to the Yellow Pine Mining Co. It has a population of about 200 persons.

The settlement of Sandy (Ripley post office) is practically abandoned. It was built about the cyanide mill of the Keystone mine. At the Potosi live about 30 miners and nearly as many teamsters and laborers connected with the property. There are numerous small camps in all parts of the district, and visitors are always welcome at any of them.

The roads in this region are very good, considering the rugged character of the topography. The main routes of travel are: The road from Arden to the Potosi mine, the main road from Jean to Good Springs and Sandy, the road southeast from Sandy through State Line Pass to Roach, and the road north from Good Springs that connects with the Arden road southwest of Cottonwood Springs.

WATER SUPPLY.

The Yellow Pine district is more favorably situated for water than some of the mining camps on the desert. In both the Mesquite Valley, to the west, and the Ivanpah Valley, southeast of the mountains, a practically limitless supply of water can be obtained from wells 10 to 50 feet deep. The water in the Mesquite Valley is so close to the surface that several people have started dry farms.

In the mountains water is scarce. The only springs are shown on Plate IV. At Good Springs all the water, which is of excellent quality, is pumped. Potosi Spring yields plenty of good water for domestic use, but it is doubtful if there is sufficient to supply a concentrating mill using wet methods.

Most of the camps are without natural water supply and nearly all the drinking water used in the district is hauled from Good Springs or the Potosi Spring. The water from the wells at Sandy is strongly mineralized and not fit for drinking.

CLIMATE AND VEGETATION.

The Yellow Pine district is on the desert and its climate is typical of the dry region. The winters are relatively cool, and on some days the temperature approaches the zero mark. From May to October there are some very hot days, but the average temperature is not oppressive. Most of the precipitation falls as rain in the summer, though in the winter there is sometimes a light fall of snow, which does not last long. The prevailing winds are from the southwest. The daily range of temperature varies from 20° to 58° F., being perhaps a little more marked in the late spring and summer.

The vegetation is scant except on the slopes of Potosi Mountain above an elevation of 5,500 feet. Below this level sagebrush, greasewood, and several varieties of cactus are all that is seen. The wood of the so-called Joshua tree, a species of yucca, is extensively used for domestic fuel at Good Springs.

North of the district, in the vicinity of Charleston Peak, there was at one time a heavy stand of yellow pine, but lumbering operations have greatly depleted it. Some few pines grow near the summit of Potosi Mountain, with juniper and cedar.

At Wilson's ranch an irrigated tract produces good crops of alfalfa and fruits, and at Good Springs a few fruit trees are kept alive by careful watering. Apples, pears, peaches, and figs are the principal fruits grown. The Mesquite Valley farms were largely abandoned in the fall of 1912, owing, it is reported, to the difficulty of irrigating. The soil is so loose, porous, and dry that ordinary ditches will not carry the water for any great distance.

HISTORY OF MINING AND PRESENT CONDITIONS.

The first mining in this district of which there is any record was done by the Mormons about 1860 at the Potosi mine, which is called by some the Old Mormon mine. Lead ores were mined and smelted here to be later cast into bullets for use in the Mormon wars against the Indians or the United States troops. The mine is located on the west side of Potosi (Olcott) Mountain, just south of the old Salt Lake and San Bernardino trail, remnants of which are still to be seen in the gulch northeast of Potosi Mountain. The discovery of this mine led to prospecting which resulted in the opening of several lead-silver deposits, a few copper prospects, and at least one gold mine, the Keystone, which is reported to have produced about $1,000,000.

From the time of the earliest discoveries to 1906 the Yellow Pine district was a small though rather steady producer of lead, silver, gold, and copper. For a number of years a heavy gray-white material accompanying the lead ores was considered country rock and was thrown on the dumps. In 1906 Connie Brown, an engineer from Socorro, N. Mex., made a professional visit to Good Springs and recognized this material as similar to some of the zinc ores mined at Magdalena, N. Mex. Trial shipments of the zinc ore were sent to the Missouri zinc smelters, but the shippers were disappointed in their returns. Prospecting was continued, however, and mixed zinc-lead oxidized ores were found at many places.

The Yellow Pine mine was the first producer of good grade zinc ore, and after much experimentation the company has finally evolved a process whereby it is possible to separate the lead and zinc of the medium-grade ores into readily marketable products.

At the present time there are about 300 miners in the Yellow Pine district. The only companies operating their own mines in September, 1912, were the Yellow Pine, Ninety-nine, and Potosi. Most of the work is done by lessees on small scattered deposits. The production from this source is considerable.

PRODUCTION.

Records of production of the Yellow Pine district prior to 1902 are very incomplete. Since 1902 the United States Geological Survey has reported the production of the several States by mining districts, but the figures prior to 1906 are not particularly reliable. The subjoined table of production of the Yellow Pine district is taken from the volumes of Mineral Resources published by the Survey.

Production of Yellow Pine district, Nevada.

Year.	Gold.	Silver (fine ounces).	Copper (pounds).	Lead (pounds).	Zinc (pounds).	Total value.
1902	$44,174					$44,174
1903	53,396	753	21,800	28,000		55,665
1904	47,878	146				47,961
1905	15,000	3,707		290,063	685,659	71,335
1906	9,150	1,573	67,341	625,175	2,885,246	234,550
1907	9,743	2,994	93,090	187,310	1,879,432	151,156
1908	7,791	10,247	42,144	720,285	1,115,851	101,482
1909	5,740	18,461	392	406,353	3,013,352	195,585
1910	1,219	16,826	122,925	1,263,837	2,707,071	227,707
1911	2,424	47,072	173,719	1,617,224	3,548,032	324,100
	196,515	101,779	521,411	5,138,247	15,834,643	1,453,715

The decrease in the gold production since 1905 is due in large part to the closing of the Keystone mine. There is no record of the production of zinc prior to 1905; in fact, the shippers of lead-silver ores did not know of the presence of this metal and were probably penalized to some extent for such zinc as was shipped with the lead. Up to 1911 the zinc produced was derived entirely from crude sorted ore. In the latter part of 1911 the Yellow Pine Mining Co. started the operation of an 80-ton separating mill, which materially added to the production of the district, as it was then possible to mine in that company's property the mixed zinc-lead ores which were avoided as much as possible at other places.

PREVIOUS DESCRIPTIONS.

The literature bearing on the geology and ore deposits of the Yellow Pine district is very meager. The following list comprises practically all that has been published on the region:

Owen, J. R. N., Manuscript notes to the California Boundary Commission, 1861, Geol. Survey California, vol. 1, Geology, 1865, p. 471.

Raymond, R. W., Mining statistics west of the Rocky Mountains, 1871, p. 168.

U. S. Geog. Surveys W. 100th Mer., vol. 3, Geology, 1875, pp. 124, 166, 179, 180.

Spurr, J. E., Origin and structure of the Basin Ranges: Bull. Geol. Soc. America, vol. 12, 1901, pp. 235–236.

—— Geology of Nevada south of the fortieth parallel: Bull. U. S. Geol. Survey No. 208, 1903, pp. 164–180.

Bain, H. F., A Nevada zinc deposit: Bull. U. S. Geol. Survey No. 285, 1906, pp. 166–169.

White, Douglas, Zinc mines of southern Nevada: Proc. Am. Mining Congress, Goldfield, Nev., 1909, pp. 401–411.

Gregory, N. B., Yellow Pine district, Nev.: Eng. and Min. Jour., vol. 90, Dec. 31, 1910, pp. 1308–1309.

Hillen, A. G., Zinc in Nevada: Los Angeles Min. Rev., Sept. 24, 1910, p. 72.

Hale, F. A., Yellow Pine district, Nev.: Eng. and Min. Jour., Apr. 22, 1911, p. 804.

—— Developments in the Yellow Pine district, Nev.: Min. and Eng. World, Nov. 4, 1911, p. 915.

—— Yellow Pine mill, Good Springs, Nev.: Eng. and Min. Jour., vol. 44, July 13, 1912, p. 68.

—— The Yellow Pine mill: Salt Lake Min. Rev., July 30, 1912, p. 33.

—— Yellow Pine mining district, Nev.: Mexican Min. Jour., vol. 15, No. 6, Dec., 1912, p. 29.

Mineral Resources U. S., 1905, p. 270; 1906, p. 297; 1907, pt. 1, p. 369; 1908, pt. 1, p. 474; 1909, pt. 1, p. 396; 1910, pt. 1, p. 509; 1911, pt. 1, p. 669.

TOPOGRAPHY.

The range called Spring Mountain is a rugged, irregularly shaped group of mountains, separated from the Kingston Range on the south and west by State Line Pass and Mesquite Valley. The mountains have a general north-south trend, but on the west side there are several long, rugged east-west spurs. The east front of the range is marked by very abrupt slopes or cliffs along the great fault. (See Pl. IV.) From Good Springs southward almost vertical cliffs face the northern part of Ivanpah Valley; and from the Potosi-Arden road northward for several miles there is a rise of 4,000 feet to the mile.

The highest point in the vicinity of the mines is Potosi Mountain, at the north end of the district, which has an elevation of 8,500 feet.

The mountains south of this mass are betweeen 5,000 and 5,500 feet above the sea.

The slopes and ridges of the mountain group are rugged, with numerous cliffs formed of the more massive members of the series. The sedimentary rocks are very much faulted and somewhat folded, and as a consequence the numerous dip slopes are of all degrees of steepness. The upturned edges of faulted beds are eroded in a steplike form characteristic of all the ridges on the west side of the range and of the flanks of Table Mountain south of the Good Springs and Sandy road.

The rugged character of the mountains is accentuated by the fact that Mesquite and Ivanpah valleys, on the west and east sides, respectively, are flat, and the mountains have the appearance of a pile of rocks dumped on this floor. Mesquite Valley, a southern continuation of the Pahrump Valley, has an almost level floor at an elevation of 2,650 feet. Its flatness is somewhat relieved by a string of sand dunes along the east side from 1 to 3 miles west of the base of Spring Mountain. The north end of the Ivanpah Valley between Borax and Roach has an elevation of about 2,600 feet. From the valleys rise long, even slopes of débris which near the mountains merge into the alluvial cones at the mouths of the canyons.

There are four intermountain "washes" that have relatively flat topography. The largest of these runs for about 7 miles north and northwest from Good Springs. The next largest is southwest of the Potosi mine, between two long east-west spurs of limestone. The third is west of Shenandoah Peak, and the fourth southeast of Sandy. Most of these intermountain valleys have a decided grade toward the large valleys, but the one north of Good Springs contains several square miles of nearly level ground.

GEOLOGY.

SEDIMENTARY ROCKS.

PREVIOUS INVESTIGATIONS.

The primary object of the visit to the Yellow Pine district was the study of the zinc deposits, and little time could be spared for the study of the stratigraphy of the region.

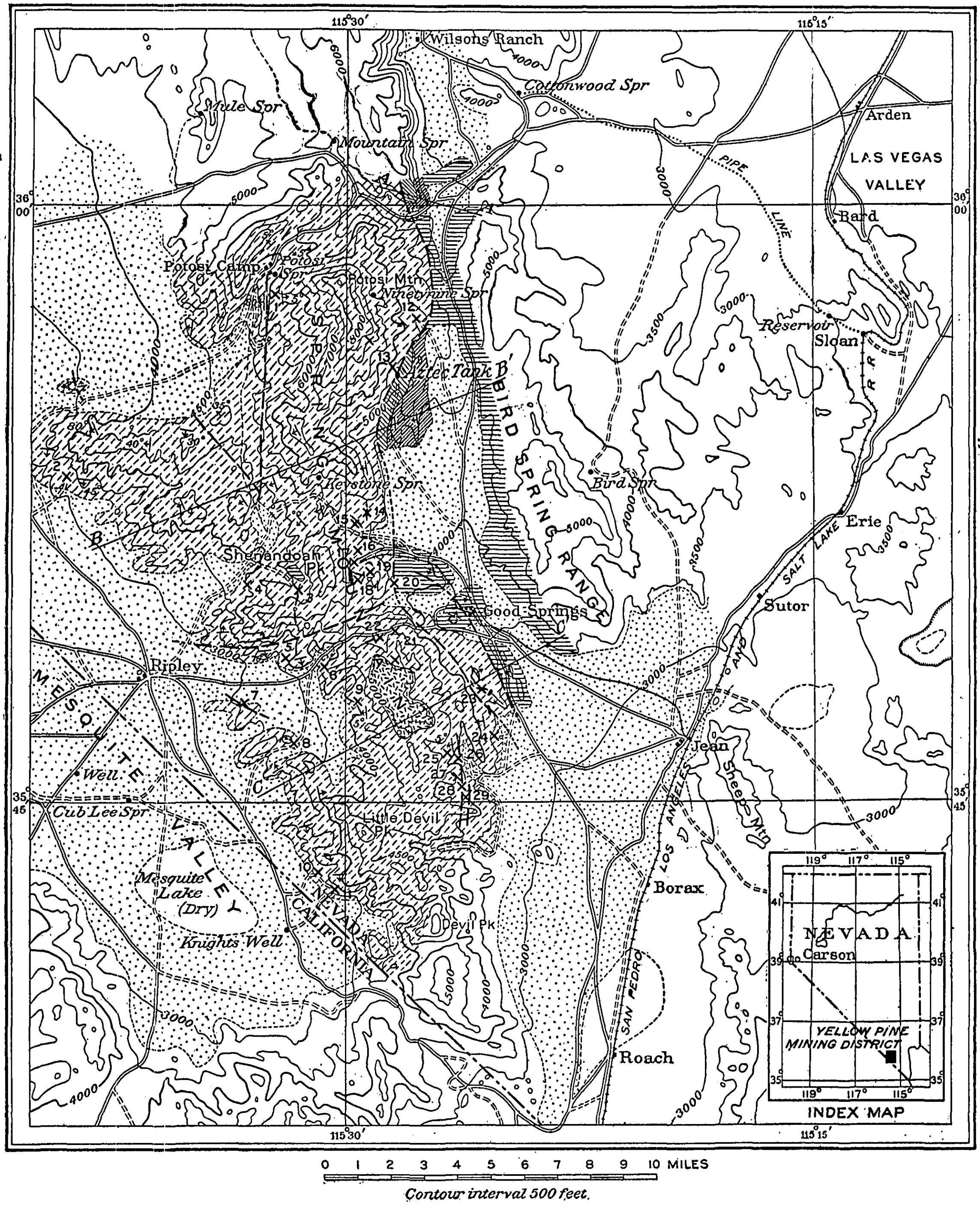
The geologists of the Wheeler Survey visited Spring Mountain and from their reports[1] the following description is abstracted.

They reported that "Carboniferous strata of prevailing gray color and with few exceptions carrying fossils of the age of the coal meas-

[1] U. S. Geol. Surveys W. 100th Mer., vol. 3, Geology, 1875, pp. 124, 166, 179 180.

LIST OF MINES

1. Potosi
2. Green Monster
3. Keystone
4. Aura Amigo
5. Whale
6. Bill Nye
7. Hoodoo
8. Springer and Tiffen
9. Hoosier
10. Milford
11. Addison
12. Ninety-nine
13. Contact
14. Ninety-three group
15. Red Cloud
16. Prairie Flower
17. Yellow Pine
18. Alice
19. Porphyry Canyon
20. Lavinia
21. Columbia
22. Fredrickson
23. Monarch
24. Lincoln
25. Porter
26. Monte Cristo
27. Accident
28. Bonanza
29. Anchor



LEGEND

SEDIMENTARY ROCKS

- Gravel, sand, and recent wash — QUATERNARY
- Light-colored cross-bedded sandstone — JURASSIC?
- Red sandstone and shale — TRIASSIC OR PERMIAN?
- Buff to pink limestone with conglomerate and some sandstone — Pennsylvanian — CARBONIFEROUS
- Massive-bedded light to dark gray limestone — Upper Mississippian ? — CARBONIFEROUS

IGNEOUS ROCKS

- Biotite andesite flows — TERTIARY?
- Intrusive quartz monzonite and granite porphyries — POST-JURASSIC

Fault

Dip and strike

Mine or prospect (*Numbers refer to list of mines*)

A — A′ Line of structure section

SKETCH MAP OF THE YELLOW PINE MINING DISTRICT, CLARK COUNTY, NEV.

ures" were present in great volume in Spring Mountain. Potosi (Olcott) Mountain they reported as composed almost exclusively of limestones containing "Lower Carboniferous" fossils, but fossils collected near Mountain Springs were found to include species older than Carboniferous. They reported Jurassic limestones near Good Springs, and gave the following section on Cottonwood Creek, 20 miles west of Las Vegas, which shows massive sandstone above the limestone:

Section on east front of the Spring Mountain Range, 20 miles west of Las Vegas, Nev.; Cottonwood Creek.[1]

[Only limestone measured. Above the massive sandstone (1) is a dark-gray limestone, not examined in place.]

		Feet.
1. Massive red and yellow sandstone:		
(*a*) Yellow	250	
(*b*) Red	150	
(*c*) Yellow	200	
(*d*) Red (shaly)	400	
		1,000
2. Bedded fine-grained to saccharoidal limestone, gray and cream-colored; beds separated by shaly layers, so as to weather in steps. Fossils: Phillipsia (?), Macrocheilus (non des.), Naticopsis, Aviculopecten, Avicula, Meekella, Myalina, *Productus semireticulatus*, *Spirifer lineatus*, *Athyris subtilita*, Synocladia		500
3. Massive gypsum, white and red, in lenticular masses		0–75
4. Gray massive cherty limestone:		
(*a*) Limestone; fossils Meekella, Productus, Chætetes, Syringopora	250	
(*b*) Unseen; red (shale?)	25	
(*c*) Limestone	200	
		475
5. Friable sandstone, in places shaly or marly; variegated with brilliant iron colors		350
		2,400

In 1900 and 1901 the late R. B. Rowe spent some time in a detailed stratigraphic study of Spring Mountain, but he died before his material was published. J. E. Spurr made use of his notebooks in the preparation of the section devoted to Spring Mountain in Bulletin 208.[2] As the material incorporated in that bulletin was fragmentary, it was the hope of the present writer that more detailed information from Mr. Rowe's notebooks could be used in the present paper, but at the time of writing these notebooks could not be found.

[1] This section was probably taken from the cliffs north of Cottonwood Spring, in the extreme north central part of the area shown on Plate IV.—J. M. H.

[2] Spurr, J. E., Geology of Nevada south of the fortieth parallel: Bull. U. S. Geol. Survey No. 208, 1903, pp. 164–180.

CARBONIFEROUS ROCKS.

UPPER MISSISSIPPIAN (?) STRATA.

The main mass of Spring Mountain south of the Potosi-Arden road is made up of rather thick bedded gray to bluish-gray limestones with a few thin beds of dense gray-black limestone. Much of the limestone appears to be pure and a rather large proportion of it is more or less crystalline. Chert is not abundant at any place but is found in small nodules in certain beds all over the area studied. Fossils are rather abundant in the noncrystalline limestones, but the writer did not collect them at all places where they were seen. The thickness of this series was not measured, and doubtless there is much repetition of beds due to the faulting and folding of the mountains.

From the data at hand it would seem that this series of limestone is 1,500 feet and possibly 3,000 feet thick.

Fossils were collected from seven localities in this limestone and the species determined by G. H. Girty, as follows:

Lot 616 was collected from the light-gray limestone immediately above the ore horizon at the Milford mine (No. 10, Pl. IV). It contains the following species:

Zaphrentis sp.
Lithostrotion? sp.

Lot 617 was collected from a small ridge on the ground of the Ninety-three group (No. 14, Pl. IV). It contains only Zaphrentis sp.

Lot 618 is a collection from the flat-lying limestones immediately above the Potosi tunnel (No. 1, Pl. IV). The following species have been identified:

Zaphrentis sp.
Lithostrotion? sp.
Echinocrinus sp.
Fenestella sp.
Diaphragmus elegans?
Orthotetes kaskaskiensis?
Spirifer keokuk var.
Euomphalus sp.
Paraparchites sp.

Lot 620 was obtained from a dark bluish-gray limestone above cherty limestone that is about 500 feet west-southwest of the Ninety-nine shaft (No. 12, Pl. IV). The species in this bed are:

Aulopora sp.
Crinoidal fragments.
Spirifer keokuk var.
Spirifer aff. arkansanus?
Spiriferina aff. spinosa?
Composita? sp.

Lot 622 was collected from a thick blue-gray limestone that is exposed on the cliff south of the Monte Cristo (No. 26, Pl. IV) and north of the Accident (No. 27), at an elevation of approximately 4,000 feet. The species are:

Lithostrotion? sp.
Batosomella sp.
Lingulidiscina sp.
Chonetes sericeus?
Productus pileiformis.
Productus aff. arkansanus.
Productus moorefieldianus.
Dielasma? sp.
Spirifer keokuk var.
Spiriferina spinosa?
Hustedia mormoni.
Composita subquadrata.
Aviculopecten sp.
Strophostylus aff. carleyanus.

Lot 623 was collected from the flat-lying, somewhat crystalline buff limestones just west of the Hoodoo mine (No. 7, Pl. IV). It contains the following species:

Zaphrentis sp.
Syringopora sp.

Lot 624 was collected in very dark gray dense limestone immediately over the ore-bearing limestone at the Green Monster mine (No. 2, Pl. IV). The following species were recognized:

Zaphrentis sp.
Syringopora sp.
Derbya? sp.
Chonetes sp.
Camarotœchia sp.
Composita? sp.
Euphemus? sp.

Mr. Girty, in his report on these fossils, says:

With the possible exception of lot 624, the remaining lots, so far as they are adequate for definite opinion, have a common facies. * * * The age of this fauna I am inclined to call upper Mississippian, but not with entire confidence. It has the general facies of some of the upper Mississippian faunas without containing any really diagnostic species. The only fact really opposed to this reference is the presence in one of the collections of the Pennsylvanian species *Hustedia mormoni*, but I have identified that species in the upper Mississippian of Arkansas. With this exception there is nothing in the fauna strongly suggesting Pennsylvanian, and the facies, as a whole, is not like the Pennsylvanian faunas which I know. Lower Mississippian (Madison) faunas have been identified in the same general region and this facies is so different that it is safe to say that it is not Madison. A conservative statement seems to be that this horizon may possibly be lower Pennsylvanian in age, but that very probably it is upper Mississippian.

PENNSYLVANIAN STRATA.

The west flank of the Bird Spring Range is composed of light-pink, greenish, and purple sandy and conglomeratic limestones which seem to be entirely similar to those seen in the low hills in the vicinity of Good Springs and to the east of the Good Springs and Monte Cristo road. (See Pl. IV.) Mr. Rowe collected Pennsylvania species from gray, brownish, and pinkish arenaceous limestones about 3 miles northeast of Good Springs.

The low knoll about a quarter of a mile north of Good Springs is composed of brown, pink, and gray-buff arenaceous limestones and limestone conglomerates. The beds strike N. 25° W. and dip 20° SW., apparently forming the northeast limb of a shallow syncline. The following table shows the sequence of these strata, the lowest member being exposed on the north slope of the hill:

Section of strata on knoll north of Good Springs.

	Feet.
Quaternary wash	10
Thin interbedded brownish to pink arenaceous limestones and conglomerates whose pebbles are from one-fourth to one-half inch in size	100
Coarse brownish conglomerate, with pebbles 4 inches or less	30
Cherty light-gray limestone	4
Gray or pink, somewhat cherty arenaceous limestones, in 2 to 10 foot beds. fossiliferous	75

Fossils (lot 621) collected by the writer from the upper part of the lowest limestones in this section comprised the following species, according to Mr. Girty:

Crinoidal fragments.
Fistulipora sp.
Lioclema sp.
Productus aff. humboldti.
Productus semireticulatus var.
Productus sp.
Marginifera sp.
Tegulifera armata?
Squamularia perplexa?
Aviculipecten 2 sp.

Mr. Girty refers this lot to the Pennsylvanian and states: "I think that it is not very high in the series."

TRIASSIC (?) AND JURASSIC (?) ROCKS.

Red sandstones and shales are exposed at the base of the cliffs north of the Potosi-Arden road, shown in figure 23, and in the low hogbacks about 6 miles north-northwest of Cold Springs, shown in section *B–B′*, figure 24. No fossils were collected by the writer from these beds.

Above this series is a yellowish-white, heavily cross-bedded sandstone at least 600 feet thick. These beds form the cliffs shown in section *A–A′*, and are well exposed south of the Contact mine (No. 13, Pl. IV), dipping west toward the great fault. No fossils were collected by the writer from these beds, but Rowe[1] collected Jurassic fossils from them.

Spurr[2] says in regard to the section north of the Potosi-Arden road:

> About 4 miles west of Cottonwood Springs is a great escarpment, at least 2,000 feet high. It consists of two terranes, the lower being red shales and sandstones, making up about one-third of the height. Above this is a heavy yellow sandstone containing occasional red lenses. These rocks are probably Mesozoic.

Spurr[2] gives the following Mesozoic section from Good Springs, but the location is not known:

Section of Mesozoic rocks at Good Springs.

	Feet.
Arenaceous limestone	610
At base, yellowish and reddish sandstone, about 50 feet. Above this are layers of red and yellow shale. This may be the same red terrane which shows at the eastern base of Olcott Peak [Potosi Mountain]	760
Heavy conglomerate	50
Gray limestone, with some layers of red or pinkish arenaceous limestone and abundant layers of chert. The upper 50 feet contains numerous large quartzite bowlders	300

[1] Spurr, J. E., Bull. U. S. Geol. Survey No. 208, p. 174.
[2] Idem, p. 173.

The fossils from the uppermost bed were described by T.W. Stanton as not younger than Triassic and possibly as old as the Permian; those from the lowest bed are questionably referred by G. H. Girty to the Permian.

QUATERNARY DEPOSITS.

Quaternary deposits cover less than half of the area shown on Plate IV. They are composed of very slightly consolidated gravels and sands. Near the mountains these deposits consist of large angular blocks of limestone, except for a small area southeast of the Jurassic (?) sandstone hills 5 miles north of Good Springs, where the wash is composed largely of sandstone fragments. The material becomes finer and finer away from the mountains. These deposits form long, even-sloped cones where they issue from narrow-mouthed canyons, but are thin coverings (5 to 15 feet deep) in the intermountain valleys north of Good Springs and southeast of Sandy. They are clearly the result of transportation by torrential waters and are scored by gullies that are deep near the mountains but dwindle to shallow branching watercourses toward the flats.

In the flat central parts of Mesquite and Ivanpah valleys there are thick deposits of sand which have been formed into low dunes on the east sides of the valleys by the prevailing southwest winds.

STRUCTURE.

GENERAL CHARACTER.

Spurr[1] says that the Spring Mountain range "shows more complex folding than any of the ranges north or east, and to this folding the irregular shape of the range is probably due. * * * In an east-west section the general structure of the range seems to be a broad syncline, with a number of minor folds of little importance. * * * In a north-south section the structure * * * appears to be anticlinal."

The writer visited only the south end of the Spring Mountain Range, in which are located the mines of the Yellow Pine district. In this region the general structure seems to be monoclinal, but it is complicated by numerous faults and some folding. The sedimentary strata of Potosi Mountain have a persistent dip to the west-southwest at fairly low angles. South of the Good Springs and Sandy road the limestones under Table Mountain dip 5°–10° WSW., as far south as an east-west line through the Anchor mine. The monoclinal structure is best seen on the east side of the summit of the range. The ridges extending westward into Mesquite Valley are faulted in a very complicated manner.

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[1] Spurr, J. E., op. cit., p. 175.

FAULTING.

Along the east front of the mountains there is a fault which at the Potosi-Arden road brings Mississippian (?) limestone against Jurassic (?) sandstone (see fig. 23) but in the vicinity of Good Springs brings the lower Pennsylvanian against the upper Mississippian (?). This fault is apparently the most profound in the district and will be referred to in this report as the great fault. At the Potosi-Arden road it appears to be nearly vertical, but the exact relations are not known, as the fault is followed by a rather deep canyon. For 4 miles south of the road the fault can not be clearly seen, but it appears to have a north-northeast course.

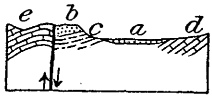

FIGURE 23.—Generalized structure section across the great fault at the Potosi-Arden road, Clark County, Nev., on line *A–A'*, Plate IV. *a*, Quaternary; *b*, Jurassic (?) heavy white sandstone; *c*, Triassic or Permian (?) red shales and sandstones; *d*, Pennsylvanian limestone; *e*, upper Mississippian (?) limestone.

At the Contact mine, about 5 miles south of the road, the great fault was again seen in some mine workings. At this place the blue limestones immediately west of the fault have a very steep dip to the east, but at a distance of 400 feet the dip is nearly as steep to the west. On the southeast flanks of Potosi Mountain, west of the mine, the usual low west-southwest dip of the limestones is well exposed. East of the fault at the Contact mine there are rather thin bedded red sandstones and shales that are similar to those at the base of the cliffs north of the Potosi-Arden road, but about three-fourths of a mile south of the mine white, heavily cross-

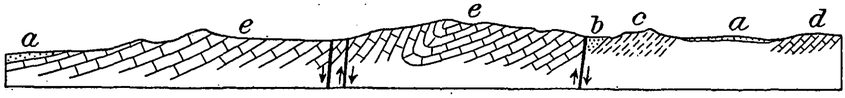

FIGURE 24.—Generalized structure section across the range 4 miles south of Potosi Mountain, Clarke County, Nev., on line *B–B'*, Plate IV. *a*, Quaternary; *b*, Jurassic (?) heavy white sandstone; *c*, Triassic or Permian (?) red shales and sandstones; *d*, Pennsylvanian limestone; *e*, upper Mississippian (?) limestone.

bedded, massive Jurassic (?) sandstone lies east of the fault. (See fig. 24.)

The fault zone itself is as a rule covered by wash, but in one pit about 10 feet east of a distinct outcrop of limestone there is 7 feet of fault breccia containing very small fragments of limestone and red sandstone in a pinkish-gray, sandy matrix that dips 75° W. This breccia zone appears to be about 35 feet wide, though its eastern limit was not certainly placed. The fault is covered from the Contact group south to the Lavina mine. It appears, however, to have a nearly north-south course.

At the Lavina the gray, somewhat crystalline limestones of the Mississippian (?) series are exposed west of the fault with a westward dip of about 45°. East of the fault the light pinkish-gray limestones and conglomerates of the lower members of the Pennsylvanian (?) are seen striking a few degrees west of north and standing nearly vertical or with a very steep dip to the east. Between these two sedimentary formations there are about 200 feet of granite porphyry and 60 feet of fault breccia consisting of fine fragments of limestone and porphyry. The actual wall of the fault was not seen, but several planes of movement, which dip 55° W., are probably parallel with the fault.

Along the east front of Spring Mountain the great fault dips steeply to the west and the beds west of the fissure have been raised relative to those on the east side by compressive stress. The faulting south of Good Springs on the east side of the range is not so clearly thrust faulting, yet it gives that impression.

South of the Lavina mine and north of the Good Springs and Sandy road there is a strong east-west fault zone which runs entirely across the mountains but appears to turn southward along the east front into the great fault.

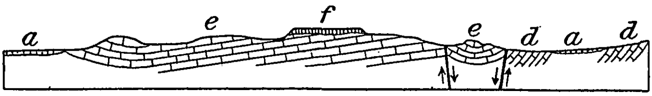

FIGURE 25.—Generalized structure section across Table Mountain, Clark County, Nev., on line C–C′, Plate IV. *a*, Quaternary; *d*, Pennsylvania limestone; *e*, upper Mississippian (?) limestone; *f*, biotite andesite flows (Tertiary ?).

In the vicinity of Crystal Pass, 2 miles south of Good Springs, there are two nearly parallel north-northwest and south-southeast faults with smaller displacement than the great fault. (See fig. 25.)

Near the Accident and Anchor mines two small north-south vertical faults cut the upper Mississippian (?) strata.

The east-west ridge at the northeast end of Mesquite Valley, at the west end of which the Green Monster mine is located, shows a most complex system of faults, but time did not permit a study of their relations.

The fault running south from the Potosi mine (No. 1, Pl. IV) appears to lie along the west side of an overturned anticline. (See fig. 24.) This fault is without much question due to compression.

A small thrust fault of about 10 feet heave occurs on the west limb of a low anticlinal fold about half a mile west of the summit on the Good Springs and Keystone road.

The low group of isolated hills 4 miles southeast of Sandy is traversed by a zone of brecciated limestone that is about 200 feet wide and trends N. 70° W. The movement along this zone appears to have been greatest in a horizontal direction, as the limestones on either side of it seem to be of about the same age.

FOLDING.

Folding of the limestone strata appears to have been much less extensive than faulting in the south end of Spring Mountain. The greatest folding noted in the reconnaissance was seen on the northwest flank of Potosi Mountain, along the line *B–B′* of plate IV. At this place there seems to have been an overturned anticlinal fold whose top was pushed over to the east-northeast, forming a tight syncline, as indicated in figure 24. Faulting occurred along the western limb of the anticline and perhaps at other places.

The Potosi Wash, which runs northeast and southwest in the northwest corner of the area mapped on Plate IV, is near the axis of a low anticline whose limbs dip 5° to the northwest and southeast on either side of the head of the canyon, but the structure of the south limb of the anticline west of the Potosi mine is very much complicated by faults.

The east-west fault across the range north of the Good Springs and Sandy road apparently follows the crest of a tightly folded anticline.

The northwest ridge, about 4 miles north of the Milford mine, seems to be the northeast end of an anticlinal fold whose axis plunges to the northeast under the intermountain valley south of the Good Springs and Sandy road.

CHARACTER AND AGE OF DEFORMATION.

The deformation of the south end of Spring Mountain seems to have been due to compressive stresses that acted in an east-northeast direction and resulted in thrust faulting of considerable magnitude and in the overturning to the east-northeast of the top of at least one anticline. With or shortly after this movement there was apparently some north-south compression. The McCullough Range, east of the northern part of the Ivanpah Valley, is largely pre-Cambrian granite, and it is thought that this formed the block against which the stress acted.

The age of the deformation is not certainly known, though it has involved the white cross-bedded sandstones of supposed Jurassic age.

INTRUSIVE IGNEOUS ROCKS.

GENERAL FEATURES.

Intrusive rocks seem to be the exception rather than the rule in Spring Mountain. By far the largest masses are seen in the vicinity of the Yellow Pine mine, though relatively small discontinuous exposures of porphyry are found north of the Lincoln mine in the vicinity of Crystal Pass, as well as at the Red Cloud, Lavina, and Keystone mines. Outside of these few places the sedimentary series so far as seen is apparently undisturbed by intrusions. It is reported that there is a small porphyry dike in the canyon east of the Milford mine, southwest of Little Devil Peak, and another at the May Kirby mine, south of the Keystone.

With the exception of the dikes at the May Kirby mine and east of the Milford mine, all these bodies of porphyry are very close to the great fault which runs approximately north and south along the east front of Spring Mountain.

The porphyry of the May Kirby mine is reported to be fairly continuous, running as far south as the east-west faulted fold which crosses the range west of Good Springs. (See Pl. IV.)

The limestones are much more resistant to weathering and erosion than the porphyry, so that croppings of the porphyry are difficult to trace. The position of the dikes is in places marked by depressions filled with soft decayed porphyry. The igneous areas can not be shown with accuracy on the map, as the outlines are irregular and are in general obscured by loose material.

The intrusions are in the form of short dikes that vary from a few feet to over 300 feet in width and thin sills that follow the tilted beds of the Carboniferous. In detail they are very irregular, a single dike ranging from 2 to 50 feet in width in a short distance. At the Keystone and Alice mines this irregularity is most conspicuous, as there development along the porphyry contacts has been more extensive than at any other places.

Just west of the Bybee mine the porphyry and limestones have been faulted. The dike (?) at this place is about 400 feet wide and is cut by two faults that strike N. 60° W. and dip about 70° N. On the south side of each of these faults the relative movement is to the east. The dike (?) apparently dips to the west nearly parallel to the bedding of the limestone, but as it is not cut in any of the levels of the Bybee mine its true character has not been determined.

PETROGRAPHY.

The intrusive rock in all exposures is much altered, usually to a red-brown color, though near the Bybee mine it is yellowish brown. It is distinctly porphyritic but differs in texture at different places. The most widely distributed variety is composed of pinkish orthoclase crystals from one-eighth to one-fourth inch in largest dimension, with some visible plagioclase crystals and a little biotite, forming about one-third of the rock, the remainder of which is a fine granular aggregate of orthoclase and plagioclase with some quartz. Apatite is a characteristic though not abundant accessory.

This facies is the best preserved of all the igneous rocks, though the thin sections were disappointing in that the plagioclase feldspars and ferromagnesian minerals were too much altered for accurate determination. The slides show phenocrysts of two ages. The earlier are small, well-formed orthoclase, plagioclase, biotite, and augite crystals; the later are all orthoclase crystals zonally built and reaching a maximum size of half an inch. Phenocrysts of the first crystallization are included poikilitically in the larger crystals. The ground mass is in excess of the phenocrysts and is composed of microcrystalline orthoclase, plagioclase, and some ferromagnesian mineral, possibly biotite, now largely altered to sericite. Here and there a little quartz is present in the groundmass. This rock is a quartz monzonite porphyry approaching granite porphyry in composition.

A different facies of the intrusive rock is exposed near the Alice mine, south of the Bybee. The rock is very coarsely porphyritic, containing beautifully developed orthoclase crystals as much as 1½ inches in diameter. These usually show zonal growth and are twinned according to the Carlsbad law. In this rock there are also rounded quartz phenocrysts a quarter of an inch or less in diameter, resembling pebbles.

This facies likewise contains phenocrysts of two ages, but there appears to be comparatively little plagioclase feldspar in the rock, which has therefore been called a granite porphyry.

There seems to be little doubt that this granite porphyry is a variation from the quartz monzonite magma rather than a distinct intrusion, though proof of this was not found.

ALTERATION OF THE IGNEOUS ROCKS.

Both the quartz monzonite porphyry and the granite porphyry are highly altered. This alteration consists of a more or less complete sericitization of the ferromagnesian minerals, accompanied by the development of iron oxide, which gives the yellow and red colors to the rock. The feldspars, both plagioclase and orthoclase, are altered to sericite and quartz. The quartz phenocrysts are somewhat strained and cracked, but not otherwise altered, and the apatite remains clear even where the rocks show the most change.

CONTACT METAMORPHISM.

There has been almost no contact metamorphism of the limestones, even at the borders of the porphyry intrusions. The contacts in most places are very sharp, and the texture of the porphyry is almost uniform from side to side of the largest dikes.

At one place about half a mile south of Crystal Pass a narrow sill of porphyry is intruded into a granular dolomitic (?) limestone which for 6 inches above the contact contains some seams of magnetite now largely altered to hematite and limonite. This material is said to carry about $10 a ton in gold. The porphyry at this locality occurs both as dikes and sills and contains small bunches of magnetite 2 inches or less in diameter.

At the Keystone and Red Cloud mines the limestone in immediate contact with the porphyry is slightly silicified and cut by narrow quartz stringers, but there is no other alteration of the sedimentary rock.

AGE OF INTRUSION.

The quartz monzonite porphyry and granite porphyry in most places are intrusive into the massive blue limestones that are probably of upper Mississippian age, and the largest areas of the intrusive rock are localized along the great fault, which occurred later than the deposition of the Jurassic (?) sandstone. Near the Lavina mine there are small dikes of quartz monzonite porphyry in the lower Pennsylvanian east of the great fault. The intrusion is therefore considered to have taken place after the faulting. Another feature which points to the same conclusion is that the dikes cut across the bedding of the limestones at whatever angles they now rest. The porphyry has been faulted, as is well shown at the Bybee, Keystone, Lavina, and Red Cloud mines, but it has not been disturbed or crushed to any such extent as it would have been had the intrusions taken place previous to the main deformation of Spring Mountain. The intrusion is therefore considered to be at least post-Jurassic in age and is possibly to be correlated with the granodiorite and monzonite intrusions of the Sierra Nevada.

EXTRUSIVE ROCKS.

GENERAL FEATURES.

The only places where extrusive igneous rocks were found in this district are on Table Mountain southwest of Good Springs, south of the Good Springs and Sandy road, and in one very small area about 5 miles southeast of Sandy.

The flows on Table Mountain cover an area of about 3½ square miles. The lower limit of rock of this type is at an elevation of 4,900 feet and is apparently at the same level on all sides of the mountain. The flows are essentially horizontal and overlie the tilted beds of the upper Mississippian (?) section. The sedimentary beds in this section, however, have a dip of only 10° W., and it was not determined whether the flow rocks rest on a single bed throughout or whether they overlap the eroded edges of several beds.

The exposure 5 miles southeast of Sandy covers an area of about 100 square feet and has the appearance of being composed of fragments of porphyry rather than of being part of a flow. The rock is similar to that of the flows on Table Mountain.

So far as known, none of these flows have suffered any faulting or folding.

PETROGRAPHY.

The flows have a total thickness of 110 to 150 feet. The lower half to two-thirds of them are light gray to reddish gray in color; the uppermost flows are dark and some are black. Most of the rock is vesicular, though at least one flow is a dense porphyry with a glassy base.

Under the microscope all these flows are seen to be very similar in mineral composition, though the proportions of the component minerals are different and the ratio of groundmass to phenocrysts varies widely. Most of the phenocrysts are small, well-formed crystals of andesine or labradorite that in a number of thin sections do not show any albite twinning, though most of them are twinned according to the Carlsbad law. Small, well-developed crystals of brownish biotite are next in number, but in all the slides they are somewhat altered to iron oxide. Augite is present in minor amounts in all the flows, the crystals being much smaller than those of the other phenocrystic minerals and as a rule not so well developed.

The groundmass is composed largely of minute microscopic plagioclase laths, together with magnetite and what appear to be small shreds of biotite. The crystals in the groundmass have a more or less concentric arrangement around the phenocrysts, due to flowage. In one slide the groundmass is seen to be partly glassy, but this is not the general rule.

The color of the rocks is probably due to the abundance of the biotite and to its degree of alteration. The gray rock contains much less biotite than the black rock, and the reddish flow is between the two extremes in the amount of biotite, with the difference that this ferromagnesian mineral is almost completely altered to iron oxide.

AGE OF EXTRUSION.

The age of these flows can not be determined in this particular area. They are most surely younger than the faulting and tilting, which has been shown to be post-Jurassic, and they are possibly to be correlated with the Tertiary period of volcanic activity common in western Nevada.

ORE DEPOSITS.

TYPES AND GENERAL MODE OF OCCURRENCE.

There are two distinct types of ore deposits in the Yellow Pine district. The more important is the replacement type, comprising deposits of zinc-lead and copper in upper Mississippian (?) limestone. The other type, which for some years was of importance, comprises the gold deposits in altered igneous rocks.

The lead mines were discovered first and from 1860 to the present time have been more or less continuously exploited. The Keystone gold mine was operated for several years previous to 1906, but in 1912 no gold mines were worked. Since the discovery of the zinc minerals in 1906 the greatest development has been in bodies of mixed zinc and lead ore.

The ore deposits of the replacement type can be divided into deposits of zinc and lead carrying some silver and deposits of slightly auriferous copper. The zinc-lead group can be still further subdivided into two overlapping types—one set consisting essentially of zinc minerals with little or no lead and the other containing argentiferous lead, but practically no zinc. These two types are distinct in a few places, but in most of the mines the ores are of the mixed zinc-lead type, though the proportion of one set of minerals to the other may be widely different in the same ore body. Some of the purely zinc-lead mines contain bodies of copper, but usually these are very small and of little importance.

There are only a few mines and prospects of copper ores alone, and these, with one exception, are on the east side of the mountains, not far removed from the great fault.

The replacement deposits seem to have little relation to the few intrusive igneous rocks in Spring Mountain, as a large number of the ore bodies are found in the limestone at a considerable distance from any known porphyry. It is true that some of the mines, notably the Bybee and Prairie Flower, are located very near masses of igneous rock, but the greater number of the mines are remote from any known intrusives.

The gold ores of Spring Mountain are found in the intrusive quartz monzonite and granite porphyry or at the contact. The Keystone deposit is the best example of gold ores in altered porphyry, and the Monarch group south of Crystal Pass shows the type of deposit at the contact.

REPLACEMENT DEPOSITS.

ZINC-LEAD DEPOSITS.

OCCURRENCE.

The zinc-lead deposits of the Yellow Pine district are very irregular replacement bodies which usually occur in more or less crystalline limestone and have been found, with one exception (the Hoosier), in the immediate vicinity of fractures or folds. No deposits have been discovered east of the great fault or in limestones younger than the upper Mississippian (?) limestones.

The Bybee and Prairie Flower ore bodies are in upper Mississippian (?) limestone near the contact of intrusive quartz monzonite or granite porphyry, but the rest of the lead-zinc mines here described are situated where no intrusive igneous rock has yet been found. The ores occur through a vertical range of 3,000 feet; at the Potosi mine they lie at an elevation of approximately 6,000 feet, and at the Milford mine at 3,000 feet.

The faulting and folding of Spring Mountain is complex and time did not permit a careful study of the structure, but it seems to be fairly certain that the ore deposits are not restricted to any paricular bed of limestone. At the Potosi mine the barren zones are dense thin-bedded dark limestones with some shale, and at the Green Monster and Milford the ore does not occur in the dense cherty dark limestone that is interbedded with the light-colored ore-bearing crystalline limestones. As a rule, the more highly crystalline the limestone the greater has been the ease of replacement, but there are exceptions to this generalization.

Th principal factor in determining the location of the ore bodies appears to have been the presence of fractures of small or large extent that in general strike east and west or nearly north and south and stand in many places almost vertical. The mineral-bearing waters moved with more ease along these openings than through the rock. They deposited their content in part in the open fissures, but they have also caused the replacement of certain beds of limestone for some distance from the fractures.

As a consequence of the location of the ore bodies near practically vertical fissures, the vertical dimension of many of them is greater than either of the horizontal measurements. At the Hoosier mine, however, the ore is in a flat tabular body in a particular bed of crystalline limestone which, in the vicinity of the mine, does not appear to have been disturbed by faulting. At the Bybee mine the upper ore body has greater horizontal than vertical extent, but at each end this body merges into others with large vertical dimensions. The border between ore and barren rock is everywhere irregular, but the transition zone in all the properties visited is less than 2 feet in width and at many of them the line between ore and waste is sharp.

VARIATIONS IN THE DEPOSITS.

The lead and zinc ores are as a rule very closely associated—that is, in practically all the zinc ores there is more or less lead. The ratio of lead to zinc is extremely diverse, even in a single ore body. At the Bybee it has been fairly well established that there is a greater lead content in the ore above the 300-foot level than below it, and at the Milford and Addison mines there is a marked decrease in lead below a depth of 50 feet. The ore at any particular level is also subject to wide variation in the relative proportions of lead to zinc. In some places the ore may be exclusively zinc and near by it may be half lead and half zinc, or largely lead. At the Bonanza mine (No. 28, Pl. IV) there is a distinct deposit of lead ore and an equally clean and distinct deposit of zinc, separated by about 150 feet of limestone. The Ingomar mine is said to produce practically pure lead ore. Clean zinc ore with almost no lead is found at the Monte Cristo and in stopes of several of the other mines.

MINERALS OF THE DEPOSITS.

With two exceptions the minerals of the zinc-lead deposits of the district are those belonging to the oxidized zone. Galena is present in subordinate quantities in all the mixed ore and in the purely lead deposits. The only occurrence of a zinc mineral belonging to the sulphide zone noted was at the Potosi mine, where there is a small undeveloped body of sphalerite surrounded by carbonate ores.

In the following paragraphs will be found a brief description of the minerals of the zinc-lead deposits, arranged in the order of their importance.

Zinc carbonate.—Smithsonite, $ZnCO_3$, which is usually spoken of simply as "carbonate" or "dry bone," contains theoretically 52 per cent of metallic zinc. The better grades of commercial carbonate run from 35 to 40 per cent of zinc. The mineral assumes a variety of forms, the most common one in the Yellow Pine district being an earthy material stained brown to red by iron oxide and having the appearance of somewhat consolidated sand. Some of the ore consists of massive hard white smithsonite which has a high specific gravity, nearly equal to the theoretical 4.3 to 4.5 of the pure mineral, and which shows in places a beautiful banded structure. Another variety is in banded form, the ore having been deposited in successive layers in open cavities; this variety may contain considerable hydrozincite. Here and there small well-developed crystals of smithsonite are seen in druses in the massive ore. These are small rhombohedrons that resemble calcite in form.

Lead carbonate.—Cerusite, $PbCO_3$, locally called lead carbonate or "sand carbonate," contains theoretically 77.5 per cent of metallic lead. Its usual mode of occurrence is in small semiporous masses of gray, brown, and yellow color surrounding kernels of unaltered galena in the zinc carbonate ore. Much of it is in very fine grains distributed all through the zinc ore, making hand sorting impossible. At a few places small stopes of lead carbonate have been mined, and at the Bybee mine, in the north stopes on the first level, there are some large bodies of pure gray cerusite which has the typical pearly luster of that mineral. At the Potosi mine a few very small fibrous white crystals of cerusite were found in a druse in massive gray lead carbonate. In the Yellow Pine district the cerusite is usually argentiferous—in fact, the silver produced in the district is derived chiefly from the galena and the cerusite.

Lead sulphide.—Galena, PbS, often spoken of as "lead" or "sulphide" in the Yellow Pine district, theoretically carries 86.6 per cent of metallic lead. Its usual mode of occurrence is as small masses surrounded by anglesite and cerusite in the smithsonite. Some of these masses show a roughly cubical outline of crystalline galena, but most of them are very irregular. The cubic cleavage is always well shown, even in the most irregular masses. At the Bonanza mine (No. 28, Pl. IV) there is a deposit of almost pure galena and cerusite. In the sphalerite ore from the Potosi mine there is a small proportion of galena intergrown with the zinc ore.

Zinc silicate.—Calamine, $(ZnOH)_2SiO_{32}$, theoretically contains 54.2 per cent of metallic zinc. In the Yellow Pine Co.'s mines it is usually found lining cavities in the other ores. At the Potosi and Bybee beautifully clear white tabular crystals of small size are found along watercourses. At the Monte Cristo mine brownish calamine is mixed with smithsonite along the western postmineral fault. This mineral is also seen in thin seams between laminæ of smithsonite in some of the banded ore from the Monte Cristo and Milford mines.

Hydrozincite.—Hydrozincite, $ZnCO_3.2Zn(OH)_2$, is the hydrous form of smithsonite, sometimes called "zinc bloom." It has a white or yellow color, an earthy texture somewhat resembling that of chalk, and a specific gravity notably lower than that of smithsonite. Theoretically it carries 60 per cent of metallic zinc. It occurs as thin white coatings on smithsonite near the surface at most of the mines and is found in fairly large masses at the Potosi and Bybee. The largest stope of this mineral seen in the district was on the first level of the Bybee mine, southwest of the shaft. (See fig. 27, p. 265.) The croppings of most of the zinc-lead deposits are marked by soft white chalklike hydrozincite with more or less cerusite and a yellow lead stain that is probably pyromorphite.

Lead sulphate.—Anglesite, $PbSO_4$, theoretically contains 73.6 per cent of PbO. In the Yellow Pine district it occurs only as thin coatings about kernels of galena and as streaks cutting that mineral. It has a black, somewhat waxy appearance quite different from the metallic lead-gray of the galena, from which it is readily distinguishable.

Lead phosphate.—Pyromorphite, $Pb_3Cl(PO_4)_3$, a yellow earthy material derived from the alteration of galena, is found at the Singer and Tiffin mines. It is seen in very small amounts mixed with cerusite, hydrozincite, and smithsonite in the croppings of other zinc-lead deposits. At the Beck mine (No. 8, Pl. IV) the mineral is fairly abundant and has been supposed to contain uranium.

Zinc sulphide.—Sphalerite, ZnS, was found in the Yellow Pine district only at the Potosi mine. It occurs here at one place on the first level above the main tunnel. The blende is in crystals as much as one-fourth inch in diameter intergrown with a small amount of calcite and a little galena. It is dark brown to black in color and was developed contemporaneously with the calcite and galena. It is altered to smithsonite around the borders.

COPPER DEPOSITS.

OCCURRENCE.

The copper ores mined in the Yellow Pine district are entirely those characteristic of the zone of oxidation, being oxide, carbonate, and silicate minerals. In their occurrence they somewhat resemble the zinc-lead ores, with the difference that the copper mineralization has been not nearly so strong. The copper deposits are as a rule clearly distinct from deposits of other minerals, yet in some fractures, cutting the zinc carbonate ore bodies, there are small deposits of copper carbonates. It therefore seems as if these deposits, at least, are younger than the secondary lead-zinc mineralization.

The four copper mines visited by the writer in the fall of 1912 are the Ninety-nine, Columbia, Lincoln, and Aura Amigo. Besides these there are several prospects south of the Ninety-nine and north of the Red Cloud which have good surface showings, and it is reported that at the Double-up mine there is a fair-sized body of copper ore. In the zinc-lead mines small bunches of copper carbonates are not uncommonly opened, but they constitute a very small part of the ore of those mines. The mines having strictly copper ores, so far as developed, are, with the exception of the Aura Amigo mine (No. 4, Pl. IV), on the east side of Spring Mountain and not far removed from the great fault.

The occurrence of the copper deposits, like that of the zinc deposits, seems to be determined largely by the presence or absence of fracture planes. They are typical replacement bodies and as a rule the boundaries between ore and waste are much less well defined than the walls of the zinc-lead deposits.

At both the Ninety-nine and Columbia there seems to be a decided tendency for the ore to decrease in copper content with increasing depth. At the Ninety-nine mine the ore is strong to a vertical depth of 260 feet, along a nearly vertical east-west fracture. At the Columbia, whose ore body makes along a nearly flat southward-dipping east-west fault, the mineralization is decidedly weaker at a depth of 70 feet than at the surface. At the Lincoln mine practically the only body of ore of workable size did not extend beyond a depth of 25 feet.

MINERALS OF THE COPPER DEPOSITS.

The copper ores are those typical of the zone of oxidation. They are all said to carry a small amount of gold. The following minerals arranged in the order of their importance were found in the copper ores of the district.

Red copper oxide.—Cuprite, Cu_2O, whose theoretical copper content is 88.8 per cent, is rarely found pure in the Yellow Pine district. It usually occurs with iron oxide in dull brownish-red to red earthy masses mixed with more or less of the carbonate minerals.

Hydrous copper silicate.—Chrysocolla, $CuSiO_3.2H_2O$, occurs as bluish-green incrustations on the red oxide, together with the carbonates.

Copper carbonate.—Malachite, $Cu_2(OH)_2CO_3$, in bright-green small masses and thin crusts, locally with a silky fibrous structure, is found intermixed with chrysocolla and azurite on the red oxide ore.

Hydrous copper carbonate.—Azurite, $Cu_3(OH)_2(CO_3)_2$, occurs as dull earthy bright-blue patches with malachite and chrysocolla.

Copper glance.—Chalcocite, Cu_2S, occurs in ore from the Ninety-nine mine, which contains some small kernels of black metallic chalcocite surrounded by the red oxide and carbonates. It is also reported that some of the Columbia ore contained this mineral, though none was seen in the mine or on the dump.

Copper phosphate.—Liebethenite (?), $Cu_2(OH)PO_4$, was found as a very thin crust of dark olive-green color on a specimen of ore from the incline at the Aura Amigo mine on the west side of the mountains.

SOURCE OF THE COPPER.

The only primary mineral-carrying copper found in the district is "cupriferous pyrite," in the gold ore at the Lavina mine. This ore is clearly associated with the quartz monzonite-granite porphyry intrusion. At the Keystone mine no sulphide ore is to be seen, but there are what appear to be casts of pyrite in some heavily iron-stained altered quartz monzonite porphyry, and some of the ore is stained by copper carbonates. As the original gold ores were "cupriferous pyrite," it seems probable that the copper of the replacement bodies may have been derived from them. Whether the copper in the so-called cupriferous pyrite occurs chemically combined in the pyrite or as chalcopyrite was not determined.

GANGUE MINERALS OF THE REPLACEMENT DEPOSITS.

As a general rule there is no real gangue in the zinc-lead ores. Limonite and red iron oxide are present, but these can hardly be considered gangue minerals in the sense in which that term is ordinarily used. Most of the zinc-lead ore bodies contain small masses and ribs of unaltered limestone which the miners of the district sometimes call gangue, though it is not gangue in the strict sense. At a few places there are small bodies of white calcite which is strictly a gangue mineral.

In the copper deposits the gangue is calcite, which may be white, green, or pink. The color is due to the presence of minute quantities of red copper oxide in the pink variety, at the Columbia mine, or to copper carbonate in the green variety, found in the Lincoln mine.

Two other minerals ordinarily spoken of as gangue minerals were noticed in the district. In the sphalerite ore body of the Potosi mine there are some small crevices lined with minute soft tabular crystals of gypsum (calcium sulphate, $CaSO_4$).

Heavy spar (barite, $BaSO_4$) occurs in coarsely crystalline form about three-fourths of a mile north of the Red Cloud mine, as a 1-foot bed that was cut in a shallow shaft on one of the claims belonging to Richard Feaster. This was the only occurrence of the mineral noted, but it is possibly of wider distribution.

ORIGIN OF THE REPLACEMENT DEPOSITS.

GENERAL MODE OF OCCURRENCE.

The replacement ore bodies, as before stated, occur near fissures along most of which there has been some movement. There are two fairly persistent sets of fractures. One strikes about east and west and either stands nearly vertical or dips to the south at medium angles. The other set strikes from N. 20° W. to N. 20° E., though the majority of the fractures depart from the true north-south line at smaller angles than these extremes. Nearly all these fractures, so far as seen, are vertical or have a very steep dip either east or west. The ore bodies make in large and small irregular masses along the fractures and penetrate beds of crystalline limestone adjacent to the fractures, as replacements.

The ores so far mined are all carbonates of lead and zinc, with some zinc silicate and lead sulphate and varying amounts of galena. They are typical ores of the zone of oxidation.

The deepest mine working in the district, at the Keystone, has reached a vertical depth of at least 700 feet and has been absolutely dry throughout. The Bybee has attained a vertical depth of at least 300 feet and shows no sign of moisture. The depth of the ground-water level is not known.

CHARACTER OF THE ORIGINAL DEPOSITS.

There is only one place where there is even a suggestion of the original character of the mineralization. At the Potosi mine, 65 feet above the main tunnel level, there is a small body of sulphide ore which is thought to be a remnant of the original ore that may be enriched. It is not certain, however, that this body may not be a deposit of secondary sulphides, but it is thought to represent the original ore. This ore consists of rather massive dark-brown to black sphalerite set in a matrix of calcite, with small crystals of galena. That the sphalerite contains a large amount of iron is beyond question.

CHARACTER OF THE PRESENT ZINC-LEAD ORES.

Most of the ore bodies that are being mined consist of irregular masses of iron-stained smithsonite with a relatively small proportion of galena as kernels, surrounded by a thin band of anglesite, outside of which there is a greater or less amount of cerusite. Some deposits consist of almost pure white smithsonite with a little calamine, but even these contain some iron-stained ore. Strictly lead deposits are sometimes found consisting of galena, anglesite, and cerusite.

ORIGIN OF THE ZINC-LEAD ORE BODIES.

It is the belief of the writer that the ores of the Yellow Pine district were derived entirely from bodies of sulphide ore whose mode of deposition is not definitely known, though they are thought to have been replacements. This primary ore, to judge from the single occurrence at the Potosi mine, consisted of iron-bearing sphalerite and small quantities of galena in a matrix of calcite. If ore of this kind were brought into the zone above water level, the processes of oxidation, carbonation, hydration, and solution characteristic of the belt of weathering would take place. Lead sulphide and zinc sulphide by simple oxidation would be changed to lead sulphate ($PbSO_4$) and zinc sulphate ($ZnSO_4$). The former, deposited as the mineral anglesite, is now found surrounding kernels of unaltered galena. If these sulphates react with calcium carbonate ($CaCO_3$), lead carbonate and zinc carbonate are formed according to the following equations:

$$PbSO_4+CaCO_3=PbCO_3+CaSO_4.$$
$$ZnSO_4+CaCO_3=ZnCO_3+CaSO_4.$$

The presence of the red iron-oxide stain in much of the ore is explained by the breaking down of the iron-bearing sphalerite, the iron going into solution probably as sulphate, to be deposited as the hydrated oxide limonite.

Galena is much more stable than sphalerite in the zone of oxidation, and its occurrence in larger amounts in the upper parts of many of the mines is due to this fact. It has been concentrated there by the solution and carrying away of a larger proportion of the zinc minerals.

It is thought that the present bodies of carbonate ore have resulted in part by alteration in place and in part from a downward concentration of the metals by surface waters that followed the fractures as the easiest paths in their movement toward the ground-water level. These strongly mineralized solutions have precipitated the zinc and lead in the more pervious crystalline limestone beds, or in zones of crushed limestone along fault planes.

GOLD DEPOSITS.

The purely gold deposits of the Yellow Pine district are less than ten in number, and of these only four were visited. These represent three types of deposits between which there seem to be all gradations. The Keystone and Red Cloud represent one type in which the gold occurs free, disseminated in very much altered quartz monzonite porphyry. At the Monarch group, south of Crystal Pass, the gold occurs free with thin seams of magnetite, now partly altered to limonite, that are found between limestone and altered quartz monzonite sills. The ore at the Lavina mine consists of stringers of quartz, calcite, and cupriferous pyrite, occurring in a zone of brecciated limestone and quartz monzonite porphyry but usually in that part of the zone near the altered though uncrushed porphyry. The quartz in these stringers is all strained by crushing since its formation and some of the calcite is fragmental. The pyrite and some calcite form the matrix of the other constituents.

From the foregoing it seems likely that the gold ores were originally formed by ascending, probably hot waters that probably closely followed the intrusion and solidification of the quartz monzonite porphyry magma. The gold was originally associated with pyrite or slightly cupriferous pyrite. When this material was brought into the zone of weathering the sulphides broke down. Iron and copper went into solution and probably most of this solution was carried away, but some of the iron and a little of the copper were left in the altered quartz monzonite porphyry, forming the brownish stain and at a few places the greenish copper carbonate minerals. These waters were somewhat siliceous, for they have deposited quartz in small cracks in the adjacent limestone and have in general caused a slight silicification by replacement of the limestone immediately at the contact. The gold in the present ores is in very small flakes and is of a rather light yellow color, apparently carrying considerable silver. The tenor of the ores is usually low, generally not exceeding $60 a ton and averaging between $15 and $20 for the grade of ores so far mined.

ECONOMIC CONSIDERATIONS.

PRODUCTS OBTAINABLE.

The Yellow Pine district has a varied production. Exclusively gold ores are obtained from at least four different mines. There is also some opportunity for the development of prospects which may yield various oxidized copper ores that are said to carry a little gold. By far the most important mines at the present writing are those from which oxidized zinc and lead ores are obtained. These produce three classes of ore, namely, lead ore, zinc ore, and zinc-lead ore, each one of which requires different treatment. All three classes may be taken from a single mine or they may be found in distinct deposits.

The lead ores—galena, cerusite, and anglesite—are found fairly clean in considerable amounts. They carry silver and are readily salable to any of the lead-smelting companies in the Western States, though the market for ore of this kind is now almost entirely restricted to the companies with smelters at or near Salt Lake City, Utah.

The zinc ore, consisting of mixed smithsonite, hydrozincite, and calamine, is found practically free from galena at many places in the district. So far as known the silver content is very low in all this ore. This grade is most acceptable to the zinc smelters of the Mississippi Valley and has of late found a market with the manufacturers of zinc-white paint pigments.

The mixed zinc-lead ore found at the Potosi, Bybee, and numerous other mines can not be sold at a profit to the miner without some sort of separation. Previous to 1911 all ore of this grade was sorted by hand into the two products, but it was realized that there was of necessity a large loss in the fine material which could not be sorted by picking. The new Yellow Pine mill has demonstrated that this ore can be separated by mechanical means and the products, lead concentrates and zinc tailings, disposed of to the smelting companies.

MILLING.

Three mills have been built in the Yellow Pine district. One of these was a cyanide mill for the treatment of gold ores, and the other two were used for treating zinc-lead ores.

The Keystone mill at Sandy is equipped with two 4-foot Huntington mills for crushing the soft altered porphyry ores and with iron leaching tanks. At the Red Cloud mine an unsuccessful experiment was made at cyanidation.

The mill now used by the Yellow Pine Co. was originally built by the Mineral Union Co. (Ltd.), in 1900, as a leaching plant to recover silver and lead from the complex ores of the district. It did not prove successful and was allowed to remain idle for several years. In 1911 the Yellow Pine Co. began the alteration of the mill to a concentrating plant for treating the mixed lead-zinc ores of the Bybee mine. The mill is rather a separating than a concentrating mill, for all the products are marketed except a very small amount of waste rock taken from the picking belt. What are ordinarily called concentrates from the tables constitute the lead product, which is said to average 57.5 per cent of lead, 10 per cent of zinc, and 40 ounces a ton of silver. The tailings that are waste in ordinary practice form in this mill the zinc product, with a content of 33 to 35 per cent of zinc, 6 to 8 per cent of lead, and 4 to 6 ounces a ton of silver. The mill is rated at 80 tons in 24 hours, but in actual practice three 8-hour shifts treat about 75 tons of crude ore daily.

This mill has been running for a little over a year on ore carrying from 16 to 17.5 per cent of lead, 27.8 to 29.8 per cent of zinc, and 11 to 11.7 ounces a ton of silver. The zinc is in the form of mixed smithsonite, calamine, and hydrozincite. The lead content is 75 per cent cerusite, the remainder being largely galena with some anglesite. The silver is almost entirely carried with the lead. Fred A. Hale, superintendent of the mine and mill, estimates that from ore of this class 68.6 per cent of the lead, 92.2 per cent of the zinc, and 62.6 per cent of the silver are saved. During the fall of 1912 the monthly shipments amounted to 1,500 tons of zinc tailings and 300 tons of lead concentrates.

A more detailed description of this mill has been prepared by the writer for publication in Mineral Resources of the United States for 1912.

TRANSPORTATION.

Hauling charges from the mines in the district to the shipping points, Arden, Jean, or Roach, are variable. The Potosi Mining Co. owns its own outfits and estimate that it costs 50 cents a ton to haul from the mine to Roach, a distance of 20 miles. On the other hand, lessees working in the vicinity of the Monte Cristo mine pay from \$2.25 to \$2.50 a ton to have their ore hauled to Jean, only 7 miles distant, and from the Milford and Addison mines to Roach, a distance of 16 miles, the usual charge is \$6 a ton. It is fair to say that the average price for hauling is \$2.50 a ton for the mines on the east side of the range and from \$6 to \$8 a ton for those on the Mesquite Valley side.

The Yellow Pine Mining Co. has built a 36-inch gage "ore road" from Jean to the Bybee mine, with switching facilities at the mill in Good Springs. A Shay geared locomotive is used to haul a train of seven 6-ton side-dump ore cars. Oil is used as fuel for this engine, the supply coming from the California oil fields at \$1.24 a barrel f. o. b. Jean. The train makes two trips daily between the mine and mill and one trip to Jean with concentrates for shipment. The estimated cost for transportation is 45 cents a ton.

The freight charges from the shipping points to the smelters are fairly well established, being $6 a ton to the Salt Lake City plants and $8 a ton to the zinc smelters in the Mississippi Valley.

MINES.

MINES WEST OF THE MOUNTAINS.

POTOSI MINE.

The Potosi mine (No. 1, Pl. IV) was first worked for lead by the Mormons in 1860. The ruins of the original small lead smelter are still to be seen in the canyon northwest of the mine. The original location was the eighth claim, to which patent was issued by the United States and the deed was signed by President Lincoln. This property, which now consists of 28 claims and 6 mill sites on the west flank of Potosi Mountain, is controlled by Mahoney Bros., contractors, of Los Angeles, Cal.

The original development consisted of a tunnel on the ore about 600 feet in length. This tunnel is not now used. The main working tunnel is about 75 feet farther south and 25 feet lower. Its mouth is at an elevation of 6,400 feet, about 800 feet above the valley bottom. In the fall of 1912 it was approximately 1,200 feet long, running eastward into the ore body. There are three very irregular levels—65, 100, and 125 feet above the working level—which follow the ore bodies and are connected by numerous stopes, raises, and chutes, making a total of nearly three miles of workings. A vertical winze about 700 feet from the tunnel mouth is down 100 feet, and nearer the mouth of the tunnel there is an inclined winze on some ore. These workings are most irregular and it was unfortunate that the writer was not permitted to use the mine maps underground, for with their aid a much better idea of the relations of the ore bodies to one another and to the dislocations of the limestone might have been worked out.

The country rock is limestone. The mouth of the main tunnel is on a westward-facing north-south cliff, which seems to be due to erosion of the beds west of a fault. Figure 26 shows this general relation and the localization of the ore near the minor north-south faults.

The upper part of the cliff is composed of dark fine-grained massive limestones in beds as much as 6 feet thick. Some of the beds carry Carboniferous fossils which Mr. Girty regards as probably of upper Mississippian age. Chert is not abundant. A few of the limestones near the top of the cliff contain unequally distributed chert nodules, but in the ore-bearing limestone there is practically no chert. Immediately below this bed there are about 20 feet of hard, shaly limestones, of very dark color and fine grain, in beds 2 inches thick. The operators thought that these "shales," as they are locally called, formed the lower limit of the ore, but recent developments in the shaft indicate that some ore occurs also at a horizon at least 50 feet below them.

The sedimentary rocks, as shown by figure 26, are almost horizontal, though they dip slightly to the south and east, probably not over 5° to 10°. They are cut by two systems of crevices, one at right angles to the cliff face and one about parallel to it. The east-west crevices show no faulting, but along the north-south zone there has been movement. The east-west crevices dip to the south at medium angles, but the faults are essentially vertical like the main fault at the mouth of the tunnel.

The ore bodies are extremely irregular in size and detail but are without question clearly related to the fractures in limestone. The

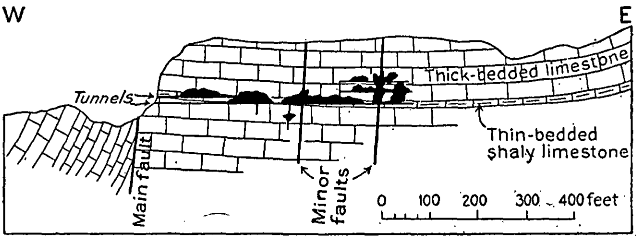

FIGURE 26.—Generalized cross section in Potosi mine, Clark County, Nev., showing relation of the ore (black) to minor faults and the position of beds on either side of the main fault.

waters which brought in the ores followed these more or less open courses and replaced the walls as well as partly filled the crevices.

The original character of the ore is indicated at one place on the 65-foot level above the main tunnel, where a small body of sulphide ore was found. This ore has not been developed but appears to be a remnant that has escaped oxidation. It consists of brown to black iron-bearing sphalerite contemporaneously intergrown with a little calcite and much less galena. Its borders are not sharp, the sulphide being irregularly altered to smithsonite. One specimen of this ore shows a fracture lined with small gypsum crystals.

The principal ore mined at the Potosi is a brownish-gray cellular smithsonite, but some of the zinc carbonate is well crystallized, particularly as linings in the cavities of the more massive ore. In a few stopes the zinc ore is an iron-stained sand. Here and there the typical white banded smithsonite is found lining cavities. Calamine is not abundant but is commonly present in the ore.

Intermixed with the zinc ore are large and small bodies of lead ore. The lead occurs commonly as pure cerusite, but also as galena, coated first with a thin layer of anglesite, outside of which is cerusite. The carbonate is dark gray, usually iron stained but showing the pearly luster characteristic of the mineral. There are a few fairly large stopes of nearly pure lead ore, but in general the lead ore is intermixed with the zinc ore and requires careful sorting.

Oxidized copper ores, largely cuprite, and a little malachite mixed with limonite are found, particularly along the north-south faults. There is evidence of movement since the formation of the carbonate zinc-lead ore bodies, but the copper ores have largely been deposited since the last movement.

The ore bodies vary from those a few feet in diameter to large masses. One of these completely blocked out is 150 by 60 feet in cross section and at least 100 feet high. Many of the stopes are 8 to 12 feet wide. Both underhand and overhand stoping are practiced, and almost no timber is used in the mine. The ore so far shipped has been taken from the tunnel level or above. It is hand sorted into two products, one largely lead and the other zinc. From the bins at the tunnel mouth the ore is carried by an 1800-foot gravity tram to the main road in Potosi Wash. At present the production is about 700 tons of sorted zinc ore a month, which runs 34 to 48 per cent of zinc and 2 to 5 per cent of lead. Besides the zinc, a considerable amount of crude sorted lead ore is sold, which is said to run 65 to 70 per cent of lead, 6 to 7 per cent of zinc, and 15 to 16 ounces a ton of silver.

GREEN MONSTER MINE.

The Green Monster mine (No. 2, Pl. IV) is in the northwestern part of the Yellow Pine district, at the west end of the long east-west spur that partly separates the Mesquite and Pahrump valleys. The mine is the property of the Hearst estate and for several years, before the discovery of the zinc ores, was a producer of lead and silver. It had been closed for some time prior to 1912 and the workings were not accessible. There are two inclines on the north lower ore body, in which considerable work has been done, and a vertical shaft sunk south of the outcrop is said to be about 300 feet deep. There was no ore on the dump of this shaft, so it seems probable that the ore zone has not yet been cut. There are two ore bodies 4 to 6 feet wide in the 40 feet of grayish-white crystalline limestone immediately below very dark fine-grained cherty fossiliferous limestones. These are parallel to the bedding of the formations, which strike N. 40° W. and dip 65° SW. A few imperfect fossils collected here are determined as probably upper Mississippian.

The outcrops consist of yellow to brown cellular earthy material showing in a few places small remnants of galena. This capping is largely limonite but contains some lead and zinc, in the form of carbonates. In some surface stopes there are still masses of grayish, yellow-stained cerusite, incrusting galena. Anglesite occurs in places as a coating between the carbonate and sulphide.

There is considerable zinc carbonate on the dump and some is visible in the open cuts. This mineral occurs both in gray-white massive and banded form and in brownish iron-stained masses. Hydrozincite coats some of the smithsonite. Calamine is, to judge from the dump, scarce but was seen as laminæ in the banded carbonate ore.

So far as could be determined the ore is localized along more or less open cavities. Some postmineral movement has taken place along these zones.

KEYSTONE MINE.

The Keystone mine (No. 3, Pl. IV) is on the west side of Spring Mountain about 2 miles southwest of Shenandoah Peak, 5 miles northeast of Sandy, and 8 miles west of Good Springs. A large group of claims is controlled by the Nevada Keystone Mining Co., but the mines have been idle since 1906. Previous to that time the Keystone was worked intermittently for about 15 years and is reported to have produced $1,000,000 in gold.

The development consists of several large open-cut glory holes, three tunnel levels, and an inclined winze from the lower working tunnel, said to be 1,100 feet deep. From the lower tunnel there are a number of crosscuts and raises to the upper levels. The workings were badly caved in September, 1912, and but little of the deposit could be seen.

The limestones of the north side of the east-west ridge on which the Keystone is located dip 30° SW. near the mine but are nearly flat at the top of the hill south of the tunnels. North of the canyon in which the mine is located there is a small area of pinkish-gray limestone which appears to be a downfaulted portion of the lower Pennsylvanian similar to the limestones in the low hill north of Good Springs. The limestones in which the mine is located are blue-gray dense rocks. They are cut in a most irregular way by dikes and sills of quartz monzonite porphyry which have a general north-south elongation. The porphyry is not exposed north of Keystone Canyon but is said to extend southward almost to the Good Springs and Sandy road. At the hoist station in the lower tunnel the intrusion varies from 70 feet to 4 feet in width in a distance of 50 feet. The limestone for 2 inches from the contact is usually somewhat bleached, silicified, and cut by little stringers of quartz; other than this there is no contact alteration.

The porphyry is much altered in all places where it was seen, though usually its original texture can be determined. The minerals formed appear to be limonite, chlorite (?), sericite, and kaolin. In one specimen cubes of hydrated iron oxide, evidently an alteration product of pyrite, were noted. This altered porphyry is the ore and its value is due entirely to free gold, which occurs in minute flakes throughout the ore, especially where the rock is most iron stained.

The tunnel could be entered for only 450 feet. It runs S. 5°–20° W. along a series of overlapping branching faults which cut both porphyry and limestone, though very commonly the movement has been at the contacts of these two rocks. These faults run into and away from one another, though all of them dip to the west, some steeply and others at low angles. There is usually from 1 to 2 inches of hard dry gouge along them, but no dominant direction of movement could be ascertained.

It is said that the smaller sills and dikelets were usually richer than the larger bodies of porphyry, which appears entirely plausible, for the big masses of quartz monzonite are usually less altered than the small ones.

The ore was all raised or dropped to the lower-tunnel level, trammed to bins on the dump, and drawn into the wagons which took it to the cyanide mill at Sandy, the nearest water. The grade of the ore is not definitely known but is thought to have been between $18 and $25 a ton in gold and a little silver.

AURA AMIGO CLAIMS.

The Aura Amigo claims (No. 4, Pl. IV) are in a small canyon south of Keystone Canyon, about 2 miles west-northwest of the Keystone mine. In 1912 they were being worked by Eggler White and C. M. Overs, the owners. The deepest working is an inclined shaft, about 30 feet under cover, and there are several other pits and open cuts over a length of two claims.

The dark gray-blue limestones, which dip to the southwest at medium angles, are here cut by a fracture that strikes N. 60° E. and dips 60° S. The ore makes along this fracture, varying from a few inches to a foot in width. The largest body seen is at the junction with a N. 30° W. vertical crevice, where there is 10 feet of ore. The ore is largely limonite with some "copper pitch ore," malachite, and chrysocolla. In a crevice in the carbonate ore there was found a thin olive-green coating, which proved to be copper phosphate.

WHALE GROUP.

The Whale group (No. 5, Pl. IV), comprising two claims, belongs to Miller & Tursick, of Good Springs. These claims are located in the hills north of the Good Springs and Sandy road, about 4 miles east of Sandy.

The principal development work is a 75-foot incline on the south side of a steep draw, at an elevation of 4,000 feet.

The ore occurs in buff-gray, somewhat crystalline limestone, immediately over a bed of blue cherty limestones, and has been traced by open cuts for about 1,800 feet. The beds strike N. 40° E. and dip 75° SE., and the ore is in the same position.

The body in the shaft is along a more or less open watercourse and varies from 2 to 12 feet in width. The ore is all iron-stained smithsonite, with a very minor amount of hydrozincite. On some drusy surfaces there are grayish crystals of calamine.

BILL NYE MINE.

The Bill Nye mine (No. 6, Pl. IV) is just south of the Good Springs and Sandy road, on the west side of the summit, at an elevation of 3,950 feet. The property belongs to John Allen and William Frederickson, of Good Springs.

A crosscut tunnel, 200 feet long, with one short drift, is the principal development work. This tunnel is run eastward through thin-bedded buff-gray limestones that locally strike N. 30° E. and dip 45° SE. The beds are cut by a vertical fault striking N. 80° E., along which the nearly horizontal movement has formed a breccia from 10 to 12 feet wide. In this breccia there are small pockets of mixed lead-zinc carbonate ores. On the surface of the hill, in irregular pockets along the bedding planes of the limestone, there seems to be more ore than at the depth of the tunnel.

HOODOO MINE.

The Hoodoo mine (No. 7, Pl. IV) is located about a mile south of the Good Springs and Sandy road, 3 miles east-southeast of Sandy. It is in a pocket in a group of low hills entirely surrounded by wash material. There are three claims in the group, belonging to the Kansas-Nevada Mining Co.

The ground is developed by a 600-foot crosscut tunnel running almost due east into the hill, from which there are four short drifts on ore.

The country rock in this vicinity is a grayish-white crystalline limestone. It is cut by an east-west vertical fault zone marked by about 200 feet of calcite-cemented limestone breccia. The sedimentary rocks on both sides of the fault dip to the north at low angles.

The ore bodies are all in the zone of brecciated limestone and are localized along later north-south planes of movement that are vertical or have a steep dip either to the east or west. The movement along them has been slight but has left the fractures more or less open.

The ore is largely white smithsonite with some hydrozincite and a minor amount of calamine. It occurs as crusts lining the open watercourses, as fairly large replacement masses adjacent to the fissures, and as a cementing material of the breccia near the main masses. At the mouth of the tunnel a body of iron-stained zinc carbonate contains small masses of lead carbonate and anglesite surrounding kernels of galena.

This mine is reported to have shipped a few carloads of sorted zinc and lead ore, but figures as to its total production are not available.

TIFFIN AND SINGER MINES.

The Tiffin and Singer claims (No. 8, Pl. IV) are on the south side of a group of isolated hills 5 miles southeast of Sandy. The Tiffin is owned by C. Beck, of Good Springs, and the Singer by Judge Ross, of Los Angeles, Cal. They are both developed by short tunnels and open cuts and are reported to have shipped only a small amount of ore.

The country rock is buff-gray limestone that in this hill dips 30°–40° SE. The up-tilted limestones are cut by small north-south fractures, along which the ore occurs.

At the Tiffin a N. 20° W. fracture has been followed for about 200 feet, with several crosscut drifts, making a total of 300 feet of work. Two raises 50 and 40 feet in height have been driven, the higher one connecting with an open cut on the surface. Along this fracture there is from 6 inches to 1 foot of mixed zinc and lead carbonate ore with a little galena. In some of the ore, especially along recent planes of movement, there were found small yellowish crystals which were said to be an uranium-bearing mineral but prove to be pyromorphite.

The Singer mine has a 50-foot tunnel run along the west side of a vertical fracture that strikes N. 10° E. In the buff-gray limestone adjacent to the fissure there are some irregular bodies of galena, now largely altered to anglesite and cerusite. Pyromorphite coats cerusite in a few specimens. Zinc minerals are absent from the ore as far as seen.

HOOSIER MINE.

The Hoosier mine (No. 9, Pl. IV) is located at the west base of Table Mountain, about 5 miles in an air line southwest of Good Springs. The two claims in this group belong to Harry Joseph, of Salt Lake City. The development work is located on both sides of the canyon, near the wash, in a buff-colored crystalline limestone that dips about 5° W. Most of this work consists of pits, open cuts, and short tunnels. The main working on the north side of the canyon, at an elevation of 4,000 feet, consists of an irregular tunnel, about 300 feet long, with two mouths, the western being 15 feet below and 200 feet distant from the eastern entrance. From this tunnel there are several small flat stopes.

The ore occurs in irregular pockets, some of them 5 feet in thickness, in buff, upper Mississippian limestone. These pockets follow the bedding planes in general, but expand into the limestone in irregular kidney form. The small ore bodies are found over a vertical range of 50 feet and for about 1,500 feet east and west and 400 feet north and south.

The ore is largely smithsonite, galena, and cerusite, with minor amounts of anglesite and calamine. The lead and zinc minerals are very closely associated, and for this reason the deposit can hardly be worked unless the ore is milled.

MILFORD MINE.

The Milford mine (No. 10, Pl. IV) is on the west side of the mountains, near the south end of the district, about 2 miles southwest of Little Devil Peak. The group of five locations is owned by the Good Springs Mining Co., but in the fall of 1912 was under bond and lease to H. J. Jarman and associates.

The mine is developed by an irregular tunnel about 200 feet long that is largely in the hanging wall and by several open cuts on the surface. In September, 1912, an inclined shaft in the hanging-wall ore was 80 feet deep, with short, irregular drifts and stopes at four levels. The ore zone is clearly traceable for about 300 feet east of the main workings by croppings of galena and lead-carbonate stains.

The country rock is all limestone; the beds strike approximately east and west and dip 75°–80° S. The footwall of the ore is a massive bed of dark-gray, almost black, cherty fossiliferous limestone of probable upper Mississippian age. The ore is found in a bed of finely crystalline gray-blue limestone for 40 feet above the dark bed. This limestone is cut by numerous watercourses which are about parallel to the position of the beds and along which the ore has developed. The hanging wall of the ore zone is a massive buff-gray limestone, below which a crevice conformable with the dip is filled with reddish-brown sandy carbonate ore containing both lead and zinc. Below the hanging-wall ore there are numerous rather large irregular pockets of white zinc carbonate. The smithsonite usually occurs in massive or banded form, but in some druses in this ore small crystals of the carbonate are seen. Calamine is present in relatively small quantities, but is seen in the banded ore and in some crusts in druses. Mixed with the zinc is a small amount of lead ore, consisting of kernels of galena coated with anglesite, outside of which there is lead carbonate. The lead ore is easily sorted from the zinc and constitutes less than 5 per cent of the product. The zinc ore is said to average 45 per cent of zinc and 6 per cent of lead.

ADDISON MINE.

The Addison mine (No. 11, Pl. IV), 1 mile southeast of the Milford, belongs to the same company. There are four locations in this group which are under lease to H. J. Jarman and associates.

The main ore body is in the low hills just east of the Mesquite Valley Wash. It is developed through a vertical range of 158 feet by open cuts, a 150-foot tunnel, and an 88-foot winze, from which there is a short drift 64 feet below the tunnel level.

The country rock is largely the buff-gray limestone characteristic of the ridge between the Milford and Addison mines, but at the Addison mine the hanging wall of the ore zone is a 20-foot bed of dark-blue limestone. The beds strike approximately east and west and dip south at medium angles. They are cut by two open crevices. One strikes N. 55°–60° E. and dips 75° N.; the other is a vertical north-south fracture along which there has been a little movement.

The ore is localized near these fractures, and the largest body occurs at their junction. There are also some irregular replacement bodies parallel to the bedding of the limestone just southeast of and above the main ore body, below the dark-blue limestone.

The ore is fairly pure white smithsonite and hydrozincite, in places stained by limonite. Calamine is very subordinate. Above the tunnel level kernels of galena, surrounded by anglesite and cerusite, are found.

OTHER MINES ON THE WEST SIDE OF THE MOUNTAINS.

Time did not permit visiting several mines and prospects in scattered localities on the west side of Spring Mountain. Several of these properties have been producers. The Azurite, Boss, Shenandoah, and Mobile are on the ridge about 3 miles northeast of Sandy, and the Bonanza is about 5 miles southeast of the same place, on the north side of the hills north of the cut-off road from Knights Well to Good Springs. The May-Kirby group is on the south side of the ridge about 1½ miles southeast of the Keystone. It is said that a large amount of manganese occurs with the zinc carbonate ore at this place. The Ingomar is near the top of the ridge between the Addison and Milford. High-grade galena and cerusite ore was shipped in 1912 from this property by D. W. Johnson.

The Volcano and Frederick Ward, both being worked in the fall of 1912, are near the top of Table Mountain, about 1½ miles south of

Summit, on the Good Springs and Sandy road. From these two properties both crude lead and crude zinc ore of good grade were being shipped.

MINES EAST OF THE MOUNTAINS.

NINETY-NINE MINE.

The Ninety-nine mine (No. 12, Pl. IV) was located in 1899 by a Mr. Over, of Good Springs, and passed into the hands of the present owner, J. B. Jensen, in the spring of 1907. There are nine adjoining claims in the group, on the lower part of the east slope of Potosi Mountain.

The principal development is a 400-foot shaft in the northeastern part of the group, at an elevation of 5,500 feet. The shaft is vertical for the first 150 feet, below which it dips 75°–80° N. It is equipped with a 15-horsepower gasoline hoist and buckets. There are short drifts at the 100, 150, 200, 250, 300, and 400 foot levels, none of which are over 200 feet in length.

The country rock is the blue limestone of the upper Mississippian(?) section, with some fossiliferous beds southwest of the shaft interbedded with coarsely crystalline limestone. These beds strike N. 25° W. and dip 45°–50° NE. in the vicinity of the shaft.

The beds are cut by a fault zone which strikes N. 65°–70° E. It dips 87° N. to a depth of 150 feet, but flattens to 65° at the 200-foot level and to 45° at the 250-foot level. At the 300-foot level the dip increases to 75° and striæ on the footwall pitch 15° E. This fault zone is filled with 2 to 4 feet of crushed limestone, in places partly cemented by calcite. The fragments are all under 1 inch in size and the great majority less than half an inch. Above the 250-foot level this filling is more or less iron-stained and contains pockets and stringers of copper carbonates and oxide constituting the ore. On the 250-foot level, from 30 to 70 feet east of the shaft, there is an open stope 4 to 6 feet wide which extends to the 200-foot level and from which a considerable body of ore was taken. In some of this ore there are small remnants of chalcocite, now largely altered to cuprite and malachite. At the 200-foot level the limestone for 8 feet north of the fault contains some limonite, which fades out into unaltered limestone at a distance of 10 feet. At one place near the east end of this level there is a flat stope where the ore is apparently conformable to the bedding of the limestone. At the 400-foot level the fault zone is still strong, but shows no mineralization.

All the ore from this mine was taken from the surface to a depth of 260 feet, where it played out, from stopes running not over 80 feet east of the shaft. The ore is sorted at the mine, and of 25 cars shipped in the fall of 1912 none ran below 20 per cent of copper, and most of it averaged 24 to 25 per cent.

CONTACT GROUP.

Five claims belonging to A. L. Chaffin (No. 13, Pl. IV) are located along the great fault about 2½ miles south of the Ninety-nine mine and 7 miles north-northwest of Good Springs. There are a number of open cuts and shallow shafts located west of the fault zone on small ore bodies and a few cuts in the fault zone itself.

All the ore is found in the Mississippian(?) limestones, none occurring in the red Triassic (?) sandstones. At several of the prospect holes there are small bodies of zinc or zinc-lead carbonate ore. The largest body seen was in an inclined shaft 400 feet west of the fault along an open watercourse that dipped 25° E. The ore here is from 1 to 2 feet thick and has been opened for a distance of 30 feet.

In some pits in the great fault zone there are small deposits of copper carbonate ores.

NINETY-THREE GROUP.

Richard Feaster, of Good Springs, has a group of eight locations (No. 14, Pl. IV) in the low hills about 2 miles north of the Bybee mine. The deepest working is an 80-foot shaft near the center of the group, though there are several shafts from 10 to 25 feet deep and numerous open cuts and pits.

The blue-gray limestones at this locality strike N. 20° E. and dip to the west at low angles. Along the center of the south end of the group there is a dike of quartz monzonite porphyry similar to the rock at the Red Cloud and Bybee mines. At one place this dike is 200 feet wide. It is traceable northward by poor discontinuous exposures for about 1,000 feet. The limestones are cut by a series of north-south fractures of apparently slight throw along which there has been some mineralization. In a few of the pits the ores are largely copper oxide and carbonates; in others lead and zinc carbonates are seen. There are a number of fairly good surface showings of both classes of ore on these claims, but no workable bodies have been demonstrated.

In one shaft near the south end of the group and 400 feet west of the porphyry dike there is a 1-foot bed of light-gray barite, near the top of the shaft. The barite is clearly an alteration product of the limestone, as there is still a small amount of calcium carbonate in the rock, though it appears on casual inspection to be entirely the barium sulphate.

RED CLOUD MINE.

The Red Cloud mine (No. 15, Pl. IV) is on the north side of the Good Springs and Keystone road about 2 miles north of the Bybee mine. This mine, the property of Joseph Armstrong and John Loup, was not operated in the fall of 1912.

A single-compartment shaft, said to be 300 feet deep, could be entered only as far as the 100-foot level. It is vertical to this depth, but pitches about 70° NE. a short distance below the station. The drifts on the first level extend about 70 feet northwest and 120 feet southeast of the shaft. About 100 feet southeast of the shaft there are two open stopes 5 to 8 feet wide, 40 feet long, and 20 and 50 feet in height. As almost no timber has been used in the mine it is caving badly.

The shaft is sunk in very soft altered granite porphyry near its southwest contact with gray limestone beds that dip 35°–45° SW. The dike is about 100 feet in maximum width and strikes N. 45° E. on the surface. Underground the contact shows some silicification of the limestone but no other alteration. A zone of crushed limestone and porphyry follows the contact, striking N. 20°–60° W.

The ore is the soft altered iron-stained porphyry near the contact. It is said to carry from $15 to $60 in gold to the ton, the lower figure being nearer the average content. Cinnabar is said to have been seen in some specimens from this mine, but none was observed during this reconnaissance.

PRAIRIE FLOWER MINE.

The Prairie Flower mine (No. 16, Pl. IV) is about half a mile north of the Bybee mine in the same canyon. The shaft is on the west side of a low ridge that separates Yellow Pine Wash from a western arm of the large wash between Spring Mountain and the Bird Spring Range. This mine is controlled by the Knight-Hyde interests but in 1912 was under lease to George Meacham.

It is developed by an inclined shaft which was about 225 feet deep in September, 1912. The shaft dips on an average 60° NW. It is equipped with a gasoline hoist, a 1-ton bucket being used for raising the ore. At the 50-foot and 100-foot levels there are drifts south on the ore, and large open stopes from 5 to 15 feet in width are carried to the surface for a length of about 70 feet.

The limestones in this vicinity have a gentle southwesterly dip and are cut about 50 feet west of the shaft by granite porphyry. On the surface the contact is covered by wash, but at the 100-foot level a crosscut 70 feet south of the shaft shows the contact. It is nearly vertical and very sharp, and the limestones show no alteration except a slight silicification.

The ore occurs along an open watercourse in the limestone about 15 feet east of the porphyry, striking N. 45° E. and dipping steeply northwest. The shaft appears to be over the main crevice below the 100-foot level, on a branch that is not so strongly mineralized. The ore is an iron-stained mixture of lead and zinc carbonate, the latter predominating, in which there are some small masses of hydrozincite and some kernels of unaltered galena.

BYBEE MINE.

The Yellow Pine Mining Co., the largest producer in the Yellow Pine district, is operating the Bybee mine (No. 17, Pl. IV), 4 miles west of Good Springs. This company owns 14 claims in the district, the largest group being about the Bybee mine and several others on which some prospect work has been done being in the vicinity of the Monte Cristo mine.

The Bybee is developed by a shaft that is 166 feet deep on the incline, which is 49° to the first level and 35° below that. From the shaft there are levels at 82, 110, and 134 feet. There are approximately 680 feet of drifts on the first level, 966 feet on the second, and 342 feet on the third. Between the first and second levels southwest of the shaft there is an intermediate level and series of stopes about 160 feet long. From the third level 156 feet southwest of the shaft there is an inclined winze dipping 55° W. that is 210 feet deep measured on the incline, from which there are three levels at 86, 130, and 182 feet below the third level. In these levels there are short drifts to the south in the ore zone. Figure 27 shows the intricacy of the levels and connections.

A 15-horsepower gas hoist operates the 1-ton skip in the main incline, and a 25-horsepower engine runs the compressor and a 12½-kilowatt generator. Electricity is used to light the mine and for hoisting in the winze below the third level.

The blue-gray, somewhat crystalline limestones of upper Mississippian (?) age in the vicinity of the Bybee mine dip 30°–45° WSW. They are intruded by granite porphyry. On the surface the east porphyry and limestone contact is 100 feet west of the shaft and the porphyry mass is 400 feet wide. The igneous rock is not clearly shown on the surface, owing to the covering of wash material, nor is it exposed underground at any place in the mine. It seems from these facts that the intrusion is either in the form of a sill or that it is a very flat-lying dike. Two faults which cut both the limestone and porphyry strike about N. 60° W. and on the surface appear to dip 70°–80° S. Along both of these faults the south side seems to have dropped from 10 to 20 feet with reference to the north side. Underground the southern fault is more clearly marked than the northern one. The direction and dip of the southern fault are seen to vary considerably at the few places underground where the wall is distinctly shown.

The ore bodies so far opened are entirely between the two fault zones. It has not been demonstrated, however, whether or not there is ore beyond them.

The ore body in the upper three levels dips about 30° W. and the lower limit of ore pitches about 15° SW. The first level is in ore for its entire length north of the shaft and for at least 190 feet south of it, but at this distance the ore is largely in the lower part of the drift. At the intermediate level the northern limit of ore is about under the shaft, but at the second level it is 120 feet south of the shaft, and at the third level the drifts are all in barren ground to a point 135 feet south of the shaft. (See fig. 27.) This ore body

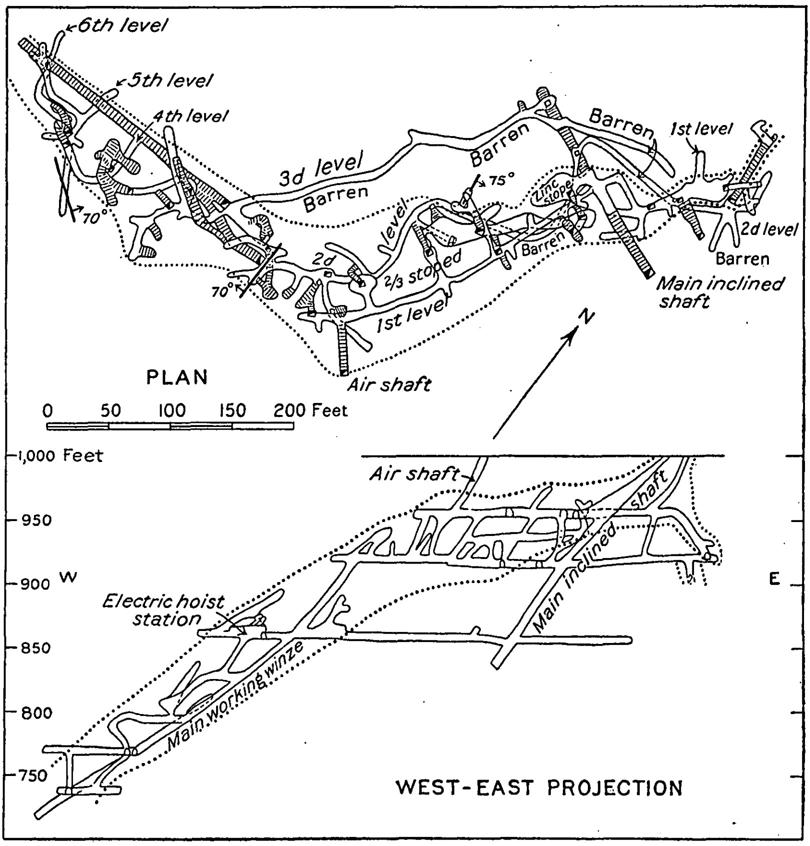

FIGURE 27.—Plan and elevation of the workings of the Bybee mine, Clark County, Nev.

is from 50 to 70 feet wide, about 360 feet long, and from 30 feet thick at the north end to about 60 feet thick at the south end. The north end gives the effect of wedging out, but it is cut off by a rather indistinct zone of brecciation that seems to represent the northern fault seen on the surface northwest of the shaft. The south end is clearly faulted. Near the face of the main drift on the first level (see fig. 27) there is a 30-foot zone of brecciated limestone and ore that is partly cemented by calcite, in which there is some calamine.

The winzes between the first and third levels shown at the left side of figure 27 are in or near this fault zone. Between the second and third levels near the fault the ore body is 77 feet wide and the ore is continuous for a distance of at least 30 feet north of the fault.

The main working winze below the third level is started north of the fault zone and the ore is found to the south of it near the brecciated area. A small open watercourse which cuts across the winze at the 600-foot level strikes N. 35° E. and dips 75° SW. This seems to be a branch from the main fault, though as yet developments are not extensive enough to determine the point.

The winze from the north end of the second level is entirely in ore that appears to be in the form of a chimney along the north fault zone.

The ores so far mined consist largely of an iron-stained mixture of smithsonite, cerusite, and galena, in which there is more or less anglesite, calamine, and hydrozincite. The latter two minerals occur as fillings of open watercourses. Calamine is found here and there as crystalline crusts in the very recent opening. Hydrozincite occurs as irregular masses in the other ore. The large stope on the first level just south of the shaft (see fig. 27) was entirely in hydrozincite. This was a remarkably large body, as the mineral occurs most commonly in masses from a few inches to 4 feet in diameter. Anglesite is seen only as thin crusts surrounding crystals of galena. Galena is found throughout all the ore, but is much more abundant above the third level than below it. Cerusite is found in sandy form mixed with the zinc carbonate and at the north stope on the first level as ribs of solid gray mineral in the smithsonite. The zinc carbonate from the Bybee is practically all iron stained and rather sandy, though both the massive and the banded forms are found.

The walls of the ore bodies are in most places sharp but very irregular in detail. The zone of transition from good ore to barren limestone is everywhere less than 2 feet wide, and usually the line separating ore and waste can be noted with exactness.

It is thought that there was movement along the faults at the ends of the ore body previous to the deposition of the carbonate ores as well as after that time. This conclusion was reached because of the presence of fragments of limestone in a matrix of smithsonite in the breccia caused by the postmineral movement.

It is understood that in the fall of 1912 the monthly production of this mine was 1,500 tons of zinc concentrate, 300 tons of lead concentrate, and 150 tons of crude ore.

The mine is well timbered, the square-set system being used; each set is 7 feet square. All the timber used is Oregon or Washington pine.

ALICE MINE.

The Alice group of 11 claims (No. 18, Pl. IV) covers the ridge a quarter of a mile south of the Bybee. The group belong to A. J. Robbins, of Good Springs. The main development work is a 375-foot incline which bears S. 30° W. and dips into the hill at an average of 20°. From this incline there are short drifts and irregular stopes on ore bodies.

The gray limestones of this ridge strike northwest and southeast and dip 30°–40° SW. They are cut by a dike of coarsely crystalline-granite porphyry which ranges from 2 to 40 feet in width and whose outline is very irregular. This dike appears on the surface only as high as the tunnel mouth and seems to come up along a vent striking N. 40° E. It is exposed in the low saddle from which the incline starts, but west of this place the intrusive rock turns down along the bedding of the limestones as a sill from 4 to 20 feet thick. The contacts are very sharp, but in most places are marked by crushed zones. The limestone is broken into angular blocks 1 to 2 inches in size for a width of 20 feet and is slightly silicified immediately at the contact. The porphyry shows only slight crushing.

The ore bodies extend along the bedding planes of the limestone both above and below the porphyry sill. They range from 2 to 5 feet in thickness and are of various sizes, from a few cubic feet to as much as 200 cubic feet.

The ore is all much iron-stained and in places carries an appreciable amount of oxidized copper ore. In some stopes the zinc minerals smithsonite, hydrozincite, and calamine are intimately mixed, the smithsonite being in excess. In other stopes, both near the surface and to the greatest depth attained, galena, cerusite, and pyromorphite are seen mixed with the zinc minerals.

This mine is a steady producer of sorted crude ore, but the present development has not demonstrated any very large bodies.

PORPHYRY CANYON CLAIMS.

There are several claims in what is called Porphyry Canyon (No. 19, Pl. IV), a small gulch about half a mile east of the Bybee mine. These claims, the Copper Glance and Middlesex group, belong to the Campbell estate, which is said to control a large number of isolated claims in various parts of the district.

The dark-gray limestones in this gulch dip southwest into the hill east of the Bybee and are cut by granite porphyry in at least two places. The igneous rocks appear to be dikes that have not reached the top of the ridge surrounding the gulch. There are several minor fracture planes cutting the limestone. One near the mouth of the canyon on the west side has an east-west direction, though on the east and south sides fractures with a north-south direction are most commonly seen.

The Copper Glance claim is on the east-west fracture, along which the limestones are shattered for a width of 2 to 3 feet and are somewhat impregnated with red copper oxide and limonite. Films of chrysocolla and malachite coat the fragments and in some specimens penetrate the red ore.

Near the head of the canyon on the west side there are some open cuts and shallow tunnels on a bedded deposit of smithsonite carrying a little lead.

At the east head of the gulch there is about 150 feet of tunnel work on a steeply westward-dipping open crevice, along which some rich argentiferous lead carbonate ore was found, but the ore bodies are small and discontinuous.

Along the east wall of the canyon there is a north-south zone in which at several places small bodies of copper carbonate ores were found. This is traced for about 800 feet by shallow pits and cuts.

LAVINA MINE.

The Lavina claims (No. 20, Pl. IV) lie along the great fault west of Good Springs. There are a large number of claims in the group which belong to Harvey Hardy & Co., of Good Springs. The Lavina shaft is on the southeast side of the hill, southeast of the Bybee mine. It is said to be 170 feet deep, but was not entered. It is sunk in highly altered, somewhat crushed granite porphyry about 120 feet east of the great fault. From the collar of the shaft there is a 150-foot tunnel running westward into the hill. The gray limestones of upper Mississippian (?) age west of the fault dip to the west-southwest at medium angles. East of the fault the light-colored grayish to pinkish Pennsylvanian limestones and conglomerates dip steeply to the west. The fault zone is at least 50 feet wide, as shown by the Lavina tunnel, which, however, does not penetrate the blue-gray limestones. Just east of the face of the tunnel is 15 feet of a fine breccia, in which there are fragments of the dark limestones. East of this belt there is 35 feet of iron-stained sandy clay gouge which grades into the altered porphyry. The line of demarcation between gouge and porphyry is not sharp; in fact, it can not be definitely stated where one begins and the other ends. In this zone and in the altered porphyry there are irregular bodies and stringers of dark ore. It consists of aggregates of quartz, calcite, and cupriferous pyrite that are crushed and recemented by quartz and pyrite. This ore is said to carry about $10 a ton in free gold. About 1,000 feet east of this shaft small dikes of porphyry cut the Pennsylvanian limestone, and along some of them there are limonitic copper-stained cellular ores that are said to carry a little gold.

COLUMBIA MINE.

The Columbia group of six claims (No. 21, Pl. IV), just south of the Good Springs and Sandy road, about 3 miles west-southwest of Good Springs, is owned by a company headed by Joseph Deidrich, of Los Angeles, Cal. The main development, consisting of five inclines and two tunnels, is near the west center of the group, about half a mile east of the summit and a quarter of a mile south of the main road. These inclines vary from 20 to 200 feet or more in depth and are all located in the same ore horizon. From most of them there are small, irregular stopes. The two tunnels are below the ore zone and were apparently used for transportation.

The limestone at this locality is buff-gray to pinkish gray in color, and in general the formations strike east and west and dip 10°–20° S. The ore occurs in a pinkish crystalline limestone immediately below a bedding plane along which there has been slight movement that has produced from half an inch to 1½ inches of gouge. This movement was subsequent to the formation of a series of north-south vertical fractures, and it is along or near the junction of the two sets that the largest ore bodies are found.

The ore, all of which is oxidized, occurs as irregular though more or less tabular masses, roughly conformable with the bedding of the limestone, and is usually associated with coarse crystals of calcite stained pink or green by iron or copper. The ore minerals are limonite, cuprite, and malachite, with minor amounts of chrysocolla and azurite. In the western incline the pink limestone for about 10 feet below the main flat fracture is speckled with small black areas that were considered to be ore but that have proved to be only iron-stained calcite.

Below a depth of 70 feet most of these inclines show very little if any mineralization of the limestone, though the fractures unquestionably continue. Whether other ore bodies occur at a lower level is not known.

FREDERICKSON MINE.

The Frederickson mine (No. 22, Pl. IV), belonging to William Frederickson, of Good Springs, is located about 400 feet south of the summit on the Good Springs and Sandy road. The mine is developed by a 100-foot drift tunnel and inclined shaft on the ore, said to be 160 feet deep. The country rock is all limestone, and a particular bed of somewhat sandy greenish-buff limestone forms the hanging wall of the ore throughout.

Immediately below the hanging wall there is a fairly regular bed of ore 1 foot thick, and below this, at several places, lie irregular bodies of various sizes. The ore at the surface is a mixture of lead and zinc carbonate, with some galena, but at the tunnel level, at a depth of 30 feet, there is very little lead, the ore consisting of massive smithsonite with some hydrozincite. In the hanging-wall streak there is a slight development of calamine as crystals in small druses.

The ore so far shipped has been taken out largely above the tunnel level and near its mouth. It is all hand sorted into lead and zinc products.

MONARCH GROUP.

The Monarch Group of claims (No. 23, Pl. IV), just south of Crystal Pass, about 1½ miles north of the Lincoln mine, belongs to C. M. Overs, of Good Springs. The development work on this group consists of three short tunnels and several shallow shafts.

The thin-bedded blue limestones in this vicinity as a rule dip to the west-southwest at medium to low angles but exhibit some folding. They are cut by small, irregular dikes and sills of quartz monzonite porphyry.

The ore found along the contacts is auriferous limonite, which is an alteration product of magnetite. It is from 1 to 6 inches in width and is said to carry from $5 to $10 a ton in gold, with a little silver.

LINCOLN MINE.

The Lincoln mine (No. 24, Pl. IV) is at the edge of the Ivanpah Valley about 6 miles west of Jean and 4 miles south of Good Springs. The mine was originally worked by a shallow shaft, but the latest development is an incline 170 feet in length that runs N. 30° W. on a dip of 12°–15°. The limestones of the locality dip about 15° WSW. The incline follows an open crevice along which the grayish limestone is rather coarsely crystalline. In this calcite near the fracture there are a few small, irregular masses and stringers of copper ore. From the surface to a depth of 15 feet there was about 6 to 8 feet of ore. The ore is a brownish-red earthy mixture of limonite and cuprite, with some chrysocolla and malachite and locally a little azurite.

PORTER GROUP.

The Porter group of four claims (No. 25, Pl. IV) is the property of the Yellow Pine Mining Co. The claims lie along eastward-facing cliffs at elevations ranging from 3,800 to 4,000 feet, south and west of the Monte Cristo mine.

There are a number of open cuts and pits on the claims south of Monte Cristo Gulch, but the principal development is on the Porter claim, about half a mile northwest of the Monte Cristo, on the north side of the canyon. At this place there are two short tunnels, about

80 feet apart, running north into the cliffs, that are connected by a drift which starts near the entrance of the west tunnel and enters the east tunnel about 25 feet from its mouth.

The bluish limestones of this vicinity have a very low dip to the west and at the mine are cut by an east-west crevice along which they are altered to white calcite. The ore, practically all galena with films of anglesite on the surface, is intergrown with the calcite, but is also found to a very minor extent in the relatively unaltered blue limestone for several feet from the crevice. At the face of the east tunnel, about 30 feet north of the fracture, the limestone appears to be unaltered.

A winze sunk from the drift about halfway between the two tunnels is on the crevice, which is here filled with a limonitic sand carrying cerusite and some small masses of galena.

The largest ore body is exposed in the mouth of the east tunnel south of the crevice, where coarse galena is intergrown with large crystals of milky-white calcite. This irregular mass, about 6 by 10 feet in cross section, has been stoped for a height of 12 feet.

MONTE CRISTO MINE.

The Monte Cristo group of eight claims (No. 26, Pl. IV) is in Monte Cristo Canyon, about 6 miles south of Good Springs and 7 miles southwest of Jean. Owing to some internal trouble the Monte Cristo Consolidated Mines Co., of Los Angeles, Cal., has not operated the mine during the last few years, but in 1912 John Frederickson, of Good Springs, had the property under lease.

The mine is developed by large open cuts, a tunnel about 150 feet long, chiefly under the ore, and a shaft that is now covered with waste sunk about 100 feet below the large roomlike stope. (See fig. 28.)

The lower Mississippian limestones have a very gentle dip to the west-southwest near the mine but are cut by a strong north-south fault with steep easterly dip a few hundred feet west of the tunnels. The ore occurs in a 40-foot bed of brownish-gray crystalline limestone carrying some chert, immediately above a series of thin-bedded dense blue limestones. The ore is exposed on the surface and the development shows that it is to be found in large and small bodies in the 40-foot bed for a distance of about 190 feet east and west. The large body from which the greater part of the ore has so far been taken occurs below a slip plane that strikes N. 50° E. and dips 40° SE. between fractures that are practically vertical and that strike a few degrees east and west of north. (See fig. 28.) The ore is not cut off by these faults, though along the western one postmineral movement which has left striæ that pitch 75° S. in the 6-inch gouge has moved the eastern segment down between 6 and 8 feet. The original work was all east of this fault and a room stoped about 70 feet long, 40 feet wide, and 30 feet in maximum height is said to have been all ore. Later developments show that the ore continues west of this fault for at least 40 feet in a 4 to 6 foot bed, the western limit of which had not been reached in September, 1912. The tunnel is in barren limestone under the ore, and it is reported that the shaft was sunk in barren ground. It has not yet been demonstrated that the ore goes north into the hill along either the particular bed or the flat fault zone.

The ore is practically pure white smithsonite that occurs both in massive and in banded form. Along the west fault plane there is some brownish-gray calamine, varying from 6 inches to 1 foot in width, which was deposited in open spaces subsequent to the last movement. The croppings show some hydrozincite, and it is possible that some of this mineral may have been mined with the smithsonite ore that came from the large stope. It is said that during three months' operation 100 cars of ore which did not require any sorting and carried more than 40 per cent of zinc were shipped from this body.

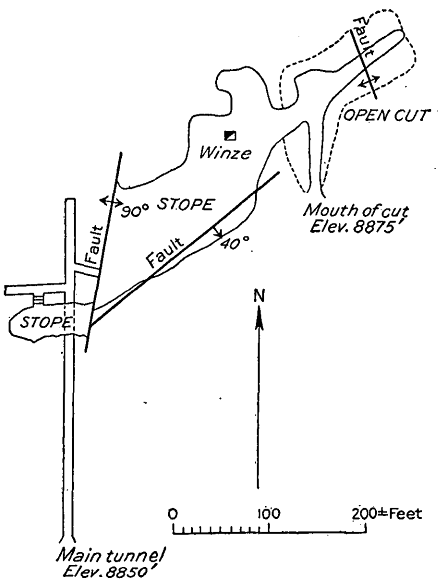

FIGURE 28.—Sketch of the Monte Cristo ore body and developments, Clark County, Nev.

ACCIDENT MINE.

The Accident mine (No. 27, Pl. IV) is in the first canyon south of the Monte Cristo mine at an elevation of 4,200 feet. This claim belongs to Yount & Fayle, of Good Springs, who have leased it to Harry Vail. The mine is developed by an irregular, slightly inclined tunnel running west-northwest into the ore bed for 250 feet, from which there are several small roomlike stopes.

The mouth of the tunnel is about 75 feet west of a strong north-south fault. East of this fault the limestones are rather thin bedded and of a blue color; west of it there are buff-gray crystalline limestones, which at other places usually underlie the thin-bedded formations. West of the fault the limestones dip 5° W.; east of it the dip is a trifle steeper, but in the same direction. The fault zone is marked by about 20 feet of limestone breccia consisting of small fragments in a matrix of crystalline calcite.

The Accident ore is found in a 2 to 4 foot bed of gray, somewhat cherty limestone immediately under a rather heavy bed of cherty blue limestone that has escaped crystallization. It consists of masses of galena coated with anglesite in a reddish-buff sandy matrix that is largely limonite but contains some cerusite. There are usually bands of fairly pure galena on the roof and floor of the ore zone, and in some places there is also a central band. The galena ore is easily sorted and is said to carry about 80 per cent of lead and 9.6 ounces silver and 60 cents in gold to the ton.

About 200 feet from the mouth of the tunnel the ore body has been displaced by a fault which strikes N. 30° W. and dips 75° NE. Northeast of this fault the ore horizon is 12 feet lower than on the southwest side.

BONANZA MINE.

The Bonanza mine (No. 28, Pl. IV) is about 1 mile south of the Monte Cristo, on the hills overlooking the Ivanpah Valley. In 1912 it was under lease to Tursick & Miller.

The country rock is buff-gray crystalline limestone with some dark-gray beds which strike north and south and dip 15° W. They are apparently undisturbed by faulting in the immediate vicinity of the ore bodies.

Two ore bodies were being worked in 1912. The lower was an irregular replacement of lightly iron-stained smithsonite along the bedding of the darker limestone and was developed by a 50-foot tunnel. The upper deposit, 150 feet above the zinc ore, is essentially a deposit of galena along a bed of buff limestone. The galena is altered to some anglesite and considerable cerusite. The deposit is developed by a 30-foot incline and an irregular stope that was 30 feet long and 20 feet in extreme height. The ore varies from 1 foot to 5 feet in thickness. The replacement, while practically parallel to the bedding, is irregular, so that much ore is left on the walls in breaking.

ANCHOR MINE.

The Anchor mine (No. 29, Pl. IV) was the southernmost mine visited on the east side of Spring Mountain. It is located about 7 miles west-southwest of Jean. This property belongs to Yount & Fayle, merchants at Good Springs, and has been worked by them at various times. The larger part of the ore has been taken from open cuts and a short north-south tunnel. A tunnel which runs N. 70° W. into the cliff and at the end of which there is a 40-foot winze with a short drift to the west at the bottom is in great part away from the main fracture, which lies east of the mouth of the tunnel. The country rock is a buff-gray crystalline limestone formation whose beds strike north and south and dip 10°–15° W. This is cut by a north-south vertical fault, along which there is a 2-foot zone of breccia, though the rock for 10 feet on either side of it is more or less broken and creviced. The largest bodies of ore are found in this zone, though one large mass at the mouth of the 70-foot tunnel trends east and west. Some small irregular bodies of ore occur in the tunnel even at a distance of 90 feet from the main fault, but it seems more probable that the largest bodies will be found near the fault.

The ore is of the mixed type which could best be concentrated, though by hand sorting two products have been obtained. The zinc is practically all in the form of carbonate, usually somewhat iron stained. The lead occurs mostly as galena coated with anglesite, and but very little cerusite was seen.

The mine is situated in a very steep side canyon which follows the fault plane, and can be reached only by a narrow sled trail half a mile in length to the loading platform.

Yount & Fayle are reported to have made several small shipments at various times from this property.

OTHER MINES ON THE EAST SIDE OF THE MOUNTAINS.

Several copper prospects are located along the great fault between the Ninety-nine and Contact groups. The Double-up mine was not working in 1912, but is reported to have a good showing of oxidized copper ore. There are several prospects of both lead and zinc ores in the vicinity of the Monte Cristo, and at one place 1 mile north of that mine considerable money has been spent in constructing ore bins, chutes, etc. It is said that there are several good zinc prospects northeast of Diablo Grande Peak, but none of them were visited.

SURVEY PUBLICATIONS ON LEAD AND ZINC.

The following list includes the more important papers on lead and zinc published by the United States Geological Survey. These publications, except those to which a price is affixed, can be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. The publications marked "Exhausted" are no longer available for distribution but may be seen at the larger libraries of the country.

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EMMONS, S. F., and IRVING, J. D., The Downtown district of Leadville, Colo.: Bull. 320, 1907, 72 pp.

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