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GEOHERMAL LOW-TEMPERATURE
RESERVOIR ASSESSMENT IN
NORTHERN DONA ANA COUNTY, NEW MEXICO

Final Report

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6. NAME AND ADDRESS OF PERFORMING ORGANIZATION New Mexico State University Energy Institute Box 3EI, Las Cruces, New Mexico 88003		
7. ABSTRACT <p style="margin: 0;">Fifty-four shallow temperature gradient holes were drilled along Interstate Highway 25 and the Rio Grande, from Las Cruces to Rincon, in northern Dona Ana County, New Mexico. This shallow temperature study (a joint exploration program performed with the cooperation and financial assistance of Trans-Pacific Geothermal, Inc. of Oakland, California) resulted in the discovery and confirmation of new and suspected major low-temperature geothermal resources. Elevated temperature and heat flow data suggest a thermal anomaly which can be generally described as being a nearly continuous linear feature which extends some 25 miles in length in a northwest-southeast direction with the only break being a 5-mile gap near the southern end of the study area. The width of the anomaly is only a few miles but tends to thicken around individual anomalies located within this larger anomaly. There are five main individual anomalies situated within the major anomaly and, listed from north to south, they are the: (1) Rincon Anomaly, (2) San Diego Mountain Anomaly, (3) Radium Springs KGRA, (4) Grande Dome Anomaly, and (5) Goat Mountain Anomaly. The main anomaly is well defined by a 4 HFU contour and the individual anomalies range from about 10 HFU to a high of near 30 HFU, estimated for the Rincon Anomaly. A bottom-hole temperature of 54°C at 50 meters was also recorded at Rincon. Deeper drilling is certainly warranted and required in the Rincon Anomaly in order to discover and confirm the true commercially exploitable potential of this geothermal resource.</p>		
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INTRODUCTION

Dona Ana County, New Mexico (see insert in Figure 1), is tectonically situated within the southern portion of the Rio Grande Rift, a north-south trending active thermo-tectonic system that extends from northern Chihuahua, Mexico, to central Colorado and is characterized by late-Pliocene to late-Quaternary faulting and volcanic activity, high heat flow, deep sedimentary basins, and numerous geothermal areas.

Reiter et al. (1978), based on a limited amount of heat flow data throughout south-central New Mexico, have placed Dona Ana County within an envelope of heat flow values greater than 2.5 heat flow units (HFU, one HFU = 1×10^6 cal cm⁻²sec⁻¹). Seager and Morgan (1979) have placed the county within a heat flow contour of greater than 3 HFU. A heat flow study of Dona Ana County (Lohse et al., 1981) gives a model range of about 2.5 to 3.6 HFU with a maximum value exceeding 16 HFU at San Diego Mountain.

Icerman and Lohse (1983) report the results of two shallow temperature gradient hole drilling programs performed in the fall of 1981 and in the summer of 1982 for the purpose of delineating the geothermal reservoirs in southern Dona Ana County (see Figure 1). They reported that a total of 64 holes had been drilled and that a maximum temperature of 54°C at 90 meters and a maximum heat flow value of 19 HFU were encountered in the northern end of the study area around Tortugas Mountain. They also reported the discovery and delineation of a major low-temperature geothermal anomaly located just a few miles to the east of Las Cruces and named the Las Cruces East Mesa Geothermal Field (see Figure 2).

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Figure 1. Location of map of study areas reported on by Icerman and Lohse (1983).

The primary objectives of this current project, which is reported on in this study, were to: (1) delineate the geothermal energy reservoirs in northern Dona Ana County along Interstate Highway 25 and the Rio Grande, from Las Cruces to Rincon, New Mexico (see Figure 3); and (2) provide the data needed to determine the locations of deeper (approximately 2,000 feet) exploratory test holes and/or production wells. The land targeted for exploration under this project is managed by the Bureau of Land Management (BLM) and the geothermal exploration leases have been applied for by Trans-Pacific Geothermal, Inc., of Oakland, California (TGI). Consequently, this project was carried out as a joint exploration program with TGI and the exploration activities were undertaken with the cooperation and financial assistance of TGI.

This joint exploration program was set up as a two-phase project. Phase I was to acquire relatively sparse data over the entire project area concentrating on easy access areas and those areas which were highly suspected of containing geothermal resources. Phase II was conducted as a follow-up to Phase I concentrating on those areas which were found to be anomalous, including the difficult access areas where warranted.

The shallow temperature gradient holes drilled during Phase I and Phase II of this project are shown in Figures 4 and 5, respectively. The locations of the shallow holes drilled during each phase have been shown separately in order to better show the development and strategy of the drilling exploration program. The data and results discussed below, however, have been summed together in the tables and figures in order to give a more comprehensive and clearer picture of the results of this study. All of the temperature data collected as part of this project are reproduced in Appendix A.

Figure 3. Location map of the study area in northern Dona Ana County.

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Figure 4. Location of temperature gradient holes (TG) in northern Dona Ana County - Phase I.

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Figure 5. Location of temperature gradient holes (TG) in northern Dona Ana County - Phase II.

TEMPERATURE-DEPTH DATA

A total of 54 shallow temperature gradient holes were drilled in northern Dona Ana County during Phase I in the fall of 1983 and Phase II in the spring of 1984. The locations of the temperature gradient holes, identified by the label TG, are shown in Figures 4 and 5, respectively. The total depths (T.D.'s) of the holes range from 18 meters to 50 meters. The holes penetrated a wide variety of geologic formations ranging from unconsolidated late-Quaternary alluvium to very hard and massive andesite lava flows. Additional lithologic information for each of the drill holes is presented below in Appendix A which also contains all the temperature-depth data, hole coordinates, elevations, and other pertinent data including bottom-hole temperature gradients and estimated thermal conductivities, all of which are discussed below. An example of the presentation of these data is given in Table 1 and Figure 6.

Measured bottom-hole temperatures range from a low of 19°C at 18 meters (TG-119) to a high of 54°C at 50 meters (TG-99). Bottom-hole temperature gradients were calculated for each of the shallow temperature gradient holes using the bottom-hole temperature-depth data and an estimated surface temperature of 20°C (Lohse, 1980; Lohse, 1982). With the exception of TG-119 which has a negative bottom-hole temperature gradient, resulting from a bottom-hole temperature less than 20°C, the range of values calculated for the rest of the holes go from a low of 10°C/km (TG-120) to a high of 686°C/km (TG-99).

Temperature gradients were calculated over specific depth intervals for each hole by a least-squares fit routine. The standard error of the estimate for each temperature gradient is also presented. The specific

TABLE 1. TEMPERATURE-DEPTH DATA FOR TG-99.

Location: latitude, $32^{\circ} 40.74'$, longitude, $107^{\circ} 03.26'$, township & range, T19S.R2W.4.343; elevation, 1,256 meters; spudded, 9-27-83; temperature logged, 11-28-83 (3:00 p.m.); total depth, 50 meters; depth of $1\frac{1}{2}$ inch PVC casing, 50 meters; bottom-hole temperature, 54.3°C ; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 686°C/km ; best estimate heat flow value, 1206 mW/m^2 (28.8 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	22.70		Fine sand; some gravel, silt, and clay; minor caliche				(1) A thin bed of pale green and dusky green clayey sand occurs at approxi- mately 115 feet (35M)
2	24.00						
3	25.30						
4	26.45						
5	27.15						
6	27.70		Carbonate-cemented sand- stone; hard				
7	28.25						
8	28.80						
9	29.35						
10	30.00						
15	33.55		(1)	2.1	1287	30.79	
20	36.80						
25	39.70						
30	42.80	612.9 ± 3.5					
35	45.85						
40	48.95		(2)	2.1	1124	26.88	
45	51.55	535.0 ± 8.7					
50	54.30						

*Detailed lithology is given in Appendix B.

† Estimated thermal conductivity values; see Table 2 and Table 3.

Figure 6. Temperature-depth curve for TG-99.

depth intervals for each hole were determined by correlating linear or nearly linear sections of the temperature-depth profiles with suspected or known changes of lithology (and therefore thermal conductivity values) based on drilling records, penetration rates, local geology and outcrops, and detailed lithologic descriptions of the drill cuttings from each drill hole. The detailed lithologies are presented in Appendix B. Many of the holes were drilled with mud and mixing of the cuttings within the borehole is known to have occurred; consequently, caution is advised when interpreting the detailed lithologies.

Figures 7 and 8 show the hole locations and their respective temperatures at 15 and 30 meters below ground surface. For those holes that had bottom-hole depths less than 30 meters, temperatures were estimated by extrapolating the measured temperature-depth data. A linear extrapolation was used for the holes that had nearly linear observed temperature gradients, while a gradual decrease in the temperature gradient with depth was assumed for holes that were drilled into areas believed to be convection dominated. The magnitude of the assumed decrease in temperature gradient is proportional to the curvature of the actual temperature-depth profile. The temperature data were hand contoured at 1°C intervals using the assumption of a constant thermal gradient between data points. The 20°C and 21°C contours have been thickened in Figure 7 and 8, respectively, for visual clarity and continuity.

ESTIMATED THERMAL CONDUCTIVITY VALUES

Thermal conductivity values were estimated for all of the different lithologic units that were penetrated below 15 meters by the shallow

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Figure 7. Temperature contours at a 15-meter depth
in northern Dona Ana County.

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Figure 8. Temperature contours at a 30-meter depth in northern Dona Ana County.

temperature gradient holes (see Table 1 and Appendix A). Values for these units were estimated by first determining what stratigraphic unit each lithologic unit belongs to in each drill hole and then assigning representative values to each stratigraphic unit. Several stratigraphic units have more than one lithology such as an andesitic lava flow grading from soft and weathered to very hard and massive, or a soft, fractured, and weathered limestone grading laterally into a very hard, recrystallized, and marbelized limestone. In these cases, the representative values were either raised or lowered to compensate for the changing lithologies. Table 2 shows the stratigraphic units believed to be penetrated by each hole. Determination of the units was accomplished by correlating local geology, drilling records and penetration rates, detailed lithology from drill cuttings, distinct changes in the temperature gradients, and similar thickness and depth of emplacement of near-linear segments of the temperature-depth profiles (Appendix A). Table 2 also references the source of the published local geology for each stratigraphic unit and the symbol for that unit.

Table 3 is a compilation of all the stratigraphic units and sub-units that were penetrated by all the shallow temperature gradient holes. Table 3 lists all the units according to geologic time and reports all the localities where each unit is believed to be penetrated and also shows the thermal conductivity value estimated for each unit. First-order approximations to the final estimates were obtained by a very close cross-examination of: (1) drilling records and penetration rates; (2) lithologic information from drill cuttings; (3) local geology, both published (Seager and Hawley, 1973; Seager 1975; Seager et al., 1976) and actual outcrop information; and (4) other published

thermal conductivity values, both measured (Reiter et al., 1975; Reiter et al., 1978; Swanberg et al., 1981) and estimated (Lohse, 1980, Lohse, 1982; Icerman and Lohse, 1983; Lohse and Gross, 1984).

TABLE 2. STRATIGRAPHIC DATA FOR NORTHERN DONA ANA COUNTY.

Hole #	Depth (m)		Stratigraphic Data
	From	To	
TG-98	0.0	50.3	Late Miocene to Pliocene; basin-floor facies; carbonate-cemented siltstone, sandstone and gypsum, hard (Rincon Valley Formation); Trv, (1)*
TG-99	0.0	6.1	Holocene; younger valley-slope alluvium; Qvy, (1)
	6.1	39.6	Early to middle Pleistocene; basin-floor fluvial facies; carbonate-cemented sandstone, hard (Camp Rice Formation); Qcrf (m, 1), (1)
	39.6	50.3	Late Miocene to Pliocene; basin-floor facies; carbonate-cemented siltstone, sandstone, and gypsum, hard (Rincon Valley Formation); Trv, (1)
TG-100	0.0	6.1	Middle to late Pleistocene; older valley-slope alluvium; Qvo, (1)
	6.1	50.3	Early to middle Pleistocene; basin-floor fluvial facies; carbonate-cemented sandstone, hard (Camp Rice Formation); Qcrf (m, 1), (1)
TG-101	0.0	9.1	Holocene; younger valley-slope alluvium; Qvy, (1)
	9.1	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1), (1)
TG-104	0.0	3.0	Middle to late Pleistocene; basin-floor facies, strongly caliche-cemented fine sand (La Mesa Surface); Qlm, (1)
	3.0	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (u, m), (1)
TG-105	0.0	6.1	Middle to late Pleistocene; basin-floor facies; strongly, caliche-cemented, fine sand (La Mesa Surface); Qlm, (1)

Table 2 (continued)

Hole #	Depth (m)		Stratigraphic Data
	From	To	
	6.1	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (u, m), (1)
TG-106	0.0	3.0	Middle to late Pleistocene; basin-floor facies; strongly, caliche-cemented, fine sand (La Mesa Surface); Qlm, (1)
	3.0	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (u, m), (1)
TG-107	0.0	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1), (1)
TG-108	0.0	3.0	Middle to late Pleistocene; basin-floor facies; strongly, caliche-cemented, fine sand (La Mesa Surface); Qlm, (1)
	3.0	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (u, m), (1)
TG-109	0.0	18.3	Middle to late Pleistocene; basin-floor sediments (latest Santa Fe); Qbf, (2)
	18.3	30.5	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (u, m), (2)
	30.5	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1), (2)
TG-110	0.0	9.1	Middle to late Pleistocene; basin-floor sediments (latest Santa Fe); Qbf, (2)
	9.1	30.5	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (u, m), (2)
	30.5	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1), (2)
TG-115	0.0	3.0	Late Pleistocene to Holocene; windblown (eolian) sand and loamy sediments; Qs, (2)

Table 2 (continued)

Hole #	Depth (m)		Stratigraphic Data
	From	To	
TG-116	3.0	6.1	Early to middle Pleistocene; piedmont-slope alluvium; carbonate-cemented, conglomeratic sandstone, hard (Camp Rice Formation); Qcrp, (2)
	6.1	21.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (u, m), (2)
	21.3	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, l), (2)
	0.0	1.5	Late Pleistocene to Holocene; wind blown (eolian) sand and loamy sediments; Qs, (2)
	1.5	3.0	Early to middle Pleistocene; piedmont-slope alluvium, nonindurated (Camp Rice Formation); Qcrp, (2)
	3.0	30.5	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, l), (1)
TG-117	30.5	50.3	Early to middle Pleistocene; basin-floor fluvial facies; carbonate-cemented, conglomeratic sandstone, hard (Camp Rice Formation); Qcrf (m, l), (2)
	0.0	3.0	Middle to late Pleistocene; loamy surficial deposits with well-developed soil-carbonate horizons (Jornada Surface); Qcrj, (3)
	3.0	12.2	Early to middle Pleistocene; piedmont-slope alluvium, nonindurated (Camp Rice Formation); Qcrp, (2)
	12.2	24.4	Early to middle Pleistocene; piedmont-slope alluvium; carbonate-cemented, conglomeratic sandstone, hard (Camp Rice Formation); Qcrp, (3)
	24.4	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf, (3)

Table 2 (continued)

Hole #	Depth (m)		Stratigraphic Data
	From	To	
TG-118	0.0	33.5	Permian; alternating, light-colored, thin to medium beds of very hard limestone and hard, shaly limestone (bottom of middle Hueco); Phm, (3)
TG-119	0.0	18.0	Permian, marbleized and recrystallized, sandy and silty limestone, very hard (lower portion of basin facies of the Hueco Limestone); Phb (1), (3)
TG-120	0.0	3.0	Holocene; younger arroyo channel, terrace, and fan alluvium; Qvy, (3)
	3.0	42.7	Eocene; hard andesitic lava flow (Palm Park Formation); Tpp, (3)
TG-121	0.0	9.1	Middle to late Pleistocene; older terrace and fan alluvium; Qvo, (3)
	9.1	21.3	Oligocene; rhyolitic, volcanoclastic sedimentary rocks; hard, conglomeratic sandstone (Unnamed Younger Dona Ana Cauldron Fill); Tcs, (3)
	21.3	27.1	Oligocene; hard, flow-banded rhyolite with feldspar phenocrysts (Flow-banded Rhyolite/younger Dona Ana Cauldron Fill); Tfb, (3)
TG-122	0.0	6.1	Holocene; younger arroyo channel, terrace, and fan alluvium; Qvy, (3)
	6.1	50.3	Eocene; thick, massive, hornblende andesite porphyry, very hard (Cleofas Andesite); Tpc, (3)
TG-123	0.0	3.0	Middle to late Pleistocene; older arroyo channel, terrace, and fan alluvium; Qvo, (3)
	3.0	9.1	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf, (3)
	9.1	24.4	Early to middle Pleistocene; carbonate-cemented, volcanic fanglomerate, hard (Camp Rice Formation); Qcrc, (3)

Table 2 (continued)

Hole #	Depth (m)		Stratigraphic Data
	From	To	
	24.4	31.1	Oligocene; weathered, densely welded, massive, rhyolitic ash-flow tuff, very hard (Dona Ana Rhyolite); Tdr, (3)
TG-124	0.0	16.5	Early to middle Pleistocene; piedmont-slope alluvium, nonindurated (Camp Rice Formation); Qcrp, (3)
	16.5	32.0	Early to middle Pleistocene; carbonate-cemented, volcanic fanglomerate, hard (Camp Rice Formation); Qcrc, (3)
TG-125	0.0	3.0	Middle to late Pleistocene; older arroyo channel, terrace, and fan alluvium; Qvo, (3)
	3.0	24.4	Early to middle Pleistocene; basin-floor fluvial facies, carbonate-cemented, conglomeratic sandstone, hard (Camp Rice Formation); Qcrf, (3)
	24.4	46.0	Early to middle Pleistocene; carbonate-cemented, volcanic fanglomerate, hard (Camp Rice Formation); Qcrc, (3)
TG-126	0.0	3.0	Middle to late Pleistocene; loamy surficial piedmont deposits with well developed soil-carbonate horizons (Jornada Surface); Qcrj, (3)
	3.0	21.3	Early to middle Pleistocene; basin-floor fluvial facies; carbonate-cemented sandstone, hard (Camp Rice Formation); Qcrf, (3)
	21.3	29.6	Oligocene; thick, massive, gray monzonite porphyry, very hard (younger Dona Ana Cauldron Fill); Tmp, (3)
TG-127	0.0	3.0	Middle to late Pleistocene; loamy surficial piedmont deposits with well-developed soil-carbonate horizons (Jornada Surface); Qcrj, (3)
	3.0	24.4	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf, (3)

Table 2 (continued)

Hole #	Depth (m)		Stratigraphic Data
	From	To	
	24.4	50.3	Early to middle Pleistocene; basin-floor fluvial facies; carbonate-cemented sandstone, hard (Camp Rice Formation); Qcrf, (3)
TG-128	0.0	9.1	Middle to late Pleistocene; older arroyo channel, terrace, and fan alluvium; Qvo, (3)
	9.1	21.3	Early to middle Pleistocene; carbonate-cemented, andesitic fanglomerate, hard (Camp Rice Formation); Qcrc, (3)
	21.3	35.1	Eocene; hard andesitic lava flow (Palm Park Formation); Tpp, (3)
TG-129	0.0	3.0	Early to middle Pleistocene; carbonate-cemented, andesitic fanglomerate, hard (Camp Rice Formation); Qcrc, (3)
	3.0	50.3	Eocene; hard, andesitic lava flow grading into very hard, and massive, andesitic lava flow (Palm Park Formation); Tpp (3)
TG-130	0.0	3.0	Middle to late Pleistocene; older arroyo channel, terrace, and fan alluvium; Qvo, (3)
	3.0	30.5	Early to middle Pleistocene; carbonate-cemented, volcanic fanglomerate, hard (Camp Rice Formation); Qcrc, (3)
	30.5	38.1	Oligocene; hard, flow-banded rhyolite with feldspar phenocrysts (Flow-banded Rhyolite/younger Dona Ana Cauldron Fill); Tfb, (3)
TG-131	0.0	3.0	Middle to late Pleistocene; complex of alluvial deposits on upper piedmont slopes; Qpa, (3)
	3.0	30.5	Early to middle Pleistocene; carbonate-cemented, piedmont-slope alluvium, hard (Camp Rice Formation); Qcrp, (3)
	30.5	50.3	Early to middle Pleistocene; carbonate-cemented, volcanic fanglomerate, hard (Camp Rice Formation); Qcrc, (3)

Table 2 (continued)

Hole #	Depth (m)		Stratigraphic Data
	From	To	
TG-132	0.0	24.4	Early to middle Pleistocene; basin floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1), 1)
	24.4	50.3	Early to middle Pleistocene; basin-floor fluvial facies, weakly, carbonate-cemented, conglomeratic sandstone (Camp Rice Formation); Qcrf (1), (1)
TG-133	0.0	3.0	Holocene; younger valley-slope alluvium; Qvy, (1)
	3.0	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1) (1)
TG-134	0.0	9.1	Middle to late Pleistocene; older valley-fill fluvial facies; sand to cobble gravel, nonindurated; Qvof, (1)
	9.1	24.4	Early to middle Pleistocene; basin-floor fluvial facies; nonindurated (Camp Rice Formation); Qcrf (m, 1), (1)
	24.4	50.3	Early to middle Pleistocene; basin-floor fluvial facies; weakly, carbonate-cemented sandstone (Camp Rice Formation); Qcrf (1), (1)
TG-135	0.0	3.0	Holocene; younger valley-slope alluvium; Qvy, (1)
	3.0	15.2	Early to middle Pleistocene; basin-floor fluvial facies; nonindurated (Camp Rice Formation); Qcrf (m, 1), (1)
	15.2	50.3	Early to middle Pleistocene; basin-floor fluvial facies; weakly, carbonate-cemented sandstone (Camp Rice Formation); Qcrf (1), (1)
TG-136	0.0	15.2	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (u, m), (1)
	15.2	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1), (1)

Table 2 (continued)

Hole #	Depth (m)		Stratigraphic Data
	From	To	
TG-137	0.0	3.0	Holocene; younger vally-slope alluvium; Qvy, (1)
	3.0	15.2	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1), (1)
	15.2	30.5	Early to middle Pleistocene; basin-floor fluvial facies; moderately, carbonate-cemented sandstone, hard (Camp Rice Formation); Qcrf (m, 1), (1)
	30.5	50.3	Early to middle Pleistocene; basin-floor fluvial facies; strongly, carbonate-cemented sandstone, hard (Camp Rice Formation); Qcrf (1), (1)
TG-138	0.0	3.0	Holocene; younger valley-slope alluvium; Qvy, (1)
	3.0	12.2	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (u, m), (1)
	12.2	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1), (1)
TG-139	0.0	3.0	Holocene; younger valley-slope alluvium; Qvy, (1)
	3.0	15.2	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1), (1)
	15.2	24.4	Early to middle Pleistocene; basin-floor fluvial facies; moderately, carbonate-cemented sandstone, hard (Camp Rice Formation); Qcrf (m, 1), (1)
	24.4	50.3	Early to middle Pleistocene; basin-floor fluvial facies; strongly, carbonate-cemented sandstone, hard (Camp Rice Formation); Qcrf (1), (1)
TG-140	0.0	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1), (1)

Table 2 (continued)

Hole #	Depth (m)		Stratigraphic Data
	From	To	
TG-141	0.0	3.0	Late Pleistocene to Holocene; wind blown (eolian) sand and loamy sediments; Qs, (2)
	3.0	15.2	Early to middle Pleistocene; piedmont-slope alluvium, nonindurated (Camp Rice Formation); Qcrp, (2)
	15.2	33.5	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1), (2)
	33.5	50.3	Early to middle Pleistocene; basin-floor fluvial facies; carbonate-cemented sandstone, hard (Camp Rice Formation); Qcrf (m, 1), (2)
TG-142	0.0	6.1	Late Pleistocene to Holocene; windblown (eolian) sand and loamy sediments; Qs, (2)
	6.1	15.2	Early to middle Pleistocene; piedmont-slope alluvium, nonindurated (Camp Rice Formation); Qcrp, (2)
	15.2	30.5	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (u, m), (2)
	30.5	39.6	Early to middle Pleistocene; basin-floor fluvial facies; carbonate-cemented sandstone, hard (Camp Rice Formation), Qcrf (m, 1), (2)
	39.6	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1), (2)
TG-143	0.0	21.3	Permian; limestone, weathered, soft (Abo Formation); Pha, (3)
	21.3	36.6	Permian; shale, fractured and weathered, soft (Abo Formation); Pha, (3)
	36.6	50.3	Permian; silty, shaly limestone, moderately hard (Abo Formation); Pha, (3)
TG-144	0.0	6.1	Early to middle Pleistocene; carbonate-cemented, limestone fanglomerate, hard (Camp Rice Formation); Qcra, (3)

Table 2 (continued)

Hole #	Depth (m)		Stratigraphic Data
	From	To	
	6.1	15.2	Permian; tan sandstone, hard (marker bed for the base of the Abo Formation); Pha, (3)
	15.2	50.3	Permian; alternating beds of hard, shaly limestone and very hard limestone (top of the middle Hueco Formation); Phg, (3)
TG-145	0.0	50.3	Permian; weathered, and fractured and crushed dolomite and silty, shaly limestone, soft (Abo Formation); Pha, (3)
TG-146	0.0	6.1	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf, (3)
	6.1	15.2	Early to middle Pleistocene; carbonate-cemented, limestone fanglomerate, hard (Camp Rice Formation); Qcrc, (3)
	15.2	33.5	Permian; thin, weathered, multi-colored, micrite (limestone) beds grading into thicker beds of hard limestone (marker beds for the top of lower Hueco Formation); Phl, (3)
	33.5	45.7	Permian; very hard limestone (dolomite), fractured (lower Hueco Formation); Phl, (3)
TG-147	0.0	12.2	Early to middle Pleistocene; carbonate-cemented, limestone fanglomerate, hard (Camp Rice Formation); Qcrc, (3)
	12.2	30.5	Eocene; very hard, massive, and altered, andesitic lava flow (Palm Park Formation); Tpp, (3)
TG-148	0.0	6.1	Middle to late Pleistocene; older arroyo channel, terrace, and fan alluvium; Qvo, (3)
	6.1	15.2	Early to middle Pleistocene; carbonate-cemented, limestone/volcanic (andesitic) fanglomerate, hard (Camp Rice Formation); Qcrc, (3)

Table 2 (continued)

Hole #	Depth (m)		Stratigraphic Data
	From	To	
	15.2	50.3	Eocene; alternating beds of very hard andesitic lava flows and hard, andesitic, laharic breccias (Palm Park Formation); Tpp, (3)
TG-149	0.0	6.1	Middle to late Pleistocene; older arroyo channel, terrace, and fan alluvium; Qvo, (3)
	6.1	50.3	Early to middle Pleistocene; carbonate-cemented, andesitic fanglomerate, hard (Camp Rice Formation); Qcrc, (3)
TG-150	0.0	3.0	Late Pleistocene to Holocene; windblown (eolian) sand and loamy sediments; Qvs, (3)
	3.0	33.5	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf, (3)
	33.5	45.7	Permian; brown sandstone, carbonate-cemented, hard (Abo Formation); Pha, (3)
	45.7	50.3	Permian; red siltstone, very hard (Abo Formation); Pha, (3)
TG-151	0.0	50.3	Permian; marbleized and recrystallized, alternating beds of very hard limestone and hard, carbonated, siliceous limestone, mineralized (lower portion of the basin facies of the Hueco Formation); Phb (1), (3)
TG-153	0.0	3.0	Late Pleistocene to Holocene; younger arroyo channel, terrace, and fan alluvium; Qvy, (3)
	3.0	6.1	Middle to late Pleistocene; older arroyo channel, terrace, and fan alluvium; Qvo, (3)
	6.1	18.3	Early to middle Pleistocene; carbonate-cemented, volcanic fanglomerate, hard (Camp Rice Formation); Qcrc, (3)

Table 2 (continued)

Hole #	Depth (m)		Stratigraphic Data
	From	To	
	18.3	50.3	Oligocene; thick, massive, monzonite porphyry grading from a hard, weathered, yellow-brown to a very hard, light gray (younger Dona Ana Cauldron Fill); Tmp, (3)
TG-154	0.0	26.2	Early to middle Pleistocene; thin to medium layers of carbonate-cemented fanglomerates, sandstones, and caliche, hard (Camp Rice Formation); Qcru, (3)
	26.2	35.1	Oligocene; thick, massive, very hard, gray, monzonite porphyry (younger Dona Ana Cauldron Fill); Tmp, (3)
	35.1	50.3	Oligocene; thick, massive, very hard, highly altered (green), monzonite porphyry (younger Dona Ana Cauldron Fill); Tmp, (3)
TG-155	0.0	24.4	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf, (3)
	24.4	36.6	Early to middle Pleistocene; basin-floor fluvial facies; carbonate-cemented sandstone, mudstone, and caliche, hard (Camp Rice Formation); Qcrf, (3)
	36.6	45.7	Early to middle Pleistocene; carbonate-cemented, volcanic fanglomerate, hard (Camp Rice Formation); Qcrc, (3)
	45.7	50.3	Oligocene; hard, weathered, purple-gray, monzonite porphyry (younger Dona Ana Cauldron Fill); Tmp, (3)
TG-156	0.0	15.2	Early to middle Pleistocene; basin-floor fluvial facies; carbonate-cemented sandstone, hard (Camp Rice Formation); Qcrf, (3)
	15.2	35.1	Early to middle Pleistocene; carbonate-cemented, volcanic fanglomerate, hard (Camp Rice Formation); Qcrc, (3)
	35.1	50.3	Oligocene; hard, weathered, yellow-brown, monzonite porphyry grading into dark purple-gray, very hard, thick, and massive, monzonite porphyry (younger Dona Ana Cauldron Fill); Tmp, (3)

Table 2 (continued)

Hole #	Depth (m)		Stratigraphic Data
	From	To	
TG-157	0.0	15.2	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf, (3)
	15.2	50.3	Early to middle Pleistocene; basin-floor fluvial facies; carbonate-cemented sandstone, mudstone, and caliche, hard (Camp Rice Formation); Qcrf, (3)
TG-158	0.0	3.0	Holocene; younger valley-slope alluvium; Qvy, (1)
	3.0	50.3	Early to middle Pleistocene; basin-floor fluvial facies, nonindurated (Camp Rice Formation); Qcrf (m, 1), (1)

*Sources:

1. Seager, W. R. and Hawley, J. W., 1973. Geology of Rincon Quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Bulletin 101, 42 pp.
2. Seager, W. R. 1975, Geologic Map and Sections of South Half San Diego Mountain Quadrangle, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Geologic Map 35.
3. Seager, W. R.; Kottowski, F. E.; and Hawley, J. W. 1976. Geology of Dona Ana Mountains, New Mexico: New Mexico Bureau of Mines and Mineral Resources, Circular 147, 36 pp.

TABLE 3. ESTIMATED THERMAL CONDUCTIVITY FOR
NORTHERN DONA ANA COUNTY.

Epoch	Stratigraphic Unit	Localities* (TG-#)	K** (W/m-°K)
Holocene	Qvy; younger valley-slope alluvium	99, 101, 120, 122, 133, 135, 137, 138 139, 153, 158	1.5
Holocene to Late Pleistocene	Qs; windblown sand and loamy sediments, caliche-cemented	115, 116, 141, 142	1.4
	Qvs; windblown alluvium, sandy deposits	150	1.5
Late Pleistocene to Middle Pleistocene	Qvo; older valley-slope alluvium	100, 121, 123, 125, 128, 130, 148, 149, 153	1.5
	Qvof; older valley-fill fluvial facies; sand to cobble gravel, nonindurated	134	1.5
	Qpa; complex of alluvial deposits on upper piedmont slopes	131	1.5
	Qbf; basin-floor sediments (latest Santa Fe)	109, 110	1.4
	Qlm; basin-floor facies, fine sand with strong caliche cementing (La Mesa Surface)	104, 105, 106, 108	1.4
	Qcrj; loamy surficial deposits with well-developed soil-carbonate horizons (Jornada Surface)	117, 126, 127	1.5
Early Pleistocene to Middle Pleistocene	Qcrf (u, m); basin-floor fluvial facies, non-indurated; grades from gravel to sandy gravel with depth (Camp Rice Formation)	104, 105, 106, 108, 109, 110, 115, 136, 138, 142	1.5

Table 3 (continued)

Epoch	Stratigraphic Unit	Localities* (TG-#)	K** (W/m-°K)
	Qcrf (m, l); basin-floor fluvial facies, non- indurated; unsorted medium to fine sand and soft sandstone	101, 107, 109, 110, 115, 116, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 158	1.7
	Qcrf (m, l); basin-floor fluvial facies; medium to fine sandstone and conglomeratic sand- stone; carbonate- cement is moderate	99, 100, 116, 141, 142 137, 139	2.1 2.9 (wet)
	Qcrf (l); basin-floor fluvial facies; fine sandstone, conglo- meratic sandstone, and siltstone; carbonate- cementing is weak	132 132, 134, 135	1.9 3.1 (wet)
	Qcrf (l); basin-floor fluvial facies; fine sandstone and conglo- meratic sandstone; carbonate-cementing is strong	137, 139	3.3 (wet)
	Qcrf; basin-floor fluvial facies, non- indurated sediments, sand and gravel to fine sand	117, 123, 127, 146, 150, 155, 157	1.7
	Qcrf; basin-floor fluvial facies, carbonate-cemented sandstone and conglo- meratic sandstone, moderate to hard	125, 126, 127, 155, 156, 157	2.1
	Qcrp; piedmont-slope alluvium, nonindurated	116, 117, 124 141, 142	1.6
	Qcrp; piedmont-slope alluvium, carbonate- cemented, conglo- meratic sandstone, moderate to hard	115, 117, 131	2.1

Table 3 (continued)

Epoch	Stratigraphic Unit	Localities* (TG-#)	K** (W/m-°K)
	Qcrc; carbonate-cemented fanglomerate comprised of volcanic and/or limestone fragments, hard	123, 124, 125, 128, 129, 130, 131, 144, 146, 147, 148, 149, 153, 155, 156	2.5
	Qcru; thin layers of carbonate-cemented fanglomerates, sand- stones, and caliche, hard	154	2.5
Late Miocene to Pliocene	Trv; basin-floor facies, carbonate-cemented siltstone, sandstone, and gypsum, hard (Rincon Valley Formation)	98, 99	2.1 (wet)
Oligocene	Tmp; monzonite porphyry (younger Dona Ana Cauldron Fill)	155, 156 126, 153, 154, 156	3.2 (hard weathered top of unit) 3.5 (very hard, massive)
		154	4.5 (very hard, massive, and altered, wet)
	Tfb; flow-banded rhyolitic with abundant feldspar phenocrysts, hard (Flow-banded Rhyolite/ younger Dona Ana Cauldron Fill)	121, 130	3.0
	Tcs; rhyolitic, volcano- clastic sedimentary rocks; conglomeratic sandstone, hard (unnamed younger Dona Ana Cauldron Fill)	121	2.1

Table 3 (continued)

Epoch	Stratigraphic Unit	Localities* (TG-#)	K** (W/m-°K)
	Tdr; densely-welded, rhyolitic, ash-flow tuff; very hard, massive (Dona Ana Rhyolite, upper-half of main unit of Dona Ana Cauldron)	123	3.2
Eocene	Tpp, sequence of epiclastic andesitic rocks and interbedded lava flows (Palm Park Formation)	148	2.7 (hard, laharic breccia)
		120, 128, 129	3.2 (hard, lava flow)
		129, 147, 148	3.5 (very hard, massive, lava flow)
	Tpc; thick, massive, hornblende andesite porphyry, very hard (Cleofas Andesite)	122	3.5
Permian	Pha; cyclical repetition of siltstones and sandstones with shales and limestones (Abo Formation)	143	2.0 (weathered limestone, soft)
		143	1.5 (shale, fractured, soft)
		143	2.2 (hard silty, shaly limestone)
		145	3.5 (fractured and crushed dolomite and silty, shaly limestone, soft, wet)
		144, 150	2.5 (hard sandstone)
		150	2.9 (very hard, very fine sandstone and siltstone)

Table 3 (continued)

Epoch	Stratigraphic Unit	Localities* (TG-#)	K** (W/m-°K)
	Phg; limestone and shaly limestone (top of Middle Hueco)	144	2.2 (hard, shaly limestone)
		144	2.8 (very hard limestone)
	Phm; limestone and shaly limestone (Middle Hueco)	118	2.2 (hard, shaly limestone)
		118	2.8 (very hard limestone)
	Phl; limestone (Lower Hueco)	146	2.2 (hard limestone)
		146	2.8 (very hard dolomite)
	Phb (1); limestone (Lower Hueco, basin facies)	151	2.2 (hard carbonated, siliceous, and mineralized limestone)
		119, 151	2.8 (very hard, recrystallized, sandy, silty limestone)

*See Table 1 and Appendix A (also Figures 4 and 5) for hole locations and coordinates. Correlate Table 1 and Appendix A with Tables 2 and 3 for additional lithologic and stratigraphic information.

**Thermal conductivity values are estimated.

Final corrections to the preliminary thermal conductivity value approximations were accomplished by making the simple assumption that the character of the flow of heat in any one particular hole location will remain unchanged. In other words, successive heat flow values for any one temperature gradient hole will continue to either increase (indicating upward or lateral convection), decrease (indicating downward or lateral convection), or remain the same (conduction dominated area) rather than establish an erratic pattern. In addition to making this assumption, most stratigraphic units were penetrated in multiple locations (see Table 3) and usually adjacent to different units from site to site. Consequently, the above condition must be satisfied by the estimated thermal conductivity of each particular stratigraphic unit at several different sites simultaneously, where it is adjacent to different units with different thermal conductivity values. This process for making the final corrections to the estimated thermal conductivity values is analogous to simultaneously solving a set of equations with specified boundary conditions for an unknown; and, similarly, results in final estimated values which are considered well constrained.

Most of the estimated thermal conductivity values are believed to be within ± 0.1 W/m-°K. The basis for estimating this degree of error comes from the fact that if an estimated value is increased or decreased by more than this amount in order to better meet the above criteria at one particular hole location, it will cause larger deviations from the same set of criteria in the other hole locations where it is present. Obvious exceptions are those values estimated for stratigraphic units that are present in only one location and, as such, are less constrained.

ESTIMATED HEAT FLOW VALUES

Heat flow values for the specified depth intervals (see Table 1 and Appendix A) were calculated for each of the temperature gradient holes from the measured temperature gradients and the estimated thermal conductivity values. The estimated best heat flow value represents a simple average of the heat flow values from each hole. These best estimates range from 1.4 to 28.8 HFU ($1 \text{ HFU} = 41.8 \text{ mWm}^{-2}$) for the holes labeled TG-131 and TG-99, respectively. The location and estimated best heat flow value for each hole is shown in Figure 9. The data are hand contoured at 2 HFU intervals using the assumption of a constant gradient between data points. Supplemental contours were constructed at 2.3 and 2.5 HFU in order to give added detail, particularly in the north end of the study area. The 2.3 HFU contour was thickened for visual clarity and continuity.

GEOLOGY

All of the shallow temperature gradient holes in the northern half of the study area, from south of San Diego Mountain--north all the way to Rincon, bottomed in Quaternary sediments (see Table 2) except for holes TG-98 and TG-99 located to the west and north, respectively, of Rincon. These two holes were finished in late-Tertiary beds of the Rincon Valley Formation described by Seager and Hawley (1973) as slightly conglomeratic, reddish beds of siltstone, sandstone, and gypsum. Drilling records indicate that the beds were well-consolidated and hard (see Table 3). The rest of the holes were completed into slightly different lithologies, all of the Camp Rice Formation of early to middle Pleistocene time.

The general characteristics of the Camp Rice Formation in this vicinity as reported by Seager and Hawley (1973) and Seager (1975) and verified by the drilling results presented in this study are that this unit: (1) is best described as a basin-floor facies composed of fluvial deposits; (2) is capped by thin hard caliche beds to the east and eroded progressively deeper to the west; (3) is generally graded from gravel to sandy gravel (upper to middle), sandy gravel to medium and fine sand (middle to lower), medium and fine sand to well-sorted, very fine sandstone (lower); and (4) becomes increasingly more indurated with depth and is most prominent around Rincon and San Diego Mountain.

The southern half of the study area is best divided into two separate areas for the purpose of discussion: the area in and to the northwest of the Dona Ana Mountains, and the area surrounding Goat Mountain located just to the southeast of the Dona Ana Mountains. Most of the temperature gradient holes in the former area bottomed in either

middle-Tertiary volcanic rocks or Permian strata. The only exceptions are holes TG-117, TG-131, and TG-149 all of which were finished in the Camp Rice Formation, described above.

Temperature gradient holes TG-143, TG-145, and TG-150 were completed in the Abo Formation (Permian). Seager et al. (1976) state that cyclical repetition of Abo red beds with Hueco marine shale and limestone characterize the Abo Formation in the Dona Ana-Robledo Mountain area. They further state that the Abo beds are usually red, hematitic siltstone or gray to brown sandstone units and that the Abo Formation occurs as a tongue between middle and upper limestone members of the Hueco (Permian), although the upper Hueco and most of the Abo Formation were eroded in pre-late Eocene time in the Dona Ana Mountains.

Hole TG-144 penetrated the Abo Formation and bottomed in the uppermost part of the middle Hueco, a hard gastropod-bearing member, while hole TG-118 bottomed in the lower portion of the middle Hueco, very hard limestone and hard shaly limestone. Hole locations labeled TG-119 and TG-151 also bottomed in Hueco strata, but unlike the other holes which finished in the Hueco's western shelf facies, these two holes finished in the eastern basin facies described by Seager et al. (1976) as marbelized and recrystallized sand and silty limestone. Hole TG-146 penetrated many thin and multi-colored layers (believed to be the marker beds for the top of the lower Hueco) before bottoming in the lower Hueco, western shelf facies.

Shallow temperature gradient holes TG-120, TG-128, TG-129, TG-147, and TG-148 bottomed-out in the Palm Park Formation described by Seager, et al. (1976) as a sequence of epiclastic andesitic rocks and interbedded lava flows. Seager et al. also state that two facies of

Eocene rocks were mapped in this area: the Palm Park Formation being one, and the Cleofas Andesite the other. The Cleofas Andesite is reported as a thick, massive hornblende andesite porphyry, probably both intrusive and extrusive. The only hole to bottom in the Cleofas Andesite is hole TG-122.

The last two holes from the area in and to the northwest of the Dona Ana Mountains are the holes labeled TG-121 and TG-130. Both of these holes bottomed in what is believed to be (based partly on the abundance of feldspar phenocryst present) the unit referred to as Flow-banded Rhyolite of the Dona Ana Cauldron Fill by Seager et al. (1976).

There are a total of ten shallow temperature gradient holes in the area surrounding Goat Mountain located to the southwest of the Dona Ana Mountains. A simple geologic model is clearly suggested by the strata penetrated by the ten holes. In general, the local geology can be described as consolidated sandstones on top of volcanic fanglomerates, both of the Camp Rice Formation. These overlie a light gray to yellow-brown monzonite porphyry which grades from a hard, weathered surface to a very hard, massive unit. All formations are believed to dip slightly to the west-southwest.

Holes TG-126 and TG-153 through TG-156 all bottomed in the monzonite porphyry. A sandstone unit and an undifferentiated unit both consolidated and hardy overlie the porphyry in holes TG-126 and TG-154, respectively, on the east side of Goat Mountain. Also, the top of the monzonite porphyry is light to dark gray, very hard, and massive in these two holes, whereas holes TG-153, TG-155, and TG-156, all located to the north and west of Goat Mountain, penetrated a hard, weathered,

yellow-brown surface on top of the monzonite porphyry before entering into either a light or dark gray facies. Holes TG-155 and TG-156 both penetrated a consolidated sandstone unit on top of a hard volcanic fanglomerate before entering the weathered monzonite porphyry. Hole TG-153 also penetrated a dark, hard volcanic fanglomerate on top of the weathered monzonite porphyry, but the consolidated sandstone unit does not appear to be present.

To the west northwest of the TG-153, hole TG-125 penetrated the consolidated sandstone unit before entering a dark volcanic fanglomerate. Although TG-125 is classified as bottoming in the fanglomerate, it is a very good chance that it bottomed in the dark gray monzonite porphyry. This interpretation is suggested by the fact that drilling came to a virtual standstill during the last foot of the hole, yet there was no noticeable change in drill cuttings. This situation could be easily explained if one drilled with mud from a hard, dark gray, volcanic fanglomerate into a hard, massive, dark gray, monzonite porphyry.

Temperature gradient holes TG-127 and TG-157, located to the south of Goat Mountain, bottomed in a hard consolidated sandstone of the Camp Rice Formation. Temperature gradient holes TG-123 and TG-124, located to the northwest of TG-125 and Goat Mountain, penetrated volcanic fanglomerates. Hole TG-123 penetrated through the fanglomerate and bottomed in a densely welded rhyolitic ash-flow tuff classified as part of the main body of the Dona Ana Rhyolite (Seager et al., 1976). Hole TG-124 bottomed in the volcanic fanglomerate but based on drilling records and penetration rates, it is believed to be very near the top of a volcanic unit (or may have even penetrated the surface), probably the monzonite porphyry.

RESULTS

The temperature and heat flow patterns for the study area are shown in Figures 7 through 9. The temperature and heat flow patterns are similar and show well-defined anomalies both in the northern half and the southern half of the study area. There are two major anomalies in the northern portion which are located at Rincon and San Diego Mountain. Rincon has the highest heat flow and temperature values of the entire study area and San Diego Mountain has the next highest temperatures. Hole TG-99 located at Rincon has an estimated best heat flow value of 28.8 HFU and encountered temperatures of 54.3°C at 50 meters (130°F at 165 feet). Temperature gradient holes TG-116 and TG-140 located just south and north, respectively, of San Diego Mountain have the two highest temperatures for this area. Hole TG-116 has a bottom-hole temperature of 30.2°C at 50 meters, while TG-140 has a bottom-hole temperature of 28.7°C at 45 meters. The highest heat flow values for the San Diego Mountain anomaly (this study) are from holes TG-139 to the north and TG-116 to the south and are 8.3 and 9.2 HFU, respectively.

The second highest heat flow values are located in the southern half of the study area in the Grande Dome area located in the northwestern portion of the Dona Ana Mountains. Although these values are the second highest, they are only slightly higher than the heat flow values from the San Diego Mountain anomaly and values that were estimated for a second anomaly located in the southern half of the study area. This second anomaly is centered about Goat Mountain which is located a few miles to the southeast of the Dona Ana Mountains. The highest heat flow values for the Grande Dome anomaly are 9.8 and 10.0 HFU from holes TG-118 and TG-129, respectively. The most elevated

temperatures for this area were encountered in hole TG-118 which measured 25.1°C at 33 meters. Hole TG-156 had the highest heat flow and temperature values, 9.9 HFU and 28.7°C at 50 meters, respectively, for the Goat Mountain anomaly.

Several other minor results are worth noting. The average heat flow and temperature values in the northern half of the study area (excluding the Rincon and San Diego Mountain anomalies which are located on the northern and southern extremes, respectively, of this section) tend to increase to the west where they form a ridge of high values with minimum values of 5.2 HFU and 24.4°C, respectively, occurring at hole TG-135 and creating a saddle in the middle of the ridge. The heat flow and temperature values increase along the ridge from the saddle towards the peaks of the ridge which are centered on the two anomalies at the ends. The only exception is a small decrease in the pattern of increasing values at hole TG-132; however, due to the curvature of the temperature-depth profile and the proximity of the hole to the Rincon Arroyo, it is believed that the hole is disturbed by lateral groundwater flow.

Based on the elevated bottom-hole temperatures and the curvature of the temperature-depth profile from TG-140, it is felt that either upward or lateral warm water movement is occurring in this locality. The only other holes that are thought to be disturbed are TG-122 and TG-145, both located in the southern half of the study area in the northwestern portion of the Dona Ana Mountains. Drilling records, temperature-depth data, hole locations (in arroyos), and the fact that both holes encountered cool groundwater along fractures (estimated at 3 to 5 gpm, each) strongly suggest that these locations are disturbed by downward

percolation or lateral flow of cool recharge waters to the local aquifers.

CONCLUDING REMARKS

A total of 54 shallow temperature gradient holes were drilled during the fall of 1983 and the spring of 1984 to delineate the magnitude and horizontal extent of suspected geothermal resources in northern Dona Ana County. The holes were sited along Interstate Highway 25 and the Rio Grande, from Las Cruces to Rincon, New Mexico. The program was highly successful in that the exploration activities resulted in the discovery and confirmation of new and suspected major low-temperature geothermal resources.

Based on elevated temperature and heat flow data, the following general picture is suggested. A thermal anomaly exists in northern Dona Ana County which extends nearly continuously for some 25 miles in length in a northwest-southeast direction with the only break being a 5-mile gap between the southernmost anomaly at Goat Mountain and the rest of the anomaly to the north. The width of the anomaly is only a few miles and tends to be thickest around individual anomalies located within the main northwest-southeast trending anomaly. There are five major individual anomalies located within the main anomaly. These anomalies are identified as the: (1) Rincon Anomaly, (2) San Diego Mountain Anomaly, (3) Radium Springs KGRA (Known Geothermal Resource Area, see Figure 3), (4) Grande Dome Anomaly, and (5) Goat Mountain Anomaly. The background heat flow of the main anomaly is considered to be about 3 to 4 HFU since the 4 HFU contour pretty well defines the anomaly. The individual anomalies (this study) range from about 10 HFU to a high of

near 30 HFU, which was estimated for the Rincon Anomaly. A bottom-hole temperature of 54°C at 50 meters (approximately 130°F at 165 feet) was also recorded at Rincon.

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APPENDIX A

Temperature Data for Northern Dona Ana County, New Mexico

Note: The data are for temperatures gradient holes TG-98 through TG-158 (see figures 4 and 5 for locations). Holes TG-102, TG-103, TG-111, TG-112, TG-113, TG-114, and TG-152 were sited but not drilled. The reported temperature gradient data are least-squares fits to the empirical data, with the standard error of the estimate given. Bottom-hole temperature gradients were computed for a 20°C surface temperature.

Hole Name: TG-98

Location: latitude, 32° 40.24', longitude, 107° 04.60', township & range, T19S.R2W.8.133; elevation, 1,237 meters; spudded, 9-26-83; temperature logged, 12-15-83 (11:55 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 22.9°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 58°C/km; best estimate heat flow value, 189 mW/m² (4.5 HFU).

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Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks		
					(mW/m ²)	(HFU)			
1	16.30		Slightly conglomeratic beds of carbonate- cemented siltstone, sandstone, and gypsum; hard	2.1					
2	17.40								
3	18.65								
4	19.20								
5	19.30								
6	19.30								
7	19.20								
8	19.20								
9	19.25								
10	19.30								
15	19.75---	90.0 ± 0.0						189	4.52
20	20.20								
25	20.65								
30	21.10								
35	21.55								
40	22.00								
45	22.45								
50	22.90								

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-99

Location: latitude, 32° 40.74', longitude, 107° 03.26', township & range, T19S.R2W.4.343; elevation, 1,256 meters; spudded, 9-27-83; temperature logged, 11-28-83 (3:00 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 54.3°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 686°C/km; best estimate heat flow value, 1206 mW/m² (28.8 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	22.70		Fine sand; some gravel, silt, and clay; minor caliche				(1) A thin bed of pale green and dusky green clayey sand occurs at approxi- mately 115 feet (35m)
2	24.00						
3	25.30						
4	26.45						
5	27.15						
6	27.70		Carbonate-cemented sand- stone; hard				(2) Slightly conglo- meratic beds of carbonate-cemented siltstone, sandstone, and gypsum; hard
7	28.25						
8	28.80						
9	29.35						
10	30.00						
15	33.55						
20	36.80						
25	39.70						
30	42.80	612.9 ± 3.5	(1)	2.1	1287	30.79	
35	45.85						
40	48.95						
45	51.55						
50	54.30	535.0 ± 8.7	(2)	2.1	1124	26.88	

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-100

Location: latitude, 32° 41.29', longitude, 107° 02.77', township & range, T19S.R2W.4.241; elevation, 1,280 meters; spudded, 9-28-83; temperature logged, 12-14-83 (2:50 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 25.2°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 104°C/km; best estimate heat flow value, 189 mW/m² (4.5 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	16.50		Gravel; some sand and silt				
2	18.85						
3	20.30						
4	21.20						
5	21.55						
6	21.70						
7	21.50						
8	21.35						
9	21.40						
10	21.50						
15	22.05	90.2 ± 1.3	Carbonate-cemented sand- stone; hard	2.1	189	4.53	
20	22.45						
25	22.95						
30	23.40						
35	23.90						
40	24.35						
45	24.75						
50	25.15						

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-101

Location: latitude, 32° 41.07', longitude, 107° 01.78', township & range, T19S.R2W.3.412; elevation, 1,283 meters; spudded, 9-28-83; temperature logged, 1-3-84 (12:10 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 22.7°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 54°C/km; best estimate heat flow value, 111 mW/m² (2.6 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	13.60		Gravel and fine to medium sand; some silt, clay and caliche				
2	15.30						
3	18.05						
4	19.45						
5	20.10						
6	20.25						
7	20.20						
8	20.05						
9	20.10						
10	20.15	65.0 ± 0.6	Fine to medium sand; some gravel, silt, clay and caliche	1.7	111	2.64	
15	20.45						
20	20.70						
25	21.00						
30	21.35						
35	21.65						
40	22.00						
45	22.30						
50	22.65						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-104

Location: latitude, 32° 40.42', longitude, 107° 00.77', township & range, T19S.R2W.11.232; elevation, 1,332 meters; spudded, 9-28-83; temperature logged, 1-3-84; total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 22.4°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 48°C/km; best estimate heat flow value, 102 mW/m² (2.4 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	14.90		Strongly caliche-cemented fine sand				
2	15.60						
3---	--16.75						
4	17.75		Gravel with some sand and silt grading into sand and gravel with some silt; gravel size decreases with depth; caliche layer occurs from 21 to 27m (70 to 90 feet)				
5	18.30						
6	18.60						
7	18.75						
8	19.00						
9	19.10						
10	19.25						
15	19.85						
20	20.35---	67.9 ± 1.6					
25	20.70						
30	20.95						
35	21.30						
40	21.70						
45	22.00						
50	22.40						

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-105

Location: latitude, 32° 39.63', longitude, 106° 59.74', township & range, T19S.R2W.13.214; elevation, 1,335 meters; spudded, 9-29-83; temperature logged, 1-3-84 (2:25 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 22.6°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 52°C/km; best estimate heat flow value, 103 mW/m² (2.5 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	14.00		Strongly caliche-cemented fine sand				
2	15.85						
3	17.65						
4	18.85						
5	19.45						
6	19.60		Gravel with some sand and silt grading into sand and gravel with some silt; gravel size decreases with depth; caliche layer occurs from 43 to 46m (140 to 150 feet)				
7	19.55						
8	19.55						
9	19.60						
10	19.65						
15	20.15	68.6 ± 0.7		1.5	103	2.46	
20	20.55						
25	20.85						
30	21.20						
35	21.55						
40	21.90						
45	22.25						
50	22.55						

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-106

Location: latitude, 32° 38.76', longitude, 106° 59.01', township & range, T19S.R1W.19.124; elevation, 1,330 meters; spudded, 9-29-83; temperature logged, 1-4-84 (1:10 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 22.0°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 40°C/km; best estimate heat flow value, 100 mW/m² (2.4 HFU).

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Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	14.70		Strongly caliche-cemented fine sand	1.5			
2	16.30						
3	17.65		Gravel with some pearly sorted sand and silt grading into fine to coarse sand below 34m (110 feet)				
4	18.70						
5	19.20						
6	19.25						
7	19.10						
8	19.10						
9	19.20						
10	19.25						
15	19.70	66.5 ± 0.6					
20	20.00						
25	20.35						
30	20.70						
35	21.05						
40	21.35						
45	21.70						
50	22.00						

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-107

Location: latitude, 32° 37.62', longitude, 106° 58.46', township & range, T19S.R1W.30.244; elevation, 1,318 meters; spudded, 9-30-83; temperature logged, 1-4-84 (2:25 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 27.3°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 146°C/km; best estimate heat flow value, 197 mW/m² (4.7 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks	
					(mW/m ²)	(HFU)		
1	17.20		Gravel with some fine to medium sand and silt and minor clay grading into fine to medium sand below 24m (80 feet)					
2	18.05							
3	19.30							
4	20.55							
5	21.30							
6	21.70							
7	21.90							
8	22.00							
9	22.10							
10	22.25							
15	23.10	116.1 ± 0.9			1.7	197		4.72
20	23.85---							
25	24.40							
30	24.95							
35	25.55							
40	26.15							
45	26.75							
50	27.30							

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-108.

Location: latitude, 32° 37.34', longitude, 106° 57.39', township & range, T19S.R1W.29.424; elevation, 1,323 meters; spudded, 9-30-84 ; temperature logged, 1-4-84 (3:30 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 23.2; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 64°C/km; best estimate heat flow value, 111 mW/m² (2.7 HFU).

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Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	13.65		Strongly caliche-cemented very fine sand	1.5			
2	15.15						
3	17.45						
4	18.90		Gravel with some sand and silt grading into sand and gravel and and silt				
5	19.55						
6	19.75						
7	19.80						
8	19.80						
9	19.85						
10	19.95						
15	20.45	73.9 ± 0.9					
20	20.90						
25	21.30						
30	21.70						
35	22.05						
40	22.40						
45	22.75						
50	23.15						

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-109

Location: latitude, 32° 36.32', longitude, 106° 56.82', township & range, T19S.R1W.33.433; elevation, 1,317 meters; spudded, 9-30-83; temperature logged, 1-5-84 (12:45 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 21.8°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 36°C/km; best estimate heat flow value, 87 mW/m² (2.1 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	14.75		Caliche-cemented very fine sand and silt; caliche-cement is minor below 9m (30 feet)				
2	16.25						
3	17.95						
4	19.00						
5	19.70						
6	19.85						
7	19.85						
8	19.60						
9	19.50						
10	19.45						
15	19.75						
20	20.20						
25	20.50	65.0 ± 2.9	Gravel and sand	1.5	98	2.33	
30	20.85						
35	21.10						
40	21.25	44.0 ± 2.0	Medium to fine sand	1.7	75	1.79	
45	21.50						
50	21.75						

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-110

Location: latitude, 32° 35.57', longitude, 106° 56.29', township & range, T20S.R1W.3.331; elevation, 1,314 meters; spudded, 10-4-83; temperature logged, 1-5-84 (2:00 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 21.8°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 36°C/km; best estimate heat flow value, 94 mW/m² (2.2 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	15.00		Caliche-cemented fine sand and silt; caliche-cement is minor below 3m (10 feet)				
2	16.60						
3	17.85						
4	18.55						
5	19.00						
6	19.25						
7	19.35						
8	19.25						
9--	-- 19.20		Gravel with some fine to medium sand and silt				
10	19.20						
15	19.60						
20	20.05--						
25	20.35	65.0 ± 2.9		1.5	98	2.33	
30--	-- 20.70--		Medium to fine sand and silt				
35	20.95						
40	21.20						
45	21.50	53.0 ± 1.0		1.7	90	2.16	
50	21.75						

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-115

Location: latitude, 32° 33.74', longitude, 106° 56.20', township & range, T20S.R1W.15.333; elevation, 1,338 meters; spudded, 10-5-83; temperature logged, 1-9-84 (12:15 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 25.4°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 108°C/km; best estimate heat flow value, 213 mW/m² (5.1 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	15.05		Caliche-cemented fine sand and silt with some gravel and clay				
2	16.60						
3	17.90						
4	18.95						
5	19.60						
6	20.10		Sand and gravel with some silt and clay				
7	20.30						
8	20.35						
9	20.40						
10	20.45						
15	21.15						
20	21.90	150.0 ± 0.0		1.5	225	5.38	
25	22.45		Medium to fine sand				
30	23.05						
35	23.70	117.5 ± 1.5		1.7	200	4.78	
40	24.30						
45	24.80						
50	25.40						

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-116

Location: latitude, 32° 33.78', longitude, 106° 57.09', township & range, T20S.R1W.16.334; elevation, 1,372 meters; spudded, 10-4-83; temperature logged, 1-9-84 (1:30 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 30.2°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 204°C/km; best estimate heat flow value, 386 mW/m² (9.2 HFU).

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Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	11.40		Fine sand; some gravel silt; clay, and caliche	1.7	410	9.80	
2	15.55						
3	17.45						
4	19.25		Fine sand with some gravel and silt and minor clay				
5	20.30						
6	20.70						
7	20.95						
8	21.05						
9	21.30						
10	21.55						
15	23.10	241.0 ± 5.2					
20	24.35						
25	25.60						
30	26.70						
35	27.55	170.0 ± 1.2	Slightly conglomeratic, carbonate-cemented sandstone; hard	2.1	361	8.64	
40	28.40						
45	29.25						
50	30.15						

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-117

Location: latitude, 32° 31.92', longitude, 106° 53.48', township & range, T20S.R1W.36.221; elevation, 1,338 meters; spudded, 10-5-83; temperature logged, 1-10-84 (11:45 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 21.4°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 28°C/km; best estimate heat flow value, 98 mW/m² (2.3 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	13.10		Caliche-cemented fine to medium sand with some silt and gravel; caliche cement is minor below 3m (10 feet)				
2	16.10						
3	17.15						
4	18.45						
5	19.20						
6	19.45						
7	19.50						
8	19.55						
9	19.40						
10	19.35						
15	19.65	30.0 ± 0.0	Carbonate-cemented conglomeratic sandstone	2.3	69	1.65	
20	19.80						
25	19.95						
30	20.25	57.7 ± 0.8	Fine to medium sand and silt	1.7	98	2.35	
35	20.55						
40	20.85						
45	21.10						
50	21.40						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-118

Location: latitude, 32° 29.36', longitude, 106° 51.68', township & range, T21S.R1E.8.433; elevation, 1,329 meters; spudded, 10-17-83; temperature logged, 1-16-84 (2:45 p.m.); total depth, 34 meters; depth of 1½ inch PVC casing, 33 meters; bottom-hole temperature, 25.1°C; bottom-hole depth, 33 meters; bottom-hole temperature gradient, 155°C/km; best estimate heat flow value, 408 mW/m² (9.8 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	14.80		Alternating light-colored, thin to medium beds of very hard limestone and hard shaly limestone				
2	16.15						
3	18.15						
4	19.75						
5	20.55						
6	21.15						
7	21.50						
8	21.65						
9	21.75						
10	21.85						
15	22.25---						
20	23.00---	150.0 ± 0.0		2.8	420	10.05	
25	23.95---	190.0 ± 0.0		2.2	418	10.00	
30	24.65						
33	25.05	137.8 ± 1.8		2.8	386	9.23	

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-119

Location: latitude, 32° 29.41', longitude, 106° 49.45', township & range, T21S.R1E.10.434; elevation, 1,414 meters; spudded, 10-6-83; temperature logged, 1-10-84 (1:45 p.m.); total depth, 18 meters; depth of 1½ inch PVC casing, 18 meters; bottom-hole temperature, 19.1°C; bottom-hole depth, 18 meters; bottom-hole temperature gradient, -50°C/km; best estimate heat flow value, 140 mW/m² (3.3 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	13.30		Marbleized and recrystal- lized very hard, fine- grained limestone	2.8			
2	13.60						
3	17.20						
4	17.75						
5	18.20						
6	18.60						
7	18.75						
8	18.90						
9	18.95						
10	18.95						
11	18.95						
12	18.95						
13	18.95						
14	18.90						
15	18.90 ---						
16	18.95	50.0 ± 0.0					
17	19.00						
18	19.05						

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-120

Location: latitude, 32° 28.29', longitude, 106° 50.39', township & range, T21S.R1E.21.223; elevation, 1,326 meters; spudded, 10-24-83; temperature logged, 1-23-84 (2:05 p.m.); total depth, 43 meters; depth of 1½ inch PVC casing, 42 meters; bottom-hole temperature, 20.4°C; bottom-hole depth, 42 meters; bottom-hole temperature gradient, 10°C/km; best estimate heat flow value, 97 mW/m² (2.3 HFU).

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Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	14.25		Gravel; some sand and silt				
2	15.60						
3	17.30		Andesitic lava flow; hard				
4	18.30						
5	19.00						
6	19.30						
7	19.55						
8	19.65						
9	19.70						
10	19.60						
15	19.55	30.2 ± 0.8					
20	19.70						
25	19.80						
30	20.00						
35	20.15						
40	20.30						
42	20.35						

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-121

Location: latitude, 32° 27.27', longitude, 106° 50.51', township & range, T21S.R1E.28.234; elevation, 1,308 meters; spudded, 10-13-83; temperature logged, 1-12-84 (3:50 p.m.); total depth, 27 meters; depth of 1½ inch PVC casing, 27 meters; bottom-hole temperature, 21.0°C; bottom-hole depth, 27 meters; bottom-hole temperature gradient, 37°C/km; best estimate heat flow value, 64 mW/m² (1.5 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	13.10		Gravel and sand				
2	15.40						
3	17.70						
4	19.40						
5	20.40						
6	20.75						
7	20.90						
8	20.75						
9	20.65		Conglomeratic sandstone; hard				
10	20.60						
15	20.65						
20	20.80	30.0 ± 0.0		2.1	63	1.51	
25	20.90		Flow-banded rhyolite; hard				
27	20.95	21.2 ± 1.1		3.0	64	1.52	

*Detailed lithology is given in Appendix B.

† Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-122

Location: latitude, 32° 27.56', longitude, 106° 49.25', township & range, T21S.R1E.27.222; elevation, 1,381 meters; spudded, 10-10-83; temperature logged, 1-12-84 (2:40 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 20.8°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 16°C/km; best estimate heat flow value, 105 mW/m² (2.5 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	15.55		Gravel with some sand				Ground water recharge was encountered in fractures at approximately 130 feet (40m); a volume of several gpm was estimated
2	16.60						
3	17.70						
4	18.85						
5	19.45						
6	19.75		Thick, massive horn- blende andesite porphyry; very hard	3.5			
7	19.90						
8	19.95						
9	19.95						
10	19.85						
15	19.95						
20	20.10	30.0 ± 0.0					
25	20.25						
30	20.40						
35	20.45						
40	20.50						
45	20.60						
50	20.75	30.0 ± 0.0			105	2.51	

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-123

Location: latitude, 32° 25.30', longitude, 106° 47.43', township & range, T22S.R1E.1.414; elevation, 1,320 meters; spudded, 11-2-83; temperature logged, 1-25-84 (2:35 p.m.); total depth, 31 meters; depth of 1½ inch PVC casing, 30 meters; bottom-hole temperature, 21.4°C; bottom-hole depth, 30 meters; bottom-hole temperature gradient, 47°C/km; best estimate heat flow value, 98 mW/m² (2.3 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	15.40		Gravel, sand, and silt; minor caliche				(1) Densely welded, rhyolitic ash-flow tuff; weathered and very hard
2	15.70						
3	19.50						
4	20.30		Gravel; minor sand and silt				
5	20.70						
6	20.90						
7	21.00						
8	20.95						
9	20.90						
10	20.90	Carbonate-cemented, volcanic fanglomerate; hard	2.5				
15	20.85						
20	21.05						
25	21.25	40.0 ± 0.0		100	2.39		
30	21.40	30.0 ± 0.0	(1)	3.2	96	2.30	

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-124

Location: latitude, 32° 26.09', longitude, 106° 46.80', township & range, T21S.R2E.31.341; elevation, 1,384 meters; spudded, 11-1-83; temperature logged, 1-26-84 (2:00 p.m.); total depth, 32 meters; depth of 1½ inch PVC casing, 32 meters; bottom-hole temperature, 22.5°C; bottom-hole depth, 32 meters; bottom-hole temperature gradient, 78°C/km; best estimate heat flow value, 178 mW/m² (4.3 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	15.20						
2	16.25						
3	17.85						
4	19.05						
5	20.00						
6	20.55						
7	20.80		Gravel with some sand, silt, and clay				
8	20.90						
9	20.90						
10	20.95						
15--	-- 21.20 --						
20	21.60						
25	21.95	71.3 ± 2.3	Carbonate-cemented volcanic fanglomerate; hard	2.5	178	4.26	
30	22.25						
32	22.45						

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-125

Location: latitude, 32° 24.73', longitude, 106° 46.33', township & range, T22S.R2E.7.241; elevation, 1,298 meters; spudded, 10-31-83; temperature logged, 1-25-84 (3:50 p.m.); total depth, 46 meters; depth of 1½ inch PVC casing, 46 meters; bottom-hole temperature, 25.5°C; bottom-hole depth, 46 meters; bottom-hole temperature gradient, 120°C/km; best estimate heat flow value, 243 mW/m² (5.8 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	13.50		Gravel; some sand; minor caliche cement	2.1	242	5.78	
2	15.40		Carbonate-cemented conglomeratic sandstone; hard				
3---	17.55						
4	19.55						
5	20.55						
6	21.15						
7	21.30						
8	21.40						
9	21.45						
10	21.60						
15	22.30---						
20	22.85	115.0 ± 2.9					
25---	23.45---	97.3 ± 0.8	Carbonate-cemented volcanic fanglomerate; hard	2.5	243	5.80	
30	23.95						
35	24.40						
40	24.90						
45	25.40						
46	25.50						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-126

Location: latitude, 32° 25.04', longitude, 106° 45.15', township & range, T22S.R2E.5.444; elevation, 1,323 meters; spudded, 10-26-83; temperature logged, 1-26-84 (3:15 p.m.); total depth, 30 meters; depth of 1½ inch PVC casing, 29 meters; bottom-hole temperature, 20.5°C; bottom-hole depth, 29 meters; bottom-hole temperature gradient, 17°C/km; best estimate heat flow value, 243 mW/m² (5.8 HFU).

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Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	12.30	120.0 ± 0.0	Fine sand, silt, and caliche	2.1	252	6.03	
2	14.45		Carbonate-cemented sand- stone; hard				
3	16.25						
4	17.35						
5	18.15						
6	18.40						
7	18.55						
8	18.65						
9	18.65						
10	18.70						
15	19.30						
20	19.90	120.0 ± 0.0					
25	20.25	66.8 ± 2.1	Thick, massive, monzonite porphyry; very hard	3.5	234	5.59	
29	20.50						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-127

Location: latitude, 32° 23.58', longitude, 106° 45.15', township & range, T22S.R2E.17.424; elevation, 1,324 meters; spudded, 10-26-83; temperature logged, 1-26-84 (4:20 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 25.0°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 100°C/km; best estimate heat flow value, 249 mW/m² (6.0 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks							
					(mW/m ²)	(HFU)								
1	14.10		Caliche-cemented fine sand, silt, and clay											
2	15.65													
3	17.10													
4	18.45													
5	19.10													
6	19.45													
7	19.70													
8	19.80													
9	19.90													
10	20.00													
15	20.65													
20	21.45		155.0 ± 2.9	1.7	264	6.30								
25	22.20		111.4 ± 1.3	Carbonate-cemented sandstone; hard	2.1	234	5.60							
30	22.80													
35	23.30													
40	23.85													
45	24.45													
50	25.00													

*Detailed lithology is given in Appendix B.

† Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-128

Location: latitude, 32° 27.64', longitude, 106° 51.74', township & range, T21S.R1E.20.433; elevation, 1,268 meters; spudded, 10-20-83; temperature logged, 1-23-84 (3:15 p.m.); total depth, 35 meters; depth of 1½ inch PVC casing, 35 meters; bottom-hole temperature, 23.2°C; bottom-hole depth, 35 meters; bottom-hole temperature gradient, 91°C/km; best estimate heat flow value, 266 mW/m² (6.4 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	13.75						
2	16.40						
3	17.95						
4	19.55						
5	20.35		Gravel with some sand and silt				
6	20.85						
7	21.00						
8	21.10						
9	21.10						
10	21.15		Carbonate-cemented, andesitic fanglomerate;				
15	21.45		hard				
20	22.00	110.0 ± 0.0		2.5	275	6.58	
25	22.40						
30	22.80	80.0 ± 0.0	Andesitic lava flow; hard	3.2	256	6.12	
35	23.20						

*Detailed lithology is given in Appendix B.

† Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-129

Location: latitude, 32° 28.64', longitude, 106° 51.98', township & range, T21S.R1E.17.341; elevation, 1,268 meters; spudded, 10-18-83; temperature logged, 1-16-84 (3:40 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 25.5°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 110°C/km; best estimate heat flow value, 417 mW/m² (10.0 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	15.95		Carbonate-cemented andesitic fanglomerate; hard				
2	17.15						
3	18.45						
4	19.45		Hard andesitic lava flows grading into very hard and massive andesitic lava flow				
5	20.10						
6	20.50						
7	20.60						
8	20.65						
9	20.70						
10	20.75						
15	21.25						
20	21.90	130.0 ± 0.0		3.2	416	9.95	
25	22.55						
30	23.10						
35	23.75						
40	24.35	119.4 ± 1.4		3.5	418	10.00	
45	24.95						
50	25.50						

*Detailed lithology is given in Appendix B.

† Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-130

Location: latitude, 32° 26.16', longitude, 106° 49.55', township & range, T21S.R1E.34.413; elevation, 1,292 meters; spudded, 10-25-83; temperature logged, 1-24-84 (2:40 p.m.); total depth, 38 meters; depth of 1½ inch PVC casing, 38 meters; bottom-hole temperature, 21.1°C; bottom-hole depth, 38 meters; bottom-hole temperature gradient, 29°C/km; best estimate heat flow value, 67 mW/m² (1.6 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	12.80		Gravel with minor sand, silt and caliche				
2	13.40						
3	15.75						
4	19.85						
5	20.35						
6	20.50						
7	20.60						
8	20.65						
9	20.65						
10	20.55						
15	20.50	24.0 ± 1.4	Carbonate-cemented, volcanic, fanglomerate; hard	2.5	60	1.44	
20	20.60						
25	20.75						
30	20.85						
35	20.95	24.5 ± 3.5	Flow-banded rhyolite; hard	3.0	74	1.76	
38	21.05						

*Detailed lithology is given in Appendix B.

[†]Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-131

Location: latitude, 32° 28.34', longitude, 106° 47.65', township & range, T21S.R1E.24.124; elevation, 1,433 meters; spudded, 10-10-83; temperature logged, 1-12-84 (1:15 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 21.0°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 20°C/km; best estimate heat flow value, 60 mW/m² (1.4 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	14.40		Gravel and sand	2.1	69	1.66	
2	15.95		Carbonate-cemented conglomeratic sandstone; hard				
3	17.85						
4	19.10						
5	19.90						
6	20.20						
7	20.25						
8	20.25						
9	20.15						
10	20.05						
15	20.10	33.0 ± 1.7					
20	20.30						
25	20.45						
30	20.60	20.0 ± 0.0	Carbonate-cemented, volcanic fanglomerate; hard	2.5	50	1.20	
35	20.70						
40	20.80						
45	20.90						
50	21.00						

*Detailed lithology is given in Appendix B.

† Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-132

Location: latitude, 32° 40.05', longitude, 107° 03.44', township & range, T19S.R2W.9.314; elevation, 1,268 meters; spudded, 6-11-84; temperature logged, 8-19-84 (12:05 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 25.30°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 106°C/km; best estimate heat flow value, 233 mW/m² (5.6 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.35		Fine sand with some gravel				
2	24.80						
3	22.50						
4	20.60						
5	19.65						
6	19.70						
7	19.85						
8	20.00						
9	20.20						
10	20.40						
15	21.55 ---						
20	22.40	165.0 ± 2.9		1.7	281	6.71	
25 ---	--- 23.20 ---						
30	23.85	115.0 ± 8.7	Weakly carbonate- cemented conglomeratic sandstone; saturated below 35m	1.9	219	5.23	
35	24.35 ---						
40	24.70						
45	25.05	64.0 ± 3.5		3.1	198	4.67	
50	25.30						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-133

Location: latitude, 32° 40.13', longitude, 107° 02.01', township & range, T19S.R2W.10.411; elevation, 1,283 meters; spudded, 6-11-84; temperature logged, 8-19-84 (10:25 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 24.25°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 85°C/km; best estimate heat flow value, 136 mW/m² (3.3 HFU).

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Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.70		Gravel with some sand				
2	25.25						
3-- --	23.60						
4	21.95						
5	20.75						
6	20.30						
7	20.35						
8	20.45						
9	20.65						
10	20.80						
15	21.45-- --	80.0 ± 0.0	Gravel and sand grading into medium to fine sand; grain size decreases with depth; lower portion is well-sorted				
20	21.85						
25	22.25						
30	22.65						
35	23.05						
40	23.45						
45	23.85						
50	24.25						

*Detailed Lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-134

Location: latitude, 32° 39.42', longitude, 107° 02.41', township & range, T19S.R2W.15.133; elevation, 1,253 meters; spudded, 6-8-84; temperature logged, 8-19-84 (9:15 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 26.30°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 126°C/km; best estimate heat flow value, 256 mW/m² (6.1 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.70		Gravel and sand				
2	25.55						
3	23.80						
4	22.30						
5	21.40						
6	21.30						
7	21.40						
8	21.60						
9	21.80						
10	21.90	155.0 ± 8.7	Medium to fine sand, well-sorted	1.7	264	6.30	
15	22.75						
20	23.60						
25	24.30	80.0 ± 0.0	Weakly carbonate-cemented sandstone; saturated below 25m	3.1	248	5.93	
30	24.70						
35	25.10						
40	25.50						
45	25.90						
50	26.30						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-135

Location: latitude, 32° 38.90', longitude, 107° 01.44', township & range, T19S.R2W.23.111; elevation, 1,245 meters; spudded, 6-7-84; temperature logged, 8-17-84 (11:45 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 24.40°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 88°C/km; best estimate heat flow value, 219 mW/m² (5.2 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks		
					(mW/m ²)	(HFU)			
1	27.40		Gravel and sand						
2	25.90								
3--	-- 23.45								
4	21.80								
5	20.85								
6	20.45								
7	20.50								
8	20.60								
9	20.70								
10	20.85								
15--	-- 21.75	70.7 ± 0.7	Medium to fine sand with some gravel		219	5.24			
20	22.30---								
25	22.65								
30	23.00								
35	23.35								
40	23.70								
45	24.10								
50	24.40								
				Weakly carbonate-cemented sandstone; saturated below 20m			3.1		

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-136

Location: latitude, 32° 39.12', longitude, 107° 00.41', township & range, T19S.R2W.13.331; elevation, 1,317 meters; spudded, 6-7-84; temperature logged, 8-17-84 (10:40 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 23.20°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 64°C/km; best estimate heat flow value, 105 mW/m² (2.5 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m²)	(HFU)	
1	26.25		Gravel grading into sand and gravel				
2	24.60						
3	22.40						
4	20.85						
5	20.20						
6	20.20						
7	20.25						
8	20.35						
9	20.50						
10	20.65						
15 --	-- 21.05 --	61.6 ± 1.1	Medium sand, well-sorted	1.7	105	2.51	
20	21.40						
25	21.75						
30	22.00						
35	22.35						
40	22.65						
45	22.95						
50	23.20						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-137

Location: latitude, 32° 38.18', longitude, 107° 00.71', township & range, T19S.R2W.23.432; elevation, 1,242 meters; spudded, 6-5-84; temperature logged, 8-16-84 (10:45 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 26.30°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 126°C/km; best estimate heat flow value, 331 mW/m² (7.9 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks	
					(mW/m ²)	(HFU)		
1	26.45		Gravel with some sand					
2	24.55							
3--	-- 22.65		Gravel and sand grading into medium to fine sand					
4	21.35							
5	20.90							
6	20.95							
7	21.10							
8	21.25							
9	21.45							
10	21.70							
15--	-- 22.60--	117.0 ± 1.7	Moderately cemented sand- stone, hard; saturated	2.9	339	8.12		
20	23.15							
25	23.75							
30--	-- 24.35--	98.0 ± 1.2	Strongly cemented sand- stone, hard; saturated below 15m	3.3	323	7.74		
35	24.85							
40	25.35							
45	25.85							
50	26.30							

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-138

Location: latitude, 32° 38.66', longitude, 106° 59.82', township & range, T19S.R2W.24.231; elevation, 1,294 meters; spudded, 6-6-84; temperature logged, 8-16-84 (11:55 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 23.90°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 78°C/km; best estimate heat flow value, 144 mW/m² (3.4 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.65		Gravel with some sand				
2	24.50						
3 --	-- 22.55		Gravel and sand grading into medium sand				
4	20.95						
5	20.10						
6	19.75						
7	19.75						
8	19.90						
9	20.05						
10 --	-- 20.25						
15	20.95 ---	84.5 ± 1.1	Medium sand, well-sorted	1.7	144	3.44	
20	21.40						
25	21.75						
30	22.15						
35	22.60						
40	23.05						
45	23.50						
50	23.90						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-139

Location: latitude, 32° 37.38', longitude, 106° 59.77', township & range, T19S.R2W.25.432; elevation, 1,247 meters; spudded, 6-4-84; temperature logged, 8-15-84 (10:30 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 26.50°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 130°C/km; best estimate heat flow value, 349 mW/m² (8.3 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.70		Gravel with some sand				
2	25.00						
3--	-- 22.60						
4	21.05						
5	20.65						
6	20.70						
7	20.85						
8	21.00						
9	21.20						
10	21.50						
15--	-- 22.75--						
20	23.40	130.0 ± 0.0	Moderately cemented sand- stone, hard; saturated	2.9	377	9.02	
25--	-- 24.05--						
30	24.60						
35	25.10						
40	25.55						
45	26.05	97.4 ± 1.6	Strongly cemented sand- stone, hard; saturated below 15m	3.3	321	7.69	
50	26.50						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-140

Location: latitude, 32° 37.45', longitude, 106° 59.11', township & range, T19S.R1W.30.323; elevation, 1,280 meters; spudded, 6-4-84; temperature logged, 8-13-84 (11:10 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 45 meters; bottom-hole temperature, 28.70°C; bottom-hole depth, 45 meters; bottom-hole temperature gradient, 193°C/km; best estimate heat flow value, 295 mW/m² (7.1 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.80						1½-inch PVC casing could be set to only 45 meters due to cave- in of bottom 5 meters of hole
2	25.50						
3	23.00						
4	21.45						
5	20.85						
6	20.95						
7	21.15						
8	21.50						
9	21.85						
10	22.15						
15	23.50---		Medium to fine sand; well-sorted in lower half of hole	1.7			
20	24.65	225.0 ± 2.9			383	9.15	
25	25.75---						
30	26.60	165.0 ± 2.9			281	6.71	
35	27.40---						
40	28.10						
45	28.70	130.0 ± 5.8			221	5.29	
50							

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-141

Location: latitude, 32° 34.42', longitude, 106° 57.12', township & range, T20S.R1W.16.114; elevation, 1,353 meters; spudded, 5-30-84; temperature logged, 8-12-84 (11:05 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 25.60°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 112°C/km; best estimate heat flow value, 221 mW/m² (5.3 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks				
					(mW/m ²)	(HFU)					
1	26.05		Fine to very fine sand								
2	24.45										
3--	-- 22.60		Medium to fine sand, silt and some clay								
4	20.95										
5	20.05										
6	19.70										
7	19.75										
8	19.85										
9	20.05										
10	20.25										
15--	-- 21.35--										
20	22.05	144.0 <u>±</u> 2.3	Medium to fine sand, some silt and caliche	1.7	245	5.86					
25	22.75										
30	23.55										
35--	-- 24.20--										
40	24.65	940.0 <u>±</u> 1.4	Moderately cemented sandstone, hard	2.1	197	4.72					
45	25.15										
50	25.60										

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-142

Location: latitude, 32° 34.35', longitude, 106° 56.47', township & range, T20S.R1W.16.223; elevation, 1,337 meters; spudded, 5-30-84; temperature logged, 8-10-84 (11:05 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 23.50°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 70°C/km; best estimate heat flow value, 162 mW/m² (3.9 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.50		Fine to very fine sand				
2	24.05						
3	21.65						
4	20.00						
5	19.05						
6--	-- 18.90		Medium to fine sand with some gravel, clay, and caliche				
7	18.95						
8	19.05						
9	19.20						
10	19.30						
15--	-- 20.10--		Medium to fine sand and gravel				
20	20.70						
25	21.25	113.0 ± 1.7		1.5	170	4.06	
30--	-- 21.80--		Moderately cemented sand- stone, hard				
35	22.15	70.0 ± 0.0		2.1	147	4.52	
40--	-- 22.50--		Medium to fine sand, well- sorted				
45	23.00						
50	23.50	100.0 ± 0.0		1.7	170	4.07	

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-143

Location: latitude, 32° 30.11', longitude, 106° 53.19', township & range, T21S.R1E.7.111; elevation, 1,288 meters; spudded, 5-15-84; temperature logged, 8-8-84 (9:40 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 26.10°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 122°C/km; best estimate heat flow value, 194 mW/m² (4.6 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	27.50						
2	24.65						
3	22.40						
4	21.10						
5	20.75						
6	20.75						
7	20.90						
8	21.00						
9	21.20						
10	21.40						
15	22.25---						
20---	22.75---	100.0 ± 0.0	Limestone, soft	2.0	200	4.78	
25	23.40						
30	24.05	130.0 ± 0.0	Shale, soft	1.5	195	4.67	
35---	24.70---						
40	25.25---						
45	25.70						
50	26.10	85.0 ± 2.9	Silty, shaly limestone	2.2	187	4.47	

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-144

Location: latitude, 32° 30.10', longitude, 106° 52.30', township & range, T21S.R1E.7.222; elevation, 1,327 meters; spudded, 5-9-84; temperature logged, 7-31-84 (9:45 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 24.15°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 83°C/km; best estimate heat flow value, 184 mW/m² (4.4 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.95		Carbonate-cemented lime- stone fanglomerate, hard				
2	24.00						
3	22.15						
4	21.05						
5	20.50						
6--	-- 20.40		Sandstone to siltstone, hard				
7	20.40						
8	20.45						
9	20.55						
10	20.60						
15--	-- 21.40--		Alternating layers of hard shaly limestone (2.2) and very hard limestone (2.8)				
20	21.80	84.0 ± 1.4		2.2	185	4.42	
25	22.25						
30	22.65--						
35	22.95--	60.0 ± 0.0		2.8	168	4.02	
40	23.40	85.0 ± 2.9		2.2	187	4.47	
45	23.80--						
50	24.15	70.0 ± 0.0		2.8	196	4.69	

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-145

Location: latitude, 32° 29.56', longitude, 106° 52.32', township & range, T21S.R1E.7.423; elevation, 1,280 meters; spudded, 5-10-84; temperature logged, 7-31-84 (11:55 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 21.95°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 39°C/km; best estimate heat flow value, 149 mW/m² (3.6 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	27.00		Fractured and crushed dolomite, some siltstone, saturated	3.5			Fault zone with ground- water in fractures between 35 and 40 meters disturbing the temperatures above. Temperatures recovering in bottom of hole.
2	24.10						
3	22.25						
4	20.85						
5	20.30						
6	20.10						
7	19.95						
8	20.00						
9	20.25						
10	20.35						
15	20.65----						
20	20.85						
25	21.00						
30	21.20	35.0 ± 0.6			123	2.93	
35	21.35						
40	21.55						
45	21.70----						
50	21.95	50.0 ± 0.0			175	4.19	

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-146

Location: latitude, 32° 29.10', longitude, 106° 53.07', township & range, T21S.R1E.18.132; elevation, 1,257 meters; spudded, 5-14-84; temperature logged, 8-1-84 (8:50 a.m.); total depth, 45 meters; depth of 1½ inch PVC casing, 45 meters; bottom-hole temperature, 24.25°C; bottom-hole depth, 45 meters; bottom-hole temperature gradient, 94°C/km; best estimate heat flow value, 222 mW/m² (5.3 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	28.00		Silt, sand, and gravel				
2	24.95						
3	22.15						
4	20.75						
5	20.25						
6	20.20						
7	20.30		Carbonate-cemented limestone fanglomerate, hard				
8	20.40						
9	20.55						
10	20.70						
15	21.45	100.0 ± 1.6	Thin, weathered, hard micrite (limestone) beds	2.2	220	5.26	
20	21.95						
25	22.40						
30	22.95						
35	23.45						
40	23.85	80.0 ± 0.0	Fine-grained dolomite, very hard	2.8	224	5.36	
45	24.25						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-147

Location: latitude, 32° 28.74', longitude, 106° 52.58', township & range, T21S.R1E.18.414; elevation, 1,259 meters; spudded, 5-22-84; temperature logged, 8-1-84 (8:50 a.m.); total depth, 30 meters; depth of 1½ inch PVC casing, 30 meters; bottom-hole temperature, 22.30°C; bottom-hole depth, 30 meters; bottom-hole temperature gradient, 77°C/km; best estimate heat flow value, 280 mW/m² (6.7 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.05		Carbonate-cemented, limestone fanglomerate; hard				
2	23.35						
3	21.50						
4	20.45						
5	19.90						
6	19.95						
7	20.05						
8	20.20						
9	20.40						
10	20.55						
15	21.40						
20	21.50	80.0 ± 0.0	Thick, massive, andesitic lava flow, very hard	3.5	280	6.70	
25	21.90						
30	22.30						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-148

Location: latitude, 32° 28.08', longitude, 106° 52.49', township & range, T21S.R1E.19.234; elevation, 1,257 meters; spudded, 5-23-84; temperature logged, 8-3-84 (11:15 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 22.35°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 47°C/km; best estimate heat flow value, 107 mW/m² (2.6 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.85		Gravel and sand, some caliche				
2	23.85						
3	21.95						
4	20.85						
5	20.25						
6	20.10		Carbonate-cemented limestone fanglomerate overlying volcanic fanglomerate				
7	20.15						
8	20.25						
9	20.40						
10	20.50						
15	21.00		Alternating andesitic beds of hard laharic breccias (2.7) and very hard, massive lava flows (3.5)				
20	21.20	40.0 ± 0.0		2.7	108	2.58	
25	21.40						
30	21.60						
35	21.75	30.0 ± 0.0		3.5	105	2.51	
40	21.95						
45	22.15	40.0 ± 0.0		2.7	108	2.58	
50	22.35						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-149

Location: latitude, 32° 26.95', longitude, 106° 51.55', township & range, T21S.R1E.29.414; elevation, 1,251 meters; spudded, 5-24-84; temperature logged, 8-3-84 (1:15 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 21.65°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 33°C/km; best estimate heat flow value, 82 mW/m² (1.9 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.65		Gravel and sand				
2	24.10						
3	21.85						
4	20.55						
5	19.95						
6	19.85		Carbonate-cemented, andesitic fanglomerate; hard				
7	19.90						
8	20.00						
9	20.10						
10	20.20						
15	20.50	32.6 ± 0.5		2.5	82	1.95	
20	20.65						
25	20.80						
30	21.00						
35	21.15						
40	21.30						
45	21.45						
50	21.65						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-150

Location: latitude, 32° 31.13', longitude, 106° 54.14', township & range, T20S.R1W.36.333; elevation, 1,305 meters; spudded, 5-29-84; temperature logged, 8-8-84 (11:30 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 25.20°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 104°C/km; best estimate heat flow value, 220 mW/m² (5.3 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	27.35		Sand and gravel				
2	24.00						
3--	--21.35		Medium sand with gravel grading to medium and fine well-sorted sand				
4	19.90						
5	19.75						
6	19.80						
7	19.95						
8	20.10						
9	20.50						
10	20.60						
15	21.20---						
20	21.90						
25	22.65	136.0 ± 3.5		1.7	231	5.53	
30	23.20						
35--	--23.95---						
40	24.35	90.0 ± 5.8	Carbonate-cemented brown sandstone, hard	2.5	225	5.38	
45--	--24.85---		Red siltstone to very fine sandstone, very hard				
50	25.20	70.0 ± 0.0		2.9	203	4.86	

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-151

Location: latitude, 32° 29.68', longitude, 106° 50.81', township & range, T21S.R1E.9.322; elevation, 1,393 meters; spudded, 5-10-84; temperature logged, 8-1-84 (10:30 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 25.45°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 109°C/km; best estimate heat flow value, 332 mW/m² (7.9 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	27.35		Alternating beds of hard, carbonated, siliceous limestone (2.2) and very hard limestone (2.8), recrystallized and mineralized				
2	24.95						
3	22.80						
4	21.05						
5	20.05						
6	19.60						
7	19.45						
8	19.50						
9	19.60						
10	19.30						
15	20.85---	160.0 ± 0.0		2.2	352	8.42	
20	21.65---						
25	22.30	120.0 ± 5.8		2.8	336	8.04	
30	22.85---						
35	23.55	145.0 ± 2.9		2.2	319	7.63	
40	24.30---						
45	24.90	115.0 ± 2.9		2.8	322	7.70	
50	25.45						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-153

Location: latitude, 32° 24.63', longitude, 106° 45.88', township & range, T22S.R2E.8.134; elevation, 1,291 meters; spudded, 6-14-84; temperature logged, 8-19-84 (7:10 p.m.); total depth, 45 meters; depth of 1½ inch PVC casing, 45 meters; bottom-hole temperature, 23.45°C; bottom-hole depth, 45 meters; bottom-hole temperature gradient, 77°C/km; best estimate heat flow value, 218 mW/m² (5.2 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.35		Gravel and sand				
2	25.05						
3--	--23.45		Conglomeratic sandstone				
4	21.65						
5	20.65		Carbonate-cemented volcanic fanglomerate; hard				
6--	--20.50						
7	20.50						
8	20.60						
9	20.80						
10	21.00						
15	21.50---	90.0 ± 0.0	2.5	225	5.38		
20--	--21.95--						
25	22.25	60.0 ± 0.0	Thick, massive, mozonite porphyry grading from a hard weathered surface to a very hard unit	3.5	210	5.02	
30	22.55						
35	22.85						
40	23.15						
45	23.45						
50							

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-154

Location: latitude, 32° 24.46', longitude, 106° 45.29', township & range, T22S.R2E.8.423; elevation, 1,326 meters; spudded, 6-18-84; temperature logged, 8-18-84 (6:50 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 23.85°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 77°C/km; best estimate heat flow value, 209 mW/m² (5.0 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	24.50		Thin layers of carbonate- cemented fanglomerates, sandstone, and caliche; hard	2.5	238	5.68	
2	23.80						
3	22.05						
4	20.85						
5	20.40						
6	20.40						
7	20.55						
8	20.70						
9	20.90						
10	21.10						
15	21.70----						
20	22.20	95.0 ± 2.9					
25----	22.65----		Massive monzonite porphyry, very hard	3.5	210	5.02	
30	22.95	60.0 ± 0.0					
35----	23.25----						
40	23.45	40.0 ± 0.0	Massive monzonite porphyry, very hard, saturated, highly altered	4.5	180	4.31	
45	23.65						
50	23.85						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-155

Location: latitude, 32° 23.99', longitude, 106° 46.02', township & range, T22S.R2E.17.113; elevation, 1,301 meters; spudded, 6-13-84; temperature logged, 8-14-84 (10:30 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 28.00°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 160°C/km; best estimate heat flow value, 290 mW/m² (6.9 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.15		Medium to fine sand and some gravel; some caliche layers in upper 10 meters				
2	24.55						
3	23.05						
4	21.90						
5	21.05						
6	20.95						
7	21.05						
8	21.25						
9	21.45						
10	21.70						
15	23.10---						
20	24.25	210.0 ± 11.6		1.7	357	8.54	
25--	--25.20--						
30	25.90	135.0 ± 2.9	Carbonate-cemented sand- stone, hard	2.1	284	6.78	
35--	--26.55--						
40	27.10	105.0 ± 2.9	Carbonate-cemented vol- canic fanglomerate, hard	2.5	263	6.28	
45--	--27.60--						
50	28.00	80.0 ± 0.0	Monzonite porphyry, hard weathered surface	3.2	256	6.12	

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-156

Location: latitude, 32° 24.29', longitude, 106° 46.24', township & range, T22S.R2E.7.441; elevation, 1,283 meters; spudded, 6-13-84; temperature logged, 8-14-84 (11:30 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 28.70°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 174°C/km; best estimate heat flow value, 412 mW/m² (9.9 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.20		Carbonate-cemented sandstone, hard				
2	24.95						
3	23.20						
4	21.95						
5	21.30						
6	21.30						
7	21.40						
8	21.60						
9	21.85						
10	22.10						
15	23.35		Carbonate-cemented, volcanic fanglomerate; hard				
20	24.25	174.0 ± 2.0		2.5	435	10.41	
25	25.05						
30	25.95						
35	26.85	Monzonite porphyry; hard weathered surface grading into very hard and massive unit					
40	27.50		130.0 ± 0.0	3.2	416		9.95
45	28.15						
50	28.70		110.0 ± 0.0	3.5	385		9.21

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-157

Location: latitude, 32° 23.58', longitude, 106° 46.23', township & range, T22S.R2E.18.423; elevation, 1,301 meters; spudded, 6-13-84; temperature logged, 8-12-84 (7:05 p.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 24.40°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 88°C/km; best estimate heat flow value, 182 mW/m² (4.4 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks	
					(mW/m ²)	(HFU)		
1	26.80		Medium to fine sand and gravel					
2	24.50							
3	22.15							
4	20.85							
5	20.40							
6	20.45							
7	20.55							
8	20.70							
9	20.85							
10	21.00							
15--	-- 21.65--		Carbonate-cemented, slightly conglomeratic sandstones and mudstones, hard	2.1	182	4.35		
20	22.15							
25	22.60	86.6 ± 1.7						
30	23.00							
35	23.40							
40	23.85--							
45	24.20							
50	24.40							

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

Hole Name: TG-158

Location: latitude, 32° 39.66', longitude, 106° 01.24', township & range, T19S.R2W.14.114; elevation, 1,280 meters; spudded, 6-8-84; temperature logged, 8-19-84 (7:50 a.m.); total depth, 50 meters; depth of 1½ inch PVC casing, 50 meters; bottom-hole temperature, 24.10°C; bottom-hole depth, 50 meters; bottom-hole temperature gradient, 82°C/km; best estimate heat flow value, 135 mW/m² (3.2 HFU).

Depth (m)	Temperature (°C)	Temperature Gradient (°C/km)	Lithology*	K [†] (W/m-°K)	Estimated Heat Flow		Remarks
					(mW/m ²)	(HFU)	
1	26.95		Gravel and sand	1.7	135	3.23	
2	25.25						
3	23.45						
4	21.75		Medium to coarse sand and gravel grading into medium to fine sand, well-sorted				
5	20.65						
6	20.20						
7	20.20						
8	20.30						
9	20.40						
10	20.65						
15	21.30	79.3 ± 0.8					
20	21.75						
25	22.10						
30	22.50						
35	22.85						
40	23.30						
45	23.70						
50	24.10						

*Detailed lithology is given in Appendix B.

†Estimated thermal conductivity values; see Table 2 and Table 3.

APPENDIX B

Lithologic Data for Northern Dona Ana County, New Mexico

Note: The data are for temperature gradient holes TG-98 through TG-158 (see Figures 4 and 5 for locations). Holes TG-102, TG-103, TG-111, TG-112, TG-113, TG-114, and TG-152 were sited but not drilled.

Hole Name: TG-98

Depth (ft)	Description
0-165	Clay, silt, fine sand, and granule to small-pebble gravel of volcanic and plutonic origin. Composition is approximately 50% pale-red to pale-reddish-brown clay, 40% fine sand that is predominantly quartz, and 10% gravel. Pebbles are rounded and appear to have been transported some distance. Depositional environment may be floodplain.

Hole Name: TG-99

Depth (ft)	Description
0-20	Clay, silt, sand, and granule to medium-pebble gravel. Of sample, 80% is fine-grain quartz sand. Caliche is minor. Granules and pebbles are mostly angular to subrounded felsic volcanics and dark-reddish-brown sandstones (Abo Formation?).
20-120	Grayish-pink to pale red silt and fine-grain sand. Sand is mostly quartz with perhaps 10% feldspar and lithic content. White clay and caliche cement are minor. Very minor granule to small pebble content at 20 to 40 feet. No pebbles below 40 feet. A thin bed of pale green and dusky-green clayey sand occurs at approximately 115 feet.
120-165	Pale red to dark-reddish-brown clayey silt and sand. Some caliche cement.

Hole Name: TG-100

Depth (ft)	Description
0-20	Silt, sand, and granule to very-large-pebble gravel. Gravel is composed of volcanic fragments of felsic and silicic composition. Some laharic or breccia fragments are visible. Gravel fraction is about 75%.
20-165	Clay, silt, and sand. A few small pebbles at 55 feet. Of interval, 90% is very fine- to fine-grain quartz sand. Finest sample is at 30 to 40 feet which is mostly clayey silt.

Hole Name: TG 101

Depth (ft)	Description
0-165	Clay, silt, sand, and granule to large-pebble gravel. Volume of gravel is variable but approximately 10% overall. First 30 feet is approximately half gravel. Gravels are of various volcanic origin and mostly subangular to subrounded. Caliche and clay occur as cement and matrix for fine- to medium-grain sand. Sand is predominantly fine and medium-grain and is mostly angular. There is a significant lithic content to sand. Depositional environment is tentatively identified as piedmont-slope to basin-floor bolson deposits.

Hole Name: TG-104

Depth (ft)	Description
0-10	Clay, silt, fine-grain sand, and caliche. Most of sample is moderately to strongly caliche-cemented fine-grain quartz sand. A few very angular clasts of aphanitic and porphyritic volcanic fragments are present.
10-30	Silt, sand, and granule to large-pebble gravel. Silt and sand fraction is approximately 10% of samples. Gravel fraction is composed of medium- to large-pebble-size angular volcanic fragments and a smaller amount of predominantly granule to small-pebble-size volcanic and sedimentary rock fragments.
30-70	Silt, sand, and granule to large-pebble gravel. Samples are similar to interval above but somewhat smaller average clast size. Most pebbles are small and medium size. Nearly all of gravel is composed of volcanic fragments of varying composition, color, and texture. Somewhat more silt and sand than above interval.
70-90	Caly, silt, fine sand, and caliche. A few percent of granule-size volcanic fragments. Most of sample is caliche-cemented fine-grain quartz sand.
90-165	Silt, sand, and granule to large-pebble gravel. Sand and gravel fractions vary but remain subequal throughout the interval. Most of the gravel is granule to small-pebble-size volcanic fragments. Clasts are mostly subangular, but some well-rounded clasts are present. Depositional environment for this hole probably includes both fan and fluvial environments. Fan facies is dominant.

Hole Name: TG-105

Depth (ft)	Description
0-20	Silt, very fine- to medium-grain sand, and caliche. Of sample, 90% is strongly caliche-cemented fine-grain quartz sand.
50-165	Silt, sand, and granule to large-pebble gravel. Coarsest interval is at 20 to 40 feet. Gravel fraction is approximately 90% of samples from 20 to 90 feet. Sand fraction increases and gravel size decreases from 90 to 165 feet. Caliche occurs in 140- to 150-foot sample. Gravel clasts vary from angular to well-rounded and are mostly from diverse volcanic rock types. Sediments probably represent interfingering fan and fluvial environments.

Hole Name: TG-106

Depth (ft)	Description
0-10	Strongly caliche-cemented silt and very fine- to medium-grain sand. Most of sample is subangular to subrounded fine-grain quartz sand.
10-110	Poorly sorted silt, sand, and granule to large-pebble gravel. Significant caliche cement at 10 to 20 feet. Gravel fraction is 75 to 90% of samples and is composed of silicic to mafic volcanic fragments that are subangular to subrounded.
110-165	Moderately well sorted fine- to coarse-grain quartz sand consisting of subangular to rounded quartz sand. Five to ten percent coarse sand and granules of quartz and other siliceous fragments. Interval to 110 feet is interpreted to be fan deposits. Finer unit below 110 feet may have fluvial origin but probably represents arroyo-channel deposits, possibly inset to dissected fan deposits seen above.

Hole Name: TG-107

Depth (ft)	Description
0-165	Silt, sand, and granule to medium-pebble gravel. Sand content is mostly fine- to medium-grain quartz sand. Gravel content is mostly granule and small-pebble clasts of volcanic and plutonic origin. Gravel is subangular to well-rounded, but most clasts are rounded. Pebble content is approximately 60% of samples from 0 to 80 feet and decreases to about 10% of samples below 80 feet. Clay content is low, but is present to perhaps 5% in a few samples. Samples appear to be of fluvial origin and probably represent floodplain, channel, and overbank deposits.

Hole Name: TG-108

Depth (ft)	Description
0-10	Clay, silt, and very fine- to fine-grain sand. Sand is strongly caliche cemented.
10-40	Silt, sand, and granule to large-pebble gravel. Gravel is approximately 80% of this interval and consists of subangular to subrounded clasts of predominantly aphanitic volcanics. Sand is very angular to subrounded and has a significant lithic content although it is mostly quartz. Some clay at 30 to 40 feet.
40-50	Pale-yellowish-brown clay, silt, and very fine- to fine-grain sand.
50-165	Similar to interval at 10 to 40 feet. Approximately half gravel and half silt and sand. Minor clay content at 110 to 130 feet. Textural immaturity of these sediments suggests a depositional environment of piedmont toe-slope to alluvial flat.

Hole Name: TG-109

Depth (ft)	Description
0-60	Clay, silt, fine sand, and caliche. Caliche cement is important from 0 to 30 feet and minor from 30 to 60 feet. Most of interval is silt and very fine-grain sand.
60-165	Clay, silt, sand, and granule to large-pebble gravel. Samples are approximately 75% gravel of felsic-volcanic composition and are subrounded to subangular. Very low clay content.

Hole Name: TG-110

Depth (ft)	Description
0-10	Clay, silt, fine sand, and caliche. Sample is mostly caliche-cemented fine-grain sand.
10-30	Clay, silt, and fine-grain quartz sand.
30-110	Silt, sand, and granule to medium-pebble gravel. Sand is predominantly fine- to medium-grain quartz sand. Gravel is mostly granules and small pebbles of predominantly felsic-volcanic origin. Pebbles are subangular to well-rounded and may represent both piedmont toe-slope and fluvial facies. Gravel content at 30 to 40 feet is about 80%, and about 60% between 40 and 110 feet.
110-165	Gradationally finer unit than above. Gravel content decreases to 5% at 165 feet. Clay and silt increase in volume from 5% to approximately 30% at 165 feet. The bulk of this interval is silt to fine-grain quartz sand.

Hole Name: TG-115

Depth (ft)	Description
0-20	Clay, silt, sand, caliche, and granule to medium-pebble gravel. Gravel is composed of angular to well-rounded clasts of volcanic and plutonic rocks. Caliche is mostly as a cement for fine-grain quartz sand. Caliche-sand is about 90% of sample. Clay content is about 5%.
20-165	Clay, silt, sand, and granule to medium-pebble gravel. Caliche is a minor constituent and nearly absent from 60 to 100 feet. Clay content is minor, but increases to perhaps 20% at 90 to 110 feet. Caliche content is again significant at 130 to 150 feet. Sand content is variable but ranges from 80 to 90% of sample throughout.

Hole Name: TG-116

Depth (ft)	Description
0-10	Clay, silt, fine-grain sand, and caliche. Material is mostly arkosic and quartz sand with a small lithic content. Granules and small pebbles of volcanic and plutonic rocks comprise about 5%. Smaller pebbles are well-rounded and appear to be from a fluvial deposit. Larger clasts are more angular and probably were contributed locally.
10-165	Silt, sand, and granule to medium-pebble gravel. Of sample, 90% is fine-grain quartz sand. Gravels are mostly rounded and of diverse rock type. Probably fluvial deposits. Pebble content variable, but low throughout. Clay content of samples is less than 5%. Cementation is weak to moderate, mostly as caliche.

Hole Name: TG-117

Depth (ft)	Description
0-10	Clay, silt, fine-grain sand, and caliche. Of sample, 90% is caliche cemented fine-grain and medium-grain quartz sand. Minor pebble content.
10-40	Same clastic composition as at 0 to 10 feet, but caliche cement diminishing in volume. Minor amount of granule-size quartz and volcanic fragments.
40-70	Very strongly caliche-cemented fine-grain quartz sand. Caliche cement decreasing towards 70 feet, and pebble content increasing from traces to 10%. Pebbles are basalt and limestone.
70-90	Dusky-yellow to light-olive-brown silt and fine-grain quartz sand.
90-160	Moderate-yellowish-brown silt and fine- to medium-grain quartz sand containing minor lithic content. Ten percent pale brown silty sandy clay. Five percent very coarse sand to granule size clasts of quartz and volcanic rock fragments. Sporadic traces of caliche.
160-165	Thirty percent fine-grain and medium-grain quartz and lithic sand. Seventy percent coarse sand to small-pebble-size clasts of volcanic rock fragments and quartz. Volcanic clasts range from silicic to mafic. Depositional environment for this hole is tentatively identified as alluvial flat to playa.

Hole Name: TG-118

Depth (ft)	Description
0-110	Light-olive-gray to medium-dark-gray fine-grain limestone and dolomite. Small amounts of shaly limestone. Most of interval is medium-dark-gray limestone.

Hole Name: TG-119

Depth (ft)	Description
0-25	Dark-gray, fine-grain limestone. Some white calcite veins.
25-40	Samples are very fine- and fine-grain sand size white calcite grains. Unit may be a clastic limestone. Subordinate amounts of dark-gray fine-grain limestone as above.
40-59	Medium-gray to medium-dark-gray fine-grain limestone. Prominent disseminated very fine pyrite. Some euhedral pyrite cubes, .01 to .05 mm. Last sample is white, fine- to coarse-grain calcite, possibly recrystallized in a fault zone.

Hole Name: TG-120

Depth (ft)	Description
9-10	Silt, sand, and granule to large-pebble gravel of volcanic origin. Silt and sand is less than 10% of sample. Volcanics are of silicic to intermediate composition. Minor amounts of limestone fragments are present.
10-140	Variably altered and weathered medium-light-gray to pale-red-purple microcrystalline porphyry. Uppermost 50 feet shows propylitic or propylitic-like alteration. Modal quartz is not evident at 25x, but rock is quite felsic and may contain normative quartz. Tentatively identified as a latite or rhyolite.

Hole Name: TG-121

Depth (ft)	Description
0-10	Sandy pebble gravel. Five percent lithic sand. Ninety-five percent granule is large-pebble-size gravel of silicic volcanic composition. Volcanics are probably rhyolite and rhyodacite.
10-20	Sand and granule to medium-pebble gravel as above.
20-30	Sand and gravel as above. Ten percent silt and clay.
30-40	Fifty percent medium and large pebbles; 50% sand, silt, and clay.
40-60	Seventy-five percent sand, silt, and clay. Twenty-five percent granule to medium-pebble-size volcanic fragments.
60-89	Grayish-red clay containing biotite and altered feldspars. Appears to be the weathered top of a volcanic lava-flow unit, possibly of andesitic composition.

Hole Name: TG-122

Depth (ft)	Description
0-20	Granule to large-pebble gravel of intermediate to silicic volcanic fragments. Fragments are probably andesite to rhyolite in composition but are mostly aphanitic and weathered. Low sand content in sample. From 10 to 20 feet, the sample is predominantly of one source rock: a light-gray to medium-light-gray porphyry.
20-40	Samples appear to be a weathered variety of the light-gray porphyry and are comprised mostly of light-gray clay with very fine-grain mafics and weathered feldspars.
40-165	Volcanic bedrock of same composition as above. Samples vary in appearance and size probably due to fracturing and alteration. Freshest samples (largest chips) occur from 130 to 160 feet. A zone near 125 feet shows considerable alteration to clay. Groundwater, encountered in fractures at approximately 130 feet, was estimated at several gpm.

Hole Name: TG-123

Depth (ft)	Description
0-10	Silt, sand, and granule to medium-pebble gravel. Silt and sand fraction is approximately one-half of sample. Gravel fraction is composed of aphanitic and porphyritic felsic volcanic clasts that are angular to subangular. Minor caliche.
10-30	Granule to medium-pebble gravel of volcanic-rock fragments as above. Silt and sand is nearly absent from the 10- to 20-foot sample, but represents about 5% of the 20- to 30-foot sample.
30-80	Clay, silt, sand, and granule to small-pebble gravel. Clay and silt fraction is probably 10% of samples. Gravel fraction is composed of volcanic fragments as above, but clasts are smaller. Minor caliche.
80-102	Very-light-gray to light-gray quartz rhyolite. Subhedral to anhedral quartz is abundant in an aphanitic groundmass. Rock appears quite siliceous both from the abundance of quartz phenocrysts and apparent siliceous streaks.

Hole Name: TG-124

Depth (ft)	Description
0-105	Clay, silt, sand, and granule to large-pebble gravel. Gravel fraction is approximately 90% of samples and is composed of angular clasts of silicic volcanic-rock fragments, probably of rhyolitic composition. Interpreted to be fan deposits.

Hole Name: TG-125

Depth (ft)	Description
0-10	Small- to large-pebble gravel consisting of angular clasts of felsic aphanitic and porphyritic volcanic rocks. Very little sand in this sample. Minor caliche cement.
10-151	Silt, sand, and granule to large-pebble gravel similar to above. Minor variations in sand and gravel fractions. Entire interval has subequal amounts of sand and gravel. Little or no clay. Depositional environment is alluvial fan.

Hole Name: TG-126

Depth (ft)	Description
0-10	Silt, fine-grain sand, and caliche.
10-80	Pale-yellowish-brown clay, silt, and sand. Most of interval is composed of fine- and medium-grain quartz sand. Minor amounts of caliche present. A few rounded granules and small pebbles of varied composition are present.
80-97	Medium-light-gray (dry) to dark-gray (wet) porphyritic volcanic rock tentatively identified as a hornblende andesite. White feldspar phenocrysts, .10 to .25 mm, are abundant and some show altered cores. Rock is probably holocrystalline and appears to be seriate porphyritic.

Hole Name: TG-127

Depth (ft)	Description
0-10	Clay, silt, fine sand, and caliche. Most of sample is caliche-cemented fine-grain quartz sand.
10-20	Clay, silt, and fine sand. Moderate-reddish-brown clay is approximately 25% of sample. Minor caliche.
20-30	Clay, silt, sand, and granule to medium-pebble gravel. Clay is minor. Subequal amounts of silt-sand and gravel. Gravel is mostly granules and small pebbles of subrounded to subangular volcanic rock fragments.
30-40	Clay, silt, and sand. Clay is probably 30% of sample.
40-90	Silt, sand, and granule to medium-pebble gravel. Gravel fraction is similar to gravel seen above and decreases from 50% at 40 feet to 10% at 90 feet. Silt content decreases from a few percent to zero percent from 40 to 90 feet. Higher degree of sorting may represent transition to fluvial environment.
90-165	Well sorted fine- to medium-grain quartz sand. Sand grains are subrounded to subangular. Minor well-rounded small pebbles. Probable fluvial depositional environment.

Hole Name: TG-128

Depth (ft)	Description
0-30	Silt, sand, and granule to medium-size gravel of volcanic origin. Most volcanics are intermediate to silicic in composition, but a few clasts of basalt are visible. Silt and sand content is less than 10% of sample. Clasts are angular to subrounded. Formation is probably alluvial-fan, sheetwash, and mudflow deposits.
30-115	Silt, sand, and granule to small-pebble gravel of volcanic origin. Silt and sand content approximately 20%. Diversity of volcanic source rock decreases with depth. Material below 80 feet is nearly all from one source: a dark-gray to brownish-gray porphyry that is probably an andesite. Hole may bottom in weathered andesite bedrock since the last sample (100-115 feet) appears homogeneous. However, this sample is almost 50% sand-size material.

Hole Name: TG-129

Depth (ft)	Description
0-10	Silt, sand, and granule to medium-pebble gravel consisting of limestone, dolomite and silicic volcanic fragments. Carbonate clasts comprise most of the sample. Clasts are angular. Formation is probably recent arroyo channel fill.
10-20	Sample is mostly medium-gray (dry) to dark-gray clay and altered volcanic porphyry of the same color. Material is probably weathered top of underlying volcanic lava flow.
20-165	Medium-gray (dry) to dark-gray (wet) volcanic porphyry. Probably of andesitic composition although the rock is altered somewhat and has an aphanitic groundmass. Zone at 40 to 50 feet is pale-red and to grayish-red color and is more altered to clay. This interval may be a fault zone.

Hole Name: TG-130

Depth (ft)	Description
0-10	Silt, sand, and granule to large-pebble gravel consisting of angular clasts of felsic aphanitic and porphyritic volcanic rocks. Silt and sand fraction is less than 5% of total. Minor caliche.
10-100	Silt, sand, and granule to large-pebble gravel as above. Silt and sand fraction is greater than at 0 to 10 feet, and represents approximately 10% of sample. Gravel fraction decreases in mean size towards bottom of interval.
100-125	Grayish-red clayey unit that appears to be the weathered top of a silicic volcanic unit. Most of sample is grayish-red clay containing partially altered to fresh phenocrysts of feldspar and quartz. A few less altered chips of rock are still present.

Hole Name: TG-131

Depth (ft)	Description
0-90	Silt, sand, and gravel to large-pebble size. Clasts are of volcanic origin and appear to be from two source rocks: rhyolite and andesite.
90-165	Silt, sand, and gravel as above, but increasing amount of rhyolite gravel. Much of rhyolite appears to be pumice and is altered to clay.

Hole Name: TG-132

Depth (ft)	Description
0-165	Very-pale-brown, very-fine- to coarse-grained, subangular to rounded quartz sand. Ninety percent of material is fine- and medium-grained-quartz sand. Minor content of granules and small to large pebbles. Minor caliche. Probably flood-plain and point-bar deposits.

Hole Name: TG-133

Depth (ft)	Description
0-60	Very-fine- to very-coarse-grained sand, granules, and small to large pebbles. Approximately 25 percent sand-size material of which most is medium- to very-coarse-grained, subrounded to rounded, quartz sand. Approximately 75 percent granules and small to large pebbles of rock fragments. Gravel fraction is mostly rounded and well-rounded. Minor caliche. Probably channel-lag and point-bar deposits.
60-165	Very-fine- to medium-grained, subrounded to well-rounded, quartz sand. Minor content of granules and small pebbles. Minor caliche. Contact with interval above is probably gradational. The lower interval is probably point-bar and flood-plain deposits.

Hole Name: TG-134

Depth (ft)	Description
0-10	Sand, granules, and small to large pebbles. Ten percent medium- to very-coarse-grained subangular to rounded, quartz sand. Ninety percent granules and pebbles of volcanic and sedimentary rock fragments. Some caliche present.
10-80	Seventy-five percent fine- to very-coarse-grained, rounded quartz sand; twenty-five percent granules and pebbles of rock fragments. Probably layered sequence of point-bar and channel lag deposits.
80-100	Silt and very-fine- to medium-grained-quartz sand. Most of material is fine- and medium-grained, well rounded quartz sand. Minor caliche cement. Possibly flood-plain deposits.
100-165	Very-fine- to coarse-grained, subrounded to well rounded quartz sand. Most material is fine- and medium-grained quartz sand. Minor caliche. Minor, sporadic granules and small pebbles of rock fragments.

Hole Name: TG-135

Depth (ft)	Description
0-165	Sand and pebbly sand. Approximately 60 percent fine- to very-coarse-grained quartz sand, subangular to subrounded; 40 percent granules to large pebbles of subangular to well-rounded lithic fragments. Probably a fluvial unit.

Hole Name: TG-136

Depth (ft)	Description
0-40	Pebbly sand. Approximately 40 percent fine- to very-coarse-grained sand; 60 percent granules and small to medium pebbles. Sand is mostly fine- to medium-grained, well rounded, quartz. Granules and pebbles are subangular to well rounded clasts of volcanic and some intrusive rocks. Probably a fluvial unit. Some caliche.
40-165	Sand and pebbly sand. Pebble content less than in interval above and somewhat smaller. Sand is mostly fine- to coarse-grained, subrounded to well rounded quartz. Sand comprises 90 percent of interval. Some caliche. Probably a fluvial unit.

Hole Name: TG-137

Depth (ft)	Description
0-165	Very-pale-brown silt and fine- to medium-grained quartz sand. Most of material is very-fine- to fine-grained, subangular to subrounded, quartz sand. Caliche cement is present in all samples but apparently in small amounts. These samples are very well sorted. Little or no clay nor coarser clasts.

Hole Name: TG-138

Depth (ft)	Description
0-60	Fine- to very-coarse-grained sand, granules, and small to medium pebbles. Approximately 80 percent well rounded granules and pebbles of lithic fragments, mostly from volcanic and sedimentary sources. Approximately 20 percent medium- to very-coarse-grained, angular to subangular quartz sand. Minor amounts of finer sand. This interval is gradational to the interval below in terms of size of material. Samples in uppermost interval are probably mostly channel-lag deposits, whereas intervals below probably have a progressively increasing volume of point-bar deposits.
60-110	Approximately 50 percent fine- to very-coarse-grained quartz sand; and 50 percent granules to medium pebbles of lithic fragments. Greater sorting of sand than above, with most sand in the medium-grained size range. Sand is mostly subrounded to well rounded. Gradational change to finer interval below. Some caliche.
110-165	Ninety percent fine- to very-coarse-grained, rounded- to well rounded quartz sand. Ten percent granules and small pebbles of lithic fragments. Greater sorting of sizes than in intervals above. Most of material is medium- and coarse-grained quartz sand that is rounded to well rounded. Minor caliche.

Hole Name: TG-139

Depth (ft)	Description
0-165	Very-pale-brown silt and fine- to medium-grained quartz sand. Most material is very-fine- to fine-grained, subangular to subrounded, quartz sand. Minor caliche in all samples. Sorting is apparently high.

Hole Name: TG-140

Depth (ft)	Description
0-165	Very-pale-brown silt and very-fine- to very-coarse-grained sand. Minor granule and pebble content. Samples are fairly well sorted. Ninety percent of material is fine- and medium-grained, rounded to well rounded quartz sand. Minor caliche present in all samples. Granules and pebbles less 5 percent overall.

Hole Name: TG-141

Depth (ft)	Description
0-165	Grayish-pink to light-brown clay, silt, and fine- to medium-grained sand. Minor content of coarser sand and granules. Most of samples are comprised of fine- and medium-grained, subangular to subrounded, quartz sand. Minor caliche, especially in upper half of hole. Possibly flood-plain desposits.

Hole Name: TG-142

Depth (ft)	Description
0-165	Grayish-pink to light brown clay, silt, and fine- to medium-grained sand. Coarser sand, granule, and small to large pebbles are minor overall, but variable. Granules and pebbles of lithic fragments constitute approximately 10 percent of samples from 80 to 100 feet. Caliche cement is present in all samples.

Hole Name: TG-142

Depth (ft)	Description
0-165	Grayish-pink to light brown clay, silt, and fine- to medium-grained sand. Coarser sand, granule, and small to large pebbles are minor overall, but variable. Granules and pebbles of lithic fragments constitute approximately 10 percent of samples from 80 to 100 feet. Caliche cement is present in all samples.

Hole Name: TG-143

Depth (ft)	Description
0-10	Yellowish gray clay, silt, and fine sand. Minor content of rock fragments.
10-20	Light-olive-gray and dark-yellowish-brown limestone, containing siliceous fragments.
20-30	Grayish red and dark-reddish-brown siltstone and silty claystone. A few fragments of light gray limestone.
30-50	Dark-reddish-brown shale and claystone, mostly soft. Minor light gray limestone containing siliceous streaks.
50-70	Medium-gray to dark-gray limestone containing microfossils (e.g., fusulinids, algae).
70-80	Medium-dark-gray limestone, somewhat softer than above and possibly more argillaceous. No microfossils.
80-90	Olive gray to dark gray indurated limestone and dolomite. Abundant microfossils and chert pebbles.
90-110	Medium-light-gray calcareous shale and minor medium gray limestone. Some vein calcite at 100-110 feet.
110-120	Dark-gray and brownish-gray limestone with microfossils.
120-130	Dusky-purple and gray limestone and gray calcareous shale.
130-140	Dark-reddish-brown siltstone and shale.
140-160	Pale-brown siltstone and fine-grained mica on bedding surfaces.
160-165	Pale brown siltstone, and gray silty calcareous claystone.

Hole Name: TG-144

Depth (ft)	Description
0-20	Silt, sand, and mostly gravel of limestone and dolomite.
20-40	Dark-yellowish-orange siltstone, platy and moderately indurated.
40-50	Dark-yellowish-orange siltstone, moderate-brown limestone containing microfossils, and light-olive-brown shale. Subequal amounts of each lithologic type.
50-70	Dark-gray limestone containing microfossils. Well indurated. Minor siltstone and shale.
70-80	Approximately equal amounts of dark-gray limestone and dark-olive-gray shale.
80-90	Medium-gray calcareous shale.
90-120	Grayish-black limestone, moderately indurated, sparse microfossils. Some dolomite.
120-130	Medium-gray, soft, argillaceous limestone and calcareous shale.
130-165	Dark-gray calcareous shale and argillaceous limestone. Some pink feldspars (potassium feldspar) at 160-165 appear to have crystallized in situ.

Hole Name: TG-145

Depth (ft)	Description
0-10	Silt, sand, and gravel. Mostly small- to large-pebble gravel comprised of limestone and siltstone.
10-20	Well indurated dark-reddish-brown silty claystone. Dark-yellowish-orange (limonite) coatings on fracture and/or bedding surfaces.
20-30	Very soft medium-dark-gray shale.
30-50	Light-gray to medium-gray dolomite.
50-60	Light-gray to medium-gray dolomite, white vein calcite with pervasive dark-yellowish-orange (limonite) coating, and clay. Much of dolomite is fine-grained sand size. Some clay-size material may merely be crushed rock. Probable fault and alteration zone.
60-70	Light-gray to medium-gray dolomite, mostly finely crushed and soft. Less evidence of vein calcite and alteration than above but probably part of same fault zone.
70-80	Light-gray to medium-gray dolomite, some crushed but mostly intact. Limonite staining common. Traces of very-fine metallic mineralization, probably pyrite but too small to confirm with 25x.
80-90	Pale-reddish-brown (dry) clay and claystone. Minor light gray sandy dolomite.
90-100	Moderate-reddish-brown siltstone. Moderately indurately.
100-110	Light-gray dolomite and reddish-brown siltstone.
110-120	Medium-gray fine-grained dolomite.
120-150	Unwashed sample is mostly very-fine clay-size material, most of which probably is true clay and some may be finely crushed rock. Washed sample consists of light-gray dolomite. Hole began making water at 118 feet. Probable fault zone at 118 feet.
150-165	Light gray dolomite as above, but less crushed and sheared. Smaller content of fine material. Probably below major fault zone. Minor content of reddish-brown silty claystone.

Hole Name: TG-146

Depth (ft)	Description
0-40	Silt, sand, and gravel comprised of silicic volcanic debris. Very angular clasts, fan facies. Minor limestone and dolomite.
40-80	Silt, sand, and gravel comprised of mostly weathered limestone and dolomite. More dolomite than limestone. Much of fine material is calcite and probably occurred as caliche cement. Minor pale green shale.
80-90	As above but with substantial caliche and clay. Fine material is approximately 50 percent of sample.
90-100	Clay, caliche, silt, and gravel. Clay, caliche, and silt comprise 90 percent of sample. Gravel composition is finer than above but of same dolomite and limestone lithology.
100-110	Clay, caliche, silt, sand, and gravel. Clay, caliche, and silt comprise 50 percent of sample.
110-130	Moderate-brown and moderate-reddish-brown fine-grained dolomite.
130-TD	Lost circulation drilling. No samples recovered.

Hole Name: TG-147

Depth (ft)	Description
0-40	Granule to large-pebble gravel of limestone and other lithic fragments. No sand or clay in samples. Basalt fragments more common towards bottom of interval.
40-50	Granule to large-pebble gravel of predominantly volcanic composition.
50-100	Grayish-purple biotite-andesite porphyry. (Field name only; feldspars are somewhat weathered and difficult to distinguish. Quartz may be abundant in the groundmass.)

Hole Name: TG-148

Depth (ft)	Description
0-30	Granule- to large-pebble gravel consisting of volcanic and limestone rock fragments. Caliche cement is visible, but not abundant in samples.
30-40	Coarse-sand to small-pebble gravel consisting of volcanic rock fragments. Most of sample is very-coarse-sand size material.
40-70	Granule- to medium-pebble gravel consisting of volcanic rock fragments.
70-165	Gravel material as above but with 10 percent clay, silt, and sand. The presence of fine material may be due to lesser washing of sample, or unit may be a mudflow. Most chips are very angular, but some are well rounded. Ninety percent of clasts appear to be from the same volcanic (andesite) unit.

Hole Name: TG-149

Depth (ft)	Description
0-165	Sandy gravel and gravel. Predominantly granule- to large-pebble gravel consisting of volcanic fragments. Minor clay content is probably drilling mud. Clasts are angular to subangular and mostly appear to be andesite. Interval from 50 to 80 feet is somewhat coarser than the rest of the section and consists mostly of medium and large pebbles.

Hole Name: TG-150

Depth (ft)	Description
0-150	Sandy gravel. Fine- to very-coarse-sand and lithic gravel. Sand comprises 50 to 75 percent of samples and is mostly fine- and medium-grained quartz. Gravel is comprised of subangular to subrounded volcanic fragments. Some caliche cement. Gravel content decreases to 10 percent at 140-150 feet.
150-160	Clay, silt, and fine- to medium-grained sand. Approximately 10 percent moderate-reddish-brown clay; 90 percent fine- and medium-grained quartz sand.
160-165	Clay, silt, and sand as above, but somewhat more clay; reddish-brown stain on sand.

Hole Name: TG-151

Depth (ft)	Description
0-40	Mineralized limestone breccia, probably of fault origin. Some evidence of mineralization and alteration. Very fine cubes, probably pyrite, that are mostly oxidized. Evidence of metal mineralization in chips from 10-30 feet; should be checked for metal content. Gray to black veins through limestone and dolomite. Slickensides visible on some chips.
40-50	Dark-gray limestone containing very-fine-grained, disseminated metallic mineralization, probably pyrite or hematite.
50-80	White, gray, and light-green carbonate and siliceous material. Minor metallic mineralization, possibly hematite. Possibly fault and fracture filling mineralization.
80-90	Medium-dark-gray, fine-grained limestone. Minor light green and white carbonate and siliceous material.
90-110	Medium-dark-gray limestone as above. Somewhat greater content of white carbonate and silica that may be from fault zone above.
110-120	Siliceous fragments of various colors and minor light-gray limestone.
120-140	White to pale-yellowish-orange siliceous material, probably quartz.
140-150	White, light-green, and light-brown siliceous fragments. Minor gray limestone. Disseminated pyrite in some chips.
150-165	Light-gray and dark-gray limestone. Siliceous fragments of various colors.

Hole Name: TG-153

Depth (ft)	Description
0-60	Sand and gravel. Coarse lithic sands comprise less than 10 percent of this interval. Most material is granule- to large-pebble-size fragments of aphanitic and porphyritic volcanics. Dominant lithology is a medium-gray porphyry containing quartz and alkali-feldspar.
60-110	Predominantly a white and dark-yellowish-orange, aphanitic volcanic unit. Some coarse, gray gravel, interpreted to have washed into the hole from the interval above, occurs in this interval. This interval appears to grade into the interval below and is probably a weathered and altered upper part of the volcanic unit below.
110-150	Light-gray to medium-bluish-gray, aphanitic volcanic unit containing abundant vein and disseminated pyrite. Some calcite associated with the pyrite. Sample at 110-to-120 feet contains material from interval above and this interval.

General remarks - Drilling supervisor lists formation contacts:

0-55 feet	alluvium
55-118 feet	weathered intrusive unit, but getting quite hard at 75 feet
118-150 feet	fresh, unaltered intrusive

Hole Name: TG-154

Depth (ft)	Description
0-110	Silt, sand, and granule- to medium-pebble gravel. Sixty percent of this interval is fine- and medium-grained, angular to subangular quartz sand. Angular granules and pebbles are of aphanitic and porphyritic volcanic rocks, mostly a medium-gray, quartz alkali feldspar porphyry. Considerable amount of caliche cement from 0 to 30 feet. Sand fraction increases in coarseness to medium- and coarse-grained from 80 to 110 feet, and gravel fraction increases in volume to 50 percent.
110-130	Fine- to very-coarse-grained sand, granules, and small to medium pebbles. Most of sand fraction is medium- to very-coarse-grained, angular to subangular, quartz and lithic sand. Gravel fraction composed of angular volcanic fragments as above. Approximately 10 percent sand and 90 percent gravel-size material.
130-165	Fine- to very-coarse-grained sand, granules, and small to medium pebbles. Less gravel than in interval above, decreasing from 40 percent at 130 feet to 10 percent at 165 feet. Sample at 160-to-165 feet is composed of fine- to coarse-grained, subangular to subrounded, quartz and lithic sand with 10 percent granule-size lithic fragments. Increase in fineness and sorting from top to bottom of interval.

Hole Name: TG-155

Depth (ft)	Description
0-165	Clay, silt, sand, granules, and small to medium pebbles. Approximately 75 percent gravel-size material consisting of angular fragments of aphanitic and porphyritic volcanic rocks. The clay-to-sand size fraction is mostly composed of fine- to medium-grained quartz and lithic sand. Caliche is present as a cement in all samples, but especially the upper 30 feet.

Hole Name: TG-156

Depth (ft)	Description
0-30	Clay, silt, sand, granules and small to large pebbles. Approximately 50 percent gravel-size material consisting of angular, aphanitic and porphyritic volcanic fragments. Clay is minor, but present. Sand is mostly fine- and medium-grained quartz and lithic fragments. Increasing content of finer material towards bottom of interval. Caliche cement well developed.
30-70	Composition similar to interval above, but finer-grained than above. Approximately 90 percent clay to medium-grained sand. Ten percent granules and small pebbles as above.
70-165	Clay, silt, sand, granules, and small to large pebbles. Composition and appearance similar to uppermost interval. Caliche cement is well developed in the 120-to-130-foot sample.

Hole Name: TG-157

Depth (ft)	Description
0-40	Fine- to very-coarse-grained sand, granules, and small to medium pebbles. Approximately equal amounts of sand and gravel. Most of sand is medium- to coarse-grained, angular to subangular, quartz and lithic sand. Granules and pebbles are mostly angular to subrounded clasts of porphyritic volcanic fragments. Sand content increases slightly towards the bottom of interval. Minor caliche cement.
40-165	Clay, silt, sand, granules, and small to medium pebbles. This interval gradually decreases in grain size from top to bottom. Approximately 80 percent medium- to coarse-grained sand and 20 percent gravel-size lithic fragments at top of interval. Gravel-size material is less than 10 percent by 90 feet and is nearly absent from 140 to 165 feet. Approximately 90 percent silt and very-fine- to fine- grained sand; and 10 percent clay at bottom of interval.

Hole Name: TG-158

Depth (ft)	Description
0-80	Very-fine- to very-coarse-grained sand, granules, and small to large pebbles. Sand content increases from 5 percent at top of interval to 50 percent at bottom of interval. Sand is mostly medium- and coarse-grained, subrounded to rounded, quartz sand. Minor caliche. This unit is probably channel lag and point-bar deposits. Gradational transition to finer unit below.
80-165	Fine- to coarse-grained, subrounded to rounded, quartz sand. Very minor content of granules and small pebbles. Minor caliche. Much better sorted than interval above. Most material is medium- to coarse-grained quartz sand.