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# WATER RESOURCES

OF

# BEAVER VALLEY, UTAH

BY

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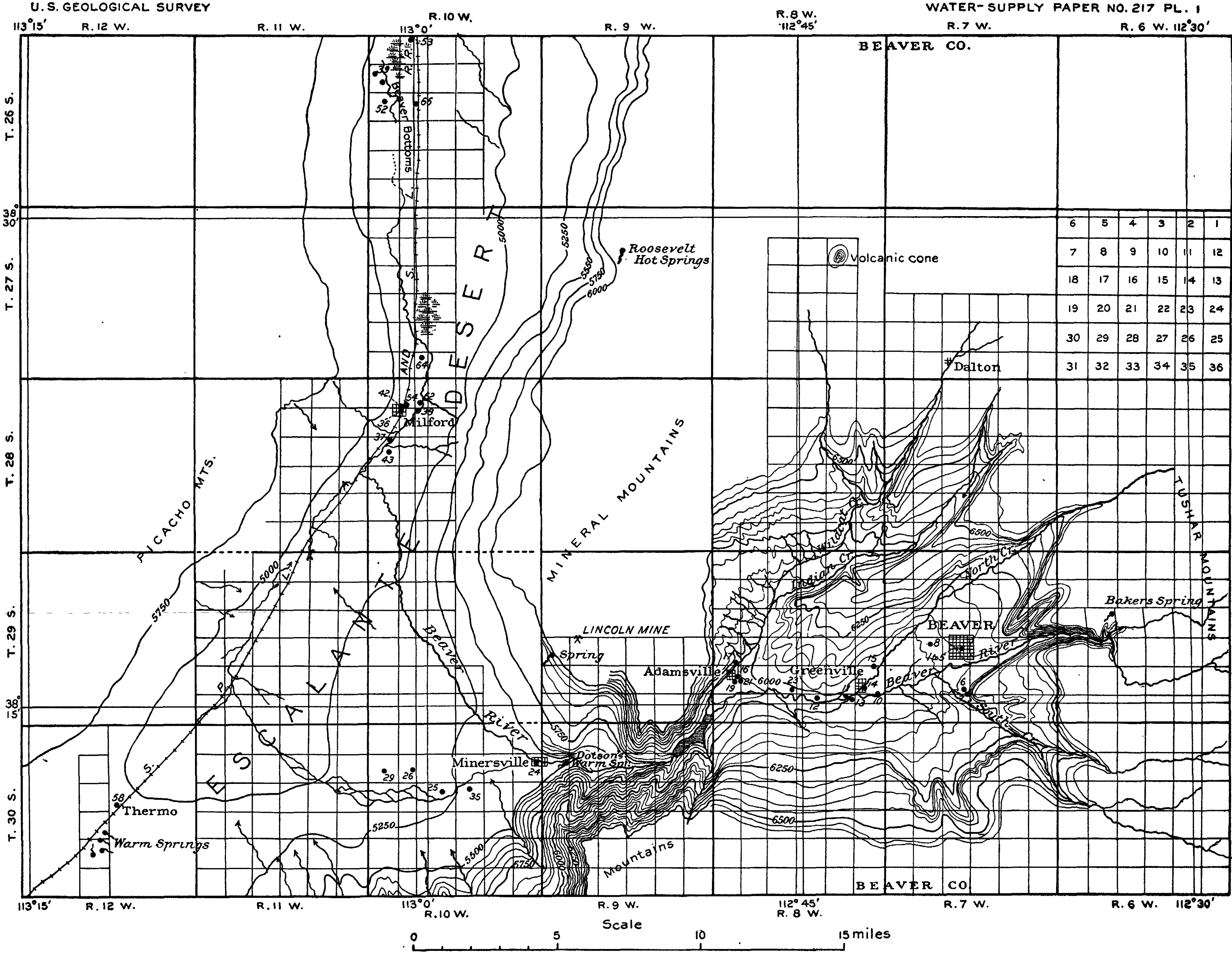
# ILLUSTRATIONS.




SKETCH MAP OF BEAVER VALLEY, IN BEAVER COUNTY, UTAH, SHOWING LOCATION OF PRINCIPAL SPRINGS AND DEEP WELLS.

# WATER RESOURCES OF BEAVER VALLEY, UTAH.

By Willis T. Lee.

## INTRODUCTION.

*Location and extent of area examined.*—Beaver Valley is located in Beaver County, in southwestern Utah, about 175 miles south of Salt Lake. It lies between the Tushar Mountains on the east and the Beaver Mountains on the west. The principal town of the valley is Beaver, which is most conveniently reached from Milford, a station on the San Pedro, Los Angeles and Salt Lake Railroad. The valley, together with its neighboring highlands, occupies the eastern third of Beaver County, an area of about 1,200 square miles. A large part of this area, however, is rocky upland and unproductive desert, the tillable land comprising a comparatively small area in the immediate vicinity of the streams.

*Purpose and scope of work.*—The purpose of this paper is to present information concerning the waters of Beaver Valley and to point out ways and means of increasing their usefulness.

The presence of a large amount of water in Beaver Valley results from local topograhic conditions, the water being supplied by precipitation in the highland to the east. Its conservation and distribution result from geologic conditions, the water being held in loose gravel and sand, which are more or less confined between ridges of consolidated rocks. The rock basins were formed partly by erosion and partly by faulting and surface deformation. In order to accomplish the purpose in view it is therefore necessary to describe the geographic and geologic conditions in Beaver Valley and neighboring regions.

The investigation included the determination of the flow of streams and springs, of the manner of occurrence and quantity of the underground waters as shown by the geologic and geographic conditions of the region and by the distribution of springs and wells, and of the chemical character of the waters with reference to their adaptability to domestic use and to irrigation. The chemical data were obtained (*a*) by field assays, which are approximately correct and probably of sufficient accuracy to be of value in comparing the various waters; (*b*) by more exact analyses, some of which were made in the laboratory of the United States Geological Survey by W. M. Barr, and others by Herman Harms, State chemist of Utah, for the San Pedro, Los Angeles and Salt Lake Railroad; and (*c*) by sanitary analyses, made also by Herman Harms.

*Cooperation.*—The work was done during the summer of 1906, the United States Geological Survey cooperating with the State of Utah through Caleb Tanner, State engineer, and with the county of Beaver through the supervisors of the county. In collecting the information the writer was assisted by J. F. Hoyt, of Nephi, Utah.

## GEOGRAPHY.

Southwestern Utah is divided into two general provinces—the plateau province and the basin province. These are separated sharply by a succession of high cliffs extending in a northeasterly direction from St. George through Beaver and northward. At the foot of these cliffs are located the principal towns of the southwestern part of the State—for example, St. George, Toquerville, Kanarraville, Cedar City, Parowan, Beaver, and Fillmore. To the east of the cliffs lie the High Plateaus of Utah, well known through the writings of Dutton, Powell, Gilbert, and others; and to the west of them lie the barren deserts of the Great Basin.

### PLATEAU PROVINCE.

The High Plateaus lie at an elevation several thousand feet above the Great Basin, and isolated mountains of volcanic origin rise to altitudes considerably greater than that of the general surface of the plateaus, the highest in the vicinity of Beaver being Delano Peak, which has an altitude of 12,240 feet. These plateaus and mountains are of the greatest importance in considering the water supply, since owing to their altitude the rainfall is greater there than in the basin region to the west. The streams which yield the water supply of southwestern Utah all rise in the highlands of the plateaus.

### BASIN PROVINCE.

#### DESERTS.

The Great Basin consists of broad sandy deserts, from the surface of which rise more or less isolated groups of rock mountains. The Great Basin has been described by Gilbert[a] and others, who show

[a] Gilbert, G. K., Lake Bonneville: Mon. U. S. Geol. Survey, vol. 1, 1890.

that the lowest parts were formerly occupied by a lake known as Lake Bonneville, an outline of which is shown on the accompanying map (fig. 1). Sands, gravels, and clays were deposited in this lake to a great though unknown depth, filling the low places generally and transforming into nearly level plains large areas which may pre-

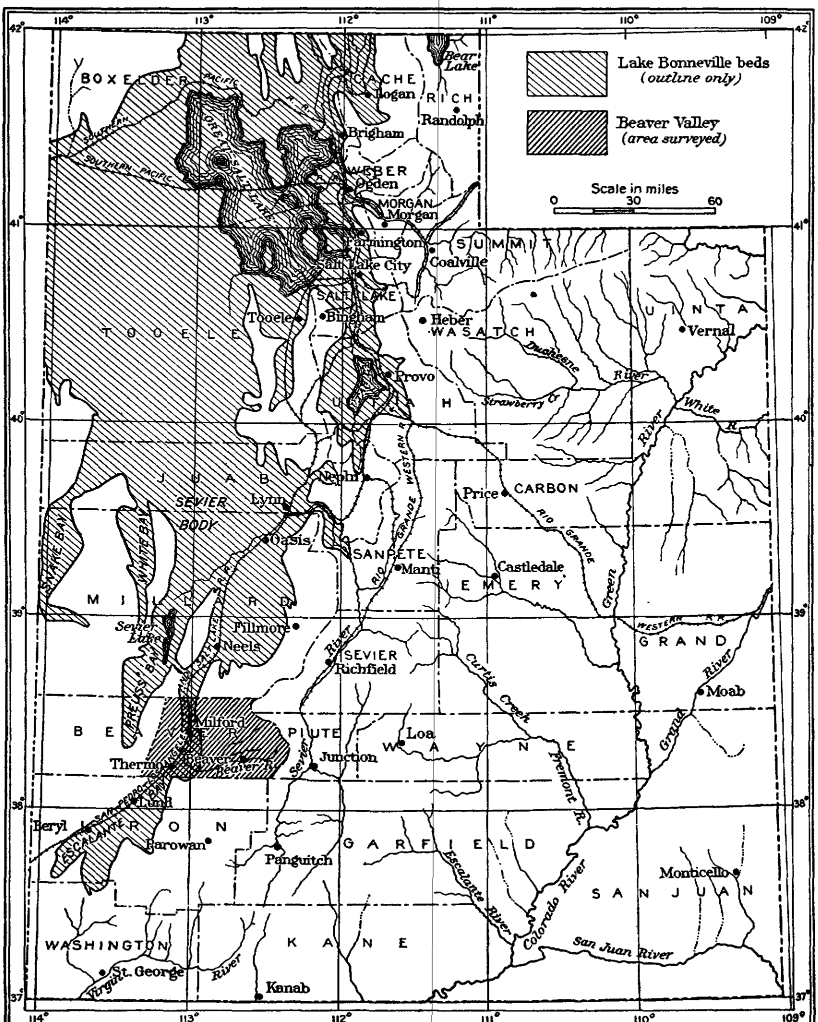



FIG. 1.—Map of Utah, showing location of Beaver Valley and outline of Lake Bonneville. (After G. K. Gilbert, Mon. U. S. Geol. Survey, vol. 1, 1890.)

viously have had very uneven surfaces. The Escalante Desert, a part of which lies within the region described in this paper, represents the southernmost extension of Lake Bonneville, called by Gilbert Escalante Bay. A comparatively narrow strait, here about 6 miles wide, connected Escalante Bay with the main body of Lake Bonneville to the north. The bed of the old lake is now represented by the level bottom lands of the desert. Rock mountains rise abruptly from the plains, and material from the mountains, borne out by the streams and deposited as alluvial slopes and cones, from the gentle outwash slopes, characteristic of the desert region.

### ISOLATED BASINS.

Between the High Plateaus and the Escalante Desert there are several comparatively small basins, some at an elevation but little greater than that of the Escalante Desert, as Rush Lake Valley; others several hundred feet higher, as Parowan Valley, which is separated from the main desert by highlands except where they are cut by a narrow canyon through which the valley was formerly drained, but which is now dry; and Beaver Basin, 1,000 feet or more above the floor of the Escalante Desert, with which it is connected by a canyon at Minersville, carved by Beaver River through the Mineral Mountains.

These basins, as described in detail in the case of Beaver Basin, are partly filled with sediments similar to those of Lake Bonneville, from which it might be inferred that they were formerly small embayments of the lake that were later elevated to their present position by crustal movements. This inference finds some confirmation in recent earthquake disturbances that are known to have occurred in this region, and in the fact that the basins lie in a zone of profound faulting, which has been subject to the differential movements that have resulted in the great differences of elevation between the High Plateaus and the Great Basin. It seems more probable, however, that these basins formerly contained isolated lakes that were tributary to Lake Bonneville and lay at altitudes somewhere greater than the main lake, much as Utah Lake is tributary to Great Salt Lake at the present time. Beaver Basin, the only one of these small basins within the area described, will be referred to frequently, and for convenience the deposits filling it may be called the Beaver Lake beds and the body of water in which they were laid down may be called Beaver Lake.

### RESIDUAL LAKES.

In certain places where the water supply is sufficient the lower portions of the old lake bed still contain small salt lakes, such as Sevier Lake, Little Salt Lake in Parowan Valley, and Blue Lake near Deseret. In other places water gathers in the depressions during wet weather and forms mud flats, one of which, known as Beaver Bottoms, is within the area here described. Many parts of the Escalante Desert are so nearly level that rain water accumulates at the surface and stands practically motionless until absorbed into the ground, and during wet weather much of the desert becomes an impassable bog.

## DRAINAGE.

The drainage with which this paper is concerned is entirely that of Beaver River and its tributaries. All the permanent streams entering the valley rise in the Tushar Mountains to the east, and the trunk stream of the system supplies the greater part of the water, since it has its origin in the highest part of the range among such lofty peaks as Delano (altitude 12,240 feet), Baldy (altitude 11,730 feet), and Belknap (altitude 12,200 feet). The main tributaries are South Creek, Burch Creek, North Creek, Indian Creek, and Wildcat Creek, all of which rise in the Tushar Mountains and join the river within Beaver Basin. There are no other tributaries having perennial flows, and after leaving Beaver Basin the river rapidly decreases in volume until at Milford it also becomes intermittent. Still farther to the north the trunk channel subdivides into the distributary channels of Beaver Bottoms. The river is nominally a part of the Sevier Lake drainage, but according to report it is only occasionally that a flood has sufficient volume to find its way into the lake.

The greater part of the water passing Minersville finds its way quickly into the sands and gravels of the Lake Bonneville beds. The sediments swept from the canyon are deposited upon the plain to the west of Minersville, forming a delta fan. The fan is so nearly flat and its surface is so regular, as compared with the outwash slopes of the mountains near by, that the delta character is inconspicuous. Its presence is made clear, however, by the distribution of the streams. Beaver River at the present time follows the northern edge of the delta, but the water diverted from the river at Minersville for the irrigation of the fields southwest of the town finds its way westward near the southern edge of the delta, gradually turning to the north and finally entering the river again about 2 miles south of Milford. The low ground obviously marks an abandoned course of Beaver River, and it would apparently require little effort, perhaps nothing more than a clogging of the present channel with débris during some flood, to turn it back into the old course.

## GEOLOGY.

### FORMATIONS.

#### GRANITE.

The oldest rocks exposed at the surface in the Beaver region are supposed to be the granites of the Mineral Mountains. They underlie and are apparently older than the Paleozoic sediments. They have been subjected to comparatively recent movements, as is made evident by the occurrence of faults and zones of crushing and shearing and by the presence of hot springs in the shear zones. It is possible, however, that the granites, instead of being pre-Paleozoic in age, are due to comparatively recent intrusions. The region is one in which great crustal disturbances have taken place, as is indicated by the faulted and tilted sediments described on page 14 and by the great masses of extrusive rock found in the Tushar Mountains and elsewhere. The volcanic disturbances have occurred repeatedly, as shown by the alternation of early Tertiary lavas and sediments and the occurrence of basalt included within the Quaternary gravels and resting upon them in the form of sheets and volcanic cones.

*Section of rocks exposed in Beaver Canyon 4 miles east of Minersville.*

| | | |
|---|---|---|
| 1. | Basalt, several hundred feet. | |
| 2. | Rhyolitic flows, tuffs and breccia, many hundred feet. | |
| 3. | Andesitic flows, tuffs and breccia, several hundred feet. | Feet. |
| 4. | Uncemented gravel and bowlders of limestone, quartzite, and andesite | 250 |
| 5. | Coarse consolidated conglomerate consisting of limestone, quartzite, and various crystalline rocks, the bowlders having a maximum diameter of 5 feet | 90 |
| | Unconformity. | |
| 6. | Red shale | 60 |
| 7. | Earthy-gray limestone | 15 |
| 8. | Red shale | 10 |
| 9. | Gray limestone | 10 |
| 10. | Red shale and ripple-marked sandstones | 40 |
| 11. | Blue limestone | 10 |
| 12. | Red shale and ripple-marked sandstones | 120 |
| 13. | Limestone containing *Aviculipecten weberensis*, *Aviculipecten* aff. *occidentalis*, *Myalina* aff. *perattenuata*, *Bakewellia* n. sp., *Pleurophorus* sp., *Schizodus* sp | 15 |
| 14. | Shale | 40 |
| 15. | Limestone containing same fossils as No. 13 | 15 |
| 16. | Buff shale with a subordinate amount of limestone | 95 |
| 17. | Shale and limestone containing *Aviculipecten* n. sp., *Pleurotomaria?* sp., *Bakewellia* n. sp., *Naticopsis* sp., *Xenodiscus?* sp., undetermined ammonoids | 100 |
| 18. | Red shale | 35 |
| 19. | Yellowish brown shales alternating with ripple-marked sandstones | 40 |
| 20. | Quartzitic basal conglomerate | 10 |
| | Unconformity. | |
| 21. | Cherty limestone containing *Zaphrentis?* sp., *Fistulipora* sp., *Septopora* sp., *Productus* aff. *subhorridus*, *Meekella?* sp., *Spirifer* aff. *cameratus*, *Squamularia* aff. *perplexa*, *Spiriferina* aff. *kentuckyensis*, *Spiriferina* sp., *Composita* aff. *subtilita*, *Hustedia* aff. *meekana*, *Pugnax* aff. *osagensis* | 450 |
| 22. | Yellowish quartzite | 200 |
| 23. | Cherty limestone containing *Squamularia?* sp. and *Hustedia* aff. *meekana* | 500 |

Base not exposed where section was measured.

### PALEOZOIC SEDIMENTS.

A thick series of massive limestones overlies the granite and is well exposed in the Mineral Mountains north of Minersville. These limestones are overlain in turn by red sandstones, shale, and volcanic products, as shown in the section on the preceding page.

The massive cherty limestone at the base of the section is referred with little doubt to the Aubrey. The fossils were examined by George H. Girty, of the United States Geological Survey, who states that they probably belong in the Aubrey fauna, although many of the most characteristic forms of that fauna are wanting. The stratigraphic position and general field relations of the limestone show that it is probably the same as the typical Aubrey limestone of the Grand Canyon region farther to the south.

The red sediments overlying the cherty limestone yielded a number of well-preserved fossils which also have been examined by Doctor Girty, who states that the fauna is the same as that of the Permian beds of Walcott's[a] Grand Canyon section and of the "Permo-Carboniferous" of the Wasatch Mountains.

In Colob Plateau, about 50 miles south of Beaver, a thickness of more than 8,000 feet of strata was measured between the base of the Permian and the top of the Benton. Of this great thickness only 565 feet of the base of the Permian remain in Beaver Canyon, the upper beds having been eroded away. The red beds are overlain by a coarse conglomerate, presumably equivalent in age to the Eocene conglomerates of the plateaus, and these are covered in turn by extensive masses of volcanic rock.

### EFFUSIVE ROCKS.

The oldest of the lavas covering the red beds and the overlying conglomerate are dark-colored andesites. These are most conveniently seen in the Beaver region in the canyon east of Minersville. They consist of flow sheets, tuffs, and volcanic breccias and occur also as bowlders in the underlying conglomerate.

Above the andesites are extensive masses of light-pink to white rhyolite. These are especially large in the Tushar Mountains, where they occur as flow sheets, tuffs, and breccias, constituting a large part of the range. The rhyolites are best known locally as the soft pink rock found near the mouth of Beaver Canyon and elsewhere, that is used for building purposes. It is a fine-grained, consolidated rhyolitic tuff which, on account of its softness, is easily quarried and

[a] Walcott, C. D., The Permian and other Paleozoic groups of the Kanab Valley, Arizona: Am. Jour. Sci., 3d ser., vol. 20, 1880, pp. 221, 225.

dressed, but which is resistant enough to make a good building stone. In many places masses of this tuff are not well consolidated and resemble beds of light-colored sand and clay.

After some, at least, and probably after all of the rhyolites of this region had been extruded they were extensively eroded, as shown by the occurrence of beds of conglomerate made up largely of pebbles and bowlders of rhyolite. These conglomerates of rhyolite occur in Beaver Canyon at Minersville, in Bakers Canyon, 5 miles east of Beaver, and elsewhere. At Minersville they are well stratified, but consist mainly of angular fragments of rhyolite. In Bakers Canyon they are several hundred feet thick and made up of well-rounded pebbles and bowlders of many kinds of rock, the largest bowlders consisting of rhyolite.

Basalt overlies the rhyolitic rocks and rests in some places upon the conglomerates and in others upon the tuffs and breccias. The basalt is the black rock used to a considerable extent as a building stone in Beaver Valley. It occurs in sheets near the mouth of Beaver Canyon, in the canyon east of Minersville, in Black Mountain north of Beaver, and elsewhere. It also forms the volcanic cones, one of which is located 13 miles north of Beaver and another 20 miles north of Beaver near the Cove Creek sulphur beds.

### YOUNGER SEDIMENTS.

The sediments to the west and north of Minersville, the only part of the Escalante Desert within the region here described, constitute a part of the Lake Bonneville beds. The Escalante Desert, an outline of which is shown in fig. 1 (p. 7), has a general elevation greater than that of the main part of the old lake basin and was included in the lake as Escalante Bay, at least during the closing stages of sedimentation, only during the maximum extension of the lake, as shown in Gilbert's map, Pl. XIII of the Bonneville monograph. For this reason the shore lines, so conspicuous along the mountain sides in the vicinity of Salt Lake, are practically absent in the vicinity of Milford, the altitude of the more conspicuous ones near Salt Lake being less than that of the surface of the Escalante Desert. For the same reason the wave-built terraces are not so conspicuous as they are in other places, although they occur as low sand and gravel benches at a greater or less distance from the hills and in many places near the center of the desert.

The lack of vertical exposures of any considerable thickness renders impossible a detailed description of the sediments except those near the surface. Such well records as are available, however, show that the beds consist principally of clay and fine sand with a subordinate amount of gravel. The wells at Thermo and Milford, the drillers' records of which are given on pages 29, 32, are within the area described and give the most exact information available regarding the character of the Lake Bonneville beds in Beaver County.

The maximum thickness of these beds is not known. The only well that penetrates through them is located at Neels, and shows a thickness of sediment of nearly 2,000 feet. It is possible that the lower parts of these sediments may be of pre-Bonneville age, but there is no indication in the driller's record (given on p. 33) that they do not all belong to the Lake Bonneville beds. It is noteworthy also that Neels is located in a narrow strait of Lake Bonneville, and it is altogether probable that in the broader parts of the basin the sediments may be much thicker.

The sediments of Beaver Basin consist of unconsolidated clay, sand, and gravel in alternating layers, as shown in detail in the well records (pp. 23–26). Their character and distribution, as well as their similarity to the Lake Bonneville beds, seems to warrant the inference that they are lake deposits. A thickness of several hundred feet is exposed in the mesas near Beaver, and an additional thickness of nearly 500 feet is shown by the wells, but the total depth of the sediments within Beaver Basin is not known.

The Beaver Lake beds are similar to the Lake Bonneville beds in general character, degree of consolidation, and association with flows of basalt. For these reasons the Beaver Lake beds are believed to be of the same age as the Lake Bonneville beds, although they lie at an elevation 1,000 feet or more above the Lake Bonneville sediments of the Escalante Desert. This difference in elevation, as previously suggested, may be due to recent elevation, but is more probably to be accounted for as the result of deposition in a lake tributary to Lake Bonneville and lying at a greater elevation.

## STRUCTURE.

The geologic structure in the Beaver region is somewhat difficult to make out owing to the occurrence of the great quantities of eruptive rock and to the recent accumulation of sediments—the Beaver Lake and the Lake Bonneville beds—which cover or obscure the faults. Farther south, however, the older sedimentary rocks are better exposed and their structural relations are plainly discernible.

Along the western border of the High Plateaus of Utah, between Beaver and St. George, several basins have been formed apparently by faulting and the displacement of large crust blocks. Rush Lake Valley (or Cedar Valley, as it is sometimes called) and Parowan Valley are perhaps the most conspicuous of these basins. The strata of the plateaus to the east lie essentially horizontal, except where faulted blocks have been displaced, but the same formations to the west of the cliffs that form the western margin of the plateaus dip eastward beneath the basins. In order to avoid possible misunderstanding, it should be noted in this connection that the hills west of Parowan, mapped by Dutton [a] as trachyte and rhyolite, were found to consist mainly of sandstones and conglomerates similar to those of the plateau east of Parowan, which, as stated by the same author, are sediments of Cretaceous and Tertiary age.

The fault at which the great displacements occurred to form these basins is known as the Hurricane fault, and the northward extension of the Hurricane ledge of the plateau region of southern Utah forms the western margin of the plateaus in Cedar and Parowan valleys. The Hurricane fault, or the zone of faulting in which it occurs, is traceable from the Grand Canyon northward to the lava fields between Parowan and Beaver valleys, where it could not be followed through the effusive rocks. But a number of facts indicate that Beaver Basin, like Parowan Valley, was formed by faulting and crust-block tilting. Among these facts are the following:

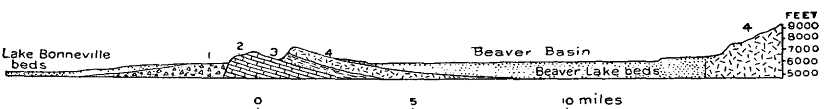



FIG. 2.—East-west section through Beaver, showing structure of Beaver Basin and relation of Beaver Lake beds to Lake Bonneville beds. 1, Volcanic breccia (Tertiary); 2, Aubrey limestone (Carboniferous); 3, red sandstone and shale (Permian); 4, andesite and rhyolite.

The sedimentary formations of the plateau region occur in the Tushar Mountains beneath the igneous rocks. They are exposed, according to Dutton,[b] in the eastern flanks of these mountains and are said to occur also in the western flanks in small detached blocks, one of which, at least, is limestone from which lime is obtained for local uses. The writer did not see these sediments, but in the Mineral Mountains the Paleozoic formations, a section of which is given on page 10, were observed dipping steeply to the east and passing underneath lavas identical in kind and constitution with those of Tushar Mountains. These in turn are finally buried by the sands and gravels of the Beaver Lake beds. The sedimentary rocks terminate abruptly at the west against the breccias composed of volcanic rock which have been described as younger than the rhyolites. This is evidently due to the presence of a fault along the western face of the Mineral Mountains. The probable structural relations are shown in the sketch section, fig. 2.

[a] Dutton, C. E., Tertiary history of the Grand Canyon district: Mon. U. S. Geol. Survey, vol. 2, 1882, atlas sheet No. 21.

[b] Dutton, C. E., Geology of the High Plateaus of Utah, 1880, atlas sheet No. 6, sec. No. 4.

Further evidence that Beaver Basin is in a zone of faulting is found in the prevalence of earthquakes. A number of severe shocks have occurred within recent years, the zone of greatest disturbance following in general the fault zone at the edge of the plateau. In this same zone also occur the volcanic cones north of Beaver, the beds of sulphur at Sulphurdale that have been described by the writer[a] as being still in process of accumulation, and numerous large springs, some of which yield waters that are hot and highly mineralized.

## WATER SUPPLY.

### PRECIPITATION.

Few rainfall records sufficiently complete to be of great use are available from southern Utah. Those that are close enough to the region here described to indicate the precipitation in this region are given below. From these records, representing 11 stations, it appears that the average rainfall, computed from the 78 complete yearly records only, is 10.81 inches.

TABLE 1.—*Records of precipitation at stations in southwestern Utah.*

BEAVER. (ALTITUDE, 5,970 FEET.)

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1889 | ------ | ------ | ------ | ------ | 1.20 | 0.86 | 0.38 | 1.93 | 0.40 | 1.62 | 0.14 | 3.79 | ------ |
| 1890 | 1.03 | 0.67 | 0.53 | 0.60 | .12 | Tr. | .51 | .44 | 1.22 | .17 | .27 | .50 | 6.06 |
| 1891 | .41 | 1.17 | .33 | 1.09 | .61 | 1.14 | 1.36 | 1.25 | 1.24 | Tr. | .00 | 1.50 | 10.10 |
| 1892 | .81 | ------ | 1.17 | 1.12 | ------ | .10 | 1.20 | ------ | ------ | ------ | ------ | 1.75 | ------ |
| 1893 | .45 | 1.38 | 1.45 | 2.04 | .50 | .00 | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 1904[a] | ------ | ------ | ------ | ------ | ------ | ------ | 1.20 | 1.13 | .38 | .67 | .00 | .40 | ------ |
| 1905 | .06 | 2.35 | 1.34 | 1.13 | 2.49 | .00 | .47 | .95 | 2.07 | .30 | .85 | .20 | 12.21 |
| 1906 | 1.10 | 1.09 | 3.59 | 1.62 | 1.86 | ------ | ------ | 2.04 | 1.27 | ------ | .85 | ------ | ------ |

[a] Ten years' record wanting.

BLACKROCK. (ALTITUDE, 4,872 FEET.)

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1901 | 0.40 | 1.43 | 0.34 | 1.29 | 0.78 | 0.94 | 0.15 | 1.02 | 0.00 | 0.56 | Tr. | 0.70 | 7.61 |
| 1902 | .26 | .20 | 1.15 | .16 | .23 | Tr. | .40 | .19 | .84 | .53 | 1.97 | .45 | 6.38 |
| 1903 | 1.11 | 1.30 | 2.00 | 2.59 | 1.72 | .33 | .41 | 1.75 | .92 | .95 | .10 | .18 | 13.36 |
| 1904 | 4.10 | 1.00 | .93 | .26 | 1.64 | .04 | .05 | .56 | .30 | .65 | .00 | .55 | 6.39 |
| 1905 | .48 | 2.26 | 1.74 | 1.28 | 1.52 | Tr. | .65 | .75 | 2.57 | .88 | ------ | ------ | ------ |
| 1906 | 1.59 | ------ | ------ | 3.31 | .91 | .12 | ------ | 1.12 | 2.33 | .03 | 2.11 | .97 | ------ |

DESERET. (ALTITUDE, 4,541 FEET.)

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1891 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0.64 | 0.62 | 0.05 | 0.00 | 0.21 | ------ |
| 1892 | 0.53 | 1.30 | 1.84 | 0.71 | 1.81 | 0.14 | 0.42 | .58 | .06 | 1.12 | .10 | .86 | 9.47 |
| 1893 | .54 | .61 | 1.85 | 1.40 | .67 | .00 | .21 | .91 | .46 | .05 | .14 | .82 | 7.66 |
| 1894 | .35 | 1.35 | .53 | .64 | .43 | 1.29 | .25 | .23 | 1.67 | .39 | .00 | .88 | 8.01 |
| 1895 | .40 | .53 | .63 | .84 | ------ | Tr. | Tr. | Tr. | .80 | .45 | .84 | .38 | ------ |
| 1896 | .32 | ------ | .29 | .47 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| 1899 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | Tr. | 1.23 | .34 | .80 | ------ |
| 1900 | .36 | .05 | Tr. | 2.85 | .10 | .03 | Tr. | Tr. | 1.12 | .39 | .48 | .00 | 5.38 |
| 1901 | .10 | 1.67 | .80 | 1.02 | 1.90 | .62 | .03 | 1.54 | .03 | .50 | .04 | .76 | 9.01 |
| 1902 | .48 | .30 | .82 | .36 | .32 | Tr. | .08 | .04 | .40 | .20 | 1.65 | .20 | 4.85 |
| 1903 | .94 | 1.30 | .40 | .90 | 1.53 | .40 | Tr. | .08 | .67 | .72 | Tr. | .05 | 6.99 |
| 1904 | .15 | .97 | 1.55 | .13 | 2.13 | .60 | Tr. | .20 | .32 | .32 | .00 | .77 | 7.14 |
| 1905 | .42 | 1.25 | 1.06 | 1.36 | 1.35 | .00 | .00 | 1.15 | 1.79 | Tr. | 1.25 | .13 | 9.76 |
| 1906 | .31 | .41 | 2.10 | 1.63 | 1.06 | .19 | ------ | .63 | .95 | Tr. | 1.38 | .94 | 11.77 |

[a] Bull. U. S. Geol. Survey No. 315, 1907, pp. 485–489.

TABLE 1.—*Records of precipitation at stations in southwestern Utah*—Continued.

FILLMORE. (ALTITUDE, 5,100 FEET.)

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1892 | ------ | ------ | ------ | 2.11 | 2.03 | 0.82 | 0.29 | 0.47 | 0.06 | 1.07 | 0.53 | 1.20 | ------ |
| 1893 | 0.81 | 1.51 | 2.89 | 2.09 | 1.53 | .00 | .48 | 1.71 | 1.21 | .46 | 1.11 | 1.79 | 15.59 |
| 1894 | .70 | .56 | 1.04 | 2.43 | .64 | 2.04 | .34 | 1.19 | 1.94 | .41 | .31 | 1.77 | 13.37 |
| 1895 | 1.93 | 2.15 | 2.06 | 1.23 | 1.51 | .80 | .56 | .97 | 1.66 | .93 | 1.46 | 1.10 | 16.36 |
| 1896 | .75 | .16 | .94 | 1.47 | 1.06 | .01 | 2.36 | 1.69 | .85 | .37 | 1.17 | .33 | 11.16 |
| 1897 | 2.15 | 2.17 | 2.89 | 1.26 | .03 | .26 | .19 | .31 | 1.50 | 3.59 | 1.15 | 1.55 | 17.04 |
| 1898 | .15 | 1.20 | 3.07 | .59 | 4.44 | .96 | .99 | .06 | Tr. | .60 | 1.27 | .76 | 14.59 |
| 1899 | .50 | 1.40 | 5.00 | 1.45 | .85 | .96 | .01 | .28 | .00 | 1.94 | 1.06 | 1.03 | 14.48 |
| 1900 | 1.25 | .45 | .15 | 3.18 | .35 | .60 | Tr. | .14 | 1.58 | .93 | .66 | .03 | 9.32 |
| 1901 | .35 | 2.00 | 1.54 | 2.35 | 1.92 | .57 | .41 | .90 | .00 | .72 | .15 | 1.97 | 12.88 |
| 1902 | 1.03 | 1.03 | 2.59 | .36 | .90 | .09 | .49 | .16 | 1.51 | .58 | 2.70 | .46 | 11.90 |
| 1903 | 1.44 | 1.26 | 1.19 | 2.66 | 2.27 | .04 | .27 | .38 | 1.00 | 1.06 | .00 | .40 | 11.97 |
| 1904 | 1.89 | 1.90 | 2.16 | .26 | 2.81 | .25 | .07 | 1.13 | .10 | .62 | .00 | .95 | 12.14 |
| 1905 | .90 | 2.48 | 2.66 | 1.53 | 2.45 | Tr. | .53 | .62 | 2.81 | .51 | 1.13 | .54 | 16.16 |
| 1906 | .72 | 1.16 | 3.88 | 4.38 | 2.18 | .40 | 1.27 | 1.20 | 2.38 | .15 | 2.93 | .63 | 21.28 |

FRISCO. (Altitude, 6,250 feet.)

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1897 | ------ | 0.30 | 0.44 | Tr. | 0.20 | 0.11 | 0.16 | 0.19 | 1.21 | 1.50 | 0.45 | 1.00 | ------ |
| 1898 | 0.42 | .10 | .12 | 0.41 | 2.59 | .11 | .97 | 1.46 | .00 | .31 | .15 | .24 | 6.88 |
| 1899 | .10 | .65 | 2.56 | 1.01 | .08 | .36 | .81 | .18 | Tr. | .51 | .28 | Tr. | 6.54 |
| 1900 | .11 | .04 | .03 | 1.73 | ------ | .04 | Tr. | .05 | 1.41 | .77 | .55 | .05 | ------ |
| 1901 | .35 | 2.36 | .28 | .86 | 1.42 | .97 | 1.76 | .64 | Tr. | .68 | Tr. | .75 | 10.07 |
| 1902 | .95 | .02 | .72 | .10 | Tr. | Tr. | .74 | .82 | .47 | .15 | 1.22 | .39 | 5.58 |
| 1903 | .75 | 1.66 | .68 | 1.49 | 1.88 | .66 | .72 | 1.12 | .82 | .85 | .02 | .07 | 10.72 |
| 1904 | .50 | .64 | .97 | .10 | 2.49 | .11 | .86 | .83 | .45 | .41 | .00 | .22 | 7.58 |
| 1905 | .66 | 1.44 | 1.71 | .58 | 1.44 | .02 | .58 | 1.04 | 2.32 | .89 | .83 | .30 | 11.81 |
| 1906 | .10 | .56 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | .98 | .95 | ------ |

GARRISON.

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1903 | 0.66 | 0.60 | 0.20 | 0.38 | 1.16 | 0.54 | 0.05 | 0.55 | 0.38 | 0.23 | Tr. | Tr. | 4.75 |
| 1904 | .07 | 1.49 | .62 | .06 | .97 | .41 | .93 | .95 | .55 | .94 | 0.00 | 0.22 | 7.21 |
| 1905 | .37 | 1.30 | .30 | .99 | 1.83 | Tr. | .10 | .83 | .85 | .00 | 2.14 | .11 | 8.82 |
| 1906 | ------ | Tr. | 2.47 | 1.58 | .77 | .06 | .33 | ------ | .50 | .10 | 1.98 | .58 | ------ |

MINERSVILLE.

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1897 | ------ | 1.75 | 2.40 | 0.16 | 0.28 | 0.03 | 0.91 | 0.49 | 2.07 | 1.57 | 0.49 | 1.52 | ------ |
| 1898 | 1.49 | .57 | 2.08 | .25 | 2.35 | .46 | .51 | .94 | .11 | .08 | .66 | .29 | 9.79 |
| 1899 | .57 | .38 | 2.40 | .71 | .65 | .17 | 1.20 | .63 | Tr. | 1.38 | .52 | .63 | 9.24 |
| 1900 | .34 | .20 | .34 | 2.32 | .32 | .13 | .04 | ------ | ------ | .62 | 1.33 | .05 | ------ |
| 1901 | .45 | 2.21 | .51 | .87 | 1.05 | .55 | .86 | 1.60 | .02 | .70 | .16 | .72 | 9.70 |
| 1902 | .91 | .29 | 1.22 | .12 | .07 | ------ | .41 | .48 | .97 | .10 | 2.70 | ------ | ------ |
| 1903 | .14 | .94 | 1.10 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | .00 | ------ |
| 1904 | .70 | 1.70 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | Tr. | .00 | .80 | ------ |

MODENA. (ALTITUDE, 5,479 FEET.)

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1902 | 0.33 | 0.32 | 0.54 | 0.13 | 0.19 | 0.02 | Tr. | 1.58 | 0.76 | 0.04 | 0.89 | 0.29 | 5.09 |
| 1903 | .12 | .85 | .74 | .61 | .55 | .13 | 0.14 | .92 | 1.48 | 1.39 | .00 | .00 | 6.93 |
| 1904 | .20 | 1.01 | .98 | .02 | 1.55 | .11 | .69 | 1.52 | 2.02 | .50 | .00 | .23 | 9.83 |
| 1905 | .86 | 1.79 | 2.09 | 1.05 | .72 | Tr. | .81 | 1.71 | 1.26 | 1.00 | .90 | .20 | 12.39 |
| 1906 | .67 | .47 | 3.22 | 2.91 | 1.31 | .00 | 2.30 | 3.40 | .91 | .34 | 1.40 | 2.13 | 19.06 |

PAROWAN. (ALTITUDE, 5,970 FEET.)

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1890 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0.93 | 0.59 | 0.43 | 0.34 | ------ |
| 1891 | 1.46 | 2.07 | 2.57 | 1.57 | 1.14 | 0.20 | 1.24 | 0.76 | 2.10 | .00 | .00 | 1.13 | 14.24 |
| 1892 | .47 | 1.03 | 1.79 | 2.03 | .83 | .04 | .66 | 1.24 | .00 | 2.32 | .20 | .39 | 11.00 |
| 1893 | .84 | 1.03 | 1.23 | 1.42 | 1.34 | .00 | 2.08 | 1.65 | 1.11 | Tr. | 1.38 | .72 | 12.80 |
| 1894 | 1.65 | .85 | 2.65 | 1.27 | .55 | .57 | .78 | 1.40 | .72 | .65 | Tr. | 1.88 | 12.97 |
| 1895 | 1.94 | 2.82 | 1.93 | .47 | .87 | .06 | .70 | .23 | .29 | .58 | 1.28 | .90 | 12.07 |
| 1896 | .16 | .48 | .71 | .83 | .93 | .08 | 1.69 | 3.00 | .47 | .36 | .30 | .16 | 9.17 |
| 1897 | 1.50 | 3.45 | 3.76 | .95 | .51 | .02 | .79 | 1.56 | 1.84 | 2.48 | .73 | .88 | 18.47 |
| 1898 | 1.99 | 1.20 | 1.66 | .64 | 3.35 | .24 | 1.19 | 1.46 | .25 | .30 | .72 | .82 | 13.82 |
| 1899 | .12 | 1.10 | 2.18 | 1.20 | 1.19 | .82 | .72 | .82 | .08 | .78 | .31 | 1.60 | 10.92 |

TABLE 1.—*Records of precipitation at stations in southwestern Utah*—Continued.

PAROWAN. (ALTITUDE, 5,970 FEET)—Continued.

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1900 | .51 | .23 | .18 | 2.64 | .61 | .13 | .11 | .84 | .82 | .56 | .34 | .07 | 7.04 |
| 1901 | .63 | 1.84 | .85 | 1.61 | .88 | .50 | .04 | 3.35 | .04 | .32 | .03 | .96 | 11.05 |
| 1902 | 1.18 | .31 | 1.83 | .21 | .18 | .06 | .49 | .76 | .50 | .61 | 1.86 | 1.03 | 9.02 |
| 1903 | 1.10 | .77 | 1.94 | 1.66 | 1.10 | .49 | .41 | 1.46 | 1.00 | 2.03 | Tr. | .53 | 11.89 |
| 1904 | .43 | 1.46 | 2.11 | 1.27 | 2.07 | .07 | .98 | 1.23 | .17 | .74 | Tr. | .79 | 11.32 |
| 1905 | .52 | 1.54 | 2.29 | .66 | 1.99 | Tr. | .75 | .37 | 3.80 | .12 | 1.11 | .32 | 13.47 |
| 1906 | 1.4 | .93 | 3.99 | 1.95 | .62 | Tr. | 1.71 | 3.10 | 3.49 | .41 | 2.09 | 1.18 | 20.87 |

PINTO. (ALTITUDE, 5,907 FEET.)

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1897 | ------ | 3.05 | 4.11 | 0.78 | 0.52 | 0.05 | 0.90 | 0.89 | 2.17 | 3.76 | 0.40 | 1.16 | ------ |
| 1898 | 1.28 | .68 | 1.33 | .39 | 2.30 | .25 | .07 | .60 | .00 | .00 | .11 | .11 | 7.12 |
| 1899 | .25 | .35 | 2.17 | .40 | .58 | .77 | .05 | 1.06 | .00 | 1.75 | .67 | .49 | 8.54 |
| 1900 | .38 | .27 | .34 | 2.31 | .65 | .25 | .13 | .08 | 1.32 | .77 | 3.16 | .05 | 9.71 |
| 1901 | 1.72 | 2.74 | .23 | .85 | .85 | .45 | .80 | 5.07 | .00 | 1.43 | .39 | .57 | 15.10 |
| 1902 | .61 | .95 | 2.66 | .25 | .19 | Tr. | .01 | 1.71 | .20 | .93 | 3.09 | 70 | 11.30 |
| 1903 | .93 | 1.06 | 1.57 | 1.30 | .80 | .17 | Tr. | 1.74 | 1.37 | 1.75 | .00 | .21 | 10.40 |
| 1904 | .80 | 1.91 | 1.72 | .44 | 1.90 | ------ | 3.25 | 1.97 | .99 | .91 | .00 | .17 | ------ |
| 1905 | .64 | 1.88 | 2.28 | 1.48 | 2.09 | .00 | 1.41 | 1.83 | 4.82 | .77 | 1.67 | .08 | 18.95 |
| 1906 | 2.72 | 1.52 | 6.45 | 2.15 | .93 | .17 | 1.64 | 2.82 | 1.82 | .10 | 2.43 | 2.85 | 25.60 |

PIOCHE, NEV.

| Year. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1877 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0.18 | 0.16 | 0.48 | 0.00 | 0.95 | ------ |
| 1878 | 0.46 | 1.67 | 0.73 | 1.31 | 1.27 | 0.04 | 0.29 | .97 | .22 | .35 | .63 | .42 | 8.36 |
| 1879 | 1.12 | .17 | .12 | 1.68 | .03 | .40 | .17 | .46 | .00 | .66 | .38 | 1.75 | 6.94 |
| 1880 | .21 | .36 | .12 | .46 | .01 | .03 | .18 | .47 | .18 | .52 | .29 | 1.84 | 4.67 |
| 1881 | .47 | .29 | .47 | 1.08 | .21 | .03 | .23 | 1.73 | .00 | .56 | .10 | .08 | 5.25 |
| 1882 | .38 | .55 | .30 | .98 | .29 | 3.23 | .21 | .95 | .03 | .60 | .71 | .08 | 8.31 |
| 1883 | .20 | .28 | .59 | 1.15 | .33 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |

## SURFACE WATERS.

### SOURCE.

The waters of Beaver Valley are derived almost entirely from the Tushar Mountains and result directly from the heavy precipitation about the lofty peaks, from which they enter the valley as streams. The rate of run-off from the mountains is regulated by the porous condition of the rocks and by the accumulations of snow. The elevation is such that the snow which falls during the winter melts gradually and feeds the streams during the spring and early part of the summer. The loose volcanic tuffs and breccias absorb large quantities of the water derived both from the rainfall and from the melting snows, and these waters are held back because of their slow movement through the rocks and finally issue in the form of springs having a comparatively regular flow. This conservation of the waters is of the greatest importance to the agricultural regions dependent upon the run-off and will be greatly enhanced by the forest reserve which has recently been established in the Tushar Mountains.

## MEASUREMENTS OF FLOW.

Little is known thus far of the actual quantity of water entering Beaver Valley. The settlement of the valley has taken place gradually, the first settlers appropriating all the water they wanted and the later ones taking what they could get. All the summer flow has long since been appropriated, although much of it is misused.

There is imperfect adjudication of rights and little knowledge of the actual volume appropriated in any particular case. The canals and ditches are poorly constructed. In some of them the water flows too rapidly and actively erodes the beds, thus increasing the volume carried. Others have not fall enough and the water fills them with silt, thus decreasing the volume carried. The amount of irrigated land is approximately as follows:

From Beaver River, 9,500 acres, of which 4,036 acres are supplied only during high water.

From South Creek, about 200 acres.
From North Creek, about 1,297 acres.
From Indian Creek, about 363 acres.
Total acreage in Beaver Valley, 11,360.

No measurements were obtained from Milford or from Beaver Bottoms. The only consecutive measurements of volume of the streams that have been made are given in the following table, the four streams named yielding practically the entire inflow:

TABLE 2.—*Discharge measurements of Beaver River and tributaries, in acre-feet.*

| Stream. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. |
|---|---|---|---|---|---|---|---|
| 1905.[a] | | | | | | | |
| Beaver River | 1,994 | 1,493 | 2,460 | 4,046 | 5,341 | 4,327 | 2,446 |
| North Creek | 129 | 122 | 166 | 196 | 228 | 304 | 344 |
| South Creek | 92 | 78 | 123 | 167 | 197 | 232 | 258 |

| Stream. | Aug. | Sept. | Oct. | Nov. | Dec. | Year. |
|---|---|---|---|---|---|---|
| 1905.[a] | | | | | | |
| Beaver River | 2,255 | 1,912 | 1,824 | 1,892 | 2,047 | 31,827 |
| North Creek | 332 | 274 | 240 | 161 | 135 | 2,631 |
| South Creek | 234 | 214 | 184 | 131 | 129 | 2,039 |

| Stream. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|
| 1906.[b] | | | | |
| Beaver River, June 15 to Sept. 22 | 9,520 | 7,190 | 4,600 | 2,450 |
| Indian Creek, June 26 to Aug. 31 | 182 | 578 | 314 | -------- |
| North Creek, June 16 to Sept. 27 | 3,510 | 2,728 | 1,556 | 1,382 |
| Canal at Minersville, June 21 to Sept. 21 | 847 | 2,290 | 2,070 | 1,570 |

[a] From weir measurements by L. L. Nunn, for the Telluride Power Company.
[b] Measurements by J. F. Hoyt.

### UTILIZATION.

The surface waters are all diverted for irrigation during the summer, but the winter flow is not utilized, although some opportunity is offered for the construction of storage reservoirs. One small dam has been built by the water users of Minersville, across Beaver River in the canyon, 5 miles east of the town, but the reservoir is too small to hold the waters of even a moderate-sized flood. It might be enlarged, however, at comparatively slight cost and its usefulness greatly increased.

## UNDERGROUND WATERS.

### SPRINGS.

*Number and distribution.*—A large number of springs occur in Beaver Valley, some in the consolidated rock formations, but most of them in the unconsolidated sediments of the Beaver Lake beds. In the vicinity of Beaver they are especially numerous and some of them are not distinguishable from the seepage where the return waters of the underflow produce swampy conditions over considerable areas. They are most numerous at the foot of the gravel benches, especially where the benches are irrigated, as east of Beaver, where the return water produces a continuous flow along the foot of the bench during the irrigation season, as shown in fig. 3 (p. 48). A few of the springs have peculiarities worthy of special description, but the essential facts regarding most of them are contained in Table 6 (p. 44).

*Sulphurdale.*—Sulphurdale is located about 20 miles north of Beaver, a little beyond the northern border of the area shown on the map (Pl. I). The sulphur deposits, locally known as the Cove Creek beds, are located at this place. Small quantities of water which would ordinarily reach the surface as a spring, but which on account of the mining operations carried on there may be classed as mine water, issue from the sulphur beds. The water is highly mineralized, as shown by the subjoined analysis, sulphites, sulphuric acid, and iron being especially abundant. Sulphureted hydrogen ($H_2S$) escapes from the beds in great quantities, and the sulphuric acid is apparently the result of the oxidation of this gas. The oxygen of the air first combines with the hydrogen (H), leaving the sulphur (S), most of which remains in the solid state and constitutes the sulphur deposits; but some of the sulphur is still further oxidized to sulphur trioxide ($SO_3$), which combines with water ($H_2O$) to form sulphuric acid ($H_2SO_4$).

*Analysis of water from Cove Creek sulphur beds.*

[Parts per million. Analyst, W. M. Barr.]

| | |
|---|---|
| Dissolved solids at 180° | 8,816 |
| Dissolved solids at 130° | 10,810 |
| Suspended matter | 52 |
| Silica ($SiO_2$) | 124 |
| Ferrous iron (FeO) | 560 |
| Ferric iron ($Fe_2O_3$) | 802 |
| Aluminum (Al) | 0 |
| Calcium (Ca) | 158 |
| Magnesium (Mg) | 232 |
| Sodium (Na)<br>Potassium (K) | 144 |
| Carbonate radicle ($CO_3$) | 0 |
| Bicarbonate radicle ($HCO_3$) | 0 |
| Sulphate radicle ($SO_4$) | 7,602 |
| Free sulphuric acid ($H_2SO_4$) | 4,523 |
| Chlorine (Cl) | 79 |
| Nitric radicle ($NO_3$) | 1.7 |
| Free sulphur (S) | 3.6 |

Constant loss of dissolved solids occurs when heated above 130°. Heated at 180°, not constant. Sample had free hydrogen sulphide ($H_2S$) when collected, with possible presence of sulphur dioxide ($SO_2$).

*McKean's spring* (Roosevelt Hot Spring; sec. ?, T. 27 S., R. 9 W.)—P. B. McKean's hot springs, of which there are several, are located on the western slope of the Mineral Mountains, northeast of Milford. The largest of these springs, having a discharge of about 10 gallons per minute, has been improved and a bath house built, to utilize the water for medicinal purposes. The spring is inclosed, so that the temperature of the water as it issues from the rock could not be measured, but as it issues from the pipe leading from the spring it has a temperature of 190° F. Within the spring the water is boiling and steam escapes also from crevices in the rock for a distance of several feet about the spring. The water contains a large amount of mineral in solution, as shown by the analysis in Table 9 (p. 50), and is strongly charged with hydrogen sulphide ($H_2S$). Much of the silica ($SiO_2$) contained in solution as the boiling water issues from the rocks is deposited as the water cools and does not appear in the analysis. The silica is precipitated as a light-green jelly which changes to white, spongy masses when artificially dried, but which in nature builds about the springs compact stony mounds. On analysis this deposit was found to consist entirely of silica.

The origin of the heat at this place is a matter of considerable interest. The springs are in the zone of faulting which follows the western face of the Mineral Mountains and which, although wholly in crystalline rock at this place, is well marked by a conspicuous shearing and brecciation of the rock. On the mountain slope to the east is a mass of black obsidian of recent origin, and on the eastern flank of the range occur the volcanic cones which still retain their original form in great perfection. The heat may be caused by the friction or by the crushing of rock in the fault zone or may be residual heat from a mass of intrusive lava.

*Spring 4 miles north of Minersville.*—This spring, like the Roosevelt Hot Spring, is located on the western slope of the Mineral Mountains in the zone of faulting. It has deposited large quantities of mineral matter, presumably silica, building up a mound subcircular in outline and about a quarter of a mile in diameter, but the water, unlike that of the Roosevelt Spring, is not notably warmer than that of ordinary springs. The water issues from the mound at several points. The flow from the main opening was estimated at 50 gallons per minute, but the total flow was not determined.

The presence of warm springs in the zone of faulting to the north at the Roosevelt Hot Spring and to the south at Minersville (Dotson's spring, described under the next heading) suggests that this may formerly have been a hot spring. The suggestion is strengthened by the presence of the large amount of silica constituting the mound. Silica is being deposited at the present time by the hot waters of the Roosevelt Spring and the Thermo springs, but apparently not by the cooler waters of the spring north of Minersville.

This spring is favorably situated for supplying the town of Minersville with drinking water. The residents of that town are now dependent on wells, the water from which is very bad, and on the river, the water from which during the summer, at least, is derived chiefly from the seepage of the lands in Beaver Basin.

The field assay of the spring water, as given in Table 6 (p. 45) shows it to contain a large amount of dissolved solids, and it would not ordinarily be considered a good drinking water. It is much better, however, than the Minersville well waters, and although it is more saline than the river water, it is from a sanitary standpoint the best supply available for the town so far as is now known.

*Dotson's spring* (sec. 7, T. 30 S., R. 9 W.).—R. W. Dotson's spring is located in the bank of Beaver River about a mile east of Minersville. The water issues at the rate of 57 gallons per minute from an opening on the fault at the western edge of the massive limestone of the Mineral Mountains. No use is now made of the spring except for bathing, a small tank having been built for that purpose. The water has a temperature of 97° F. and is hard and saline, as shown by the field assay given in Table 6 (p. 45).

*Warm springs near Thermo.*—There is a group of warm springs about 3 miles south of Thermo, a siding on the San Pedro, Los

Angeles and Salt Lake Railroad. The springs occur in two conspicuous mounds built up from the surface of the plain by silica deposited from the spring waters. The southermost mound is about 10 feet high, 160 feet wide, and 3,000 feet long, and the northernmost one is 15 to 20 feet high, 500 feet wide, and about 5,000 feet long. Water issues from these mounds at many points, but no one of the springs yields any great volume of water. The water has a temperature of 140° F. and contains hydrogen sulphide ($H_2S$), much of which escapes as gas. The results of a laboratory analysis of this water are given in Table 9 (p. 50). The water contains also a large amount of silica in solution, most of which is deposited at the surface when the water cools and does not appear in the analysis.

*Other springs.*—Data were obtained of 23 other springs. The information is largely chemical in nature and is given in Table 6, in the section describing chemical character, on pages 42–45.

### SEEPAGE WATERS.

*Location.*—In the lower portions of Beaver Basin the surface of the ground water is at or very close to the land surface. During spring and early summer the ground-water level gradually rises, and during late summer and early autumn a considerable part of the lowlands of the valley between Beaver and Adamsville is transformed into a marsh. Many of the roads are rendered impassable and many of the fields useless for tillage or even pasturage. Nearly half of the town of Beaver was thus affected during the summer of 1906. Some of the principal streets were impassable. Water was found flowing freely from dug wells and from cellars, in some cases making houses uninhabitable. The area rendered swampy within the city is shown in fig. 3 (p. 48).

The lowlands in the vicinity of Milford and to the north, especially in Beaver Bottoms, are similarly affected, although on account of the large area of lowlands and the limited water supply swampy conditions are not so serious in the Milford region.

*Volume.*—The volume of return water is known to be very large in comparison with the flow of the streams, but no measurements are available at the present time. Some conception of the volume, however, may be obtained from the fact that 2,000 acres of the cultivated land of the valley are irrigated wholly by seepage waters. Besides this a large proportion of the seepage finds its way directly into the river and can not be measured separate from the stream flow. The chemical character of the seepage waters is shown in Table 5 (p. 43).

## DEEP WELLS.

### CLASSIFICATION.

The wells of Beaver Valley may be conveniently described in two divisions: (*a*) the bored wells, including both flowing and nonflowing wells, and (*b*) the shallow or dug wells. For the purpose of easy reference it will be convenient also to subdivide these by districts, each district being named from the town that it surrounds, except in the case of the railroad wells, which for convenience are described as being in the Milford district, although some are far from the town of Milford.

The following descriptions of the more important deeps wells are arranged in order from Beaver westward through Greenville, Adamsville, Minersville, and Milford including Beaver Bottoms.

### BEAVER DISTRICT.

*Barton well.*—J. H. Barton has a 3-inch bored well in Beaver. It is 66 feet deep and yields an ample supply of water. Saturated sands and gravels extend more or less continuously from top to bottom. The clay partings are apparently not continuous for any great distance, as the water is under no pressure. The driller's record is as follows:

*Record of J. H. Barton's well, Beaver.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 1 | 1 |
| Gravel | 25 | 26 |
| Clay | 3 | 29 |
| Gravel | 12 | 41 |
| Clay | 4 | 45 |
| Gravel | 21 | 66 |

*Cemetery well.*—There is a 2-inch drilled well at the Beaver cemetery, 180 feet deep. A gravel stratum which has water under considerable pressure, although not sufficient to produce a surface flow, was encountered at a depth of 170 feet.

*Record of Beaver cemetery well.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 1 | 1 |
| Gravel | 3 | 4 |
| Clay | 7 | 11 |
| Sand, gravel, and clay | 169 | 180 |

*Mumford well* (sec. 28, T. 29 S., R. 7 W.).—George Mumford has a 2-inch bored well, 200 feet deep, located south of Beaver. The well is not now in use, but is of interest especially in showing the character of the Beaver Lake beds and for the reason that an oil stratum was penetrated at a depth of 140 feet. The evidences of oil were not sufficient, however, to indicate the presence of any large quantity.

*Record of George Mumford's well, near Beaver.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 30 | 30 |
| Sand | 16 | 46 |
| Clay | 15 | 61 |
| Sand | 16 | 77 |
| Gravel and bowlders | 35 | 112 |
| Clay | 28 | 140 |
| Gravel | 35 | 175 |
| Sand | 25 | 200 |

*Nower well* (sec. 27, T. 29 S, R. 7 W.).—J. A. Nower has a 3-inch bored well, 213 feet deep, located near the point of the mesa south of Beaver. The water rises to a level 17 feet below the surface and has a temperature of 54° F.

*Record of J. A. Nower's well, near Beaver.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 3 | 3 |
| Clay | 3 | 6 |
| Sand and gravel | 79 | 85 |
| Clay | 5 | 90 |
| Alternating layers of sand and clay | 123 | 213 |

*Shepherd well* (sec. 20, T. 29 S., R. 7 W.).—Warren Shepherd has a 4-inch bored well, 300 feet deep, located about a mile west of Beaver, in which the water stands 2 feet below the surface of the ground. It is noteworthy that in boring this well black volcanic rock, probably basalt, was penetrated, indicating that the Beaver Lake beds, like the Lake Bonneville beds, contain sheets of basalt within the sands and gravels.

*Record of Warren Shepherd's well, west of Beaver.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 4 | 4 |
| Gravel | 2 | 6 |
| Clay | 6 | 12 |
| Sand and gravel | 31 | 43 |
| Sand and gravel alternating with black volcanic rock | 257 | 300 |

*Wolfenden & Murdock's well* (sec. 22, T. 29 S., R. 7 W.).—This well is located at the grist mill about a mile east of Beaver and is 60 feet deep. It does not reach beyond the influence of the surface changes described under the heading of shallow wells (p. 37), as do many of the deeper wells of the Beaver region, the water level being about 40 feet lower in February than in July.

*Record of Wolfenden & Murdock's well, east of Beaver.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 2 | 2 |
| Gravel | 28 | 30 |
| Clay | 2 | 32 |
| Sand and gravel | 10 | 42 |
| Clay | 10 | 52 |
| Sand | 8 | 60 |

*Other Beaver wells.*—Other deep wells were found in the Beaver district, but little was learned of them further than the meager information contained in Table 3 (p. 35).

GREENVILLE DISTRICT.

*Greenville school well* (sec. 25, T. 29 S., R. 8 W.).—This is a 3-inch bored well located in the town of Greenville. It is 244 feet deep and encountered water under pressure at 180 and 244 feet. The surface flow is about 11 gallons per minute and the quality good.

*Record of Greenville school well.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 2 | 2 |
| Gravel (water-bearing) | 178 | 180 |
| Clay | 61 | 241 |
| Sand (water-bearing) | 3 | 244 |

*Other Greenville wells.*—Several flowing wells have been bored in the vicinity of Greenville, but few definite records of the rocks penetrated are available and little information was obtained other than that given in Table 3 (p. 35).

ADAMSVILLE DISTRICT.

*Griffith well* (sec. 30, T. 29 S., R. 8 W.).—J. M. Griffith has three bored wells near the town of Adamsville. One is a 3-inch well 30 feet deep and flows 4 gallons per minute, another is a 2-inch well 100 feet deep and flows 3 gallons per minute, and the third is a 3-inch well 475 feet deep, which, on account of its location on ground higher than the others, does not flow. The driller's record of the third well is given below.

The artesian conditions of Beaver Basin are well illustrated at this point. Wells located in the lowest ground, whether deep or shallow, yield flowing water. Wells located on ground a few feet higher, although they penetrate much deeper beds—475 feet in this case—do not yield flowing water. The wells in the low ground flow apparently not because of pressure caused by an impervious layer overlying a water-bearing stratum, but because these wells afford places of comparatively easy escape for water which would eventually reach the surface by natural means but which is somewhat retarded on account of the friction within the beds through which it passes.

*Record of J. M. Griffith's well No. 3, near Adamsville.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Gravel | 14 | 14 |
| Clay | 14 | 29 |
| Gravel (water-bearing) | 32 | 60 |
| Clay | 47 | 107 |
| Gravel (water-bearing) | 68 | 175 |
| Clay | 300 | 475 |

*Parkinson well* (sec. 28, T. 29 S., R. 8 W.).—Earl Parkinson has a 3-inch bored well, 385 feet deep, about 2 miles east of Adamsville. This well differs from most of the wells in the vicinity of Adamsville in that it does not flow, the water standing 13 feet below the surface. The material penetrated also differs notably from that in the other deep wells, being mainly fine sand and clay.

*Record of Earl Parkinson's well, 2 miles east of Adamsville.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil and gravel | 27 | 27 |
| Sand and clay | 358 | 385 |

*Other Adamsville wells.*—Several other wells have been put down in the Adamsville district, but little information was obtained other than that contained in Table 3 (pp. 35–37).

MINERSVILLE DISTRICT.

*Baker & Walker's well* (sec. 8 (?), T. 30 S., R. 10 W.).—This well is located about 5 miles west of Minersville. It is a 3-inch bored well 223 feet deep. Water-bearing gravel was encountered at a depth of 185 feet, but the water is not under pressure.

*Record of Baker & Walker's well, 5 miles west of Minersville.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Clay soil | 10 | 10 |
| Gravel | 165 | 175 |
| Clay | 10 | 185 |
| Gravel (water-bearing) | 5 | 190 |
| Clay | 33 | 223 |

*Goodson well* (sec. 8, T. 30 S., R. 10 W.).—E. J. Goodson has a 3-inch bored well, 124 feet deep, about 6 miles west of Minersville. Water was found from 96 feet downward, but is under no pressure. A well belonging to Henry Baker, located about 2 miles southwest of Mr. Goodson's well, is 210 feet deep, with water under little pressure at 180 feet.

*Record of E. J. Goodson's well, 6 miles west of Minersville.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 6 | 6 |
| Gravel | 84 | 90 |
| Clay | 6 | 96 |
| Gravel (water-bearing) | 10 | 106 |
| Sand and clay | 18 | 124 |

*Van Patten well.*—F. A. Van Patten has a 3-inch drilled well, 125 feet deep, at Minersville. Water was not found below a depth of 95 feet, and the casing was drawn back to that depth.

*Record of F. A. Van Patten's well, Minersville.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 1 | 1 |
| Gravel | 24 | 25 |
| Alternating layers of clay, sand, and gravel (water-bearing) | 90 | 115 |
| Clay | 10 | 125 |

*Other Minersville wells.*—There are several bored wells in Minersville, but little of interest was learned of them. The scanty information is to be found in Table 3 (p. 36).

MILFORD DISTRICT.

*Milford town well.*—The town of Milford is supplied with water from a bored well 425 feet deep, located at the foot of the gravel bench which occurs at the west edge of the town. The upper 300 feet of the well is cased with 6-inch pipe, from the lower end of which a 4-inch pipe extends to the bottom of the well, the water coming entirely from a depth of 425 feet. The water has a pressure of 6 pounds per square inch at the surface, flows 30 gallons per minute, and has a temperature of 72° F.

The natural flow of the well is not sufficient to supply the town, and the water is pumped by a 10-horsepower gasoline engine to a cement reservoir, 28 by 72 feet and 6½ feet deep, located on the gravel bench 60 feet above the town. The pump ordinarily discharges 156 gallons per minute, and the well readily yields this amount. No determination has been made of the maximum possible yield of the well, but it would apparently supply much more than 156 gallons per minute.

The surface water at Milford is brackish and for this reason is cased out of the town well. The analysis in Table 9 (p. 50) shows that the water from the depth of 425 feet is very good for domestic purposes.

*Lewis well.*—A. B. Lewis has a bored well in the town of Milford that is cased to a depth of 450 feet with 4-inch pipe, inside of which a 2-inch pipe extends to a depth of 750 feet. From the outer pipe water flows at the rate of 37 gallons per minute and has a temperature of 80° F. Water also flows from the inner pipe at the rate of 2 gallons per minute, and since it is surrounded by the water of the outer pipe it issues with the same temperature, 80° F. The water from the 750-foot level differs from that at 450 feet in containing much more mineral matter in solution, as shown in Table 3 (p. 36), and also in containing hydrogen sulphide ($H_2S$).

*Record of A. B. Lewis's well, Milford.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 12 | 12 |
| Gravel | 48 | 60 |
| Clay and sand in alternating layers | 390 | 450 |
| Clay | 80 | 530 |
| Quicksand | 5 | 535 |
| Clay | 215 | 750 |
| Sand | | (?) |

*Winberg well.*—A. W. Winberg has a 2-inch bored well at the steam laundry in Milford. It is 326 feet deep and penetrates water-bearing strata at depths of 260, 285, 310, and 326 feet, all four beds yielding flowing water. The pressure at the mouth of the well is 6 pounds per square inch and the flow 9 gallons per minute. The quality of the water is excellent and is practically the same as that from the town well.

*Record of A. W. Winberg's well, Milford.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Clay | 16 | 16 |
| Gravel (water-bearing) | 44 | 60 |
| Alternating beds of clay, sand, and gravel (water-bearing) | 266 | 326 |

*Railroad well.*—The San Pedro, Los Angeles and Salt Lake Railroad has three flowing wells at Milford. Two of them are 2-inch wells about 400 feet deep, each discharging 18 gallons per minute; the third, a 12-inch well, 310 feet deep, located near the railroad station, ordinarily flows 30 gallons per minute, the pressure at the surface being about 6 pounds per square inch. Ground water here occurs at a depth of 8 feet and artesian flows at 170 and 310 feet. The flow is not sufficient to supply enough water for railroad use at this station, and water is pumped from the 12-inch well at the rate of 270 gallons per minute. The driller's record of this well follows, and an analysis of the water is given in Table 10 (p. 51).

*Record of the San Pedro, Los Angeles and Salt Lake Railroad 12-inch well, Milford.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 4 | 4 |
| Sand | 6 | 10 |
| Blue clay | 22 | 32 |
| Sand | 33 | 65 |
| Blue clay | 10 | 75 |
| Sand and gravel | 15 | 90 |
| Blue clay | 25 | 115 |
| Hardpan | 4 | 119 |
| Quicksand | 35 | 154 |
| Blue clay | 15 | 169 |
| Sand (artesian flow) | 5 | 174 |
| Red clay | 81 | 255 |
| Quicksand | 10 | 265 |
| Sand | 5 | 270 |
| Clay | 8 | 278 |
| Sand | 10 | 288 |
| Yellow clay | 17 | 305 |
| Cemented gravel (artesian flow) | 5 | 310 |

*Milwaukee Leasing Company's well* (sec. 31(?), T. 28 S., R. 11 W.).—This well is located about 8 miles southwest of Milford, at the Milwaukee Leasing Company's stamp mill. It was originally a 6-inch drilled well, 90 feet deep, with water at a depth of 45 feet. Later an open shaft was dug to water level. The water is pumped for use in the stamp mill in sufficient quantity to supply the 20 stamps operated.

East and south of the mill and on lower ground water is found under considerable pressure. Large so-called artesian springs are reported there, and one well drilled several years ago still flows to some extent.

*Majestic Copper Mining and Smelting Company's wells.*—There are four flowing wells at the smelter 2 miles south of Milford, 95, 340, 465, and 470 feet deep. The smelter is not now in operation, and little information regarding the wells could be obtained. The flow is slight, owing probably to the location of the wells on a bench several feet above the valley bottom.

*Wells in Beaver Bottoms.*—J. C. White reports 20 flowing wells in Beaver Bottoms, many of them bored by himself. Water having pressure sufficient to produce a slight surface flow from wells located on the lowest ground occurs in beds of sand and gravel at depths of 180 to 200 feet below the surface. The wells are all very small, the casing varying from 1 to 2 inches in diameter, and the flow is only 1 to 3 gallons per minute.

An attempt was made several years ago to find other water-bearing strata, and a well was sunk on the Ryan ranch near Read (formerly Smith's station) to a depth of 860 feet. The sediment encountered was all very fine. Some sand was found with the clay to a depth of 300 feet, but below this the material penetrated was wholly clay.

The waters of Beaver Bottoms are strongly charged with saline matter, the artesian waters more so than the surface waters. In this respect the relations at Milford, 10 miles to the south, are reversed. The surface waters of Milford and of Beaver Bottoms probably do not differ greatly in salinity, but the artesian waters of the latter place are so strongly saline that the surface waters seem good by comparison. The field assays of water from James Forgie's dug well, 18 feet deep, and artesian well, 215 feet deep, are shown in Table 3 (p. 36).

A laboratory analysis of water from J. C. White's artesian well, 185 feet deep, located in Beaver Bottoms about 2 miles east of James Forgie's well, is given in Table 9 (p. 50).

## RAILROAD WELLS OUTSIDE OF BEAVER VALLEY.

No great thickness of the Lake Bonneville beds is exposed at the surface in the Escalante Desert, and the character of the sediments is best shown by well records. There are few carefully kept records available within the limits of the area described in this paper, and for this reason it is thought advisable to include some obtained from places outside of Beaver County, but within the limits of the Escalante Desert, and therefore having a direct bearing on the discussion of underground waters in Beaver Valley. Several wells have been bored for the San Pedro, Los Angeles and Salt Lake Railroad in the Escalante Desert between Beryl and Lynn, the locations of which are shown in fig. 1 (p. 7). J. A. Shanahan, one of the officials of the railroad, has very kindly furnished the following information for use in this report.

*Beryl.*—The railroad has a 13-inch bored well at Beryl, 208 feet deep. Water was encountered at depths of 23, 180, and 203 feet and rises within 19 feet of the surface. During a pumping test of twenty-four hours the well is said to have yielded 183 gallons of water per minute.

*Record of the San Pedro, Los Angeles and Salt Lake Railroad well at Beryl.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 8 | 8 |
| Clay and gravel | 8 | 16 |
| Gravel (water-bearing) | 7 | 23 |
| Gravel and clay | 15 | 38 |
| Clay | 80 | 118 |
| Clay and gravel | 57 | 175 |
| Gravel (water-bearing) | 5 | 180 |
| Clay | 20 | 200 |
| Sand (water-bearing) | 3 | 203 |
| Clay | 5 | 208 |

*Lund.*—The well at Lund, completed in 1903, is 585 feet deep. Flowing water was encountered at five horizons, as shown by the following log. The well is cased with 12-inch pipe at the top, but this is reduced below to 10, 8, and finally to 6 inches. The well flows 20 gallons per minute and when pumped yields 100 gallons per minute, with a temporary depression of the water surface of less than 20 feet.

*Record of the San Pedro, Los Angeles and Salt Lake Railroad well at Lund.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Sand | 2 | 2 |
| Clay | 4 | 6 |
| Gravel (small flow) | 6 | 12 |
| Coarse gravel | 4 | 16 |
| Hardpan and clay | 49 | 65 |
| Quicksand | 4 | 69 |
| Blue clay | 80 | 149 |
| Sand | 4 | 153 |
| Red clay | 12 | 165 |
| Blue clay | 159 | 324 |
| Red rock | 6 | 330 |
| Blue clay | 70 | 400 |
| Quicksand | 20 | 420 |
| Green shale rock | 10 | 430 |
| Clay and sand | 10 | 440 |
| Sand (small flow) | 3 | 443 |
| Blue clay | 11 | 454 |
| Clay and sand | 8 | 462 |
| Sand (large flow) | 13 | 475 |
| Clay | 3 | 478 |
| Sand | 6 | 484 |
| Red clay | 2 | 486 |
| Very fine sand | 8 | 494 |
| Red clay | 10 | 504 |
| Dark clay | 4 | 508 |
| Blue clay | 14 | 522 |
| Very fine sand | 3 | 525 |
| Blue clay | 2 | 527 |
| Fine sand (small flow) | 3 | 530 |
| Brown clay | 19 | 549 |
| Sand | 1 | 550 |
| Brown clay | 23 | 573 |
| Coarse sand | 10 | 583 |
| Coarse gravel (large flow) | 2 | 585 |
| Blue clay | | |

*Thermo.*—The well at Thermo, completed in 1905, is 401 feet deep and encountered water at several horizons. It is cased with 12-inch pipe to a depth of 337 feet. During a pumping test the well supplied 100 gallons of water per minute, with a temporary lowering of the water surface of less than 16 feet.

*Record of the San Pedro, Los Angeles and Salt Lake Railroad well at Thermo.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 5 | 5 |
| Fine gravel | 5 | 10 |
| Red sand | 3 | 13 |
| White clay | 25 | 38 |
| Fine gravel (water-bearing) | 3 | 41 |
| White clay | 54 | 95 |
| Red clay | 45 | 140 |
| Quicksand | 27 | 167 |
| Red clay | 13 | 180 |
| Sand and clay | 25 | 205 |
| Blue clay | 20 | 225 |
| Sand | 10 | 235 |
| Clay | 9 | 244 |
| Clay and gravel | 31 | 275 |
| Clay and sand | 41 | 316 |
| Clay and gravel | 12 | 328 |
| Sand | 13 | 341 |
| Clay and gravel (water-bearing) | 60 | 401 |

*Neels.*—The well at Neels, completed in 1906, is 1,998 feet deep. Water was encountered at several horizons, as indicated in the following log, but nowhere under pressure enough to force it to the surface. All of the water is said to have been hot, and steam escaped freely from the well during the process of boring. The water at every horizon was found to be of poor quality, although a large quantity was obtained, 260 to 300 gallons per minute being pumped during a test lasting continuously for twenty-four days. This test was made with the hope that continuous pumping would clear the well and improve the quality of the water, but no improvement was shown. An attempt was then made to sink the well deeper into the granite, but the rock was found to be fractured and the crevices deflected the drill laterally and otherwise proved so bothersome that the well was abandoned.

A slight amount of oil was found at several horizons in this well, and gas under great pressure was encountered at a depth of 1,802 feet.

*Record of the San Pedro, Los Angeles and Salt Lake Railroad Well at Neels.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Surface soil | 4 | 4 |
| Sedimentary (alkali) | 5 | 9 |
| Fire clay | 40 | 49 |
| Water-bearing quicksand | 9 | 58 |
| Shale and soapstone | 21 | 79 |
| Rock (sedimentary) | 6 | 85 |
| Water-bearing quicksand | 3 | 88 |
| Soapstone | 11 | 99 |
| Soapstone with fossil bowlders | 39 | 138 |
| Water-bearing quicksand | 4 | 142 |
| Fire clay | 12 | 154 |
| Blue waxy clay | 34 | 188 |
| Gray shale and clay mixed | 7 | 195 |
| Gray waxy clay | 36 | 231 |
| Lava rock | 12 | 243 |
| Blue waxy clay | 12 | 255 |
| Sedimentary sandstone | 6 | 261 |
| Blue waxy clay | 25 | 286 |
| Water-bearing quicksand | 6 | 292 |
| Blue waxy clay | 28 | 320 |
| Water-bearing quicksand | 7 | 327 |
| Sedimentary sandstone | 10 | 337 |
| Yellow clay | 16 | 353 |
| Water-bearing quicksand | 5 | 358 |
| Yellow clay | 27 | 385 |
| Blue waxy clay | 110 | 495 |
| Yellow clay | 15 | 510 |
| Sedimentary sandstone | 24 | 534 |
| Blue waxy clay | 17 | 551 |
| Soapstone | 50 | 601 |
| Blue waxy clay | 11 | 612 |
| Silt | 8 | 620 |
| Water-bearing quicksand | 3 | 623 |
| Yellow clay | 53 | 676 |
| Sedimentary sandstone | 12 | 688 |
| Yellow clay | 34 | 722 |
| Blue waxy clay | 117 | 839 |
| Yellow clay | 9 | 848 |
| Blue waxy clay | 210 | 1,058 |
| Blue shale (sand mixed) | 18 | 1,076 |
| Blue waxy clay | 13 | 1,089 |
| Blue shale | 45 | 1,134 |
| Blue shale (sand mixed); yielded hot water | 71 | 1,205 |
| Red shale | 12 | 1,217 |
| Blue shale | 70 | 1,287 |
| Red shale | 24 | 1,311 |
| Blue shale | 28 | 1,339 |
| Red "keel" stone | 6 | 1,345 |
| Water, sand, gravel, and bowlders | 70 | 1,415 |
| Sedimentary sandstone, brown | 35 | 1,450 |
| Red sandstone | 95 | 1,545 |
| Red shale, burned | 35 | 1,580 |
| Trap rock, dark brown | 36 | 1,616 |
| Red shale, burned | 56 | 1,672 |
| Lava rock with calcite crystals | 14 | 1,686 |
| Red sandstone | 68 | 1,754 |
| Red clay, sticky | 48 | 1,802 |
| Volcanic deposit, ash, and bowlders; gas under pressure sufficient to raise 6,200 pounds of tools 400 feet | 105 | 1,907 |
| Bowlders, cemented | 6 | 1,913 |
| Cavity | 9 | 1,922 |
| Bowlders | 22 | 1,944 |
| Cavity | 6 | 1,950 |
| Granite with crevices and gas | 48 | 1,998 |

*Oasis.*—The well at Oasis, completed in 1905, is 656 feet deep and is cased with 12-inch pipe to a depth of 73 feet, below which 10-inch casing extends to the bottom of the well. Water under pressure sufficient to cause it to flow at the surface was encountered at ten different horizons, and there seems to be an unusual quantity of water present. During a pumping test the well supplied 200 gallons per minute, with a temporary depression of the water surface of only

3 feet. At no horizon, however, was the water found to be suitable for boiler purposes. A drinking water of good quality, prized for its mineral qualities, occurs at a depth of 350 feet, and the casing was shot off, so that the present flow of 30 gallons per minute comes entirely from this depth. The drinking water used on the dining cars and in the offices of the railroad is supplied by this well.

*Record of the San Pedro, Los Angeles and Salt Lake Railroad well at Oasis.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 8 | 8 |
| Sand | 3 | 11 |
| Blue clay | 49 | 50 |
| Sand | 10 | 60 |
| Lime and shells | 20 | 80 |
| Quicksand | 45 | 125 |
| Blue clay | 40 | 165 |
| Sand | 5 | 170 |
| Blue clay | 20 | 190 |
| Red clay | 45 | 335 |
| Sand | 15 | 350 |
| Blue clay | 20 | 370 |
| Red clay | 25 | 395 |
| Sand | 13 | 408 |
| Sandstone | 4 | 412 |
| Blue clay | 68 | 480 |
| Sand | 11 | 491 |
| Red clay | 9 | 500 |
| Blue clay | 27 | 527 |
| Quicksand | 3 | 530 |
| Clay and sand | 29 | 559 |
| Black sand | 3 | 562 |
| Clay and gravel | 13 | 575 |
| Clay | 23 | 598 |
| Cemented gravel | 12 | 610 |
| Soft sandstone | 7 | 617 |
| Clay | 6 | 623 |
| Rock | 2 | 625 |
| Clay | 15 | 640 |
| White clay | 16 | 656 |

*Lynn.*—The well at Lynn, completed in 1905, is 235 feet deep and is cased with 12-inch pipe to a depth of 225 feet. The water does not flow at the surface, but has been pumped at the rate of 90 gallons per minute.

*Record of the San Pedro, Los Angeles and Salt Lake Railroad well at Lynn.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Clay | 8 | 8 |
| Gravel | 10 | 18 |
| Sand | 12 | 30 |
| Sand and gravel | 10 | 40 |
| Sand | 20 | 60 |
| Blue clay | 95 | 155 |
| Blue sandy clay, water bearing | 60 | 215 |
| Sand | 10 | 225 |
| Coarse gravel, water bearing | 10 | 235 |

## STATISTICS OF DEEP WELLS.

The following table comprises such information in regard to the deep wells of Beaver Valley as can be conveniently presented in this form:

TABLE 3.—*Statistics of deep wells in Beaver Valley.*

[Chemical determinations in parts per million. Wells marked with asterisk not on Pl. I.]

| No. on Pl. I. | District and owner. | Location. | Character of well. | Depth. | Depth to water horizons. | Flow per minute. | Temperature. | Iron (Fe). | Total alkalinity as $CaCO_3$. | Alkaline carbonate. | Sulphate radicle ($SO_4$). | Total hardness ($CaCO_3$). | Chlorine (Cl). | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BEAVER DISTRICT. | | | *Feet.* | *Feet.* | *Gals.* | ° *F.* | | | | | | | |
| 1 | Barton, J. H. | Beaver | Nonflowing | 66 | 29<br>45 | ..... | 52 | 0 | 243 | 0 | <35 | ..... | 60 | |
| 2 | Beaver cemetery | do | do | 180 | 170 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | |
| 3 | Hurst, Wm. | do | do | ..... | ..... | ..... | ..... | 1 | 255 | 0 | <35 | ..... | 28 | |
| 4 | McGregor, D. A. | do | do | 60 | ..... | ..... | 55 | 0 | 142 | 0 | Tr. | ..... | 120 | |
| 5 | Murdock | do | ..... | 40 | ..... | ..... | ..... | 0 | 203 | 0 | Tr. | ..... | 58 | Low in February, high in July; variation, 24 feet. |
| 6 | Mumford, George | Sec. 28, T. 29 S., R. 7 W | Nonflowing | 200 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | Well not in use. |
| 7 | Nower, J. A. | do | do | 213 | ..... | ..... | 54 | ..... | ..... | ..... | ..... | ..... | ..... | |
| 8 | Shepherd, Warren | Sec. 20, T. 29 S., R. 7 W | do | 300 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | |
| *9 | Tolton, J. F. | Beaver | do | 62 | 45<br>61 | ..... | 51 | 0 | 203 | 0 | 0 | ..... | 60 | |
| | GREENVILLE DISTRICT. | | | | | | | | | | | | | |
| 10 | Barton, S. R. | Sec. 36, T. 29 S., R. 8 W | Flowing | 314 | 200<br>314 | 7 | 74 | 0 | 142 | 0 | Tr. | 56 | 20 | Low in February, high in July. |
| 11 | Blackner, O. | Sec. 35, T. 29 S., R. 8 W | do | 23 | ..... | ..... | ..... | 0 | 364 | 0 | <35 | ..... | 30 | |
| 12 | Edwards, Wm. | Sec. 34, T. 29 S., R. 8 W | Nonflowing | 95 | 36<br>44<br>95 | ..... | ..... | Tr. | 446 | 0 | <35 | ..... | 106 | |
| 13 | Farnsworth, G. T. | Sec. 35, T. 29 S., R. 8 W | do | 35 | 5 | ..... | ..... | 0 | 405 | 0 | <35 | ..... | 81 | Low in February, high in June. |
| 14 | Greenville school | Greenville | Flowing | 244 | 180<br>244 | 11 | 68 | 0 | 242 | 0 | Tr. | 90 | 10 | |
| 15 | Murdock, J. M. | Sec. 24, T. 29 S., R. 8 W | do | 163 | ..... | 15 | 55 | 0 | 132 | 0 | Tr. | 75 | 15 | |
| | ADAMSVILLE DISTRICT. | | | | | | | | | | | | | |
| 16 | Griffiths, J. M. | Sec. 30, T. 29 S., R. 8 W | Flowing | 100 | ..... | 3 | 52 | 0 | 162 | 0 | <35 | 65 | 50 | |
| 17 | do | Sec. 19, T. 29 S., R. 8 W | do | 30 | ..... | 4 | 51 | Tr. | 240 | 0 | <35 | ..... | 60 | |
| *18 | do | Sec. 30, T. 29 S., R. 8 W | Nonflowing | 475 | 8<br>37<br>100 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | |

TABLE 3.—*Statistics of deep wells in Beaver Valley*—Continued.

| No. on Pl. I. | District and owner. | Location. | Character of well. | Depth. | Depth to water horizons. | Flow per minute. | Temperature. | Iron (Fe). | Total alkalinity as $CaCO_3$. | Alkaline carbonate. | Sulphate radicle ($SO_4$). | Total hardness ($CaCO_3$). | Chlorine (Cl). | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ADAMSVILLE DISTRICT—Con. | | | *Feet.* | *Feet.* | *Gals.* | ° *F.* | | | | | | | |
| 19 | Grimshaw, F. T | Sec. 30, T. 29 S., R. 8 W | Flowing | | | | | | | | | | | |
| *20 | Gunn, Fred T | Sec. 30, T. 29 S., R. 8 W | do | | | 60 | | | | | | | | |
| 21 | Johnson, Sam'l | Sec. 30, T. 29 S., R. 8 W | Nonflowing | 32 | 14<br>32 | | | 1 | 364 | 0 | <35 | 194 | 80 | |
| 22 | Joseph, J. H | Sec. 30, T. 29 S., R. 8 W | do | 50 | | | 55 | | | | | | | |
| 23 | Parkinson, E | Sec. 28, T. 29 S., R. 8 W | do | 385 | | | 53 | | | | | | | |
| | MINERSVILLE DISTRICT. | | | | | | | | | | | | | |
| 24 | Baker, H. F | Minersville | Nonflowing | | | | 56 | 0 | 324 | 0 | 113 | | 101 | |
| 25 | Baker, Henry | Sec. 16, T. 30 S., R. 10 W | do | 210 | 180 | | | | | | | | | |
| 26 | Baker & Walker | Sec. 8, T. 30 S., R. 10 W | do | 223 | 185 | | | | | | | | | |
| *27 | Dotson, R. W | Sec. —, T. 30 S., R. 10 W | do | 53 | | | | 1 | 447 | 0 | 168 | 230 | 131 | |
| *28 | do | Minersville | do | | | | | Tr. | 360 | 0 | 35 | 272 | 80 | |
| 29 | Goodson, E. J | Sec. 7, T. 30 S., R. 10 W | do | 124 | 93 | | | | | | | | | |
| *30 | Hollingshead, S. B | Minersville | do | 100 | | | | Tr. | 223 | 0 | 328 | 550 | 808 | |
| *31 | Kelsey, W. M | do | do | 56 | 25<br>36<br>58 | | 56 | 12 | 295 | 0 | 191 | | 446 | |
| *32 | Marshall, Geo | do | do | 38 | | | 55 | 0 | 358 | 0 | 222 | 689 | 242 | |
| *33 | Murdock, L. E | do | do | 42 | | | | 0 | 324 | Tr. | <35 | | 40 | |
| *34 | Van Patten, F. A | do | do | 125 | 95 | | 56 | 0 | 326 | 0 | 56 | | 95 | |
| 35 | Walker, H. A | Sec 15, T. 30 S., R. 10 W | do | 180 | 180 | | 55 | 0 | 370 | 0 | 71 | | 161 | |
| | MILFORD DISTRICT. | | | | | | | | | | | | | |
| 36 | Forgie, John | Milford | Flowing | 336 | 150<br>315 | 25 | 65 | 0 | 140 | Tr. | 0 | | 13 | Flow ceases when railroad well 200 yards away is pumped. |
| 37 | do | Sec. 18, T. 28 S., R. 10 W | do | 357 | | 25 | 78 | 0 | 141 | 0 | Tr. | | 14 | |
| 38 | do | Sec. 8, T. 28 S., R. 10 W | do | 381 | 345 | 13 | 65 | | | | | | | |
| 39 | Forgie, James | Sec. 7, T. 26 S., R. 10 W | do | 215 | | | | 4 | 466 | 0 | 36 | | 1,752 | |
| *40 | do | Sec. 7, T. 26 S., R. 10 W | Dug | 18 | | | | 0 | 648 | 283 | 0 | | 662 | |
| *41 | Grace Bros | Milford | Nonflowing | 48 | | | 60 | 0 | 162 | 0 | 35 | 216 | 148 | |
| 42 | Harrington, Mrs | do | do | 55 | 43 | | | | | | | | | |
| 43 | Holderman & Sons | Sec. 18, T. 28 S., R. 10 W | Flowing | 420 | | | | | | | | | | |
| *44–45 | Lewis, A. B | Milford | do | 750 | 300<br>750 | 37<br>2 | 80<br>80 | 0<br>0 | 145<br>283 | 0<br>0 | 0<br>0 | | 17<br>35 | Sulphur water from bottom. |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *46 | McCauley, J. D | do | Flowing | 280 | | 7 | 68 | | | | | | | Flow has decreased from 17 gallons per minute. |
| *47 | McKean, P. B | do | Nonflowing | 60 | | | 59 | Tr. | 152 | 0 | 38 | | 181 | |
| *48 | Milford town | do | Flowing | 425 | | 30 | 72 | 0 | 162 | 0 | Tr. | 69 | 13 | 117 gallons per minute pumped. |
| *49 | Milford school | do | Dug | 35 | | | | | | | | | | |
| *50 | Milwaukee Leasing Company | T. 28 S., R. 11 W | Nonflowing | 90 | 45 | | | | | | | | | Supplies a 20-stamp mill. |
| *51 | Mowre, A. W | Milford | do | 45 | | | | 0 | 162 | 0 | 41 | | 424 | |
| 52 | Murdock, J. M | Sec. 18, T. 26 S., R. 10 W | Flowing | 180 | | | | 0 | 263 | 0 | 0 | | 836 | |
| 53 | Ryan ranch | Sec. 5, T. 26 S., R. 10 W | do | 860 | | | | | | | | | | Not used. |
| 54 | San Pedro, Los Angeles and Salt Lake R. R.[a] | Milford | do | 310 | 170, 310 | 30 | 71 | 0 | 160 | 0 | Tr. | 49 | 12 | 270 gallons per minute pumped. |
| *55 | do | do | do | 400 | | 18 | | 0 | 142 | 0 | Tr. | | 15 | |
| *56 | do | Beryl | Nonflowing | 208 | | | | | | | | | | 183 gallons per minute pumped. |
| *57 | do | Lund | Flowing | 585 | | 20 | | | | | | | | 100 gallons per minute pumped. |
| 58 | do | Thermo | Nonflowing | 401 | | | | | | | | | | Do. |
| *59 | do | Neels | do | 1998 | | | | | | | | | | 300 gallons per minute pumped. |
| *60 | do | Oasis | Flowing | 656 | | 30 | | | | | | | | 200 gallons per minute pumped. |
| *61 | do | Lynn | Nonflowing | 235 | | | | | | | | | | 90 gallons per minute pumped. |
| 62 | Tanner, E | Sec. 5, T. 28 S., R. 10 W | Flowing | 286 | | 8 | 71 | 0 | 101 | 0 | <35 | | 38 | |
| *63 | do | Sec. 5, T. 28 S., R. 10 W | do | 370 | | 8 | 67 | | | | | | | |
| 64 | Whitaker, Arthur | Sec. 32, T. 27 S., R. 10 W | do | 403 | | 18 | | | | | | | | Many water-bearing strata. |
| *65 | Winberg, A. W | Milford | do | 326 | 260, 285, 310, 326 | 9 | 68 | 0 | 130 | Tr. | <35 | | 24 | Pressure 7 pounds per square inch. |
| 66 | White, J. C | Sec. 17, T. 26 S., R. 10 W | do | 185 | | | | 0 | 666 | 383 | 0 | | 1787 | |

a For exact analyses of water from railroad wells see Table 10 (p. 51).

## SHALLOW WELLS.

*Tabulated data.*—There is little to be said of individual shallow wells and the available information is probably best presented in tabular form. For convenience of reference these wells are arranged like the deep wells, by districts, and in order to avoid duplication the chemical analyses described on page 46 are included in the table.

TABLE 4.—*Statistics of shallow wells in Beaver Valley.*

[Chemical determinations in parts per million.]

| District and owner. | Location. | Depth. | Fluctuation of water surface. | Iron (Fe). | Total alkalinity at $CaCO_3$. | Alkaline carbonates. | Sulphate radicle ($SO_4$). | Chlorine (Cl.). | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| BEAVER DISTRICT. | | *Feet.* | *Feet.* | | | | | | |
| Ash, Joseph | Beaver | 24 | 16 | 0 | 223 | 0 | Tr. | 35 | Low in February, high in July. |
| Atkins, Alice | do | | | 0 | 281 | 0 | <35 | 70 | |
| Baldwin, M. D | do | | | 0 | 255 | 0 | 0 | 24 | |
| Barrachouch, J | do | | | 2 | 253 | 0 | <35 | 50 | |
| Bastian, L. H | Sec. 21, T. 28 S., R. 7 W | 29 | 14 | 0 | 142 | 0 | <35 | 19 | Low in February, high in June. |
| Boyter, A | Beaver | 52 | 44 | | | | | | Low in February, high in July. |
| Do | Sec. 9, T. 29 S., R. 7 W | 8 | 7 | | | | | | Do. |
| Burt, William | Beaver | | | 0 | 264 | 0 | 0 | 28 | |
| Briggs, John | Sec. 2, T. 29 S., R. 7 W | 50 | | | | | | | Water only during irrigation. |
| Day, Joseph | Sec. 35, T. 28 S., R. 7 W | 14 | 10 | Tr. | 122 | 0 | <35 | 15 | Low in February, high in July. |
| Dean, Jeddy | Beaver | 22 | 19 | 0 | 223 | 0 | 0 | 20 | Do. |
| Farnsworth, R | Sec. 21, T. 28 S., R. 7 W | 23 | | Tr. | 157 | 0 | <35 | 186 | Do. |
| Farnsworth, L. E | Do | 35 | 18 | | | | | | Do. |
| Farnsworth, W. H | Beaver | | | Tr. | 233 | 0 | <35 | 198 | |
| Gale, O. W | Sec. 3, T. 29 S., R. 7 W | 30 | 22 | | | | | | Do. |
| Gale, M. H | Sec. 4, T. 29 S., R. 7 W | 42 | 15 | 0 | 207 | 0 | <35 | 30 | Do. |
| Geordy, David | Beaver | 37 | 29 | | | | | | Do. |
| Grimshaw, D | Do | 33 | 30 | 0 | 273 | 0 | Tr. | 43 | Do. |
| Goodwin, I. S | Do | | | 0 | 233 | 0 | Tr. | 51 | |
| Hanson, W. L | Sec. 28, T. 29 S., R. 7 W | 10 | 6 | 0 | 202 | 0 | 0 | 10 | Do. |
| Harris, H | Beaver | | | Tr. | 182 | 0 | <35 | 80 | |
| Harris, L. H | Do | | | Tr. | 252 | 0 | Tr. | 28 | |
| Harris, Lydia | Do | | | 0 | 283 | 0 | Tr. | 60 | |
| Huntington, Mrs. E | Do | | | 0 | 195 | 0 | Tr. | 53 | |
| Hodges, C. H | Sec. 3 T. 29 S., R. 7 W | 30 | 13 | | | | | | Do. |
| Howd, S. F | do | | | 3 | 253 | 0 | Tr. | 47 | |
| Jackson, Jos | do | | | 0 | 298 | 0 | <35 | 141 | |
| Jones, J. F | Beaver | 24 | 20 | 0 | 273 | 0 | <35 | 80 | Sample taken Aug. 24, 1906. Low in February, high in July. |
| Do | do | | | 0 | 243 | | <35 | 65 | Sample taken Aug. 2, 1906. |
| Lawrence, A. L | do | | | Tr. | 250 | 0 | <35 | 70 | |
| Manhardt, W. M | Sec. 31, T. 28 S., R. 6 W | 20 | 15 | 0 | 152 | 0 | <35 | 24 | Low in February, high in July. |
| Mansfield, E. M | do | 47 | 31 | 0 | 223 | 0 | Tr. | 25 | |
| Morgan, Edward | do | | | 0 | 234 | 0 | Tr. | 33 | |
| Muir John J | do | | | 0 | 245 | 0 | <35 | 63 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Mumford, Geo | Sec. 28, T. 29 S., R. 7 W | 40 | 10 | | | | | | Low in February, high in July; water brackish. |
| Neilson, N. B | Beaver | | 42 | 0 | 253 | 0 | 0 | 49 | Low in February, high in July. |
| Okenden, C | do | | | 0 | 241 | 0 | <35 | 303 | |
| Owens, G. E | Sec. 22, T. 29 S., R. 7 W | 17 | 12 | 0 | 253 | 0 | 0 | 35 | Do. |
| Paice, Geo | Beaver | 33 | 29 | | | | | | Do. |
| Rees, Watkin | do | 25 | 22 | 0 | 243 | 0 | <35 | 46 | Do. |
| Robinson, Eliza | do | | | 2 | 223 | 0 | Tr. | 40 | |
| Smith, Seth W | do | | | 0 | 243 | 0 | 0 | 65 | |
| Stony, F. J | do | | | 0 | 304 | 0 | Tr. | 18 | |
| Swindelhurst, E. B | do | | | 0 | 242 | 0 | Tr. | 35 | |
| Thompson, Wm | do | 46 | 38 | | | | | | Low in January, high in July. |
| Twitchell, W. A | Sec. 31, T. 29 S., R. 6 W | 20 | 15 | | | | | | Variation caused wholly by irrigation. |
| Twitchell, D. F | Sec. 21, T. 28 S., R. 7 W | 15 | 4 | | | | | | Low in February, high in July; water brackish. |
| Valentine, Jos | Sec. 35, T. 28 S., R. 7 W | 12 | 4 | | | | | | |
| Wolfenden, C | Beaver | | | 0 | 235 | 0 | Tr. | 30 | |
| Whitaker, O. A | do | 44 | 3 | | | | | | Low in February, high in July. |
| Wilden, E | do | 13 | 8 | 0 | 121 | 0 | 0 | 25 | Do. |
| Woodbury, Chas | Sec. 10, T. 29 S., R. 7 W | 101 | | | | | | | Water only during irrigation season. |
| Wolfenden & Murdock | Beaver | 60 | 40 | 0 | 344 | 0 | <35 | 70 | |
| Woolsey, D. M | Sec. 35, T. 28 S., R. 7 W | 85 | | | | | | | No water. |
| GREENVILLE DISTRICT. | | | | | | | | | |
| Edwards, William | Sec. 25, T. 29 S., R. 8 W | 5 | 1 | 0 | 308 | 0 | <35 | 63 | Low in September, high in July; hardness 263. |
| Farnsworth, G. T | Sec. 35, T. 29 S., R. 8 W | 35 | 0 | 0 | 405 | 0 | <35 | 81 | |
| Murdock, John M | Sec. 24, T. 29 S., R. 8 W | 20 | 0 | | | | | | Water brackish. |
| ADAMSVILLE DISTRICT. | | | | | | | | | |
| Johnson, C | Sec. ?, T. 29 S., R. 8 W | 7 | 7 | Tr. | 496 | 0 | <35 | 141 | Low in September, high in June. |
| Jones, Cutler & Fennemore | Sec. 32, T. 29 S., R. 8 W | 49 | 20 | Tr. | 284 | 0 | Tr. | 121 | Water brackish; improves during irrigation. |
| Stewart, Lewis | Sec. 29, T. 29 S., R. 8 W | 23 | | 0 | 567 | 0 | 43 | 132 | Low in February, high in July. |
| MINERSVILLE DISTRICT. | | | | | | | | | |
| Banks, J. R | Minersville | 28 | 16 | 0 | 324 | 0 | <35 | 41 | |
| Banks, W. H | do | 21 | | 0 | 370 | 0 | 265 | 232 | Total hardness 438. |
| Burke, Lydia | do | 13 | 7 | 0 | 370 | 0 | 168 | 125 | Low in September, high in June. |
| Dotson, R. W | do | 23 | 7 | Tr. | 360 | Tr. | <35 | 80 | |
| Minersville town well | T. 30 S., R. 11 W | 80 | | 2 | 125 | 0 | 0 | 50 | |
| Walker, H. A | Minersville | 23 | 5 | 0 | 370 | 0 | 85 | 161 | |

*Water-bearing material.*—The material near the surface of the Beaver Lake beds consists mainly of coarse sand and gravel and is but slightly consolidated. Some of it is made up of sand and rounded pebbles, presumably lake sediments, deposited before Beaver basin was drained by the down cutting of the river in the canyon at Minersville, and some of it is coarse and subangular, deposited by the streams. In some places the gravels are exposed at the surface over considerable areas and in others they are covered with a thin veneer of soil. In no place observed had soil or silt accumulated to any great depth. The wells are nearly all in gravel, as illustrated in Mr. Boyter's well, a record of which is given below:

*Record of A. Boyter's well, Beaver.*

| | Thickness. | Depth. |
|---|---|---|
| | *Feet.* | *Feet.* |
| Soil | 1 | 1 |
| Gravel | 24 | 25 |
| Clay | 2 | 27 |
| Gravel | 24 | 51 |
| Sand | 1 | 52 |

The abundance of unconsolidated gravel near the surface and the scarcity of surface soil are due, in part at least, to the steep grade of the streams, causing current velocities that preclude the possiblity of deposition of the finer materials. The gravels exposed at the surface allow the rain water, the stream water, and the irrigation water to sink readily into the ground and the absence of fine material from the gravel beds makes it possible for water to move rapidly through them.

Where the Beaver Lake beds are exposed to view through any considerable thickness, as in the bench south of Beaver and in similar exposures to the east and north, they are found to contain a much greater proportion of fine material than is encountered in digging wells in the center of the valley. This is probably due to the varying conditions under which the material was accumulated. The older parts of the Beaver Lake beds were laid down in Beaver Lake, and coarse and fine materials were deposited together. When the lake ceased to exist because of the filling with sediment on the one hand and the down cutting of the outlet between Adamsville and Minersville on the other, the river deposited only the coarser material within Beaver Basin, carrying the finer material through the outlet to form part of the Lake Bonneville beds of the Escalante Desert. There is furthermore ample evidence in Beaver basin, as in other places throughout the semiarid region of western America, that varied conditions of erosion and deposition have prevailed during recent geologic time. The streams were sometimes depositing sand and gravel and building up the floors of the valleys and at other times eroding away the material previously laid down. Both operations have had a tendency to cause coarse material to accumulate in the center of the valley. While the river was building up its valley, the finer sediments were carried through to Escalante Bay and the coarser material was dropped within the basin. On the other hand, while the river was eroding, it worked over the sediments previousy deposited in Beaver Basin, bearing away such material as it was able to carry and leaving the heavier rock fragments. In this way the coarser material accumulated in the center of the valley both by direct deposition and by surface concentration of the gravels.

West of Minersville, however, a different set of conditions prevailed. The water-bearing materials there are the lake sediments of the Lake Bonneville beds. The river has deposited comparatively little sediment and there has been practically no erosion since the beds were formed. The sediments in the midst of the desert, extending from the surface to some unknown depth, consist of clay, sand, and fine gravel, as shown by the well records previously given; along the margins they consist of coarser material derived from the neighboring hills. Since the Lake Bonneville beds are lake deposits, the various layers are presumably persistent over considerable areas. For these reasons the waters are mainly artesian and the surface waters of comparatively little importance, as stated in the description of the deep wells of the Milford district.

*Changes in water level.*—On account of the coarseness and unconsolidated condition of the gravels in Beaver Basin, the water moves readily through them and great changes of level are caused at different times of the year. During the winter much of the precipitation is retained in the mountains in the form of snow and little water is spread over the land for irrigation. There is, therefore, in this season a minimum contribution to the underground supply and a general low-water condition prevails in the shallow wells, the lowest stage being reached in February. In the spring, however, the melting snow supplies large volumes of water to the streams, and this in turn is not only spread over the land for irrigation purposes, but great quantities find their way into the gravels, raising the level of the underground water, which reaches its highest stage in July. The extreme difference in level is variously reported, as shown under "Remarks" in Table 4 (pp. 38–39), the greatest variation of water level being 42 feet.

This rise of the underground water causes serious damage in the lowlands, especially during seasons of more than ordinary rainfall, such as the summer of 1906. During the writer's investigations in Beaver Valley from July to September of that year the lowlands of the valley were in a boggy condition approaching that of a swamp.

Fields were observed with crops that could not be harvested because of the swampy condition. Roads were rendered impassable and animals were mired on land which had formerly been dry. In the town of Beaver many of the dooryards were swampy and water filled the cellars and flowed freely from the dug wells, which during the winter have water only at depths of 25 or 30 feet. Many of the streets were impassable, and a general unhealthful condition prevailed throughout the town. The area within the town that was made more or less swampy by the return waters during July, 1906, is shown in fig. 3 (p. 48). The long arm shown on this map extending northward to the Beaver cemetery is due to the irrigation of the gravel bench east of the town, the return waters issuing at the foot of the bench.

## CHEMICAL CHARACTER OF WATERS.

### METHODS OF DETERMINATION.

A chemical outfit for determination of some of the principal elements contained in ordinary waters was taken to Beaver Valley, and a large number of the waters were tested. These field assays, though much less accurate than those made in the laboratory, give a fairly adequate conception of the chemical character of the waters. Although they are not sufficiently exact to be relied on for the minor differences in character, the major differences are plainly brought out, as will be observed by an inspection of the various tables that follow.

In addition to the field assays, laboratory analyses were obtained from three sources: (1) samples of water were sent to the laboratory of the United States Geological Survey and analyzed by W. M. Barr, of the water resources branch; (2) sanitary analyses of four samples of water were made by Herman Harms, of Salt Lake City, State chemist of Utah; and (3) the analyses of water used by the San Pedro, Los Angeles and Salt Lake Railroad have been kindly furnished for this report by E. G. Tilton, chief engineer of the road.

### STREAMS.

The waters of the streams at their points of issuance from the hills are very pure. Farther down the valley they become more highly charged with saline matter, as shown by the assays in Table 5. The chlorine of Beaver River, for example, increases from 9 to 53 parts in a million parts of water between the mouth of the canyon and Minersville, a distance of only 17 miles. There is also a marked change toward alkalinity, the carbonates increasing from 71 to 225 parts in the same distance. It is furthermore to be noted that the alkaline carbonates (sodium carbonate and potassium carbonate), which are not contained in the waters as they issue from the hills, are present farther downstream. This is probably caused by the entrance of seepage or return waters that are more highly charged with salts than the streams. The spring waters of the valley are also more saline than the streams and contribute in some measure to the increasing salinity toward the lower parts of the valley.

TABLE 5.—*Field assays of stream waters.*

[Parts per million.]

| Source. | Location. | Iron (Fe) | Total alkalinity as $CaCO_3$. | Alkaline carbonates. | Sulphate radicle. ($SO_4$) | Total hardness as $CaCO_3$. | Chlorine (Cl). |
|---|---|---|---|---|---|---|---|
| Beaver River | 4 miles east of Beaver | 0 | 71 | 0 | <35 | 42 | 9 |
| Do | Greenville | 0 | 203 | 21 | <35 | 160 | 30 |
| Do | Minersville | 0 | 182 | 43 | <35 | ...... | 53 |
| Canal | Beaver | 0 | 71 | 0 | <35 | ...... | 15 |
| North Creek | North of Beaver | 0 | 61 | 0 | <35 | ...... | 3 |
| North Creek Canal | .....do | 0 | 71 | 0 | <35 | ...... | 10 |
| North Creek | Greenville | Tr. | 203 | 0 | <35 | ...... | 39 |
| South Creek | South of Beaver | 0 | 71 | 0 | <35 | 45 | 4 |
| Seepage | Beaver | 0 | 253 | 0 | <35 | ...... | 55 |
| Do | Sec. 21, T. 29 S., R. 7 W | 0 | 263 | 0 | 68 | ...... | 247 |
| Do | .....do | 0 | 122 | 0 | <35 | ...... | 25 |
| Seepage (Sly, T. J.) | Sec. 29, T. 28 S., R. 6 W | 0 | 240 | 0 | <35 | ...... | 95 |
| Seepage (Griffiths, T. M.) | Sec. 30, T. 29 S., R. 8 W | Tr. | 410 | 0 | <35 | ...... | 43 |
| Do | Sec. 20, T. 29 S., R. 7 W | Tr. | 240 | 0 | <35 | ...... | 91 |
| Do | Sec. 19, T. 29 S. R. 7 W | 0 | 232 | 0 | 0 | ...... | .19 |

## SPRINGS.

Laboratory analyses were made of the waters of three springs, as previously described (pp. 20, 21), and field assays were made of 15, as shown in Table 6. The same change in character found in the stream waters is seen also in the springs, the waters being purer in the upper parts of the valley than farther down. The average chlorine in the spring waters in the Beaver district is 19 parts per million, in the Greenville district 39, and in the two springs examined near Minersville a still greater amount. The alkalinity increases from 159 parts per million near Beaver to 191 near Greenville and much greater amounts at Minersville. This increase in salinity is evidently caused by the passage of the water through the sands and gravels of the Beaver Lake beds and by the leaching of the land through irrigation.

TABLE 6.—*Statistics of springs in Beaver Valley.*

[Chemical determinations in parts per million.]

| District and owner | Location. | Flow per minute. | Temperature. | Iron (Fe). | Total alkalinity as $CaCO_3$. | Alkaline carbonates. | Sulphate radicle ($SO_4$). | Total hardness as $CaCO_3$. | Chlorine (Cl). | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| BEAVER DISTRICT. | | *Gals.* | °*F* | | | | | | | |
| Baker, ——— | Bakers Canyon | | 56 | 0 | 141 | 0 | 0 | 63 | 20 | |
| Beaver Land and Livestock Co. | Sec. 9, T. 27 S., R. 8 W | 7 | 48 | | | | | | | |
| Do | Sec. 10, T. 27 S., R. 8 W | 6 | 62 | | | | | | | |
| Do | Sec. 4, T. 27 S., R. 8 W | 6 | | | | | | | | |
| Boyter, A | Sec. 9, T. 29 S., R. 7 W | 50 | | 0 | 121 | 0 | Tr. | | 5 | |
| Cartwright, J. H | Sec. 21, T. 29 S., R. 7 W | 22 | 52 | 0 | 162 | 0 | Tr. | | 45 | |
| Farnsworth & Bastian Bros. | Sec. 28, T. 28 S., R. 7 W | 50 | 52 | | | | | | | |
| Gale, O. W | Sec. 4, T. 29 S., R. 7 W | 305 | | 0 | 203 | 0 | <35 | | 15 | Decreases three-fourths in winter. |
| Gale, Hannah | do | 606 | | | | | | | | Decreases one-half by August 1. |
| Gillies, Geo. B | do | 35 | 52 | | | | | | | Maximum flow in June. |
| Gillies, D. M | do | 332 | | 0 | 172 | 0 | <35 | | 49 | Minimum flow in August, one-third of maximum flow. |
| Greene, Henry | Sec. 36, T. 28 S., R. 7 W | 112 | | | | | | | | Minimum flow in February, maximum in July. |
| Jackson, Jos | Sec. 28, T. 29 S., R. 7 W | 164 | 54 | 0 | 182 | 0 | 0 | | 15 | Minimum flow one-fourth of maximum. |
| Mumford, Geo | do | 180 | | | | | | | | |
| Owens, G. E | Sec. 27, T. 29 S., R. 7 W | 270 | | 0 | 253 | 0 | 0 | | 34 | Variation in volume one-third. |
| Parkinson, G. A | Sec. 22, T. 29 S., R. 7 W | 250 | | | | | | | | |
| Patterson, Ed | Sec. 32, T. 29 S., R. 7 W | 1 | | 0 | 143 | 0 | 0 | | 10 | |
| Sly, T. J | Sec. 29, T. 28 S., R. 6 W | 90 | | 0 | 61 | 0 | <35 | 63 | 5 | |
| Warby, Isaac | Sec. 35, T. 28 S., R. 7 W | 256 | | | | | | | | Minimum flow in February, maximum in July. |
| White, C. D | Sec. 33, T. 28 S., R. 6 W | 27 | 62 | | | | | | | |
| Yardley, W. E | Sec. 21, T. 29 S., R. 7 W | 103 | | | | | | | | Decreases one-third in winter. |
| GEEENVILLE DISTRICT. | | | | | | | | | | |
| Ashworth, H. H | Sec. 31, T. 29 S., R. 7 W | 16 | | 0 | 132 | 0 | Tr. | | 20 | |
| Farnsworth, P. T | do | | | 0 | 134 | 0 | Tr. | | 45 | |
| Do | do | | | 0 | 162 | 0 | 0 | | 30 | |
| Gillies & Bro | Sec. 11, T. 27 S., R. 8 W | 7 | 52 | | | | | | | |
| Green, Henry | Sec. 36, T. 28 S., R. 7 W | 112 | | | | | | | | |
| Murdock, Chas. and J. M | Sec. 11, T. 27 S., R. 8 W | 7 | | 0 | 244 | 0 | Tr. | | 45 | |
| White, C. D | Sec. 31, T. 29 S., R. 7 W | 12 | | | | | | | | Water brackish. |

TABLE 6.—*Statistics of springs in Beaver Valley*—Continued.

[Chemical determinations in parts per million.]

| District and owner. | Location. | Flow per minute. | Temperature. | Iron (Fe). | Total alkalinity as $CaCO_3$. | Alkaline carbonates. | Sulphate radicle ($SO_4$) | Total hardness as $CaCO_3$. | Chlorine (Cl). | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| MINERSVILLE DISTRICT. | | *Gals.* | °*F* | | | | | | | |
| Dotson, R. W. | Sec. 7, T. 30 S., R. 9 W | 57 | 97 | 0 | 205 | 0 | 87 | 300 | 70 | |
| Four miles north of Minersville. | | 50 | | 0 | 243 | 0 | <35 | 236 | 40 | |
| Warm springs | Thermo | | 140 | 0 | 304 | 0 | 124 | | 299 | For exact analysis see Table 9 (p. 50). |
| McKean, P. B. | T. 27 S., R. 9 W | 10 | 210 | | | | | | | Roosevelt Hot Spring. For exact analysis see Table 9 (p. 50). |
| Sulphur beds | Cove Creek | | | | | | | | | See description on p. 19. |

### DEEP WELLS.

Field assays were made of the waters of 36 deep wells. In general these show greater quantities of dissolved solids than the springs and shallow wells. The average chlorine in the deep wells near Beaver is 51 parts in a million parts of water, and the average alkalinity 251. For the Greenville region the average chlorine is 44 and the alkalinity 288, for the Adamsville region the average chlorine is 63 and the average alkalinity 255, for the Minersville region the average chlorine is 266 and the average alkalinity 328. A statement of averages in the Milford region would be misleading. The waters are very pure at Milford and very saline in Beaver Bottoms, where the chlorine content reaches a maximum of 1,787 parts per million. The chlorine occurs in these waters in the form of common salt (NaCl) and gives them a strong brackish taste. Exact analyses were made of the waters from two of the wells in the Milford district—the Milford town well and J. C. White's well at Beaver Bottoms. (See Table 9, p. 50).

### SHALLOW WELLS.

Field assays of waters from the shallow wells are given in Table 4 (pp. 38–39). From this table it appears that the waters are variable in character and, like those of the streams, springs, and deep wells, increase in salinity toward the west, or away from the source of supply.

It is noteworthy in this connection that the samples were taken during a time when the water was high, in many places overflowing the wells. The salt content is therefore much less than it would have been at a time of low water. This is shown by the several assays made of water from J. F. Jones's well, in Beaver, given below. The water was flowing from the top of the well August 2, when the first sample was taken. August 24 it had fallen about 1 foot and no longer flowed from the well. September 11 the water surface was 6 feet below the top of the well. The figures here given are perhaps sufficient to show that during the lowest stage the water of some of the wells might be very unhealthful.

*Field assays of water from J. F. Jones's well, Jones Hotel, Beaver.*

[Parts per million. Analyst, Herman Harms.]

| | Aug. 2. | Aug. 24. | Sept. 11. |
|---|---|---|---|
| Iron (Fe) | 0 | 0 | 0.2 |
| Total alkalinity as $CaCO_3$ | 243 | 273 | |
| Alkaline carbonates | 0 | 0 | |
| Sulphate radicle ($SO_4$) | >35 | >35 | 66 |
| Chlorine (Cl) | 65 | 80 | 99 |

### BEAVER WELLS.

The variability in character of water in shallow wells is best illustrated by the wells of the town of Beaver, where samples were taken at no great distance apart and on the same day. Although a town of considerable size, Beaver has no water system and no sewers. The people depend for drinking water almost entirely on wells, most of them shallow and open. The town is the center of an agricultural district and according to the general custom in that part of the country, the ranchmen live in the town, driving their herds into the town at night and out of it to pasture in the morning.

Beaver is located in the center of the valley, where the land consists mainly of beds of unconsolidated gravel covered with scanty soil. There is little to prevent surface contamination from entering directly into the wells, and apparently the only reason for the water being in any measure fit for domestic use is that the open condition of the gravels allows the underflow to pass rapidly through them, thus keeping them in some degree cleansed and free from impurities which might otherwise produce serious consequences.

The contamination is strikingly shown by the assays given in Table 7. Several factors should be carefully considered in interpreting this table. The water samples were taken during the highest stage of the underground waters, a time when they contain the least quantity of saline matter. During the lower stages some of these same waters are reported unfit for use. The river water, which is the principal source of the underflow at Beaver, is very pure, as shown by the assay of water taken 4 miles upstream. This assay is placed at the head of Table 7 for comparison. The high chlorine content shown by most of the assays can not be ascribed to residual salt ($NaCl$) in the sediments of the Beaver Lake beds, in the case of the shallow wells, for the obvious reason that the river and irrigation waters flowing through them are less saline than that of the wells and tend continually to freshen the underground waters.

The only adequate explanation of the large quantities of the various salts in the well waters is that they are due to surface contamination. This explanation is confirmed by the variable amounts of chlorine shown by the assays. The chlorine is probably present in the form of common salt ($NaCl$) and is the element that shows surface contamination most clearly. The table is arranged to correspond with the map of Beaver (fig. 3), and the numbers in the first column correspond with the location numbers on the map. From an inspection of the table and map it appears that wells only a few rods apart vary greatly in the quantity of chlorine, the minimum amount being 18 and the maximum 303 parts in a million parts of water.

TABLE 7.—*Field assays of well waters in Beaver.*

[Parts per million.]

| No. on fig. 3. | Owner. | Iron (Fe). | Total alkalinity as $CaCO_3$. | Alkaline carbonates. | Sulphate radicle ($SO_4$). | Chlorine (Cl). |
|---|---|---|---|---|---|---|
| | Beaver River, 4 miles east of Beaver | 0 | 71 | 0 | <35 | 9 |
| 1 | Stony, F. J. | 0 | 304 | 0 | Tr. | 18 |
| 2 | Wolfenden, C. | 0 | 344 | 0 | <35 | 70 |
| 3 | Smith, Seth W. | 0 | 243 | 0 | 0 | 65 |
| 4 | Okenden, C. | 0 | 241 | 0 | <35 | 308 |
| 5 | Burt, Wm. | 0 | 264 | 0 | 0 | 28 |
| 6 | Muir, Jno. J. | 0 | 245 | 0 | <35 | 63 |
| 7 | Farnsworth, W. H. | Tr. | 233 | 0 | <35 | 198 |
| 8 | Owens, G. E. | 0 | 253 | 0 | 0 | 35 |
| 9 | Barrachouch, J. | 2 | 253 | 0 | <35 | 50 |
| 10 | Harris, L. H. | Tr. | 252 | 0 | Tr. | 28 |
| 11 | Harris, Lydia | 0 | 283 | 0 | Tr. | 60 |
| 12 | Harris, H. | Tr. | 182 | 0 | <35 | 80 |
| 13 | Brooks, John | 0 | 263 | 0 | <35 | 91 |
| 14 | Atkins, Alice | 0 | 281 | 0 | <35 | 70 |
| 15 | Morgan, Ed. | 0 | 234 | 0 | Tr. | 33 |
| 16 | Lawrence, A. L. | Tr. | 250 | 0 | <35 | 70 |
| 17 | Swindelhurst, E. H. | 0 | 242 | 0 | Tr. | 35 |
| 18 | Wilden, E. | 0 | 121 | 0 | 0 | 25 |
| 19 | Robinson, Eliza | 2 | 223 | 0 | Tr. | 40 |
| 20 | Goodwin, I. S. | 0 | 233 | 0 | Tr. | 51 |
| 21 | Houd, S. F. | 3 | 253 | 0 | Tr. | 47 |
| 22 | Manhardt, W. M. | 0 | 152 | 0 | <35 | 24 |
| 23 | Jones, J. F. | 0 | 273 | 0 | <35 | 80 |

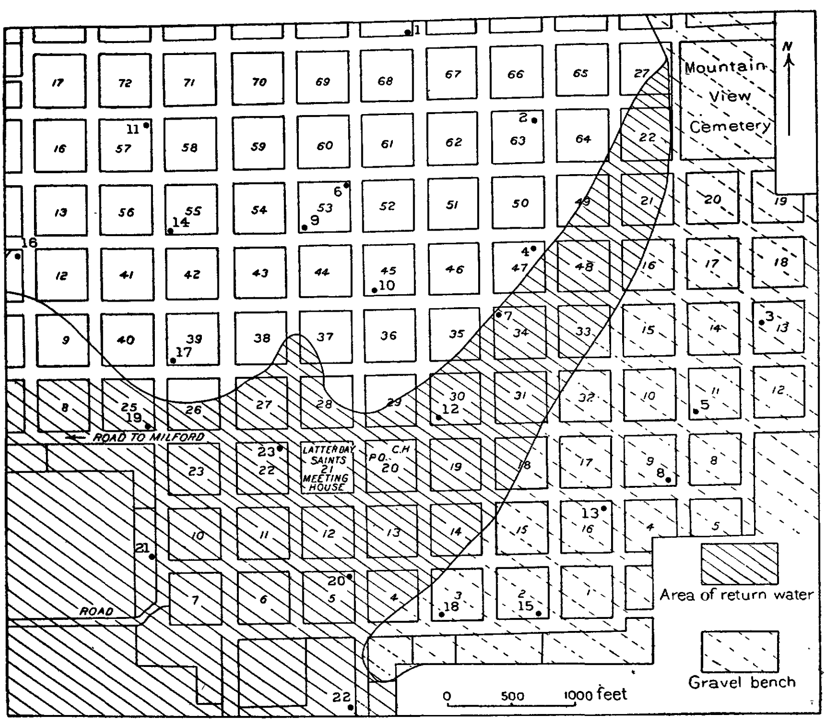



FIG. 3.—Map of Beaver, showing seepage area and location of wells included in Table 7.

## SANITARY ANALYSES.

On account of the obviously unhealthful conditions affecting the waters of Beaver, four samples, taken September 1, 1906, were sent to Herman Harms, of Salt Lake City, State chemist of Utah, for sanitary analysis. The samples represent the principal sources of the water used for domestic purposes in Beaver. The results of Mr. Harms's analyses are given in Table 8. In commenting on them he unqualifiedly condemns the waters as unsuitable for domestic purposes.

TABLE 8.—*Sanitary analyses of Beaver waters.*

[Parts per million. Analyst, Herman Harms.]

| | Canal at Stake Academy building. | Open well (Wm. Thomas, jr.). | Drilled well (J. F. Tolton). | Dug well (J. F. Jones, hotel). |
|---|---|---|---|---|
| Depth ... feet | Stream. | 46 | 62 | 24 |
| Odor | Faint. | Slight. | Faint. | Marked. |
| Odor on heating | Pronounced. | Pronounced. | Pronounced. | Decided. |
| Nitrates (diphenylamine reaction) | Trace. | Abundant traces. | Trace. | Abundant traces. |
| Nitrites (Greiss-Islosvay reaction): | | | | |
| Cold | Faint. | Abundant. | Trace. | Abundant. |
| Heated to 175° F. | Trace. | Abundant. | Decided traces. | Abundant. |
| Hydrogen sulphide ($H_2S$) | 0 | 0 | 0 | 0 |
| Alkaline sulphides | 0 | 0 | 0 | 0 |
| Metallic impurities | 0 | 0 | 0 | 0 |
| Total dissolved solids at 212° F. | 409 | 420 | 380 | 633 |
| Calcium chloride ($CaCl_2$) | 0 | 0 | 0 | 0 |
| Magnesium chloride ($MgCl_2$) | 0 | 0 | 0 | 0 |
| Volatile matter | 75 | 80 | 63 | 173 |
| Mineral matter | 354 | 339 | 317 | 459 |
| Chlorine (Cl) | 8 | 33 | 53 | 70 |
| Common salt (NaCl) | 13 | 55 | 87 | 115 |
| Free ammonia | .03 | .14 | .05 | .16 |
| Albuminoid ammonia | .22 | .19 | .12 | .35 |
| Oxygen consumed | 7.12 | 3.00 | 1.66 | 5.38 |

## OTHER EXACT ANALYSES.

Six samples of water were sent to W. M. Barr, of the United States Geological Survey, for laboratory analysis. Three of these were from springs and three from wells. Of the springs one is acid water from the Cove Creek sulphur beds; one from Roosevelt Hot Spring, on the western slope of the Mineral Mountains, the waters of which are supposed to have valuable medical properties; and one from the group of warm springs near Thermo. The samples from the wells were selected to represent the shallow wells of the Beavêr region (Jones's well), the artesian wells of the Milford district (Milford town well), and the artesian wells of Beaver Bottoms (J. C. White's well). The analyses are as follows:

TABLE 9.—*Laboratory analyses of water from Beaver Valley, Utah.*

[Parts per million. Analyst, W. M. Barr.]

| Name. | Location. | Source. | Suspended matter. | Total dissolved solids at 180° C. | Silica ($SiO_2$). | Iron (Fe). | Calcium (Ca). | Magnesium (Mg). | Sodium and potassium (Na, K). | Carbonate radicle ($CO_3$). | Bicarbonate radicle ($HCO_3$). | Sulphate radicle ($SO_4$). | Chlorine (Cl). | Nitric radicle ($NO_3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| McKean, P. B. | Sec. 7 (?), T. 27 S., R. 9 W. | Roosevelt Hot Spring | 1,238 | 645 | 101 | 5 | 31 | 9.7 | 102 | 0 | 30 | 90 | 87 | 1.83 |
| Milford | City | Flowing well | [a] 540 | 248 | 35 | .1 | 11.2 | 6.6 | 66 | 0 | 190 | 53 | 13 | .5 |
| Jones, J. F. | Hotel | Surface well | 0 | 520 | 40 | .2 | 106 | 29 | 43 | 0 | 276 | 66 | 99 | 1.7 |
| Utah Sulphur Co. | Sulphurdale | Sulphur mine | 52 | 10,810 | 124 | 1,362 | 158 | 232 | 144 | 0 | 0 | 7,602 | 79 | 1.7 |
| (?) | Thermo | Warm springs | 0 | 1,620 | 55 | 1.4 | 86 | 11 | 432 | 0 | 414 | 522 | 238 | .0 |
| White, J. C. | Beaver Bottoms | Flowing well | 0 | 2,937 | 24 | 0 | 133 | 127 | 727 | 0 | 495 | 35 | 1,570 | .0 |

[a] The suspended matter is largely if not wholly due to the presence of fine sand drawn from the well by the pump. The well has recently been completed and the water-bearing beds had not been entirely cleared of loose sand when the sample was taken.

Several analyses of water used by the San Pedro, Los Angeles and Salt Lake Railroad have been made by Herman Harms, State chemist of Utah. The analyses were made with reference to the use of the waters for boiler purposes. The results are given by Mr. Harms, in grams per United States gallon, in the form of combined salts, but are here reduced to parts per million and to the ionic form in accordance with present usage of the United States Geological Survey.

TABLE 10.—*Analyses of waters from deep wells of San Pedro, Los Angeles and Salt Lake Railroad.*

[Chemical determinations in parts per million. Analyst, Herman Harms.]

| Location. | Depth at which sample was taken. | Total dissolved solids. | Siliceous matter. | Undetermined and loss. | Ferric oxide ($Fe_2O_3$) and aluminum oxide ($Al_2O_3$). | Calcium (Ca). | Magnesium (Mg). | Sodium (Na). | Carbonate radicle ($CO_3$). | Sulphate radicle ($SO_4$). | Chlorine (Cl). |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | | | | | | | | | | |
| Beryl | 207 | 344 | 61 | 49 | 2 | 44 | 12 | 27 | 72 | 29 | 43 |
| Lund (No. 1) | (?) | 485 | 64 | 159 | 4 | 29 | 18 | 46 | 73 | 23 | 70 |
| Lund (No. 2) | 585 | 517 | 68 | 140 | 4 | 45 | 16 | 52 | 93 | 2 | 80 |
| Thermo | 401 | 689 | 161 | 244 | 10 | 32 | 15 | 57 | 84 | 4 | 87 |
| Milford | 305 | 330 | 90 | 137 | 3 | 47 | 10 | 8 | 51 | 0 | 12 |
| Neels (No. 1) | 1,382 | 3,336 | 48 | 544 | 14 | 284 | 3 | 293 | 20 | 658 | [a] 1,065 |
| Neels (No. 2) | 1,398 | 3,345 | 370 | 488 | 13 | 197 | 15 | 691 | 36 | 472 | 1,063 |
| Neels (No. 3) | 1,974 | 2,888 | 39 | 586 | 10 | 239 | 6 | 552 | 25 | 458 | [b] 863 |

[a] Samples taken after pumping 190 hours at 75 gallons per minute.
[b] Samples taken after pumping 38 hours.

## POSSIBILITIES OF DEVELOPMENT.

### SURFACE WATERS.

The surface waters used at the present time for irrigation in Beaver basin might, by proper manipulation, be made to serve a greatly increased acreage with no loss to the land now irrigated, and even, in the case of tracts that are being impaired by the use of too much water, with notable benefit to that land. The distribution of irrigation water at the present time is not under the supervision of any public official, and is wanting in adequate central control of any kind. An effort on the part of the community to bring about the passage and enforcement of some law providing for the equitable distribution of water would undoubtedly result in a great improvement of present conditions.

### UNDERGROUND WATERS.

*Drainage.*—The conditions brought about by the behavior of the underground water in Beaver basin have become serious and are apparently growing worse year after year. According to report, the swampy areas caused by the midsummer rise of the water are increasing in size, and during the summer of 1906 roads and city streets that had never before been affected were rendered impassable, and dwellings that heretofore had been regarded as safe became uninhabitable.

An effort has been made by some of the citizens of Beaver, who realize the serious consequences to health likely to result from these conditions, to secure public action in draining the town or otherwise disposing of the superfluous water, but up to the time of the present writing nothing has been accomplished. The comparatively steep grade of the valley floor renders such drainage possible not only for the towns, but for much of the land which is now useless during the latter part of the summer. It is probable, however, that the water might be controlled more effectively and economically in other ways.

*Pumping plants.*—In many parts of the country where conditions similar to those of Beaver Valley prevail, pumping water for irrigation has proved more satisfactory in many ways than obtaining it by means of seepage ditches, and in view of the favorable conditions in Beaver basin it is probable that the establishment of a large number of pumping plants would not only serve the same purpose as expensive drainage systems in satisfactorily disposing of the overabundant underground water, but would render the water thus obtained more useful, since it could be better controlled and placed where it is most desired for irrigation.

The underground conditions in Beaver basin, so far as they are known, are very favorable for the operation of pumping plants, although no pumping experiments have ever been made there. The gravels are coarse and unconsolidated and the water moves through them with great readiness, as evidenced by the unusual yearly fluctuation of the water level within them. The lift would be small, since the water in summer reaches the surface of the ground over a large area. It is furthermore to be noted in this connection that the underground water reaches its maximum height during the summer—a fact especially favorable to the use of pumps, since the available quantity of water is greatest and the lift least during the time when the water is most needed for irrigation.

It should further be borne in mind that in the spring and early summer, when the maximum amount of water is carried by the streams, the underground water is moderately low. Later in the summer, when the streams are low, the underground waters attain their maximum volume. The increase in volume of the underground waters, although not coincident in time with the increase in volume of the streams, is primarily due to the increase in stream volume and secondarily to the use of the stream waters for irrigation. The lagging in effect is due to the obstruction offered by the sands and gravels to the passage of the water through them. The rain waters, irrigation waters, and stream waters enter the ground wherever it is porous enough to allow them to pass and gradually work their way down the valley, not in definite or well-defined underground channels, as is often believed, but as a general sheet saturating the sands and gravels of the valley filling. The coarser the material the faster will be the movement; hence there may be courses through the valley filling along which the water moves more rapidly than along others, but these can not be considered as underground channels. The water entering the valley filling at the upper end of the valley works its way slowly downward, as a general saturation of the sands and gravels, the maximum volume reaching a given point long after the time of maximum volume of the surface waters. Thus in Beaver basin the surface waters attain their maximum volume during May and June and the underground waters during July and August.

To judge from experience in other places where large quantities of water are pumped for irrigation, wells might be constructed in Beaver basin similar to those extensively used in southern California and in the Salt River Valley of Arizona,[a] with casing perforated from top to bottom, since the gravels are sufficiently coarse to act as strainers, and by means of centrifugal pumps such wells might be made to yield large quantities of water. It is within conservative limits to state that a single, properly constructed 12-inch well, 100 feet or less in depth, would easily yield 1,000 gallons of water per minute, a quantity more than sufficient to irrigate the average-sized ranch in Beaver Valley.

For the economic use of pumps for irrigation a convenient source of power is necessary. This is being provided for Beaver Valley. The Telluride Power Company has undertaken the construction of a large electric plant in Beaver Canyon, known locally as the Puffer Lake site, and the work of construction was begun during the autumn of 1906. The main object of the company is to produce power for use at the mines in the vicinity of Beaver Valley, but one of the transmission lines will pass through Beaver Basin, and power for pumping can probably be furnished at rates much cheaper than it can be produced in any other way.

Since no development of the underground waters of Beaver Basin has been effected, there is no information at hand by which their available quantity can be estimated, but to judge from the quantities pumped in Salt River Valley, Arizona, in southern California, and in other places where the underground conditions are similar to those in Beaver Basin, many hundreds of acres might be irrigated with pumped water in this valley. The writer is of the opinion that with the proper conservation and distribution of the surface waters, as previously suggested, and the development of the underground

[a] Lee, W. T., Underground waters of Salt River valley, Arizona: Waters-Sup. and Irr. Paper No. 136, U. S. Geol. Survey, 1905.

waters, the acreage of cultivated land in Beaver Valley might easily be doubled.

*Artesian conditions.*—Water occurs under sufficient pressure in both the Beaver Lake and the Lake Bonneville beds to produce flowing wells. In the Beaver Lake beds the flow is probably due to the comparatively steep gradient of the surface of the underground water rather than to confinement of the water under impervious layers of rock. The sediments are apparently porous throughout and the underground water tends to return to the surface in the lowest parts of the valley. A well bored in the sediments furnishes an easier way of escape for the waters than the passage through the gravels. The slight pressure of the water in the flowing wells and the fact that only such wells flow as are located in or very close to areas where the underground water reaches the surface indicates the probable absence of any impervious layer that would tend to hold the waters in confinement. In other words, the Beaver Lake beds are not constituted in the manner commonly understood as necessary for the occurrence of artesian wells. The beds may rather be termed subartesian. Furthermore, the area in which flowing water is to be found is very small and nothing more is to be expected of the wells than to furnish a moderate supply of water for domestic purposes.

In the Lake Bonneville beds of the Escalante Desert, however, a different set of conditions prevail. Here the water is much less in volume than in the Beaver Lake beds, but the constitution of the sediments is such that the supply is better conserved. The Lake Bonneville beds are made up of alternating layers of sand, fine gravel, and clay. The sands and gravels are porous, allowing the water to work its way slowly through them, while the clay is impervious, thus retaining the water in confinement within the porous layers.

Much more is to be expected of flowing wells in the Escalante Desert than in Beaver Basin on account of the great volume of the Lake Bonneville beds. Although the small supply of water entering these beds is unfavorable to the occurrence of any great quantity of underground water within them, the great mass of the sediments and the fact that they are now saturated with water assures the permanence of the water supply for a long time to come. In the absence of experiments it is uncertain whether the underground waters could be obtained in sufficient quantity and at a cost sufficiently low to render them useful in irrigation; but it is reasonably certain that enough water for stock-raising purposes could be obtained throughout the Escalante Desert to make useful in this way a large territory that is now practically unproductive.

# INDEX.

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