DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

Bulletin 618

GEOLOGY AND UNDERGROUND WATER

OF

LUNA COUNTY, NEW MEXICO

BY

N. H. DARTON

WASHINGTON
GOVERNMENT PRINTING OFFICE
1916

CONTENTS.

ILLUSTRATIONS.

PREFACE.

By F. L. Ransome.

The study of the geology of Luna County, which includes the area known as the Deming quadrangle, was not deliberately planned but had its inception in a brief visit by Mr. Darton in 1903, when he was in charge of the western section of the division of hydrology of this Survey. His main purpose was to gain only such information on the general geologic structure as would enable him to ascertain whether or not artesian conditions exist in the wide desert plains of the region. During later years he made additional observations with a view to determining how to obtain and utilize for irrigation the water from comparatively shallow depths. Incidentally, he made examinations of the geology of the several isolated buttes and mountain ranges and finally mapped these in detail. The result is the present report and also the Deming folio, now in course of publication. Much attention was given to underground water problems, for there is great demand from settlers for information as to the area in which water is obtainable, the depth to water, and the quantity available. To meet this demand a brief preliminary report on the underground waters was published in 1914.[1]

The work embodied in the present report and in the Deming folio supplements other investigations already completed in New Mexico. The area here described lies about 40 miles west of the El Paso quadrangle and adjoins at its northwest corner the Silver City quadrangle, both of which have been geologically studied.

The belt of mountainous but generally low country, by which the Colorado Plateau province is bordered on its southwest side, not only contains some of the largest copper deposits in Arizona and New Mexico, including the Chino, Clifton-Morenci, Globe-Miami, Ray, and Jerome ore bodies, but is also of much geologic interest, particularly in its stratigraphic and structural problems. Along this belt eight quadrangles, five on the scale of 1:125,000 and three on the scale of 1:62,500, have been geologically surveyed for folio publica-

[1] Darton, N. H., U. S. Geol. Survey Water-Supply Paper 345, pp. 25–40 (Water-Supply Paper 345–C).

tion. These quadrangles, named in order from southeast to northwest, are the Van Horn, Tex. (Folio 194, by G. B. Richardson); El Paso, Tex. (Folio 166, by G. B. Richardson); Deming, N. Mex. (folio by N. H. Darton in preparation); Silver City, N. Mex. (Folio 199, by Sidney Paige); Clifton, Ariz. (Folio 129, by Waldemar Lindgren); Bisbee, Ariz. (Folio 112, by F. L. Ransome); Globe, Ariz. (Folio 111, by F. L. Ransome); and Bradshaw Mountains, Ariz. (Folio 126, by T. A. Jaggar and Charles Palache). As these quadrangles are distributed along a distance of about 500 miles, much work remains to be done before the differences in stratigraphy and structure between the several areas can be fully explained and the significance of these differences in relation to the general geologic history of the region be clearly understood. Outside of its local resources in underground water and some fluorite deposits of considerable productiveness, Luna County is not known to possess great mineral wealth. Consequently the present report and the Deming folio are likely to prove of most value as contributions to accurate knowledge of a region whose broader geologic problems possess exceptional interest.

GEOLOGY AND UNDERGROUND WATERS OF LUNA COUNTY, NEW MEXICO.

By N. H. Darton.

INTRODUCTION.

This report presents the results of an examination of the greater part of Luna County, in southwestern New Mexico (see fig. 1), made in the autumn of 1910 and some supplemental observations in 1911, 1912, and 1913. The purpose of the work was to determine the geologic structure of the region and to procure all data bearing on prospects for obtaining underground water for domestic use and irrigation. During the last few years many settlers have come into the county and taken homesteads in the broad desert valleys, or bolsons, with the expectation of using underground water for irrigation. They have been encouraged by the excellent results obtained by several of the earlier settlers, and many of them have sunk wells and established pumping plants with satisfactory prospects for successful irrigation. The main source of supply is the widespread underflow fed by the scanty rainfall and also by Mimbres River, a mountain stream which normally passes underground near the northwest corner of the county. This water has been accumulating for a long time and now saturates the gravel and sand deposits underlying most parts of the bolsons. Unfortunately the entire area is not underlain by these water-bearing deposits, and in places the water is too deep or too scanty in amount to be utilized. Therefore one of the principal purposes of the investigation was to determine the extent of the area underlain by water-bearing deposits, the depth to these deposits, and the amount of water available.

The mountains rising out of the bolsons of Luna County exhibit a great variety of sedimentary and igneous rocks, in places containing mineral deposits that have been worked to some extent. Except in some notable bonanza "finds," however, these deposits have not proved very profitable.

TOPOGRAPHY.

MOUNTAINS AND RIDGES.

A large part of Luna County consists of a desert plain, or bolson, mostly from 4,000 to 5,000 feet above sea level and having a general

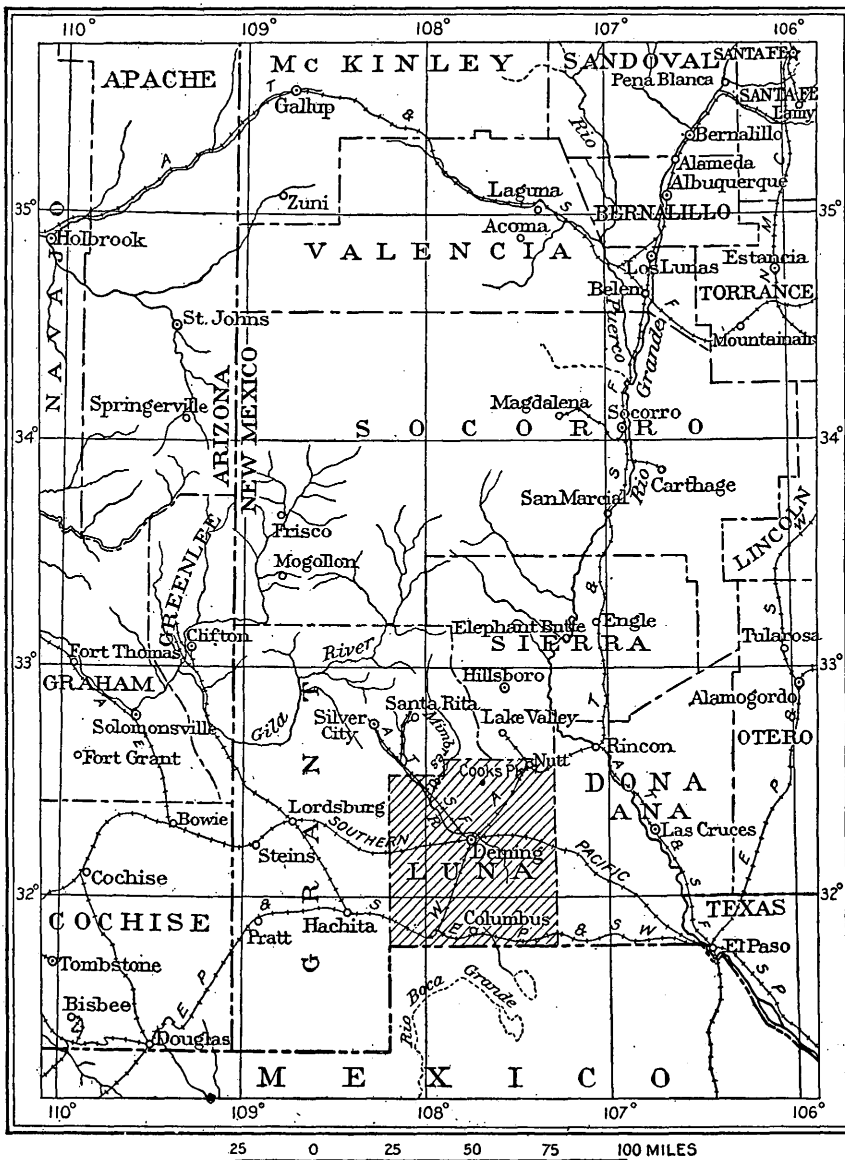
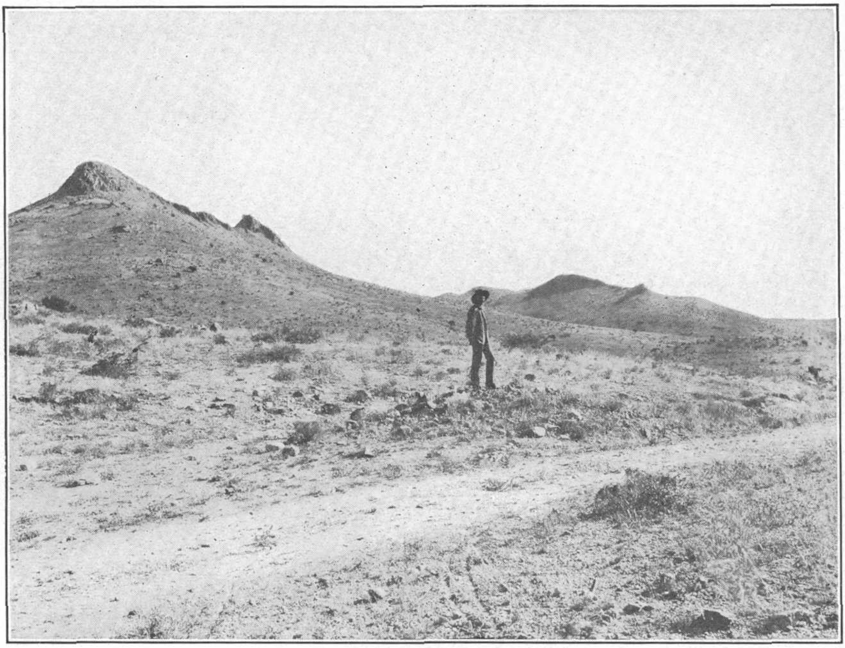


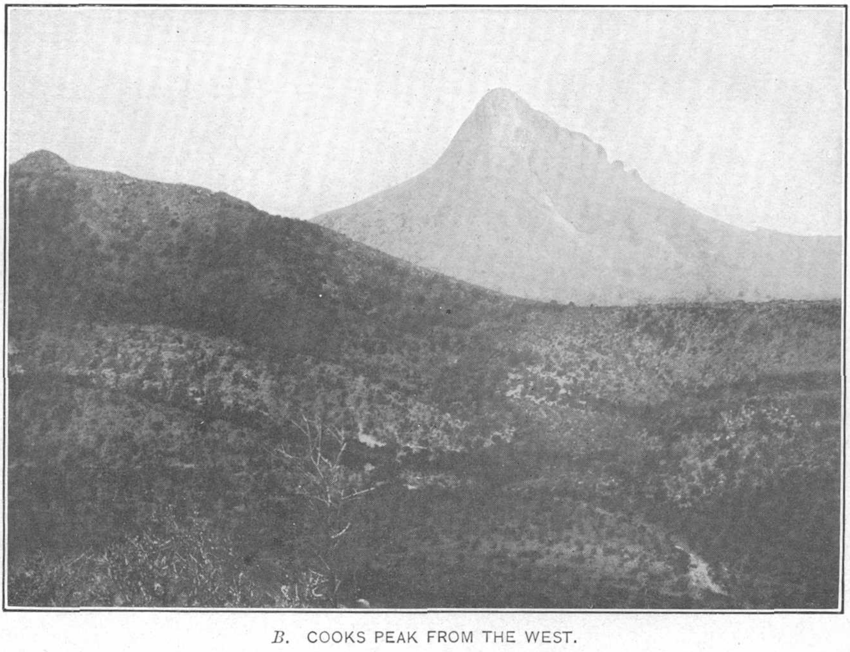
FIGURE 1.—Map of southwestern New Mexico and adjoining region, showing location of Luna County.

up grade to the west. Rising from the bolsons at intervals are narrow rocky ridges ranging in length from 2 to 20 miles and in height



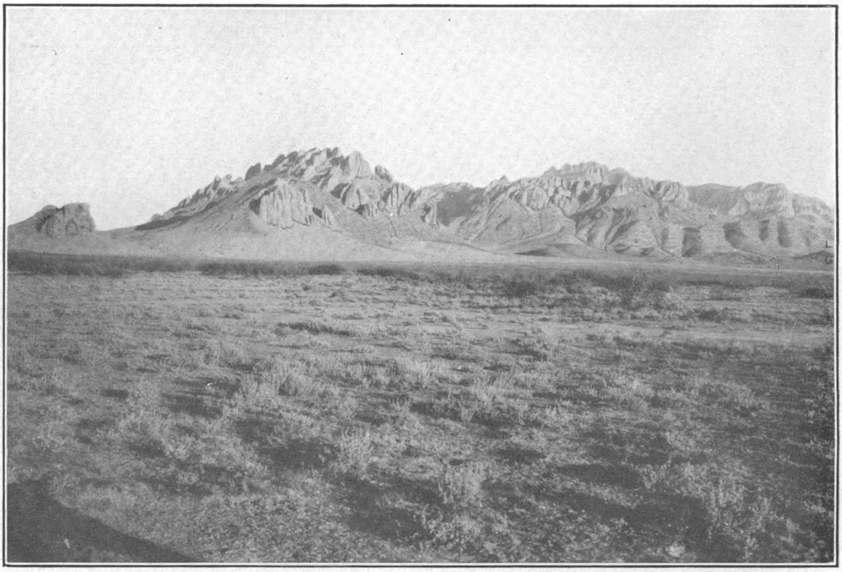
A. VIEW LOOKING SOUTHWEST THROUGH THE PASS ACROSS COOKS RANGE ON OLD BUTTERFIELD ROAD.

The knobs are igneous masses in the agglomerate. The man stands on the grave of party of immigrants massacred by Apaches.



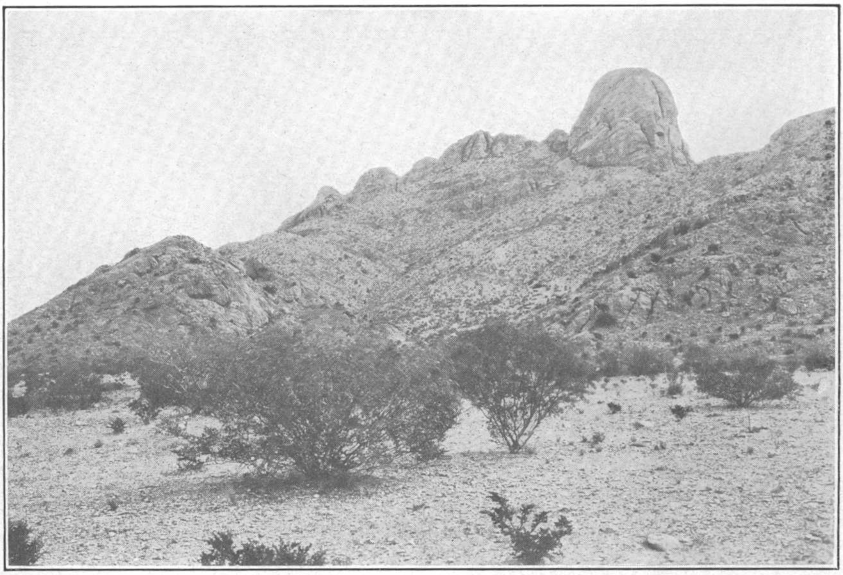
B. COOKS PEAK FROM THE WEST.

Paleozoic limestones in foreground. The peak is porphyry.



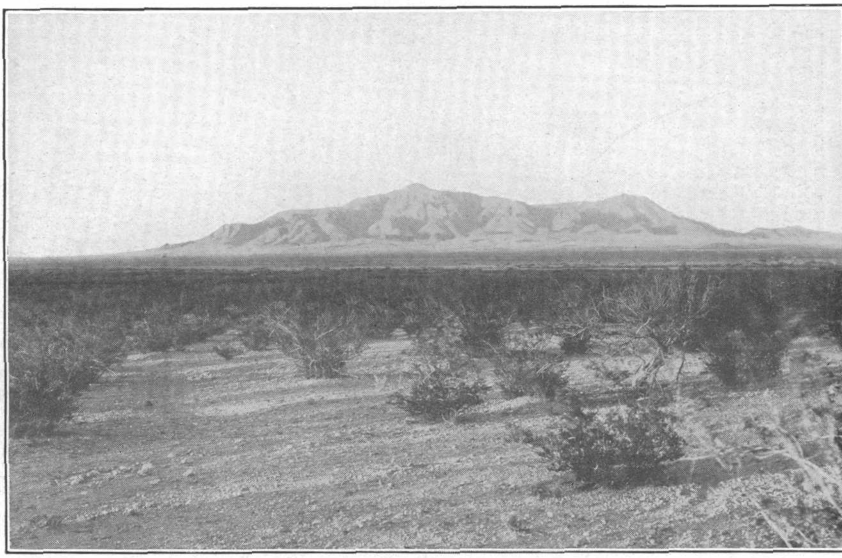
A. NORTH END OF FLORIDA MOUNTAINS, 12 MILES SOUTHEAST OF DEMING, N. MEX.

View looking southeast. Most of the rocks are agglomerates and flows. At extreme right edge Paleozoic limestone (L) rests on granite (G).



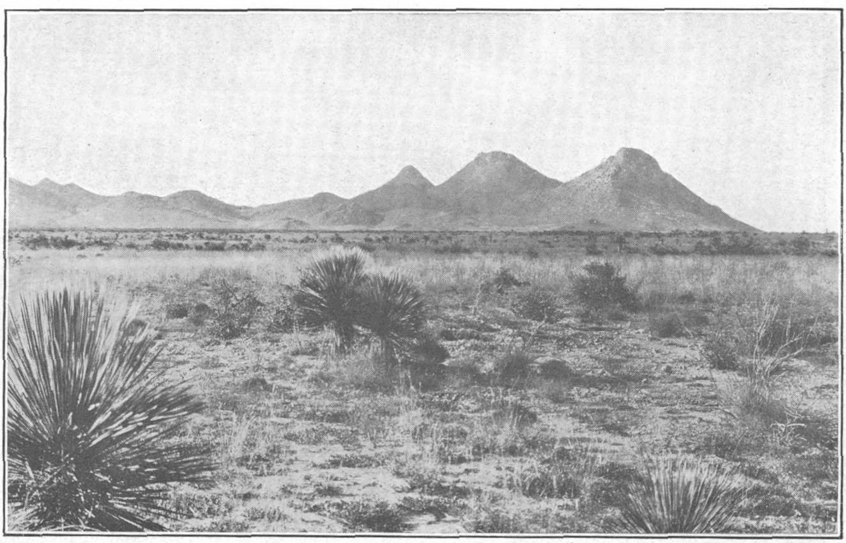
B. CAPITOL DOME NEAR NORTH END OF FLORIDA MOUNTAINS.

View from the west. The dome consists of agglomerate and igneous flows; below Paleozoic limestones and sandstone lie on granite, which rises in knob at left of view.



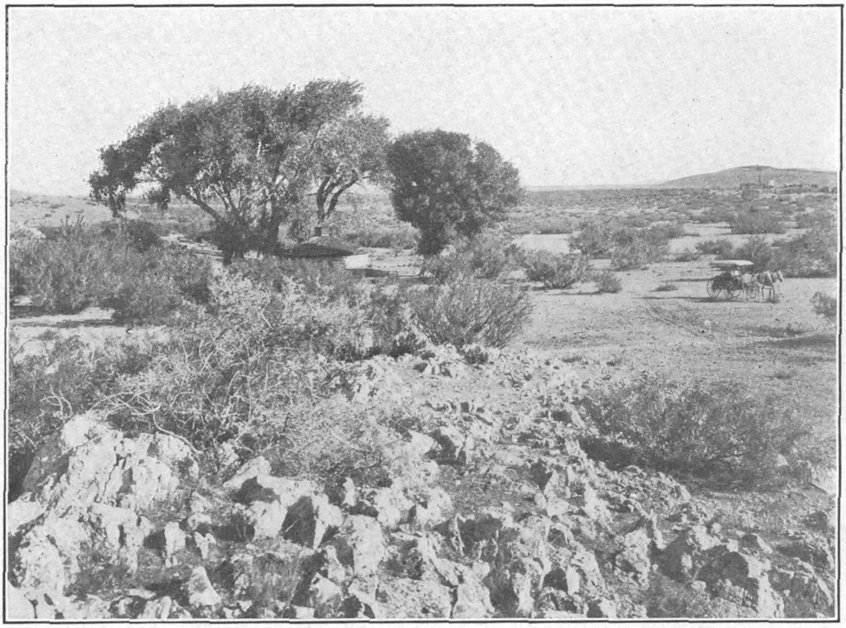
A. SOUTH END OF FLORIDA MOUNTAINS.

Shows the wide bolson out of which the mountains rise. This bolson is underlain by water which in places comes nearly to the surface.



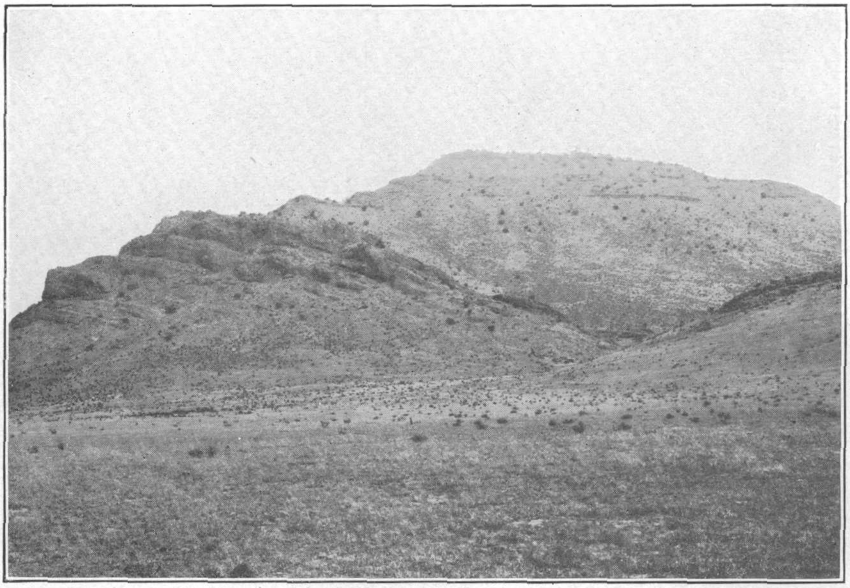
B. TRES HERMANAS MOUNTAINS.

Peaks of porphyry 25 miles south of Deming, N. Mex. View looking northwest.



A. THE GREAT SPRING AT OLD FORT CUMMINGS, NORTH OF DEMING, N. MEX.

A natural rock dam across the valley has formed the spring, which is under building near center of view. Remains of fort in distance at the right.



B. GOODSIGHT PEAK, 8 MILES EAST OF FLORIDA STATION, N. MEX.

View looking northeast. Ridge of massive bedded agglomerate on left, overlying sandstone and tuffs. Three sheets of basalt occur in high ridge in distance.

from a few hundred feet to nearly 2,500 feet. The largest of these is Cooks Range (Pl. II) and its outlying ridges, culminating in the conspicuous high summit known as Cooks Peak, which has an altitude of 8,408½ feet. The Florida Mountains (Pls. III, IV, *A*) form a short but very prominent and rugged range a short distance southeast of Deming, rising to an altitude of 7,400 feet, or 2,500 feet above the bolson. They lie in line with Cooks Range, and not far south, on a continuation of the same line, are the Tres Hermanas Mountains (Pl. IV, *B*), which extend nearly to the international boundary. It is probable that all these ridges are portions of one range and have an underground connection not far below the surface in the gaps which separate them. The Cedar Grove Mountains, a long, narrow ridge of considerable prominence, cross the southwest corner of the county; the Carrizalillo Hills are a southern continuation of them and the Klondike Hills an outlying ridge. The Victorio Mountains rise with considerable prominence 3 miles south of Gage, and the Grandmother Mountains are a group of conical peaks 7 miles north of that place. Still farther north are the scattered rocky buttes of the Cow Spring Hills with the conspicuous Cow Cone at their north end. Red Mountain and Black Mountain (Pl. VII, *B*, p. 15) are two small but high buttes rising on the south and north sides, respectively, of Mimbres River, southwest and northwest of Deming. Taylor Mountain and the Fourmile Hills are low dome-shaped areas of rocky ledges a few miles west of Cooks Range. The Goodsight Mountains form a high ridge extending through the northeast corner of the county and culminating in the well-known landmark Goodsight Peak (Pl. V, *B*). The Sierra Rica extends from Mexico into the extreme southwest corner of the county, where it terminates in a group of high limestone buttes. Among minor hills and ridges rising above the bolsons are the Burdick Hills, west of Iola, the Snake Hills, southwest of Deming, some ridges east and northeast of Arena, and some low buttes of basalt west of Mimbres.

The distribution and configuration of these features are shown on the geologic map (Pl. I, in pocket), and further information regarding elevations along certain level lines is given at the end of this report.

BOLSONS.

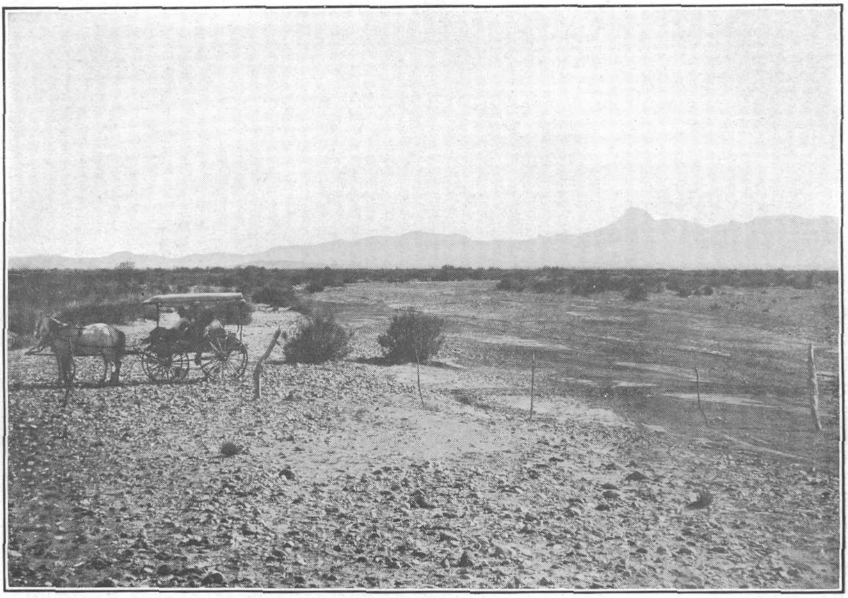
The smooth desert plain that occupies a large part of Luna County is part of a great plain of gravel and sand which extends continuously across southern New Mexico from the Rio Grande to and over the Continental Divide. Where the Rio Grande has excavated a wide valley 300 feet deep the altitude of this plain is about 4,000 feet, but at the Continental Divide south of Silver City its altitude is about 6,000 feet, showing a general up grade of about 20 feet to the mile. In general in Luna County the plain rises regularly from less than 4,000 feet on the southeast to 5,400 feet in the northwest corner, an up grade of about 22 feet to the mile, but the slope is considerably greater from Deming northwestward.

From most points of view the plain appears to be flat (see Pl. IV, *A*) with low mounds of sand or shallow arroyos here and there. In places near Deming the Mimbres has cut a trench 15 to 20 feet deep, and some of the local draws have steep banks. There are three prominent rises in the plain—one constituting a step 200 feet high east of Arena and extending northward across the southeast corner of the county; one at the south end of the Tres Hermanas Mountains just east of Mimbres station, a rise of 333 feet; and the third in the Burdick Hills. Toward the mountains the gentle slope of the bolson plain gives place to a much steeper grade, due to a long alluvial fan, a feature which is especially conspicuous around the Florida Mountains.

DRAINAGE.

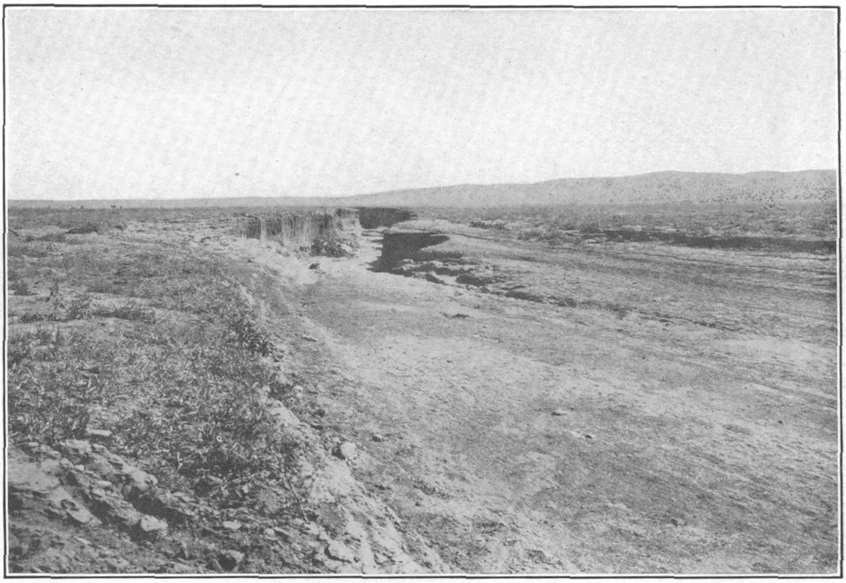
Mimbres River drains all of Luna County except a small district south of the Cedar Grove Mountains which slopes into Mexico. The Mimbres is usually a running stream at the north margin of the county, but farther south it flows over the surface only when flooded by exceptional rainfall. Its extreme freshet flow rarely extends beyond the central part of T. 25 S. east of the Florida Mountains, but nearly every year the water passes Spalding once or twice, and not infrequently it extends to Deming and beyond. Its flood period is very short, however, and for the greater part of the year most of its bed is dry sand. (See Pl. VI, *A*.)

An important affluent is the San Vicente Arroyo (Pl. VI, *B*), which joins the Mimbres a mile south of Spalding and in time of flow brings a large volume of water from the Silver City district. Cow Creek, draining an area of moderate size in the Cow Spring Hills, is a western branch which seldom flows. The drainage of Cooks Range, the Little Florida Mountains, and the east side and north slope of the Florida Mountains belongs to the main Mimbres system, but it is rare that these waters reach the river channel. A line from Red Mountain to the White Hills and the center of the west side of the Florida Mountains defines a watershed, south of which the surface slopes into the valley of Palomas Arroyo. This arroyo heads in the slopes and ridges in the west-central part of Luna County and in Grant County, and flows through the gap at the north end of the Tres Hermanas Mountains, finally emptying into the Palomas Lakes in Mexico. It occupies a southern continuation of the Mimbres Valley, in the southern part of the country. It flows only at times of freshets, and although these are of short duration sometimes the volume of water is considerable.



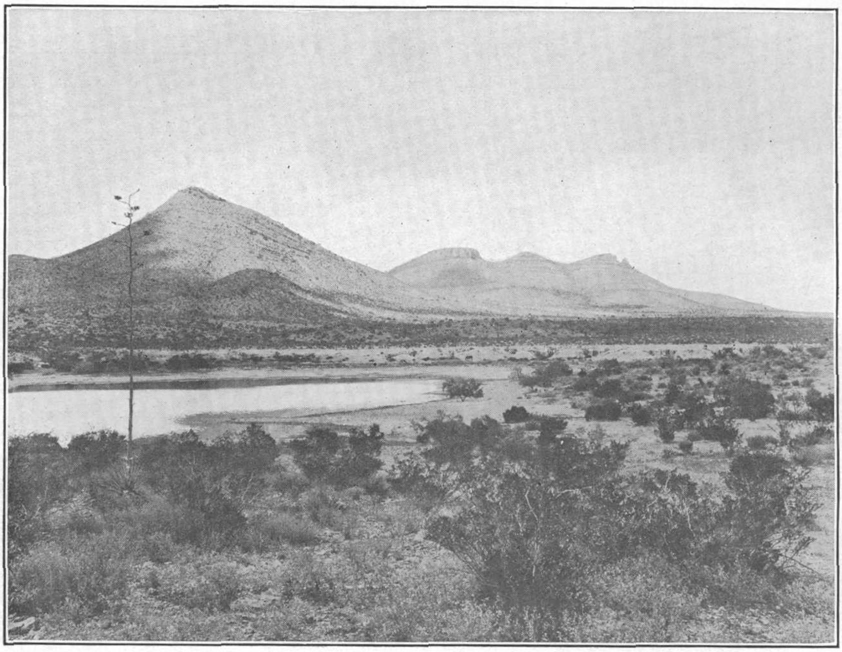
A. DRY BED OF MIMBRES RIVER JUST EAST OF SPALDING, N. MEX.

View looking upstream. Cooks Range and Cooks Peak in distance.



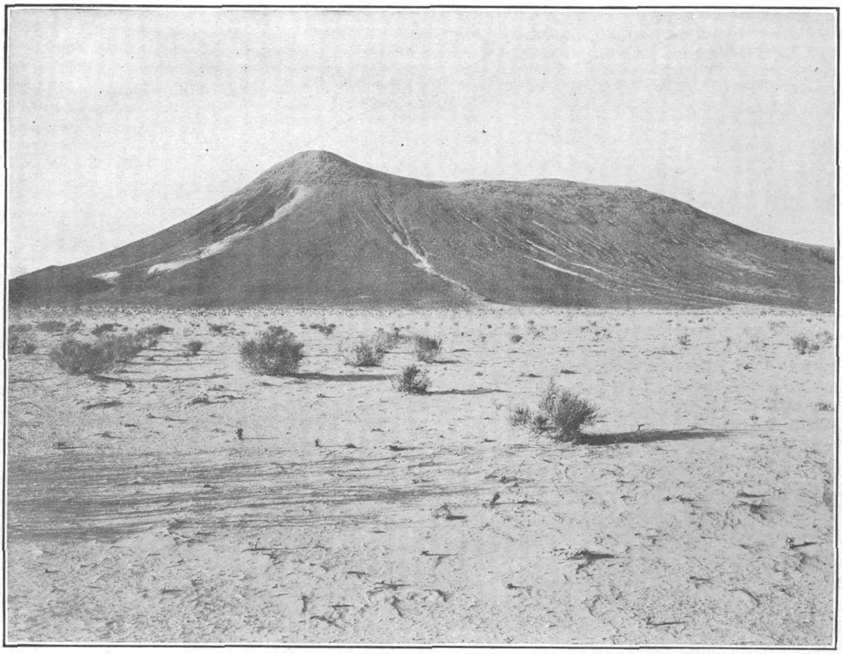
B. SAN VICENTE ARROYO NEAR WHITEWATER, N. MEX.

View looking downstream. Shows wide alluvial flat trenched by arroyo working upstream.



A. LIMESTONE KNOBS AT NORTH END OF SIERRA RICA IN SOUTHWESTERN CORNER OF LUNA COUNTY, N. MEX.

View looking northwest. The rocks are of Comanche age.



B. BLACK MOUNTAIN, 8 MILES NORTHWEST OF DEMING, N. MEX.

View from south. Basalt sheet capping Quaternary deposits of gravel, sand, ash, and tuff.

CLIMATE.

The climate of southwestern New Mexico is in general similar to that of districts of similar altitude in a wide district extending from western Texas to the southwestern part of California. The winters are mild, and although the summers are decidedly hot the air is so dry that the heat is much more endurable than the sultry summer weather of the Eastern and Central States. As the altitude of the

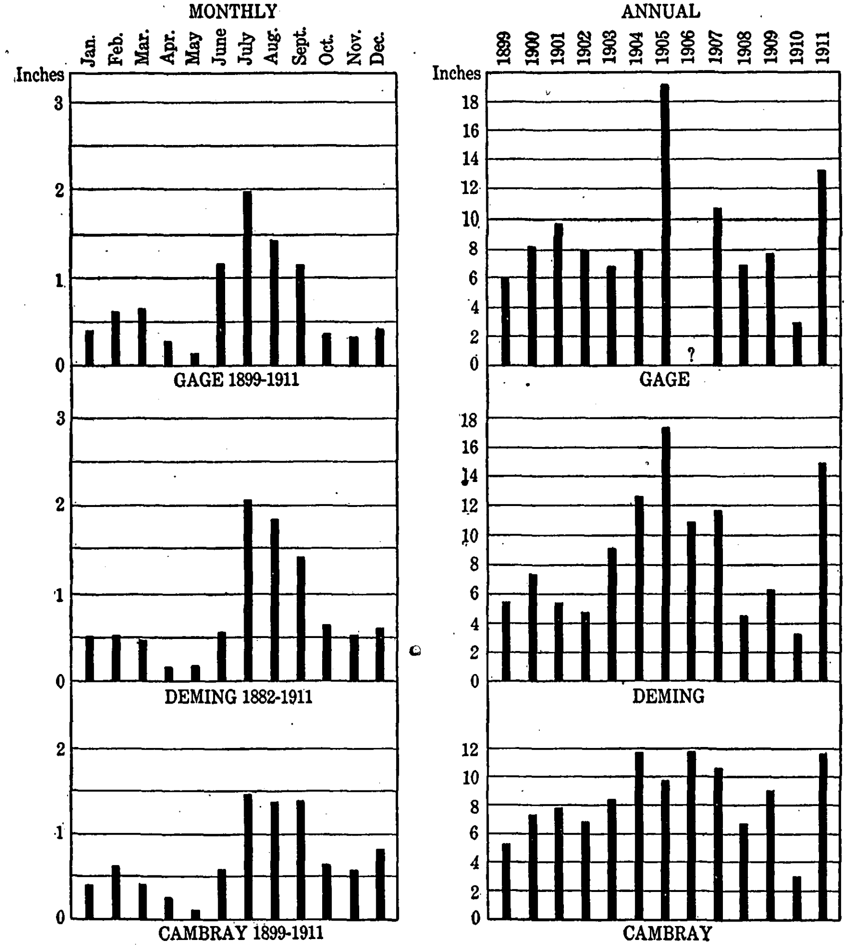


FIGURE 2.—Diagram showing precipitation at Gage, Deming, and Cambray, N. Mex.

greater part of the bolson area ranges from 4,000 to 5,000 feet, the heat is much less than in the lower lands of the Southwest. The principal rainy season is in July, August, and September. The rainfall is moderate, averaging slightly less than 10 inches a year in the lowlands. On the higher ridges the amount is much greater, for many rains and snows fall on the high areas when there is no precipitation in the adjoining desert valleys. The region lies outside of the normal storm track extending across the central United States, and in consequence the weather is much more uniform than in regions farther north and east. On nearly 300 days in a year there is sunshine for the greater part of the day, and storms of long duration are rare.

The following tables give the monthly and annual precipitation at Gage, Deming, Cambray, and Columbus, and figure 2 shows the annual and average monthly precipitation at the first three points. The data are taken from the reports of the United States Weather Bureau.

Precipitation, in inches, at Deming, N. Mex., 1882–1911.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1882	0.75	1.00	0.50	0.00	0.00	0.43	1.22	2.55	0.52	0.00	1.54	0.20	8.71
1883	.10	.00	1.77	.00	.00	.10	2.95	1.41	.53	1.32	.30	.88	9.36
1884	.80	.70	.20	.20	.00	.00	.52	1.04	.80	1.53	.54	1.35	7.68
1885	.00	.75	.52	.00	.77	1.33	1.38	.81	.09	.28	.50	.91	7.34
1886	.68	.50	.00	.00	.00	.00	1.13	4.19	4.36	.50	.00	.00	11.36
1887	.00	.20	.00	.00	.00	.00	2.02	3.46	3.39	2.13	.31	.05	11.56
1888	.26	1.77	.24	.50	.70	.50	1.08	.60	.00	1.60	1.45	.27	8.97
1889	1.09	.10	.12	.05	.00	.90	1.09	.64	3.55	.84	.80	.00	9.18
1890	.53	.00	.00	.13	.00	.16	4.09	2.20	2.26	.47	.42	1.25	11.51
1891	.40	.53	.64	.00	.48	.14	.18	1.20	.80	.00	.00	.18	4.55
1892	.45	.86	1.34	.10	.00	.90	.20	.39	.08	1.21	1.80	.60	7.93
1893	.19	.59	.42	.00	1.45	.01	2.82	4.38	2.64	.00	.06	.10	12.66
1894	.05	.66	.45	.00	.00	.00	.65	.95	Tr.	.45	.00	.36	3.57
1895	.50	.15	.00	Tr.	.58	.25	3.76	.35	.00	.15	.90	.15	6.79
1896	.60	Tr.	.00	.20	.00	.15	4.30	1.95	2.00	3.25	.25	.00	12.70
1897	1.55	.20	.42	.00	.00	.50	2.89	1.41	1.87	1.57	.00	Tr.	10.41
1898	.75	Tr.	1.42	.30	.00	Tr.	1.66	1.73	.21	.00	.10	.60	6.77
1899	.05	Tr.	.00	.00	.00	Tr.	3.92	.78	.54	Tr.	.45	Tr.	5.74
1900	.56	.46	.74	.00	.10	Tr.	2.10	.08	3.10	.20	.04	.03	7.41
1901	.40	1.87	.11	Tr.	Tr.	Tr.	.98	.90	.05	.75	.31	Tr.	5.37
1902	Tr.	Tr.	Tr.	.00	.20	.00	.91	1.61	.36	.01	.27	1.30	4.66
1903	.49	.85	1.00	.00	.13	3.32	.01	.40	2.84	.00	.00	.05	9.09
1904	.00	.00	.00	.00	.00	.60	1.57	1.58	4,16	.80	.64	1.18	12.53
1905	1.53	2.08	2.15	1.87	.00	1.05	.90	1.25	2.74	.32	2.72	.98	17.59
1906	.66	.63	.56	.10	.05	.00	1.98	2.98	.64	.02	1.34	1.83	10.79
1907	1.42	.08	.06	.19	.39	.35	3.18	1.95	2.40	.41	1.26	.00	11.69
1908	.64	.31	.18	.94	.03	.08	1.18	1.01	.00	.00	Tr.	.13	4.50
1909	Tr.	1.03	.51	.00	.00	.02	.40	1.58	.88	.89	.00	.70	6.01
1910	.00	.00	.19	.02	.00	.43	.96	1.02	.80	.00	.00	.00	3.42
1911	.77	1.40	.67	.38	.00	.96	7.13	.30	1.77	1.30	.00	.42	15.10
Mean	.53	.53	.49	.18	.18	.59	2.07	1.86	1.43	.69	.52	.63	9.70

1908, first killing frost Oct. 19; last, Mar. 19; 23 rainy days; 231 clear; 91 part cloudy; 44 cloudy; 1 foot snow.
1909, first killing frost Oct. 19; last, Apr. 23; 23 rainy days; 230 clear; 107 part cloudy; 28 cloudy; 10½ inches snow.
1910, first killing frost Oct. 20; last, Mar. 30; 14 rainy days; 136 clear; 136 part cloudy; 96 cloudy; no snow.
1911, first killing frost Oct. 22; last, Mar. 13; 40 rainy days; 167 clear; 102 part cloudy; 96 cloudy; 5 inches snow.

Precipitation, in inches, at Gage, N. Mex., 1899–1911.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1899	0.36	0.20	0.16	0.12	Tr.	0.00	3.40	1.00	0.15	0.10	0.10	0.11	5.70
1900	.16	.35	.83	.15	.00	.27	1.65	.75	3.13	.28	.63	.00	8.20
1901	.28	.99	.11	.00	.00	.45	3.05	2.08	.30	1.45	1.00	.00	9.71
1902	.00	.30	.00	.00	.00	.24	1.45	3.02	1.10	.10	.52	1.30	8.03
1903	.27	.20	.90	.00	.25	1.20	.51	.72	2.84	.00	.00	Tr.	6.89
1904	Tr.	.00	.00	.00	Tr.	.62	1.16	1.35	.65	2.00	.55	1.50	7.83
1905	1.60	3.00	2.95	1.78	.06	.62	1.17	2.25	2.04	.44	2.80	.75	19.46
1906	......	......	......	......	......	......	......	.41	.84	.00	.47	2.40	......
1907	1.41	.11	.15	.13	.62	.98	1.67	2.05	1.31	1.18	1.10	.00	10.71
1908	.56	.22	.17	.74	.12	.00	1.92	2.15	.31	.00	.10	.70	6.99
1909	.04	.15	1.40	.00	.00	2.32	.00	1.97	.45	.00	.00	.45	7.68
1910	.23	.00	.20	.04	.14	.50	.68	1.00	.05	.00	Tr.	.00	2.84
1911	1.06	1.00	.50	.20	.00	1.30	4.50	.30	2.20	1.00	.00	.72	13.38
Mean	.36	.63	.66	.28	.12	.66	1.96	1.47	1.18	.38	.35	.47	8.52

Precipitation, in inches, at Cambray, N. Mex., 1899–1911.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1899	0.05	Tr.	0.10	0.27	0.00	0.31	1.90	0.64	0.98	0.00	0.54	0.18	4.97
1900	.00	.70	.90	.00	.45	.17	1.67	.62	1.78	.10	.45	.10	6.94
1901	.31	.59	.08	.10	.05	.35	2.02	.19	.37	2.95	.70	.00	7.71
1902	.00	.04	.05	.00	.24	.32	.67	1.72	1.53	.02	.60	1.45	6.64
1903	.74	1.55	.80	Tr.	.40	.43	.09	2.58	1.43	.00	.00	.00	8.02
1904	.04	.10	.00	.02	.12	.18	.82	1.19	5.23	1.48	.50	1.78	11.46
1905	1.69	2.01	1.02	.55	.00	.50	.75	.50	.50	Tr.	1.50	.60	9.62
1906	.65	.72	.60	1.20	.00	.00	1.65	2.57	1.39	.00	1.38	1.28	11.44
1907	.65	.00	.00	.00	.23	1.15	1.72	.60	2.05	3.01	1.10	.00	10.51
1908	.27	.28	.00	.53	.00	.00	1.64	3.15	.00	Tr.	.45	.10	6.42
1909	Tr.	.10	1.00	.00	.00	2.05	1.40	2.60	1.25	.00	Tr.	.60	9.00
1910	.20	.00	.08	.40	.00	.95	.79	.91	.03	Tr.	.02	.00	3.38
1911	.80	1.87	.55	.33	.00	1.25	3.80	.40	1.31	.31	Tr.	.66	11.28
Mean	.36	.61	.40	.26	.11	.59	1.46	1.34	1.37	.61	.56	.80	8.19

Precipitation, in inches, at Columbus, N. Mex., 1910–11.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1910	0.14	0.03	1.13	0.09	0.01	2.34	0.54	1.17	0.35	0.03	0.19	Tr.	6.61
1911	.65	1.03	.05	.23	.00	.81	5.19	.09	1.81	.50	.21	.97	11.54

1910, first killing frost Oct. 21; last, Mar. 30; rainy days, 29; clear days 227; partly cloudy, 42; cloudy, 96.
1911, first killing frost Oct. 22; rainy days 34; clear days 203; partly cloudy, 70; cloudy, 92.

The mean monthly and annual temperatures of Luna County are much more uniform than the rainfall. The hottest month is June in some years and July or August in other years. December is usually the coldest month. The following tables are taken from the records of the United States Weather Bureau:

Monthly and annual temperatures, in degrees Fahrenheit, at Deming, N. Mex., 1908–1911.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1908	41.8	43.6	52.6	56.4	64.4	76.6	72.2	72.6	70.3	56.2	46.7	41.9	57.9
1909	45.8	43.0	48.2	58.6	64.0	78.6	81.2	74.4	70.2	62.5	52.0	37.0	59.6
1910	43.0	44.8	57.2	58.9	70.3	78.0	80.6	78.5	76.2	62.3	51.7	42.8	62.0
1911	43.3	43.2	54.9	57.2	65.8	76.1	76.7	78.6	72.7	62.6	45.2	33.4	59.1
Mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	59.6

Monthly and annual temperatures, in degrees Fahrenheit, at Gage, N. Mex., 1908–1911.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1908	42.4	44.7	53.8	56.8	63.8	74.2	77.9	76.3	70.6	54.9	46.4	40.5	58.5
1909	47.4	44.4	50.0	58.7	68.8	78.6	79.6	75.7	70.0	65.1	51.4	37.0	61.8
1910	43.3	46.8	56.8	59.8	69.6	78.2	81.1	78.8	72.4	66.7	51.6	43.4	62.4
1911	46.0	45.0	56.0	57.8	67.4	75.9	75.2	79.4	75.5	60.2	44.2	35.0	59.8
Mean	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	60.6

GEOLOGY.

GENERAL RELATIONS.

In southwestern New Mexico there is a thick succession of sedimentary rocks ranging from Cambrian to Recent in age and lying on pre-Cambrian granite, which appears in some of the hills and mountains. There are also many kinds of later igneous rocks—porphyries, latites, andesites, rhyolites, and basalts—some of them surface flows and others intruded among the sedimentary rocks. The wide smooth-surfaced valleys known as bolsons are filled with sand, clay, and gravel, in places overflowed by sheets of relatively young basaltic lava. The older sedimentary rocks are in widespread sheets, but they are considerably flexed and faulted and appear in scattered ridges rising out of the bolsons. They comprise a basal sandstone of Cambrian age, two limestones of the Ordovician, a thin representative of the Silurian, black shale of the Devonian, two great limestones representing the Mississippian and Pennsylvanian epochs of the Carboniferous period, a formation of shale and limestone of unknown equivalence, but tentatively regarded as of possible Triassic age, representatives of the early and later Cretaceous, and thick bodies of sands, clays, and gravels of Quaternary age. Tertiary time appears to have produced a great succession of igneous rocks, partly in thick accumulations of agglomerate, tuff, and ash and thin sheets of various kinds of lavas. Much of this material underlies the bolsons. Some portions of geologic time are not represented by known deposits in the region, notably the earlier Cambrian, Jurassic, and possibly the Triassic, also portions of the Ordovician, Silurian, Devonian, Carboniferous, and Cretaceous. The Mississippian and Devonian, which are prominent in the northern part of Luna County and adjoining regions, are absent to the south, but this is the only important notable local variation in the succession. The general distribution of the formations is shown on Plate I (in pocket), and their names, general character, thickness, and classification are given in the following table:

Sedimentary formations in Luna County, N. Mex.

System.	Series.	Formation.	Thickness (feet).	Character.
Quaternary.		Bolson deposits.	1,665±	Sand, clay, and gravel.
		Unconformity		
Tertiary.		Agglomerate.	2,000+	Fragmental volcanic materials, in part water-laid, and sand and gravel. Igneous sheets at intervals.
		Unconformity		
Cretaceous.	Upper Cretaceous.	Colorado shale.	300+	Gray shale with impure thin limestone and sandstone layers.
		Unconformity		
	Comanche (Lower Cretaceous).	Sarten sandstone.	300	Massive gray sandstone, in part quartzitic.
		Limestone of Comanche age.	0–400	Gray limestones, mostly slabby, and sandy shale.
		Unconformity		
Triassic (?).		Lobo formation.	95–500	Reddish shale, impure limestone, and conglomerate.
		Unconformity		
Carboniferous.	Pennsylvanian.	Gym limestone.	30–1,000	Gray limestones, some dark, in part brecciated; dark shale member.
		Unconformity		
		Magdalena formation.	0–40	Shale and slabby limestone.
		Unconformity		
	Mississippian.	Lake Valley limestone.	0–700	Light-gray limestone with shale members; chert at top.
Devonian.	Upper Devonian.	Percha shale.	175	Black shale.
Silurian.		Fusselman limestone.	100–300	Massive gray limestone.
Ordovician.	Upper Ordovician.	Montoya limestone.	300	Gray limestones with thick chert members; dark limestone at base.
		Unconformity		
	Lower Ordovician.	El Paso limestone.	500–800	Light-gray limestones, mostly slabby.
		Unconformity (?)		
Cambrian.	Upper Cambrian.	Bliss sandstone.	30–200	Sandstone and sandy shale; glauconitic.
		Unconformity		
Pre-Cambrian.		Granite.		

THE ROCKS.

PRE-CAMBRIAN ROCKS.

GENERAL CHARACTER.

The general basement of Luna County consists of pre-Cambrian crystalline rocks, which appear at the surface in several areas of small extent. They are overlain unconformably by the sedimentary rocks, the contact showing an irregularly eroded surface of granite, which is the prevailing rock in the outcrop areas. Its age is not known, except that it is pre-Cambrian. Some portions of the granite are gneissic, and in places it includes syenitic and porphyritic masses and hornblende dikes of unknown age.

DISTRIBUTION.

The most extensive exposures of granite are in the Florida Mountains, which consist largely of that rock. It appears also in the north end of Cooks Range, in small areas on the slopes south and north of Fluorite Ridge, and as a very small outcrop in the midst of the Klondike Hills. The area in the Florida Mountains is nearly 30 square miles in extent, and here the rock constitutes peaks and ridges reaching an altitude of 7,000 feet, or 2,500 feet above the adjoining bolson. This large granite area is terminated on the north by a fault, but the rock reappears just west of Capitol Dome and extends northward along the foot of the range for a mile to another fault which carries it far below the surface.

RELATIONS AND AGE.

The granite is Algonkian or Archean in age, but as its relations to the older rocks are not exposed there are no means of determining in which system it belongs. It is all of igneous origin and part of one great mass except, possibly, a small amount of rock of gneissic and dioritic character which may be projections or inclusions of an older complex. It is overlain unconformably by the Bliss sandstone, of Upper Cambrian age, and the contact shows the usual features of shore deposition without sign of metamorphism in the sandstone or change of texture in the granite. At several places the granite adjoins higher sedimentary rocks, but these contacts are faults. On the slope 2 miles south of Gym Peak the granite is so intricately faulted that it appears to include and to penetrate the upper beds of the Gym limestone, but the limestone is not metamorphosed and the granite retains its coarse grain up to the contact and shows evidence of crushing; the relations indicate a complex overthrust. In the Pony Hills the granite is brought into contact with the Sarten sandstone, probably by faulting, but possibly by overlap.

A dike of amphibolite outcrops in the slopes a short distance south of Capitol Dome and diorite appears at several places along the west slope of the Florida Mountains. Both of these rocks appear to be of pre-Cambrian age. Some small masses of rock of porphyritic character in the granite areas may be younger intrusives. In the eastern part of the pre-Cambrian area west of Fluorite Camp there is a mass of diorite which is penetrated by light-colored granite and finally gives place to that rock in the slopes farther west. Well-developed gneiss occurs in large angular fragments in a coarse breccia which lies in the south slopes of this same ridge half a mile northwest of Fluorite Camp. This breccia lies on the limestones and porphyry and appears to have been brought up by a local explosion or by the porphyry intrusion. The principal rock in the small outcrop in the Klondike Hills is typical gneiss, and part of the rock in the basin north of Fluorite Ridge is distinctly banded.

PETROGRAPHY.

By John L. Rich.

Most of the granite is a massive, coarse-grained, pale reddish to light greenish-gray rock weathering into rugged forms of brownish aspect. Local variations in color and texture are subordinate features. It has a uniform mineral constitution, consisting essentially of feldspar, quartz, chlorite, and iron oxides, but in general the granite of the Florida Mountains contains a larger proportion of soda feldspars than that farther north. The predominating granite in the Florida Mountains near Capitol Dome (Pl. III, *B*, p. 13) and to the south is light pink and of medium to coarse texture. It consists almost entirely of microperthite and quartz, the former slightly in excess. The quartz crystals show strain and are somewhat shattered. The original existence of a small amount of mica is indicated by characteristic outlines now filled with iron-stained chloritic aggregates. Accessory minerals are magnetite, apatite, and zircon.

The granite of the Florida Mountains presents, in areas of small extent, some local variations from the type described above. South of Capitol Dome, for instance, a gray, rather fine grained, slightly porphyritic granite differs from the type principally in having a markedly finer texture and apparently a greater proportion of quartz. A pinkish granite occurring south of The Park differs from the type only in having a higher proportion of quartz. The red color of this rock, as well as of most of the granite of the Florida Mountains, is due in part to staining by hematite, which, as a product of the decomposition of the femic minerals, has spread into the cleavage cracks of the feldspar and into the fracture planes of the quartz crystals.

In external appearance the granite from the north end of Cooks Range closely resembles the massive pinkish rock just described as typical of the Florida Mountain localities. It differs, however, in having the albite in the form of separate crystals rather than as microperthite. It has an even granular texture of medium coarseness with crystals averaging 2 to 5 millimeters in diameter. It is composed essentially of quartz, microcline, a subordinate amount of albite, scattered crystals of andesine, and a greenish-brown biotite. The quartz in some crystals shows incipient granulation. In the granite of Fluorite Ridge the albite and orthoclase are in separate crystals, but otherwise the rock is closely similar to that of the Florida Mountains. The granite of the Pony Hills, north and northwest of Fluorite Ridge, is mostly light pinkish to gray and has a moderately coarse texture.

The granite of the Klondike Hills differs slightly from the others. Two varieties, both having well-developed gneissic banding, are distinguished. The first is a biotite granite of strong red color and coarse texture; the second is distinctly porphyritic, having white phenocrysts of albite oligoclase lying in a dark medium-grained matrix of quartz, albite, and green biotite. It contains considerable epidote.

Portions of the granite on the slope south of Capitol Dome are gneissic. At one place a fine-grained light-gray granitic or aplitic gneiss, composed almost entirely of quartz and feldspar (orthoclase and albite), with very subordinate ferromagnesian minerals, has distinct gneissic banding revealed by the stringing out of the few dark constituents. A typically granitic rock with pronounced gneissic banding is found in large fragments in the breccia on the limestone and porphyry on the south slope of Fluorite Ridge. Its color is gray with a pink to purplish tinge; its texture medium, with feldspars reaching a maximum length of 3 millimeters. A somewhat similar gneissic granite of dull-gray color and slightly finer grain occurs in places in the Pony Hills, north of Fluorite Ridge. A third notable variety crops out on the lower slopes of the ridge half a mile southwest of Fluorite Camp, about 500 yards south of the breccia just mentioned. It is bright red and of medium, even granular texture, with banding only slightly developed, though the microscope reveals strong granulation of the quartz. As noted on a preceding page, part of the granite of the Klondike Hills is gneissic.

Although the gneissic granites just described differ somewhat in color, texture, and the extent of banding and granulation, they are closely similar in composition and doubtless of the same age.

Part of the granite at the foot of Fluorite Ridge, southwest of Fluor mine, has a marked green color and is notably porphyritic. Phenocrysts of pink orthoclase as much as 2 centimeters in length by 1 centimeter in width are embedded in a granular matrix of albite, biotite, and quartz. Granulation of the quartz and a stringing out of the mica flakes indicate that the rock has been subjected to slight dynamic disturbance.

The granitic mass of the Florida Mountains include some light-gray rocks differing considerably from the normal pink granite. These outcrop in the slopes west of Arco del Diablo and also in the pass east of The Park, in the central portion of the Florida Mountains. They are either local developments, intrusions into the ordinary pinkish granite, or, possibly, irregular dikes of post-Cambrian age. They are moderately coarse grained, the crystals averaging about 1 centimeter in diameter. Fresh specimens have a slaty blue to drab color and weather yellowish brown. They are composed almost entirely of feldspar and quartz, the quartz always in small amounts but varying considerably in specimens from different localities. The feldspars are sodic, anorthoclase and albite predominating. At the Window Mountain mine, southwest of Arco del Diablo, is a finer-grained phase which has a higher quartz content and a considerable proportion of potash feldspar. A closely similar rock is associated with the gneissic granite just south of Capitol Dome.

The more siliceous types of the rocks cutting or included in the granite of the Florida Mountains approach sodic granite porphyries in character, while some of the more basic rocks are related closely to the typical quartz monzonite porphyries. All are moderately dark, with a greenish-gray cast. White phenocrysts of feldspar as much as 15 millimeters in length, mostly albite, lie embedded in a darker fine-grained groundmass of orthoclase, albite, and oligoclase in varying amounts, green hornblende, in part at least derived from augite, and biotite. In addition to the usual accessory minerals there is a little pyrite.

Dark, heavy rocks of two or three kinds are found in the granite at several places in the Florida Mountains and about Fluorite Ridge. The most numerous are dikes of amphibolite which traverse the granite south and west of Capitol Dome. These rocks are moderately fine grained and are composed essentially of green hornblende, together with a small amount of albite and a little quartz.

On the lower slopes half a mile southwest of Fluorite Camp a rock of similar character is associated with the granite and probably cut by it. The rock is almost black, with lighter bands of feldspar. The texture varies in different bands, the crystals of some reaching a diameter of 1 centimeter. Green hornblende predominates, and the feldspar ranges from oligoclase to andesine. More or less gneissic banding is developed in most of these rocks.

In the granite at Capitol Dome is a dike or included mass of porphyritic diorite with phenocrysts of white labradorite as much as 8 millimeters in diameter set in a dense dark-green to black fine-textured groundmass of diabasic character.

CAMBRIAN SYSTEM.

BLISS SANDSTONE.

DISTRIBUTION AND RELATIONS.

At the base of the Paleozoic succession in Luna County there is a sandstone that stratigraphically and lithologically so closely resembles the Upper Cambrian Bliss sandstone, of the El Paso region, that the name Bliss is here applied to it. Its thickness ranges from 150 to 200 feet in most of the area, but in places it is considerably less. In the Florida Mountains the formation crops in the lower slopes west of Capitol Dome, in the cliffs east of The Park, and in the long slope just north of Gym Peak. In the slope west of Capitol Dome the sandstone is exposed for a mile, lying on granite. It disappears under the bolson at the south and is cut off by a fault to the north. The exposures east of The Park are less than a mile in length, and their continuity is interrupted by faulting and talus. In some of the outcrops northwest of Gym Peak the sandstone appears to be absent locally, but possibly in places this apparent absence is due to faulting. In the long outcrop down to the slope and spurs north of Gym Peak the sandstone is well exposed, extending northward to the draw, where it is finally cut out by a fault. In Fluorite Ridge the nearly vertical beds of sandstone lie against the granite but apparently are separated by a fault of small throw a short distance west of Fluorite Camp. In the north end of Cooks Range the Bliss sandstone rises gradually out of the bolson on the west side, caps the ridge for a short distance, and is cut off by the fault on the east side. In the Klondike Hills there is a small exposure of the sandstone separating granite from the El Paso limestone, but apparently it is cut off by a slight fault on the west side of the granite area. It is thin at this locality and may possibly thin out at one or two places.

The Bliss sandstone consists mainly of gray to brown sandstone, in part quartzitic, in members 30 to 40 feet thick separated by sandy shale. In Cooks Range and Fluorite Ridge and near Capitol Dome the upper beds are slabby sandstone and sandy shale with intercalated thin limy beds. Some of the sandy shale contains a large amount of green glauconite in disseminated grains, a feature characteristic of some of the Cambrian rocks in other regions. The basal contact is well exposed in the area west of Capitol Dome, in the Florida Mountains, where coarse sandstone lies on the slightly uneven eroded surface of the coarse-grained pinkish granite. The basal beds are arkosic and pebbly, and their material is evidently derived from the granite. Similar conditions are exposed east of The Park and north of Gym Peak. At its top the sandstone gives place abruptly to the El Paso limestone without discernible evidence of erosional unconformity to represent the time interval which is believed to exist between the two formations.

AGE AND CORRELATION.

No fossils were found in the formation in Luna County, but the Bliss sandstone, which has the same character and the same relative position in the type locality in Franklin Mountains, near El Paso, Tex., contains a few Upper Cambrian fossils. Its character and relations also indicate that it is the same as the "Shandon" sandstone of central New Mexico and the basal sandstone of the Silver City region.

ORDOVICIAN SYSTEM.

CLASSIFICATION.

In Luna County the Ordovician system comprises an extensive succession of limestones ranging in age from Beekmantown (early Ordovician) to Richmond. Portions of Ordovician time, however, apparently are not represented by deposits, so that there are unconformities between the formations. On the basis of lithology, fossils, and stratigraphic position the lowest limestone series has been correlated with the El Paso limestone of the El Paso quadrangle and the upper series has been correlated with the Montoya limestone of that quadrangle. In Fluorite Ridge and the Florida Mountains it is difficult to separate the upper beds of the Montoya from the Fusselman limestone, which is of Silurian age. Therefore these two limestones are mapped together on Plate I.

EL PASO LIMESTONE.

DISTRIBUTION AND CHARACTER.

The El Paso limestone appears at the surface at several widely separated localities in Luna County. It is conspicuous in the northern part of Cooks Range, in several areas in the Florida Mountains, in the east end of Fluorite Ridge, in the Snake Hills, and in the Klondike Hills.

It consists mainly of gray, slabby limestone and dolomitic limestone from 500 to 800 feet thick. This limestone begins at the top of the Bliss sandstone and terminates abruptly at the base of the Montoya limestone without notable discordance of dip. Portions of the El Paso limestone are slightly cherty, and some beds contain considerable sand or clay, but these are minor features. Pale-reddish elongated blotches on the bedding planes are characteristic of most beds, and the slabby bedding and light tint are also distinctive of the formation. Several of the exposures in the Florida Mountains exhibit all the beds of the formation, but in Fluorite Ridge some portions appear to be crushed out or faulted down. Small outcrops of the upper part of the formation appear at the west end of the two ridges west of The Park. The section west of Capitol Dome is complete with the Bliss sandstone below and the Montoya limestone above the El Paso, the formation having a thickness of about 800 feet and cropping out along the slope for about a mile. This area is terminated at the north by a cross fault that brings down agglomerate and at the south by a fault that brings up the granite. The rocks are mostly the typical light-gray, slabby limestone in beds 2 to 6 inches thick, in part dolomitic and containing a small amount of chert, but the basal beds for about 140 feet are more massive and darker than at other places. The exposures east of The Park on the summit and western slope of the Florida Mountains show about 700 feet of beds lying on the Bliss sandstone and capped by the Montoya limestone or Gym limestone. To the south these beds are cut off by granite brought up by the great cross fault, and other smaller faults break the continuity of the exposures. The rocks here are similar to those at Capitol Dome, but the dark basal bed is absent. The formation is exposed extensively in the northern slope of Gym Peak ridge and in the outlying ridges on the north, underlying the Montoya limestone and cut off by several faults. Here its thickness appears to be fully 800 feet, and possibly more, notably in one long section of nearly vertical beds on the north side of the draw, slightly more than a mile northwest of the peak. A small mass is faulted against the granite just north of the road half a mile east of Byer Spring. In the slopes a mile southeast of that spring the formation includes a thick mass of chalcedony, apparently due to local replacement of some of the limestone, and other similar masses crop out along a fissure in the slopes east of The Park.

The El Paso limestone constitutes the central and eastern portions of the ridge of rounded knobs known as the Snake Hills, southwest of Deming. (See fig. 11, p. 88.) The strata here dip at low angles, and the total thickness of beds exhibited is not more than 700 feet. The lowest beds exposed at the east end of the ridge are made up of typical slabby light-gray limestone. These are overlain abruptly by the dark-colored massive limestone at the base of the Montoya.

The El Paso limestone crops out for nearly a mile in the high knob just west of Fluorite Camp, but the beds here are nearly vertical and the outcrop zone is very narrow. The Bliss sandstone is in contact with the limestone on the south and the Montoya limestone on the north, and the intervening ledges of El Paso limestone measure only 400 feet in thickness at the east end of the ridge and somewhat less at the west end. This small thickness is probably due to faulting and crushing along a plane or planes parallel to the obvious fault between the Bliss sandstone and the pre-Cambrian granite.

The outcrop of the El Paso limestone near the north end of Cooks Range is on the summit and the western slopes, where the beds appear in regular order between the Bliss sandstone and Montoya limestone in a succession, dipping gently to the south-southeast. The thickness is about 600 feet, and the rocks have the characteristics which they present in other localities.

The El Paso limestone constitutes a large part of the Klondike Hills, where it lies on the Bliss sandstone and is overlain by sandstone at the base of the Montoya limestone. Its thickness here is about 650 feet, and the beds present the characteristic light-gray color, slabby bedding, and pale-reddish markings on many of the bedding planes.

FOSSILS AND CORRELATION.

Fossils are scarce in the El Paso limestone, but those collected just west of Capitol Dome, in Fluorite Ridge, near Gym Peak, in the ridges east and west of The Park, in the Snake Hills, and in the Klondike Hills suffice to indicate its approximate age. These fossils were examined by E. O. Ulrich and Edwin Kirk, who found that most of them are a species of Ophileta, of Beekmantown or early Ordovician age.

Fossils found in the upper beds in the center of the Snake Hills were identified by Mr. Kirk as Dalmanella cf. *D. pogonipensis* H. and W. and Hormotoma sp. On the west slope of the Gym Peak were found, also in the upper beds, Strophomena near *S. nemea* H. and W., Hormotoma sp., and Trochonema sp. The brachiopods are close to forms described from the upper part of the Pogonip limestone of the Eureka and White Pine districts in Nevada and indicate late Beekmantown or possibly early Chazyan age. On the evidence of fossils, close similarity in rocks, and stratigraphic relations there is no difficulty in correlating the formation with the El Paso limestone of the type locality in the Franklin Mountains near El Paso, Tex. It also represents the greater part of what Gordon has called the Mimbres limestone of the region north of Luna County, but Gordon's Mimbres includes also the Fusselman and Montoya limestones.

MONTOYA LIMESTONE.

OCCURRENCE.

The Montoya limestone crops in the northern part of Cooks Range, in the northern and central parts of the Florida Mountains, in the Victorio Mountains, in the Klondike Hills, and in the Snake Hills. In all these areas the rocks are light-gray slabby limestone with highly fossiliferous layers, a large amount of chert, and at the bottom a dark-colored massive limestone or sandstone. The chert is a characteristic feature and gives considerable prominence to the outcrops. It occurs mostly in thin beds alternating with layers of limestone, and the greater part of it is in two thick members, with purer limestones above and below. The thickness of the formation varies somewhat, but the average amount is near 300 feet. As the upper limit of the formation is not distinct in part of the area and the outcrop zones are narrow, the Montoya and Fusselman limestones are not separated on the geologic map (Pl. I, in pocket).

The largest area in the Florida Mountains are the three masses extending nearly across the range at The Park and Gym Peak, where the outcrop zone is repeatedly brought up by the faults. There the Montoya limestone lies on the El Paso limestone, but some of the faults bring it into contact with granite and other formations, and at several places the Gym limestone lies directly on its eroded surface. Elsewhere it is overlain by the Fusselman limestone, but the plane between the two formations is difficult to discern. On the west side of the summit the Montoya limestone crops out in irregular cliffs facing west, and a long exposure crosses the ridge just north of Gym Peak. Other outcrops appear in ridges west of The Park, and there is an outlier along the fault a mile southeast of Byer Spring. In this region, as elsewhere, cherty ledges are conspicuous features at two horizons, and the massive dark limestone occurs at the base.

The small mass of Montoya limestone in the slope west of Capitol Dome is overlapped unconformably by the Lobo formation to the east, north, and south. Here 145 feet of the formation was measured, comprising a 40-foot cherty member at the top, 30 feet of dark sandy limestone and 25 feet of cherty limestone in the middle, and 50 feet of dark massive limestone at the base.

The Montoya limestone constitutes part of the limestone ridge extending north from Cooks Peak. It rises from beneath the bolson at a point about a mile north of the main road forks, west of the mountain, and reaches the summit some distance farther north, where it is cut off by the great fault. The thickness of the beds at this place is about 250 feet, and the limits of the formation are well defined, as the overlying Fusselman limestone is distinctive in appearance. The top member consists of 60 feet of light-colored slabby limestones with 6 feet of very fossiliferous beds at the base. This is underlain by 150 feet of limestones with numerous thick and thin cherty layers, followed by a basal member 40 feet thick of dark-gray massive limy sandstone lying on El Paso beds.

The formation is extensively exposed in the high knob and ridge of the western half of the Snake Hills, beginning a short distance west of the main road. At the base is the usual dark-colored massive limestone. This is overlain by very cherty limestone with alternating layers of purer limestone. Next comes 30 feet of massive dark-gray sandy limestone giving rise to low cliffs and grading up into a purer, partly massive limestone which weathers to a dirty olive tint; then a 60-foot member of alternating layers of chert and limestone, with fossils; and at the top, capping the highest butte on the ridge, a thick mass of very cherty rock. The thickness of beds classed as Montoya is 300 feet, and they extend to the bolson on either side and to the west without indication of the Fusselman limestone.

The formation is prominent in the hill west of Fluorite Camp on account of its conspicuous thick cherty layers. The beds dip steeply to the north, and are cut off by a fault to the east. (See fig. 10, p. 86.) At the base is a dark-colored massive limestone, as at other places. This is followed by cherty limestone, with the chert mostly in thin layers. Next above are finer slabby gray limestones with many fossils, and still higher is a thick body of highly cherty limestone. At the top is 50 feet of massive limestone of unknown age, possibly Fusselman, extending to or from a small fault which cuts the section in this vicinity and drops the Percha shale and associated beds for some distance. A short distance to the southeast there are several small but prominent ridges consisting of thick bodies of massive chert apparently replacing a limestone, presumably the Montoya, but as it is nearly surrounded by porphyry and displaced by faults its relations could not be ascertained.

The high buttes and east end of the Klondike Hills consist of the Montoya limestone. (See fig. 14, p. 92.) The beds dip east at a low angle and the outcrops are repeated by one or more cross faults. The basal member is dark-gray sandstone 6 to 8 feet thick lying on a slightly irregular surface of the El Paso limestone. It is followed by 30 to 40 feet of dark massive sandy limestone, as in other areas, and this gives place abruptly to the typical cherty beds of the Montoya limestone. There are two or possibly three cherty members, mostly alternations of thin beds of chert and pure olive-gray limestones with intervening layers of slabby gray limestone containing abundant fossils.

In the Victorio Mountains the Montoya limestone constitutes the north, east, and west slopes of Mine Hill, and the outcrop extends northwestward along the lower southern slopes of the range, as shown in figure 9 (p. 84). The strata in Mine Hill dip to the south at low angles, and about 300 feet of beds are exposed, but in the slopes on the west they dip to the north and are overlapped by or faulted against the Gym limestone. The basal beds are covered by bolson deposits in the gap north of Mine Hill, and the beds exposed in this hill are mostly dark-gray limestone with thick chert layers and intercalated light-colored beds containing many fossils of the Richmond fauna.

It is difficult to separate the Montoya from the overlying Fusselman on Mine Hill, and apparently the Fusselman is absent in the ridges to the west.

FOSSILS AND CORRELATION.

The Montoya limestone contains numerous fossils in considerable variety and in excellent state of preservation. The following species have been identified by E. O. Ulrich in material collected northwest of Cooks Peak, near Gym Peak, in Fluorite Ridge, in the Klondike Hills, and in slopes a mile northwest of the Victorio mining camp: Eurydictya cf. *E. montifera; Dinorthis subquadrata*, *Plectorthis whitfieldi*, *Hebertella occidentalis*, Dalmanella cf. *D. meeki*, Dalmanella near *D. jugosa*, *Platystrophia acutilirata* var., Strophomena cf. *S. subtenta*, *Rafinesquina loxorhytis* W. and S., *Leptæna unicostata*, *Plectambonites saxea*, *Rhynchonella anticostiensis* (*argenturbica* White), *Rhynchotrema capax*, *Zygospira recurvirostris*, Cyrtodonta sp., Vanuxemia sp., and Bumastus sp.

In beds between the two cherty members on the limestone knob west of Fluorite Camp were obtained Strophomena cf. *S. subtenta* Conrad, Platystrophia cf. *P. acutilira* Conrad var., *Rhynchotrema perlamellosa* Whitfield, and *Streptelasma rusticium* Billings. These fossils are characteristic of the Richmond fauna, which occurs in various portions of the Rocky Mountain region. No fossils were collected from the basal dark massive bed.

The paleontologic and lithologic evidence is ample for correlating the beds in Luna County, here designated Montoya limestone, with the Montoyo limestone in the type locality in the Franklin Mountain region south of El Paso, Tex.

SILURIAN SYSTEM.

FUSSELMAN LIMESTONE.

DISTRIBUTION AND CHARACTER.

The Fusselman limestone crops out at several localities in Luna County. One of the most notable exposures, on account of its fossils, is on the south slope of Mine Hill, at Victorio mining camp, and the formation is a conspicuous feature in the series of limestones in the ridge at the north end of Cooks Range. It overlies the Montoya limestone in most of the Gym Peak area and in the ridge northwest of Fluorite Camp, but it is much less characteristic at these places. In Cooks Range the typical rock is massive limestone of gray color and exceptionally hard, compact texture, about 200 feet thick, and it is the source of most of the lead, silver, and zinc ores. There it is overlain by the Percha shale. The thickness at Victorio and other places is difficult to determine because of lack of distinctive features defining the limits of the formation. It constitutes the south slope of Mine Hill. Near Gym Peak and The Park the dark slabby limestone above the Montoya yielded a few fragments of corals believed to be of Silurian age, but the rocks do not closely resemble the Fusselman limestone of other areas. Moreover, the Percha shale is absent, so there is great difficulty in separating the Fusselman from the Gym limestone, which lies unconformably on the older limestones in this area. The conditions are somewhat similar west of Fluorite Camp, for although the Percha shale is present the succession is cut by a fault of undetermined amount which lifts the supposed Fusselman into contact with the Lake Valley limestone.

FOSSILS AND CORRELATION.

In the Cooks Peak district and near Silver City the Fusselman limestone contains large numbers of a distinctive Pentamerus, and in the south side of Mine Hill, in the Victorio Mountains, it carries corals as follows: *Heliolites megastoma*, Heliolites? sp. (very small corallites like *Lyella puella* Davis), Favosites cf. *F. venustus*, Favosites sp. (closely septate, cells larger than in *F. venustus*), Cyathophyllum cf. *C. radicula*, Heliophyllum sp., *Halysites catenulatus* (large and small varieties), and Syringopora sp. This is also an orthoid suggesting *Rhipidomella hybrida.* These were determined by E. O. Ulrich, who states that they represent a Silurian zone hitherto practically unrecognized in the Southwest. It probably corresponds to the late Niagaran of the Mississippi Valley and is slightly younger than the dolomitic Silurian containing Pentamerus in Cooks Range. Mr. Ulrich says: "The only other occurrence of a similar coral fauna in the far West known to me is that described by Dr. Kindle, who found it in southeastern Utah." On the basis of lithology, stratigraphic position, and fossils, these rocks in Luna County are correlated with the Fusselman limestone of the type locality in the Franklin Mountains, near El Paso, Tex.

DEVONIAN SYSTEM.

PERCHA SHALE.

A mass of black fissile shale lying between the Fusselman limestone and the Lake Valley limestone in Cooks Range lithologically resembles and is believed to represent the Percha shale, of which the type locality is in the Lake Valley mining district, not far north. No fossils were found, but the character of the material and its stratigraphic relations make the correlation reasonable. A small mass of similar shale a short distance north of Fluorite Camp is also believed to be the Percha shale. In Cooks Range the thickness is about 175 feet and the rock is a uniform black shale of moderate hardness separating into thin, brittle layers. It crops out extensively along the limestone slopes on both sides of the range northwest of Cooks post office, and there are two smaller exposures 2 miles east and 3 miles southeast of Cooks Peak. The southern of these exposures lies between porphyry and the overlying Lake Valley limestone. The shale is conspicuous along the road up the mountain at Cooks post office, where it overlies the ore-bearing Fusselman limestone. Its outcrop extends through the gap over which this road passes and far down the hollow on the west slope of the range. It appears again between the Fusselman and Lake Valley limestones north of the road on the west side of the ridge, and its outcrop extends up the slope to the northeast and, passing over the summit, is finally cut off by the great fault on the east slope. (See fig. 3, p. 70.)

In Fluorite Ridge there are two small exposures a short distance northeast of Fluorite Camp, but they extend only a short distance and are terminated by faults and porphyry. Here the shale lies in regular order under the Lake Valley limestone, but is separated from the Fusselman and Montoya limestones by faults. The Percha shale appears to be absent in the Florida and Victorio mountains. Some black shale cropping out a mile south of Gym Peak closely resembles it in appearance, but seems to be included in a regular succession of beds of the Gym limestone; possibly, however, it is cut off by overlap or faulting. Some dark shale overlies the Lake Valley limestone 1½ miles southwest of Cooks post office, but it contains numerous Pennsylvanian fossils.

CARBONIFEROUS SYSTEM.

CLASSIFICATION.

In Luna County the Carboniferous system is represented by portions of the Pennsylvanian and Mississippian series, apparently separated by a hiatus of considerable amount, and it is probable that in each series there is not a complete sequence of the sediments which appear in other regions. There is also an overlap of the higher limestone toward the south, for in the Florida and Victorio mountains the later Carboniferous rocks lie directly on the Ordovician limestones, and the Mississippian and the earlier Pennsylvanian, or Magdalena, appear to be absent. The later Pennsylvanian or Manzano group is represented by a thick limestone formation, and a still younger formation, here separated as the Lobo and tentatively assigned to the Triassic (?), may possibly represent the upper part of the Manzano.

LAKE VALLEY LIMESTONE.

DISTRIBUTION AND CHARACTER.

The Lake Valley limestone consists of rocks that are mostly of light-gray color and have massive to slabby bedding. Some limy shales are included between the more massive bodies of limestone, and at two localities dark shale members reach a thickness of nearly 100 feet. The thickness in the Cooks Range is between 600 and 700 feet, but the formation thins to the south and is absent in the Florida and Victorio mountains.

The most extensive exposures of the Lake Valley limestone in Luna County are in Cooks Range, where they constitute high ridges with prominent cliffs, nearly encircling the Cooks Peak igneous masses. Here the formation consists largely of gray limestone of light color and slabby bedding, lying on the Percha shale, except locally, where there has been intrusion of porphyry.

Most exposures in this region show a succession of massive cliffs of limestone 80 to 100 feet high separated by slopes of softer limy shale. The basal member consists of 150 feet of bluish-gray limestone with some chert in its lower portion. Next above is 50 feet of shale with layers of limestone, mostly very fossiliferous. The limestone constitutes the crest of the mountain west of Cooks post office and extends for some distance northward. In some places it is overlain by the Lobo formation, and in others it is cut off by faults or porphyry intrusions. It is extensively exposed in the deep canyons 2 miles south of Cooks Peak, where the Percha shale is overlain by 450 feet of limestone in three massive cliffs separated by steep slopes of limy shale. The upper cliff marks the outcrop of a body of hard limestone about 100 feet thick, which is overlain by the beds indicated in the following section:

Section of upper members of Lake Valley limestone, Gym limestone, and Lobo formation in Cooks Range just north of latitude 32° 30′ N.

	Feet.
Lobo formation:	
Conglomerate with limestone matrix	30
Shale, red	50
Conglomerate	10
Gym limestone:	
Limestone, nodule-bearing	5
Limestone, blue	20
Conglomerate, some red jasper	5
Lake Valley limestone:	
Limestone, cherty	3
Limestone, gray (Mississippian fossils)	3
Conglomerate or breccia of white chert	10
White chert with crinoid stems	20

The white chert lies on the massive limestone above mentioned and is a conspicuous bed in the ridges about Cooks Peak. The nodule-bearing limestone, blue limestone, and jasper-bearing conglomerate represent the Gym limestone, for the upper beds yield distinctive Manzano fossils on the west slope of the range. On the slopes southwest of Cooks Peak the cherty member is overlain by black to gray shale with thin impure limestone layers that yielded Magdalena fossils in considerable abundance, indicating that this formation locally overlies the Lake Valley limestone.

In the southwest end of Fluorite Ridge, half a mile northeast of Fluorite Camp, the Percha shale is overlain by a small thickness of limestone containing Mississippian fossils. Some of the relations at this place are shown in the section given in figure 10 (p. 86). The beds are cut off within a short distance by faults and intrusive porphyry. It has been stated that the limestone at the zinc mine at the north end of the Tres Hermanas Mountains is of Mississippian age, but as the fossils noted there are not distinctive of that epoch of geologic time it is believed more probable that the beds belong to the Gym limestone.

FOSSILS AND CORRELATION.

The Lake Valley limestone contains large numbers of fossils in some places, notably in the exposures south, east, and north of Cooks Peak. A collection made in the cliffs 4 miles northwest of Fort Cummings was determined by G. H. Girty as follows: Endothyra? sp., *Leptæna rhomboidalis*, *Productus semireticulatus*, *P. lævicosta?*, Productus aff. *P. burlingtonensis*, Schuchertella sp., Paraparchites sp., and Bairdia sp. From exposures on the northward slope of Cooks Peak were collected Triplophyllum sp., Fenestella sp., *Schuchertella chemungensis*, *Productus lævicosta*, *Spirifer suborbicularis?*, *S. centronatus*, *Composita humilis*, Rhombopora sp., Cystodictya aff. *C. pustulosa*, and Cladochonus sp. Some of these forms were also collected at other points along the Cooks Peak road and the slopes on the north. These fossils indicate that the limestone belongs to the Mississippian series of the Carboniferous.

Near the top of the mountain 1½ miles northwest of Cooks post office were obtained Menophyllum sp., Fenestella sp., *Rhipidomella pulchella?*, Productus aff. *P. wortheni*, *Spirifer centronatus*, and Paraparchites sp., all Mississippian forms. In limestones overlying the Percha shale, half a mile west by south of Fluorite Camp, were found *Spirifer centronatus*, *Leptæna rhomboidalis*, Pinnatopora sp., and several species of Fenestella.

MAGDALENA FORMATION.

CHARACTER AND OCCURRENCE.

High in the slopes on the northwest side of Cooks Peak some dark shale intervenes between the nodular limestone of the Gym limestone and the white chert at the top of the Lake Valley limestone. This shale is not more than 40 feet thick and it appears not to be of great extent, for erosion has removed most of the sedimentary rocks in the vicinity. It is of dark-gray color, but contains layers of limy shale and thin limestone, and in this respect differs from the Percha shale and the shale members in the Lake Valley limestone. Possibly it occurs in other portions of the area, but in exposures south and west of the peak chert and fossiliferous beds of the Gym limestone lie directly on top of the Lake Valley limestone.

FOSSILS AND CORRELATION.

This shale contains abundant fossils, which were determined as follows by G. H. Girty: Rhombopora sp., Lingulidiscina sp., *Derbya crassa*, *Chonetes mesolobus*, *Productus semireticulatus*, *Pustula nebraskensis?*, *Marginifera muricata*, Pugnax sp., *Spirifer cameratus*, *S. rockymontanus*, *Ambocœlia planiconvexa*, Aviculipecten, 2 sp., *Acanthopecten carboniferus*, *Lima retifera*, *Astartella vera*, *Edmondia subtruncata*, Phillipsia aff. *P. scitula*. This fauna is regarded by Mr. Girty as early Pennsylvanian and as belonging to the Magdalena group.

GYM LIMESTONE.

DISTRIBUTION, NAME, AND RELATIONS.

In the central and southeastern portions of the Florida Mountains and the central portion of the Victorio Mountains and extending part way around the north end of the Tres Hermanas Mountains there is a thick series of limestones to which it is proposed to apply the name Gym limestone, from Gym Peak, where the formation is extensively exhibited. The formation constitutes the summits of the high ridges at and northwest of Gym Peak and the two ridges west of The Park, and it extends down and along the east slope of the mountain east of Gym Peak. In this vicinity the formation is in several large detached masses capping fault blocks and cut off to the southeast by the great fault which uplifts the granite in the southern part of the mountain. Several small outlying masses are intricately faulted into the granite in the lower slopes 2 miles south of Gym Peak. The thickness of the formation is near 1,000 feet. It lies on an unevenly eroded surface of the Montoya limestone and in places on the top member of the El Paso limestone. In the Victorio Mountains it lies on or is faulted against the Montoya limestone, and in the Tres Hermanas Mountains it is uplifted and cut by the granite porphyry.

Overlying formations are not exposed in the Florida and Tres Hermanas Mountains but in the Victorio Mountains the Gym limestone is overlain by supposed agglomerate. The formation appears not to crop out in Fluorite Ridge, but a thin representative underlies the Lobo formation in Sarten Ridge and along the flanks of Cooks Range.

CHARACTER AND LOCAL FEATURES.

The formation consists chiefly of limestone, in greater part massively bedded, of light-gray color and showing a brecciated structure in many beds. In Gym Peak and vicinity the lower member is dark and the one next above it is much lighter in color, with an abrupt change from one to the other, and the thickness remaining in this area and west of the peak is at least 700 feet. In the canyon 1 mile southeast of Gym Peak limestone apparently in the middle of the formation dips steeply southeastward under 80 feet of dark-gray fissile shale which is traceable for about half a mile and again appears along the great fault on the trail a short distance west of Gym Peak. This black shale is overlain on the east by cherty limestone containing abundant Manzano fossils and this limestone is finally cut off by the great fault which crosses the mountain. To the east the Gym limestone of this area passes beneath the bolson deposits. In the outlier 2 miles south of Gym Peak the rock is a light-colored massive limestone weathering dark gray and containing many fossils. In the mass lying farther southwest the limestone lies in part on the coarse granite and in part on gray quartzitic sandstone about 12 feet thick, the sedimentary rocks apparently overthrust onto the granite. A few rods east and northeast of this outlier are several large irregular masses of the limestone, upon and into which the granite has been faulted with relations described on pages 73–75.

At the north end of the great mass of porphyry of the Tres Hermanas Mountains there are two extensive outcrops of the Gym limestone, separated by the large draw draining the north slope, and another area constitutes the westernmost ridge of the range. About the old zinc mines the limestones constitute a low ridge, in which the beds dip to the north and northeast at low angles. Along the porphyry contact the limestone is metamorphosed to marble and the more impure portions to hornfels. Two miles farther east the limestone appears again, flanking the porphyry for a mile or more and constituting a ridge of considerable prominence, which is a spur of the highest peak of the range. Here the beds dip to the northeast and north, and the limestone passes under gray quartzite, which is the highest member exposed. Marble appears at the porphyry contact, and several masses of this altered rock are included in the porphyry. The limestone extends for several miles along the eastern slope of the high peaks of these mountains, in some places in contact with porphyry and in others cut by rhyolite and keratophyre. It dips mostly to the east and southeast at low angles and 500 to 600 feet of beds are exposed, some of them very fossiliferous. Here also the limestone at the porphyry contact is largely metamorphosed to coarsely crystalline white marble, and some of it is included in the igneous body, notably one very large mass on the east slope of the southernmost of the three high peaks constituting the high northern ridge. The limestone in the westernmost ridge of the Tres Hermanas Mountains, west of the Hancock mine, overlies gray to red quartzite, of which 50 to 60 feet is exposed. The strata all dip to the west and over 400 feet of limestone is visible, some of which yields distinctive fossils. The quartzite appears to be the same as that overlying the limestone on the north side of the mountains, 2½ miles east of the zinc mines. Its relations on the east are hidden by igneous rock.

In the Victorio Mountains the Gym limestone constitutes the higher parts of the three limestone peaks south of Victorio Peak and extending for about a mile along a northwesterly course. It appears to lie on the Montoya limestone, but some Fusselman limestone may intervene. The lower beds are dark-gray limestone, partly brecciated, and the upper beds comprise slabby gray limestones.

The two small limestone knolls rising out of the bolson halfway between Tomerlin and the Tres Hermanas Mountains yielded Pennsylvanian fossils and are supposed to be Gym limestone continuous underground with the western ridge of the Tres Hermanas area, which strikes toward them.

The prominent limestone ridges 10 miles northeast of Arena, in T. 27 S., R. 5 W., present a series of beds dipping 15°–20° WSW. and exposing fully 400 feet of strata. The only fossil obtained here was a pelecypod resembling Schizodus and probably of Pennsylvanian age.

The Gym limestone in Sarten Ridge and Cooks Range appears as the beds rise from the great fault 4 miles northwest of Fort Cummings and extends across the range in the high northward-facing ridge 2 miles south of the peak. It is cut out by porphyry southwest of the peak, but comes in again northeast of the 55 ranch and is also exposed under the sandstone knobs to the north and east. It underlies a wide area of the cuesta east of Cooks post office and crops out in the cliffs on the north and northeast sides of this cuesta. In all this area it lies between the cherty limestone supposed to mark the top of the Lake Valley limestone and locally the black shale of the Magdalena formation and a 10-foot bed of conglomerate underlying red shale of the Lobo formation. Its total thickness here is only 25 to 30 feet, comprising 5 feet of nodular limestone at the top, 20 feet of blue limestone, and a 5-foot bed of conglomerate with some red jasper, which probably marks the base of the formation. The limestone contains abundant Manzano fossils at various places, notably in a gulch half a mile northeast of the 55 ranch. Possibly a small amount of the top of these beds appears in the Goat Ridge uplift and in the draw just north of the sandstone quarry a mile south of Fryingpan Spring. A small displaced wedge of the limestone is exposed along the fault a few rods northeast of this quarry, lying on conglomerate a few yards east of the road.

FOSSILS AND CORRELATION.

Fossils were found in various parts of the Gym limestone, and while most of them are stated by G. H. Girty to be distinctive of the Manzano group of the Pennsylvanian series they do not afford a sufficiently definite basis for correlation with any formation of that group in central New Mexico, nor do they indicate how much of the group is represented. Some of the gastropods strongly suggest the Hueco fauna.

In the small mass of limestone faulted into the granite on the south side of the Florida Mountains, 2 miles south of Gym Peak, were obtained Fusulinella sp., *Productus semireticulatus*, *Pugnax utah*, *Composita subtilita*, Astartella? sp., Bellerophon aff. *B. crassus*, Pleurotomaria sp., Euomphalus aff. *E. pernodosus*, Meekospira sp., and Orthonema sp., determined by G. H. Girty.

Fossils were obtained near the base of the formation west of Gym Peak, from beds above the black shale member southeast of Gym Peak, in the Victorio Mountains, from the nodular limestone east of the 55 ranch, from the beds east of the middle part of the Tres Hermanas Mountains, from the limestone ridge on the west side of the Tres Hermanas Mountains, and from the outliers east of Tomerlin. The following species from the beds over the black shale southeast of Gym Peak were determined by G. H. Girty: *Chonetes platynotus?*, *Marginifera splendens?*, *Echinocrinus ornatus*, *Bellerophon crassus*, and Phymatifer n. sp. Phymatifer n. sp. was also found in the area east of Tomerlin.

From slightly higher beds a short distance farther southeast of Gym Peak the following were collected: Fusulinella sp., sponge and sponge spicules, *Echinocrinus ornatus*, Productus aff. *P. semireticulatus*, Ambocœlia? sp., Composita sp., *Parallelodon politus?*, Astartella sp., *Plagioglypta canna?*, *Bellerophon crassus* var. *wewokanus?*, *Bucanopsis modesta*, *Pleurotomaria texana*, Pleurotomaria 3 sp., Murchisonia 4 sp., Discohelix? n. sp., *Rhynchomphalus obtusispira*, Sphærodoma aff. *S. humilis*, Sphærodoma aff. *S. primigenia*, Cyclonema sp., Glyptobasis? sp., *Orthonema socorroense?*, Orthonema sp., Pseudomelania? 4 sp., Zygopleura n. sp., Loxonema? 2 sp., and *Bulimorpha inornata*.

Echinocrinus ornatus was also collected from the Gym limestone near the Mahoney mine.

In a bed near the middle of the Gym limestone half a mile south of Victorio Peak the following species were obtained: Solenomya? sp., *Nucula levatiformis*, *Nucula levatiformis* var. *obliqua*, *Manzanella* *elliptica*, Edmondia sp., *Monopteria marian?*, Myalina sp., Schizodus sp., Pleurophorus sp., Astartella n. sp., *Plagioglypta canna?*, Murchisonia n. sp., Euomphalus? sp., Cyclonema? sp., and Sphærodoma? aff. *S. fusiformis.* In a bed somewhat lower in the formation exposed in the same draw were collected *Manzanella elliptica*, Astartella n. sp., Schizodus sp., Murchisonia n. sp., Naticopsis sp., and a number of undeterminable pelecypods.

In the extensive series exposed at the foot of the middle peak of the Tres Hermanas Mountains were collected *Meekella mexicana?*, *Productus cora*, *Composita mexicana?*, *Pinna peracuta*, *Bellerophon majusculus?*, and Euomphalus sp. In the beds on the ridge west of the Hancock mine, on the west side of the Tres Hermanas Mountains, were obtained *Productus occidentalis*, Productus sp., and *Squamularia perplexa.* These were all determined by G. H. Girty, who calls attention to the fact that the *Productus occidentalis* is a form characteristic of the limestone capping Sacramento Mountain at Cloudcroft, a bed which is very high in the Carboniferous.

The upper nodular limestones of the formation in slopes east of the 55 ranch southwest of Cooks Peak yielded Productus sp., *Composita subtilita*, and Euomphalus sp.

TRIASSIC (?) SYSTEM.

LOBO FORMATION.

RELATIONS AND NAME.

The shales, conglomerates, and impure limestones, herein designated the Lobo formation, lie unconformably on the Gym and older limestones and are unconformably overlain by the Sarten sandstone of the Comanche series in the Cooks Range region and by agglomerate in the Florida Mountains. They are called the Lobo formation from Lobo Draw, on the east slope of the Florida Mountains, where the rocks are extensively exposed. The thickness of the formation at that place is about 350 feet.

DISTRIBUTION.

The outcrop of the Lobo formation extends for about 5 miles in the higher slopes of the northern third of the Florida Mountains, which it crosses on a general northwesterly course. It lies on the Montoya and El Paso limestones to the north, but at Capitol Dome it overlaps granite uplifted by a pre-Lobo fault. From that place as far as it is exposed to the southeast it lies directly on a planation surface of granite. It is overlain by the agglomerate throughout this mountain range, and, while there is an apparent erosional unconformity at the contact there is no great discordance in dip.

Apparently the same formation appears again in the northeast face of the high ridge of Sarten sandstone in Cooks Range and in small outcrops on Goat Ridge and Fluorite Ridge. A small exposure is revealed in the deep hollow near the south end of Sarten Ridge, just north of the sandstone quarry. A closely similar formation lies between the andesite and the Gym limestone on the south side of the main high ridge of the Victorio Mountains, but as it includes conglomerates containing andesites and other eruptive rocks believed to be younger than Lobo, the deposit is regarded as part of the great agglomerate series.

CHARACTER AND THICKNESS.

The Lobo formation consists largely of reddish and gray shale and gray to pinkish impure limestone, but it includes much conglomerate at its base. In its overlap on the granite southeast of Capitol Dome there is some basal arkosic sandstone. A section on the west slope of Capitol Dome, beginning at the unconformity at the base of the agglomerate, is as follows:

Section of Lobo formation at Capitol Dome.

	Feet.
Sandstone, soft, reddish, with a few thin conglomerate layers and some limy beds (top)	50
Conglomerate, light colored, with limestone pebbles	8
Sandstone, pink, soft, with conglomerate streaks	30
Limestone, slabby, in bodies 3 to 10 feet thick, separated by buff and reddish shale with thin limestone layers; limestones weather buff	180
Shale, dark reddish	20
Limestone, massive, impure, with scattered pebbly streaks	10
Limestone, conglomerate, coarse, with chert and quartzite pebbles, red-sand matrix (bottom)	20
	318

The conglomerate lies on an irregularly eroded surface of the Montoya and El Paso limestones, but the dips of the three formations, as well as that of the overlying agglomerate, are all to the east at angles from 18° to 20°. A few rods southeast of the base of Capitol Dome the formation extends across the fault shown in figure 6 (p. 77), which lifts the granite to the level of the top of the El Paso limestone, a displacement of 1,000 feet or more. This feature indicates that the block, uplifted by this fault, was eroded to a plane before the deposition of the Lobo beds. Some of the limestone beds in the Lobo formation closely resemble lithographic stone but are harder and contain only 27 per cent of calcium carbonate, the remainder consisting of about 10 per cent of magnesium carbonate and of matter insoluble in acid. At the typical locality in Lobo Draw the formation consists largely of buff and red shale and massive, very fine grained sandstone and limestone.

In the Cooks Range exposures the formation is thinner and presents certain differences in stratigraphy but no more than might be expected in a formation of this character. A section measured at the north end of Sarten Ridge, at a point 4 miles northwest of Fort Cummings, is as follows, beginning at the first bed below an apparent marked unconformity at the base of the Sarten sandstone:

Section of Lobo formation and underlying strata at north end of Sarten Ridge.

	Feet.
Lobo formation:	
Sandstone, snuff-colored	20
Conglomerate with limy matrix	25
Shale, red	40
Conglomerate	10
Gym limestone:	
Limestone, nodular, in red shale	5
Limestone, blue	20
Conglomerate, with some red jasper	5

The three beds at the base of this section doubtless represent the Gym limestone, for the nodular bed contains Manzano fossils on the west slope of the range.

AGE AND CORRELATION.

No fossils were found in the Lobo formation, so that its age is not determined. In the central part of Cooks Range it lies unconformably on the Gym limestone, of late Pennsylvanian age, and is also separated from the overlying Sarten sandstone (Lower Cretaceous) by an unconformity; hence its age may be Pennsylvanian, Permian, Triassic, or even earliest Cretaceous. Because of its unconformable relations with both the overlying and underlying formations, however, the Lobo is tentatively classified as Triassic (?).

CRETACEOUS SYSTEM.

CLASSIFICATION.

In Luna County the Cretaceous system is represented by Lower Cretaceous rocks carrying Washita and Trinity fossils and by the Colorado shale, of Upper Cretaceous age, the intervening formations apparently being absent, and higher formations being either absent or hidden beneath much later deposits.

Rocks of Washita age crop out extensively on the flanks of the central part of Cooks Range, in Fluorite Ridge, and in Goat Ridge northwest of China Tank. Limestones apparently of somewhat lower position in the Comanche series constitute the prominent buttes at the north end of Sierra Rica, in the southwest corner of the county (Pl. VII, *A*, p. 15). In the region north of Deming the rocks are mainly hard massive sandstone, for which the name Sarten sandstone is proposed.

LIMESTONE OF COMANCHE AGE.

CHARACTER AND RELATIONS.

The ridges constituting the northern extension of the Sierra Rica, in the extreme southwest corner of Luna County, consist of limestones of Comanche (Trinity) age. They are similar to the Mural limestone, described by Ransome in the Bisbee folio, but it is thought undesirable to correlate them at present. In the lower slopes of these hills, at the International mine, there are alternating beds of limestone and limy shales, apparently of Washita age, which dip toward the buttes, but are doubtless separated from them by a fault. The greater part of the area is shown in Plate I (in pocket). The limestone of the buttes is a rock of light blue-gray color, in part massive and in part thin bedded. About 400 feet of it is exposed, and the beds dip to the north at a low angle. On the southeast slopes are limy shales and alternations of shale and limestone containing many fossils. The ledges of these rocks extend to the International mine, northeast of which there are ledges of gray quartzite, apparently at a lower horizon, but possibly separated by a fault.

FOSSILS AND AGE.

Fossils were collected in the limestone along the south slopes of both of the larger limestone ridges at the north end of Sierra Rica. They were determined by T. W. Stanton as a small terebratuloid, apparently closely related to *Kingena wacoensis* Roemer, which is common in the Comanche series, and the foraminifer *Orbitolina texana* (Roemer), which is characteristic of the Trinity group of the Comanche series. The former are very abundant. These fossils indicate a horizon the same as or near to that of the Mural limestone of the Bisbee quadrangle.

Impure limestone and shaly beds exposed in the flats just southeast of these ridges, a short distance north of the International mine, contain Ostrea, Corbula, Anchura, Turritella, and a few other fossils, including a great number of large Exogyras related to *E. quitmanensis* (Cragin), which are believed to be of Washita age. This evidence of fossils indicates that there is a fault between the limestone ridges yielding Trinity fossils and the flats where the Washita fossils were obtained.

SARTEN SANDSTONE.

OCCURRENCE AND RELATIONS.

The most extensive exposure of the Sarten sandstone is in the prominent southern extension of Cooks Range, known as Sarten Ridge, and the name, which is used here for the first time, is taken from that locality. Fluorite Ridge is also capped by the rock, and it is brought to the surface in the dome-shaped uplift of Goat Ridge. It constitutes the high cuesta or sloping plateau north and east of Cooks post office and appears in several knobs and ridges adjoining the porphyry of the Cooks Peak intrusion south of that post office and east and south of the 55 ranch. Most of these areas are cut off by faults or igneous rocks, and some of the outcrops slope down into the agglomerate of the bolson. At the north end of Sarten Ridge, in the Cooks post office area, in Goat Ridge, and in a canyon on the southeast side of Sarten Ridge the Sarten sandstone is exposed, lying without notable discordance of dip on the Lobo formation, which shows but slight evidence of erosion.

In the Pony Hills, north of Fluorite Ridge, the sandstone lies directly on or against granite, but apparently this relation is due to faults. In the eastern slope of the Pony Hill area a separating fault is well exposed. Some of the relations at this place are shown in figure 11 (p. 88).

At four localities south, southwest, and east of Cooks Peak and half a mile south of the 55 ranch the Sarten sandstone is overlain by Colorado shale without discordance of dip or other evidence of unconformity to represent the long interval between Washita and Colorado time.

CHARACTER AND THICKNESS.

The Sarten sandstone consists almost entirely of light-gray, massive sandstone, most of it quartzitic or very hard. Some beds are slabby and a few of them contain a little calcium carbonate. At the base there is more or less conglomerate, part of it containing angular and subangular fragments. The thickness of the formation in Sarten Ridge, Goat Ridge, and the ridges east of Cooks post office is 300 feet, but in many areas the top has been removed by erosion or covered by later deposits. Faults and porphyry cut off the lower beds in various places.

FOSSILS AND CORRELATION.

Most portions of the Sarten sandstone are barren of fossils, but some beds contain them in abundance and in excellent state of preservation. This is notably the case in the east slopes of Sarten Ridge about a mile north of Fryingpan Spring, where limy beds not far below the middle of the formation yielded the following forms: *Cardita belviderensis* Cragin, *Cardium kansasense* Meek, *Protocardia texana* Conrad, *P. quadrans* Cragin, *Tapes belviderensis* Cragin?, Turritella aff. *T. seriatim-granulata* Roemer, Ostrea sp., Nucula sp., Trigonia sp., Lunatia sp., Cyprimeria sp., and Anchura sp. These were determined by T. W. Stanton, who states that they represent the forms of the Washita group of the Comanche series and show about the same faunal facies as that found in the marginal deposits of southern Kansas and near Tucumcari, N. Mex. The following fossils, obtained in the west end of Fluorite Ridge at apparently about the same horizon as at the locality northwest of Fryingpan Spring, were determined by Mr. Stanton: Ostrea sp., Trigonia sp., Leptosolen sp., Homomya sp., and Turritella sp.

COLORADO SHALE.

DISTRIBUTION.

The Colorado shale crops out at three places in Luna County, two of them in the north edge of the structural and topographic basin west of Fryingpan Spring and the other in a small syncline 2 miles southwest of Cooks Peak. The outcrops are small, but probably the shale underlies a large part of the basin north of Goat Ridge, and there may be much of it under the great bolson deposits in other parts of the country. The most extensive outcrop is 2½ miles northwest of Fryingpan Spring, where the shale occupies an area of nearly 1 square mile and the strata dip gently to the southwest. To the east are slopes of the Sarten sandstone, and at the north the shale is cut off by a large mass of porphyry intruded near its base. To the south and west the shale passes beneath bolson deposits and agglomerate, but it rises again with steep dip in a narrow outcrop zone along the foot of the Sarten sandstone ridge which lies 4 miles south-southwest of Cooks Peak. The exposures 2 miles southwest of Cooks Peak are mainly in a small low mound along a draw a few rods east of the main north and south road. Here the beds lie in a local deepening of a syncline of the Sarten sandstone. A narrow area of Colorado shale extends along the foot of the mountain east of Cooks Peak from Cooks post office to the south line of T. 20 S. It lies on the Sarten sandstone in part in a syncline and cut off on the west by the fault. It is also cut off on the southeast by a fault separating it from the agglomerate series.

CHARACTER AND RELATIONS.

In the easternmost area above described there are about 200 feet of beds exposed. They consist mainly of dark shale with interbedded layers of sandstone and sandy shale and several thin beds of dark blue-gray limestone which weathers to a dirty buff color. The uppermost shale is darker than that below, and a few feet of slabby buff sandstone appears at one point where the formation passes beneath the overlapping agglomerate. The shale is separated from the underlying Sartèn sandstone by abrupt change in character of materials, but there is no noticeable discordance of dip, and coarse fragmental sediments are lacking. There is probably at this horizon a hiatus representing the Dakota sandstone and associated beds, covering a considerable portion of early Upper Cretaceous time.

FOSSILS AND AGE.

Numerous fossils occur in the Colorado shale at all outcrops. The following were determined by T. W. Stanton: *Gryphæa newberryi* Stanton, *Inoceramus labiatus?* Schlotheim, Metoicoceras sp., and Prionotropis sp. These forms all belong to the Benton fauna. The little Gryphæas weather out in large numbers from some of the beds and accumulate on the surface. One limestone layer near the middle of the beds exposed contains many scattered cephalopods, which are difficult to obtain in good condition.

Fossils are numerous in a sandy layer at the eastern margin of the outcrop zone 2 miles west-southwest of Wallace's ranch, each of Cooks Peak. At this place the following were collected: Ostrea sp., Gryphæa? sp., Modiola sp., Astarte sp., Veniella? sp., Anatina? sp., Corbula sp., *Glauconia coalvillensis* (Meek)?, Volutoderma? sp., and Fasciolaria? sp. They were determined by T. W. Stanton, who regards them as Upper Cretaceous. They are casts, and several appear to be undescribed species.

TERTIARY SYSTEM.

AGGLOMERATE AND ASSOCIATED ROCKS.

CHARACTER AND RELATIONS.

In Luna County the Tertiary system is represented mainly by a great thickness of irregularly stratified, nonfossiliferous deposits, chiefly of volcanic origin and pyroclastic character, interbedded with intrusive sheets and volcanic flows. The material consists of agglomerate, tuff, volcanic ash, flows of volcanic mud, and some flow breccias. The greater part of the finer material was wind borne, but portions have been deposited or rearranged by water. Some beds of sand, sandstone, gravel, and conglomerate of ordinary detrital origin are also included. The thickness of the deposits is more than 2,000 feet, and as they are extensively exposed in nearly all the ridges it is probable that they also underlie a large part of the bolson areas. They lie unconformably on various formations up to and including the Colorado shale, of middle Upper Cretaceous age, and are regarded as Tertiary, although the lower part may be late Cretaceous, and some of the beds at the top may be of Quaternary age. They are overlain unconformably by the Quaternary bolson deposits. The thick sheets of volcanic flows of various kinds which are interbedded at intervals in parts of the area were the products of intermittent volcanic eruptions. The deposits are also cut by dikes, some of them the feeders of the eruptive flows.

The typical agglomerate, which is the predominating deposit, is a massive rock, mostly very hard, made up of angular masses of eruptive rocks, chiefly dark-gray andesite or purplish latite embedded in a matrix of tuff or ash. In places the matrix is crystalline and the rock is probably of a flow breccia. There are also mud flows and thin sheets of lava, which have flowed over the unconsolidated deposits and become mixed with a large amount of fragmental ejected material. Accumulations of tuff and other volcanic materials deposited in part, at least, by water are of common occurrence, including irregular bodies of volcanic ash of considerable thickness and extent. Some of the water-laid material consists of ordinary sand and gravel, the detritus of various rocks, sedimentary and volcanic, now mostly hardened to sandstone or conglomerate, but in some places difficult to distinguish from the bolson deposits.

DISTRIBUTION.

The most extensive exposures of the pyroclastic rocks are in the north end of the Florida Mountains, the crest and east side of the Little Florida Mountains, the east side and south end of Cooks Range, the wide area northeast of Cooks Range, the Carrizalillo Hills, the Cedar Grove Mountains, the southeast and northeast slopes of the Tres Hermanas Mountains, the west slope of the Goodsight Mountains, the Fourmile Hills and Taylor Mountain area, the valley of the Mimbres above Taylor Mountain, and under the andesite in the Victorio Mountains. Smaller exposures occur about Fluorite Ridge, on Goat Ridge, at the south end of the Burdick Hills, at a few points about the Cow Spring Hills, and in the southwest corner of T. 27 S., R. 5 W. There is a very small outcrop on the south side of Red Mountain. Ash and gravel under the basalt of Black Mountain are classed with this formation, but may be somewhat younger than the main body of agglomerate in other areas.

LOCAL FEATURES.

The agglomerate forming the rugged peaks and deeply dissected slopes of the north end of the Florida Mountains exhibits the relations shown in the sections in figure 3 (p. 70). The thickness exposed is about 1,600 feet, but as a portion has been removed by erosion, doubtless there is more of it under the bolson east of the mountains. It lies unconformably on the Lobo formation, but without notable discordance in the dip, which is at a low angle to the east and northeast. Much of the agglomerate in the Florida Mountains is a hard gray rock in massive beds, which are 50 to 80 feet thick in many places. These beds consist mostly of large angular fragments of andesite and other contemporaneous eruptive rocks in a matrix of partly crystalline nature. Toward the base at Capitol Dome there is an alternation of less massive beds, as follows:

Section of pyroclastic rocks at Capitol Dome.

	Feet.
Agglomerate, very massive, purplish gray	150
Sandstone, gray to reddish	4
Conglomerate, coarse, bowlders 1 to 6 inches, mostly volcanic rock, but some blue limestone and coarse reddish granite	30
Sandstone slabby, light dirty green, made up mostly of comminuted volcanic rocks	12
Conglomerate, coarse, bowlders, largely volcanic rocks, some blue limestone and coarse red granite	10
Agglomerate, massive, fine grained, and tuff full of small angular fragments of eruptive rocks (andesite, etc.)	50
Keratophyre flows, slabby to massive, gray, fine grained, with beds of andesite tuff in layers of varying thickness, some showing mud cracks	40
Agglomerate, with rounded to subangular masses of andesite, bedded	25
Keratophyre flow, gray, slabby, fine grained	3
Conglomerate, coarse, with rounded bowlders of andesite, limestone, granite, etc	20

The basal bed lies unconformably on 50 feet of soft reddish sandstone of the Lobo formation, and, although there is some evidence of erosion at the contact, there is no noticeable difference in direction or rate of dip. In places the middle and upper members of the series contain finer-grained beds, such as the body of fine-grained light-colored tuff that has been quarried for building stone on the east end of a spur 2 miles northeast of Arco del Diablo. The agglomerate in the faulted block 1½ miles southeast of Arco del Diablo is capped by a thin sheet of hornblende-augite andesite considerably leached and carrying masses of epidote.

The agglomerate in the Little Florida Mountains has the relations shown in figure 7 (p. 78). Part of it underlies the great sheet of felsitic rhyolite, but the greater part lies above that sheet and dips gently eastward down the east slope of the range. Presumably this body is at a higher horizon than the agglomerate in the Florida Mountains, but nothing could be ascertained as to the relations owing to the covering of bolson deposits in the intervening gap. The agglomerate above the rhyolite is a massive deposit of dark-reddish coarse angular to subangular fragments, some of them 4 feet in diameter. This rock gives rugged topography to the top and west slope of the mountains, notably in the deep canyon just north of Black Rock. The coarse deposit thins greatly at the low pass across the range toward its north end. Possibly it gives place to finer sediments, for volcanic tuff and ash are exposed in slopes just east of the northern ridge of the mountains. The deposits exposed underlying the main igneous flow are mostly tuff and volcanic ash, in places considerably silicified.

A thick succession of agglomerates, tuffs, ash beds, and eruptive sheets is exposed in the various ridges constituting the south end of Cooks Range. It is cut off on the west by the great fault and on the east it passes beneath the bolson deposits. Besides the igneous materials the series includes sandstone and sand, and some of the fragmental material of igneous origin or nature has been deposited by water. Some brecciated mud flows are included, probably the edges of the larger eruptive sheets or small separate extrusions. The beds are all uplifted to moderately high angles, so that the general order of succession is exhibited from southwest to northeast. It begins with a thick series of agglomerates and ash including some sandstone that is prominent in two high buttes 3 miles northwest of Mirage Siding, where the rock is a red quartzite. In the next series of ridges to the north there is tuff overlain by several sheets of andesite and latite; then follow quartz basalt and hornblende-mica rhyolite interbedded in gray agglomerate and beds of volcanic ash. The succession is irregular, but some of the beds of fragmental rocks and igneous sheets crop out continuously for 5 to 6 miles along the strike. The thicknesses vary greatly, however, especially that of the bodies of volcanic ash, which thicken and thin within short distances.

Extensive exposures of fragmental volcanic rocks of various kinds appear about the foot of Fluorite Ridge, Goat Ridge, and the south slope of Cooks Range west of Sarten Ridge. They include some agglomerate and many beds of ash and tuff, and also of sandstone composed mostly of grains of volcanic rocks.

The material under the basalt cap of Black Mountain is largely waterlaid, but it consists mainly of rocks of volcanic origin, beds of ash, and more or less tuff. In all, about 400 feet of these materials lie above the level of the bolson at the south end of the mountain. The eastward dip of their own bedding and also of the basalt cap carries them beneath the surface to the east.

The agglomerate series in the Victorio Mountains lies on the Gym limestone and is overlain by andesite. The dips are somewhat west of north at angles close to 20° throughout, and the thickness of the deposit is about 700 feet. There is no great difference in attitude between the agglomerate and the limestone. The younger formation begins with red sandstone and reddish to purplish-brown shale, with included conglomerate deposits. Some of the conglomerate is very coarse and contains pebbles and bowlders of andesites and other volcanic rocks, and it is because of this evidence that the formation is not correlated with the Lobo formation, which it closely resembles in all other respects. Near the top are green sandstones and coarse conglomerates with limestone pebbles, some containing Carboniferous fossils. Dark purplish-brown fine-grained massive shale or sandstone is the predominating rock in the formation in this region. Some of the dark beds contain considerable calcium carbonate.

The tuff at the Mimbres Dam site is a white massive rock near rhyolite in composition, in which the groundmass is probably albite.

A tuffaceous agglomerate of rhyolitic composition constitutes part of Taylor Mountain. It is a light-pink rock of medium density containing fragments of pumice and small, apparently waterworn pebbles, showing the fragmental character of the rock. The microscope reveals fragments of quartz and cloudy microcline, or microcline and quartz, as well as of various kinds of aphanitic rocks, embedded in a matrix consisting of angular pumice and a formless mass of nearly isotropic character, doubtless fine ash. The fragments of quartz and microcline, particularly the latter, are most certainly derived from a granite. The whole agglomerate is probably a reworked tuff in which granitic sand became incorporated.

A rock of almost exactly similar character is found 3 miles northeast of Taylor Mountain, along the side of Mimbres Valley. A short distance farther east, near the Grant-Luna county line, there is a white rhyolitic tuff showing distinct stratification. It is overlain by a sheet of pink rhyolite bearing numerous fragments of pumice, and this in turn is overlain by andesite.

The exposure of agglomerate at the foot of the south slope of Red Mountain extends only a few rods and is but a few yards in width. The material is a typical agglomerate with angular fragments, largely of dark purplish-gray rock, apparently hornblende-augite latite, in a matrix of finer material of the same general character. A low mound of bluish-gray agglomerate rises above the bolson on the south point of the Burdick Hills, 5 miles southwest of Iola. It is cut by dikes of various kinds, one of latite and another of quartz porphyry 10 feet wide.

AGE.

The agglomerates and associated rocks have yielded no fossils. To judge by their relations here and in adjoining areas they were accumulated during Tertiary time and probably in the later part of that period. Possibly the agglomerate is later than the porphyry intrusions, but no fragments of the porphyry have been observed in the agglomerate, and at one or two points in Cooks Range some features suggest that the agglomerate is cut by porphyry dikes. The time of deposition of the upper members of the agglomerate series may have continued into the Quaternary, for the relatively young basalts lie on volcanic ash and tuff deposits, and the earliest of the agglomerates may be as old as late Cretaceous.

QUATERNARY SYSTEM.

BOLSON DEPOSITS.

Luna County contains many thick deposits of sand, gravel, and clay of Quaternary age. In greater part they underlie the wide bolsons, and their smooth top surfaces are not incised very deeply by the present streams. Along the lower flats are accumulations of recent alluvium, but these can not be separated from the older deposits. Some portions of the alluvium consist of loose sand which blows from place to place, giving rise to local sand dunes, a feature mainly confined to the country along Mimbres River near Deming and the sandy slopes northeast of Arena. More or less of the talus accumulating on the slopes of hills and mountains is of Quaternary age, but its limits are too indefinite for representation on the geologic map.

The thickness and character of the deposits in the great bolsons between the mountains is known at certain localities from well borings, a few of which have reached the "bedrock." A deep hole bored in Deming in 1887 entered rock at 963 to 980 feet, having passed through a succession of clay, sand, "cement," and gravel in alternating deposits 5 to 18 feet thick. The detailed record of a 950-foot boring at Lenark, a station on the Southern Pacific Railroad 60 miles east of Deming, shows a succession which is probably characteristic, although possibly some of the materials reported as sand and clay may be soft sandstone and shale of Cretaceous or Tertiary age. The following is the record as given by the driller, H. F. Gansirer:

Record of deep boring at Lenark, N. Mex.

	Thickness.	Depth to base.		Thickness.	Depth to base.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Red soil	13	13	Sand	106	562
Chalky clay	2	15	Red clay	28	590
Sandrock, hard	63	78	Yellow clay	50	640
Cemented stones	47	125	Sandstone, soft	26	666
Red clay	61	186	Sandstone, hard	2	668
White sand	18	204	Yellow clay	32	700
Sandy clay	10	214	Sand	10	710
Sand	12	226	Sandy clay	20	730
Red clay	26	252	Clay	20	750
Sand	38	290	Sand	25	775
Cemented sand, hard	4	294	Clay, hard	6	781
Red clay, hard	42	336	Yellow clay	19	800
Yellow clay	46	382	Sand	10	810
Sand	14	396	Sandy clay	30	840
Red clay, hard	32	428	Sand	30	870
Quicksand	18	446	Sandy clay	22	892
Cemented sand	6	452	Clay	8	900
Clay	4	456	Sandy clay	50	950

The following is a representative well record of the region northeast of Deming:

Record of well in the SW. ¼ sec. 30, T. 23 S., R. 7 W.

	Thickness.	Depth to base.		Thickness.	Depth to base.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Loam and clay	22	22	Sandrock	2	65
Gravel	2½	24½	Quicksand	1	66
Clay	4½	29	Gravel and sand, water bearing	6	72
Gravel with much water	5½	34½	Clay	3	75
Sand, tightly packed	5½	40	Gravel, coarse	1	76
Clay	10	50	Gravel, water bearing	3	79
Sand, tightly packed	5	55	Sandrock, soft	32	111
Clay	8	63			

In the Columbus region several borings penetrated basalt, evidently in thin sheets, included between sands and clays of the bolson deposits. Some features of the materials constituting the higher plain at the south end of the Tres Hermanas Mountains are exposed in deep railroad cuts east of Mimbres. The rise of the railroad grade here is 333 feet, but the only good exposures are in cuts through the upper deposits. These consist of soft pebbly sandstones and conglomerates in thick beds dipping 30° ENE. In the 200-foot rise at the western edge of the higher plain or plateau east of Arena the materials are more sandy, and in places there are soft sandstones, which are probably of Quaternary age but may be Tertiary.

CENOZOIC IGNEOUS ROCKS.[1]

CHARACTER AND AGE.

A great variety of younger igneous rocks are exposed in Luna County, comprising mainly porphyry of several varieties, an ex-

[1] The petrographic descriptions under this heading have been supplied by John L. Rich.

tensive series of latites, andesites, rhyolites and felsitic rhyolites, and basalt. The porphyry is in laccoliths and sills cutting strata as young as late Cretaceous and is believed to be of early Tertiary age. The latites, andesites, and rhyolites are mainly flows included in a great deposit of volcanic agglomerate and other fragmental material, regarded as of later Tertiary age, which underlies a large part of the region and rises in great prominence in the north end of the Florida Mountains and the ridges farther north. The order of succession of igneous flows in the agglomerate series is andesite, quartz latite, olivine-bearing andesite or quartz basalt, rhyolite and felsitic rhyolite. Keratophyre and quartz keratophyre occur in dikes and thin sheets, but their stratigraphic position is not clear, and there is also some doubt as to the relative position of the felsitic rhyolites. The basalt occurs as lava flows on Quaternary sediments and in dikes.

EARLY TERTIARY IGNEOUS ROCKS.

QUARTZ MONZONITE PORPHYRY AND SODIC GRANITE PORPHYRY.

Distribution.—Large masses of intrusive porphyry occur in Cooks Range west of the great fault, and Cooks Peak consists of that rock. A large irregular laccolith about 3 miles long constitutes the greater part of Fluorite Ridge. There are several dikes and sills offshooting from the larger masses, notably on the west slope of Cooks Range at Cooks post office and in Sarten Ridge. A small sill of similar rock is intruded in limestone south of Victorio Peak. Another small mass appears in a butte 3 miles east of Arena, and dikes of similar rock cut granite south of Capitol Dome. The porphyry cuts strata from Cambrian to later Cretaceous in age and probably also cuts the agglomerate or a part of it. It appears, however, to be older than any of the great flows in the agglomerate series. Therefore it is believed to be of early Tertiary age.

Character.—There is considerable variation in the character of the rock which ranges, with all gradations, from sodic granite porphyry to quartz monzonite porphyry and even to granodiorite porphyry. The porphyry in Fluorite Ridge and along the south side of the Cooks Peak mass has a dark-gray groundmass with white feldspar phenocrysts and abundant small hornblendes, while about Cooks Peak the groundmass is much lighter in color, the feldspar phenocrysts are larger, and the hornblende is much less abundant.

Petrography.—The sodic granite porphyry from Fluorite Ridge, which may be regarded as typical for the northern part of the area, is a porphyritic gray rock with phenocrysts of feldspar (mainly albite), hornblende, biotite, and quartz in a dark-gray felsitic groundmass. Hornblende and biotite in about equal proportions, generally more or less altered to chlorite, occur in subordinate amounts. Quartz phenocrysts, many of them resorbed, are moderately abundant. The groundmass is essentially orthoclase and quartz with a little albite and augite.

The dikes and sills extending out from the larger masses present some variations from these features, either in a diminished amount of quartz, with increase in the proportion of hornblende, which occurs characteristically as long crystals, in places crossed or even as rosettes, or in a change to the more calcic feldspars—oligoclase and andesine—which mark the transition to typical quartz monzonite porphyry. The rock from the south slope of Fluorite Ridge is representative of these quartz monzonite porphyries. The phenocrysts are mainly andesine grading to albite in the outer zones, biotite, and quartz. The groundmass is a mosaic of quartz and orthoclase. The porphyry 1½ miles south of Cooks Peak contains more hornblende, a little more calcic feldspar, and less quartz in the groundmass than the rock just described and is typical quartz monzonite porphyry, as is also the rock near the fault 2 miles southeast of the peak.

The porphyry in the mass east of Arena is similar to the rock of Cooks Range but has larger phenocrysts of andesine.

Lindgren [1] has described the rock of Cooks Peak as a massive porphyry of gray color with prominent phenocrysts of andesine feldspar, many of which exhibit marked zonal structure. There are also a few crystals of hornblende and biotite; magnetite is relatively abundant, the groundmass is microcrystalline granular and consists essentially of the same minerals, together with quartz and orthoclase. The ferromagnesian minerals are partly altered to chlorite. Lindgren gives the following chemical analysis and norm:

Analysis of porphyry at Cooks Peak.

[By George Steiger.]

SiO_2	62.95	Na_2O	4.05	BaO	0.03
Al_2O_3	15.91	K_2O	2.95	SiO	.03
Fe_2O_3	3.30	H_2O	1.19		
FeO	1.37	TiO_2	.67		100.07
MgO	2.18	P_2O_5	.18		
CaO	4.46	MnO	.08		

Norm of porphyry of Cooks Peak.

[Calculated by B. S. Butler.]

Quartz	16.62	Diopside	3.89	Ilmenite	1.37
Orthoclase	17.79	Enstatite	3.60	Apatite	.34
Albite	34.06	Magnetite	2.55		
Anorthite	16.40	Hematite	1.60		98.22

[1] U. S. Geol. Survey Prof. Paper 68, p. 37, 1910.

In the quantitative system the rock is a dacose. By the ordinary classification it is best designated as a granodiorite porphyry, as it contains too much plagioclase to be termed a quartz monzonite.

GRANITE PORPHYRY.

Occurrence.—The peaks and higher portions of the Tres Hermanas Mountains consist of a porphyritic granite or granite porphyry which is intruded into limestones of later Carboniferous age. The mass is a large one, for the igneous rock exposed is 800 feet or more thick and occupies an elliptical area 5 miles long by 2½ miles wide. The rock cuts across and penetrates the limestone and includes huge masses of it. The sedimentary rock is metamorphosed into marble near the contacts, and various minerals are developed along them. The porphyry is a coarse-grained rock of massive structure and relatively uniform character throughout, except that the grain is slightly finer near the contacts with limestone. The rock is of light-gray color, but it weathers to a light-brownish tint, and the porphyritic character is brought out by weathering. A small mass of somewhat similar rock crops out in a butte 10 miles northeast of Arena, lying on agglomerate.

Petrography.—The rock of the Tres Hermanas Mountains has the composition of granite but differs considerably in aspect and composition from the pre-Cambrian granites of the Florida Mountains and the area to the north. Lindgren[1] calls it a coarse granite porphyry and gives the following description of a sample collected near the zinc mine:

> The rock is brownish gray and contains phenocrysts of orthoclase up to 15 millimeters in length, also small foils of biotite and small crystals of dark-green hornblende. Some oligoclase is associated with the orthoclase; the groundmass is micropegmatitic, consisting of quartz and orthoclase.

Of samples collected on the northern slopes of the mountains two were found to contain quartz in normal amount for a granite, orthoclase, the most abundant feldspar, with small amounts of oligoclase and albite, considerable biotite, and some hornblende. Another sample from the northeast corner of the Tres Hermanas area had abundant quartz and albite, considerable orthoclase and hornblende, and a small amount of biotite.

The rock in the butte northeast of the Birchfield ranch, in the southeastern corner of the county, contains abundant quartz and albite as the principal feldspar. Ferromagnesian (mafic) minerals are scarce.

[1] Op. cit., p. 38.

LATER TERTIARY IGNEOUS ROCKS.

GENERAL RELATIONS.

The series of eruptive sheets interbedded at several horizons in the great succession of agglomerates and other fragmental rocks underlying much of Luna County comprises rocks of various kinds, mostly in widespread flows. These rocks crop out most extensively in the ridges extending along the east side of Cooks Range and constituting the southern extension of that range. The Little Florida Mountains contain a thick eruptive sheet; the Cedar Grove Mountains, Carrizalillo Hills, Fourmile Hills, and Taylor Mountain consist of a succession of flows and tuffs, and there are extensive flows in the Cow Spring Hills and on the flanks of the Tres Hermanas Mountains. Grandmother and Red Mountains and the high northern ridge of the Victorio Mountains consist of igneous rocks. Smaller areas appear in the Midway and Burdick hills, the hills north and east of Arena, and a number of low mounds rising out of the bolson. There are also many dikes and a few stocks, and doubtless extensive areas are hidden beneath the bolson deposits. In the great succession of flows and agglomerates, tuffs, and ash on the east side and south end of Cooks Range there is a wide area in which the sheets dip 5° to 40° NE., indicating a thickness of more than 2,000 feet, allowance being made for some duplication of outcrops by faulting. From two to six thick sheets of eruptive rocks are interbedded in the succession. Some of them are of great extent but others are small, so far as can be judged from outcrops. The largest flows in this area, which are near the middle of the series, consist of latite. The flows below the latite are andesite and those above are andesite, quartz basalt, and rhyolite. In the Little Florida Mountains the agglomerate includes a thick sheet of felsitic or vitreous rhyolite with local intrusions of keratophyre. The thick mass of agglomerate at the north end of the Florida Mountains consists largely of fragmental material with thin local sheets of keratophyre. The total thickness of the succession in the mountains appears to be between 1,700 and 1,800 feet in the great eastward-dipping mass which rises out of the bolson. The relations of these three large series of volcanic rocks to one another is not known, but the mass in the Little Florida Mountains appears to be stratigraphically higher than the mass in the Florida Mountains and probably represents at least a portion of the series appearing in Cooks Range. The agglomerates are described on pages 45–50. The wide area of agglomerate northeast of Cooks Range was not examined in detail and it contains several sheets of eruptive rock which are not shown on the map (Pl. I).

QUARTZ LATITE.

Relations and character.—The latite occurs mainly as flows, most of them thick and of great extent, interbedded at several horizons among the agglomerate and other pyroclastic deposits. Some of the masses are dikes in the agglomerate, doubtless feeders of surface flows. The largest outcrops are in the south end of Cooks Range and in the Cedar Grove Mountains. The rocks are compact but mostly coarse grained, of purplish-gray color, and of more or less porphyritic character, showing light-colored feldspar, dark hornblende, and in most specimens biotite. Some are dark gray and vesicular, others are of lighter color and include considerable tuff, and many of them are more or less deeply weathered. The rocks vary somewhat in mineral constitution, mainly in the amount of augite, which is lacking in some of the masses, and in quartz, which as a rule occurs in greater or less amount in the groundmass. Some of the latite resembles the andesites, but differs in containing a larger amount of potash feldspar, a distinction discernible only under the microscope; generally, however, the latites are much coarser grained and of lighter color. Varieties of the latite are difficult to separate in the field, and apparently they occur not only in separate flows but in different portions of the same mass.

Distribution.—The largest bodies of latite constitute the crest and part of the slopes of the Cedar Grove Mountains and of the south end of Cooks Range 5 miles west and southwest of Florida station. At the latter place there are two principal sheets separated by a varying thickness of agglomerate, ash, and other fragmental deposits, all dipping 10°–15° NE. Each of these sheets is probably made up of a succession of outflows. Another thick mass is interbedded in the agglomerate 4 miles northwest of Fort Cummings, probably at the same horizon as the others, and there is an extensive sheet in the Fourmile Hills and the slopes to the north. Smaller detached outcrops of latite appear in the Burdick Hills, in the slopes 3 miles southeast of Waterloo, and in a low knoll 2 miles east of the 76 ranch. Some of these may represent flows of considerable size, and possibly some may be dikes, but their structural relations are not exposed. In the outcrop 2 miles north of Mirage a dike of latite cuts the agglomerate.

In the ridges south of Fort Cummings and in a small outcrop west of Florida station the rhyolite is overlain by a thin sheet of brown latite containing augite, the highest horizon at which latite has been observed in this region. Augite-bearing latite predominates in the Cooks Range area, and latite with little or no augite constitutes the mass 3 miles northwest of Fort Cummings, a small intermediate flow 1 mile northeast of the Wilson ranch, a small mass 1½ miles southwest of Fort Cummings, and some masses in the Burdick Hills and Cedar Grove Mountains and possibly in other places.

Petrography.—Most of the latite is pink to purplish in color, moderately compact, and porphyritic. Phenocrysts constitute about one-third of the rock. In order of abundance they are andesine-labradorite, brown hornblende, augite, and biotite in scattered large crystals. They lie in a felsitic groundmass, consisting mainly of minute laths of feldspar, much of which is orthoclase, and in many of the rocks there is also considerable quartz in the groundmass. The feldspar phenocrysts are commonly zonal and bordered by a rim of minute inclusions. In most exposures the ferric minerals, particularly hornblende and biotite, are considerably altered. In many of the masses augite is lacking, but in others it occurs in considerable amount. Pleochroic apatite is a characteristic accessory mineral. The quartz in the groundmass is as a rule difficult to distinguish. Determinations of silica in three specimens by Chase Palmer in the laboratory of the United States Geological Survey gave 64.75, 60.94, and 58.93 per cent, which indicate the presence of free silica. The first of these specimens was taken from the upper part of the large flow north of the Wilson ranch, the second from a thin flow 2½ miles southwest of Florida station, and the third from a fragment in agglomerate in the Goodsight Mountains.

One of the dikes cutting the agglomerate 2 miles northeast of Mirage siding contains augite. The extensive sheet on the northern slope of the Fourmile Hills is identical with some of the latite west of Florida station. It consists of phenocrysts of andesine-labradorite, brown hornblende, augite, and brown mica in a dense felsitic groundmass. The latite on the summit of the Cedar Grove Mountains at the Smith ranch and a sample from the west end of the range consist of phenocrysts of andesine and brown hornblende in a semi-vitreous purplish-brown quartz-bearing groundmass. The rock exposed 3 miles southwest of the 76 ranch contains augite. The latites in the Burdick Hills are nonaugitic. One of them is dark red to maroon in color, slightly besicular, and moderately porphyritic, with phenocrysts of hornblende and white or colorless feldspar. The rock in the large mass due west of Midway station is dense and rather poor in phenocrysts, particularly of the femic minerals. All have a dense matrix, apparently containing much orthoclase.

The rock of the sheet on the main road across the Cedar Grove Mountains, north of the Williams ranch, has abundant brown hornblende in a peculiar partly devitrified groundmass. Closely similar rock occurs in the sheet half a mile south of Hermanas station. The rock capping a foothill of the Tres Hermanas Mountains southeast of Waterloo is also a hornblende latite.

ANDESITE.

Character and occurrence.—The andesites differ from the latites just described principally in having a groundmass composed mainly of albite or oligoclase instead of orthoclase. Most of the andesites of this region appear to be richer in soda than normal andesites. It is difficult to distinguish some of the andesites from latite in the field, especially where the rocks are much weathered, but most of the andesites are much finer grained and darker colored than the latite. The andesites present considerable variation in the proportion of the dominant ferromagnesian minerals, hornblende, and augite. Most of them contain augite in abundance, but some have little or none. The andesites occur mostly in sheets interbedded in the agglomerate series, and although some of these sheets are higher in the succession than the latites and some lower, all belong to the same general period of effusion. A number of andesite dikes cut Paleozoic strata, granite, latite, and agglomerate. A sheet of andesite about 450 feet thick constitutes the high northern ridge of the Victorio Mountains. A thinner sheet lying on agglomerate, except near its west end, where a thin sheet of felsitic rhyolite intervenes, occurs below and above the latite sheet of the Cedar Grove Mountains, separated by more or less tuff. There are several thin sheets of andesite in the foothill ridges of Cooks Range 4 miles west and southwest of Florida station, at a horizon somewhat above that of the upper long sheet of latite. The lower one is about 80 feet thick and extends southeastward nearly to the railroad. The others are thinner and appear to lie in the midst of a thick body of volcanic ash and tuff. One thin sheet of latite occurs in this succession. Another sheet of andesite lies a short distance below the latite in the hills 4 miles northwest of Fort Cummings. It appears to be 200 to 300 feet thick and is flexed with the inclosing agglomerate. A small sheet or stock of similar andesite occurs a short distance below the base of the great latite sheet 3 miles northeast of Mirage siding. It gives rise to a small knob a few hundred yards west of the railroad and is inclosed in the agglomerate. A 20-foot dike of andesite traverses the latite of the main sheet on an east-west course a mile northwest of this locality, and other dikes of andesite with little or no augite appear in the agglomerate area 2 miles northeast of Mirage siding. One of these dikes or a sheet from it extends to the railroad and is exposed in a cut for 100 feet. Large dikes of andesite crop out in Massacre Peak, in the small ridge half a mile to the west, and in the prominent ridge just north of Puma Spring. These dikes cut the agglomerate, and the mass in Massacre Peak is a stock. The dikes in the ridge next west and in the ridge on the south trend northwest, or at right angles to the large masses. A dike of very mafic character cuts the granite 2½ miles northeast of China Tank. Other dikes cut the granite just south of Capitol Dome, in the Florida Mountains. A thin sheet of andesite occurs in the agglomerate at Capitol Dome and another caps the small knob of agglomerate in the faulted block a mile southeast of Arco del Diablo. A small outcrop in the slope west of the Little Florida Mountains is apparently overlain by rhyolite. These rocks in the Florida and Little Florida mountains show little or no augite. A small hill of andesite lies near monument 14 of the Mexican boundary and a thin sheet appears in the tuff and agglomerate a short distance below the main latite sheet on the west slope of the Fourmile Hills. Fragments of andesite occur in the agglomerate of the Florida Mountains, in Red Mountains, and in Cooks Range.

Petrography.—The andesites are characterized by medium dark color inclining toward purple tones. All are fine grained and compact and none are vesicular. Fluidal texture is common. Phenocrysts of feldspar (oligoclase-andesine to labradorite), brown hornblende, augite, and rarely biotite are embodied in a finely crystalline groundmass rich in albite. Chlorite and calcite are common secondary products, and magnetite, titanite, and apatite are the usual accessory minerals.

The andesite sheet in the Victorio Mountains is a massive purplish-gray rock with feldspar, hornblende, and biotite phenocrysts in a dense groundmass.

The sheet of andesite on the south side of the Cedar Grove Mountains is closely similar to the sheet above the latite near the Smith ranch, on the opposite side of the mountains, and also to the intrusive mass of Massacre Peak. The lower sheet of andesite 4 miles southwest of Florida station differs from all the other andesites in containing numerous phenocrysts of unaltered green hornblende instead of the usual brown hornblende. It has little or no augite. The next higher flow, a thin one, is an andesite of the normal type, with brown hornblende and abundant augite. The next sheet contains but little augite and approaches keratophyre, while the uppermost sheet, which lies above considerable agglomerate, is a hornblende andesite bordering on latite.

The andesite occurring in dikes shows no special characteristics but is finer grained and darker colored than that of the sheets.

QUARTZ BASALT.

Distribution and character.—In the region south and southwest of Fort Cummings the igneous sheet next above the latite consists of a dark-colored, moderately coarse-looking, distinctly porphyritic rock, with white phenocrysts of striated feldspar embedded in a purplish-gray aphanitic groundmass. In composition it ranges from quartz basalt to olivine-bearing andesite, but all of it is of the same general appearance and very unlike the igneous rocks above and beneath it. Parts of the rock now contain no olivine, but apparently its absence is due to alteration, as in some specimens there are outlines of an altered mineral which appears to indicate its former presence. The largest exposures are in the center and east slope of the large dome-shaped uplift half a mile south of Fort Cummings, where it has been bared by the removal of the overlying rhyolite and ash. It is also exposed along the bases of the ridges 2 and 3 miles south of the fort, where the outcrop is repeated by faulting, and remnants of a widespread sheet cap some of the ridges on both sides of the main road east and north of Massacre Peak. An interrupted outcrop zone also extends along the slopes south and southeast of that peak on the west slope of the structural dome. The southwesternmost exposure is a quarter of a mile northwest of Puma Spring. The sheet is at least 200 feet thick in the dome south of Fort Cummings, but it is thinner to the west and is probably discontinuous in places along the western margin of its outcrop. In the center of the dome south of the fort the lowest rock appears to be coarser grained than the main body above. The latter is overlain by a series consisting of tuff, agglomerate, and ash containing a thin sheet of andesite, which extends to the base of the thick rhyolite sheet capping the main ridge. This relation is general throughout the area south and southwest of the fort, but the intervening body of pyroclastic rocks ranges from 40 to 150 feet in thickness. Below the sheet of quartz basalt, between it and the top of the main latite body, there is also some agglomerate. This relation is well exposed in the outcrop 2 miles west of the fort, where 40 feet of ash intervenes between the two sheets.

Petrography.—The quartz basalts show moderately abundant phenocrysts of feldspar (andesine-labradorite), biotite, hornblende (represented in most specimens only by characteristic outlines filled with secondary alteration products), and olivine (also generally altered, either to iddingsite or to serpentine). These minerals lie in an aphanitic groundmass composed of small plagioclase laths, augite rods, and magnetite specks in a matrix of poorly crystallized feldspar, some of it apparently orthoclase. The rocks from different outcrops vary somewhat in the proportions of olivine and orthoclase, and therefore range in composition from olivine-bearing latites to basalts.

Quartz in xenocrysts as much as 1.1 millimeters in diameter is a common constituent. The quartz crystals are bordered by reaction rims of augite, and most of them show resorption.

KERATOPHYRE.

Distribution and relations.—Keratophyre, some of it grading to quartz keratophyre, occurs in sheets and dikes at a number of places in Luna County. The largest mass is one which partly encircles the Tres Hermanas Mountains, where it separates the porphyry and felsitic rhyolite. A small sheet caps agglomerate just east of the Cedar Grove ranch. A small outcrop of keratophyre extends for a short distance along the foot of the west slope of the Little Florida Mountains, as shown in section B, figure 7 (p. 78). Its relations are not well exposed, but it appears to cut or be faulted against the obsidian and tuff deposits that underlie the main sheet of felsitic rhyolite. A wide dike of the same rock cuts the rhyolite, obsidian, and tuff succession at the southeast corner of the same range. The rocks here consist mostly of thin, nearly vertical plates of reddish color. Thin sheets of keratophyre or of tuff of nearly the same material are interbedded in the lower members of the pyroclastic series near Capitol Dome. A large vertical northeast-southwest dike of keratophyre 20 to 30 feet wide in places and nearly a mile long cuts the agglomerate 4 miles northwest of China Tank and crops out as a long, narrow ridge. It has two short branches near its middle. A similar dike with nearly the same thickness and trend crosses the bolson slope 1½ miles farther south. A small dike cuts the El Paso limestone half a mile north of Capitol Dome, and other similar dikes are in the granite west and south of the dome. A short distance south of Arco del Diablo a large dike of keratophyre extends from the bottom of the mountain nearly to the top. It ranges in width from 15 to 25 feet in greater part and cuts the granite for 1,000 feet or more. As it is softer than the granite, its course is marked by a deep ravine up the slope, in parts of which the relations are clearly exposed. Along the contact on each side much epidote is developed in nodules arranged parallel to the granite. The keratophyre of the Tres Hermanas Mountains appears to be a sheet surrounding the porphyry and in part uplifted in the general dome-shaped uplift of the area. Apparently it underlies the felsitic rhyolite, which has flowed over the irregular surface of the keratophyre, but it may be a later intrusion.

Character.—The keratophyre is a fine-grained dark-gray, highly sodic rock, with little or no quartz and with subordinate mafic minerals. Some masses have a lighter greenish tinge due to grains of epidote. Most of the rocks are apparently intermediate between andesites and the felsitic rhyolites and quartz keratophyres. Their texture is generally felsitic, but they show a tendency toward the development of small phenocrysts of feldspars less than 0.5 millimeter long.

Petrography.—The microscope reveals a well-developed porphyritic fabric. Small phenocrysts of feldspar ranging from albite to oligoclase lie in a microfelsitic groundmass apparently made up largely of albite. Calcite and epidote have replaced any mafic minerals which may have been present. The keratophyre of the Tres Hermanas Mountains does not differ essentially from the type. The rock of the sheet on the side of the Cedar Grove Mountains is a little more basic than the others but is closely related.

The dikes of quartz keratophyre traversing the granite west of Capitol Dome have orthoclase phenocrysts as much as 5 millimeters long, rather sparsely distributed in a microgranular groundmass of quartz and albite with a little magnetite. The phenocrysts are of local development, for some of the rock contains none.

RHYOLITE.

Distribution and relations.—Rhyolite occurs at many places in Luna County, but the largest masses are parts of a widely extended sheet or succession of sheets lying not far above the quartz basalt west and south of Fort Cummings. Originally this sheet probably extended over a wider area toward the west and it has been removed from the wide dome about Massacre Peak. The easterly dip carries it beneath the bolson southeast of the fort, and it may extend underground in that direction for some distance. A large area of similar rock forms the southeastern slope of the Cow Spring Hills, and it also occurs in the west end of the Klondike Hills and the eastern and southern parts of the Carrizalillo Hills. A thin sheet lies on the agglomerate on the west slope of the Cedar Grove Mountains north to the Williams ranch and also in the slopes east of Cow Spring. The large area northeast of the Grandmother Mountains consists of three sheets 120 feet thick lying on 150 feet of ash and fine tuff, apparently in a block uplifted above the felsitic rhyolite to the north. The upper sheet is light colored, the lower one brownish, both are massive and each is about 60 feet thick. A thin bed of darker rock separates these sheets. All the rocks appear to be closely similar in mineralogic character. A dike of similar rock appears on the west side of the Little Florida Mountains and there is a small outcrop of it near the north end of that range. Other small exposures are found in the Burdick Hills and in a small knoll 4 miles west of Black Mountain. A small sheet caps the hill of agglomerate east of Fluorite Camp, and another mass rises out of the bolson in a low knoll half a mile southeast of the camp. A small outlier rises into a prominent knob half a mile northeast of Massacre Peak. It dips east and owes its presence here to a fault. The extensive sheet south and west of Fort Cummings is about 100 feet thick and lies on volcanic ash and tuff 20 to 150 feet thick, which separates it from the underlying quartz basalt. In most places it consists of two flows, the lower one light colored and coarse grained, the upper one pinkish and fine grained. At one place on the ridge 1½ miles south of the fort these flows are separated by a local bed of volcanic ash 15 feet thick. In part of this area also there is another sheet 30 feet thick 100 feet below. No overlying beds are exposed except near Fort Cummings, where the much younger basalt appears.

Character.—The rhyolite presents some diversity in appearance though but little in composition. In texture it ranges from compact semivitreous to dense porphyritic rock with prominent phenocrysts of quartz, feldspar, and mica. In color it ranges from white in the more vesicular varieties through varying shades of gray and pink, the latter locally inclining to purple tones. Its mineral composition is uniform. It consists of a glassy, axiolitic, partly devitrified groundmass, in which are phenocrysts of quartz, sanidine, plagioclase, biotite, and usually brown hornblende. Biotite is present in all specimens, but the hornblende is moderately abundant in some places and absent in others.

Petrography.—The dense porphyritic rock of the large sheet 1½ miles southwest of Fort Cummings is representative of the rhyolite as a whole. It is pinkish and shows small phenocrysts of quartz, feldspar, hornblende, and biotite in a pink felsitic groundmass. The biotite flakes are mostly of characteristic coppery-brown color. Quartz phenocrysts are abundant. They are commonly corroded and many of them have been fractured subsequent to the corrosion, probably as a result of flow movement in the cooling lava.

The feldspars consist of sanidine and plagioclase in about equal proportions. The plagioclase differs somewhat in composition, but in general, as indicated by the index of refraction, it corresponds with sodic andesine, approaching oligoclase. The feldspar phenocrysts, like those of quartz, are both resorbed and fractured, the plagioclase in particular showing marked corrosion. Hornblende is conspicuous, though nowhere so abundant as biotite. The groundmass is notably axiolitic and contains considerable glass. Accessory minerals are titanite, in crystals nearly 0.5 millimeter in length, and magnetite. The ratio of groundmass to phenocrysts averages about 3 to 1.

Other specimens of rhyolite differ from the typical rock above described in several respects. In color they range from white through varying shades of gray and pink, and in texture from moderately vesicular to compact, almost glassy. In some places the rock contains abundant fragments of pumice. In mineral composition there is variation in the proportions of the feldspar phenocrysts, plagioclase being slightly in excess in some of the rocks and sanidine in others. The hornblende also varies in proportion, and in some of the masses it is absent. The proportion of glass in the groundmass varies, and a black obsidian from the west base of the Little Florida Mountains is almost wholly glass.

FELSITIC RHYOLITE.

Distribution.—Felsitic rhyolite, or dacite, of slightly varying composition crops out extensively in different parts of Luna County. Some occurs in the form of irregular masses, as in the Grandmother Mountains, Red Mountain, Gray Butte, Cow Cone, and the White Hills, probably representing the stocks of old volcanoes, and in the Little Florida Mountains, on the flanks of the Tres Hermanas Mountains, in the Cow Spring Hills, and on Taylor Mountain there are sheets of similar rock. Small masses of unknown structure rise out of the bolson in the Midway Buttes south of Iola, northeast of Spalding, 3 miles south of the Victorio Mountains, in slopes west of the Little Florida Mountains, on the Grant-Luna county line, 5 miles north of Cow Cone, and in hills 2 miles southeast of Arena. Another small mass, apparently intrusive, separates rhyolite from latite in a hill 6 miles west of Iola. A long dike crosses the Florida Mountains south of Arco del Diablo, cutting agglomerate, the Lobo formation, and granite.

Relations.—In the Tres Hermanas Mountains and in the small butte 3 miles east of Cow Spring the felsitic rhyolite is overlain by basalt, and in the former place it overlies keratophyre. These are the only evidences of its relation to other igneous rocks. The sheet in the Little Florida Mountains appears to be younger than a dike of hornblende-biotite rhyolite that cuts sediments on the west slope of the mountains, but the evidence of this is not conclusive. In the Gray Butte region the felsitic rhyolite appears to overlie the other rhyolite, but there may be a fault between them. In the ridge 4 miles northwest of Gray Butte hornblende-biotite rhyolite occurs higher on the slope than the felsitic rhyolite, but the relations of the two masses are not clear.

Character.—The felsitic rhyolite is fine grained and mostly white, though in places it is brownish red, gray, or light purplish gray. It varies from a rock near normal rhyolite in one direction toward quartz keratophyre or toward dacite in others, but the differences can not be recognized in the field; and on account of the small size of the crystals it is difficult to determine the varieties with certainty under the microscope. There is probably a gradation through all stages from rocks high in potash to those high in soda.

A characteristic of the felsitic rhyolite is its micrographic texture. Spherulitic fabric also is perfectly developed in some of the rocks. A chalky appearance and texture is a further peculiarity of most of them. Part of the larger sheet in the Little Florida Mountains is vitreous, in places containing some fragmental material in its lower part and near the center of the mountains showing much silicification. Much of it is pale brownish pink.

Petrography.—The typical felsitic rhyolite in Red Mountain and the White Hills is almost pure white, of perfectly uniform felsitic texture, and almost entirely free from phenocrysts. The microscope shows orthoclase and abundant quartz in micropegmatitic intergrowth. Spherulites, mainly of feldspar, are recognizable, but are not so prominent as in many of the other masses. Femic minerals are represented only by scattered specks of iron oxide, mostly hematite, and a very little biotite. Zircon is a moderately abundant accessory. The rock from the small masses east of Arena is closely similar, but has scattered phenocrysts of biotite and oligoclase. The rock on the northwest slope of Taylor Mountain is a white, fine-grained rock with a few phenocrysts of oligoclase-andesine, a little brown hornblende, and a subordinate amount of interstitial quartz. The rock of Cow Cone is nearly white and fine grained, and consists of very small phenocrysts of oligoclase-andesine, and a few flakes of biotite in a micrographic groundmass rich in albite and containing a very little quartz. The rock in massive ledges at the north end of the Cow Spring Hills, half a mile southeast of Cow Spring, has a minute granular texture with irregular intergrowth of quartz and albite, the latter in excess. The rock from the Grandmother Mountains has a granophyric texture with no well-marked phenocrysts. Interstitial quartz is moderately abundant. The feldspars appear more calcic than in most of the other rocks of the group. The felsitic rhyolite in the northeastern foothills of the Tres Hermanas Mountains is very similar to that of Red Mountain, except that it shows no quartz. The lower sheet of igneous rock in the southwest end of the Victorio Mountains is a dark-gray felsitic rhyolite or dacite. A 10-foot sheet of somewhat similar rock of white color is interbedded on the north side of the ridge near its northwest end. In the massive rock at the base of the main flow at the middle of the west side of the Little Florida Mountains the rhyolite is vitreous, reddish brown, and somewhat banded in structure. It contains much quartz, which is due to silicification. The orthoclase is radial, and there is some blue amphibole. Some of the rock at the north end of the mountains is similar and also includes fragmental matter.

RHYOLITE PORPHYRY.

Dikes of rhyolite porphyry, doubtless closely related genetically to the rhyolites, traverse the granite west of Arco del Diablo and 2 miles south of Gym Peak and form a small group of knolls 4 miles southwest of Iola. All are closely similar, do not differ greatly from the felsitic rhyolite in appearance, and range in color from almost pure white to light pink. They have a microgranular groundmass of quartz and orthoclase, through which are scattered small phenocrysts of quartz, sanidine, and albite, abundant in the order stated.

QUARTZ DIORITE.

A body of quartz diorite crops out in a small area at the Hancock mine, in the foothills on the west side of the Tres Hermanas Mountains. Apparently it underlies the rhyolite. The rock is unlike any others found in the county, but resembles some which occur near Silver City. It consists of green hornblende, biotite, augite, and feldspar, mainly labradorite. The quartz is interstitial and not specially abundant.

QUATERNARY IGNEOUS ROCKS.

BASALT.

Distribution and relations.—The youngest volcanic rocks in Luna County are flows and dikes of basalt. These flows lie on and perhaps are also interbedded with the Quaternary bolson gravels, which belong to the latest epoch in the geologic history of the region. A thick sheet of the basalt caps tuff and other fragmental deposits in Black Mountain and sinks beneath the bolson at its east end. A smaller mass, possibly connected underground, rises out of the bolson 2 miles to the northwest. Large sheets of basalt cap the Goodsight Mountains and the northeastern ridge of the Cedar Grove Mountains. They lie on sand, tuff, and ash deposits. An irregular flow underlies the area about Fort Cummings and rises in low ridges to the east and west of the fort. Part of this material near the fort is very spongy with gas cavities, and some of it is an agglomerate or mud flow. Flows of moderate extent appear along the El Paso & Southwestern Railroad between Mimbres and Hermanas and lie on the south slope of the Cedar Grove Mountains at the Williams ranch. Two masses rise out of the bolson southeast of Tomerlin; small areas constitute low buttes just south of Columbus, in the gap at the south end of the Florida Mountains, and both sides of the valley east of Cow Spring. A thin sheet of basalt caps the buttes on the northeast end of the Tres Hermanas Mountains and the butte known as Black Top, on the west side of that range, in both places lying on rhyolite. A small mass, probably a flow, crops out in the valley 6 miles southwest of Iola. Long, narrow dikes of basalt cut porphyry and sandstones in Fluorite Ridge, and a small dike of it cuts across the southwest end of Black Mountain. Other dikes cut limestones and associated rocks

5 miles northwest of Fryingpan Spring and at Cooks post office. Two dikes, 20 feet wide, with branches cut tuff 1¼ miles south of Massacre Peak, and others cut granite south of Capitol Dome.

The basalt of these localities is a fine-grained black rock of exceptional hardness. Some of the rock of the flows contains many gas cavities, but the dike rock is dense and more coarsely crystalline.

Petrography.—The basalt in the flows is nearly uniform in appearance. The commonest sort, such as that of Black Mountain, contains phenocrysts of feldspar and olivine, the latter generally clear in the center but changed to iddingsite around the borders. The groundmass is made up of laths of labradorite, between which are packed small anhedrons of augite, olivine, and magnetite.

The basalt of the other flows differs from that above described only in minor particulars. The flow at Fort Cummings is in part highly vesicular, and the cavities are filled with thomsonite and heulandite. In the knoll 3 miles east of Cow Spring the basalt is very fine grained, black, and full of cracks and flow lines which are well brought out by weathering. It is a sheet 40 feet thick and lies on tuff and felsitic rhyolite. The basalt capping the low ridge 2½ miles farther east is a coarser-grained rock of peculiar brown color, due to deep weathering. The basalt of the eastern ridge of the Cedar Grove Mountains is fine grained, and the olivines are not very abundant. The basalt in the small area 5 miles southwest of Iola is probably an extension of the same flow.

Certain notable features appear in the basalt sheet capping the Goodsight Mountains. It is coarser in crystallization than most of the other flows, or more like the dike forms. It shows peculiar rims of clear olivine around cores of the red variety, except where the olivine is entirely surrounded by the feldspars or where the olivine crystals adjoin phenocrysts of feldspar; in other words, the rim is not developed between olivine and feldspar. This relation suggests two periods of growth of the olivine—one producing the iddingsite prior to the crystallization of the feldspar phenocrysts, the other and later doubtless corresponding in time with the crystallization of the augite and feldspar of the groundmass.

The basalt of the dikes is coarser and more uniform in texture than that of the flows, though evidently of about the same composition. The dike cutting the agglomerate at the west end of Black Mountain is typical. It is holocrystalline and almost black. Laths of feldspar as much as 2 millimeters long and irregularly shaped olivines 1 millimeter or less in diameter lie in a matrix of feldspar, olivine, augite, and magnetite. Being comparatively fresh, this rock exhibits the beginning of an alteration of the olivine to felted green and brown aggregates of talc and biotite. In the other dike basalts this alteration has progressed so far that it partly obscures the original nature of the rock.

The dikes of Fluorite Ridge, south of Capitol Dome, near Cooks post office, and 5 miles northwest of Fryingpan Spring are closely similar in character, but the rock from Fluorite Ridge is more altered. The dikes in granite south of Capitol Dome contain much magnetite in specks through the augites and even in the feldspars.

STRUCTURAL GEOLOGY.

GENERAL FEATURES.

Owing to the fact that the rocks exhibiting structure are in isolated ridges and hills widely separated by bolsons, it is not possible to determine the general structure in Luna County. There are no visible features which indicate extensive monoclines, synclines, or anticlines. The relations in the Florida Mountains suggests the east limb of an anticline, but the western limb of the flexure is not apparent. Cooks Range is in part an anticline rising to the north and pitching down into a broad syncline at the south end. A great fault extends along the east side of the main Cooks Range with a drop of several thousand feet in its east side, but no other longitudinal faults of any great displacement were observed. Possibly the lowlands now occupied by the bolsons are down-faulted blocks, but there is no evidence of it. On account of these conditions no general cross sections of the region are presented in this report, and the structure of each ridge or outcrop area will be described separately. In general, it is suggested that the bolson depressions are due chiefly to erosion of the softer rocks of the later formations, notably the soft shale and sandstone of later Cretaceous and early Tertiary ages, but no direct evidence on this matter is available.

COOKS RANGE.

SUBDIVISIONS.

Cooks Range is divided into two very distinct geologic districts by the great fault which passes along the east side of the range and crosses it southwest of Fort Cummings. To the west are Paleozoic and Mesozoic limestones and sandstones, penetrated by a great laccolithic mass of porphyry; to the east is the agglomerate series with its included sheets of igneous rocks. Accordingly these two portions will be described separately in the following pages.

MOUNTAINS AND RIDGES WEST OF THE GREAT FAULT.

The dominant feature of the main Cooks Range and of Cooks Peak, its culminating summit, is a large laccolithic mass of granodiorite porphyry. This rock has been intruded mainly in the Lake Valley limestone, but locally it rises across the strata up to the Sarten sandstone and Colorado shale. The sedimentary rocks have in general a steep dip away from the central igneous mass, and there is some faulting along the flanks of the uplift. Several separate intrusions of large masses of porphyry rise in ridges to the southwest and south of the central area, but these are much more irregular in their structural relations than the laccolith of Cooks Peak. The salient features of the main Cooks Range are shown in the sections of figure 3 (p. 70).

Numerous small dikes and sheets are intruded at various places, notably about Cooks post office, where there are several dikes of basalt and porphyry. On the west slope of the range the limestones are cut at several localities by irregular projections from the main porphyry mass. North of the Cooks Peak igneous mass there is a shallow syncline which crosses the range near Cooks post office. On the north side of this flexure there are low dips to the south and the strata rise in successions in a long ridge that narrows toward the north. The formations exposed are the Lake Valley limestone, Percha shale, Fusselman limestone, Montoya limestone, El Paso limestone, Bliss sandstone, and granite. The granite extends for some distance north out of the county. East of this ridge there is a profound fault which crosses the high ridges north of Cooks post office and extends far south along the east side of the Cooks Peak mass and Sarten Ridge. Between this fault and Cooks Peak there is a shallow syncline which holds beds up to the Sarten sandstone, the sandstone occurring mainly in small outliers lying high against the east slope of the mountain. Other similar outliers cap peaks north and northwest of Cooks Peak. The Sarten sandstone appears at intervals on the lower part of the west slope northwest of the peak, and it is probably continuous under the bolson deposits to the 55 ranch, where it lies in a syncline that extends southeastward far up into the ridge between the two masses of porphyry. At one place this syncline holds a small area of the Colorado shale. Farther south the Lobo formation, Gym limestone, and Lake Valley limestone rise to the surface and these formations together with the Sarten sandstone constitute the high ridge extending across the range 2 miles south of Cooks Peak. The strata in this ridge all dip south at moderate angles, as shown in section 4 of figure 3, and are cut off by the great fault to the east. The Sarten sandstone is a conspicuous feature in this area, constituting the very prominent dip slope 2 miles south of the peak which on the east swings around to the south and becomes Sarten Ridge. It also extends several miles to the southwest, so that with Sarten Ridge on the other side it finally forms the rim of a wide syncline. The north side of this syncline is cut by an irregular mass of

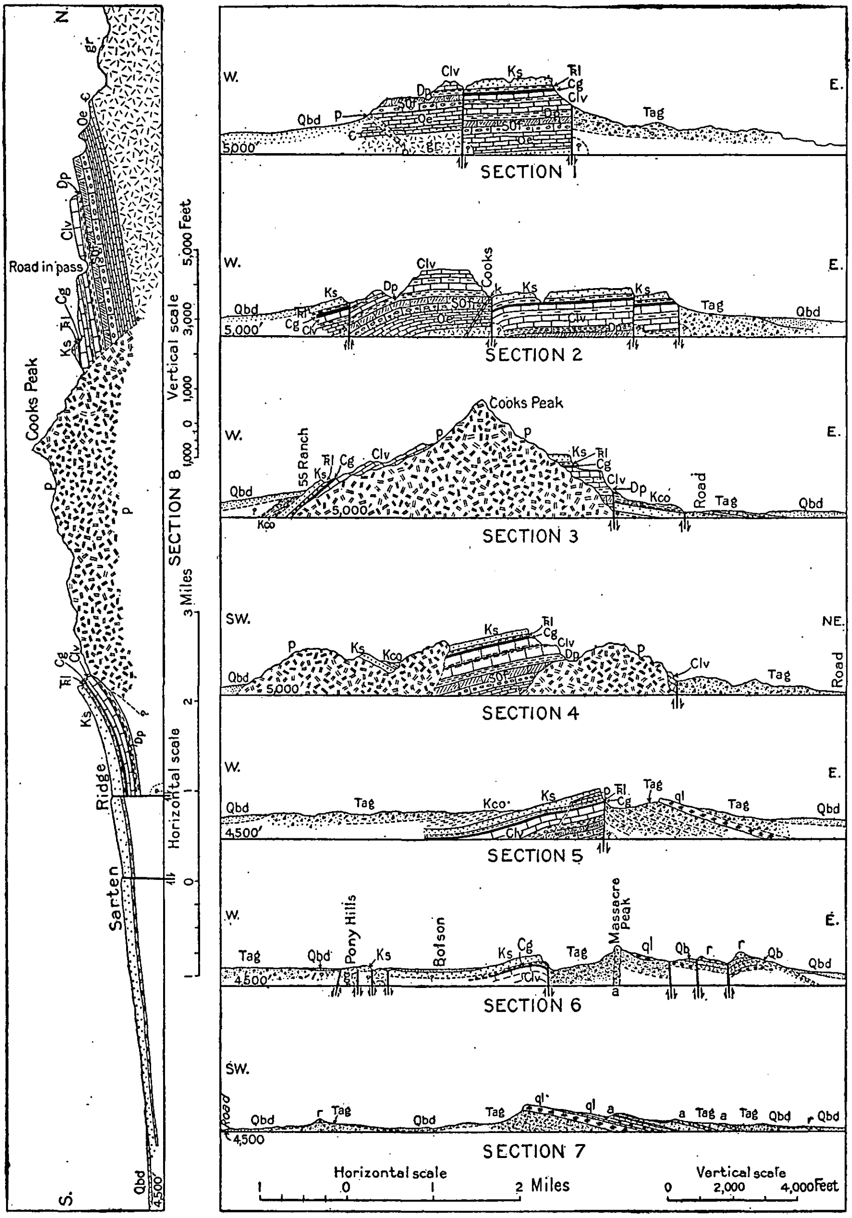


FIGURE 3.—Sections across Cooks Range. 1, 1½ miles north of Cooks post office; 2, through Cooks post office; 3, through Cooks Peak; 4, 2 to 3 miles south of Cooks Peak; 5, 1½ miles north of Fort Cummings; 6, 1¼ miles south of Fort Cummings, passing just south of sandstone quarry; 7, from point 1½ miles southeast of Fluorite Camp to point 1½ miles northwest of Florida station; 8, through Cooks Range from southeast end of Sarten Ridge to the Luna-Sierra county line. Base of sections 1–4, 5,000 feet above sea level; 6–8, 4,500 feet. p, Porphyry; Tag, agglomerate; r, rhyolite, andesite, and latite; Qbd, bolson deposits; Kco, Colorado shale; Ks, Sarten sandstone; Trl, Lobo formation; Cg, Gym limestone and Magdalena formation; Clv, Lake Valley limestone; Dp, Percha shale; SOf, Fusselman and Montoya limestones; Oe, El Paso limestone; €, Bliss sandstone; gr, granite; a, andesite; Qb, quartz basalt; ql, quartz latite; k, keratophyre.

porphyry high on the mountain slope, but lower down there is a small area of the Colorado shale and large areas of agglomerate and associated deposits.

In Sarten Ridge the sandstone is underlain by the Lobo formation and the Gym and Lake Valley limestones, which crop out along the north and east slopes of that ridge until they are finally cut off by the great fault north of Fryingpan Spring. A small amount of the Percha shale also appears in this area, cut by the porphyry of the main Cooks Peak laccolith. There is a large intruded mass of the porphyry on the south slope of the high sandstone ridge, and some small dikes and sills of it to the east in Sarten Ridge. At two places the sandstone is exposed overlain by the Colorado shale, and doubtless this formation underlies an area of considerable extent in the syncline west of Sarten Ridge, but it is mostly covered by agglomerate and later deposits.

Sarten Ridge consists of a wide exposure of the Sarten sandstone dipping south of west and finally passing beneath bolson deposits at the south end of the ridge. The great fault passes along the foot of the east side of the ridge, and owing to this dislocation the agglomerate abuts against the Sarten sandstone to the south and then against the Lobo formation and Lake Valley limestone as these formations rise to the north. At Fryingpan Spring the Sarten sandstone with a nearly north strike and a very low dip to the west abuts against the agglomerate series, which strikes northwest and dips at angles mostly greater than 20°. The vertical displacement caused by the fault at this place is probably more than 1,000 feet, but there is no way of determining the precise amount. Half a mile south of Fryingpan Spring a deep canyon in Sarten Ridge cuts through the sandstone and reveals the underlying Lobo formation in a small area. A few rods to the southeast a small mass of limestone appears along the fault, probably a wedge that was slightly more uplifted than the Sarten Ridge block. It appears to be the Gym limestone, but no fossils were obtained on which to base precise correlation. The beds are nearly horizontal and lie on conglomerate, of which the top crops out a few yards east of the road.

AGGLOMERATE AND IGNEOUS AREA EAST OF THE GREAT FAULT.

The southern extension of Cooks Range east of Sarten Ridge consists of the great agglomerate series with its included igneous masses, the latter mostly in sheets. There is an alternation of strata and interbedded lava flows, in part in regular succession from southwest to northeast, for the dip is generally to the east and northeast at a moderate angle. Several faults break the succession locally, and it is all cut off diagonally on the west side by the great fault that extends along the east foot of Sarten Ridge. To the east it passes beneath the bolson deposits, and these also form an irregular margin along its southern and southwestern portions. About Fort Cummings some later basalts lie on the margin of the series. The lower members of the agglomerate series exposed constitute a thick succession of deposits of fragmental volcanic materials with a few small dikes of various rocks. Interbedded brown quartzites constituting the two prominent knobs 3 miles west of Mirage are exceptional features, for apparently they do not contain igneous material. Several strata of sedimentary origin are interbedded with the agglomerate, and all dip nearly due east at an angle of 4°. In the steep, high ridges east of the Wilson ranch the first great sheet of latite appears lying in the agglomerates, both dipping 10° NE. Above this thick sheet there is a thick succession of flows and local deposits of agglomerate, tuff, and ash, all dipping at low angles to the northeast. North of the Wilson ranch, however, an anticline or dome is indicated by westerly and southwesterly dips, mainly in an area limited on the east by a crescentic fault which cuts off the beds in an irregular manner. The deposits of sedimentary and fragmental rocks thicken and thin from place to place, and thin flows of andesite are included which thicken to the east and south. A widespread sheet of quartz basalt, apparently merging into olivine andesite, is a prominent member of the series west of Florida, and not far above it is an extensive sheet of light-colored rhyolite in the ridges south of Fort Cummings. The two sheets of igneous rock are separated by deposits of volcanic ash, which in most places are 100 feet thick. Two faults cut the rocks in this portion of the area, repeating the succession of rocks from quartz basalt to rhyolite along two zones of outcrop. The individual relations of these faults are shown in section 6 on figure 3 (p. 70).

Northwest of Fort Cummings the igneous rocks are in thick masses in the agglomerate and appear to terminate by thinning out. Here the members of the series generally dip to the east and northeast at various angles, but there are southeast dips on the curved outcrops 3 miles northwest of the fort. To the west this body of igneous rocks is cut off diagonally by the great fault, and to the east it disappears beneath bolson deposits.

South of Fort Cummings the rhyolite and underlying rocks exhibit an oval dome with axis trending southeast. The upper rhyolite has been removed from the top of the dome, revealing the quartz basalt, which on the southeast side extends down to the bolson.

In the area about Puma Spring and for several miles to the north there is a low dome lying between the faults. One of the most notable effects of the uplift is the presence of a sheet of the rhyolite in the high ridge west of the spring. This sheet appears to be at the same horizon as the other bodies of rhyolite to the northeast. It dips southwestward and lies on a thick body of volcanic ash, which in turn is underlain by quartz basalt. Next east is a thick dikelike mass of andesite which extends to Puma Spring. Farther north, toward Massacre Peak and the main road, the dome is nearly flat and the sheets of rock dip northward. At the fault half a mile northeast of Massacre Peak the rocks dip steeply to the east, notably the wedge of rhyolite forming the 5,050-foot peak, which dips 25° ENE.

FLORIDA MOUNTAINS.

GENERAL STRUCTURE.

The Florida Mountains consist mainly of pre-Cambrian granite and agglomerate, the latter constituting the high, rugged ridge at the north end of the range. Paleozoic limestones also occur in several areas, one mass forming the crest of the mountains for a short distance east of The Park. In general the range has a monoclinal structure with an easterly dip. Possibly it is the eastern limb of an anticline whose axis lies under the bolson on the west, or the uplift may be bounded on that side by a fault. At Capitol Dome the Paleozoic rocks and agglomerate beds all dip to the east-northeast, and the granite crops out along the foot of the western slope. This easterly dip, with repetition of the limestones by faulting, is exhibited again farther south, at The Park and Gym Peak. The range is crossed near its north end by a profound fault that trends nearly east and has an upthrow of several hundred feet on its south side, and the limestones of The Park and Gym Peak are cut off to the south by a great fault which uplifts the granite more than 2,000 feet. The salient structural features of the range are shown in the sections of figure 4 (p. 74).

FLEXURES.

The rocks of the Florida Mountains are tilted in various directions in extensive monoclines, but they are not flexed into anticlines or synclines to any great extent. The agglomerate dips gently to the east and east-northeast, and the underlying Lobo formation has essentially, if not precisely, the same attitude. The Paleozoic rocks also, with a few exceptions, dip eastward. At Gym Peak, as shown in section C, figure 4, there is slight arching, and the faulted blocks to the west include some shallow synclines.

FAULTS.

Faults are numerous in the Florida Mountains, and the larger ones cross the range from east to west. The largest, which passes along the south side of The Park and a short distance south of Gym Peak,

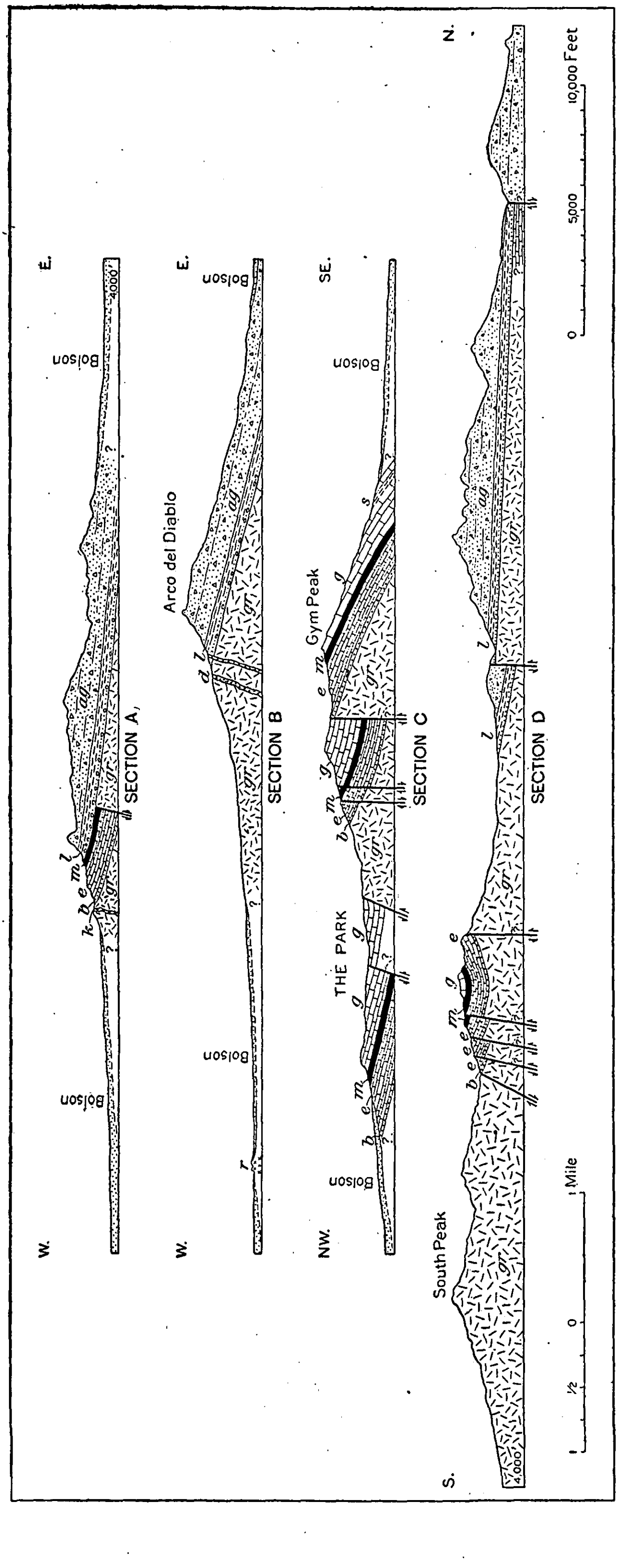


FIGURE 4.—Sections across the Florida Mountains. A, Through Capitol Dome; B, through Arco del Diablo; C, through The Park and Gym Peak; D, from south to north along the higher portion of the range. *b*, Bliss sandstone; *e*, El Paso limestone; *m*, Montoya and Fusselman limestones; *r*, felsitic rhyolite in White Hills; *d*, rhyolite porphyry dikes; *l*, Lobo formation; *g*, Gym limestone; *s*, black shale member; *k*, keratophyre; *gr*, granite; *ag*, agglomerate.

has a throw of 2,000 feet for part of its course, where it lifts the granite of the south end of the range so high that it abuts against upper beds of the Gym limestone. The fault plane dips 40°–70° S., and the granite is thrust over on the block to the north. The slope of this plane is well exposed in the spur southwest of The Park, where it dips 40° S., and also in places near the trail south of Gym Peak. This fault branches in The Park, but along its northwestern branch the uplift is on the northeast side, bringing up the granite and leaving a depressed wedge-shaped block of the Gym limestone and underlying rocks between the branches. The uplifted block on the northeast is tilted eastward at a moderately steep angle and half a mile west of Gym Peak is cut off by another fault, shown in the middle of section C, figure 4. This fault has a vertical uplift of about 2,000 feet and extends south of the great northwest fault. It branches just northwest of Gym Peak, one branch passing northeast and the other curving to the north; in both, the upthrow is on the east side. The eastern branch is well shown by the Montoya limestone abutting against the Bliss sandstone 1½ miles northeast of Gym Peak, and the western branch brings the Gym limestone and granite into contact east of the zinc mine. Apparently this fault branches again to the north, the western branch bringing upturned Montoya limestone against granite, and the eastern branch cutting off the El Paso limestone in the spur half a mile southwest of Byer Spring. The tilted block east of The Park is cut off on the north by a large fault that lifts the granite against the El Paso limestone on the main divide, as shown in section D, figure 4. The block is also crossed by several smaller step faults of 40 to 200 feet displacement, which trend nearly east (see section D, fig. 4), and are well exposed in the cliff east of The Park. They are lost in the Gym limestone slopes east of the summit. A fault trending northeast in the ridge extending northwest from The Park drops the Gym limestone to the level of the El Paso limestone. Another fault brings the El Paso limestone and granite into contact a short distance east and also southeast of Byer Spring. In the south slope a mile southeast of Byer Spring the plane of the fault appears to have a low dip to the east, for the granite and limestone contact slopes gradually down the hill nearly to the main northeast fault.

In the slopes 2 miles south by east from Gym Peak the granite and some outlying masses of the Gym limestone are intricately faulted together, so that wedges of the limestone are partly included in the granite and a tongue of the granite projects through the limestone at one place, the relations suggesting igneous intrusion. However, the limestone is not at all metamorphosed and the granite is a very coarse grained rock of the typical pre-Cambrian character. The southwestern mass consists of limestone and sandstone lying on a gently sloping surface of granite. The larger eastern mass is underlain and overlain by granite on planes dipping gently eastward, and it is through this mass that a tongue of the granite has been forced, as shown in figure 5.

The limestone near the contact is shattered and brecciated for a foot or more and includes fragments of the granite. The granite is red, coarse grained, and massive, of the sort which constitutes a large part of the mountain, and while it is very much broken and crushed it shows no fining of grain such as occurs at igneous contacts. The precise method of faulting of the mass can not be ascertained, but doubtless the granite is a wedge between two fault planes carried westward into the limestone. These planes were part of a great fault similar to the one a mile farther north, but only these few scattered wedges of limestone remain to indicate its effects.

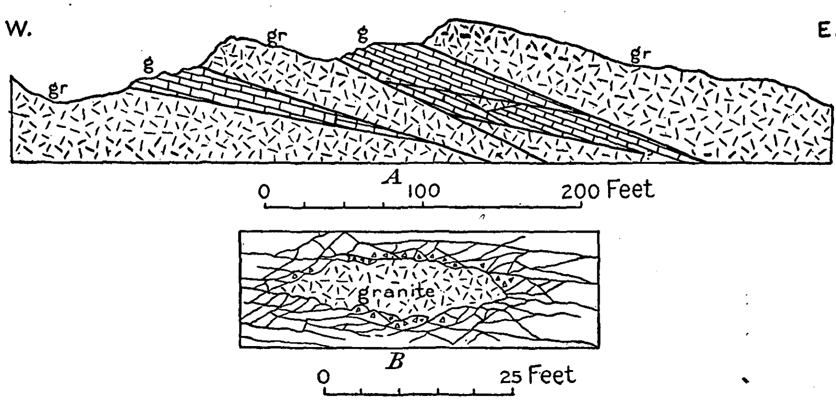


FIGURE 5.—Section showing relations of granite (gr) and Gym limestone (g) at southeast end of Florida Mountains, 2 miles south of Gym Peak. *B* shows relations of small mass of granite in center of *A*.

The fault near the north end of the Florida Mountains trends nearly east, and drops the agglomerate on the north side so that it abuts against older beds, from the Lobo formation to granite, on the south side. The maximum displacement is unknown, but at the granite contact the throw is at least 2,000 feet. Some of its relations are shown in section D, figure 4 (p. 74). The agglomerate and the Lobo formation are cut by another prominent easterly fault southeast of Arco del Diablo, the relations of which are shown to the right of the middle of section D. The beds on the south side are dropped about 400 feet vertically by this fault. The direction of the dip of the fault plane was not ascertained. A similar fault of much smaller throw crosses the range a mile southeast of Capitol Dome. Just south of Capitol Dome a northeast fault with vertical throw of more than 1,500 feet lifts the granite to the base of the Lobo formation.

The fault plane dips 45° NW., and along part of its course there is a dike of quartz porphyry 20 feet thick. In places the strata are upturned along the fault and dip northward. The fault is shown in figure 6.

The movement occurred long before Lobo time, for south of the fault the Lobo formation lies on the eroded surface of the granite. The plane of erosion crosses the fault and extends across the edges of the Montoya and El Paso limestones to the west and north. These relations indicate that during or after the faulting there was a great amount of erosion, which removed from the uplifted side of the fault the sandstone and limestone that overlie the granite just north and doubtless removed some of the granite also, for the granite plane beneath the Lobo formation may be much lower in the granite mass than the granite plane beneath the Bliss sandstone. Also at the time of faulting the locality may have been overlain by more or less Gym limestone. Large areas of this formation remain a few miles to the south, but it is absent in the overlap north of Capitol

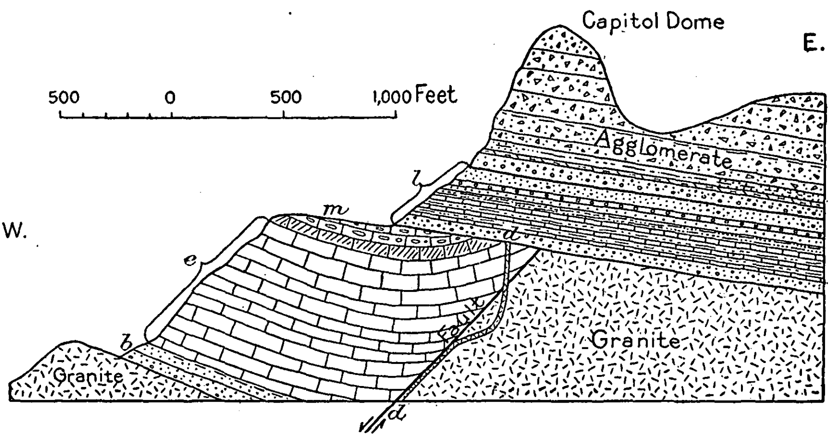


FIGURE 6.—Section at Capitol Dome showing relations of pre-Lobo fault. *l*, Lobo formation; *m*, Montoya limestone; *e*, El Paso limestone; *b*, Bliss sandstone; *d*, dike.

Dome, in which the Lobo formation lies on the eroded surface of the middle members of the Montoya limestone and still farther north extends somewhat lower over the El Paso limestone.

LITTLE FLORIDA MOUNTAINS.

The ridge known as the Little Florida Mountains consists of a thick sheet of felsitic or vitreous rhyolite included in the great agglomerate series. Apparently the horizon is somewhat above that of the agglomerate exposed in the Florida Mountains, as the latter range lies slightly west of the line of strike of the rocks in the Little Florida Mountains; but there may be a fault between the two ranges. The felsitic rhyolite appears to be mainly the product of one outflow, or a succession of outflows without intervening deposits, and probably it ends by thinning out not far beyond the termination of the ridge. Some other igneous masses are exposed in places on the west slope. The structure is shown in figure 7, in which section A shows the relations that prevail along the greater part of the ridge and section B shows certain local features of the faulted portion farther south.

All the rocks dip to the east at low angles, mostly less than 10°. In the northern part of the area the dips are from 10° to 20° north of east, but farther south the direction is in greater part due east. This dip carries the main sheet of felsitic rhyolite under the agglomerate to the east, so its thickness and extent in that direction are not known. The thickness in the middle of the mountains, as shown in section A, figure 7, is about 600 feet, and the amount gradually

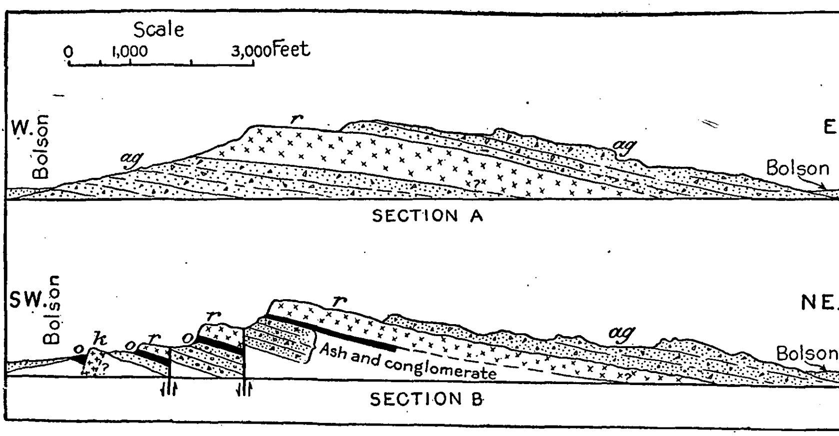


FIGURE 7.—Sections across the Little Florida Mountains. A, Across center of range; B, 1½ miles farther south. *ag*, Agglomerate; *r*, felsitic rhyolite; *o*, obsidian; *k*, keratophyre.

diminishes to the north and south. In the gap which crosses the ridge near its north end the thickness is less than 150 feet, but it increases again to double that amount in the knob to the northwest. Near the center of the mountains the underlying deposits of volcanic ash and other fragmental materials extend about halfway up the western slope, but the altitude of the contact diminishes to the north and south.

The relations shown in the western part of section B, figure 7, are due to two or more faults which appear to extend for some distance along the western slope of the southern half of the range. At and south of this place the rhyolite sheet is underlain by a flow of obsidian, 8 to 20 feet thick, which in turn lies on a bed of compact coarse volcanic ash of greenish tint. The faults cause the repetition of this characteristic succession in two prominent steps on the slope. The obsidian appears again at the edge of the bolson in the base of a small knoll consisting of keratophyre, either a local sheet or a dike, probably faulted into its present position. A short distance southeast of the locality of section B the blocks shown in that section are displaced by a northeast fault. As the downthrow is on the east side the outcrops on this side are offset to the southwest. The blocks east of this transverse fault slope toward the south, and this structure, together with the thinning of the igneous sheet, causes the southern termination of the ridge. The easternmost of the longitudinal faults continues to be a conspicuous feature to the end of the ridge. Near the southeastern termination of the slopes there is a low spur caused by a dike of keratophyre, which cuts agglomerate and underlying volcanic ash for a short distance. It is a reddish rock jointed in vertical plates that strike a few degrees east of north.

Just west of the gap which crosses the northern part of the Little Florida Mountains there is a long, narrow outcrop of felsitic rhyolite, extending from the main felsite sheet some distance into the bolson on the west. It is probably a dike or feeder by which the sheet reached the surface at the time of its eruption. In the west slope, half a mile south of this outcrop, the strata under the main igneous sheet are traversed by a small dike of hornblende-biotite rhyolite, which appears to have disturbed the beds considerably and caused greatly increased silicification in them. There are several small outcrops of rhyolite, felsitic rhyolite, and andesite in the bolson a short distance west of the foot of the Little Florida Mountains, but they afford no evidence of their relations or underground extent.

TRES HERMANAS MOUNTAINS.

The ridges and peaks known as the Tres Hermanas Mountains occupy an area of about 35 square miles, lying 30 miles south of Deming. They extend about 10 miles from north to south, have a maximum width of about 5 miles, and rise abruptly from the great bolson. In a general way they are on the southern extension of the line of strike of the Florida Mountains, and doubtless there is an underground connection between the two ranges under the bolson deposits in the gap between them. The rocks and structure, however, are markedly different in most respects. In the Tres Hermanas Mountains there is a central igneous mass of coarse granite porphyry, flanked in part by andesites and felsitic rhyolite, in part by agglomerate, and in part by Gym limestone. The limestone has been upturned by the intrusion, and part of it near the contact has been metamorphosed to marble. There are no signs of the granite and earlier Paleozoic rocks, which are so prominent in the Florida Mountains, and the agglomerate appears in the lower foothills on the southeast slopes and northeast end of the range. In general there is an igneous succession consisting of a central mass of granite porphyry, partly surrounded by andesite, then felsitic rhyolite, and last the basalt, which appears to underlie parts of the surrounding bolsons. The sections in figure 8 show the salient features of the structure along the slopes of the range, but most of the underground relations are not indicated by the outcrops.

The porphyry which constitutes the large central mass of the Tres Hermanas Mountains presents little evidence as to its structural relations. It cuts across and upturns the limestone on the northern slope and includes large fragments of that rock displaced some distance from their original position and metamorphosed to marble.

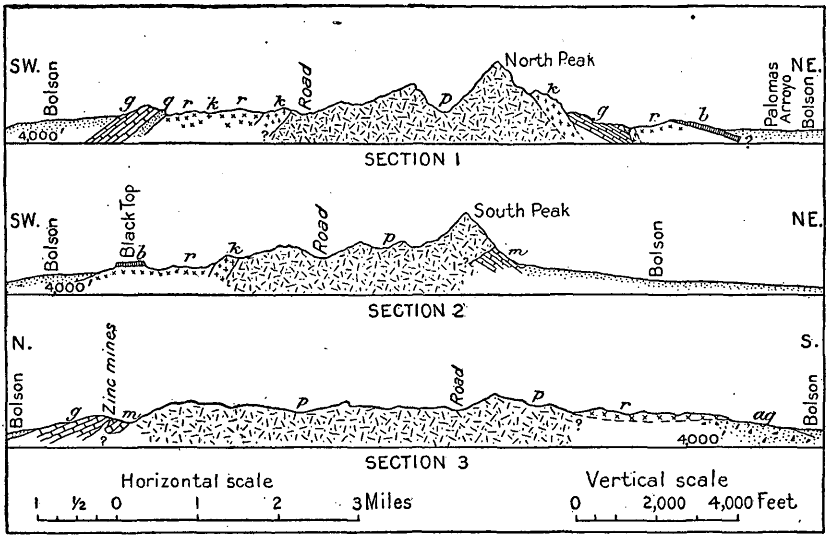


FIGURE 8.—Sketch sections across the Tres Hermanas Mountains. 1, From point southwest of Hancock mine through North Peak; 2, from Black Top through South Peak; 3, through center of range east of zinc mines. *p*, Porphyry; *r*, rhyolite; *b*, basalt; *ag*, agglomerate; *g*, Gym limestone; *m*, marble in Gym limestone; *q*, quartzite; *k*, keratophyre.

It is undoubtedly a thick body, probably connected underground with a large feeder or stock. The rock is classed as a granite porphyry or a quartz syenite porphyry by Lindgren, and while it is very different from the granite of the Florida Mountains it somewhat resembles the intrusives of Cooks Peak and Fluorite Ridge. Its character is very uniform throughout, its coarse grain, brownish color, and massive structure being shown in all exposures. Its topography is rugged, especially in the three prominent peaks shown in Plate IV, *B* (p. 12). Near Willow Spring the porphyry is flanked by typical agglomerate, but on its west side and along the northeastern spur of the range it is in contact with a sheet or dike of andesite several hundred feet wide. The relation of the three rocks was not observed, so that their relative age is not known. The andesite on the west side and northeast slope of the range separates the granite porphyry from a wide zone of felsitic rhyolite for most of its course. This rhyolite appears to be in an irregular sheet or a succession of sheets with some intervening fragmental deposits, and it is penetrated by dikes of andesite similar to that which separates the rhyolite and porphyry masses. In the southeastern part of the range and in its northeastern foothills the rhyolite lies on the great agglomerate. A thin sheet of basalt caps the rhyolite in the prominent butte known as Black Top, 2 miles west of Willow Spring, and also in the buttes just west of the Grade road 4 miles southeast of Waterloo.

In the vicinity of the old zinc mines at the north end of the range the limestone gives rise to a low ridge with its steeper slopes facing inward, toward the porphyry hills. The strata are cut off abruptly by the porphyry to the south and dip gently to the north, finally passing beneath the bolson deposits. Lindgren[1] has described the principal features at this locality in relation to the occurrence of the zinc ores. The main igneous contact extends eastward along the foot of the high ridge southeast of the mines. The limestone is considerably disturbed, showing many variations in dip, and evidently the contact is very abrupt and irregular, with projections of porphyry into the limestone. The dips range from 30° to 60° in amount and from northeast to northwest in direction. A sill or dike of the porphyry also cuts the limestone for 200 yards along an easterly course a few rods north of the main contact. For some distance from the igneous contacts the limestone is altered to a white, coarsely crystalline marble, and some beds show various secondary minerals, mainly garnet. At several places the more impure beds of limestone or shale are metamorphosed to a hornfels. The zone of alteration is very irregular in horizontal extent, but averages about 1,000 feet in width at one place mentioned by Lindgren. Marble and garnet appear in some of the beds half a mile north of the contact. Most of the metamorphism has occurred in the gap and on the south slope of the limestone hill. The principal zinc workings in the limestone are on the slope a quarter of a mile west of the little gap south of the limestone hill. The only sign of metamorphism at this place is the occurrence of bunches of wollastonite. Fossils of Carboniferous age were found by Lindgren in the limestones, even in greatly altered portions.

[1] Lindgren, Waldemar, The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, p. 293, 1910.

Limestone constitutes a flanking ridge and spur extending northward from the high peak near the north end of the range. The strata dip at low angles to the east-northeast and east-southeast and at the south are cut off abruptly by a nearly vertical porphyry contact. Much of the limestone for 100 feet from the igneous rock is altered to a coarsely crystalline marble, as in the area near the zinc mine. To the east the limestone is penetrated by a thick mass of andesite which lies along the east side of the porphyry and projects northward from it. To the north this body of limestone dips beneath gray quartzite which extends as a prominent ledge trending east for some distance along the lower mountain slope and apparently is nearly if not quite cut off on the east by the north end of the andesite. The limestone of this area extends southward for several miles along the foot of the slopes of the central and southern high peaks of the range, and near the contact much of it is changed to white marble. In general the beds dip steeply to the east, or away from the igneous mass. There are several branch intrusions, and some large masses of marble are included in the porphyry, notably at the South Peak, where the marble extends halfway up the slope and is in one place 200 feet wide. The south contact of this mass is very irregular, but on the north side the contact extends almost vertically up the slope. In places there is considerable yellowish-green vesuvianite or garnet in veins 6 inches to 3½ feet wide along the junction of the two rocks. In the upper part of the marble mass there is a nearly vertical hole about 25 feet in diameter and 80 feet deep. It was caused by solution of the limestone. At the bottom there is considerable bat guano, which has been mined to some extent. More or less marble appears along the contact low on the east slope of the middle peak, and one thin bed of the limestone at this place is changed to a heavy white rock, mostly garnet, vesuvianite, and diopside. Many fossils occur in associated strata here and farther north. The small mass of limestone that crops out a mile east of the Hancock mine lies along the west margin of the porphyry intrusion.

The westernmost range of the Tres Hermanas Mountains lies a mile west of the Hancock mine. It consists of 600 to 800 feet of the Gym limestone, dipping steeply westward. The rocks are light colored and include some brecciated beds. They have yielded late Pennsylvanian fossils. Under this limestone is a gray to reddish quartzite, in part brecciated, which crops out as a cliff along a low ridge on the east side of this westernmost range and shows a thickness of 40 to 50 feet. Next east of it is a valley occupied by the felsitic rhyolite, which extends in a broad zone along the west side of the Tres Hermanas igneous area. The relation of the rhyolite to the limestone is not exposed, but some features suggest that they are separated by a fault trending northwest.

VICTORIO MOUNTAINS.

The main ridge of the Victorio Mountains consists of a tilted sheet of andesite and its south slope and the scattered knobs to the south are of sandstone and limestone. The principal structural features are shown in the sketch map and sections forming figure 9.

The prominent northern ridge consists of a massive sheet of hornblende andesite dipping 20°–25° NNE. It is about 200 feet thick and gives rise to the crest and south slope of the ridge, including the prominent Victorio Peak. To the west it is underlain by a thin sheet of felsitic rhyolite, and there is another thin sheet of the rhyolite near the northwestern termination of the ridge. This upper sheet is 10 feet thick and nearly pure white in color. It crops out about half a mile south of the railroad, which passes just north of the end of the igneous outcrop. The main andesite sheet lies on about 700 feet of shales and sandstones, largely of reddish tints, which dip 15°–20° slightly east of north, having the same or nearly the same attitude as that of the andesite. Dark purplish-brown fine-grained massive shales or sandstones predominate, but the beds include several layers of coarse conglomerate, containing bowlders of andesite, and some greenish sandstones near the top contain conglomerate carrying pebbles of fossiliferous Paleozoic limestones. This formation is underlain by limestones that begin abruptly, and at the contact, which is well exposed near the locality of section 1, figure 9, there is but little evidence of unconformity and no suggestion of a fault.

The structure of the limestone ridges and hills constituting the southern part of the range is complicated by several faults and some overlapping, and the outcrops are not sufficiently continuous to exhibit the relations fully. In Mine Hill there appears to be a regular monocline, and the southward-dipping Fusselman limestone with characteristic coral fauna on the south slope is underlain by cherty and siliceous beds of the Montoya limestone, which constitute the north summit, north slope, and east and west sides. The underlying El Paso limestone crops out in the hill next to the north, dipping to the south and southeast and apparently in regular succession. The strata appear to be cut off on the west side of the monocline by a fault that extends along the foot of the slope with a north-northeasterly course and has the uplift on the east side. It is well shown in the shaft on the Lesdos-Rambler claim. Owing to this fault, the outcrop of the Montoya limestone on the west side of the fault is offset to the north, and it extends along the southern slopes west of the road to and beyond the line of section 1, figure 9. For most of its course on this side of the fault the limestone dips at first to the southwest and then to the north. The inclination is

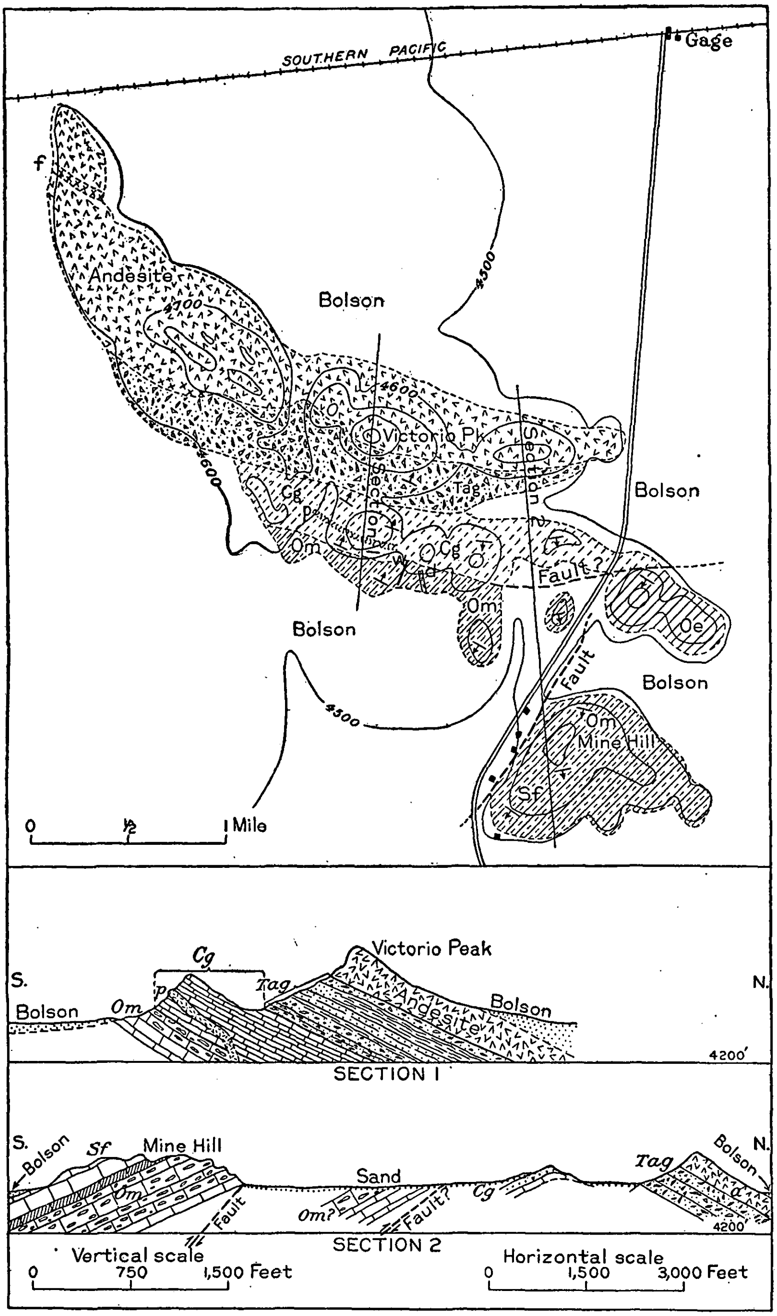


FIGURE 9.—Sketch map and cross sections of Victorio Mountains. The contour lines, 100 feet apart, are based on aneroid readings. *a*, Andesite; *Tag*, agglomerate, shale, and sandstone; *Cg*, Gym limestone; *Sf*, Fusselman limestone; *Om*, Montoya limestone; *Oe*, El Paso limestone; *p*, porphyry; *f*, felsite; *d*, dike of andesite and quartz porphyry; *w*, quartz vein with wolframite.

steep near the wolframite pits, but farther west it is only from 15° to 20°, as shown in section 1. In this area the cherty beds of the Montoya are overlain by the Gym limestone, and while some Fusselman limestone may intervene, no direct evidence of its existence was obtained, and it appears to be cut out either by faulting or unconformable overlap. Not far above the fossiliferous layer in the Montoya is a bed of gray sandstone, which extends all along the south slope of the range and crosses the road half a mile north of the mining camp. Near this road and for a few rods to the east there is a low anticline, on the south side of which the dips are to the south-southeast. East of the road the sandstone and associated conglomerate, limestone conglomerate, and fine-grained sandstone appear to pass under the El Paso limestone, a relation probably due to overthrust of the limestone along a branch of the fault above mentioned. Some distance west of the road the sandstone member is overlain by 300 feet of limestone, which constitute the three round knobs on the southern ridge of the mountains. Some of the beds are very fine grained and slabby; others are brecciated and massive. They yield abundant Manzano fossils, by which they are identified as the Gym limestone. In the highest knob, as shown in section 1, figure 9, the dip is 20° N., and the limestone passes under the conglomerates and shales. In the middle slope of this knob and to the west the limestones are parted by a 60 to 80 foot sill of porphyry similar to the rock in Fluorite Ridge. A short distance southeast, on the slope of the middle knob, are two small dikes, one of which is quartz porphyry and the other gray andesite, side by side and trending nearly due north.

FLUORITE RIDGE.

Fluorite Ridge consists of a thick central mass of porphyry so intruded as to cause an irregular dome-shaped uplift, elongated to the northwest and southeast. The strata on the south and east sides of the dome stand nearly vertical, but those on the north and west sides have more moderate dips. The plane of intrusion is low in the Paleozoic strata at the southeast end of the uplift, but it rises rapidly toward the north and west to the base of the Sarten sandstone. Along part of the southwest slope of the ridge, where the porphyry extends down to the edge of the bolson, the structural relations are not revealed. At the south end of the ridge two or three faults cause considerable complexity of structure. The salient structural features are shown in figure 10.

The crystalline rocks exposed in the lower slopes southwest of Fluorite Camp are red granite and diorite, in part gneissic and in places porphyritic. They are cut off on the north by a vertical fault of slight amount, which at one point brings them into contact with beds as high as the medial member of the Bliss sandstone. In some places there are limy shales at the contact, in others reddish quartzitic sandstone. The sandstone extends in conspicuous ledges along the slope of the ridge for half a mile, at one place offset to the north by a cross fault. The beds dip steeply north and present a succession comprising the El Paso limestone, Montoya limestone, and cherty beds, probable Fusselman limestone, Percha shale, and the lower portion of the Lake Valley limestone. Some of the beds are greatly squeezed, notably the El Paso limestone, which presents a thickness of only 400 feet at the east end of the ridge and somewhat less to the west. The cherty members of the Montoya limestone are very conspicuous in the high knob at the southeast corner

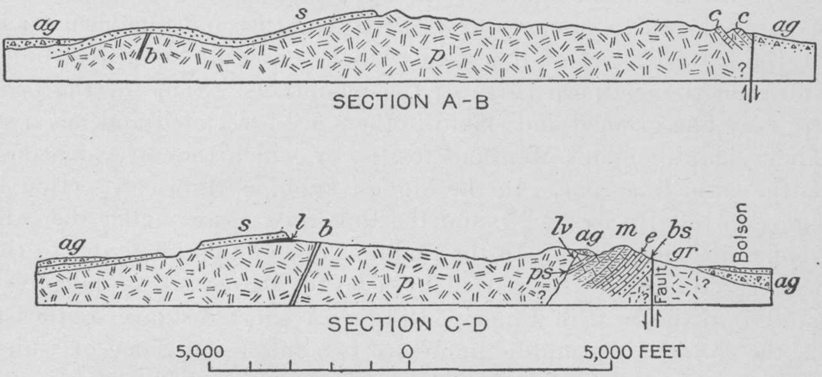


FIGURE 10.—Sections across Fluorite Ridge. A–B, Section west-northwest to east-northeast; C–D, section from northwest to southeast across east half of the ridge. *gr*, Granite and diorite; *bs*, Bliss sandstone; *e*, El Paso limestone; *m*, Montoya limestone overlain in part by limestone of undetermined age; *ps*, Percha shale; *lv*, Lake Valley limestone; *l*, Lobo formation; *s*, Sarten sandstone; *ag*, agglomerate; *b*, basalt dike; *c*, chert.

of the ridge. There appear to be a westerly fault, or two of them, near the north end of this limestone knob, but owing to lack of evidence as to the age of the limestones north of the Montoya ledges the presence of the fault is not certain. The plane of porphyry intrusion descends considerably across the beds in the saddle at the north end of this knob, but in the slopes just east and west of the saddle the Percha shale appears; and as the plane of porphyry intrusion rises still higher to the northeast, several hundred feet of the lower part of the Lake Valley limestone is exposed. Farther east and north are several great masses of white silica rock, most of it entirely surrounded by porphyry. Its character indicates that it is limestone replaced by silica. One of these masses extends as a foothill ridge for some distance north of Fluorite Camp, where at one place it is 90 feet thick. A small outlying mass rises above the agglomerate a quarter of a mile east of the camp. The age of this silica rock is not known; it may be either Lake Valley or Montoya, but is presumably the latter.

A fault of considerable magnitude, with downthrow on the east, extends along the east side of Fluorite Ridge and cuts off the granite, sandstones, and limestones, which therefore abut against the porphyry. Possibly, however, the porphyry was intruded since the faulting. There are some indications that the fault or a branch of it trends northeastward just north of Fluorite Camp and passes east of the silica ridge; and, if so, it may be a continuation of the great fault that passes through Fryingpan Spring. The slickensided plane of this fault is exposed in some of the fluorite workings just west of the camp, but whether or not it cuts the agglomerate or separates it from the porphyry is not known. The agglomerate appears all around the flanks of Fluorite Ridge, but the exposures are so obscure that its relations to the porphyry are not exhibited; in places the two are separated by faults. No fragments of the porphyry of the kind forming the intrusive mass were observed in the agglomerate—a fact which suggests that the porphyry may be younger than the agglomerate, or at least than the portion in this vicinity. A mass of breccia of considerable size lies on the south slope of Fluorite Ridge, just west of the limestone knob that constitutes the southeast end of the ridge. This breccia consists mainly of large masses of gneiss as well as abundant smaller fragments of the same rock, and was apparently brought up by the porphyry as a friction breccia from the pre-Cambrian basement, which is not far below.

The structure of the central part of Fluorite Ridge (see section A-B, fig. 10) is very different from that of the east end. There is a long slope of porphyry down to the bolson on the south side, and the Sarten sandstone dips steeply down on the north side. The sandstone extends to the top of the ridge, where it presents a high cliff to the south as well as to the east and west. On the east side of this high central ridge there is probably a cross fault continuous with the fault that crosses the road 2 miles farther north. At one point in the cliff at the summit of Fluorite Ridge the sandstone is underlain by a small amount of conglomerate of the Lobo formation lying on the porphyry. To the west of the high central ridge the plane of the porphyry intrusion descends to the point where the Sarten sandstone arches over the igneous body in an anticline that pitches down into a shallow cross syncline in the gap across the west end of the ridge. The porphyry rises again a short distance to the west, creating a low ridge with crest and north slope of porphyry. Large masses of agglomerate rise above the bolson along the base of this portion of the ridge, especially on its north side. The contact of the porphyry and the Lobo and Sarten formations is well exposed in places on the south slope of the central ridge. The contact is very irregular, and in places long projections of the porphyry extend into the sedimentary rocks. Near the contact the sedimentary rocks are considerably altered and the porphyry is finer grained.

The Sarten sandstone of the central peak of Fluorite Ridge dips north and is probably cut off on the east by a fault that crosses the ridge and passes northward to and through the Pony Hills. The sandstone extends some distance north from the foot of the ridge in a line of low cliffs facing east and marking this fault, which is traceable to and beyond the old Butterfield road. Near that road granite crops out on the east side of this fault, and this rock also appears farther west in the midst of the Pony Hills and constitutes the northern part of the ridge north of China Tank.

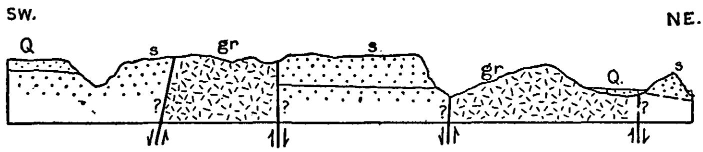


FIGURE 11.—Section across the Pony Hills, 13 miles north of Deming. Q, Bolson deposits; s, Sarten sandstone; gr, granite.

PONY HILLS.

The small group of low hills in the center of the structural basin lying between Sarten Ridge and Fluorite Ridge consists of outcrops of the Sarten sandstone and granite. The relations of the rocks are considerably obscured, especially to the west, by gravel and sand of the bolson deposits. The most conspicuous feature is a cliff of the Sarten sandstone extending to the old Butterfield road and nearly continuous southward with a low spur of Fluorite Ridge. Low hills of gneissic granite rise just east of the sandstone area, and there is a fault separating them, as shown in figure 11.

In the rolling hills west of the main body of sandstone there are outcrops of schistose granite, in one place penetrated by a dike of diorite. The sandstone lies on a sloping plain on the granite, a relation which may indicate overlap but more likely is due to faulting. The basal sandstone is coarse, but not more so than some of the beds at high horizons. Much of the contact of the larger mass of sandstone and of the smaller masses to the west is covered by sand and gravel. The sandstone in the two knolls northeast of the road is typical Sarten sandstone, but its relations to the granite are not revealed.

GOAT RIDGE.

Goat Ridge rises about 500 feet above the bolson, and is on the prolongation of the strike of the anticline of Fluorite Ridge. It is an elongated dome with axis trending northwest and brings up the Sarten sandstone. The slopes and crest consist of rocky ledges of sandstone and quartzite, which are eroded through along the west slope and in the south end of the ridge, exposing the underlying Lobo formation nearly if not quite to its base. At the foot of the ridge is exposed more or less agglomerate, which at the north end is cut by a dike of keratophyre extending northeast to and beyond the road.

GOODSIGHT MOUNTAINS.

Only a brief reconnaissance was made of the Goodsight Mountains, but it was found that they consist of a mass of agglomerate capped by a sheet of basalt dipping east at a low angle. Their highest part is at Goodsight Peak. There is a gentle slope to the east on the

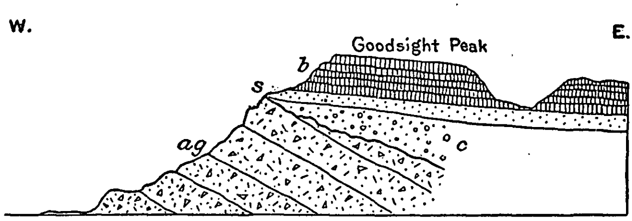


FIGURE 12.—Sketch section through Goodsight Peak. *b*, Basalt lava flows; *s*, gray sandstone; *c*, conglomerate; *ag*, agglomerate.

uplifted basalt sheet and a steep slope on the west side in the underlying deposits of agglomerate and ash. In the valley east of the mountains the basalt finally passes beneath bolson deposits of gravel, sand, and clay. The section at Goodsight Peak given in figure 12 shows the main structural features of the range.

The agglomerate in slopes below Goodsight Peak is a very massive rock and consists mostly of large and angular fragments of hornblende andesites in a more or less crystalline matrix. It is precisely similar in aspect to the agglomerate constituting the north end of the Florida Mountains and appearing in Cooks Range 2 miles southwest of Fort Cummings and at other places. It is overlain unconformably by gray conglomerate and 40 feet of soft gray sandstone, both consisting largely of volcanic materials. Probably this deposit is of Quaternary age. The basalt is in three sheets, 200 feet thick in all, and probably represents three effusions of lava. Much of it is vesicular. Just east of Nutt there is a long railroad cut through the ridge which reveals a thick mass of agglomerate containing fragments of hornblende latite and andesite. This is capped by the main basalt sheet farther east.

RED MOUNTAIN.

Red Mountain consists of a large mass of nearly white felsitic rhyolite rising abruptly out of the bolson 10 miles southwest of Deming. Much of the rock is so jointed that it weathers into nearly vertical plates and slabs, mostly trending north. At its northeast end the mass appears to dip to the northwest, but elsewhere it presents no suggestion of structure and there is no evidence as to its thickness. At the base of the slope on the south side there is a small exposure of agglomerate, presumably underlying the rhyolite. This material is dark bluish gray, and the fragments, which are all angular, consist of andesite or latite. At other points the rhyolite or its talus extends down to the edge of the bolson deposits. It is probable that the Red Mountain igneous mass was extruded in a highly viscous condition, so that it piled up thickly without extending far beyond its present area. The date of its extrusion and its subsequent history are not known, but if it is of the same age as the other masses of similar rock it was once covered by agglomerate.

BLACK MOUNTAIN.

Black Mountain, which rises high above the bolson 8 miles northwest of Deming, consists of a sheet of basalt about 250 feet thick, capping a mass of volcanic ash and sand. Apparently it is the remnant of a flow or series of flows which originally had considerably greater extent. At the west end of the mountain the base of the basalt is about 500 feet above the bolson, and the long slope below shows deposits of sand and volcanic ash and tuff, largely covered by talus of the black rock from the cliffs above. The igneous sheet dips to the east at a low angle, and this dip finally carries it beneath the surface at the east end of the mountain. How much farther it extends underground and its former extent to the west are not known. A small outlying mass, separated by erosion, caps a knob on the south-central slope of the mountain. A small area of similar rock appears in two low buttes 2 miles northwest of Black Mountain, and there may be underground connection between the two areas. The basalt of Black Mountain is mostly dense and massive, but portions are somewhat cellular, and in a few places, especially near the basalt contact, the cellular structure is so highly developed that the rock is a scoria or pumice. The basal contact appears to be a relatively smooth plane, so far as can be inferred from widely scattered exposures. The underlying beds of fragmental material dip east at about the same angle as the igneous sheet. Their principal component is sand, more or less mixed with volcanic material in the form of ash and pumice, and some portions contain cross-bedded pebbly streaks. Low down at the southwest corner of the mountain there are exposures of igneous rocks cutting these sediments. One mass is a dark-gray obsidian or perlite in a sheet 4 or 5 feet thick. It has a circular outcrop, presents low cliffs to the south and west, and apparently is connected with a vertical dike on its east side. In the center of this area is a small body of light-colored intrusive biotite rhyolite with pronounced cleavage into slabs. A few rods southwest of this locality there is a small knob about 50 feet high separated from the foot of Black Mountain by a low saddle. This knob consists of a vertical dike of basalt 15 to 20 feet wide, cutting the agglomerate along a northerly course. Possibly this was a feeder for the main outflow of the basalt of Black Mountain, but the surface connection has been removed by erosion.

SNAKE HILLS.

The Snake Hills, sometimes called the Rattlesnake Hills, consist of a ridge of limestone which crops out across the southern part of T. 24 S., R. 10 W. Its length is about 2½ miles, and the knobs of the higher

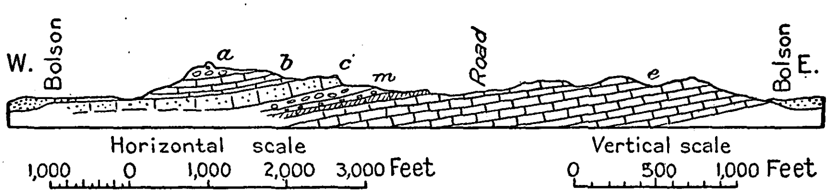


FIGURE 13.—Section through Snake Hills. *a*, Limestone with chert in large bodies; *b*, limestone with chert mostly in thin alternating layers; *c*, massive dark sandy limestone; *m*, Montoya limestone; *e*, El Paso limestone.

summits are mostly from 150 to 200 feet above the plain. The east half consists of the El Paso limestone dipping 5° to 8° W., and thus exposing about 700 feet of beds. The west half consists of the overlying Montoya limestone, which first dips west and then is flexed in a low dome, deeply eroded in its center and almost flat along the west side of the ridge. The cherty beds of the Montoya limestone form the dominant topographic features, giving rise to the high central buttes. The structure is shown in figure 13.

The succession of rocks in the Montoya limestone comprises a dark massive limestone at the base, next a lower chert member, then a medial member of dark massive limestone presenting low cliffs, and at the top a highly cherty member capping the highest knob and extending down the west end of the ridge. This rock appears again in a small outcrop rising out of the bolson a few rods northeast of the west end of the ridge. The basal contact of the massive lower member of the Montoya limestone on the El Paso limestone shows evidence of unconformity by erosion, although there is no notable discordance in dip.

KLONDIKE HILLS.

The Klondike Hills, near the west edge of the county, consist mainly of two narrow limestone ridges trending east and in part rising into buttes of considerable prominence. The principal structural features are shown in figure 14.

The granite exposure occupies a small area in the middle of the hills, a short distance west of the southern high knob. The rock is red to gray in color, and although part of it is coarse grained, much of it has a well-developed banded structure and may be classed as gneiss. The granite appears to be cut off on the west by a slight fault, but to the east it passes under brown sandstone (the Bliss),

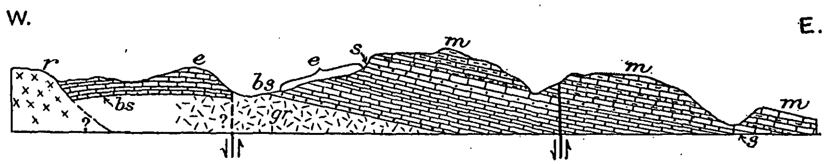


FIGURE 14.—Section through Klondike Hills. *gr*, Granite and gneiss; *bs*, Bliss sandstone; *e*, El Paso limestone; *m*, Montoya limestone (sandstone, dark limestone, and cherty limestone); *s*, sandstone at base of Montoya limestone; *r*, felsitic rhyolite.

which is only a few feet thick and is largely obscured by talus. Next to the east is an eastward-dipping succession of typical El Paso limestone several hundred feet thick and cherty Montoya limestone apparently 150 feet thick. At the base of the Montoya is sandstone 6 to 8 feet thick lying on an irregularly eroded surface of the El Paso limestone and grading up into 30 or 40 feet of dark sandy limestone. These two members are supposed to represent the dark basal limestone at many other localities. The purer Montoya beds contain abundant fossils. The cherty beds give rise to the two conical high buttes and the rugged ridges at the east end of the hills. To the east there is some cross faulting, which is clearly indicated by the reappearance of the basal sandstone of the Montoya on the slope of the southeastern ridge, and by the duplication of certain fossiliferous layers.

The western portion of the Klondike Hills consists in part of the characteristic El Paso limestone dipping mainly at low angles to the north and cut off to the southwest by rhyolite, which crops out in an area about half a mile long. In places near the igneous rock there has been a large amount of siliceous replacement in the limestone, doubtless due to the secondary deposition in connection with the intrusion.

CEDAR GROVE MOUNTAINS.

The Cedar Grove Mountains were examined only at a few widely separated localities. The range is a single-crested ridge extending continuously across the southwest corner of the county to Carrizalillo Spring. It consists mainly of a long sheet or succession of sheets of latite lying on agglomerate. In places the latite is underlain by andesite and rhyolite. The dip is toward the northeast at a low angle, which carries the main igneous sheet below the agglomerate, but in places it is overlapped by bolson deposits. A sketch section made along the main road through the Williams ranch is given in figure 15.

About 20 feet of the rhyolite is exposed at the foot of the mountain slope overlain by 60 feet of red to gray coarse breccia and tuff

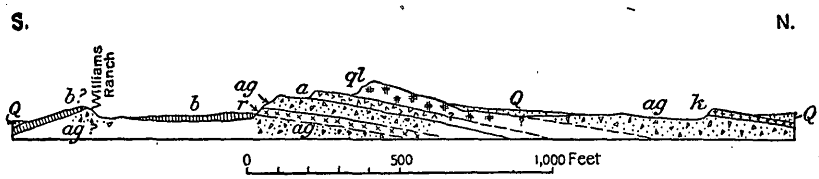


FIGURE 15.—Sketch section across the Cedar Grove Mountains north of Williams ranch. Thicknesses approximate. Vertical scale exaggerated. *ag*, Agglomerate; *ql*, quartz latite; *a*, hornblende-augite andesite; *k*, keratophyre; *b*, basalt; *r*, hornblende-biotite rhyolite; *Q*, bolson deposits.

of the agglomerate series. The sheet of hornblende andesite may be separated from the hornblende latite by tuff, but the contacts are not exposed. The latite constitutes the crest and northeastern slope of the main ridge, and evidently is a very extensive flow, for it was observed at intervals to the south end of the range. The relations at its top are not well exposed, owing to the covering of bolson deposits and talus, but above it there is a thick mass of agglomerate penetrated by various igneous masses and overlain by a thin sheet of dark fine-grained keratophyre. The light-gray agglomerate is well exposed in the slopes below this sheet of keratophyre along the little valley extending west toward the Cedar Grove ranch. In the prominent ridge west of that ranch the latite is overlain by a coarse pink rhyolite, although possibly the two masses are separated by a fault. At Smith's ranch the igneous rock constituting the crest and east slope of the mountain is a thick sheet of latite. It is overlain by a succession of andesite, rhyolite, trachyte, and latite sheets, in all about 160 feet thick and dipping gently to the east. These rocks are overlain by tuffs and agglomerate, with thin flows of rhyolite extending south up the valley to the Cox ranch and beyond. At the Cox ranch a sheet of the rhyolite is especially conspicuous. It gives rise to a line of knobs and foothills at the base of the northeast slope of the mountains in this region. A short distance northeast of the main Cedar Grove Mountains, or on the east side of the valley referred to above, there is a parallel ridge extending north from Hermanas nearly to the main road southwest of the Klondike ranch. It is not as high as the mountains, and its crest is broken into knobs and ridges of moderate prominence. This outlying ridge is capped by a thick sheet of basalt lying on fragmental volcanic deposits and dipping gently to the northeast under the bolson. Another area of basalt occurs on the south side of the Cedar Grove Mountains about the Williams ranch, and a small mass appears near the main road 3 miles southwest of the Klondike ranch.

CARRIZALILLO HILLS.

The Carrizalillo Hills form a detached southern continuation of the Cedar Grove Mountains, and the structure and rocks are similar. The northern group of hills consists of hornblende latite and the southern group of hornblende-biotite rhyolite and rhyolite tuff. Both latite and rhyolite lie on tuffs and agglomerate, and all the beds dip eastward at low angles. There is some faulting, but the relations of the faults were not ascertained. The latite sheet, or a dike of that rock, crosses the valley just below Carrizalillo Spring, and doubtless it is the presence of this barrier to the underflow that brings the water to the surface.

SIERRA RICA.

The north end of the Sierra Rica extends a short distance into the southwest corner of Luna County and consists of Lower Cretaceous strata. The principal rock outcrops are two prominent knobs or buttes, shown in Plate VII, *A* (p. 15), and there are several smaller ridges, all in an area of about 2 square miles. The most abundant rock is limestone, which constitutes the large buttes. It is of a light blue-gray color and is in part massive and in part thin bedded. It contains Trinity fossils. There is a general dip of 4°–5° N. in most of the area, but near the international boundary line the monocline gives place to a low anticline. The axis of this flexure trends east and passes through a small gap a quarter of a mile north of boundary stone 39. East of the southeast end of the southern high butte there are slopes and a valley of limy shale, east of which sandy limestone rises in low ridges. This rock is highly fossiliferous, some of the upper layers being filled with large Exogyras believed to be of Washita age. If this correlation is correct these beds are separated from the older limestone of Trinity age by a fault with downthrow on the east side. A mile east of boundary stone 39 there is a mineral lead trending northeast, along this fault or a large joint plane. On its east side is a gray quartzite which crops out in the axis of the anticline a quarter of a mile northwest of boundary stone 38. The vein is of varying width and consists of iron oxides carrying disseminated bodies and grains of fairly rich argentiferous galena. It has been worked in a small way for several years, apparently without much profit, if any. The diggings are known as the International mine. Near the mine and west of it are small dikes of felsite. Boundary stone 38 is on a knoll which is the easternmost outcrop of the area. It consists of gray slabby limestone.

GRANDMOTHER MOUNTAINS.

The Grandmother Mountains, in T. 23 S., Rs. 12 and 13 W., consist of a group of peaks and ridges composed of felsitic rhyolite. The rock rises abruptly out of the bolson 6 miles north of Gage and presents no evidence of its relations to the sedimentary rocks or to the agglomerate which probably underlies most of the area. It was not possible to determine the structure of the igneous mass, but it appears to be a center of eruption and possibly an irregular series of stocks or dikes and sheets. The rock is very uniform in character throughout and includes but little fragmental material.

COW CONE AND COW SPRING HILLS REGION.

The conspicuous conical butte known as Cow Cone, in the northwestern part of the county, and the knobs and ridges southeast of it, comprising most of the Cow Spring Hills, are masses of felsitic rhyolite. The high ridge at the south end of these hills is a widespread sheet or succession of sheets of hornblende-biotite rhyolite lying on agglomerate and other fragmental deposits. Cow Cone and the adjoining knobs appear to be stocks or fragments of sheets. The cone presents a strongly marked bedded structure, with dips of about 30° W. The rock on top is pink and flaky and the material lower down is gray and massive. The rocks in the knob next east are nearly white. Cow Spring Hills begin in a high ridge just south of Cow Spring. The rock here is coarse grained and massive and appears to be an irregular sheet extending 6 miles along its southeasterly course. It has various minor irregularities, due partly to intercalated fragmental beds, and appears to be cut off by an east-west fault near the south line of T. 22 S., R. 12 W. Doubtless it underlies the area on the east which is covered by bolson deposits, for it is exposed by erosion in the hollow in that direction.

South of the supposed fault just mentioned rises a prominent escarpment, which extends to the west end of the ridge and thence swings around its point and for some distance down the northeast side of the Cow Creek valley. This escarpment shows 200 to 300 feet of volcanic ash, tuffs, and other fragmental beds, in large part water-laid, overlain by a thick sheet of rhyolite. This sheet and the underlying deposits slope to the southeast and finally pass beneath the bolson deposits. The igneous rock is a coarse-grained massive hornblende-mica rhyolite, apparently in two sheets each about 60 feet thick, with an intervening sheet of finer-grained rock 30 feet thick. The top flow is light colored; the bottom one has a reddish tint and weathers into large blocks and cliffs. A sheet of rhyolite similar to the lower member crops out along the north side of the valley in the northern and eastern parts of T. 22 S., R. 12 W. Part of it lies on white massive agglomerate, which in turn is underlain by felsitic rhyolite, probably in a northern extension of the great flow of the Cow Spring Hills. If this is the case, it indicates that in this general region there is a succession of felsitic rhyolite, agglomerate, and hornblende-biotite rhyolite. Not far above the hornblende-biotite rhyolite at the locality above mentioned is a sheet of fine-grained dark-brown basalt 40 feet thick. It lies on conglomerate and dips 10° N. 20° E. Three miles farther west there is a 40-foot sheet of very fine grained black basalt, lying on a few feet of light-colored agglomerate, which in turn is underlain by felsitic rhyolite that forms part of the Cow Spring mass. The black basalt at this place is full of flow cracks and lines, which appear plainly in the weathered rock. A mile to the west is exposed a mud flow, which may be part of the same igneous extrusion. It lies on several hundred feet of sandstone and conglomerate, white, red, and green in color, probably members of the great agglomerate series.

ARENA HILLS.

East of Arena, in the southeast corner of the county, there is a low bench or step rising to a wide plateau, in places 200 feet higher than the bolson at and west of Arena. The west slope and surface of the plateau is made up of sand, but out of it rise scattered knolls of rocks of various kinds, which probably indicate the existence of a long rocky ridge nearly buried by Quaternary deposits. One large knoll rising 200 feet above the sandy surface east of Arena consists in part, or perhaps entirely, of quartz monzonite porphyry somewhat similar to some of the rock of the Cooks Peak region. A small knoll at international boundary stone 14 consists of hornblende andesite, and two small ridges northwest of boundary stone 15 are made up of felsitic rhyolite.

There are several prominent peaks and ridges northeast of the Birchfield ranch. The westernmost one rises 300 feet above the bolson and consists entirely of limestone. The beds dip 20° west by south, and the thickness exposed is about 1,000 feet. The rocks are blue-gray of various tints, and the bedding varies from slabby to massive; near the top are some ledges of coarse limestone conglomerate. A few fragmentary fossils observed appear to be of Pennsylvanian age, but this identification is by no means certain. A short distance east of the limestone ridge is a butte showing some agglomerate and a sheet of soda granite porphyry. Farther northeast, along the east margin of the county, are some other outcrops of igneous rocks rising above the plateau, but they were not visited. The plateau here consists partly of a soft sandstone with some conglomerate layers which may be older than Quaternary, but the relations were not ascertained.

BURDICK HILLS.

The Burdick Hills are a series of outlying knolls at the edge of a higher level or step in the plain of bolson deposits south of the valley of Palomas Arroyo west of Iola. These hills consist largely of small masses of various igneous rocks, which show but little of their relations to one another. There is an eastern or outer rim of hornblende latite, some dikes and probable stocks of felsitic rhyolite and quartz porphyry, and some small showings of hornblende-biotite rhyolite. No contacts are clearly exposed except in the larger area in the southeast corner of T. 26 S., R. 11 W., where the agglomerate appears to be cut by dikes of rhyolite and quartz porphyry. At one point farther west there is a small showing of black basalt similar to that which appears in Black Mountain and at several other places in the county.

MIDWAY BUTTES.

The Midway Buttes are knobs of felsitic rhyolite rising out of the bolson 3 miles south-southwest of Iola. They appear to be stocks, but no details of structure or relations are revealed.

GEOLOGIC HISTORY.

General sedimentary record.—Some of the rocks appearing at the surface in Luna County are of sedimentary origin; others are igneous outflows or intrusions. The sedimentary rocks consist of limestone, sandstone, shale, sand, loam, and gravel, all presenting more or less variety in composition and appearance. The principal materials of which they are composed were originally gravel, sand, or mud derived from the waste of older rocks, or chemical precipitates from salty waters.

These rocks afford a record of geologic events in the region from pre-Cambrian time to the present. The composition, appearance, and relations of the strata indicate in some measure the conditions under which they were deposited. Sandstone ripple-marked and cross-bedded by currents and shale cracked by drying on mud flats were deposited in shallow water; pure limestone indicates open seas and scarcity of land-derived sediment. The fossils which the strata contain may belong to species known to inhabit waters that are fresh, brackish or salt, warm or cold, muddy or clear.

The character of the adjacent land may be indicated by the sediments derived from its waste. The quartz sand and pebbles in coarse sandstones and conglomerates had their source in the older rocks, but in many places have been repeatedly redistributed by streams and concentrated by wave action on beaches. Red shale such as that of the Lobo formation results as a rule from the revival of erosion on a land surface long exposed to rock decay and oxidation, and hence covered by deep residual soil. Limestone, on the other hand, if deposited near the shore, indicates that the land was low and that the streams were too sluggish to carry off coarse material, the sea receiving only fine sediment and matter in solution.

The older formations exposed by the uplifts in Luna County were laid down in seas that covered a large part of the west-central United States, for many of the formations are continuous throughout a vast area. The land surfaces were probably large islands of an archipelago that was in a general way coextensive with the present Rocky Mountain province, but the peripheral shores are not even approximately determined for any one epoch, and the relations of land and sea varied greatly from time to time. The strata brought to view by the uplifts in southwestern New Mexico record many local variations in the geography and topography of the ancient land.

Cambrian submergence.—One of the notable events of early Paleozoic time in North America was the wide expansion of an interior sea over the west-central region. The submergence reached the Rocky Mountain province in the Cambrian period, and for a time a large part of the province remained as land rising above the waters. Its rocks were granites, gneisses, and in some areas sandstones and quartzites of Algonkian age. From the ancient crystalline rocks streams and waves gathered and concentrated sand and pebbles, which were deposited as a widespread sheet of sandstone on sea beaches, partly in shallow waters off shore and partly in estuaries. Abutting against the irregular surface of the crystalline rocks which formed the shore are sediments containing this local material. Subsequently, the altitude being reduced by erosion and the area possibly lessened by submergence, the land yielded the finer-grained mud now represented by the shale in the upper portion of the Cambrian in some areas. In southern New Mexico and the adjoining regions on the east and west the surface of the crystalline rocks was finally buried beneath the sediments.

Ordovician and Silurian conditions.—The southern New Mexico region was submerged by the sea during parts of Ordovician and Silurian time, and thick deposits of calcium carbonate were laid down. The deposits now form limestones that are prominent members of the stratigraphic series. There were several widespread uplifts of the region during this long period, causing protracted interruption of the sedimentation, and doubtless also the resulting land surfaces were more or less extensively reduced by erosion. The older formations were not deformed, however, and the erosion of the land surfaces progressed in such a way as to produce no marked irregularities in the floor on which the succeeding formation was deposited.

Devonian conditions.—In some portions of the Southwest the Devonian system is represented by extensive deposits of limestone, but in a part of southern New Mexico only black shale appears, and it represents but a small fraction of Devonian time. This meager record is probably due to the fact that during a large part of this period this region was covered by an extensive but shallow sea, or else the land was so low as to leave no noticeable evidence of erosion. On the other hand, it is possible that the sea was so deep and the area so far from shore that it did not receive appreciable deposits. Whether it remained land or sea or alternated from one to the other, the region shows no evidence of having undergone any considerable general uplift or depression until early Carboniferous time. Then there was an extensive subsidence, which established relatively deep-water and marine conditions throughout a large part of the Rocky Mountain province.

Carboniferous sea.—Under the marine conditions of early Carboniferous time calcareous sediments were laid down in southern New Mexico and adjoining regions. They are now represented by several hundred feet of nearly pure limestone known as the Lake Valley limestone. As no coarse deposits of this age occur, it is probable that no crystalline rocks were then exposed above water in this immediate region, although in central New Mexico these rocks rise as a shore cutting off the earlier Carboniferous sediments.

In later Carboniferous (Pennsylvanian) time there were several widespread oscillations of land and sea resulting in alternations of submergence, shore, and land which continued for varying lengths of time and affected somewhat different areas during different portions of the period. Apparently at times the entire Rocky Mountain province was under water and calcium carbonate was deposited in a widespread mantle. In the Deming region the earlier sediments of the Pennsylvanian series are absent, but the later portion of that epoch is represented by limestones which are thick in the Florida Mountains and lie on an irregular surface that was developed by subaerial erosion. In Cooks Range small amounts of the earlier Pennsylvanian sediments remain. There is uncertainty as to the representation of later deposits of the Carboniferous period, for the age of the Lobo formation is not indicated by any evidence at present available, and in view of the unconformities at the base and top of that formation it is herein tentatively classified as Triassic (?). It is evident that before the deposition of that formation there was uplift with more or less tilting and that great erosion ensued, for an uplifted block along the fault at Capitol Dome was planed off 1,000 feet or more before the deposition of the Lobo.

Early Mesozoic conditions.—As the Triassic and Jurassic periods are not known to be represented in southern New Mexico, it is probable that the area was a land surface for a long time during the early part of the Mesozoic era. As stated above the Lobo formation is tentatively classified as Triassic (?), but it may represent late Carboniferous or even early Cretaceous times. It is probable that some deposits were laid down in the Triassic or Jurassic period, even if they were only the products of streams or lakes and were removed by erosion prior to the Cretaceous period. Aside from some widespread planation there was at this time no notable deformation, and apparently irregularities of land surface, if developed, did not persist.

Cretaceous seas.—During the Cretaceous period a great series of deposits of various kinds but generally uniform throughout wide areas were accumulated over a large part of the western United States. Probably, however, some areas in the central part of the Rocky Mountains were not submerged during this period or were land surfaces during parts of it. The earliest Cretaceous sediments were such as are characteristic of shallow seas and estuaries along a coastal plain. These passed into sediments from marine waters, and these in turn changed toward the end of the period to fresh-water sands and clays with marsh vegetation. Toward the south were open seas in the earlier part of the period in which extensive deposits of calcium carbonate were laid down. In part of southwestern New Mexico a thick body of nearly pure sand was deposited in Comanche time, mainly on the surface of the Lobo formation but possibly overlapping granite in the Pony Hills region. It is now the Sarten sandstone, and although that formation does not crop out in the southern half of the county and in adjoining regions to the southeast and southwest, it was probably deposited over an area of considerable extent. The later Comanche deposits and also the Dakota sandstone appear to be absent, as the Sarten sandstone is succeeded by the Colorado shale, but without notable evidence of unconformity to represent the long-time interval between them. The shale is a product of marine deposition, which was of great extent in the Rocky Mountains and adjoining provinces. In Luna County only a small thickness of the shale appears, and although later rocks of the Cretaceous period were probably deposited they are buried under the agglomerate or the bolson deposits.

Tertiary deposition, volcanism, and uplift.—The great deposit of agglomerate which occupies so large a part of southwestern New Mexico is believed to have been accumulated chiefly during earlier Tertiary time, although some of the deposits may be of Quaternary age and some may be as old as Cretaceous. The Tertiary was a period of great igneous activity, for at times great sheets of lavas of various kinds were extruded and a vast amount of fragmental volcanic material was poured out. The location of the vents or volcanoes from which these rocks came is not known, but undoubtedly they are represented in part by the stocks and dikes now visible. Igneous rocks were also intruded into the sedimentary strata, mainly the porphyries, which welled up as great laccoliths in the Cooks Range, Fluorite Ridge, and the Tres Hermanas Mountains. Water was an important agency of deposition during the accumulation of the agglomerate, for it includes intercalated beds of water-laid sand, conglomerate, and ash. The great mass of the agglomerate, however, was erupted largely as mud flows and showers of coarse ash and rock fragments. At intervals lavas of several kinds were extruded, andesites and latites first, followed by quartz basalt and rhyolite. The felsitic rhyolite and keratophyre were also extruded, but their relations to the other sheets are not known.

After this epoch there was extensive tilting and faulting of the region, and probably much of the present configuration was outlined. The depressions, filled later with bolson deposits, were excavated and the country was rougher than at present.

Quaternary valley filling.—In Quaternary time the wide depressions received a thick filling of gravel, sand, and clay, borne mainly by streams, which built up the great plain or series of wide bolsons now extending from the Rio Grande to the Continental Divide. This material came from the mountains and ridges, some of it brought from afar. Much of it is fine grained and its thickness is great, showing that a long time was required for its deposition. At intervals there were outflows of basalt as lava sheets on the surface. Later erosion has cut some trenches in the bolson deposits, and the canyons and draws in the mountains and ridges are still being cut deeper. The alluvial fans on the mountain slopes receive more or less detritus from time to time and occasional freshets spread a thin mantle of sand or silt on some of the bolsons. Wind moves some of the loose materials from place to place and modifies their surface configuration. The wind-blown sand and changes of temperature are powerful agencies in the erosion of the rocks.

MINERAL RESOURCES.

SCOPE OF OBSERVATIONS.

But little study was given to the mineral resources of Luna County, mainly because previous observers have presented accounts of their general features. Descriptions by Lindgren and Gordon [1] and by F. A. Jones [2] have supplied most of the facts in the following pages.

METALS.

COOKS PEAK DISTRICT.

Lead ores carrying silver occur as irregular deposits in the Fusselman limestone in the central and northern portions of Cooks Range. A deposit of silver ore was also mined at the Graphic mine in the agglomerate on the slope east of the range. At present the only production is incidental to prospecting in active progress on a few claims, and the principal output is zinc ore. The original discoveries in the district were made in 1876, but the first openings of importance were made by Taylor and Wheeler in 1880. The total output to the present time has been estimated at about $3,000,000. Of this amount the Desdemona group is credited with $2,000,000, the Graphic group with $450,000, the Summit group with $350,000, and the remaining mines with about $200,000.[3]

The production from 1902 to 1914 is as follows, according to Mineral Resources of the United States, published by the United States Geological Survey:

Production of gold, silver, copper, lead, and zinc in Cooks Peak district, 1902–1914.

Year.	Crude ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
	Tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1902	1,778	....	9,275	....	663,300	....	$31,176
1903	2,050	....	5,748	....	1,343,361	....	59,997
1904	1,078	....	4,401	....	576,795	....	27,347
1905	846	....	5,199	....	463,956	....	24,946
1906	1,133	....	7,519	....	627,344	....	40,808
1907	811	....	5,354	....	592,1[illegible]	....	34,918
1908	253	....	1,009	....	127,535	....	5,891
1909	695	....	4,317	46	597,488	....	27,943
1910	457	....	1,917	47	242,137	....	11,695
1911	45	....	200	....	32,638	....	1,575
1912	927	....	960	....	142,680	433,129	36,897
1913	1,271	....	1,248	1,395	255,901	695,697	51,189
1914	1,995	$68	2,423	2,181	381,324	793,588	56,843

[1] Lindgren, Waldemar, Gordon, C. H., and Graton, L. C., The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, 1910.

[2] Jones, F. A., Mines and minerals of New Mexico, 1904.

[3] Idem, p. 181.

The best-known mines in the district are the Desdemona, Graphic, Poe, Othello, and Monte Cristo and the openings of the Faywood Lead Co. on the west slope of the mountain. The mines are of various kinds, mainly cuts or tunnels, but there are several shafts at Cooks and a deep shaft at the old Graphic mine. The following statements regarding the ores and their occurrence are taken from a report by C. H. Gordon.[1] The ores are mainly lead carbonate with zinc carbonate, galena, sphalerite, limonite, and pyrite, and they occur in the silicified upper part of the limestone (Fusselman) just below the Percha shale. Some of the deposits are under broad arches in the limestone. The ore is in kidneys, pockets, and pipes of irregular shape and varying from some of very small size to valuable bodies. One large chamber in the El Paso was nearly 100 feet long and 35 to 50 feet wide at one place. It yielded about $450,000 worth of ore. Offshoots extending irregularly into the limestone appear to indicate that the ore is a replacement of the limestone, and cross sections of some of these offshoots show a core of unaltered galena surrounded by lead carbonate with a superficial coating of limonite. More or less quartz is associated with the carbonate ore, and although some of the masses are entirely lead carbonate, others have galena, calcite, and some of them fluorite in the center. There are spaces or caves above some of the ore bodies and extending into them, which are usually lined with calcite or quartz or more or less completely filled with clay. In the large ore chamber in the El Paso mine above referred to there was an open space or cave of considerable size above the ore, lined with crystals of calcite and having stalactites of gypsum. The ore deposits are a short distance north of the great mass of porphyry of Cooks Peak, and dikes of porphyry and diabase cut the limestone and overlying Percha shale at several places about Cooks post office. Two dikes of the basic rock 6 feet apart, exposed just west of Coe's house, appear to cut the ore bodies below. It is stated that the space between them was filled with ore and that a body of zinc sulphide occurred in one of them. There is considerable minor faulting in the rocks, and a fault of great amount passes up the main draw at Cooks.

VICTORIO DISTRICT.

The detached hill of limestone at the southeast extremity of the Victorio Mountains has been extensively mineralized with lead ore carrying silver, and several profitable bodies of this ore have been mined. Part of this hill is the Fusselman limestone, of Silurian age, which carries ores in the Cooks Peak and other districts. No igneous rocks appear in the mineralized area of Victorio, but a large sheet of andesite constitutes the main mass of the high ridges a short distance

[1] U. S. Geol. Survey Prof. Paper 68, pp. 288–289, 1910.

to the north, and it may be that this or some underground igneous mass has been a factor in the ore deposition. The structure of the range is shown in figure 9 (p. 84).

Lindgren[1] has reported on the general features of the ore deposits and mining operations at the Victorio camp. He found that the ore bodies were irregular deposits of galena in limestone, in places 20 feet wide, but abruptly thinning to tight seams running northeast. The ore is partly oxidized and accompanied by coarse calcite and siderite or by quartz as a gangue. All the ores contain arsenic. No igneous rocks appear in the outcrop or workings in Mine Hill, but it is suggested that there may be a buried mass to which the ore owes its origin. The ore body crops out only at one point on the west end of the hill, and where it thins out it is represented only by a tight white seam. The main vein so far developed passes through the west end of the hill on a north-northeast course, dipping 60° WNW., but its course is irregular and the ore bodies show variations in attitude. This vein is mostly covered by the Chance and Jessie claims, each of which has produced ore valued at $800,000. The ore body was brecciated material carrying oxidized galena in calcite and locally in quartz gangue. The higher-grade ores, with 15 to 22 per cent of lead, are richer in precious metals, yielding about 50 ounces of silver and 2 ounces of gold to the ton. The ore continued for about 1,000 feet along the vein and was mainly above a tunnel that followed the vein from a crosscut in the northwest slope of the hill. Some years later an additional ore body was discovered near the main vein and yielded nearly $100,000, and other bodies were developed to some extent on the southwest end of the hill. Similar ore-bearing fissures were found in the limestone in other portions of the hill, but they have not yet proved profitable.

A vein of quartz carrying wolframite traverses the Montoya limestone on the south slope of the hills about half a mile west of the mining camp. The vein trends S. 5° W. and dips 70° S. 85° E., or about at right angles to the dip of the limestone. Its width ranges from 8 inches to 2½ feet, and the mineral is in black masses scattered irregularly through parts of the quartz. There are also small amounts of pyrite, galena, wulfenite, and probably also scheelite, and the quartz is reported to carry a little gold. The production of wolframite so far has been about 14 tons of closely cobbed mineral, leaving very little of it remaining in sight. The principal operations in the Victorio camp were in 1880 to 1886 and again in 1909 and 1910, when small shipments were made from the Helen, Last Chance, and Rambler mines. In 1912 and 1913 mining was in active operation on a small scale and considerable high-grade ore was produced.

[1] Op. cit., pp. 290–292.

TRES HERMANAS MOUNTAINS.

For many years ores of various kinds have been known to exist in the Tres Hermanas Mountains, and at times there has been a small production which appears to have afforded some profit. The only mining in progress in 1912 was in a small lead in the central part of the mountains, where a little silver-bearing galena was produced by two workmen. Zinc ores in the Tres Hermanas Mountains have been described in considerable detail by Lindgren,[1] and the following facts are taken from his descriptions. The openings are a series of small pits in the north-central margin of the district near the base of the hills, about a mile west of the north peak. The ore was discovered in 1904, and several shipments were made in 1905. The ore is in limestone of Carboniferous age that lies near the great mass of porphyry and is penetrated by offshoots from that mass. This limestone contains bunches of wollastonite in the area yielding zinc. The zinc deposits are in irregular bodies and were opened originally for galena, which occurred in small amount at the surface. The galena was worked to some extent, but there was difficulty in obtaining ore of sufficiently high grade to repay the cost of the long wagon haul to the railroad and shipment to smelters.

The zinc ore consists of oxidized zinc minerals and some galena, in part interbedded in the limestone and in part in short, ill-defined, nearly perpendicular fissures and veins cutting across the beds and varying in strike from northwest to southwest. In places it also forms irregular bunches in the limestone. In one locality on the south slope of the limestone hill the oxidized zinc ores occur in kidneys and bunches between beds of coarse crystalline limestone and garnet rock. A veinlike deposit striking N. 60° E. and standing nearly vertical also contains zinc ore at this place.

Much ore occurs in altered limestone near the igneous contact. At the principal workings part of the ore is interbedded with the limestone and part occurs along a vein with west-northwest strike. The ore grades into limestone and has to be carefully picked.

Lindgren suggests that systematic prospecting with drills might reveal deposits interbedded among the altered limestone strata. The ore is in dark-gray cellular masses, consisting largely of the very unusual anhydrous silicate willemite. The willemite forms small radial aggregates of slender hexagonal prisms terminated by a flat rhombohedron and is accompanied by small amounts of a dark material which looks like pyrolusite and gives a dark tint to the ore. It also forms loose crystalline aggregates and crusts of needle-like crystals. Smithsonite, or zinc carbonate, of light-gray color and mammillary form is also present. Hydrozincite occurs as an in-

[1] Lindgren, Waldemar, The Tres Hermanas mining district, N. Mex.: U. S. Geol. Survey Bull. 380, pp. 123–128, 1909; The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, p. 292, 1910.

crustation, and tabular crystals of calamine were noted in crevices of the ore. The galena seen at the principal workings is accompanied by a little pyrite and is intimately intergrown with wollastonite in a manner indicating contemporaneous deposition. The ores shipped from these mines probably contained about 30 per cent of zinc. Shipments of lead-zinc ores are stated to have contained from 11 to 40 per cent of lead and 2 ounces of silver to the ton, also as much as 19 per cent of zinc and 4 per cent of lime, 4.2 per cent of iron, and 7.4 per cent of silica.

Several ore-bearing veins occur in the rhyolite on the west side of the Tres Hermanas igneous mass, notably one which has been worked in the Cincinnati, Hancock, Yellow Jacket, and Alexander mines. This lode has a west-southwest course and is traceable for about a mile, or to a point about 1½ miles south of the zinc mines. The Cincinnati mine is reported to have produced $100,000 from ore rich in lead and gold. At the Hancock mine the vein is said to be 8 inches wide in places. There is a 400-foot shaft at this mine, which is largely in a body of quartz diorite, cutting or underlying the rhyolite. This mine is reported to have produced 1,000 tons of rich lead ore carrying some gold. The only mine in operation on this lode in 1912 was the Alexander, where two men were obtaining a small amount of galena carrying silver. This mine is near the contact of the rhyolite with a mass of limestone which lies along the main porphyry contact. A few small prospects have been reported in the main mass of the porphyry, but they have not as yet proved valuable. One a short distance south of the zinc mines disclosed some copper ore.

CARRIZALILLO HILLS.

The igneous rocks of the Carrizalillo Hills have been prospected at many points and evidently yielded some mineral, but not in paying quantity. A vein recently opened high in the slopes half a mile south-southwest of Hermanas station shows considerable rich copper ore containing gold, of which a small shipment has been made.

SIERRA RICA.

Considerable mining and prospecting have been done in the northern extension of the Sierra Rica, in the extreme southwest corner of Luna County. The principal claim, known as the International mine, is situated a short distance from the boundary line, at a point about half a mile west of boundary post 38. The following facts regarding this mine are taken from notes by J. M. Hill.[1] Operations

[1] U. S. Geol. Survey Prof. Paper 68, pp. 346–347, 1910.

were begun by Volney Rector in 1880, and it is reported that 50 tons of lead-silver ore was produced, which was valued at $25 a ton. The best material obtained, a 10-ton shipment, contained 40 per cent of lead and 65 ounces of silver to the ton. In 1909 there was about 80 tons of galena ore of medium grade on the dump, and as much more in one of the stopes. The ore occurs in a vein of banded quartz from 2 to 10 feet wide, averaging about 3 feet, occupying a fault that trends N. 30° E. and stands nearly vertical. It traverses limestone dipping 30°–40° NW. On the south side is massive red limestone; on the north or hanging-wall side there are thin gray to buff beds, separated from the vein by coarser red grit, with grains showing silica enlargement. The vein is traceable for nearly a mile, its south end being in Mexico, and it has been prospected by numerous pits. The ore from stopes near the Mexico line consists of malachite, azurite, some cerusite, and a few nodules of chalcopyrite and galena, in a limonitic quartz gangue. Some of this ore is reported to assay 10 per cent of copper and 60 ounces of silver to the ton. About 500 feet farther north a 150-foot shaft found good galena ore in the upper levels, but at a lower depth the vein was barren quartz. In a 50-foot shaft 250 feet still farther north there is a drift extending southwest 60 feet along the vein. It found in the hanging wall limonitic quartz, with a little galena and considerable silver, probably as chloride and in cerusite, and in the footwall 2 or 3 feet of massive galena ore, reported to carry about $35 a ton in lead and silver.

FLORIDA MOUNTAINS.

Many claims have been located in the Florida Mountains, but only a few of them have shown sufficient mineral to be of any importance. The principal ores observed have been silver-bearing galena and zinc ores in the limestone. Several small mines have been developed, and from time to time have produced sufficient ore for shipment; but of late only two mines are in operation. One known as the Silver Cave is on the limestone high on the southeast slope of Gym Peak. It is reported to have yielded $60,000 worth of ore in 1905. The workings consist of a drift and several small stopes. The ore is silver-bearing galena and occurs as a replacement of the limestone. Just west of Gym Peak, at the Mahoney mine, are a number of pits and drifts in the limestone, following a series of small irregular masses of oxidized zinc ore. Similar ore has also been mined in small amount from the limestone on the west slope of Capitol Dome. Several small leads of copper ore have been worked in the granite in claims along the west slope of the mountains, and small shipments of ore were made from two localities. The ore consists of chalcopyrite and other copper sulphides impregnating the granite along joints and zones in which the rock is considerably shattered. The bodies, so far as known, are small and irregular. A short distance south of Capitol Dome[1] there is a vein trending N. 62° E. and dipping 80° SE. Two tunnels, one 280 feet long and a lower one 420 feet long, have been driven. A 100-foot shaft 40 feet above the upper tunnel connects with the lower tunnel by a raise. These workings have long been abandoned.

FLUORITE.

The following statements are condensed from a detailed account of the fluorite deposits:[2]

From the southeast end of Fluorite Ridge there was mined in 1909 to 1911 about 9,000 tons of fluorite. This mineral consists of calcium fluorite, with a small amount of impurities, and is in considerable demand in the manufacture of open-hearth steel and for several other purposes. The fluorite of Fluorite Ridge occurs in steeply dipping veins, mostly in the porphyry, and ordinarily it is of exceptionally good quality. The veins range from a few inches to 12 feet or more in thickness, but the general range in the workings is from 2 to 5 feet. They extend along planes of fracture of the rock, some of which are slightly faulted. One set of veins strikes N. 17°–27° E. and another set N. 6° E. to N. 18° W., but others strike at various angles between N. 17° E. and N. 18° W. There are three principal areas—one at Fluorite Camp, a second a quarter of a mile or more to the northeast, and the third about a mile northwest of the camp. In 1912 a mine was opened still farther west.

The opening at the camp is in porphyry near the fault plane which passes along the east side of the limestone ridge and separates the Ordovician limestones from an extension of the main porphyry mass. In the largest pits the vein has been worked to a depth of 80 feet and for a distance of about 100 feet along its north-northeast course. This vein dips 65°–70° SE. and ranges in thickness from 4 to 12 feet. Other veins have been opened to some extent at several points in the immediate vicinity.

At the openings northeast of the camp the fluorite vein appears to be along a fault plane with agglomerate on the east side and chert on the west side. The deepest workings reach a depth of 75 feet and the vein ranges in thickness from 1 to 8 feet. Its course is S. 10° W., and it stands nearly vertical. There are several minor twists in it and indications of some faulting, notably in the occurrence of slickensided surfaces.

---

[1] U. S. Geol. Survey Prof. Paper 68, pp. 289–290, 1910.

[2] Darton, N. H., and Burchard, E. F., Fluorspar near Deming, N. Mex.: U. S. Geol. Survey Bull. 470, pp. 533–545, 1911.

Two veins of fluorite have been opened but not worked in the locality a mile northwest of the camp. They are in the porphyry not far below the overlying sandstone and stand nearly vertical. One vein ranges from 1 foot to 4 feet in thickness and the other averages about 1 foot, but the mineral is not all pure.

Some analyses of carload lots of fluorite from Fluorite Ridge made by the Colorado Fuel & Iron Co. showed a variation from 88.3 to nearly 94 per cent of CaF_2, with an average of 92 per cent. The principal impurity, silica, ranged from 3.84 to 9.85 per cent, iron oxide and alumina from 0.68 to 1.12 per cent, and calcium carbonate from 0.48 to 1.12 per cent, the latter quantity being in the fluorite which contained 94 per cent CaF_2. Compared with fluorite from Colorado, Kentucky, Illinois, and other places the Fluorite Ridge mineral averaged much higher in grade, notwithstanding the fact that it had not been washed.

MARBLE.

Some of the gray limestones of this region are suitable for use as marble, and true crystalline limestone has been found at a number of localities. The most notable occurrence of such limestone is on the south side of the southern one of the high peaks at the north end of the Tres Hermanas Mountains. There is a body of considerable size at this place, lying against the porphyry and evidently a wedge of Gym limestone altered by the heat of the igneous intrusion. Much of the rock is of a pure white color and a coarsely crystalline texture and is well suited for decorative purposes. It is considerably fissured so far as exposed. Similar marble occurs along the igneous contact at the zinc mines on the northwest slope of the same range, but it is not very attractive in appearance and is very irregular in character and structure.

In the Victorio Mountains, a short distance northwest of the mining camp, is a body of fine-grained pure white marble, but it appears not to be large. Doubtless it has been altered by igneous intrusions, but none of the igneous rock appears at the surface at this point, although there are large dikes a short distance to the west.

Marble deposits are of no economic value unless they are so situated that the rock may be quarried and transported economically, and they should be large, free from serious shattering, and yield a product of attractive appearance. Uniformity of texture and tint are requisite features.

ONYX.

Deposits of onyx occupy fissures in the agglomerate at a number of places, and some small masses have been uncovered, one of them in the southwest slope of the agglomerate ridge 3 miles northwest of

Mirage. The color is nearly white and the texture somewhat uneven, and the bodies appear not to be sufficiently large to be of economic importance. There are onyx claims on the slopes 4 miles west of Columbus which have yielded some very good samples, but the extent of the deposits was not ascertained.

BUILDING STONE.

Many of the rocks in the ridges about Deming are suitable for building stones, and some of them would be of considerable value for that purpose if they were nearer to market. The granite and some of the other igneous rocks would dress and polish satisfactorily, and there are sandstones of several varieties. Some of the limestone could be used for gray marble. The only developments are two quarries, one in the Sarten sandstone on the main road a mile south of Fryingpan Spring and the other in the tuff of the Florida Mountains 2 miles northeast of Arco del Diablo. The sandstone is nearly white in color and is easily worked in blocks of good dimensions. The quarry was opened to supply material for the new county courthouse at Deming. The quarry in tuff is a small one, but has exposed a large quantity of excellent gray freestone in massive beds. The color is bright, and although there is some slight mottling by darker-gray fragments the general effect is good.

LIMESTONE.

Limestone suitable for burning into lime or for the manufacture of Portland cement is abundant in the limestone areas of the Florida Mountains, Fluorite Ridge, and the Snake Hills. Considerable portions of the El Paso, Gym, and Lake Valley limestones and some of the Montoya limestone that does not contain chert are sufficiently pure for these purposes, but there is at present no disposition to utilize them.

BRICK CLAY.

Portions of the bolson deposits are loamy mixtures of clay and fine sand suitable for making common brick, and a small number of brick have been made. The principal use of the material, however, has been for the larger unburned brick known as adobe, which have been extensively used for building in Deming and at ranches in the surrounding country.

ROAD METAL.

Rocks of various kinds which could be crushed for road metal are available in endless supply in the ridges, but so far they have not been utilized. The caliche, a mixture of sand and calcium that lies a short distance below the surface in many places, has been employed for surfacing the main road north of Deming, and the excellent results obtained should be an encouragement to extend the treatment over other roads.

GUANO.

Considerable bat guano was found in the large pit in the marble on the east slope of the south peak of the Tres Hermanas Mountains. A trail was built up the steep slope and an incline placed in the pit for the removal of this material, and several tons of it was taken out for use as fertilizer.

GARNET.

The yellowish garnet occurring along the contact of marble and porphyry at the pit just described is sufficiently hard to use as an abrasive. This material is extensively mined at some places in the United States, and when of satisfactory quality its average value is $30 a ton.

WATER RESOURCES.

STREAMS.

The streams in Luna County flow only during times of freshet, and these are of short duration. Often in the spring or early in the summer Mimbres River has a flood of such volume that the water is 10 to 15 feet deep and overflows the lower lands adjoining its channel. This condition may last a few days and recur two or three times in a season. In some years the maximum stage of the river is a very small flow, not reaching far beyond Deming, but occasionally it extends into the wide valley east of the Florida Mountains as far as T. 25 S., where it widens into a shallow lake. From December, 1904, to May, 1905, and again in January to April, 1906, the Mimbres flowed nearly to the Mexico boundary for the only time in 18 years. In Recent geologic time, however, it flowed through this valley and out into the Palomas Lakes and other basins in Mexico. At no distant time, also, it flowed through the wide bolson west of the Florida Mountains and found an outlet through the low pass between that range and the Tres Hermanas Mountains.

In April, 1908, a gaging station was established on Mimbres River just below the Rio Mimbres dam site, in sec. 7, T. 20 S., R. 10 W., about 6 miles southeast of Faywood Springs and about 10 miles northeast of Faywood station, on the Silver City branch of the Santa Fe Railway. Gage-height records and discharge measurements have been obtained since 1908. The channel at the station is very shifting in character, and numerous measurements are necessary to obtain the best results. For this reason the results recorded and the estimates of flow for periods between measurements and at high stages are only approximate. The following table shows the monthly run-off in acre-feet:

Monthly run-off, in acre-feet, of Mimbres River east of Faywood, N. Mex.

Month.	1908	1909	1910	1912	1913	1914
January	....	1,060	314	....	793	1,190
February	....	530	245	....	142	334
March	....	548	144	....	468	243
April	....	187	131	....	3,400	236
May	713	136	111	553	247	228
June	577	74	147	482	202	655
July	7,750	364	364	2,190	193	....
August	7,620	701	1,650	2,640	548	5,300
September	3,750	212	155	2,150	352	1,590
October	3,090	275	0	707	133	3,890
November	1,420	411	10	655	464	1,300
December	1,860	139	0	615	1,270	12,300
	26,800	4,640	3,270	9,990	8,210	....

NOTE.—Owing to the shifting character of the stream bed and the few discharge measurements, no estimates of flow can be made for 1911. Gage out of order May 11-16, 24-30, July 21-25, and Aug. 12-15, 1914.

The maximum daily flow, from 1908 to 1913, was in August, 1908, when two days are estimated at 910 and 1,000 second-feet, respectively. Probably this was exceeded in the great flood of July 18 to 24, 1914, but unfortunately the volume of this was not determined owing to a mishap to the gage. There was also a notable flood from December 22 to 25, 1914, with flows of 1,420, 1,270, 970, and 580 second-feet. Other notable flows were 61 second-feet for 14 days in October, 1908, 93 second-feet July 13, 1909, 108 second-feet August 14 and 15, 1909; 196 second-feet August 10, 1910.[1] The mean yearly flows for 1909, 1910, and 1913 are 6.4, 4.5, and 8.6 second-feet, respectively. The ordinary flow is between 1 and 8 second-feet, but this small amount is due to the fact that much of the water is drawn off for irrigation above the gaging station. Accordingly, most of the figures given above represent flood conditions and the total amount of normal flow is not indicated.

After rainy periods the water of the Mimbres frequently flows down the valley as far as Taylor Mountain, in T. 20 S., or to and beyond Spalding. Its main branch, the San Vicente Arroyo, is also subject to frequent floods in which the water flows as far as its mouth. Streams flowing out of Cooks Range are occasionally filled with water by a succession of heavy storms, but their flow is short-lived and rarely reaches the Mimbres. The same is true of Palomas Arroyo, which has a large drainage basin in the bolson, but ordinarily the flood waters even of cloud-bursts mostly sink in the porous bolson soil.

[1] Territorial Engineer Second Bien. Rept. to Governor of New Mexico, 1905–1910, Santa Fe, 1911.

SPRINGS.

There are few springs with large discharge in Luna County, and even seeps are not common in the rocks of the ridges. The largest spring is on the Butterfield road just west of Fort Cummings. It was cleared out by the Government when the fort was established and made into a curbed well 15 feet in diameter protected by a roofed house, shown in Plate V, *A* (p. 13). Now the water is piped to Florida station for use by the railway company. This spring is largely due to a rock dam of rhyolite which crosses the small arroyo. Its underground source is not known, and it may either come out of sedimentary deposits covered by basalt or rise from the agglomerate which doubtless lies not far below.

A notable spring rises in the arroyo a mile below Cooks post office, and the water from it usually flows for a short distance. Its source is in the Sarten sandstone. Another spring rises from the sandstone in this same hollow at the fault a mile farther southeast. Several springs and seeps occur in canyons in the Cooks Peak area, but their volume is small.

A well-known stock-watering place called Cow Spring is in the northern part of T. 22 S., R. 13 W. It yields a large amount of water, and the supply is stated not to vary greatly in volume. The spring appears to be caused by a rock dam raising the underflow in the valley, which has a small drainage basin to the northwest. The rock does not reach the surface at the spring, but rises in ridges to the south and northwest.

Carrizalillo Spring rises from the bottom of a small valley a short distance west of Hermanas and is caused by a rock dam which crops out near by. The spring is a large one and its water has been utilized for stock for many years. Part of it is now piped to Hermanas for use by the railroad. Since it has been pumped the water level has been lowered so that it is now 3 feet below the surface. An analysis of the water is given on page 125.

Niggerhead Spring is a seep flowing out of the joints of igneous rocks in the Tres Hermanas Mountains. It was a favorite camping place for the Apache Indians and later for the soldiers who came to drive these Indians out of the country.

Willow Spring is a water hole in the agglomerate on the southeast side of the Tres Hermanas Mountains. Now it is used as a well for windmill pumping by a Mexican who has a ranch there.

In the slopes of the Florida Mountains there are several small seeps and springs which are used as watering places for goats and cattle. Byer Spring, 3 miles southeast of Arco del Diablo, is the best known of these, but its volume is very small.

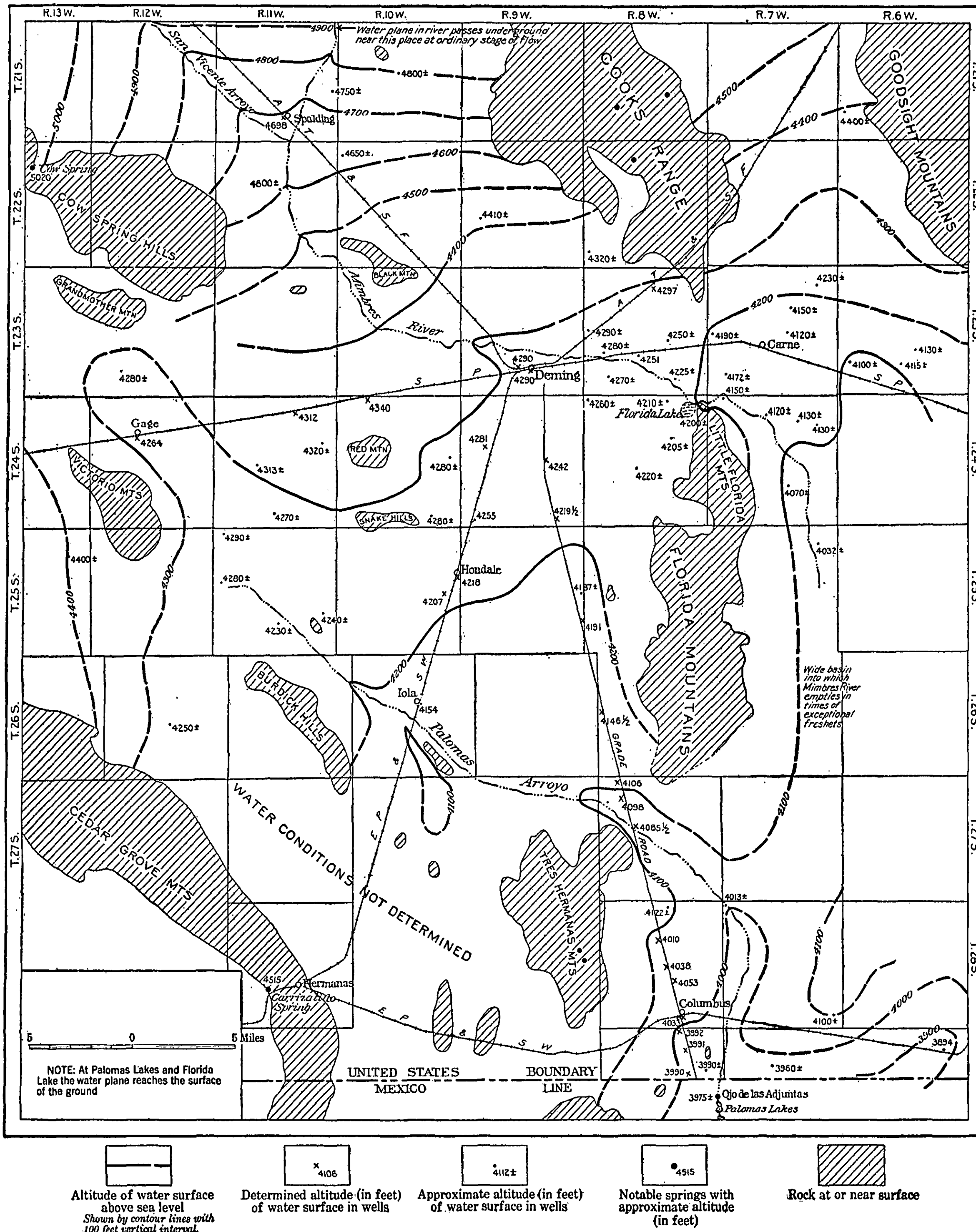
Fryingpan Spring rises along the great fault 2½ miles west by south of Fort Cummings. It has a small flow which runs down the draw a few rods and supplies cattle in the adjoining range.

Puma Spring is a small one rising from the agglomerate a mile northwest of the Wilson ranch northeast of Fluorite Camp. It is dug out as a well and is not in use at present.

UNDERGROUND WATER.

GENERAL CONDITIONS.

The thick body of sand and gravel underlying the wide bolsons of Luna County contains a very large volume of water, most of which is within 25 to 150 feet of the surface. The local conditions as to depth and volume of water vary from place to place, but there are extensive districts in which the depth probably is not too great for profitable pumping and the volume is ample for the irrigation of large areas. Numerous wells have been sunk which indicate the water resources in many places, but in some sections little information is available. One of the principal objects of the investigation here reported was to collect all the available facts that would throw light on the limits of the water-bearing areas and on the thickness, depth, and water-bearing capacity of the different strata. It is a popular belief that the water is a wide extension of the underflow from Mimbres River, but, while the stream had originally much to do with the deposition of the water-bearing materials, it does not furnish much of the water. There are wide areas in some of the bolsons in which water is not available or lies too deep to be of service for irrigation, and these are in some measure delimited on the map (Pl. I, in pocket). A district containing shallow underground waters in good volume lies about Deming and in the wide bolson extending southward from that place on the west side of the Florida Mountains. In the great valley on the east side of these mountains the conditions are unfavorable, for south of T. 24 S. there is barely sufficient water for stock. Another district in which underground waters are available lies along the valley of Palomas Arroyo from Iola to and below Columbus. In the following pages there is given a list of wells and descriptions of the local conditions. In Plate VIII are shown the form and elevation of the water surface, based on heights of water in representative wells tied to the best available data as to land elevations. The contour lines show the elevations of the water surface above sea level. Plate IX (p. 116) shows some of the underground water conditions about Deming and is based on well records and other data supplied by Mr. R. H. Case, of Deming.



MAP SHOWING GRADE OF UNDERGROUND WATER SURFACE IN LUNA COUNTY, N. MEX.

EXTENT OF THE WATER-BEARING STRATA.

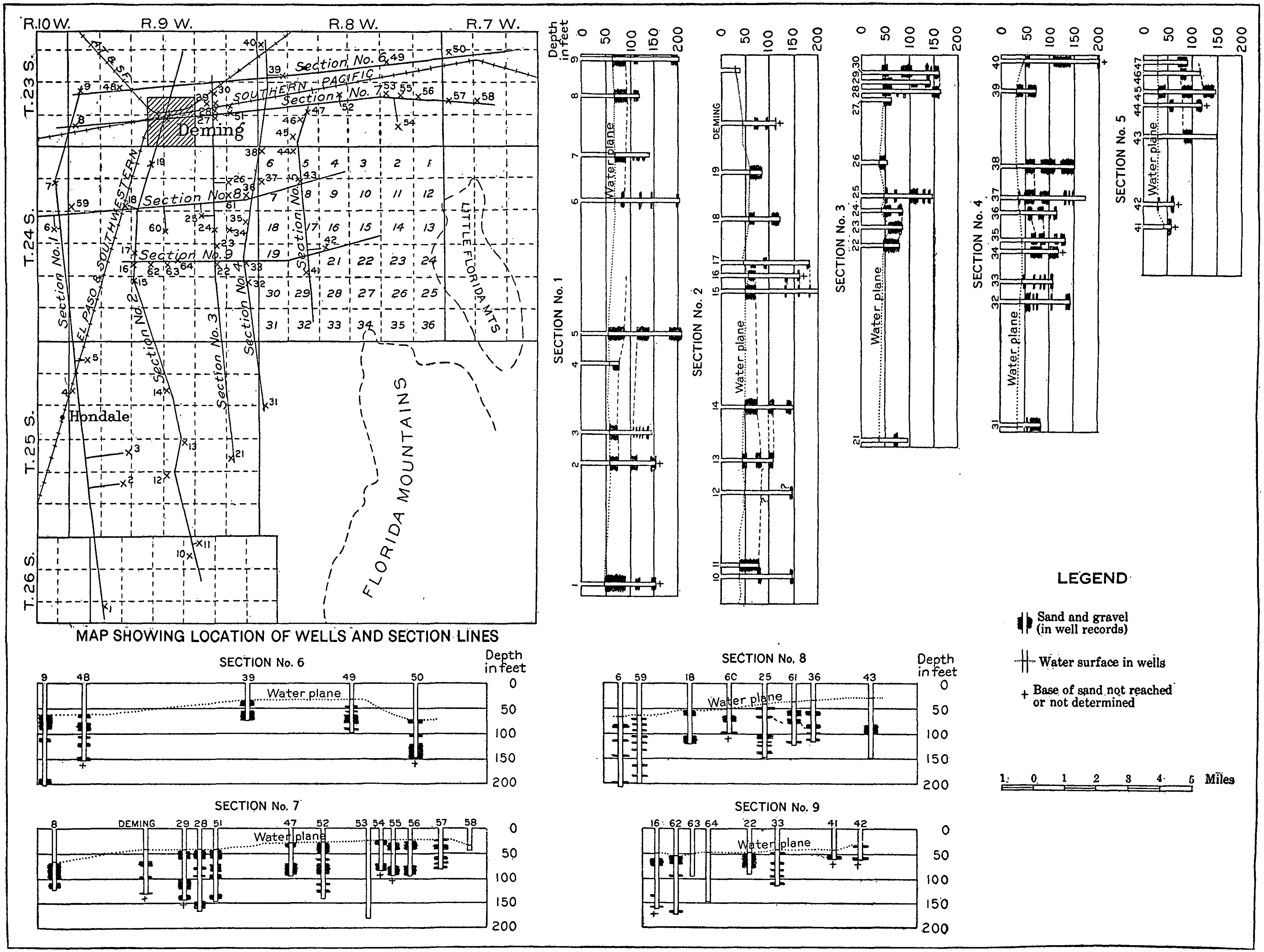
By far the largest volume of water in Luna County underlies the broad bolson extending southward from Deming to the foot of the Tres Hermanas Mountains and thence southeastward through the gap between that range and the Florida Mountains to the Palomas Lakes. Most of the wells in T. 24 S., Rs. 8 and 9 W.; T. 25 S., R. 9 W.; and T. 26 S., Rs. 9 and 10 W., and the valley of Palomas Arroyo found a large supply of water at depths of 50 to 200 feet that rises within 20 to 60 feet of the surface. The limits of the district in which this favorable condition exists are of great practical importance to settlers, for outside of the area underlain by an adequate water supply the land is of but little value for agriculture. Unfortunately, without records from many wells, the underground conditions in the bolson deposits are difficult to trace and the limits of the water-bearing strata can not be located with precision. The Florida Mountains and other ridges delimit the area in places, but the form of the bedrock floor under the bolson deposits is not indicated. Doubtless also there are many small ridges of rock underground similar to those appearing in the Snake Hills and Midway Buttes as well as many other projections which are not sufficiently high to rise above the bolson but which approach so near to the surface as to cut off the underflow. On the map (Pl. I, in pocket) the underground-water conditions are set forth so far as information concerning them is available. Undoubtedly a large part of the area shown on this map with the symbol for "water conditions not determined" is barren of serviceable underground supplies, and most parts of the areas in which water is more than 60 feet below the surface do not contain water in large volume. The broad basin south of the Cedar Grove Mountains contains but little water, and the great sink of the Mimbres east of the Florida Mountains appears to have but a scanty water supply. In the district lying between Cooks Range and the Goodsight Mountains the conditions appear to be more favorable, but they have not been adequately tested. Probably there the water surface is considerably deeper than in the Deming region.

SOURCE OF THE UNDERGROUND WATER.

Much of the water contained in sand and gravel under the great bolsons of Luna County is derived from local rainfall. This amounts to about 10 inches a year (see p. 16), and though most of the water evaporates a considerable proportion passes underground. Mimbres River brings a certain amount of water into the region, and the flow which it gathers from the mountains on the north has been passing underground for a very long time and gradually adding to the bulk of water in the coarser beds underlying the wide bolsons about Deming and farther south.

There is no run-off in the bolson except after cloud-bursts, when small amounts of water may flow to the lower ground, where it either evaporates or sinks. On the mountain slopes there is considerable run-off which flows out upon the bolsons. Owing to lack of knowledge as to the proportion of rainfall which passes underground in the region, it is not possible to give figures as to the rate at which the underground water accumulates in the bolson deposits. The loss by evaporation is very great, especially in some deeper portions of the bolsons, where there are at times accumulations of run-off water, and in areas where thick deposits of relatively impervious clay hold the water at the surface. Capillary action in soils and subsoils, which is especially strong in arid regions, adds greatly to the depletion of the water absorbed by the soil from rainfall, for this agency returns much of it to the surface, where it is lost by evaporation. The extent of this action is well illustrated in this region by the great accumulation of caliche, which is calcium carbonate that was brought up by capillary movement of the underground water.

The only notable sources of underground-water supply entering the county are the underflows of Mimbres River and Arroyo San Vicente. It has been estimated by engineers of the Mimbres Dam Co. that Mimbres River above the dam site in sec. 6, T. 20 S., R. 10 W., has a catchment area of about 600 square miles. One quarter of this is in mountains, where the total annual precipitation is about 20 inches, one-half is a high area having a precipitation of about 15 inches, and the remainder is made up of foothills in which the precipitation is about 12 inches. In all, this gives an annual rainfall of nearly 500,000 acre-feet of water, but evidently there is great loss by evaporation and other causes, for the surface flow gaged since 1908 at the dam site shows only about 3,270 to 30,000 acre-feet a year with an average near 10,000 feet, and the additional underflow at that place is estimated at 2,000 acre-feet a year. As this water is not held by a dam at present, considerable of it passes down in floods, and when the stream overflows on the low lands adjoining the channel a fairly large proportion is lost by evaporation. When it is held by the dam it will not be free to pass underground until it has done duty in irrigation, which will greatly increase the loss by evaporation and correspondingly diminish the volume of underflow. Assuming that all the 12,000 acre-feet of water passes underground and extends under the 14 townships contiguous to the line of its southward flow to Palomas Lakes along a course west of the Florida Mountains would give an annual increment of less than half an inch a year under that area.



MAP AND SECTIONS SHOWING RELATIONS OF THE WATER-BEARING STRATA IN THE DEMING REGION.

Prepared mainly from records furnished by R. H. Case.

THICKNESS OF WATER-BEARING BEDS.

The deposits that underlie the bolsons of Luna County vary greatly in their capacity to hold water, not only from bed to bed but in the same bed from place to place. There are many deposits of sand, and some of the well records show that these attain a thickness of 40 to 50 feet. In most places, however, the thickness is much less, and many of the borings show more or less admixture of clay. The thickness and relations of the principal water-bearing beds of the Deming region are shown in Plate IX.

Some representative sections are given in the following paragraphs to show the thickness of the water-bearing beds in various parts of Luna County.

In T. 23 S., R. 7 W., the water-bearing sands show much variation in thickness. A 195-foot well in the SW. ¼ sec. 21 has sands at 74–87, 89–117, and 177–195 feet, or 59 feet in all. A 147-foot well in the NW. ¼ sec. 19 has sands at 70–78, 102–108, and 130–147 feet, or 31 feet in all. Wells from 90 to 100 feet deep in the southeastern part of the township have from 8 to 23 feet of sand. A 101-foot well in the SW. ¼ sec. 30 has sands at 22–24, 29–35, and 64–101 feet, or 45 feet in all, but a 90-foot well in the NW. ¼ of this section had only 23 feet, the lower sand member containing beds of fine-grained material. A 290-foot boring in the NW. ¼ sec. 12 penetrated several sand beds, apparently more than 50 feet in all.

In the southern half of T. 23 S., R. 8 W., the sand deposits are thick and carry a large volume of water. A 200-foot well in the SW. ¼ sec. 18 has sands at 51–59, 110–141, and 197–200 feet, or 42 feet in all, and a 72-foot well in the SW. ¼ sec. 19 has 31 feet. A 115-foot well in the NW. ¼ sec. 23 has sands at 45–50, 56–60, 66–80, and 88–92 feet, or 27 feet in all, and a group of wells from 92 to 103 feet deep in secs. 25, 26, and 27 find from 37 to 44 feet of sand. A 143-foot well in the NE. ¼ sec. 28 has sands at 34–60, 66–83, 112–118, and 136–143 feet, or 57 feet in all, and a 156-foot well in the SW. ¼ sec. 32 has the same amount in beds at 29–45, 80–104, and 140–156 feet. That the sands thin somewhat to the south is shown by the record of a 105-foot well in the SW. ¼ sec. 12, which has sands at 65–72, 80–81, 83–85, 88–92, and 98–105 feet—only 21 feet in all.

In the township in which Deming is situated (T. 23 S., R. 9 W.) records are available for 11 wells more than 100 feet deep, mostly in the southern tiers of sections. A 143-foot well in the SW. ¼ sec. 25 has sands at 44–62, 66–78, 85–100, and 122–134 feet, or 58 feet in all, but another well of similar depth in the same quarter section has only 36 feet, the second and fourth strata not being represented. A 164-foot well in the SE. ¼ sec. 26 has sands at 40–58, 74–80, 86–90, and 145–160 feet, or 43 feet in all, and a 142-foot well in the center of this section has a similar amount. A 160-foot boring in the NW. ¼, however, has sands at 40–50, 73–80, 88–90, and 145–160 feet, or only 34 feet in all. A 160-foot well in the SE. ¼ sec. 27 has sands at 47–55, 84–105, 125–129, 140–145, and 150–158 feet, or 41 feet in all. A 150-foot boring in the NE. ¼ sec. 29 has sands at 61–68, 75–90, 102–108, 115–125, and 148–154 feet, or 42 feet in all. A 203-foot boring in the NW. ¼ sec. 30 has sands at 65–83, 109–112, and 190–200 feet, or 31 feet in all, and a 120-foot well a mile farther south has sands at 65–96 and 105–114 feet, or 40 feet in all. A 215-foot well 3 miles northeast of Deming has seven thin beds of sand at intervals, or 19 feet in all, and some of the sand is very fine grained.

In the northwestern part of T. 24 S., R. 8 W., there are several 150-foot wells which penetrated more than 50 feet of water-bearing sands. One in the NW. ¼ sec. 7 reports water-bearing sand from 46 to 100 feet; one in the NW. ¼ sec. 6 has sands at 50–70, 85–110, and 122–147 feet, or 70 feet in all; and a 114-foot well in the northwest corner of sec. 5 has sands at 54–65 and 104–114 feet, or only 21 feet in all. In the northwest corner of sec. 21 a 510-foot boring has sands at 32–38, 60–65, 265–270, 319–325, and 502–508 feet, only 28 feet in all, and a deep well in the SE. ¼ sec. 20 has only 35 feet. A 161-foot test boring in the NW. ¼ sec. 30 has sands at 45–50 feet and at intervals from 67 to 96 feet, with clay below, aggregating only about 20 feet of sand.

In T. 24 S., R. 9 W., the next township west, there are many records showing considerable diversity in the strata. An 80-foot well in sec. 4 and a 133-foot well in the SE. ¼ sec. 8 have 28 feet of sand each. Two wells, 115 and 123 feet deep, in the southern part of sec. 12 have 24 and 26 feet of sand in beds mostly from 6 to 9 feet thick. A 128-foot well in the NE. ¼ sec. 13 has sands at 58–68, 78–86, 105–114, and 118–125 feet, or 34 feet in all, and a 115-foot well in the SW. ¼ of this section has 35 feet in two beds. A 150-foot well in the NW. ¼ sec. 13 has only 14 feet of sand in its second, third, and fourth strata. A 145-foot well in the NW. ¼ sec. 14 has sands at 48–53, 65–72, 102–112, 125–129, and 133–138 feet, or 31 feet in all. A 100-foot well in the SW. ¼ sec. 15 has 10 feet of sand, mostly at the bottom. A 177-foot well in the NW. ¼ sec. 21 has sands at 63–70, 83–88, and 165–177 feet, or 24 feet in all, and another well in the SW. ¼ of this section has sands at 56–68, 124–134, and 152–158, or 28 feet in all, respectively. Two wells in sec. 23, 79 and 83 feet deep, have 27 and 29 feet of sand. A 110-foot well in the SE. ¼ sec. 24 has five sands 4 to 5 feet thick, or 22 feet in all; and beds of similar character and the same aggregate thickness are found in a 145-foot well in the NE. ¼ sec. 25. In the NW. ¼ sec. 28 a 203-foot well penetrated sands at 53–75, 130–132, 158–162, and 180–182 feet, or 30 feet in all.

In T. 24 S., R. 10 W., the sands are of irregular extent and thickness, owing in part to their interruption by Red Mountain and the Snake Hills, but in the eastern part of the township conditions are the same as in adjoining townships on that side. A 135-foot well in the NE. ¼ sec. 12 has sands at 64–90, 103–106, 115–118, and 127–130 feet, or 35 feet in all, but a 208-foot well in the SE. ¼ sec. 13 found the top sand much thinner and a 7-foot bed of sand at the bottom, or only 17 feet in all, though these beds contain a large supply of water.

In T. 24 S., R. 11 W., the next township west, the sands are thinner, a 105-foot well in the NW. ¼ sec. 21 having only 10 feet of sand in the bottom and a 300-foot hole in sec. 34 finding sand only at 78 to 80 feet, which yielded but little water.

Several wells recently sunk in the northwestern part of T. 24 S., R. 7 W., show an extension of a thick but variable succession of sands under that area. Detailed sections are given on another page, but a few general features will be mentioned here. A 140-foot well in the NW. ¼ sec. 1 has 70 feet of sand, not all water-bearing. A 130-foot well in the NE. ¼ sec. 11 has 35 feet, and one of about the same depth in the NW. ¼ sec. 11 has 56 feet of sands. In secs. 12 and 13 there are from 30 to 48 feet of sand in wells 122 to 128 feet deep. In a well in sec. 26 there are six sand deposits in 144 feet, aggregating about 46 feet.

Wells in T. 25 S., R. 9 W., show the wide extension of several thick beds of sand containing much water. The 550-foot boring in the SW. ¼ sec. 6 had sands at 50–90, 110–143, and 183–210 feet, or 160 feet in all, but a 150-foot well a mile to the southwest apparently found the principal water-bearing sand at 62–78 feet. A 150-foot well in the SW. ¼ sec. 10 had sands at 50–75, 102–112, and 135–145 feet, or 45 feet in all. A 148-foot well in the NE. ¼ sec. 148 had the first water sand at 52–69 feet and sand at intervals from 103 to 142 feet, probably about 35 feet of sand in all. A 110-foot well 2 miles farther east, in the NE. ¼ sec. 22, found 29 feet of sand but did not reach the fourth stratum. A 152-foot well in the NE. ¼ sec. 29 had sands at 55–73, 97–112, and 135–152 feet, or 50 feet in all. A well in the NW. ¼ sec. 35 reported only two sands, at 45–55 and 75–82 feet, or 17 feet in all, but possibly the supply is derived from another sand at the bottom. A well only 85 feet deep in the NW. ¼ sec. 18 of the next township east had 23 feet of sand, a 21-foot bed in the bottom containing much water. It is reported that 100 feet of sand was found in the bottom of a 275-foot well in the SW. ¼ sec. 18, T. 25 S., R. 10 W. A 191-foot well in the SW. ¼ sec. 18, T. 25 S., R. 11 W., found sand only at 60–65 and 182–191 feet, or only 14 feet in all.

In most parts of T. 26 S., R. 9 W., the water-bearing sands are thick and contain a large volume of water. An 80-foot well in the NW. ¼ sec. 3 has 40 feet of sand, but two wells 116 and 150 feet deep in the southern part of this section have only 15 and 18 feet of sand, respectively. In the NW. ¼ sec. 18 sands were penetrated at 45–75, 110–120, and 145–155 feet, or 50 feet in all, and an 80-foot well in the southeastern part of the township showed five beds of sand at intervals from 30 to 80 feet, aggregating 25 feet.

In the Waterloo region and the vicinity of Palomas Arroyo, in T. 27 S., Rs. 9 and 10 W., the main water-bearing sand is near the surface and most of the wells penetrate it only from 20 to 30 feet to obtain all the water desired. A test hole in the SW. ¼ sec. 1, T. 27 S., R. 9 W., found sand and gravel at 27–46 feet, with clay below to the bottom of the hole at a depth of 105 feet.

In the Columbus region the sand deposits are varied in thickness and position, and in some districts the material is quicksand, which does not yield a satisfactory supply. In the SW. ¼ sec. 24, T. 28 S., R. 8 W., a 200-foot well penetrated 41 feet of sand, but it was mostly quicksand. Several wells about Columbus and farther south penetrated thick bodies of sand containing a large volume of water, but these deposits are irregular in size and of slight extent. In a 221-foot well in the northwest corner of sec. 11, 2 miles south of Columbus, gravel extends from 110 to 130 feet and sand from 165 to 221 feet, 76 feet in all, and this body of coarse material appears to extend southeastward to the international boundary.

VOLUME OF UNDERGROUND WATER.

It has been shown in preceding statements that the water-bearing deposits vary greatly in thickness, texture, and continuity from place to place, and that it is therefore difficult to determine accurately the amount of water stored in these deposits, and also that only an approximate figure can be offered as to the annual increment. It would appear that in most parts of the Deming region and the country to the south 40 feet is near the average for the aggregate thickness of the water-bearing beds in the first 150 or 200 feet below the surface. On the assumption that this 40 feet of sand contains 20 per cent of its volume in water, which is a fair average, the amount of water in a given area would be near 8 cubic feet to the square foot, equivalent to 60 gallons, or approximately 2,608,000 gallons to the acre, or 8 acre-feet. This is much more than the amount obtainable, because it is impossible to pump out all the water, the proportion available depending on the texture of the sand and some other minor factors.

The area under which there are 40 feet of water-bearing beds containing a fair volume of water is about 500 square miles, and with this volume at 8 cubic feet to the square foot, or 8 acre-feet for every acre, the underground water supply is 2,560,000 acre-feet. There is, besides this area of 500 square miles, a region of large extent containing a smaller volume of water, some of which can be utilized for irrigation.

It is impossible to make an accurate estimate of the time required for the accumulation of this amount of water or for the replenishment of the supply if it were pumped out. Probably the few inches of increment from rainfall and the Mimbres underflow of 12,000 acre-feet, as above estimated, passing into the 14 townships which are in the line of its travel southward, would amount to an annual increment of less than half an inch for that area. At this rate many years would be required to fill the voids in the 40 feet of water-bearing beds.

GRADIENT AND RATE OF UNDERFLOW.

Gradient.—The word underflow implies a movement of the water down a grade of greater or less amount. The gradient and the porosity of the materials through which the water flows are the principal factors bearing on the rate of flow. The gradient in Luna County is represented on Plate VIII (p. 114), based on numerous accurate determinations of elevations of the water surface and many approximate data. In order to determine the altitudes south of Deming a special level line was run over the old grade road to the international boundary.

At Spalding the underground water is 30 feet below the surface, or 4,698 feet above sea level. At Deming it is 50 feet below the surface, or 4,290 feet above the sea, and at Columbus it is 30 feet below the surface, or about 4,033 feet above the sea. As the distance from Spalding to Deming is 17 miles, the down grade between the two places is therefore about 24½ feet to the mile. As the distance from Deming to Columbus is 31½ miles, the slope in that distance is 8.3 feet to the mile. At Iola the water surface is 46 feet below the surface, or 4,154 feet above sea level, a grade of slightly more than 7½ feet to the mile from Deming. At Gage the water level is 26 feet lower than at Deming, probably because the upper beds are too fine to admit any notable volume of water. This causes the long loop in the 4,300-foot line of grade shown in Plate VIII. There are some other deflections of the lines, due to special local causes, notably in the area of increased depth just south of Iola and in the area east of Columbus, where the lines apparently have a close relation to the topography. The strong deflection of the 4,100-foot line up the main Mimbres Valley east of the Florida Mountains defines the water plane in that bolson, where the water lies somewhat lower than on the west side. However, as the sediments on the east side are too fine to hold a large volume of water, the position of the water plane is of little economic importance. There is a general rise of the water plane toward the high ridges, especially the Florida Mountains, where the alluvial fan holds a small underflow that moves down the slope.

Movement.—The rate of movement of the underground water in this region has not been tested at any point and can only be inferred in a general way from measurements in other regions. It diminishes somewhat with increase in depth, for in a region of low gradient increase in depth is accompanied by a proportionate decrease in grade. To judge from the water-bearing materials excavated at a number of wells, it is evident that the degree of porosity varies greatly. The rate of movement has been found to be as much as 100 feet a day in coarse materials, with the volume of water as high as 35 per cent, but in the average sand the rate is much less. Slichter and Wolff [1] found that the underflow of Platte River at Ogalalla, Nebr., had an average rate of 6.4 feet in 24 hours, or a mile in 825 days. At a depth of 16 to 22 feet the velocity averaged 12.8 feet a day, and at 55 and 85 feet it was 2.55 feet. The slope of the valley is about 8.3 feet to the mile. Slichter found that the underflow of Arkansas River at Garden City, Kans., averaged 8 feet a day, or a mile in 660 days, with a grade of 7½ feet to the mile. Much of the water of this underflow is derived from the side slopes, part of which are made up of loose sand, that imbibes 60 per cent of the rainfall.

In the Mesilla Valley, N. Mex., the underflow of the Rio Grande, having a grade of 4.6 feet to the mile, was found to have very slow movement,[1] and at the canyon of the Rio Grande, just above El Paso, Tex., the movement of the underflow, 10 to 20 feet below the bed of the river, was less than 3 feet a day.[2]

DEPLETION OF WATER SUPPLY.

Nearly 200 pumping outfits are installed or under erection in the Deming-Columbus region, and the average output will be near 700 gallons a minute for about 400 hours a year. If the number of pumps were placed at 500, which, however, is probably far in excess of the financial means of settlers now on the ground, the total yearly pumping of water for irrigation would be 8,400,000,000 gallons, or nearly 26,000 acre-feet. This would be equal to water 2 feet deep on 20 square miles, and with the duty of water at 2 acre-feet a season, 20 square miles to 500 ranches is equivalent to an average of only 25.6

[1] Slichter, C. S., and Wolff, H. C., The underflow of the South Platte Valley: U. S. Geol. Survey Water-Supply Paper 184, pp. 9–10, 1906.

[2] Slichter, C. S., Observations on the ground waters of Rio Grande valley: U. S. Geol. Survey Water-Supply Paper 141, pp. 9–13, 1905.

acres under ditch to each ranch. As 500 quarter-section homesteads occupy 125 square miles, the 26,000 acre-feet would be drawn from that area, where it would represent about one-third acre-foot of water, or less than 4 per cent of the 8 acre-feet available as estimated on page 120.

The estimated annual increment of 3 inches by rainfall and underflow would be sufficient to provide for the irrigation of only about one-eighth of the area in which the underground storage conditions are favorable, on the basis of the duty of water as 2 acre-feet an acre (2 feet deep over the area irrigated each season).

Of course 20 square miles under cultivation, as above estimated, is a very small proportion of the 125 square miles, or area of 500 homesteads, under consideration, nearly all of which could be irrigated by plants with an average of 700 gallons a minute. Eventually, no doubt, the proportion of land utilized in each homestead will increase, as it must for profitable operation, and then the draft on the underground supply will increase proportionately. If half of the area of the 500 homesteads were irrigated, the draft on the underground supply would be about 12 per cent instead of 4 per cent, and this would cause a serious diminution in the total amount available in some areas.

An important condition affecting the amount of the water that can be pumped from a particular area is the rate of lateral flow of the underground water. The movement is started when the pump begins to lower the water in the well, and the local depletion is more or less completely replaced by influx from a constantly widening area. In places where several heavy pumping plants are in close proximity, all drawing water at the same time, there will be a limit to the amount of water immediately available, and doubtless a scarcity of water would result at most localities. At many places the principal supply comes from a deeply buried stratum that is not very thick, and vigorous pumping drains out much of the water near the pump. A most important factor in underground flow is the relatively slow adjustment of water level compared with that of surface water, for the rate of movement in fairly coarse sand averages about 1 mile a year, or less than 15 feet in 24 hours. If, for example, there are four pumps of 1,000 gallons' output in the centers of four adjacent quarter sections, draining from a 5-foot bed of sand capable of yielding 20 per cent of its volume in water, or 1 foot deep for the total area, at the end of 20 hours' pumping the amount taken out by each pump would be 3.68 acre-feet—that is, all the water under 3.68 acres, or within a radius of about 200 feet. This is one-thirteenth of the distance to the next pump, and ordinarily water would require several days to flow this distance, the time depending on the head of the water and the porosity of the sand.

QUALITY OF THE WATER.

In general, the water from the wells of Luna County is moderate in mineral content and suitable for most uses. At a few localities the water, especially that near the surface, contains too much alkali, but this condition is unusual. Water from wells that are properly sunk and protected at the surface is free from contamination. The water pumped for irrigation in the broad area about Deming and to the south is nearly all low in mineral content and far above the average of waters of the West. However, all well and surface waters contain some mineral matter in solution; and if large volumes of these waters are allowed to evaporate on the land, this matter will gradually accumulate as "alkali" in or on the soil and poison it for plant growth.

Nine analyses of ground waters in this region are given in the accompanying table (p. 125). Most of them have been obtained through the courtesy of the chief engineer of the Southern Pacific Co. and Mr. H. J. Simmons, general manager of the El Paso & Southwestern System. They have been computed at the United States Geological Survey from conventional combinations in grains per gallon into ionic form in parts per million.

The water from the 85-foot well of the Southern Pacific Co. at Deming (analysis No. 1) is entirely acceptable for domestic use and for irrigation and is fair for boilers, being noncorrosive, low in foaming constituents, and capable of causing the formation of only a moderate amount of scale.

The water from the well at Gage (analysis No. 2) is acceptable for irrigation or for domestic use. As it is noncorrosive and low in foaming constituents and scale-forming ingredients, it may be considered fair for boiler use.

The water from the well at Cambray (analysis No. 3), though acceptable for domestic use, is rather poor for boiler use, because its high content of alkalies makes it likely to foam. It could be used for irrigation if care were taken to prevent accumulation of alkali.

The first stratum of the well at the Birchfield home ranch, in the Mimbres Valley east of the Florida Mountains (analysis No. 4), yields a sodium sulphate water of very high mineral content. A considerably less saline water was recently obtained at somewhat greater depth, but no analysis of it is available. The other two Birchfield wells yield waters considerably lower in mineral content (analyses Nos. 5 and 6).

Though the water from the railroad well at Columbus (analysis No. 7) is regarded as suitable for locomotives, the analysis indicates that it would be poor for that purpose because of its high content of foaming constituents. It would probably be acceptable for domestic use, but its high content of alkali renders it poor for irrigation.

The water from Carrizalillo Spring (analysis No. 8) is conveyed by pipe to Hermanas and is used by the El Paso & Southwestern System at that place. The analysis indicates that the water is acceptable for irrigation and domestic use. It is low in foaming ingredients and noncorrosive, and as it would probably form only a moderate amount of scale in boilers it may be classed as fair for boiler use.

The 503-foot boring at Arena (analysis No. 9) yields water too heavily charged with saline ingredients to be usable. It is unfit for boiler use because of its high content of foaming ingredients and it is too strong in alkali to be acceptable in irrigation. The same condition renders it unsuitable for domestic supply, though possibly it is drinkable.

Analyses of underground waters in Luna County, N. Mex.

[Parts per million.]

	1	2	3	4	5	6	7	8	9
Silica (SiO_2)	26	30	76	84	....	....	42	58	45
Oxides of iron and aluminum ($Fe_2O_3+Al_2O_3$)	1.0	2.0	2.0	8.0	....	....	4.8	2.6	9.9
Calcium (Ca)	38	48	29	....	....	....	8.8	36	28
Magnesium (Mg)	8.2	7.5	11	30	....	....	3.1	17	14
Sodium (Na) } Potassium (K) }	27	21	127	858	360	300	232	37	757
Potassium (K)				Trace.	32	26			
Carbonate radicle (CO_3)[a]	91	83	114	275	160	252	184	112	194
Sulphate radicle (SO_4)	21	27	102	1,176	150	144	155	24	903
Nitrate radicle (NO_3)	....	....	....	74	....	....	....	....	....
Chlorine (Cl)	13	22	67	445	284	53	52	20	435
Organic and volatile matter	....	....	....	61	....	....	....	....	178
Suspended matter	....	....	....	34	....	....	....	....	....
Total solids	224	240	527	3,011	1,090	840	682	308	2,564
Total solids in grains per United States gallon	13.1	14.0	30.8	175.9	59.0	4.9	39.9	18.0	150

[a] Carbonate and bicarbonate radicles not differentiated.

1. 85-foot well of the Southern Pacific Co., Deming. Sample collected Apr. 4, 1897, and analyzed by the company.
2. 340-foot well of the Southern Pacific Co., Gage. Sample collected Mar. 5, 1897, and analyzed by the company.
3. 269-foot well of the Southern Pacific Co., Cambray. Sample collected Feb. 23, 1897, and analyzed by the company.
4. First stratum in well of W. P. Birchfield, sec. 2, T. 25 S., R. 7 W. In Mimbres Valley east of the Florida Mountains. Analysis by Dearborn Chemical Co.
5. Well of W. P. Birchfield, 4 miles south of the home ranch in the bolson east of the Florida Mountains. Analysis by W. B. Hicks, U. S. Geological Survey.
6. Well of W. P. Birchfield, 10 miles southeast of the home ranch in the bolson east of the Florida Mountains. Analysis by W. B. Hicks, U. S. Geological Survey.
7. Well of the El Paso & Southwestern System, Columbus. Analyzed by the company.
8. Carrizalillo Spring. Analyzed by El Paso & Southwestern System.
9. Boring 503 feet deep at Arena. Analysis by El Paso & Southwestern System.

WELLS.

There are about 280 wells of various kinds in Luna County, most of them sunk within the last six years, and considerable well drilling is still in progress. Most of the wells are south and east of Deming, the largest number of them being in Tps. 24 and 25 S., R. 9 W., T. 24 S., R. 8 W., and the southern part of T. 23 S., Rs. 8 and 9 W. There are also groups of them near Hondale, Iola, Waterloo, and Columbus. The distribution, depth, and depth to the water surface in wells are shown on the map (Pl. I, in pocket) and in the tables on the following pages. It has been found somewhat difficult to obtain complete data for all the wells, and for several of them the figures given by the driller and the well owner are not the same. The yields of the wells as given in the tables are the owners' or drillers' estimates and were not verified. The depth to the water surface was measured in some wells, but as a rule the figures were supplied by the owner or driller. Many important facts as to depth, water level, yield, and sections of material penetrated were supplied by Mr. R. H. Case, of Deming. In presenting the data for wells those in the vicinity of Deming will be given first.

T. 23 S., R. 8 W.

T. 23 S., R. 8 W., is next east of the township in which Deming is situated, its western margin lying 2 miles east of that city. Luxor, a siding on the Southern Pacific Railroad, is near the center of the township. Twenty wells have been reported in this area, mostly in the southern half. The principal facts regarding them are given in the following table:

Wells in T. 23 S., R. 8 W.

Location.	Depth.	Depth of water below surface.	Reported yield.[a]	Depth of water-bearing sands.
	Feet.	*Feet.*	*Gallons.*	*Feet.*
Sec. 3, NW. ¼ SW. ¼	....	....	Few.	
Sec. 3, SE. ¼ SW. ¼	....	80	Not tested.	
Sec. 12, NW. ¼ SW. ¼	105	65	480	65–72, 80–85, 88–92, 98–105.
Sec. 18, SW. ¼ SW. ¼	200	[b] 46	....	51–59, 110–141, 197–200.
Sec. 19, SE. ¼ SE. ¼	72	29	250	30–44, 53–70.
Sec. 20, NE. ¼ NW. ¼	200	54	50	
Sec. 21, NE. ¼ NE. ¼	87	28	200	Second stratum.
Sec. 23, SW. ¼ NW. ¼	115	30	400	45–50, 56–60, 66–80, 88–92.
Sec. 25, SW. ¼ NW. ¼	95	18	600	25–38, 50–60, 73–90.
Sec. 25, SW. ¼ SW. ¼	....	....	....	
Sec. 25, NW. ¼ SW. ¼	90	18	600	18–21, 69–71, 80–83.
Sec. 26, SW. ¼ NE. ¼	92	20	450	25–40, 52–62, 74–92.
Sec. 26, center of NW. ¼	180	28	500	
Sec. 27, NE. ¼ SE. ¼	103	20	800	20–23, 43–65, 72–75, 87–96.
Sec. 28, SE. ¼ NE. ¼	143	29	1,000	34–60, 65–83, 112–118, 136–143.
Sec. 29, SW. ¼ SE. ¼	710	24	800	Flowed originally. Water from 95 feet.
Sec. 30, SW. ¼ NE. ¼	....	34	300	
Sec. 31, NW. ¼ SW. ¼	140	30	1,000	
Sec. 32, center of SW. ¼ [c]	156	24	1,250	29–45, 80–103, 140–156.
Sec. 32, NE. ¼ NW. ¼	120	30	Many.	73–84, 116–120.
Sec. 35, SW. ¼ NE. ¼	78	15	Many.	15–23, 63–78.

[a] All yields in this report are in gallons a minute.
[b] Another report gives the depth of the water as 43 feet below the surface.
[c] Another report gives the depth as 145 feet and depth of the water as 29 feet below the surface.

The wide arroyo of the Mimbres extends across the southern part of the township and in its vicinity the water rises within 13 to 28 feet of the surface. The wells about Luxor find water at three principal horizons. In the 143-foot well on the Case ranch, in the east-central part of sec. 28, southeast of Luxor, the bore is 26 inches to 86 feet and 16 inches to the bottom. The casing is fitted with a strainer with 40 per cent perforations to take water from the 47 feet of sands which extend at intervals from a depth of 34 feet to the bottom of the well. The first water, at 30 feet, is shut out. The Paxton well, in the east-central part of sec. 27, a mile farther southeast and within half a mile of the river bank, penetrated 37 feet of water-bearing beds and obtained a large volume of water at 87 to 96 feet. Clay extends from 96 to 103 feet. The well is a 24-inch pit 40 feet deep, with a bore hole in the bottom 18 inches in diameter for 25 feet and 12 inches for the remainder. In the group of wells in the southeast corner of the township there are several wells 78 to 95 feet deep in which water rises within 15 to 20 feet of the surface and which have reported yields of 400 to 800 gallons a minute. In the Russell well, in sec. 25, 40 feet of water-bearing sands were penetrated. It is stated that in this well the water level sinks to 47 feet when the well is yielding 700 gallons a minute.

The Burdick well, in the southwestern part of sec. 29, 3½ miles east of Deming, was sunk to a depth of 710 feet in the hope of obtaining an artesian flow. The water now stands about 24 feet below the surface.

In the 156-foot well at the Shull ranch, in the SW. ¼ sec. 32, the first water at 29 feet does not rise, but the second water, at 80 to 103 feet, and the third or main water, in gravel and sand at 140 to 156 feet, rise within 24 feet of the surface. The well consists of a pit 2 feet in diameter and 50 feet deep, below which is a 9⅝-inch casing with screens at the second and third water beds. Heavy pumping for half an hour lowers the water to 45 feet below the surface, but it remains stationary at that level even for 12 hours with an output reported at 1,250 gallons a minute. In the NW. ¼ sec. 26 it was necessary to sink to a depth of 180 feet to obtain the volume required, but the water rises within 28 feet of the surface.

In the northern half of the township the water lies deeper and is of less volume than in the southern half. In the 200-foot well at the Hollis ranch, in the southwest corner of sec. 18, 42 feet of water-bearing sands in three beds were penetrated, but the volume of water is stated to be less than was expected. A 200-foot well in the NW. ¼ sec. 20 is closely similar to the Hollis well, with water 54 feet below the surface, but its pumping limit is stated to be 50 gallons a minute. Both wells are in fine sand for the greater part of their depth.

Two trials for water have been made near Mirage siding, but only small yields were obtained, and in a new boring a few rods southeast of the siding the water is 80 feet below the surface. It is possible that the conditions will be found more favorable in the southwest corner of the township than they are to the southeast, but no wells have been sunk to test the water resources of that area.

T. 23 S., R. 9 W.

The city of Deming is situated in the south-central part of T. 23 S., R. 9 W., and the arroyo of Mimbres River crosses the township from west to east in secs. 19 to 23 and 25. In Deming there are many wells for domestic supply, mostly pumped by windmills, and also a city waterworks, which pumps from wells 139 feet deep. In the eastern part of the city the water surface is only about 45 feet deep, but the depth gradually increases to 58 feet in the western part of the city. In the trench cut by the river the depth to the water is 15 to 20 feet less.

The following is a list of the wells in this township, except most of the private wells in Deming:

Wells in T. 23 S., R. 9 W.

Location.	Depth.	Depth of water below surface.	Reported yield.	Depth of water-bearing sands.
	Feet.	*Feet.*	*Gallons.*	*Feet.*
Sec. 8, SE. ¼ NW. ¼	....	83	....	
Sec. 7, SE. ¼ NE. ¼	100	92	....	
Sec. 12, SE. ¼ SE. ¼	215	65	....	67-70, 85-86, 159-162, 185-191, 199-201, 210-212.
Sec. 17, NW. ¼	85	80	200	
Sec. 22, NE. ¼ NE. ¼	....	30	....	
Sec. 25, NW. ¼ SW. ¼	150	42	500	42-68, 88-98.
Sec. 25, SW. ¼ SW. ¼	143	44	1,150	44-62, 66-78, 85-100, 122-135.
Sec. 26, SW. ¼ NE. ¼ (Chinese Gardens).	160?	44?	400	
Sec. 26, NW. ¼ SE. ¼	164	40	600	40-58, 74-80, 86-90, 145-160.
Sec. 26, SW. ¼ SE. ¼	60	44	700	44-60.
Sec. 26, NE. ¼ SW. ¼	142	40	....	45-62, 104-120, 130-140.
Sec. 28, SE. ¼ SE. ¼ (city well, not in use).	....	....	....	
Sec. 29, NW. ¼ NE. ¼	154	51	1,000	61-68, 75-90, 102-108, 115-135, 148-154.
Sec. 29, NW. ¼ NW. ¼	70	62	(*a*)	62-68.
Sec. 30, NE. ¼ NW. ¼	203	63	Few.	65-83, 109-112, 190-200.
Sec. 31, SW. ¼ NW. ¼	120	64	1,000	65-96, 105-114.
Sec. 34, SE. ¼ NW. ¼ (in middle of town).	....	....	....	In middle of town.
Sec. 35, NW. ¼ NE. ¼	60	44	....	
Deming station (railroad well)	112	45	Many.	65-75, 90-95.
Deming waterworks, SW. ¼ sec. 27.	139	55	1,000	
Deming, new park at station	160	47	800	47-50, 84-105, 125-129, 140-145, 150-158.

a Windmill.

The wells in Deming obtain abundant supplies of remarkably pure water, mostly at 50 to 60 feet below the surface. The 139-foot well at the city waterworks, in the southwest corner of sec. 27, penetrated three water-bearing beds, but the main supply is obtained from sand at 90 to 105 feet, and when the pumps are raising 1,000 gallons a minute the water is lowered only a few feet. The water rises within 55 feet of the surface or to the top of the gravel containing the first water. The 112-foot well near the railroad station, a short distance east of the waterworks, furnishes the supply for the three railroads. The water surface in this well is 45 feet deep. In the new well at the city park in front of the Deming station, 160 feet deep, a deeper bed supplies the water.

The group of wells just east of Deming are mostly from 140 to 169 feet deep and each one yields from 400 to 1,000 gallons a minute. The water is used in greater part for irrigation of truck farms. The wells penetrate from 40 to 45 feet of water-bearing sands. Some wells west of Deming, in secs. 29 and 30, are 70 to 203 feet deep and most of them have developed large water supplies. One of these, in the northern part of sec. 29, is 154 feet deep and penetrated 43 feet of sands; another, 70 feet deep, had 6 feet of water and gravel; and a 203-foot well a mile to the west had 31 feet of water-bearing beds.

There are very few wells in the portion of this township lying north of Mimbres River, and some wells in that district have not yielded as large a supply as was expected. The depth to water increases toward the north, and probably it is 70 feet or more in the northeast corner of the township and near 100 feet in the southwest corner. This is indicated by the group of wells in secs. 7, 8, and 17, in which wells 85 to 100 feet deep have water at 80 to 92 feet below the surface.

The 215-foot well at the Brack ranch, in the southeast corner of sec. 12, throws much light on the underground conditions in the northeastern portion of the township. It penetrated seven thin sands at intervals from 67 to 212 feet, and finally obtained a fair supply of water rising within 65 feet of the surface. Clay extends from 212 to 515 feet.

T. 24 S., R. 8 W.

T. 24 S., R. 8 W., lies southeast of the township in which Deming is situated, and its northwest corner is 2 miles southeast of that city.

The underground waters have been reached by numerous wells, mainly in the northern, central, and western portions of the township. The following list includes all borings for which definite data could be obtained:

Wells in T. 24 S., R. 8 W.

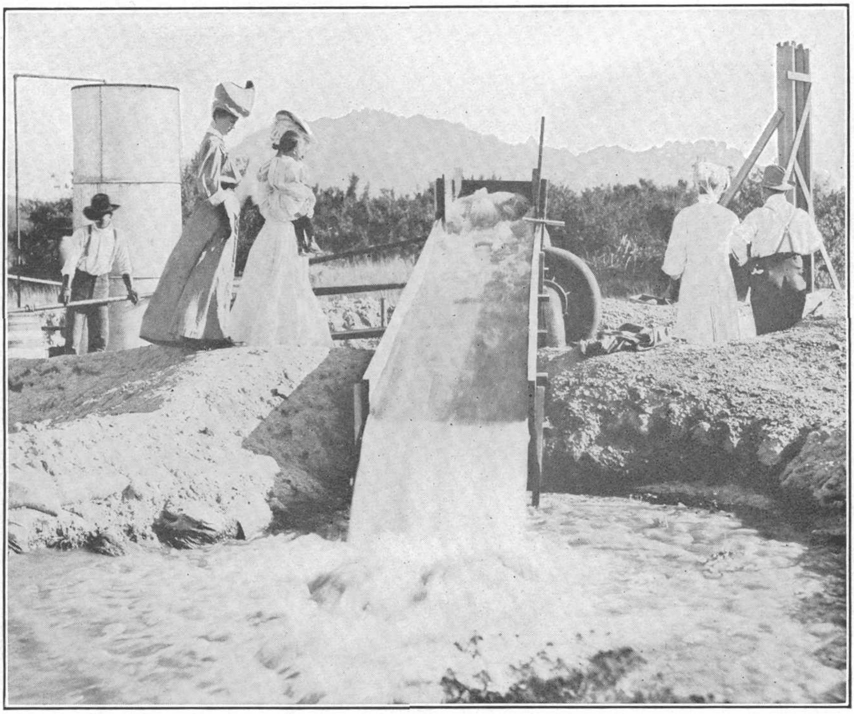
Location.	Depth.	Depth of water below surface.	Reported yield.	Depth of water-bearing sands.
	Feet.	*Feet.*	*Gallons.*	*Feet.*
Sec. 1, SW. ¼ NE. ¼		16	Many.	
Sec. 2, SW. ¼ NW. ¼	96	17	400	17-31, 44-52, 88-96.
Sec. 2, SE. ¼ SE. ¼	60	a 4		
Sec. 3, SW. ¼ SE. ¼		18	750	
Sec. 5, NW. ¼ NW. ¼	114	30	700	54-65, 104-114.
Sec. 6, NW. ¼ NW. ¼	149½	32	1,200	50, 70, 85-110, 122-147.
Sec. 7, NW. ¼ NW. ¼	150	35	1,000	Mostly 46-100 feet.
Sec. 7, NW. ¼ SW. ¼	180			
Sec. 8, NE. ¼ NW. ¼	150	30	1,000	83-100.
Sec. 8, NW. ¼ SW. ¼	180			
Sec. 8, SE. ¼ SE. ¼	32	30	(b)	
Sec. 11, NW. ¼ NW. ¼	80	18	400	
Sec. 11, SW. ¼ SW. ¼	85	13	600	Third stratum.
Sec. 11, SE. ¼ SW. ¼		20		
Sec. 11, NE. ¼ NE. ¼	63	30		
Sec. 14, NW. ¼ SE. ¼	60		Many.	First bed.
Sec. 15, SE. ¼ NW. ¼		12	600	
Sec. 18, SW. ¼ NW. ¼	90	43	500	Do.
Sec. 18, SW. ¼ NW. ¼	110	44	700	87-96; clay below.
Sec. 18, SW. ¼ SW. ¼	150	48	700	
Sec. 19, SW. ¼ SE. ¼	70	43		
Sec. 20, SW. ¼ SE. ¼	1,665	17	800	50-62, 485-508.
Sec. 21, NW. ¼ NW. ¼	560	33	850	32-38, 60-65, 265-270, 319-325, 502-508.
Sec. 21, NW. ¼ NE. ¼	c 35	33		
Sec. 21, NE. ¼ NE. ¼	138	40	(b)	
Sec. 26, NE. ¼ NE. ¼	(d)		Not any.	
Sec. 27, NW. ¼ NE. ¼	d 80		(e)	
Sec. 28, NE. ¼ NW. ¼	40		(e)	
Sec. 30, NW. ¼	161	44	400	45-50, 67-96.
Sec. 33, NW. ¼ SW. ¼			Many.	

a Flows into long trench.
b Windmill.
c Another report gives the depth as 165 feet and the depth of water as about 35 feet.
d To rock.
e Quality unsatisfactory.

Several of the wells in the southern and western parts of this township are notable for the large volumes of water they yield, most of which is used for irrigation. One of the best known is the Hund well, in the northwest corner of sec. 6, which draws from the third bed at 149½ feet. A view of the outlet is shown in Plate X, *A*. It is pumped with a 35-horsepower engine and is reported to yield 1,200 gallons a minute, which draws down the water level to 49 feet below the surface.

The Hick well, in the northwest corner of sec. 7, draws its main supply from sand and gravel extending from 46 to 100 feet. A test hole at this place found nothing but clay from 150 to 170 feet. The water rises to the level of the first water at 35 feet, but it is stated that pumping at the rate of 1,000 gallons a minute lowers the water 15 feet.

In the E. ½ sec. 21 excellent water is obtained at a depth of 138 feet, apparently in large supply, but the water found at a depth of 40 feet was of bad quality. In the NE. ¼ NW. ¼ sec. 28 the water at 40 feet contains considerable mineral matter and can be used only for stock. A mile farther east, in sec. 27, an 80-foot well reached

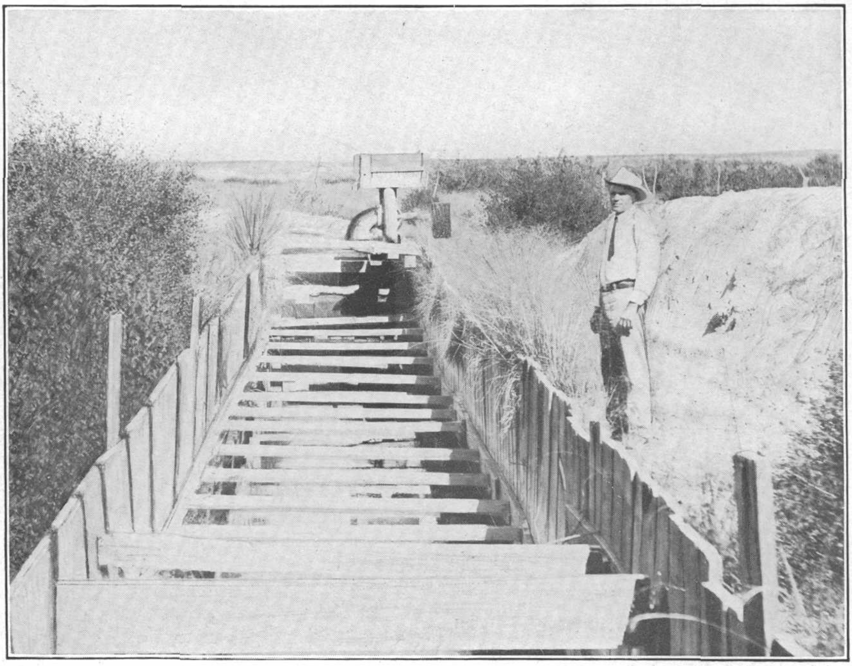


A. DISCHARGE OF 1,200 GALLONS A MINUTE FROM A 150-FOOT WELL EAST OF DEMING, N. MEX.

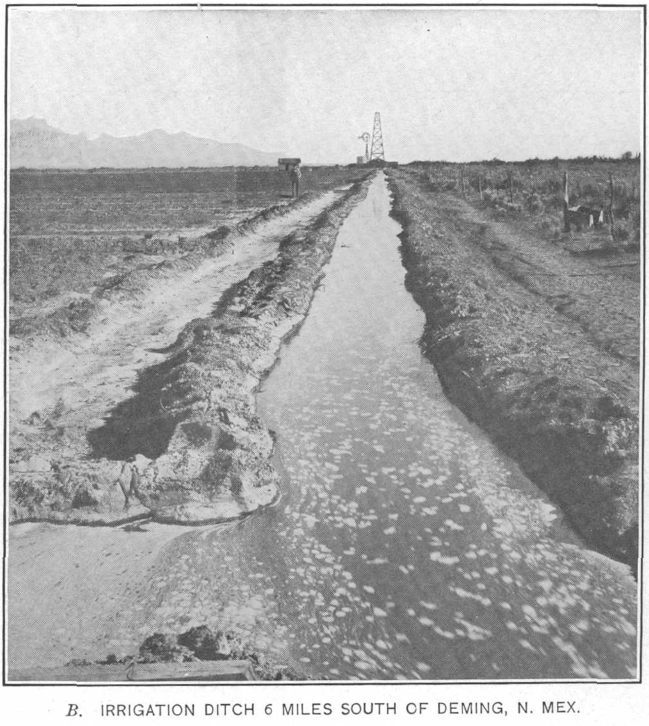
Pumped by gasoline engine.

B. WELL ON YOUNG RANCH SOUTHWEST OF DEMING, N. MEX.

Pumped by electricity to yield 700 gallons a minute.



A. DITCH AT SOLIGNAC RANCH, 8 MILES EAST OF DEMING, N. MEX.
Dug to surface of underflow.



B. IRRIGATION DITCH 6 MILES SOUTH OF DEMING, N. MEX.
Flows 500 gallons a minute, pumped from well on bolson. View looking south. Florida Mountains in distance.

rock and found water in ample supply but too highly mineralized to use for irrigation. A well a mile still farther east, in sec. 26, reached rock and found no water.

At the Solignac ranch, which is in the Mimbres bottom lands, the underground water comes within 4 feet of the surface. It has been developed by a trench 40 feet long and about 10 feet deep, in the center of which a 9⅝-inch hole has been bored 60 feet to and into the second stratum. When water is pumped from the trench there is sufficient flow from the boring to yield a large amount of water for irrigation. Some features of this plant are shown in Plate XI, *A*.

At Berryman place, half a mile southeast of the Solignac ranch, the land is higher and the first water is 30 feet below the surface. The second stratum is at a depth of 54–63 feet and appears to contain a very large amount of water.

In the 96-foot well at Lesdo's ranch, a mile northwest of the Solignac ranch, the water rises to the top of the first stratum, or 17 feet below the surface. Three water-bearing sands were penetrated, containing 30 feet of sand in all, but the principal supply is from the second sand, at 44 to 52 feet.

On the McBride desert claim, in sec. 30, a 161-foot test well found the first water in coarse gravel at 45 to 50 feet. From 50 to 63 feet this well passed through compact clay, and from 67 to 96 feet alternations of clay, sand, and gravel containing considerable water, which rose within 44 feet of the surface and stood a pumping test stated to be at the rate of 400 gallons a minute. From 96 feet to the bottom there was clay with no water.

At the Stroup well, in sec. 19, a satisfactory water supply is obtained from an alternation of mud, gravel, and clay deposits beginning at 43 feet and extending to the bottom of the well at 70 feet.

The deep well in the south-central part of sec. 20 was sunk to a depth of 1,665 feet in the hope of obtaining an artesian flow. At 520 feet the water rose to 17 feet below the surface, or 23 feet higher than in shallow wells in the vicinity, and a supply of 800 gallons a minute was pumped in a test run with a 25-horsepower pump. Very little water was found below 520 feet, the depth from which the well is now pumped.

In a 560-foot boring in the northwest corner of sec. 21 only 28 feet of water-bearing sands were penetrated, with much fine compact material below 82 feet. The water rises within 33 feet of the surface, and it is reported that when the well is pumped at the rate of 800 to 1,000 gallons a minute the water is drawn down to a depth of 80 feet, where it remains while pumping continues.

T. 24 S., R. 9 W.

T. 24 S., R. 9 W., is next south to the township in which Deming is located and for 1 to 1½ miles its north line is the southern limit of that city. In this township there are many successful wells that afford a large amount of water, which is used mostly for irrigation. The following table gives the principal features of the wells so far as they could be obtained.

Wells in T. 24 S., R. 9 W.

Location.	Depth.	Depth of water below surface.	Reported yield.	Depth of water-bearing sands.
	Feet.	*Feet.*	*Gallons.*	*Feet.*
Sec. 2, NW.¼ NW.¼ (very old well).	....	....	....	
Sec. 4, SW.¼ SE.¼	90	52	400	52–80.
Sec. 4, NW.¼ SE.¼	80	52	400	
Sec. 4, SE.¼ SE.¼	50	47	200	
Sec. 5, NE.¼ NE.¼	55	52	....	
Sec. 5, NE.¼ SE.¼	55	50	....	
Sec. 7, NW.¼ NW.¼	150	60	600	
Sec. 7, NW.¼ SW.¼	200	61	450	No water below third stratum at 181 feet.
Sec. 8, center of SE.¼	133	55	800 to 1,000	56–64, 68–74, 115–129.
Sec. 9, W.½ SW.¼	127	50	600	
Sec. 9, NE.¼ SW.¼	115	52	1,000	
Sec. 10, NW.¼ NW.¼	75	47	Many.	
Sec. 11, NE.¼ SE.¼	....	....	....	
Sec. 12, NW.¼ NW.¼	52	33	350	33–45.
Sec. 12, NW.¼ SW.¼	123	40	1,250	55–61, 66–78, 111–117.
Sec. 12, NW.¼ NE.¼	....	....	....	
Sec. 12, NW.¼ SE.¼	115	38	800	56–65, 78–86, 98–102, 108–113.
Sec. 12 (?), SW.¼ NE.¼	128	42	....	58–68, 78–86, 105–114, 118–125.
Sec. 13, NW.¼ NW.¼	150	41	300	67–71, 80–85, 145–150.
Sec. 13, NW.¼ NE.¼	52	37	....	
Sec. 13, NW.¼ SW.¼	115	48	....	60–82, 103–115.
Sec. 13, SW.¼ NE.¼	128	42	875	58–68, 78–86, 105–114, 118–125.
Sec. 14, NW.¼ NW.¼	145	45	800	48–53, 65–72, 102–112, 125–129, 133–138.
Sec. 14, NW.¼ SE.¼	85	47	300	50–62, 78–85.
Sec. 14, SW.¼ SW.¼	....	57	....	
Sec. 15, NW.¼ SW.¼	100	50	....	59–62, 93–100.
Sec. 15, NW.¼ SE.¼	150	50	700	
Sec. 17, NW.¼ NW.¼	....	55	....	
Sec. 21, SW.¼ NW.¼	177	50	500	63–70, 83–88, 165–177.
Sec. 21, NW.¼ SW.¼	158	52	800	56–68, 124–134, 152–158.
Sec. 21, NW.¼ SE.¼	177	52	300	
Sec. 21, NW.¼ NW.¼	130	54	....	
Sec. 22, NE.¼ NE.¼	81	....	Many.	
Sec. 22, NE.¼ NE.¼	67	....	Few.	
Sec. 22, NW.¼ SW.¼	90	50	400	
Sec. 22, NE.¼ SW.¼	150	46	....	Third stratum 145 to 150 feet.
Sec. 22, SE.¼ SE.¼	61	51	25	
Sec. 23, NW.¼ NE.¼	79	52	....	52–79.
Sec. 23, NW.¼ SE.¼	89	45	1,200	45–74.
Sec. 24, NW.¼ SW.¼	....	....	....	In progress.
Sec. 24, NW.¼ SE.¼	110	43	600	46–51, 65–69, 85–89, 94–98, 103–108.
Sec. 24, NW.¼ NE.¼	....	46	....	
Sec. 25, NW.¼ NE.¼	145	42	600	50–60, 65–67, 71–74, 77–79, 103–108.
Sec. 26, NW.¼ SW.¼	[a] 158	52	350	
Sec. 27, NW.¼ NE.¼	150	50	700	
Sec. 27, NW.¼ SW.¼	149	52	100	
Sec. 28, NW.¼ NW.¼	203	53	700	53–75, 130–132, 158–162, 180–182.
Sec. 29, SW.¼ SW.¼	63	58	Many.	
Sec. 29, NW.¼ NE.¼	....	63	Many.	
Sec. 31, SW.¼ NE.¼	67	57	....	
Sec. 32, NE.¼ NE.¼	....	58	....	
Sec. 32, NW.¼ SE.¼	112	59	1,100	
Sec. 33, NE.¼ SE.¼	....	....	....	
Sec. 34, NW.¼ SE.¼	70	46	700	
Sec. 35, NW.¼ SW.¼	....	46	....	
Sec. 35, NW.¼ SE.¼	....	....	....	

[a] Another report gives 58 feet.

The volume of water appears to be large throughout the township, for large amounts are pumped for irrigation, and prolonged pumping reduces the water level only a few feet while the pumps are in operation.

The Young well (Pl. X, *B*, p. 130), in the northwest corner of sec. 28, is 203 feet deep and is the deepest one in the township. Although considerable water was found in the first stratum, at 53 to 75 feet, the main supply was reached in the second stratum, at 176 feet, and the amount increased somewhat as boring progressed. The water level is 53 feet below the surface and is lowered to 64 feet by 4 hours' pumping with a No. 5 pump having an 8½-inch discharge. The well is dug 55 feet with a diameter of 5¾ feet and bored 1 foot in diameter to the bottom.

The well at Sander's ranch, in the northwest corner of sec. 7, consists of a pit 12 feet in diameter and 84 feet deep, with two 6-inch holes in the bottom, one extending to 130 feet and the other to 150 feet below the surface. The water rises within 60 feet of the surface and is reported to yield 600 gallons a minute, with a temporary drop of only a few feet while the pump is in operation. On the next quarter section to the south is the Milliken well, 200 feet deep, which is reported to yield 450 gallons a minute, and a 10-hour run lowers the water surface only about 10 feet.

The well on the McBride ranch, near the center of sec. 12, consists of an 80-foot pit 2 feet in diameter with an 18-inch boring 40 feet deep in the bottom. Water was found at 40 feet, but the first notable supply is in gravel at 55 to 61 feet, and the main supply is derived from the third stratum at 111 to 117 feet. Between the second and third strata there are some additional thin water-bearing beds.

In the Bumpass well, in the center of the SE. ¼ sec. 8, water is obtained from the third stratum at a depth of 115 to 129 feet. Clay was penetrated at 64 to 68 feet and at 129 to 130 feet, and there are many alternations of clay and sand from 74 to 115 feet.

At the Bradshaw & McBride well, in the western part of sec. 12, the main supply is obtained from the second stratum, at 65 to 78 feet. It is reported that this well yields 1,250 gallons a minute and has been pumped steadily for three days and parts of the intervening nights without lowering the water level greatly, although pumping soon exhausts the water of the first stratum. Half a mile south of this well, in the northwest corner of sec. 13, is the Connaway well, which has given much less satisfactory results than neighboring wells to the north and west. The pump is set at a depth of 55 feet, and perforated screen extends from 60 to 150 feet, except in some caliche at 80 to 85 feet, where the screen is blank. A small amount of water occurs at 50 feet. It is reported that the well can be pumped at a rate of 300 gallons a minute all day, but apparently this rate is the limit, for with greater production the water rapidly drops below the pump intake at 55 feet.

The Bowman well, in the northwest corner of sec. 12, indicates that the water conditions are more favorable to the north, for at a depth of only 52 feet it yields 350 gallons a minute for 18 hours a day pumping. A 6-horsepower engine is used. This well consists of a 6-foot pit 40 feet deep with a 10-inch boring in its bottom to the main water-bearing gravel at 52 feet.

T. 24 S., R. 10 W.

There are about 20 wells in T. 24 S., R. 10 W., most of them in its southeastern and central parts, with isolated wells in sec. 35 and southwest of Tunis. Red Mountain occupies an area of about 4 square miles in the central western part of the township, and the Snake Hills cut off the underground waters in secs. 32, 33, and 34. The following list presents all the data which could be obtained regarding wells in this township:

Wells in T. 24 S., R. 10 W.

Location.	Depth.	Depth of water below surface.	Reported yield.	Depth of water-bearing sands.
	Feet.	*Feet.*	*Gallons.*	*Feet.*
Sec. 1, SE. ¼ SW. ¼	67	60	....	
Sec. 12, NW. ¼ NW. ¼	69	....	....	
Sec. 12, NW. ¼ NE. ¼	135	64	....	64–90, 103–106, 115–118, 127–130.
Sec. 13, NW. ¼ SE. ¼	208	64	....	85–87, 113–118, 145–148, 196–203.
Sec. 14, NW. ¼ NW. ¼	....	58	....	
Sec. 15, NW. ¼ SE. ¼	160	65	500	
Sec. 15, NW. ¼ SW. ¼	....	65	....	
Sec. 28, N. ½	78	59	900	
Sec. 27, NW. ¼ NW. ¼	61	39	....	
Sec. 35, NW. ¼ SE. ¼	100	50	500	

So far as tested the waters in this township lie somewhat deeper than those in the adjoining township on the east and the water-bearing strata are less regular. In most of the wells the supply is satisfactory and fully as great as in the township east of this one. The first and second strata hold very small supplies, and in the center of secs. 15 and 13 it was necessary to go to the fourth bed, which in sec. 13 was found to lie at a depth of 196 to 203 feet. The water in it rises within 64 feet of the surface. At the Hughes well, in sec. 15, there was so little water in the upper beds that it was necessary to sink to a depth of 160 feet. The supply at that depth, however, was found to be so great that heavy pumping lowers the water surface only 5 feet, where it remains constant all day.

T. 24 S., R. 11 W.

T. 24 S., R. 11 W., lies west of Red Mountain, and the Southern Pacific Railroad crosses its northern portion. There are several wells in the northeastern sections which obtain satisfactory water supplies, but to the west and south the conditions appear to be less favorable. The following is a nearly complete list of the wells:

Wells in T. 24 S., R. 11 W.

Location.	Depth.	Depth of water below surface.	Reported yield.	Remarks.
	Feet.	*Feet.*	*Gallons.*	
Sec. 2, SE. ¼ SW. ¼	98	94		
Sec. 3, SE. ¼ SE. ¼	110	109		
Sec. 3, SE. ¼ NE. ¼	112	110		
Sec. 10, NE. ¼ SE. ¼	102	102		Windmill.
Sec. 11, NW. ¼ NE. ¼	185	94	100	Water at 94 feet.
Sec. 11, SE. ¼ NE. ¼	94	94		
Sec. 13, N. ½	160	90		Small pump.
Sec. 21, NW. ¼ NW. ¼	105	86½	Few.	Good supply in sand at 95 to 105 feet.
Sec. 34, W. ½	300	80		Water at 80 feet only.

Apparently the water supply is variable in amount, and the 300-foot boring in sec. 34 shows that in the southeastern corner of the township at least the volume is too small to be serviceable. The volume available in secs. 1, 2, 11, and 12 has not been fully determined, but the well in the NW. ¼ sec. 11, which is reported to yield 100 gallons a minute without materially lowering the water level, indicates a fairly large amount. In the low land in sec. 31 the water conditions may be favorable for a moderate supply, as indicated by the well a short distance to the south, in the next township.

T. 25 S., R. 8 W.

The northern half of the Florida Mountains lies in the eastern part of T. 25 S., R. 8 W., and the long western slope of the alluvial fans at the foot of the range extends to its western margin. The main underflow zone, however, underlies the western tier of sections and may extend some distance farther east, though there are no data to show its eastern limit. The McCann well, in the NW. ¼ sec. 18, is 85 feet deep, and the water in it rises within 38 feet of the surface. Some water-bearing beds were penetrated at 52 feet, and a thick body of sand extends from 62 feet to the bottom of the well. A pump run by a 35-horsepower engine is reported to raise 800 gallons a minute, and the water is used for irrigation. Another well 2 miles farther south is of less depth, and the water level is 37 feet below the surface.

No doubt other wells will be sunk on the slopes farther east in the township, and they will have a fair prospect of finding water in some of the coarser beds in the great alluvial fans of which this area is constituted.

T. 25 S., R. 9 W.

Underground waters are extensively utilized about Hondale and at various localities in nearly all parts of T. 25 S., R. 9 W. The following is a nearly complete list of the wells:

Wells in T. 25 S., R. 9 W.

Location.	Depth.	Depth of water below surface.	Reported yield.	Depth of water-bearing sands.
	Feet.	*Feet.*	*Gallons.*	*Feet.*
Sec. 1, NW. ¼ NW. ¼	92	45	250	Main supply, coarse gravel, 45-52½ feet.
Sec. 3, NE. ¼ NW. ¼		46		
Sec. 6, NW. ¼ SE. ¼	550 (214)	50	800+	50-90, 110-143, 183-210.
Sec. 7, NE. ¼ NW. ¼			100	
Sec. 7, NW. ¼ SW. ¼	150	60	800	62-78.
Sec. 10, NW. ¼ SW. ¼	150	50		50-75, 102-112, 135-145.
Sec. 14, SW. ¼ NW. ¼	52	48		
Sec. 15, NW. ¼ NW. ¼	150	50	(a)	
Sec. 17, NW. ¼ NW. ¼		57	75	
Sec. 17, NW. ¼ NE. ¼	75	53	70	
Sec. 17, NW. ¼ SE. ¼		51		
Sec. 18, NW. ¼ SE. ¼		55		
Sec. 19, NW. ¼ NW. ¼		55		
Sec. 19, NW. ¼ SW. ¼		48		
Sec. 20, SE. ¼ NE. ¼	148	52		52-69, at intervals, 103-142.
Sec. 21, NW. ¼ SW. ¼	95	49	650	
Sec. 22, NW. ¼ NE. ¼	110	45	1,200	45-54, 74-84, 100-110.
Sec. 24, NE. ¼ NE. ¼	165	35	1,000	
Sec. 24, NW. ¼ SW. ¼	98	38	450	66-76.
Sec. 24, SE. ¼ SE. ¼	51	37		Second stratum.
Sec. 25, NE. ¼ SE. ¼		31		
Sec. 26, SW. ¼ SW. ¼	158	32	310	
Sec. 27, NW. ¼ NW. ¼	147	50	(a)	
Sec. 29, center NE. ¼	152	50	(a)	55-73, 97-112, 152.
Sec. 30, NW. ¼ NW. ¼	150	50	(a)	
Sec. 33, NW. ¼ SW. ¼	152	55	600	
Sec. 34, NW. ¼ NW. ¼		49		
Sec. 35, NW. ¼ NW. ¼	140	42	1,000	45-55, 75-82.

a Installing; capacity not determined.

The deepest well in the township is in sec. 6, where a test boring reached a depth of 550 feet without finding any notable increase in volume of water below 210 feet. The supply is so great in sand extending from 183 to 214 feet that vigorous pumping lowers it only slightly while the pump is in operation. About Hondale the first water is at 54 to 57 feet below the surface, and this also is the level to which the water rises in the deeper wells.

In the northwest corner of sec. 35 the first water is in a bed of sand and gravel at 43 to 53 feet, and the main supply is obtained from a depth less than 100 feet.

In the north-central part of sec. 17, east of Hondale, a moderate supply of water is obtained from a 4-foot bed of sand and gravel which extends from 71 to 75 feet and is overlain by gravel and sand cemented by caliche.

T. 25 S., R. 10 W.

Several wells in the central and northwestern portions of T. 25 S., R. 10 W., and others in secs. 8, 17, and 18 have demonstrated the extension of the underground waters, and doubtless they will be found to be available throughout the township. The following list presents the data obtained:

Wells in T. 25 S., R. 10 W.

Location.	Depth.	Depth of water below surface.	Reported yield.	Remarks.
	Feet.	*Feet.*	*Gallons.*	
Sec. 1, NW. ¼ SW. ¼	....	60	....	
Sec. 8, NW. ¼ SW. ¼	77	49	Many.	
Sec. 11, NW. ¼ NW. ¼	....	....	....	
Sec. 11, NE. ¼ NE. ¼	....	55	500	
Sec. 12, NW. ¼ SE. ¼	61	58	75	
Sec. 17, NW. ¼ NW. ¼	....	48½	Many.	
Sec. 18, NW. ¼ NW. ¼	126	60	500	
Sec. 18, NW. ¼ SW. ¼	275	55	300	Drawdown 10 feet; sand at 175-275 feet.
Sec. 22, NW. ¼ NW. ¼	....	52	....	
Sec. 24, NE. ¼ NW. ¼	100	49	400	
Sec. 15, center	160	65	500	

These wells show that the underground conditions are fairly uniform and that the water is in large volume. One well half a mile northwest of Hondale obtained an excellent supply from a depth of 61 feet, with the water level 58 feet below the surface. It has been tested only to 75 gallons a minute. In general the water lies deeper to the north and west, mainly because the land is slightly higher in that direction. Probably along the southern tier of sections the water will come within less than 50 feet of the surface.

At the Hughes well, in the center of sec. 15, the water is from the fourth stratum and the yield is reported to be 500 gallons a minute. The drawdown is only 5 feet in an all-day run.

T. 25 S., R. 11 W.

Two wells have been sunk at the Watkins ranches, in T. 25 S., R. 11 W. One recently completed at the 76 ranch is 130 feet deep and reaches the third stratum. The water rises within 32 feet of the surface and occurs in fair supply. When pumped at the rate of 1,000 to 1,200 gallons a minute the water sinks to 54 feet below the surface. A deeper boring is to be made to obtain water in still larger volume, in order to extend the irrigated area. The old wells at this ranch are 40 to 45 feet deep and are pumped by windmills to supply stock. A well sunk for Mr. Watkins in the northwest corner of the township is 150 feet deep to the second stratum, and the water rises within 110 feet of the surface. It also is pumped by a windmill.

At the Jordan ranch, in the SW. ¼ sec. 18, a well 191 feet deep has water within 38 feet of the surface and yields 400 gallons a minute. The first water was reached at 60 to 65 feet and the second at 182 to 191 feet. The well is in the arroyo.

The Darbyshire well, in the NW. ¼ NE. ¼ sec. 25, is 200 feet deep and obtains a good supply, which rises within 49 feet of the surface.

Probably the entire township is underlain by water-bearing beds at various depths, the depth increasing regularly with the rise of the land to the north and west. There may be masses of igneous or other rocks not far underground at some points, similar to the one which rises above the surface 2 miles east of the 76 ranch, and an occurrence of this kind would locally displace the water-bearing beds.

T. 26 S., R. 8 W.

There are several wells at ranches along or near the grade road in the southwestern portion of T. 26 S., R. 8 W. One in sec. 19 has the water level 40 feet below the surface. Another, in the NW. ¼ SE. ¼ sec. 30, is 36 feet deep and the water is 26 feet below the surface. In a third, in the northeast corner of sec. 31, the water is 21 feet below the surface. These wells obtain plenty of water for irrigation and domestic use and the one in sec. 30 is said to yield 500 gallons a minute. It found coarse sand at 26 to 36 feet. How far east toward the foot of the Florida Mountains the underground waters extend has not been fully determined, but a well recently sunk in the NE. ¼ SE. ¼ sec. 19 found water-bearing sand at 100 to 112 feet, from which water rises within 75 feet of the surface and appears to be in satisfactory volume. The results in this well indicate that more or less water-bearing material will be found nearly to the foot of the rocky slope.

T. 26 S., R. 9 W.

Wells in the central and northern portions of T. 26 S., R. 9 W., together with those in adjoining townships to the east and west, show a general extension of the underground waters in this district. The following is a nearly complete list of the wells in the township. Most of them supply water for irrigation.

Wells in T. 26 S., R. 9 W.

Location.	Depth.	Depth of water below surface.	Reported yield.	Depth of water-bearing sands.
	Feet.	*Feet.*	*Gallons.*	*Feet.*
Sec. 1, NW. ¼	....	38	....	
Sec. 2, center NW. ¼	....	....	....	
Sec. 3, NE. ¼ NW. ¼	80	40	700	40-80.
Sec. 3, SW. ¼ SE. ¼	116	40	....	34-35½, 52-80, 107-116.
Sec. 3, NW. ¼ SW. ¼	150	40	....	73-80, 142-150.
Sec. 3, NW. ¼ NW. ¼	161	42	300	42-80.
Sec. 4, NW. ¼ NE. ¼	150	45	700	
Sec. 8, NW. ¼ NW. ¼	....	....	....	
Sec. 8, NE. ¼ SE. ¼	....	....	....	
Sec. 9, NE. ¼ NE. ¼	....	....	....	
Sec. 10, NW. ¼ NE. ¼	116	34	Many.	
Sec. 12, SW. ¼ NW. ¼	40	32	500	
Sec. 15, NW. ¼ SW. ¼	70	34	....	65-70.
Sec. 18, NE. ¼ NW. ¼	155	45	800	45-75, 110-120, 145-155.
Sec. 22, W. ½	....	40	....	
Sec. 24, NE. ¼ SW. ¼	55	27	800	Water in 20 feet of gravel.
Sec. 34, NW. ¼ NW. ¼	80	27	900	30-35, 40-48, 54-56, 60-65, 75-80.

The water is mostly 40 to 45 feet below the surface, except in the southeast corner of the township, where it probably stands at about 25 feet. In the western part of sec. 22 the water is 40 feet below the surface. The volume of water is great, for vigorous pumping lowers the water surface only a few feet in most of the wells and it rises again soon after the pump is stopped. A very satisfactory well in the northwest corner of sec. 3 is only 81 feet deep and found 38 feet of water-bearing sand. A well a mile farther southeast, in the southern part of sec. 3, obtains a large volume of water, mainly at the bottom of a 9-foot stratum of sand and gravel.

T. 26 S., R. 10 W.

Numerous wells about Iola and in the southeastern part of T. 26 S., R. 10 W., show that the underground waters are available under all of the area north of Palomas Arroyo, but the conditions are less favorable south of that valley. The wells so far reported are as follows:

Wells in T. 26 S., R. 10 W.

Location.	Depth.	Depth of water below surface.	Reported yield.	Remarks.
	Feet.	*Feet.*	*Gallons.*	
Sec. 1, NW. ¼ SW. ¼	110	49		
Sec. 2, SW. ¼ SE. ¼	74	50		
Sec. 3, SE. ¼ SE. ¼	51	49½		
Sec. 7, SW. ¼ SW. ¼	31	23		Windmill.
Sec. 9, NE. ¼ SE. ¼		50		
Sec. 10, NE. ¼ NE. ¼	160	49	300	
Sec. 10, NW. ¼ SE. ¼	156	50	325	
Sec. 10, NW. ¼ SW. ¼	100	53½	500	
Sec. 11, NW. ¼ NW. ¼		40		
Sec. 11, NW. ¼ SW. ¼	160	50		Do.
Sec. 11, NW. ¼ NE. ¼	50			
Sec. 14, NW. ¼ SW. ¼		40		
Sec. 14, NW. ¼ NW. ¼	49	46½		
Sec. 15, SW. ¼ SW. ¼	80	46		
Sec. 17, center of NW. ¼	90		40	
Sec. 17, SE. ¼ SW. ¼	42			Dug well; in rock below 79 feet.
Sec. 19, SW. ¼ NW. ¼	150		Few.	
Sec. 19, NW. ¼ SW. ¼	200		Few.	
Sec. 20, SW. ¼ NE. ¼	82	39		
Sec. 20, NE. ¼ SE. ¼	60			Rock at 57-60 feet.
Sec. 20, SW. ¼ SW. ¼	120	50	60	In rock.
Sec. 21, SW. ¼ NW. ¼	160	70	Few.	
Sec. 23, NW. ¼ SW. ¼		40		
Sec. 24, NW. ¼ NE. ¼	150	40	900	
Sec. 28, NW. ¼ NE. ¼	212	55		Pumps dry in a few minutes.
Sec. 28, NW. ¼ SW. ¼	98	60	Very few.	
Sec. 29, SE. ¼ NW. ¼	86			In rock; no water.
Sec. 29, NW. ¼ SW. ¼	200		Few.	
Sec. 33, NE. ¼ NE. ¼	112	110	Few.	
Sec. 33, center of SE. ¼	100	90	Few.	
Sec. 35, NW. ¼ NE. ¼		50		

The wells about Iola obtain large supplies of water at depths less than 100 feet, and the water rises within 40 to 50 feet of the surface. One well in sec. 10 is reported to pump 300 gallons a minute and another 600 gallons without reducing the water level greatly. A 150-foot well in the northern part of sec. 24 is reported to yield 900 gallons a minute, and continued pumping for irrigation lowers the water level only 11 feet.

The igneous masses in Midway Buttes cut off the water-bearing beds for some distance, but wells in the plain to the north and east obtain satisfactory supplies rising within 50 feet of the surface. The water conditions appear to be very irregular and mostly unsatisfactory in the southwestern quarter of the township. Some of the wells are in rock, which comes near to the surface and contains but little water, and some of that is of unsatisfactory quality. A deep boring in the NW. ¼ NE. ¼ sec. 28 found a small volume of water, which rises within 55 feet of the surface but quickly pumps out. Possibly with greater depth a larger amount could be obtained in the wells that have been unsatisfactory. In the southwest corner of the township igneous rocks displace the water-bearing beds, and it is possible that the area in which this condition exists is of considerable extent.

T. 27 S., R. 8 W.

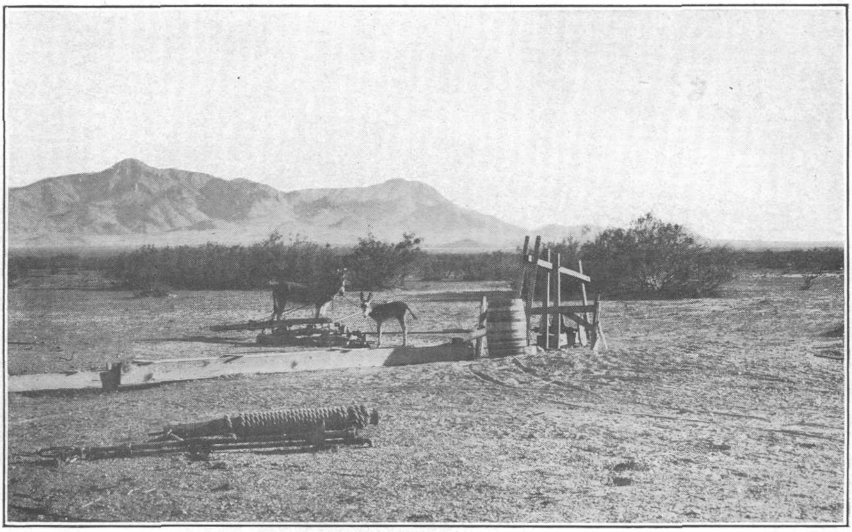
Underground waters have been developed by wells at short intervals in a zone extending along the slopes of Palomas Arroyo from northwest to southeast across T. 27 S., R. 8 W. These wells have shown that the water rises within less than 25 feet of the surface in part of the area and that there is a large volume of water available, at least near the arroyo.

The arroyo is more than half a mile wide where it crosses the line between the Florida and Tres Hermanas mountains. Undoubtedly it contains a large underflow moving slowly southeastward. Part of the water is from the upper course of the Palomas, but the larger volume comes from the wide bolson on the northwest, including the southern extension of part of the Mimbres Valley.

The following is a list of wells so far recorded in this township:

Wells in T. 27 S., R. 8 W.

Location.	Depth.	Depth of water below surface.	Reported yield.	Remarks.
	Feet.	*Feet.*	*Gallons.*	
Sec. 1, NE. ¼	250			No water.
Sec. 5, NW. ¼				Windmills (old wells).
Sec. 6, NE. ¼	39	22½	300	
Sec. 7, NE. ¼	34	23	950	
Sec. 7, NW. ¼ NW. ¼	40	24	1,000	
Sec. 8, SW. ¼ NW. ¼	37	21½	500	
Sec. 8, NW. ¼ NW. ¼	26	21	300	
Sec. 8, NW. ¼ NE. ¼	30	21		
Sec. 9, SE. ¼ NW. ¼	36	19	250	
Sec. 9, SW. ¼	39	25	300	
Sec. 11, NW. ¼	500	475		Salty water below 325 feet.
Sec. 12, NW. ¼	125			Small supply.
Sec. 15	23	18	50	
Sec. 17, N. ½ SE. ¼	20	17	Many.	
Sec. 23, NW. ¼ SW. ¼	192	21	700	
Sec. 25, SE. ¼ SW. ¼	35	30	150	
Sec. 25, NW. ¼		31		Two wells.
Sec. 27, NE. ¼ NE. ¼	37½	36½		Not tested.
Sec. 35, NE. ¼ NW. ¼	35	29½	750	



A. A WATERING PLACE IN THE DESERT.

Well with pump worked by burro supplies water for sheep. Typical view of bolson north of Tres Hermanas Mountains. Florida Mountains in distance.

B. DISCHARGE FROM WELL PUMPED BY GASOLINE ENGINE AT PIERCE RANCH NEAR COLUMBUS, N. MEX.

Shows the wide bolson of the Mimbres near the international boundary. View looking north.

The well shown in Plate XII, *A*, is in the N. ½ SE. ¼ sec. 17, in the bed of Palomas Arroyo. It is 20 feet deep, has a water level 17 feet below the surface, and furnishes a large supply of excellent water. A mile to the northeast is a well 39 feet deep, with the water level 25 feet below the surface, which is pumped for irrigation to the extent of 300 gallons a minute. There are two other similar wells 1½ miles farther north.

The Dixon well, in the northeastern part of sec. 6, penetrated 8 feet of compact loam, 27½ feet of loose sand, 1½ feet of clay, and 2 feet of quicksand in the bottom. In the western part of sec. 7 a large volume of water has been found rising within 23 to 24 feet of the surface. The test boring sunk at the Laffoon ranch, in the SW. ¼ sec. 23, to a depth of 192 feet with the expectation of finding water that would rise higher in the well obtained no large supply below the first stratum at 21 feet, which affords ample volume. Most of the material penetrated was "cement gravel" containing some water and including several thin water-bearing sands that gave no notable increase in volume or head.

In two wells in the NW. ¼ sec. 25 the water is within 31 feet of the surface, and although only a moderate volume is now being pumped it is said that much more could be obtained.

In the center of the township the underflow apparently does not extend far southwest of the Palomas Arroyo, for the rocks of the Tres Hermanas Mountains soon rise in that direction. Farther south the conditions have not been tested, and there may be a considerable area in which water may be available. A few wells in the northeastern portion of the township indicate rather unfavorable conditions. A 500-foot boring in the NW. ¼ sec. 11 obtained only salty water and no water above 325 feet, and two wells to the east and northeast had most unsatisfactory results.

T. 27 S., R. 9 W.

There is a group of successful wells about Waterloo on the northeastern corner of T. 27 S., R. 9 W., which furnish water for extensive irrigation. They are all near Palomas Arroyo, and in all except one the water rises within 23 feet of the surface. The wells are from 25 to 30 feet deep, with the exception of an old one at the 3 C ranch, which is 39 feet deep and contains only 4 feet of water, though this is enough to serve for ranch use. The Peters & White well, at Waterloo post office, is 30 feet deep and has 7 feet of water-bearing sand and gravel in its bottom. A test hole 16 feet deeper was entirely in gravel. The yield of this well is 600 gallons a minute, and two other wells in the group furnish similar amounts. A well in the northwest corner of sec. 1 is 30 feet deep, and the water rises within 23 feet of the surface and furnishes about 600 gallons a minute. Coarse, loose water-bearing gravel was entered at 23 feet, and a test hole continued to a depth of 46 feet did not reach the bottom of that material.

The Manning well, in the SW. ¼ sec. 1, is 40 feet deep, and the water rises within 23 feet of the surface. It furnishes 1,000 gallons a minute for the irrigation of 30 acres. The Watkins well, in the NE. ¼ sec. 3, is 105 feet deep and has water within 27 feet of the surface. It found gravel extending from 27 to 46 feet, with plenty of water, but clay from 46 to 105 feet.

There are several wells along the Palomas Arroyo in secs. 4 to 6. One in the NE. ¼ sec. 4 is 50 feet deep, and the water rises within 33 feet of the surface and pumps 300 gallons a minute. It is in 12 feet of gravel. Half a mile farther west is a shallow well, with water 33 feet below the surface. In the SW. ¼ sec. 5, a 50-foot well has water 35 feet below the surface and is pumped by a windmill for stock. In the northeast corner of sec. 6 a 36-foot well, with 6 feet of water in it, pumps 20 gallons or more a minute, and a well in the NW. ¼ SE. ¼ of the same section is 40 feet deep and has 1 foot of water in it, apparently only in small volume.

T. 27 S., R. 10 W.

Underground waters have not been extensively developed in T. 27 S., R. 10 W., and the principal use for water has been for stock. There are several fairly satisfactory wells in the lowlands in the northeast corner of the township. One in the NE. ¼ sec. 1 is 50 feet deep, has water within 41 feet of the surface, and yields 32 gallons a minute. A 60-foot well in the northwest corner of sec. 12 contains 3 feet of water and yields a fair supply. A 72-foot dug well in the NE. ¼ NW. ¼ sec. 3 appears to be satisfactory. Wells at the old ranch 2 miles east of Tomerlin are 160 feet deep and obtain water at 100 feet, which rises within 90 feet of the surface, but the supply is small.

COLUMBUS REGION.

Underground water is extensively developed about Columbus in the wide bolson traversed by Palomas Arroyo. The wells range from 25 to 200 feet in depth and obtain water, which rises within 2 feet of the surface near the international boundary but only within 50 feet or more in the area farther north. The volume is large at most places, but several of the wells southeast of Columbus have not obtained a sufficient amount for irrigation. The following list gives the principal features of most of the wells:

Wells in the Columbus region.

Location.	Depth.	Depth of water below surface.	Reported yield.	Remarks.
T. 29 S., R. 8 W.	*Feet.*	*Feet.*	*Gallons.*	
Sec. 1, SW. ¼ SE. ¼	23	12	....	Windmill.
Sec. 3, NE. ¼ NE. ¼	200	46	500	
Sec. 11, NW. ¼ NW. ¼	221	12	1,200	Second water at 165–221 feet.
Sec. 12, center of SE. ¼	250	17	1,000	Third water at 224–250 feet; chief supply.
Sec. 12, SW. ¼	187	3½	Many.	
Sec. 13, NW. ¼ NW. ¼	185	2	2,000	Water at 126 feet; none below.
Sec. 13, NW. ¼ NW. ¼	165	2	....	Second water.
Sec. 14, west-central part	165	25	....	Water begins at 95 feet.
T. 28 S., R. 8 W.				
Sec. 1, NW. ¼	35	30	300	
Sec. 2, SE. ¼	77	57	....	Domestic supply.
Sec. 3, NW. ¼	146	78	....	First water at 90 feet, not much; second water at 132–146 feet.
Sec. 9, S. ½	258	200	25–40	
Sec. 10, NE. ¼	177	....	6	
Sec. 11, NE. ¼	....	60	....	Dug well, good supply.
Sec. 11, N. ½ SE. ¼	....	{ 42 72 }	....	
Sec. 15, SW. ¼ NE. ¼	165	100	....	First water at 135 feet.
Sec. 17, SE. ¼	120	....	0	
Sec. 20, NE. ¼	253	....	0	
Sec. 21, NE. ¼	....	205	....	
Sec. 22, NE. ¼	209	120	60	First water at 140 feet; second water at 175 feet.
Columbus, railroad well	330	30	....	
Do	122	32	....	First water.
Do	70, 73	40	....	
Do	152	41	....	
2 miles north of Columbus	398½	70	....	Mainly at 160 feet.
Sec. 22, NW. ¼	300	138	80	Water at 205 feet.
Sec. 24, NW. ¼ SW. ¼	200	32½	10	
Sec. 25, NW. ¼ NW. ¼	217	29	150	Supply at 188–217 feet.
Sec. 35, NE. ¼ SW. ¼	151	40	Many.	
T. 29 S., R. 7 W. (UNSURVEYED).				
Sec. 6, NW. ¼	160	....	Few.	
Sec. 7, SW. ¼	246	4	2,000	
Sec. 8, SE. ¼	250	12	....	
Sec. 9	500	12	Few.	
T. 28 S., R. 7 W.				
Sec. 3, NE. ¼	120	90	Few.	Stock well.
Sec. 4, SW. ¼	50	40	10	
Sec. 4, W. ½	42	36	Few.	Fine sand.
Sec. 5	147	12	Few.	Shay ranch. Bored 1,000 (975) feet; water at intervals from 43 feet. Not tested.
Sec. 6, NW. ¼	45	38½	150	
Sec. 6, SE. ¼	45	....	Few.	
Sec. 7, SE. ¼	40	....	Few.	
Sec. 7, NW. ¼	45	40	....	Not tested.
Sec. 7, SW. ¼	78	....	....	
Sec. 8, NW. ¼	204	....	Few.	
Sec. 8, SE. ¼	44	42	1	
Sec. 8, SW. ¼	45	40	2	
Sec. 8, SW. ¼	46	43	12	
Sec. 9, SW. ¼	43	32	15	
Sec. 9, NW. ¼	40	....	Few.	
Sec. 9, SE. ¼	80	....	Few.	
Sec. 10, SW. ¼	90	90	Few.	
Sec. 14, SW. ¼	95	95	Few.	
Sec. 15, NW. ¼	90	....	Few.	In 10-inch sand bed.
Sec. 15, SW. ¼	85	77	Few.	
Sec. 17, NE. ¼	47	40	40	
Sec. 17, NW. ¼	45	....	Few.	
Sec. 17, SW. ¼	50	....	Few.	
Sec. 18, NW. ¼	83	....	Few.	
Sec. 18, NE. ¼	46	....	Few.	
Sec. 18, SE. ¼	46	....	....	Fair supply.
Sec. 19, SE. ¼	130	....	....	No water.
Sec. 20, NW. ¼	240	....	Few.	Do.
Sec. 20, SW. ¼	130	....	....	No supply.
Sec. 21, NW. ¼	130	....	....	Small supply.
Sec. 21, SE. ¼	107	....	....	Do.

Wells in the Columbus region—Continued.

Location.	Depth.	Depth of water below surface.	Reported yield.	Remarks.
T. 28 S., R. 7 W.—continued.				
Sec. 21, SW. ¼	226		Few.	Fine sand.
Sec. 22, SW. ¼	91	85	Several.	
Sec. 24, NW. ¼	109		Few.	
Sec. 25	100			Fair supply.
Sec. 26, SE. ¼	510	3		Flowed at first.
7½ miles east of Columbus	106			Very little water.
Sec. 27, SE. ¼	200			Very little.
Sec. 30, SW. ¼	355			Small supply.
Sec. 30, SE. ¼	200			Do.
Sec. 31, SW. ¼	200			Very little.
Sec. 33, SE. ¼	30			No water.
Sec. 35, NW. ¼	285			Do.
Sec. 35, north-central part	290	92	10	Quicksand with water at 128, 185, and 285 feet.
T. 27 S., R. 7 W.				
Sec. 26, SW. ¼	500			
Sec. 30	300			Small supply.
Sec. 31, SW. ¼	45	37	200	
Sec. 32	50	36	Many.	
Sec. 34, SW. ¼	130	110	Few.	Do.

All available information regarding most of these wells is given in the table. The Bailey well, in sec. 13, was the first to test the underground water conditions in the southern part of Luna County. It is only about 2 miles north of the large springs known as Ojo de las Adjuntas, in Mexico, where the underflow of Palomas Arroyo comes to the surface and accumulates in the Palomas Lakes. It developed a large volume of water at 126 feet, rising within 2 feet of the surface, but when the pump is producing 2,000 gallons a minute the water gradually drops to 7 feet below the surface, where it remains stationary. It is stated that the water level in a second well a few feet away is not noticeably affected by this draft on the underground supply. At this well the first water is in gravel and sand extending from 12 to 40 feet and it rises only to 12 feet below the surface. At the old Bailey ranch, in sec. 14, a few rods north of the international boundary, the main water supply is obtained from sandy beds, which occur at intervals from 95 to 165 feet, and the water rises within 25 feet of the surface.

In the Pierce well (Pl. XII, *B*, p. 140) in the center of the SE. ¼ sec. 12, half a mile northeast of the Bailey irrigation well, the water rises within 6 feet of the surface. Rock was reported in this well from 197 to 250 feet. Water was found at depths of 25, 65, 177, 194, and 225 feet, increasing in volume and head to 250 feet. The water at 194 feet came within 17 feet of the surface and that at 240 feet within 12 feet of the surface. When the well is pumped at the rate of 1,000 gallons a minute the water level is not greatly lowered, and the same thing is true of most of the wells at and south of Columbus.

In the well of Mrs. English, in the southwest corner of sec. 12, 3 miles southeast of Columbus, water from a depth of 187 feet rises within 3½ feet of the surface. In the Keenum well, in the northwest corner of sec. 11, 2 miles south of Columbus, water from a depth of 221 feet rises within 12 feet of the surface. The first water at the Keenum well is in gravel, extending from 110 to 130 feet. This stratum is underlain by 4 feet of "malpais" (basalt?), 31 feet of clay, and 56 feet of sand, extending from 165 to 221 feet. The well is cased with 8 and 6 inch pipe.

In the 246-foot well at the Hallock ranch, half a mile east of Pierce's, the water rises within 4 feet of the surface. The first flow was found in rock at a depth of 200 feet, and the second at 225 feet. The material above the rock is clay with thin deposits of sand containing water at 30 and 135 feet, but these waters did not rise. An 18-horsepower engine and a No. 7 pump with 10-inch discharge yields, it is said, 2,000 gallons a minute without greatly lowering the water. In the 250-foot well on the Poole ranch, half a mile farther east, the water comes within 12 feet of the surface. Hard rock, supposed to be "malpais," overlain by 5 feet of blue clay, was entered at 246 feet. At 165 feet and again at 200 feet there was sand which yielded some water that rose within 50 feet of the surface. "Alkali" water was found at 35 feet, and water of good quality, which rose within 53 feet of the surface, at 78 feet.

In the 500-foot boring in sec. 9 the water rises within 12 feet of the surface, but the supply is so slight that a small engine pumps it down to 170 feet in 20 minutes. Water-bearing sand was found at 210 feet. The materials to 308 feet were largely red clay. Blue clay extended from 308 to 320 feet, soft red rock which yielded a small amount of water from 320 to 340 feet, and a very hard black rock, regarded as "malpais," from 340 to 500 feet.

The wells near Columbus find somewhat variable water conditions, as they are some distance west of the main arroyo. The railroad well, 330 feet deep, with water at about 30 feet below the surface, obtains plenty of water for locomotive supply. (For analysis, see p. 125.) In another well near by the first water is obtained at 122 feet and rises within 32 feet of the surface. Two wells south of the railroad have water in moderate amount at 70 and 73 feet. In the 200-foot well on the Waterbury ranch, half a mile to the south, water is within 46 feet of the surface. In the 151-foot well at the De Rosear ranch, half a mile southeast of Columbus, water is within 40 feet of the surface, and a small amount of water that rose within 60 feet of the surface was found at 110 feet. Clay extended from 110 to 145 feet, where the water-bearing sandstone was entered.

A well 398½ feet deep 2 miles north of Columbus found the first main water-bearing bed at 160 feet, from which water rose within 80 feet of the surface, and with increase in depth the water finally rose within 70 feet of the surface. The 258-foot well at the Stearly ranch, in the SE. ¼ sec. 9, T. 28 S., R. 8 W., is somewhat similar, but the water is 200 feet below the surface. As the lift is great a 4-inch cylinder pump is used with a yield reported to be 25 to 40 gallons a minute, but it is said that with more power the yield might be greatly increased.

On the Thomas ranch in the NW. ¼ SW. ¼ sec. 24, T. 28 S., R. 8 W., it was necessary to sink 200 feet, but the water rises within 32½ feet of the surface and furnishes a satisfactory supply for ranch use. The first water was found at a depth of 94 feet. The beds penetrated were as follows:

Record of well in the NW. ¼ SW. ¼ sec. 24, T. 28 S., R. 8 W.

	Feet.
Loam, clay to sandy	0– 20
Sand (clean)	20– 29
Gravel	29– 31
Clay and compact sand	31– 94
Quicksand	94– 98
Clay	98–118
Quicksand	118–143
Clay and quicksand alternating (2 to 3 feet)	143–197
"Hardpan"	197–199
Sand and gravel with water (thickness unknown)	199–200

The 217-foot well at the Peters & White ranch, in the northwest corner of sec. 25, 2 miles northeast of Columbus, reached water-bearing sands at 188 feet, in thin deposits between beds of red clay. The water came within 29 feet of the surface and was satisfactory in amount. In a well only 10 feet from this one the strata reported from 200 to 300 feet, were gravel with thin deposits of clay at intervals.

In a 65-foot dug well at the Hansen ranch, in the SE. ¼ sec. 2, T. 28 S., R. 8 W., the water rose 8 feet and was sufficient for ranch use, but the well was finally clogged up with quicksand. Another well 200 feet away found harder sand at 67 to 77 feet from which water rose 20 feet in the well. In two other wells in the N. ½ SE. ¼ sec. 11, in the same township, 60 rods apart, water was obtained at 42 feet in one and at 72 feet in the other.

In the 300-foot well at the Engendorf place, on the grade road 2½ miles northeast of Columbus, the main supply was found at 205 feet and rises within 138 feet of the surface.

Most of the wells near Palomas Arroyo, northeast of Columbus, are in the western half of T. 28 S., R. 7 W. They are mainly 35 or 40 feet deep and obtain only moderate supplies of water. In most of them the water-bearing bed is fine sand or quicksand. A 240-foot well in the NW. ¼ sec. 19 failed to procure a supply. It is reported that a 975 or 1,000 foot boring at the Shay ranch, in sec. 6 (or 7), T. 28 S., R. 7 W., found water at intervals from 43 feet down, but the supply was small. A well in sec. 32, T. 27 S., R. 7 W., obtains a supply of water at a depth of 36 feet, which is pumped for irrigation. Wells farther east in this township have obtained but little water. One 500-foot boring in the SW. ¼ sec. 26 found a very small supply, and a 300-foot boring in the SW. ¼ sec. 30 is reported unsatisfactory. Wells in secs. 35, 26, 27, 22, and 15, T. 27 S., R. 7 W., yield only small volumes of water.

The Kaltenmeyer well, 44 feet deep, in the SE. ¼ sec. 8, T. 28 S., R. 7 W., has a 12-foot tunnel, in the bottom of which water accumulates to the amount of about 5 barrels, and this is pumped out three times a day. Another well 500 feet to the west is slightly deeper and contains 5 feet of water which yields about 2 gallons a minute. Unfortunately the clay in suspension clogs the strainer and stops the flow when the pumping cylinder is sunk more than 3 inches into the water. Many wells from 40 to 204 feet deep in the northwestern and west-central part of this township (T. 28 S., R. 7 W.) have failed to obtain a satisfactory supply, except for moderate domestic use, and wells 200 to 355 feet deep in the southwestern and southern parts of the township have had similar results.

There are several wells in the southern and eastern parts of this township, but many of them contain a very scanty water supply and several borings failed to obtain sufficient water for domestic use. The sand is in thin deposits, and much of it is quicksand. A boring recently made in the NE. ¼ sec. 26, T. 28 S., R. 7 W., found but little water until it reached a depth of 510 feet, where a small flow was found. This flow continued for a time but finally ceased, and the water was 3 feet below the surface in the summer of 1913. It is said that the flow stopped because of clogging in the lower part of the casing.

Several deep wells have been sunk west of Columbus, and though some of them have obtained small supplies others have been dry holes. The Hoppe well, in the SW. ¼ sec. 4, T. 29 S., R. 9 W., 9 miles west of Columbus and 2 miles north of the international boundary, is 500 feet deep. The water rises within 380 feet of the surface and yields 6 gallons a minute to a 16-foot windmill. It is stated that the water is of excellent quality. Four miles to the southeast, on the Moaty ranch, is a 300-foot well with 100 feet of water, and 5 miles to the south, on the Lane ranch, a 250-foot well has 50 feet of water. Within 3 or 4 miles of the Hoppe ranch, however, there are four dry holes 300 to 400 feet deep.

CARNE REGION.

DEVELOPMENT OF UNDERGROUND WATER.

Underground waters have been extensively developed by wells about Carne and in the region extending southward down the Mimbres Valley. In part of the area the volume of water is large and it is being utilized for irrigation. The following list gives most of the facts obtained regarding the wells:

Wells in Carne region.

Location.	Depth.	Depth of water below surface.	Reported yield.	Depth of water-bearing sands, in feet, and remarks.
T. 23 S., R. 7 W.	*Feet.*	*Feet.*	*Gallons.*	
Sec. 10, SE. ¼ SE. ¼	103	100½	Domestic supply.	
Sec. 12, NW. ¼ NW. ¼	294	55½		Fifth stratum.
Sec. 19, NW. ¼	147	70		70–78, 102–108, 130–147.
Sec. 21, SW. ¼ SW. ¼	195	70	800	74–87, 89–117, 177–195.
Sec. 22, NW. ¼ NE. ¼	150	80	Few.	
Sec. 25, SW. ¼	90	78		18–21, 69–71, 80–83.
Sec. 26, NE. ¼	92	20		20–23, 43–47, 77–90.
Sec. 29, SW. ¼ SW. ¼	40	28		
Sec. 30, SW. ¼ SW. ¼	111	22	800	22–24, 29–35, 64–77, 77–101.
Sec. 30, NW. ¼	90	23		23–28, 32–38, 65–71, 75–77, 82–86.
Sec. 34, NE. ¼	98	51	1,000	51–53, 63–64, 78–81, 83–84.
T. 24 S., R. 7 W.				
Sec. 1, NW. ¼ NW. ¼	120	47½		
Sec. 1, NW. ¼	140	48	1,000	48–54, 66–70, 75–80, 82–140.
Sec. 2, E. ½ E. ½	139	45	1,500	88–128.
Sec. 3, NW. ¼ NW. ¼	76	44	Not tested.	
Sec. 4, SE. ¼		50		
Sec. 4, NE. ¼, NE. ¼	80	46		
Sec. 4, SW. ¼ SE. ¼	124	47	125	117–124 (first water at 72).
Sec. 6, NE. ¼ lot 2	50	33		Windmill.
Sec. 8, NW. ¼		47		
Sec. 9, NE. ¼ NW. ¼	85	43	1,000	
Sec. 9, NW. ¼	64	50		
Sec. 11, NE. ¼	130	49	1,500	49–64, 75–82, 93–99, 123–130.
Sec. 11, NW. ¼	156	46	1,800	46–73, 77–85, 87–93, 95–110, 113–123.
Sec. 11, NW. ¼ NW. ¼	125	46	Good supply.	
Sec. 13, NW. ¼	122	66	1,000	66–67, 71–81, 84–99, 103–122.
Sec. 12, NW. ¼ NW. ¼	106	48	1,000	48–57, 60–64, 74–79, 94–99.
Sec. 12, NE. ¼	128	49	1,000	49–58, 66–78, 90–91, 94–107, 121–128.
Sec. 12, SW. ¼	122	48	1,000	48–58, 68–73, 83–97, 102–122.
Sec. 15, NE. ¼ NE. ¼		50		
Sec. 26, N. ½ SW. ¼	160	76	1,000	76–78, 86–99, 110–119, 121–144.
Sec. 27, N. ½	64	62	Not tested.	
Sec. 36, NW. ¼ NW. ¼	75	71		
T. 24 S., R. 6 W.				
Sec. 6, NW. ¼ NW. ¼	135	80		Good quality.
Sec. 7, southeast corner	200		No water.	In progress.
T. 25 S., R. 7 W.				
Sec. 2, SE. ¼ SE. ¼	94	82	Good volume.	Quality bad.
T. 23 S., R. 6 W.				
Sec. 22, SE. ¼ SE. ¼	80	75	Not tested.	
Sec. 27, NW. ¼ SW. ¼	275	80	250	
Sec. 30	92	90	3	

WELLS.

T. 23 S., R. 7 W.—There are several wells about Carne which obtain excellent supplies of water for domestic use or irrigation. On the Glasser ranch, in the SW. ¼ sec. 30, there are two wells yielding a large amount of water for irrigation. One is 111 feet deep and the other 40 feet deep, with water 22 feet below the surface. The deeper of these wells penetrated the following materials:

Record of well in the SW. ¼ sec. 30, T. 23 S., R. 7 W.

	Feet.
Clay, etc	0–22
Gravel	22–24½
Clay	24½–29
Gravel	29–34½
Sand (packed)	34½–40
Clay	40–50
Sand	50–55
Clay	55–63
Sandrock	63–65
Quicksand	65–66
Gravel and sand, water	66–72
Clay	72–75
Very coarse gravel	75–76
Gravel, water	76–79
Soft sandrock	79–111

A 147-foot well in the NW. ¼ sec. 19 found the water 70 feet below the surface. This well penetrated 29 feet of water-bearing sands, but the third stratum, from 130 to 147 feet, contained the main water supply.

At the Connor well, in the SW. ¼ sec. 21, 1½ miles northwest of Carne, the main water supply is in 18 feet of sand and gravel at 177 to 195 feet, and it rises within about 70 feet of the surface. The well consists of a pit 5 feet in diameter and 74 feet deep, a 30-inch hole 13 feet deep, with screen casing, and 18 and 12 inch casing with screens to the bottom. Sand and gravel were the principal materials penetrated. At a depth of 87 feet there was a 2-foot layer of rock, and at 117 feet a 1½-foot layer. Below the lower layer was 60 feet of tightly packed sand and clay. The first water was found at 74 feet, the second water appeared at 90 feet and rose 2 feet higher than the first, and there was a rise of an additional 18 inches in the third water, at 119 feet.

A 294-foot well recently completed at the Hayes ranch, in the northwest corner of sec. 12, throws important light on the underground-water conditions of that region. The water rises within 55⅓ feet of the surface in the well, although in the pit it is 64½ feet below. The first water was found at 102 feet; the second at 149 feet, rising to 100 feet below the surface; the third at 169 feet, rising to 100 feet; the fourth at 176 feet, rising to 100 feet; and the fifth at 188 feet, rising to 88 feet. This water is all in quicksand and is in moderate volume. At 212 feet water was forced up around the casing and stood within 76 feet of the surface in the pit. Water rose to 70 feet from water-bearing materials at 230 to 253 feet and to 66 feet from sand at 258 to 268 feet. At 280 to 284 feet there were two beds of sand and gravel, and this material also extended from 285 to 293 feet. The pit in which the casing is sunk is 90 feet deep, the last 6 feet in gravel. It is believed that this well contains a large volume of water, but the amount has not yet been tested.

A well in the NW. ¼ NE. ¼ sec. 22, 2 miles northeast of Carne, has tested the beds to a depth of 150 feet and found water which comes within 80 feet of the surface, but the volume is stated to be very small.

One of the wells of the Mimbres Valley Farms Co., in the NW. ¼ sec. 34, throws light on the conditions southeast of Carne. It found a large supply of water. The following record was supplied by the company:

Partial record of well in the NE. ¼ sec. 34, T. 23 S., R. 7 W.

	Feet.
Sand	51–53
Crumbly clay	53–57
Rock	57–60
Clay	60–63
Sand	63–64
Clay and bowlders	64–73
Clay	73–78
Sand and gravel	78–81
Rock	81–83
Sand	83 84
Rock and clay	84–90
Pack sand	90–94
Rock	94–96
Clay	96–98

T. 24 S., Rs. 6 and 7 W.—There are several wells along the Mimbres bottom lands south of Carne which yield supplies of excellent water in volume sufficient for extensive irrigation. The depths, however, are somewhat greater than in the tier of townships next west, for apparently part of the Mimbres underflow is dammed off by an underground ridge extending northward from the Little Florida Mountains toward and possibly connecting underground with Cooks Range. A series of test wells recently sunk by the Mimbres Valley Farms Co. in the central northern and northeastern portions of T. 24 S., R. 7 W., have found thick deposits of water-bearing beds, and most of them have yielded volumes reported as 1,000 to 1,800 gallons a minute. The water rises within 44 to 50 feet of the surface in the greater part of the area. The following records of the wells have been furnished by the company:

Partial record of well in the NW. ¼ sec. 1, T. 24 S., R. 7 W.

	Feet.
Sand and gravel, water bearing	48–54
Clay	54–65
Rock	65–66
Sand and gravel, water bearing	66–70
Rock	70–71
Clay and sand	71–75
Sand and gravel, water bearing	75–80
Caliche	80–82
Sand and gravel, water bearing	82–86
Rock	86–87
Sand, water bearing	87–91
Rock	91–92
Sand and gravel, water bearing	92–106
Rock	106–107
Sand and clay, water bearing	107–112
Sand and gravel, water bearing	112–140

Partial record of well in the NW. ¼ sec. 11, T. 24 S., R. 7 W.

	Feet.
Sand, water bearing	46–73
Clay	73–77
Sand, water bearing	77–85
Limerock	85–87
Sand and gravel, water bearing	87–93
Stone	93–95
Clay and water-bearing sand	95–110
Stiff clay	110–113
Sand and gravel, water bearing	113–123
Clay	123–156

Partial record of well in the NE. ¼ sec. 11, T. 24 S., R. 7 W.

	Feet.
Limy material	47–49
Sand, water bearing	49–64
Rock	64–75
Sand and gravel, water bearing	75–82
Stiff clay	82–93
Sand and gravel, water bearing	93–99
Sandy clay	99–123
Sand and gravel, water bearing	123–130

Record of well in the NW. ¼ sec. 12, T. 24 S., R. 7 W.

	Feet.
Soil	0–30
Sand and gravel	30–48
Sand and gravel, water bearing	48–53
Caliche	53–55

	Feet.
Pack sand, water bearing	55–57
Rock	57–60
Sand, water bearing	60–64
Bowlders and clay	64–73
Sand and stone	73–74
Sand and gravel, water bearing	74–79
Sandstone	79–81
Sand and gravel, water bearing	81–87
Limerock	87–90
Clay	90–94
Gravel, water bearing	94–99
Clay	99–101
Rock and sand	101–106

Partial record of well in the NE. ¼ sec. 12, T. 24 S., R. 7 W.

	Feet.
Clay and water-bearing sand	49–56
Sand, water bearing	56–58
Bowlders and clay	58–66
Sand and gravel, water bearing	66–68
Caliche	68–70
Sand and gravel, water bearing	70–78
Silt	78–83
Sand and gravel, water bearing	90–91
Rock	91–94
Sand and gravel, water bearing	94–101
Sand, water bearing	101–107
Joint clay	107–121
Sand and joint clay, water bearing	121–128

Partial record of well in the SW. ¼ sec. 12, T. 24 S., R. 7 W.

	Feet.
Rock	47–48
Sand and gravel, water bearing	48–58
Compact sand, some water	58–61
Rock	66–68
Sand and gravel, water bearing	68–73
Rock	73–83
Sand and gravel, water bearing	83–93
Sand and stone	93–94
Sand and stone, water bearing	94–97
Caliche	97–98
Sand and clay	98–100
Sand and gravel, water bearing	102–122

Partial record of well in the NW. ¼ sec. 13, T. 24 S., R. 7 W.

	Feet.
Clay	48–60
Caliche	60–62
Clay	62–66
Sand, water bearing	66–67
Rock	67–71
Sand, water bearing	71–73
Rock	73–74

	Feet.
Sand and clay, water bearing	74–81
Sand and rock	81–84
Sand and gravel, water bearing	84–90
Rock	90–91
Sand and gravel	91–99
Clay	99–102
Sandstone	102–103
Sand and gravel, water bearing	103–122

Partial record of well on center of north line of the SW. ¼ sec. 26, T. 24 S., R. 7 W.

	Feet.
Rock	75–76
Sand and gravel, water bearing	76–78
Rock	78–82
Clay	82–85
Rock	85–86
Sand, water bearing	86–99
Clay	99–102
Rock	102–105
Clay	105–107
Rock	107–110
Sand and clay, water bearing	110–114
Rock	114–115
Sand and clay, water bearing	115–119
Limy layer and clay	119–121
Sand, water bearing	121–130
Rock	130–131
Sand, water bearing	130–144
Joint clay	144–160

At the Sadler ranch, in the NE. ¼ NE. ¼ sec. 15, and at the Kelly ranch, in the N. ½ SE. ¼ sec. 4, T. 24 S., R. 7 W., the water is about 50 feet below the surface. At the Taber ranch, in the SW. ¼ SE. ¼ sec. 4, T. 24 S., R. 7 W., a 124-foot well has water within 47 feet of the surface. A good supply was found at 72 feet, but the water at 117 to 124 feet rose 3 feet higher. In the 80-foot well at the Kimball ranch, in the NE. ¼ sec. 4, T. 24 S., R. 7 W., the first water was found at 46 feet and the second water at 60 feet, rising to the level of the first. In a well in the north-central part of T. 24 S., R. 6 W., water was found 80 feet below the surface, and at a point about 4 miles south of that place the depth was 120 feet. A boring in the SE. ¼ sec. 7 in this township reached a depth of 200 feet without finding any water-bearing beds. In the southern part of T. 24 S., R. 7 W., the water conditions are less satisfactory, owing to small supply, the presence of quicksand, and considerable mineral matter in solution. One of the Birchfield wells, in the NW. ¼ sec. 36, is 75 feet deep and has a good volume of water rising within 71 feet of the surface, but the quality is not entirely satisfactory.

T. 23 S., R. 6 W.—A few wells sunk north and west of Myndus siding have found the water at about the same depth as in the region northeast of Carne, but the volume is less. A 92-foot well, at the Liljegren ranch, in sec. 30, all in hard clays, contained only 2 feet of water and yielded about 3 gallons a minute. An 80-foot well in the southeast corner of sec. 22 contains 5 feet of water, and though its capacity had not been ascertained at the time of the investigation it appeared not to be great. A test boring in the NW. ¼ SW. ¼ sec. 27 found a good volume at a depth of 275 feet. The water rises within 80 feet of the surface, but pumping at the rate of 250 gallons a minute lowers it to 250 feet.

LOWER MIMBRES VALLEY.

In the wide bolson east and southeast of the Florida Mountains the conditions for underground water supply appear to be unfavorable at most localities. Many test holes have been sunk to depths of 100 to 375 feet, and most of them have found quicksand yielding little or no water or water of saline character. The district is a basin into which Mimbres River spreads out as a lake in times of exceptional freshets, and here while evaporating the water deposits fine sediments. Evidently this condition has continued for a long time, as most of the materials pierced in boring are fine grained and contain saline compounds resulting from evaporation.

Several wells have been bored to various depth at the Birchfield home ranch, in the northeastern part of T. 25 S., R. 7 W. The old well, 92 feet deep, has water within 80 feet of the surface, which it is stated can be pumped at a rate of 650 gallons a minute with a drawdown of only 3 feet. The water contains much mineral matter, as shown in the analysis on page 125, but has been used satisfactorily by stock for many years. Another well recently bored to a depth of 160 feet obtains water of much better quality rising within 72 feet of the surface.

The next well, 5 miles down the valley, yields a moderate supply of fairly good water. Test wells east of this place found only salty water; others 375 and 275 feet deep, to the southwest, obtained no water or only a small amount in quicksand.

A well at one of the Birchfield ranches in the southeastern part of T. 26 S., R. 6 W., is 135 feet deep and obtains only a small volume of water, which is stated to be so strongly mineralized "that cattle have to be very thirsty to drink it."

NORTH-CENTRAL TOWNSHIPS.

In T. 22 S., R. 8 W., the bolson deposits occupy wide, shallow valleys and probably have a very irregular configuration underground.

A few wells have been sunk, some of them successful and others not. The most notable well is one in the southwestern part of the township which afforded the supply for the camp at the Fluor mine and appeared to contain a large amount of water. The depth is 220 feet and the water rises within 80 feet of the surface. It is pumped by a windmill. The well at the Wilson ranch, 3 miles northeast of the Fluor mine, is 43 feet deep and, although it affords sufficient water for cattle and stock, it pumps down with a long run of the windmill. There is an old well in the arroyo 2 miles northeast of the Fluor mine, but the yield was too small to be of much service.

NORTHEASTERN TOWNSHIPS.

Three borings have been made in the western part of T. 21 S., R. 6 W. One at the Phillips ranch, in the northwest corner of the NE. ¼ sec. 30, is 196 feet deep and yields to windmill pumping from 20 to 30 gallons a minute. Water began at a depth of 166 feet and the supply gradually increased to the bottom of the boring. Another well, 3 miles due south of this one, is 280 feet deep and yields a satisfactory supply for stock watering. Water began in this well at a depth of 266 feet. A 340½-foot boring in the southeast corner of sec. 32, 2 miles southeast of the Phillips ranch, obtained no water.

A well sunk in 1913 in the SW. ¼ SE. ¼ sec. 29, T. 22 S., R. 7 W., about 5 miles south of Florida, is 170 feet deep, the last 10 feet in water-bearing sand. No statement can be given as to the amount of water available or the height to which it rises.

A well in the northwest corner of sec. 6, T. 21 S., R. 6 W., is near the railroad and about midway between Florida and Nutt stations. It is 310 feet deep, and the water, which began at 300 feet, rises within 270 feet of the surface. This water is said to be slightly tepid.

In the valley east of the Goodsight Mountains the water supply has been tested by several wells with satisfactory results. Three of them are a short distance south of the railroad, about 6 miles southeast of Nutt. They range from 80 to 100 feet in depth and are pumped by windmills to supply water for cattle. Farther south along the valley, at a point nearly due east of Goodsight Peak, is a 110-foot well belonging to Ed Price, which appears to have an ample supply. At the ranch of Tom Hall, in the NE. ¼ sec. 3, T. 22 S., R. 5 W., there are two wells 225 feet deep in which water rises within 160 feet of the surface. Water began at 158 feet, but the volume was small until the well reached a depth of 200 feet, where coarser gravel was entered. One well is pumped with a 5-horsepower pump, which does not lower the water level noticeably. The water is used to irrigate gardens and supply a large herd of cattle. The water-bearing beds appear to extend along the middle of this valley and to lie nearly horizontal, the increased depth to the south being due to the rise of the land. On the slopes farther east several borings from 300 to 500 feet deep failed to obtain water. To the west are rocky slopes of basalt that probably do not contain any water supplies. At Cambray the railroad company has a large dug well 269 feet deep, in which the water is 180 feet below the surface. Its capacity is about 150,000 gallons a day. The quality is fair. (See analysis, p. 125.)

SOUTHEASTERN TOWNSHIPS.

Little is known as to the water conditions in the southern part of Luna County east of longitude 107° 30′. Most of the area is underlain by sand and gravel containing some water, but the amount appears not to be large. Several wells on the Birchfield ranches, one just east of Arena and the other 6 miles northeast of Arena, obtain small supplies, but the depth of the wells and the water surface could not be learned. The railroad company has recently made a boring 504 feet deep at Arena and found no water below the main flow at 299 feet, which rose within 66 feet of the surface. The volume was found to be at least 100 gallons a minute, but the water was unsuited for locomotive use, and the well is not in service. (See analysis, p. 125.) There are old wells supplying windmills in the north-central part of T. 27 S., R. 6 W., the eastern part of the next township to the north, and 5 or 6 miles west of Birchfield, but their depths and water levels could not be ascertained. They afford water for stock.

A 72-foot well in sec. 24, T. 28 S., R. 6 W., obtained only a small supply of salty water, and the Merrifield well, 3 miles southeast, 400 feet deep, had a similar result.

WEST-CENTRAL TOWNSHIPS.

At Gage station the railroad company has two wells, one 330 feet deep with 7-inch casing and the other 340 feet deep with 10-inch casing. The water rises within 226 feet of the surface but is pumped from a depth of 265 feet. The capacity of each well is 30,000 gallons in a day of 24 hours. An analysis of the water is given on page 125. A mile and a half farther north are two windmills drawing from wells 300 feet deep in which the water rises within 270 feet of the surface. Their capabilities are not known. At Van Meter's ranch, 3 miles north of Gage, there is a 380-foot well in which the water level is 310 feet below the surface. Originally the level was higher, at about 304 feet, but it has gradually been pumped down. A windmill is used to supply the water for stock and domestic service. Four miles west of Van Meter's a boring 381 feet deep failed to obtain water. The bolsons in this region are underlain by a thick deposit of clay with many layers of sand and gravel, but the water level is low and the supply meager. Possibly deeper wells might develop additional amounts of water. The 191-foot well at the Jordan ranch in the SW. ¼ sec. 18, T. 25 S., R. 11 W., has water within 38 feet of the surface and its capacity is estimated at 400 gallons or more. It is in the arroyo. At the Todhunter ranch, in the SW. ¼ NW. ¼ sec. 11, T. 24 S., R. 12 W., there is a well 100 feet deep supplying sufficient water for stock. It entered the water-bearing sand at 75 feet, and the water rises within 75 feet of the surface. At a ranch in the SW. ¼ NW. ¼ sec. 12, T. 25 S., R. 13 W., or nearly 6 miles farther west, there is a well 150 feet deep with the water level about 100 feet below the surface. It yields about 15 gallons a minute when pumped by windmill. The water is used for stock. A 220-foot boring made in the shallow, dry lake basin just north of the mount of rhyolite, halfway between these two ranches, obtained no water. This boring probably indicates that there are no water supplies in the slopes south of the Victorio Mountains. A 103-foot well in the W. ½ sec. 26, T. 24 S., R. 12 W., and a 116-foot well 2 miles northeast of that place failed to obtain water, but they were not sufficiently deep to reach beds in which water is to be expected. There is a well just east of Gray Butte and another one up the main draw 4 miles to the northwest, but no facts are available as to their depth or yield.

SOUTHWESTERN TOWNSHIPS.

In the wide basin lying between the Cedar Grove Mountains and the Sierra Rica there is a thick mass of bolson deposits which contain more or less water. All the tests made indicate that the water is far below the surface. In a well a mile south of Victorio station it was necessary to sink 430 feet, and the supply at that depth is not great. Six miles farther southeast, near the international boundary, is a well 320 feet deep, which yields a satisfactory supply of water for stock. At the Williams ranch, at the foot of the Cedar Grove Mountains, there is a shallow well which yields a fair amount of excellent water, probably from agglomerate. North of the Cedar Grove Mountains the water conditions vary greatly. At the Cox ranch a 165-foot well in the rock has water at a depth of 135 feet, and the supply is about 8 gallons a minute. At the Klondike ranch, near the center of T. 26 S., R. 12 W., it was necessary to sink 410 feet to obtain a very moderate supply of water, which rises within 375 to 380 feet of the surface. It is pumped by a windmill, but when this raises more than 9 gallons a minute the water level drops rapidly. In the arroyo 2½ miles west-northwest of this ranch there is a well 50 feet deep in which water rises within 40 feet of the surface, and the volume is sufficient for stock. Farther up this valley, at a point just south of the Klondike Hills, a shallow well obtained water, but the supply was inadequate. At the Bisbee watering place, in the southeast corner of T. 26 S., R. 11 W., the wells are 125 feet deep, have water within 90 feet of the surface, and yield 60 gallons a minute to windmills. An unsuccessful attempt was made to develop a water supply 2 miles west of Tomerlin by sinking a shaft 200 feet and drifting laterally.

SPALDING REGION.

There appears to be a large supply of water in the underflow along the Mimbres and for some distance on both sides in the region about Spalding. At Spalding the water level is about 30 feet below the surface, and a large supply of excellent water is available. At the Jacobsen ranch, in the center of the SE. ¼ sec. 13, T. 21 S., R. 11 W., there is a large dug well 70 feet deep, which is extensively pumped for irrigation. The first water occurs at 42 feet, and a test boring continued to 170 feet found the water-bearing gravel to be about 100 feet thick. The water rises within 38 feet of the surface, but it sinks to 70 feet when the pump is yielding 800 gallons a minute, which is probably near the limit of the capacity of the well. A stock well with a windmill 3 miles northeast of Jacobsen's has the water level 80 feet below the surface, and another in the southeast corner of sec. 9, a mile to the southeast, is 116 feet deep and has water 112 feet below the surface. A well in the SW. ¼ sec. 6, T. 22 S., R. 10 W., is 63 feet deep with water 57 feet below the surface, and another half a mile to the northwest in the S. ½ NE. ¼ sec. 1, T. 22 S., R. 11 W., is 50 feet deep and has water within 46 feet of the surface. Both appear to be capable of yielding good supplies. A test pit sunk in the center of sec. 19, T. 20 S., R. 10 W., a mile north of Mimbres, is 12 feet in diameter and 24 feet deep to bedrock. Most of the water is in gravel at 19 to 22 feet. It rises within 12 feet of the surface and was tested to 250 gallons a minute.

Several wells near Spalding obtain good water supplies at depths less than 50 feet. One 2 miles southwest of the station has water within 30 feet of the surface; another 1½ miles west-southwest has water within 40 feet of the surface; and a third 1½ miles northwest of the station has water within 32 feet of the surface.

An old well in the NW. ¼ sec. 15, T. 22 S., R. 11 W., 3 miles south of Spalding, is about 40 feet deep, has water 30 feet below the surface, and is said to be capable of yielding 100 gallons or more a minute.

DEEP BORINGS.

At several places in Luna County deep borings have been made with the hope of finding artesian flows, but they have not been successful. The results, however, have thrown interesting light on the deeper underground conditions. The available data from them are as follows:

The most important test of the deeper underground water in Luna County was made in 1907 at a point 2,000 feet south by east of the center of sec. 20, T. 24 S., R. 8 W., 6 miles southeast of Deming. The town of Deming contributed $4,000 toward its cost. The total depth was 1,665 feet, and a 12-inch casing was put down for 1,200 feet. Water at 520 feet rose within 17 feet of the surface, and when boring was finished a 25-horsepower pump rasing 800 gallons a minute did not lower the level greatly. Very little water was found below 520 feet, and there were many thick bodies of reddish clay all the way down.

The Burdick well, in the SE. ¼ SW. ¼ sec. 29, T. 23 S., R. 8 W., 3½ miles east of Deming, was sunk to a depth of 710 feet to test for artesian water. It is reported that a flow was found which lasted for a short time, and the water level is now 24 feet below the surface. No record of the boring was obtained, but it is said that there were many beds of sand, some with considerable water but others containing very little. In 1887 Mr. Burdick had a well sunk to a depth of 980 feet in the western part of Deming, but the result was unsatisfactory as no flow was obtained. The boring began with an 8-inch pipe and ended with a 6-inch pipe. According to a report of the driller, F. E. Hickox, "bedrock" was entered at 963 feet. Water was found at 60 feet and then at intervals of 20 to 40 feet for a considerable depth. At 773 feet it rose within 28 feet of the surface; at 836 feet, within 21 feet; at 886 feet, within 19 feet; and from 912 to 980 feet, within 9 feet of the surface, where it continued for a year, after which it dropped to 16¼ feet.[1] The materials penetrated were clay, sand, "cement," and gravel in beds 5 to 18 feet thick. Several years ago a deep well was sunk at Lenark, on the Southern Pacific Railroad, about 80 miles east of Deming. It reached a depth of 950 feet, passing through the beds given on page 51. The water rises within 384 feet of the surface and is pumped at the rate of 35 gallons a minute.

At the Taylor ranch in the S. ½ sec. 6, T. 25 S., R. 9 W., 1½ miles northeast of Hondale, a deep boring found water at 202 feet and then no further supply except a very slight one at 550 feet.

At the Shay ranch, in sec. 6 (or 7), T. 28 S., R. 7 W., a boring was sunk to a depth of 975 or 1,000 feet. Water was found at intervals all the way down from 43 feet, but it came only within 15 feet of the surface.

[1] Report on artesian wells: Fifty-first Cong., 1st sess., Senate Ex. Doc. 222, p. 217, 1890.

A well 398½ feet deep 2 miles north of Columbus found but little increase in amount or head of the water below 160 feet, but the railroad well at Columbus went to a depth of 330 feet with gradually increasing supply. At Arena the railroad company has recently sunk to a depth of 504 feet in the hope of getting water for locomotives. At a depth of 299 feet water rose within 66 feet of the surface and was tested at 100 gallons a minute, but the quality was unsatisfactory.

IRRIGATION.

IRRIGATION BY UNDERGROUND WATER.

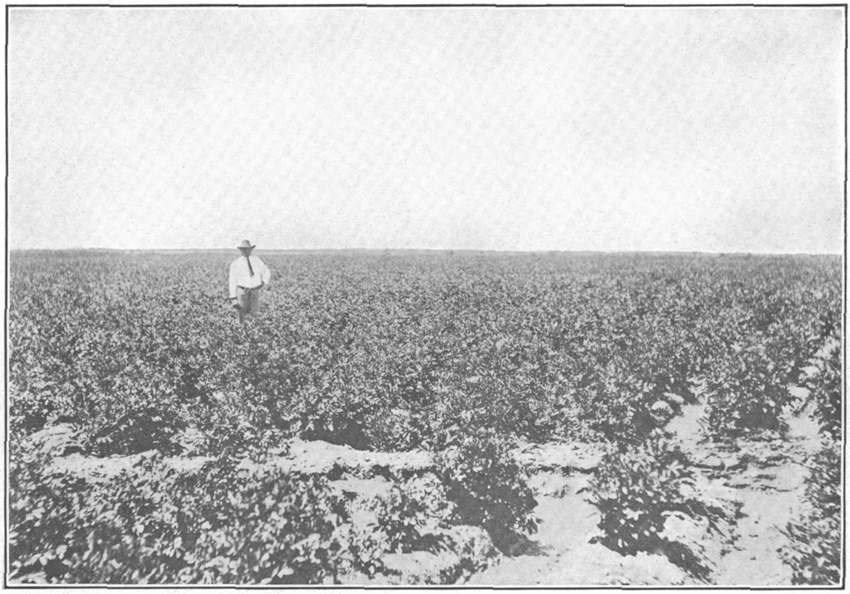
GENERAL FEATURES.

The water in the gravel and sand under the deserts of Luna County has been pumped to the surface and used for irrigation at many ranches, in general with very satisfactory results as to products and cost. The wells are mainly from 50 to 200 feet deep, and the water is pumped with small engines, mostly using naphtha for fuel and yielding from 200 to 1,000 gallons a minute. The water is in every way suitable for irrigation and its temperature averages about 65° F. Some irrigated fields are shown in Plates XI (p. 131) and XIII. Beyond a canvass of the water conditions no detailed investigation was made of the irrigation plants nor of their products. However, scattered facts were obtained as to some features of representative irrigated areas, and they will be presented in the following paragraphs.

DEMING REGION.

There are many irrigated areas about Deming, all using waters pumped from wells mostly from 40 to 200 feet deep. The Hund farm, in the northwest corner of T. 24 S., R. 8 W., is one of the best-known and most representative irrigation plants. The well is 149½ feet deep and the water level is 44 feet below the surface. The pump is in a 50-foot pit and has a 59-foot lift. It is run by a 35-horsepower engine, with a reported yield of 1,200 gallons a minute. (See Pl. X, *A*, p. 130.) A considerable variety of crops is raised, including 24 acres of beans, which, it is said, netted $2,000 in 1910.

The Shull well, in the SW. ¼ sec. 32, T. 23 S., R. 8 W., is 3 miles east by south of Deming. It is stated to be the first large well in the district. The depth is 156 feet, and the water stands within 24 feet of the surface. It is reported that a 45-horsepower gasoline engine at this well pumps 1,100 to 1,250 gallons a minute. The water is used for irrigating 170 acres, mainly of cane, potatoes, corn, beans, milo, and Kafir corn.



A. FIELD IRRIGATED BY WATER PUMPED FROM A SHALLOW WELL NEAR DEMING, N. MEX.

B. IRRIGATION IN BOLSON SOUTHEAST OF DEMING, N. MEX.

Field contains 80 acres of beans. Little Florida Mountains in distance.

The Bowman well, in the NW. ¼ sec. 12, T. 24 S., R. 9 W., 2 miles southeast of Deming, is only 52 feet deep but can furnish 350 gallons a minute, which is sufficient for about 20 acres. It is equipped with a 6-horsepower engine run by naphtha, and the consumption of that fuel is stated to be a gallon an hour. Eight acres are under ditch, comprising cane, Kafir corn, melons, pumpkins, squash, and alfalfa.

At the Hicks ranch, in the northwest corner of sec. 7, T. 24 S., R. 8 W., 3 miles southeast of Deming, there is a notably successful irrigation plant. The water is obtained from a stratum 46 to 100 feet deep and rises within 35 feet of the surface. It yields 1,200 gallons a minute. A 35-horsepower gasoline engine is used.

The Connaway well, in the NW. ¼ sec. 13, T. 24 S., R. 9 W., 3 miles southeast of Deming, was expected to provide water for the irrigation of many acres, but it is reported that the yield was only 300 gallons a minute. Its depth was 150 feet, and the water level stood 41 feet below the surface.

At the McBride ranch, near the center of sec. 12, T. 24 S., R. 9 W., 3 miles southeast of Deming, a 115-foot well furnishes water for irrigating 25 to 30 acres. The water rises within 38 feet of the surface, and the pumping capacity is stated to be about 1,500 gallons a minute. At the adjoining ranch of Bradshaw & McBride a pumping capacity of about 1,250 gallons is reported, with the water level 40 feet below the surface. The area under cultivation is about 45 acres, mainly in beans, alfalfa, and feed.

At the Ernst ranch, in the SW. ¼ sec. 9, T. 24 S., R. 9 W., 3 miles south-southwest of Deming, a 115-foot well supplies water for the irrigation of 40 acres. The water rises within 52 feet of the surface, and the yield by pumping is reported to be 1,000 gallons a minute.

At the Burdick ranch, in sec. 29, T. 23 S., R. 8 W., 4½ miles east of Deming, there is a deep well, but most of the water is derived from beds at moderate depth, with the water level 24 feet below the surface. The water is pumped with a 36-horsepower crude-oil engine, stated to yield 600 to 800 gallons a minute, and is used for irrigating 25 to 30 acres, largely in potatoes and cane. Water from the 1,665-foot well on the Burdick place 6 miles southeast of Deming is used for irrigating about 30 acres. This well is pumped to yield about 800 gallons a minute.

At the Sanders ranch, in the northwest corner of sec. 7, T. 24 S., R. 9 W., 4 miles southeast of Deming, wells 130 and 150 feet deep are reported to yield 600 gallons a minute. The water is used for irrigating 35 acres of corn and an extensive garden. The water level is about 60 feet below the surface. Several other ranches in this vicinity irrigate small areas from wells 65 to 70 feet deep. In secs. 4, 5, and 10, T. 24 S., R. 9 W., 1½ to 2 miles southwest and southeast of Deming, wells 55 feet deep furnish water for irrigating areas of 5 to 10 acres.

At the Solignac ranch, in the southeast corner of sec. 2, T. 24 S., R. 8 W., the water is developed by a trench 40 feet long and 10 feet deep, scooped into the first water stratum, and a well 60 feet deep from which water flows when the trench is heavily pumped. The water is used for irrigating wild hay. Some features of the plant are shown in Plate XI, *A* (p. 131). It is situated in a low swale, where the water level is only 4 feet below the surface.

At the Wilson ranch, three-fourths of a mile northwest of Luxor, an 87-foot well furnishes water to irrigate an area of considerable extent. A 2-inch pump with a 7-horsepower engine working all day, with an output stated to amount to about 200,000 gallons, lowers the water only a few feet. Similar irrigation outfits have been installed at three other ranches near Luxor. About halfway between Luxor and Carne is the Russell ranch, in the northwest corner of sec. 25, T. 23 S., R. 8 W., where about 12 acres is irrigated. The pump is 4 inches in diameter and the engine 10 horsepower. The well is 105 feet deep, and the water stands about 12½ feet below the surface. It is reported that pumping 1,500 gallons a minute does not lower the water greatly.

Wells on the Glasser ranch, southwest of Carne, yield large volumes of water for irrigation. Two wells, 111 and 40 feet deep, are pumped with a No. 6 pump and a 25-horsepower engine and yield, it is said, 500 to 1,000 gallons a minute without much reduction of the water level.

HONDALE REGION.

About Hondale and southeast of that place there are several pumping plants which are irrigating areas of greater or less extent. On the ranch of J. W. Young, in the northwest corner of sec. 28, T. 24 S., R. 9 W., halfway between Hondale and Deming, there is a 203-foot well pumped by a No. 5 pump, run by electricity brought from Deming. The water rises within 55 feet of the surface, and the capacity is stated to be from 600 to 700 gallons a minute. It is used to irrigate about 80 acres of diversified crops. At the Ramsey ranch, a mile southeast of Young's, alfalfa, corn, and cane are irrigated by well water. At the R. L. Taylor ranch, 1½ miles north of Hondale, a 200-foot well, with a pump run by a 50-horsepower engine, has a capacity of about 1,200 gallons a minute. The average yield is stated to be 800 gallons, which is used for 25 acres of beans, potatoes, and forage. P. L. Rose, 1¾ miles east of Hondale, has a 75-foot well which pumps 70 gallons a minute. An area of 7 acres is under ditch and is mostly in milo maize. At the Hines ranch, in sec. 31, T. 24 S., R. 9 W., 3 miles north of Hondale, a 57-foot well furnishes water for 4 acres of miscellaneous crops.

The Stephenson ranch, in the NW. ¼ sec. 1, T. 25 S., R. 9 W., 7 miles northeast of Hondale, pumps water from a depth of 52 feet, with a capacity stated to be about 250 gallons a minute. A 24-horsepower engine is used and is reported to consume 53 gallons of naphtha in a 36-hour run. An area of about 17 acres is under ditch, comprising 10 acres of beans, 2 acres of alfalfa, and 3 acres of feed stuff, garden truck, etc. A second well, 70 feet deep, is to be used for supplying an additional area. The Smith ranch, in the NW. ¼ sec. 3, T. 26 S., R. 9 W., 5 miles southeast of Hondale, has about 10 acres of miscellaneous crops under irrigation. The well is 161 feet deep to the third water-bearing bed, and the water rises within 42 feet of the surface. The present pumping capacity is reported to be from 300 to 500 gallons a minute. At the next ranch, three-fourths of a mile to the southeast, a well 116 feet deep furnishes water for 22 acres under cultivation. In the next section on the south several acres of corn and other crops are irrigated by well water.

Several ranches 7 miles east-southeast of Hondale have irrigation plants with small areas of flourishing crops. The water is within 37 feet of the surface. One ranch in sec. 24, T. 25 S., R. 9 W., has 2½ acres of garden.

At the Hughes ranch, in the center of sec. 15, T. 25 S., R. 10 W., an area of 25 acres is irrigated, the crops comprising cane, maize, beans, and alfalfa. The well is 160 feet deep, and the water is within 15 feet of the surface. It is reported that a No. 4 pump supplies 500 gallons a minute. With this production the water is lowered only 5 feet and then remains constant. The 25 acres can be irrigated in a three-day run of 10 hours' pumping a day. This run is repeated every 10 days during the growing season. The engine used consumes daily 20 to 25 gallons of crude oil, a fuel which costs 4½ cents a gallon at Deming.

At the G. Thompson ranch, in the NE. ¼ sec. 24, T. 26 S., R. 10 W., 80 acres is under irrigation from a 150-foot well, which has a 40-foot lift and yields 1,000 gallons a minute.

WATERLOO REGION.

There are several irrigation plants near Waterloo which give satisfactory results. The land is a smooth plain along Palomas Arroyo, and the water rises within 21 to 26 feet of the surface. The volume of water is large, so that it is not necessary to sink the wells deeper than 25 to 30 feet. Among the ranches may be mentioned that of

Peters & White, at Waterloo, on which 40 acres of wheat, oats, millet, barley, milo maize, and sorghum are under cultivation, together with some corn and garden truck. A 5-inch horizontal centrifugal pump is used with a 15-horsepower engine, consuming about a gallon of naphtha an hour, and the reported yield is 600 gallons a minute. About 3½ hours is required to wet an acre by flooding in strips 1½ rods wide and 40 rods long. At a well a short distance to the northeast a 25-horsepower engine is stated to pump 1,000 gallons a minute, which irrigates about 10 acres a day. A well 2½ miles east of Waterloo is pumped from 21 feet below the surface by an 8-horsepower engine which obtains 200 gallons a minute and in a 10-hour run consumes 6 gallons of fuel. This plant irrigates about 30 acres.

At the Snow ranches, in the NW. ¼ sec. 7, T. 27 S., R. 8 W., 100 acres is under irrigation from wells 40 and 34 feet deep, each yielding about 1,000 gallons a minute. At the White ranch, in the next section east, 30 acres is irrigated from a 37-foot well yielding 500 gallons a minute. At the Manning ranch, in sec. 1, T. 27 S., R. 9 W., 30 acres is irrigated from a 40-foot well yielding 1,000 gallons a minute. At the Laffoon ranch, near Palomas Arroyo, 5 miles southeast of Waterloo, 60 acres is irrigated from a 192-foot well having a 21-foot lift and yielding 700 gallons a minute.

At the J. H. Fowler ranch, in the NW. ¼ sec. 12, T. 26 S., R. 9 W., 40 acres is irrigated from a 40-foot well with a 500-gallon yield.

COLUMBUS REGION.

At the Bailey farm, 3 miles southeast of Columbus, water is pumped from a 185-foot well, in which the level is 2 feet below the surface, and it is reported that 2,000 gallons a minute is obtainable with the No. 6 pump used. The casing is 8¼ inches in diameter. The ordinary yield of the well is said to be 1,200 to 1,500 gallons a minute, and this consumes 0.8 gallon of naphtha an hour. About 100 acres is under cultivation, the crops comprising milo maize, wheat, oats, and alfalfa, all growing most luxuriantly.

The Pierce farm, three-fourths of a mile northeast of the Bailey pump, is irrigated from a well 250 feet deep. The principal supply, from a depth of 225 to 250 feet, rises within 6 feet of the surface. The outflow from this well is shown in Plate XII, *B* (p. 140). The yield is reported to be about 1,000 gallons a minute, with a No. 6 pump run by a 15-horsepower engine. It is stated that the engine consumes 22 gallons of naphtha every 10 hours, and this fuel has cost 13 cents a gallon delivered at Columbus. The area under cultivation is 8 acres, mainly in Kafir corn, milo maize, sweet potatoes, and alfalfa. It requires about 12 hours' pumping, or about 3 inches of water, to wet this area thoroughly.

C. B. Keenum, 2 miles south of Columbus, has a 22-foot well with the water level 12 feet below the surface. A No. 6 pump with a 20-horsepower engine is reported to furnish 1,200 gallons a minute, which is used to irrigate most of the farm of 160 acres. The crops are alfalfa, beans, and orchard fruits. It is stated that 15 gallons of naphtha, costing 11 cents a gallon, suffices for a 10-hour run.

Some other irrigated areas near Columbus are 20 acres on the Waterbury ranch; 10 acres on the De Rosear ranch, half a mile southeast of Columbus; 20 acres at the Engendorf ranch, 2 miles northeast of Columbus; 40 acres at the Gibson ranch, in the NW. ¼ sec. 35, T. 27 S., R. 8 W., from a well 40 feet deep yielding 750 gallons a minute; 10 acres at the Hunt ranch, in the southwest corner of T. 27 S., R. 7 W.; and 20 acres at the Hollock ranch, 4 miles southeast of Columbus, with a 1,800-gallon yield from a 246-foot well.

DUTY OF WATER.

There is considerable difference in the soils of the bolsons of Luna County, as they range from very sandy and porous loam to almost impervious silt, and the thickness of soil and character of the subsoil also vary widely. As the land lies nearly level the porosity of the soil is the principal factor in the duty of the water, which also varies somewhat with the crop, amount of drought, winds, degree of cultivation of the soil, arrangement and extent of ditches, and in some places the volume of water immediately available. No special attention was given to these factors, but a few general figures were supplied by the irrigators. There was considerable difference of opinion as to the amount of water required for irrigation in this region. It is probable, however, that 2½ acre-feet an acre a year will be required at most places, as this is the amount used in some other similar regions. With careful cultivation of the soil, however, a very much smaller amount will give good returns.

At one plant it was said that 70 gallons a minute, pumped 10 hours a day during the growing season, would provide for the irrigation of 10 acres; but at this rate of pumping 78 days would be required to provide 1 acre-foot over the entire 10 acres. With such light irrigation the crops should be well cultivated to conserve the moisture. At the Pierce ranch, south of Columbus, where 8 acres is under cultivation, about 2 acre-feet of water is required to each wetting, which is about 3 inches to the acre, but this is repeated several times during the season. At the Peters & White ranch, at Waterloo, 1 acre-foot of water will wet about 2½ acres at a wetting, and at a plant near by pumping 1,000 gallons of water a minute, 10 acres a day can be irrigated. At the Hughes ranch, 6 miles southwest of

Deming, a pump producing 500 gallons a minute can irrigate 25 acres in about three days, running 10 hours a day, which is a yield of nearly 3 acre-feet, or one-eighth of an acre-foot to each acre under cultivation. This irrigation is repeated every 10 days during the growing season.

COST OF PUMPING.

No attempt was made to ascertain the cost of pumping water from wells in Luna County, but a few figures were obtained incidentally during the investigation. Ordinarily in this region the engines are small—5 to 10 horsepower—the water is lifted only about 40 feet, and the volume of output ranges from 200 to 1,500 gallons a minute. The fuel used at most places is "gasoline" or "naphtha" from the Texas refineries and has cost from 11 to 15 cents a gallon at the railroad station. It is estimated that under favorable conditions 1 gallon an hour will provide for pumping 500 gallons a minute from a depth of 40 feet, which, with naphtha at 14 cents a gallon, is a fuel cost of about $1.50 an acre-foot, or 325,850 gallons. As 2½ acre-feet an acre is usually regarded as sufficient for most crops in this region, the fuel cost on this basis would be $3.75 an acre. The experience at several plants, however, has shown a wide range in the figures.

At the Hund well, east of Deming, the lift is 49 feet and the output is stated to be about 1,200 gallons a minute. The pump is run by a 35-horsepower engine, which is reported to consume about 35 gallons of naphtha in a 10-hour run, or 3½ gallons an hour. With fuel at 14 cents a gallon the cost of the water is $1.21 an acre-foot. The cost of the outfit at this place is stated to be about $3,500 (engine $1,500, well and pump $1,700, engine house $200). The water from this well irrigates about 2 acres an hour for most crops, but an hour and a half is required for 2 acres of alfalfa.

At the Shull well, east of Deming, the lift is 27 feet when the pump starts, but the water gradually pumps down to 42 feet in a couple of hours. The production of 1,250 gallons a minute by a pump run by a 45-horsepower engine requires 4 gallons of naphtha an hour. The cost at this plant, with fuel at 14 cents a gallon, is $1.43 an acre-foot. The outfit cost $3,000, and the water will irrigate 250 acres.

At the ranch of L. Stephenson, in the NW. ¼ sec. 1, T. 25 S., R. 9 W., the pump yields 250 gallons a minute from a depth of 45 feet, with a consumption of 1½ gallons an hour. A 24-horsepower engine is used. The cost under these conditions, with naphtha at 14 cents a gallon, is $4.20 an acre-foot.

At the Bowman ranch, in the NW. ¼ sec. 12, T. 24 S., R. 9 W., 2 miles southeast of Deming, the well is 52 feet deep, and 350 gallons a minute is pumped with a 6-horsepower engine, which consumes 1 gallon of naphtha an hour. With fuel at 14 cents a gallon, the cost here is $2.10 an acre-foot.

At the Peters & White ranch, at Waterloo, the water is pumped from a depth of about 23 feet, and the yield is stated to be 600 gallons a minute. A 5-inch pump is used, run by a 15-horsepower engine, which consumes a gallon of naphtha an hour, and it is estimated that about 3½ hours of pumping is required to irrigate 1 acre. With naphtha costing 14 cents a gallon the cost per acre-foot of water is $1.70.

A similar well a short distance northeast of Waterloo yields 1,000 gallons a minute when pumped with a 25-horsepower engine, and it is said that this will wet 10 acres a day. A smaller plant 2½ miles east of Waterloo, lifting water from 21 feet below the surface by an 8-horsepower engine, uses 6 gallons of naphtha in a 10-hour run.

At the Hughes ranch in sec. 15, T. 25 S., R. 10 W., the water is pumped from a depth of 65 feet, yielding 500 gallons a minute, and 25 acres is now under irrigation. A No. 4 pump is used, run by a crude-oil engine, and it takes three days of pumping, 10 hours a day, to water the entire area. This wetting is repeated every 10 days during the growing season. The fuel used amounts to 20 or 25 gallons a day and costs 4½ cents a gallon, not including cost of haulage 7½ miles. This is a fuel expense of about $1 a day, 3,000 gallons of water for 1 cent, $1.09 an acre-foot, or $3 for each run to irrigate 25 acres, the cost per acre being 12 cents for each wetting. The economy in the use of crude oil for fuel is being strongly urged, and the assertion is made that the oil properly used gives as much power as gasoline. With the estimate of 8 horsepower an hour from a gallon of oil, and with oil at $2 a barrel, the cost of oil for fuel is only slightly in excess of half a cent a horsepower an hour. Gas producers using coal or oil are even more economical.

In the Columbus region the water is somewhat nearer to the surface and the pumping cost is less than in the region to the north. At the Bailey plant the production of 1,200 to 1,500 gallons an hour with water only 2 feet below the surface requires, it is said, 0.8 gallon of naphtha an hour, the cost being thus 48 cents an acre-foot. At the Pierce farm, near by, where the water is 6 feet below the surface, the pumping is done by a No. 6 pump, run by a 15-horsepower engine, requiring 22 gallons of naphtha for a 10-hour run. This is $1.68 an acre-foot with naphtha at 14 cents a gallon. At the Keenum well, 2 miles south of Columbus, the water is 12 feet below the surface and is lifted by a No. 6 pump with a 20-horsepower engine, consuming 15 gallons of naphtha in a 10-hour run. The yield is 1,200 gallons an hour, and with naphtha at 14 cents a gallon the cost of pumping is 94½ cents an acre-foot.

The following table gives a summary of some of these figures and also the cost per foot of lift per acre-foot:

Cost of pumping at irrigation plants in Luna County.

	Lift (feet).	Reported yield (gallons a minute).	Cost per acre-foot.	Approximate cost per acre-foot per foot raised.	Fuel.
Near Deming	49	1,250	$1.21	$0.025	Naphtha at 14 cents a gallon.
Do	27–42	1,250	1.43	.036	Do.
Do	52	350	2.10	.04	Do.
Near Hondale	a 45–50	250	4.20	.084	Do.
Do	a 67–70	500	1.09	.015	Crude oil at 4½ cents a gallon.
Waterloo	23–25	600	1.70	.07	Naphtha at 14 cents a gallon.
Near Columbus	2–7	1,500	.48	.07	Do.
Do	a 6–12	1,000	1.68	.017	Do.
Do	a 12–18	1,200	.945	.055	Do.

a Estimated drawdowns.

According to figures compiled by the Reclamation Service, the cost of pumping in central Kansas, where liquid fuel is only moderately expensive, is about 7 cents an acre-foot for every foot the water is raised, or $3.50 for a lift of 50 feet, but this includes not only fuel but all other expenses of the pump, interest, etc.

PUMPING TESTS.

By A. T. SCHWENNESEN.

Plan of tests.—Estimates of the yield from irrigating plants are usually based on the manufacturer's figures of the capacity of the pumps under certain ideal conditions. As such conditions seldom exist in actual practice, the yields are usually much overestimated. To obtain some reliable data in the Mimbres Valley a series of five pumping tests were made during August and September, 1913.

The plants chosen for testing represent average types, and no attempt was made to select the largest or more efficient. Thus the Baker and McBride plants are representative of the ordinary large plants, the Graham plant is a good example of one of intermediate size, and the Deane plant is an example of the smallest plants used in the district. Most of the existing plants are of the intermediate class represented by the Graham plant; few are larger in point of equipment than the Baker plant, although some very much larger yields have been reported; and very few are smaller than the Deane plant.

The discharge from the pumps was measured by a standard rectangular weir board set in the ditch. Simultaneous measurements of both the head of water on the weir and the drawdown in the well were made every 15 minutes during the test.

The principal data in regard to the pumping plants that were tested are given in the following table:

Results of pumping tests in Luna County, N. Mex.

	Baker.	Graham.	McBride.	Hollinshead.	Deane.
Depth of well ... feet..	75	67	100	...	67
Depth to water ... do....	58.5	24.8	47.1	46.9	46.3
Cost of engine ...	$1,680	$550	$1,000	...	...
Cost of pump ...	$250	$110	$608	...	...
Cost of well ...	$1,145	$278	...	...	...
Total cost of plant ...	$3,075	$928	...	...	...
Duration of test ... hours..	1⅝	1½	1¼	1½	1¾
Maximum discharge measured gallons a minute..	898	558	518	178	156
Average discharge ... do....	603	555	444	166	122
Maximum drawdown ... feet..	10.2	11.0	27.6	12.3	8.8
Average discharge lift ... do....	58.6	22.6	69.0	50.8	54
Average suction lift ... do....	15	14.3	9.7	11.4	2.8
Average total lift ... do....	73.6	36.9	78.7	62.2	56.8
Effective horsepower [a] ...	11.2	5.18	8.83	2.62	1.75
Rated horsepower ...	40	12	32	11	7
Efficiency [b] ... per cent..	28.1	43.2	27.6	23.8	25.0
Specific capacity of well [c] ...	88.0	50.7	18.8	14.5	17.7
Fuel:					
Kind ...	Distillate.	Distillate.	...	Distillate.	Crude oil.
Cost per gallon ... cents..	6½	9½	...	9½	5½
Amount used ... gallons an hour ...	2½	1	...	...	...
Cost of fuel per acre-foot of water pumped ...	$1.46	$0.93	...	...	...
Cost of fuel per acre-foot of water lifted 1 foot ... cents..	2	2½	...	...	...

[a] Effective horsepower $= \frac{\text{pounds of water pumped per minute} \times \text{total lift in feet}}{33{,}000}$.

[b] Efficiency $= \frac{\text{effective horsepower}}{\text{rated horsepower}}$.

[c] Specific capacity is the yield (in gallons a minute) per foot of drawdown.

Baker plant.—The plant of C. L. Baker, in the SW. ¼ SE. ¼ sec. 4, T. 24 S., R. 9 W., is equipped with a 40-horsepower engine manufactured by the Bessemer Gas Engine Co., of Grove City, Pa. It is designed to burn crude oil and the cheaper grades of distillate. The pump is a Blackham-Scale single-stage horizontal centrifugal pump with a 19-inch runner. The pump is set 53 feet below the ground surface and connected with the engine through a vertical shaft and belt.

The well is dug 75 feet deep. It was originally bored 115 feet deeper, but the bored part was afterward filled in. For the first 52 feet the well is 9 by 9 feet in cross section, for the next 18 feet it is 5 by 5 feet, and for the last 5 feet it is 4 by 4 feet. It is curbed from top to bottom with planks. No complete log of the well was obtained, but the owner stated that the materials passed through were yellow clay and gravels in alternate layers. The clay beds averaged about 10 feet in thickness and the interbedded gravels from 1 to 4 feet. Two gravel beds near the bottom, separated by 12 feet of clay and sand, furnish most of the water. The cost of the well as given by the owner is as follows:

Constructing 75 feet of dug well ...	$800
Boring 12-inch hole, 115 feet, at $1 ...	115
Casings, 12-inch, 115 feet, at $2 ...	230
	1,145

The cost of the dug part of this well was excessive, and ordinarily a well of this kind costs much less.

This plant irrigates about 30 acres. The principal crops are alfalfa and beans. Five cuttings of alfalfa a year, yielding from 1¼ to 1½ tons an acre a cutting, are usually obtained. Each crop requires two waterings. From 6 to 7 acres of alfalfa can be irrigated during a 10-hour pumping day.

Graham plant.—The plant of J. M. Graham, at the southwest corner of sec. 11, T. 24 S., R. 8 W., is equipped with a 12-horsepower Fairbanks-Morse engine, belted to the vertical shaft of a single-stage horizontal American centrifugal pump set at the bottom of a 22-foot pit. The engine is designed to burn gasoline and the higher grades of distillate.

The depth of the well is 67 feet, of which the first 22 feet is dug 9 by 5 feet in cross section and the remaining 45 feet bored 22 inches in diameter. The dug part is curbed with pine lumber, and the bored part is cased with perforated casing. The owner reports the following log for the well:

Log of well in the northwest corner of sec. 11, T. 24 S., R. 8 W.

	Thickness.	Depth.
	Feet.	*Feet.*
Mostly clay with some thin beds of sand and caliche	56	56
Medium to coarse water-bearing gravel	11	67

The cost of constructing the well was as follows:

Digging pit, 22 feet at $3	$66.00
Lumber for curbing	10.00
Boring 22-inch hole, 45 feet at $2.50	112.50
Casing, 22-inch, 45 feet at $2	90.00
	278.50

This plant furnishes water for 10 acres of alfalfa.

McBride plant.—The equipment of the plant of M. L. McBride in the NW. ¼ SW. ¼ sec. 30, T. 24 S., R. 8 W., consists of a 32-horsepower Fairbanks-Morse engine using crude oil and the cheaper grades of distillate. A No. 5 Layne & Bowler pump is set 65 feet below the surface and connected to the engine at the surface through a belt and vertical transmission shaft. The pump, with 20 feet of 7⅝-inch suction pipe and 70 feet of 8⅝-inch discharge pipe, cost $608.50 f. o. b. at Deming.

Three water-bearing beds were penetrated in the well in a total depth of approximately 100 feet. The following log was furnished by the owner:

Log of well in the NW. ¼ SW. ¼ sec. 30, T. 24 S., R. 8 W.

	Thickness.	Depth.
	Feet.	*Feet.*
Soil, clay, and sand	64	64
Gravel and sand, water bearing	6	70
Clay	2	72
Sand with some gravel, water bearing	10	82
Clay and sand	18	100
Gravel, water bearing	(?)	(?)

The plant irrigates 20 acres of beans and 5 acres of maize. The beans are watered three times during the growing season of 4 months. One watering takes from 75 to 90 hours of continuous pumping.

Hollinshead plant.—The plant of M. W. Hollinshead, in the NE. ¼ NE. ¼ sec. 10, T. 26 S., R. 10 W., is equipped with an 11-horsepower Foos engine burning gasoline and the better grades of distillate. The pump is a single-stage centrifugal pump set at water level in a pit and connected to the engine at the surface by a belt and vertical shaft. The well consists of a dug pit 47 feet deep and curbed with lumber. From the bottom of the pump pit the well is bored and cased with perforated casing.

The plant irrigates 20 acres of beans, Indian corn, and milo maize.

Deane plant.—The plant of E. S. Deane, at the northwest corner of the SE. ¼ sec. 2, T. 24 S., R. 9 W., is run by a 7-horsepower Simple engine, manufactured at Trinidad, Colo. Crude oil and the cheaper grades of distillate are used for fuel. The pump is a Buffalo No. 2 single-stage centrifugal pump with a 12-inch runner. It is set at the bottom of a 53-foot pit and connected with the engine through a vertical shaft and belt. The well is 67 feet deep and contains one water-bearing bed. From the bottom of the pit a 15-inch hole cased with perforated casing extends down for 14 feet. The following log was reported:

Log of well in the SE. ¼ sec. 2, T. 24 S., R. 9 W.

	Thickness.	Depth.
	Feet.	*Feet.*
Soil, clay with some caliche	65	65
Water-bearing gravel	2	67

This plant is operated in connection with a small earth reservoir and furnishes water for 5 to 8 acres of alfalfa, melons, and garden truck.

PUMPING IN RIO GRANDE VALLEY.

In 1904 Slichter[1] made some careful tests of the amounts of fuel required to run pumping plants in the Rio Grande valley; and as the conditions there are somewhat similar to those in the Deming region, a summary of the results is given in the following table:

Fuel cost of pumping at some wells in Rio Grande valley.

Depth of well (feet).	Lift (feet).	Yield (gallons a minute).	Gasoline used (gallons an hour).	Cost.[a]	
				Per 1,000 gallons.	Per acre-foot.
30	28	258	0.5	$0.004	$1.35
66	31	269	.8	.006	1.93
60	41½	1,325	2.5	.00375	1.22
60	36	658	1.4	.0045	1.48
48	45½	131	.5	.009	3.20
58	27	648	1.08	.003	1.04
52	40½	725	2	.0055	1.78
52	40	[b] 658	1	.0028	.95
63	35	325	1.8	.0113	3.63
59	36	271	1.5	.0106	3.40

[a] Costs are recalculated on basis of gasoline at 12 cents a gallon.
[b] Alfalfa irrigation, three wettings, 7 days apart, 16 hours' run for each. The amount required was 3 inches, which cost $2.02 an acre, and the crops averaged 1 ton to the acre.

The cost of pumping by electricity was obtained at one plant where the well is 68 feet deep, the water is lifted 39 feet, and the yield is 378 gallons a minute. The production was reported to be 134,400 foot-gallons of water to the kilowatt hour of current, and the total cost $5.75 an acre-foot with power at 5 cents a kilowatt-hour. A crude-oil gas generator working a No. 6 pump with 37-foot lift and a yield of 938 gallons a minute cost 0.9 cent a thousand gallons, or 70 cents an acre-foot, with oil at 3 cents a gallon, and the same pump run with gasoline at 12 cents a gallon cost $2.52 an acre-foot. There was about 20 per cent advantage in running all night, and storage reservoirs are an important economy.

IRRIGATION BY SURFACE WATER.

At present practically no surface water is used for irrigation in Luna County. Ditches have been constructed at several places to take water out of the Mimbres during flood stages, and they have conveyed some water into a few sections. The Rio Mimbres Land Co. has a project of building a dam in the narrows in sec. 1, T. 20 S., R. 10 W., to store flood waters of the river. The topographic conditions are favorable, for at the dam site the valley is narrow and in rock, but just above this place it widens into a broad basin which would make a reservoir approximately 2 square miles in area.

[1] U. S. Geol. Survey Water-Supply Paper 141, pp. 34–35, 1905.

This would be filled by the flow of the river, mainly at times of flood. The ditches leading out on the west bank would extend past Faywood Springs and Faywood station and thence south near the west line of R. 11 W. The eastern ditch would pass behind the old village of Mimbres through the middle of R. 10 W. to and through the southeast corner of T. 22 S., R. 10 W. The area served by these ditches north of the Southern Pacific Railroad would be about six townships, or more than 200 square miles. The catchment area of the Mimbres basin above the dam has been estimated at 600 square miles, and with rainfall varying from 20 inches on the Black Mountains to about 12 inches in the foothills a total volume of 500,000 acre-feet a year is indicated. There is, however, a very large loss by evaporation and other causes, for the gagings from 1908 to 1913 at the dam site, as explained on page 112, have shown only from 3,270 to possibly 30,000 acre-feet a year, and the average is considerably below 10,000 acre-feet. This would provide water for irrigating only about 5,000 acres, or less than 38 quarter sections, with the duty of water at 2 feet. Even this does not allow for loss by reservoir evaporation and leakage from ditches, which would probably amount to 50 per cent.

Another project that has been contemplated is to dredge out the depression of Florida Lake to tap the underflow and then to convey this water in ditches leading east and south into a wide area northeast of the Little Florida Mountains.

ELEVATIONS.

On Plate I (in pocket) the topography of Luna County is shown by contour lines spaced 200 feet apart vertically, with sea level as the datum. Each line indicates the altitude along its course, and from the distances between the lines the general rates of slope can be inferred. With a 200-foot contour interval, however, features less than 200 feet above the adjacent country and minor changes of slope are not shown. The contours shown by full lines are condensed from the map of the Deming quadrangle much of which is accurately surveyed. Those shown by broken lines are based on determinations of altitude by barometer compared with many elevations given in railroad profiles, level lines of the United States Geological Survey, the International Boundary Survey, and some recently established stations of the United States Coast and Geodetic Survey.

A knowledge of precise elevations in the bolson areas of Luna County is of great importance in the study of the altitudes or grade of the underground water. These altitudes should be recorded and as wells become numerous comparisons should be made from time to time to ascertain the effect of heavy pumping, possibly with a view of so restricting excessive draft as to prevent final depletion of the supply. In order to determine water levels it is necessary to utilize all available accurate data as to elevations of the land, and accordingly in the following pages are given those which are now established as compiled from various sources.

UNITED STATES GEOLOGICAL SURVEY.

The following list gives the results of precise leveling along the Atchison, Topeka & Santa Fe Railway from Rincon to Silver City by M. S. Bright, of the United States Geological Survey, in 1905. They are tied to a line run in 1905 to 1907 from Yuma to Deming, but are not otherwise adjusted.[1]

	Feet.
Hockett, 50 feet west of track, 5 feet south of milepost 1094, in front of section house; iron post stamped "195"	4,512.278
Hockett, 3 miles south of, 45 feet west of track, 5 feet north of milepost 1097; iron post stamped "198"	4,483.521
Hockett, 6 miles south of, 40 feet east of track, opposite milepost 1100; iron post stamped "201"	4,491.682
Easley, in front of sign board; top of rail	4,516.13
Easley, 2 miles west of, 75 feet north of track, 30 feet east of milepost 1103; iron post stamped "204"	4,607.728
Nutt, 260 feet south of station, 234 feet south of south rail in main line, 40 feet east of gate near wire fence, in concrete; iron post stamped "206"	4,718.486
Nutt, 260 feet south of station, 234 feet south of south rail on main line, 40 feet east of gate near wire fence, set in cement 4 inches from above bench mark; aluminum tablet stamped "206"	4,717.963
Nutt, 3 miles south of, 165 feet south of milepost 1108, 45 feet west of track, 6 feet north of telegraph pole; iron post stamped "208"	4,652.021
Nutt, 6 miles south of, 45 feet west of track, 4 feet south of milepost 1111; iron post stamped "211"	4,610.256
Nutt, 9 miles south of, 45 feet west of track, 6 feet north of milepost 1114; iron post stamped "214"	4,583.268
Nutt, 12 miles south of, 45 feet west of track, 6 feet north of milepost 1117; iron post stamped "217"	4,523.648
Florida, in front of sign board; top of rail	4,505.32
Florida, 2 miles south of, 45 feet west of track, 6 feet north of milepost 1120; iron post stamped "220"	4,482.705
Florida, 5.2 miles south of, about 0.25 miles south of milepost 1123, at north end of cut, 80 feet east of track, 12 feet west of wagon road, near wire fence; iron post stamped "223"	4,411.703
Mirage siding; top of rail	4,377.53
Mirage siding, 3 miles south of, 45 feet west of track, 6 feet north of milepost 1129; iron post stamped "229"	4,332.711
Deming, 210 feet north of second switch block in station, Atchison, Topeka & Santa Fe Railway yards, then 100 feet east of main line, 200 feet southeast of milepost 1132, at fence corner; iron post stamped "232"	4,325.157
Deming, in front of Atchison, Topeka & Santa Fe Railway station; top of rail	4,335.553
Deming, in front of Southern Pacific Railroad station; top of rail	4,335.81
Deming, at southwest corner of Silverton and Railroad avenues, at corner of concrete sidewalk, in concrete; iron post stamped "233"	4,334.928

[1] Later work by the United States Coast and Geodetic Survey has shown that they are 0.97 foot too low.

	Feet.
Deming, city waterworks, 222 feet south of Southern Pacific Railroad track, in northwest corner of foundation stone; aluminum tablet stamped "234"	[1] 4,345.802
Deming, 3 miles northwest of, 45 feet north of track, 6 feet east of milepost 1136; iron post stamped "236"	4,376.552
Deming, 6 miles northwest of, 90 feet northeast of track, 50 feet northeast of wagon road, 30 feet northeast of milepost 1139; iron post stamped "239"	4,451.165
Deming, 9 miles northwest of, 75 feet northeast of track, 35 feet northeast of milepost 1142 and wagon road; iron post stamped "242"	4,530.022
Deming, 12 miles northwest of, 90 feet northeast of track, 45 feet northeast of milepost 1145 and wagon road; iron post stamped "245"	4,610.191
Deming, 15 miles northwest of, five telegraph poles west of milepost 1148, 80 feet north of bridge 4, at fence corner; iron post stamped "248"	4,672.429
Spalding, in front of signboard; top of rail	4,728.01
Spalding, 0.5 mile northwest of, 75 feet north of track, 30 feet north of milepost 1151; iron post stamped "251"	4,738.973
Spalding, 3.5 miles northwest of, 45 feet north of milepost 1154, 5 feet north of wagon road; iron post stamped "254"	4,806.387
Faywood, 340 feet east of station, 45 feet north of road crossing, seven telegraph poles west of milepost 1157; iron post stamped "257"	4,910.751
Faywood, in front of station; top of rail	4,914.47
Faywood, 3 miles west of, 95 feet south of milepost 1160, 55 feet south of track, 30 feet north of wagon road; iron post stamped "260"	5,000.982
Faywood, 6 miles west of, 110 feet south of milepost 1163, 70 feet south of track, 1 mile east of Whitewater, 18 feet north of wagon road; iron post stamped "163"	5,128.36
Whitewater, in front of station at milepost 1164; top of rail	5,156.77
Whitewater, 700 feet northwest of station, 85 feet south of junction of Silver City-Deming and Whitewater-Hanover roads, 21 feet south of wagon roads, in limestone rock; aluminum tablet stamped "264-B-1905"	5,157.825
Whitewater, 3 miles northwest of, 500 feet east of milepost 1167, 65 feet north of bridge 23, on point of ridge; iron post stamped "267-B-1905"	5,210.045

The following list gives the results of precise leveling along the Southern Pacific Railroad from Deming to the west line of Luna County, connected with a line of levels brought from Yuma but otherwise not adjusted.[2] The work was done in 1906–7 by A. R. Carver and W. A. E. Hult, of the United States Geological Survey.

	Feet.
Milepost 1203, 100 feet south of, 20 feet north of wagon road; iron post stamped "4-C-1906"	4,382.608
Parma, opposite milepost 1202; top of rail	4,393.4
Parma, 2 miles west of, 100 feet south of milepost 1200, 50 feet north of wagon road; iron post stamped "7-C-1906"	4,410.588

[1] U. S. Coast and Geodetic Survey gives 4,346.77 feet.
[2] According to the latest data 0.97 foot should be added.

	Feet.
Tunis, in front of signboard; top of rail	4,423.8
Tunis, 1¼ miles west of, 100 feet south of milepost 1197, 15 feet north of wagon road; iron post stamped "10–C–1906"	4,434.155
Tunis, 4¼ miles west of, 75 feet south of milepost 1194, 20 feet north of wagon road; iron post stamped "13–C–1906"	4,422.177
Mongola, in front of signboard; top of rail	4,430.2
Mongola, 0.9 mile west of, 100 feet south of track, 15 feet north of wagon road, 75 feet south of milepost 1191; iron post stamped "16–C–1906"	4,435.946
Gage, 1 mile east of, 110 feet south of track, 15 feet north of road, 75 feet south of milepost 1188; iron post stamped "19–C–1906"	4,479.401
Gage, in front of; top of rail	4,489.2
Gage, 2 miles west of, 100 feet south of track, 30 feet north of wagon road at grade crossing; iron post stamped "22–C–1906"	4,530.170
Aitkin (now Quincy), in front of signboard; top of rail	4,563.8
Aitkin (now Quincy), 40 feet north of wagon road, 75 feet south of milepost 1182; iron post stamped "25–C–1906"	4,560.536

UNITED STATES COAST AND GEODETIC SURVEY.

In 1910 a network of primary triangulation was extended across Luna County by the United States Coast and Geodetic Survey. Cooks Peak, the Florida Mountains, and other high points were occupied, and the observers measured a very precise base line passing through Deming. The results give accurate determinations of latitude, longitude, and altitude of various points which are briefly described in the following paragraphs. More detailed descriptions are given in the Coast Survey report.[1]

Stations established by United States Coast and Geodetic Survey in Luna County, N. Mex.

Name.	Latitude.			Longitude.			Elevation.	
	°	′	″	°	′	″	*Meters.*	*Feet.*
Cooks Peak	32	32	9.548	107	43	52.419	2,562.9	8,408.45
Florida	32	7	1.834	107	37	36.040	2,145.0	7,037.39
Hermanas	31	48	11.577	107	56	52.331	1,611.0	5,285.42
Red [Mountain]	32	13	.806	107	53	31.665	1,651.4	5,417.97
Deming, south base	32	3	.447	107	50	14.406	1,280.4	4,200.78
Deming, north base	32	10	19.489	107	45	21.268	1,301.0	4,268.36
Deming, city waterworks	32	16	10.606	107	46	1.390	*1,324.9	[b] 4,346.77
Near [Sierra Rica]	31	47	23.753	108	11	3.844	1,649.4	5,411.41
Boundary monument 31, top of masonry base	31	47	1.169	107	55	45.394	[a] 1,437	4,714.56
Boundary monument 32, top of masonry base	31	47	1.200	107	57	18.025	*1,495	4,904.85
Boundary monument 39, top of masonry base	31	47	1.260	108	11	11.468	1,534.2	5 033.45
Boundary monument 40, top of masonry base	31	47	1.265	108	12	29.563	*1,501.4	4,925.84
Black Mountain (cairn)	32	19	59.0	107	53	1.40	[a] 1,638.7	5,376.30
Cone [Victorio Peak]	32	12	2.71	108	6	32.8	1,510.4	4,955.37

[a] Not checked.
[b] United States Geological Survey gives 4,345.802 feet.

The elevations marked * were determined by spirit leveling by other surveys, and the error is believed to be not more than 2 inches. The elevation at the Deming waterworks is that of bench mark 234,

[1] Bowie, William, The Texas-California arc of primary triangulation: U. S. Coast and Geodetic Survey Special Pub. 11, 1912.

established by the United States Geological Survey, and this was used as a datum after adding 0.97 foot to accord with the elevation at El Paso. The possible error in the other elevations, determined by reciprocal vertical angles, range from 4 to 35 inches. The elevation given for the top of the masonry base of monument 31 is not deduced from reciprocal angles and may have an error of several feet. The international boundary survey gives 1,433.5 meters for this monument, with a possible error of 1 meter, 1,487.8 meters for monument 32, 1,518.4 meters for monument 39, and 1,494.2 meters for monument 40, all determined by spirit levels along the boundary line. Black Mountain and cone [Victorio Peak] were measured by angles from the two Deming bases. The elevation stations are as follows:

Cooks Peak: Summit marked by brass disk having for reference mark a cross cut in rock about 35 feet away.

Florida: On a flat-topped knob in a saddle about midway between the high rock peak to the north and the round-top peak to the south, about 500 yards south of the highest rock peaks at the north end of the Florida Mountains. Station marked by a brass disk having for reference mark a cross cut in rock about 15 feet away.

Hermanas: On the highest one of four summits of the Carrizalillo Hills 3 miles S. 5° E. from Hermanas, marked by a brass disk having for reference mark a cross cut on large bowlder about 35 feet away.

Red: Marked by brass disk, about 20 paces, a little north of east of highest point of Red Mountain.

Deming, south base: About 15 miles southwest of Deming, 1 mile S. 85° E. from Midland station, on F. W. Schweiyer's ranch, 1¾ miles N. 75° E. from ranch house and windmills of R. W. Yeargins. The place is marked by a brass cap on a 3-inch iron pipe set in the top of a cylinder of concrete 20 inches in diameter and 24 inches long, set flush with the ground. There is also an underground mark set in a concrete column and a reference mark a short distance southeast.

Deming, north base: About 6 miles south of Deming, near the center of sec. 34, T. 24 S., R. 9 W. It is marked in same manner as the south base, with reference mark about 50 feet distant a little east of north.

Near: On the easternmost limestone peak, 1 mile west-northwest of the International mine, 5 miles S. 33° W. from Victorio station, marked by brass disk set in rock having for reference mark a cross cut in rock about 13 feet southeast.

Boundary monuments: Nos. 39 and 31 are iron monuments on the international boundary; No. 32 is a stone monument 4 miles south of

Hermanas, on the highest point of the boundary line, where it crosses the Carrizalillo Hills; and No. 40 is at the angle where the boundary turns to the south, 2½ miles west of the International mine.

Deming waterworks: High red tank in northwestern part of Deming, with United States Geological Survey bench mark 234 a short way south, which, with 0.97 foot added, is used to control the vertical-angle elevations of all the triangulation stations in this vicinity.

RAILROAD PROFILES.

Leveling by the Southern Pacific Co. has given the following elevations at points from Cambray to Deming. (For Deming to Quincy, see United States Geological Survey levels, pp. 174–176.)

	Feet.
Cambray	4,225.0
Akela	4,168.3
Myndus	4,149.3
Carne	4,188.73
Luxor	4,273.98
Deming station (U. S. G. S. 4,335.81)	4,331.95

In the following list of elevations along the El Paso & Southwestern Railroad in Luna County the figures are those given by the company and are not adjusted. The level line begins in the station at El Paso, with an initial altitude of 3,714.6 feet (3,724 feet according to the United States Geological Survey, and about 3,726 feet according to the Coast and Geodetic Survey).

	Feet.
Dona Ana-Luna County line	4,142
Arena station	3,953
Milepost 66	3,980
Milepost 70	3,999
Milepost 71	4,001
Milepost 72	4,001
Milepost 73	4,027
Columbus station	4,054
Summit one-half mile east of Mimbres	4,341
Mimbres station	4,340
Valley bottom 6½ miles west of Mimbres	4,215
Hermanas station	4,448
Carrizalillo Spring (water surface)	4,515
Summit at milepost 97	4,594
Victorio station	4,568
Grant-Luna County line	4,693

The following elevations along the Deming branch of the El Paso & Southwestern Railroad were taken from a profile prepared by the company:

	Feet.
Deming yards, joining Southern Pacific R. R.	[1] 4,350.00
Milepost 123 from El Paso (down grade south)	4,334.55
Milepost 122	4,332.02
Milepost 121	4,327.83
Milepost 120	4,319.50
Milepost 119	[2] 4,314.00
Milepost 118	4,300.61
Milepost 117	[2] 4,290.50
Milepost 116	[2] 4,284.00
Milepost 115	[2] 4,267.00
Hondale (114.94 miles)	4,266.93
Milepost 114	[2] 4,251.00
Milepost 113	[2] 4,235.00
Milepost 112	4,227.90

[1] About 5 feet lower than the elevation given by the United States Coast and Geodetic Survey.

[2] Interpolated from near-by points.

	Feet.		Feet.
Milepost 111	[1] 4, 211. 00	Milepost 103	4, 266. 62
Milepost 110	4, 209. 01	Tomerlin (102.65 miles)	[1] 4, 272. 00
Milepost 109	[1] 4, 195. 00	Milepost 102	[1] 4, 300. 00
Midway (108.96 miles)	[1] 4, 194. 00	Milepost 101	4, 330. 70
Arroyo crossing (foot of grade)	4, 190. 99	Milepost 100	[1] 4, 355. 00
		Milepost 99	[1] 4, 362. 00
Milepost 108 (up grade south)	[1] 4, 199. 00	Milepost 98	4, 382. 02
		Milepost 97	4, 382. 02
Milepost 107	[1] 4, 204. 00	Milepost 96	4, 390. 02
Milepost 106	[1] 4, 217. 26	Milepost 95	[1] 4, 400. 00
Milepost 105	[1] 4, 225. 00	Milepost 94	[1] 4, 438. 00
Milepost 104	[1] 4, 238. 75	Hermanas (93.41 miles)	4, 448. 65

LEVEL LINE FROM DEMING ALONG GRADE ROAD TO MEXICAN BOUNDARY.

In the spring of 1913 a line of levels was run by R. C. Seitz from the Santa Fe Railway station at Deming to and along the grade road to the international boundary and joined to boundary monument 23. It was also tied to the "north base" of the Coast and Geodetic Survey, and the figures given below are reduced to that datum by distributing a discrepancy of 1.56 feet between that place and Deming station. The elevation of Deming station is given as 4,335.553 feet by the United States Geological Survey, and a correction of 0.97 foot is added to bring it into accord with the Coast Survey figure for the United States Geological Survey bench mark at the waterworks. At the south end the tie to monument 23 is very close, where 13 feet is added to the Boundary Commission's determination, 4,000.65 feet. This figure (13 feet) is the mean discrepancy found by the United States Geological Survey at El Paso and in southern Arizona, and if it is correct it indicates that the level line down the grade road tied 2.34 feet too high. This 13-foot correction is not very useful, however, for the Coast Survey determinations of altitude of monuments 32, 39, and 40 indicate much higher figures. Therefore in the following table it will be assumed that the level line by Mr. Seitz is correct from "north base" to monument 23 with the altitude of the latter at 4,015.94 feet:

	Feet.
Deming (Atchison, Topeka & Santa Fe Railway depot), top of rail	4, 336. 5
Grade road at crossing of railway tracks	4, 335. 0
Line between T. 23 S. and T. 24 S	4, 318. 8
Corner of secs. 2, 3, 10, and 11, T. 24 S., R. 9 W	4, 309. 6
Corner of secs. 10, 11, 14, and 15	4, 301. 2
Corner of secs. 14, 15, 22, and 23	4, 295. 2
Line between secs. 23 and 26	4, 280. 5
Line between secs. 26 and 35	4, 267. 3

[1] Interpolated from near-by points.

	Feet.
"North Base," near center of SE. ¼ sec. 34	4,268.4
Line betwen T. 24 S. and T. 25 S	[1] 4,253.5
Corner of secs. 1, 2, 11, and 12, T. 25 S., R. 9 W	4,243.5
Line between secs. 12 and 13	4,233.9
Line between secs. 13 and 24	4,222.5
Line between secs. 24 and 25	4,218.0
Bottom of grade in east-central part of sec. 25	4,216.5
Line between secs. 30 and 31, T. 25 S., R. 8 W	4,228.0
Top of grade, west-central part of sec. 31	4,241.0
Line between T. 25 S. and T. 26 S	4,239.5
Line between secs. 1 and 12, T. 26 S., R. 9 W	4,236.4
Line between secs. 7 and 18, T. 26 S., R. 8 W	4,217.5
Line between secs. 18 and 19	4,183.5
Line between secs. 19 and 30	4,162.8
Line between secs. 30 and 31	4,148.7
Line between T. 26 S. and T. 27 S	4,131.1
Line between secs. 5 and 8, T. 27 S., R. 8 W	4,118.8
Line between secs. 8 and 17	4,112.5
Palomas Arroyo (bottom)	4,102.5
Line between secs. 17 and 20	4,154.0
Corner of secs. 20, 21, 28, and 29	4,182.5
Line between secs. 28 and 33	4,000.5
Line between T. 27 S. and T. 28 S	4,204.5
Top of grade near center of sec. 4, T. 28 S., R. 8 W	4,205.5
Line between secs. 4 and 9	4,205.3
Corner of secs. 9, 10, 15, and 16	4,196.2
Line between secs. 15 and 22	4,176.5
Line between secs. 22 and 27	4,123.2
Line between secs. 27 and 34	4,088.0
Columbus station	[2] 4,063.3
Line between T. 28 S. and T. 29 S	4,037.7
Line between secs. 2 and 11, T. 29 S., R. 8 W	4,003.0
Line between secs. 11 and 14	3,991.1
International boundary	3,997.1
Monument 23	4,014.2

ELEVATIONS OF MONUMENTS ALONG INTERNATIONAL BOUNDARY.

In the final survey of the boundary between Mexico and the United States a spirit-level line was run and elevations of the boundary monuments and other points near by were determined with precision. A topographic map published with the report of the Boundary Commission shows the topography by contour lines with 20-meter intervals in a narrow zone along the line, and the following list of elevations of monuments is printed in the report. The elevations were given in meters and represent the tops of the masonry bases of the

[1] Iron post near this point is marked "4254."
[2] Railroad profile gives 4,054 feet.

monuments. As a portion of the line was run before the monuments were set there are possible errors in some of the figures, as shown by the footnotes. The line began at the bench mark of the Southern Pacific Railroad at El Paso, which was later, when the level line reached the Coast Survey bench mark at San Diego, found to be marked 2.62 meters too high. Apparently from the statement in the report the elevations are reduced to mean tide level at San Diego. In the Coast Survey work in this area vertical angles were taken to and from monuments 32, 39, and 40, which were found to be respectively 23.6, 51.8, and 23.6 feet higher in altitude than the figures given by the commission. Monument 31 was sighted and found to be about 19 feet higher. The Coast Survey also found monument 2, near El Paso, to be given as 12.47 feet too low, and the United States Geological Survey found at monuments 1, 3, 88, and 92 elevations averaging 13 feet higher than those given by the Boundary Commission.

Elevations of monuments on international boundary along Luna County line.

No.	Elevation.		Possible error (meters).	No.	Elevation.		Possible error (meters).
	Meters.	Feet. [a]			Meters.	Feet. [a]	
14	1,319.3	4,328.40	0.5	28	1,306.0	4,284.77	
15	1,280.1	4,199.79		29	1,272.6	4,175.19	0.5
16	1,269.7	4,165.67	1.0	30	1,271.7	4,172.23	
17	1,202.6	3,944.22	.5	31	[b] 1,433.5	4,702.42	1.0
18	1,205.6	3,955.04		32	[c] 1,487.8	4,881.22	
19	1,208.4	3,964.56		33	1,387.6	4,552.48	
20	1,211.0	3,973.09		34	1,387.2	4,551.17	
21	1,213.1	3,979.98		35	1,346.2	4,416.65	.5
22	1,212.9	3,979.32		36	1,347.2	4,419.93	
23	1,219.4	4,000.65		37	1,384.7	4,542.97	
24	1,259.3	4,131.55		38	1,458.8	4,786.08	2.0
25	1,297.7	4,257.54	1.0	39	[d] 1,518.4	4,981.62	2.0
26	1,315.8	4,316.92		40	[e] 1,494.2	4,902.22	
27	1,294.8	4,248.02					

[a] United States Geological Survey elevations at El Paso and west are 13 feet higher.
[b] Coast and Geodetic Survey gives 1,437.0 meters; may be a few meters in error.
[c] Coast and Geodetic Survey gives 1,95.0 meters.
[d] Coast and Geodetic Survey gives 1,534.2 meters.
[e] Coast and Geodetic Survey gives 1,501.4 meters.

INDEX.