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MEMORANDUM ON GEOLOGY AND GROUND-WATER RESOURCES IN THE VICINITY OF ORACLE, PINAL COUNTY, ARIZ.

By

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55-64

Prepared in cooperation with
Arizona State Land Department
Roger Ernst, Commissioner

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INTRODUCTION

Location, purpose, and scope of investigation

The community of Oracle, Pinal County, Ariz., lies on the north slope of the Santa Catalina Mountains, about 40 miles by road north of Tucson. It is reported that the population of Oracle has grown from about 350 in 1950 to about 800 in 1954. The increase is attributed partly to proximity of the community to the newly developed San Manuel copper mine, and partly to the attractiveness of the area for summer residence. There is no public water supply, owing to the rugged terrain and to the fact that no water supply large enough to serve more than one or two familes has yet been developed.

In response to requests from many residents of the area this memorandum has been prepared to summarize the available information in the files of the ~~Ground-Water Branch~~, United States Geological Survey, about the geology and ground-water resources of the area. The data on which this memorandum is based were collected as a part of the continuing program in cooperation with the Arizona State Land Department.

The Oracle area, as discussed in this report, comprises parts of Tps. 9 and 10 S., Rs. 15, 16, and 17 S., and includes about 125 square miles (fig. 1).

Physiography and drainage

The Oracle area is situated at the north end of the Santa Catalina Mountains. The mountain area is in the form of a prominent ridge that

passes through Rice Peak, Apache Peak, and Oracle Hill, at a gradually decreasing altitude from about 7,000 to about 5,000 feet. The altitude at Oracle is about 4,500 feet. At the new town of San Manuel, about 8 miles east of Oracle, the altitude is about 1,000 feet lower. Oracle is near a drainage divide, from which the land slopes eastward toward the San Pedro River and westward toward the Santa Cruz River. All streams in the area are intermittent, though in wet years portions of some may flow the year around.

Climate

Precipitation at Oracle averages about 19 inches per year and has ranged from less than 15 to more than 30 inches per year. Precipitation is divided evenly between the summer and winter "rainy periods" and, at altitudes of 4,500 feet and higher, much of the winter precipitation occurs as snow.

Well-numbering system

In this report the well-numbering system is based upon the division of land areas into successively smaller quadrants, and locations are to the nearest 10 acres. With the intersection of the Gila and Salt River Base and Meridian as a central point, the state is divided into quadrants A, B, C, and D, progressing counterclockwise from the northeast or A quadrant. The first figure following the quadrant letter signifies the township, the second figure the range. The quadrant letter and township and range figures are enclosed within parentheses. Section numbers are given immediately following the parenthesis. Each section is again divided into lettered 160-acre quadrants, but for these quadrants lower-case letters are used. Further subdivision into 40-acre plots and finally into 10-acre plots is achieved by the addition of two more lower-case letters. Thus, by this

system, a well legally described as being in the NW¼ of the NW¼ of the NE¼ of Sec. 16, T. 11 N., R. 12 W. would be designated as (B-11-12)16abb.

GENERAL GEOLOGY

Rock sequence

The geology of the area is complex and comprises rocks of nearly all ages. Included are schists and granitic rocks of probable pre-Cambrian age, well-indurated Paleozoic and Mesozoic sedimentary rocks consisting of conglomerate, sandstone, mudstone, and limestone, in part altered by later intrusions, and Tertiary and Quaternary alluvium. Stream beds contain thin deposits of unconsolidated Quaternary sand and gravel that are still in the process of being transported.

Structure

The geologic structure is dominated by two ages of faulting (fig. 1). The earlier brought the Paleozoic and Mesozoic sedimentary rocks in contact with the granitic rocks along a large fault trending west-northwest. The older sedimentary rocks predominate southwest of the fault, and only granitic rocks are exposed to the north and northeast. The rocks on both sides of this fault have been broken intricately by smaller faults not shown on the map.

The later major system of faults bounds the Santa Catalina Mountains on the west and northeast. These faults cannot everywhere be seen and are in part inferred. The Santa Catalina Mountains were raised along these faults relative to the valleys to the east and west and the present topography is in a large measure a result of this structural movement.

Concurrently with the uplift of the Santa Catalina Mountains, masses of debris were washed down into the lower flanking areas. These

alluvial beds in general dip gently away from the bedrock highs. Movement along the faults locally continued after the alluvial beds were deposited, and their contact with the older rocks may be either depositional or faulted.

Water-bearing character of formations

The water-bearing characteristics of a rock depends largely on its permeability, which in turn depends on the interconnection of pore spaces and the size of openings through which ground water may move. The water-bearing characteristics of the granitic and older sedimentary rocks are for the most part controlled by fracturing, with the exception that in limestone solution channels may play a part. Fracturing in these rocks tends to lessen with depth because the increasing weight of overburden diminishes the size and number of fractures. Furthermore, the lower fractures become filled with fine material resulting from the weathering of the overlying rock, not just the overlying but the rock in place. The water-carrying capacities of these rocks are small. Solution channels in limestone may carry considerable quantities of water but are difficult to locate; furthermore, in one area of semiarid climate such channels in limestone would tend to drain quickly and might not be a reliable aquifer. Movement of water in the granitic rocks is strongly influenced by dikes. Some which are extensively fractured tend to localize the occurrence of ground water, to form aquifers and however, decompose Others disintegrate more rapidly than the granite and become dense and clayey, forming Still others impermeable barriers to ground-water movement. Some have no apparent influence on ground water. Many successful small wells are located at favorable dike intersections. It is generally accepted that little or no ground water can be developed below depths of 300 feet in granitic rocks.

The water-carrying capacity of the alluvial fill varies considerably with the size and sorting of the fragmental material. The presence of large quantities of silt and clay or cement greatly reduces the permeability of these rocks. Movement of ground water within the alluvial beds is along

interstices between fragments and is concentrated along more permeable beds. A few wells obtain water from the unconsolidated sand and gravel along the stream beds, and some have been drilled on the flanks of the area into the thicker consolidated conglomerate beds. These deposits carry moderate amounts of water.

GROUND WATER

Source, occurrence, and movement

The ultimate source of ground water is precipitation. The largest proportion of precipitation in the area is returned to the atmosphere by plant transpiration and by evaporation. A much smaller proportion runs directly at the surface off, and an even lesser amount sinks into the ground as recharge. Some ground water occurs in all rocks in the area. Movement of ground water is down gradient hill and in general conforms to the surface topography. Water levels in in depth wells in the granitic rocks range from less than 30 feet to about 125 feet, and water levels in wells in the alluvium range from less than 40 feet to about 700 feet.

Recharge

Recharge to the ground-water reservoir in the Oracle area is directly from precipitation and from surface runoff. Recharge from precipitation occurs mainly as infiltration from snowmelt during spring thaws. Much of the water in the granitic and older sedimentary rocks in the area is recharged in this way, as demonstrated by reported fluctuations in the flow of springs. Infiltration from surface runoff provides most of the ground-water recharge to the alluvial deposits. On the basis of partial data from other areas, recharge constitutes perhaps 3 to 5 percent of the on the drainage area tributary to any given stream annual precipitation. The amount of ground water available to a well is

affected by the recharge, the size of the drainage basin, the thickness of the saturated portion of the rock, and the permeability.

Discharge

Discharge of ground water from the area occurs by evapotranspiration, seepage, spring flow, and pumpage. No data are available for this area about the quantity of ground water discharged by evapotranspiration but, because the water table in many places is shallow and the vegetative cover is heavy, it must account for a large proportion of the total discharge. An unknown amount of ground water is discharged from the granitic and older sedimentary rocks by movement downward along the hydraulic gradient into the adjacent alluvium.

Discharge by spring flow in the Oracle area is relatively small. Springs issue from the granitic and older sedimentary rocks and along fault zones (table 1). Springs in the granitic rocks have generally been developed into small wells for domestic or livestock use. The discharge of all the springs fluctuates seasonally and has been affected by the current drought.

Discharge by pumpage is almost entirely from small domestic or stock wells (table 1). Wells in granite yield from less than 1 to about 5 gpm (gallons per minute) and many wells become dry or decrease in yield during dry seasons. With one exception, the wells in alluvium yield from about 2 to about 15 gpm, but some may not have been tested to their maximum capacities. A deep well at San Manuel yielded about 70 gpm from a depth of about 500 feet for a period of nearly 2 years without diminution of yield or noticeable increase in pumping lift. This well has been abandoned since the development of a well field along the San Pedro River.

Utilization

Records of many of the wells in the area are given in Table 1. Records have not been made of all the wells within the community of Oracle, but for the rest of the area records have been collected for practically all of the wells.

Data are not available regarding the quantity of water withdrawn from wells in Oracle. By making certain assumptions an approximation of the water requirements can be made. Using an estimated per capita consumption of 100 gpd (gallons per day) during 6 months of the year and 200 gpd during the remainder of the year, and using an estimated population of 800, current annual water requirements average about 120,000 gpd, or about 85 gpm. In dry seasons of the year, when the water level in the local wells is at a low stage, it has been necessary to haul water by truck to Oracle. Although the area is known to have been in a drought period for several years, the town has been growing rapidly, and it is not possible to separate the effect of the drought from the effect of increased demand for water.

Development of limited quantities of ground water sufficient for small domestic and stock supplies is possible in the granitic area around Oracle. Development of ground water in the older sedimentary rocks in the area is similarly limited. In both areas a supplementary source of water is catchment and storage of precipitation in cisterns, now practiced.

Possible methods of obtaining water beyond the immediate environs of Oracle include development of surface runoff in the Oracle Ridge area 4 to 6 miles south of Oracle, or development of ground water from the older alluvium. The springs in the area are now fully developed. The only

comparatively large supply that has been developed to date of water in the area is the supply for the town of San Manuel, which is obtained from wells along the San Pedro River at altitudes of about 2,500 feet. As the general elevation at San Manuel is about 3,500 feet, the water would have to be lifted another 1,000 feet and transported about 8 miles for delivery to Oracle.

QUALITY OF WATER

The ground water in the Oracle area is hard and contains moderate amounts of dissolved solids (table 2). The waters from the older sedimentary, granitic, and alluvial rocks are similar in chemical content of dissolved solids. Concentrations of ~~total~~ dissolved solids range from about 250 to about 500 parts per million. Hardness ranges from about 150 to about 400 parts per million. The fluoride content of the water from some wells exceeds slightly the amount recommended in U. S. Public Health Service Standards (1946) which state that satisfactory drinking water should contain less than 1.5 parts per million of fluorides. Some typical ground-water analyses are shown in table 2.

SUMMARY

1. Ground water in the vicinity of Oracle is developed in limited quantities from shallow wells constructed in granitic, older sedimentary, rocks and ~~alluvial rocks~~ alluvium.

2. Additional limited quantities in the granitic and older sedimentary rocks may be developed through detailed geologic investigation of the relation of faults and dikes to ground-water movement.

3. Moderate quantities of water are available in the older alluvium, which in general has not been adequately tested.

4. Adequate quantities of ground water are developed along the San Pedro River and lifted to San Manuel, at an altitude about 1,000 feet lower than

Oracle.

5. Surface water could be developed in some of the mountain areas whose gradients, drainage basin areas, and geology may be favorable.

6. The quality of the ground water in the area is satisfactory for domestic and municipal use according to U. S. Public Health Service Standards, except where there is a fluoride content in excess of 1.5 parts per million. The temperature of the water, particularly from deep sources, exceeds 110° F in places.

REFERENCES

U. S. Public Health Service, 1946, Public Health Service drinking water standards: Reprint no. 2697, Public Health Reports, vol. 61, no. 11, pp. 371-384.

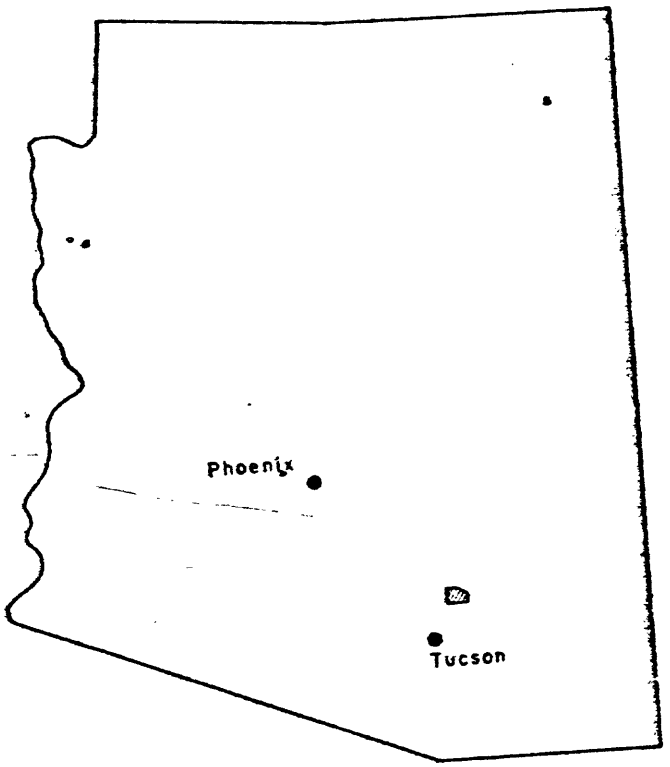

Figure 1.--Map of Arizona showing area described in this report.

Table 1.—Records of wells and springs in the Oracle area, Pinal County, Ariz.

Well no.	Depth of well (feet)	Type of well a/	Water level: Depth below land-surface datum (feet)	Water level: Date of measurement (b)	Type of lift c/	Yield gpm d/	Use of water e/	Temperature (°F)	Analyses on file	Log on file	Remarks
(D-9-15)											
12ddd	170	Dr	82	6/49 R	C,W,G	2 R	S	-	-	-	-
f/13bab	200	Dr	-	-	C,W	-	S	69	X	-	In granitic conglomerate.
13cbb	350	Dr	-	-	-	-	S	-	-	-	In granitic conglomerate. Reported good well.
15aad	835	Dr	760	6/49 R	C,G	5 R	S	-	X	X	-
18(Lot 1)	395	Dr	180	6/49 R	C,G	5 R	S	-	-	X	Not within area shown on map (fig.1).
22cdd	375	Dr	175.0	4/50 M	C,G	6 R	D,S	-	-	-	In granite. Reported yielded 15 gpm for 24 hours; drawdown unknown.
23ad	75	Du-Dr	-	-	-	-	S	-	-	-	In granite. Reported "good" well.
26cbd	265	Dr	111.0	4/50 M	-	-	U	-	-	-	In granite. Reported water level in 1945 was 100 feet.
26db	239	Dr	70	6/49 R	C,E	6 R	S	-	-	X	Reported bailed 2 hours at 7 gpm with 50 feet drawdown.
26dd	75	Du-Dr	-	-	C,W	2 R	D	-	-	-	Old mine shaft. Reported requires week to refill after yielding 6,000 gallons.
35ab	250	Dr	-	-	C,E	-	D	-	-	-	Reported small yield
f/36aba	225	Dr	73.5	8/49 M	C,E	8 R	P	-	X	-	In granitic rocks.
36 ac	75	Du	53.5	5/50 M	C,W	-	D	-	-	-	Do.
36bbe	92	Du	68.54	9/49 M	C,W,G	-	D	-	-	-	Do.
36cd	97	Du	86.40	9/50 M	C,E	-	D	-	-	-	Do.

a/ Dr, drilled; Du, dug.
b/ R, reported; M, measured.
c/ C, cylinder; T, turbine; S, submersible; B, bucket; W, windmill; G, gasoline; E, electric, Si, siphon; H, hand power.
d/ R, reported; E, estimated; M, measured.
e/ S, stock; D, domestic; U, unused; P, public supply.
f/ See table 2 for analysis.

Table 1.--Records of wells and springs in the Oracle area--Continued

Well no.	Depth of well (feet)	Type of well a/	Water level: Depth below land surface datum (feet)	Water level: Date of measurement (b)	Type of lift c/	Yield gpm d/	Use of water e/	Temperature (°F)	Analyses on file	Log on file	Remarks
(D-9-16)											
20cb	-	Du	42.60	9/50 M	-	-	U	-	-	-	In granitic rocks.
28bd	42	Du	31.3	10/49 M	C,W,G	7 R	S	-	-	-	In granitic rocks. Almost flows in wet years.
31cd	95	Du	-	-	C,E	1½ E	D	-	-	-	-
31dc	70	Du	61.3	10/49 M	C,E	7 E	D	70	X	-	In granitic rocks. Reported drawdown 2 feet after pumping 7 gpm for ½ hour.
32ba	380	Dr	24.1	10/49 M	C,G	7 R	S	-	-	-	-
32cd-1	45	Du	33.0	10/49 M	C,W,G	8 E	S	64	X	-	In granitic rocks.
32cd-2	170	Dr	34.6	10/49 M	C,G	3 E	S	-	-	-	Do.
32db	35	Du	22.2	10/49 M	C,G	15 E	D,S	63	-	-	In granitic rocks. Reported 1,000 gallons pumped every day.
(D-10-15)											
1db	-	Du	33.0	5/50 M	C,G	-	S	-	-	-	In granite. Reported water level fluctuates seasonally.
2dc	667	Dr	Dry	4/50 M	-	-	U	-	-	-	In granite
(D-10-16)											
5bbb	-	Dr	-	-	C,W	-	D,S	-	-	-	In granitic rock.
5cab	14	Du	8.7	10/49 M	Si	-	D	70	-	-	In granitic rock. Well was dug at a spring.
7aab	53	Du	45.4	10/49 M	C,E	3 E	D,S	70	-	-	In granitic rock. Yields 1,200 gallons once a month.
7aba	33	Du	9.6	10/49 M	C,G	8 R	D,S	-	-	-	In granitic rock. Well was dug at a spring; yields 1,200 gallons once a month.
f/9bcc	33	Du	25.5	8/49 M	C,E	-	D,S	80	X	-	In granitic rock. Water level measured quarterly 9/49 to 4/52.
14dac	56	Dr	43.2	8/49 M	C,W	6 M	S	75	X	-	In granitic rock.
16cab	40	Du	16.88	11/54 M	C,W	-	D	-	-	-	In granitic rock. One of 3 wells at YMCA camp.

Table 1.—Records of wells and springs in the Oracle area—Continued

Well no.	Depth of well (feet)	Type of well a/	Water level: Depth below land-surface datum (feet)	Water level: Date of measurement (b)	Type of lift c/	Yield gpm d/	Use of water e/	Temperature (°F)	Analyses on file	Log on file	Remarks
(D-10-16)											
17bcb	34	Du	26.9	8/49 M	B,H	-	D	68	X	-	In granitic rock.
f/18dbc	200	Dr	0	8/49 R	C,G	20 E	D	-	X	-	In granitic rock near "Mogul" fault. Almost flows.
21add	204	Dr	123.1	8/49 M	C,E	5 R	D,S	70	X	-	In granitic rock.
22bbd	60	Dr	37.6	8/49 M	C,W	-	S	70	X	-	Do.
22cbb	365	Dr	104	4/49 R	C,E	12 R	S	-	-	-	Bottomed in granitic rock.
24bda	30	Du	16	8/49 R	C,G	32 E	D,S	70	X	-	In younger alluvium overlying granitic rock. Reported 2,000 gallons pumped every day.
27be	18	Du	13.2	8/49 M	-	-	U	-	-	-	-
28abc-1	16	Du	12.2	8/49 M	C,E	4 R	D	68	X	-	In younger alluvium overlying Paleozoic and Mesozoic sedimentary rocks.
(D-10-17)											
f/ 5bca	700	Dr	515	2/53 R	T,E	70 R	P	78	X	-	In alluvium. Reported yield, 70 gpm with no drawdown.
f/22abb-1	1,010	Dr	57	3/54 R	S,E	1,500R	P	82	X	X	In alluvium along San Pedro River. San Manuel public supply. Well of same depth 50 feet distant tested in March 1954 by engineers of Utah Constr. Co.; drawdown 263 feet after pumping 36 hours at 1,900 gpm.
SPRINGS											
(D-10-16)											
21dab	-	-	-	-	-	10 E	D,S	60	X	-	Issues along fault zone.
28baa	-	-	-	-	-	Seep	S	60	-	-	In older sedimentary rocks. Reported formerly yielded 2-3 gpm; almost dry November 1954.

Table 1.--Records of wells and springs in the Oracle area-Continued

Well no.	Depth of well (feet)	Type of well	Water level: Depth below land-surface datum (feet)	Water level: Date of measurement (b)	Type of lift c/	Yield gpm d/	Use of water e/	Temperature (°F)	Analyses on file	Log on file	Remarks
			SPRINGS - Continued								
(D-10-16)											
33adb	-	-	-	-	-	Dry	S	-	-	-	In older sedimentary rocks. Reported formerly yielded about 1 gpm.
33dcc	-	-	-	-	-	Seep	S	65	X	-	In older sedimentary rocks. Reported formerly yielded about 1 gpm.

Table 2.--Analyses of water from representative wells in the Oracle area, Pinal County, Ariz.
(Parts per million except specific conductance and percent sodium)
(Analyzed in Albuquerque district)

Well no.	Date of collection	Depth of well (feet)	Temperature (°F)	Parts per million: Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25°C)
(D-9-15)																
13bab	5-4-51	200	69	19	37	26	97	341	34	64	1.4	1.3	448	200	-	765
36aba	8-8-49	224	-	15	55	19	51	322	13	30	2.0	.3	344	215	-	594
(D-10-16)																
9bcc	8-16-49	33.1	80	33	72	25	73	434	35	30	2.2	1.6	486	282	-	790
18dbc	do.	200	-	22	80	47	46	482	42	38	.2	.0	513	393	-	864
(D-10-17)																
5bca	3-24-54	700	78	28	46	12	29	228	4.5	21	.8	6.4	260	164	28	429
22abb-1	do.	1,010	82	38	129	27	95	247	382	23	1.9	2.0	819	433	32	1,140

pH values available?
Inclusion of iron results is most desirable
WHS

Suggest calculated % Na for first analyses
D

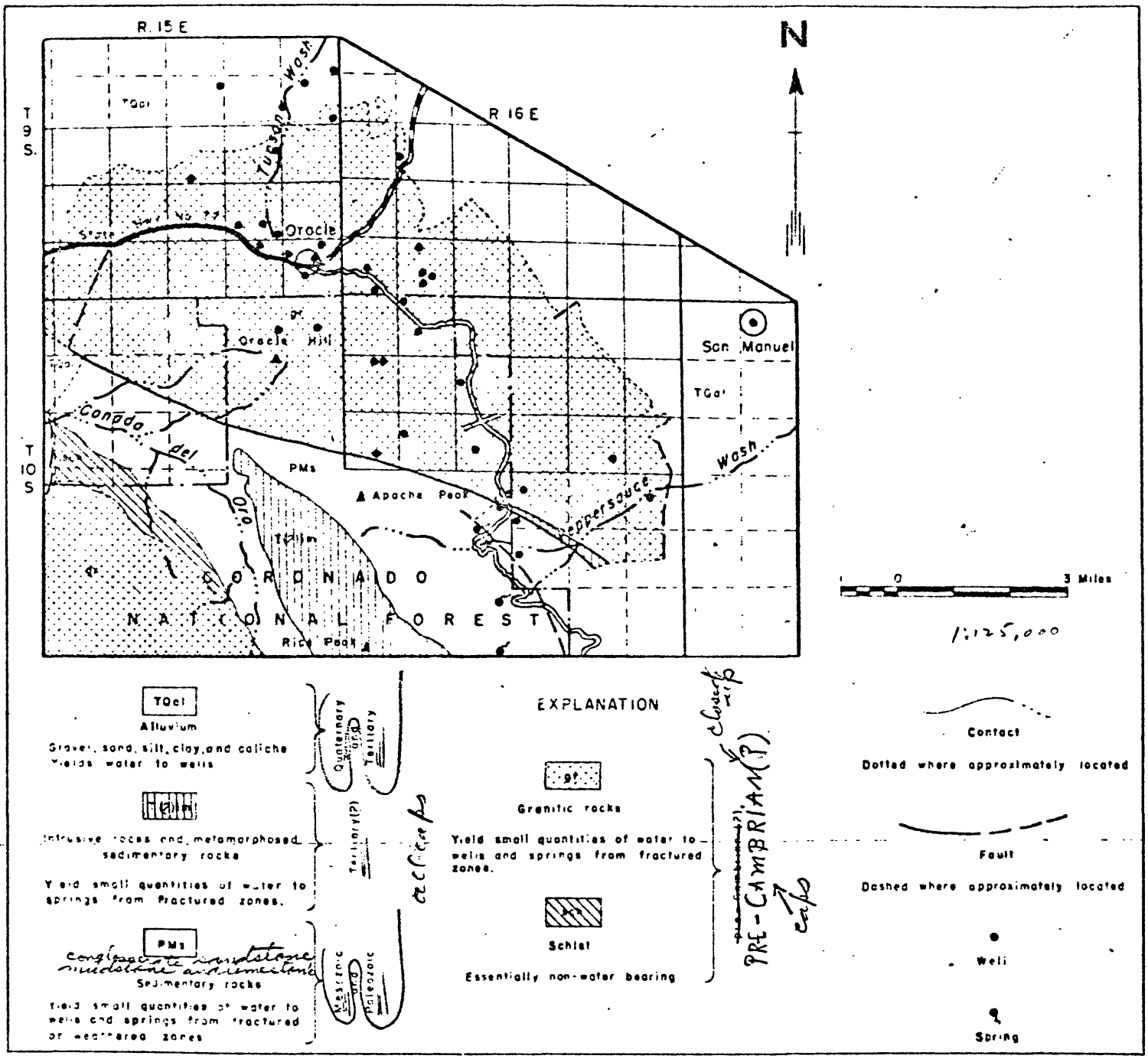

Figure 2.--Reconnaissance map of Oracle area, Santa Catalina Mountains, Pinal County, Ariz., showing geology and locations of wells and springs.