SELF-POTENTIAL SURVEY

ANIMAS PROSPECT

HIDALGO COUNTY, NEW MEXICO

Prepared for AMAX Exploration, Inc., Geothermal Group

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February, 1977

Contents

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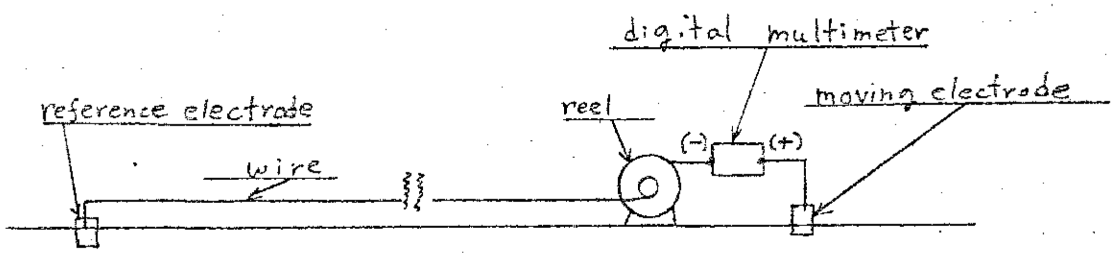
Plates (in rear pocket)

Introduction

On 24-27 January, 1977, three self-potential lines (shown on Plates 1 and 2) were run in the Animas, New Mexico area. This report describes the survey procedure and data reduction techniques, briefly discusses the survey results, and presents recommendations for possible future work. An equipment list and the data and field notes are included in an Appendix.

Survey Procedure and Data Reduction

The sketch below illustrates the "total field" survey procedure used.



The reference electrode is buried at a central location, and a reel holding 4 km of wire is used to make connection to the moving electrode. The potential of the reference electrode is arbitrarily called zero, and all readings are relative to this value. This method eliminates the accumulation of error possible when using a "leapfrog" procedure.

Before beginning and after concluding the survey, the potential between the reference and moving electrodes is measured in the electrode carrying case (in which the electrodes sit on a sponge saturated with copper sulfate solution), and these readings are used to obtain the electrode polarization and drift values which are later subtracted from the field data (this procedure is described in the Appendix).

A telluric voltage recorder, consisting of two electrodes, an amplifier, and a battery-operated strip chart recorder, is set up along or parallel to the survey line to detect long-period (greater than 30 sec) telluric variations which otherwise may be erroneously mapped as spatial self-potential anomalies. The time of each reading is recorded for reference back to the strip chart record so that any significant telluric pulses may be removed from the field data. Each reading is made for at least 30 seconds to check for telluric activity in the 0.05 Hz band. If such activity is present, several successive cycles are averaged to obtain a final value.

The circuit resistance also is recorded at each station as a check on the quality and consistency of electrode contact with the ground. Soil type and other geographical data which may affect the readings also are recorded.

Survey Results

a) Data quality

Due to recent rainfall, the soil in the survey area was moist and allowed good electrode contact and low, uniform contact resistance. Under these conditions, reproducibility of any given self-potential reading should be no worse than about ±3 millivolts (mV). No magnetic storm activity was seen on the telluric monitor chart records (Figs. 14-17), and no telluric pulses of more than 1 mV/km or 5 minutes duration were recorded during the survey period. Therefore, no corrections for telluric activity were made. (For greater accuracy, the amplitude of the telluric variations should be scaled by the ratio of the resistivity at the survey point to the resistivity at the monitoring station, at a depth corresponding to the period of the variation.

As resistivity information for the survey area at depths corresponding to periods of several minutes is not available, this was not done.)

Electrode polarization and drift for this survey generally were in the usual range of 5 mV or less. The exception occurred during the western half of line SP-2, where polarization was measured at about 15 mV after finishing the line. This was removed linearly from the final data, although it is likely that most of the drift took place while the electrodes were being used in a cornfield with very sticky, clayey soil, which may also have contained some agricultural chemicals. In general, changes in self-potential did not correlate with obvious changes in soil type or cultural activity.

b) Interpretation

The corrected, unsmoothed data for all three lines is shown in Fig. 1, with the zero of line SP-3 shifted so that all three lines are geographically aligned. The unsmoothed data exhibits a short-wavelength geologic noise level of about ±5 mV, with occasional larger variations, typical of self-potential measurements in desert soils (see also Fig. 8). The same data smoothed by use of a three-point running mean is plotted directly on 1:24000 quadrangles in Plates 1 and 2, which also show the survey lines in detail. The smoothed data plotted to 1:62500 map scale is shown in Figs. 2, 3, and 4, which also are reproduced as transparent overlays (Plates 2, 3, and 4) for convenience in comparing with other data on the same scale (Figs. 11, 12, and 13).

Several features of interest are apparent on the smoothed data. The most striking is the positive trend of the data to the west, beginning at about 1 km W on lines SP-1 and SP-2, and at about 0 km on SP-3 (equivalent to 1.6 km W on lines SP-1 and SP-2). It is dangerous to try matching anomalies line-to-line on such noisy data, but if the data from SP-2 is shifted about

Corrected Self-Potential Data Animas, N.M. 24-27 Jan 1977

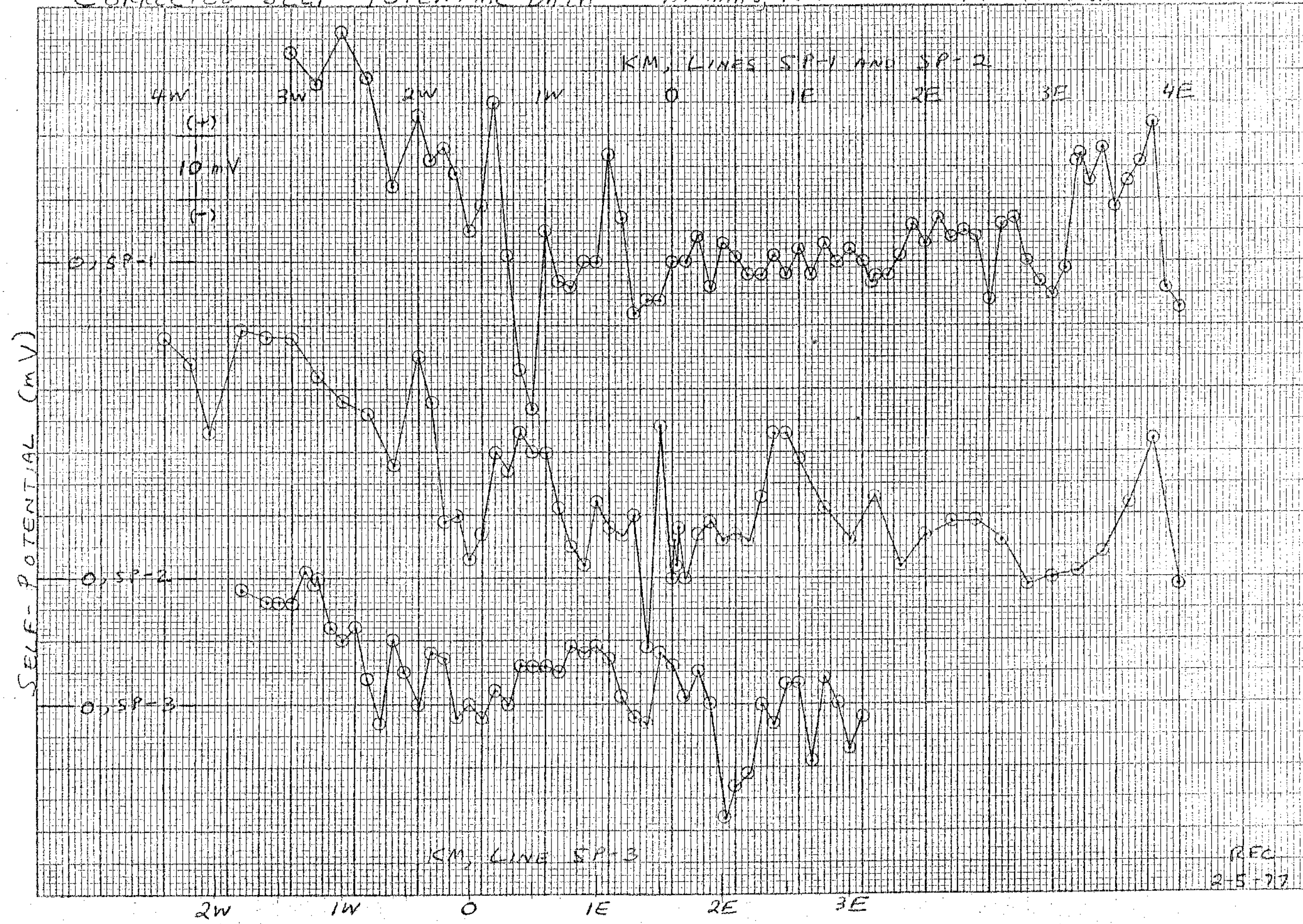


FIGURE 1

FIGURE 2

SMOOTHED SELF-POTENTIAL DATA, LINE SP-1

Scale 1:62500

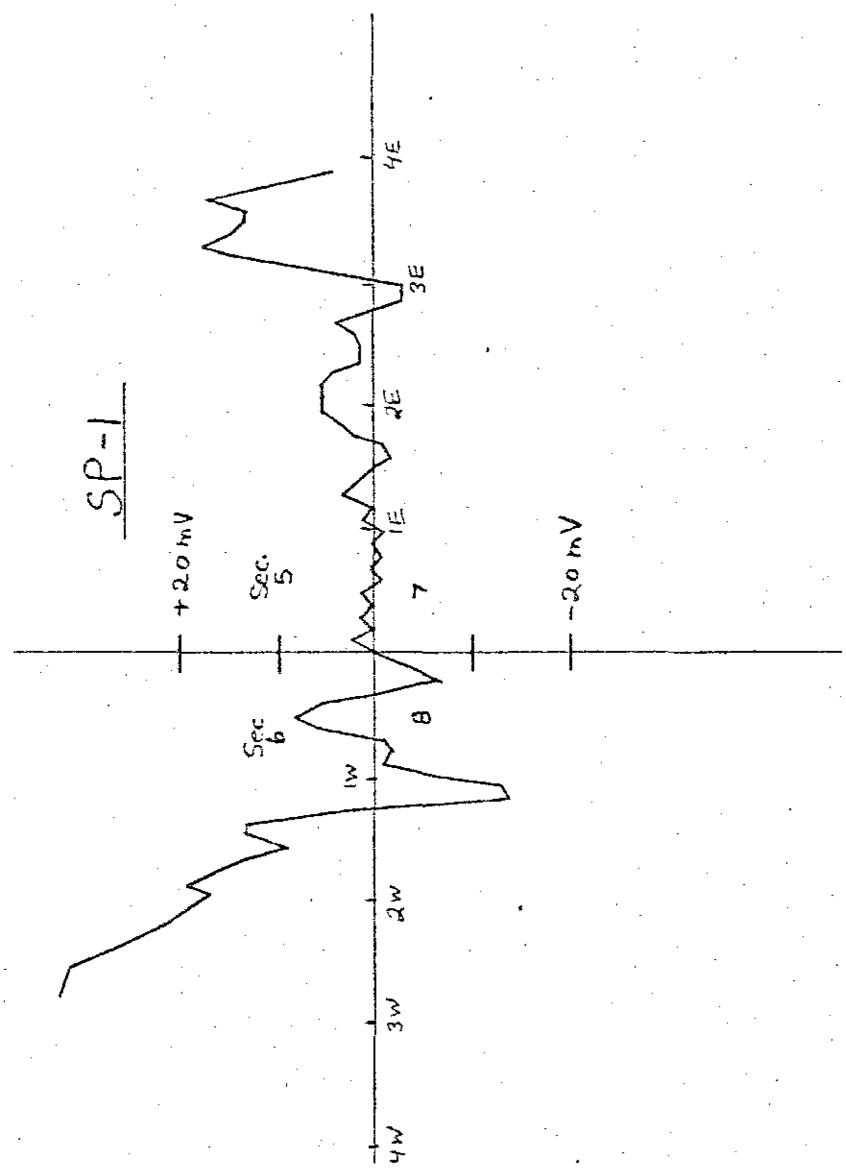
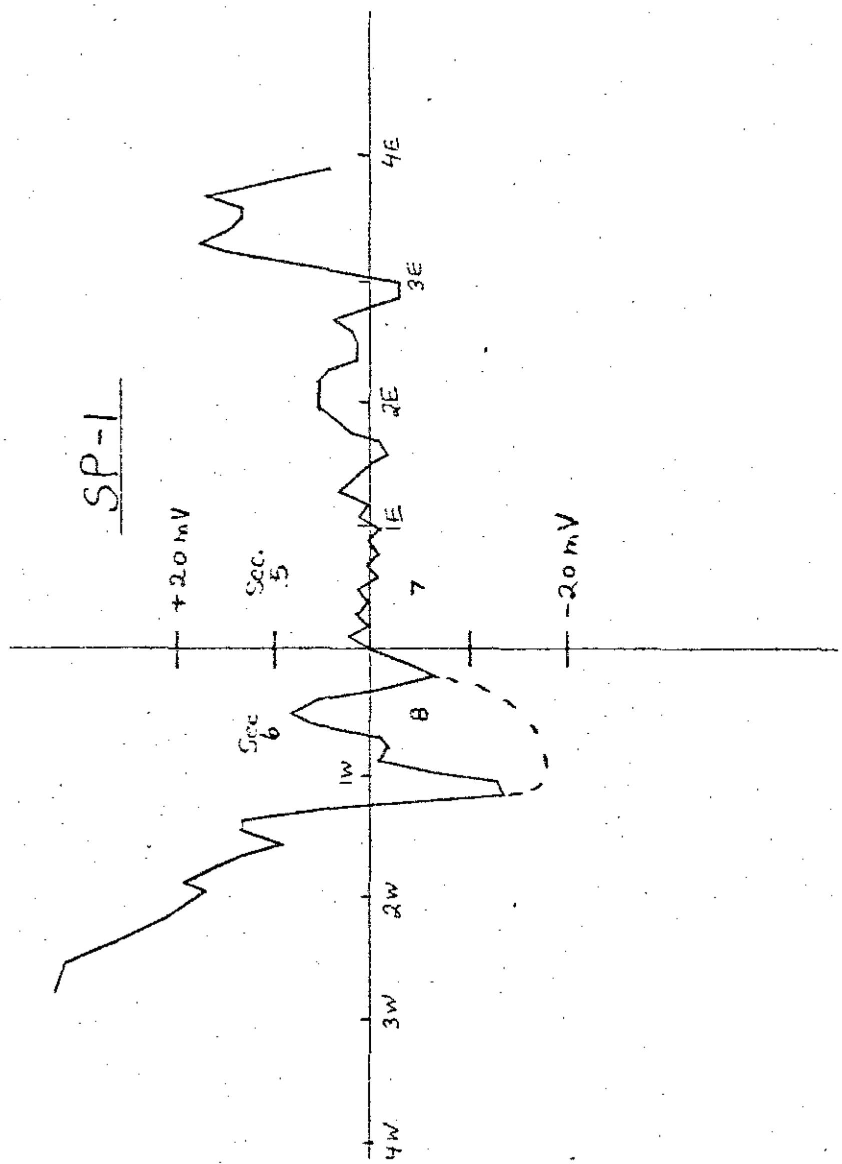


FIGURE 2a

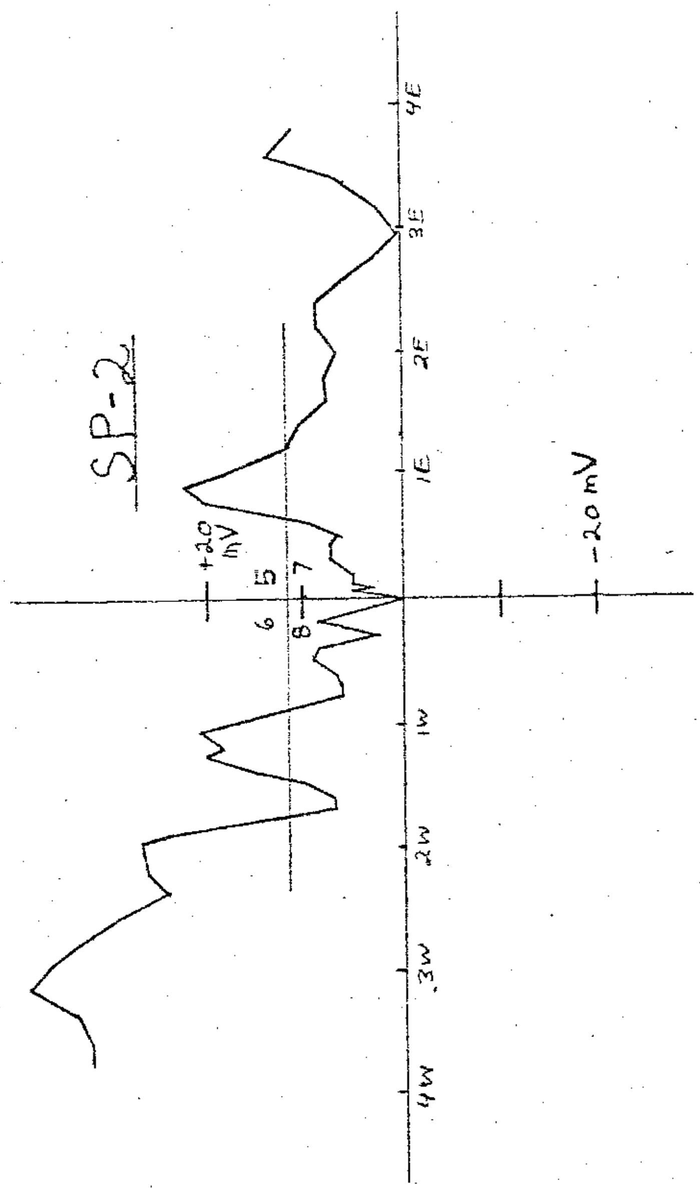
SP-1



Scale 1:62500

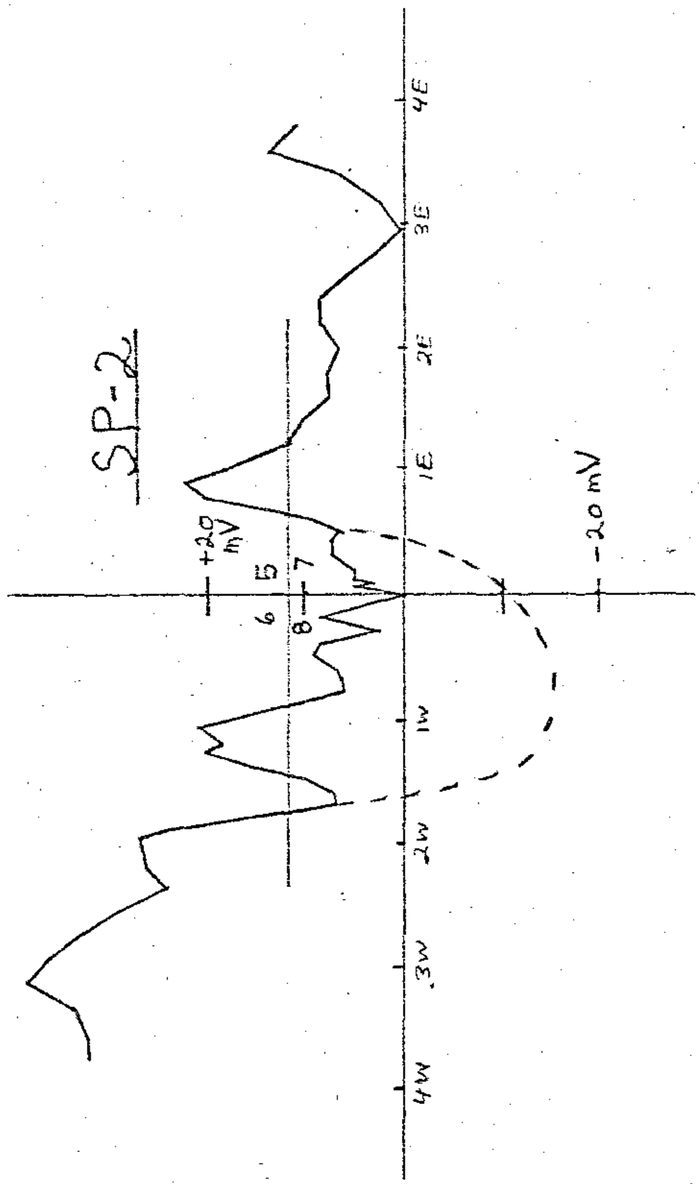
FIGURE 3

SMOOTHED SELF- POTENTIAL DATA, LINE SP-2



Scale 1:62500

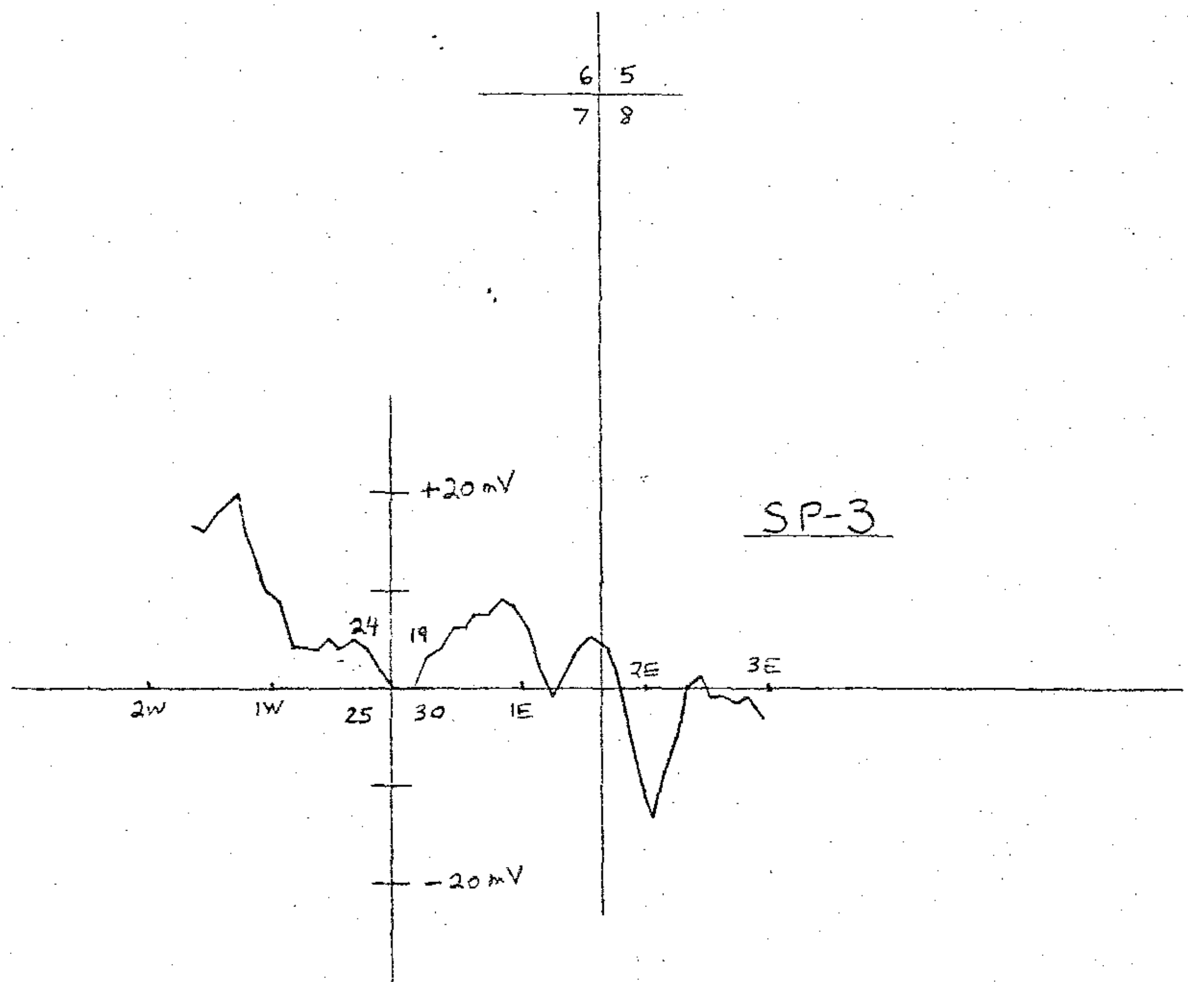
FIGURE 3a



Scale 1:62500

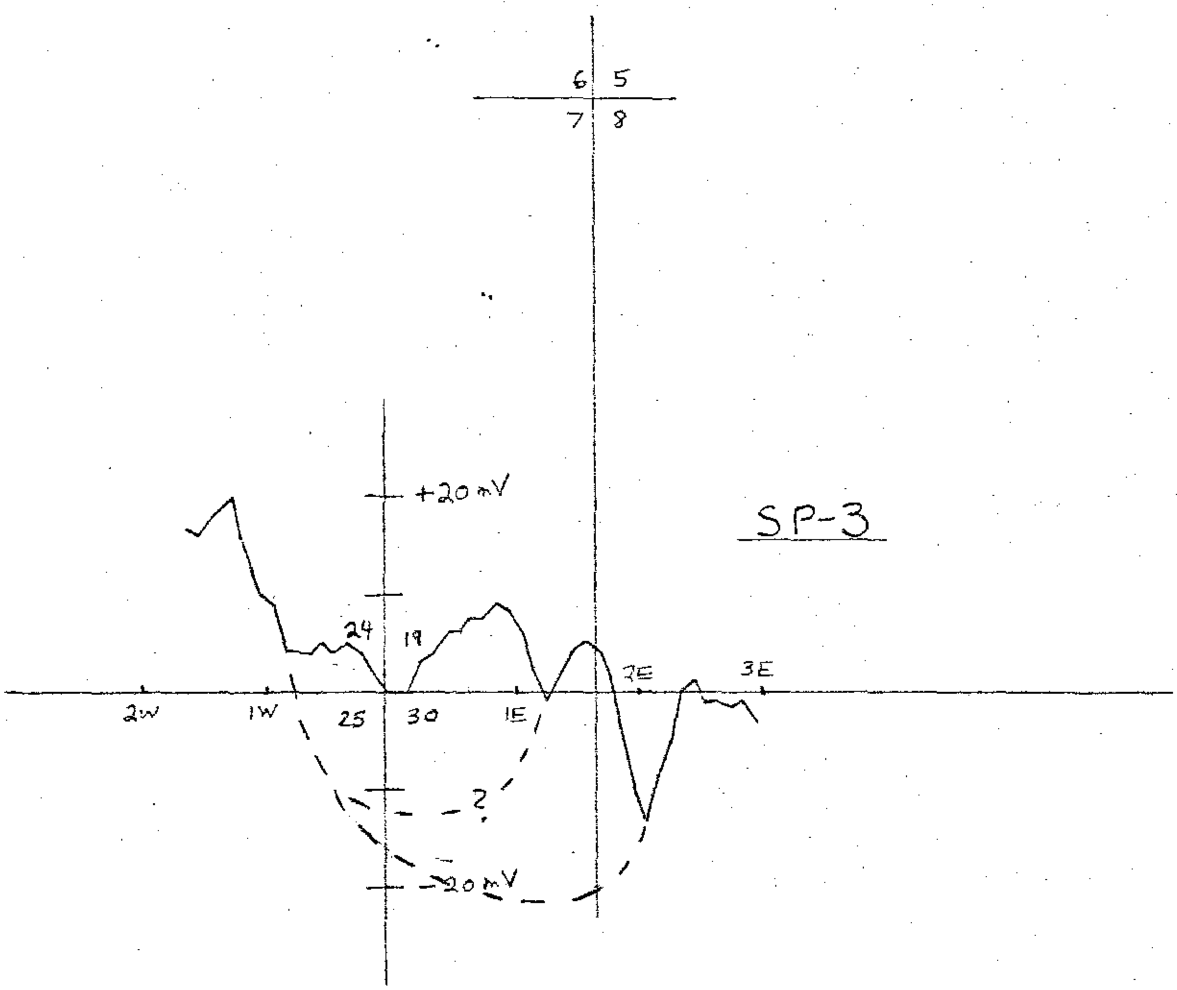
FIGURE 4

SMOOTHED SELF-POTENTIAL DATA, LINE SP-3



Scale 1:62500

FIGURE 4a



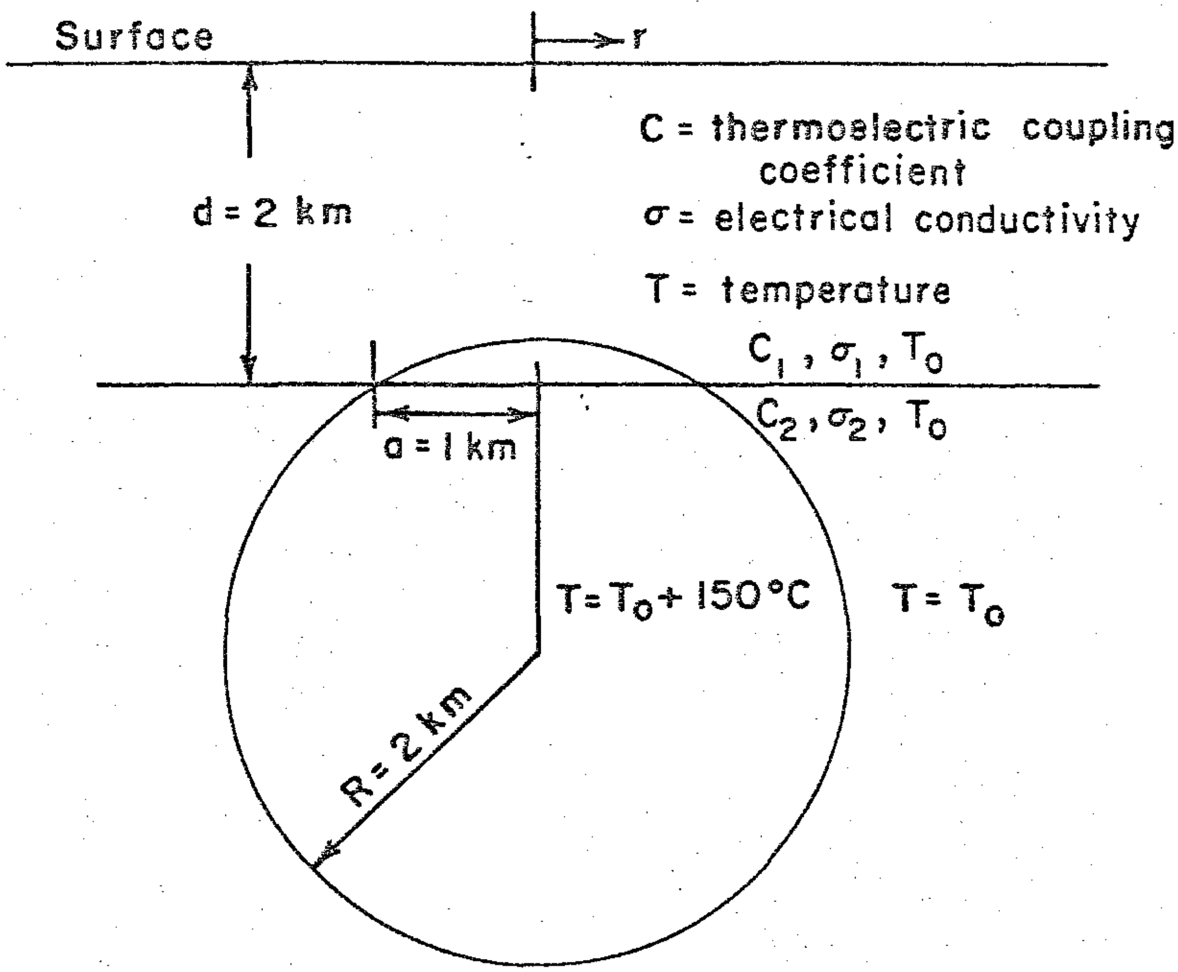
Scale 1:62500

500 m to the east it appears quite similar to the data from SP-1 between 0 km and 2 km W, and somewhat similar to SP-3 from about 1 km E to 1.2 km W. (An even more striking similarity is seen by overlaying the negative anomaly at 2 km E on line SP-3 on the similar negative anomalies at 1 km W on SP-1 and at 1.8 km W on SP-2, pointing out the difficulty of line-to-line matching without additional data between SP-2 and SP-3.) The zone of strong self-potential activity between 0 and 2 km W on SP-1 and between 2 km W and 1 km E on SP-2 is of particular interest because it encompasses the area of high heat flow shown on Fig. 11, and the center and western flank of the buried ridge implied by the gravity and resistivity data shown in Figs. 12 and 13.

There are four major sources of self-potential activity: conductive mineralization; near-surface variations in soil temperature, chemistry, or moisture content; thermoelectric potentials generated by a buried mass of elevated temperature; and streaming potentials generated by subsurface fluid flow. As there is no evidence for the existence of steady telluric currents, the subsurface resistivity pattern would not be expected to directly influnce the self-potential field. However, the channeling of currents generated by streaming potentials or thermoelectric coupling by boundaries of resistivity contrast could create an indirect effect on the surface self-potential field. There is no evidence of conductive mineralization in the area of interest, and there does not appear to be any consistent effect of cultural activity, so these two sources will not be considered further in this analysis.

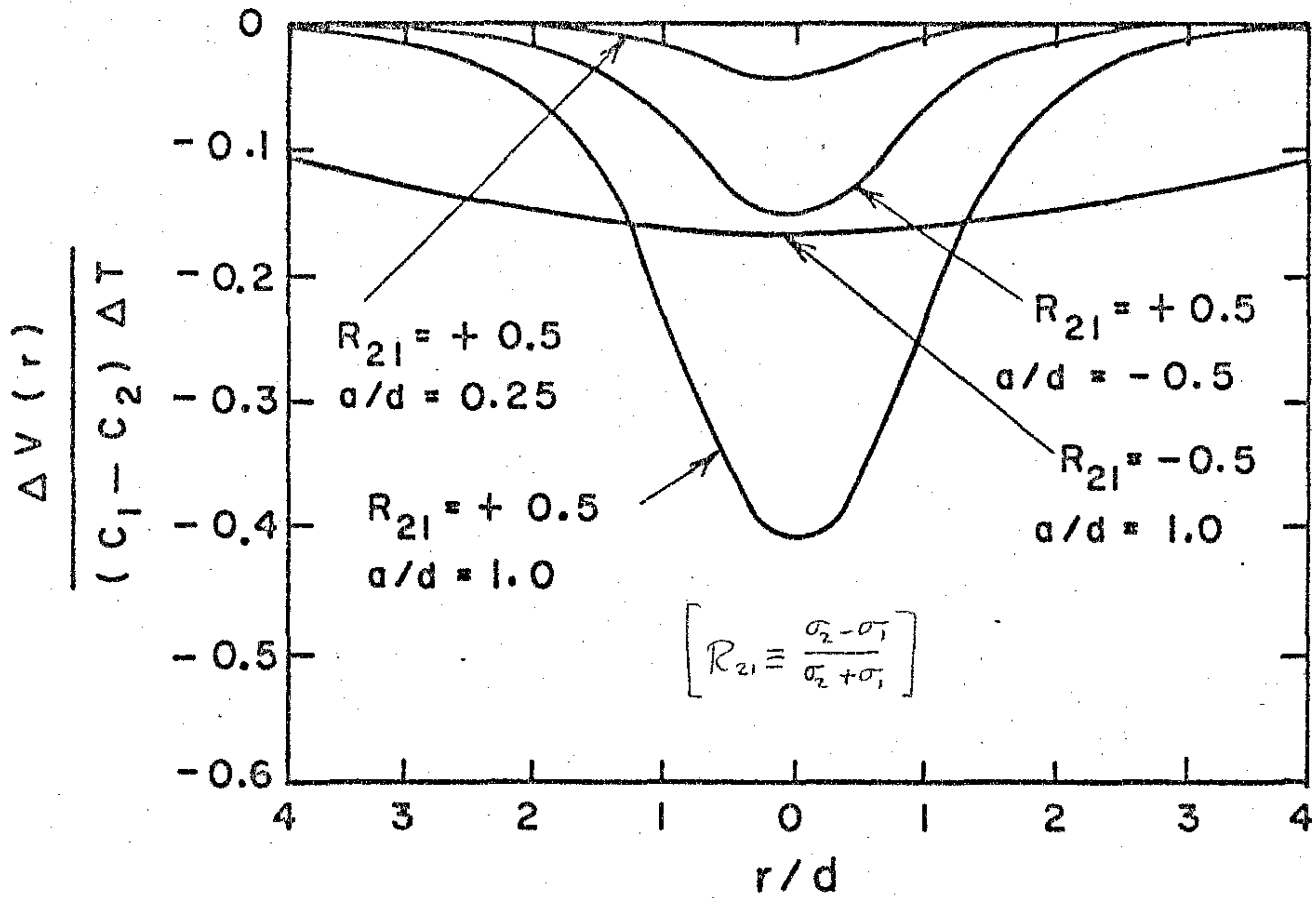
A brief study of the thermoelectric field generated by a buried sphere of elevated temperature done by Corwin (1976), based on the work of Nourbehecht (1963), indicates that thermoelectric effects may generate measurable self-potential anomalies (Figs. 5 and 6). The anomalies may be positive or negative, depending on the signs of the thermoelectric coupling coefficients.

FIGURE 5



XBL 7411-8277

Fig. 5. Thermoelectric Potential Generation (After Nourbehecht, 1963). By a Buried Sphere of Elevated Temperature



XBL7411-8268

FIGURE 6

Fig. 6. Plots of Thermoelectric Potential (After Nourbehecht, 1963). Over a Buried Sphere of Elevated Temperature

The generally broad shape of these anomalies could be altered to the sharper anomalies characteristic of the Animas data by inhomogenieties in the subsurface resistivity, such as the resistive buried ridge implied by the gravity and electrical resistivity data (Figs. 12 and 13). Two other previous geothermal self-potential surveys appear to give results similar to those at Animas; that is, a sharp-sided anomaly enclosing an area of known high heat flow. The first of these, shown in Fig. 7, was done by Zhody et al. (1973) over the thermal area of Yellowstone National Park. Here, the polarity of the anomaly is positive, but the steep-sided nature of the anomaly is apparent. The second is a survey done over the Leach Hot Springs area of Grass Valley, Nevada, shown in Figs. 8 and 9. Here, a steep-sided negative anomaly is seen to enclose the hot spring area, roughly coinciding with the 2 HFU contour Fig. 10). The geology of the Leach Hot Springs area shows a certain similarity to that of Animas, in that the thermal area is underlain by a zone of high resistivity; in this case a silicified "plug", the boundary of which roughly coincides with the 2 HFU contour, with an area of elevated P-wave velocity, and with the boundary of the self-potential anomaly. The hydrology of the Leach Hot Springs area has been studied in some detail by Olmsted et al. (1975), and it appears that vigorous water circulation takes place along a well-defined fault passing through the hot spring area.

Based on the above, a working hypothesis which may apply both to the Animas and Leach Hot Springs areas is that thermoelectrically generated currents may be responsible for the generally negative self-potential anomaly surrounding the thermal area, and that the high general level of shorter-wavelength activity over the thermal area is caused by vigorous subsurface fluid circulation. The steep-sided nature of the anomaly may be caused by

FIGURE 7

SELF-POTENTIAL OVER THE YELLOWSTONE THERMAL AREA

(from Zohdy et al, 1973)

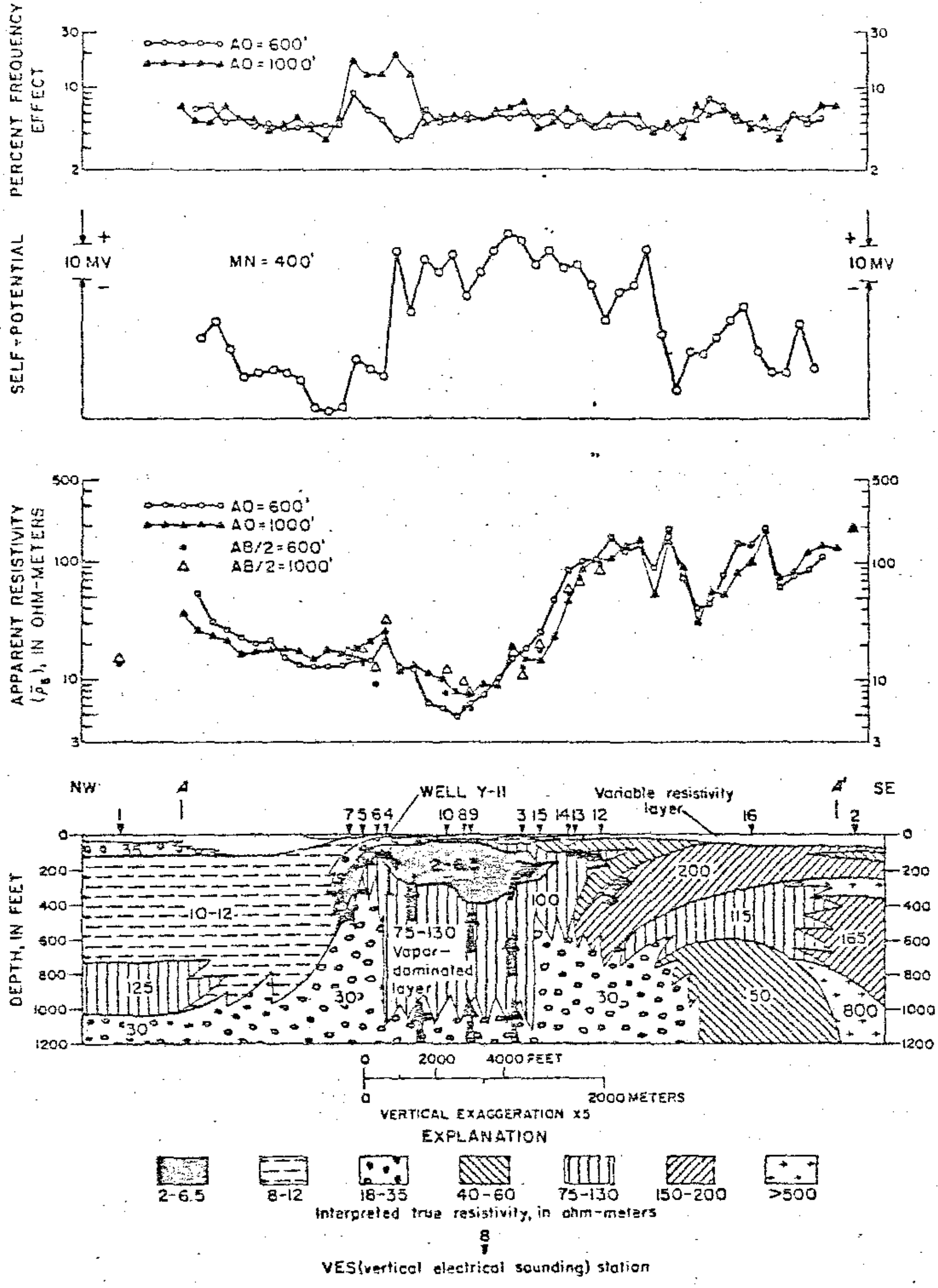


FIG. 13. Horizontal profiling data obtained with resistivity, SP, and IP (percent frequency effect). Arrows designate movement of steam and water. AO, distance from current electrode, A, to center of potential electrodes, O. MN, distance between potential electrodes. AB/2, Schlumberger-electrode spacing of VES curves.

potential is caused b
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of anions by the rock.
concentrate the cation
in a positive anomaly
water.

On the basis of Pol
to assume that the bro
portion directly over
from upward-moving
vection currents eman
ergy source. The low
northwest edge of the
result of downward-m
cycling process invol
thermal waters (comp
White et al, 1971).

The reason for th
anomaly beyond the
geothermal field (as in
is not understood. Po
amounts of the therm
the ground surface m
they reach the more
low apparent resistivi
The downward-movin
observed low level c
zones of low resistivi

The two IP profil
arithmic scale in the
The profiles are sim
tively high IP backg
cent which is attrib
of clayey materials a
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the amplitude of th
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by an increased qua
deposited by circula
the mineralogical an
that pyrite exists fro
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AO = 1000 ft anomal
that seen on the sh
that the pyrite and l
depth at the bounda
sibly a similar pyri
the small IP anoma
the vicinity of VES

FIGURE 8

Self-Potential, Line A-A', Grass Valley, Nevada, September, 1975

Note negative anomaly around thermal area, and high geologic noise level

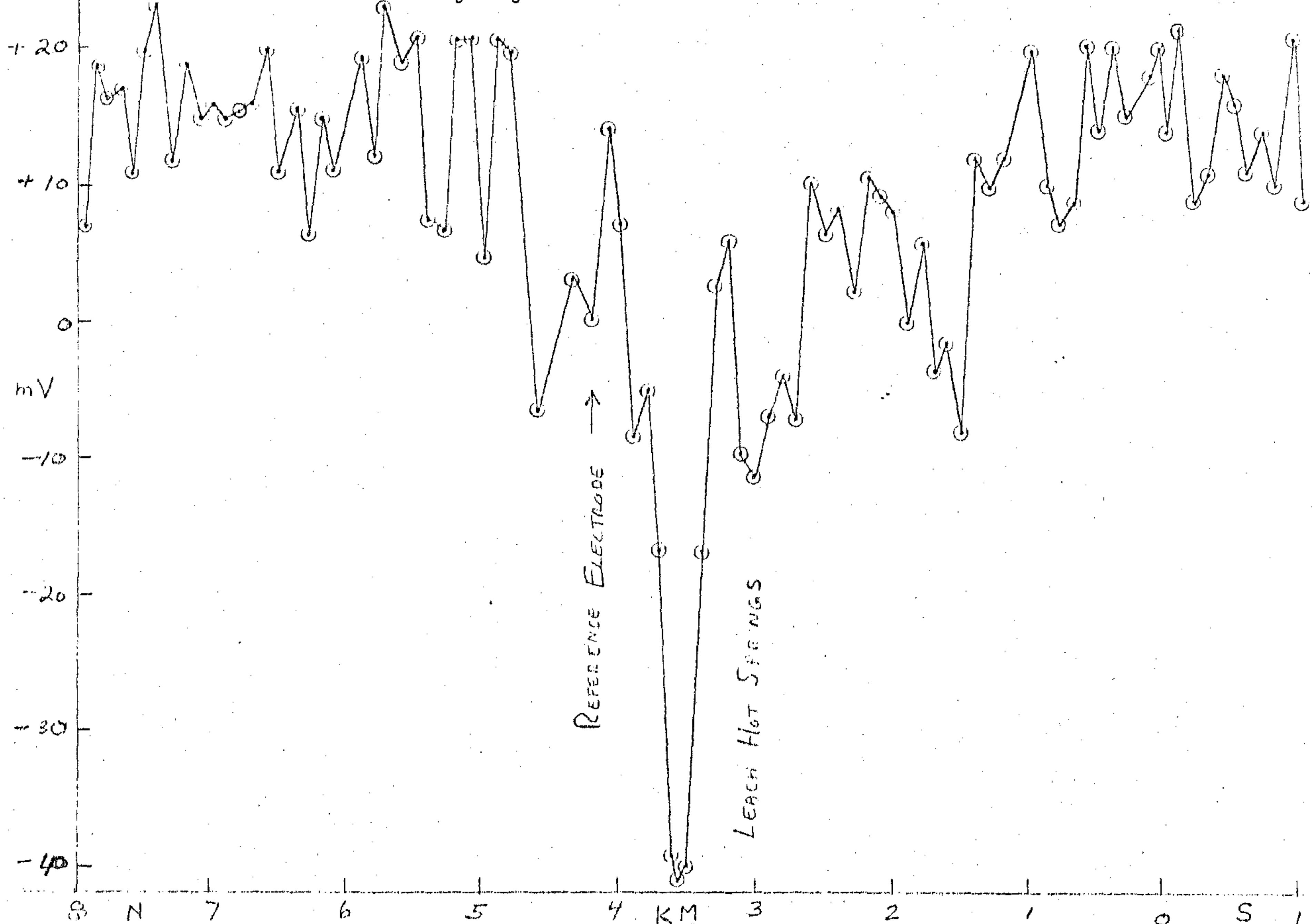


FIGURE 8

FIGURE 9

SELF-POTENTIAL
LEACH HOT SPRINGS AREA
GRASS VALLEY, NEV. SEPT. 1975

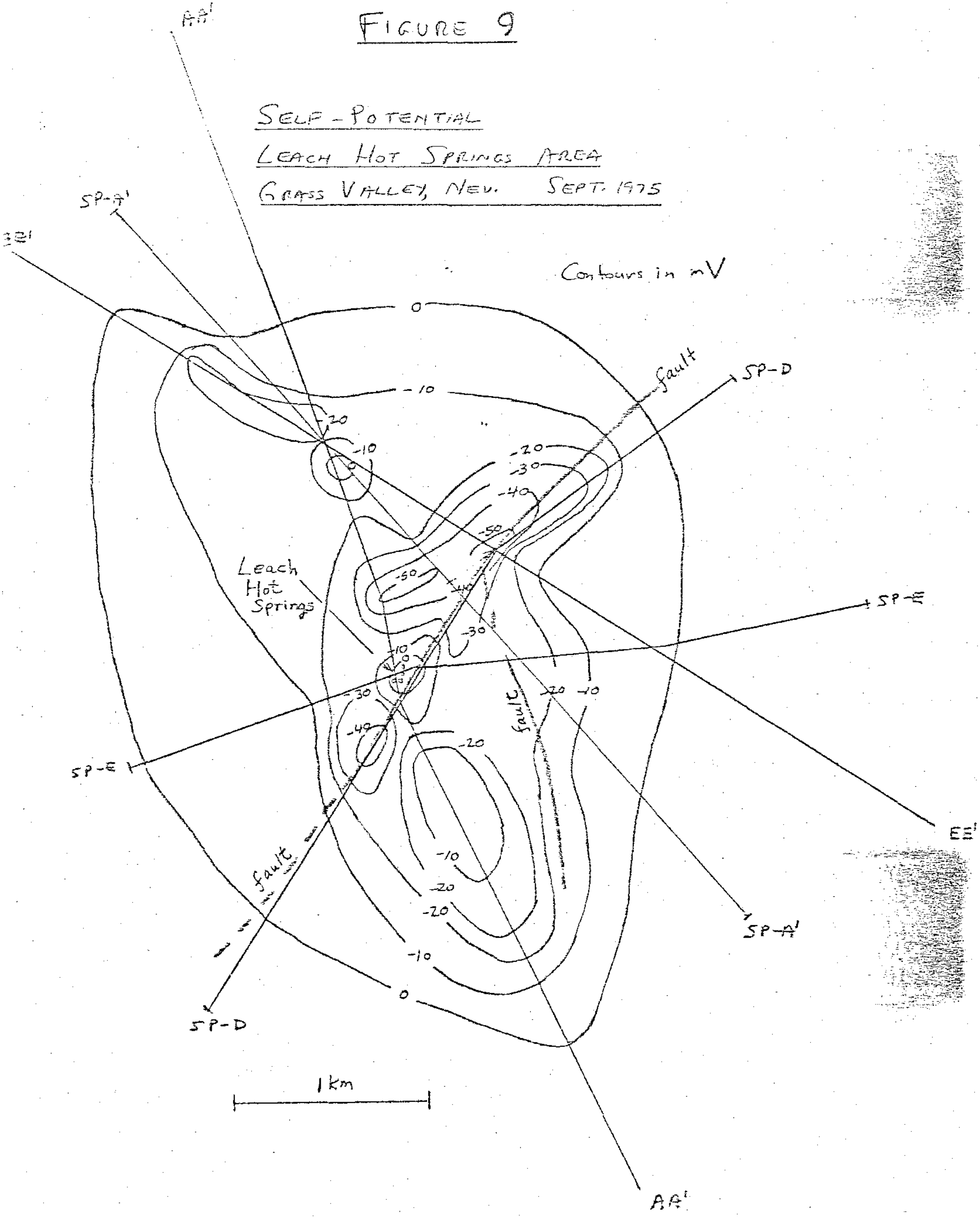
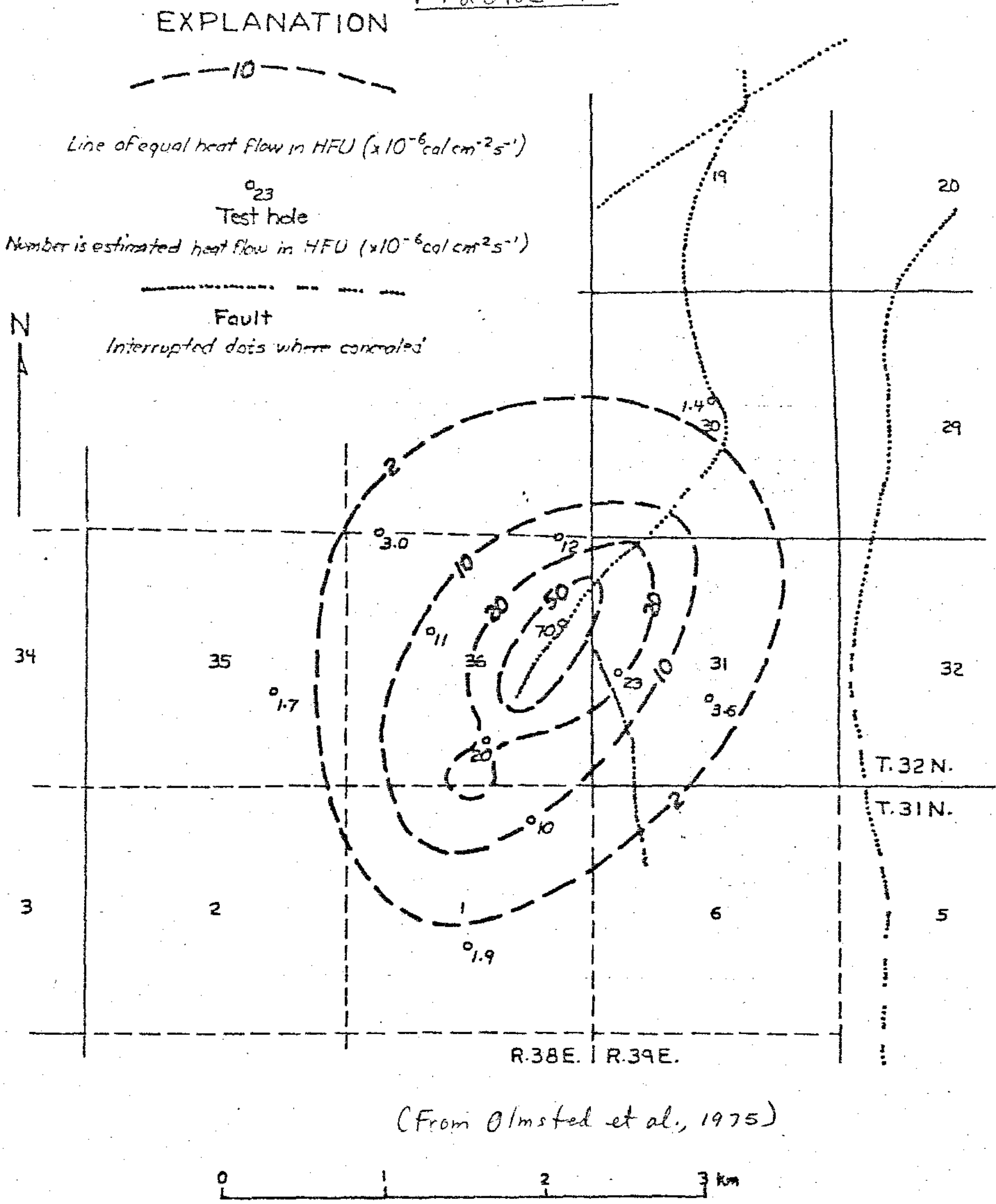


FIGURE 10



(From Olmsted et al., 1975)

Figure 10.--Map of Leach Hot Springs thermal area showing estimated near-surface heat flow.

FIGURE 11

HEAT FLOW DATA, ANIMAS, NEW MEXICO

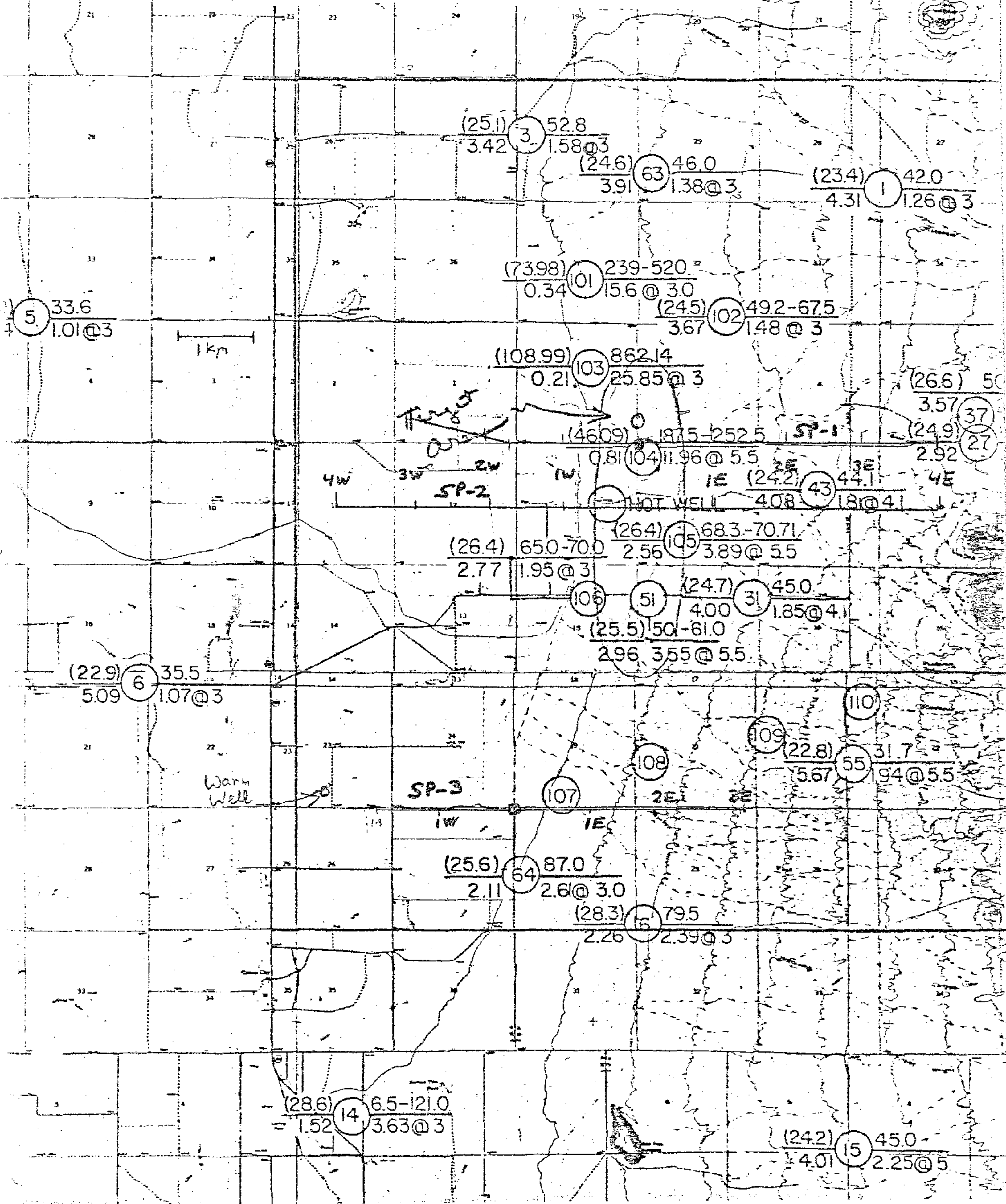


FIGURE 12

GRAVITY DATA, ANIMAS AREA, NEW MEXICO

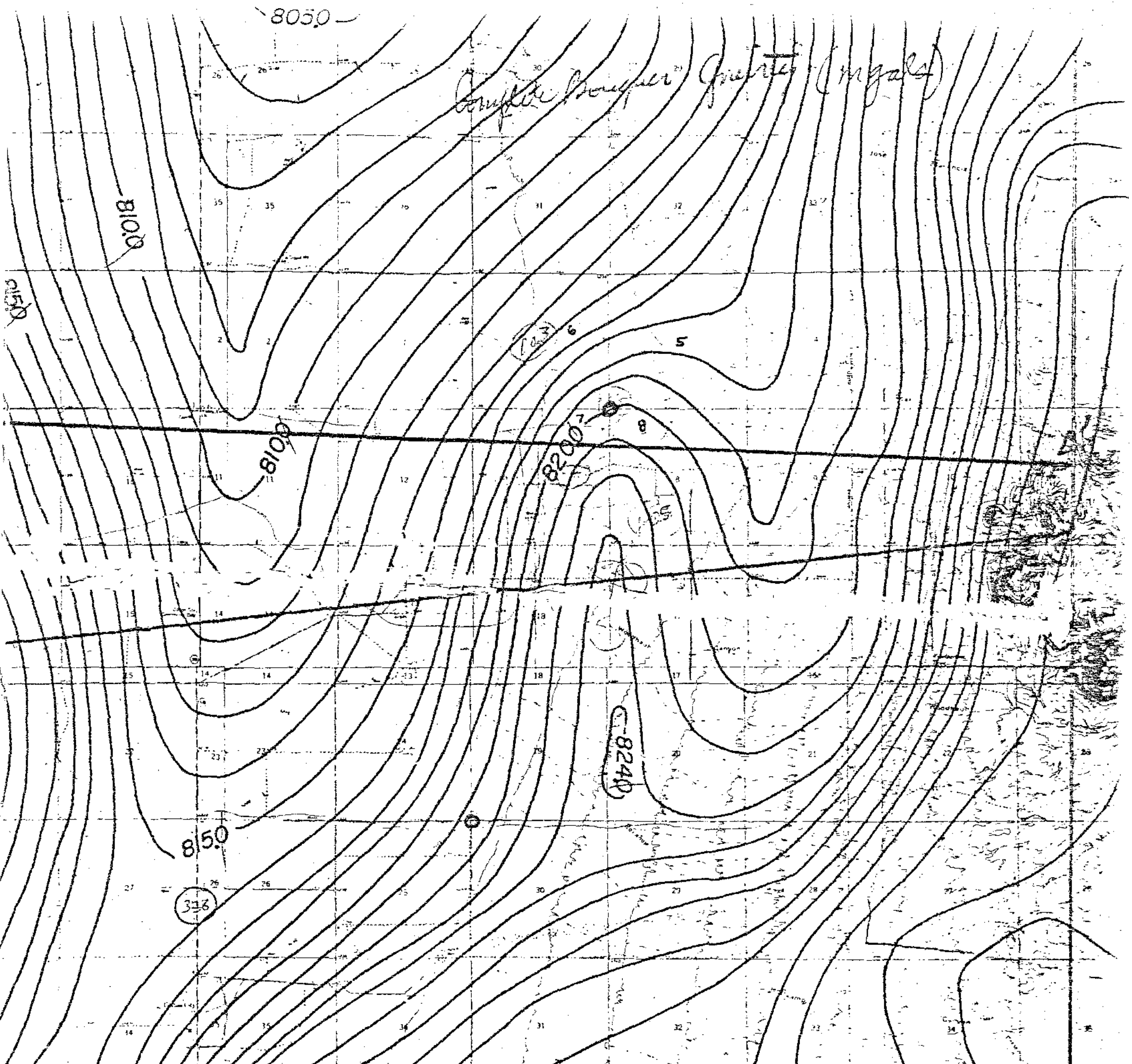
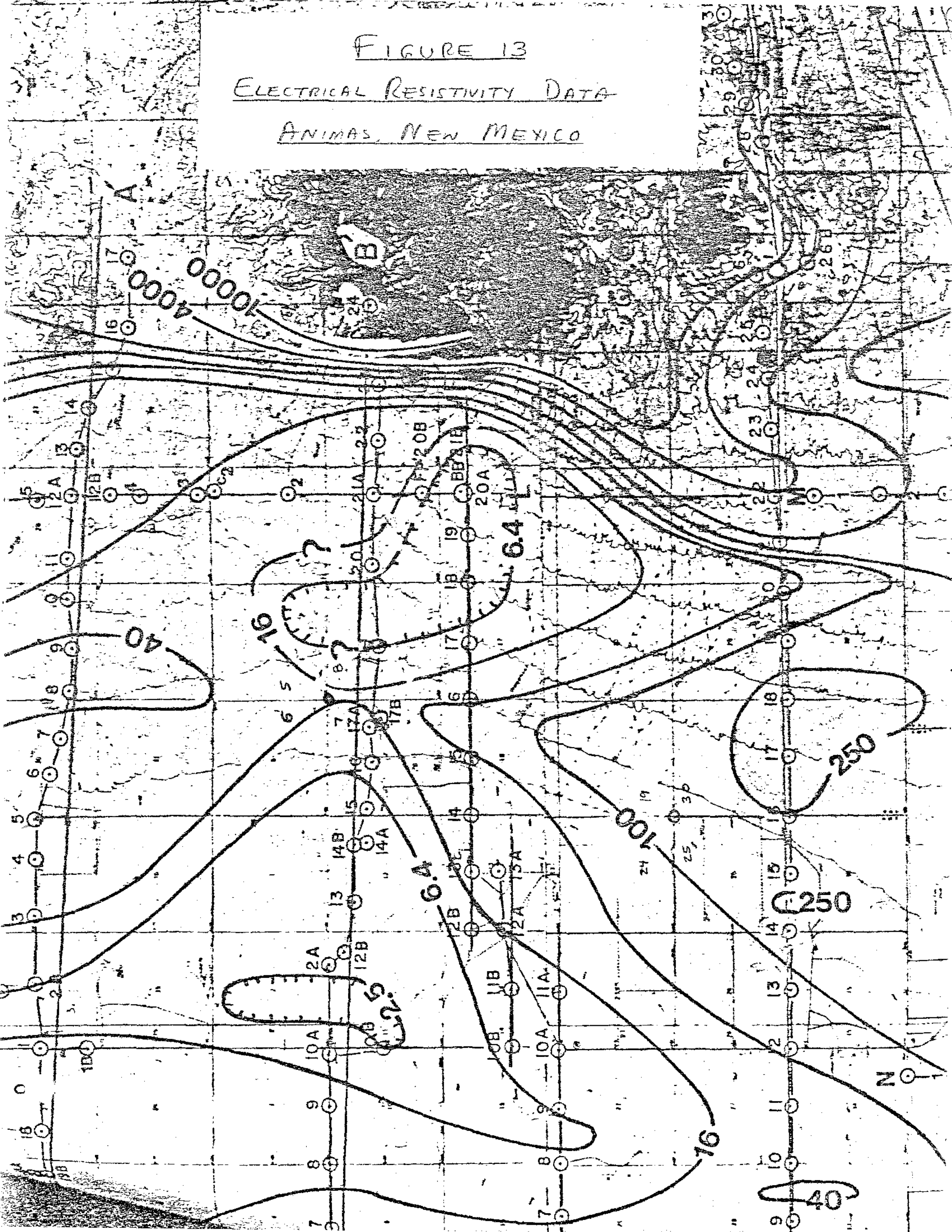


Figure 13

Electrical Resistivity Data

Animas, New Mexico



the channeling of the thermoelectric currents and streaming potentials by the electrically resistive material underlying the thermal area. Thus, the dotted lines on Figs. 1a, 2a, and 3a may represent the "thermoelectric" component of the anomaly, and the positive peaks at 0.5 km W on SP-1 and at 1.2 km W and 1 km E on SP-2 may represent areas where high heat flow and strong water movement interact near the edges of the subsurface resistive area. A similar effect, reduced in amplitude, may be seen on SP-3, where the positive climb of the data to the west corresponds to the steep western flank of the gravity contours; with a sharp negative anomaly toward the eastern edge of the ridge.

The significance of the positive areas on the eastern ends of lines SP-1 and SP-2 is difficult to evaluate, as they seem to be separated from the anomalous areas to the west by an area of more normal background, especially on SP-1. These eastern zones may represent an independent area of thermal or non-thermal water circulation in a fault zone, although there is no evidence for faulting at that location in the gravity or resistivity data.

It should be strongly stressed that the above analysis is hypothetical, and could be considerably modified by additional self-potential, heat flow, or hydrological data.

Conclusions and Recommendations

There appears to be significant self-potential activity in the area of known thermal activity, possibly caused by the interaction of thermoelectric currents and streaming potentials at the edges of a subsurface ridge of high electrical resistivity. The activity appears to continue, at reduced amplitude, to the south of the presently known thermal area.

If future self-potential work is done in the area, it would be useful to extend at least one line considerably to both the east and west, to ascertain that the anomalous activity is unique to the thermal area. Also useful would be additional lines between SP-2 and SP-3 to better trace the anomalous zone; a north-south tie line; and possibly a line several km to the north of SP-1, where no thermal activity is thought to exist. A proposal for the development of analytical techniques for the calculation of geochemical, thermoelectric, and streaming potential effects has been submitted to the U.S.G.S., and these techniques may become available in the next year if the proposal is funded.

A significant improvement in field technique could be effected by routinely carrying a container holding a stable reference electrode to check for drift of the moving electrode. This was tried successfully on one line in Animas. Also useful would be a small 60 Hz filter for use in areas close to power lines.

References

Corwin, R.F., 1976, Self-potential exploration for geothermal reservoirs: Proceedings, Second U.N. Symposium on the Development and Use of Geothermal Resources, V. 2, p. 937-945.

Nourbehecht, B., 1963, Irreversible thermodynamic effects in homogeneous media and their applications in certain geoelectric problems: Ph.D. thesis, Mass. Inst. of Tech.

Olmsted, F.H., P.A. Glancy, J.R. Harrill, F.E. Rush, and A.S. VanDenburgh, 1975, Preliminary hydrogeological appraisal of selected hydrothermal systems in northern and central Nevada: U.S.G.S. Open-File Report # 75-56.

Zhody, A.A.R., L.A. Anderson, and L.J.P. Muffler, 1973, Resistivity, self-potential, and induced polarization surveys of a vapor-dominated geothermal system: Geophysics, v.38, no.6, p.1130-1144.

FIELD DATA - LINE SP-1 24-25 JAN 1977

Reference electrode at section marker 5-6-7-8

Voltmeter: NLS LM-3. Reel resistance 1.24KΩ. Reference electrode TR-9, Moving electrode TR-10. Soil moist at ~1 cm depth. Weather cool, clear. "Virgin" desert unless otherwise noted.

TIME (MDT)	STATION (M)	ΔV (mV)	RES. (KΩ)	CORRECTIONS: DRIFT & POLARIZ. (mV)	CORRECTIONS: TELLURICS (mV)	CORRECTIONS: TOTAL (mV)	FINAL ΔV (mV) a	FINAL ΔV (mV) b (3-point running mean)	Comments
									Begin 24 Jan 77
1600	In Case	+3	—	—	—	—	—		TR9⁻, TR10⁺
1615	0	+6	2.4	−3	0	−3	+3	—	
1621	100E	+3	2.8	↓	↓	↓	0	+2	
1626	200E	+7	2.4				+4	0	
1630	300E	−1	2.4				−4	+1	
1635	400E	+6	2.4				+3	0	
1641	500E	+4	2.6				+1	+1	Creek bed; rocky soil
1646	600E	+1	2.4				−2	−1	
1651	700E	+1	2.6				−2	0	
1656	800E	+4	2.4				+1	−1	
1702	900E	+1	2.5				−2	0	
1707	1000E	+5	2.6				+2	−1	
1712	1100E	+1	2.5				−2	+1	
1718	1200E	+6	2.5				+3	0	
1723	1300E	+3	2.5				0	+3	
1745	0	+8	2.2				+5	—	
1755	In Case	+3	—	↓	↓	↓	—		TR9⁻ TR10⁺
									End 24 Jan 77

LINE SP-1 (Cont'd) 25 Jan 77

Equipment as for 24 Jan. Ref. electrode (TR-9) at sec. mkr. 5-6-7-8-

① TIME (MDT)	② STATION (m)	③ ΔV (mV)	④ RES. (KΩ)	⑤ CORRECTIONS: DRIFT & POLARIZ. (mV)	⑥ TELLURICS (mV)	⑦ TOTAL (mV)	⑧ FINAL ΔV (mV) a	b	⑨ COMMENTS
									Weather cool, clear
									Begin 25 Jan 77
0933	In Case	+3	—	—	—	—	+3		
0941	0	+10	2.6	-4	0	-4	+6		
1007	1000E	+9	2.8	↓	↓	↓	+5		
1017	1300E	+8	2.6				+4		electrode hole from 24 Jan
1018	1300E	+6	—				+2	+2	new electrode hole, 10 cm (5)
1024	1400E	+6	2.7				+2	+1	
1028	1500E	+4	2.5				0	0	
1034	1600E	+1	2.6				-3	-2	at sec. mkr. 5-4-8-9. 80 m E of 1500E
1039	1600E	+2	2.7				-2	-2	
1053	(1700E) 1800E	+5	2.6				(-2) +1	-1 +2	(missed 1700E; read later)
1058	1900E	+10	2.5				+6	+3	
1102	2000E	+7	2.6				+3	+5	
1106	2100E	+11	2.8				+7	+5	
1111	2200E	+8	2.5				+4	+5	
1114	2300E	+9	2.5				+5	+4	Sparse vegetation
1121	2400E	+8	2.5				+4	+1	9m. W. of mkr. ¼ sec 4-9
1126	2500E	-2	2.7				-6	+1	
1131	2600E	+10	2.7				+6	+2	
1136	2700E	+11	3.5				+7	+4	Soil rockier
1141	2800E	+4	2.8				0	+1	
	2870E			↓	↓	↓	—		Animas road

LINE SP-1 (Con't'd) 25 Jan 77

①	②	③	④	⑤	⑥	⑦	⑧ a	⑧ b	⑨
1146	2900E	+1	3.1	-4	0	-4	-3	-3	Rocky soil
1152	3000E	-1	3.0				-5	-3	"
1200	3225E	+21	2.9				+17	+15	" At sec. mkr. 4-3-9-10
1203	3200E	+20	3.2				+16	+11	Rocky
1207	3100E	+3	3.2				-1	+3	"
1214	3300E	+17	3.5				+16	+17	"
1219	3400E	+22	3.2				+18	+14	"
1224	3500E	+13	3.0				+9	+13	"
1228	3600E	+17	2.9				+13	+13	
1233	3700E	+20	3.2				+16	+17	Creek bed, rocky
1238	3800E	+26	3.1				+22	+11	
1243	3900E	0	2.3				-4	+4	20m E of creek bed. Soil wet, not rocky
1250	4000E	-3	2.9				-7	—	Rocky soil
1338	1700E	+2	2.5				+2	—	(missed earlier)
1423	0	+11	2.2				+7	—	
									Begin line to west
1445	100W	-2	2.4				-6	-4	
1454	200W	-2	2.3				-6	-7	
1506	300W	-4	2.4				-8	-2	
1510	400W	+11	2.9				+7	+5	
1514	500W	+21	2.7				+17	+8	
1518	600W	+4	3.3				0	+6	
1523	700W	+4	2.0				0	-1	
1527	800W	0	2.1	↓	↓	↓	-4	-2	25m W. of 1/2 sec. mkr.

LINE SP-1 (Cont'd) 25 Jan 77

①	②	③	④	⑤	⑥	⑦	⑧ a	⑧ b	⑨
1534	900W	+1	2.1	-4	0	-4	-3	-1	
1538	1000W	+9	2.8				+5	-7	
1541	1100W	-19	2.9				-23	-13	Sparse vegetation
1546	1200W	-13	3.0				-17	-14	Soil harden dryer some grass
1549	1300W	+5	2.1				+1	+3	Playa-like area, silty soil
1555	1400W	+29	1.8				+25	+13	Muddy soil, dense waist-high grass
1559	1500W	+13	2.0				+9	+13	60 m to sec. mkr. 1-6-7-12 Still grassy, less muddy
1606	1600W	+9	2.1				+5	+9	Soil grasy, hard, wet
1611	1700W	+18	2.0				+14	+13	30 m E of fence
1616	1800W	+22	1.9				+18	+16	} Heavily grazed grass,
1620	1900W	+20	2.0				+16	+19	} thistles, hard, wet soil
1624	2000W	+27	2.1				+23	+17	Playa-like area Wet soil
1630	2200W	+16	2.1				+12	+21	Fence at ~ 2380 W
1635	2400W	+33	2.4				+29	+26	
1642	2600W	+40	2.3				+36	+31	
1649	2800W	+32	1.9				+28	+32	300 m N. of section lines; light brown brick shed.
1703	3000W	+37	—				+33	—	Wire broken after Voltage rdng. At fence, 300 m. N of road, abandoned yellow Caterpiller tractor.
1756	0	+10	2.2	↓	↓	↓	+6		
1803	In case	+4	—	—	—	—	—		TR-9⁻, TR-10⁺

End line SP-1, End 25 Jan 77

LINE SP-2   26 Jan 77

Reference electrode at 1/2 section marker 7-8. Rain previous night. Soil wet. Weather cool, cloudy. Equip. as for 24 Jan.

① TIME (MDT)	② STATION (m)	③ ΔV (mV)	④ RES. (KΩ)	⑤ CORRECTIONS DRIFT + POLAR. (mV)	⑥ TELLURICS (mV)	⑦ TOTAL (mV)	⑧ FINAL ΔV (mV) a Raw	⑧ b 3 point mean	⑨ COMMENTS
0848	In case	+1	—	—	—	—	—		TR-9 (Ref.)⁻, TR-10⁺
0859	0	+2	3.2	-2	0	-2	0	—	
0904	100W	+26	2.7	-2		-2	+24	+4	
0909	200W	-8	2.6	-3		-3	-11	+8	
0916	300W	+13	2.6	-3		-3	+10	+2	
0923	400W	+11	2.5	-4		-4	+7	+8	30 m S. of first power pole (on section line)
0931	500W	+12	2.7	-4		-4	+8	+9	60 m S. of power line; hot well
0935	600W	+17	2.5	-5		-5	+12	+7	±1mV 60~ noise 60 m S. of Section line
0941	700W	+7	2.7	-5		-5	+2	+6	"
0948	800W	+11	2.4	-6		-6	+5	+6	Cows. On levee. ±2mV 60~. 60 m S. of sect. line
0954	900W	+17	2.3	-6		-6	+11	+12	In cornfield, waist-high stubble. Wet, sticky, clayey soil
0959	1000W	+26	2.2	-6		-6	+20	+17	"
1006	1100W	+27	2.2	-7		-7	+20	+21	"
1012	1200W	+30	2.2	-7		-7	+23	+20	Out of cornfield, in bare plowed area.
1019	1300W	+25	2.1	-8		-8	+17	+20	Back into cornfield. ±2mV 60~
1026	1400W	+28	2.1	-8		-8	+20	+15	"
1032	1500W	+16	2.3	-9		-9	+7	+10	"
1040	1600W	+12	2.2	-9		-9	+3	+7	"
1046	1700W	+19	2.5	-9		-9	+10	+7	" 10 m N. of sect. line
1052	1800W	+19	2.4	-10	V	-10	+9	+16	" ±3mV 60~

LINE SP-2 (Cont'd) 26 Jan 77

①	②	③	④	⑤	⑥	⑦	⑧ a	⑧ b	⑨
1058	1900W	+38	2.1	-10	0	-10	+28	+24	Burned area, Hard, rocky soil ±3mV 60~
1106	2000W	+46	2.1	-11		-11	+35	+27	Harder, dryer soil ±3mV 60~
1114	2200W	+29	2.4	-11		-11	+18	+26	" , sandy. Cows. ±3mV 60~
1122	2400W	+38	2.2	-12		-12	+26	+24	dryer soil ±3mV 60~
1128	2600W	+40	3.1	-12		-12	+28	+29	"
1134	2800W	+45	2.6	-13		-13	+32	+33	" playa area
1141	3000W	+51	3.0	-13		-13	+38	+36	vegetation – small trees
1149	3200W	+51	2.4	-13		-13	+38	+38	8 m SW of sec. mkr
1156	3400W	+53	2.5	-14		-14	+39	+33	
1201	3600W	+37	2.9	-14		-14	+23	+32	
1207	3800W	+49	2.5	-15		-15	+34	+32	
1214	4000W	+53	1.9	-15		-15	+38	–	At section corner
1326	0	+15	2.8	-16		-16	-1		
			Begin line to East						
1355	100E	+26	2.6	-16		-16	0	+5	
1359	50E	+24	3.3	-16		-16	+8	+3	Rocky
1401	25E	+18	2.8	-16		-16	+2	+5	
1404	15E	+21	2.6	-15		-15	+6	+3	
1411	200E	+22	2.8	-15		-15	+7	+5	
1416	300E	+24	2.7	-15		-15	+9	+7	
1420	400E	+21	2.4	-15		-15	+6	+7	At road. Rocky.
1425	500E	+22	2.6	-15		-15	+7	+6	Along road
1429	600E	+20	3.0	-14		-14	+6	+9	Rocky
1435	700E	+27	2.8	-14	↓	-14	+13	+14	↓

LINE SP-2 (Cont'd) 26 Jan 77

①	②	③	④	⑤	⑥	⑦	⑧		⑨
1441	800E	+37	2.5	-14	0	-14	+23	+20	along road
1444	900E	+37	2.5	-14	|	-14	+23	+22	"
1449	1000E	+33	2.5	-14		-14	+19	+18	Scattered yuccas. "
1454	1200E	+24	2.8	-13		-13	+11	+12	S. of road
1500	1400E	+18	2.4	-13		-13	+6	+10	along road
1506	1600E	+26	2.6	-13		-13	+13	+7	"
1511	1800E	+15	3.1	-13		-13	+2	+7	"
1518	2000E	+20	2.9	-13		-13	+7	+6	"
1524	2200E	+22	2.6	-13		-13	+9	+8	"
1529	2400E	+21	2.7	-12		-12	+9	+8	"
1533	2600E	+18	2.4	-12		-12	+6	+5	"
1541	2800E	+11	2.4	-12		-12	-1	+2	2900m = animas road. Yuccas end "
1548	3000E	+12	2.6	-12		-12	0	0	
1553	3200E	+13	2.6	-12		-12	+1	+2	~3275: 50m N of well, windmill, corral
1604	3400E	+15	3.4	-11		-11	+4	+6	Rocky - Online
1611	3600E	+23	2.8	-11		-11	+12	+13	" "
1616	3800E	+33	4.2	-11		-11	+22	+11	" "
1622	4000E	+10	2.7	-11		-11	-1	—	" "
1722	0,SP-2	+8	2.7	-11		-11	-3		
1736	0,SP-1	+14	2.5	-10		-10	*		* 0,SP-2 is -6mV wrt 0,SP-1
1756	0,SP-2	+4	2.8	-10		-10	—		
1800	In case	+3	—		V				TR-9⁻, TR-10⁺

End Line SP-2

LINE SP-3   27 Jan 77

Equipment as for 24 Jan. Weather partly cloudy, cool.
Ref. electrode (TR-9) at section marker 24-19-25-30, on levee.
Electrode TR-11 carried in case as portable drift reference, readings of TR-11⁻, TR-10⁺ recorded in col. ⑨. Soil wet, rocky

① TIME (MDT)	② STATION (m)	③ ΔV (mV)	④ RES. (KΩ)	⑤ CORRECTIONS: DRIFT & POLAR. (mV)	⑥ TELLURICS (mV)	⑦ TOTAL (mV)	⑧ FINAL ΔV (mV) RAW	⑧ FINAL ΔV (mV) 3 point mean	⑨ TR-11⁻ TR-10⁺	⑩ Comments
0951	In case	+1	—	—	—	—	—		+6	TR9⁻ (Ref), TR-10⁺
1011	0	+6	2.3	0	0	0	—	0	+7	Up slight pediment,
1018	100E	-2	2.4	|	|	|	-2	0		Virgin desert ↓
1025	200E	+2	2.5				+2	0		
1028	300E	0	2.4				0	+3		
1033	400E	+6	2.5				+6	+4		
1038	500E	+6	2.5				+6	+6	+8	
1044	600E	+6	2.4				+6	+6		
1049	700E	+5	2.5				+5	+7		
1054	800E	+9	2.4				+9	+7		
1058	900E	+8	2.5				+8	+9		
1102	1000E	+9	2.3				+9	+8	+9	
1107	1100E	+7	2.4				+7	+6		
1112	1200E	+1	2.8				+1	+2		
1118	1300E	-2	2.5				-2	-1		
1126	1400E	-3	2.5				-3	+1		
1131	1500E	+8	2.5	↓	↓	↓	+8	+4	+9	

1570 m sec. mkr 19-20-30-29

LINE SP-3 (Cont'd) 27 Jan 77

①	②	③	④	⑤	⑥	⑦	⑧ Raw	⑧ 3 point mean	⑨	⑩
1139	1600E	+6	2.8	0	0	0	+6 (circled)	+5		
1144	1700E	+1	2.3				+1	+4		~±1mV tellurics
1149	1800E	+5	2.4				+5	+2		"
1154	1900E	0	2.7				0	-4		
1202	2010E	-18	2.8				-18	-10	+8	~10m E of creek bed very rocky soil
1209	2100E	-13	2.3				-13	-14		
1216	2200E	-11	2.4				-11	-9		
1221	2300E	0	2.4				0	-5		
1227	2400E	-3	2.4				-3	0		
1232	2500E	+3	2.6				+3	+1	+8	
1241	2600E	+3	2.6				+3	-1		± 1mV tellurics
1247	2700E	-9	2.5				-9	-1		clay soil
1253	2800E	+4	2.5				+4	-2		sandy soil ±1mV tellurics
1259	2900E	0	2.8				0	-1		
1304	3000E	-7	2.5				-7	-3	+6	±2mV tellurics
1316	3100E	-2	3.0				-2	—		Sandier soil
1323	3200E	—	—				—		+5	Wire broken. 20m W. of sec. mkr
1421	0	+9	—				—			

Begin use of new reel, wire resistance = 1.39 KΩ

Begin line to west; flat, cultivated land

①	②	③	④	⑤	⑥	⑦	⑧ Raw	⑧ 3 point mean	⑨	⑩
1450	0						0	—	+3	
1503	100W	-2	2.0				-2	+2		Hard soil, scattered junk, barren
1507	200W	+7	2.0				+7	+4		"
1512	300W	+8	2.0				+8	+5		"
1517	400W	0	1.9	V	V	V	0	+4		Hard soil At 1/4 section.

LINE SP-3 (Cont'd) 27 Jan 77

①	②	③	④	⑤	⑥	⑦	⑧ RAW	⑧ 3 point mean	⑨	⑩
1523	500W	+43	1.9	0	0	0	—		ignore- probable buried junk	bare, clayey playa-like. Scattered junk.
1527	500W	+14	1.9				—		+2	in plowed cornfield, across rd, 20m to S
1534	520W	+5	2.0				+5	+5		in "playa"
1540	600W	+10	1.9				+10	+4		cotton-corn boundary across rd to S
1544	700W	-3	2.0				-3	+4		sheetwash area
1551	800W	+4	1.9				+4	+4		Eedge of cornfield, in road shoulder
1556	900W	+12	2.0				+12	+9		wet, clayey soil, heavily plowed S. border of cornfield to N of Rd.
1559	1000W	+10	2.0				+10	+10	+2	"
1606	1100W	+9	2.0				+9	+13		" 60~, +6⟺+12
1612	1200W	+20	1.9				+20	+16		" " +16⟺+23
1618	1220W	+19	2.1				+19	+20		" " +15⟺+22
1624	1300W	+21	1.9				+21	+19		" +17⟺+24 In cornfield to S. of rd
1630	1400W	+16	1.9				+16	+18		+12⟺+20 "
1636	1500W	+16	2.2				+16	+16	+2	"
1644	1600W	+16	2.2				+16	+17		~40 m E of sec mkr
1653	1800W	+18	2.2				+18	—	+1	In plowed-under cornfield possible gas pipeline
1732	0	+9	2.2	↓	↓	↓			+1	
	In case	-2		$TR-11^{-}$, $TR-9^{+}$						
	"	+4		$TR-9^{-}$, $TR-10^{+}$						

End line SP-3

DRIFT AND ELECTRODE POLARIZATION CORRECTION (COLUMN 5)

The electrode polarization as read in the carrying case is subtracted from all readings. If initial and final readings differ, drift is assumed to be linear with time unless other data (e.g., repeated reading at zero or other station, or measurement against an independent reference electrode) indicate otherwise. Repeated readings made in the ground are not a good indication of drift, as the disturbed soil tends to dry between readings and thus change potential. Drift is ignored if it is less than 2-3 mV; the limit of reproduceability in most desert soils. The reference electrode is arbitrarily considered to be at zero potential unless referenced to another line.

1) Line SP-1 24 Jan 77

Initial reading in case	+3mV	Polarization correction -3mV
Final " " "	+3mV	Drift = 0

2) Line SP-1 25 Jan 77

Initial reading in case	+3	Polarization correction -4mV
Initial reading at 0 km	+10	Drift = 0
1423 " " "	+11	
1756 " " "	+10	
Final " in case	+4	

3) LINE SP-2 26 Jan 77

0848	Initial reading in case	+1 mV
1326	at 0	+15
1722	" "	+8
1800	In case	+3

Polarization correction −2 mV. Drift correction, from 0848 to 1326 = −14 mV/32 rdngs or −0.44 mV/rdng. ∴ Total correction is −(2+.44 n) mV, thru 4000 W.

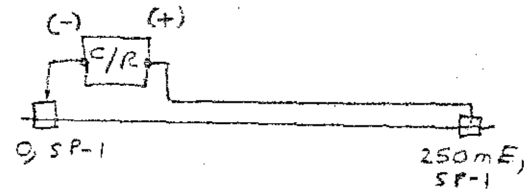
For 0 − 4000 E, initial polarization is +16 mV, final is +10 (8+2)

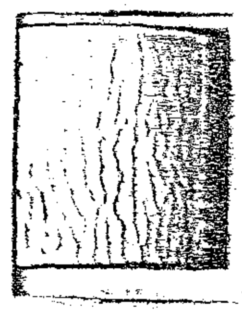
∴ Correction is $-(16 - \frac{6\,mV}{31\,rdngs} \times n)$ or $-(16 - .194n)$

4) LINE SP-3 27 Jan 77

0951	In case TR9⁻ TR10⁺	+1	Polarization ~1 mV - ignore. Drift ~ −1 mV - ignore ∴ no correction for 0 - 3200 E
"	" TR11⁻ TR10⁺	+6	
"	at 0	+6	
1421	"	+9	
1421	TR11⁻ TR10⁺	+5	
1450	In case TR11⁻, TR10⁺	+3	Drift & polarization ~ 2 mV : ignore
1732	" " "	+1	
	" TR9⁻ TR10⁺	+4	

TELLURIC MONITOR





Each small division = $\frac{20}{50} \times \frac{1000}{250}$ or 1.6 mV/km, East^{+} →

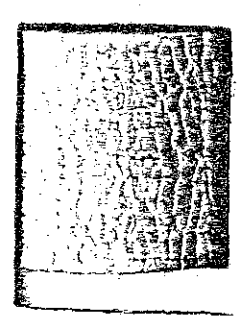
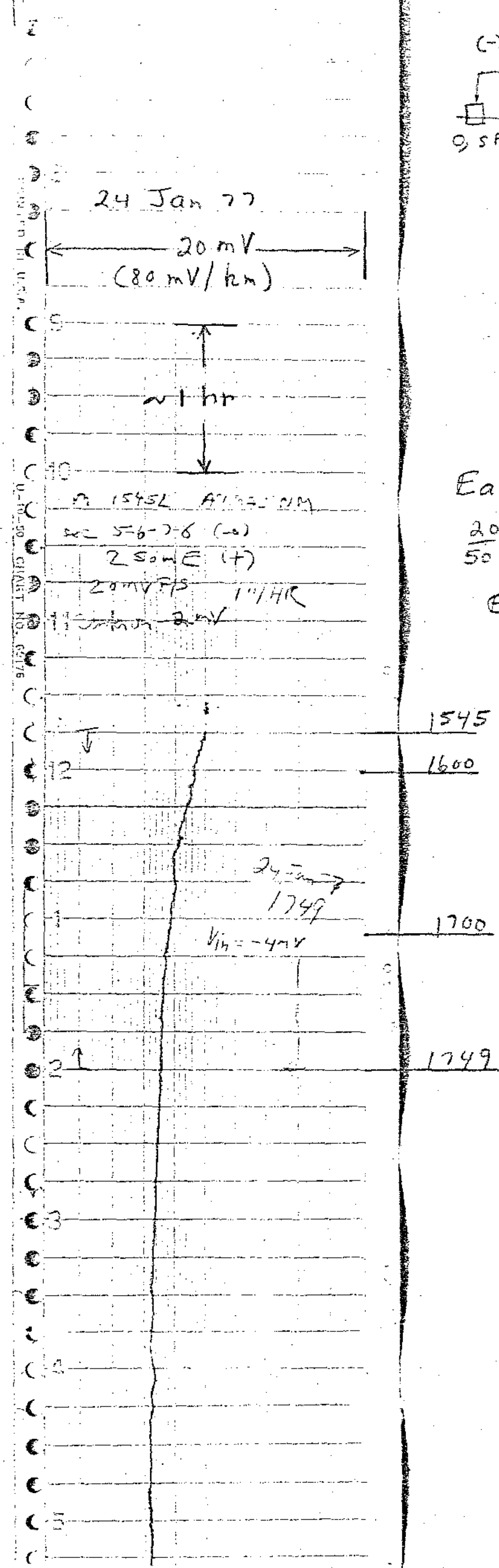


FIG. 14



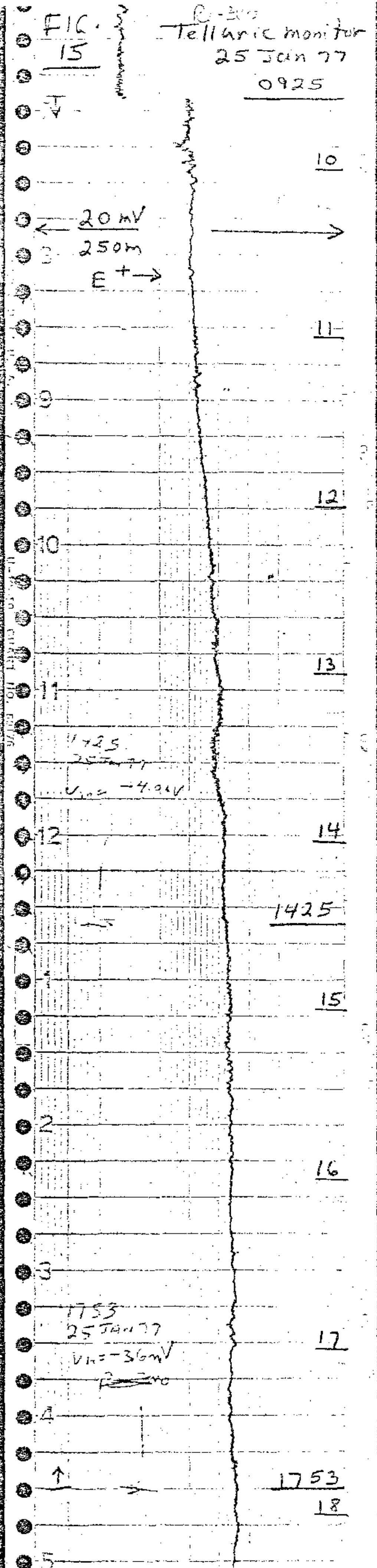


FIG. 15
Telluric monitor
25 Jan 77
0925
10
20 mV
250m
E +
11
12
13
1425
14
1425
15
16
1753
25 JAN 77
17
1753
18

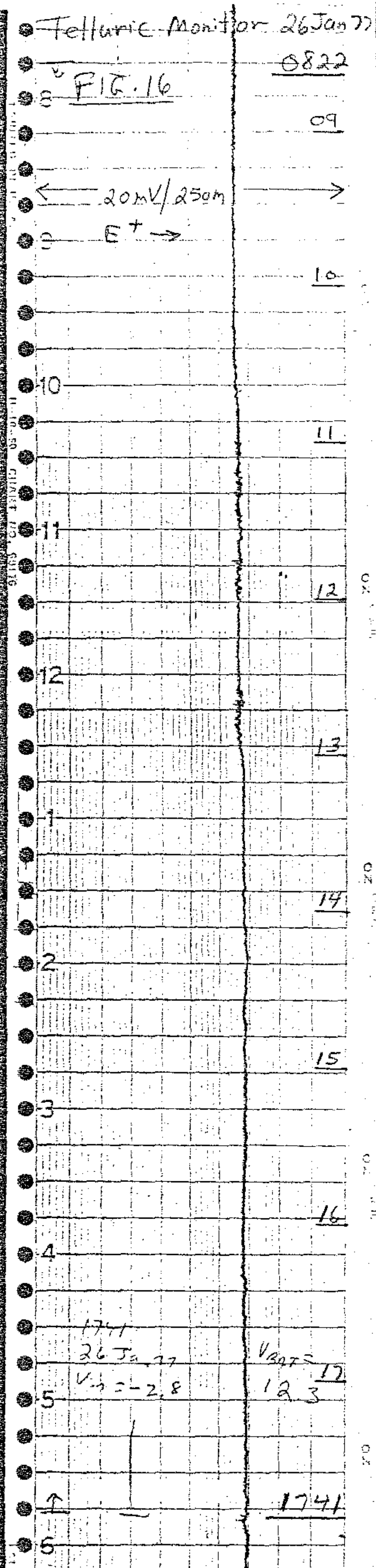
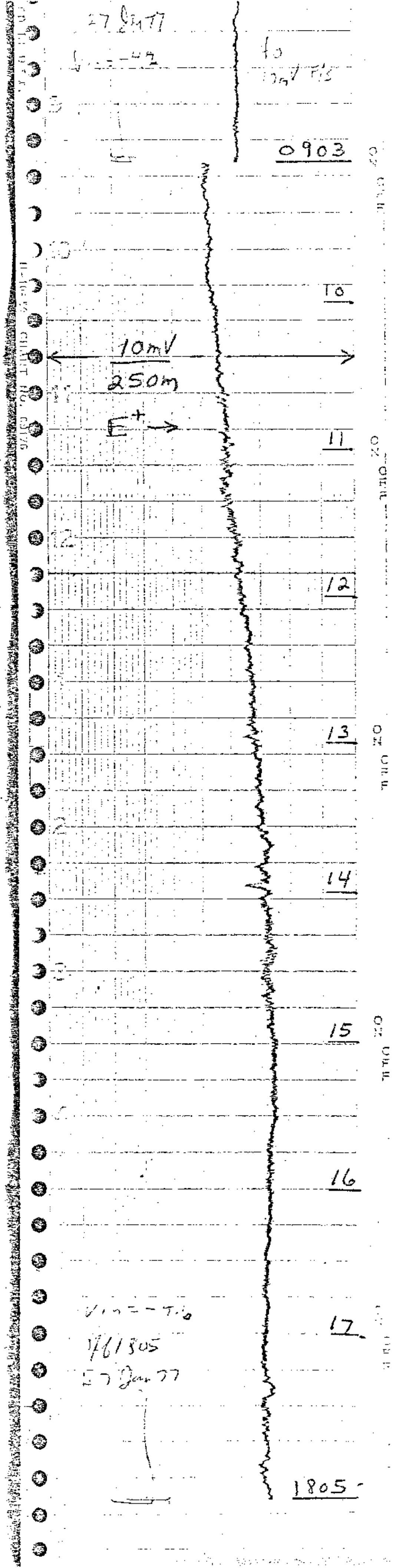

Telluric Monitor 26 Jan 77
0822
FIG. 16
09
20mV/250m
E+ →
10
11
12
13
14
15
16
1741
26 Jan 77
V = -2.8
V BAT =
12.3
17
1741

FIG. 17

Telluric monitor
27 Jan 77



Equipment

The equipment used for this survey is listed below. Prices are approximate.

1) Digital voltmeter: Non-Linear Systems model LM-3, w/ leather case (1mV resolution, 10 megohms input impedance)	$150
2) Electrodes: Tinker & Rasor model 3A (copper-copper sulfate, plastic body, ceramic junction) 2 @ $35	70
3) Reel: Edgar Sharpe model GZ-1000 w/ one spool	100
4) Shoulder straps for reel	25
5) Wire: AWG #30, 7/38 stranded copper, vinyl insulated $7/1000 ft x 12000 ft	85
6) Belt and leather holster to carry electrode, data book, and other misc. field equipt.	25
7) Misc. equipt.: Electrode cleaning brush, wire cutters, heat-shrink tubing, data books, spade, electrode carrying case	25
8) Spares:	
Electrodes (as above)	70
Reel w/ 4 km wire	100
Voltmeter	125
Total field equipment	$ 775

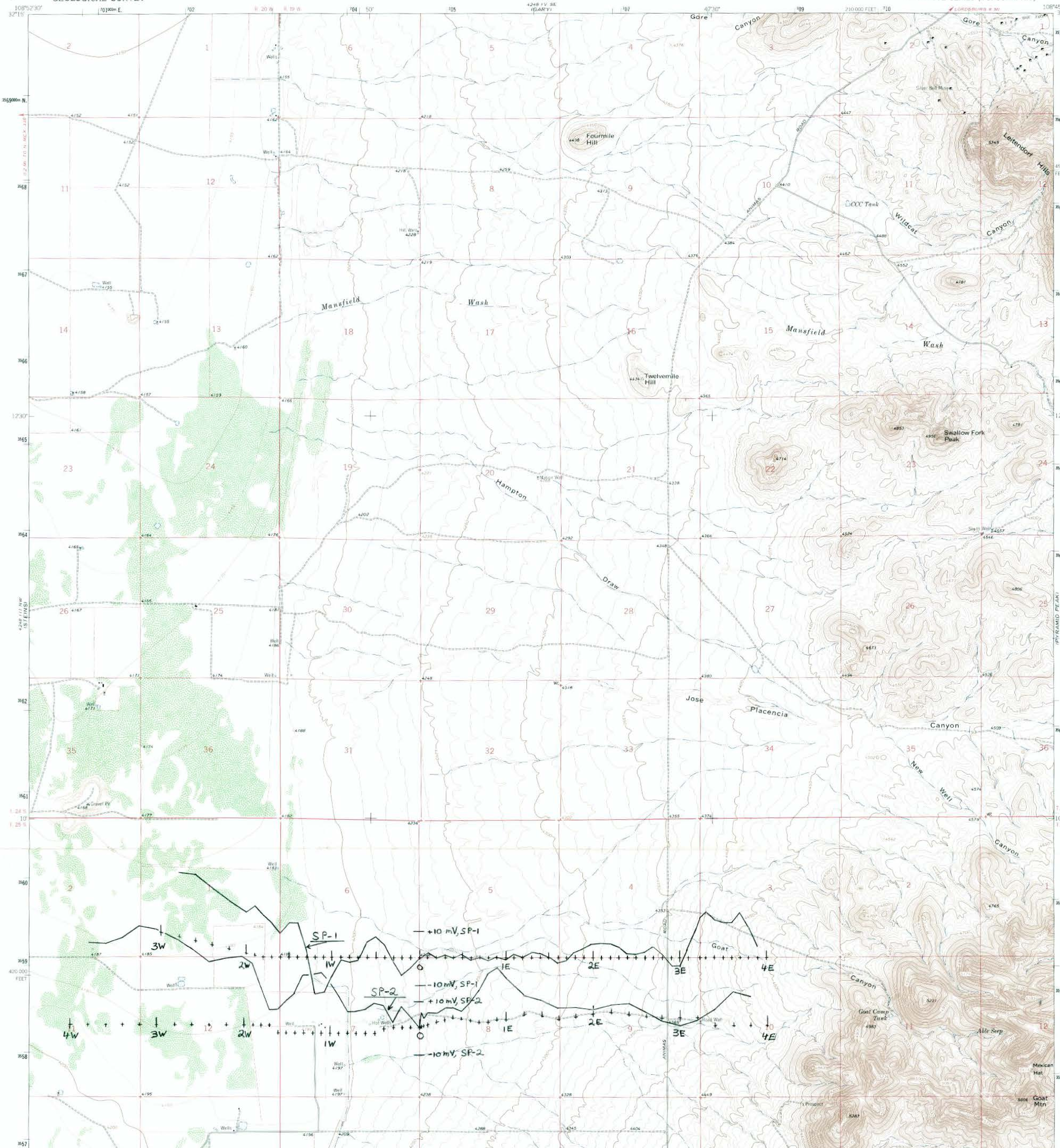
9) Telluric monitor	
a) Strip chart recorder: Rustrak model 288, 12VDC motor, 100 microamp full scale, 1 in/hr chart speed	$180
b) Amplifier to convert recorder to desired range and isolate impedance (custom built)	200

c) 12 V battery, 4.5 amp hour, rechargeable	$25
d) Connecting wire: 100 to 500 m of any appropriate field wire	25
e) Electrodes (as above)	70
f) Plastic case	30
Total for telluric monitor	$525

Total for equipment and telluric monitor $1300

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SWALLOW FORK PEAK QUADRANGLE
NEW MEXICO–HIDALGO CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



(COTTON CITY) 4248 III SW

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography by photogrammetric methods from aerial photographs taken 1963 and planetable surveys 1965

Polyconic projection. 1927 North American datum
10,000 foot grid based on New Mexico coordinate system, west zone
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

Fine red dashed lines indicate selected fence lines

UTM GRID AND 1965 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

NEW MEXICO
QUADRANGLE LOCATION

ROAD CLASSIFICATION
Light-duty ——— Unimproved dirt - - - -

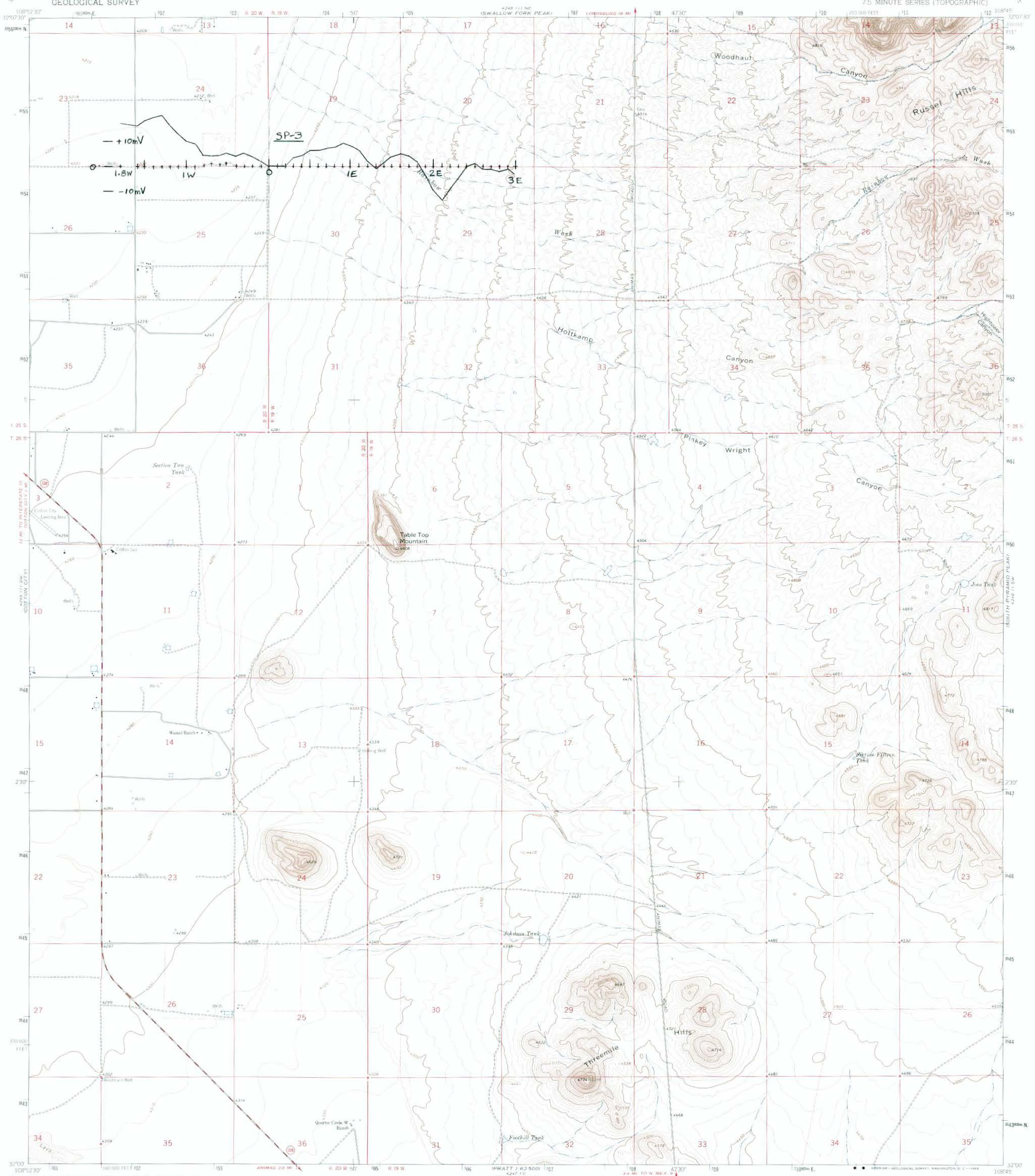
(SOUTH PYRAMID PEAK) 4248 II SW

SWALLOW FORK PEAK, N. MEX.
N3207.5–W10845/7.5
1965
AMS 4248 III NE–SERIES V881

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TABLE TOP MOUNTAIN QUADRANGLE

NEW MEXICO–HIDALGO CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



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Topography by photogrammetric methods from aerial photographs taken 1963. Field checked 1964

Polyconic projection. 1927 North American datum
10,000-foot grid based on New Mexico coordinate system, west zone
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue

Fine red dashed lines indicate selected fence lines

UTM GRID AND 1964 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

1°10′ 21 MILS
13° 231 MILS

SCALE 1:24 000

1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 KILOMETER

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5 FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
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A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

NEW MEXICO

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Medium-duty ... Light-duty ...

Unimproved dirt ...

State Route

TABLE TOP MOUNTAIN, N. MEX.

N3200–W10845/7.5

1964

AMS 4246 III SE–SERIES V881

PLATE 3

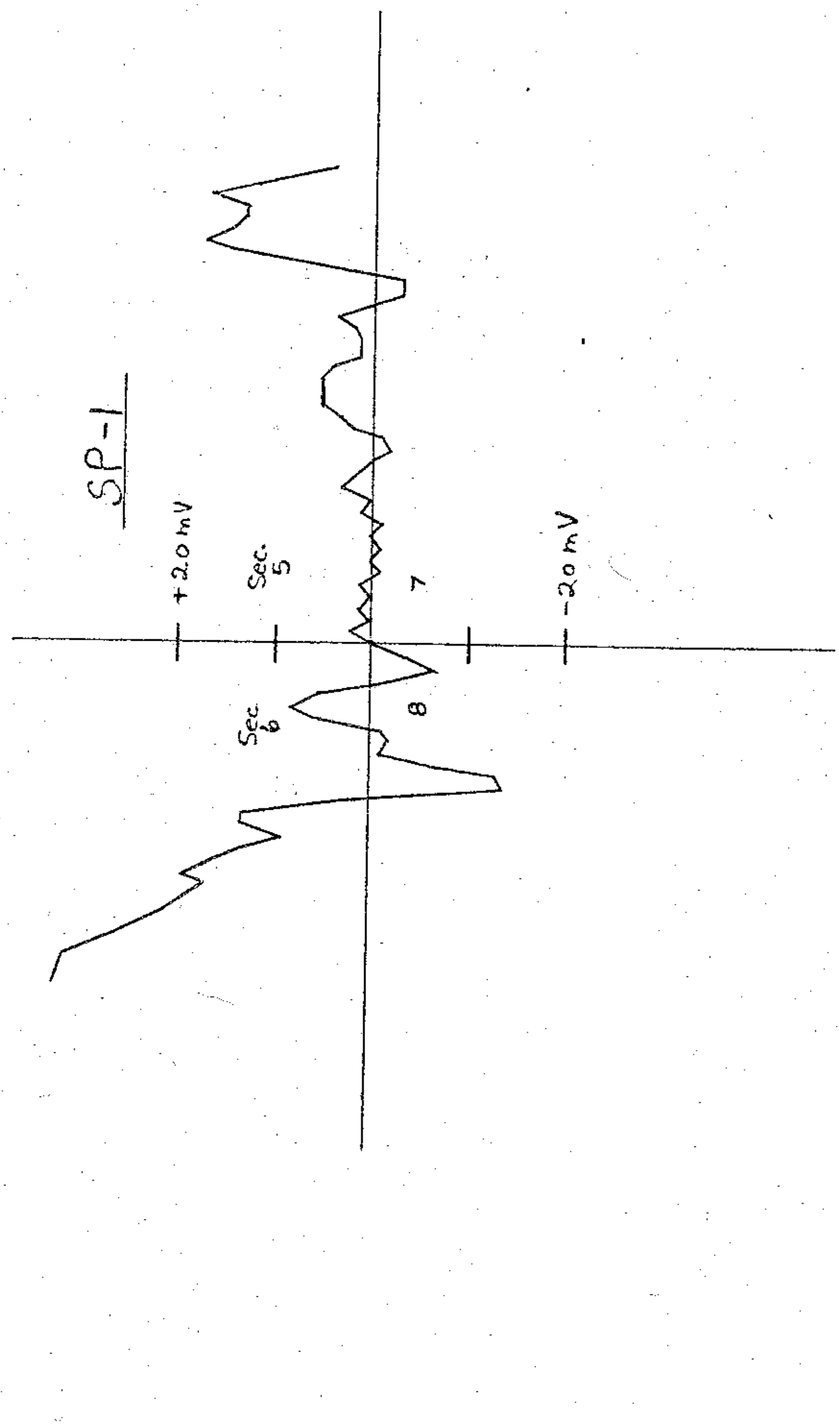

PLATE 4

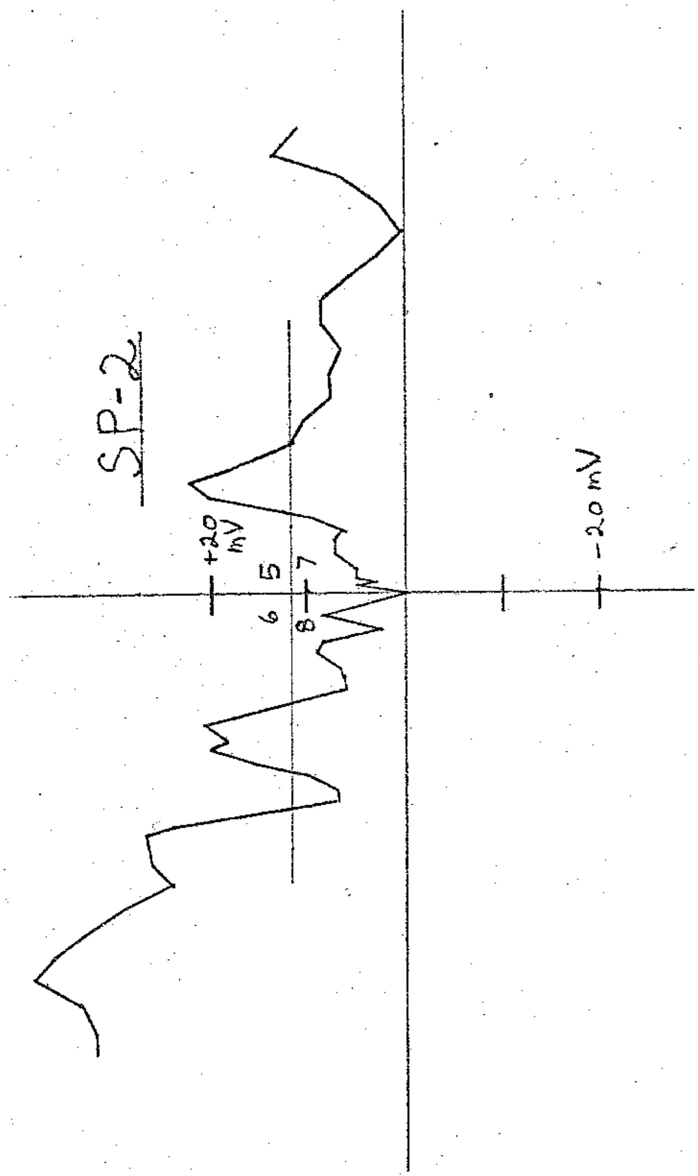

PLATE 5