DEVELOPMENT AND TESTING OF A SMALL MODERATE TEMPERATURE GEOTHERMAL SYSTEM

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ABSTRACT

Geological and geophysical exploration of the Monroe-Red Hill geothermal system in southern Utah has been followed by the drilling of two intermediate depth test holes and the drilling and testing of a 457 meter production well. The test holes confirmed that the hot water system was structurally controlled by the steeply dipping Sevier Fault and suggested that the exploitable reservoir temperature was about 74°C. The production well intersected the top of the Sevier Fault zone at about 305 meters and was successfully completed to 457 meters. Preliminary testing of the production well indicated a reservoir with acceptable storage but somewhat limited permeability.

BACKGROUND

The Monroe-Red Hill geothermal system is situated on the Sevier Fault near Monroe, Utah (see Figure 1). The proximity of the geothermal system to the town of Monroe, population 2,000, presents an ideal situation for direct heat application if the resource base can be proven sufficient.

Geological and geophysical exploration of the geothermal system (Miller, 1976; Mase, 1978; Kilty, 1978; Chapman, *et.al.*, 1978) has resulted in the following information: (1) the hot springs and geothermal system are structurally controlled by the Sevier Fault which separates upthrown Tertiary Volcanics to the east from Quanternary alluvium to the west; (2) the system is effectively mapped by dipole-dipole resistivity with low resistivities of 3 ohmmeters coinciding with discharge areas; (3) temperature-depth profiles show a pattern consistent with a model of hot water discharge essentially confined to the Sevier Fault zone which dips at an angle of about 70° to the west; and (4) the total conductive and convective heat loss for the system is 8 megawatts.

In order to further define the structural controls of the anomaly, two 6-3/4 inch diameter test holes, designated MC 1 and MC 2, were drilled to 110 meters and 251 meters, respectively. The well lithologies, indicated in each case a sinter deposit in the shallow subsurface, altered Quaternary alluvium consisting primarily of quartz latite fragments derived from the volcanic range to the east, and at the base more consolidated volcanic bedrock. The alluvium bedrock interface in each case was delineated by a change in the drilling rate, and the caliper, natural gamma, and lithology logs.

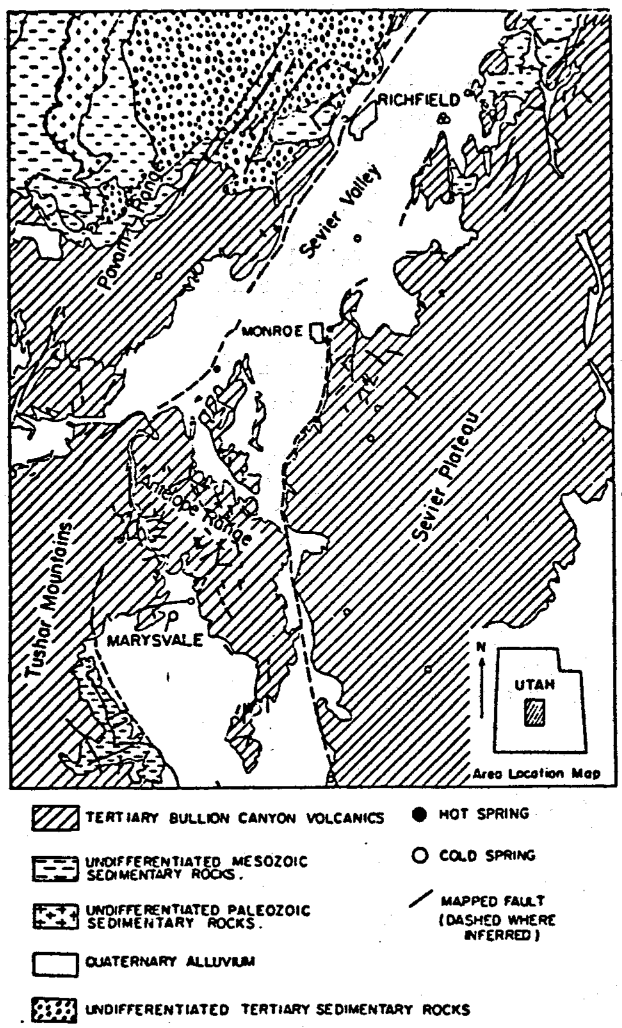

Figure 1. Location and General Geology of the Monroe-Red Hill Geothermal System.

A dip of 67° ± 3° for the Sevier Fault zone was computed on the basis of the intersections with more consolidated volcanics, the well geometries, and an assumed fault trend of north 10° west. This dip is shallower than that deduced from the geophysical modeling and may indicate step faulting. Temperatures observed in MC 1 and MC 2 and the thermal gradient holes M1-M4 shown in Figure 2, indicate a strong convective system rigorously confined along the fault zone.

PRODUCTION TEST WELL

Strong artesian flows from fractures in the footwall of the fault at 229 meters led to the conclusion that the sinter deposits at the surface were capping a potentially productive resource driven by a strong hydraulic gradient. Penetration of fractures, thereby inducing production from depth was the principle goal of the production test drilling. Flow rates up to 40 liters per second would be required to service the planned district heating scheme, and therefore, a large diameter surface casing would be necessary to accommodate

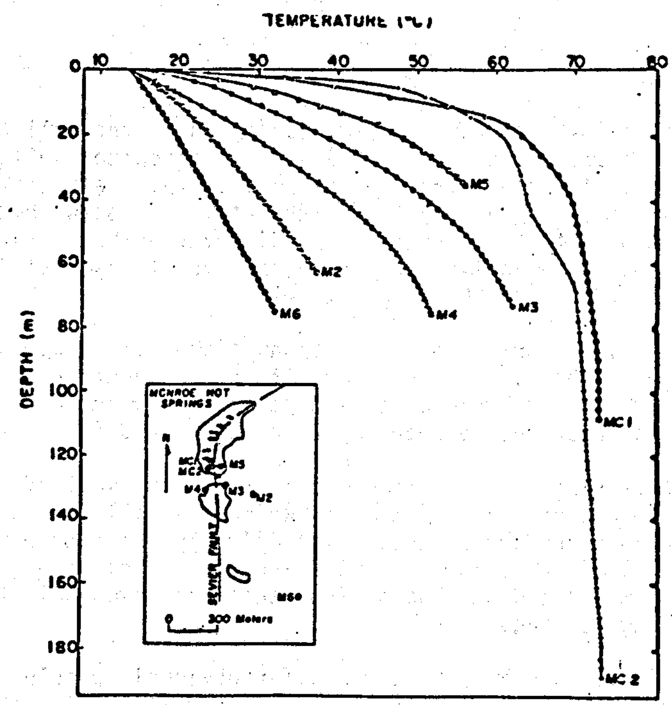

Figure 2. Temperature Profiles in Thermal Gradient and Test Holes.

the appropriate pump should the productivity of the well prove to be adequate. The well was designed and located on the basis of the geometry inferred from the test hole drilling to intersect the volcanic bedrock at 274-305 meters. Alluvium was anticipated above this point. Major production was expected from fractures in the bedrock. It was felt that production from the 305 meter plus level offered the advantages of good artesian flows due to increased driving potential with depth, the possibility of temperatures exceeding 80°C which would be of considerable benefit in view of retrofit requirements for existing building heating systems, and minimum influence on surface hydrologic conditions.

An unexpected lacustrine formation was encountered at 207 meters. This generally hard limestone formation with interbedded narrow clay zones persisted to approximately 305 meters. A gradual increase in the fraction of volcanic material in the drilling returns from 320 to 350 meters was interpreted as the intersection of a brecciated zone at the volcanic's interface. The transfer between this region and more consolidated bedrock was not immediately evident in the drill rate or caliper logs and was difficult to identify in the lithology logs. The upper portion of the hole was reamed and 16-inch casing was cemented to 680 feet. The total drilled depth at this time was 400 meters and after cleaning, the well produced an artesian flow rate of approximately 6 liters per second.

The lithology logs indicated that the well had penetrated at least 46 meters of bedrock; however, no significant lost circulation had been encountered or fracture zones identified in the caliper or temperature logs. The well was deepened to 457 meters in an effort to intersect the water carrying fractures which had been the original target.

WELL TESTING RESULTS

Results of a 70-hour drawdown test during which the well was pumped at 20.5 liters per second are shown in Figure 3. The two monitor wells MC 1 and MC 2 are 50 meters and 110 meters from the production well respectively. Computed storage coefficients indicate that confinement increases with depth. This result is consistent with the presence of a discharging hot spring zone. Simple Theis (1935) type curve analysis of the data gives transmissivities of 2.5 m^2/hr and 1.7 M^2/hr for MC 1 and MC 2 respectively.

The large initial drawdown in the production well is due in part to formation damage near the wellbore. The leveling off in drawdown after approximately 12 minutes indicates the presence of a high permeability or recharge zone, perhaps a water carrying fracture, at between 12 and 20 meters from the wellbore.

The well was surged in an effort to increase the well efficiency. The results of a subsequent drawdown test in which the well was pumped at 38 liters per second for 30 hours are shown in Figure 4. Apparent transmissivities of 2.3 M^2/hr and 1.5 M^2/hr in MC 1 and MC 2 are consistent with results from the previous test. The drawdown results from the production well however, do not indicate a strong recharge zone.

The complicated geometry of the aquifer obviously precludes the use of the simple Theis analysis. The two shallow monitor wells MC 1 and MC 2 probably exhibit the characteristics of the alluvium in the shallow subsurface. The production well draws both from storage in the alluvium and directly from the brecciated fault zone which carries water to the surface.

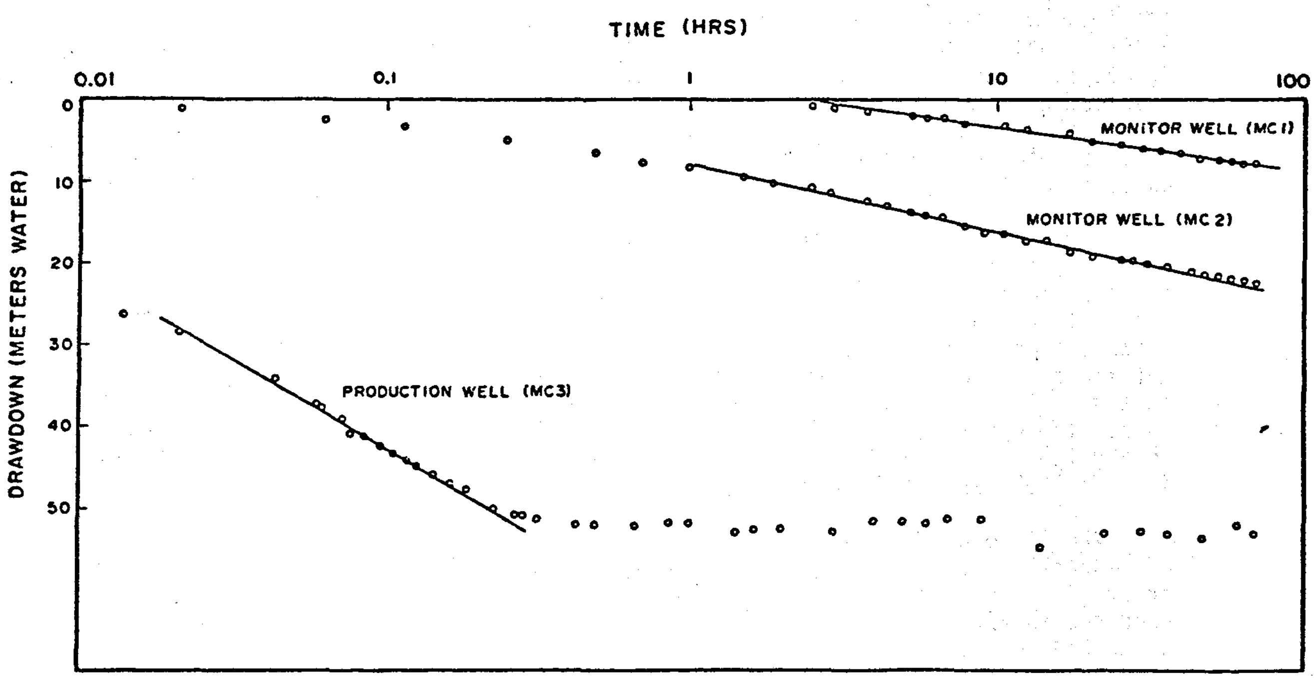

Figure 3. Drawdown Data for 70-Hour Pump Test.

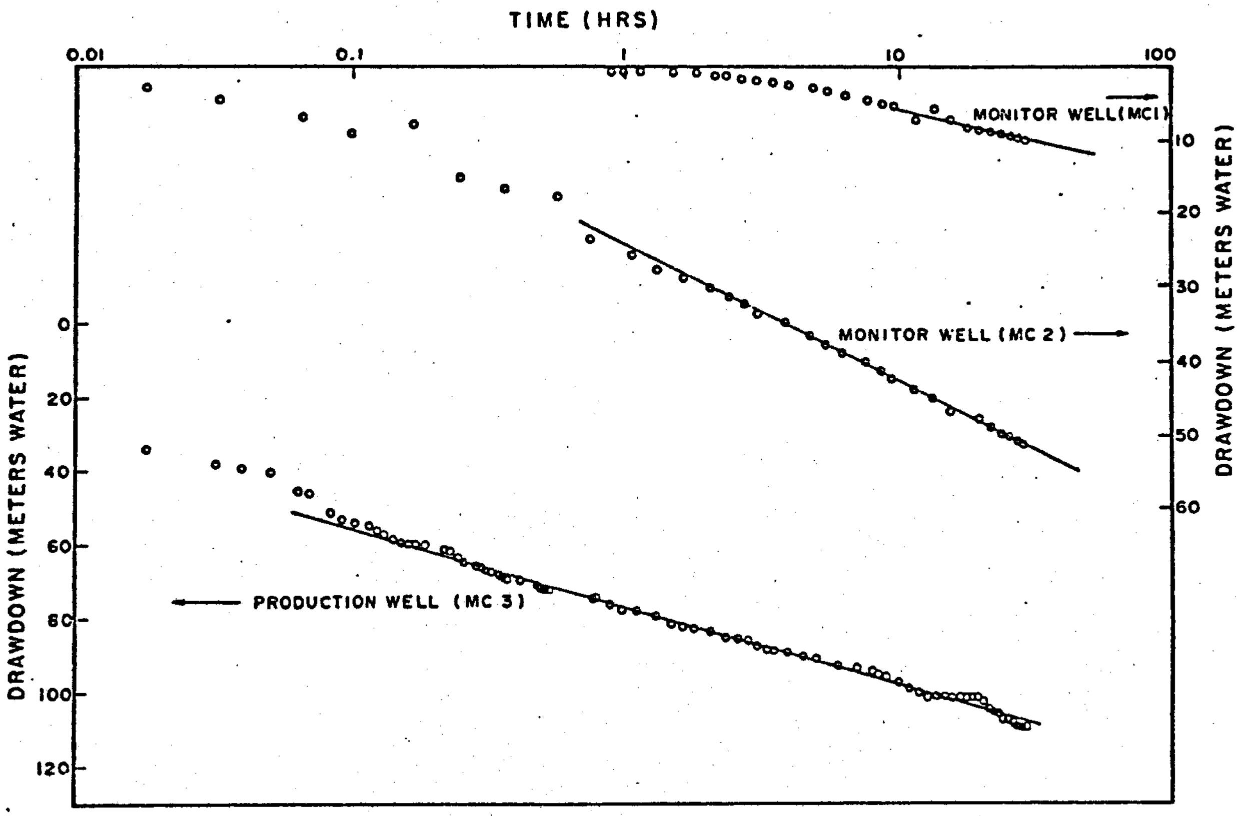

Figure 4. Drawdown Data for 30-Hour Pump Test.

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