TECHNICAL REPORT 26

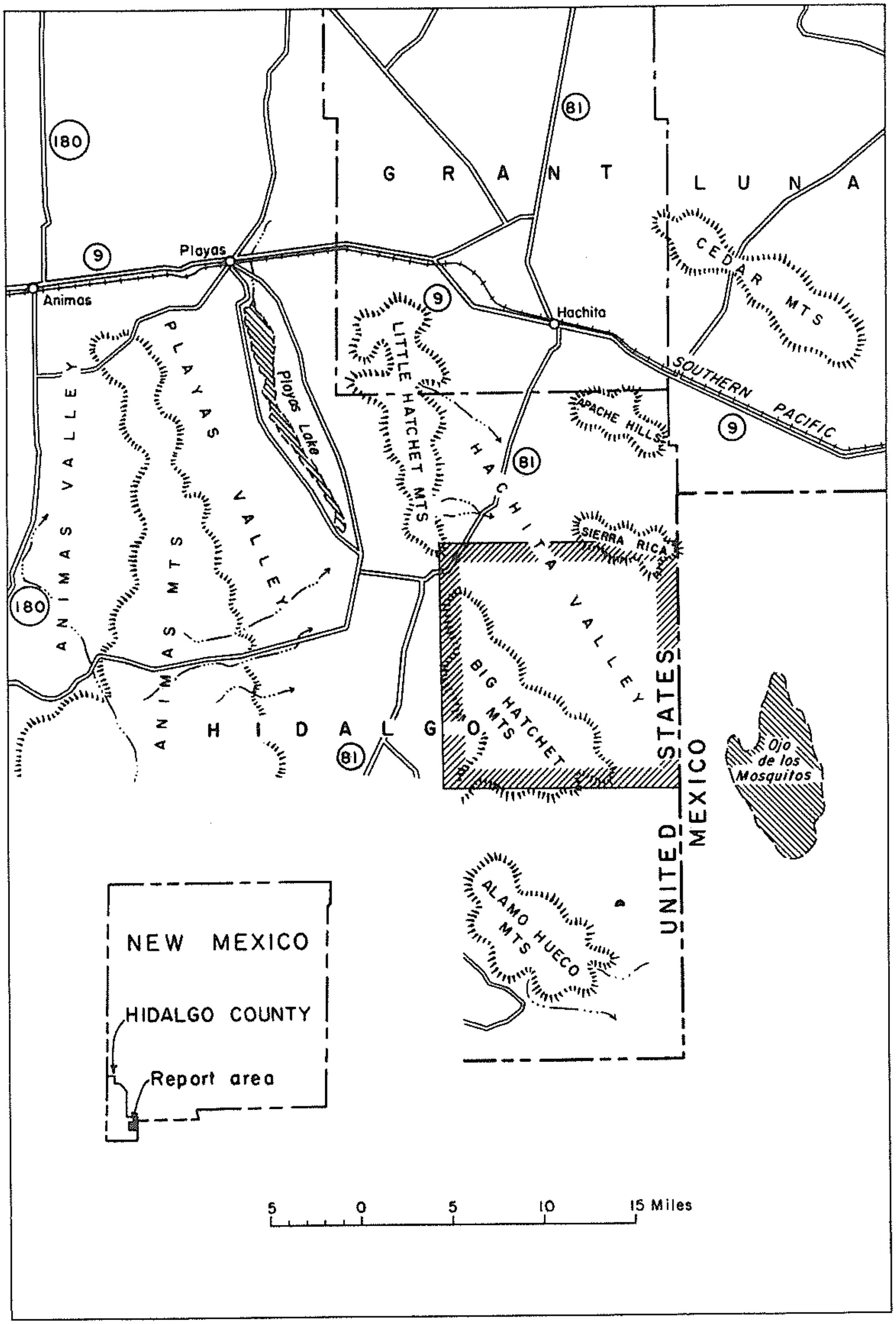
New Mexico State Engineer
Santa Fe, N. Mex.

GROUND WATER IN CENTRAL HACHITA VALLEY NORTHEAST OF THE BIG HATCHET MOUNTAINS, HIDALGO COUNTY, NEW MEXICO

By
F. D. Trauger and E. H. Herrick

Prepared in cooperation with
the United States Geological Survey
and
the United States Army Corps of Engineers

GROUND WATER IN CENTRAL HACHITA VALLEY NORTHEAST OF THE BIG HATCHET MOUNTAINS, HIDALGO COUNTY, NEW MEXICO



Map of southwestern New Mexico showing area discussed in this report.

TECHNICAL REPORT 26

New Mexico State Engineer
Santa Fe, N. Mex.

GROUND WATER IN CENTRAL HACHITA VALLEY NORTHEAST OF THE BIG HATCHET MOUNTAINS, HIDALGO COUNTY, NEW MEXICO

By
F. D. Trauger and E. H. Herrick
United States Geological Survey

1962

CONTENTS

ILLUSTRATIONS

CONTENTS (continued)

TABLES

GROUND WATER IN CENTRAL HACHITA VALLEY NORTHEAST OF THE BIG HATCHET MOUNTAINS, HIDALGO COUNTY, NEW MEXICO

By

F. D. Trauger and E. H. Herrick

ABSTRACT

Marine sedimentary rocks, consisting mainly of limestone, are exposed in most of the Big Hatchet Mountains on the west side of Hachita Valley, and in Sierra Rica on the east side of the valley. Hachita Valley is underlain by several hundred feet of alluvium, which at the foot of the mountains consists of coarse gravel firmly cemented to form a hard conglomerate but which in the central part of the valley is mostly fine grained and unconsolidated.

The consolidated sedimentary rocks are dense and relatively impermiable and are not aquifers. Alluvium in the valley is moderately permeable, has a total thickness of more than 600 feet, and has a saturated thickness of at least 200 feet in most places. The water table apparently is relatively flat across the central part of the valley and in a large part of the alluvial fan along the northeastern front of the Big Hatchet Mountains. The gradient of the water table down the axis of the valley is about 6 feet per mile. Ground water moves into the central part of the valley from the north and from the flanks of the Big Hatchet Mountains and Sierra Rica; thereafter it moves southeastward down the valley to discharge in the vicinity of Ojo de los Mosquitos, a large ephemeral lake in Mexico about 5 miles east of the international boundary.

Test-pumping data considered reliable indicate that the specific capacities of wells in the alluvium range from about 0.2 to about 10 gpm (gallons per minute) per foot of drawdown of the water level.

All samples of ground water that were analyzed were potable so far as chemical content is concerned, although water from some wells near the axis of the valley yields as much as 300 ppm (parts per million) of sulfate. Water from wells on the alluvial fans generally contains less than 500 ppm of dissolved solids and less than 100 ppm of sulfate.

INTRODUCTION

A reconnaissance of a part of the Big Hatchet Mountains and the adjacent part of Hachita Valley in December 1955 was made by the United

States Geological Survey at the request of the U.S. Army Corps of Engineers. The purpose of the investigation was to determine whether a supply of 36,000 gpd (gallons per day) of potable water could be developed for a small installation planned in Thompson Canyon in the Big Hatchet Mountains (pl. 1). The topography and geology were examined briefly, wells in the area were inventoried, samples of water from five wells were collected for chemical analysis, and approximate specific capacities of some of the wells were determined. It was concluded on the basis of these data that a water supply adequate for the anticipated needs of the proposed installation could be developed from one or two wells on the slope of the alluvial fan that extends northeastward from the mouth of Thompson Canyon, and five locations for test drilling were suggested.

Two test holes were drilled under contract by the Corps of Engineers in the summer of 1956. Drill cuttings were examined during the test drilling, samples of water were collected for chemical analysis, and pumping tests were made to determine the yield of the test holes.

The yield of water from the second test hole was adequate for the supply needed. However, for reasons not related to water supply, plans for the proposed installation were tabled, and further drilling and testing operations were suspended by the Corps of Engineers

A preliminary report of the occurrence of ground water in the area and suggestions for test drilling were prepared for the Corps of Engineers and were supplemented by brief summaries of the results of test drilling. This report was prepared in cooperation with the New Mexico State Engineer to make available the data collected in the 1955 study, along with information contained in earlier reports, and to summarize all that is known of the occurrence of ground water in the area.

The wells investigated for this report are listed in table 1, and their locations are shown on plate 1. They are numbered on the basis of townships, ranges, sections, and parts of sections (fig. 1). The first three parts of the well number, separated by decimal points, are

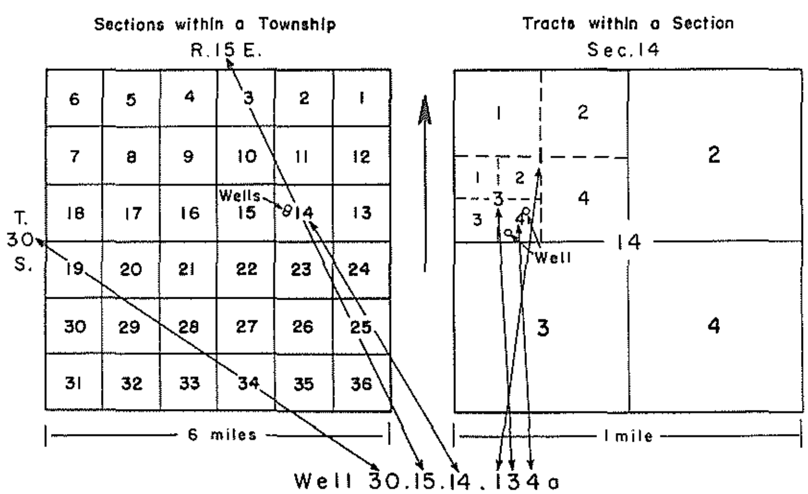


Figure 1.--System of numbering wells in New Mexico.

the township south, range west, and section number, respectively. For convenience the quarters of a section are numbered 1, 2, 3, 4, as indicated in figure 1. The first digit of the last part of the well number gives the quarter section; the second digit gives the quarter of that quarter, etc. Thus well 30.15.14.134a is in the SE$\frac{1}{4}$SW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 14, T. 30 S., R. 15 W., and it is the second well (indicated by letter "a") visited in that quarter section.

Mr. Mahlon Everhart, owner; Lewis Lynch, foreman; and other personnel of the Hatchet Ranch furnished records of wells in the area, accompanied the writers to wells difficult of access, and provided accommodations. Their assistance is gratefully acknowledged. Appreciation is expressed also to Dr. Robert Zeller, geologist of the New Mexico Bureau of Mines and Mineral Resources, for information concerning the geology of the area.

GEOGRAPHY

Location and Size of the Area

The area considered in this report is in Hachita Valley in Hidalgo County, N. Mex., between the northeastern flank of the Big Hatchet Mountains and the southwestern flank of Sierra Rica. It extends from approximately 14 miles south to 28 miles south of the community of Hachita and comprises the major parts of Tps. 30 and 31 S., Rs. 14 and 15 W., as shown on plate 1.

Topography and Drainage

Hachita Valley lies between the Little Hatchet-Big Hatchet-Alamo Hueco mountain chain on the west and the Cedar Mountains, Apache Hills, and Sierra Rica on the east. The Continental Divide, which trends roughly east and west about 4 miles north of the community of Hachita, determines the northern limit of the valley. Because the divide is inconspicuous, Hachita Valley falsely appears to be coextensive with the valley area to the north.

The valley is divided into three distinct sections: northern, central, and southern. The northern and central sections extend for a distance of about 30 miles in the United States. The central section, with which this report is primarily concerned, extends from about the latitude of Hatchet Gap between the Little and Big Hatchet Mountains southeastward to within a mile or so of the Mexican boundary. The greater part of the southern section lies in Mexico. The valley and the mountain ranges bordering Hachita Valley lie in the Mexican Highland section of the Basin and Range province as defined by Fenneman (1931, p. 380).

The axial slope of Hachita Valley is southeastward. The altitude of the valley floor at the Continental Divide is approximately 4,490

TABLE 1

RECORDS OF WELLS AND TEST HOLES IN CENTRAL HACHITA VALLEY, HIDALGO COUNTY, N. MEX.

Well number: See description of well-numbering system.
Altitude of well: Estimated from topographic map.
Topographic situation: C, canyon floor; P, plain; S, slope.
Use of water: D, domestic; S, stock; T, test hole.

Depth of well and depth to water: Depths recorded to the nearest tenth of a foot were measured; to the nearest foot, reported.
Method of lift: P, plunger or piston; T, turbine; N, none.

Location number	Well name	Owner	Altitude of well (feet)	Topographic situation	Use	Diameter of well (in.)	Depth of well below land surface (feet)	Elevation of measuring point above land surface (feet)	Water level: Depth below measuring point (feet)	Water level: Date measured	Temperature (°F)	Method of lift	Average yield (gpm)	Drawdown (feet)	Remarks
30.14.29.141*	Badger Windmill	Hatchet Ranch	4,251	P	S	7	157.3	1.0	107.8	12- 8-55	68	P	3	10.3	Not the same well reported in U.S. Geol. Survey Water Supply Paper 422; old well destroyed.
33.211	Richens North Well	do.	4,247	P	S	6	117.5	1.0	105.7	12- 7-55	69	P	3	-	-
33.211a	Richens East Well	do.	4,248	P	S	6	116.1	.5	106.7	12- 7-55	70	P	5	1.9	-
30.15.12.323	Test hole	Hatchet Dome Oil Co.	4,335	S	T	-	1,930	-	-	12- 4-55	-	N	-	-	Oil-test well; rotary drilling in progress at time of visit.
14.134*	Hdqrs. NE Well	Hatchet Ranch	4,280	P	D,S	6	-	-	-	-	-	P	-	-	Well equipped with windmill at ranch headquarters.
14.134a	Electric Well	do.	4,284	P	D,S	8	-	1.0	119.4	12- 8-55	67	T	25	13.2	Well equipped with submersible pump at ranch headquarters.
14.312	Hdqrs. SW Well	do.	4,272	P	S	6	143.3	.8	107.7	12- 1-55	-	P	-	-	Unused well at ranch headquarters.
16.313*	Witch Well	do.	4,387	S	S	6	289.7	1.1	205.2	12- 8-55	68	P	3-5	.4	-
30.16.12.134	Old Hatchet Ranch Well	do.	4,301	P	D,S	5	-	.8	-	-	-	P	-	-	Water reported to be alkaline.
12.314	South Well	do.	4,299	P	S	6	78.6	.0	57.5	12- 8-55	65	P	3	-	Water level measured during pumping.
31.14. 1.333	Irrigation test hole	do.	4,180	P	T	-	460	.9	55.8	11-16-53	-	N	160	16	Found caved in December 1955.
2.232*	Double Well	do.	4,185	P	S	6	92.6	2.3	70.8	12- 7-55	65	P	5	12.6+	Water level not fully recovered when last measured; only one well at this location in 1955.
9.441*	High Lonesome Well	do.	4,326	S	S	6	200	.0	186.0	12- 7-55	74	P	2	.1	-
13.212*	Cabin Well	do.	4,148	P	S	6	38.3	1.3	27.1	12- 7-55	66	P	5	-	Intermittent pumping at time of measurement.
24.444	Artesian Well	do.	4,150	P	S	6	32.6	2.5	7.0	12- 6-55	-	P	-	-	Out of order at time of visit.
29.322	Deep Well	do.	4,760	C	S	6	657.9	1.1	556.5	12- 8-55	-	P	-	-	Out of order at time of visit; reportedly is pumped out quickly.
35.242	Hatchet New Well	do.	4,240	P	S	6	115	7.3	40.2	12- 6-55	-	P	-	-	Out of order at time of visit.
31.15. 2.213*	Test hole T-1	Corps of Engineers	4,700	S	T	8	595.0	.0	556	7- 3-56	72	N	5-6	27	Drilled June 1956; not cased; drawdown 27 ft. after bailing for 1 hour at a rate of 5 to 6 gpm; water encountered in bouldery gravel composed of limestone, some chert, partly cemented with calcium carbonate.
2.221*	Test hole T-2	do.	4,600	S	T	8	600.0	.0 2.4	456 458.1	8-31-56 5-15-58	75	N	50	64	Drilled June 1956; cased to 600 ft., perforated 475 to 600 ft.; drawdown 64 ft. after being pumped for 6 hours at a rate of 50 gpm; water encountered in bouldery gravel composed of limestone rocks, some chert, partly cemented with calcium carbonate; blowing air May 15, 1958.
3.344	Lower Thompson test hole	Hatchet Ranch	5,095	C	T	10	297.5	.0	220.8	12- 1-55	-	N	-	-	Reportedly contained no water when drilled; perched water believed to have entered well.
9.322	Upper Thompson test hole	do.	5,575	C	T	10	202.0	.0	Dry	12- 1-55	-	N	-	-	Reportedly drilled to 700 ft., but has caved.
10.121	Middle Thompson test hole	do.	5,135	C	T	10	101.0	.0	Dry	12- 1-55	-	N	-	-	-
23.144	Sheridan Well	do.	5,045	C	S	6	173.9	1.0	54.8	12- 6-55	65	P	.5	.3	-
32.14.26.111	Mengus Tank Well	do.	4,370	P	S	6	215.6	1.0	211.6	12- 6-55	-	P	-	-	Not shown on plate 1; nearby hole dry at 207.4 ft.

* See table 2 for chemical analyses.

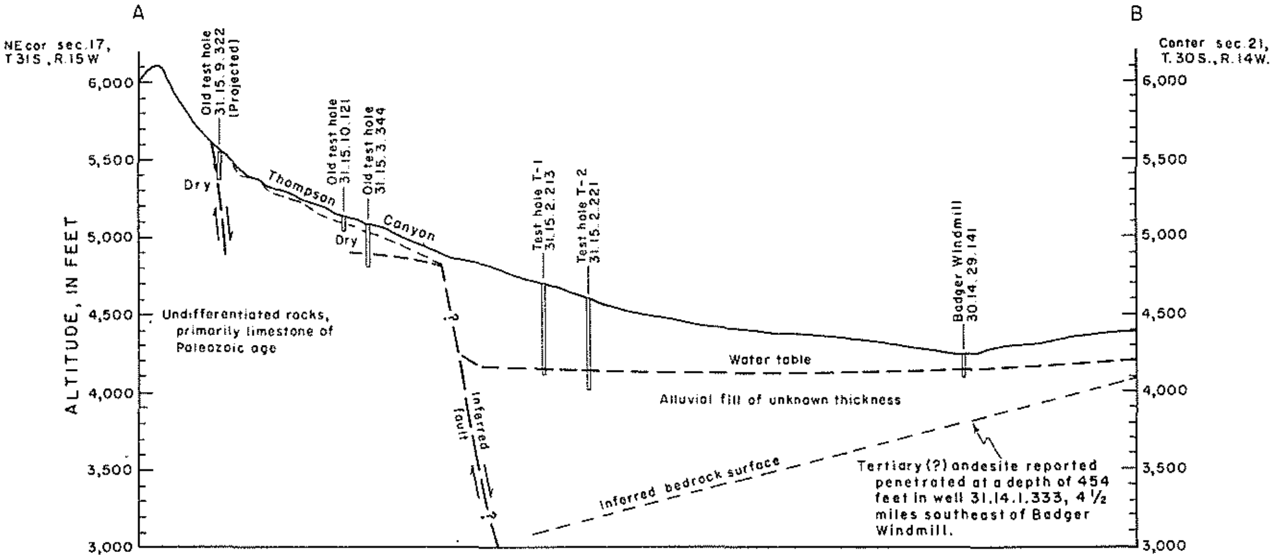


Figure 2 – Profile and section along line A–B (pl. 1) showing probable relation of water table, bedrock, and alluvial fill.

0 1 2 Miles
Horizontal scale

feet; at the Mexican boundary, about 31 miles to the southeast, it is 4,150 feet. The overall gradient of the valley floor is approximately 11 feet per mile. The slope of the central section is nearly 12 feet per mile.

The lateral slopes of the central section of the valley become increasingly steep toward the bordering mountains. Along the line A-B (fig. 2 and pl. 1) the gradient from Badger Windmill (30.14.29.141) toward the Big Hatchet Mountains increases from about 75 feet in the first mile to 150 feet per mile in the middle slope and to about 300 feet per mile at the mouth of Thompson Canyon. The increasing steepness is characteristic of the lateral slopes of the valley along the west side of the central section.

Climate

The area is semiarid; the average annual precipitation at Hachita is about 11 inches, as reported by the U.S. Weather Bureau. Approximately half the annual precipitation occurs in July and August as rain accompanying thunderstorms. The storms are generally brief but may be intense and result in flash floods in the arroyos. Snowfall generally averages about 5 inches a year.

The average annual temperature at Hachita is about 60°F. The average summer temperature is about 77°F and the average winter temperature about 40°F. Temperatures higher than 100°F in summer are common, and the minimum in winter may be 0°F or a little below.

GEOLOGY

Rocks exposed in the area consist mainly of marine consolidated rocks and continental deposits of fluvial origin, there being lesser amounts of granitic and volcanic rocks. Limestone and minor amounts of shale and sandstone make up the thick sequence of folded and faulted marine sedimentary rocks exposed in the Big Hatchet Mountains and Sierra Rica. Boulders, gravel, sand, and clay, derived by weathering and erosion of the rocks exposed in the mountains and carried down the slope by flood runoff, make up the deposits underlying the floor of Hachita Valley.

General Distribution and Age of the Rocks

Precambrian granite, exposed at the north end of the Big Hatchet Mountains, is presumed to underlie the marine sedimentary rocks of Paleozoic and Mesozoic age that are exposed in the Big Hatchet Mountains on the west side of the area and in Sierra Rica on the east. Granite which is of uncertain age, but which is believed by Lasky (1947, pl. 14) to have been emplaced in Late Cretaceous or early Tertiary time, is exposed on two low hills in Hatchet Gap and in the southern part of the Little Hatchet Mountains (pl. 1). Zeller (1958, p. 16) believes that the granite exposed in the low hills in Hatchet Gap, like that at the north end of the Big Hatchet Mountains, is of Precambrian age.

The sedimentary rocks of Paleozoic age (undifferentiated in this report) that overlie the Precambrian granite include the Bliss, El Paso, Montoya, Fusselman, Percha, and Lake Valley formations (Darton 1928, p. 346). The Bliss is characteristically a sandstone and the Percha a shale; the other formations are primarily limestone. The Magdalena limestone, of Pennsylvanian age, overlies these rocks and constitutes the main mass of rocks exposed in the Big Hatchet Mountains.

According to Zeller (1953; 1958, p. 14) the Sierra Rica is composed mainly of rocks of Lower Cretaceous age. The log of the Hachita Dome Co. test well indicates that the limestone cropping out at the oil-test site in sec. 12, T. 30 S., R. 15 W., occurs above limestone which probably is of Cretaceous (Comanche) age. Zeller (1958, p. 22) has indicated the belief that the rocks exposed at the site probably are of Cretaceous age, but states (p. 23) that the questions of the age of the rocks exposed at the outcrop have not been settled. Dane and Bachman (1961), in the preliminary geologic map of the southwestern part of New Mexico, show the outcrop to be of Devonian-Mississippian age. Cave reported that the well bottomed at a depth of 2,726 feet in rhyolite of Precambrian(?) age underlying the Bliss sandstone (Zeller, 1958, p. 23).

Quartzite and limestone of uncertain age but probably dating from Paleozoic time occur with granite in the two low hills in Hatchet Gap. Sedimentary rocks of Cretaceous age, consisting mainly of sandstone and limestone, occur in a small area on the southwest flank of the Big Hatchet Mountains (pl. 1).

Older alluvium of Pleistocene age, in most places firmly cemented by calcium carbonate to form a hard conglomerate, stretches outward from the foot of the Big Hatchet Mountains and the Sierra Rica toward the axis of Hachita Valley. Except for a small area where limestone crops out, a mile northeast of the Hatchet Ranch headquarters (pl. 1), the older alluvium covers all older rocks lying between the mountain masses. Younger alluvium and valley fill of Recent age, consisting mainly of wind- and water-borne sand and some silt and clay, lie in a narrow strip down the axis of the valley. Volcanic rocks of Tertiary age are not exposed in the valley but crop out in Sierra Rica and adjacent areas and are reported to underlie the valley fill in part of Hachita Valley.

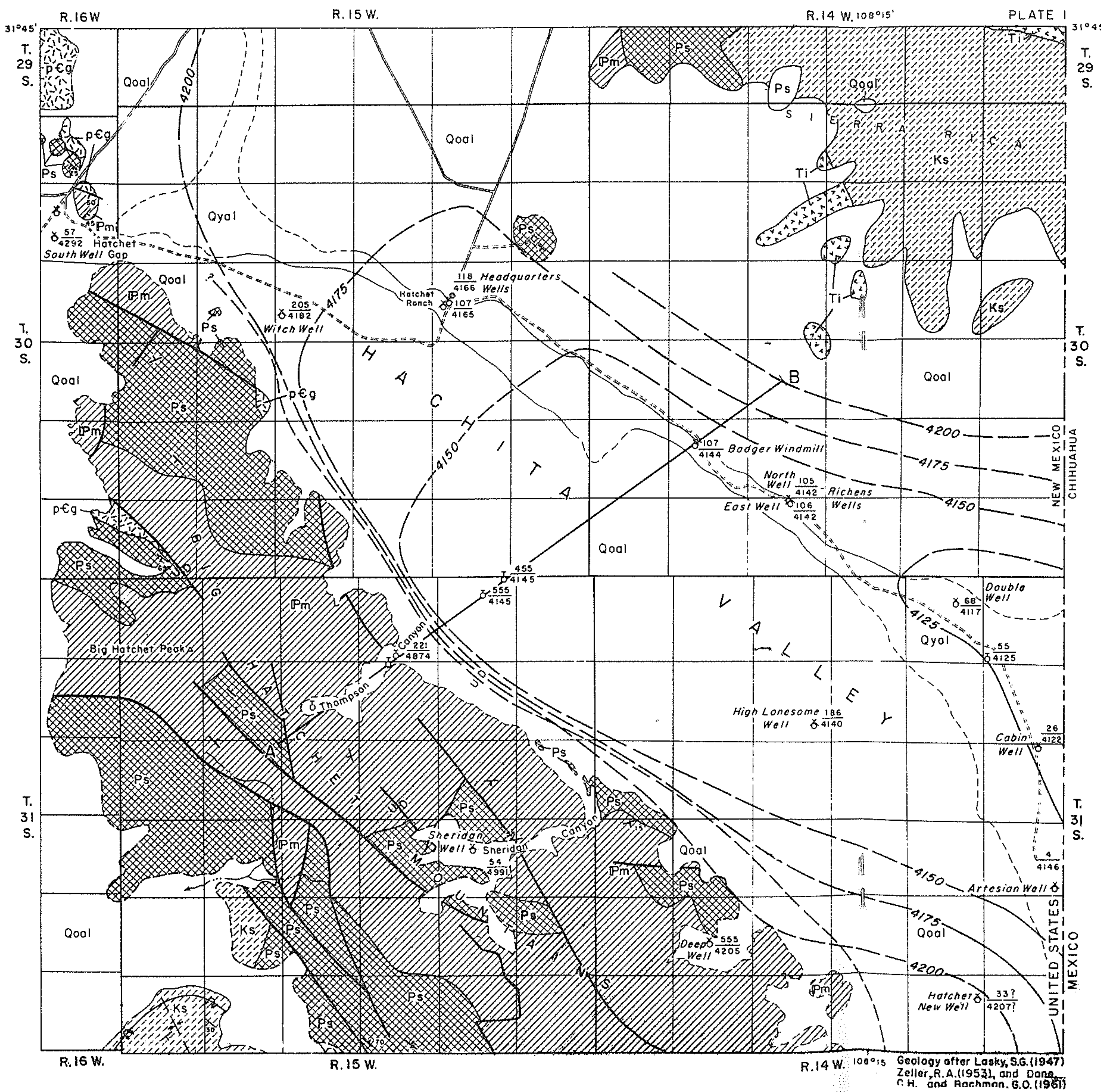
Structure

Paleozoic and Mesozoic rocks in the Big Hatchet Mountains and vicinity have been faulted, warped, and in places overturned by folding (Lasky, p. 51). The principal structures within the project area are related to faulting. Evidence that the Big Hatchet Mountains owe their origin to faulting is cited by Lasky (pl. 14), who mapped faults within the mountain mass and in Hatchet Gap, and by Zeller (1958, p. 18), who found thrust faults within the range. Lasky infers that the Big Hatchet Mountains are bounded on the east side by a fault or faults; but, inasmuch as any faults are buried beneath the older alluvium gravel and are not visible in outcrop, they were not indicated on his map. Lasky, (p.50-51) postulated also that the Hatchet Gap fault is either a part of the fault along which rocks of the Big Hatchet Mountains were thrust over those of the Little Hatchet, or is a related fault. Zeller (1958, p. 16) has indicated the fault to be a normal gravity fault. Whether it is of the gravity or thrust type, a fault cutting the bedrock may be presumed to extend along the eastern foot of the Big Hatchet Mountains, and to be concealed by the older alluvium. The fact that two test holes on the alluvial slope did not hit bedrock at depths of 600 feet, at distances of about 1 mile, and $1\frac{1}{2}$ miles outward from the mountain front, is interpreted to indicate that the fault lies between the site of the test holes and the mountains. Because the location of this fault has an important bearing on the occurrence of ground water in the area, its inferred location is shown on plate 1 of this report.

The faults cutting the main mass of the Big Hatchet Mountains apparently have little or no direct influence on the occurrence of ground water in the area, as the rocks they cut are largely impermeable and as there is no evidence of large-scale movement of water in the faults.

The limestone on the southwestern flank of the Sierra Rica dips southwesterly at 2° to 4° and passes beneath the alluvial fill. It appears again at the surface northeast of the Hatchet Ranch, where it is exposed over approximately a quarter of a square mile. This outcrop has been interpreted by others to be a dome, but no radial dips were observed by Zeller (oral communication) when he mapped the area; he is of the opinion that the outcrop resulted from a relatively small fault block

PLATE 1



EXPLANATION

QUATERNARY

Recent

Qyal

Younger alluvium and valley fill

Clay, silt, and fine sand, some windblown. Generally unconsolidated; water bearing in the vicinity of Double well and southeast; elsewhere considered to be above the general water table.

Pleistocene

Qoal

Older alluvium and valley fill

Sand, medium to coarse, gravel and boulders, mostly derived from limestone rocks. Poorly sorted, generally moderately to well cemented with calcium carbonate; water-bearing but does not yield water in large quantities.

TERTIARY

Ti

Intrusive rocks

Igneous rocks of varied composition. Dense impermeable rocks, generally not water bearing.

CRETACEOUS

Ks

Sedimentary rocks

Mudstone, shale, sandstone, conglomerate; limestone, and coquina, locally contain beds of volcanic rock. May yield small quantities of water.

PENNSYLVANIAN

Pm

Magdalena limestone

Dense, medium- to dark-gray, locally cherty. Joints not well developed; in general not water bearing.

PALEOZOIC

Ps

Limestone, shale, and hard quartzitic sandstone. Dense, relatively impermeable, and not water bearing.

PRECAMBRIAN

p€g

Granite

Dense, impermeable, not water bearing.

118/4166 Well equipped with turbine pump

186/4140 Well equipped with windmill

455/4145 Water test hole, unequipped

Oil test hole

The upper number by the well is depth to water, in feet below land-surface datum; lower number is altitude of water level, in feet.

4150 Contour on water table, dashed where approximate. Contour interval 25 feet.

15 Strike and dip of beds

60 U D Fault, dashed where inferred. Dip of fault plane indicated.

Formation contact, dashed where uncertain

Axis of syncline

Axis of overturned anticline

1 0 1 2 Miles

Plate 1. Map of Hachita Valley northeast of the Big Hatchet Mountains, Hidalgo County, N. Mex., showing generalized geology, wells and test holes, and contours on the water table, December 1955.

being incompletely buried or partly uncovered by erosion. In general, the southwestward dip of 2° to 4° of the limestone is believed to prevail under most of the alluvial fill in Hachita Valley. Farther west the Magdalena and younger limestones are presumed to be in contact, through faulting, with lower Paleozoic and perhaps Precambrian rocks underlying the Big Hatchet Mountains.

Geologic History

The geologic history of the area, insofar as it affects the availability of ground water, began immediately after the last period of major faulting. A detailed review of the earlier geologic history of the region is given by Lasky (p. 51-53).

The geologic history of the area subsequent to the formation by faulting of the mountain ranges bordering Hachita Valley has been primarily one of erosion in the uplands and deposition in the lowlands, with minor periods of erosion interrupting the periods of deposition in the lowland areas. The accumulation of alluvial deposits in the basin began with the uplift of the mountains and has continued to the present.

It is believed that the first debris carried down by the streams as the mountains were uplifted was coarse and was deposited outward for a considerable distance from the base of the newly formed mountains. After uplift ceased the amount of coarse material decreased in proportion to the amount of the finer material transported. Alluvial fans were built outward from the mouths of newly developed canyons, and the level of the intervening valley floor was gradually built up as the consolidated rocks were buried beneath a mantle of alluvial debris.

Much of the material eroded from the Big Hatchet Mountains and Sierra Rica was carried downvalley and deposited in the southern part of the valley, in Mexico; as a consequence, alluvial deposits in Hachita Valley, northeast of the Big Hatchet Mountains, are believed to be no more than 1,700 feet thick at the most, and generally to be much thinner. For relatively brief periods during Pleistocene time, Hachita Valley was occupied in part by an extension of the lake that filled the lower valley in Mexico (Schwennesen, 1918, p. 27). The blue clay and mud penetrated in drilling along the axis of the valley are believed to have been deposited in lake waters. With the last recession of the lake and a slight rejuvenation of the streams, the trenching of the alluvial fans and the removal of pediment gravel -- gravel thinly veneering the consolidated rocks at the foot of the mountains -- and upper-slope gravel began. This material now is being moved down the slopes toward the axis of the valley.

Character of the Rocks

Marine sedimentary rocks will be discussed only briefly. These rocks carry virtually no water but are important to the occurrence of ground water in the area because they form the bottom and walls of the basin containing the water-bearing valley fill. The character and origin of the valley fill, which constitutes the only important source of water in the area, is discussed in more detail below.

Marine Sedimentary Rocks

The limestone, shale, and sandstone of marine origin in the Big Hatchet Mountains and Sierra Rica are for the most part dense and relatively impermeable. The Magdalena limestone (Pennsylvanian) makes up the greater part of the mass of the Big Hatchet Mountains (pl. 1). It is a medium- to dark-gray, dense, locally cherty limestone, characteristically cliff-forming where the beds are more massive. It is approximately 1,400 feet thick (Lasky, p. 13). The limestone is not cavernous generally, and systems of joints are not well developed. Water falling on or running over exposures of the limestone cannot easily penetrate the rock, and the limestone has little or no storage capacity. The limestone, shale, and hard quartzitic sandstone of earlier Paleozoic age underlying the Magdalena limestone probably are equally dense.

The rocks of Lower Cretaceous age exposed in Sierra Rica may be the equivalent of Lasky's Howells Ridge and Corbett formations of the Little Hatchet Mountains (Zeller, 1958, p. 14). The Howells Ridge formation in these mountains consists mostly of mudstone, shale, limestone, coquina, sandstone, and conglomerate overlain by massive to thinly bedded limestone, with some local volcanic rocks (Lasky, p. 22). The Corbett formation mainly consists of sandstone, in part quartzitic and massive, containing beds of sandy shale ranging to 15 feet in thickness (Lasky, p. 24).

Alluvial Fill

Character

The rocks constituting the valley fill are described in detail by Schwennesen (p. 30-35). They are composed of weathered detrital material eroded from the mountains, and consist of fragments ranging in size from boulders to clay. Most of the stream-deposited material is poorly sorted, but some reworking by wind and lake waters has resulted in local deposits of well-sorted material.

Most of the rock fragments, large and small, making up the valley fill are of limestone from the adjacent mountains. Because of the high percentage of limy material and the climate peculiar to arid and semiarid regions, the valley fill is cemented to a high degree, particularly the upper part. A zone of caliche 2 to 5 feet thick commonly underlies the surface deposits of the alluvial fans. The caliche appears to be related to an alluvial-fan surface other than the present surface, as present-day gullying reveals it to be buried at many places by later alluvial debris. Elsewhere, the caliche forms a hard pavement immediately underlying the fan surface, all overlying material having been stripped away.

According to the driller, most of the materials penetrated in test holes 31.15.2.213 and 31.15.2.221 on the middle slope of the alluvial fan were cemented with calcium carbonate, ranging from moderately firm to very firm. However, some data indicate that not all the alluvial material of the slopes is firmly cemented. Two of the three uncased test holes drilled in recent years in Thompson Canyon, wholly or partly in alluvial material, were closed or nearly closed by caving. The third test hole (31.15.3.344) was open below the water table. These facts show that deposits of the alluvial slope are not always cemented firmly enough to stand in a well wall without the support of casing.

Thickness

The alluvial fill is 454 feet thick at the site of irrigation test well 31.14.1.333 near the axis of the valley. Volcanic rock (andesite) of Tertiary(?) age (oral communication, Zeller, 1955) was penetrated in the hole at that depth. Limestone crops out at the site of the oil-test well (30.15.12.323). The limestone there has a southwestward dip and is believed to be faulted upward. The authors infer that the limestone maintains a southwestward dip west from the outcrop. Therefore, the alluvial fill between the outcrop and the Big Hatchet Mountains thickens toward the mountains. In the vicinity of Hatchet Ranch the fill probably is about 400 feet thick; close to the mountains it may be as much as 1,700 feet thick.

As much as 600 feet of alluvial-slope material was penetrated in the test holes on the fans that extend outward from the foot of the Big Hatchet Mountains. How much additional alluvial material lies between the bottom of the holes and the limestone bedrock is conjectural. A projection of the bedrock slope from the west side of the Sierra Rica, on the basis of an average dip to the southwest of 3°, and data on the depth to volcanic bedrock in well 31.14.1.333 suggest that the alluvial fill may be as thick as 1,700 feet in the vicinity of test hole 1 and 1,300 feet at test hole 2. The surface of the bedrock is presumed to be irregular as well as inclined; therefore, the depth to bedrock at any point on the valley floor is unpredictable, but the depths cited are believed to be of the proper magnitude. The thickest part of the alluvial fill is believed to be about $3\frac{1}{2}$ miles west of the valley axis and along a line more or less parallel to the axis and the inferred fault shown on plate 1. This relation is indicated on the cross section shown in figure 2.

Method of deposition

The occurrence of water in alluvial fans and in valley fill depends to a great extent on the method of deposition and the character of the sediments. Some of the materials underlying the floor of the valley are fine-grained lake deposits; but most of the material underlying the fan slopes, and much of that underlying the valley floor, was deposited by flood runoff from the mountains and is coarse grained.

It is generally recognized that mountain floodwaters, especially those resulting from cloudbursts, commonly transport a heterogeneous mixture of boulders, gravel, sand, silt, and clay which, upon sudden deposition on a rapidly flattening gradient, forms a poorly sorted alluvial aggregate having poor water-bearing properties. Accordingly, the farther a stream carries a load, and the more slowly the velocity of the stream diminishes, the better is the sorting of the material carried. The materials deposited at the mouths of canyons such as Thompson and Sheridan are coarse but poorly sorted. These deposits should not be expected to yield large quantities of water. Generally the sorting is better and the material is therefore increasingly more permeable with increasing distance from the canyon mouth. Finally, however, the sediments of high to moderate permeability are all deposited, and only fine materials -- clay, silt, and fine sand -- are left to be deposited along the axis of a valley or in a playa. Because of the fineness of these materials, the permeability generally is low and the sediments will not yield water in large quantities.

The first materials deposited as a result of uplift of a mountain range are likely to be very coarse if the uplift has been relatively rapid and if the rocks uplifted are of a type subject to rapid disintegration in an arid climate, as are those of the Big Hatchet Mountains. It seems reasonable to assume, therefore, that the deeper alluvial fill immediately overlying bedrock is, in general, extremely coarse. As the alluvial fans grew, the depositional processes outlined above, in conjunction with processes of cementation peculiar to the geology and climate, resulted in deposition of even less permeable material above the coarse basal debris. Thus, the permeability of the basal alluvial fill, although low, may be greater than that of the fill at shallower depths.

The almost universal presence of a zone of caliche at or near the surface of the fans and the similarity of the caliche to cemented material at depth suggests that the process of cementation takes place at or near the surface as the fans grow.

The initially rapid deposition of coarse debris at the base of the rising mountain front probably precluded complete cementation of the basal part of the fans. As the fans expanded outward and vertically the rate of growth slowed, giving time for caliche to deposit at or near the surface.

GROUND WATER

General Occurrence

Ground water in the area occurs under both water-table conditions (unconfined, in permeable sediments) and artesian conditions (confined beneath relatively impermeable sediments). The relatively shallow penetration of most of the wells below the nonpumping (static) water level indicates that water-table conditions prevail in most of the area. Toward the south end of the area, artesian pressures are reported in Cabin

Well (31.14.13.212) and Artesian Well (31.14.24.444), both of which are reported to have flowed when first drilled. The nonpumping water levels in Hatchet New Well (31.14.35.242) and Witch Well (30.15.16.313) stand relatively high above the bottoms of the holes, suggesting the possibility of some artesian head. Artesian pressures are common in most large alluvial fans, as the result of interfingering and overlapping of relatively impermeable clay and the more permeable beds of sand and gravel.

The general shape of the water table is shown by the contours on plate 1. The slope of the water table down the valley is somewhat less than that of the land surface. Consequently, the depth to water along the axis of the valley is greatest at the northern or upper end and progressively less toward the southern end.

The water levels in test holes T-1 (31.15.2.213) and T-2 (31.15.2.221) have the same altitude as the water level in Badger Windmill (30.14.29.141), 3 miles to the northeast on the axis of the valley, indicating either that the water table is relatively flat across this part of the valley or that the axis of the water-table trough lies between the test holes and the topographic axis of the valley. Probably both hypotheses are correct in part, as is indicated by the water-table contours on plate 1, although control is slight. This conclusion is consistent with geologic data, which indicate that the lowest part of the structural trough also is west of the topographic axis of the valley (fig. 2), and that the rock materials in the lowermost part of the trough are more permeable than those in the upper part. The reduction in permeability in the upper zone results in a reduction in recharge of water moving downward through the fan and, as a consequence, the water table in the lower zone has time to flatten out.

Recharge, Movement, and Discharge

Recharge to the ground-water body is derived primarily from precipitation. However, only a very small part of the precipitation reaches the water table. The cementation of the alluvial-fan material in general and the caliche zone underlying most of the surface of the fan preclude infiltration of appreciable amounts of water through the surface of the fan. The ground-water reservoir probably is recharged mainly during flood runoff by infiltration in stream channels that have cut through the near-surface caliche zone. Some recharge may occur during heavy, soaking rains or as the snow melts, and areas of dune sand or extremely sandy soil may receive and pass some water directly down to the water table during showers.

The water-table contours (pl. 1) show that ground water is moving into the area from the northern part of Hachita Valley. Other investigations have shown that a ground-water divide approximately coincides with the Continental Divide, north of Hachita. As the drainage area that receives recharge in the northern part of the valley is relatively small, and as the annual precipitation is small, the amount of water recharging the alluvial deposits and moving down the axis to the central part of the valley probably is small. The water in Witch Well and the two Corps of Engineers test holes is of much better chemical quality than the water in most of the wells near the axis of the valley (table 2), indicating that the ground-water reservoir is recharged along the northeastern edge of the Big Hatchet Mountains. The relatively high mineralization of most of the ground water underlying the axis of the valley suggests that the water has moved down the valley from the north. The relatively good chemical quality of the water in the Badger Well indicates that this water has moved to the valley from Sierra Rica. The rocks composing Sierra Rica are similar to those in the Big Hatchet Mountains, and ground water moving from the two areas should be of similar chemical quality.

The water table in the Playas Valley on the west side of the Big Hatchet Mountains is considerably higher than that in Hachita Valley. This condition was explained by Schwennesen (p. 122) who postulated a bedrock ridge underlying the alluvium in Hatchet Gap which acted as a dam (sec. 12, T. 30 S., R. 16 W.) and concluded that the amount of water moving through the gap from Playas Valley to Hachita Valley probably is small.

Ground water underlying Hachita Valley moves southeastward into Mexico and discharges by evaporation and transpiration and possibly through springs in the vicinity of the playa lake called Ojo de los Mosquitos, about 5 miles east of the Mexican border. The area of discharge has not been investigated, but maps indicate the presence of springs. To the writers' knowledge, no springs discharge in that part of Hachita Valley in the United States. Some ground water in Hachita Valley is discharged artificially as a result of pumping from wells. Probably some ground water is discharged by transpiration in the vicinity of Artesian Well (31.14.24.444), where the water table lies at a shallow depth, and possibly also near Cabin Well (31.14.13.212).

Chemical Quality

Chemical analyses of water collected in 1955 and 1956 from five wells in the area and the two Corps of Engineers test holes are given in table 2, together with analyses reported by Schwennesen. The analyses indicate that water from two of the wells sampled, the Hatchet Ranch Headquarters NE Well (30.15.14.134) and Double Well (31.14.2.232), is notably more highly mineralized than water from the other wells and the test holes. Water sampled from all the wells and test holes is of a chemical quality generally considered potable. However, water from the Hatchet Ranch Headquarters Well contained 316 ppm of sulfate, which is somewhat in excess of the limit of 250 ppm recommended for drinking water by the U.S. Public Health Service (1946) in the standards for common carriers. Also, water from four of the wells sampled contained fluoride somewhat in excess of 1.5 ppm, which is the maximum permitted in drinking water and public water supplies under Public Health Service standards. The water from test hole T-2 (31.15.2.221) was moderately hard, 228 ppm, but the hardness was mainly of the carbonate or "temporary" type and could be removed if desired.

TABLE 2
CHEMICAL ANALYSES OF WATER FROM WELLS AND TEST HOLES IN CENTRAL HACHITA VALLEY, HIDALGO COUNTY, N. MEX.

(Units in parts per million)

Location number	Well name	Date collected	Temperature (°F)	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (ppm)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Percent sodium	Sodium adsorption ratio (SAR)	Specific conductance (micromhos at 25°C)	pH
30.14.29.141*	Badger Windmill	1913	-	-	41	21	118	240	0	147	32	-	-	509	189	-	-	-	-	-
Do.	do.	12- 1-55	68	-	-	-	91	217	0	82	16	2.6	21	382	112	-	64	-	595	7.9
33.211*	Richens Well	1913	-	-	26	14	78	253	0	57	17	-	-	337	122	-	-	-	-	-
30.15.14.134*	Hdqrs. NE Well	1913	-	-	58	19	100	189	0	239	26	-	-	577	223	-	-	-	-	-
Do.	do.	12- 1-55	64	-	-	-	147	242	0	316	28	2.2	3.2	714	255	-	56	-	1,060	7.4
16.313	Witch Well	12- 1-55	68	-	-	-	98	254	0	94	47	.6	7.4	433	168	-	56	-	734	7.8
31.14. 2.232*	Double Well	1913	-	-	139	63	312	424	0	686	156	-	-	1,659	606	-	-	-	-	-
Do.	do.	12- 7-55	68	-	-	-	-	397	0	155	40	1.8	-	-	258	-	-	-	1,080	7.4
9.441	High Lonesome Well	12- 8-55	74	-	-	-	-	261	0	91	14	2.2	-	-	192	-	-	-	620	7.4
13.212*	Cabin Well	1913	-	-	57	21	56	256	0	104	23	-	-	417	229	-	-	-	-	-
31.15. 2.213	Test hole T-1	7- 3-56	72	-	-	-	42	237	0	56	40	-	16	-	230	36	29	1.2	615	8.1
2.221	Test hole T-2	9- 5-56	75	21	37	33	51	242	0	73	40	.8	8.2	383	228	30	33	1.5	646	7.7

* From Hare in Schwennesen, 1918.

The water samples collected from test holes T-1 (31.15.2.213) and T-2 (31.15.2.221), Witch Well (30.15.16.313), and High Lonesome Well (31.14.9.441), all of which are on the alluvial slope along the northeastern flank of the Big Hatchet Mountains, were of similar chemical quality and were considerably less mineralized than water from the Hatchet Ranch Headquarters Well and Double Well, both of which are on the axis of the valley. The difference in quality of the water from these two areas indicates that ground water moving beneath the alluvial slope from the Big Hatchet Mountains is not as highly mineralized as that moving southeastward beneath the axis of the valley. A comparison of the chemical quality of the water from wells on the alluvial fan with that from wells near the axis of the valley indicates that the ground water in the valley fill in the vicinity of the Hatchet Ranch Headquarters is mixed to a considerable extent with water of better chemical quality before it reaches the vicinity of Badger Windmill.

Water from Badger Windmill (30.14.29.141), which is exactly on the topographic axis of the valley, contains even fewer dissolved solids than wells on the alluvial slope. From this fact and from the elevations of the water table at the various wells it is inferred that the ground water at the Badger Windmill has moved mainly from Sierra Rica, and that the deepest part of the ground-water trough is not beneath the topographic axis of the valley but southwest of it, beneath the alluvial slope at the northeastern flank of the Big Hatchet Mountains (pl. 1). Apparently, the greater part of the ground water in the central part of Hachita Valley in the southwestern part of T. 30 S., R. 14 W., and the northwestern part of T. 31 S., R. 14 W., is contributed from the Sierra Rica and the Big Hatchet Mountains.

It is possible that the inferences made regarding movement of water by comparison of analyses of water from some of the wells is not justified because the relations of the water-bearing zones are not known. A comparison of the analysis of a water sample collected in 1913 by Schwennesen from one of the two wells at Double Well (31.14.2.232) with that of a sample collected in 1955 from the one well remaining at the site indicates with certainty that the samples came from different sources. The waters are different chemically, and it does not seem reasonable to assume that the chemical quality of water from the same source would change so radically in that length of time.

Utilization

All but one of the wells in use in the area are equipped with cylinder pumps and windmills; Electric Well (30.15.14.134a) at the Hatchet Ranch Headquarters is equipped with a small submersible turbine pump reported to yield about 25 gpm. Water in the valley is used only for domestic purposes and for watering stock. Well 31.14.1.333, drilled as a test for an irrigation supply, is reported to have been pumped at 160 gpm from a level of about 70 feet, but it was not equipped with a permanent pump. The hole was found to be caved when sounded in December 1955.

Availability

Data obtained in the course of the investigation indicate that small to moderate supplies of potable ground water are available from valley fill under most of the floor of Hachita Valley. Only in those areas within approximately half a mile of the foot of the mountains is a well not likely to develop a supply of water sufficient for at least stock use.

The possibilities for the development of adequate supplies of ground water in the areas immediately underlain by bedrock are poor. The rocks of marine origin that make up the Big Hatchet Mountains are not aquifers. No springs or seeps discharge from these rocks, and of three test holes in the Magdalena limestone in Thompson Canyon two were dry; the third tapped some water but not enough for stock use. Deep Well (31.14.29.322) at the south end of the range yielded so little water that it was not considered worthwhile by the owner to keep the windmill in operable condition. Sheridan Well (31.15.23.144) yields a reliable but small supply (3 to 4 gpm) of water adequate only for stock use. Reports by the drillers of the oil-test well (30.15.12.323) indicate that no appreciable amount of water had yet entered the hole at a depth of 1,930 feet. However, it is reported by Cave (Zeller, 1958, p. 23) that circulation was lost between 1,510 and 1,630 feet in the Montoya limestone, and the loss of circulation was interpreted to indicate that the upper part of the Montoya limestone was porous. If the Montoya is porous to a degree sufficient to cause loss of circulation of drilling mud, it possibly could be an aquifer. The quality of water from the formation in all probability would be poor.

Most of the ground water developed in the valley is derived from the alluvial deposits of the valley fill. However, the ability of the alluvial deposits to yield water varies appreciably from place to place, as is indicated by marked differences in the yields of wells (table 1). The characteristics that affect the yield of the alluvial deposits are chiefly the permeability and porosity of the fill which, in turn, depend largely on factors of transportation and deposition of the sediments composing it.

The construction of a compound alluvial fan of the sort that extends outward from the base of the Big Hatchet Mountains is such that a well drilled at any point on the slope will penetrate a succession of materials ranging in texture from fine to extremely coarse, and in sorting from poor to moderately well. With present data it is not possible to predict the order of succession of materials. Commonly the logs of wells no more than 100 feet apart on an alluvial slope are impossible to correlate. Test holes T-1 (31.15.2.213) and T-2 (31.15.2.221) were drilled to depths of 595 and 600 feet, respectively. The driller believed that limestone bedrock had been penetrated in test hole T-1 at a depth of about 485 feet; however the available data indicate that both test holes probably were bottomed in partly cemented fan deposits.

Yields and drawdowns of wells in the area show a considerable variation. The yield of a well is affected not only by the permeability of the material in which it is finished but also by the thickness and extent of the aquifer and by the depth of penetration into the aquifer. To obtain the largest yield, a well should penetrate to the bottom of the aquifer. The volume of water pumped by a windmill can reveal much about the potential yield of the well if the drawdown can be measured when the well is pumped at a steady rate. The drawdowns of several windmill-equipped wells were measured under reasonably favorable conditions, and several were measured under less favorable conditions. Measurements were made of the discharge and drawdown of the well equipped with an electric pump. The Corps of Engineers test hole T-1 was bailed and test hole T-2 was test pumped with a turbine pump.

The discharge of Electric Well (30.15.14.134a) at the Hatchet Ranch was measured at 25 gpm and the drawdown at that rate of discharge was 13.2 feet. The specific capacity of the well at that rate of pumping is thus about 1.9 gpm per foot of drawdown. The specific capacity of Richens East Well (30.14.33.211a) was 2.6 gpm per foot of drawdown. Data for Witch Well (30.15.16.313) and High Lonesome Well (31.14.9.441) are not fully reliable, but they indicate the specific capacity to be higher, possibly as much as 12 gpm per foot of drawdown for Witch and 20 gpm for High Lonesome. Both wells are on the middle slope of the alluvial fan.

Test Drilling

It was concluded from the reconnaissance of the area that a water supply of the magnitude desired could be obtained from one or two wells located on the slope of the alluvial fan that extends northeastward from the mouth of Thompson Canyon. Five test-hole sites were suggested to be explored in succession eastward from the site nearest the proposed installation.

In June 1956, the Corps of Engineers contracted with Lee Childress and Son of Silver City, N. Mex., for drilling two or three test holes, the number to be determined by the amount of water encountered as drilling proceeded. Test holes T-1 and T-2 were completed in the basic construction of the contract. Test hole T-3 was covered by an alternate part of the contract and was to be drilled only if the quantity of water encountered in the first two holes proved to be inadequate.

The two Corps of Engineers test holes were drilled approximately 1 mile from the mouth of Thompson Canyon (pl. 1), also on the middle slope of the fan. Test hole T-1 (31.15.2.213) was drilled through 584 feet of alluvial-fan material consisting mostly of loosely cemented limestone pebbles and a few small pieces of chert. Some water was encountered at 579 feet. At 584 feet the driller reported limestone bedrock had been encountered. A rough bailing test indicated a yield of less than 2 gpm. Drilling was continued for 11 feet. The hole was bottomed at a depth of 595 feet. Bailing at an average rate of about 5 gpm resulted in a drawdown of 27 feet after 1 hour, which indicates a specific capacity of about 0.2 gpm per foot of drawdown. Test hole T-2 (31.15.2.221) was drilled to a depth of 600 feet and cased to that depth with 8-inch casing, the lower 125 feet of which was slotted with 1/8- by 4-inch torch-cut slots. The test hole was pumped at a rate of 50 gpm for 6 hours. The drawdown was 64 feet which indicates a specific capacity of 1.3 gpm per foot of drawdown.

The specific capacities of Badger Windmill (30.14.29.141) and Double Well (31.14.2.232) apparently are less than 1 on the basis of somewhat unreliable data. Test pumping of the irrigation test hole (31.14.1.333), 460 feet deep, showed the well to be capable of producing about 160 gpm with a drawdown of 16 feet after more than 24 hours of pumping. A specific capacity of 10 thus is indicated. Data for this well are considered to be reliable. It is significant that this hole penetrated the aquifer fully in an area where most of the material was fine grained. The Badger, Richens, Double, and Hatchet Ranch Headquarters wells did not penetrate the aquifer fully and have relatively low specific capacities.

REFERENCES CITED

Dane, C. H., and Bachman, G. O., 1961, Preliminary geologic map of the southwestern part of New Mexico: U.S. Geol. Survey. Scale: 1:380,160.

Darton, N. H., 1928, "Red Beds" and associated formations in New Mexico, with an outline of the geology of the State: U.S. Geol. Survey Bull. 794, 356 p.

Fenneman, N. M., 1931, Physiography of Western United States: New York, McGraw-Hill Book Co., 534 p.

Hill, E. R., and Cave, Hal, 1958, Well log, Tidball-Berry No. 1, in Roswell Geol. Soc. Guidebook 11th Ann. Field Conf., Hatchet Mountains and the Cooks Range-Florida Mountain areas, Grant, Hidalgo, and Luna Counties, southwestern New Mexico, 1958: in pocket.

Lasky, S. G., 1947, Geology and ore deposits of the Little Hatchet Mountains, Hidalgo and Grant Counties, New Mexico: U.S. Geol. Survey Prof. Paper 208, 101 p.

Schwennesen, A. T., 1918, Ground water in the Animas, Playas, Hachita, and San Luis Basins, New Mexico, with analyses of water and soil by R. F. Hare: U.S. Geol. Survey Water-Supply Paper 422, 152 p.

United States Public Health Service, 1946, Drinking water standards: Public Health Repts., v. 61, no. 11, p. 371-384.

Zeller, Robert A., Jr., 1953, Contribution to: Generalized geologic map of southwestern New Mexico and adjacent States, in New Mexico Geol. Soc. Guidebook 4th Ann. Field Conf., southwestern New Mexico, 1953: at back.

Zeller, Robert A., Jr., 1958, Road log, Deming to Big Hatchet Mountains via Wilna and Hachita, New Mexico, *in* Roswell Geol. Soc. Guidebook 11th Ann. Field Conf., Hatchet Mountains and the Cooks Range-Florida Mountain areas, Grant, Hidalgo, and Luna Counties, southwestern New Mexico, 1958: p. 7-24.