WATER RESOURCES REPORT NUMBER 4

ARIZONA STATE LAND DEPARTMENT

OBED M. LASSEN, COMMISSIONER

GEOLOGY AND GROUND-WATER RESOURCES OF THE PALOMAS PLAIN-DENDORA VALLEY AREA, MARICOPA AND YUMA COUNTIES, ARIZONA

BY

C. A. ARMSTRONG AND C. B. YOST, JR.

PREPARED BY THE GEOLOGICAL SURVEY,
UNITED STATES DEPARTMENT OF THE INTERIOR

Phoenix, Arizona
January 1958

CONTENTS

ILLUSTRATIONS

TABLES

GEOLOGY AND GROUND-WATER RESOURCES OF THE PALOMAS PLAIN-DENDORA VALLEY AREA, MARICOPA AND YUMA COUNTIES, ARIZONA

By

C. A. Armstrong and C. B. Yost, Jr.

ABSTRACT

The Palomas Plain-Dendora Valley area is in western Maricopa and eastern Yuma Counties, Ariz., about midway between Phoenix and Yuma. The climate is arid, the annual precipitation being about 5 inches, and is characterized by torrid summers and mild winters.

The characteristic landforms are wide valleys and isolated northwest-trending mountains. The most conspicuous physiographic features are Dendora Valley, Palomas Plain, several isolated hills projecting above the plain, the so-called Sentinel lava flow, and the surrounding mountains which have altitudes as high as 3,400 feet. The gently sloping valley floors are dissected to varying degrees by numerous subparallel washes. All the drainage of the area is intermittent. It is controlled largely by the Gila River and to a lesser extent by the northwest structural trends. Drainage on the Sentinel lava flow is, for the most part, in a youthful stage of development.

The rock units described in this report are: (1) gneissic, schistose, and granitic rocks of probable Precambrian age; (2) acidic and intermediate volcanic rocks of Cretaceous and Tertiary age; (3) basaltic rocks of Quaternary age; (4) sedimentary rocks of Tertiary age; and (5) alluvial fill of Quaternary age. The age assignments of these rocks are tentative except those of the limestones of Tertiary age, the Quaternary fill, and the Quaternary basalt.

Normal faults are the most conspicuous structural features in the area. Folding has been minor since the extrusion of the earliest Cretaceous and Tertiary volcanic rocks.

The older rocks of Precambrian age, and of Paleozoic age if present, were subjected to erosion which continued through the Mesozoic era until the Cretaceous period, which was marked by marine deposition and further erosion. Faulting and volcanic activity started in Late Cretaceous time and continued intermittently throughout most of the Tertiary period. Limestone was deposited during one of the quiescent intervals. Large-scale erosion and deposition occurred in the Quaternary period. The deposition was followed by more vulcanism. Erosion then reduced the land surface to its present position.

The most important aquifers are sand and gravel lenses within the alluvium-filled valleys. The movement of ground water within the fill is toward the Gila River and downstream.

The aquifers are recharged by streamflow within the area, underflow from areas upstream, rainfall and local runoff, and seepage from irrigation. Ground water is discharged from the aquifers by pumping, evapotranspiration, and underflow. Neither the total amount of recharge nor that of discharge is known.

The quantity of ground water in storage in the alluvial fill within the area depends upon several factors which have not yet been fully determined. It is estimated that the quantity in storage in the first hundred feet below the water table may be about 5,000,000 acre-feet. The percentage of this that can be recovered practicably cannot be estimated from available data.

Chemical analyses of 55 samples of ground water show a range of 312 to 12,500 ppm (parts per million) in dissolved solids. The analyses show that the most highly mineralized ground water is within a mile of the Gila River.

INTRODUCTION

Purpose and Scope of the Investigation

The increased use of water in the State of Arizona has called attention to the need for information concerning the State's ground-water resources. Recognizing this need, the Arizona State Legislature in 1939 appropriated funds for an investigative program, and a cooperative agreement was entered into by the State of Arizona and the U. S. Geological Survey. The program has been continued since that time; this report is one of a series prepared in cooperation with, and published by, the Arizona State Land Department, Obed M. Lassen, Commissioner.

The principal object of this investigation was to determine, as nearly as possible, the geologic and hydrologic characteristics of the area before the development of ground water reached an advanced stage. It was desired also to evaluate the possibilities for future development, even though the data for such an evaluation were meager. A record of conditions in the initial stages of development, such as was obtained in this reconnaissance investigation, should be of great value in future studies.

Location

The area included in this report is in western Maricopa and eastern Yuma Counties, Ariz. (fig. 1). It lies about midway between Phoenix and Yuma and includes Palomas Plain, Dendora Valley, and the surrounding mountains, as well as the northern part of the Sentinel lava flow. The area is bounded on the west by the Palomas, Tank, and Kofa Mountains. The Little Horn Mountains, the Clanton Hills, and the Gila Bend Mountains bound the area on the north, and a southern projection of the Gila Bend Mountains and the Painted Rock Mountains bound the area on the east. The southern boundary was arbitrarily chosen as a line through the center of T. 6 S., Rs. 7 to 13 W. (pl. 1). The total area within these boundaries is about 1,225 square miles. About 875 square miles is within the Palomas Plain drainage basin, about 260 square miles within the Dendora Valley drainage basin, and about 90 square miles within the Sentinel lava flow.

Climate

The climate of the Palomas-Dendora area is arid and is characterized by torrid summers and mild winters. No climatological data within the area are available, but U. S. Weather Bureau records have been kept at Gila Bend to the east, Sentinel to the south, and Yuma to the southwest. A comparatively long record was kept at Mohawk, southwest of the area, but it was discontinued in 1952. The records show that the average rainfall at Mohawk was 4.43 inches per year. Other records have been or are being kept nearby, but the records are very short or too incomplete to be used in this report. The Palomas-Dendora area is not far from Sentinel, where an incomplete record (table 1) shows an average annual precipitation of 4.96 inches, and it is probable that 5 inches for the Palomas-Dendora area would be a fair approximation. The records at Gila Bend and Yuma corroborate this assumption. Temperatures above 110° F are common, and temperatures below 20° F at Gila Bend and 25° F at Yuma are unusual.

Landforms

The Palomas-Dendora area, part of the Sonoran Desert section of the Basin and Range province (Fenneman, 1931, p. 367), is characterized by wide valleys and isolated mountains. This topography resulted from large-scale block faulting and tilting. The general trend of the faults in the region is northwest; consequently, the mountains and valleys also have a northwest trend.

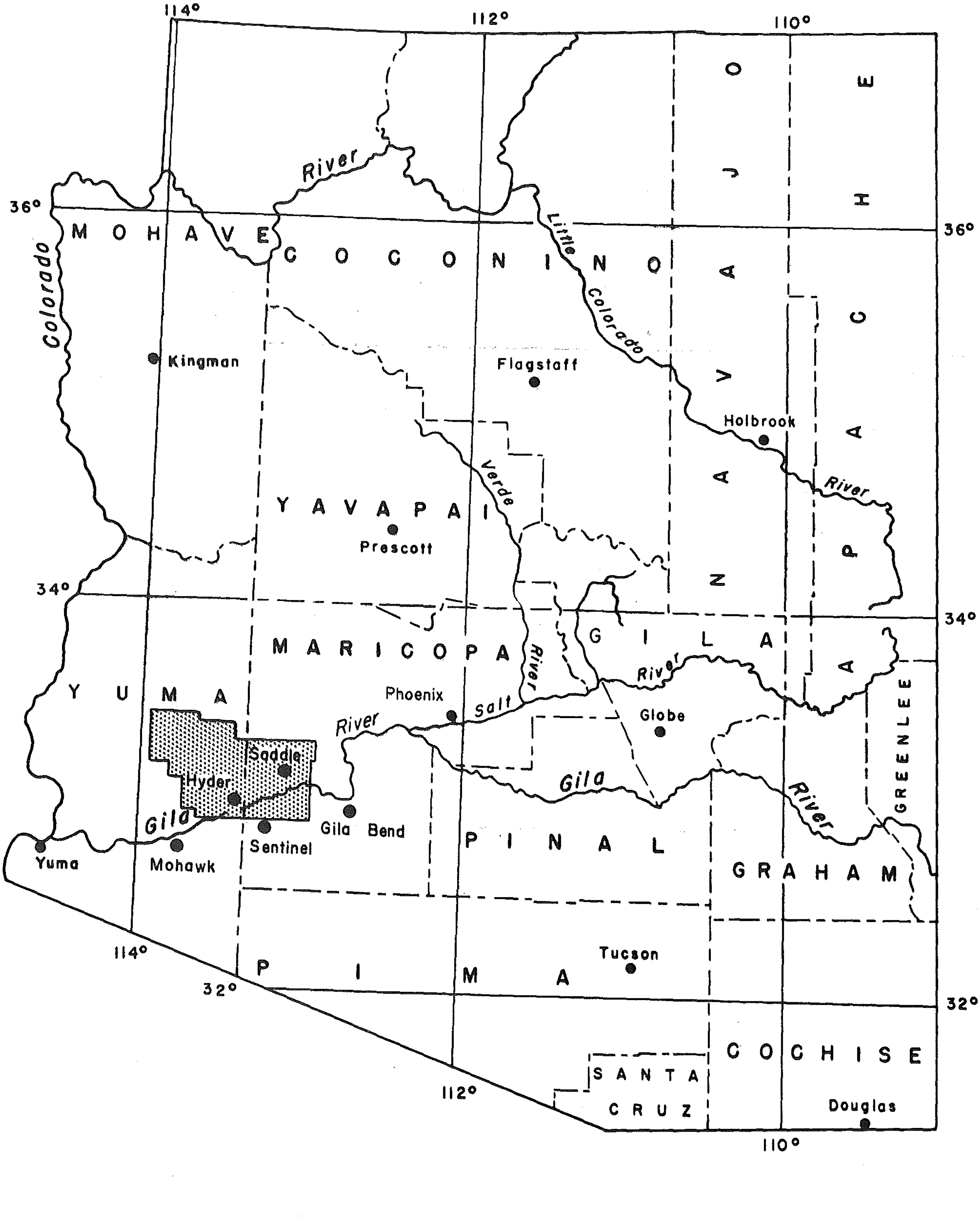

Figure 1.--Map of Arizona showing Palomas Plain-Dendora Valley area.

Table 1.--Average annual precipitation at Gila Bend, Sentinel, and Yuma and maximum and minimum temperatures at Gila Bend and Yuma.

Precipitation (inches)				Temperature (°F)			
Year	Gila Bend	Sentinel	Yuma	Gila Bend Max.	Gila Bend Min.	Yuma Max.	Yuma Min.
1870	-	-	3.10	-	-	-	-
1871	-	-	.65	-	-	-	-
1872	-	-	2.73	-	-	-	-
1873	-	-	3.14	-	-	-	-
1874	-	-	7.55	-	-	-	-
1875	-	-	2.32	-	-	-	-
1876	-	-	1.13	-	-	114	30
1877	-	-	3.66	-	-	114	33
1878	-	-	2.88	-	-	118	29
1879	-	-	3.29	-	-	116	27
1880	-	-	.74	-	-	111	25
1881	-	-	.98	-	-	113	31
1882	-	-	1.78	-	-	114	27
1883	-	-	3.96	-	-	117	-
1884	-	-	5.86	-	-	113	34
1885	-	-	2.72	-	-	114	36
1886	-	-	5.35	-	-	112	30
1887	-	-	3.90	-	-	116	27
1888	-	-	2.95	-	-	114	27
1889	-	-	4.69	-	-	117	34
1890	5.19	-	4.67	-	-	115	30
1891	2.68	-	2.67	-	-	116	25
1892	6.95	-	3.35	-	-	116	28
1893	7.11	-	3.00	-	-	111	32
1894	4.25	-	2.95	-	-	113	28
1895	3.29	-	1.33	-	-	114	30
1896	10.21	-	2.55	-	-	117	31
1897	6.69	-	4.18	-	-	112	28
1898	4.79	-	2.38	-	-	113	26
1899	4.92	-	.60	-	-	112	28
1900	2.12	2.45	.85	-	-	112	31
1901	2.55	1.91	3.65	-	-	114	24
1902	-	4.49	1.93	-	-	116	31
1903	-	-	.98	-	-	113	29
1904	-	-	1.43	-	-	110	32
1905	-	-	11.41	-	-	116	35
1906	-	3.87	5.40	-	-	111	28
1907	6.32	-	2.61	-	-	114	34
1908	7.69	6.79	5.93	-	-	114	28
1909	-	-	8.63	-	-	112	26
1910	-	-	3.93	-	-	120	25

Table 1.--Average annual precipitation at Gila Bend, Sentinel, and Yuma and maximum and minimum temperatures at Gila Bend and Yuma--continued.

Precipitation (inches)				Temperature (°F)			
Year	Gila Bend	Sentinel	Yuma	Gila Bend Max.	Gila Bend Min.	Yuma Max.	Yuma Min.
1911	-	-	2.79	-	-	115	22
1912	-	-	3.11	-	-	115	29
1913	5.64	3.23	1.04	-	-	115	24
1914	8.76	6.86	3.70	-	-	115	33
1915	7.53	6.45	4.33	-	-	116	28
1916	8.47	4.76	2.45	-	-	116	28
1917	4.87	6.68	2.22	-	-	119	35
1918	-	9.24	2.90	-	-	117	27
1919	9.01	-	2.04	-	-	116	28
1920	5.85	-	4.75	-	-	116	32
1921	5.38	-	6.98	-	-	111	28
1922	5.71	-	3.03	-	-	115	29
1923	7.29	-	3.91	-	-	114	32
1924	2.89	-	.78	-	-	113	31
1925	6.62	-	3.78	-	-	116	31
1926	-	-	9.23	-	-	114	31
1927	-	-	3.92	-	-	118	35
1928	2.88	-	.47	-	-	116	33
1929	5.48	-	2.36	-	-	117	30
1930	5.86	-	1.79	-	-	113	29
1931	-	-	5.91	-	-	116	31
1932	7.27	-	6.35	120	20	113	26
1933	5.67	-	3.56	120	24	119	29
1934	3.86	-	2.32	121	24	116	35
1935	2.81	-	3.28	-	22	114	34
1936	6.82	-	1.29	123	-	118	32
1937	4.07	-	4.30	118	-	117	22
1938	4.07	-	2.92	118	23	112	35
1939	4.97	-	6.66	117	24	119	32
1940	7.74	-	2.33	119	24	116	38
1941	13.50	-	6.71	-	-	115	34
1942	3.37	-	2.41	-	-	117	31
1943	-	-	2.42	-	-	120	35
1944	6.70	-	4.07	116	-	115	32
1945	5.45	-	4.10	117	27	116	34
1946	8.32	-	2.25	114	27	113	27
1947	2.66	-	1.03	117	22	115	31
1948	4.17	-	1.83	117	23	117	26
1949	-	-	-	117	18	115	29
1950	2.13	1.41	3.35	120	18	123	30
1951	-	7.10	4.25	116	24	115	31

Table 1.--Average annual precipitation at Gila Bend, Sentinel, and Yuma and maximum and minimum temperatures at Gila Bend and Yuma--continued.

Precipitation (inches)				Temperature (°F)			
Year	Gila Bend	Sentinel	Yuma	Gila Bend		Yuma	
				Max.	Min.	Max.	Min.
1952	6.30	5.51	3.79	116	24	114	30
1953	2.68	3.18	.42	119	23	114	31
1954	3.75	5.46	.90	116	21	117	28
Avg.	5.58	4.96	3.33				

The principal physiographic features in the Palomas-Dendora area are the two basins, Palomas Plain and Dendora Valley, separated by Oatman and Face Mountains, and the surrounding hard-rock areas. Isolated hills such as the Agua Caliente Mountains, Baragan Mountain, Turtle Back Mountain, and other smaller hills project above the plain at various places. The Sentinel lava flow is characterized by low, rolling hills and ridges.

The highest point in the area, about 3,400 feet, is in the Kofa Mountains (pl. 1). Farther west the Kofas rise to nearly 4,000 feet. Southward from the Kofas the altitudes of the Tank and Palomas Mountains successively decrease; similarly, the altitudes of the Little Horn Mountains and the Clanton Hills decrease eastward. The Clanton Hills, on the north side of the basin, have a maximum altitude of 1,600 feet. To the east and south, the Gila Bend, Face, Oatman, and Painted Rock Mountains attain altitudes of approximately 2,500, 2,000, 1,300, and 1,400 feet, respectively. The highest point — 1,077 feet — on the Sentinel lava flow is Sentinel Peak, about a mile south of the area shown on plate 1.

Approximately 400 of the 1,225 square miles of the Palomas-Dendora area is mountainous. Palomas Plain heads as a narrow valley in the foothills of the Kofa Mountains and slopes to the southeast, where it widens to more than 20 miles near the Gila River. Dendora Valley is about 12 miles wide in the northern part near the mountains and narrows to about 5 miles near the Gila River. About 24 square miles of this valley extends south of the Gila River. Both Dendora Valley and part of Palomas Plain abut the foot of the escarpment formed by the northern edge of the Sentinel lava flow.

Palomas Plain and Dendora Valley have gently sloping surfaces broken by hard-rock outliers, and are dissected to varying degrees by numerous subparallel washes. Several terraces of older depositional remnants also break the even surface. The most conspicuous of these is the terrace along the south side of the Gila River (fig. 2), where lava flows have formed a protecting cap and have caused the development of an escarpment 40 to 80 feet high. Another large terrace has been formed on the east side of Dendora Valley near Woolsey Wash. It has been suggested (Ross, 1923, p. 71) that this terrace was formed when the Gila River was dammed by lava flows at the head of the Gila Bend basin. This suggestion is corroborated to some extent by the presence in the alluvium of rock types that are foreign to the mountains immediately above the terrace. There are several elongated, relatively flat-topped ridges in the higher parts of Palomas Plain and Dendora Valley which may be terraces, dissected alluvial fans, or the remnants of older, higher deposits. Other remnants occur as small, light-colored, discontinuous bands of alluvial material 20 to 50 feet above the base of some of the mountains. Even though these bands are discontinuous they would, if connected, form gently sloping surfaces, suggesting that originally they were terraces.

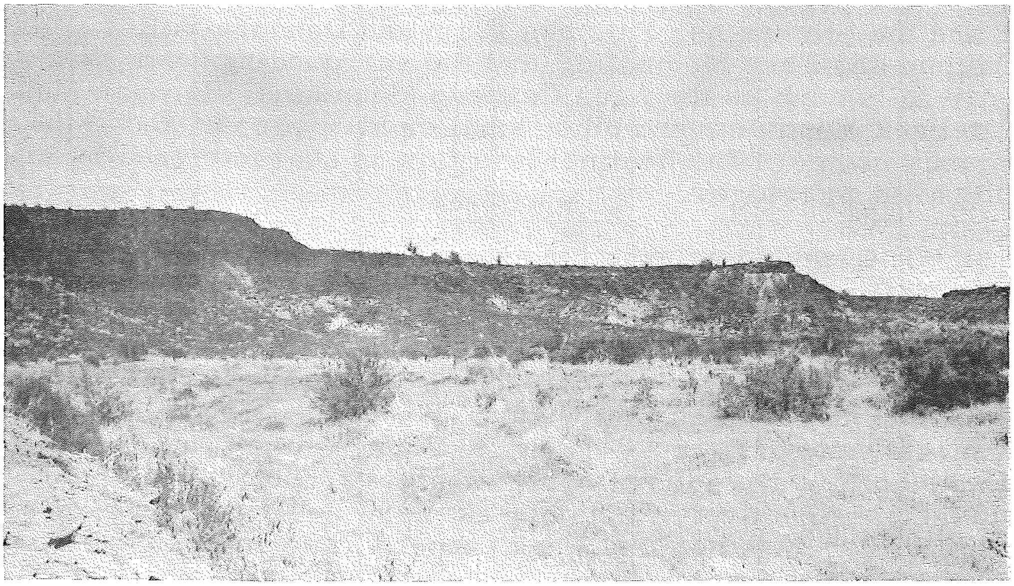

Figure 2.--Terrace along the Gila River. Basalt overlying Pleistocene alluvium.

Drainage

All the drainage in the Palomas-Dendora area is intermittent and is controlled largely by the Gila River, the local base level toward which the other streams flow, and to a lesser extent by the northwest structural trend. The drainage in the mountains to the west and northwest follows the topographic features which are the result of structural disturbances and forms a rectangular pattern. The structural trends in the eastern mountains have been largely obscured by volcanic flows and thus are not well shown by the drainage.

One of the largest washes in the Palomas Plain area originates in a higher basin to the north and extends southward through the gap in the Clanton Hills to the Gila River. Several other large washes originate in the Kofa and Tank Mountains.

Dendora Valley is drained on the east side by Woolsey Wash and on the west by Yellow Medicine and Loudermilk Washes and their tributaries.

The drainage pattern on the Sentinel lava flow area is, for the most part, in a youthful stage of development. Incipient radial drainage has started near some of the lava cones, but channels have not become incised.

Field Work and Maps

Field work was started in April 1954 and was carried on intermittently until September 1955. The geologic mapping was done by C. B. Yost, Jr.; most of the hydrologic data were obtained by J. M. Cahill and R. S. Stulik, under the immediate supervision of H. N. Wolcott (deceased), Phoenix area geologist. C. A. Armstrong had the principal responsibility for preparing the report. The work was under the supervision of J. W. Harshbarger, district geologist of the Ground Water Branch of the Geological Survey for Arizona.

The geologic investigation was of a reconnaissance nature because the time available and the requirements of the study did not warrant a more detailed investigation. Geologic mapping in the northern part of the area was done entirely on aerial photographs, as no topographic maps were available. In the southern part of the area aerial photographs were used in conjunction with U. S. Geological Survey topographic maps. The photographs were made by the U. S. Army. The base map (pl. 1) was prepared from the photographs, topographic maps, and Arizona grazing-district maps.

Most of the wells in the Palomas-Dendora area have been visited and mapped. Records of these wells are shown in table 3. Drillers' logs of 56 wells, indicating the type of rock material penetrated at various depths, are shown in table 4.

Well-Numbering System

The well numbers used by the Ground Water Branch of the Geological Survey in Arizona are in accordance with the Bureau of Land Management's system of land subdivision. The land survey in Arizona is based on the Gila and Salt River Base Line and Meridian, which divide the State into four quadrants (fig. 3). These quadrants are designated counterclockwise by the capital letters A, B, C, and D. All land north and east of the point of origin is in A quadrant, that north and west in B quadrant, that south and west in C quadrant, and that south and east in D quadrant. The first digit of a well number indicates the township, the second the range, and the third the section in which the well is situated. The lowercase letters a, b, c, and d, after the section number, indicate the well location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract (fig. 3). These letters are assigned in a counterclockwise direction beginning in the northeast quarter. If the location is known within a 10-acre tract, three lowercase letters are shown in the well number. In the example shown, well number (C-4-2)19caa designates the well as being in the $NE\frac{1}{4}NE\frac{1}{4}SW\frac{1}{4}$ sec. 19, T. 4 S., R. 2 W. Where there is more than one well within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes.

Previous Investigations

The Palomas-Dendora area has been included in studies of larger areas by other investigators, among whom are Bancroft, Bryan, Ross, and Wilson. However, none of these men attempted any ground-water study of this particular area, and their work was done prior to most of the agricultural development. Previous papers are listed in the bibliography at the end of this report.

Acknowledgments

Appreciation is expressed to all ranchers and other individuals who rendered assistance in various ways during this investigation. Organizations that were especially helpful in contributing valuable data include the Arizona Highway Department, the Arizona Public Service Co., the Southern Pacific Railroad, and the University of Arizona.

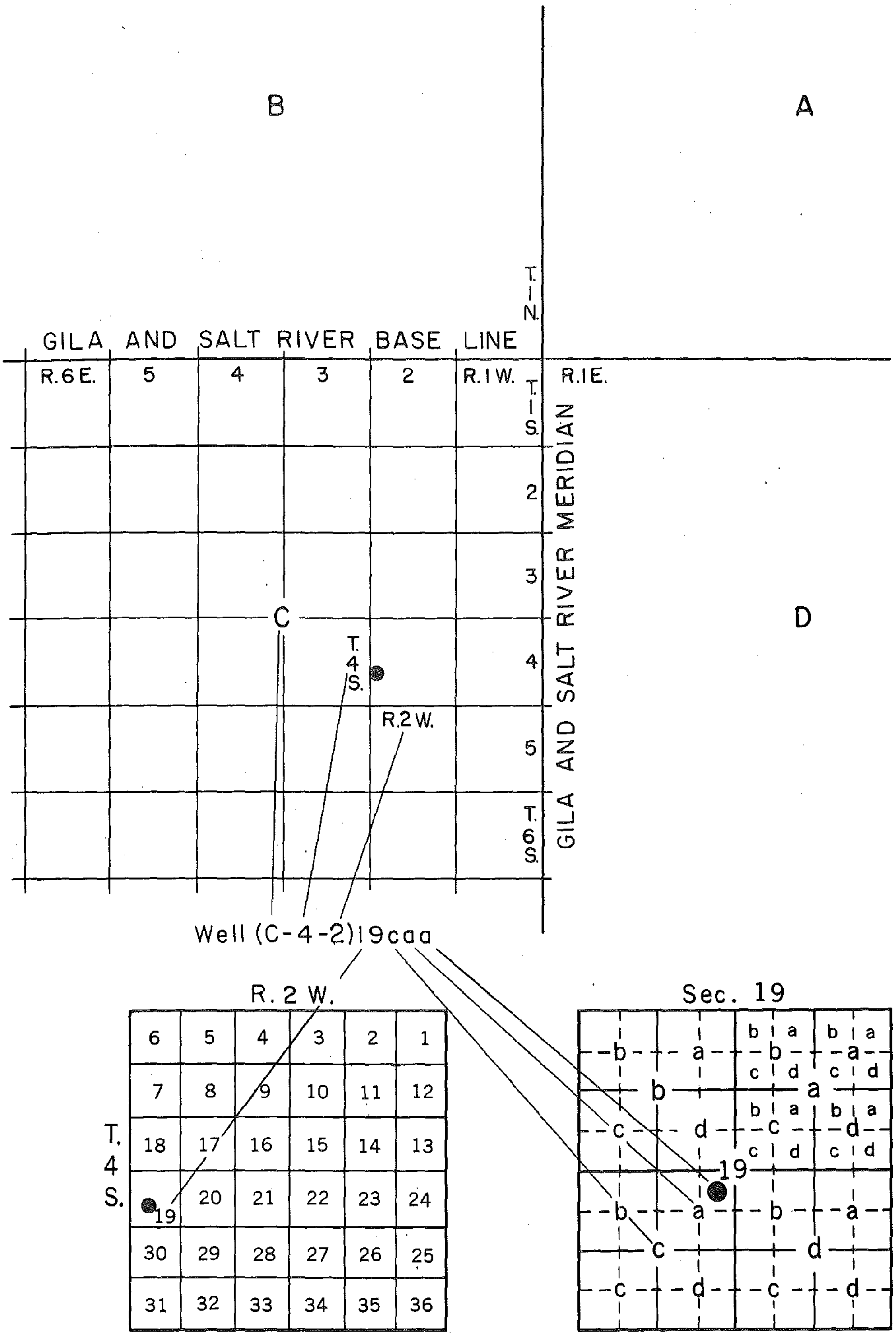

Figure 3.--Well-numbering system in Arizona.

GEOLOGY

Rock Units

Most of the pre-Cretaceous rocks in the area have been covered by lava or by alluvial material deposited at different times from Cretaceous time to the present. Scattered outcrops of Precambrian sedimentary, metamorphic, and granitic rocks now are exposed only where erosion has removed the younger rocks. Rocks of Paleozoic age are not known to occur in this area. The relative ages of the various rock types have been assigned largely on the basis of contact relationships, but definite geologic ages, as in much of southern Arizona, are difficult to determine. Plate 1 shows the areal distribution and tentative age assignments of the various rock types.

Metamorphic Rocks

Gneiss

Gneiss is extensively exposed in the western part of the Gila Bend Mountains and forms a few isolated hills at the northeastern end of Palomas Plain. Apparently the gneiss was exposed as an irregular surface during part of the Cretaceous period, and later was covered by Cretaceous and Tertiary lava flows. It is now exposed only where the lavas have been removed by erosion.

The coarsely crystalline texture as well as the composition — quartz, orthoclase feldspar, and biotite — of these gneissic rocks indicates that they originally were part of an intrusive mass or masses that have undergone metamorphism since emplacement. Most of the individual crystals have been elongated and oriented in one direction. Sheeting has developed, but not to the extent that the rock will split along clearly defined planes.

Previous investigators have considered the gneisses of southwestern Arizona to be Precambrian, and as no contrary evidence was found in the Palomas-Dendora area, the gneiss here is tentatively assigned that age.

Schist

Small dark-colored basic schistose dikes occur in the low granitic hills extending southward from the Palomas Mountains. Rocks into which the dikes are intruded have not been metamorphosed. Small outcrops of schist occur also in the low hills extending southeast from the Tank Mountains. These schists and schistose dikes have been regarded as part of the Precambrian complex. The schists are probably of Precambrian age and the schistose dikes, although younger than the surrounding rocks, are too small to be shown on the map; no definite age can be assigned to them.

No important water supply is known to have been developed in the metamorphic rocks. However, prospect holes and other depressions may store water for short periods after rains, and wells drilled in the metamorphic rocks may yield small quantities of water, if fault zones, joints, or other openings are encountered.

Igneous Rocks

Igneous rocks, predominantly volcanic, constitute the largest part of the mountains in the area; most of the volcanic rocks have been extruded since Paleozoic time. Granitic rocks also are present and probably were emplaced prior to the extrusion of volcanic material, perhaps in the Precambrian.

Granitic rocks

Exposures of granitic rocks occur in several localities within the area. However, only three outcrops occupying more than a square mile each were observed. The two largest are on the south sides of the Tank and Palomas Mountains, the third in the Painted Rock Mountains. There are also several small, isolated exposures in the area.

The granitic rocks cropping out in the Tank Mountains form low, rounded hills and a pediment area. Most of the structural relationships within this area are obscured by local detrital material. The exposures of granitic rocks in the Palomas Mountains are elongated in a northwest direction. The outcrops are more than a mile wide and are bounded on the northeast by a fault contact with Cretaceous and Tertiary lavas. A low ridge in the Palomas Mountains extending southward from the main granite mass is cut by a series of high-angle northwest-trending faults and basic dikes. It is possible that the dikes represent the source of some of the younger lavas.

The granitic rocks in the Palomas-Dendora area are generally medium grained and contain varying proportions of quartz, orthoclase, plagioclase, biotite, and ferromagnesian minerals, predominantly hornblende. Most of these rocks contain more plagioclase and ferromagnesian minerals than normal granite, thus tending toward granodiorite in composition.

There are compositional and textural variations within the granite in the larger exposures. Some of these variations are due to later intrusions and others to differentiation within the original magma. Some outcrops in the Tank Mountains show numerous gradations from very coarsely crystalline masses, containing phenocrysts as long as 1 inch, to fine, equigranular bodies.

In a few places, granite crops out near or adjacent to sedimentary rocks of probable Tertiary or Cretaceous age. In these exposures the granitic rock either is older than the sedimentary rock or is of indeterminate age. Tertiary limestone, tuff, and volcanic rocks are adjacent to, and stratigraphically higher than, the granite exposed at the west end of Clanton Hills. Two outcrops — one of limestone, the other of granite — were found in the Kofa Mountains about three-quarters of a mile southeast of the Hoodoo well (C-1-15)18cb. These outcrops are surrounded by younger Cretaceous and Tertiary volcanic rocks. A single outcrop of limestone surrounded by alluvial material was found in an area of granitic outliers at the southeastern end of the Tank Mountains. The age relationship between the limestone and granitic rocks is unknown, but both are older than the alluvial material. In this investigation the granitic rocks, as well as the schist and gneiss, have been mapped as Precambrian, but a part of at least the granitic rocks may be as young as Cretaceous.

Volcanic rocks

An immense volume of lava was extruded in the Palomas-Dendora area during Cretaceous, Tertiary, and Quaternary time. More than 2,000 feet of volcanic rock is exposed in the Kofa Mountains; however, the base of the series is not visible at most places, and the maximum thickness is not known. The volcanic rocks, in most places, terminate near the edges of alluvium-filled valleys, either as abrupt fault scarps or as gentle surfaces of original deposition that dip under the valley fill, and it is obvious that the lavas covered a larger area than that in which they now crop out. Outliers of volcanic rocks at various places within the valleys probably represent partly buried hills, and some may have been local sources of lava.

On the basis of composition and appearance the lavas can be separated into two series of flows: an older series of light-colored, acidic or intermediate lavas; and a younger series that is dark and basic. The distinction between these lavas is useful in determining their relative ages.

Volcanic rocks of Cretaceous and Tertiary age

These rocks compose a series of lavas and subordinate amounts of tuff and agglomerate, and form most of the mountains bordering the Palomas-Dendora area. Even the lavas mapped as Quaternary are, in most places, underlain by Cretaceous and Tertiary volcanic rocks at depths of less than 100 feet. All the mountains have exposures of these older lavas, although in some places the exposures are limited to small areas along steep slopes of fault scarps or sides of washes and are not of sufficient size to show on the map. Wilson (1933, p. 29) found that the series makes up a large part of the mountains north of the Gila River, but occurs only in the Cabeza Prieta and Aguila Ranges south of the river in Yuma County.

The most conspicuous exposures of Cretaceous and Tertiary volcanic rocks are in the Kofa, Tank, and Gila Bend Mountains, where the lava has been exposed by faulting and deep erosion. A contact between the lava and underlying gneiss is exposed in the Gila Bend Mountains. At other places granite and sediments underlie the volcanic rocks.

As such large areas are covered with lava, there must have been numerous local sources. The high viscosity of the acidic lavas probably contributed to the thickness of individual flows.

Massive tuff deposits, common in the northern and western mountain areas, attest to the explosive nature of some of the eruptions. Tuff is particularly conspicuous in the Tank Mountains, where several hundred feet is exposed in the deeply eroded interior portion of the range.

In many localities the tuff is overlain by basaltic lava, and there may be some doubt concerning which of the two lava series the tuff should be assigned to. However, petrologic similarity to the underlying older Cretaceous and Tertiary volcanic rocks favors assigning the tuff to that series. Wahlstrom (1950, p. 183) states "basaltic rocks . . . are more likely to be erupted as fissure flows than acidic rocks but this difference may be explained by assuming that fissure flows are of deep derivation, whereas acidic rocks come from shallower portions of the earth's crust and are the result of complex processes of differentiation and syntexis." The tuff in the Tank Mountains is overlain by typical Cretaceous and Tertiary volcanic flows and therefore is definitely within that older series.

The Cretaceous and Tertiary volcanic rocks range in composition from rhyolite to andesite. The rocks are dense and fine grained and contain phenocrysts. The color of the rocks varies, but hues of red, brown, yellow, and green predominate.

Although direct evidence as to age is lacking, these rocks are tentatively assigned a Cretaceous and Tertiary age because of the physical similarity to other rocks of southern Arizona that have been assigned to that age.

Ground water may exist in open spaces in the Cretaceous and Tertiary volcanic rocks; however, the distribution of any such water-filled openings would be impossible to predict. In the Rawley Mine, on the northwest side of the Painted Rock Mountains, a flow of warm water is reported to have been encountered in a fault zone. The Agua Caliente springs probably are related to faults in the Cretaceous and Tertiary volcanic rocks.

In general, the groundmass of the Cretaceous and Tertiary volcanic rocks is relatively impermeable. The "white tanks" which give the Tank Mountains their name have been eroded in relatively impermeable tuff and hold water for days or even weeks after precipitation.

Volcanic rocks of Quaternary age

A relatively thin series of basalt flows of Quaternary age covers the Sentinel flow area (fig. 2) and much of the mountainous areas. Erosion has removed large quantities of basalt, but none of the mountains lack remnants. The Kofa and Tank Mountains have relatively small areas covered by basaltic lavas; the mountains bordering Dendora Valley have large areas; the Little Horn, Agua Caliente, and Baragan Mountains, as well as many outliers of the older rocks are almost covered by Quaternary basalt. The wide extent of this basaltic lava may be attributed to its low viscosity when molten, as compared to that of the more acidic lavas. The total thickness of the series of flows ranges from about 10 to 150 feet, and 8 to 10 distinct flows are visible in some of the mountains bordering Dendora Valley.

The breaks in the land surface where the lava issued are, for the most part, obscured or eroded. A large vertical dike extends surfaceward from the depths of Oatman Mountain and strikes parallel to the mountain's axis. The dike probably is the solidified remnant of magma in a fissure through which lava was extruded on the surface. The buildup of many thin flows which dip and thin or converge away from the dike, and the presence of red ash beds, scarce in basaltic areas of this region except near volcanic orifices, indicate that the dike was a source of some of the lava.

Sedimentary Rocks

There are two small outcrops of sedimentary rocks of undetermined age in the area. The smallest is at the southeastern end of the Tank Mountains, where light-colored, weathered, fractured, and re-cemented limestone is exposed in an area 30 feet across. The other outcrop is in the Kofa Mountains about three-quarters of a mile southeast of well (C-1-15)18cb. It is surrounded by Cretaceous and Tertiary volcanic rocks, and is predominantly of limestone similar to that of the smaller outcrop described above; interbedded light-colored medium-grained quartzite, quartzite-conglomerate, and reddish-brown shale also are present. No definite age can be assigned to these rocks.

Sedimentary rocks of Tertiary age

Limestone, conglomerate, and sandstone crop out in several localities in the Clanton Hills and the Gila Bend Mountains. The largest of these exposures is in the central portion of the Clanton Hills, where dark-brown to gray thin-bedded cherty limestone (fig. 4) and a few thin interbeds of tuff are exposed. The individual limestone beds are usually less than half an inch thick. Ross (1923, p. 23) reported that some of the beds contain small, indistinct fossils of probable Tertiary age, and on the basis of paleontological evidence he assigns the limestone a possible Miocene age. He also reported a 30-foot bed of reddish sandstone composed of quartz grains with a calcareous cement. The only other comparatively large outcrop of limestone is about three-quarters of a mile southeast of the largest exposure. There is a small outcrop about a mile to the east. The limestones in the three outcrops are lithologically similar and it is probable that they were laid down as a continuous deposit and have since been separated by erosion and faulting. Six other scattered outcrops of the thin-bedded limestone of similar lithology indicate that the deposit originally covered a much larger area than at present. The most westerly of these small outcrops is on an isolated hill about 2 miles south of the Clanton Hills. The two most easterly outcrops are in the Gila Bend Mountains near the head of Yellow Medicine Wash. The limestone in these outcrops contains no recognizable fossils. The other outcrops of limestone are about 1 mile and 1-1/2 miles, respectively, northwest of Sundad. The limestone in these small outcrops is interbedded with tuff. There has been faulting in all the exposures and the limestone has been brecciated in some places. The fractures have since been filled with calcite or iron-stained quartz and chalcedony.

A microscopic and X-ray examination of three random samples of limestone from the Clanton Hills was made by R. A. Bailey, U. S. Geological Survey (written communication), who reports the

Figure 4.--Outcrop of Tertiary limestone in Clanton Hills.

following: "Specimen No. 1. Limestone consisting chiefly of extremely fine-grained white calcite with a small amount of detrital quartz, orthoclase, biotite, and muscovite. Dust-like particles of hematite are abundant throughout. Powder X-ray patterns of the clay-size fraction of the insoluable residue (about 15% of the sample) show chiefly kaolinite, quartz, potassic feldspar and muscovite." He also reports that a few very small pelecypod-like fossils, possibly fresh-water clams, are present. The report on specimen number 2a is as follows: "Sandy siltstone containing a small amount of volcanic debris partly replaced by calcite. The constituent detrital minerals are chiefly quartz, orthoclase, microcline, plagioclase, biotite, muscovite, and kaolinite. Grains of zircon, zoisite, and sphene are present and tiny grains of magnetite are abundant. Sand-size fragments of volcanic rock, largely of basaltic and andesitic composition but some of devitrified glass of more silicic composition are common." The report also states, "The detritus appears to have been derived from two different types of source rock: plutonic or metamorphic and volcanic." The report further states, "A rough estimate of the material definitely recognized as volcanic (both rock fragments and mineral grains) would be about 10%, but this estimate may be low since much of the quartz may be of volcanic origin . . . the volcanic material is of detrital origin and was not deposited as ash." The third sample was essentially the same as number 2 except that it contained fossils similar to those in sample number 1.

There are three exposures of conglomerate in the Palomas-Dendora area. In the smallest of these the conglomerate consists of metamorphic and volcanic rocks, occupying an area of about a quarter of a square mile. It is about 3 miles north of Sundad. A larger exposure covers more than 6 square miles in the northern part of the Palomas Mountains, and another covers more than a square mile in the southern part of the Tank Mountains. In both of the larger exposures the conglomerate consists predominantly of acidic and intermediate volcanic material. The age of these conglomerates has not been definitely determined, but they are assigned tentatively to the Tertiary period.

Alluvial fill

The drillers' logs of various wells (table 4) in the Palomas-Dendora area indicate that the alluvial fill is similar in character to that in other basins of southwestern Arizona. Gravel, sand, silt, and clay occur as lenses of varying thickness at various depths. The lower part of the fill has not been penetrated, and nothing is known about its composition or mode of deposition. The upper part is of terrestial origin and the material appears to have been derived from the surrounding mountains. Streams, probably similar to those now present in the area, deposited the material. The coarsest sediments generally were deposited near the mountainous areas and in the stream channels, and the finer sediments were deposited farther out in the valleys and on the flood plains. Large floods occasionally carried coarse material to the centers of the valleys, and smaller flows deposited "fines" near the mountains. Normally, the rock types in the fill are similar to the rocks in the nearest mountains, but exceptions occur where drainage from one mountain extends near another. Because of these conditions, the lenses containing rock materials of different grain size are distributed haphazardly and have tenuous continuity. The types of material at a given level are usually very different, even in closely adjacent wells (logs of wells (C-5-11)1dcb1, 2, and 3, table 4). Some continuity probably exists along buried washes, but the data necessary to delineate these channels are not available.

The heterogeneity of the alluvial deposits is illustrated by the sections on plates 2 and 3. The sections along lines A-A', C-C', and D-D' are entirely within the Palomas Plain; the section along line B-B' extends from B in Palomas Plain to B' in Dendora Valley. Some wells that did not lie on the lines of sections were projected to the respective lines at right angles.

Section A-A' is about 16 miles long and extends from well (C-5-12)33cda2 at Horn to well (C-4-10)34bbb. The most noticeable characteristic shown by the columnar section is the preponderance of fine-grained material in the lower parts of the deeper wells.

Section B-B' is about 30 miles long and shows one comparatively deep well in Palomas Plain, which indicates that the finer grained material noted at depth in cross section A-A' may be fairly extensive.

Section B-B' shows also that part of Dendora Valley is underlain by thick gravel-bearing deposits which apparently are not well sorted.

Sections C-C' and D-D' are about 9 and 12 miles long respectively. These sections, as well as sections A-A' and B-B', indicate the lenticular character of the alluvial deposits and show that individual layers cannot be definitely correlated.

Malpais, a term used for basalt by many drillers, has been reported in some wells. This malpais is usually in the form of boulders, but it is possible that tongues, dikes, or sills of young lava occur within the alluvial fill. Such intrusions, if present, could be the source of the heat that has been reported within the fill locally — for example, the "hot mud" in well (C-5-12)15bcb.

Structure

The most conspicuous structural features in the hard-rock areas are normal faults. The larger faults trend northwest and the smaller faults trend in several directions, generally north to northeast. No faults other than normal were observed during this investigation. The estimated vertical displacement along the faults that were examined is less than 200 feet and generally less than 50 feet. The major faults or fault zones in the area are covered by alluvium and must be inferred. In similar valleys in this region the bedrock surface near the mountains generally dips toward the centers of the valleys at a slope little greater than that of the surface of the alluvial fill, forming what is called a pediment. Some distance out from the mountains there is an abrupt change in slope, and the depth to bedrock becomes much greater. The maximum depth to bedrock in the Palomas-Dendora area has not been determined but could be several thousand feet, as in many other areas of southwestern Arizona.

Ross (1923, p. 27) stated: "There appear to have been three general periods of faulting — one before and one after the outpourings of Tertiary lava [Cretaceous and Tertiary lava of this report] and a third after the deposition of the older Quaternary alluvium. The faults of these three periods of movement cannot be sharply differentiated . . ." A fourth period of faulting has occurred since the outpouring of Quaternary lavas, although the movement during this period has been relatively insignificant.

Folding in the area appears to have been minor since the extrusion of the earliest Cretaceous and Tertiary volcanic rocks. The strike and dip of the sedimentary beds in the Clanton Hills indicate an anticlinal fold, but the tilting could have resulted from faulting on the northeast and southwest sides of the hills rather than from regional compressive forces.

The Quaternary volcanic rocks on the Oatman, Face, and Gila Bend Mountains form domelike structures and dip radially away from the mountain axes. These dips are predominantly original, but later differential "puckering" may have superimposed secondary dips upon those already present. In other parts of the area the basalts dip at less than 30°, but structures are homoclinal and the primary dips are not distinguishable. Some of these dips may be the result of the tilting of fault blocks.

Geologic History

As the early geologic history of the area can be only inferred, and as it has little bearing on present ground-water conditions, it is not discussed in this report. Evidence of events in most of the Mesozoic era is missing in the Palomas-Dendora area, but the rocks in adjacent regions indicate that alternating periods of deposition and erosion started late in Precambrian time and continued through the Paleozoic era. It is believed that during most of the Mesozoic era the region was a land mass, and erosion removed most of the older sedimentary rocks. Some marine deposition, followed by more erosion, probably occurred during the Cretaceous period.

Granitic masses and dikes of various types were intruded into the rocks of the region at some time before the end of the Cretaceous period. Some of the intrusive rocks in the Palomas-Dendora area probably were emplaced during the Cretaceous period, but no age differentiation was attempted during this investigation.

Sometime after emplacement of the granitic rocks, faulting occurred, both prior to and contemporaneously with the outpouring of extensive lavas, and it is believed that the major areas of uplift which formed the present mountains may have been established at that time. The earliest volcanic flows have been tentatively assigned to the Late Cretaceous epoch.

The extrusion of acidic or intermediate flows and ejecta probably was intermittent and may have lasted from Cretaceous to near the end of Tertiary time. The interbedded limestone and tuff probably were deposited in a lake or in an estuary of the sea.

After the eruptions diminished, another period of faulting occurred and some blocks were uplifted to form mountains; others were depressed to form valleys. The earth movements at any one time probably did not exceed a few tens of feet, but faulting took place over a long period and the total movement along the major boundary faults may be as much as several thousand feet. The rate of erosion increased as the degree of relief became greater, and the newly formed basins began to fill with debris from the surrounding mountains. Terrace remnants indicate that the alluvial surface which resulted from this deposition was as much as 80 feet higher than the present surface.

Another period of vulcanism commenced in the Quaternary period after nearly stable conditions of erosion and deposition had been established in the valleys. The period is marked by the outpouring of the basalts which form the Sentinel lava flow and cover many of the hills in the area. It is believed that this latest vulcanism occurred during the Pleistocene epoch, but it is possible that at least a part of it is Recent.

Subsequent to the Quaternary vulcanism, the Gila River base level was lowered, and erosion has modified the land surface to its present configuration.

GROUND-WATER RESOURCES

Occurrence and Movement of Ground Water

The sand and gravel deposits that constitute part of the valley fill are the only important aquifers in the Palomas-Dendora area. Ground water occurs also in the clay and silt, but these finer materials have a low permeability and yield only small quantities of water to wells. Data obtained from well records indicate that individual beds in the valley fill are lenticular and almost discontinuous. However, they probably are remotely interconnected, as the water levels in all the wells form a comparatively uniform plane.

Known depths to water range from 8 feet in wells near the Gila River to 284 feet in a well southeast of Turtle Back Mountain. In most of the cultivated areas, depths to water are little more than 100 feet, and the levels in many wells are less than 50 feet (pl. 1). No information can be given as to pumping lifts because there is a wide variation in the amount of drawdown, depending upon the types of materials penetrated and the efficiency of the well.

Because of the comparatively great distances between wells and areas of development, it was not considered feasible to construct a water-table contour map of the area. There is at present insufficient knowledge of subsurface conditions, and many irregularities in the water table cannot be understood or satisfactorily explained by available data. Therefore, only general statements are possible as to the directions of ground-water movement.

In the Palomas-Dendora area the direction of ground-water movement is generally south to southwest, or toward the Gila River and downstream. In the cultivated and other relatively flat areas the slope of the water table approximates that of the land surface except where pumping causes local ground-water depressions. Between the margins of the flat lands and the mountains the gradient of the land surface is considerably greater than the gradient of the water table, and depths to water become progressively greater toward the mountains.

There are probably many fault zones in the alluvial fill in the Palomas-Dendora area. Some of these may form avenues by which water moves into or near sources of heat such as buried igneous rocks, and then rises to the upper part of the saturated fill. Hot ground water from some such source issues from the springs at Agua Caliente. The relatively high temperature of the water in many of the wells in the area indicates that ground water moves along fault zones in localized areas beneath the surface.

Recharge

Recharge to the aquifers of the region is derived from four sources: precipitation, runoff, underflow, and irrigation.

Precipitation

Recharge to the ground-water reservoirs of the Palomas-Dendora area by direct infiltration of rainfall is believed to be negligible. Part of the rainfall on the hard-rock areas runs off. The balance is lost by evaporation and transpiration. Most of the moisture that falls on the alluvial areas is absorbed by the soil and then lost by evaporation or is transpired by the desert plants. During and shortly after heavy summer storms some runoff from the alluvial areas occurs and some recharge is added to the ground-water reservoirs from this source. A small part of the rain falls directly on coarse sediments in the open washes; much of this is lost by evapotranspiration but some undoubtedly reaches the water table after heavy rains.

Runoff

A large part of the recharge to the ground-water reservoir of the Palomas-Dendora area is derived from runoff in intermittent streams of the region. No streamflow or recharge studies have been made in the area, but it is believed that recharge occurs in a manner similar to that described in the report of the Queen Creek investigation (Babcock and Cushing, 1942, p. 49-56). These authors stated, "The computed average rate of infiltration over the wetted area for the different floods varied from 0.14 to 2.09 feet per day and averaged 1.08 feet per day.

The rate of infiltration for the summer-type flash floods was less and showed a wider range than those for the winter-type floods. This is attributed to the fact that floods of the summer type are of shorter duration and on the average carry more silt than those of the winter type.

"A comparison of the rates of infiltration over the wetted area between the gaging-stations during floods with the rates determined from seepage-measurements during moderate to low flows of comparatively clear water is instructive. The average for the floods over the entire stretch was only about a foot a day, while the average for the clear water in the individual parts of the stretch during the seepage runs was more than four feet a day. The smaller rate of infiltration during the floods was due in part to the large silt-load carried during the early stages of the flood, and in part to the spreading of the flood water during large flows upon the silty rather impermeable material in areas outside the channels.

"In the seepage-measurements it was noted that the rate of infiltration progressively decreased in a downstream direction as the material in the channel bottom became progressively finer. It was also observed that during continuous flows of clear water after floods, the rate of infiltration increased with time ... In each case the water was clear at the upper gaging-station but became progressively muddier downstream, showing that the clear water had sufficient velocity to transport the fine material, leaving the coarser and more permeable material." The report states also that during the period February 12, 1940 to March 13, 1941, about half the water that entered a 19-mile reach of the Queen Creek channel was recharged to the ground-water reservoir.

The Gila River, which ultimately drains all the excess runoff from the Palomas-Dendora drainage basins, is influent from the Painted Rock Mountains to the point where it leaves the area. Within this reach the river may contribute more recharge than any other source, but the quantity cannot be determined until more data are obtained.

Underflow

The quantity of underflow that enters the Palomas-Dendora area is apparently small. The gap at the north end of the Painted Rock Mountains and the gap in the Clanton Hills are both about a quarter of a mile in width. Test drilling by the Corps of Engineers has shown that the gap at the north end of the Painted Rock Mountains is filled to a maximum depth of about 80 feet with fairly permeable alluvium. The amount of underflow that passes through this gap is estimated, on the basis of a preliminary pumping test, not to exceed 300 acre-feet per year. No data are available as to the total depth of fill in the gap in the Clanton Hills. However, the depth to water in the

Clanton well, just upstream from the gap is 245 feet. No estimate of the underflow through this gap can be made until the depth and permeability of the alluvial material are known, but because of the small annual rainfall and the relatively small size of the upstream drainage basin, the quantity probably is not large.

Another source of recharge is ground water that moves westward around the south end of the Painted Rock Mountains. Water levels in three wells in this vicinity indicate that there is such ground-water movement, but the amount of recharge from this source is not known.

Irrigation

An average of about 37,000 acre-feet of ground water was pumped annually during the period 1952-54 for irrigation of the cultivated land in the Palomas-Dendora area. It has been estimated (Turner and others, 1941, p. 28) that at least 20 percent of the water applied directly to the land in the Safford and Duncan-Virden Valleys, Ariz., infiltrates to the water table. If 20 percent of the applied water returns to the ground-water reservoir in the Palomas Plain-Dendora Valley area, then about 7,000 acre-feet of the irrigation water can be considered annual recharge.

Discharge

Discharge of ground water from Palomas Plain and Dendora Valley occurs both by pumping and by natural means. Natural discharge of ground water includes that lost by evaporation, transpiration, and underflow. There is no surface flow out of the area, except occasional flood flows.

Pumping

Palomas Plain.--The principal development of ground water in Palomas Plain has taken place since 1950. There are records of only 7 irrigation wells in the Palomas area that were drilled prior to 1951, but completion dates are missing from the records of 14 other irrigation wells, and a few of these may have been completed before the greater part of the development took place. From 1951 through 1954, 34 more wells were put into operation. The total amount of ground water pumped for irrigation in 1950 is estimated at 9,000 acre-feet. The use of water was about 15,000 acre-feet in 1951, 26,000 acre-feet in 1952, 37,000 acre-feet in 1953, 30,000 acre-feet in 1954, and 25,000 acre-feet in 1955. These figures do not include the small quantity of ground water pumped by windmills for stock or domestic use.

Two or more water-level measurements have been made in a few wells in the area. The water levels in some wells have been measured at intervals of several years; others have been measured annually for 2 or 3 years. The measurements indicate that the trend of the water table is slightly downward, but the period of record is short and the amount of change small.

The yield of ground water varies from well to well within the Palomas-Dendora area, depending upon the type of material in which the well has been developed. The type of material and yield at any particular site cannot be predicted without test drilling. Table 2 shows the maximum, minimum, and average yield of wells within various townships and may indicate in a general way the areas where productive wells can be located.

Table 2.--Yields of wells in the Palomas-Dendora area.

Location		Number of wells	Maximum* (gpm)	Minimum* (gpm)	Average (gpm)
Township	Range				
4 S.	8 W.	6	2,500	700	1,600
4 S.	10 W.	3	800	500	700
4 S.	11 W.	2	1,500	1,400	1,400
5 S.	10 W.	5	1,300	500	800
5 S.	12 W.	13	1,700	800	1,300

* Quantities are approximate, as methods used for obtaining discharge measurement had some inherent inaccuracies. Discharge measurements made in August 1954.

Several wells have had a satisfactory initial yield but have failed subsequently, owing to an excessive discharge of fine sand. In a few places this condition has resulted in caving of the well and the loss of pump and casing. Gravel packing has been resorted to in an effort to eliminate or reduce the pumping of sand, but so far as known there has been no use of screens in conjunction with the gravel packing. Any such undertaking should be preceded by laboratory tests to determine the proper screen openings and gravel size.

Dendora Valley.--The major part of the ground-water development in Dendora Valley took place in the late 1930's and early 1940's, when the land was cleared and most of the wells were drilled. Since that time the cultivated area has remained nearly constant and there has been no great variation in the amount of ground water used. The quantity of ground water pumped was 6,000 acre-feet in 1950, 6,000 acre-feet in 1952, 5,000 acre-feet in 1953, 7,000 acre-feet in 1954, and 6,000 acre-feet in 1955. No record is available for 1951. The amount of ground water pumped for stock and other purposes during this time was comparatively small.

Natural discharge

Surface flow.--No ground water is discharged as streamflow, because the streams are influent throughout most or all of their courses in the Palomas-Dendora area. The only surface water discharged is that part of the flood flows which does not infiltrate to the water table or is not lost by evaporation or transpiration.

A group of small springs at Agua Caliente have a total flow of about 1,400 acre-feet per year. All the spring discharge is transported away from the source in ditches and a small part is used for irrigation. The balance either infiltrates to the water table as recharge or is lost by evaporation and transpiration.

Evapotranspiration.--Based on aerial photographs, it is estimated that the acreage covered by phreatophytes in the Palomas Plain-Dendora Valley area is about two-thirds the acreage in the Gila Bend area. Evapotranspiration in the Gila Bend area has been estimated by the Geological Survey to be roughly 23,000 acre-feet per year. Thus it may be estimated that evapotranspiration in the Palomas Plain-Dendora Valley area is 15,000 acre-feet.

Underflow.--No data are available to indicate the quantity of water that leaves the area as underflow in the alluvial fill of the Gila River Valley.

Storage

More than 500,000 acres in the Palomas-Dendora area is underlain by unconsolidated alluvial material. The numerous small interstices in this material normally constitute about 10 to 40 percent of the total volume of uncemented alluvium, and below the water table they contain water in storage. Much of the water in storage is available for pumping when a long period of time is considered, but some will never be available because it adheres to the surfaces of individual grains. The percentage of water that will drain from a rock by gravity compared to the total volume of the rock is called the specific yield. In the younger alluvial material in the Palomas-Dendora area, the specific yield may be as much as 15 percent of the total volume. The older alluvium usually contains more fine material, is more tightly cemented, and the specific yield is lower, possibly less than 10 percent. Assuming an average specific yield of 10 percent, the first 100 feet of alluvial material below the water table would contain about 5,000,000 acre-feet of ground water.

The thickness of the alluvium in the Palomas-Dendora area is not known, as the deepest wells have not penetrated to bedrock, but geologic evidence suggests that the basins are comparable to other basins in southwestern Arizona in which bedrock is more than 1,000 feet deep.

The agricultural life of the area depends on the rate of use and the quantity of recoverable ground water in storage. The total quantity stored may be several times that calculated for the first 100 feet of saturated alluvial fill, but the percentage recoverable cannot be estimated from available data.

Quality of Water

Chemical analyses (table 5) were made of 55 samples of ground water collected at irregular intervals from 1946 through 1955. Supplemental partial chemical analyses were made of water from some of the wells, and the data are on file in the U. S. Geological Survey office, Phoenix, Ariz. The analyses indicate that the ground water in the Palomas-Dendora area is extremely varied in quality, ranging in dissolved-solids content from 312 to 12,500 ppm. Chloride, sodium, sulfate, calcium, and in places bicarbonate are the predominant constituents in the more highly mineralized water. The data indicate that the temperature of the water also has an unusually wide range, from 73° to 112° F, and has no apparent relationship to the amount of dissolved solids in the water.

Most of the ground water from wells near the Gila River contains enough dissolved minerals to have a salty taste; that from wells to the north has smaller quantities of mineral matter and little or no taste.

Chemical analyses of water from wells near the Gila River indicate that most of the water may be rated, with respect to percent sodium and specific conductance, as "doubtful to unsuitable" or "unsuitable" for irrigation use as classified by Wilcox (1948, p. 6). The application of water having a percent sodium exceeding 60 may cause the soil to become less permeable and so retard the downward movement of water. However, good drainage and the use of excess water tends to minimize this effect of sodium on the soil. Water having a specific conductance greater than 2,000 micromhos is classified by Wilcox as "doubtful to unsuitable" for irrigation. Wilcox's classifications are based on the assumption that the water will be used under average conditions with respect to quantity, soil permeability, drainage, climate, and crops. Some ground waters that might be classified as "unsuitable" are being used successfully for irrigation. Analyses of ground water from irrigation wells more than a mile north of the Gila River indicate that most of the water may be rated, with respect to percent sodium and specific conductance, as "permissible to doubtful," although some is rated "doubtful to unsuitable." Much of the water north of the river has a relatively low specific conductance, less than 2,000 micromhos, but the percent sodium may be as high as 90, which causes an otherwise "good to permissible" water to be classified as "doubtful to unsuitable." However, this high sodium content usually has little harmful effect when the water is used on permeable soils.

Boron is essential to plant growth. However, in concentrations only slightly above the optimum boron is exceedingly toxic. The observed concentration of boron in the ground water in the Palomas-Dendora area, classified according to Wilcox (1948), ranged from "excellent" to "unsuitable" for sensitive and tolerant crops. Water containing more than 1.25 ppm boron is unsuitable for boron-sensitive crops; more than 2.50 ppm is unsuitable for semitolerant crops; and more than 3.75 ppm is unsuitable for the tolerant crops.

The fluoride content of the water ranges from 0.4 to 8.0 ppm. Moderate quantities of fluoride are not known to be harmful to crops, animals, or adult human beings. It is recognized generally that fluoride in drinking water consumed by children during the time that their permanent teeth are being formed reduces the occurrence of dental caries (tooth decay), but an excess may cause dental fluorosis (mottled enamel). According to Galagan and Lamson (1953, p. 507), a satisfactory drinking water should contain no more than 0.8 ppm fluoride. Water having quantities in excess of this may cause moderate to severe dental fluorosis. Water containing 0.6 to 0.8 ppm of fluoride may cause mild fluorosis which is generally not objectionable, and water containing 0.6 ppm or less causes no perceptible fluorosis.

There are two principal sources of dissolved solids in the Palomas-Dendora area. The high concentrations near the Gila River are due primarily to recharge from the low flow and underflow of the river. This is indicated by analyses of water from two wells, (C-4-7)18dda and (C-4-7)18dd, which have been drilled in the river channel at the north end of the Painted Rock Mountains. These analyses were of samples taken at different times from the wells, and they show a range of 5,400 to 12,500 ppm in dissolved solids. Shortly after periods of flood flow, the water may contain less than 5,400 ppm, and after long periods of no flow the concentration may be even greater than 12,500 ppm. The dissolved solids in the less concentrated water north of the Gila River result from the dissolving action of water as it moves through the alluvial materials.

Table 3.--Records of wells and springs in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.

Well location	Well owner, tenant (T), or name (W)	Date of completion	Chemical analysis in report	Well log in report	Tem-pera-ture (°F)	Type of well a/	Depth of well b/	Diameter of well casing (inches)	Water level (depth below land surface) b/	Date of meas-urement	Pump and power c/, d/	Use of well e/	Remarks
(C-1-15)													
12c	Hovatter	-	-	-	-	-	150R	13	80.3	5/11/54	H	D	
13a	Hovatter no. 4	-	-	-	-	-	-	-	160 R	-	C,W	D	
13d	Sheep Tank Well (W)	1932	-	-	-	D	1,050R	18	463 R	-	-	-	
18cb	Hoodoo Well (W)	-	x	-	76	-	-	-	Shallow	-	C,W	S	
(C-2-9)													
27abc1	Wild Life Restoration Unit?	-	-	-	-	-	-	-	18.5	9/54	C(?)W	S	
27abc2	-	-	-	-	-	-	-	6	18.1	9/54	N	N	
(C-2-12)													
12aa	Clanton Well (W)	-	x	-	-	D	360R	4 to 3 to 2-3/4	244.7	5/7/54	C(?)W	S	
(C-3-8)													
22bb	So. Pacific RR	1/15/27	-	x	-	D	655	10	204.6	2/54	G	RR,D	
(C-3-9)													
7bcc	McDonald	-	x	-	81	D	200R	-	60 R	-	G	D	
(C-3-11)													
34bba	Red Mountain Well (W)	-	x	-	-	D	-	6	283.9	5/27/55	C	N	
(C-4-7)													
18dda	Corps of Engineers	4/53	x	-	73.5	D	18	18	7.5	4/15/53	N	O	
18dd	Corps of Engineers	1953	x	-	74	D	71	24	7.5	5/54	-	O	
(C-4-8)													
1bbd	-	-	-	-	-	D	-	6	76.1	9/26/54	C,W	S	
9dca	-	-	-	-	-	D	-	6	57.3	9/26/54	C,W	S	
14bbb	Frederick, C. H.	-	-	-	-	D	150	20	27 R	-	-	I	

a/ D, drilled well; Dug, dug well.
b/ Measured unless R, reported.
c/ C, cylinder; T, turbine; Ce, centrifugal.
d/ E, electric; G, gasoline, natural gas or butane; H, hand; D, diesel; W, wind; N, none.
e/ D, domestic; I, irrigation; S, stock; O, observation; N, none; RR, railroad; A, abandoned; Ind, industrial.

Table 3.--Records of wells and springs in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

Well location	Well-owner, tenant (T), or name (W)	Date of completion	Chemical analysis in report	Well log in report	Temperature (°F)	Type of well a/	Depth of well b/	Diameter of well casing (inches)	Water level (depth below land surface) b/	Date of measurement	Pump and power c/, d/	Use of well e/	Remarks
(C-4-8) con.													
23dbb	Pettit, A. E.	before 1934	-	-	-	D	100R	20	27.2	1/24/46	-	-	Well has been destroyed
23ddd	Bates Bros. (T)	1937	-	-	-	D	180R	20	37.5	5/31/54	E	I	Pump has been removed
26aab	Pettit	before 1934	-	-	-	D	124R	20	29.4	5/14/55	None	A	
26add	Pettit, A. E.	10/48	-	x	91	D	185R	-	52.3	1/8/54	T,E	I	Original well collapsed
26ddd	Bates Bros.	1940	x	x	95	D	192R	24	50.6	1/8/54	T,E	I	Salty taste
27dda	Bates Bros.	1939	x	x	75	D	100R	24	23.2	12/22/53	T,E	I	Salty taste
27dda (N.E.)	Bates Bros.	-	x	-	83	D	246R	8	-	-	Ce,E	D	Good taste
31ccc	Sevey, G. T.	1940	-	x	-	Dug	40	10 ft.	21.6	12/23/53	Ce,E	I	
31cdd	Sevey & Williams	1952	x	-	85	D	-	-	28.8	12/30/54	T,E	I	
34cdd	Pettit, A. E.	1937	-	-	-	D	120R	20	27.6	1/24/46	N	A	Caved and filled
34ddd	Bates Bros. (T)	1939	x	x	79	D	438R	24	37.9	12/22/53	T,E	I	Deepened from 100 feet 1952
35bdd	Dendora Ranch	1951	x	x	87	D	272R	20	45.8	3/4/54	T,E	I	
35cac	Bates Bros. (T)	1944	-	x	83	D	214R	24	37.9	1/24/46	T,E	I	
35daa	Bates Bros. (T)	5/46	-	x	87	D	212R	24	62.6	1/8/54	T,E	I	
35dbb	Bates (T)	2/54	x	-	86.5	D	224R	8	-	-	E	D	Good taste
(C-4-9) 9aad	-	1953	-	-	-	D	190R	-	168?	9/54	W	S	Measurement only approximate
(C-4-10)													
3daa	Roe	1955	-	x	-	D	451R	16	-	-	-	-	Well not completed on 5/8/55
6bba	Mollohan, H. D.	-	-	-	96	D	-	16	236.8	3/4/54	T,D	I	
6bbb	Mollohan, H. D.	12/52	x	x	95	D	450R	16	237.4	1/22/54	T,G	I	
7bbb	Mollohan, H. D.	-	x	-	93	D	500R	16	209.5	3/24/53	T,D	I	
9baa	Smith, M. T.	1953	-	-	-	D	628R	16	192.8	1/22/54	N	I	
21bbb	Whiting Bros.	1953	-	-	-	D	265R	-	129.7	8/27/54	N	-	Well never used
22abb	Whiting Bros.	6/53	-	x	-	D	500R	16	128.0	8/27/54	N	-	Pump pulled
24ccb	Webb	-	-	-	-	D	212	6	96.0	9/54	N	O	
32aba	Whiting Bros.	-	-	-	-	D	1,500?	16	101.4	1/19/54	N	-	No pump 1/19/54
32abb	Whiting Bros.	5/51	-	x	-	D	176R	20	103.5	1/19/54	T,E	I	
32cdd	Tennyson, Tom	-	-	-	-	D	-	18	78.9	3/4/54	-	-	
33acc	Tennyson, Tom	-	-	-	-	D	700R	20	88.2	1/19/54	-	I	
33bdd	Tennyson, Tom	6/48	x	x	78	D	640R	20	88.6	1/19/54	T,E	I	
34bbb	Amely, Sofia (T)	3/48	-	x	-	D	240R	20	92.8	11/6/54	N	-	Pump out 11/54
(C-4-11)													
5bbb	Hauser, W. M.	5/53	x	x	105	D	465R	16	280.6	5/8/55	T,D	I	Temp. reported to be 112° after 4 days of pumping
6aab	-	-	x	-	100	D	-	16	280	5/13/54	T,D	I	Water level approximate
12bbb	Goldstein, Ben	1/53	x	x	-	D	415R	16	221.2	3/24/53	T,D	I	

Table 3.--Records of wells and springs in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

Well location	Well owner, tenant (T), or name (W)	Date of completion	Chemical analysis in report	Well log in report	Temperature (°F)	Type of well a/	Depth of well b/	Diameter of well casing (inches)	Water level (depth below land surface) b/	Date of measurement	Pump and power c/, d/	Use of well e/	Remarks
(C-4-11) con.													
26baa	Edwards & Porter	12/53	-	-	-	D	335R	20	139 R	-	T,E	I	
26bbb	Edwards & Porter	1/12/54	-	x	-	D	330R	16	139.5	1/13/54	-	-	
(C-4-13) 25c	-	-	-	-	-	D	-	6	70.6	4/54	W	S	
(C-5-8) 3aac	Dendora Ranch	1954	-	x	-	D	-	-	-	-	-	-	Being drilled
6baa	Sevey, L. V.	1932	-	-	-	Dug	30R	96	16.7	12/23/53	C,E	I	
(C-5-9) 6ddd	-	-	-	-	-	Dug	-	42 to 6	28.4	1/6/54	C,W	S	
12acd	Hunsaker	7/47	x	x	91	D	620	24 to 20	19.3	8/27/54	T,E	I	
(C-5-10) 7cbb	Carpenter, J. C.	-	x	-	83	Dug,D	155R	-	55.9	1/19/54	C,G	D	Dug to approximately 90 feet
7dcc	Carpenter, J.	-	-	-	-	D	-	6	-	-	-	S	
8ccd	Morris Ranch	-	-	-	-	Dug,D	110	12	49.2	1/6/54	C,N	N	Dug to approximately 30 feet
10ddb	-	-	-	-	-	D	-	6	23.6	3/23/53	C,W	S	
14baa	Carpenter, J. C.	-	-	-	-	Dug,D	-	-	-	-	Ce,G	S	
16abb	Robertson, Jimmy	-	x	-	77	D	72R	20	33.9	1/6/54	T,E	I	
16acb	Robertson, Jimmy	-	-	-	77	D	72R	20	30.7	1/6/54	T,G	I	
16cbb	Robertson	1954	-	x	91	D	72R	20	35.0	1/6/54	T,E	I	
16ccb	Robertson	1954	x	x	103	D	84R	20	26.4	1/6/54	T,E	I	
19aa	Modesti, A.	-	x	-	96 to 104.5	Sprs.	-	-	-	8/27/54	-	-	
20dbb	Eagle, Scout Grey	-	-	-	-	Dug	-	60	12.7	5/15/55	Ce,E	N	Not in use
20dbd	Eagle, Scout Grey	-	x	-	92	Dug	14R	72	10.8	1/6/54	Ce,E	N	Not in use
23dbb	McGann, J. A.	5/52	-	-	-	D	100R	16	18.4	1/14/54	T,G	I	Deepened 1954
28dad	Walker, Clyde	-	-	-	-	D	290R	18	21.2	1/13/54	T,G	I	
28dba	Walker, Clyde	-	x	-	76	D	104R	16	21.8	1/13/54	T,G	I	
28ddc	Walker, Clyde	-	-	-	-	D	104R	18	19.4	1/13/54	N,N	N	Not in use
32aaa	Wertz, Fred	5/52	x	x	74	D	112R	16	17.2	4/23/53	T,D	I	
32cac	Wertz, Fred	9/52	-	x	-	D	86R	18	19.5	8/26/54	T,D	I	
32ddc	Krausse, F.	1/54	-	-	-	D	180R	20	24.6	8/27/54	T,D	I	
36aca	Browning, E. V.	3/52	-	x	-	D	700R	16	156.8	8/27/54	T,D	I	

Table 3.--Records of wells and springs in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

Well location	Well owner, tenant (T), or name (W)	Date of completion	Chemical analysis in report	Well log in report	Temperature (°F)	Type of well a/	Depth of well b/	Diameter of well casing (inches)	Water level (depth below land surface) b/	Date of measurement	Pump and power c/, d/	Use of well e/	Remarks
(C-5-11)													
1dcb3	So. Pacific RR no. 3	1943	-	x	-	D	229R	12	72.0	1/13/54	N,N	-	
2bbb	Tri-Delta Farms	6/51	-	x	-	D	423R	20	81 R	10/23/52	-	-	
3bab	Winfield Cattle Co.	-	-	-	-	D	280	6	100.0	5/8/55	W,G	S	
10dda	Porter, P. L.	3/53	x	x	-	D	510R	16	65.6	1/22/54	N,N	N	
12aaa	Keafer, H. W.	-	x	-	-	D	262R	6	65.4	1/14/54	N,N	O	
12cba1	Keafer, H. W.	-	x	-	88	D	100R	12	67 R	-	T,G	I	
12cba2	Cunningham, E. (T)	-	-	-	-	D	88R	12	67.3	1/22/46	C,N	N	
12ddb	Keafer, H. W.	-	-	-	-	Dug	75	72	69.7	1/22/46	N,N	N	Pump and platform fallen in well 1/54
15abb	Porter, P. L.	-	-	-	-	D	-	16	64.0	3/4/54	N,N	N	
17bbb	Winfield Cattle Co.	-	-	-	-	Dug	71	-	62.8	2/12/53	C,W	S	
(C-5-12)													
4bcb	Willard & Downing	11/53	x	x	85.5	D	370R	20 to 16	139.0	8/26/54	T,E	I	
5aab	Willard & Downing	12/52	-	x	87	D	330R	16	140 R	-	T,E	I	
8bdd	Jim's Well (W)	-	-	-	-	Dug	-	72	107.1	4/54	C,W	N	
9bbb	Willard, John	4/49	-	x	85	D	560R	14	126.6	8/26/54	T,E	N	Deepened from 380
15bcb	Riddle, W. H. no. 10	12/52	-	x	92	D	505R	20	95.5	12/28/53	T,E	I	
15cca	Riddle, W. H.	7/52	-	x	93.5	D	475R	16	104 R	-	T,E	I	
16aab	Riddle, W. H.	5/51	x	x	91	D	400R	16	88.5	12/28/53	T,E	I	
16aba	Riddle, W. H.	-	x	-	90.5	D	426R	14	110+	12/29/53	T,E	I	
16acc	Riddle, W. H.	1/52	x	x	92	D	925R	18 to 12-1/4	104.5	12/29/53	T,E	I	
16baa1	Riddle, W. H.	4/53	-	x	89	D	504R	20	104.5	12/28/53	T,E	I	
16baa2	Riddle, W. H.	3/51	-	-	-	D	235R	16	103.0	3/4/54	N	A	
16bbb	Riddle, W. H.	4/51	x	-	99	D	329R	16	110.1	12/28/53	T,E	I	
21bbb	Riddle, W. H.	7/51	-	x	93	D	612R	16	101.3	12/29/53	T,E	I	
21bbd	Riddle, W. H.	6/53	x	x	92	D	260R	16	102.1	12/29/53	T,E	I	
22acd	Riddle, W. H.	1954	x	-	82	D	-	-	-	-	T,E	D	
22bbc	Riddle, W. H.	-	x	x	94	D	570R	20	74.5	12/28/53	T,E	I	
28aaa	Riddle, W. H.	2/52	x	x	92	D	715R	18 to 12	61.6	12/28/53	T,E	I	
33cda1	So. Pacific RR	7/26	x	-	-	D	153R	5-5/8	75 R	-	C,G	D	Water level measured during drilling
33cda2	So. Pacific RR (Horn)	11/54	-	x	-	D	137R	8	87 R	-	-	RR	
35bbb	Cultra, Rice, Riley & Riley	2/53	x	x	87.5	D	486R	20	56.0	1/22/54	T,E	I	
(C-5-13)													
25ddd	Pierce, Paul	1954	-	-	-	D	510R	20	87.8	4/54	N,N	N	

Table 3.--Records of wells and springs in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

Well location	Well owner, tenant (T), or name (W)	Date of completion	Chemical analysis in report	Well log in report	Temperature (°F)	Type of well a/	Depth of well b/	Diameter of well casing (inches)	Water level (depth below land surface) b/	Date of measurement	Pump and power c/, d/	Use of well e/	Remarks
(C-6-8) 17caa	Craig-Stroud Land & Cattle Co.	-	-	-	-	D	260	6	239.2	12/1/54	C,W	N	
(C-6-9) 9aa	U. S. Lee Wells	-	x	-	79.5	D	184	6	170.2	1/21/46	C,W	S	
(C-6-10) 5bd	-	-	x	-	73	D	-	4	-	-	C,W	S	
(C-6-11) 4aba	Mitchell, J. C.	4/53	-	x	-	D	267R	16	23.0	1/22/54	T,E	I	
4bab	Mitchell, J. C.	-	-	-	-	D	-	-	23.9	8/25/54	T,E	I	
5aaa	Mitchell, J. C.	4/53	-	x	-	D	603R	20	24.0	1/22/54	T,E	I	
15daa	-	-	-	-	-	D	-	6	62.4	1/14/54	C,W	N	
(C-6-12) 3aba	Riley, N. H., and others	9/52	-	x	-	D	505R	24 to 20	61.4	3/4/54	N	A	Well collapsed
3baa	Riley, N. H., and others	4/53	x	-	85	D	800R	20 to 16	60.9	1/22/54	T,E	I	
4aaa	Riley, N. H., and others	4/54	-	x	-	D	-	-	74	4/54	N,N	N	Yield insufficient for irrigation
7bbb	Horn Sturgis Gin	-	-	x	-	D	103R	-	71.8	5/12/54	-	Ind	
17baa	Western Farm Management	4/51	-	x	-	D	266R	16	47.5	1/7/54	N	N	E. T. pump has been pulled
17cba	Western Farm Management	3/46	-	x	-	D	112R	24	46.8	1/7/54	T,E	I	
17daa	Western Farm Management	4/51	-	x	75	D	206R	16	35.9	1/7/54	T,E	I	
17dba	Western Farm Management	1939	x	x	75	D	175R	20	42.0	1/7/54	T,E	I	
18dab	Western Farm Management	-	x	x	77	D	77R	20	38 R	1940	T,E	I	
(C-6-13) 2bdd	Fort Horn	-	-	-	-	D	-	-	99.5	4/54	N,N	N	
3aac	-	-	-	-	-	D	-	6	132.5	4/54	N,N	N	

Table 4.--Drillers' logs of wells in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.

	Thickness (feet)	Depth (feet)
(C-3-8)22bb		
Sand, gravel, and boulders	108	108
Semi-cemented material, clay, and gravel	195	303
Gravel and clay	30	333
Conglomerate rock	290	623
Hard granite rock	10	633
Conglomerate rock	42	675
Original depth		700
(C-4-8)26add		
Silt with mountain wash	14	14
Mountain wash	16	30
Sand, gravel, and boulders	18	48
Stratas of mountain wash, gravel, and cemented mountain wash	8	56
Clay with mountain wash	40	96
Mountain wash and loose mountain rock	78	174
Cemented mountain rock and mountain rock	18	192
(C-4-8)26ddd		
Top soil	3	3
Caliche	3	6
Dry mountain wash	18	24
Clay and caliche mixed with mountain wash	12	36
Sand, gravel, and boulders, water at 46 feet	18	54
Cemented sand and gravel	5	59
Dry mountain wash mixed with clay and strata of cemented mountain wash	51	110
Mountain wash and loose mountain rock	34	144
Mountain wash and mountain rock	8	152
(C-4-8)27dda		
Silt, water at 13 feet	17	17
Sand and gravel	28	45
Clay	15	60
Mountain wash	4	64
Cemented mountain wash	4	68
Sandy clay and mountain wash	24	92
(C-4-8)31ccc		
Silt	12	12
Sand and gravel	28	40
(C-4-8)34ddd		
Casing	124	124
Mountain wash, sand, and gravel	32	156
Strata of clay, mountain wash, gravel, and sandstone	14	170
Hard dry clay with mountain wash, gravel	11	181
Sandy clay with mountain wash, gravel	13	194

Table 4.--Drillers' logs of wells in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

	Thickness (feet)	Depth (feet)
Mountain wash, sand, and gravel	16	210
Clay with mountain wash, gravel, and rock	12	222
Mountain wash, sand, and gravel	48	270
Mountain wash, sand, and gravel with clay.	15	285
Mountain wash, sand and gravel and rock.	35	320
Clay with mountain rock	8	328
Mountain wash, sand and gravel and rock.	15	343
Mountain rock with clay	4	347
Mountain wash, sand and gravel and rock.	4	351
Cemented mountain rock	6	357
Mountain wash, sand and gravel and rock with strata of cemented mountain rock	33	390
Hard cemented mountain rock	8	398
Cemented sand and mountain wash, gravel and rock	40	438
(C-4-8)35bdd		
Top soil	3	3
Clay	3	6
Mountain wash, gravel, and sand	3	9
Silt	4	13
Mountain wash, gravel, and sand	13	26
Sand, gravel, and boulders	36	62
Clay with mountain wash, gravel	8	70
Sand and gravel with strata of sandstone	32	102
Strata of mountain wash and cemented mountain wash	24	126
Sandy clay	24	150
Clay with mountain wash, gravel	26	176
Loose mountain wash, sand, and gravel	76	252
Strata of mountain wash and cemented mountain wash	20	272
(C-4-8)35cac		
Top soil	2	2
Hard pan	6	8
Sand	1	9
Clay	7	16
Sand and gravel	8	24
Sand, gravel, and boulders, water 34 feet	42	66
Clay mixed with sand and gravel	114	180
Cemented mountain rock and sand	34	214
(C-4-8)35daa		
Top soil	3	3
Caliche	4	7
Strata of clay, caliche, and mountain wash	33	40
Clay	8	48
Fine sand	2	50
Sand and gravel, water at 62 feet	36	86

Table 4.--Drillers' logs of wells in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

	Thickness (feet)	Depth (feet)
ay with mountain vash and rock	20	106
›ose mountain wash ınd rock with some ;ravel	94	200
›nglomerate	12	212
'-4-10)3daa		
ırface soil	4	4
aliche	16	20
ınd, boulder streaks.	40	60
lay, boulder streaks.	120	180
ınd, clay streaks	48	228
ındy clay	22	250
ınd and clay	22	272
ınd and clay, few boulders	22	294
ocky	23	317
ınd and gravel	22	339
ınd and clay	66	405
ostly clay	23	428
ınd and clay	23	451
C-4-10)6bbb		
ill	245	245
ravel (pea size)	19	264
ill	53	317
ravel (pea size)	17	334
ill	61	395
ravel (pea size)	40	435
ınd and clay	15	450
C-4-10)22abb		
ırface gravel	28	28
lay	113	141
ine sand, small amount of water	8	149

	Thickness (feet)	Depth (feet)
Clay	25	174
Sand	24	198
Clay	13	211
Sand	36	247
Clay	16	263
Sand, black	39	302
Clay	79	381
Sand	6	387
Clay	73	460
Sand	7	467
Clay	33	500
(C-4-10)32abb		
Top soil	40	40
Sand and gravel, fine	40	80
Gravel, rough	86	166
Clay	10	176
(C-4-10)33bdd		
Top soil and sand streaks	40	40
Gravel, boulders, and sand	55	95
Sand, gravel, and boulders	45	140
Clay and shale with sand breaks	60	200
Hard red sandy shale	440	640
585 - 590 Crevice		
625 - 630 Crevice		
(C-4-10)34bbb		
Top soil	7	7
Clay	33	40
Boulders and gravel	58	98

Table 4.--Drillers' logs of wells in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

	Thickness (feet)	Depth (feet)
Gravel and boulders	12	110
Gravel	25	135
Shale	35	170
Sand and gravel	5	175
Red clay	25	200
Boulders and gravel	10	210
Clay and gravel	30	240
(C-4-11)5bbb		
Sandy fill	280	280
Gravel (pea size)	55	335
Sand mixed with clay	64	399
Coarse gravel	49	448
Clay	17	465
(C-4-11)12bbb		
Fill	219	219
Gravel (pea size)	19	238
Fill	43	281
Gravel (pea size)	16	297
Fill	60	357
Gravel (pea size)	28	385
Sand and clay	30	415
(C-4-11)26bbb		
Gravel, sandy fill	108	108
Sandy clay	40	148
Fine sand	33	181
Sandy clay	70	251
Gravel (pea size)	12	263
Sandy clay	33	296
Gravel (marble size)	13	309
Red clay	21	330
(C-5-8)3aac		
Top soil	2	2
Mountain wash	8	10
Silt	6	16
Mountain wash	4	20
Sand, gravel, and boulders	42	62
Clay with mountain wash	78	140
Clay and strata of sand and small gravel	42	182
Sandy clay with mountain wash, sand and gravel	24	206
Cemented mountain wash, sand, and gravel	3	209
Sandy clay with mountain wash, sand, and gravel	51	260
Mountain wash, sand and gravel with strata of cemented sand and gravel	50	310
Strata of cemented mountain wash, sand, and mountain rock	8	318
Mountain wash, sand, and gravel, and mountain rock	64	382
Cemented mountain rock	6	388
Mountain wash, sand, rock with little clay	-	-
Being drilled, total depth unknown		

Table 4.--Drillers' logs of wells in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

	Thickness (feet)	Depth (feet)
C-5-9)12acd		
urface fill	8	8
urface fill with scattered malpais boulders	18	26
ellow clay (little water at 50 feet)	24	50
ellow clay	35	85
ellow clay (quite a lot of water seemingly in cavities, salty) water level 36 feet	55	140
ellow clay with streaks of red-gray sand containing sweet water, water level 34 feet	5	145
ellow clay with light gray sand	2	147
ellow clay	40	187
ight fine gray sand	11	198
ellow clay	39	237
ery fine gray sand	7	244
ellow clay	66	310
lay with a little fine sand and tightly packed gravel	5	315
ellow clay	75	390
treaks of yellow sand and streaks of sand and gravel	35	425
ine gray loose sand	2	427
oft gray sandstone with some streaks of clay	60	487
ostly yellow clay with some fine gray sand	13	500
ine gray sand to small gravel, practically cemented	105	605
Some sand, gravel, and small boulders, water level rose to 15.4 feet	10	615
(C-5-10)16cbb		
Silt	15	15
Not reported	10	25
Quicksand	5	30
Gravel	20	50
Clay	20	70
(C-5-10)16ccb		
Silt	15	15
Coarse sand	10	25
Quicksand	5	30
Gravel	20	50
Clay	20	70
(C-5-10)32aaa		
Soil	18	18
Quicksand	8	26
Gravel and boulders	44	70
Brown clay	13	83
Streaks of sand and gravel	29	112
(C-5-10)32cac		
Silt	17	17
Boulders and sand	31	48
Silt	32	80
Clay	6	86

Table 4.--Drillers' logs of wells in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

	Thickness (feet)	Depth (feet)
(C-5-10)36aca		
Soil	3	3
Malpais	35	38
Brown clay	196	234
Clay and sand streaks	27	261
Gray sand	21	282
Clay with sand streaks	263	545
Sand	11	556
Clay and sand streaks	144	700
(C-5-11)1dcb3		
Red clay and caliche	5	5
Sand	3	8
Sandy red clay	20	28
Fine sand	12	40
Sand and boulders	20	60
Sand and clay	20	80
Red clay	82	162
Packed sand	28	190
Sand and gravel	12	202
Packed sand	14	216
Malpais	13	229
(C-5-11)2bbb		
Top soil	3	3
Caliche	17	20
Gravel and sand one-half inch	10	30
Yellow clay, sandy	32	62
Gravel two inches	14	76
Yellow clay	5	81
Gravel and sand, one inch, water	12	93
Yellow clay	184	277
Sandstone	3	280
Yellow clay	143	423

	Thickness (feet)	Depth (feet)
(C-5-11)10dda		
Soil	8	8
Conglomerate	14	22
Clay and sand mixed	12	34
Gravel	74	108
Clay	52	160
Gravelly clay	40	200
Clay	20	220
Gravelly clay	6	226
Clay	239	465
Clay cinders	10	475
Cinders	35	510
(C-5-12)4bcb		
Decomposed granite and gravel layer	110	110
Solid decomposed granite	35	145
Sand and gravel	105	250
(C-5-12)5aab		
Lava rock, boulders, sand, and clay	140	140
Volcanic ash, pebble	15	155
Clay, decomposed granite	20	175
Granite wash	25	200
Volcanic ash, sand, pebbles	30	230
Decomposed granite, boulders, clay	55	285
Sand, granite wash, gravel	45	330

Table 4.--Drillers' logs of wells in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

	Thickness (feet)	Depth (feet)
(C-5-12)9bbb		
Top soil	4	4
Cemented rocks	6	10
Clay and gravel	110	120
Gravel with clay	110	230
Conglomerated rock and clay, hard	150	380
Decomposed granite	40	420
Malpais boulders	140	560
(C-5-12)15bcb		
Soil	3	3
Sand and gravel	17	20
Sand and clay	45	65
Sand	5	70
Sand and clay	45	115
Sand (water)	15	130
Sand and thin layers of clay	90	220
Coarse sand	10	230
Sand and clay	15	245
Hot mud	10	255
Sand with thin layer of clay	25	280
Clay	5	285
Sandy clay	5	290
Gravel	30	320
Sand and gravel	38	358
Sand	7	365
Sandy clay	10	375
Sand	20	395
Sandy clay	5	400
Sand and gravel	20	420
Sand and clay	10	430
Sand and gravel	10	440
Sand and clay	5	445
Sand	15	460
Sandy clay	20	480
Sand	6	486
Clay	4	490
Sand	15	505
(C-5-12)15cca		
Soil	5	5
Sand and rock	20	25
Sandy clay	15	40
Sand, brown, owner reports sandy clay (soft)	40	80
Clay, white	23	103
Water sand	7	110
Sandy clay	20	130
Sand	39	169
Gravel	3	172
Sand	6	178
Sandy clay	5	183
Sand, fine	4	187
Sand, coarse	8	195
Sand	25	220
Clay	25	245
Sandy clay	10	255
Sand	10	265
Sand, streaked clay	30	295
Clay and sand	5	300
Clay	5	305
Sand	10	315
Sand and clay	5	320
Clay	5	325
Sandy clay	25	350
Clay	5	355
Sandy clay	5	360
Clay	15	375
Sand	5	380
Sand and clay	20	400
Sand	15	415
Clay	5	420
Coarse sand	15	435
Sand	23	458
Sandy clay	7	465
Clay	10	475

Table 4.--Drillers' logs of wells in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

	Thickness (feet)	Depth (feet)
(C-5-12)16aab		
Gravel	30	30
Clay	100	130
Malpais gravel and clay	270	400
(C-5-12)16acc		
Soil	15	15
Black and red sand	19	34
Sand and gravel	18	52
Brown clay	33	85
Fine sand and a few clay streaks	262	347
Coarse gravel	21	368
Hard sand with streaks of soft sand	237	605
Gray sand and sea shells	9	614
Hard sand	5	619
Brown sand	6	625
Coarse sand and clay streaks	29	654
Soft fine red sand	51	705
Hard red and gray sand	220	925
(C-5-12)16baa1		
Soil	2	2
Loose rock	38	40
Sandy clay	65	105
Sand	25	130
Sandy clay	10	140
Sand	20	160
Sandy clay and gravel	55	215
Sand	15	230
Sand and clay	10	240
Sandy clay and hot mud	40	280
Sand and clay	55	335
Fine sand	15	350
Sand	10	360
Coarse sand	10	370
Sand and clay	45	415
Coarse sand	10	425
Clean fine sand	5	430
Sand and clay	74	504
(C-5-12)21bbb		
Silty soil	10	10
Rock	10	20
Sandy clay	30	50
Sand and gravel	10	60
Sand and clay	30	90
Water sand	20	110
Sand and clay	20	130
Sand	10	140
Clay	10	150
Sand	10	160
Clay	20	180
Sand	20	200
Clay	25	225
Sand	10	235
Sandy clay	15	250
Sand	10	260
Clay	180	440
Sand	15	455
Clay and sandy clay	157	612
(C-5-12)21bbd		
Rock	20	20
Sand and clay	75	95
Sand, first water	5	100
Sand and clay	30	130
Clay	5	135
Sand	7	142
Sand and clay	8	150
Clay	15	165

Table 4.--Drillers' logs of wells in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

	Thickness (feet)	Depth (feet)
Clean sand	5	170
Clay	5	175
Clean sand and gravel	8	183
Sandy clay	9	192
Clean coarse sand	4	196
Sandy clay	14	210
Clay	3	213
Coarse sand	12	225
Sand and clay	23	248
Clay	2	250
Sand and clay	10	260
(C-5-12)22bbc		
Soil	12	12
Sand and gravel	36	48
Brown clay	22	70
Sand and clay streaks	128	198
Red and brown streaks of loose sand and gravel	114	312
Clay and sand streaks	73	385
Gravel	10	395
Clay and sand streaks	175	570
(C-5-12)28aaa		
Soil, sand, and gravel	30	30
Brown clay	205	235
Gravel and clay streaks	60	295
Brown clay	35	330
Sand and clay streaks	49	379
Brown clay	46	425
Sand and clay streaks	41	466
Clay	10	476
Gravel	19	495
Clay	13	508
Sand and clay	30	538
Clay	21	559
Gravel	16	575

	Thickness (feet)	Depth (feet)
Sand and clay streaks	83	658
Brown clay	13	671
Sand	16	687
Clay	5	692
Sand, gravel, and boulders	23	715
(C-5-12)33cda2 Horn		
Caliche and boulders	35	35
Clay and boulders	40	75
Sand and boulders	62	137
(C-5-12)35bbb		
Soil	3	3
Rock and gravel	27	30
Sandy clay	15	45
Rock and gravel	5	50
Sandy clay	65	115
Sand	3	118
Sandy clay	17	135
Clay	5	140
Sandy clay	30	170
Sand and silt	15	185
Clay	20	205
Sandy clay	25	230
Coarse gravel	6	236
Sand and clay	9	245
Sandy clay	45	290
Muddy sand	12	302
Coarse gravel	8	310
Sandy clay	10	320
Sand and gravel	5	325
Sandy clay	45	370
Coarse sand and gravel	12	382
Red clay	3	385
Clay	15	400
Sandy clay	48	448
Tough clay	4	452

Table 4.--Drillers' logs of wells in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

	Thickness (feet)	Depth (feet)
Sandy gravelly clay ...	30	482
Tough clay	4	486
(C-6-11)4aba		
Silt	23	23
Gravel	25	48
Clay	16	64
Quicksand	14	78
Clay	22	100
Gravel and clay	23	123
Sand and clay	97	220
Large gravel and clay .	20	240
Clay	27	267
(C-6-11)5aaa		
Soil	19	19
Gravel and sand	30	49
Clay	15	64
Quicksand	14	78
Clay	19	97
Quicksand	29	126
Sticky clay	28	154
Clay and fine sand mixed	50	204
Clay	26	230
Quicksand	4	234
Hard packed clay	20	254
Fine sand	18	272
Gravel, sand, and clay mixed	21	293
Clay	310	603
(C-6-12)3aba		
Sand and gravel	20	20
Sand	10	30
Sand and gravel	8	38
Sandy clay	22	60

	Thickness (feet)	Depth (feet)
Sandy clay and gravel .	28	88
Sand	7	95
Sandy clay	15	110
Sand	10	120
Sandy clay	70	190
Fine silty sand	8	198
Sticky clay	42	240
White clay	7	247
Sand and gravel	6	253
Clay	5	258
Gravel	4	262
Sticky clay	8	270
Sandy clay	40	310
Sand	6	316
Sandy clay	59	375
Red clay	35	410
Clay	15	425
Sandy clay	80	505
(C-6-12)4aaa		
Soil	5	5
Loose rock	20	25
Sandy clay	53	78
Fine sand	7	85
Clay	5	90
Sandy clay	10	100
Clay	25	125
Partial log		
(C-6-12)7bbb		
Caliche and malpais ..	40	40
Granite wash and caliche	8	48
Malpais rock	4	52
Hard caliche	18	70
Dirt clay	2	72
Solid clay	18	90
Gravel and light clay .	2	92

Table 4.--Drillers' logs of wells in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.

	Thickness (feet)	Depth (feet)
ay	3	95
ne sand	8	103
-6-12)17baa		
ndy soil	9	9
nd	43	52
avel (Gila)	24	76
nd and clay strata	28	104
ay	70	174
nd, mucky	15	189
ay	8	197
ucky sand	4	201
ay, soft	20	221
description	5	226
ndstone and mucky sand	12	238
ay	4	242
ucky sand	4	246
ay	20	266
-6-12)17cba		
p soil, very sandy	50	50
nd, gravel, and river boulders	20	70
ay	42	112

	Thickness (feet)	Depth (feet)
(C-6-12)17daa		
Silt soil	4	4
Sandy clay	14	18
Clay, soft	24	42
Gravel (Gila)	32	74
Clay	10	84
Sand, mucky	11	95
Clay	2	97
Sand, mucky	17	114
Clay, tough	32	146
Mucky sand and clay strata	46	192
Clay, tough	14	206
(C-6-12)17dba		
Dirt	44	44
Hard streak	1	45
Boulders, small to large	35	80
Clay	95	175
(C-6-12)18dab		
Valley soil	14	14
Hard clay	37	51
Gravel	22	73
Hard clay	4	77

Table 5.--Chemical analyses of water from wells in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.
(Analyses in parts per million, except as indicated)

Well location	Date of collection	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)	Boron (B)	Dissolved solids: Parts per million	Dissolved solids: Tons per acre-foot	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	Analyses other than USGS	Remarks
(C-1-15)																				
?	4/17/55	77	41	55	14	34	307	0	8.8	3	0.4	4.9	-	312	0.42	194	28	493		One of the Hovatter wells
18cb	4/17/55	76	59	62	39	164	478	0	68	144	.7	6.2	-	778	1.06	315	53	1,280		Hoodoo well
(C-2-12)																				
12aa	6/1/55	82	35	13	3.5	100	237	0	17	22	1.0	25	-	334	.45	47	82	520		Clanton well
(C-3-9)																				
7bcc	11/20/54	81	32	39	13	118	350	0	29	59	1.4	5.6	-	469	.64	151	63	776		
(C-3-11)																				
34bba	1/22/46	85.5	-	41	1.4	176	96	0	110	202	3.9	3.6	0.74	585	.80	108	81	1,030		
(C-4-7)																				
18dda	4/15/53	73.5	24	394	124	1,440	382	0	713	2,510	8.0	2.4	3.4	5,400	7.34	1,490	68	8,710		
18dd	5/27/54	74	32	925	425	3,100	422	0	1,380	6,380	-	16	-	12,500	17	4,060	62	18,900		
(C-4-8)																				
26ddd	4/11/46	95		74	12	442	94	0	225	615	5.1	4.1	1.4	1,420	1.93	234	84	2,530		
26ddd	10/54	95	38	123	13	534	79	0	235	850	3.6	5.9	-	1,840	2.5	350	76	3,210		
27dda	4/11/46	74		391	153	859	294	0	601	1,830	1.0	27	.55	4,010	5.45	1,600	61	6,910		
27dda (N.E.)	5/14/55	83	45	25	6.4	327	186	0	88	390	1.8	1.2	-	975	1.33	89	89	1,740		
31cdd	5/14/55	84.5	38	421	90	987	204	0	603	1,790	2.7	298	3.9	4,330	5.89	1,420	60	6,780		
34ddd	4/11/46	79		159	23	936	177	0	601	1,220	6.8	21	-	3,050	4.15	491	84	5,020		
35bdd	5/26/55	87.5	66	218	28	779	132	0	471	1,220	6.4	21	3.8	2,870	3.90	659	72	4,770		
35dbb	5/14/55	86.5	42	32	3.7	360	92	0	191	412	7.0	5.4	-	1,100	1.5	95	89	1,880		
(C-4-10)																				
6bbb	8/25/54	95	49	21	3.4	205	98	0	123	199	6.4	8.8	-	664	.90	66	87	1,090		
7bbb	8/25/54	93		-	-	-	111	0	-	190	-	-	-	-	-	-	-	1,090		
33bdd	8/27/54	78	37	302	16	556	113	0	464	985	5.9	59	-	2,480	3.37	820	60	4,170		
33bdd	9/10/52	78	39	190	14	414	114	0	358	650	5.6	42	-	1,770	2.41	532	63	2,900		
(C-4-11)																				
5bbb	7/53	-	-	15	8	158	107	0	100	146	-	14	-	548	-	70	87	-	U. of A.	
5bbb	5/11/53	112	51	23	2.1	147	112	0	86	129	4.8	12	5.3	510	.69	66	83	826		Pumped 4 days. Temperature reported to increase with time from 105°
6aab	8/25/54	100	57	22	1.5	133	128	0	81	100	4.8	10	-	472	.64	61	83	749		
12bbb	Spring '53	-	-	8	4	216	117	0	120	194	6.0	9	.88	668	-	36	95	-	U. of A.	
(C-5-9)																				
12acd	7/47	-	-	53	4	413	12	T	309	500	3.6	-	-	1,300	-	149	88	-	U. of A.	
12acd	6/5/55	91	21	55	3.3	421	34	0	314	494	4.8	2.8	1.2	1,330	1.81	150	86	2,290		

T: Trace

Table 5.--Chemical analyses of water from wells in the Palomas-Dendora area, Maricopa and Yuma Counties, Ariz.--continued.
(Analyses in parts per million, except as indicated)

Well location	Date of collection	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)	Boron (B)	Dissolved solids: Parts per million	Dissolved solids: Tons per acre-foot	Total hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)	Analyses other than USGS	Remarks
(C-5-10)																				
7cbb	1/26/46	83	-	7.0	1.0	226	121	-	131	184	5.1	6.0	0.74	620	0.84	22	97	1,070		
16abb	8/27/54	77	51	234	24	846	176	0	917	975	6.9	38	-	3,180	4.32	682	73	4,810		
16ccb	1/53	-	-	8	4	243	81	7	170	214	-	4	1.4	731	-	36	95	-	U. of A.	
19aa	1/30/46	96 to 102	-	10	1.2	226	101	0	143	192	5.5	4.7	.92	632	.86	30	95	1,100		Composite sample
20dbd	3/23/53	92	42	27	3.7	255	101	0	187	244	5.6	1.4	1.6	816	1.11	82	87	1,370		
28dba	3/23/53	76	28	221	75	473	302	0	441	835	.8	2.9	-	2,230	3.03	860	54	3,640		
28dba	8/26/54	74	28	421	147	695	305	0	698	1,550	.6	2.1	-	3,690	5.02	1,660	48	5,870		
32aaa	9/29/52	-	-	465	150	993	305	0	840	1,980	-	-	-	4,730	-	1,780	55	-	U. of A.	
(C-5-11)																				
10dda	6/53	-	-	8	4	194	83	0	110	188	-	9	-	596	-	36	94	-	U. of A.	
12aaa	7/22/48	-	-	38	4	24	122	0	134	288	1.5	2	-	614	-	111	38	-	U. of A.	
$12cba_1$	1/22/46	88	-	16	1.7	249	90	0	138	250	4.9	72	.92	711	.97	47	93	1,240		
(C-5-12)																				
4bcb	8/26/54	85.5	58	17	3.1	166	150	0	88	129	4.0	11	-	550	.75	55	87	870		
16aab	5/6/52	91	-	14	2	136	117	0	88	100	-	12	-	469	-	43	89	-	Ariz. Fertilizer Inc.	
16aba	10/52	-	-	23	8	152	134	0	100	138	-	10	-	565	-	89	83	-	U. of A.	
16acc	8/26/54	91.5	43	14	2.6	152	125	0	81	120	4.4	10	-	488	.66	46	88	798		
16bbb	5/6/52	99	-	18	3	150	115	0	84	136	-	12	-	518	-	52	88	-	Ariz. Fertilizer Inc.	
21bbd	8/25/54	92	55	20	3.6	169	120	10	92	145	4.0	8.6	-	566	.77	65	85	920		
22acd	8/26/54	82	41	75	18	285	126	0	157	402	3.6	47	-	1,090	1.48	261	70	1,880		
22bbc	8/26/54	94	52	26	9.5	185	124	0	110	190	3.6	16	-	653	.89	104	79	1,090		
28aaa	8/25/54	93	48	40	6.2	222	102	0	96	285	4.4	15	-	767	1.04	126	79	1,310		
$33cda_1$	4/23/46	-	-	11	1.7	163	109	0	77	142	4.0	10	-	462	.63	34	93	865		Sample taken from tank
35bbb	3/24/53	87	39	21	3.1	175	104	0	77	188	3.2	9.0	-	566	.77	65	85	969		
(C-6-9)																				
9aa	1/21/46	79.5	-	32	3.7	293	111	0	201	284	5.9	20	1.4	894	1.22	95	89	1,540		
(C-6-10)																				
5bd	1/30/46	73	-	433	175	980	330	0	682	2,090	.5	1.4	.37	4,520	6.15	1,800	62	7,280		
(C-6-12)																				
3baa	8/26/54	85	31	13	.5	153	103	0	90	122	3.6	10	-	474	.64	34	91	787		
17dba	4/23/46	75	-	256	146	962	317	0	671	1,670	2.1	14	-	3,880	5.28	1,240	71	6,340		
18dab	4/23/46	77	-	147	80	1,040	282	9.8	554	1,490	4.2	18	-	3,480	4.73	696	89	5,240		

REFERENCES

Babcock, H. M., and Cushing, E. M., 1942, Recharge to ground water from floods in a typical desert wash, Pinal County, Ariz.: Am. Geophys. Union Trans., p. 49-56.

Bancroft, Howland, 1911, Reconnaissance of the ore deposits of northern Yuma Co., Ariz.: U. S. Geol. Survey Bull. 451.

Bryan, Kirk, 1925, The Papago country, Arizona, a geographic, geologic, and hydrologic reconnaissance with a guide to desert watering places: U. S. Geol. Survey Water-Supply Paper 499.

Fenneman, N. M., 1931, Physiography of western United States: New York, McGraw-Hill Book Co., Inc.

Galagan, D. J., and Lamson, G. G., 1953, Climate and endemic dental fluorosis: U. S. Public Health Repts., v. 68, no. 5, p. 497-508.

Ross, C. P., 1922, Geology of the lower Gila region, Arizona: U. S. Geol. Survey Prof. Paper 129.

__________ 1922, Routes to desert watering places in the lower Gila region, Arizona: U. S. Geol. Survey Water-Supply Paper 490-C.

__________ 1923, The lower Gila region, Arizona, a geographic geologic, and hydrologic reconnaissance with a guide to desert watering places: U. S. Geol. Survey Water-Supply Paper 498.

Turner, S. F., and others, 1941, Water resources of Safford and Duncan-Virden Valleys, Ariz.: U. S. Geol. Survey open-file report (mimeographed).

Wahlstrom, E. E., 1950, Theoretical igneous petrology: New York, John Wiley & Sons, Inc.

Wilcox, L. V., 1948, Explanation and interpretation of analyses of irrigation waters: U. S. Dept. Agr. Circ. 784.

Wilson, E. D., 1933, Geology and mineral deposits of southern Yuma County, Arizona: Arizona Bur. Mines Bull. 134.