DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Audio-magnetotelluric soundings at Ablah in the Al Aqiq quadrangle, sheet 20/41D, Kingdom of Saudi Arabia

by

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Open-File Report 87- 190

Report prepared by the U.S. Geological Survey in cooperation with the
Deputy Ministry for Mineral Resources, Saudi Arabia

1/ USGS, Denver, CO

1987

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AUDIO-MAGNETOTELLURIC SOUNDINGS AT ABLAH IN THE AL AQIQ QUADRANGLE, SHEET 20/41 D, KINGDOM OF SAUDI ARABIA

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ABSTRACT

Audio-magnetotelluric (AMT) soundings were made at the Ablah breccia pipe (MODS 0027), in the al Aqiq quadrangle near longitude 41°55' E. and latitude 20°12' N., as part of the mineral assessment of the prospect. This survey covered an area of approximately 12 km^2 and consisted of 15 AMT stations.

An apparent-resistivity map prepared from 270-Hz data shows an area of low resistivity that corresponds to a breccia zone at the Ablah site, an area which was mined by the ancients. A one-dimensional inversion of some of the AMT soundings shows that the low-resistivity zone ranges in depth from 150 to 350 m.

INTRODUCTION

The Ablah breccia pipe (MODS 0027) is located at latitude 20°12' N., longitude 41°55' E. in the southeast corner of the Al Aqiq quadrangle (sheet 20/41 D) (fig. 1). Geological and geochemical studies by Kemp (1972), White (1987), and Cartier (1983), as well as drill-hole data collected by Allcott (1970), indicate the presence of lead, zinc, copper, and gold within the breccia pipe.

Ablah hill, which is approximately 100 m high and 500 m in diameter, is the dominant topographic feature in the area. The Ablah breccia pipe, which forms the peak and upper portions of the hill, is ovate in plan, 300 m long, and is elongated to the northeast (fig. 2). According to Kemp (1972) and White (1987), the breccia contains clasts of diorite, granite, aplite, and pegmatite in a matrix of white quartz. Clasts are partially altered to white mica, quartz, and fluorite. Sulfides and gold occur mostly in the matrix.

The breccia intrudes earlier units of an igneous complex, which includes granite, pegmatite, and aplite, but the surrounding country rock, which crops out at the base and lower flanks of the hill, is diorite. A younger fluorite pipe, about 20 m in diameter, transects the Ablah breccia on the upper south flank of the hill. The fluorite pipe was mined, presumably for copper, by the ancients.

The audio-magnetotelluric (AMT) survey described in this report was undertaken as part of the evaluation of the mineral potential of the Ablah breccia pipe. The purpose of the survey was to learn more of the spacial distribution of the brecciated and altered zone at depth.

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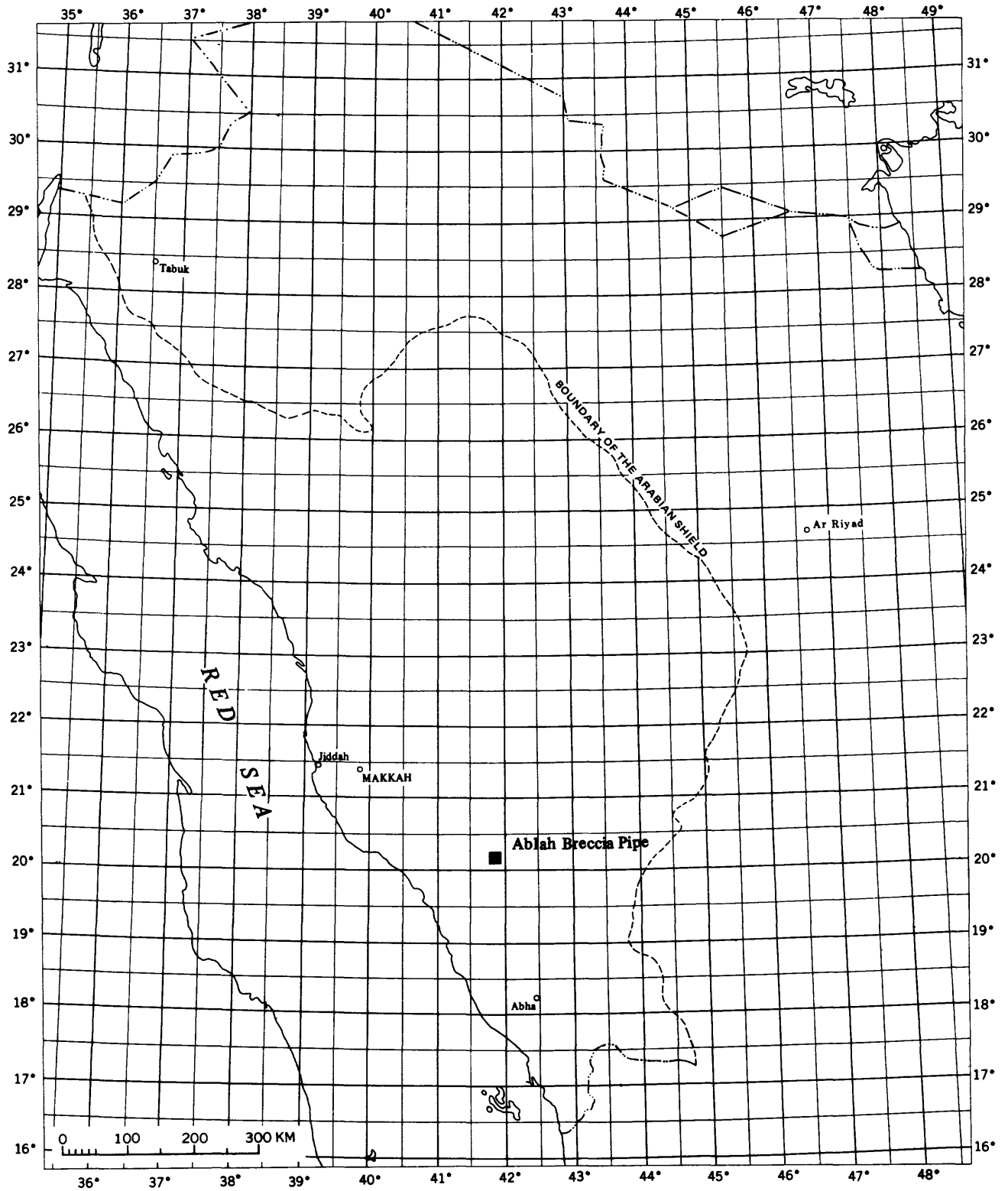

Figure 1.--*Index map showing location of Ablah breccia pipe.*

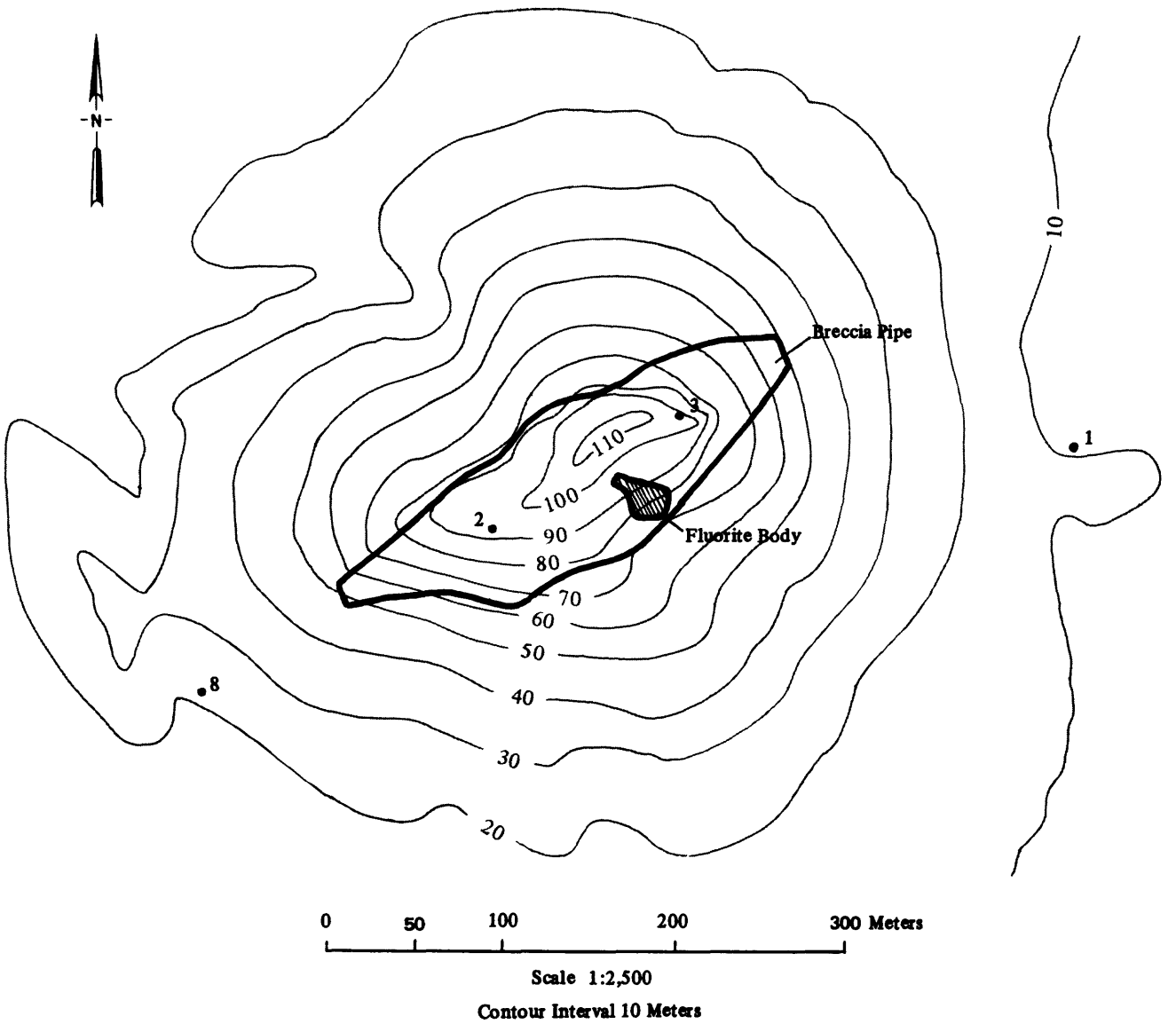

Figure 2.--*Topographic map of Ablah hill showing location of breccia pipe, fluorite body, and AMT stations.*

DATA AND INTERPRETATION

The locations of the AMT stations relative to the Ablah breccia and fluorite pipe are shown in figure 2. Contours of the average E./W. and N./S. apparent resistivity at 270 Hz along with AMT-station locations are shown in figure 3. The depth of penetration at 270 Hz made this frequency the most appropriate for delineating the low-resistivity zone. The low-resistivity zone is localized to the brecciated zone of Ablah hill. Low resistivities seen in figure 3 at stations 6, 12, and 13 are located on the south and east of Ablah suggest that near-surface sediments are more conductive than over the breccia pipe. Lower resistivities seen at AMT stations, 1, 2, 3, 4, 8, 9, and 13 suggest an east-west trend to the resistivity zone. Stations 5 and 10 (fig. 3) show what would be expected from AMT soundings on tight, unaltered igneous rocks where near-surface low resistivities are caused by weathering.

A resistivity cross section along line A-A' (fig. 3) based on one-dimensional inversion of the sounding data is shown in figure 4. The resistivity cross section delineates a zone of low resistivity at a depth of approximately 150-300 m beneath Ablah hill. The cause of the low-resistivity zone is interpretated as an area of alteration due to hydrothermal activity during the formation of the breccia pipe and(or) increased porosity due to the brecciation.

DATA STORAGE

DATA FILE

All data used in the preparation of this report are included in the Appendix; therefore, no Data File was established.

MINERAL OCCURRENCE DOCUMENTATION SYSTEM (MODS)

No new MODS entries were made as a result of the work described in this report; the bibliography for Ablah (MODS 0027) was updated to include reference to this report.

The work on which this report is based was performed in accordance with the cooperative agreement between the Saudi Arabian Ministry of Petroleum and Mineral Resources and the U.S. Geological Survey.

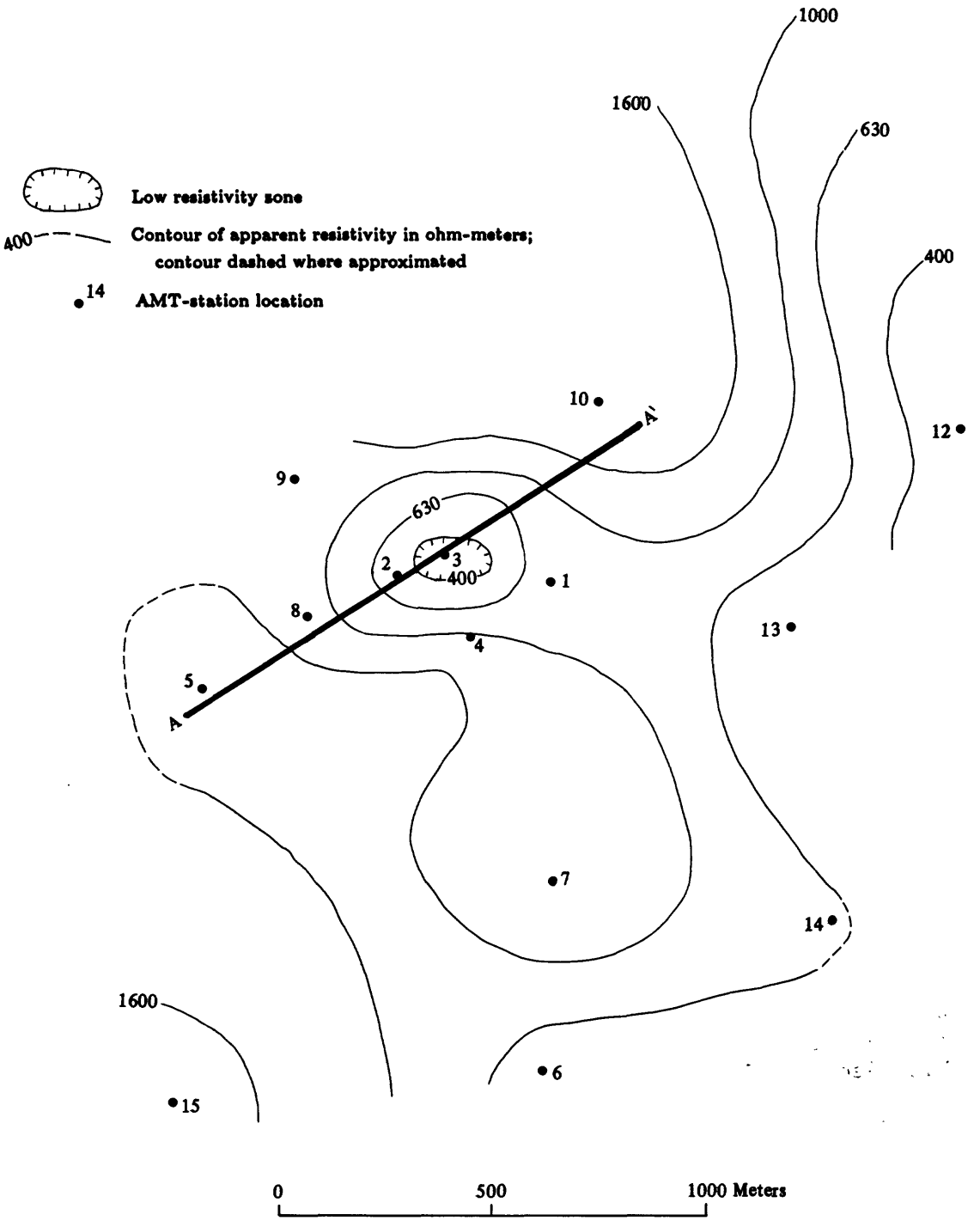

Figure 3.--*Contours of the average East-West and North-South apparent resistivity (at 270 Hz), along with AMT-station locations. Number at each station refers to those listed in printout of AMT data.*

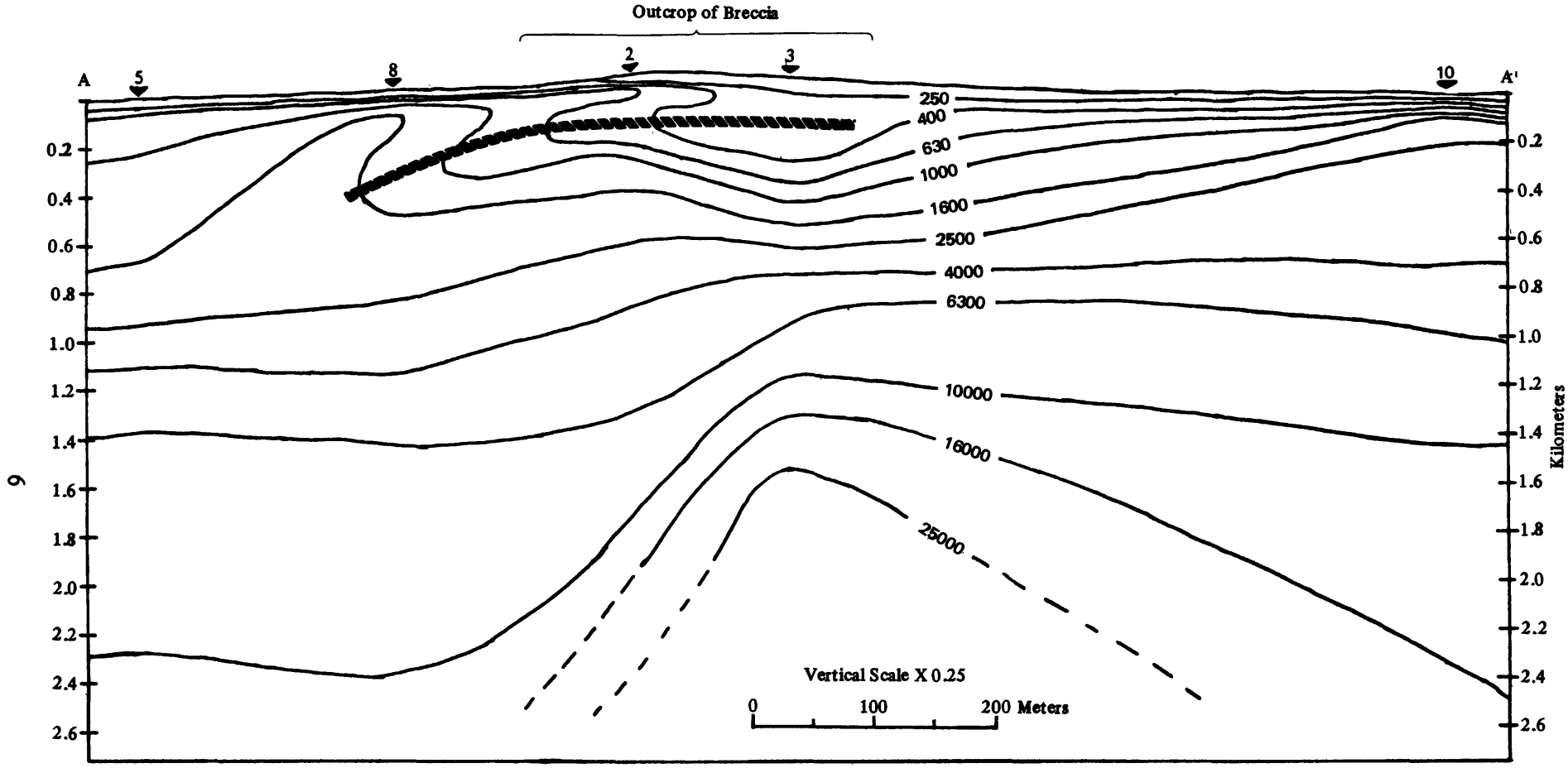

Figure 4.--*AMT-resistivity cross section A-A', derived from contouring one-dimensional models. Profile location shown on figure 3. Numbers on surface are AMT-station locations projected onto the profile line. Hachures indicate low resistivity zone. Contours of resistivity are in ohn-meters. Contours are a logarithmic interval of five divisions per decade.*

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APPENDIX

EXPLANATION

In the following, a list of the computer-derived AMT sounding data obtained from this study and the corresponding interpretations is presented in tabular form. Station ID=station identification. NO FREQ=number of frequencies. FREQ=frequency in hertz. AP-RES=apparent resistivity in ohm-meters. N OBS=number of observations. STE ERR=standard error in ohm-meters. NS=telluric line orientation. This data is followed by a plot of the data obrained from the calculations for visual comparison.

PROJ= ABLAH
STA-IDAB 1FILE NAME=AB1E

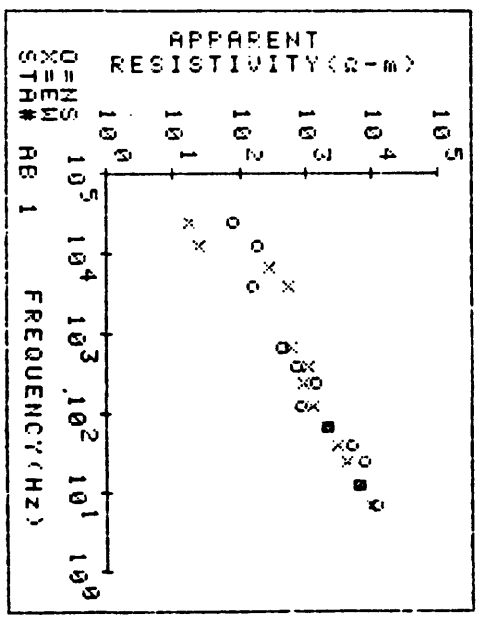
PROJECT=ABLAH

STA. ID_AB 1 NS NO FREQ= 12

FREQ	AP-RES	N OBS	STD ERR
7.5	8780.20	11	3439.40
14.0	4860.20	11	700.64
27.0	6199.60	13	1365.10
45.0	3854.80	11	1288.90
75.0	1673.40	10	256.75
140.0	669.53	12	108.66
270.0	1063.10	14	288.05
450.0	575.55	16	33.89
750.0	330.86	10	54.03
4500.0	119.93	3	35.21
14000.0	144.89	10	20.76
27000.0	60.30	10	8.53

STA. ID_AB 1 EW NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
7.5	7897.30	13	958.03
14.0	5152.30	19	203.48
27.0	3222.60	12	97.46
45.0	2280.50	15	106.66
75.0	1725.60	13	37.93
140.0	1031.30	13	43.58
270.0	757.15	11	23.30
450.0	857.32	14	46.42
750.0	475.36	10	44.09
4500.0	440.70	16	43.06
7500.0	239.50	13	20.83
14000.0	20.05	3	1.10
27000.0	13.95	15	.66



PROJ= ABLAH
STA-IDAB 2FILE NAME=AB2E

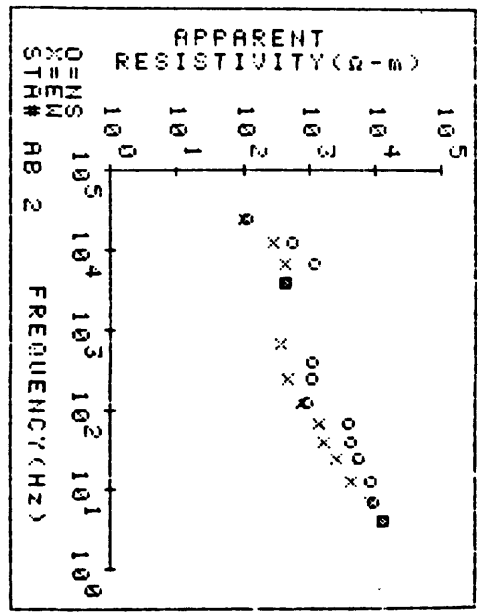
PROJECT=ABLAH

STA. ID_AB 2 NS NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	9986.70	4	2748.20
7.5	6923.30	9	752.36
14.0	6752.10	9	528.72
27.0	4169.50	12	232.32
45.0	3370.10	8	337.92
75.0	3167.00	7	487.50
140.0	706.21	4	139.32
270.0	890.54	4	160.60
450.0	860.42	8	39.34
4500.0	329.93	6	71.73
7500.0	961.79	8	48.43
14000.0	453.56	9	22.74
27000.0	84.82	4	22.45

STA ID_AB 2 EW NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	10226.00	4	4819.70
7.5	6531.30	9	602.70
14.0	3249.20	13	130.03
27.0	2018.60	14	116.33
45.0	1288.10	13	58.19
75.0	1083.20	8	80.91
140.0	613.68	9	27.95
270.0	372.21	11	25.00
750.0	297.60	7	11.21
4500.0	343.36	9	14.70
7500.0	336.51	9	22.99
14000.0	224.02	9	13.87
27000.0	81.81	8	11.77



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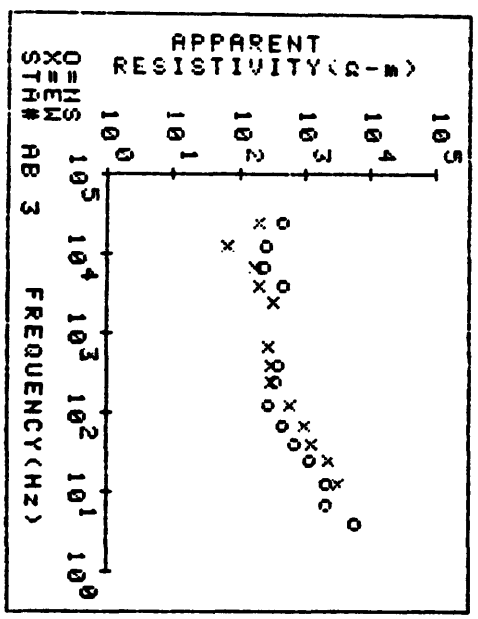
PROJECT=ABLAH

STA. ID_AB 3 NS NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	4517.70	4	824.66
7.5	1730.60	13	105.32
14.0	1637.80	9	106.66
27.0	962.26	13	69.93
45.0	566.31	16	29.06
75.0	382.06	11	25.24
140.0	222.99	11	18.13
270.0	294.56	10	40.24
450.0	321.07	9	31.57
4500.0	367.75	6	28.57
7500.0	188.47	8	18.29
14000.0	200.45	4	12.51
27000.0	356.02	11	42.36

STA. ID_AB 3 EW NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
14.0	2497.90	11	294.26
27.0	1838.90	8	144.54
45.0	992.87	10	130.10
75.0	791.95	9	115.43
140.0	458.52	10	44.34
270.0	246.12	9	33.33
450.0	239.64	9	28.79
750.0	232.09	8	39.57
2700.0	256.42	3	296.61
4500.0	154.61	7	9.92
7500.0	133.09	8	3.63
14000.0	57.91	9	3.09
27000.0	156.27	7	52.37



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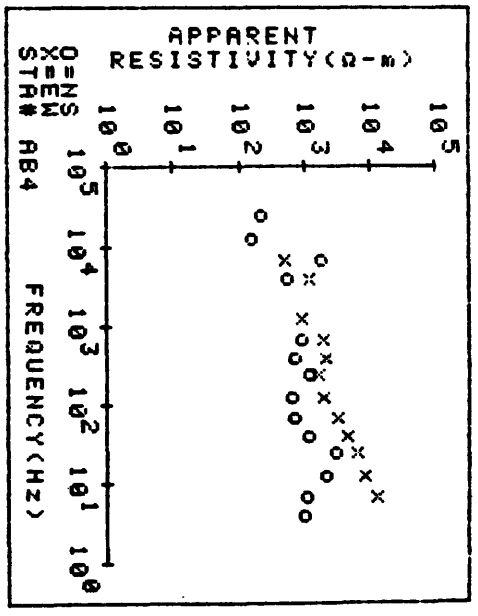
PROJECT=ABLAH

STA. ID_AB4 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	814.31	4	525.45
7.5	857.47	6	317.50
14.0	1632.00	10	169.30
27.0	2350.90	7	443.89
45.0	960.44	9	83.57
75.0	579.06	10	53.50
140.0	512.31	10	81.49
270.0	918.02	10	59.92
450.0	550.88	6	46.07
750.0	742.25	9	42.12
4500.0	435.15	9	26.55
7500.0	1377.60	10	100.92
14000.0	118.88	11	5.71
27000.0	177.92	10	6.67

STA. ID_AB4 EW NO FREQ= 12

FREQ	AP-RES	N OBS	STD ERR
7.5	10256.00	10	1175.60
14.0	6648.10	12	473.74
27.0	5181.90	12	386.19
45.0	3497.90	13	184.07
75.0	2509.70	13	105.62
140.0	1512.70	12	86.08
270.0	1283.50	12	110.07
450.0	1657.20	11	152.75
750.0	1587.00	7	136.37
1400.0	709.52	2	34.56
4500.0	898.72	11	58.01
7500.0	405.64	10	33.93



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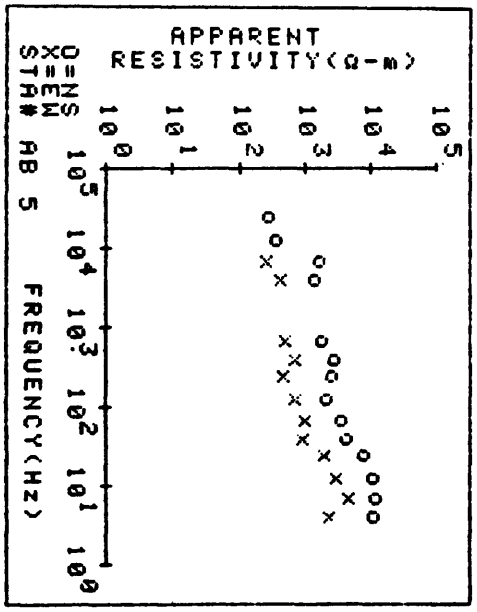
PROJECT=ABLEH

STA. ID_AB 5 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	8081.20	5	2044.00
7.5	9455.10	9	435.83
14.0	8302.30	14	497.25
27.0	6040.50	10	885.67
45.0	3379.20	10	297.56
75.0	2781.20	12	187.09
140.0	1721.30	11	121.58
270.0	2029.50	7	258.85
450.0	2099.70	15	153.41
750.0	1398.90	6	188.74
4500.0	1097.10	8	78.39
7500.0	1364.60	3	643.03
14000.0	292.95	11	17.91
27000.0	220.16	10	17.42

STA. ID_AB 5 EW NO FREQ= 12

FREQ	AP-RES	N OBS	STD ERR
4.5	1827.90	9	207.58
7.5	3681.30	11	264.88
14.0	2353.60	13	127.67
27.0	1580.30	8	165.68
45.0	754.59	8	43.19
75.0	801.69	12	175.05
140.0	548.31	8	66.85
270.0	368.21	9	90.87
450.0	569.62	6	233.97
750.0	393.49	4	49.35
4500.0	328.47	9	42.69
7500.0	204.28	8	16.78



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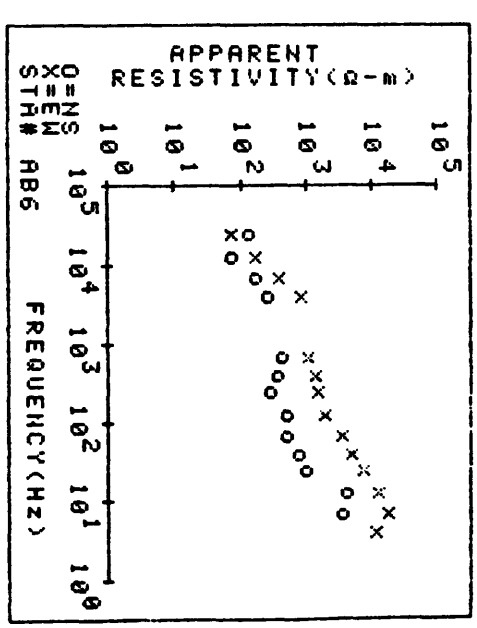
PROJECT=ABLAH

STA. ID_AB6 NS NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
7.5	2840.90	8	543.87
14.0	3269.80	9	492.50
27.0	809.63	10	198.87
45.0	620.77	13	149.75
75.0	396.40	8	113.68
140.0	405.39	10	74.87
270.0	230.27	7	74.74
450.0	276.70	9	54.54
750.0	349.43	11	53.51
4500.0	209.14	11	31.33
7500.0	133.12	10	16.38
14000.0	59.61	11	5.35
27000.0	101.85	9	15.33

STA. ID_AB6 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	9013.80	7	624.30
7.5	14485.00	10	929.41
14.0	10218.00	10	163.69
27.0	6162.10	10	221.14
45.0	4023.20	10	252.54
75.0	2742.50	11	159.74
140.0	1539.20	10	107.22
270.0	1166.80	11	75.99
450.0	1096.60	11	128.95
750.0	828.88	9	54.10
4500.0	668.20	10	79.68
7500.0	313.50	10	31.20
14000.0	129.33	8	23.10
27000.0	55.75	6	21.53



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PROJECT=ABLEH

STA. ID_AB 7 NS NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	4365.80	6	793.65
7.5	7164.60	6	644.87
14.0	4628.80	7	780.04
27.0	2478.20	7	222.08
45.0	2132.90	4	348.87
75.0	1167.00	9	87.52
140.0	505.41	6	69.69
270.0	1168.70	6	127.18
450.0	1665.50	9	255.40
750.0	598.94	9	65.90
7500.0	531.80	5	201.04
14000.0	104.18	7	15.12
27000.0	138.19	9	43.14

STA. ID_AB 7 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	8438.40	11	600.58
7.5	13620.00	15	1005.20
14.0	10785.00	11	843.46
27.0	6996.40	12	296.62
45.0	5192.30	10	149.28
75.0	3095.60	14	115.44
140.0	2051.40	11	150.81
270.0	1669.80	9	109.21
450.0	2310.30	8	74.88
750.0	2280.60	10	211.15
4500.0	848.11	9	186.61
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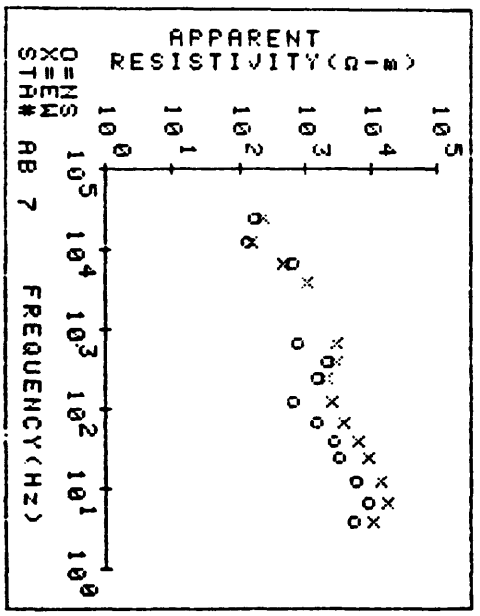
14000.0	128.45	9	7.93
27000.0	180.86	8	18.26



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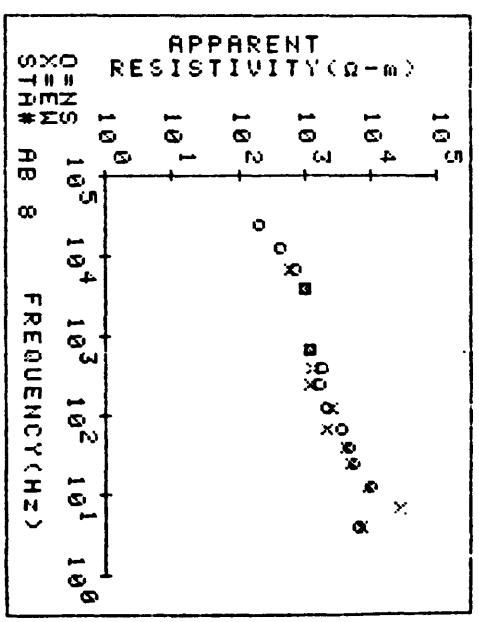
PROJECT=ABLEH

STA. ID_AB 8 NS NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	4938.90	10	802.55
14.0	7897.00	12	517.80
27.0	4456.70	12	226.10
45.0	3651.40	13	332.59
75.0	2876.30	12	217.08
140.0	1636.00	14	93.46
270.0	1292.30	13	100.25
450.0	1393.30	11	117.64
750.0	970.61	11	108.19
4500.0	802.35	6	99.87
7500.0	560.33	11	19.31
14000.0	329.76	9	10.20
27000.0	165.40	7	12.38

STA. ID_AB 8 EW NO FREQ= 12

FREQ	AP-RES	N OBS	STD ERR
4.5	5441.00	13	651.93
7.5	21617.00	13	6131.60
14.0	6959.60	10	486.44
27.0	3850.70	11	331.86
45.0	3251.30	3	217.15
75.0	1685.00	8	218.28
140.0	2035.70	13	132.70
270.0	968.66	9	77.41
450.0	1028.40	8	106.59
750.0	921.72	8	61.54
4500.0	759.90	9	86.85
7500.0	457.54	12	70.55



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STA-IDAB 9FILE NAME=AB9E2

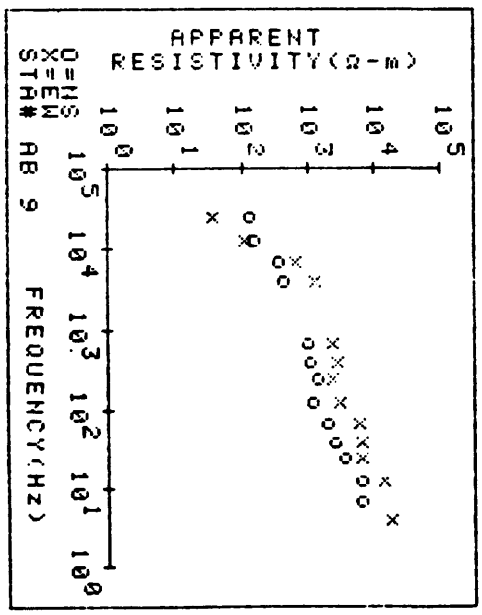
PROJECT=ABLEH

STA. ID_AB 9 NS NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
7.5	5045.50	9	522.68
14.0	5021.70	15	354.39
27.0	2744.10	17	87.67
45.0	1970.40	13	126.71
75.0	1541.40	12	142.60
140.0	950.61	13	61.91
270.0	1083.60	8	56.47
450.0	890.10	12	41.96
750.0	786.46	13	114.30
4500.0	337.44	6	42.62
7500.0	283.78	11	9.40
14000.0	121.57	13	7.04
27000.0	107.87	11	4.94

STA. ID_AB 9 EW NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	14081.00	9	1567.10
14.0	11087.00	13	1340.60
27.0	4967.00	9	411.27
45.0	5256.70	8	622.53
75.0	4600.90	11	370.17
140.0	2318.20	10	107.96
270.0	1764.80	11	101.74
450.0	2141.10	13	115.48
750.0	1878.90	9	344.93
4500.0	983.06	9	260.61
7500.0	524.09	15	57.07
14000.0	85.28	14	13.77
27000.0	28.97	9	2.84



PROJ= ABLAH
STA-IDAN 10FILE NAME=AB10E

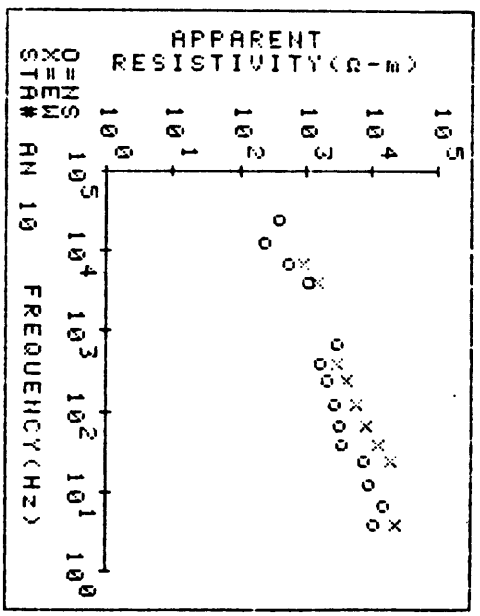
PROJECT=ABLAH

STA. ID_AN 10 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	8559.50	5	2053.00
7.5	11427.00	11	1145.40
14.0	6981.10	10	1149.60
27.0	6162.10	9	953.98
45.0	2738.20	12	470.63
75.0	2495.20	7	298.16
140.0	2114.50	7	481.71
270.0	1704.00	5	140.49
450.0	1353.60	8	164.08
750.0	2355.50	7	340.13
4500.0	889.86	7	103.67
7500.0	449.49	8	44.86
14000.0	195.31	8	23.20
27000.0	299.73	5	50.56

STA. ID_AN 10 EW NO FREQ= 9

FREQ	AP-RES	N OBS	STD ERR
4.5	18005.00	7	2050.60
27.0	15752.00	11	1498.50
45.0	9797.10	9	233.46
75.0	6354.90	7	1585.10
140.0	4831.90	9	350.95
270.0	3350.40	8	683.84
450.0	2298.10	6	390.17
4500.0	1223.50	9	133.76
7500.0	754.16	8	152.50



PROJ= ABLAH
STA-IDAB 11FILE NAME=AB11E

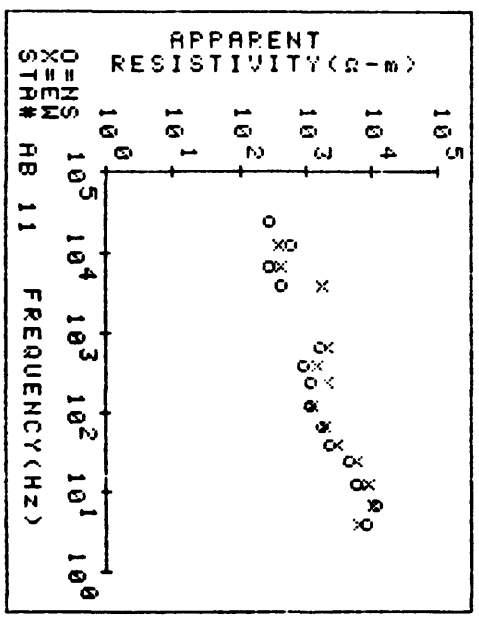
PROJECT=ABLAH

STA. ID_AB 11 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	6419.70	5	889.78
7.5	9299.90	9	1415.10
14.0	4611.30	6	600.90
27.0	3613.00	7	334.79
45.0	1875.00	9	161.50
75.0	1437.90	9	125.84
140.0	974.11	9	35.14
270.0	924.45	11	88.39
450.0	709.62	5	67.38
750.0	1339.20	8	221.89
4500.0	333.87	9	8.54
7500.0	217.64	9	19.49
14000.0	466.81	11	40.67
27000.0	217.84	6	53.99

STA. ID_AB 11 EW NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	5149.40	8	708.94
7.5	8224.30	6	626.20
14.0	7207.00	9	559.70
27.0	4615.00	7	672.12
45.0	2398.10	7	129.47
75.0	1539.00	7	121.33
140.0	1033.20	7	175.96
270.0	1622.90	5	178.55
450.0	1232.80	6	155.22
750.0	1659.10	4	458.56
4500.0	1402.20	7	228.51
7500.0	343.19	7	28.53
14000.0	316.24	4	295.51



PROJ= ABLAH
STA-IDAB 12FILE NAME=AB12E

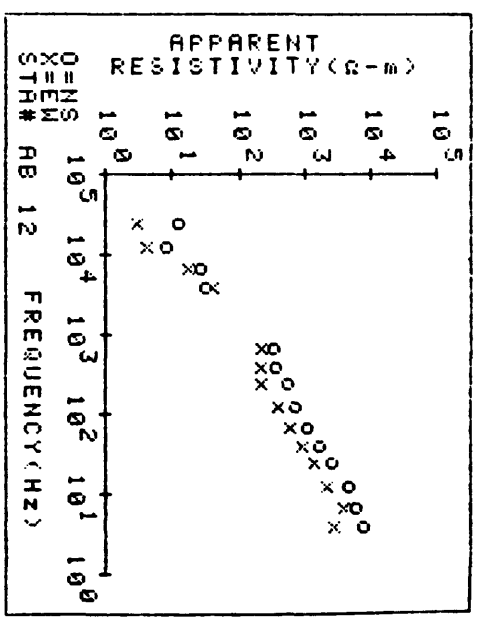
PROJECT=ABLAH

STA. ID_AB 12 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	6048.00	9	1041.70
7.5	4606.50	11	481.82
14.0	3580.50	10	98.86
27.0	2019.30	11	149.40
45.0	1267.30	11	103.65
75.0	894.68	10	56.95
140.0	556.75	10	33.90
270.0	428.07	10	27.77
450.0	298.87	12	17.59
750.0	270.57	12	28.24
4500.0	24.07	10	1.14
7500.0	20.51	10	1.35
14000.0	6.62	13	.23
27000.0	9.88	9	.84

STA. ID_AB 12 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	2195.40	9	149.29
7.5	3162.10	13	84.37
14.0	1688.30	12	53.65
27.0	1106.00	11	26.74
45.0	703.44	13	24.40
75.0	471.82	12	20.43
140.0	316.05	13	8.07
270.0	177.35	13	16.54
450.0	172.58	11	16.92
750.0	176.98	9	20.93
4500.0	30.96	10	1.97
7500.0	14.14	10	.64
14000.0	3.28	11	.06
27000.0	2.43	11	.28



PROJ= ABLAH
STA-IDAB 13FILE NAME=AB13E

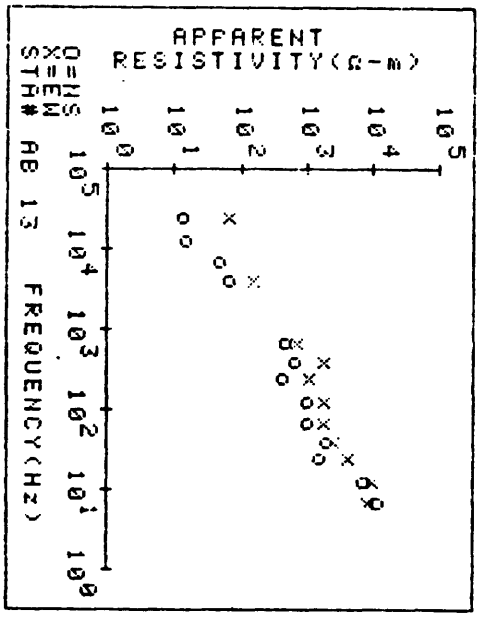
PROJECT=ABLAH

STA. ID_AB 13 NS NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
7.5	9370.30	8	2924.30
14.0	5491.80	8	454.70
27.0	1179.70	4	123.01
45.0	1600.20	7	233.30
75.0	791.96	7	264.73
140.0	812.85	8	287.15
270.0	350.96	8	44.38
450.0	506.97	8	41.58
750.0	377.46	8	61.85
4500.0	54.10	7	8.13
7500.0	38.55	7	2.74
14000.0	11.90	10	.67
27000.0	10.51	8	.76

STA. ID_AB 13 EW NO FREQ= 11

FREQ	AP-RES	N OBS	STD ERR
7.5	6665.30	7	843.73
14.0	7474.80	7	669.89
27.0	3453.80	8	501.11
45.0	2058.90	6	549.39
75.0	1437.70	9	187.11
140.0	1445.40	8	138.63
270.0	868.57	4	221.29
450.0	1369.90	6	293.28
750.0	562.11	7	102.21
4500.0	125.59	7	29.79
27000.0	52.80	5	10.52



PROJ= ABLAH
STA-IDAB 14FILE NAME=AB14E

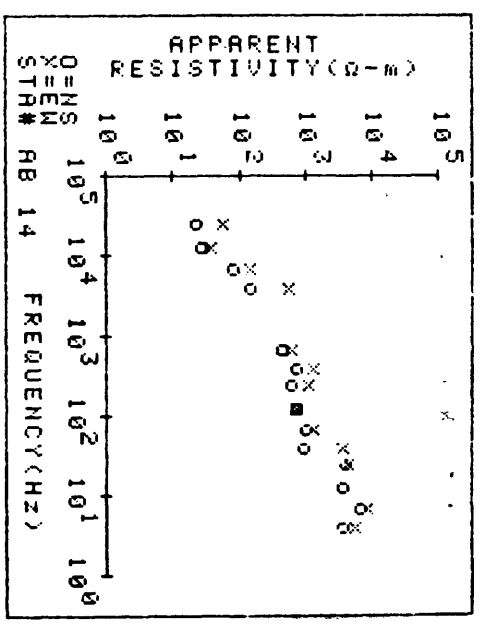
PROJECT=ABLAH

STA. ID_AB 14 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	2810.60	4	909.93
7.5	5156.10	5	1094.20
14.0	2813.40	8	295.40
27.0	2960.40	9	428.91
45.0	710.66	9	111.50
75.0	820.91	10	59.20
140.0	580.64	10	75.13
270.0	458.34	10	66.13
450.0	569.84	8	70.92
750.0	329.16	11	43.66
4500.0	110.78	9	12.10
7500.0	61.49	8	3.25
14000.0	21.46	7	1.10
27000.0	18.41	9	1.10

STA. ID_AB 14 EW NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	4126.40	3	1844.70
7.5	6511.50	7	793.65
27.0	3423.40	12	311.06
45.0	2767.80	7	541.56
75.0	1002.10	9	73.18
140.0	587.94	7	53.17
270.0	894.88	7	96.07
450.0	1047.20	7	82.32
750.0	469.13	6	75.12
4500.0	432.68	6	159.07
7500.0	111.49	6	10.81
14000.0	29.91	5	6.55
27000.0	46.71	4	8.37



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PROJ= ABLAH
STA-IDAB 15FILE NAME=AB15E

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PROJECT=ABLAH

STA. ID_AB 15 NS NO FREQ= 13

  FREQ    AP-RES  N OBS    STD ERR
   4.5 5729.50      4      886.76
  14.0 6999.00     13      458.31
  27.0 3843.00     10      192.40
  45.0 2334 80      6      160.59
  75.0 1818.20     11      141.32
 140.0 1134.20     14       59.77
 270.0  902.43     14       62.28
 450.0 1288.50     10       77.60
 750.0 1306.20      9       84.18
4500.0  582.78      8       72 35
7500.0  480.68      9       17 86
14000.0 181.09      9        5.41
27000.0 231.38      7       13.64

STA. ID_AB 15 EW NO FREQ= 13

  FREQ    AP-RES  N OBS    STD ERR
   4.515434.00      7     2181.70
  14.016402.00      6     2081.20
  27.013490.00     11     2187.90
  45.0 6774.90     10      560.35
  75.0 5519.30     10      224.34
 140.0 2706.70      9      202.89
 270.0 3749.80      6      407.16
 450.0 3139.20      9      249.39
 750.0 3228.10      5      680.55
4500.0 1206.70      6      139.08
7500.0 1091.40      5      120.61
14000.0  172.83     4       31.02
27000.0  175.70     3       36.87

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