GL09447-7

1980 Geothermal Reconnaissance in New Mexico - Project 1114

Final Report

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This report summarizes the geothermal exploration conducted by AMAX in the state of New Mexico during the 1980 field season.

The reconnaissance program began on June 7 with two primary objectives: 1) to investigate known geothermal anomalies and structurally favorable regions, and 2) to locate new prospect areas by reconnaissance investigations. Two weeks in August were spent conducting follow-up investigations in the Mojave Desert in California.

The field crew was: Alan Shenker, reconnaissance coordinator; Bill Huntsman, party chief; Karol Gillespie, chemist and reconnaissance geologist; Walter Avramenko and Jim Lovekin, reconnaissance geologists. All geologists did literature research on the areas to be investigated and studied and plotted surface anomalies such as mineral deposits, faults, geothermal manifestations, cauldrons and other features of interest.

Techniques used in the course of the summer field season consisted of heatflow determinations in existing boreholes (e.g. water wells, gradient and mineral exploration test wells, and mine shafts) and the collection and analysis of spring and well waters. Additional hydrogeochemical analyses have been gathered through the U.S.G.S. and state agencies. During the three month field season, 275 heatflow measurements were made and 220 hydrogeochemical samples were collected and analyzed.

Most of AMAX's exploration was conducted in the Rio Grande Rift and in the Basin and Range physiographic provinces. Typical background heatflow values in these areas are 2-2.5 H.F.U. Known geothermal systems and K.G.R.A.'s in New Mexico were also investigated with respect to high temperature geothermal potential and leaseable land. Figure 1 shows the location of the eight K.G.R.A.'s in New Mexico designated by the U.S.G.S.; Baca Location, Lightning Dock, Gila Hot Springs, Lower Frisco Hot Springs, Socorro Peak, San Ysidro, Kilbourne Hole, and Radium Springs, and the locations of prospects discussed in this report. These areas were designated both on the basis of competitive interest and surface geothermal manifestation. The AMAX lease map (New Mexico portfolio) shows all federal lease activity in New Mexico.

Reconnaissance exploration of New Mexico has revealed several potential geothermal prospect areas with heatflow greater than 3.0 H.F.U. and/or hydrogeochemistry indicating sub-surface temperatures in excess of 100°C. Most systems discussed in this report are in areas with little or no leasing activity. Areas warranting additional exploration are:

Name	Location	$T^{o}C_{sur}$	$T^{o}C_{SiO_2}$	$T^{o}C_{Na\text{-}K\text{-}Ca}$	$T^{o}C_{Na\text{-}K\text{-}Ca\text{-}Mg}$
Hillsboro	West-central Sierra County	38	161	170	170
San Francisco River Basin	Grant County	46	129	121	105
Columbus	So. Luna County	31	120	120	119

Name	Location	T^oCsur	T^oCSiO_2	$T^oCNa\text{-}K\text{-}Ca$	$T^oCNa\text{-}K\text{-}Ca\text{-}Mg$
Chise	No. Sierra County	30	92	153	134
Derry	No. Dona Ana Co.	34	95	155	60
Lake Valley	Central Sierra Co.	35	106	94	94
Potrillo Mtns.	So. Dona Ana Co.	28	79	186	114
Plains of San Augustin	Socorro County	Heatflow	4.31 HFU	No chemistry	
Bear Mtn.	Socorro County	Heatflow	4.95 HFU	No chemistry	
Lower Animas Valley	Hidalgo County	Heatflow	7.5 HFU	No chemistry	

Hillsboro

Interest in the Hillsboro area developed over an anomalous hydrogeochemical analysis obtained from the Cement Pool (38°C) in Warm Springs Canyon just north of Hillsboro, New Mexico. Listed below is the chemical analysis and the calculated geothermometers for the Cement Pool Warm Spring.

Na - 160.0	B - 0.2	$TSiO_2^oC$ - 161.2
K - 11.0	F - 15.0	$TNa\text{-}K\text{-}Ca^oC$ - 170.2
Ca - 6.0	HCO_3 - 275.8	$TNa\text{-}K\text{-}Ca\text{-}Mg^oC$ - 170.2
Mg - 0.4	SO_4 - 129.7	
Li - 0.3	SiO_2 - 150.0	
Cl - 18.0	pH - 7.75	

The spring waters, measuring 38°C, are about 20°C warmer than any other groundwater measured in the area. In addition to the thermal nature of the spring, there are regular emissions of gas; apparently carbon dioxide.

Leasing of federal (BLM) land was initiated in July 1980 and a one year lease was signed on February 5, 1981 with Vernon Cunningham of Hillsboro for the use of his fee land (including Cement Pool Spring).

The Hillsboro area lies at the boundary of the Datil-Mogollon volcanic complex of the Colorado Plateau and the Rio Grande Rift just north of where the rift spreads into the Basin and Range Province. The Emory Cauldron, to the west of Hillsboro, is a large complex of predominantly rhyolitic volcanic rocks of Tertiary age with tuffaceous, flow and laharric facies. The Cement

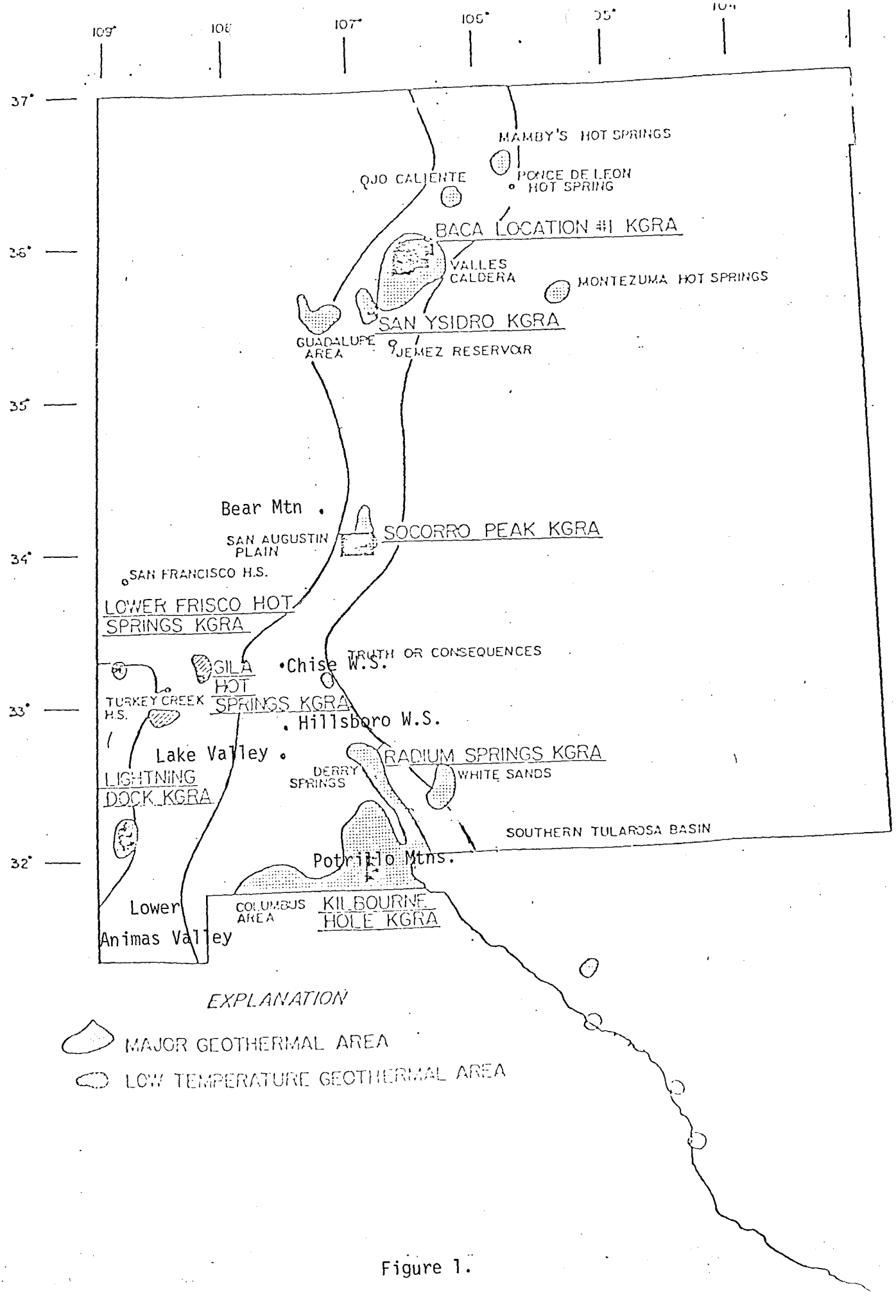
109°
108
107°
106°
105
104
37°
36°
35°
34°
33°
32°
MAMBY'S HOT SPRINGS
OJO CALIENTE
PONCE DE LEON HOT SPRING
BACA LOCATION #1 KGRA
VALLES CALDERA
MONTEZUMA HOT SPRINGS
SAN YSIDRO KGRA
GUADALUPE AREA
JEMEZ RESERVOIR
Bear Mtn
SAN AUGUSTIN PLAIN
SOCORRO PEAK KGRA
SAN FRANCISCO H.S.
LOWER FRISCO HOT SPRINGS KGRA
TRUTH OR CONSEQUENCES
GILA HOT SPRINGS KGRA
Chise W.S.
TURKEY CREEK H.S.
Hillsboro W.S.
Lake Valley
RADIUM SPRINGS KGRA
LIGHTNING DOCK KGRA
DERRY SPRINGS
WHITE SANDS
SOUTHERN TULAROSA BASIN
Potrillo Mtns.
Lower Animas Valley
COLUMBUS AREA
KILBOURNE HOLE KGRA
EXPLANATION
MAJOR GEOTHERMAL AREA
LOW TEMPERATURE GEOTHERMAL AREA

Figure 1.

Pool Spring issues from an indurated unit of fanglomerate, part of the Santa Fe Group (Tertiary-Quaternary). The spring appears to be controlled by the intersection of a major north trending fault and the ring fracture zone associated with an early Tertiary intrusive mass.

Future exploration planned for the Hillsboro project includes:

1. Detailed mapping of lithologies, structure, and spring deposits (in progress).

2. An SP survey.

3. Drilling of several shallow thermal gradient wells. Test wells also to be sampled for hydrogeochemical analysis if water is encountered.

San Francisco River Basin

The San Francisco River Basin lies within the Datil section of the Colorado Plateau in an area known as the Mogollon Plateau. The target area mainly occupies western Catron County, but extends across the extreme northwestern portion of Grant County as well.

Two thermal springs, Wet Leggett Spring (7S 20W Sec. 15 420), and Lower San Francisco Hot Spring (12S 20W Sec. 23 120), display geothermometers in excess of 100°C. A well (12S 20W Sec. 13) with a gradient of 170°C/km was also located during our exploration of the area.

Wet Leggett Spring, 30 miles north of Glenwood, New Mexico, displays anomalous hydrogeochemistry indicating sub-surface temperatures as high as 112°C. The analysis of Wet Leggett Spring is as follows:

Na - 50.0	B - 0.2	Tsur.°C - 22.0
K - 4.8	F - 0.4	$TSiO_2$°C - 85.0
Ca - 3.0	HCO_3 - 82.0	TNa-K-Ca°C - 173.4
Mg - 0.8	SO_4 - 10.0	TNa-K-Ca-Mg°C - 112.0
Li - 1.0	SiO_2 - 34.	
Cl - 4.0	pH - 9.01	

Numerous springs in close proximity to Wet Leggett were sampled. All samples were 8°C-15°C cooler than Wet Leggett Spring and none had anomalous hydrogeochemistry. No boreholes in the area are known to exist and almost all available water samples have been collected. At this time, follow-up exploration for this area has not been planned.

The Lower Frisco Hot Springs discharge from lava of late Tertiary age, at temperatures ranging from 26°C to 55°C. All samples collected from this series of springs contain from 76-100 ppm silica. These greater than background values are believed to be a result of amorphous silica (chalcedony) present in the area. Two springs sampled lie 800 feet (244m) apart and are representative of the thermal water from the Lower Frisco Springs. The hydrogeochemistry of two of these springs yield alkali geothermometers of 105°C and 100°C and silica geothermometers of 104°C and 110°C. The analyses of the two springs is as follows:

	W14134	W14135		W14134	W14135		W14134	W14135
Na	260.0	320.0	B	0.3	0.3	Tsur	46.0	45.0
K	14.0	16.0	F	1.6	2.0	$TSiO_2$chal	101.0	110.0
Ca	39.0	46.0	HCO_3	104.0	98.0	TNa-K-Ca	150.0	149.0
Mg	5.5	7.0	SO_4			TNa-K-Ca-Mg	105.0	100.0
Li	0.5	0.6	SiO_2	86.0	100.0			
Cl	420.0	520.0	pH	7.9	8.0			

These are sodium chloride waters.

An anomalous gradient was measured in a well one mile northeast of the Lower Frisco Hot Springs. The measurement (80-237) was a gradient of 170°C/km with a bottom hole temperature of 31.3°C. Although the warm water may be causing the elevated gradient, the water in this well is at least 10°C warmer than other wells in the area. If possible, a hydrogeochemical sample will be taken from this well in 1981.

No geothermal leasing or drilling has been reported for this target area even though it is part of the Lower Frisco Hot Springs K.G.R.A., and the U.S.G.S. estimates subsurface temperatures of 150°C.

In 1981, follow-up exploration in the Lower Frisco Hot Springs area will consist of collecting hydrogeochemical samples from all possible sources and measuring any available gradients. In particular, it is desired to find boreholes in which conductive heatflow can be measured.

Columbus, New Mexico

A very large hydrogeochemical anomaly was located 30 miles south of Deming, New Mexico, in close proximity to the Tres Hermanas Mountains. Ten hydrogeochemical samples collected yielded geothermometers indicating elevated

subsurface temperatures. The geothermometers and the fluoride concentrations of the samples collected are:

Sample #	$TSiO_2$	TNa-K-Ca	TNa-K-Ca-Mg	F(ppm)
14110	96.0	100.0	72.0	2.7
14111	97.0	120.0	119.0	10.0
14119	120.0	57.0	57.0	0.9
14160	81.0	167.0	76.0	5.2
14162	93.0	162.0	61.0	4.0
14163	101.0	159.0	73.0	5.2
W62NM	70.0	120.0	36.0	3.6
W64NM	134.0	194.0	65.0	4.0
W87NM	60.0	139.0	138.0	1.3
PAL4NM	109.0	172.0	99.0	7.7

Other thermal waters ($>25^{o}C$) were observed in the area, but not all have been sampled. Three thermal gradients in excess of 3.0 heatflow units were measured in the Cedar Mountain Range, 15 miles west of the Tres Hermanas Mountains; these are:

Measurement #	Heatflow Units	Gradient	Depth	B.H.T.
80-202	3.2	$42^{o}C/km$	90	23.2
80-203	3.3	$66^{o}C/km$	64	19.4
80-225	4.9	$89^{o}C/km$	75	23.0

No outstanding heatflows were measured within twelve miles of the Tres Hermanas Mountains. The most recent volcanics in the Tres Hermanas are basalt dikes which cut all known Tertiary rocks and are of late Tertiary or early Quaternary age. No shallow volcanic heat source is anticipated.

In conclusion, hydrogeochemistry indicates subsurface temperatures in a range approaching $100^{o}C$. Finding the source of the thermal waters would

require resistivity surveys over a large area (≈500 miles). At present there appears to be no potential for electrical generation and very little for alcohol production due to the absence of the required temperatures.

Chise Warm Springs

Interest in Chise Warm Springs (located 40 miles west of Truth or Consequences) is based on two heatflow measurements, a thermal spring, and known silicification and fluorite deposits along faults in the Cuchillo Mining District. The thermal information collected by AMAX is as follows:

Measurement #	Heatflow Units	Gradient	Depth	B.H.T.
80-124	4.1	51°C/km	58m	20.2
80-124	3.3	60°C/km	94m	20.4

The only hydrogeochemical data available is for Chise Warm Spring. Hydrogeochemical analysis of this water yields the following geothermometers:

Sample #	$TsiO_2$	TNa-K-Ca	TNa-K-Ca-Mg
14025	92.0	152.9	133.6

The spring discharges from a fault in limestone at a rate of 1200 liters per minute and a flow temperature of 30°C.

It is important to note that Chise Warm Spring lies only 20 miles north of Hillsboro and appears to be controlled by the same major north-south structure.

In 1981 exploration efforts will be focused on the collection of numerous hydrogeochemical samples from springs and wells in the area, field studies of the Cuchillo District, and to the collection of heatflow data from any boreholes which can be found.

Derry Warm Springs

Derry Warm Springs are located on the east side of the Rio Grande Valley, about one mile north of Derry and 50 miles north of Las Cruces.

At this location there are a few small springs with an estimated flow of about 200 liters per minute issuing from openings in a small travertine mound. The springs apparently rise along a fault in limestone at the west base of the Derry fault block. The temperature of the warmest spring is 34°C. This spring has a very mild sulfurous odor and taste, and is measurably radioactive to about the same extent as the thermal waters at Truth or Consequences (Kelly and Silver). This spring occurs in the largest fluorspar district in the state.

The geothermometers for the spring are:

Sample #	$TSiO_2$	TNa-K-Ca	TNa-K-Ca-Mg
14088	95	155	60

The sample appears to be in disequilibrium and may reflect a hydrologic system with mixing.

In 1981 we plan to get a better understanding of the local hydrology and geology and to appraise the potential of this area for moderate temperature geothermal development. (e.g. ethanol production).

Lake Valley

Interest was developed in the Lake Valley region on the basis of six sites with heatflow greater than 3.0 H.F.U. and five hydrogeochemical samples that display high geothermometers.

Sample #	$TSiO_2$	TNa-K-Ca	TNa-K-Ca-Mg
14075	106	94	94
14090	110	55	55
14095	112	85	85
14096	126	85	85
14097	130	96	77

Most waters appear to be disequilibrium and the true subsurface temperatures are probably in the range of 85-90°C.

The elevated gradients in the area seem to be controlled by the local hydrologic system. Some subsurface water temperatures were measured at 37°C.

Measurement #	Heatflow Units	Gradient	Depth	BHT
80-149	4.0	57°C/km	63	20.6
80-151	6.3	210°C/km	85	37.5
80-157	3.0	49°C/km	150	25.8
80-160	3.9	56°C/km	95	24.9
80-217	4.7	157°C/km	60	20.5

Measurement 80-151 is located in the center of an O'Brien lease block called "Florida, New Mexico". Their lease package is based solely on this high gradient. AMAX ran an analysis of the water from this well and acquired the following geothermometers:

Sample #	$TSiO_2$	TNa-K-Ca	TNa-K-Ca-Mg
14093	99	59	Not used if TNa-K-Ca is less than 70°C.

This water is almost chemically identical to other waters in the Lake Valley area.

In 1981 a more extensive field investigation of the area will be conducted in order to more completely appraise any geothermal potential.

Potrillo Basalt Field

This region of New Mexico (located 40 miles west-northwest of El Paso, Texas) covers over 500 square miles in southwestern Dona Ana County and part of eastern Luna County. Included in this area is the Strauss Cattle Company on whose lands AMAX conducted exploration (see final report on Strauss Land dated March 1981).

The term Potrillo Basalt Field refers to the Quaternary basaltic lava flows and associated volcanoes that crop out between the Rio Grande and Mimbres Valleys. There are more than 150 cinder cones and three maar volcanoes in the region.

The entire area displays a background heatflow of about 2.5 H.F.U. and four reliable measurements greater than 3.0 H.F.U. were made. These are:

Measurement #	Heatflow (HFU)	Gradient (°C/km)	Depth(m)	B.H.T.(°C)
80-194	3.2	82.0	74	29.2
80-195	3.4	86.0	57	25.0
80-250	3.1	88.0	57	24.0
80-269	3.2	91.3	57	24.0

Two water samples were obtained from pumping wells which were found to have anomalously high subsurface equilibrium temperatures based on silica and alkali (Mg corrected) geothermometry. These are:

Sample #	$TSIO_2$	TNa-K-Ca	TNa-K-Ca-Mg
W14217	79	186	114
W14219	96	180	95

Initial exploration efforts at this time are complete. All possible gradients have been measured and very few hydrogeochemical samples remain to be collected. A resistivity survey of the area may reveal the source of the thermal waters.

At present, extensive geothermal leasing and exploration drilling is being conducted by Hunt Energy. Some land is still available and the Strauss Cattle Company is looking forward to any joint venture on their property. The area has very little potential for electrical generation capability.

Plains of San Agustin

Located 60 miles west of Socorro are the Plains of San Agustin, where a number of thermal anomalies were discovered. Interest is based on five heat-flow measurements and a number of thermal wells at least 8°C above mean annual temperature. The five elevated gradients measured by AMAX are:

Measurement #	Heatflow Units	Gradient	Depth	B.H.T.
80-45	4.0	122	35	14.3
80-72	4.3	143	70	36.0
80-54	3.66	50	90	21.0
80-86	4.6	84	135	23.4
80-87	3.7	67	180	25.1

The U.S.G.S. completed a hydrogeochemical analysis of 80-72 and achieved SiO_2 and Na-K-Ca geothermometers of 75°C and 58°C respectively. The fifteen sections around this well are currently under lease application by the O'Brien Resources as part of their Tres Montosas project.

One other well was found by AMAX to have a B.H.T. of 20° at 90 meters and the U.S.G.S. reported two more wells with high B.H.T.

Givens (1959, State Bureau of Mines and Minerals, Resource Bull. 58) published a map showing that the majority of rocks in this area consist of Tertiary rhyolites and latite crystal tuffs with minor amounts of basalt and numerous volcanic necks, to the north of the plains, in the Gallinas Mountains. To the south of the Plains of San Agustin are two large circular features, Cordury Canyon Depression, where thermal waters (35°C) have been found containing 7.3ppm fluoride and Mt. Withington Cauldron where only meteoric waters have yet been observed.

At present, no hydrogeochemical samples have been collected that indicate temperatures greater than 100°C. A more detailed hydrochemical sampling program is planned for the 1981 field season for both Catron, and western Socorro counties. AMAX's exploration program for this area will be assisted by the U.S.G.S. quality of groundwater reports (Watstore) and the chemical analysis were collected by O'Brien Resources.

Bear Mountain

A small heatflow anomaly was located on the eastern plains of Bear Mountain located 20 miles northwest of Socorro. Three wells logged by AMAX display elevated heatflow and are listed below.

Measurement #	Heatflow Units	Gradient	Depth	B.H.T.
80-36	4.0	110	40	20
80-39	3.0	50	100	21.4
80-41	3.8	76	70	23.4

Measurement 80-36 has a gradient curve that is convective and indicates that groundwater is elevating the gradient. Nonetheless, the bottom hole temperatures are still 5°C greater than most wells in this area.

There is no recent volcanism in the immediate area and those hydrochemical samples which have been collected indicated no temperatures greater than 75°C. This area has a low priority, but should we become interested, there are numerous wells and springs that can be sampled and probed.

No geothermal leases have been applied for, even though the area borders the northwest corner of the Socorro KGRA.

Animas Valley

The lower Animas Valley is located 50 miles south of Lordsburg, New Mexico and 25 miles south of the Lightning Dock KGRA. So far, very little evidence indicate any major geothermal anomalies, but one well was measured that did display an elevated gradient. The hole measured by AMAX is:

Measurement #	Heatflow Unit	Gradient	Depth	B.H.T.
79-1550	7.5	251	50	22.7

This gradient may be caused by a shallow warm aquifer as there are other holes in the area with greater bottom hole temperatures.

There is also a small travertine deposit in the same section and the U.S.G.S. reported a hot stock well 4 miles north of well 79-1550. AMAX has not visited this stock well, but in 1966 the U.S. Soil Conservation Service reported that a well did exist at that location but the windmill would not lift water for field test; the well drilled in 1938 but no specific information is available for it from state files.

In our 1981 exploration program, more information (gradients and chemical analyses) will be collected through state agencies and AMAX's field reconnaissance program for the area.

No leasing activities are known in this area and the true geothermal potential on the Lower Animas Valley is not known.