ANCR-1222

1/1 to 3/31/75
MRD

The reactivity of the geothermal fluid upon reinjection to the subsurface also depends on the oxygen content. The initially low O_2 content in the geothermal fluid should be preserved throughout all above ground operations. Particular design features may be needed where $CaCO_3$ is precipitated. Whether this concern is warranted depends on (1) how susceptible to oxidation the rocks are near the reinjection site and (2) how much the reinjected waters mingle with geothermal fluids that will be produced for power generation.

2.3 Environmental and Area Impact Considerations

Preliminary design criteria were established for an environmental monitoring system to be installed at the RRGE-1 site now that significant flows of geothermal water are available. To be included are hydrogen sulfide, radon, and CO_2 detectors, and a meteorology station, and a gauging station in the nearby Raft River. Procurement of the various system components is currently underway.

Work continued on identifying applicable federal and state environmental regulations for input to the test loop and power plant design efforts. A comparison of the relative merits of aquifer cooling vs cooling towers was made; with particular attention paid to the impact either system would have on the area. The results were coordinated with the engineering conceptual design studies.

An archeological clearance survey of the two proposed sites for RRGE-2 was conducted by the Curator of Archaeology at Idaho State University. Arrangements are being made for additional archaeological surveys and biological surveys of the valley to be performed by area university staffs.

TABLE 1

COMPOSITIONAL ANALYSIS OF RRGE-1 WATER SAMPLES AND COMPARISON WITH OTHER WELLS IN AREA

Conditions: Cased hole, full flow and pressurized samples, 205°F (boiling temperature at elevation), samples taken after well allowed to flow freely.

	RRGE-1[a]	Crank Well	BLM Well	Jack Pierce Well
pH	7.05-7.40	7.94	7.40	7.6
Conductivity (μmhos/cm)	2800.0	6080	3030	1720
Salinity (μg/ml or ppm)	1715.0	3360	1720	1204
Na absorption ratio †	19.5	26.8	18.3	- -
Metals: (All values in ppm)				
Ag	ND	- -	- -	- -
Al	m-t	- -	0.012 ppm	- -
B	0.2	0.25	0.15	- -
Ba	<0.4 ppm	ND	ND	- -
Be	<0.002 ppm	ND	ND	- -
Ca	57 ppm	125 ppm	52 ppm	157 ppm
Cd	ND	- -	- -	- -
Co	NO	- -	- -	- -
Cr	m-t	- -	- -	- -
Cu	t	0.02 ppm	0.02 ppm	- -
Fe	0.32[b]	<0.02	<0.02	- -
K	26.7 ppm	32 ppm	21 ppm	16 ppm
Li	1.25 ppm	2.5 ppm	1.4 ppm	- -
Mg	0.76 ppm	0.3 ppm	0.2 ppm	18 ppm
Mn	0.07 ppm	0.02 ppm	0.02 ppm	- -
Na	400 ppm	1110 ppm	560 ppm	184 ppm
Ni	3.7 ppm	<0.05 ppm	<0.05 ppm	- -
Pb	t	<0.06 ppm	<0.06 ppm	- -
P	0.016 ppm	- -	- -	- -
Si	46 ± ppm	97 ppm	90 ppm	54 ppm
Sn	ND	- -	- -	- -
Sr	1.44 ppm	2.8 ppm	1.4 ppm	- -
Ti	t-m	- -	- -	- -

	RRGE-1[a]	Crank Well	BLM Well	Jack Pierce Well
Metals:				
V	ND	- -	- -	- -
Zr	m	- -	- -	- -
Zr	ND	- -	- -	- -

Non-Metals (All values in ppm):

	RRGE-1	Crank	BLM
Cl^-	614[b]	1900	880
Br^-	<2.5	3.1	1
I^-	0.036	0.06	0.02
F^-	5.4	5.7	6.9
$PO_4^{\equiv}$	(0.05)[c]	0.04	0.08
$SO_4^{=}$	61	60	69
$S^{=}$	<0.2	- -	- -
NO_3^-	0.44	<0.5	<0.5
HCO_3^-	45.4[f]	33.1	50.7
$CO_3^{=}$	8.8[2]	16.8	25.5
SiO_2	99[d]-105[e]	94	81
NH_4^-	1.99	1.4	0.3
$Si(OH)_4$	167.2	- -	- -

c Calculated from total Phosphoras content

d Calculated from total Silion Contect

e Calculated from total $Si(OH)_4$ content

f Calculated from $Ca(HCO_3)_2$ content

g Calculated from $CaCO_3$ content

Dissolved Gases (RRGE-1)

Gas	RRGE-1 (STP ml/liter H_2O)	RRGE-1 Volume %	BLM Volume %
Hydrogen	0.28	0.73	- -
Helium	0.02	0.051	- -
Nitrogen	50.50	87.5	95
Oxygen	0.06	0.19	5.0
Argon	0.82	1.60	
Carbon Dioxide	0.50	9.97	0.84
Methane	- -	- -	0.25
Total	56.7		

† Sodium Absorption Ratio Calculations

$$\text{Na Abs. Ratio} = \frac{\frac{(\text{Na ppm})}{\text{Mol. wt}} \times \text{ionic charge (1)}}{\sqrt{\dfrac{\frac{(\text{Ca ppm}) \times \text{ionic charge (2)}}{\text{mol. wt}} + \frac{(\text{Mg ppm}) \times \text{ionic charge (2)}}{\text{mol. wt.}}}{2}}}$$

where ppm = parts per million by weight in solution

$$\text{Na Abs. Ratio} = \frac{(0.0435)\ (\text{Na ppm})}{\sqrt{\dfrac{(0.0499)\ (\text{Ca ppm}) + (0.0823)\ (\text{Mg ppm})}{2}}}$$

a RRGE-1 tested for many more metals and non-metals than the Crank, BLM, or fresh water wells. Figures based on average of up to 14 samples from RRGE-1.
b Eliminated samples because of suggested contamination.

ND = none detected
M = major = $\geq$ 5%; m = minor = <5% >0.1%; t = trace = <0.1%

2.4 Deep Drilling Program

2.4.1 Initial Drilling to 4632 ft)*

Drilling at the RRGE-1 site began on January 4, 1975. Mud was selected as the drilling fluid for the 900 ft of surface hole. Drilling was routine and the depth of 900 ft was reached on January 9, 1975. A set of electric logs were obtained, followed by the placement and cementing of the 20 inch surface casing to 900 ft.

During the surface casing cementing operation, a normal maintenance inspection revealed that the high drum sprocket assembly bearing had been cracked. Further investigation disclosed that the shaft itself was cracked and could not be repaired. A total of seven days were required to locate and recondition a replacement shaft.

Drilling resumed again on January 20, 1975, using water as the drilling fluid. A depth of 4477 ft was reached on January 31, 1975, and a diamond core taken down to 4537 ft with 23 ft of rock core recovered from the upper portion of the 60 ft barrel section. Drilling was then resumed and continued until the bit was worn out at a depth of 4632 ft at which point well logging was initiated. Logs included caliper, temperature, sonic, gamma-gamma ray, natural gamma, self-potential, dual induction-laterolog and compensated neutron.

2.4.2 Well Logging - Spontaneous Flow

During the well logging operation on February 2, 1975, artesian flow began to develop approximately 12 hours after forced circulation had been stopped. Flow developed to approximately 800 gpm after ten hours. The flow reached a maximum of approximately 1400 gpm at 4:00 a.m. on February 3, 1975, before being shutin (14 hours after initial flow). Several flow tests, injection - coolant tests and wellbore temperature probes were conducted over the next several days. Bottom hole temperature at this time was 138°C (280°F).

*All depths are given with respect to ground level (4835 ft above sea level). Base data recorded during the drilling operation was with respect to the Kelly bushins, 18 ft above ground level.

Additional temperature logging was conducted on February 10, 1975, in conjunction with selected injection and flow testing. The neutron, sonic, and temperature logs gave some indication of the likely region of hottest water production. Though by no means conclusive evidence existed, it was decided to leave the hole barefoot below the 3700 ft level where the hottest production zone appeared to begin.

In order to provide a base for the casing to be set and cemented to approximately the 3700 ft level, it was decided to backfill the hole to this depth with sand. The sand was inserted into the bottom of the hole through the drill stem. Two check valves were used at the bottom, and neither failed during the injection of the 1160 barrels of sand slurry. This amount filled the bottom of the hole with 880 ft of sand. A 7 ft layer of barite was placed on top of a sealant. Then a 120 ft thick layer of cement plug was emplaced in preparation for running and cementing the 13-3/8 inch production casing down to the 3624 ft depth. Prior to casing, this upper portion was flow tested, resulting in an average flow of only 125 gpm from the 3624 deep well.

2.4.3 Production Casing Collapse

During the cementing operation, the production casing parted at a joint near the 240 ft level. This suddenly released the 2100 psig pressure applied to the cement inside the casing (the cement had thickened prematurely, creating the need for such a pressure). The casing was successfully reconnected at the "popped" thread, and the cementing operation was completed from the top by pumping cement into the annulus between the surface casing and production casing.

The cement left in the casing (807 ft) was eventually drilled out after encountering considerable difficulty in milling through two collapsed casing areas between the 3312 ft to 3323 and 3567 to 3569 ft intervals. The exact cause of the collapsed casing is not known, though the two small isolated lengths of collapse lead to the conclusion that a buckling load and not excessive external pressure were responsible. The hole was then thoroughly cleared of all casing pieces, machinery chips and other drill test debris. Drilling then proceeded through the cement plug and into the sand. The original bottom of the hole was reached (4632 ft) on March 15, 1975. Extensive flow and injection tests were subsequently conducted on the well.

2.4.4 Final Drilling (to 4989 ft)

During the previous operations and as a result of the wet weather, the drilling rig was 33 inches out of vertical alignment. The rig was then leveled and preparations completed for deeper drilling. On March 31, 1975, total depth (TD) was reached at 4989 ft. Core samples were taken from 4668 to 4680 ft (9 ft recovered) and 4987 to 4989 ft. The entire lower 500 ft of hole consisted of hard quartsite "basement" type rocks. Three or four different lithologic strato were encountered in this distance. Figures 2 and 3.

Production was not increased by the additional drilling although the bottom hole temperature increased slightly to 146^{0}C (294^{0}F). The primary reason for deeper drilling was to gather geologic information on the deeper rock types. Basement rock (Pre-Cambrian Quartz Monzonite) was encountered at 4930 ft and drilling was halted at the 4989 ft level.

2.4.5 Completed Well Characteristics

The results of the flow and reinjection tests are as follows:

1) It is impossible to "kill" the well completely by pumping in cold water over a short period of time (up to 15 hours). When filled (presumably) with "cold" water, shutin pressure is still 60 psi.

2) Hot shutin pressure after flowing (with 280+^{0}F water in entire bore) is 160 - 170 psig.

3) The flow rate from the well is 650 gpm before development of back pressure from flashing occurs. This reduced flow (approximately 1400 gpm in the uncased hole) is a result of casing and sealing off some of the cooler production zones above the 3624 ft level.

4) Peak bottom hole (4989 ft) temperature, measured to date is 146^{0}C (294^{0}F).

5) The temperature of the geothermal water reaching the surface has reached 136^{0}C (277^{0}F) following a 2 hour flow test.

2.5 Geology and Geophysics

2.5.1 RRGE-1 Geology and Geophysics

The geological sequence of RRGE-1 is as depicted in Figure 2. It was anticipated that the Paleozoic section (limestone, quartzite and dolomite) would be encountered around the 4500 ft level, however the Pre-Cambrian phyllite, quartzite and quartz monzonite was found. This indicates that the movement along the Bridge Fault is much greater than originally estimated or that a major unconformity occurs directly above the Pre-Cambrian sequence. See Figure 3. Geophysical data supports the existance of the unconformity. If an unconformity exists, the Paleozoic section and possibly the upper units of the Pre-Cambrian section may not be present in this location. RRGE-2 drilling should confirm or refute the occurrence of the Paleozoic section in this area.

The interpretation by USGS personnel prior to the drilling (December 1974), of the resistivity and seismic data in the vicinity of RRGE-1 is presented in Figure 3.

2.5.2 Surface Measurement Program (USGS)

1) Surface geology - Interpretation of the surface geology of the Raft River Valley and Cotterell Mountains has been completed. Interpretation of the paleo-magnetic data is continuing.

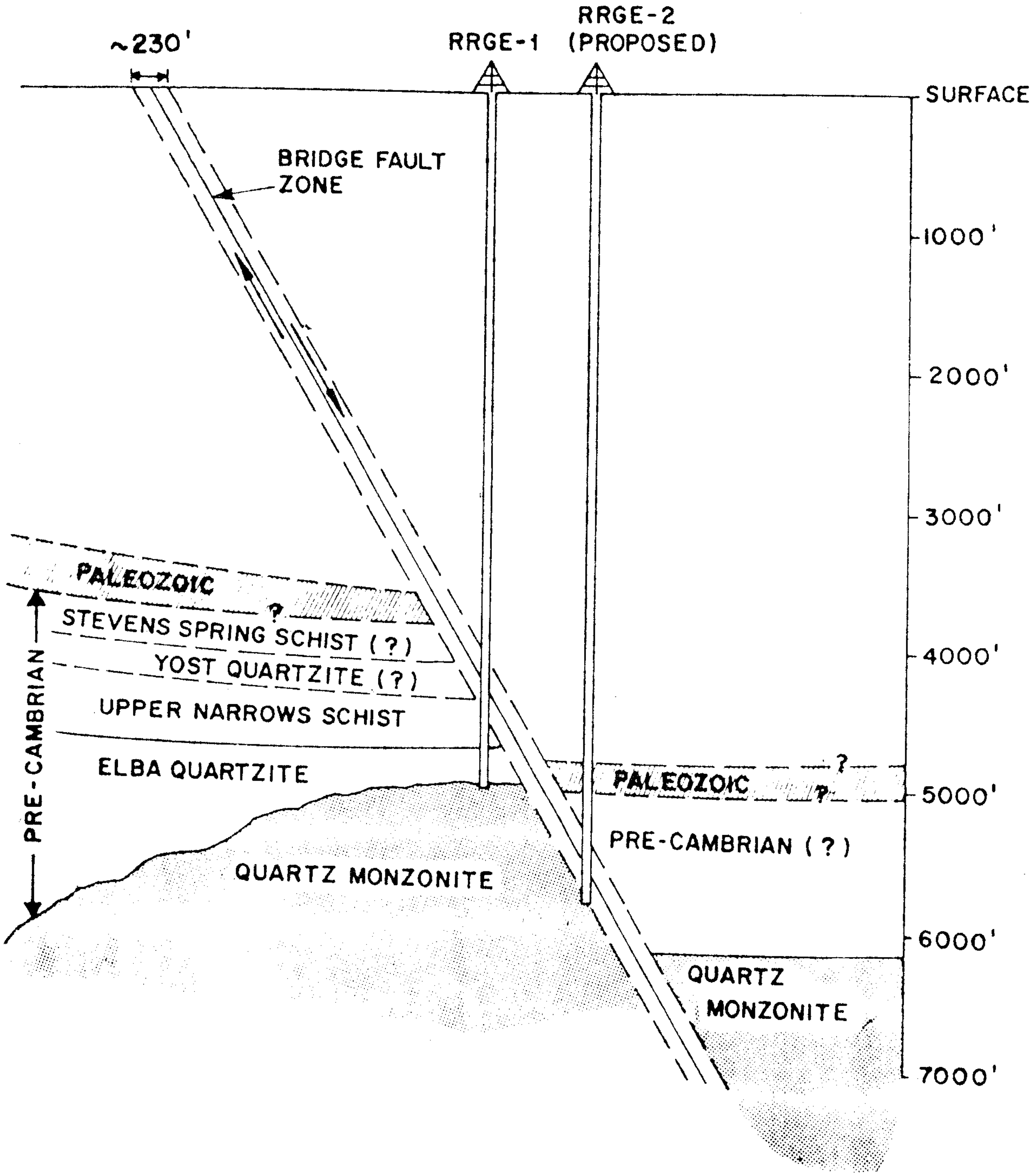

Figure 3 RRGE-1 Geologic Cross Section

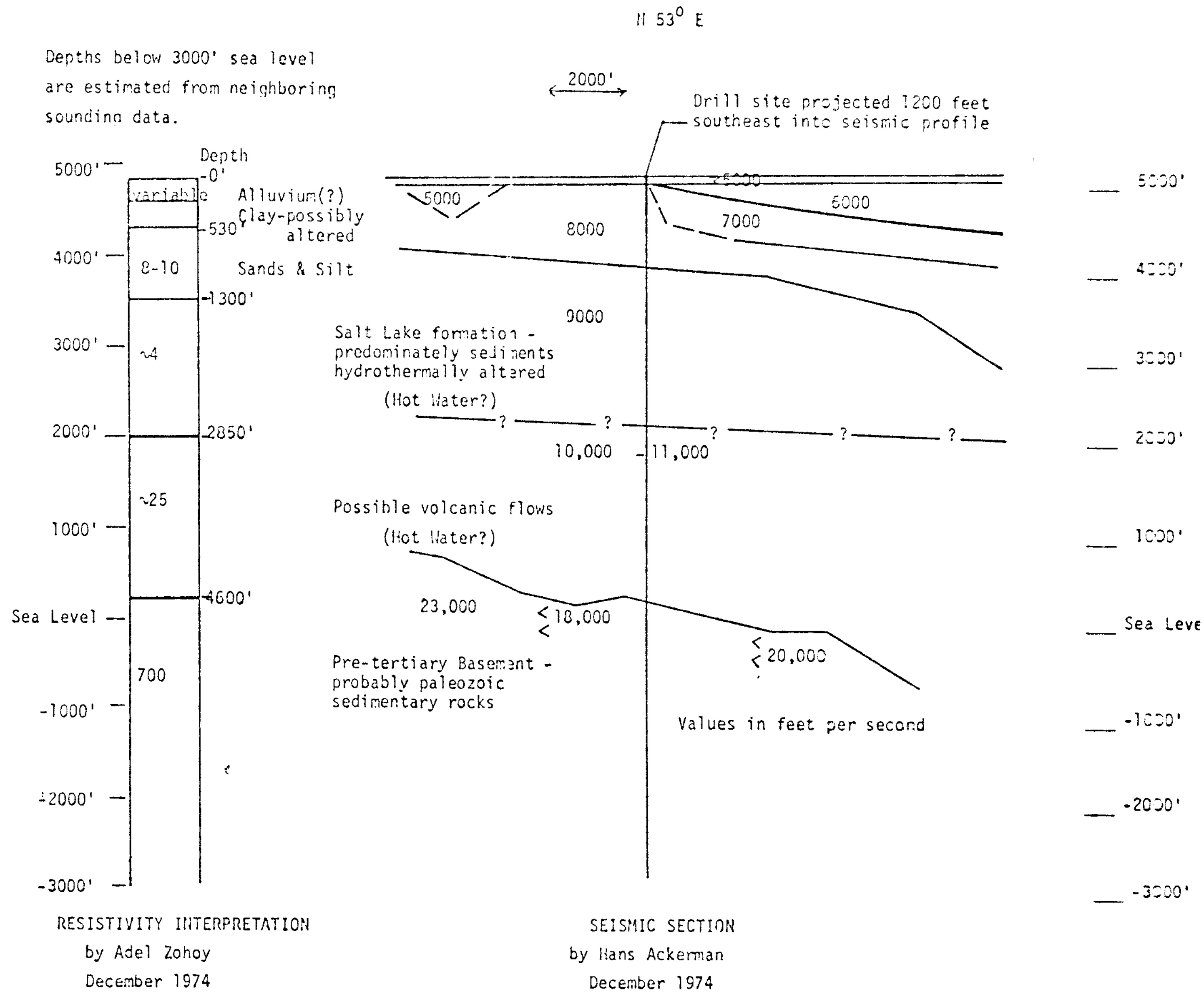

Fig. 4 RRGE-1 Profile

2) Geophysics - All surveys have been completed and consisted of the following.

   a) Active seismic
b) b) Spontaneous electric potential
   c) Bipole - dipole
   d) Schlumberger deep resistivity
   e) Airborne infrared
   f) Gravity
   g) Residual Magnetic
   h) Audiomagnetotelluric

   All relevant USGS survey information to date has recently been open-filed and will be available in report form in the near future.

2.5.3 Intermediate Depth Test Wells

A total of five wells have been drilled and completed. The first three wells have been described in the two previous quarterly reports. The fourth and fifth wells were completed this last quarter. See Figure 5 for the test well locations.

1) Test well #4 (252 ft deep) - the hole exhibited a temperature inversion at approximately 100 ft. The maximum temperature was $42^{o}C$ ($108^{o}F$) at 100 ft and decreased linearly to $38^{o}C$ ($100^{o}F$) at the bottom of the hole. Alluvium was encountered from the surface to 60 ft at which point an altered rhyolite occured and continued to the bottom of the hole. The rhyolite was jointed and exhibited dense 5-10 ft sections from 170 to 220 ft.

2) Test well #5 (719 ft deep) - the hole encountered a basal cobble conglomerate between 665 and 680 ft and a granite below 680 ft. The granite was generally unexpected. The interpretation of the geophysical model for the area is being re-examined by USGS.

   The well was completed with 2-inch casing installed and cemented down to the bottom and will be used as a heat flow measurement well.

Test well #3 (1423.5 ft deep) was also cased to 1100 ft and will be used as a heat flow and water level observation well.

There are no current plans for other intermediate depth test wells.

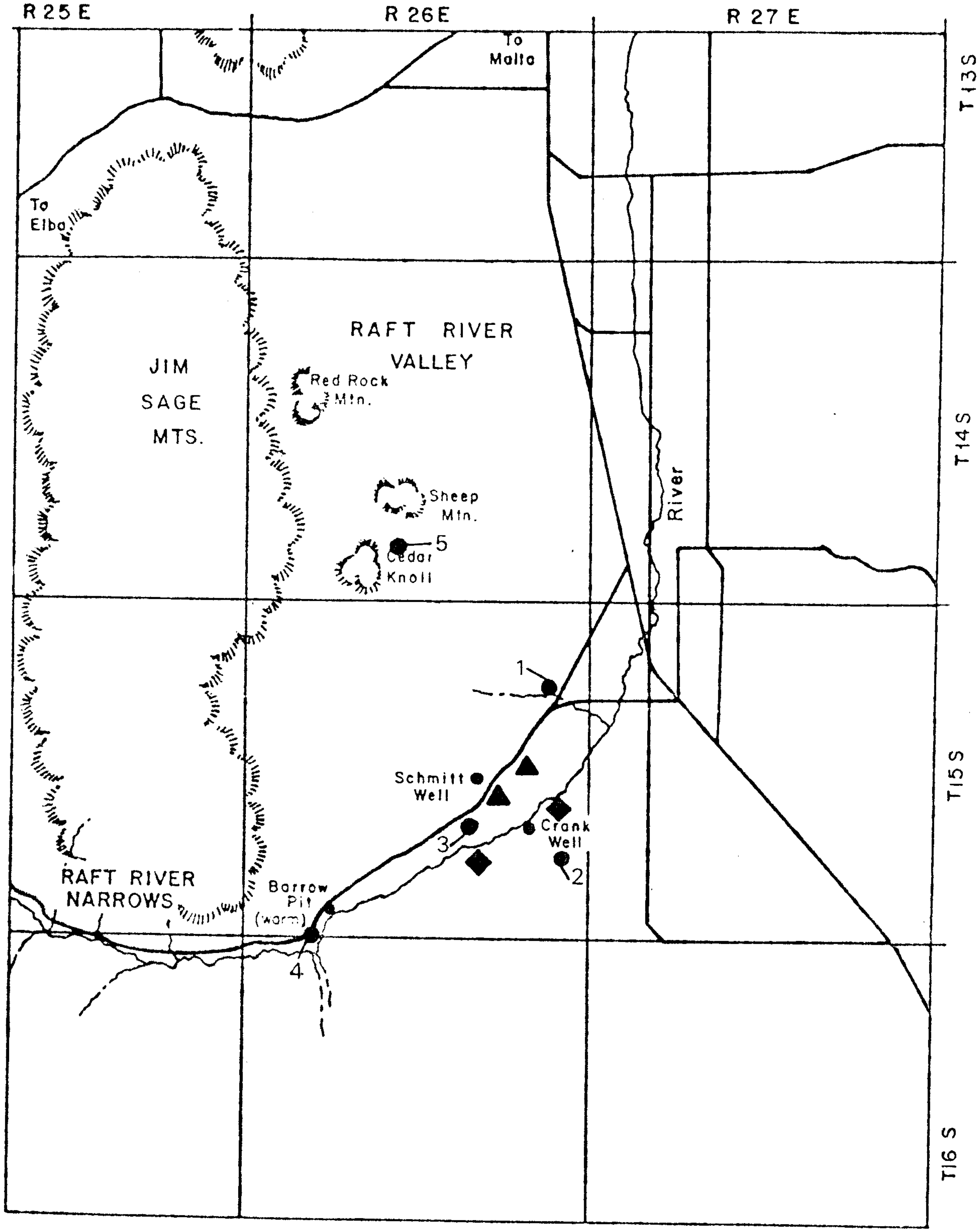

Figure 5 ● 5 Intermediate Depth Test Wells
♦ 2 Pump Test Wells
▲ 2 Deep Exploratory Wells

2.5.4 RRGE-2 Well Site Selection

The Idaho National Engineering Laboratory in consultation with the USGS, ERDA, State of Idaho and other interested parties selected the site of the second well 3915 ft (3/4 mile) to the northeast of RRGE-1. See Figure 6. The site has good all-weather road accessibility and convenient utility connections.

In relation to RRGE-1 and the Bridge Fault, RRGE-2 is offset 650 ft from the down dipped side of the fault and approximately 3860 ft along the strike of the fault to the northeast from RRGE-1. Assume all lithological units and the fault attitude remain constant and that there are no other major faults occurring between the well sites. The RRGE-2 hole should intersect the Pre-Cambrian sequence at approximately 5060 ft and the fault zone from 5305 ft to 5700 ft.

2.6 Hydrology

2.6.1 USGS

Geologic structure, lithology, and physiographic history determine the surface-drainage pattern as well as the occurrence and movement of ground water. The principal water-bearing formations (older to younger) are the Salt Lake Formation of Pliocene (3-1/2 to 14 million years) age, consisting mainly of weakly consolidated sandy sediments and some layers of volcanic rock; the Raft Formation of Pleistocene (2.5 thousand to 3-1/2 million years) age consisting of sand and gravel, lake sediments, and thin beds of silt and clay; and alluvial deposits of Holocene (recent) age that form aquifers beneath the bottom lands of the valleys.

Ground water occurs in perched water tables, normal water tables, and under confined artesian conditions with the water bearing aquifer often located less than 40 ft below the land surface. Yields of irrigation wells in the area range from a few hundred to a few thousand gpm with average depths of from 200 to 400 ft.

Several wells yield warm to hot water. The hot water plumbing system is poorly understood however, geological and geophysical evidence suggests that the water rises from several thousand feet along fault zones and then moves laterally through permeable beds of the aquifer system. The five intermediate depth test wells core drilled by the USGS are being used to investigate the nature of the hot water and character of the rocks to depths of approximately 1000 ft (see discussion of wells under 2.5.2).

The cores and cutting from the intermediate wells were examined at the well site and presently are undergoing lab tests, petrographic examination, etc. Most of the material cored was claystone, siltstone, and sandstone, with several beds of conglomerate. These materials exhibit extensive alteration to clay due to low temperature percolating thermal waters. These wells have been sampled for chemical analysis. (See Section 2 for analysis of the RRGE #1 well and several surrounding wells). Preliminary indications are that the deeper water is somewhat salty (sodium chloride) with conductivities of 7000 to 10,000 micromhos/cm.

Additional geophysical borehole logs were run this quarter (flow meter, televiewer and etc.).

The water level in test well #1 is about 150 ft below the surface; in #2, it is about 70 ft below the surface; in #4, it is about 20 ft below the surface; and in #5, it was about 30 ft below the surface before it was cased in. Test well #3 flows about 60 gpm of 92^{0}C water. Shutin pressure is 16 psig and is equipped with a shutoff valve.

The results of drilling generally reinforce the interpretation of the USGS geophysical data except for the granite member encountered in test well #5. The presence of this granite in the area of Sheep Mountain and Cedar Knoll will require a reevaluation of the data for this area. The granite shows a striking similarity to that occurring in the City of Rocks; an area located in the Sanctuary Mountains, one mountain range (16-3/4 miles) away to the west-southwest.