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INTRODUCTION

Purpose and Scope of Investigation

The purpose of the present investigation was to make a preliminary survey of the geology and hydrology of the Rabbithole Placer and surrounding area, including the watersheds of Rabbithole Creek and of Granite Springs Wash. (See Fig. 1.) Also, the purpose was to evaluate the test drilling program underway in July 1957 and to seek answers to the problems of water supply for the placer operation.

Itinerary and Contacts

The author arrived at Rabbithole Placer Monday, July 8, 1957 at 4 p.m. That evening, the next day and following morning were spent in company with Mr. Eugene C. Iverson examining the area, studying the springs and other hydrologic features, and visiting wells under construction and those recently tested. On the morning of Wednesday, July 10, the author left Rabbithole Placer for Reno and Carson City. In Reno the library of the University of Nevada was visited in search of information on the Rabbithole area. Later in the afternoon the Groundwater office of the U. S. Geological Survey was visited in Carson City. The following morning, Thursday, July 11, contact was made with the office of the State Engineer in Carson City.

The author returned to Orem Thursday, July 11 via Ely, Nevada and Delta, Utah.

This preliminary investigation is based on only three days in the field and a like period of time spent in the library or further research of the geology and hydrology of the area.

Definitions

In this report the following definitions of technical terms are adhered to.

The property of a porous water-bearing material that relates to its ability to conduct water under a hydraulic gradient is known as its <u>permeability</u>. The author uses the definition of this term accepted in the petroleum industry. Thus, the permeability is the horizontal volume-flow per unit area per unit time per unit horizontal pressure gradient of a fluid of a unit viscosity and unit specific weight. The flow may be expressed in cubic centimeters per square centimeter per second, the horizontal pressure gradient in atmospheres per centimeter, the viscosity in centipoises, and the specific weight in grams per cubic centimeter. With this choice of units, the unit of permeability is called the darcy.

In soil mechanics and foundation engineering, the term permeability is often applied to another constant. This second constant or characteristic typifies not only the porous material but also the fluid flowing through it, and includes in addition to the permeability as defined above, the fluid factors viscosity and specific weight. In this report this product is termed <u>hydraulic conductivity</u>. In terms of hydraulic conductivity Darcy's law of flow may be expressed as follows: The discharge per unit area is equal to the product of the hydraulic conductivity by the hydraulic gradient, or loss of head per unit distance in the direction of flow. The hydraulic conductivity is the permeability multiplied by the specific weight of fluid and divided by its viscosity.

A convenient term used to describe the ability of a uniformly thick bed or aquifer to transmit water is its transmissivity (same as transmissibility of Theis). The transmissivity is the hydraulic conductivity multiplied by the thickness of transmissive formation.

The ability of an aquifer to store water is expressed by a number called in this report its storativity. This is the same as "coefficient of storage" or "storage coefficient" of Theis. It is defined as the volume of water removed from storage under a unit surface area by a unit decline of head, or expressed otherwise, it is the volume of water stored under a unit surface area by a unit rise of head.

In unconfined aquifers, the storativity approaches the porosity of the material if it is very coarse grained. If it is fine grained, the effective porosity is reduced by the amount of water held in the material by capillary action. Thus the storativity is the difference between the porosity and the "specific retention."

In confined aquifers the storage of water arises from the compressibility of the water itself and the expansibility of the aquifer that contains it. As the pressure on the water is reduced, it expands, and the aquifer itself is compressed. This specific volume of storage is of the order of one thousandth the specific volume of storage in unconfined aquifers.

The specific drawdown is defined as the drawdown per unit discharge of the well. Inasmuch as the drawdown varies not only [illegible], but with discharge, the specific drawdown likewise varies with time and with discharge.

GEOLOGY

The geology of the Rabbithole area is briefly outlined here as it relates to the occurrence of groundwater. The characteristics of rocks that relate to their ability to store and transmit water are their porosity and permeability, respectively. (See Definitions in the INTRODUCTION.) Determinations of porosity and permeability by field or laboratory methods were not made during this investigation. However, certain generalizations may be drawn from the known character of the rocks as exhibited in their outcrops and where they are encountered by drilling.

There was not sufficient time in the investigation to make a geologic map of the area from independent field study. The map given herein (Figure 2) is taken from King's Map V in the Atlas of the report of U. S. Geological Exploration of the Fortieth Parallel in 1876. The author has made certain modifications in King's map according to the later studies of Ransome [1909] and the U. S. Geological Survey [1932].

Jurassic and Triassic Rocks

Slates and phyllites of supposed Jurassic or Triassic age crop out in a number of places within the watersheds of Rabbithole Creek and Granite Springs Wash. The largest outcrop is along the west side and at the south end of Antelope Range. Another outcrop is along the east side of Kamma Mountains. There are also two outcrops of these slates on the range just to the west of Granite Springs Wash, one at the north end and the other toward the southeast.

Except where jointed or faulted, these slates are quite impervious to the flow of water. It is not believed that they store or transmit much groundwater anywhere in the area.

Jurassic and Cretaceous Rocks

Intrusive rocks of supposed Jurassic or Cretaceous age are found in a number of places at the surface in the area. These igneous intrusives consist principally of granite, diorite, and dacite, with intermediate kinds. The greater part of the range west of Granite Springs Wash is made up of granite of this age. The hill immediately south of Rabbithole Springs is diorite, supposedly of the same age. The northwest corner of Seven Troughs Range is likewise granitic, as is also a large part of Antelope Range.

These granitic rocks are very low in porosity and permeability and supply groundwater only where extensively faulted or otherwise fractured. It is very improbable that much groundwater issues from the granitic rocks in this area.

Tertiary Rocks

Tertiary rocks of two kinds are common in the area: First, continental deposits of supposed Miocene age, and second, volcanic rocks (rhyolites and andesites) of Tertiary age.

Miocene silts. The Miocene sediments in the area are largely silt with interbedded volcanic ash. Similar deposits elsewhere are known as the Truckee formation, from their outcrop along the Truckee River. The buried backbone of the hill just northwest of Rabbithole camp is believed to be made up largely of these Miocene silt beds. These continue up the northwest flank of Kamma Mountains to the sulphur mine. (The sulphur is found imbedded in this very formation.)

The mountain south of Rabbithole Springs is encircled with an outcrop of Truckee formation. Also, the upper drainage of Placeritos Creek is underlain by these Miocene silts.

It is very unlikely that the silts and interbedded ash of Miocene age conduct very much groundwater in the area. They may have large porosity, but because of their relatively low permeability, they prove ineffective as aquifers.

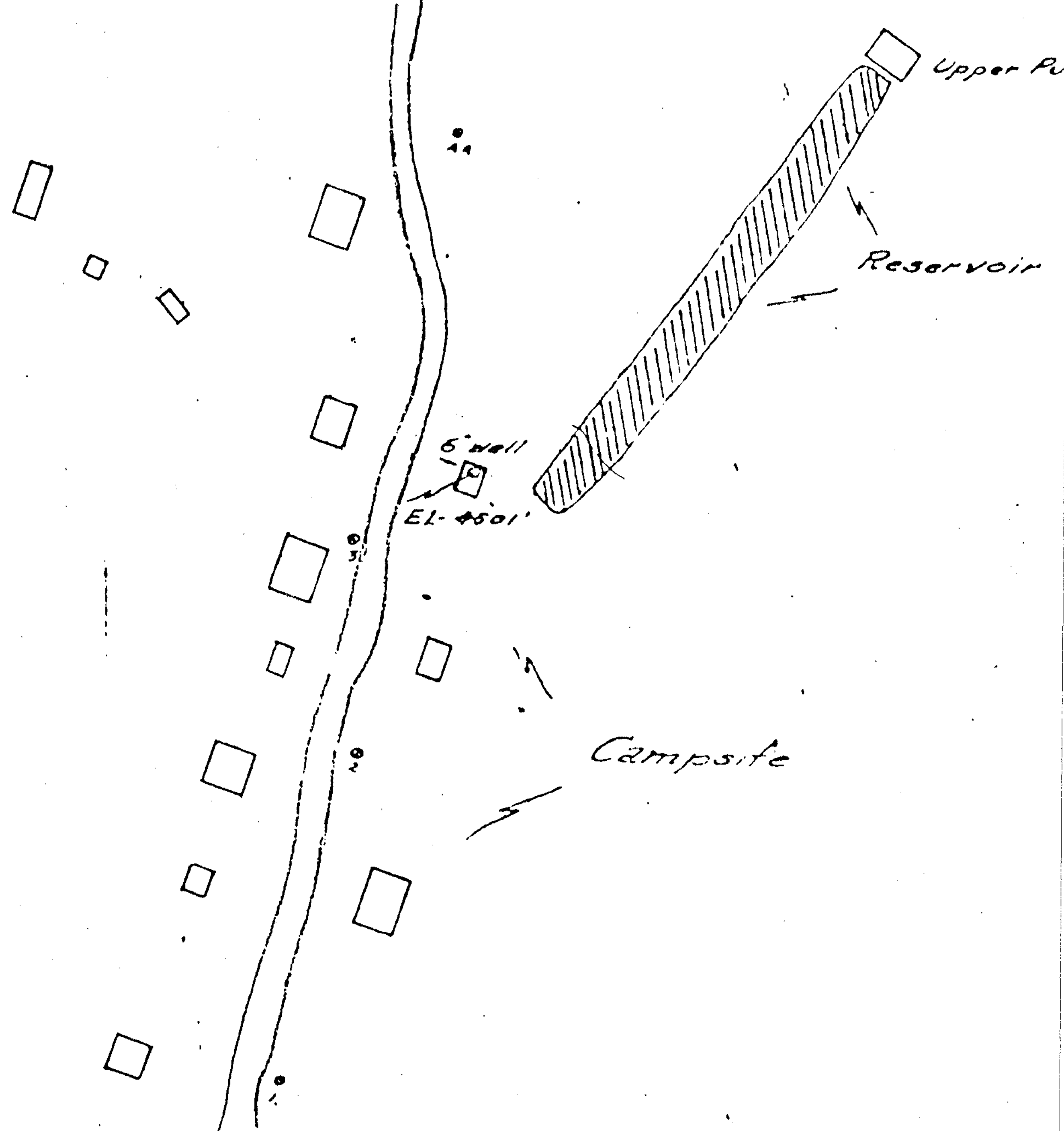
Volcanic rocks. The Tertiary volcanic rocks of the area are principally rhyolites and andesites. Much of the northern end of Kamma Mountains is rhyolite, while the southern extension is largely andesite, as shown in Fig. 2. Outcrops of similar rocks are found at the north end and along the east side of Seven Troughs Range.

These extrusive rocks of Tertiary age are largely above the water table. Moreover, they are not very porous, except in areas of steep relief and where weathered. Therefore, they are not important as water-bearing formations.

Quaternary Rocks

Volcanic rocks of supposed Pliocene or Pleistocene age also crop out in the area. These rocks are mainly basaltic. An outcrop is seen at the extreme north end of Seven Troughs Range, and another prominent outcrop is Black Rock Point, northwest across the Black Rock Desert from the Sulphur station on the Western Pacific.

Alluvium. The most promising rocks of the area as far as groundwater is concerned are the alluvial deposits. Much of drainage area


Upper Pu
Reservoir
6" well
EL- 4501'
Campsite

of Granite Springs Wash and of Rabbithole Creek is underlain by Quaternary alluvium. However, because of the nature of the source rocks from which this alluvium is derived, most of it is very fine and not very permeable. In places, gravels are found, as for example in the Rabbithole placer and elsewhere in Rosebud Canyon and in Placeritos Canyon, but they are generally discontinuous, being enclosed by a matrix of silts and clays. Therefore, they are not likely to conduct very much water from the area.

The soils of the area are generally silty-loams and clay-loams. Their "field capacity" or moisture holding capacity is moderately high. In view of the small annual rainfall it is therefore unlikely that appreciable runoff occurs except following storms of high intensity.

Geologic Structure

The Jurassic and Triassic slates in the area strike generally northeast and dip rather steeply toward the northwest. The upturned slates surrounding Majuba Hill were found by Ciavella [1952] to have dips ranging from 61° to 56° northwestward. Ransome [1909] found similar slates on the east flank of Seven Troughs Range to dip northwestward about 40°. These upturned beds of slate are overlain unconformably by the continental deposits of Miocene age, where these are above the slates, or by the volcanic rocks of younger age. In places the slates have been intruded by granitic rocks of Jurassic or younger ages. These intrusive rocks are similar to those of the Sierra Nevada batholith.

The Miocene sills are tilted and perhaps faulted, and in some places are overlain unconformably by flows of extrusive rock.

The flows of basalt, rhyolite and andesite are from a few to several hundred feet thick. They dominate the topography in Seven Troughs Range (northern part) and in Kamma Mountains.

TEST DRILLING

At the time of the author's visit to Rabbithole placer in July 1957, eleven test holes had been completed and one was nearing completion. These wells are designated Meyer Nos. 1 to 4 and Pulati Nos. 1 to 8. Pertinent data concerning these wells are found in Table 1. Their logs are plotted diagramatically in Figs. 3 and 4. The kinds of material penetrated are indicated by customary symbols. The part of the casing perforated is shown by dashed lines, the unperforated casing by full lines. Also shown on Figs. 3 and 4 is the position of the groundwater level at the time each well was completed and tested. In Fig. 3 the wells are plotted according to elevation differences, the top of the casing of Pulati Well 1 being taken as 100.00 ft. On Fig. 4 the relative elevations of the ground surface at the three wells are only approximate—being taken from the topographic map (Fig. 1).

The logs of most of these wells are given in Appendix A. The logs for Pulati Wells 1 and 4 were not available to the author.

Wells drilled in the Rabbithole Placer ranged in depth from 85 ft to 500 ft and averaged about 270 ft. The logs of six of these eight wells are available, and they all show the wells terminating in clay. The two wells for which logs are not available are

TABLE 1

DATA ON WELLS DRILLED NEAR RABBITHOLE PLACER, NEVADA

[1] Well	[2] Relative elevation, ft	[3] Depth, ft	[4] Casing diam. in.	[5] Perforated from	[6] to
Pulati 1	100.0	500			
Pulati 2	78.5	948	---	------	
Pulati 3	64.3	85	---	10'	90'
Pulati 4	-9.5	400	---	18'	75'
Pulati 5	61.1	250	---	------	
Pulati 6	----	168	---	0'	119'
Pulati 7	----	240	---	55'	109'
Pulati 8	----	220	---	------	
Meyer 1	86.2	241	6 12 to 135' 8, 127' to 241'	50' 40'	120' 240'
Meyer 2	88.0	200	8 to 144'		
Meyer 3	13.9	250	10 to 121'	40'	140'
Meyer 4	---	1,112	10 to 20' 6 to 591'	20' none	120'
Upper pond	56.9				
Camp well	75.4				
Lower pond	50.6				
Benny's well	19.7				

TABLE 1, cont'd

DATA ON WELLS DRILLED NEAR RABBITHOLE PLACER, NEVADA

[1] Well	[7] First water at, ft.	[8] Chief aquifer, ft.	[9] Other aquifers, ft.	[10] Standing water level, ft.	[11] Date of completion, (1957)
Pulati 1	---	---	---	45.0	---
Pulati 2	---	---	---	8.5	---
Pulati 3	---	---	---	24.5	---
Pulati 4	---	---	---	30.0	---
Pulati 5	---	---	---	5.5	---
Pulati 6	---	---	---	52.0	---
Pulati 7	---	---	---	56(?)	---
Pulati 8	---	---	---	55	---
Meyer 1	42	75 - 79	125 - 134	35	22 Feb.
Meyer 2	47	47 - 66	114 - 135	41	8 Mar.
Meyer 3	25	25 - 35	---	20	18 Mar.
Meyer 4	160	---	160 - 161 580 - 590 648 - 680	258	11 Apr.
					6 June
Upper pond					
Camp Well					
Lower pond					
Benny's Well					

TABLE 1, cont'd

DATA ON WELLS DRILLED NEAR RABBITHOLE PLACER, NEVADA

[1] Well	[illegible] Discharge, gpm	[13] Drawdown (below SWL), ft	[14] Specific drawdown, ft/gpm	[15] Remarks
Pulati 1	20*	175	8.75*	Bowls set at 220'
Pulati 2	75	55	.73	
Pulati 3	41	34	.83	
Pulati 4	25*	120	4.80*	
Pulati 5	150	54	.36	
Pulati 6	90	38	.42	
Pulati 7	--	--	--	Bailed dry in 15 min; no pump installed.
Pulati 8	60	45	.75	
Meyer 1	36	41	1.14	
Meyer 2	30*	99	3.30*	
Meyer 3	20*	100	5.00*	
Meyer 4	5*	292	---*	Drilled 711' by cable tool; finished by rotary.
Upper pond				
Camp well				
Lower pond				
Benny's well				
Avg. (exc.*)	75	45	.70	

Table 1 gives data on the 12 wells drilled at and near Rabbithole Placer. The first column gives the name of the well and the second column the relative elevation of the top of its casing, the top of Pulati 1 being taken as 100.00 ft. The three wells in Placeritos Canyon (Pulati Nos. 6, 7 and 8) had not been leveled in at the time of the author's visit. Relative elevations are given for the Camp Well, for Benny's Well and for the Upper and Lower Ponds for comparison, in Column 2.

Column 3 gives the depth of each well in feet. Column 4 gives the diameters of the casings in inches. At the time of this writing (August 1957), complete data on the first seven Pulati Wells were not available to the author. In Columns 5 and 6, the range of depths of perforations are given. Other data relating to the occurrence of water and productivity of the wells are given on the continuation pages of Table 1. These will be discussed in a later section.

HYDROLOGY

Springs

Most of the existing or historic springs of any significance in the area were visited by the author in company with Mr. Iverson in July 1957. Such small springs as are now flowing in the area reflect a very small excess of precipitation over evaporation and transpiration over the last few years, on the average. Formerly, when rainfall was much higher, there were many more springs. For example, the Rabbithole Springs and Rosebud Springs have almost ceased to flow, whereas formerly they were significant sources of supply in the area.

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Groundwater Theory and Well Tests

A discussion of the theory of flow of groundwater may be found in the book by Muskat listed below and also in the chapter by the author in "Engineering Hydraulics," edited by Hunter Rouse. The theory of nonsteady flow, on which interference tests of wells are based, is given in Jacob (1940). Simplified procedures for evaluating drawdown, recovery and interference data from wells is given in Cooper and Jacob (1946). The theory and conduct of step-drawdown tests for determining the characteristics of well are found in Jacob (1947).

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