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Geology and ground-water resources of the Upper Pinal Creek Area, Arizona

by

G. E. Hazen and S. F. Turner

prepared in cooperation with the City of Globe

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ILLUSTRATIONS

Photographs not included

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ABSTRACT

During 1945 the Geological Survey, United States Department of the Interior, made an investigation of the geology and ground-water resources of the Upper Pinal Creek Area, Arizona. The surface geology was mapped, the structural history was investigated and the Gila conglomerate in particular was studied. Records were obtained of most of the wells in the area. Recharge to the ground-water reservoir was measured. Geophysical probes were made to supplement information from well logs regarding the type and thickness of beds.

INTRODUCTION

Scope of report

This report is based on the results of an investigation of the geology and ground-water resources of the Upper Pinal Creek Area that includes the City of Globe, Gila County, Arizona. The City of Globe engaged the consulting engineering firm of Headman, Ferguson and Carollo of Phoenix for post-war planning. After a preliminary study of the possibilities of development of additional water supplies for the city, they recommended that the city should request the Geological Survey to investigate the ground-water resources of the area.

The Geological Survey in 1945 made a reconnaissance study of the area within a radius of ten to fifteen miles of Globe. As a result, Upper Pinal Creek was selected as the most promising area in which a ground-water supply might be developed without interfering with existing well fields. A relatively detailed geologic and hydrologic study was then made of this area, as shown on plates 1 and 2.

Cooperation

The work was performed under a cooperative agreement between the City of Globe and the U. S. Geological Survey. It was under the supervision of Samuel F. Turner, District Engineer of the Division of Ground Water in the Water Resources Branch of the Geological Survey. J. F. Hostetter, Mrs. Theda P. Shelley, and Miss Geraldine Morris assisted with the geophysical probes. John D. Hem, of the Quality of Water Division in the Water Resources Branch, analyzed the water samples. The runs of seepage measurements were made by J. F. Hostetter. Philip F. Fix, L. C. Halpenny, J. D. Hem, J. F. Hostetter and Miss Mary J. Scott assisted in preparation of the report.

Acknowledgements

Generous assistance was rendered by the local residents. Valuable information about old wells and mines of the region was supplied by many miners and cattlemen. The cooperation rendered by the City of Globe facilitated the work, and in particular, thanks are due Guy V. McGowen, Mayor; Julian Melton, City Engineer; and J. F. Mayer, Clerk-Treasurer. Dr. Ernst Antevs, geologist, aided in interpreting the geology of the region. N. P. Peterson, C. M. Gilbert and G. L. Quick, of the Geologic Branch of the Geological Survey, were mapping the mining geology of the area and they cooperated fully. Officials of the Miami Copper Company and the Inspiration Copper Company cooperated by furnishing well data and information on water levels in the mines.

Previous investigations

During 1901 and the spring of 1902 the late Frederick L. Ransome, of the Geological Survey, investigated the geology and mineral resources of the Globe quadrangle, an area about fifteen miles square lying between the meridians 110°45' and 111°00' west longitude and between the parallels 33°15' and 33°30' north latitude. The results of his work were published in Professional Paper 12, 1903. The Globe Folio, also prepared by Ransome, was published in 1904.

Beckett described a serious problem of inflow of water in the Old Dominion Mine that recurred in several different years. His article, published in the 1916 Transactions, American Institute of Mining Engineers, volume 55, pp. 35-66, 1917, was entitled "The water problem at the Old Dominion Mine (Globe, Arizona)".

In 1919, Professional Paper 115, "The copper deposits of Ray and Miami, Arizona" by Ransome, was published by the Geological Survey. It included results of additional field studies in 1910, 1911, 1912, 1914, and 1916.

The Globe area also was discussed by Ransome in Guidebook 14, Excursion C-1, the 16th International Geological Congress, 1933.

Other information on the geology of the area is in N. H. Darton's "A resume of Arizona geology" published by the University of Arizona as Bulletin 119, Geological Series No. 3, 1925, and in a paper on "The Devonian section on Pinal Creek, Arizona", published by C. R. Stauffer in the Ohio Journal of Science, volume 28, pp. 253-260, 1928.

A. A. Stoyanow discussed the sedimentary rocks and geologic history of the Globe area in two papers: "Correlation of Arizona Paleozoic formations", published in the Bulletin of the Geological Society of America, volume 47, pp. 459-540, 1936, and "Paleozoic paleography of Arizona", published in the publication cited, volume 53, pp. 1255-1282, 1942.

"The Pre-Cambrian Mazatzal revolution in central Arizona" by Eldred D. Wilson, and published in the Bulletin of the Geological Society of America, vol. 50, pp. 1113-1164, 1939, is helpful also although it refers to an area north of Globe.

Routes of travel

Globe is on the Miami branch of the Southern Pacific Railroad that joins the main line at Bowie. U. S. Highways 60 and 70 pass through Globe. State Highway 88 leads north to Roosevelt Dam, Pine and Flagstaff. State Highway 77 leads south to Hayden, Oracle and Tucson. County roads serve ranches and resorts in the vicinity.

Towns and settlements

Globe is the county seat and chief commercial center of Gila County. It was founded about 1877, and was incorporated in 1907. The census of 1940 lists the population as 6,141. The principal industries are mining and ranching. Miami, with a 1940 population of 4,722, lies six miles west on Highway 70. Between the two towns are the communities of Claypool and Central Heights and several Federal emergency housing projects. Twenty miles east of Globe is the Indian village of San Carlos on the Apache Indian Reservation. Many homes are located south of Globe along Pinal, Sixshooter and Icehouse Creeks.

Climate

The climate of the area is mild and dry, lacking the high summer temperatures of the lowlands and the cold winters of the plateau region of the northern part of the State. During winter months snow falls on the higher surrounding mountains and occasionally in the city. The annual precipitation and mean temperature are given in table 1.

Vegetation and agriculture

The vegetation in the vicinity of Globe is typical of the higher desert slopes of southern and central Arizona. The dominant types found upon the slopes are creosote bush, mesquite, acacia, palo verde, snakeweed, yucca and several varieties of cactus and flowering annuals (see pl. 6). Hackberry, sycamore and cottonwood trees, as shown in plate 3, are found in the canyons of Pinal Creek and other nearby streams, where the water table is within reach of the roots. On the lower slopes of the Pinal Mountains are found scrub oak, juniper, manzanita, and walnut. Coniferous forests cover the peaks of the Pinal Mountains.

The principal use of the land is for grazing of cattle, although a few small gardens are found along the creeks where irrigation water is available. Cattle are grazed on the lower slopes in winter and spring and on the higher slopes in summer and fall.

History of mining

The following brief history of mining is taken chiefly from Ransome[1].

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[1] Ransome, F. L., Geology of the Globe copper district, Ariz.: U. S. Geol. Survey Prof. Paper 12, pp. 114-118, 1903.
Ransome, F. L., Copper deposits of Ray and Miami, Ariz.: U. S. Geol. Survey Prof. Paper 115, pp. 19-21, 1919.

Prospecting in the vicinity of Globe was begun in 1874, and Ramboz Camp was established about four miles northeast of Globe in 1875. The Globe claim, filed in 1874, later became part of the Old Dominion Mine. Most of the mining in the seventies was for silver, and although the presence of copper ore bodies was known, their value was not realized.

In 1881 copper mining was begun, and it continued on a small scale until the formation of the Old Dominion Company in 1888. In 1892 the United Globe Company was organized, and by 1896 it was in operation. After 1900 the mines at Miami began to overshadow the Globe area in production, and at the present time the Old Dominion Mine is no longer in operation except as a source of water supply.

Present water supply

Since 1932 the City of Globe has secured most of its water from the Old Dominion Mine, near the north end of the city. The mine formerly produced large amounts of copper, but has been closed since 1928. Water is pumped from the mine by the Miami Copper Company for use in its properties at Miami, six miles to the west, and a part of the water produced is sold to the City of Globe for municipal use. For every gallon of potable water pumped from a depth of 800 feet in the mine, an equal or larger volume of "bad" water, high in sulfates, must be pumped from below 800 feet, in order to prevent inundation of the source of potable water. Moreover, the City of Globe has grown in population to the extent that the demand is as high as twenty million gallons a month in the summer time, whereas a maximum of only ten million gallons a month can be purchased from the Miami Copper Company. An additional supply is obtained from three wells drilled in the valley of Pinal Creek, about two miles south of Globe, which will produce a maximum of six million gallons a month.

PHYSIOGRAPHY

The Upper Pinal Creek Area lies in the Basin and Range Province[2/].

2/ Fenneman, N. M., Physiographic divisions of the United States: Assoc. Am. Geographers Annals, vol. 6, pp. 19-98, 1916.

The City of Globe is in a northwest-trending trough, the northwestern part being known as Pinal Creek valley and the southeastern part as Aliso Creek valley. The two parts of the trough are separated by a low alluvial divide about two miles southeast of Globe. There is considerable topographic and geologic evidence that the divide was as far to the northwest as Miami, in comparatively recent time. The reversal in direction of flow in the Globe area was probably caused by comparatively recent upward movement on the southeast side of the Pinal Creek fault. The trough lies between the Globe Hills to the northeast and the Pinal Range to the southwest (see pl. 4). Valleys of this type in the state were filled to a depth of as much as several thousand feet by fluviatile and lacustrine deposits of Tertiary and Quaternary age. Several stream terraces were developed on these deposits in Quaternary time.

The Globe Hills (see pl. 5) consist of Paleozoic sedimentary rocks dipping at moderate angles southwestward toward the city, and of Mesozoic or late Paleozoic (?) diabase. The altitude of the highest peak in the Globe Hills is nearly 5,000 feet, or about 1,200 feet above the city.

The Pinal Range, whose highest peak is 7,850 feet above sea level, is about seven miles southwest of Globe. The part of the range shown in plate 1 consists of pre-Cambrian igneous rocks and schists separated from the valley fill by a large fault. From the foot of the range, at an altitude of about 4,500 feet, long slopes of Tertiary and Quaternary deposits, dissected to a depth of as much as several hundred feet by streams, extend northeastward toward the City of Globe.

GEOLOGY

Rocks of the Upper Pinal Creek area

Because at the time of this investigation the Geologic Branch of the Geological Survey was studying the older rocks as part of its investigation of the ore deposits of the area, and because the older rocks are of secondary importance in the hydrology of the area, they were not studied in detail by the writers. The discussion of the older rocks in this report therefore is based on the work by Ransome, with some changes based on more recent papers, and on reconnaissance study by the writers. The Gila conglomerate, however, was studied in detail because of its hydrologic importance.

Sedimentary rocks

Pre-Cambrian and Cambrian

Apache group (including the Troy quartzite)

The oldest sedimentary rocks in the area are quartzites, sandstones, conglomerates, shales, and dolomitic limestones of the Apache group cropping out in the Globe Hills. These rocks are so disrupted by faulting that neither their relationships to known pre-Cambrian rocks, nor the sequence of rocks within the group is certain. The uppermost beds were called the Troy quartzite. Ransome[3/] considered all these rocks of

3/ Ransome, F. L., The copper deposits of Ray and Miami, Ariz.: U. S. Geol. Survey Prof. Paper 115, p. 39, 1919.

Cambrian age.

As the result of later work in the Globe and nearby areas, Ransome, Stoyanow, Wilson[4], and others came to the conclusion that, although fossils

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4/ Ransome, F. L., General geology and summary of ore deposits, in Ore deposits of the Southwest: 16th Internat. Geol. Congress U. S. 1933, Guidebook 14, Excursion C-1, p. 6, 1932.

Stoyanow, A. A., Correlation of Arizona Paleozoic formations: Geol. Soc. America Bull. vol. 47, pp. 462-479, 1936

Wilson, E. D., Pre-Cambrian Mazatzal revolution in central Arizona: Geol. Soc. America Bull., vol. 50, p. 1130, 1939.

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show that the Troy quartzite is Cambrian, the unfossiliferous remainder of the Apache group probably is pre-Cambrian, younger than the Pinal schist. The Apache group as thus restricted excludes the Troy quartzite, but, because time did not permit mapping the two separately, the geologic map (pl. 1) shows both under the name Apache group as it was originally used by Ransome in 1903.

Devonian, Mississippian, and Pennsylvanian

Globe limestone of Ransome

The geologic map (pl. 1) shows all Devonian, Mississippian, and Pennsylvanian sedimentary rocks as the Globe limestone, as that name was used originally in 1903 by Ransome in the Globe folio.

Ransome[5] later, from better exposures in the Ray Quadrangle south of

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5/ Ransome, F. L., The copper deposits of Ray and Miami, Ariz.: U. S. Geol. Survey Prof. Paper 115, pp. 45-48, 1919.

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the Globe area, divided these rocks into (1) the Martin limestone, about 325 feet thick, of Devonian age, and (2) the Tornado limestone, about 1,000 feet thick, of Carboniferous age.

Stoyanow[6] divided these rocks into four parts on the basis of his work

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6/ Stoyanow, A. A., op. cit., pp. 489-490, 508, 518, 1936 and that of others, as follows:

Pennsylvanian - Galiuro limestone.
Light gray limestone with chert nodules and bands. Fossiliferous. Lowermost 40 feet chiefly sandy shale, 950 feet thick in type section 6 miles east of Winkelman, Arizona, but thin to absent in the Globe area. The top is an old erosion surface.

Mississippian - Escabrosa limestone.
Cliff-forming gray limestone. Fossiliferous. 150 feet thick in Globe area. The original thickness is unknown because the top is an old erosion surface.

Devonian - Lower Ouray limestone.
54 feet thick on Pinal Creek north of Globe (36 feet of yellow shale overlain by 18 feet of buff shaly limestone

Martin limestone.
271 feet thick on Pinal Creek north of Globe. Gray to yellow limestone and limy sandstone.

Tertiary or Mesozoic (?)

Whitetail conglomerate

The Whitetail conglomerate consists of subangular fragments of diabase, limestone, and other rocks ranging in size from silt and sand to boulders more than one foot in diameter. The material in the formation in the northeastern part of the Globe Hills, a quarter to half a mile west of U. S. Highway 60 (see pl. 1), ranges from fine sand to pebbles one inch in diameter, but in the larger outcrop of the formation, farther west, the material is less sorted.

The age of the formation is not known. Ransome[7] who named the

7/ Ransome, F. L., Geology of the Globe copper district, Ariz.: U. S. Geol. Survey Prof. Paper 12, pp. 46-47, 1903

Whitetail conglomerate, assigned an early Tertiary age because the deposit lay on an old erosion surface, contained fragments of diabase believed to be of Mesozoic age, and was overlain by dacite believed to be of Tertiary age. The Whitetail conglomerate may be considerably older than Tertiary, because it has not been proved that all diabase in the area is contemporaneous, nor that the diabase is Mesozoic.

Tertiary and Quaternary

Gila conglomerate

Stream, playa, and lake deposits of rock materials from the mountains fill the broad valley occupied by Pinal Creek in the vicinity of Globe. These deposits near the mountains consist of sand and silt filling the interstices between coarse, subangular rock material, with boulders as much as 20 feet in diameter near the Pinal Range, but they grade into pebbly sands and silts in the central part of the basin. These deposits are believed to be more than 1,000 feet thick.

Gilbert[8/] proposed the name, Gila conglomerate, for more than 1,000 feet

8/ Gilbert, G. K., Report on the geology of portions of New Mexico and Arizona: U. S. Geol. Survey west of the 100th Meridian (Wheeler), 3, p. 540, 1875.

of conglomerate with some sands and interbedded basalts along the upper course of the Gila River and its tributaries about 100 miles southeast of Globe. He believed these beds to be of Pleistocene age.

Ransome[9/] adopted the name, Gila conglomerate, for the post-dacite

9/ Ransome, F. L., Geology of the Globe copper district, Ariz.: U. S. Geol. Survey Prof. Paper 12, pp. 47-57, 1903
Ransome, F. L., The copper deposits of Ray and Miami, Ariz.: U. S. Geol. Survey Prof. Paper 115, pp. 71-74, 1919.
Ransome, F. L., Description of the Ray quadrangle, Ariz.: U. S. Geol. Survey Atlas Ray fol. (No. 217), pp. 13-14, 1923.

deposits in the valley of Pinal Creek at Globe, and accepted their age as Pleistocene because no identifiable fossils were found in the deposits. Later workers[10/] in nearby areas believed that the deposits in which they

10/ Ross, C. P., Geology and ore deposits of the Aravaipa and Stanley mining districts, Graham County, Ariz.: U. S. Geol. Survey Bull. 763, p. 31, 1925.
Gidley, J. P., Preliminary report on fossil vertebrates of the San Pedro Valley, Ariz.: U. S. Geol. Survey Prof. Paper 131, pp. 120-121, 1922.

found fossils of Pliocene age should be correlated with lower beds of the Gila conglomerate. Thus, the age designation of the Gila conglomerate is now generally accepted as Pliocene and Pleistocene.

In the upper Pinal Creek area the Gila conglomerate includes all Tertiary and Quaternary alluvial deposits not included in the Whitetail conglomerate or the Recent alluvium. In several places, such as in a wash between Globe and the junction of U. S. Highway 60 and 70 southeast of the city, an unconformity in these deposits exists (see pl. 6). It is probable therefore that the deposits described as the Gila conglomerate ultimately may be divided into at least two formations, but in this paper the whole is referred to as the Gila conglomerate. The older Gila beds, at least in part, may be contemporaneous with the Whitetail conglomerate.

Quaternary

Recent alluvium

Alluvium of late Quaternary age, consisting of silt, sand and gravel, was deposited along Pinal Creek and its tributary channels, and also forms a belt about a quarter of a mile wide along Russell Canyon, west and northwest of Globe (see pl. 1).

Igneous rocks

Pre-Cambrian

Madera diorite

Ransome[11] proposed the name Madera diorite for a pre-Cambrian igneous

11/ Ransome, F. L., Geology of the Globe copper district, Ariz.: U. S. Geol. Survey Prof. Paper 12, pp. 58-65, 1903.

rock, intrusive into the Pinal schist in the Pinal range southwest of Globe. He described the rock as gray in color, of granitic texture, and made up of plagioclase feldspar, quartz, and biotite mica. The rock closely resembles true granite in appearance and mode of weathering. A small outcrop of diorite similar to that forming many square miles of the Pinal Range was found in a wash that is tributary to Kellner Canyon about half a mile above the junction of Kellner Canyon with Icehouse Canyon, and about two miles from the major fault bounding the front of the range (see pl. 1). The outcrop is truncated on the southwest by a normal fault dipping 75° toward the Pinal Range, and is part of the pre-Gila bedrock surface.

Another body of diorite was found on the east side of Pinal Creek half a mile below the junction with Sixshooter Canyon, and about one mile from the frontal fault of the range.

A third small body of diorite was found in the Globe Hills about a quarter of a mile north of Globe.

Mesozoic or late Paleozoic (?)

Diabase

Ransome[12] described as of probable Mesozoic age a diabase that is

12/ Ransome, F. L., op. cit., pp. 80-86.

intrusive into the Paleozoic sedimentary rocks of the Pinal Range and Globe Hills. It is especially common as sills in the limestone of the Apache group. He described the diabase as a tough, dark-gray crystalline rock of medium grain made up of plagioclase feldspar, augite, and magnitite. Locally the rock is either fine-grained or coarsely crystalline and the coarser varieties are especially tough. The outcrops are characterized by a dark olive green color and scanty vegetation.

Tertiary (?)

Dacite

Light pinkish-gray dacite, a volcanic rock, crops out along the southwest margin of the Globe Hills, as well as in many places in the other nearby mountain ranges. Ransome[13] described the rock as consisting

13/ Ransome, F. L., op. cit., pp. 88-95.
Ransome, F. L., The copper deposits of Ray and Miami, Ariz.: U. S. Geol. Survey Prof. Paper 115, pp. 68-71, 1919.

of a more or less glassy groundmass enclosing numerous phenocrysts of plagioclase feldspar and small six-sided plates of biotite mica. Locally, small fragments of other rocks are included in the dacite, and diabase is particularly abundant among these. In some places a dark-gray glassy variety of the rock occurs at the base of the dacite flows, and bedded dacitic tuffs are present locally below the glassy rock. The thickness of the dacitic series was estimated as more than 1,000 feet. The dacite weathers characteristically into large boulders. Ransome believed the dacite probably is of Tertiary age, although no direct proof was found.

Quaternary (?)

Basalt

A small body of basalt, possibly of Quaternary age, crops out near the top of a hill along U. S. Highway 60 about two and a half miles east of Globe (see pl. 1). The basalt probably lies on deposits of the Gila conglomerate, and is overlain by well rounded stream gravels possibly deposited by the Salt River as described later in this report.

Metamorphic rocks

Pre-Cambrian

Pinal schist

Ransome[14] described the Pinal schist, the oldest rock of the Globe area,

[14] Ransome, F. L., Geology of the Globe copper district, Ariz.: U. S. Geol. Survey Prof. Paper 12, pp. 23-38, 1903

as light-gray to bluish-gray, fine-grained sericitic schist, and quartz-muscovite schist. A large part of the Pinal Range southwest of Globe is made up of the Pinal schist intimately associated with the Madera diorite.

Geologic structure

The mountain ranges of the Globe region trend northwest, and apparently are controlled by northwest-trending faults, although in many places northeast-trending faults are numerous. The mountain ranges are separated by valleys also controlled by faults. Ransome[15] said that northeast-trending

[15] Ransome, F. L., The copper deposits of Ray and Miami, Ariz.: U. S. Geol. Survey Prof. Paper 115, fig. 5, p. 82, 1919.

normal faults dominate the structure of the Globe Hills. He described the faults as having dropped downward-pointing wedges or segments of younger rocks between upward-pointing wedges of older rocks. Ransome[16] also

[16] Ransome, F. L., op cit., p. 77.
Ransome, F. L., Geology at Globe, Ariz.: Min. and Sci. Press, p. 257, February 12, 1910.

described a fault as having thrust pre-Cambrian diorite over Tertiary dacite along a plane dipping 37° southwest. This occurred prior to deposition of the Gila conglomerate. This fault shattered all the adjacent rocks, as is shown in diorite in Copper Canyon, and along U. S. Highway 60 and 70 near the mine rescue station at the north edge of Globe (see pl. 7).

The width of the thrust fault block is unknown, but in Copper Canyon the crushed diorite is exposed for a distance of one-eighth mile at right angles to the strike of the fault. The fault disappears to the southeast under the Gila conglomerate.

The Pinal Range southwest of Globe is bounded by a normal fault that dips 85° northeast and has a zone of kaolin as much as 50 feet wide. The Gila conglomerate lies against this fault surface at many places (see pl. 1). Several faults, also marked locally by kaolin, trend northwestward in the Gila conglomerate between the range front and Globe (see pl. 1 and fig. 1), and they probably represent the more recent displacements on old faults in the buried pre-Gila rocks. The Gila conglomerate also is cut by many other faults that have resulted from compaction of the Gila deposits (see pl. 8). These faults are small and strike in various directions. Faults in the Gila conglomerate are of especial importance because they may impede the movement of ground water.

Geologic history

The sedimentary rocks of the Apache group rest on an erosion surface of the Pinal schist and pre-Cambrian intrusive rocks. This unconformity indicates a long period of erosion in pre-Cambrian time. A period of erosion also followed deposition of the Apache rocks, and the Troy quartzite was deposited on this surface. The absence of known Ordovician and Silurian rocks indicates another period of erosion prior to deposition of the Devonian, Mississippian, and Pennsylvanian rocks.

Little is known of the geologic history of the Globe area from Permian to early Tertiary time. Diabase invaded the older rocks during this time, and the Whitetail conglomerate, containing fragments of the diabase and other rocks, was deposited on an erosion surface developed on the diabase and older rocks. Mountain ranges and valleys that were bounded by faults developed at the end of the Mesozoic and the early Tertiary, and eruptions of dacite and dacitic ash occurred in the Tertiary. During the Tertiary period rock waste that was deposited in the valleys formed the deposits in the lower part of the Gila conglomerate. Renewed uplift of the mountains in late Teriary time accelerated deposition of rock waste in the valleys, and formed the younger part of the Gila conglomerate, which is presumably of Pleistocene age. Subsequently, the streams of the region deposited alluvium along their courses.

Many changes have occurred in the drainage system of the Globe area, but all of the details are not known. It is believed that the Upper Pinal Creek Area, from Miami south, formerly drained down Aliso Creek to the Gila River. Upward movement along the Pinal Creek fault caused the direction of drainage to be reversed. Several terraces were formed in the Gila deposits, presumably in late Pleistocene time.

Source of rock materials in the Gila conglomerate

Southwest of Globe

The Gila conglomerate on the northeast flank of the Pinal Range, south-west of Globe, contains boulders more than 20 feet in diameter (see pl. 9). Many large boulders were found in these deposits along Pinal Creek and along Icehouse Canyon to their junction 3½ miles from the bed-rock of the Pinal Range. The decrease in size of rock fragments in the formation down Russell Canyon is so much more rapid than on Pinal Creek that few rocks larger than six inches in diameter can be found two miles from the mountains.

Much diorite was found in the lower exposures of the Gila conglomerate. The diorite disintegrates readily, especially under cover of other materials and in the presence of considerable moisture, into fine material surrounding a small central core that simulates a stream-rounded boulder (see pl. 10).

However, the presence of rocks of other types usually shows that such material did not develop from the disintegration of bedrock. Pinal schist makes up most of the rock materials in the upper part of the Gila conglomerate, apparently because the diorite has disintegrated. The Gila conglomerate throughout the area contains many boulders of quartzite, although no quartzite remains in place on the northeast side of Pinal Peak. Boulders of quartzite up to 10 feet in diameter were seen in the lower parts of Pinal Creek and Icehouse Canyon.

In the vicinity of Globe

Subangular fragments of diorite, schist, and quartzite, probably derived from the Pinal Range, and usually less than a foot in diameter, are the principal rock materials in the Gila conglomerate south and southwest of Globe. Northwest and southeast of the city, however, the Gila deposits contain subangular fragments of quartzite, limestone, and diabase of somewhat smaller average diameter (see pl. 11). These materials probably came from the Globe Hills. An angular unconformity in the Gila conglomerate, with the underlying beds tilted to the southwest at a moderate angle, is exposed in Ruiz Canyon, a short distance above the junction with Pinal Creek at the south edge of Globe. The overlying beds were traced southwestward along Pinal Creek and its tributaries, to within two miles of the Pinal Range. The dip of these beds is approximately parallel to the present stream gradient.

Well-rounded gravels were found in the uppermost beds of the Gila conglomerate or lying on them, about two miles southeast of Globe and one-half mile north of U. S. Highway 70 (see pls. 5 and 12). These gravels are similar to those found in the valley of the Salt River and were probably brought into this area by the Salt River or some other major stream. They were not brought in by the Gila River because certain rock types commonly found in the gravels of the Gila River could not be found in these gravels. There is reason to believe from certain rock types found in the uppermost beds of the Gila conglomerate northwest of Globe that the drainage as far northwest as Miami formerly was to the Gila River to the southeast.

GROUND-WATER RESOURCES

Igneous and metamorphic rocks

The Pinal schist and Madera diorite of the Pinal Mountains are not sufficiently porous or permeable to store or transmit ground water to lower elevations. A large part of the precipitation occuring on the mountains is carried to the valley as runoff, and the balance is evaporated from the surface or utilized by the vegetation. However, a few intermittent springs and shallow wells in these areas are used to supply public recreation areas and ranches in the mountains.

The diabase found in the Globe Hills is nearly impermeable and is not conducive to collection and movement of ground water except where it is fractured.

The dacite found in the Globe Hills probably transmits very little ground water from areas of recharge to the center of the valley or to more permeable beds. There are no wells or springs known which derive their supply from dacite beds, but it is reported that the water found at the 12th level in the Old Dominion Mine is partly discharged from beds of fractured dacite.

Older sedimentary rocks

The rocks of the Apache group and the Troy quartzite are sufficiently fractured to carry water underground from the Globe Hills. A few small springs and seeps on the northern flank of the Globe Hills apparently derive their water from these rocks, and water also enters the Old Dominion Mine from them. The Paleozoic limestones are sufficiently cavernous and fractured to serve as aquifers, or water-bearing formations. A part of the water in the Old Dominion Mine is said to enter the underground workings from these limestones.

Beckett[17] states that water enters the Old Dominion Mine from two

[17] Beckett, P. G., The water problem at the Old Dominion Mine: Vol. 55, Trans., 1916, AIME, 1917, pp. 35-66.

sources, namely, "East Side water" and "West Side water". He explains that water entering the east side of the mine amounted to between 1,500,000 and 2,000,000 gallons a day for many years, that it was mineralized, and that it entered the mine through fractured Paleozoic and pre-Cambrian rocks. This water entered the mine at successively lower levels as the workings became deeper, and thus each new level would drain the levels above. Beckett measured the temperature of the water as 90°F. An analysis of the water is given in table 2.

Two wells in the Globe area were reported to derive their water from limestones (see analyses, table 2). Well 1a, on the bank of Maurel Wash, northwest of Globe, was reported to produce 15 gallons a minute from a limestone underlying diorite at a depth of 87 feet (see log, table 3). Well 11, near Pinal Creek at the west edge of Globe, was reported to produce two gallons a minute from limestone at 25-50 feet.

The Whitetail conglomerate is so nearly impermeable that it cannot be considered a water-bearing formation.

Gila conglomerate

The Gila conglomerate is in some places so poorly sorted that it will deliver little or no water to wells penetrating it. However, there was some sorting of the fill materials deposited in front of large canyons that existed in the mountains at the time the Gila conglomerate was deposited. This is proved by the fact that several ranch wells in the area have obtained water from beds in the Gila conglomerate, and a large amount of water was obtained from wells in the formation in the Miami Basin. The fact that permeable zones are not present in all parts of the Gila conglomerate is shown by several deep wells that have failed to secure adequate water supplies.

Most of the water found in the Gila conglomerate is derived from runoff from rains and melting snows in the surrounding mountains (see pl. 3). Most of this runoff occurs in spring and early summer. At this season all the creeks draining from the mountains flow steadily for several months. A part of this flow sinks through the Recent alluvium of the stream channels and thus recharges the more permeable beds of the Gila conglomerate lying beneath.

Occurrence of ground water

Plate 1 shows a probable fault along Pinal Creek that, although offset along the frontal fault of the Pinal Range, apparently controlled the course of Pinal Creek for a long time, thereby causing deposition of materials coarser than elsewhere along the mountain front. This resulted in more permeable beds in the Gila conglomerate along Pinal Creek and immediately to the west. Wells 31, 39, 41, and 48 (see pl. 2 and table 4) probably obtain the major part of their water from the permeable beds of the Gila near the Pinal Mountains. They have a much more nearly constant supply of water than do the shallow wells in the fill of the creek bottoms. Wells

26 and 27 that lie east of the probable fault also are in the Gila conglomerate, but they were unproductive.

Wells 4, 6, 8, 10, 12, 13, 16, 20, 21, and 33 all lie in the vicinity of Globe, and all derive water from the Gila conglomerate. Many of these wells are not in use because their owners now obtain water from the city supply.

Maurel Spring (see analysis, table 2) is reported to produce from 50 to 200 gallons a minute, in large part from the Recent alluvium and possibly some from the Gila conglomerate. It is located at a concrete cut-off wall that was built on bedrock across Pinal Creek in 1909. Long-time residents of Globe report that the spring started to flow when this cut-off wall was built. The wall was constructed by the Old Dominion Mining Company in an attempt to divert water from their mine by carrying the underflow of Pinal Creek through a flume to a point 2,300 feet downstream.

The water found in the west end of the Old Dominion Mine is very similar in quality to water from the Gila conglomerate (see table 2). According to Beckett[18], pre-cambrian diorite has been overthrust above

18/ Beckett, P. G., The water problem of the Old Dominion Mine: Vol. 55, Trans., 1916, AIME, 1917, pp. 35-66.

Tertiary dacite in the west end of the mine, beneath Pinal Creek. The Recent alluvium of the creek apparently rests directly on diorite here. Water entered this end of the mine through fractured dacite in 1906, and it has continued to enter in the vicinity of the 12th level until the present day. The water was reported by Beckett to be 65°F., and thus must have been percolating downward when it entered the mine workings. Since the low dam across Pinal Creek and the 2,300 feet of flume along the creek did not decrease the flow in the mine, the source must be permeable beds in the Gila conglomerate which are in contact with the fault zone to the west of Pinal Creek.

Well 33 was completed in 1945 (see log, table 3). It is on a mesa overlooking Pinal Creek and about 500 feet southwest of the creek. It is located in a series of faults in the Gila conglomerate that strike approximately parallel with the course of Pinal Creek (see pl. 8). This structure tends to obstruct movement of the ground water, as the water level rose 10 feet when the aquifer was tapped, and now stands about level with the channel of Pinal Creek.

Well 20, City of Globe well 3, is on the east bank of Pinal Creek near the junction of Icehouse Creek. It is about 80 feet in depth and is cemented nearly to the bottom. Well 21, about 50 feet west of Pinal Creek, is actually two wells, which are connected with a tunnel. City well 2, the southernmost of these, is 235 feet in depth. A tunnel from it extends 40 feet towards the creek, at a depth of about 230 feet. Another tunnel, at a depth of about 60 feet, connects it with city well 1. City well 1 is at a lower elevation then city well 2, and was dug to 85 feet. These three wells derive most of their water from the Gila conglomerate.

Well 1b is reported to produce 100 gallons a minute and to furnish water for 200 families. It is located near Central Heights, about two miles northwest from Globe. It is 375 feet in depth and is reported to derive its water from permeable sections of the Gila conglomerate.

In the vicinity of Cutter, eight miles southeast of Globe, the Southern Pacific Railroad owns a well which struck water at about 252 feet (see log, table 3). The depth of the well is 275 feet and the elevation at the ground surface is 3,194 feet. The reported depth to the water level is 124 feet.

Water-table contours

The wells used for plotting contours of the water table (see pl. 2) were all located near major stream channels, with wide areas between where no wells had been drilled. Thus, the water table could not be accurately plotted. However, the contours do show that the water table slopes from the Pinal Mountains toward the City of Globe, thence northwest along the course of Pinal Creek. The slope of the table is steep along Russell Canyon, indicating either a lower permeability or a greater rate of recharge than in the vicinity of Pinal Creek. The size of the rock materials near Russell Canyon suggest the first alternative to be more likely.

Ground-water reservoir

The area of Gila conglomerate drained by Pinal Creek and its tributaries above Globe is about twelve square miles. The area in the Pinal Mountains that contributes runoff to Pinal Creek is also about twelve square miles. The pattern of faulting and the general southwest dip in the Gila conglomerate have a tendency to retard the flow of ground water northeast from the Pinal Mountains. Movement toward the east is restricted by the probable fault along Pinal Creek. The pattern of northwest trending, parallel faults in the Gila conglomerate from the mouth of Icehouse Canyon extending northwest as far as exposures have been found, tend to force ground water to move down the valley to the west of Pinal Creek. It is eventually forced to the surface at the narrows in Pinal Creek, about 15 miles downstream from Globe.

Recharge

Measurements

Seepage measurements, to determine where recharge from surface-water flow to the ground-water reservoir occurred in the Upper Pinal Creek Area, were made during the first part of April 1945. The locations of the points where measurements were made are shown on plate 2 and the results are given in table 5. Water from melting snows and spring rains had been flowing in the upper sections of Pinal Creek, Sixshooter Canyon, Icehouse Canyon, Kellner Canyon, and Russell Canyon for several weeks. From April 6, 1945 to April 13, 1945 inclusive, 2 sets of measurements were made, totaling 43 measurements along the five creeks. The measurements were divided as follows: Pinal Creek 11, Sixshooter Canyon 6, Icehouse Canyon 12 (includes one measurement of a small diversion canal), Kellner Canyon 6, and Russell Canyon 8.

Results

Pinal Creek lost in flow throughout the section measured, with the exception of a small gain at the mouth of Icehouse Canyon on April 7. The greatest rate of loss occurred near the mouth of Sixshooter Canyon. The net losses between stations P-5 and P-1 were 1.2 and 0.9 cubic feet per second on April 7 and 13, respectively.

Sixshooter Canyon usually gained in flow, except for a small loss between stations S-3 and S-2 on April 13. Icehouse Canyon gained in flow April 6 and lost in flow April 13. Kellner Canyon showed practically no change in flow.

Russell Canyon lost in flow throughout its course, the loss being greatest in the reach from station R-2 to station R-1. The net loss was 1.7 and 1.6 cubic feet per second on April 7 and 13, respectively. Surface flow disappeared entirely about one-half mile downstream from station R-1.

It is probable that the measurements made on April 7 and 13 gave about the lowest possible recharge rates. This was because the creeks had been flowing continuously for two to three months prior to the measurements, and therefore all of the underlying beds were full and took in only the amount of water that could be transmitted toward the discharge areas.

Natural discharge

Most of the underflow of the ground-water basin of Upper Pinal Creek is forced to the surface as flow of the creek at Springle Ranch, about 15 miles downstream from Globe. At this point in the valley several large wells withdraw 1,500 to 2,000 gallons a minute for use in the mines and mills at Miami.

On March 28, 1945 there was no surface flow in Pinal Creek for about 10 miles below Globe and the creek had been dry in this reach for at least several weeks. Surface flow started in the creek two to three miles above the narrows at the pumping plant at Springle Ranch and the amount of flow increased to a maximum of eight second-feet or 3,600 gallons a minute past the pumping plant. About 2,000 gallons per minute was being pumped from the wells and it was estimated that the underflow through the Recent alluvium past the plant at that time was between one and two thousand gallons per minute. This estimate is based on the effective width and depth of water-bearing material, as obtained from the logs of the wells at the pumping plant; the hydraulic gradient of the bed of the stream through the narrows; and the permeability of the water-bearing material, as estimated from the water produced by the wells and laboratory tests on one sample of creek-bed material taken several miles upstream. These data were applied to a formula developed by Meinzer[19] to measure underflow.

19/ Stearns, N. D., Laboratory tests on physical properties of water-bearing materials: U. S. Geol. Survey Water-Supply Paper 596-F, p. 148, 1928.

Thus the total water available at the narrows on March 28, 1945 was 6,000 to 7,000 gallons a minute. A small amount of this may have been derived from storage, as the water-table was lowered near the wells, but the major portion had to pass through the water-bearing strata upstream where the creek was dry.

It is believed that 2,000 gallons per minute is the maximum amount that can flow through the Recent alluvium underlying Pinal Creek. This means that 4,000 to 5,000 gallons a minute had to be brought to the narrows at Springle Ranch through water-bearing strata in the Gila conglomerate or brought in from the sides of the valley by the older rocks. Some of the water may have been contributed by the limestones in the older rocks but since their outcrop areas are relatively small, the amount thus contributed must have been small. Thus, the major part of this four to five thousand gallons per minute must have been contributed by the Gila conglomerate.

The width of the Gila conglomerate in the valley is about three miles just above the narrows that forces the flow to the surface. An estimated permeability of 200 for the water-bearing beds of the Gila is used, based on the production from wells in the basin. The hydraulic gradient is taken from the gradient of the creek bed as 50 feet per mile. Using these figures it would take a thickness of 200 feet of water-bearing material in the Gila to bring the extra water to the narrows. Farther upstream, where the valley is 5 miles wide, the required thickness would be about 120 feet. The above data indicate the presence of fairly thick, permeable beds in parts of the Gila conglomerate.

The logs of the wells in the Miami area also indicate substantial thicknesses of water-bearing material in the Gila conglomerate, most of it occuring above a depth of 500 feet.

Possible well sites in the Gila conglomerate

The information that was obtained indicates that permeable beds occur in the Gila conglomerate. They are doubtless thicker at some places than in others, but apparently there is continuous movement of ground water through the formation from the Pinal Mountains to the narrows at Springle Ranch.

The following possibilities might be considered for obtaining an increased water supply for Globe from the Gila conglomerate: 1) A deep well could be drilled at Probe 3, near Pinal Creek, upstream from wells 20 and 21. 2) A deep well could be drilled in the vicinity of Central Heights. Here the water would have to be lifted to a total height of more than 350 feet to reach Globe. The same water-bearing beds would probably be found by drilling a well in Hays Wash, about one to one and a half miles southwest of well 33. Water pumped at this site would flow by gravity into Globe. 3) A deep well could be drilled near Cutter, east of Globe, but the total lift here would be almost 700 feet and a long pipe line would be required.

Recent alluvium

The Recent alluvium in the channels of Pinal Creek and its tributary washes furnish water for many shallow dug and drilled wells. The water levels in these wells fluctuate with the season, and many of them fail in times of drought. They usually furnish sufficient water for a family or a few head of stock, and under favorable conditions larger supplies have been obtained, but all of the wells fail or nearly fail under severe drought conditions.

QUALITY OF WATER

Surface water

Analyses of samples of water from the late winter and early spring flow of the washes in the area are given in table 2. These samples were taken at the time the measurements of seepage losses were made. They show no significant changes of chemical content as the water progressed downstream, indicating that either no ground water seepage increased the flow or the ground water had not travelled far enough through the sediments to increase its mineral content perceptibly. The consituents of the dissolved matter in the water are those normally expected in surface runoff from rains and melting snow on mountains of this elevation or shallow ground-water runoff.

Ground water

Older beds

Wells 1 a, 1 c, and 11 derive their water from beds older than the Gila conglomerate. They all produce more highly mineralized water than do wells in the Gila conglomerate or the Recent alluvium.

Gila conglomerate

Wells 21, 39, 41, and 48 are sufficiently deep to have passed through the Recent alluvium and reached the Gila conglomerate. The conductivity ($K \times 10^5$) ranges from 29.9 to 51.0 and averages 40.7. The total dissolved solids in these samples ranges from 172 to 286 parts per million, and averages 234 parts per million. The sulfates range from 27 to 59 parts per million, with an average of 43 parts per million. The chlorides range from 13 to 59 parts per million with an average of 33 parts per million. The total hardness ranges from 120 to 223 parts per million, with an average of 168 parts per million. The fluoride content of all samples is less than 1.0 part per million. Water from the Gila formation may be termed as having a moderate mineral content with rather high hardness.

Recent alluvium

Wells 7, 40, 42, and 47 are not of great depth, and derive their water from Quaternary deposits in the creek beds. The conductivity ($K \times 10^5$) ranges from 25.4 to 76.7 and averages 45.3. The chlorides range from 5 to 38 parts per million with an average of 16 parts per million. The other constituents cannot be averaged, as two of the samples were only partially analyzed. In the two samples tested for fluoride, less than 1.0 part per million was found. The wells in Recent alluvium show a wider variation in quality of water than do the wells penetrating the Gila conglomerate.

GEOPHYSICAL INVESTIGATIONS

The equipment used in this investigation was built from designs prepared by O. H. Gish and W. J. Rooney and is known as the Gish-Rooney apparatus. The theory of design and operation is explained in several recent books[20]. The principal of operation is based on the fact that different rock materials offer different degrees of resistance to the passage of an electric current. The values are usually expressed in ohm-centimeters. Clay and silt usually show lower resistivity than sand and gravel, though the amount and conductivity of the interstitial water probably affects the value and may alter this general relation. The values of resistivity are plotted in graphs against depth, and the resulting curves are analyzed mathematically to indicate the type of formations which the electric current passed through.

Table 6 gives the results of the ten probes made in the Globe area, and the locations of the probes are shown on plate 1. Figures 2 and 3 show graphs of typical curves. A study of table 6 shows that the probes indicating most favorable conditions for test drilling are along Pinal Creek, with with the exception of probe 7, which is near Icehouse Canyon. These probes indicate likelihood of sand and gravel beds of considerable thickness lying beneath the surface.

[20]
Heiland, C. A., Geophysical exploration: Prentice Hall, Inc., 1940
Eve, A. S., and Keyes, D. A., Applied geophysics in the research of minerals: Cambridge University Press, 1938.
Jakosky, J. J., Exploration geophysics: Times-Mirror Press, 1940.

CONCLUSIONS

The geologic study indicated that the Gila conglomerate should, in certain areas, be a satisfactory aquifer from a standpoint of access to recharge, attitude of beds, permeability and porosity, and volume of storage. The fault system along the upper part of Pinal Creek caused deposition of coarser sediments in this vicinity.

The measurements of stream-flow losses from the creeks indicated two areas where losses were large: a) in Pinal Creek in the vicinity of the mouth of Sixshooter Canyon; b) in Russell Canyon in the reach from R-2 to R-1.

The large volume of water leaving the valley as surface flow, underflow, and pumpage from the Miami and Springle Ranch wells indicates that the ground-water reservoir is not confined to Recent alluvium in the stream channels, but it must also include water-bearing beds in the Gila conglomerate through-out a part of the basin. Somewhere in the Gila deposits must lie some permeable beds.

The analyses of water samples show: 1) water which recharges the ground-water reservoir is of good quality; 2) the quality of water through-out the Gila conglomerate is uniform to depths reached by wells, and it is suitable for municipal, domestic and stock consumption; 3) water in the Recent alluvium is more affected by local conditions and therefore more variable in quality than water in the Gila conglomerate.

The geophysical tests showed that the most favorable area for test drilling lies along Pinal Creek, upstream from the present city wells. If a test well is drilled along Pinal Creek, near probe 3, about two miles above the existing city wells, it should be drilled at least 500 feet, with a completed diameter of eight inches or larger. Samples of the well-cuttings should be saved, at least one quart in volume, from each ten feet of depth, for examination by a geologist. Larger samples, 15 pounds each, should be taken from each water-bearing bed for testing in the hydrologic laboratory. A complete and accurate driller's well log should also be made. If bailing shows that the hole will yield water in sufficient amount to make a pumping test practicable, a thorough test should be made. The pumping should be continued for a considerable period, and systematic and accurate measurements should be made of the discharge and of the drawdown and recovery at appropriate intervals.

Table 1

Annual precipitation, 1931-1944, monthly precipitation, 1944, and annual mean temperature at Globe, 1931-1944.
Altitude, 3,440 feet. Record begun, 1900.
(From Annual Reports, Arizona Section U. S. Dept, of Commerce.)
Weather Bureau

Precipitation by Years, 1931-1944
(All amounts given in inches)

Year	Total for year	Deviation	Greatest monthly	Month	Least monthly	Month	Total snowfall
1931	19.85	+2.99	3.66	Feb.	0.16	May	-
1932	15.89	-0.97	4.05	Dec.	0	Nov.	T
1933	12.56	-4.30	1.96	Jan.	T	Mar.	4.0
1934	9.53	-7.33	2.80	Aug.	0	Oct.	0
1935	24.31	+7.45	6.02	Aug.	0	Oct.	1.5
1936	21.23	+4.37	4.12	Aug.	0.1	June	-
1937	14.10	-2.76	3.89	Aug.	0	Apr.	-
1938	15.89	-0.97	3.80	Jul.	0	Oct.	T
1939	15.17	-1.69	6.30	Aug.	0	June	11.0
1940	20.27	+3.41	4.61	Dec.	0.17	Mar.	0
1941	27.11	+10.25	4.69	Mar.	0.03	June	0.2
1942	12.03	-4.83	3.10	Jul.	0	May	6.0
1943	14.12	-2.74	3.39	Jan.	0	Nov.	3.0
1944	16.46	-0.40	2.65	Aug.	0	June	T

Precipitation by Months, 1944

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Inches	0.83	2.26	1.23	0.69	0.58	0	2.39	2.65	1.76	0.87	2.36	0.84	16.46

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Table 1-Cont.

Mean Temperature by Years, 1931-1944 (Degrees Fahrenheit)						
Year	Mean	Deviation	Highest	Month	Lowest	Month
1931	61.6	-1.3	107	July	17	Dec.
1932	59.9	-2.9	107	July	13	Jan.
1933	60.4	-2.3	107	June	13	Feb.
1934	62.5	-0.1	108	July	14	Dec.
1935	60.6	-2.0	103	July	14	Jan.
1936	62.7	+0.1	106	June	20	Jan.
1937	62.2	-0.4	105	June	11	Jan.
1938	62.2	-0.4	107	July	20	Nov.
1939	61.7	-0.9	104	July	16	Feb.
1940	63.3	+0.8	110	June	21	Jan.
1941	60.6	-2.0	105	July	21	Dec.
1942	60.1	-2.5	104	July	16	Jan.
1943	61.1	-1.3	105	July	22	Jan.
1944	59.7	-2.7	105	Aug.	12	Jan.

Table 2. Analyses of samples of water collected in the upper Pinal Creek area, Globe, Arizona. Numbers correspond to numbers in table of well records.

Analyzed by J. D. Hem, Quality of Water Division, Geological Survey. (Parts per million)

Meas. sta. or well no.	Date of collection	Specific conductance ($K \times 10^5$ at 25°C)	Total dissolved solids (calc.)	Calcium (Ca)	Magnesium (Mg)	Sodium and Potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Total hardness as $CaCO_3$ (calc.)
Streams												
K-1	Apr.12,1945	14.8	-	-	-	-	68	a/ 11	3	-	-	b/ 52
K-3	do.	10.3	59	8.7	5.0	6.7	48	a/ 12	2	0.6	0.1	42
I-1	do.	22.2	-	-	-	-	105	a/ 14	4	-	-	-
I-2	do.	19.5	99	18	7.7	9.0	89	a/ 15	4	0.3	1.0	76
I-4	do.	21.7	118	20	8.0	14	103	a/ 18	5	0.3	1.9	83
I-8	do.	12.4	-	-	-	-	57	a/ 11	2	-	-	b/ 34
S-1	do.	17.7	-	-	-	-	-	-	3	-	-	-
S-3	Apr.13,1945	15.7	-	-	-	12	69	a/ 16	3	0.3	0.1	b/ 52
P-2	Apr.12,1945	23.6	-	-	-	-	-	-	7	-	-	-
P-3	do.	20.6	108	20	8.6	8.0	89	a/ 24	3	0.4	0.3	86
c/	Apr.11,1946	67.4	406	84	17	41	274	73	36	0.6	19	280
Wells												
				7.09	2.30	1.78	4.39	5.37	0.99			
1 a	Apr.11,1946	98.6	662	142	28	41	268	258	35	0.3	26	470
1 c	do.	111	670	138	16	58	317	169	73	-	60	460
7	Feb.24,1945	51.0	298	39	19	37	121	74	38	0.8	31	176
11	do.	112	728	157	24	49	235	115	112	0.3	155	490
21	Apr.12,1946	42.3	249	45	13	30	183	46	19	0.4	5.8	166
39	Apr.12,1945	39.6	227	40	15	27	209	27	13	0.8	0.8	162
40	do.	25.4	-	-	-	-	-	-	5	-	-	-
41	do.	29.9	172	30	11	18	126	40	8	0.8	2.1	120
42	Apr. 5,1945	28.0	-	-	-	-	-	-	13	-	-	-
47	Apr. 4,1945	76.7	459	89	39	26	384	105	7	0.7	2.8	382
48	do.	51.0	286	53	22	23	234	59	11	0.8	2.3	223
d/	Dec.14,1945	-	472	98	28	21	254	148	33	-	-	362
e/	do.	-	2,354	317	190	78	256	1,539	25	-	-	1,585

a/ By turbidity
b/ Determined
c/ Maurel Spring
d/ Old Dominion Mine, "domestic water". Analyzed by Miami Copper Company.
e/ Old Dominion Mine, "East side water". Analyzed by Miami Copper Company.

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Table 3. Logs of wells in the Upper Pinal Creek area

	Thickness (feet)	Depth (feet)
Driller's log of well 1a.		
Emile Maurel, owner		
NW¼SW¼ sec. 23, T. 1 N., R 15 E.		
Sandstone - - - - - - - - -	45	45
Conglomerate - - - - - - -	6	51
Crystallized quartz - - -	2	53
Conglomerate- - - - - - - -	21	74
Diabase - - - - - - - - - - -	13	87
Limestone, porous, manganiferous - - - - - -	6	93
TOTAL DEPTH - - - - - - - -		93

Struck water at 66 feet. Struck strong flow of water at 88 feet; very black at first.

	Thickness (feet)	Depth (feet)
Driller's log of well 54.		
Carretto Dairy, owner		
NE¼SW¼ sec. 31, T. 1 N., R. 16 E.		
Loose gravel with some clay	32	32
Conglomerate - - - - - - - -	36	68
Sandy gravel, water- - - -	2	70
Conglomerate - - - - - - - -	13	83
Hard rock - - - - - - - - -	10	93
Conglomerate - - - - - - - -	9	102
Gravelly sand, lighter color above 110 ft; hard rock at 110 ft. - - - - - -	23	125

Drilling at 125 ft.
Reported water level, 60 ft.

	Thickness (feet)	Depth (feet)
Driller's log of well 55.		
Southern Pacific R. R., owner		
Located at Cutter, east of area shown on map		
Gravel and boulders - - - -	130	130
Clay and sand - - - - - - - -	50	180
Sand rock - - - - - - - - - -	2	182
Clay and sand - - - - - - - -	28	210
Sand rock - - - - - - - - - -	3	213
Clay and sand - - - - - - - -	39	252
Sand rock - - - - - - - - - -	8	260
Clay - - - - - - - - - - - -	15	275
TOTAL DEPTH - - - - - - - - -		275

Struck water at 252 feet. Water level when drilled, 123.6 feet. Pumping level 178 feet.

Table 3. Logs of wells in the Upper Pinal Creek area-Cont.

DESCRIPTION OF WELL CUTTINGS FROM WELL 33; SW¼NE¼ sec. 36, T. 1 N., R. 15 E: owned by H. J. Hagen. Elevation 3.667 feet above sea level.

Mechanical analysis and mineral descriptions
by Ila I. Jones

All samples reacted with 10% solution of hydrochloric acid indicating some calcium carbonate. The mineral determinations were made with a stereoscopic binocular microscope. A petrographic microscope was not available.

Depth	Color	Maximum size of pebbles (length)	Mechanical analysis. Tyler Screens, using 50 Grams, wet method			Mineral content of 28 to 100 fraction		
			Retained on 28	28 to 100	Passing 100	Quartz and quartzite	Feldspar	Other
(feet)		(inches)	%	%	%	%	%	%
5	Reddish-brown	3/5	42	28	30	65	15	20
10	Reddish-brown	1	40	22	38	65	15	20
15	Brownish buff	1/2	48	18	34	50	15	35
20	Buff	1/2	45	19	36	65	15	20
25	Buff	1 1/2	41	21	38	60	15	25
30	Buff	3/4	38	20	42	55	15	30
35	Buff	1/4	42	21	37	60	15	25
40	Reddish-buff	3/4	33	23	44	65	15	20
45	Brownish-buff	3/4	40	22	38	55	15	30
50	Brownish-buff	3/4	49	17	34	65	15	20
55	Reddish-buff	3/4	44	19	37	65	15	20
60	Reddish-buff	3/5	46	19	35	60	15	25
65	Reddish-buff	7/8	42	18	40	50	15	35
70	Brownish-buff	3/4	33	21	46	70	10	20
75	Brownish-buff	3/4	41	20	39	60	15	25
80	Reddish-buff	7/8	41	21	38	60	15	25
85	Reddish-buff	1/4	41	21	38	60	13	27

Depth (feet)	Remarks
5	Cemented conglomerate of sand, silt, and clay, with angular pebbles of schist, granite and quartzite. Some pebbles coated with caliche.
10	Same as above. Kaolin coats many grains of quartz.
15	Pink quartzite is angular while the larger schist and granitic rock fragments are slightly rounded.
20	Epidote is an ever present mineral, along with quartz, feldspar and mica. Fewer pebbles. Some are of basic igneous composition.
25	Larger pebbles somewhat rounded, many of which are freshly broken. Limonite stains are frequent in the samples.
30	Some of the quartz grains are rounded and frosted. Dark minerals are abundant. Caliche cement.
35	Firmly cemented with caliche.
40	Sericite specks visible in all the samples. Some of the larger pebbles are well-rounded schists.
45	A few pink quartzite pebbles have their corners slightly rounded. Some pink feldspars present.
50	Some yellow-tinted quartz is visible, also the clear and milky varieties. Diabase and diorite pebbles are sub-angular.
55	Many of the quartz grains have black inclusions. The feldspars are somewhat rounded at this depth.
60	Chalcedony is present. Pebbles are composed of schist, granite and quartzite.
65	Sericite-quartz-schist. Many pebbles are freshly broken in the drilling of the well.
70	Some reddish-colored quartzite. Also tourmaline. The pebbles are buff quartzite, granite, schist, and basalt.
75	Epidote is invariably present in all the above samples associated with granites. A basalt pebble is partly rounded.
80	The quartzite is colored pink, white, buff, clear, or red. A freshly broken diorite fragment has red iron stain.
85	The feldspars are white, pink, or clear. Some rounding of the minerals.

Table 3. Logs of wells in the Upper Pinal Creek area-Cont.

Depth	Color	Maximum size of pebbles (length)	Mechanical analysis. Tyler Screens, using 50 Grams, wet method			Mineral content of 28 to 100 fraction		
			Retained on 28	28 to 100	Passing 100	Quartz and quartzite	Feldspar	Other
(feet)		(inches)	%	%	%	%	%	%
90	Brownish-buff	1/4	37	25	38	60	15	25
95	Brownish-buff	1/2	48	19	33	60	15	25
100 to 125 No samples			-					
125	Brownish-buff	1	69	13	18	60	15	25
130	Brownish-buff	1/4	51	18	31	60	10	30
135	Brownish-buff	1/2	51	17	32	50	15	35
140	Brownish-buff	1/2	57	17	26	50	10	40
145	Brownish-buff	1/2	50	19	31	50	10	40
150	Brownish-buff	1/2	51	17	32	50	10	40
155	Buff	1/2	48	21	31	50	10	40
160	Buff	1 1/4	60	16	24	45	15	40
165	Buff	1	54	17	29	45	15	40
170	Buff	1/2	63	13	24	45	15	40
175	Buff	4	65	15	20	45	15	40
180	Buff	1/3	58	15	27	55	10	35
185	Buff	2	70	11	19	55	10	35
190	Buff-brownish	1 1/2	74	10	16	60	10	30
195	Buff	1/2	66	15	19	55	10	35
200 to 320 No samples								
320	Grey-buff	-	32	44	24	50	15	35
325	No sample							
330	Grey	3/4	5	75	20	50	15	35
335	Grey-buff	-	3	29	68	55	10	35

Depth (feet)	Remarks
90	Rounded granules of buff-colored limestone. Angular kaolin fragments. Biotite in six-sided plates.
95	Schist, quartzite, basalt, diorite and granitic rock fragments. Buff colored limestone. Larger and more abundant angular pebbles.
100 to 125 No samples	
125	Contains many angular granitic pebbles and less silt and clay. Other recognizable rock types are quartzite, basalt, diorite, and schist.
130	Fewer pebbles and more silt and clay appear at this depth. Gneiss fragments and basic igneous rocks are present.
135	Angular chert, sub-angular quartzite and basalt. The more rounded granitic pebbles are coated with caliche.
140	Dark minerals more abundant at this depth. Cemented.
145	Kaolin. Organic material (twigs, etc.) cemented with limonite.
150	Metamorphic minerals present. Caliche coats many of the larger pebbles. Quartzite, limestone, gneiss, basalt, schist and diorite.
155	Quartzite, little granite, cherts of various colors, hematite, magnetite and limonite.
160	Many pebbles. Not as well cemented as above.
165	Quartzite, chert, basalt, granite. Most of the mica minerals are fresh.
170	Kaolin, chert, and granitic type rocks. Asbestos present. Many caliche-coated quartzites of various colors.
175	Fewer schists. Grey quartzite and granitic types of pebbles predominate. Some cherts.
180	More of the rocks show weathering and rounding. Brown limestone. Not well cemented. Limonite staining is not as prevalent as near surface.
185	The micas are black, white, green, and brown. Pebbles are larger, Quartzite predominates. Dark grey limestone.
190	Pebbles are abundant. Quartzites of various colors, granite, basalt, chert, and a few schistose rocks.
195	Many pebbles and granules (gravel).
200 to 320 No samples	
320	Some of the rounded quartz grains are stained red with iron-oxide. No pebbles appear in this sandy specimen. Dark grey sand grains abundant.
325	No sample.
330	Biotite in six-sided plates. White, pink, colorless and yellow quartz. The sample is a medium coarse sand, subangular, with a few pebbles.
335	Finer sand, much silt and clay, rounded to sub-angular grains.

Table 3. Logs of wells in the Upper Pinal Creek area-Cont.

Depth	Color	Maximum size of pebbles (length)	Mechanical analysis. Tyler Screens, using 50 Grams, wet method			Mineral content of 28 to 100 fraction		
			Retained on 28	28 to 100	Passing 100	Quartz and quartzite	Feldspar	Other
(feet)		(inches)	%	%	%	%	%	%
340	Grey-buff	-	29	34	37	50	10	40
345	No sample							
350	No sample							
355	Buff grey	-	38	46	16	70	5	25
360	Buff grey	-	47	37	16	60	5	35
365	No sample							
370	Grey buff	-	35	51	14	70	5	25

Summary

The entire well appears to have been drilled in a more or less cemented conglomerate with occasional layers of sand and silt. Most of the pebbles are angular, even when not shattered by drilling, but some round to sub-angular pebbles are found in almost every sample. The largest pebbles and the softest pebbles are the most rounded. The larger-sized constituents, the pebbles, are composed of schist; vein quartz; cherts of various shades (may be flint in part); quartzites colored pink, white, buff, grey, or red; granitic rocks of grey, white or pink colors; some buff and dark grey limestone; dark basalt and other volcanic rocks; a little tuff; and a few shales. The smaller-sized constituents are granules and sand grains composed of minerals which normally make up granites and the other rocks mentioned above. Quartz and feldspar are the most abundant minerals of the sand-grain size and at some depths they have black inclusions. The cement is calcium carbonate, with subordinate iron oxide. Some organic remains are present, such as twigs, and some angular fragments of kaolin appear at a few levels.

Depth (feet)	Remarks
340	The minerals are generally rounded. Some of the quartz sand grains have red iron stains through them. Other quartz grains have black inclusions. Feldspar is kaolinized.
345	No sample.
350	No sample.
355	All sand-grain size or smaller. Some quartzite granules are distinctly rounded.
360	The largest granule is two millimeters long. Some of the quartz grains are entirely rounded.
365	No sample
370	All are of sand-grain size or smaller. Much chert in various colors.

The samples from 100 to 125 feet were not submitted for laboratory study. However, a change in the proportion of pebbles in relation to silt and clay occurs between the 95- and the 130-foot depth. The section begins with the appearance in the 95-foot sample of larger and more abundant angular pebbles than in preceding samples, and ends with the 130-foot sample containing many large pebbles. This probably indicates that the section contains a good water-bearing stratum, and it was reported that the first water was struck at 105 feet.

Another possible water-bearing stratum is indicated near the 200-foot depth by the fact that the proportion of pebbles as compared with silts and clays is somewhat greater than the average for the well. However, samples immediately below this depth were not submitted and its significance therefore cannot be positively stated.

All of the samples below 320 feet were predominantly sandy and uncemented as compared with the samples above this depth. The sample at 330 feet had some gravel with pebbles as large as three-fourths of an inch in length.

Table 4

Records of wells and springs in the Upper Pinal Creek area.
All wells are dug unless otherwise noted in "Remarks" column.
All elevations are from measurements with aneroid barometer or reported by owner.

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth of well (feet)	Diameter of well (in.)
	T. 1 N., R. 15 E.						
1	NE¼SE¼ sec. 15	Kenneth Hoopes	-	-	-	-	48
c/1a	NW¼SE¼ sec. 23	Emile Maurel	Emile Maurel	-	-	93	11½
1b	NW¼SE¼ sec. 22	- West	-	-	-	375	-
c/1c	SW¼NW¼ sec. 23	H. B. Maurel	- Maurel	1900	-	47	48
1d	SW¼SE¼ sec. 23	U. S. Bureau of Mines	Old Dominion Mine	1915	-	458	16
	T. 1 N., R. 16 E.						
2	SE¼SE¼ sec. 17	Dave Lewis	-	1933	-	95	48
3	SW¼NW¼ sec. 21	Lon Walters	-	1930	3,685.8	120	48
	T. 1 N., R. 15 E.						
4	SW¼NE¼ sec. 26	Rose Tellez	-	1934	-	150	48
5	do.	J. A. Clark	-	-	3,508	70	48
6	do.	- Reddin	-	-	-	-	48
c/7	SE¼NE¼ sec. 26	A. H. Bednorz	A.H.Bednorz	-	3,464.7	12	36
8	do.	do.	Denny Gleason	1900	3,503.1	60	60
9	SE¼SE¼ sec. 26	-	-	do.	-	-	48
10	SW¼SW¼ sec. 25	- DeComa	-	-	3,516	-	48
11	do.	A.G.Cochrane	-	1914	3,495	50	48
12	NE¼NE¼ sec. 35	- Delbridge	-	-	-	110	48
13	do.	Geo. F. Johnson	-	-	3,553	-	48
14	NW¼NE¼ sec. 36	- Ice Co.	-	-	-	-	78

a/ C, cylinder; B, bucket; T, turbine; W, windmill; H, hand; E, electric; G, gasoline.

b/ N, not used; D, domestic; P, public supply; S, stock; I, irrigation; Ind., industrial.

Records obtained by G. E. Hazen and S. F. Turner

No.	Water level: Depth of water below land surface (feet)	Water level: Date of measurement	Pump and power a/	Use of water b/	Remarks
1	80.7	Mar. 20, 1945	C,W	N	-
1a	66	d/	C,H	D	Drilled well. See log, table 3
1b	131	d/	C,E	P	Drilled well. Reported discharge, 100 gallons a minute.
1c	47	d/	C,G	D	Water reported from diorite.
1d	33.3	Apr. 12, 1946	None	N	Drilled near Pinal Creek to pump water from mine. Reported water level 285 feet, discharge 400 gallons a minute, 1915.
2	90.6	Mar. 11 1945	C,G	D,S	Water from sand.
3	96.9	do.	C,W	D,S	Water from Gila conglomerate.
4	91.8	Feb. 26, 1945	None	N	Do.
5	62.9	do.	C,W	N	Do.
6	61.5	do.	B,H	N	Do.
7	9.9	Feb. 23 1945	T,E	I	-
8	43.3	do.	None	N	Water from Gila conglomerate.
9	110.9	Feb. 26, 1945	None	N	Do.
10	59.8	do.	C,E	N	Do.
11	42.2	do.	C,E	I	Water reported from limestone.
12	87.0	Feb. 24, 1945	-	N	Water from Gila conglomerate.
13	77.9	do.	C,H	N	Do.
14	21.7	do.	-	Ind.	Water from gravel.

c/ See table 2 for analysis of water sample.
d/ Water level reported.

Records of wells and springs in the Upper Pinal Creek area- Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth of well (feet)	Diameter of well (in.)
15	NE¼NW¼ sec. 36	Southern Pacific R.R.	-	-	-	54	180
16	SE¼NW¼ sec. 36	Inez Costaneda	-	1915	3,520.6	60	60
17	SW¼NE¼ sec. 36	Ralph Sandoral	-	-	3,548	49	48
	T. 1 S., R. 15 E.						
18	SE¼SE¼ sec. 4	Angelo Dimerio	Angelo Dimerio	1909	3,538	50	42
19	SE¼SE¼ sec. 9	-	-	-	3,896	20	48
	T. 1 N., R. 16 E.						
20	SW¼SW¼ sec. 31	City of Globe	-	-	-	80	48
c/21	do.	do.	-	-	3,574	85	-
	T. 1 S., R. 15 E.						
22	NW¼NW¼ sec. 1	A.W. Bundrick	-	-	-	30.5	72
23	do.	Mary E. Bilson	-	-	-	25	48
24	SE¼NE¼ sec. 2	Caretto Bro. Dairy	-	1915	-	30	48
25	SW¼SE¼ sec. 2	W.E. Tuttle	W.E. Tuttle	1917	-	35	-
	T. 1 N., R. 16 E.						
26	SW¼SE¼ sec. 31	Daou Packing Co.	-	-	-	300	6
27	SW¼SW¼ sec. 32	do.	-	1930	-	302	6
	T. 1 S., R. 15 E.						
28	SW¼NE¼ sec. 11	Mrs. L.F. Hughes	-	-	-	25	60
c/29	cen., sec. 11	Charlie Knox	-	-	-	35	60

Records obtained by G. E. Hazen and S. F. Turner

No.	Water level: Depth of water below land surface (feet)	Water level: Date of measurement	Pump and power a/	Use of water b/	Remarks
15	20.5	Feb. 26, 1945	C,E	Ind.	Water from gravel and sand, Infiltration gallery 50 feet in length, 59-54 feet.
16	40.6	Apr. 9, 1945	-	N	Water from Gila conglomerate.
17	17.0	Feb. 27, 1945	-	D,I	-
18	18.0	Mar. 7, 1945	C,H	D,S	-
19	8.4	do.	B,H	D,S	-
20	-	-	T,E	N	City well 3. On east bank of Pinal Creek. Water from Gila conglomerate.
21	17.8	Feb. 27, 1945	-	P	Drilled well. City wells 1 and 2, connected with tunnel 250 feet in length.
22	9.7	Apr. 6, 1945	-	N	-
23	6.4	Apr. 7, 1945	C,E	D	Water from gravel.
24	12.4	do.	C,E	D,S	Water from Gila conglomerate.
25	13.8	-	C,E	D	Water from diorite gravel.
26	290	-	-	N	Drilled well.
27	-	-	-	N	Drilled well. Did not produce water.
28	12.4	Apr. 7, 1945	C,W	D,S	-
29	7.1	Apr. 6 1945	C,E	D	-

Records of wells and springs in the Upper Pinal Creek area-Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth of well (feet)	Diameter of well (in.)
30	SW¼SW¼ sec. 11	-	-	-	-	-	-
31	do.	C.A. Austin	- Freestone	1944	3,789	187	8
32	SW¼NE¼ sec. 11	-	-	-	3,698.4	-	48
	T. 1 N., R. 15 E.						
33	SW¼NE¼ sec. 36	H. J. Hagan	H. J. Hagan	1945	3,667.4	200	6
	T. 1 S., R. 15 E.						
34	NW¼NW¼ sec. 14	W.A. Evans	-	-	3,860.3	29	72
35	NW¼NE¼ sec. 15	F. H. Sheppard	-	-	-	-	48
36	NE¼SE¼ sec. 16	Harry Jackson	-	-	3,896	16	48
37	Lot 11, sec. 12	Ada Anteva	-	-	-	71.6	48
38	SE¼NW¼ sec. 12	Chas. E. Collins	-	1915	3,677	28.1	60
c/39	NW¼SE¼ sec. 12	Irwin L. Smith.	-	1942	-	119	6
c/40	SW¼SE¼ sec. 12	T.L. Bryant	-	-	3,737	70	48
c/41	do.	Robert Owen	H.J. Hagan	1944	-	102	6
c/42	do.	M. J. Van Horn	-	1915	-	48	48
43	NE¼SE¼ sec. 16	J.L. Fitzpatrick	-	-	4,101.5	-	48
44	SW¼SE¼ sec. 15	John Belcher	-	-	4,157.3	27	48
45	NE¼SE¼ sec. 15	Frank Parker	-	-	-	12	48
46	NW¼SW¼ sec. 23	do.	Ralph Beard	-	4,080.9	450	16
c/47	SE¼SE¼ sec. 14	do.	-	-	3,881	14	48
c/48	NE¼SW¼ sec. 13	L. Waldman	- Freestone	-	-	185	6
49	do.	- Forrester	-	-	3,803	25	48

Records obtained by G. E. Hazen and S. F. Turner

No.	Water level: Depth of water below land surface (feet)	Water level: Date of measurement	Pump and power a/	Use of water b/	Remarks
30	-	-	-	N	Former city well.
31	15.2	Mar. 12, 1945	C,E	D	Drilled well. Water from Gila conglomerate.
32	6.6	May 25, 1945	-	N	-
33	98.2	Aug. 7, 1945	T,E	Ind.	Drilled well. See table 3 for log. Water from gravel.
34	6.6	Apr. 7, 1945	C,G	D,S,I	Water from Gila conglomerate.
35	10.2	-	C,G	D	-
36	3.2	Apr. 9, 1945	-	D	-
37	67.2	Apr. 5, 1945	C,E	D,S,I	Water from gravel.
38	5.5	do.	C,E	D,S	Do.
39	20	-	C,E	D,S	Drilled well. Water from sand.
40	7.8	Apr. 6, 1945	C,G	D,S,I	Water from quicksand and gravel.
41	30	-	C,E	D	Drilled well. Water from caliche and sand.
42	12.6	-	C,E	D,S,I	Water from gravel.
43	7.2	May 28, 1945	-	N	Owner reports well goes dry during drought.
44	5.8	Apr. 9, 1945	C,G	D,S	Water from Gila conglomerate.
45	4.5	Apr. 10, 1945	C,H	D	Owner reports well goes dry in late summer.
46	7.5	Mar. 12 1945	C,G	S	Drilled well. Water from diorite. Former city well.
47	2.4	May 25, 1945	C,G	D	-
48	7	-	C,E	D,S	Drilled well. Water from Gila conglomerate.
49	4.2	Mar. 8, 1945	C,E	D	-

Records of wells and springs in the Upper Pinal Creek area–Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth of well (feet)	Diameter of well (in.)
	T. 1 S. R. 16 E.						
50	NE¼NE¼ sec. 19	U. S. Dept. Agric.	-	-	4,082.5	300	30
51	NW¼NE¼ sec. 29	- Chinnman	C.W.Freelove	1930	-	160	6
	T. 1 S., R. 15 E.						
52	NW¼SW¼ sec. 19	- Schniffen	-	1945	3,800	105	6
	T. 1 N., R. 15 E.						
53	SW¼SW¼ sec. 25	City of Globe	H.J. Hagan	1946	-	150	10
	T. 1 N., R. 16 E.						
54	NE¼ SW¼ sec. 31	Caretto Dairy	do.	do.	-	125	6
55	San Carlos Indian Reservation, Cutter	Southern Pacific R.R.	-	-	3,194	275	12
	T. 1 N., R. 15 E.						
c/-	SW¼NW¼ sec. 25	E. Maurel	-	-	-	-	-

a/ C, cylinder; B, bucket; T, turbine; W, windmill; H, hand; E, electric; G, gasoline.

b/ N, not used; D, domestic; P, public supply; S, stock; I, irrigation; Ind., industrial.

Records obtained by G. E. Hazen and S. F. Turner

No.	Water level: Depth of water below land surface (feet)	Water level: Date of measurement	Pump and power a/	Use of water b/	Remarks
50	83.3	Mar. 13 1945	C,G	S	-
51	-	-	-	-	Drilled well.
52	14.5	June 21, 1946	None	N	Drilled well.
53	32.2	July 19, 1946	T,E	P	Drilled well in yard by fire tower. Struck water at 38-40,50 and 70 feet.
54	60	d/	None	N	Drilled well; not completed, July 1946. See table 3 for log.
55	123.6	-	T,G	Ind.	Railroad well at Cutter on San Carlos Indian Reservation; along railroad 4 miles east border of map. See table 3 for log.
-	-	-	None	P	Maurel Spring. Seep in bed of Pinal Creek upstream from under flow dam across creek. Flow began when dam built in 1909. Measured discharge, 50 gallons a minute, April 11, 1946.

c/ See table 2 for analysis of water sample.
d/ Water level reported.

Table 5. Summation of gains and losses in flow of streams in the Upper Pinal Creek area, 1945
Measurements made by J. F. Hostetter

Name of stream and description of reach	Length of reach, miles	Distance from uppermost station, miles	Date of measurements, 1945 April 6-7 Gain +	April 6-7 Loss −	April 6-7 Temp. of water °F	April 12-13 Gain +	April 12-13 Loss −	April 12-13 Temp. of water °F
			Cubic feet per second			Cubic feet per second		
Pinal Creek								
Discharge at P-5 plus S-1: above mouth of Sixshooter Canyon	-	0		3.10	63		2.72	44
Sta. P-4, below mouth of Sixshooter Canyon	0.35	0.35		1.03	63		0.47	45
Sta. P-3: near well 38	1.25	1.6					0.13	49
Sta. P-2: above mouth of Icehouse Canyon	1.10	2.7		0.47	62		0.34	53
Sta. P-1: below mouth of Icehouse Canyon	0.30	3.0	0.26		44	0	0	43
Total loss measured				1.24			0.94	
Sixshooter Canyon								
Discharge at S-3: 0.1 mile south of well 46		0		2.23	64		1.97	42
Sta. S-2: "Halfway Point"	0.48	0.48	0.4		63		0.04	42
Sta. S-1: north of Sixshooter Canyon	1.05	1.53	0.81		63	0.75		44
Total gain measured			0.85			0.71		

Table 5. Summation of gains and losses in flow of streams in the Upper Pinal Creek area, 1945-Cont.
Measurements made by J. F. Hostetter

Name of stream and description of reach	Length of reach, miles	Distance from uppermost station, miles	Date of measurements, 1945 April 6-7 Gain +	Loss -	Temp. of water °F	April 12-13 Gain +	Loss -	Temp. of water °F
			Cubic feet per second			Cubic feet per second		
Icehouse Canyon								
Discharge at I-8; near end of Sixshooter Canyon Road		0					0.53	45
Sta. I-7; 0.15 mile north of well 44	0.85	0.85		0.68	57	0.08		47
Sta. I-5; at head of canal	0.90	1.75		↑			0.09	47
Sta. I-4; mouth of Kellner Canyon	0.60	2.35		0.16	60	0.43		62
Sta. I-3; Griesser Ranch	0.40	2.75		↑		0.02		63
Sta. I-2; 0.65 mile above mouth	1.0	3.75		0.24	56		0.34	64
Sta. I-1; mouth of Icehouse Canyon	0.65	4.40		0.22	56		0.03	56
Total gain or loss measured				0.62		0.07		
Kellner Canyon								
Discharge at K-3; 0.2 mile south of well 43		0		1.41	58		1.10	59
Sta. K-2; "Halfway Point"	1.15	1.15	0.05		63	0.10		63
Sta. K-1; mouth of Kellner Canyon	1.0	2.15		0.06	63	0	0	63
Total gain or loss measured				0.01		0.10		
Russell Canyon								
Discharge at I-4; John Brock Ranch		0		1.94	64		1.68	48
Sta. R-3; "Three Sycamores"	1.2	1.2		0.21	64		0.23	50
Sta. R-2; "Hackberry"	1.05	2.25	0.06		64		0.24	53
Sta. R-1; "Field crossing"	1.60	3.85		1.58	71		1.15	61
Total loss measured				1.73			1.62	

Table 6. Results of geophysical investigations in the Upper Pinal Creek area
(See plate 1 for locations of probes)

Probe number	Approximate depth (feet)	Resistivity	Probable material	Recommendations for test drilling
1	0-15	High	Sand and gravel	
	15-120	Low	Silt, clay and boulders (cemented conglomerate)	Unfavorable
	120-210	High	North end, conglomerate; south end, across fault, granite at 120 feet.	
2	0-20	High	Sand and gravel	
	20-100	Low	Silt, clay and boulders (cemented conglomerate)	
	100-250	Medium	Sand or sandy conglomerate	Favorable
	250-400	Variable	Silty conglomerate with lenses of sand	
3	0-20	High	Sand and gravel	
	20-150	Low	Silt, clay and boulders (cemented conglomerate)	
	150-220	Medium	Sand or sandy conglomerate	Favorable
	220-440	do.	Sand and gravel	
	440-500	Low	Cemented conglomerate	
	500-560	Medium	Sand and gravel	
4	0-30	Medium	Silty conglomerate	
	30-200	Low	Silt, clay and boulders (cemented conglomerate)	Moderately favorable
	200-440	Variable	Silty conglomerate with lenses of sand	

Table 6. Results of geophysical investigations in the Upper Pinal Creek area-Cont.

Probe number	Approximate depth (feet)	Resistivity	Probable material	Recommendations for test drilling
5	0-15	Medium	Sand and gravel	
	15-30	Low	Silt, clay and boulders (cemented conglomerate)	
	30-50	Medium	Sand or sandy conglomerate	Unfavorable
	50-250	Low, variable	Silty conglomerate with lenses of sand	
	250-520	Medium, variable	Sand with lenses of silt	
6	0-20	Medium	Terrace sand and gravel	
	20-220	Low	Silt, clay and boulders (cemented conglomerate)	Unfavorable
	220-360	Medium	Sand or sandy conglomerate	
	360-500	High	Hard rock	
7	0-25	High	Gravel	
	25-40	Low	Silt and clay	
	40-50	High	Gravel	
	50-90	Low	Silt, clay and boulders (cemented conglomerate)	Favorable
	90-100	High	Gravel	
	100-350	Medium	Silty conglomerate with lenses of sand	
	350-460	Low	Silt, clay and boulders (cemented conglomerate)	
8	0-20	High	Coarse gravel	
	20-50	Low	Silt, clay and boulders (cemented conglomerate)	
	50-100	Medium-low	Sand, silt and boulders	Favorable
	100-120	Medium	Sand	
	120-220	Low	Silt, clay and boulders (cemented conglomerate)	
	220-400	Medium	Sand, silt and boulders	

Table 6. Results of geophysical investigations in the Upper Pinal Creek area-Cont.

Probe number	Approximate depth (feet)	Resistivity	Probable material	Recommendations for test drilling
9	0-5	High	Coarse sand	
	5-25	Low	Silt, clay and boulders (cemented conglomerate)	
	25-30	Medium	Sand	
	30-100	Medium-low	Sand, silt and boulders	Moderately favorable
	100-120	Medium	Sand	
	120-240	Low	Silt, clay and boulders	
	240-300	Medium	Sand	
	300-340	Low	Silt, clay and boulders	
	340-460	Medium	Sand	
10	0-10	High	Coarse sand	
	10-35	Low	Cemented conglomerate	
	35-40	High	Sand	Unfavorable
	40-70	Low	Cemented conglomerate	
	70-400	Variable	Cannot be interpreted a/	

a/ One electrode crossed old tailings pile and other electrode crossed a fault.

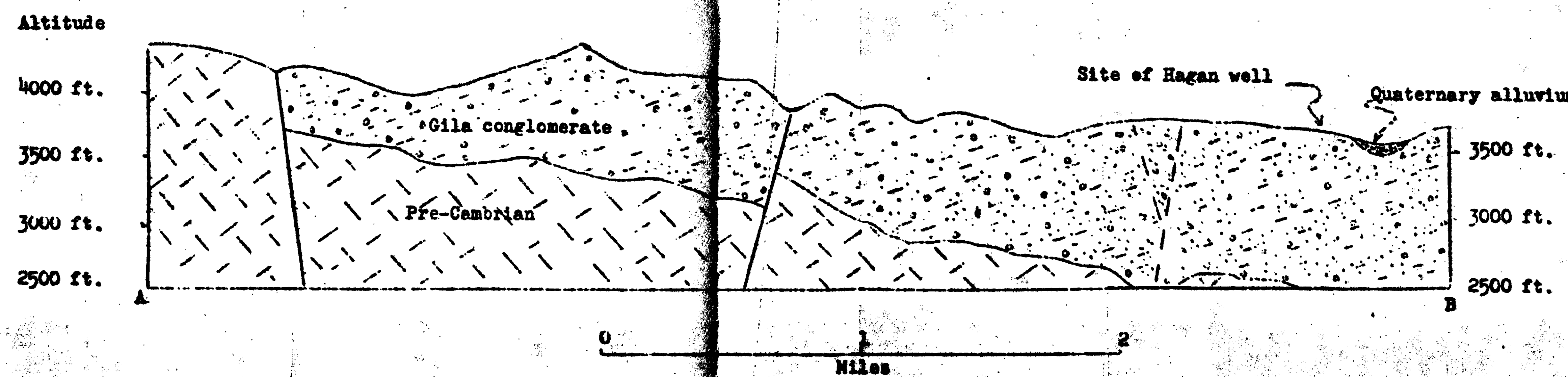

FIGURE 1 - IDEALIZED GEOLOGIC SECTION OF LINE A - B, PLATE 1

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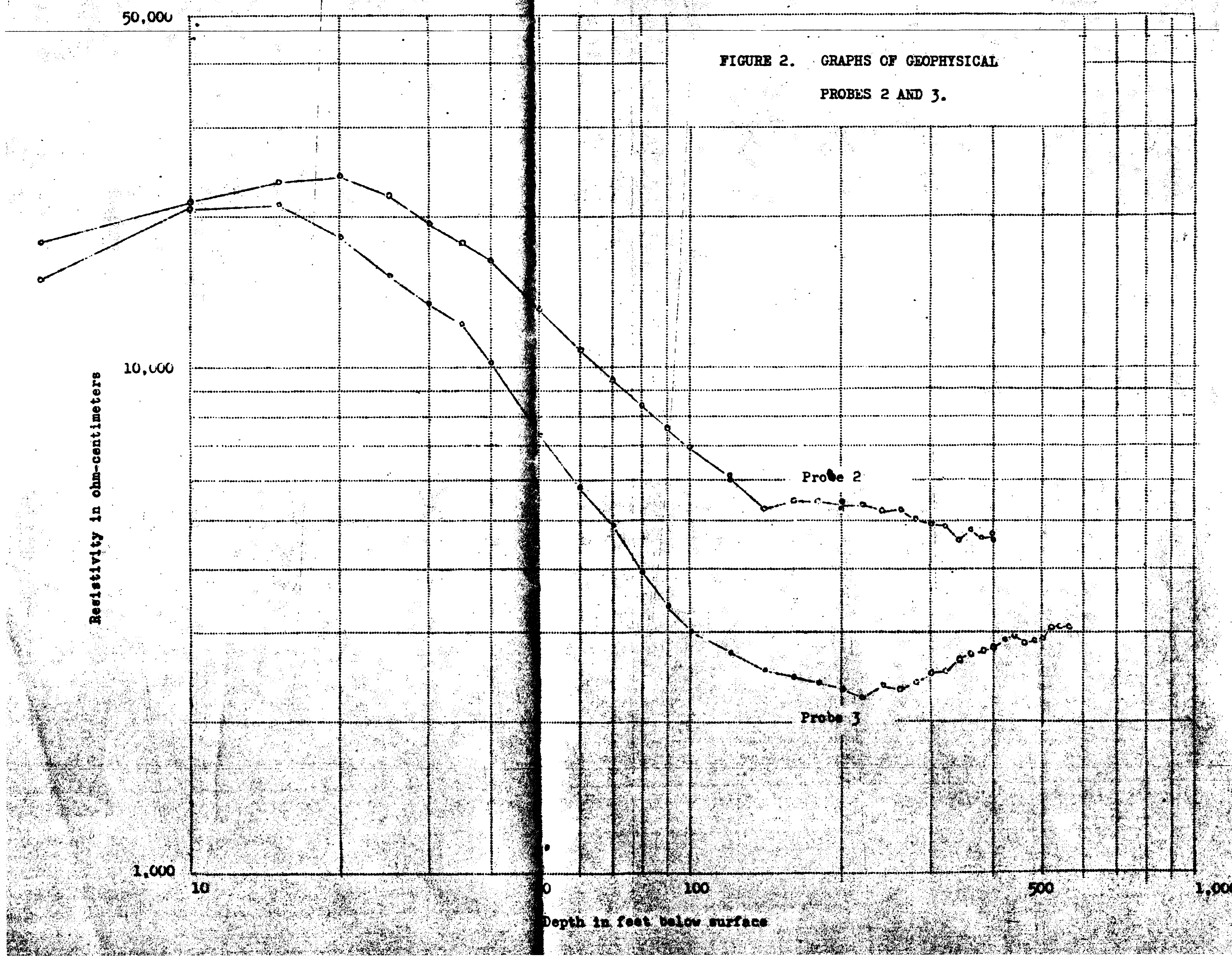

FIGURE 2. GRAPHS OF GEOPHYSICAL PROBES 2 AND 3.

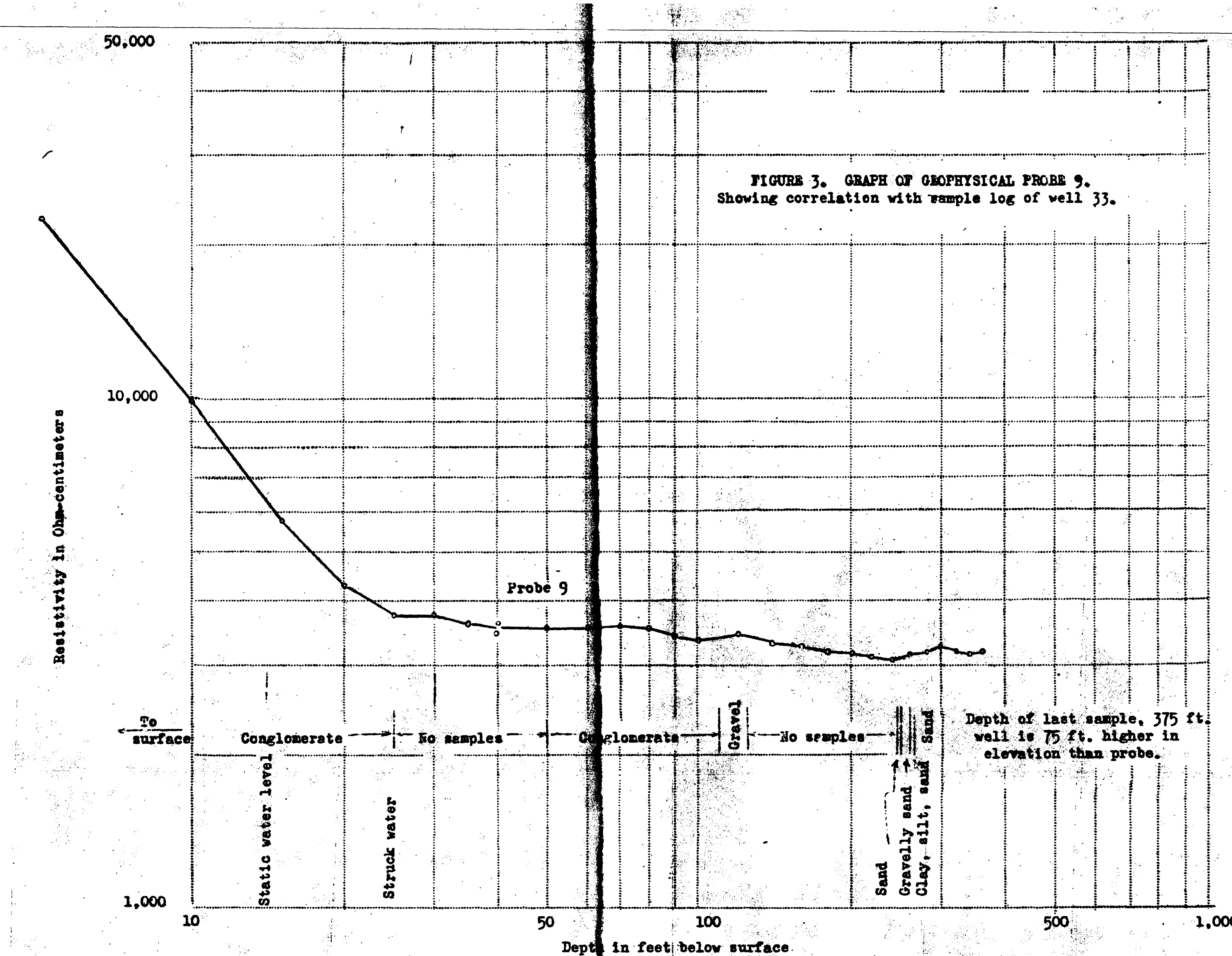

FIGURE 3. GRAPH OF GEOPHYSICAL PROBE 9.
Showing correlation with sample log of well 33.

PLATE 2. MAP OF UPPER PINAL CREEK (GLOBE) AREA, GILA COUNTY, ARIZONA

SHOWING LOCATIONS OF WELLS AND SEEPAGE MEASUREMENTS AND CONTOURS OF THE WATER TABLE AS OF MAY 24-25, 1945.

-SCALE-
0 1 2 MILES

FIELD WORK BY
GUY HAZEN
AND
J. F. HOSTETTER

BASE COMPILED FROM AERIAL PHOTOGRAPHS AND FIELD NOTES

—EXPLANATION—

- WELL WITH HAND PUMP BUCKET OR BAILER
- WELL WITH WINDMILL OR SMALL POWER PUMP
- UNUSED WELL
- SPRING
- WELL WITH PUMPING PLANT 5 HORSEPOWER OR LARGER
- R-1 LOCATION OF STREAM FLOW MEASUREMENT; LETTER REPRESENTS NAME OF STREAM.
- IMPROVED ROAD
- TRAIL

N

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