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SUBSURFACE TEMPERATURE DATA IN THE SOCORRO PEAK KGRA, NEW MEXICO

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INTRODUCTION

The Socorro Peak KGRA is located in central New Mexico within the Rio Grande rift, a large continental structure running from central Colorado past El Paso, Texas. Extensional forces began forming the Rio Grande rift about 24 to 29 m.y. ago along zones apparently influenced by late Paleozoic and Laramide uplifts (Chapin and Seager, 1975). The rift is a zone of high terrestrial heat flow (Reiter and others, 1975). Within the Socorro Peak KGRA very high geothermal gradients appear to be confined to the eastern part of the Socorro Mountain block—an intergraben horst uplifted after the formation of the rift structure (Denny, 1940).

Modern uplift has been observed in the Socorro area (Reilinger and Oliver, 1976) over a magma chamber at a depth of 18 km proposed by Sanford and others (1975). The Socorro Mountain block is covered by silicic volcanic rocks and exhibits centers of silicic volcanism approximately 10.7 m.y.b.p. (Burke and others, 1963). Several thermal springs having temperatures of about 32°C are present on the eastern slope of the Mountain (Hall, 1963, Figure 1).

PRESENTATION OF DATA

Subsurface temperature measurements were performed within the vicinity of the Socorro Peak KGRA in 11 drill tests ranging from 20 to 110m in depth. The locations of the sites are shown in Figure 1. Temperature logs are presented in Figure 2 and basic subsurface temperature data are tabulated in Table 1. The drill tests are rather shallow, and therefore considerable uncertainty exists in extrapolating measured geothermal gradients to greater depths. Because most of the measurements were taken in air, the effect of groundwater movements on the geothermal gradients is uncertain. A description of the experimental technique used to obtain temperature data is given in Reiter and others (1975).

Temperature data are believed to have an accuracy of ±0.1°C; however, wellbore instabilities may very well be greater within the tests of this study. Thermal conductivity was measured for samples representing the lithologies penetrated by drill test (1) (Table 1). Thermal conductivity values were multiplied by the appropriate measured thermal gradients to yield an estimate of the terrestrial heat flow at site (1) (Table 1).

Geothermal gradients in the upper part of the tests collared at ground level are always greater than gradients in the lower part of the tests. Near-surface gradients are more affected by surface disturbances such as topographic relief, climate and vegetation changes. High near-surface geothermal gradients may also correlate at many sites with low near-surface thermal conductivities resulting from lack of compaction and saturation.

DISCUSSION

Observed temperature gradients greater than 150°C/km are confined to the eastern part of the Socorro Mountain block. The heat flow at site (1) is 11.7 HFU. A significant decrease in temperature gradients is observed in sites east of the mountain front within the valley fill. The extent of elevated geothermal gradients to the south and west of Socorro Peak is more ambiguous. Data do suggest a decrease in the geothermal gradients. No test sites exist to the north or the southwest of Socorro Peak.

The significant decrease in observed geothermal gradients just east of the Socorro Mountain block may be caused in part by the appreciable southward flow of ground water in the Rio Grande

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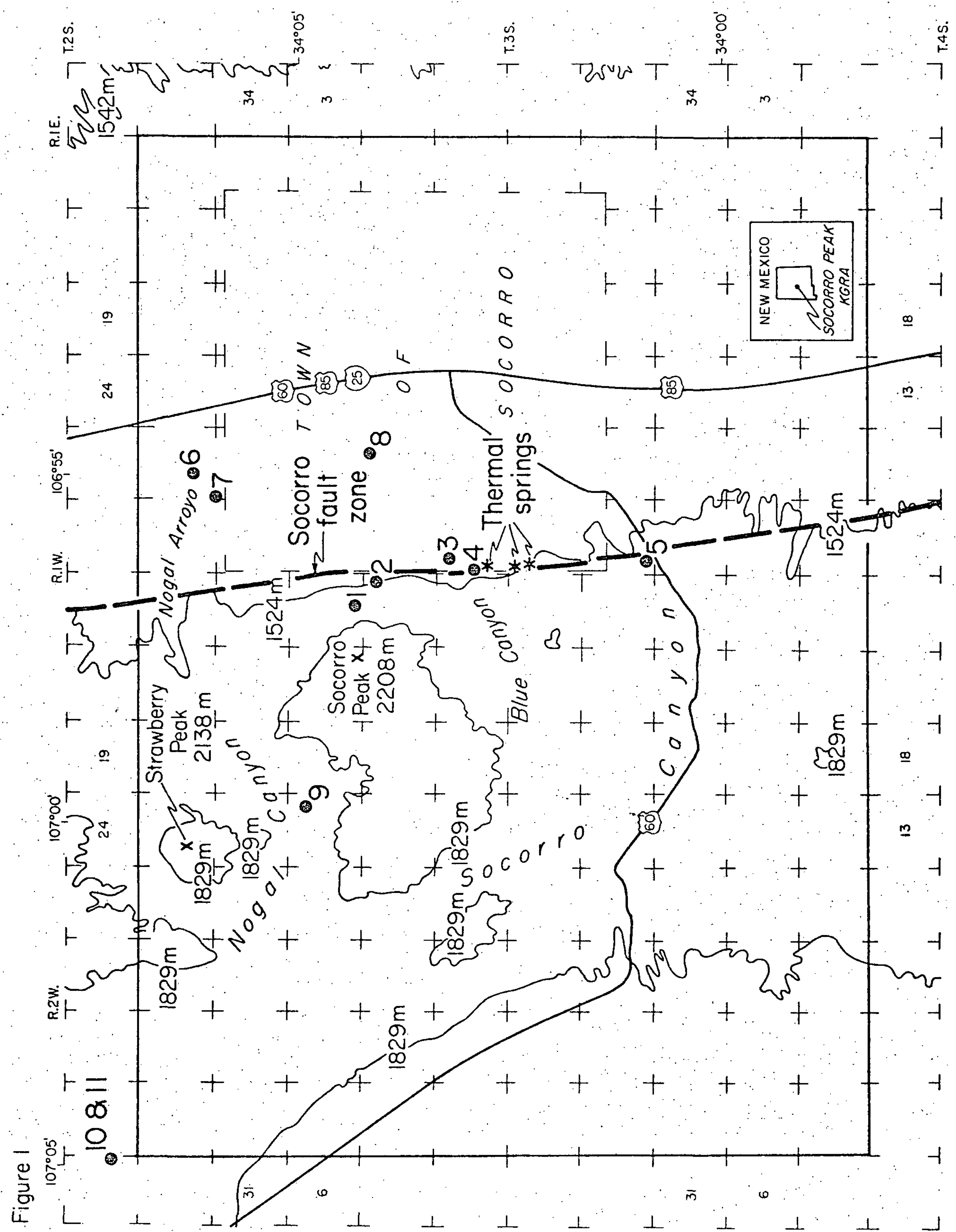

Figure 1. *Map showing the locations of subsurface temperature measurement sites in the vicinity of the Socorro Peak KGRA (within the solid line). Boundaries of Socorro Peak KGRA from Stone and Mizell, 1977.*

Table 1. Tabulation of subsurface temperature data in the Socorro Peak KGRA

Locality	Collar Elev. (m)	Depth Interval (m)	Least Squares Temperature Gradient ± St. Dev. (°C/km)	Temperatures (°C)		
				20m	30m	40m
(1) Socorro Peak* East No. 1	1560	11-51	159. ± 2.			
(2) Socorro Peak East No. 2	1512	10-20	245. ± 24.	23.4	25.4	26.9
		25-40	159. ± 11.			
(3) Blue Canyon East No. 1	1493	10-20	119. ± 20.	18.4	18.9	19.2
		35-70	35.5 ± 0.2.			
(4) Blue Canyon East No. 2	1509	10-20	98.2 ± 12.2	19.0	19.2	19.5
		25-35	39.2 ± 0.7			
		40-60	19.3 ± 0.4			
		70-100	24.3 ± 0.7			
(5) Socorro Canyon East	1536	10-20	83.7 ± 14.3	18.7	18.8	19.2
		25-60	45.6 ± 2.4			
		90-110	50.1 ± 6.6			
(6) Nogal Arroyo No. 1	1417	10-20	96.2 ± 6.7	19.1		
(7) Nogal Arroyo No. 2	1451	10-20	93.9 ± 13.4	18.4		
(8) N. M. Tech Golf Course	1417	10-20	96.9 ± 1.9	16.8		
		20-25	44.4			
(9) Nogal Canyon	1695	10-20	97.9 ± 28.6	16.6	17.0	
		15-25	47.8 ± 3.5			
		25-35	28.0 ± 2.4			
(10) Snake Ranch Flats No. 1	1786	10-20	107. ± 10.	15.5	16.2	
		20-30	73.0			
(11) Snake Ranch Flats No. 2	1786	30-40	44.2		17.0	17.4
		40-50	20.7			
		50-80	10.2 ± 0.4			

**Socorro Peak East No. 1 is located inside of a mine and is therefore collared approximately 125 meters below the ground surface. Seven lithologic samples taken from this test were used for measurements of thermal conductivity; the mean value is 7.33 ± 0.67 mcal/cm-sec-°C. The heat flow at this site then becomes* $q = K\cdot\frac{\Delta T}{\Delta z} =$ *(7.33 ± 0.67) mcal/cm-sec-°C x (159. ± 2.) °C/km = 11.7 ± 1.2 HFU (μ cal/cm²-sec).*

Figure 2a

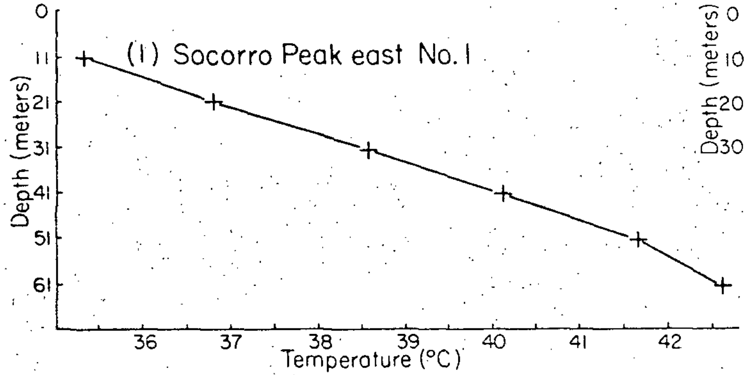

Figure 2a. Temperature log measured in test (1). (All logs in Figures 2a through 2e are shown with the same depth and temperature scales even though temperatures may be shifted; this permits visual comparison of temperature gradients.)

Figure 2b

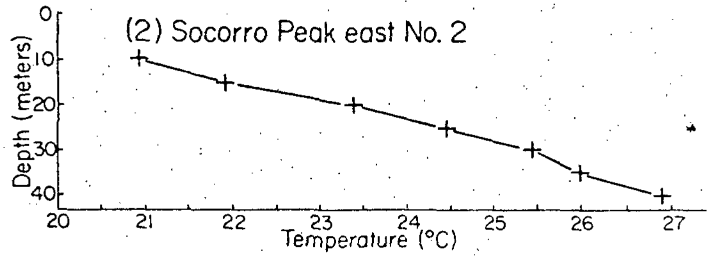

Figure 2b. Temperature log measured in test (2).

Figure 2c

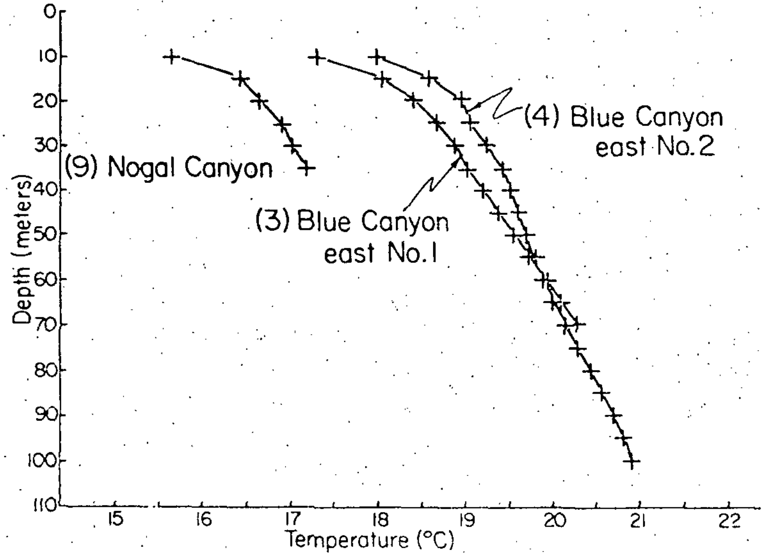

Figure 2c. Temperature logs measured in tests (3), (4), and (9).

Figure 2d

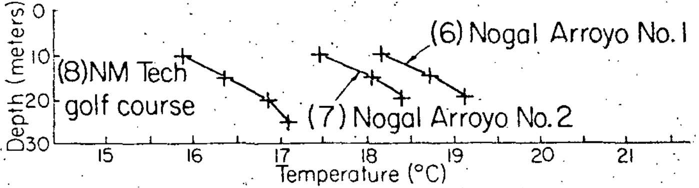

Figure 2d. Temperature logs measured in tests (6), (7), and (8).

Basin (Bushman, 1963) abstracting heat associated with possible thermal sources. In such a case, the potential thermal sources may be greater in extent than anticipated from drill test data.

Observed temperature data within the Socorro Mountain block may also be significantly affected by fluid movement. Ground water passing west to east through the mountain along fault and fissure zones (Holmes, 1963; Summers, 1976) may be heated by relatively shallow thermal sources (such as magma bodies in the upper crust) and may transport heat out of the mountain block. Waters passing through the mountain block may also interact with fluids that have percolated downward or upward along vertical fractures.

Fluids percolating vertically may be warmed while coming in relatively close proximity to thermal sources; alternatively, these fluids may be warmed while undergoing deep circulation under the influence of a somewhat above normal geothermal gradient associated with the magma body at 18 km. If ground water moves through the Socorro Mountain block such that its main effect is to transport heat out of the mountain, then potential thermal sources in the mountain block will be shallower, larger, and hotter than anticipated from the observed data.

If groundwater movement is such that there is a significant transport of heat upward, then relatively shallow geothermal gradients will be elevated, and potential thermal sources may be very deep and/or very local. The potential interaction between possible vertical and horizontal groundwater movement in the mountain block complicates a characterization of the thermal anomaly.

It would seem that geothermal gradients of 150°C/km and greater are caused by thermal sources shallower in the crust than the magma body proposed by Sanford and others (1973) at 18 km. By assuming a steady state continuous thermal source at 18 km which is 100 to 500°C

Figure 2e

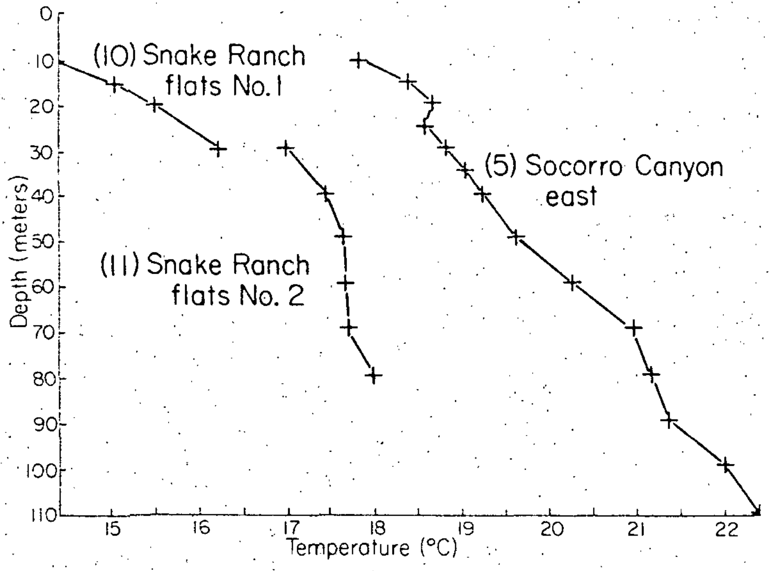

Figure 2e. Temperature logs measured in tests (5), (10), and (11).

above insitu rock the geothermal gradient could be increased only 5.5 to 28°C/km if diffusion were the only heat transfer process. Although the thermal regime of a magma body with time is quite uncertain this calculation represents the maximum temperature gradient increase that might be expected.

It is also probable that significant heat is being transferred vertically by convention and that deep sources could provide heat to the near surface if deep fractures allowing vertical hydrothermal movement were present. It appears that the Socorro Peak anomaly is local because the heat flow decreases from above 10 HFU near Socorro Peak to 2.2 HFU at Chupadera Mesa 15 km to the east (Reiter and others, 1975). The continuation of the elevated geothermal gradients in the eastern part of the mountain block and the potential for shallow magma bodies in the crust may be decided by drilling tests several km deep.

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