2.3 Metamorphic rock

A small isolated rock body of amphibolite is found at northern Al Wasit of the upper reach of the Wadi Jizzi. It occurs in fault contact with surrounding rocks, so stratigraphic relations with the ophiolite complex as well as the Hawasina Group could not be determined. It may be a block of older rocks, considering its lithofacies, but any solid evidence is not observed yet.

2.4 Hawasina Group

The group distributes in the middle and upper streams of the Wadi Jizzi. Those distributing in the middle stream area consist of massive siliceous limestone with many cracks and of well-stratified reddish violet chert. They show a general strike of N-NW and a dip of 15-60°E and constitute the basement of the dam site. Those occurring in the upper reaches are bordered from the Semail Ophiolite Complex by two major faults which extend from Daqiq to the NE - NNE direction along the Wadi Jizzi. They have a general strike of NW and a dip of 40 to 70°NE, consisting mainly of well-bedded reddish violet to dark green chert.

2.5 Semail Ophiolite Complex

The complex occupies the vast area in the middle and upper streams of the Wadi Jizzi. Various kind of rock facies are observed which can be grouped into effusive rocks, basic dyke swarms, gabbroic hypabyssal rocks, basic to ultrabasic rocks and peridotite.

The effusive rocks lie in the eastern margin of the complex with the N-S trending elongated distribution. In the southern part, they are covered by the Hawasina Group and the Hawasina Mélangé and overlie the basic dyke swarms, while, in the northern part, they are in fault contact with the basic dyke swarms. The lower horizon of the effusives is occupied by typical pillow lava with a subordinate amount of agglomerate. They grades upward into greenish basalt lava which is brecciated to blocks.

The basic dyke swarms show almost the same distribution with the overlying effusive rocks. They constitute medium-relief mountains in the basin of the upper stream. They consist of basalt, dolerite and diabase, having a general strike of NNW to NNE and a dip of 40° to 80°S.

The gabbroic hypabyssal rocks occur in the basin of the upper stream and also in the middle stream area, consisting of gabbro, diorite and tonalite. This formation and the next one can be grouped separately because of lithofacies and topography. The former is characterized by gabbroic rocks and medium-relief landforms, while, the latter by much more basic facies and strong-relief mountains.

The basic and ultrabasic rocks distribute in the upper reaches of the Wadi Jizzi, making strong-relief mountains. They consist of olivine gabbro, troctolite, wehrlite, dunite and peridotite.

Two big masses of peridotite, partly serpentinized, is located at the upper reaches of the basin and constitute major ridges in the area.

2.6 Hawasina Mélangé

The formation distributes at the boundary between the Hawasina Group and the Semail Ophiolite Complex. It is a mixture of various blocks of limestone, chert, basalt, biotite schist and serpentinite. Topographycally, the formation takes a peculiar feature as monadnocks of several meters to several hundred meters height.

2.7 Neogene Tertiary Formation

The Neogene Tertiary Formation distributes in the lower stream area covered by the river terrace deposits, and is small in scale. It has a general strike of N-NNE and a dip of 20° to 40°E. Most of the formation consists of yellowish brown soft mudstone mixed with a small amount of rounded pebbles, while, at Wadi Yambu, tightly consolidated basal conglomerate is observed on a underlying chert bed of the Hawasina Group.

It is considered to be Miocene in age, but any paleontological evidences have not been found.

2.8 Dilluvium

Dilluvium river terrace deposits show an extensive distribution in the drainage area of the Wadi Jizzi, especially in the basins of the upper reaches and in the middle to lower stream areas. The river terrace can be classified into four steps which is mentioned in the preceding chapter in detail. Terrace deposits are composed of sand and gravel, and they are well consolidated appearing a feature of conglomerate except the lower terrace deposits. Grade of consolidation increases downward to the bottom of the formation with each terrace deposits.

2.9 Alluvium

Alluvium is represented by fan, deltaic fan, dune, talus and recent fluvial river bed deposits.

Fan deposits take a representative landform in the lower stream area and consist of sand and gravel. Grain size decreases toward the lower stream side, and, at the top of the fan of an altitude of 100 m above sea level, gravels of maximum diameter of 40 cm are observed. The course of river flow is indefinite and always changes its way on the fan.

Deltaic fan deposits occupy the very low gradient plain of an altitude of less than 20 m above sea level. Flood water flow goes down on the fan deposits forming a network pattern and decreases its flow speed at this deltaic fan plain, resulting a sedimentation of very fine materials.

Recent river floor deposits are found in the main stream of the Wadi Jizzi and in another major streams of the middle to upper stream side area. Unconsolidated sand and gravel are major constituent but a little amount of very fine sand and silt are recognized in some places.

Dune sediments develop along the sea coast and composed of fine to medium sand. They are well developed especially at the coast of Oman Gulf, northern side of an estuary of the Wadi Jizzi, where the maximum width of 500 m is observed.

Talus deposits are locally distributing at the foot of the mountains and hills, and in the tributary small valleys. They develop especially in the area where the Hawasina Group crops out. They are generally composed of angular pebbles and gravels with silt and clay.

2.10 Economic geology

Cupriferous massive sulphide deposits of Cyprus-type occur in the area where pillow lava of the Semail Ophiolite Complex distributes. In the investigated area, ore indications are known at Lasail, Aarja and Bayda. Among these three indications, the biggest lasail deposits are now in preparation for extensive exploitation as one of the national project of The Sultanate of Oman.

In the neighbouring area of Farfar, chromite deposits in ultrabasic rocks are found. They are small in scale and none of them is in operation.

Gravel and pebble of the fan deposits in the lower stream are quarried extensively by private companies for a engineering purpose, especially for roads, and a part of product is sold as constructing materials.

Clay in the deltaic fan deposits near sea coast is excavated to make bricks which are used by habitants of Sohar as building materials.

3. Geology of the Dam Site

3.1 Topography

The planned dam site is situated at the hill land of the middle stream of the Wadi Jizzi. The dam site is composed of river bed of 650 m wide and of steep walls of river terrace deposits at both abutments. An outline of topographic characteristics around the damsite is given here.

The river terrace deposits composed of sand and gravel form the right and left banks of the river which have slopes of about 20° in gradient from the river bed. However, the surface of the terrace is a flat plane of the upper terrace deposits (Tu), 165 to 170 m in height above sea level and extensively distributed. On the plane of this terrace deposits, several tributary valleys are developing which erode the plane about five meters downward at the dam site. Downward erosion continues actively even now.

The present river bed of the Wadi Jizzi broadens its width from the encountering part with the Wadi Awhin, that is, the dam site, to the lower stream side and continues into the fan. In the upper stream side from the dam site, rivers have a rather narrow width and show various intricated flow pattern because of complicatedly stretching mountains. However, the main stream of the Wadi Jizzi can be clearly discriminated. At around the dam site, four disinct river streams including the Wadi Awhin can be recognized.

The gradient of river bed is about 1/120 in the middle stream area including the dam site and 1/160 in the fan deposits area.

3.2 Geology

Geolog- of the dam site is composed of recent fluvial sediments, river terrace deposits and sedimentary rocks of the Hawasina Group. Detailed geological description of these rocks around the planned dam site is given here. Geological map and geological cross section of the dam site are presented in Drawing D-1002 in Main Report.

Both banks of the river at the dam site are constructed by the upper terrace deposits (Tu) of Pleistocene age which is composed of sand and gravel beds intercalated with lenticular layers of well-sorted sand and/or mud in places. Sand and gravel are rounded ones and most of them is of basic rocks derived from the ophiolite complex. Some of them, especially a part of diabase and gabbro, have been considerably weathered. The formation is well consolidated as a whole and the grade of consolidation increases toward the lower horizon. The lowest part is composed of conglomerate tightly cemented by calcareous matrix. Sedimentary rocks of the Hawasina Group are underlying beneath these terrace deposits, but do not crop out at around the dam site.

Geology of the river bed of the dam site is composed of recent fluvial deposits, the upper terrace deposits and the basement Hawasina Group (limestone) in descending order. Recent fluvial deposits contain poorly-sorted round to subangular sand and pebble. These sand and pebble are not consolidated and, for this reason, they can be distinctly discriminated from the underlying upper river terrace deposits. Thickness of the deposits increases toward the right bank of the river and the maximum thickness of 5 m is recognized. The underlying river terrace deposits demonstrate almost the same lithofacies with those situated at both banks, that is, composed mainly of rounded sand and gravel with partial intercalations of fine sand and/or muddy beds, and well consolidated by calcareous cementing materials. Permeability test was performed within this formation.

The basement of these Quaternary sediments is considered to be limestone of the Hawasina Group and the maximum thickness of the overburden is estimated to be 30 m.

Electric prospecting indicated the possibility of existence of another formation beneath the Hawasina Group, tentatively referred to the ophiolite complex.

Any existing or inferred faults are not recognized at the dam site.

3.3 Permeability of the dam foundation

As above-mentioned, geology of the dam foundation is composed of recent river bed deposits, the upper river terrace deposits and limestone of the Hawasina Group in descending order. Permeability test utilizing drill holes was performed in the horizon of the upper river terrace deposits. The result is shown in Table D-1.

Permeability of the upper river terrace deposits have a range from 8.7×10^{-1} cm/sec to 1.8×10^{-3} cm/sec with a mean value of 1.6×10^{-1} cm/sec. Although the coefficient varies markedly from place to place, it can be said that the formation has remarkably high permeability. This fact is also supported by the observation that the river terrace deposits of both banks of the river have shown high permeability against falling rain.

In the case of the planned dam, it is not necessary to control infiltration of water into basement rocks, considering its purpose. However, it is said that the high permeability of rocks has much possibility to cause the destruction of basement by infiltration and that probability of destruction would become greater when the coefficient is higher than 10^{-4} cm/sec. It is also said that the destruction by infiltration tends to occur readily in the case that sediments are consist of fine materials like sand and silt, or well-sorted non-cohesive sand and pebble, in any way, of loosely sedimented materials.

Recent fluvial deposits of the dam site are composed of loose sediments on one hand, but of poorly-sorted one without much fine materials like silt on the other. Furthermore, the river terrace deposits are well consolidated like conglomerate although accompanied by a partial intercalation of lenticular layers of fine materials. Consequently, the destruction by infiltration could be prevented by such suitable countermeasures as filter setting, embankment and so on.

It must be also emphasized that abutting parts of the dam on both banks of the river and also surroundings of the spillway would have a possibility of the destruction by infiltration and of erosion by surging water. In order to protect the terrace walls and the dam itself from these troubles, such suitable measures as counter-weight and embankment on the wall would be indispensable.

Table D-1 Result of Permeability Test

Name of Hole	Depth Tested (m)	Permeability (cm/sec)				Method of Test
		1st Test	2nd Test	3rd Test	Average	
H - 1	15 ~ 20	0.013	0.011	0.011	0.012	Falling head test
H - 2	20.5	0.82	0.91	-	0.87	Constant head test
H - 3	14.6	0.062	0.091	0.056	0.070	Falling head test
H - 4	15	0.12	0.10	0.12	0.12	"
H - 5	10	0.011	0.016	0.018	0.015	"
H - 6	10	-	-	-	-	"
H - 7	5	0.016	0.034	0.037	0.029	"
H - 8	5	0.0018	-	-	-	Constant head test

Data sheets for permeability test are attached in Annex 1.

FIGURE D-3 GEOLOGICAL LOG OF BORE HOLE

Name of hole	H-1	Permeability tested date	11/Mar/82
Depth drilled	20.5 (m)	Date of drill completion	10/Mar/82
Bore hole diameter	200 (mm)	Depth permeability tested	15 - 20.5 (m)
Static water level	2.12 (m)	Coefficient of permeability	1.2×10^{-2} (cm/sec)

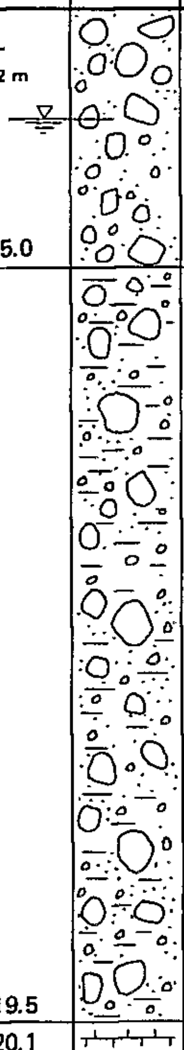
Depth (m)		Log	Rock Type	Lithology
5	W.L 2.12 m 5.0		Recent wadi bed deposits	Sand & gravel gravels are round to subangular
10 15 20	19.5		Upper terrace deposits	Sand & gravel gravels are round to subround with calcareous matrix
	20.1		Hawasina	Limestone, white, soft

FIGURE D-4 GEOLOGICAL LOG OF BORE HOLE

Name of hole	H - 2	Permeability tested date	13/Mar/82
Depth drilled	20.5 (m)	Date of drill completion	12/Mar/82
Bore hole diameter	150 (mm)	Depth permeability tested	20.5 (m)
Static water level	1.19 (m)	Coefficient of permeability	8.7×10^{-1} (cm/sec)

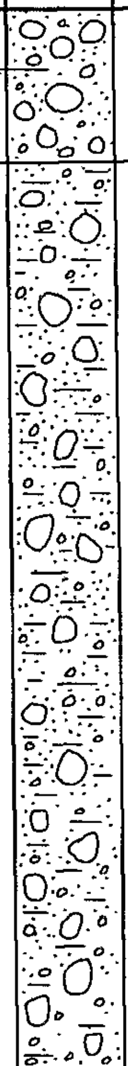
Depth (m)	Log	Rock Type	Lithology
W. L. 1.19 m; 3.0		Recent wadi bed deposits	Sand & gravel gravels are round to subangular
5; 10; 15; 20; 20.5		Upper terrace deposits	Sand & gravel cemented, gravels are round to subround with calcareous matrix

FIGURE D-5 GEOLOGICAL LOG OF BORE HOLE

Name of hole	H-3	Permeability tested date	17/Mar/82
Depth drilled	15.0 (m)	Date of drill completion	15/Mar/82
Bore hole diameter	150 (mm)	Depth permeability tested	14.6 (m)
Static water level	2.23 (m)	Coefficient of permeability	7.0×10^{-2} (cm/sec)

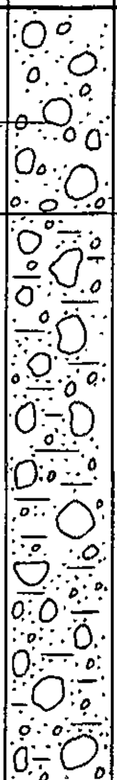
Depth (m)		Log	Rock Type	Lithology
	WL 2.23 m 4.0		Recent wadi bed deposits	Sand & gravel gravels are round to subangular
5 10 15	15.0		Upper terrace deposits	Sand & gravel gravels are round to subround with calcareous matrix.
20				

FIGURE D-6 GEOLOGICAL LOG OF BORE HOLE

Name of hole	H-4	Permeability tested date	14/Mar/82
Depth drilled	15.0 (m)	Date of drill completion	13/Mar/82
Bore hole diameter	150 (mm)	Depth permeability tested	15.0 (m)
Static water level	0.62 (m)	Coefficient of permeability	1.2×10^{-1} (cm/sec)

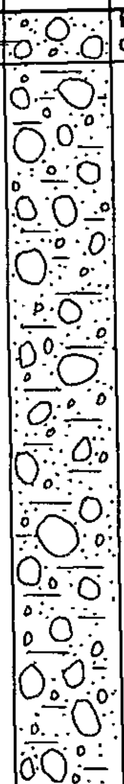
Depth (m)		Log	Rock Type	Lithology
	W L 0.62m 1.0		Recent wadi bed deposits	Gravel & sand
5 10 15	15.0		Upper terrace deposits	Sand & gravel gravels are round to subround with calcareous matrix
20				

FIGURE D – 7 GEOLOGICAL LOG OF BORE HOLE

Name of hole	H - 5	Permeability tested date	15/Mar/82
Depth drilled	10.0 (m)	Date of drill completion	14/Mar/82
Bore hole diameter	150 (mm)	Depth permeability tested	10 (m)
Static water level	1.73 (m)	Coefficient of permeability	1.5×10^{-2} (cm/sec)

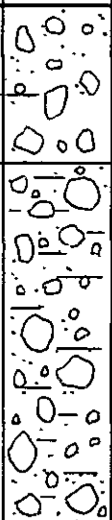
Depth (m)		Log	Rock Type	Lithology
	W.L 1.73 m 3.0		Recent wadi bed deposits	Gravel & sand gravels are round to subangular
5 10	10.0		Upper terrace deposits	Gravel & sand gravels are round to subround with calcareous matrix
15 20				

FIGURE D-8 GEOLOGICAL LOG OF BORE HOLE

Name of hole	H-6	Permeability tested date	18/Mar/82
Depth drilled	10.0 (m)	Date of drill completion	16/Mar/82
Bore hole diameter	150 (mm)	Depth permeability tested	10.0 (m)
Static water level	3.30 (m)	Coefficient of permeability	(cm/sec)

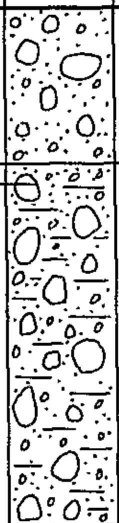
Depth (m)	Log	Rock Type	Lithology
3.0		Recent wadi bed deposits	Gravel & sand gravels are round to subangular
W.L 3.30 m 5 10 10.0		Upper terrace deposits	Gravel & sand gravels are round to subround with calcareous matrix
15 20			

FIGURE D－9 GEOLOGICAL LOG OF BORE HOLE

Name of hole	H・7	Permeability tested date	16/Mar/82
Depth drilled	5.0 (m)	Date of drill completion	15/Mar/82
Bore hole diameter	150 (mm)	Depth permeability tested	5.0 (m)
Static water level	1.90 (m)	Coefficient of permeability	2.9×10^{-2} (cm/sec)

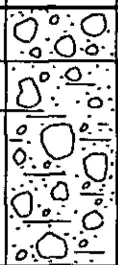
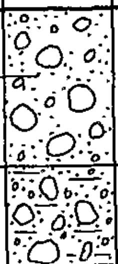
Depth (m)		Log	Rock Type	Lithology
	1.0		Recent river bed deposits	Gravel & sand
5	W.L 1.90 m 5.0		Upper terrace deposits	Gravel & sand gravels are round to subround with calcareous matrix
10				
15				
20				

FIGURE D-10 GEOLOGICAL LOG OF BORE HOLE

Name of hole	H・8	Permeability tested date	18/Mar/82
Depth drilled	5.0 (m)	Date of drill completion	16/Mar/82
Bore hole diameter	150 (mm)	Depth permeability tested	5 0 (m)
Static water level	1.29 (m)	Coefficient of permeability	1.8×10^{-3} (cm/sec)

Depth (m)		Log	Rock Type	Lithology
	W L 1.29 m 3.0		Recent river bed deposits	Gravel & sand gravels are round to subangular
5	5.0		Upper terrace deposits	Gravel & sand gravels are round to subround with calcareous matrix
10				
15				
20				

DATA SHEET FOR PERMEABILITY TEST

No. 1

Name of Hole: H-1

Tested Date: March 11, 1982

Borehole Diameter: 200 (mm)

Depth Drilled: 20.5 (m)

Tested Depth: 15 - 20.5 (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
		2.12	0	416.7	injection started
	0	1.63	0.49		stabilized injection stopped
	19	1.82	0.30		
	24	1.86	0.26		
	32	1.91	0.21		
	46	1.99	0.13		
	52	2.00	0.12		
	1-29	2.07	0.05		
	26	2.10	0.02		
	36	2.11	0.01		
	58	2.12	0		
	2-09	2.12	0		
	19	2.12	0		
	27	2.12	0		

DATA SHEET FOR PERMEABILITY TEST

No. 2

Name of Hole: H-1 Tested Date: ______

Borehole Diameter: ______ (mm) Depth Drilled: ______ (m)

Tested Depth: ______ (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		2.13	0	250	injection started
2-56		1.65	0.48		stabilized
4-12	0	1.65	0.48		injection stopped
32	20	1.70	0.43		
48	36	1.90	0.23		
57	45	1.93	0.20		
5-00	48	1.96	0.17		
05	53	1.98	0.15		
09	57	2.00	0.13		
14	1-02	2.01	0.12		
20	08	2.04	0.09		
39	27	2.08	0.05		
49	37	2.10	0.03		
6-04	52	2.10	0.03		
28	2-16	2.11	0.02		
38	26	2.11	0.02		
45	33	2.11	0.02		
8-12	4-00	2.12	0.01		
49	37	2.12	0.01		
12-29	7-17	2.13	0		

DATA SHEET FOR PERMEABILITY TEST

No. 3

Name of Hole: H-1

Tested Date: ____________

Borehole Diameter: ________ (mm)

Depth Drilled: ________ (m)

Tested Depth: ____________ (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		2.13	0		injection started
7-11		1.63	0.50		stabilized
41	0	1.63	0.50		injection stopped
53	12	1.65	0.48		
58	17	1.72	0.41		
8-07	26	1.85	0.28		
20	39	1.94	0.19		
26	45	1.97	0.16		
31	50	1.99	0.14		
37	56	2.02	0.11		
44	1-03	2.05	0.08		
49	08	2.06	0.07		
57	16	2.09	0.04		
9-40	59	2.10	0.03		
10-50	3-09	2.11	0.02		
14-11	6-30	2.12	0.01		
18-18	10-37	2.12	0.01		

DATA SHEET FOR PERMEABILITY TEST No. 1

Name of Hole: H-2 Tested Date: March 13, 1982

Borehole Diameter: 150 (mm) Depth Drilled: 20.5 (m)

Tested Depth: 20.5 (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
		1.19	0	240	injection started
		0	1.19		stabilized
		1.19	0	260.9	injection started
		0.03	1.16		stabilized

DATA SHEET FOR PERMEABILITY TEST

No. 1

Name of Hole: H-3

Tested Date: March 17, 1982

Borehole Diameter: 150 (mm)

Depth Drilled: 15 (m)

Tested Depth: 14.6 (m)

casing diameter: 150 (mm)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		2.23		214.3	injection started
16-10	0	1.68	0.55		injection stopped not stabilized
46	36	2.05	0.18		
49	39	2.08	0.15		
57	47	2.10	0.13		
17-03	53	2.13	0.10		
12	1-02	2.15	0.08		
26	16	2.17	0.06		
43	33	2.20	0.03		
18-20	2-10	2.21	0.02		
41	31	2.22	0.01		
19-39	3-29	2.22	0.01		

DATA SHEET FOR PERMEABILITY TEST

No. 2

Name of Hole: H-3

Tested Date: ____________

Borehole Diameter: ________ (mm)

Depth Drilled: ________ (m)

Tested Depth: ____________ (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		2.22	0	145.6	injection started
3-11	0	1.92	0.30		stabilized injection stopped
30	19	2.10	0.12		
40	29	2.12	0.10		
47	36	2.14	0.08		
52	41	2.16	0.06		
4-02	51	2.17	0.05		
07	56	2.18	0.04		
13	1-02	2.19	0.03		
27	16	2.20	0.02		
52	41	2.21	0.01		
6-07	2-56	2.215	0.01		
7-00	3-49	2.22	0		

DATA SHEET FOR PERMEABILITY TEST

No. 3

Name of Hole: H-3 　　 Tested Date: ______

Borehole Diameter: ______(mm) 　 Depth Drilled: ______(m)

Tested Depth: ______(m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		2.23	0	214.3	injection started
8-00		1.56	0.67		stabilized
9-32	0	1.56	0.67		injection stopped
34	2	1.60	0.63		
39	7	1.65	0.58		
40	8	1.70	0.53		
43	11	1.75	0.48		
47	15	1.80	0.43		
51	19	1.86	0.37		
56	24	1.90	0.33		
10-01	29	1.95	0.28		
07	35	2.00	0.23		
15	43	2.05	0.18		
27	55	2.10	0.13		
45	1-13	2.15	0.08		
11-06	34	2.18	0.05		
16	44	2.19	0.04		
33	2-01	2.20	0.03		
12-07	35	2.21	0.02		
55	3-23	2.22	0.01		

DATA SHEET FOR PERMEABILITY TEST No. 1

Name of Hole: H-4 Tested Date: March 14, 1982

Borehole Diameter: 150 (mm) Depth Drilled: ____ (m)

Tested Depth: 15 (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		0.62	0	123.7	injection started
		0.06	0.56		stabilized
11-8	0	0.06	0.56		injection stopped
33	25	0.50	0.12		
50	42	0.58	0.04		
12-04	56	0.60	0.02		
12-29	1-21	0.605	0.015		
13-38	2-30	0.61	0.010		
15-30	4-22	0.615	0.005		

DATA SHEET FOR PERMEABILITY TEST

No. 2

Name of Hole: H-4

Tested Date: ____

Borehole Diameter: ____ (mm)

Depth Drilled: ____ (m)

Tested Depth: ____ (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		0.62	0	122.4	injection started
		0.06	0.56		stabilized
6-21	0	0,06	0.56		injection stopped
23	2	0.30	0.32		
31	10	0.40	0.22		
37	16	0.47	0.15		
42	21	0.50	0.12		
47	26	0.54	0.08		
54	33	0.57	0.05		
7-03	42	0.59	0.03		
14	53	0.60	0.02		
23	1-02	0.61	0.01		
9-09	2-48	0.61	0.01		
10-53	4-32	0.62	0		

DATA SHEET FOR PERMEABILITY TEST No. 3

Name of Hole: H-4 Tested Date: ________

Borehole Diameter: ________ (mm) Depth Drilled: ________ (m)

Tested Depth: ________ (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		0.62	0	63.2	injection startee
		0.15	0.47		stabilized
3-46	0	0.15	0.47		injection stopped
56	10	0.37	0.25		
4-03	17	0.45	0.17		
07	21	0.48	0.14		
11	25	0.51	0.11		
14	28	0.54	0.08		
17	31	0.55	0.07		
22	36	0.58	0.04		
31	45	0.59	0.03		
51	1-05	0.60	0.02		
5-38	52	0.61	0.01		
6-29	2-43	0.61	0.01		
8-45	4-59	0.62	0		

DATA SHEET FOR PERMEABILITY TEST

No. 1

Name of Hole: H-5

Tested Date: March 15, 1982

Borehole Diameter: 150 (mm)

Depth Drilled: 10 (m)

Tested Depth: 10 (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		1.73	0		injection started
11-54		0.55	1.18		not stabilized
12-20	0	0.55	1.18		injection stopped
22	2	0.60	1.13		
35	15	0.65	1.08		
50	30	0.69	1.04		
57	37	0.71	1.02		
13-07	47	0.72	1.01		
15	55	0.73	1.00		
20	1-00	0.74	0.99		
35	15	0.75	0.98		
41	21	0.76	0.97		
14-01	41	0.77	0.96		
13	53	0.78	0.95		
15-24	3-04	0.78	0.95		
35	15	0.78	0.95		
16-03	43	0.79	0.94		
41	4-21	0.80	0.93		
17-28	5-08	0.81	0.92		
19-35	7-15	0.82	0.91		
28-30	16-10	0.83	0.90		

DATA SHEET FOR PERMEABILITY TEST No. 2

Name of Hole: H-5 Tested Date:

Borehole Diameter: ______(mm) Depth Drilled: ______(m)

Tested Depth: ______(m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		1.73	0	57.1	injection started
		0.04	1.69		stabilized
8-33	0	0.04	1.69		injection stopped
40	7	0.40	1.33		
50	17	0.51	1.22		
58	25	0.58	1.15		
9-02	29	0.63	1.10		
06	33	0.66	1.07		
09	36	0.70	1.03		
19	46	0.76	0.97		
24	51	0.80	0.93		
28	55	0.81	0.92		
33	1-00	0.83	0.90		
36	03	0.84	0.89		
42	9	0.85	0.88		
48	15	0.86	0.87		
55	22	0.87	0.86		
10-02	1-29	0.88	0.85		
14	41	0.89	0.84		
30	57	0.90	0.83		
11-18	2-45	0.91	0.82		
45	3-12	0.92	0.81		
12-17	44	0.93	0.80		
13-09	4-36	0.94	0.79		
14-53	6-20	0.95	0.78		
15-57	7-24	0.96	0.77		

DATA SHEET FOR PERMEABILITY TEST

No. 3

Name of Hole: H-5 Tested Date: ________

Borehole Diameter: ________ (mm) Depth Drilled: ________ (m)

Tested Depth: ________ (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		1.73	0	63.4	injection started
		0.04	1.69		stabilized
4-40	0	0.04	1.69		injection stopped
44	4	0.36	1.37		
48	8	0.47	1.26		
51	11	0.50	1.23		
55	15	0.57	1.16		
58	18	0.56	1.15		
5-01	21	0.60	1.11		
4	24	0.61	1.10		
8	28	0.67	1.04		
14	34	0.73	1.00		
19	39	0.76	0.97		
26	46	0.80	0.93		
37	57	0.84	0.89		
45	1-05	0.85	0.88		
50	15	0.86	0.87		
56	16	0.87	0.86		
6-08	28	0.88	0.85		
19	39	0.89	0.84		
31	51	0.90	0.83		
56	2-16	0.91	0.82		
7-21	41	0.92	0.81		
49	3-09	0.93	0.80		

DATA SHEET FOR PERMEABILITY TEST

No. 1

Name of Hole: H-6

Tested Date: March 18, 1982

Borehole Diameter: 150 (mm)

Depth Drilled: 10.0 (m)

Tested Depth: 10.0 (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
		3.30	0		injection started
	0	0.12	3.18		injection stopped
	3-53	0.14	3.16		
	7-07	0.15	3.15		
	13-35	0.16	3.14		
	22-45	0.17	3.13		
	25-49	0.18	3.12		
	35-50	0.20	3.10		
	47-52	0.21	3.09		

DATA SHEET FOR PERMEABILITY TEST No. 1

Name of Hole: H-7 Tested Date: March 16, 1982

Borehole Diameter: 150 (mm) Depth Drilled: 5.0 (m)

Tested Depth: 5.0 (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		1.90	0	66.7	injection started
1-49		0.29	1.61		stabilized W.L.
2-11	0	0.29	1.61		injection stopped
21	10	1.00	0.90		
24	13	1.25	0.65		
33	22	1.30	0.60		
40	29	1.34	0.56		
44	33	1.38	0.52		
49	38	1.40	0.50		
55	44	1.45	0.45		
3-20	1-09	1.54	0.36		
33	1-22	1.59	0.31		
39	1-27	1.60	0.30		
48	1-37	1.62	0.28		
4-06	1-55	1.65	0.25		
25	2-14	1.67	0.23		
52	2-41	1.70	0.20		
5-32	3-21	1.71	0.19		
59	3-48	1.73	0.17		
6-23	4-12	1.74	0.16		
7-15	5-04	1.75	0.15		
8-35	6-24	1.76	0.14		
9-57	7-46	1.76	0.14		

DATA SHEET FOR PERMEABILITY TEST   No. 2

Name of Hole: H-7   Tested Date:

Borehole Diameter: ________ (mm)   Depth Drilled: ________ (m)

Tested Depth: 5.0 (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		1.77	0	103.4	injection started
2-27	0	0.29	1.48		stabilized injection stopped
31	4	0.80	0.97		
37	10	0.87	0.90		
41	14	0.93	0.84		
44	17	0.97	0.80		
47	20	1.03	0.74		
51	24	1.08	0.69		
54	27	1.13	0.64		
3-00	33	1.18	0.59		
3	36	1.22	0.55		
8	41	1.25	0.52		
14	47	1.30	0.47		
18	51	1.35	0.42		
29	1-02	1.40	0.37		
35	08	1.43	0.34		
39	12	1.45	0.32		
45	18	1.48	0.29		
50	23	1.50	0.27		
56	29	1.52	0.25		
4-02	35	1.54	0.23		
06	39	1.55	0.22		
13	46	1.57	0.20		
21	54	1.59	0.18		
26	59	1.60	0.17		
30	2-03	1.61	0.16		

DATA SHEET FOR PERMEABILITY TEST No. 3

Name of Hole: H-7 Tested Date: ____

Borehole Diameter: ____ (mm) Depth Drilled: ____ (m)

Tested Depth: 5.0 (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
4-36	2-09	1.62	0.15		
42	15	1.63	0.14		
48	21	1.64	0.13		
54	27	1.65	0.12		
5-01	34	1.66	0.11		
08	41	1.67	0.10		
17	50	1.68	0.09		
27	3-00	1.69	0.08		
36	09	1.70	0.07		
48	21	1.71	0.06		
6-03	36	1.72	0.05		
19	52	1.73	0.04		
50	4-23	1.74	0.03		
7-36	5-09	1.75	0.02		
8-28	6-01	1.76	0.01		
9-08	41	1.76	0.01		

DATA SHEET FOR PERMEABILITY TEST

No. 4

Name of Hole: H-7 Tested Date: ____

Borehole Diameter: ____ (mm) Depth Drilled: ____ (m)

Tested Depth: 5.0 (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
0		1.77	0	105.3	injection started
1-58		0.29	1.48		stabilized
2-28	0	0.29	1.48		injection stopped
33	5	0.74	1.03		
38	10	0.80	0.97		
40	12	0.85	0.92		
43	15	0.90	0.87		
45	17	0.95	0.82		
49	19	1.00	0.77		
54	24	1.08	0.69		
57	27	1.10	0.67		
3-04	34	1.15	0.62		
07	37	1.20	0.57		
13	43	1.25	0.52		
20	50	1.30	0.47		
27	57	1.35	0.42		
36	1-06	1.40	0.37		
45	15	1.45	0.32		
55	25	1.50	0.27		
4-14	44	1.55	0.22		
36	2-08	1.60	0.17		
53	25	1.63	0.12		
58	30	1.64	0.13		
5-05	37	1.65	0.12		
13	45	1.66	0.11		
20	52	1.67	0.10		

DATA SHEET FOR PERMEABILITY TEST No. 5

Name of Hole: H-7 Tested Date: ____________

Borehole Diameter: ________(mm) Depth Drilled: ________(m)

Tested Depth: ____________(m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
5-29	3-01	1.68	0.09		
41	12	1.69	0.08		
50	21	1.70	0.07		
6-02	3-33	1.71	0.06		
21	52	1.72	0.05		
47	4-18	1.73	0.04		
7-23	54	1.74	0.03		
8-06	5-37	1.75	0.02		
9-47	7-18	1.76	0.01		
10-57	8-28	1.765	0.01		

DATA SHEET FOR PERMEABILITY TEST

No. 1

Name of Hole: H-8

Tested Date: March 18, 1982

Borehole Diameter: 150 (mm)

Depth Drilled: 5.0 (m)

Tested Depth: 5.0 (m)

Time after test started (min-sec)	Time after injection stopped (min-sec)	Water level (mbgs)	Drawdown (m)	Rate of injected water (lit/min)	Remark
		1.29	0	0.56	injection started
	0	0	1.29		stabilized injection stopped
	15	0.01	1.28		
	30	0.02	1.27		
	51	0.025	1.27		
	1-07	0.03	1.26		
	2-18	0.04	1.25		
	5-34	0.06	1.23		
	13-00	0.09	1.20		
	16-57	0.10	1.19		
	19-42	0.11	1.18		
	23-44	0.12	1.17		
	27-30	0.14	1.15		
	34-05	0.15	1.14		

D-2. Geo-Electric Survey

1. Outline of Survey

The vertical sounding and the equi-depth sounding were applied to the survey. As illustrated in the location map of the sounding points (Figure D-11), the vertical sounding was carried out along two sounding lines in longitudinal direction and three sounding lines in the cross-sectional direction against the wadi in the area between the coastal line and the mountain area with intervals ranging from one kilometer to three kilometers. The aforesaid sounding lines were determined by those courses that pass through the spots such as observation wells and equi-depth sounding lines which are expected to provide the clear geological conditions so as to utilize possibly many data/information for successful analysis in this survey.

The equi-sounding was carried out along eight sounding lines in the whole Project Area, including three (ES-H 2.3.6) in the littoral area, three (ES-H 4.5.7) in the potential dam site (D.1, D.2) and two (ES-H 1.8) in the gravel plain.

The sounding lines in the littoral area covered surveys on the sea-water intrusion and the status of the underlying marine consolidated layers, while those in the dam site covered the surveys on the bed rock depth, thickness of the alluvium and the dilivium, both developed in the mid-stream of the wadi. The sounding lines in the mid-basin, on the other hand, were selected to cover the supplemental surveys for the variable faces that could not be precisely sounded by vertical soundings.

The vertical sounding lines applied the equi-depth sounding lines were selected to carry out the soundings in overlapping each other so that the results can be mutually supplemented for rectification. The equi-depth sounding, which can secure highly precise results with much volume of the sounding to be carried out,

Table D-3 Quantity of Electric Prospecting

Vertical Sounding

Line No.	Point No.	Investigation Depth	Location
ES-V1	No.1-11	120m (No.8:80m, No.1:100m)	Left side bank of wadi, near the wadi suq.
ES-V2	No.1-8	120m (No.1:100m)	Right side to center of wadi.
ES-V3	No.1,2	120m	Near the sea coast.
ES-V4	No.1-3	120m	Middle courses of wadi
ES-V5	No.1	120m	Down stream of wadi.
Total 5 lines	25 points		

Equi-depth Sounding

Line No.	Line Length	Investigation Depth (Unit Electrode Separation)	Arrangement	Location
ES-H1	500m	100m (10m)	CPPC,PCCP CCPP,PPCC	Middle courses
ES-H2	500m	100m (10m)	-ditto-	Near the coast
ES-H3	500m	100m (10m)	-ditto-	Near the coast
ES-H4	520m	100m (10m)	-ditto-	Dam site (D-2)
ES-H5	260m	100m (5m)	-ditto-	Dam site (D-1)
ES-H6	500m	100m (10m)	-ditto-	Near the coast
ES-H7	490m	100m (10m)	-ditto-	Dam site (D-2)
ES-H8	500m	160m (10m)	CPPC,CCPP	Middle courses
Total 8 lines	3,770m			

FIGURE D – 11 LOCATION MAP OF ELECTRIC PROSPECTING

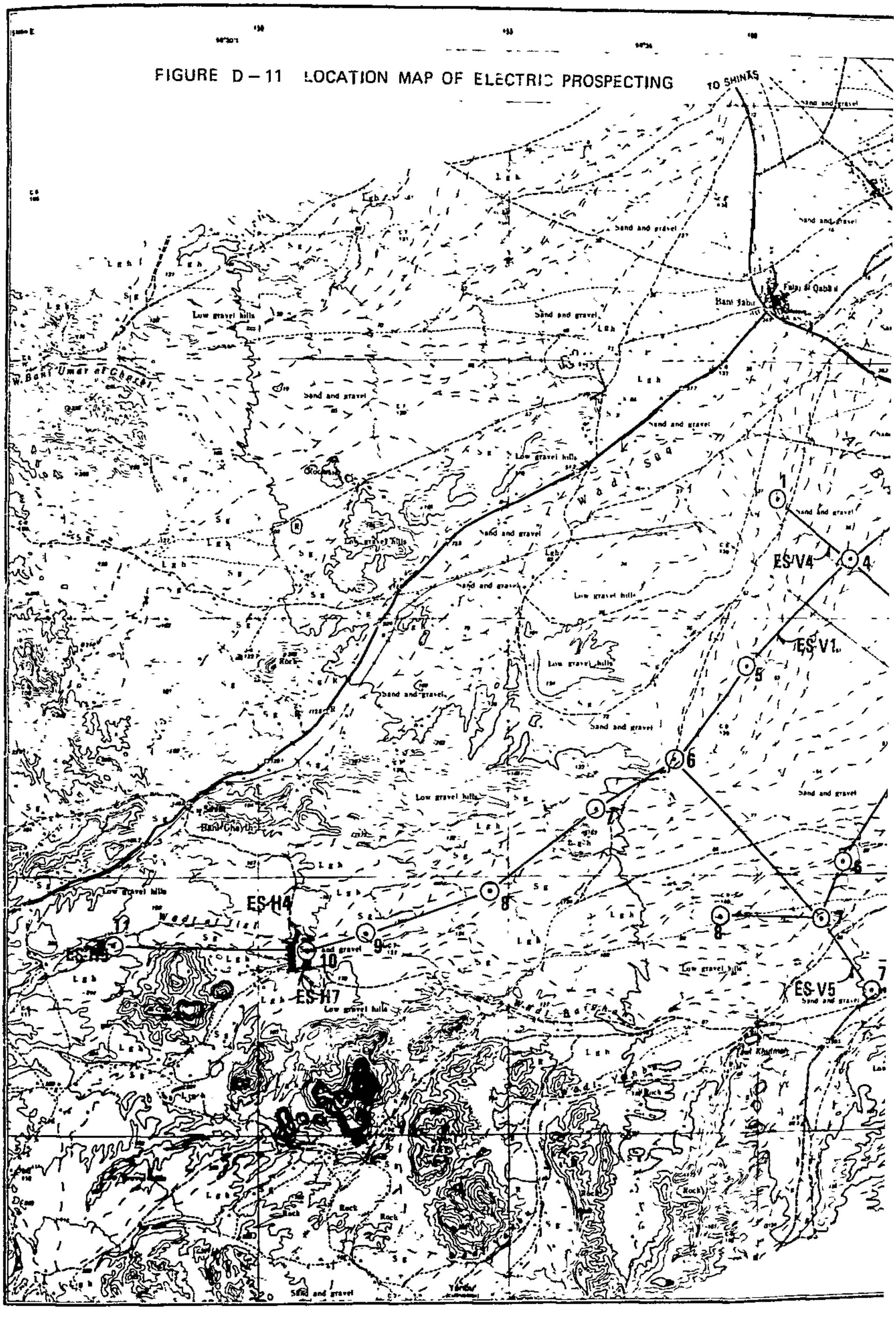
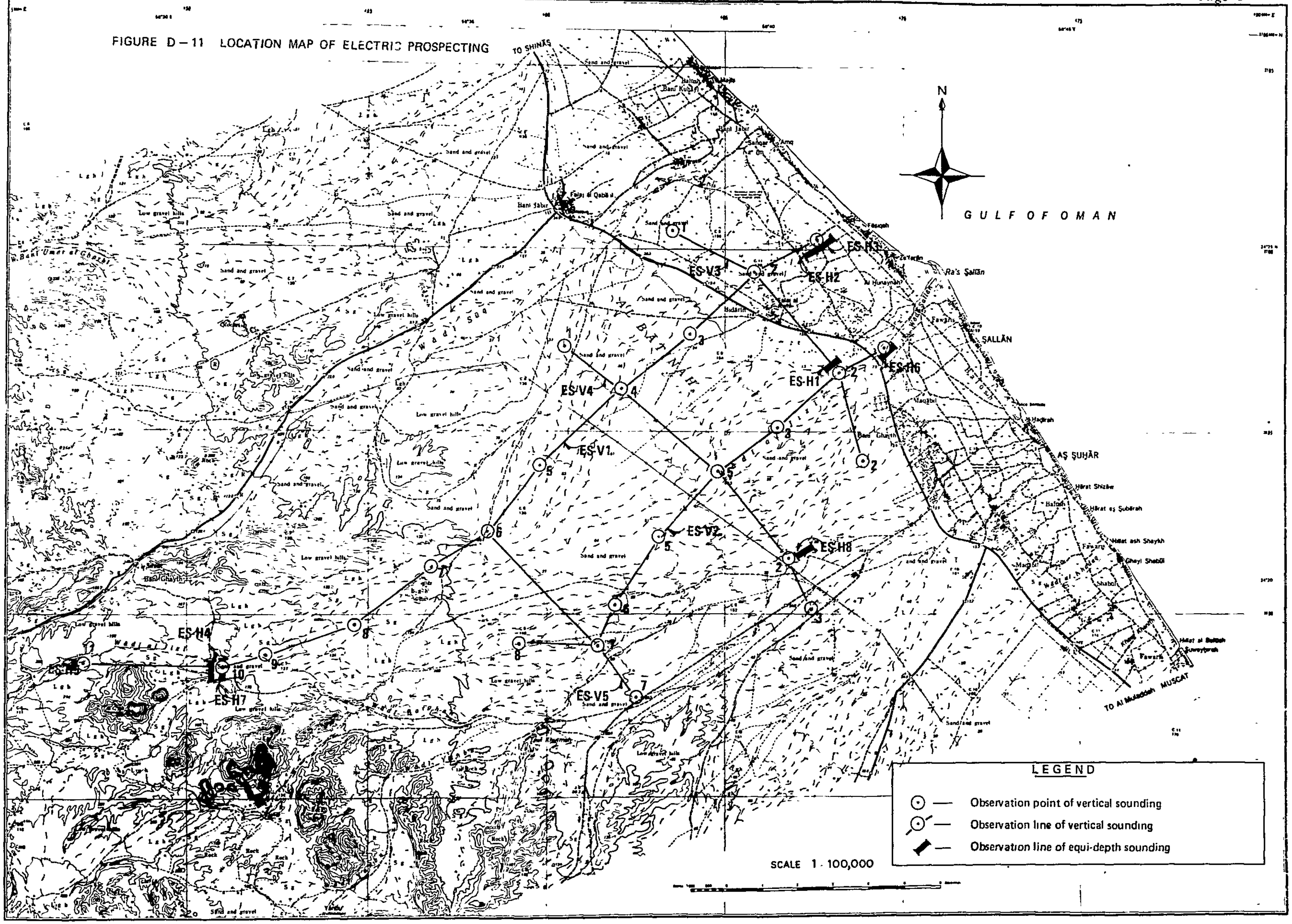


FIGURE D-11 LOCATION MAP OF ELECTRIC PROSPECTING



is considered unsuitable to the sounding covering wide areas as objective. The vertical sounding, on the other hand, will have some problems in its preciseness of the results, although applicable to the works for the lengthy sounding. The related analyses, therefore, should be made through measuring the local resistivity in its horizontal and vertical change by equi-depth sounding, and furthermore, the vertical sounding was carried out to trace the horizontal continuity of the resistivity stratigraphy that had been analyzed by equi-depth sounding.

2. Sounding Method

The sounding methods employed in the study were the vertical sounding method and the equi-depth sounding, the analysis methods for which are developed from the theoretically same base. The equi-depth method is carried out by moving the survey points of the four-electrode method at the intervals of the distance of the sounding depth on the sounding lines.

The sounding equipment of type of ES-G2 made by Oyo-Chisitsu Co., Japan, was used for sounding.

The equipment, having 800 volts in three ampares of the maximum allowable current, usually works, in the arid zone like the Project Area, to indicate the surface layer value of over several thousand ohm in maximum. In this study, however, the detailed survey has not been conducted on the terrace gravel to secure precise measurement.

The followings detail the methodology of the vertical sounding and the equi-depth sounding, and the procedures of the related analyses.

2.1. Vertical Sounding

The Wennar method was employed in the vertical sounding. The Wennar method, the so-called the four-electrode method, makes the electrode arrangement that four electrodes should be earthed at the equal intervals as illustrated in Figure D-12, and when the electric current shall run from the two electrodes of C_1 and C_2 in outer position, the voltage difference caused therefrom shall be measured by the other two of P_1 and P_2 in inner position. With this measurement, the apparent resistivity ρ can be obtained by the following equation.

$$\rho = 2 \cdot \pi \cdot a \cdot \frac{V}{I}$$

Where,

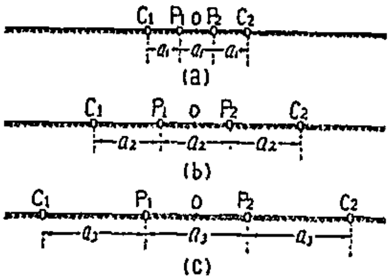
ρ = apparent resistivity
a = electrode separation
I = electric current
V = voltage difference

The resistivity of the ground, which is measured in the condition of electrode separation by a is equal to the apparent resistivity measured by the depth of a. The measurements of the apparent resistivity with gradual increase in value of a, will allow to analyze the change of resistivity against the depth. The current study covered the measurements of the apparent resistivity in 16 cases of the depth illustrated as 1, 2, 3, 4, 6, 8, 10, 16, 20, 30, 40, 48, 60, 80, 100 and 120 m respectively.

The measured apparent resistivities against the respective values of the depth - a, shall be plotted on the double logarithmic section paper to make the P-a curve for estimating the critical depth and the specific resistivity by the Sandberg's Standard Curve Method which is commonly applied.

FIGURE D-12 METHOD OF VERTICAL RESISTIVITY SOUNDING ANALYSIS

FIGURE D-12-1 Wenner Electric Array



Electric separation — a —

a_1	1	a_9	20
a_2	2	a_{10}	30
a_3	3	a_{11}	40
a_4	4	a_{12}	48
a_5	6	a_{13}	60
a_6	8	a_{14}	80
a_7	10	a_{15}	100
a_8	16	a_{16}	120 (m)

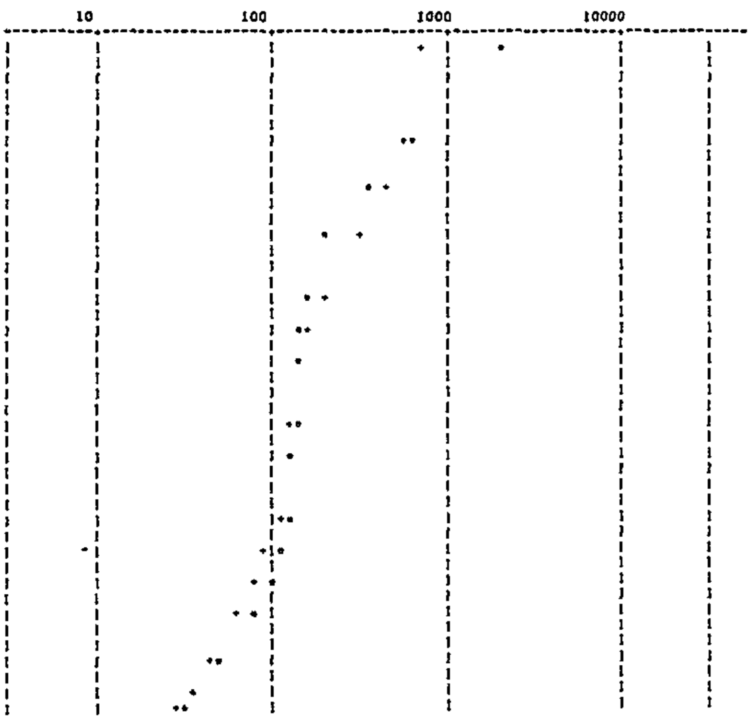
FIGURE D-12-2 Complate Curve Matching Method Using PSH Program

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OHAN ES-V4-3

------APPARENT RESISTIVITY:OHM-METER------

DEPTH*METER*

A	H(A)	CAP(A)	MAR(A)
1.00	0.9514	761.102	2214.000
2.00	0.7675	624.031	695.000
3.00	0.5641	451.240	377.000
4.00	0.4141	331.318	220.000
6.00	0.2633	210.625	169.000
8.00	0.2107	166.559	159.000
10.00	0.1910	152.800	152.000
16.00	0.1717	137.372	148.000
20.00	0.1635	130.773	140.000
30.00	0.1417	113.377	133.000
40.00	0.1195	95.626	118.000
48.00	0.1035	82.837	112.000
60.00	0.0837	66.947	87.000
80.00	0.0609	48.716	54.000
100.00	0.0473	37.841	35.000
120.00	0.0393	31.409	34.000



+:CALCALATED VALUE

*:MEASUREMENT VALUE

SPECIFIC RESISTIVITY,OHM-METER

LAYER 1:	600.0	
		2M
LAYER 2:	140.0	
		30M
LAYER 3:	50.0	
		60M
LAYER 4:	20.0	

The Sandberg's Standard Curve method has been developed for analyzing the horizontal two-layer structure models, while the Hummel's Equivalent Resistivity Method has been applied to the models with layers more than two for identifying the deeper layers. The Hummel's Equivalent Resistivity Method, however, is not always so practically applicable as to be expected due to producing considerable errors in the results. And the deeper layers will be found hard in their identification in the case that the subsurface layers are found so extremely high resistivity against the subsurface layers as in the Project Area.

Under the conditions, generally the ρ-a curves for the four - or five-layer models found in the Project Area should be developed by the theoretical equation and the comparative study of those calculated results with the measured values by the above method will be required for identifying the necessary structures.

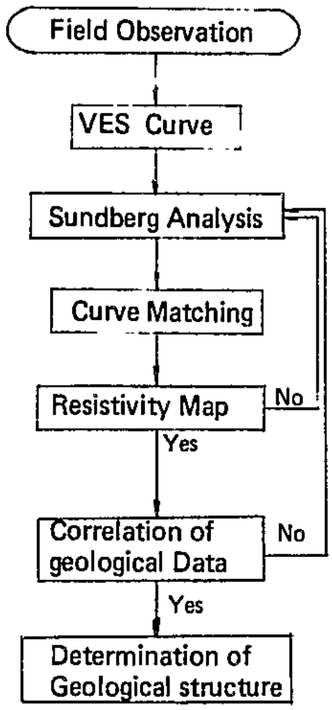
In this study, however, the structure was identified by the Complete Curve Matching Method in applying the PSH Programme shown in Figure D-12. In the case, since the matching was manually operated, pre-estimation of the critical resistivity values by the Sandberg's Standard Curve Method has enabled to reduce the troublesome works by inputing these values at first.

The results obtained at each sounding point from these procedures were plotted along the sounding lines to prepare the resistivity map for presuming the geological structures of the whole area; however, when the discrepancies found between the results of the respective curve matching and the analysis results on the related sounding point, repeating curve matching works should be practised.

The following flow chart (Figure D-13) illustrates the procedures for analysis.

FIGURE D-13 FLOW CHART OF VERTICAL RESISTIVITY SOUNDING ANALYSIS

RESISTIVITY SOUNDING



1. Plotting of VES curve
2. Analysis using Sundberg standard curve and auxiliary curve
3. Analysis of curve matching using PSH program
4. Resistivity map drawing
5. Correlation of other geological investigation along observation line
6. Determination of geological structure

2.2. Equi-depth Sounding

The equi-depth sounding was carried out by four arrangements with two of the Wennar Method and two of the Dipole-Dipole Method taking the unit electrode separation by 5.0 m and 10.0 m, respectively. (See Figure D-14-1). This sounding method, the so-called ρa - $\rho \mu$ method, is an analysis made in the presumption that the underground structure along sounding lines would be a mass of the unit volume with $\rho \mu$ of the resistivity. (See Figure D-14-3)

The specific resistivity values can be approximated by the rectified Ono's formula with resistivities measured for each arrangement.

$$\rho e = \frac{\sqrt{d_1{}^2 + d_2{}^2 + 2\ d_1 \cdot d_2 \cdot \ \rho_2\ /\ \rho_1}}{d_1/\rho_1\ +\ d_2/\rho_2}$$

Commonly, the said analyses are made on the basis of the some hundreds or some thousands of measurements for one sounding line and the exactness of these measured values should be kept in the same level for the successful analysis.

The verification and rectification of these values shall be made in the use of the characteristic features of the resistivity that it should theoretically show no difference between the values of Arrangement I. and II by the Wennar Method as well as the Wennar method can cover the wide investigation field of the sounding area and no large differences are found in the values obtained from adjacent sounding points as illustrated in Figure D-14-2.

The resistivity contour map of Figure D-15 expresses the specific resistivity in equi-resistivity line, derived from the aforesaid rectified resistivity or by the equivalent equation. The Types of II including arrangement of C.P.P.C are used for vertical sounding and most suitable identifying the large scale structure of the underground, while the types of III. IV, including the

FIGURE D-14 METHOD OF EQUI-DEPTH SOUNDING ANALYSIS

FIGURE D-14-1 Electrode Arrangment of Equi-Depth Sounding

Electrode No. / Array No.	1	2	3	4
I	C1	P1	P1	C2
II	P1	C1	C2	P2
III	C1	C2	P2	P1
IV	P1	P2	C2	C1

Array No.	Equation
I	$\rho a=2\pi aV/I$
II	$\rho a=2\pi aV/I$
III	$\rho a=6\pi aV/I$
IV	$\rho a=6\pi aV/I$

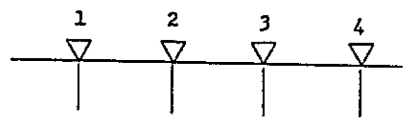
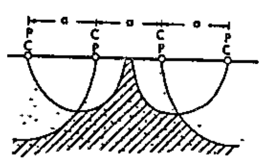


FIGURE D-14-2 Investigation Field of Equi-Depth Sounding



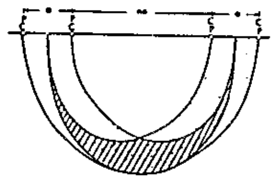
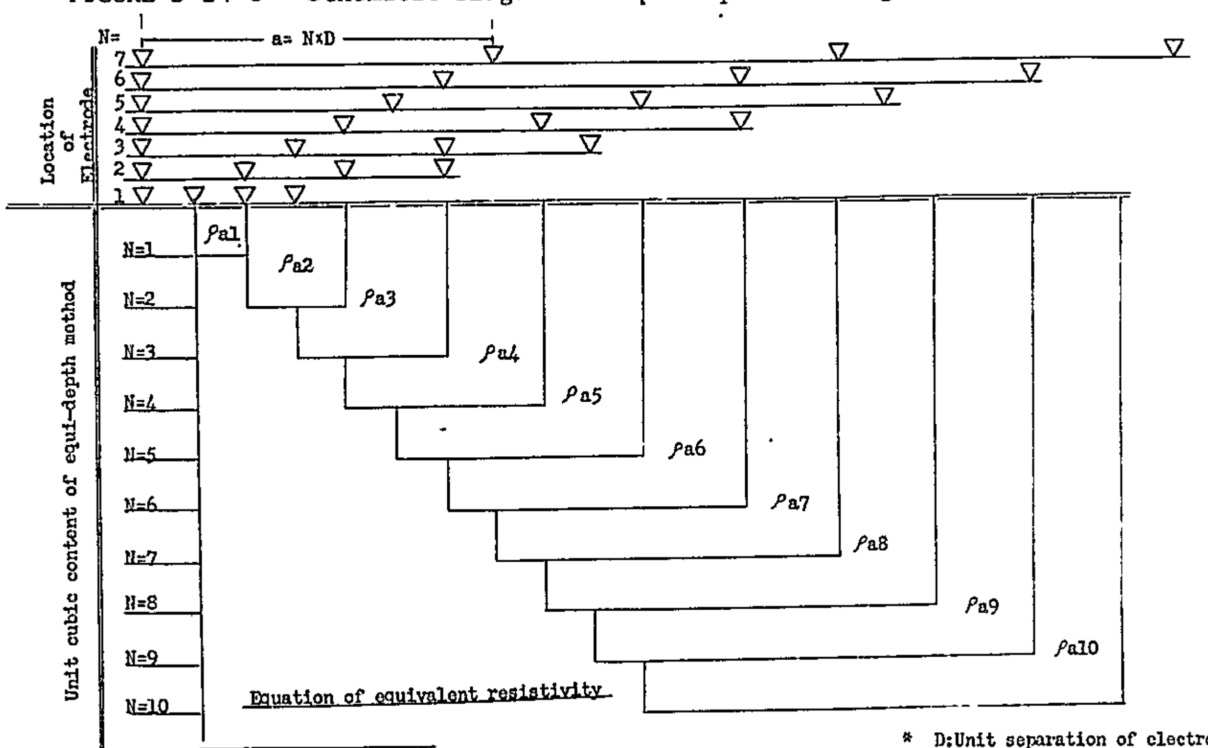
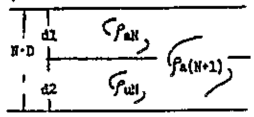


FIGURE D-14-3 Schematic Diagram of Equi-Depth Sounding



* D:Unit separation of electrode

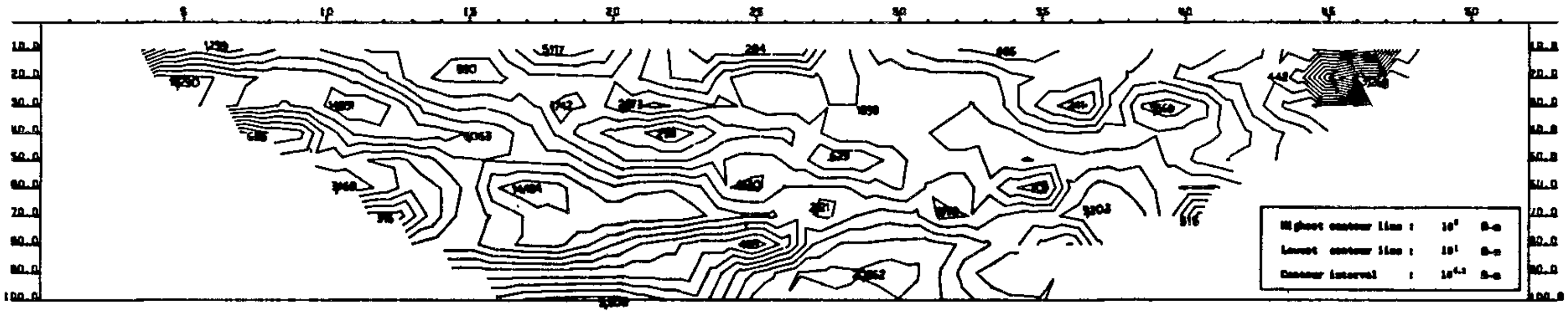


$$\rho a(N+1) = \frac{\sqrt{d1 + d2 + 2 \cdot d1 \cdot d2\, \rho u \cdot N / \rho a \cdot N}}{d1/\rho a \cdot N + d2/\rho u \cdot N}$$

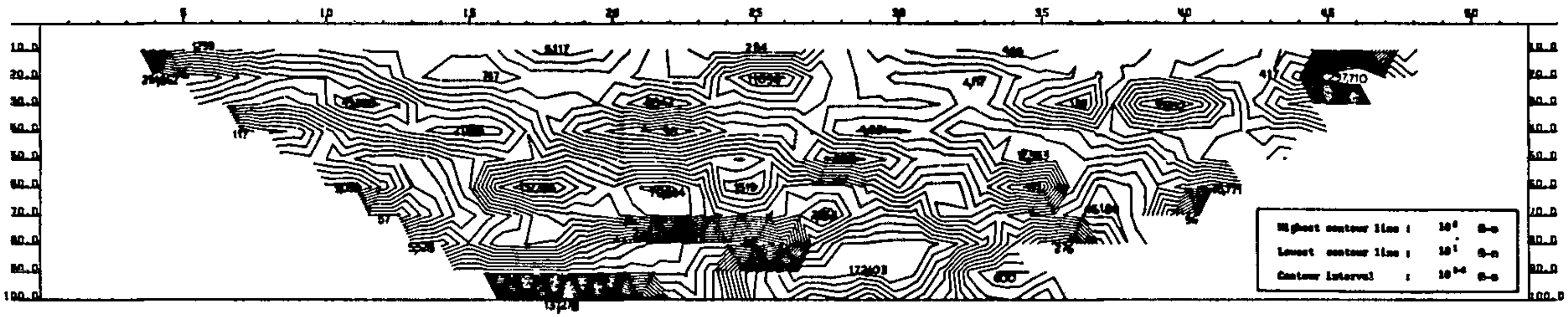
FIGURE D – 15 RESISTIVITY CONTOUR MAP OF EQUI-DEPTH SOUNDING

LINE 1 ARRANGEMENT 1

APPARENT RESISTIVITY MAP



SPECIFIC RESISTIVITY MAP



Arrangement of P.P.C.C., can be used for investigating the structural line because of the availability for finding the changes in horizontal direction as well as fine changes in the deeper structures due to comparatively narrow field of sounding area.

The resistivity contour map, expressing the underground geological conditions along the sounding lines by the resistivity values, can identify the general structures of the said underground.

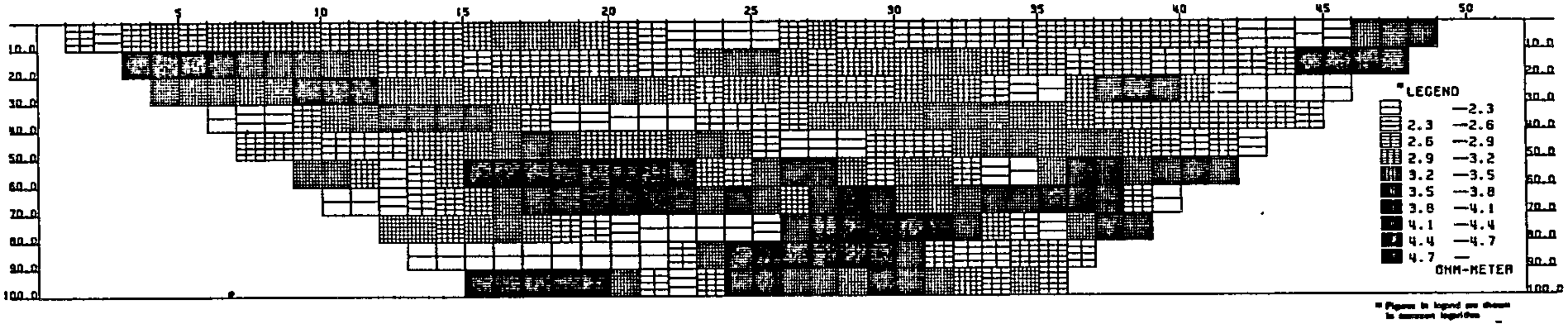
The resistivity pattern map was developed by selecting the resistivity range reflecting the geological structures and with the Wennar Method's values which can directly read as the results of sounding of the structures. (See Figure D-16)

The analysis is conducted in comparison of the geological conditions identified through observation of bore holes and loggings provided along the sounding lines. For assuming the rock faces below the sounding lines, in general, comparison shall be made between the resistivity obtained around the bore hole the rock faces of which is clarified and the rock faces to prepare the temporary comparison table to meet the conditions of the sounding area, and thereby, the distribution of the rock faces shall be studied. The geological profile (Figure D-16) should be developed based on the study results of the Dipole-Dipole method for the vertical structures such as structural lines and of the Wennar method for the horizontal structures such as faces' boundaries according to the aforesaid characteristic features of the respective electrode arrangements. The following flow chart (Figure D-17) illustrates the procedures of the said analysis.

FIGURE D – 16 Re RESISTIVITY PATTERN MAP AND GEOLOGICAL PROFILE

LINE 1 ARRANGEMENT 1

RESISTIVITY PATTERN MAP



CORRELATION OF GEOLOGICAL STRUCTURE

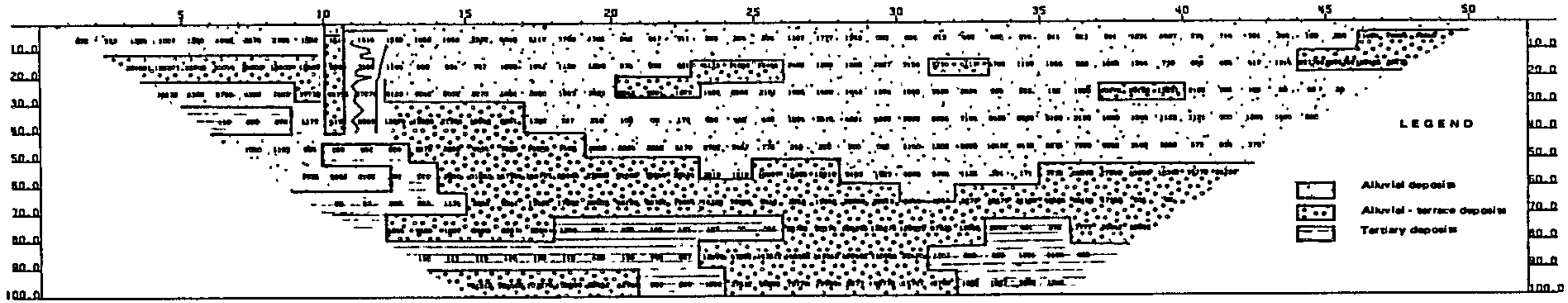
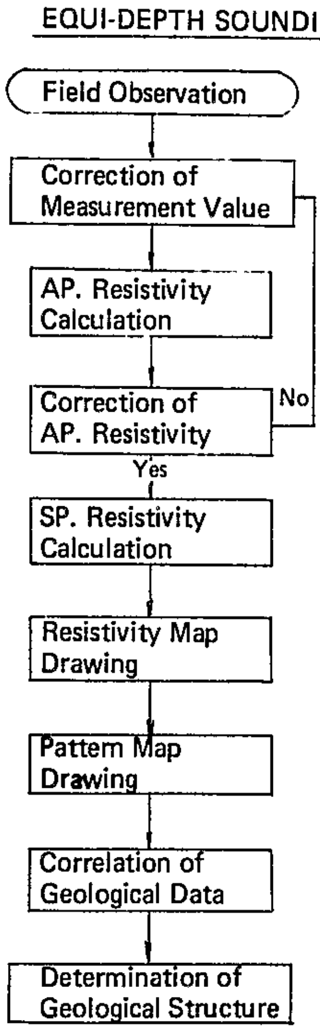


FIGURE D - 17 FLOW CHART OF EQUI-DEPTH SOUNDING ANALYSIS



1. Correction of measurement value
2. Calculation of apparent resistivity
3. Correction of apparent resistivity
4. Calculation of specific resistivity
5. Resistivity contour map drawing
6. Resistivity pattern map drawing
7. Correlation of other geological investigation along the observation line
8. Determination of geological structure

3. The Sounding Results

The resistivities measured in the Wadi plain have the values more than 10,000 Ωm in the surface layers, whereas those measured in the coastal area have several Ωm only.

The distribution of the resistivities, although varying heavily in their ranges, shows a general tendency that the resisties have reduced in their values from the surface layers to the deeper layers and also from the upperstream areas to the downstream areas.

The layers composing the area are roughly classified into the basement rocks and the clastic deposts.

The basement rocks, consisting of the old rocks like the Ophiolite, form the sedimentary basin, and the distribution of the layers with the low resistivities suggest that the basement rocks have a shape in widely developing towards the east or the coastal area.

The clastic deposits composing the surface layers, thickly developing over the basement rocks in the mid-and down, can be divided into further detailed layers according to the resistivities. Among these layers, the alluviums in the top layers are deemed as the horizon providing the characteristics as the most favorable aquifer, which indicates extremely high resistivities over the groundwater table, while comparatively low under the groundwater. These alluviums thickly distribute in the coastal area and the eastern part of the area as well as the basement rocks do.

Along the shoreline, the highly resistive coastal deposits found in the alluviums show the complicated rock facies. Under the situation, the clear trace can not be found for the sea-fresh water boundary which is expected to extend from the shore line.

The item-wise detailed discussion is made in the following paragraphs regarding the resistivity classifications made by the vertical sounding method, corresponding stratigraphy and area-wise results of the equi-depth sounding.

3.1. Resistivity Classification

The rock facies in the sounding area can be classified into the resistivity layers of the four to six layers by the analysis of the R-S curve obtained from the vertical sounding. The resistivities corresponding to the respective resistivity layers vary from one place to another in the whale Wadi area, showing different values in the upstream area, gravel plain and coastal area as shown in Table D-4. These matters suggest that the respective areas would provide their own sedimentary environment and the different hydrogeological environment.

The aforesaid resistivity classification, the equi-depth sounding results and the comparative study of the survey results of the bore holes in the Project Area revealed that the geology of the Wadi basin consists from the lower layers towards the upper one, of the old rocks, the tertiary deposits, the terrace deposits and the recent wadi deposits.

The following paragraphs discuss the details of these components of the stratigraphy.

<u>Basement rocks</u>

The old rocks such as limestones and ophiolite which compose the mountain mass surrounding the Wadi basin are the basement of the sedimentary basin in lying under the younger deposits towards the downstream or the present wadi bed as shown in Figure D-18 to D-20. The depth of these basement rocks consisting of the old rocks is comparatively shallow, being estimated at some 20 m around the D-1

Table D-4 Resistivity Classification according to Vertical Method

Location / Geological Unit	Upstream (ohm m)	Gravel Plain (ohm m)	Coastal Strip (ohm m)
Alluvial Deposits	> 2000	35 - 13000	< 2500
Terrace Deposits	120 - 650	30 - 850	
Tertiary Deposits	1800	1800 - 3500 1/ 100 - 700 < 40	< 40
Basement Rocks	< 500	< 500	

1/ Values are classified into three types based on different facies

FIGURE D-18

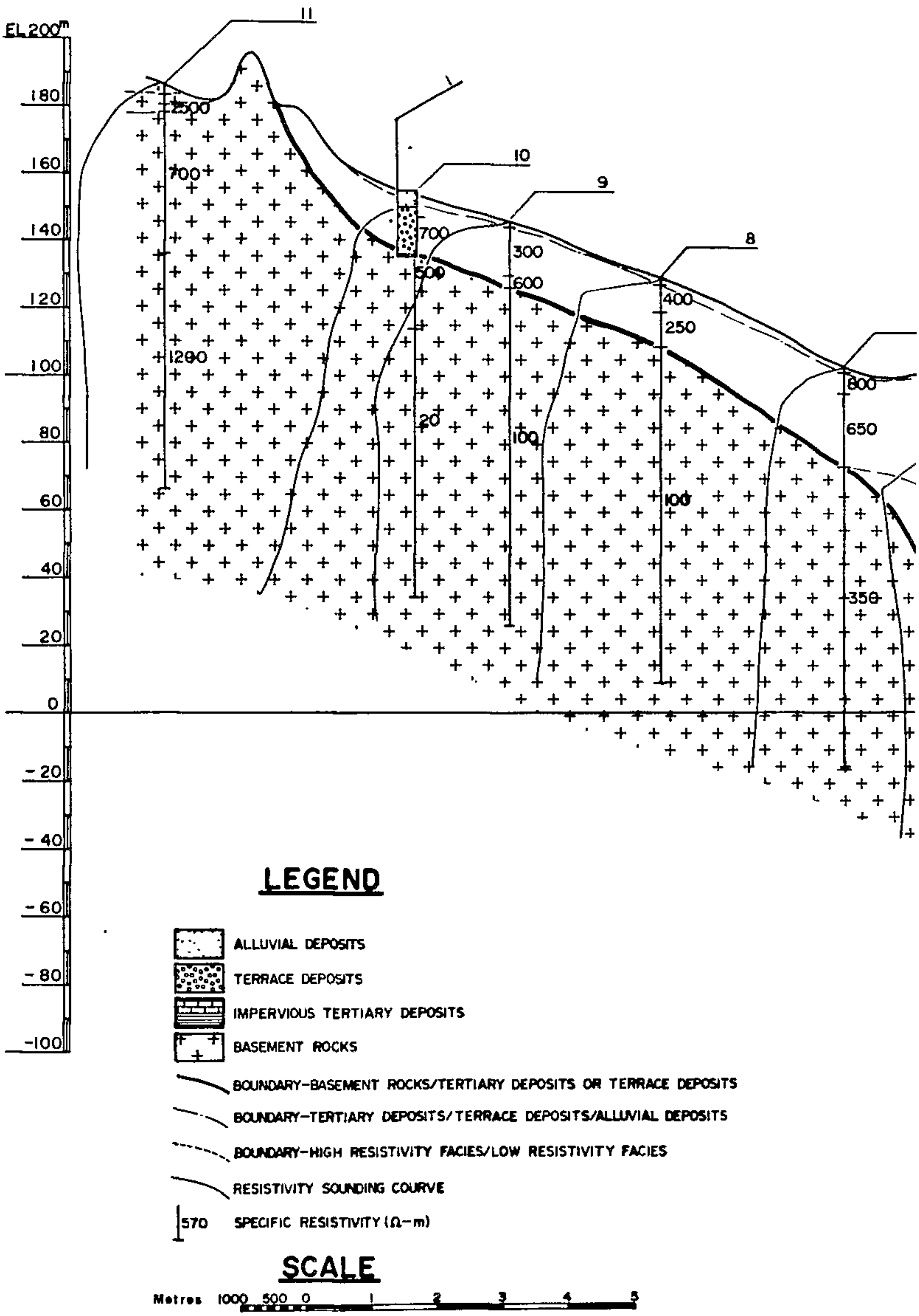

EL 200m
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
11
10
9
8
2500
700
1200
700
500
20
300
600
100
400
250
100
800
650
350
LEGEND
ALLUVIAL DEPOSITS
TERRACE DEPOSITS
IMPERVIOUS TERTIARY DEPOSITS
BASEMENT ROCKS
BOUNDARY-BASEMENT ROCKS/TERTIARY DEPOSITS OR TERRACE DEPOSITS
BOUNDARY-TERTIARY DEPOSITS/TERRACE DEPOSITS/ALLUVIAL DEPOSITS
BOUNDARY-HIGH RESISTIVITY FACIES/LOW RESISTIVITY FACIES
RESISTIVITY SOUNDING COURVE
570 SPECIFIC RESISTIVITY (Ω-m)
SCALE
Metres 1000 500 0 1 2 3 4 5

FIGURE D-18 GEOLOGICAL PROFILE

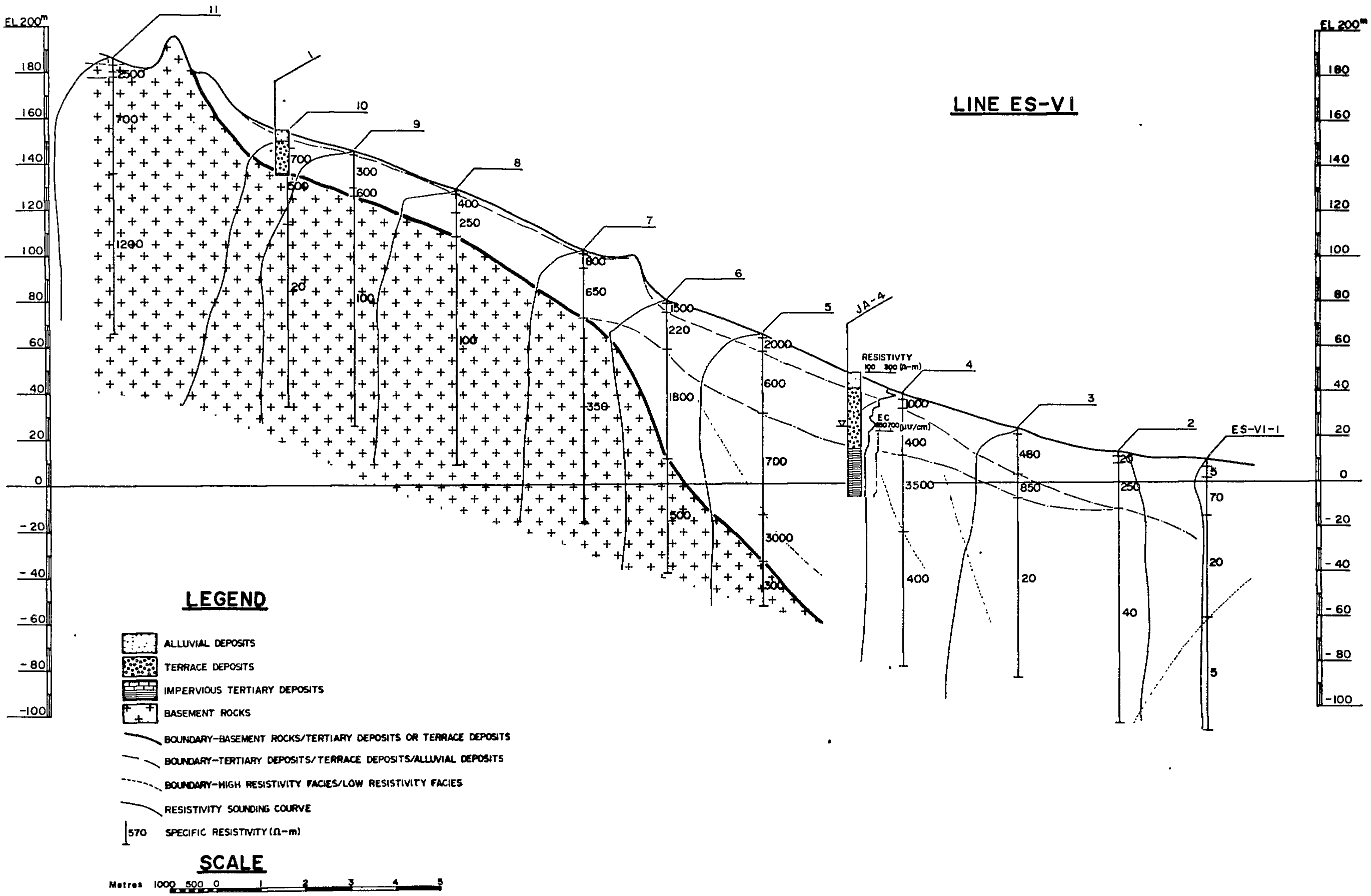


FIGURE D-19 GEOLOGICAL PROFILE

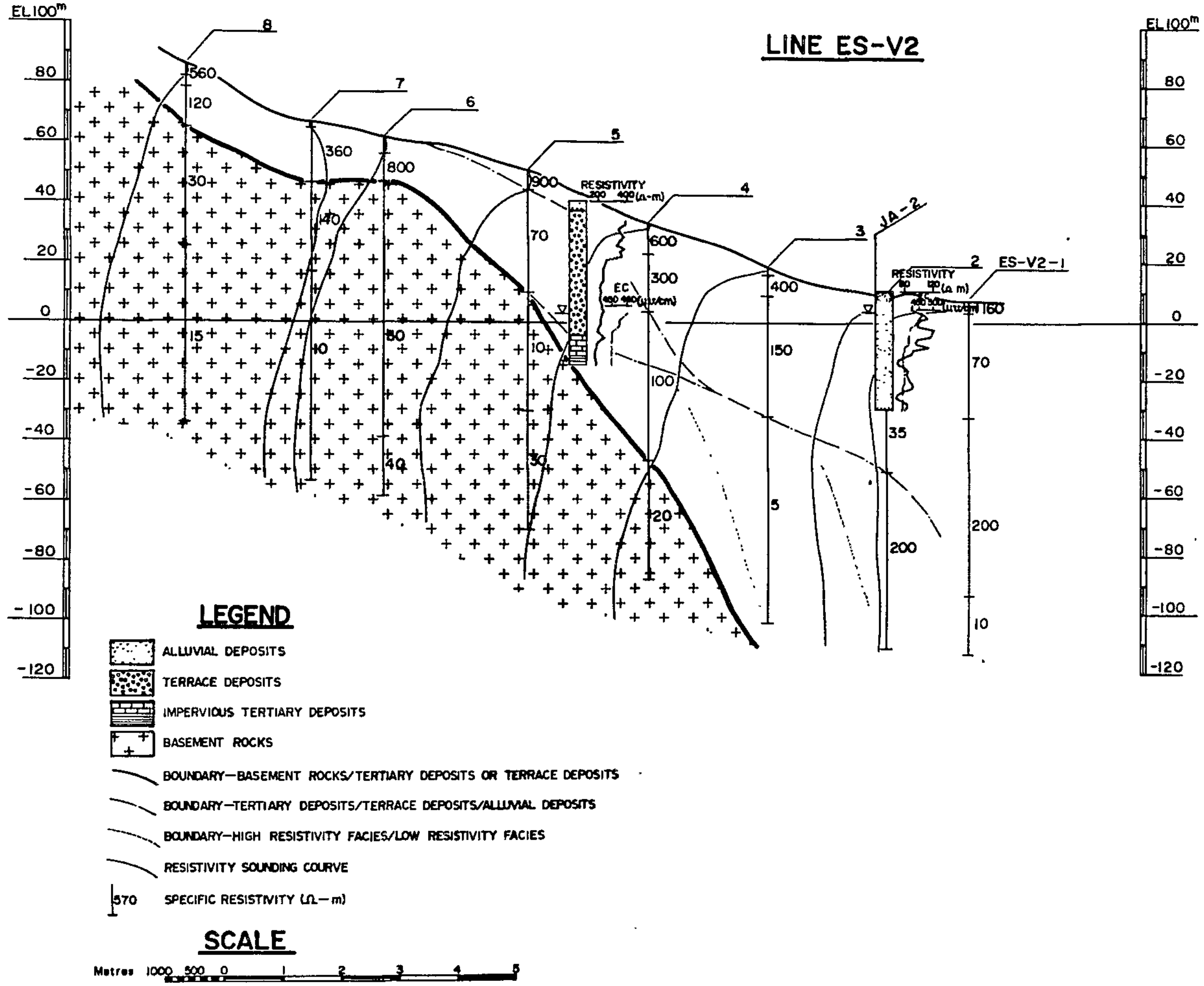
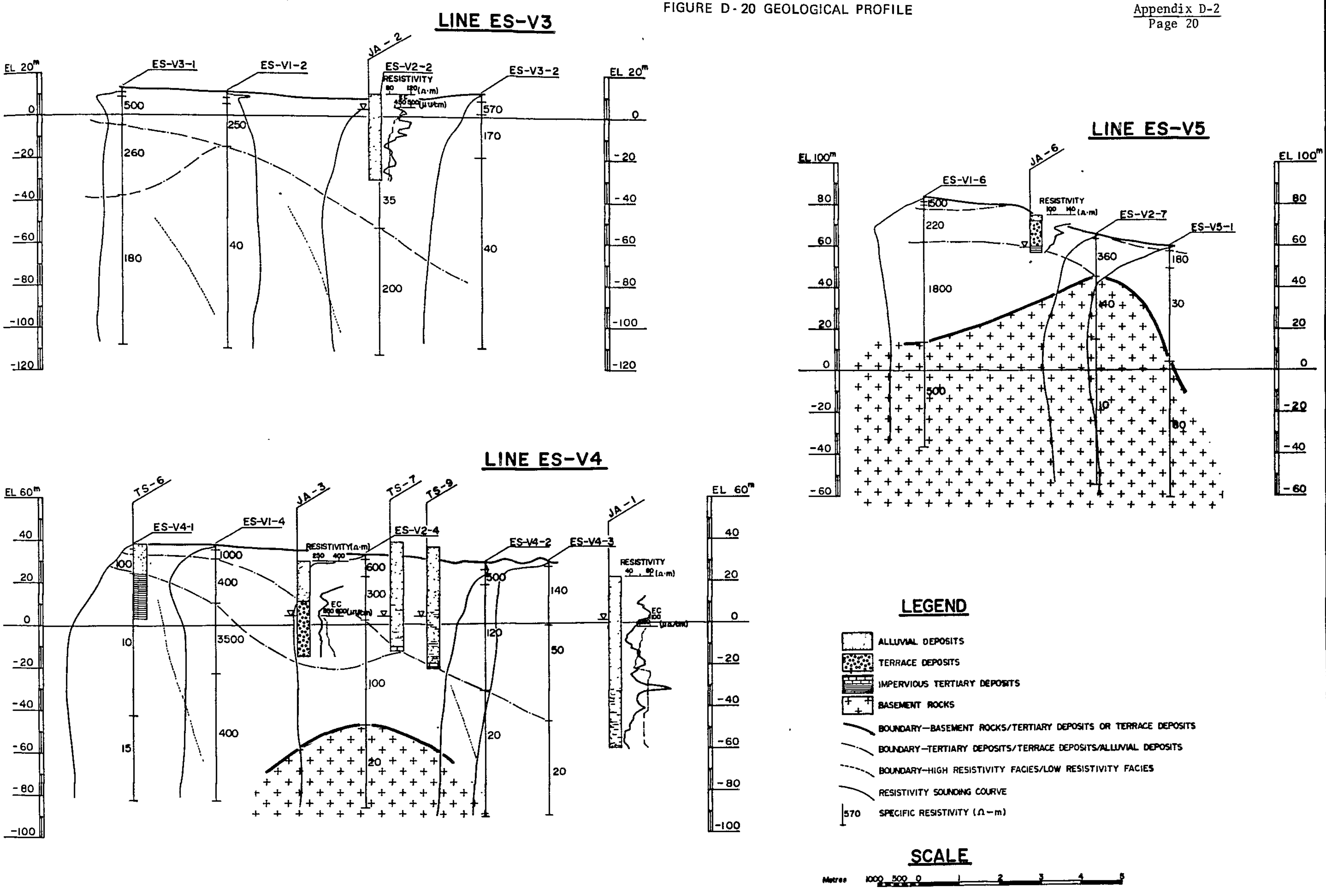


FIGURE D-20 GEOLOGICAL PROFILE



and the D-2 proposed dam sites, while estimated at more than 200 m around coastal area after abruptly deepened at the fan apex where the Wadi develops larger and larger. As a whole, the resistivities are as small as 500 Ωm and below.

Tertiary deposits

The tertiary deposits appear to overlying the basement rocks. The tertiary deposits exist in different status such as out cropping along the Wadi Suq and the bore holes provided in the Project Area, and the rock facies have a variety of the limestones, lutaceous deposits, etc. In other respect, the resistivities corresponding to each sounding point vary largely in their ranges. These facts may suggest that there are the horizons which would provide considerably variable rock facies in the lateral direction.

Terrace deposits

The terrace deposits were found as outcrops in the sounding areas and in the bore holes, and in many cases, these deposits assume to be a considerably solid facies with calcareous materials. These facies are characterized by the resistivities in range from some ten Ωm to some hundred Ωm being found on the basement rocks of the upstream basin and in the tertiary deposits of the gravel plain in the mid-basin.

The thickness of the layers was estimated at some 40 m at maximum in the gravel plain and the relevant resistivities have allowed to presume the permeability of this formation to be favorable.

The favorable permeability in these layers can be proved by the fact that in general the sand and gravel aquifer, which provides resistivity of some hundred Ωm, forms a favorable permeable layers.

Recent Wadi deposits

The recent Wadi deposits are found in the development in the Wadi plain extending from the proposed dam sites to the coastal area, and the relevant facies consist mainly of gravels in the upper basin and of the sand and gravel layers with dominant fine grains deposits of sand, silt, etc. in the coastal area. With varying facies, the resistivity indicates the decreasing tendency in its value in the area from the upper basin to the lower basin.

The layer thickness was measured by about 5.0 m around D-2 proposed dam site, developing thicker and thicker towards the coastal area and the eastern part of the area, and around the coastal area the thickness was estimated at 100 m or so.

The permeability of the deposits, considered favorable, can be proved to be good by the fact that the resistivity values differ over from below the groundwater table.

3.2. Coastal Area

The sounding lines in the coastal area are illustrated as ES-H2 in Figure D-21, ES-H2 in Figure D-22 and ES-H6 in Figure D-23, respectively. The former two, ES-H2 and -H3 are one continuous sounding line, running about 1.5 km apart from the shore line, while the line, ES-H6 extends about 2.5 km apart from the shore line.

The characteristic feature of the resistivity pattern is that most of the blocks indicate the considerably low $\rho\mu$ values except those horizons 10 m deep, 30 m deep and 60 m deep in ES-H6, and 80 m deep in ES-H3.

The high resistivity values indicated in the above exceptional horizons are considered to be correlative with the consolidated layers observed at shallow well in the coastal area and pits for installation of the water level gauging equipment. These consolidated layers identified quite differently from other horizons have not been founded through sounding in the inland area and are presumed to be classified into the marine deposits. These layers also have a characteristic to extend from the coastal area to the inland area in several layers.

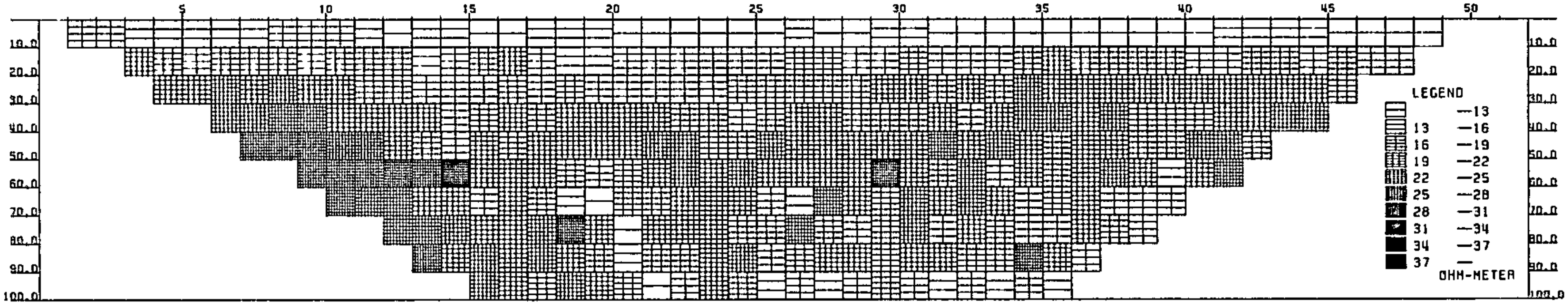
On the other hand, the vertical sounding found that the low resistivity layers would correspond to the recent Wadi deposits. The aforesaid marine deposits and the recent Wadi deposits are presumed to show the interfinger relation in the area along the sounding line.

The sea-water intrusion was sounded at the horizons about 80 m deep in the ES-H6 and 90 m deep in ES-H3, and the resistivity of these layers were as low as below 10 Ωm.

FIGURE D-21 GEOLOGICAL PATTERN MAP AND GEOLOGICAL PROFILE ON THE COASTAL AREA

LINE 2 ARRANGEMENT 1

RESISTIVITY PATTERN MAP



CORRELATION OF GEOLOGICAL STRUCTURE

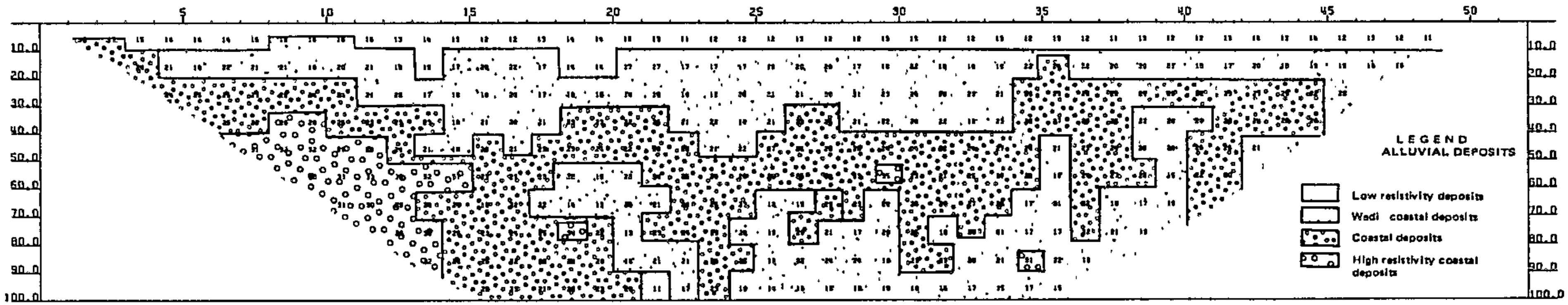
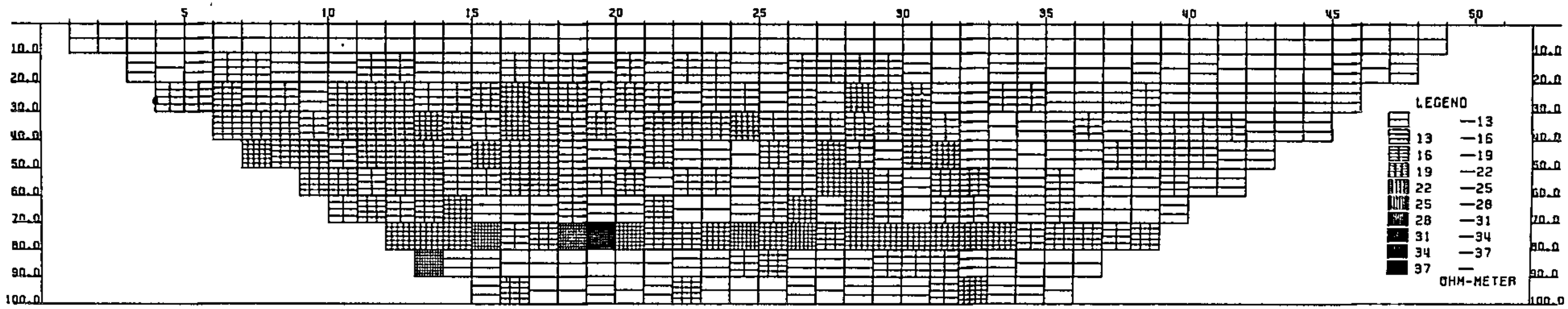


FIGURE D-22 RESISTIVITY PATTERN MAP AND GEOLOGICAL PROFILE ON THE COASTAL AREA

LINE 3 ARRANGEMENT 1

RESISTIVITY PATTERN MAP



CORRELATION OF GEOLOGICAL STRUCTURE

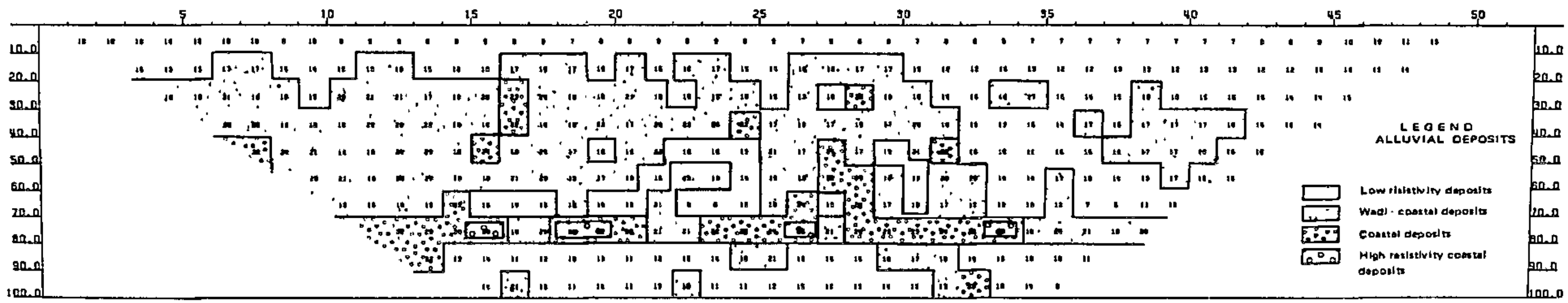
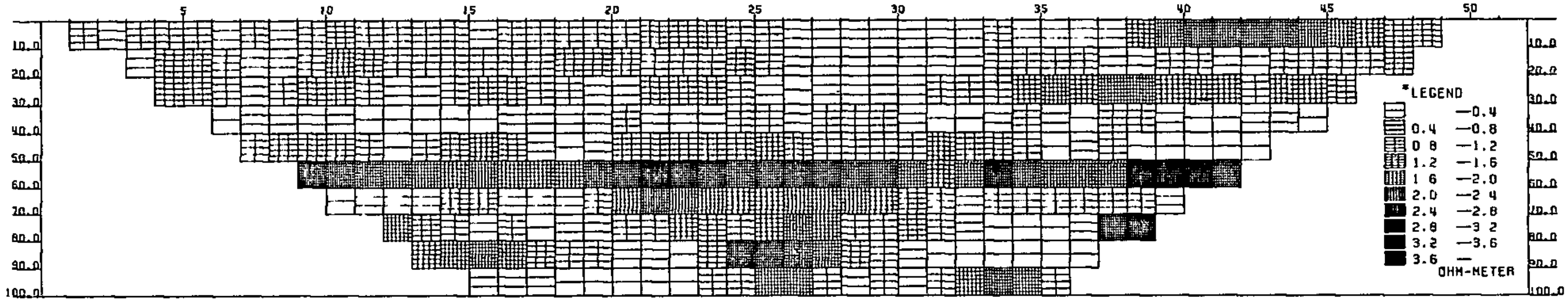


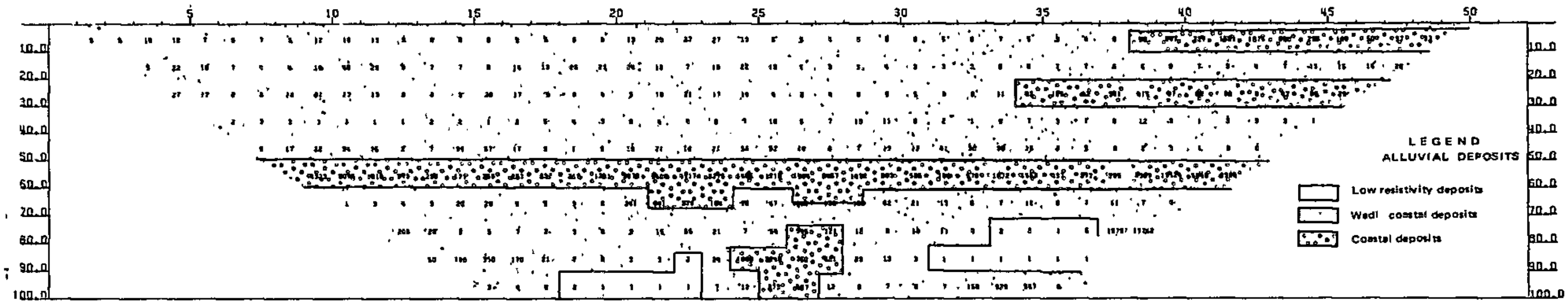
FIGURE D-23 RESISTIVITY PATTERN MAP AND GEOLOGICAL PROFILE ON THE COASTAL AREA

LINE 6 ARRANGEMENT 1

RESISTIVITY PATTERN MAP



CORRELATION OF GEOLOGICAL STRUCTURE



The coastal area, providing a complicated geological structures with the marine deposits and the loosely consolidated Wadi deposits complicatedly interfinger, cannot be revealed easily for the sea-fresh water boundary.

3.3. Gravel Plain

The sounding lines of ES-H1 and ES-H6 are extending at 4 km upstream of Sallan and at 7.5 km upstream of Sohar in the gravel plain developed from the end of the mountainous area.

The resistivity pattern shows the complicatedly alternate existences of the layers with low resistivity and those with high resistivity excepting the clearly contrasted resistivity by the groundwater surface at 30 m deep layers in ES-H8.

The results of observation of the bore holes along the sounding line and the vertical sounding can suggest the existence of the deposits abundant with consolidated terrace deposits with partially calcareous matrix and calcareous or muddy tertiary deposits and the present river bed.

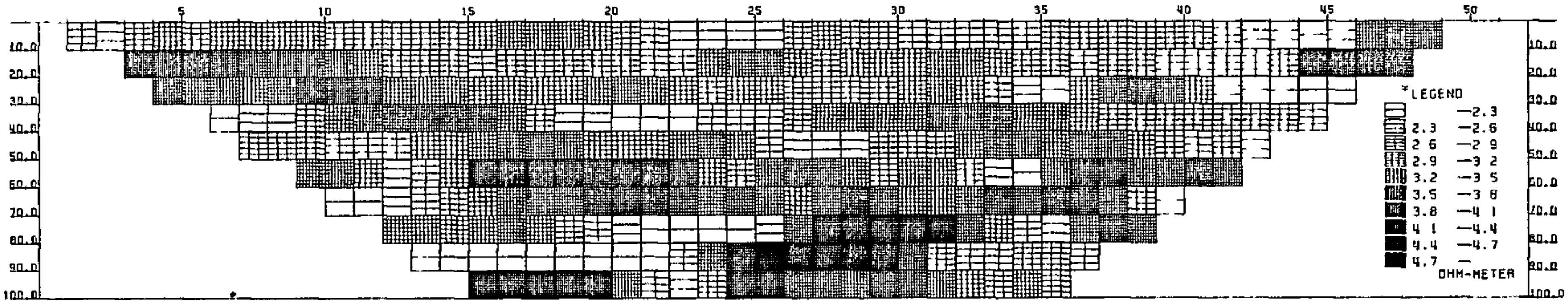
Such geological composition can be learned from the results of observations to suggest that there will be presence of the layer-boundary of the present river bed deposits and the terrace deposits in about 60 m deep at ES-H1 and about 80 m deep at ES-H8.

The resistivity of the terrace deposits and the tertiary deposits fluctuates heavily at parts, and these facts may suggest that the aforesaid layers would contain the muddy layers with low resistivity and the calcareous layers with high resistivity.

FIGURE D-24 RESISTIVITY PATTERN MAP AND GEOLOGICAL PROFILE ON THE GRAVEL PLAIN

LINE 1 ARRANGEMENT 1

RESISTIVITY PATTERN MAP



CORRELATION OF GEOLOGICAL STRUCTURE

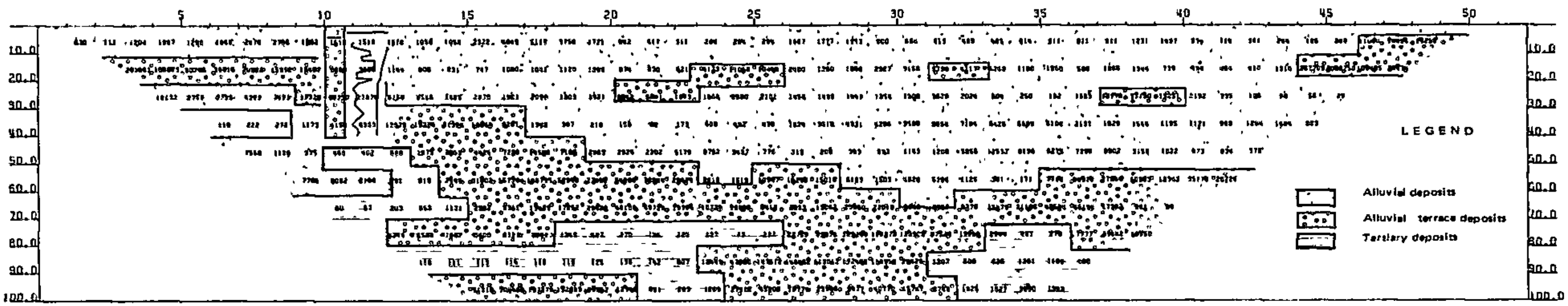
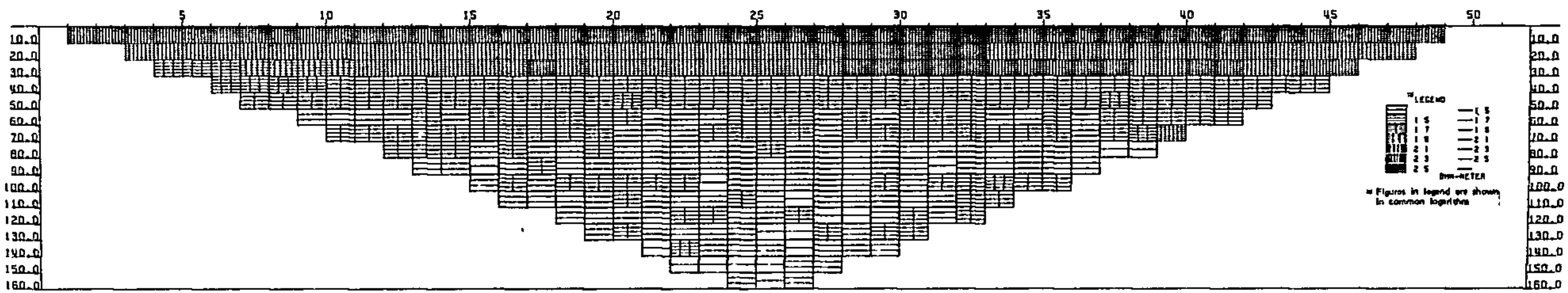


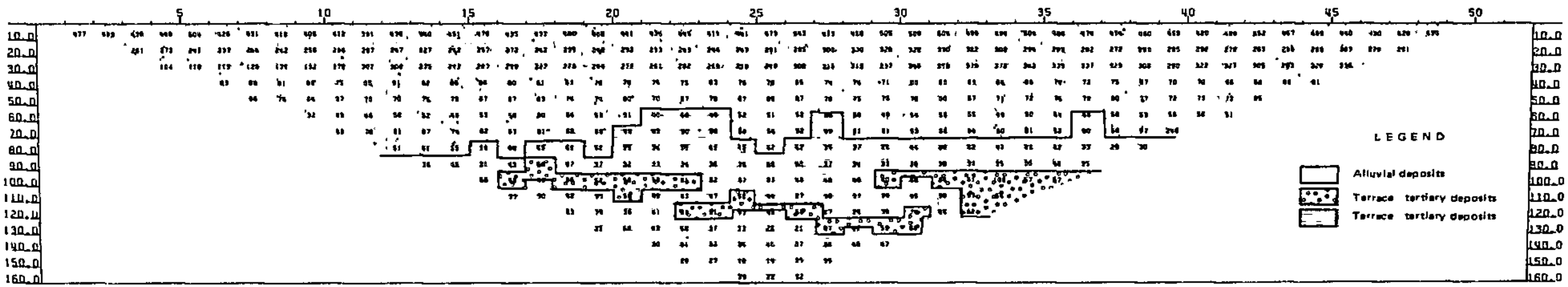
FIGURE D-25 RESISTIVITY PATTERN MAP AND GEOLOGICAL PROFILE ON THE GRAVEL PLAIN

LINE 8 ARRANGEMENT 1

RESISTIVITY PATTERN MAP



CORRELATION OF GEOLOGICAL STRUCTURE



3.4. Potential Dam Site (D-1)

The sounding line ES-H5 runs along the dam axis of the potential dam (D-1), extending 260 m long. The resistivity pattern shows the same level of the depth of the layer and low ρμ value as those of the proposed dam site (D-2), and is characterized by providing the different distribution type of the resistivity of the upper portion from the lower parties bounded by the layer of 500 Ωm to 600 Ωm.

The upper layers with resistivity more than 500 Ωm corresponds to the present river bed and the terrace deposits with thickness of 10 m at the minimum in the right bank and 20 m at maximum in the left bank. The boundary of the present river bed and the terrace deposits could not be learned from the sounded values, and the facts of outcropping of the lower terrace deposits and 5.0 m thickness of layer at maximum in the proposed dam site, D-2, in the downstream suggest that the river bed deposits would develop thinly to extend slightly as the surface layer.

The horizons under the terrace deposits have characteristic features that the rocks of these horizons indicate the resistivity below 500 Ωm. The said horizons appear to link with the old rocks distributing in the mountain mass surrounding the Project Area, and the rock faces of those horizons are composed of the silicaceous limestones, ophiolite, etc.

3.5. Proposed Dam Site (D-2)

The sounding lines running near the proposed dam site, D-2, are ES-H5 m -H7, each of which crosses the river course apart 100 m and 300 m downstream from the proposed dam axis.

The resistivity pattern shows the tendency to decrease in values toward the deeper horizons; particularly, being characterized by the fact that the resistivities differ in the distribution of the upper part from the lower part with the 500 Ωm layer as the boundary.

The bore hole observation carried out along the dam axis revealed that the said resistivity boundary would correspond to the boundary between the old rocks and sand and gravels.

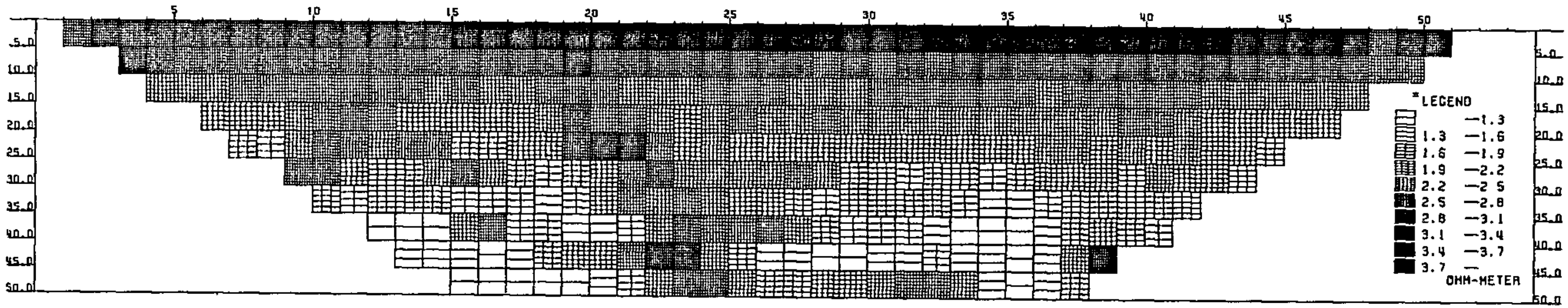
The sand and gravel layers lie thicker in the left bank, having 10 m thick at minimum while 40 - 50 m thick at maximum. The recent Wadi deposits as the surface layers have developed most thickly at the center of the present wadi bed. The old rocks can be classified into two according to the ρμ value; the upper layers were measured by 200 to 5000 Ωm in resistivity, while the lower layers by less than 200 Ω m. Observation of the geological outcroppings there around and the bore holes revealed that the upper layers would consist of the old limestones, while the lower layers would consist of the considerably clastered ophiolite.

The sounding suggest that the boundary of the upper layers and the lower layers would extend about 50 m deep from the ground surface.

FIGURE D-26 RESISTIVITY PATTERN MAP AND GEOLOGICAL PROFILE ALONG D-1 DAM AXIS

LINE 5 ARRANGEMENT 1

RESISTIVITY PATTERN MAP



CORRELATION OF GEOLOGICAL STRUCTURE

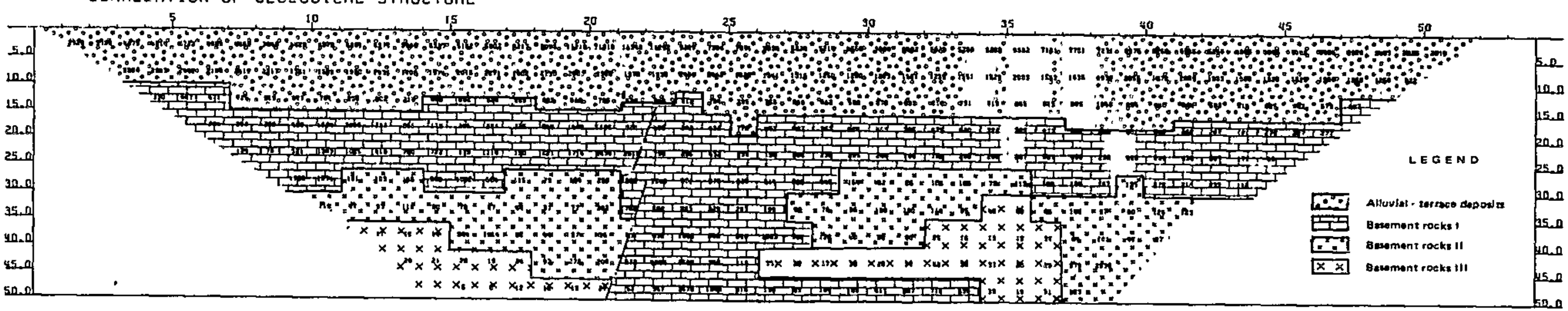
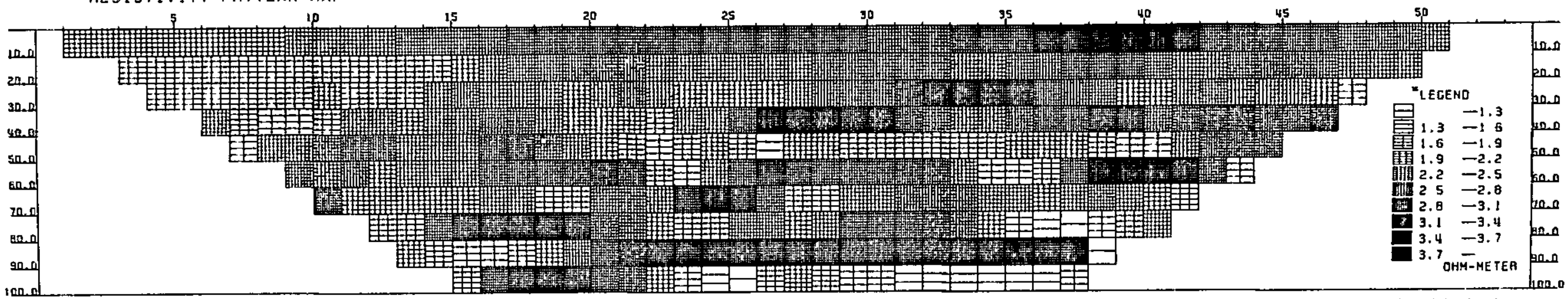


FIGURE D-27 RESISTIVITY PATTERN MAP AND GEOLOGICAL PROFILE ALONG D-2 DAM AXIS

LINE 4 ARRANGEMENT 1

RESISTIVITY PATTERN MAP



CORRELATION OF GEOLOGICAL STRUCTURE

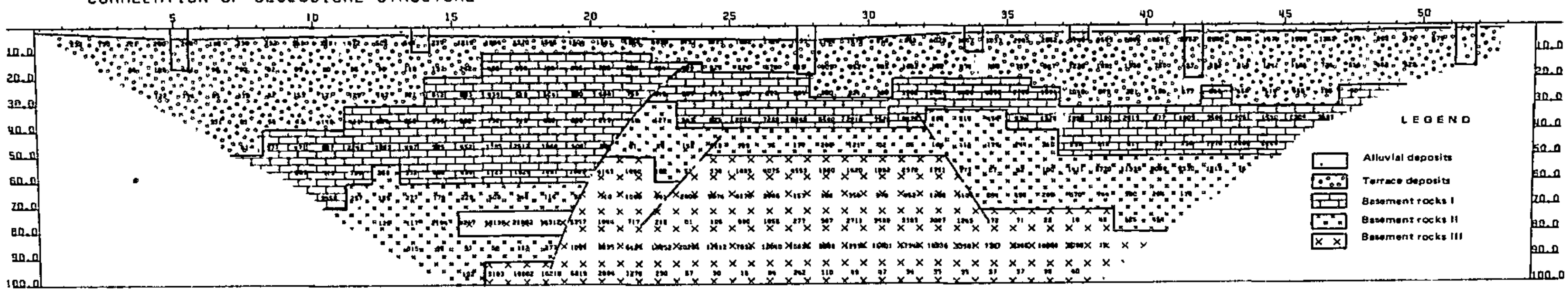
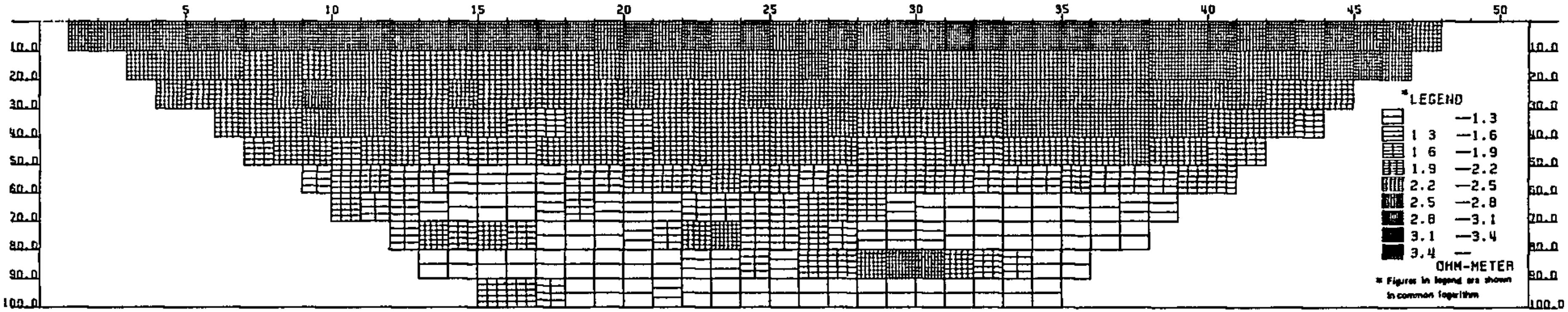


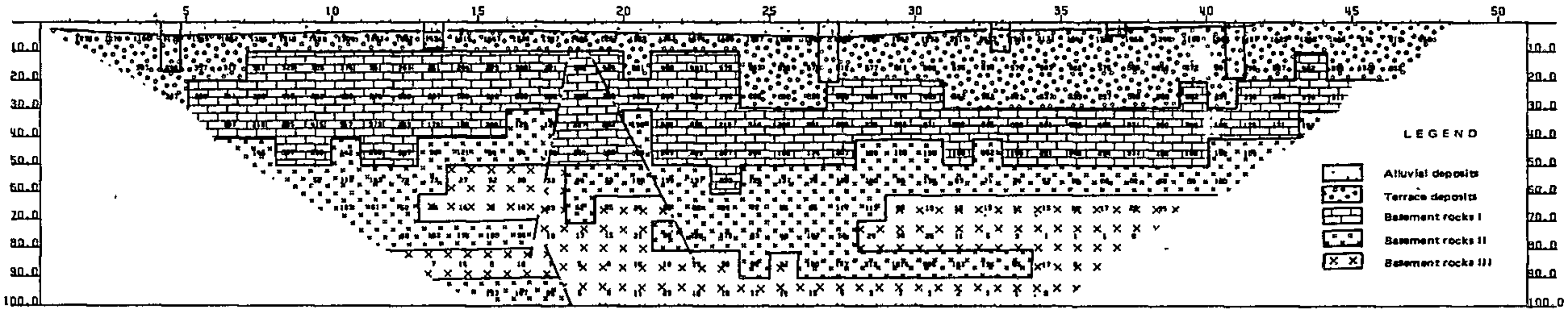
FIGURE D-28 RESISTIVITY PATTERN MAP AND GEOLOGICAL PROFILE ALONG D-2 DAM AXIS

LINE 7 ARRANGEMENT 1

RESISTIVITY PATTERN MAP



CORRELATION OF GEOLOGICAL STRUCTURE

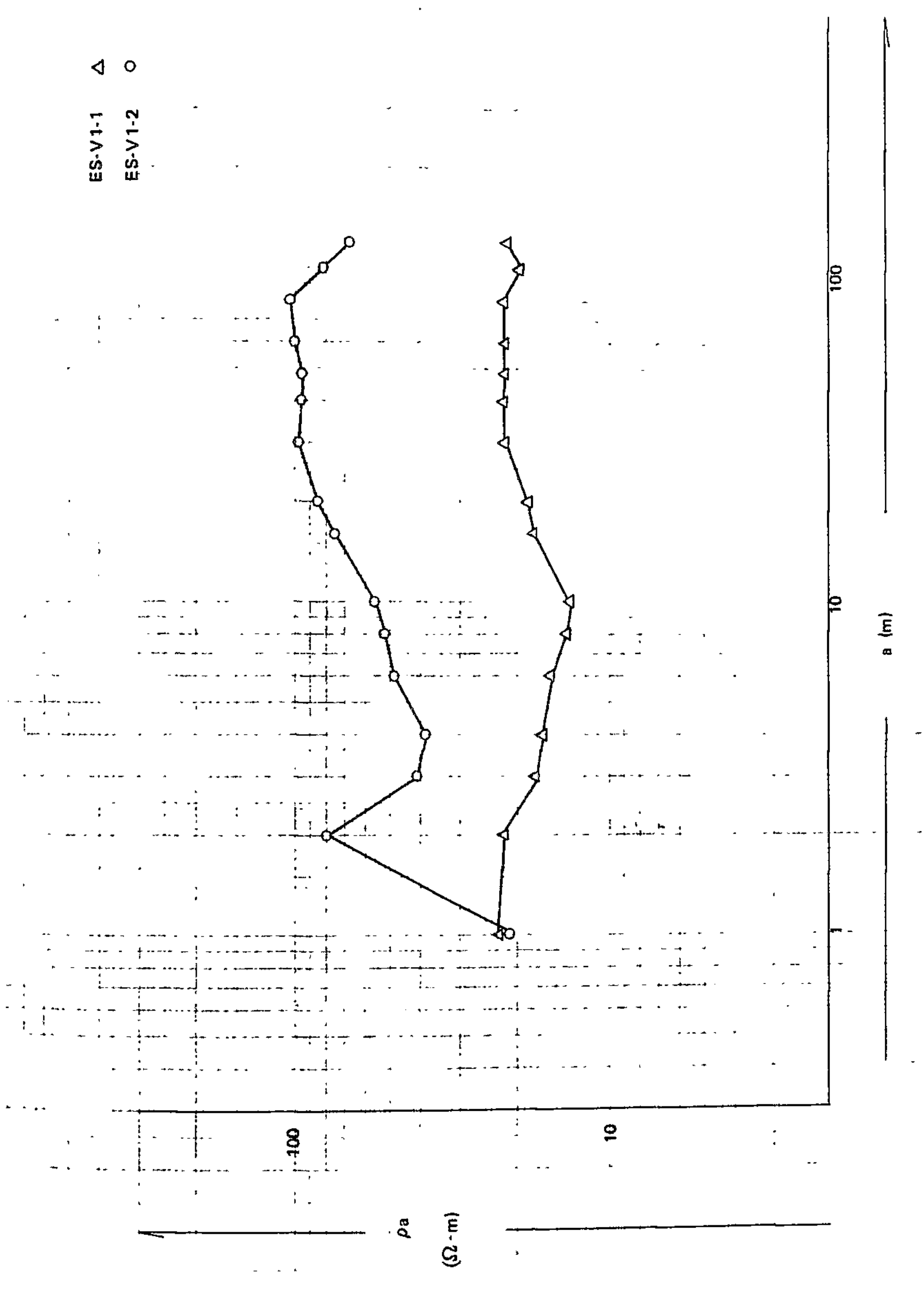


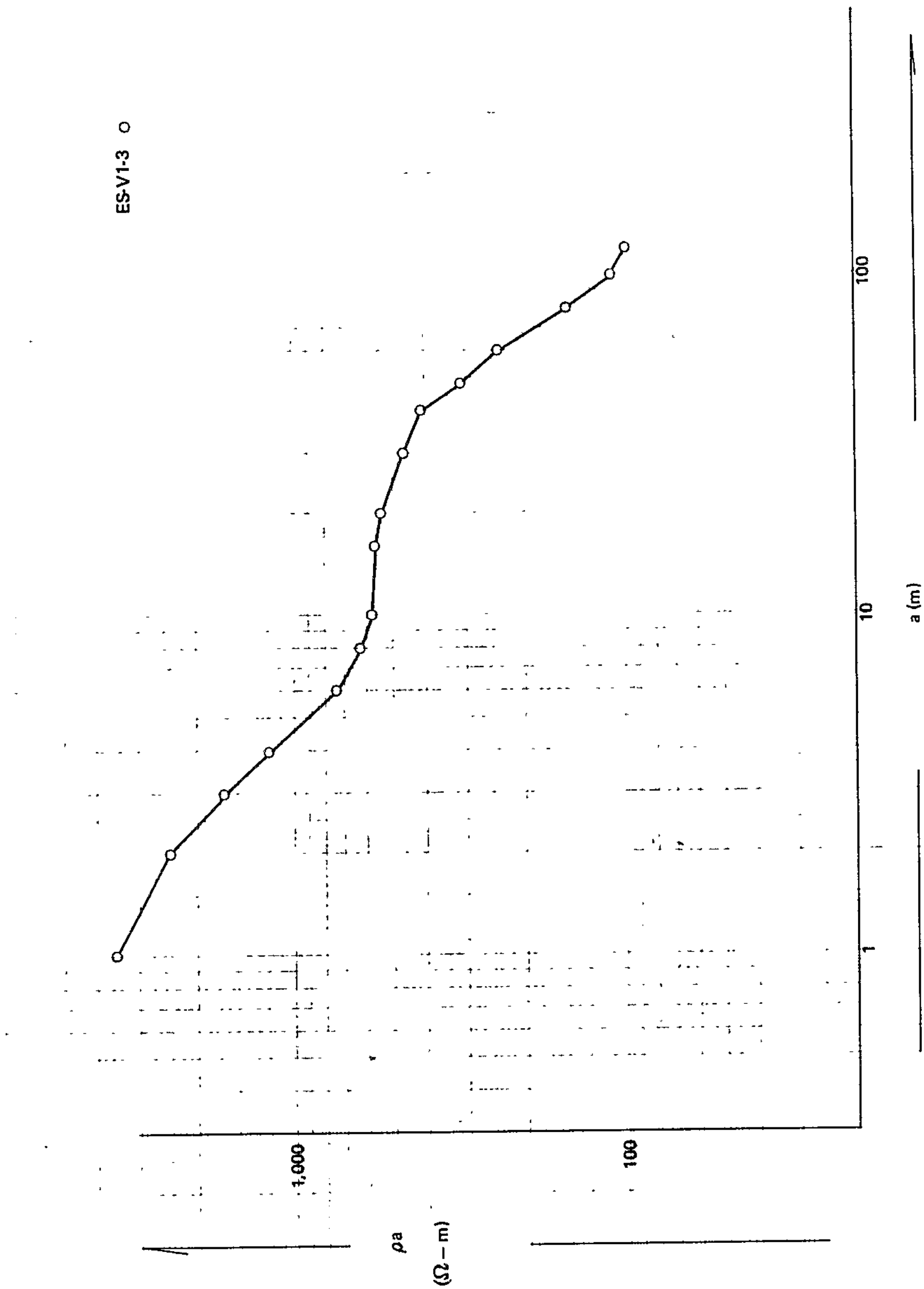
4. Data Collected

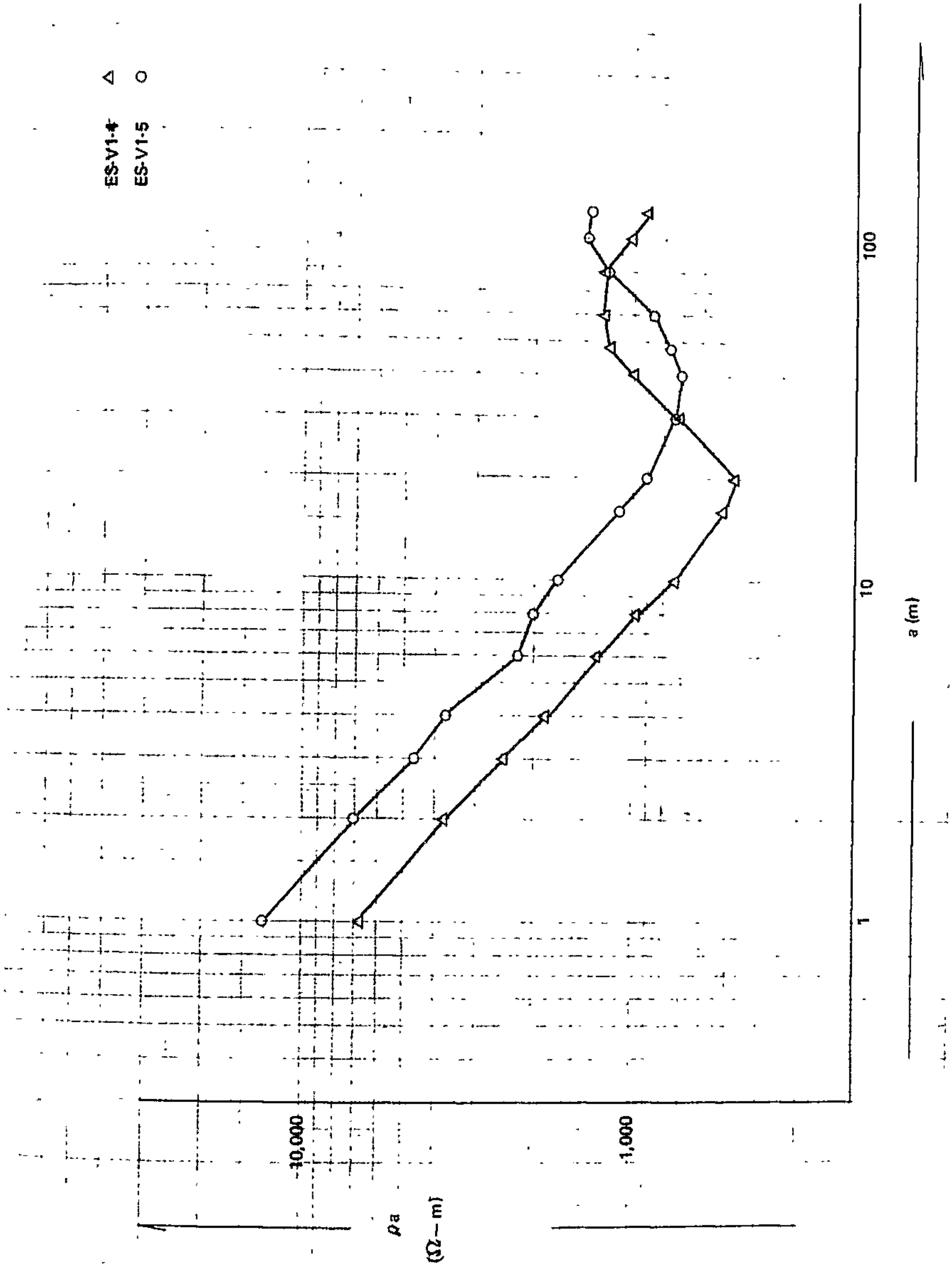
Annex 2. ρa - a curve

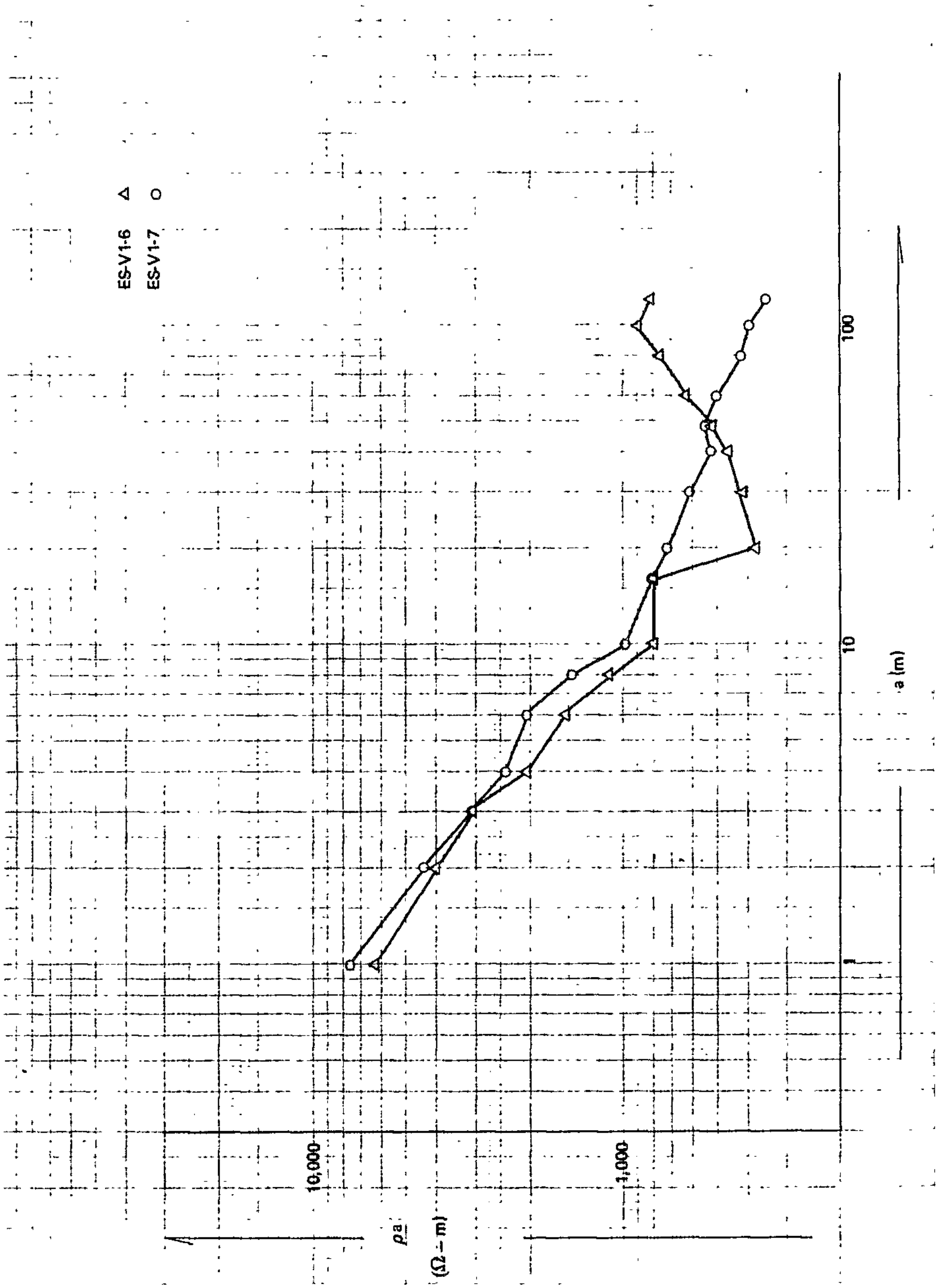
Annex 3. Analysis of ρa - a (by Ushijima method)

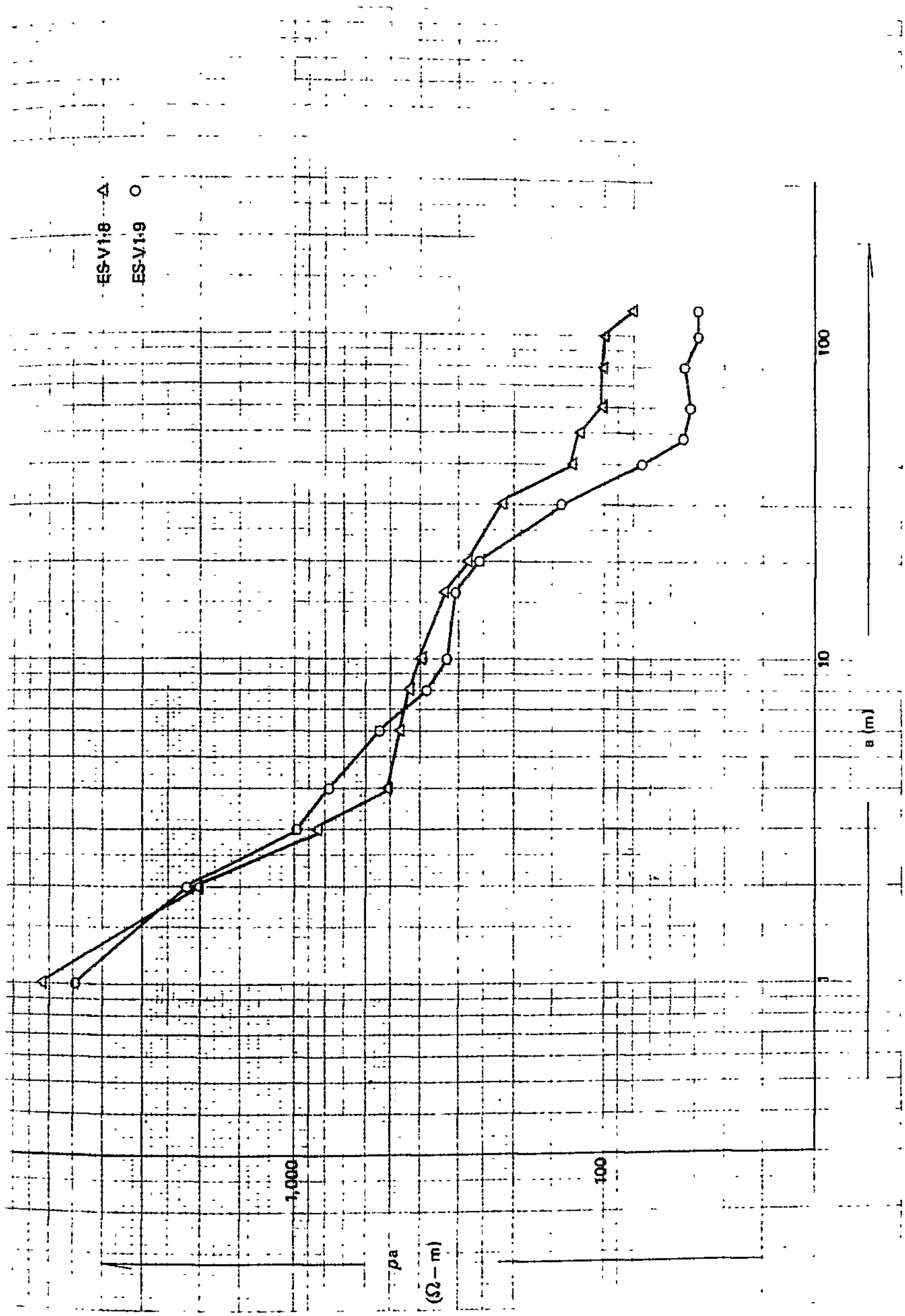
Annex 4. ρa - ρμ ← resistivity ← Map

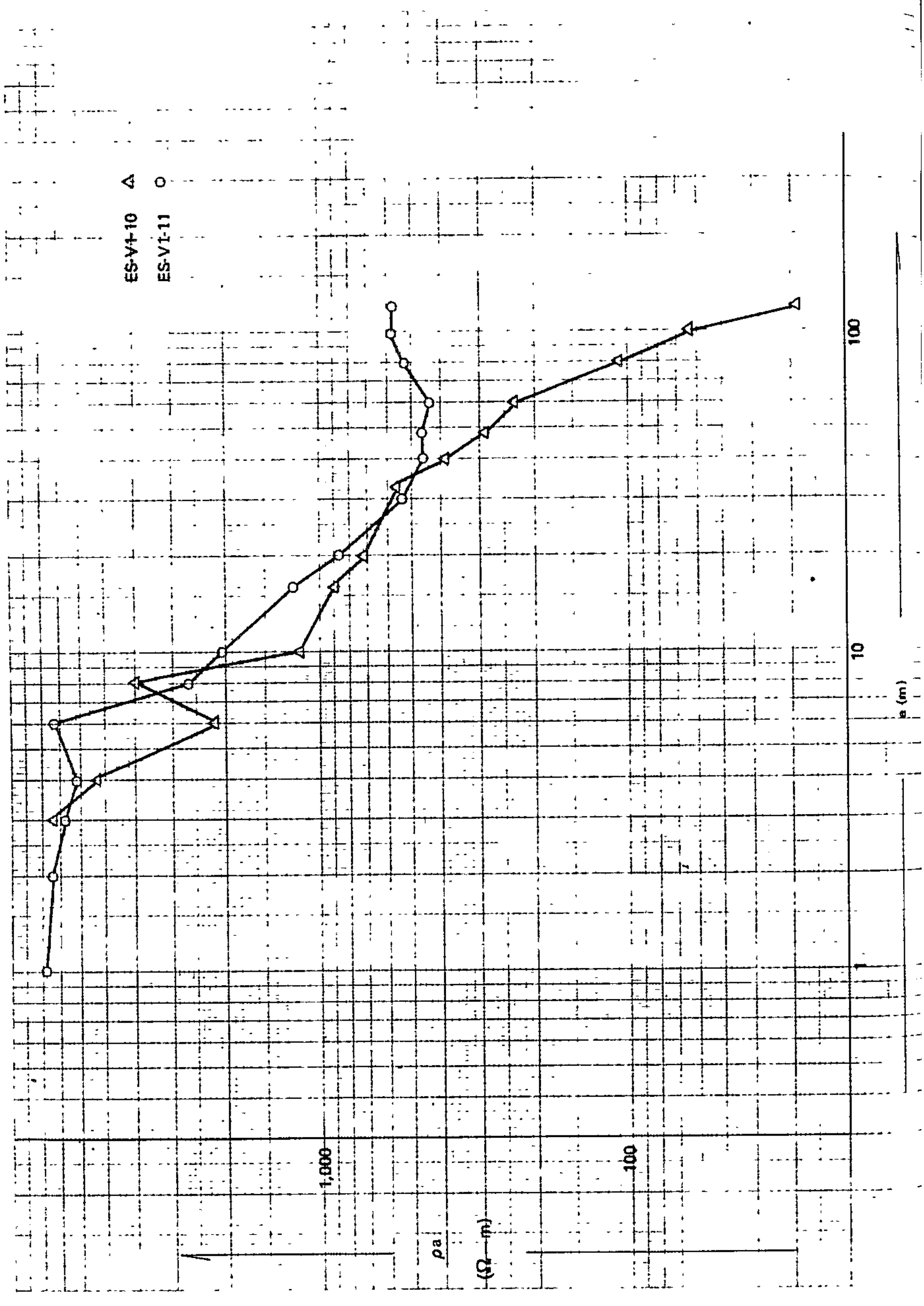

ES-V1-1
ES-V1-2
100
10
1
a (m)
100
10
ρa
(Ω·m)

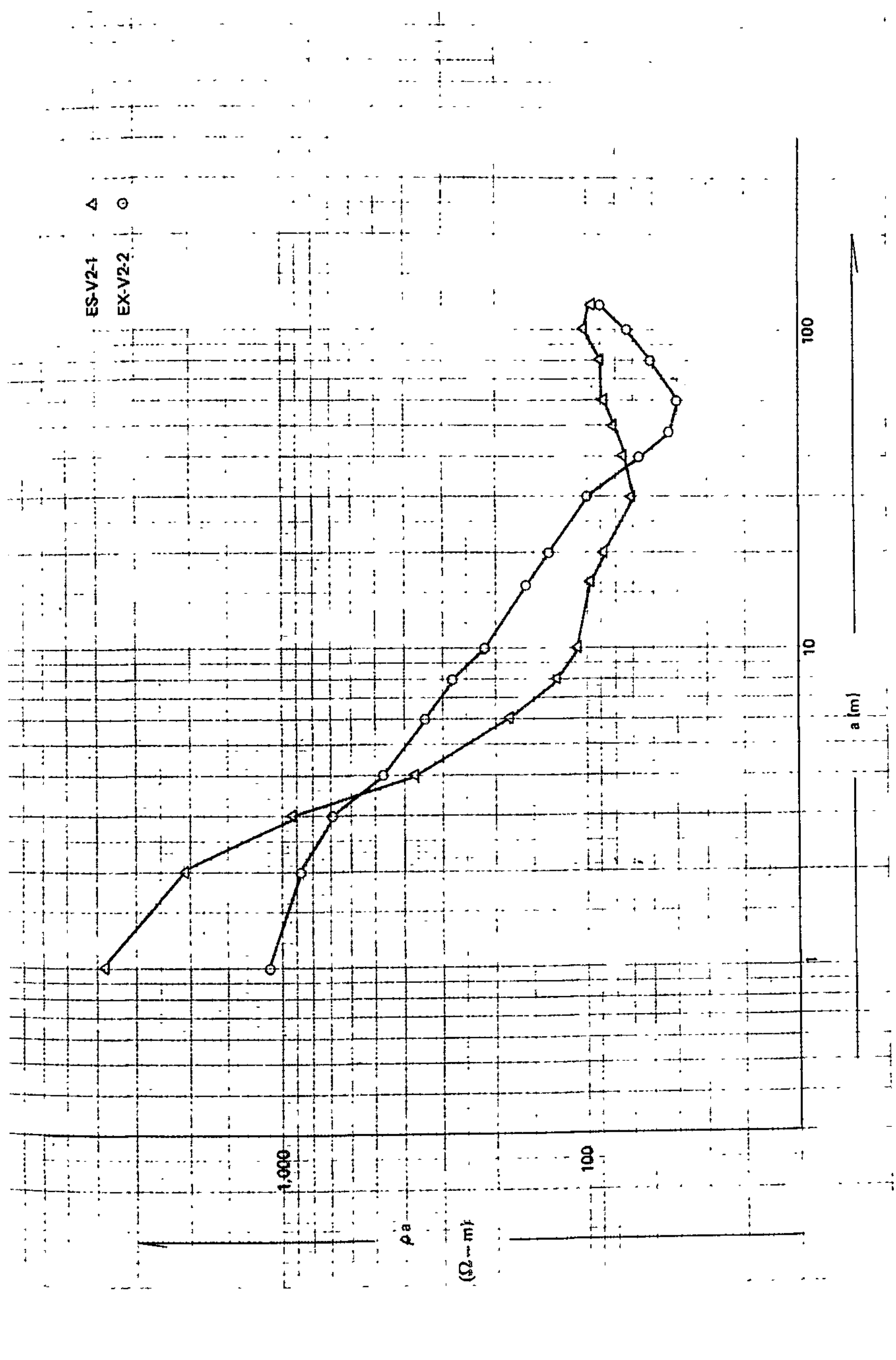

ES-V1-3
100
10
1
a (m)
1,000
100
ρa
(Ω−m)

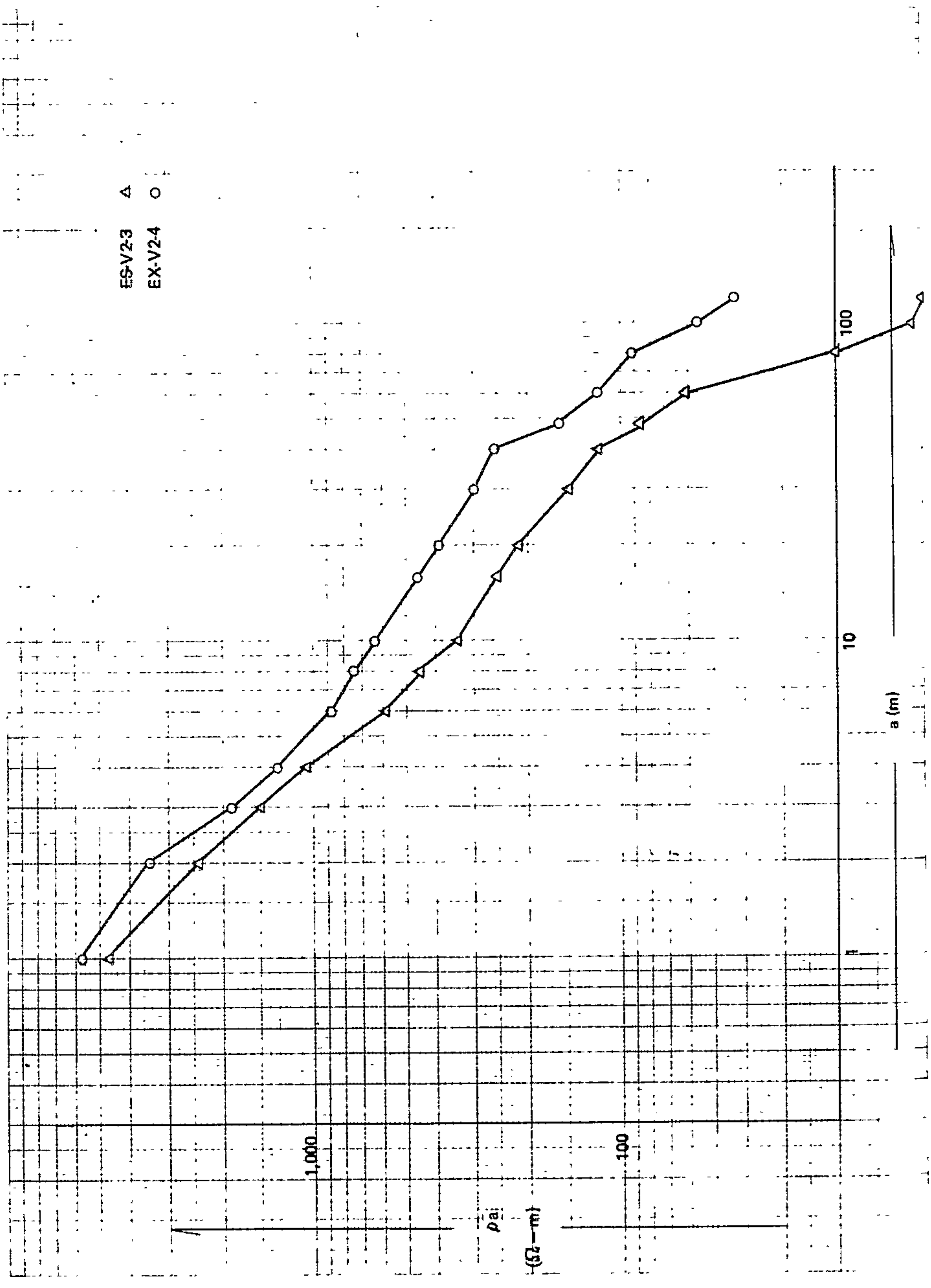

ES-V1-4 △
ES-V1-5 ○
1
10
100
a (m)
10,000
1,000
ρa
(Ω－m)


ES-V1-6 △
ES-V1-7 ○
100
10
1
a (m)
10,000
1,000
ρa
(Ω – m)

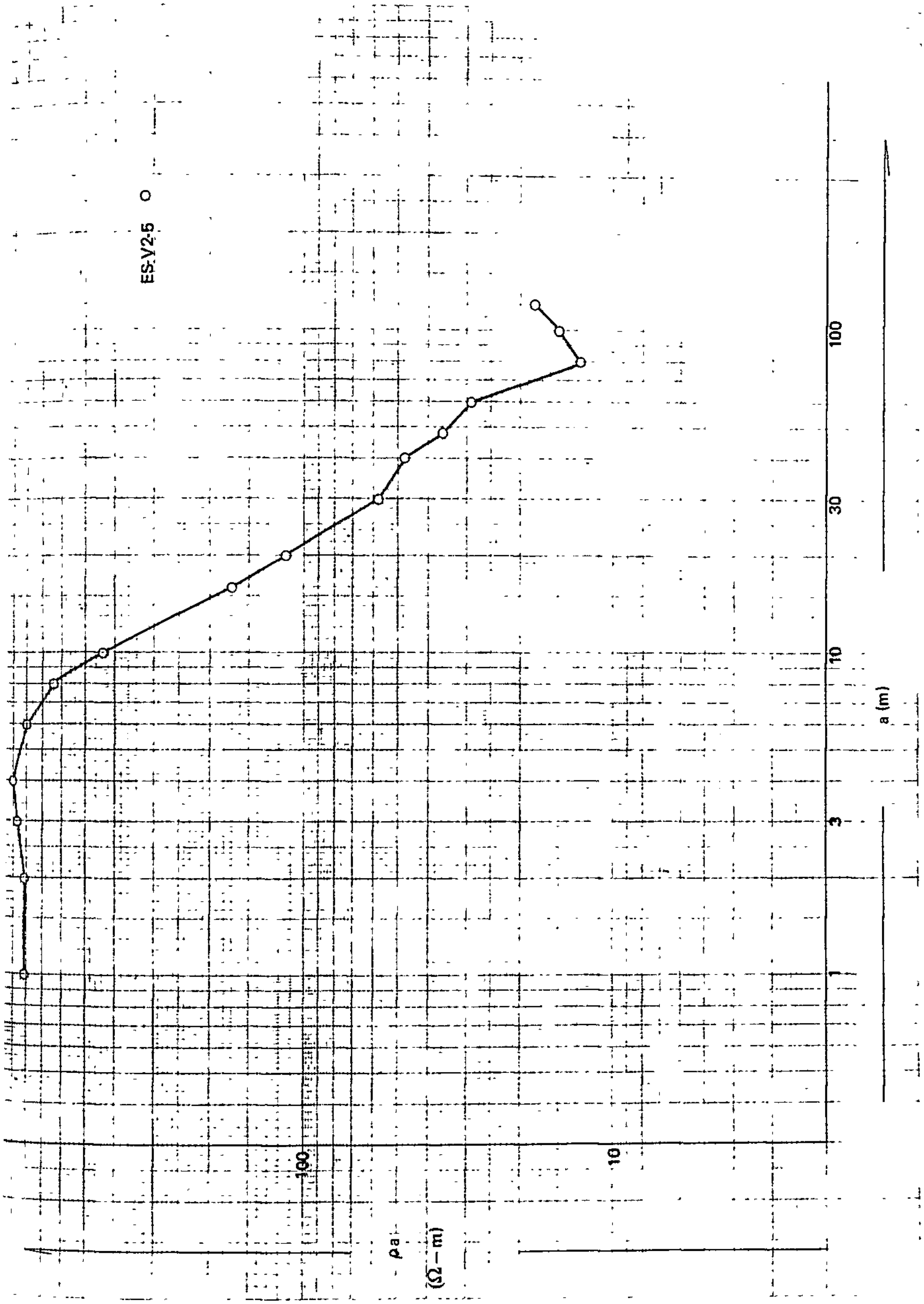

ES-V1:8 —△
ES-V1:9 ○
1
10
100
a (m)
1,000
100
ρa
(Ω − m)

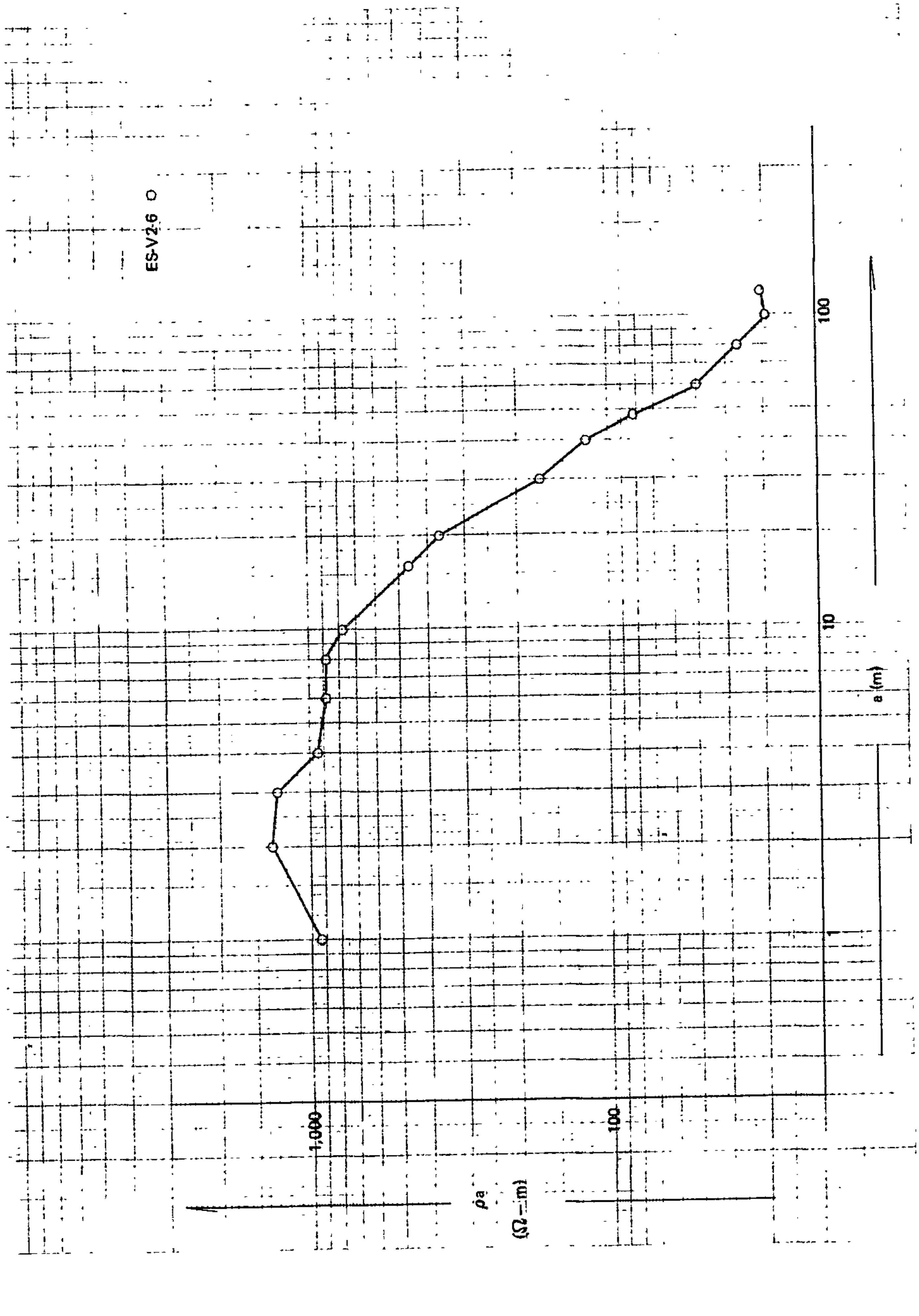

ES-V1-10
ES-V1-11
100
10
1
a (m)
1,000
100
ρa
(Ω-m)

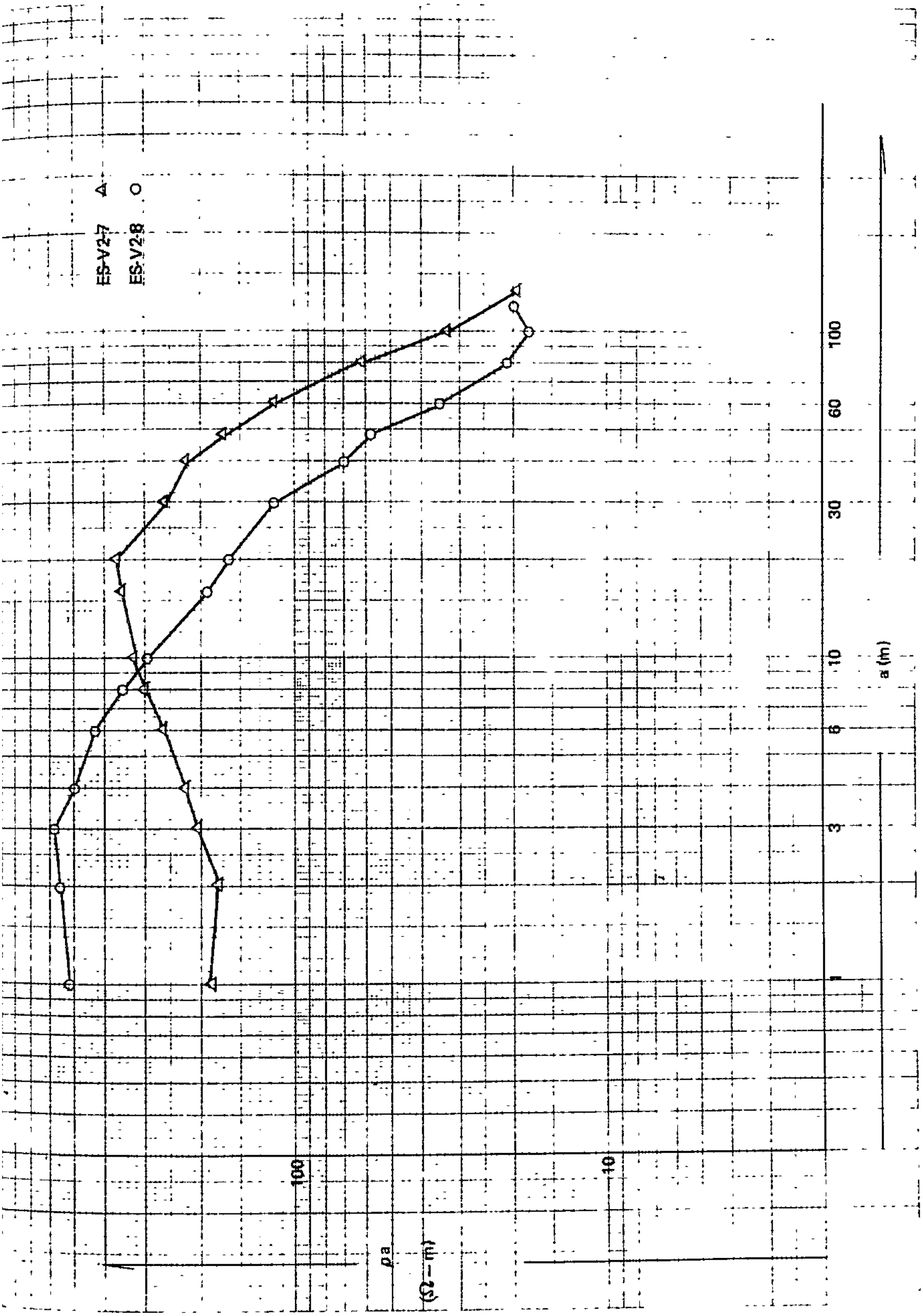

ES-V2-1 △
EX-V2-2 ○
100
10
1
a (m)
1,000
100
ρa
(Ω-m)

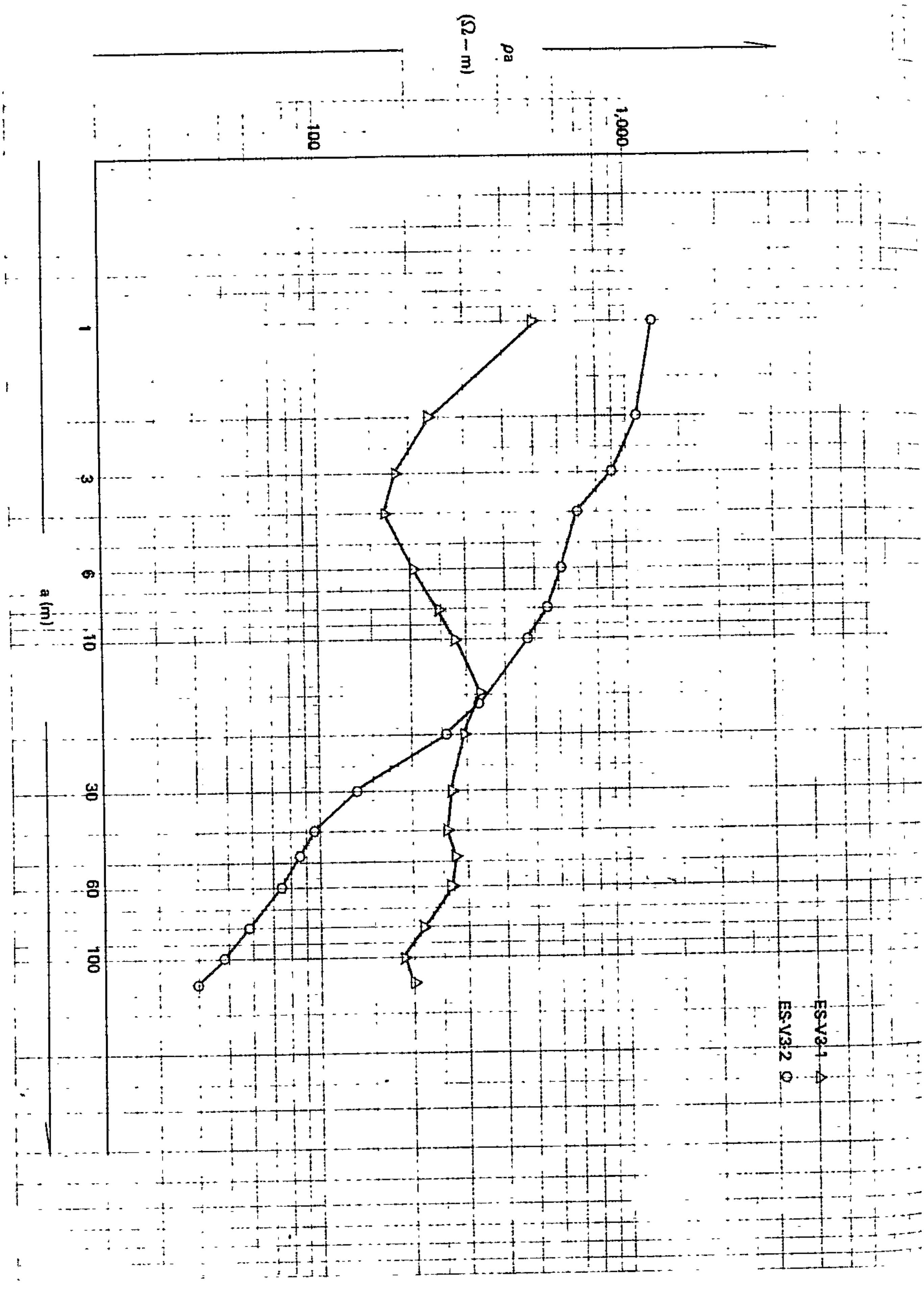


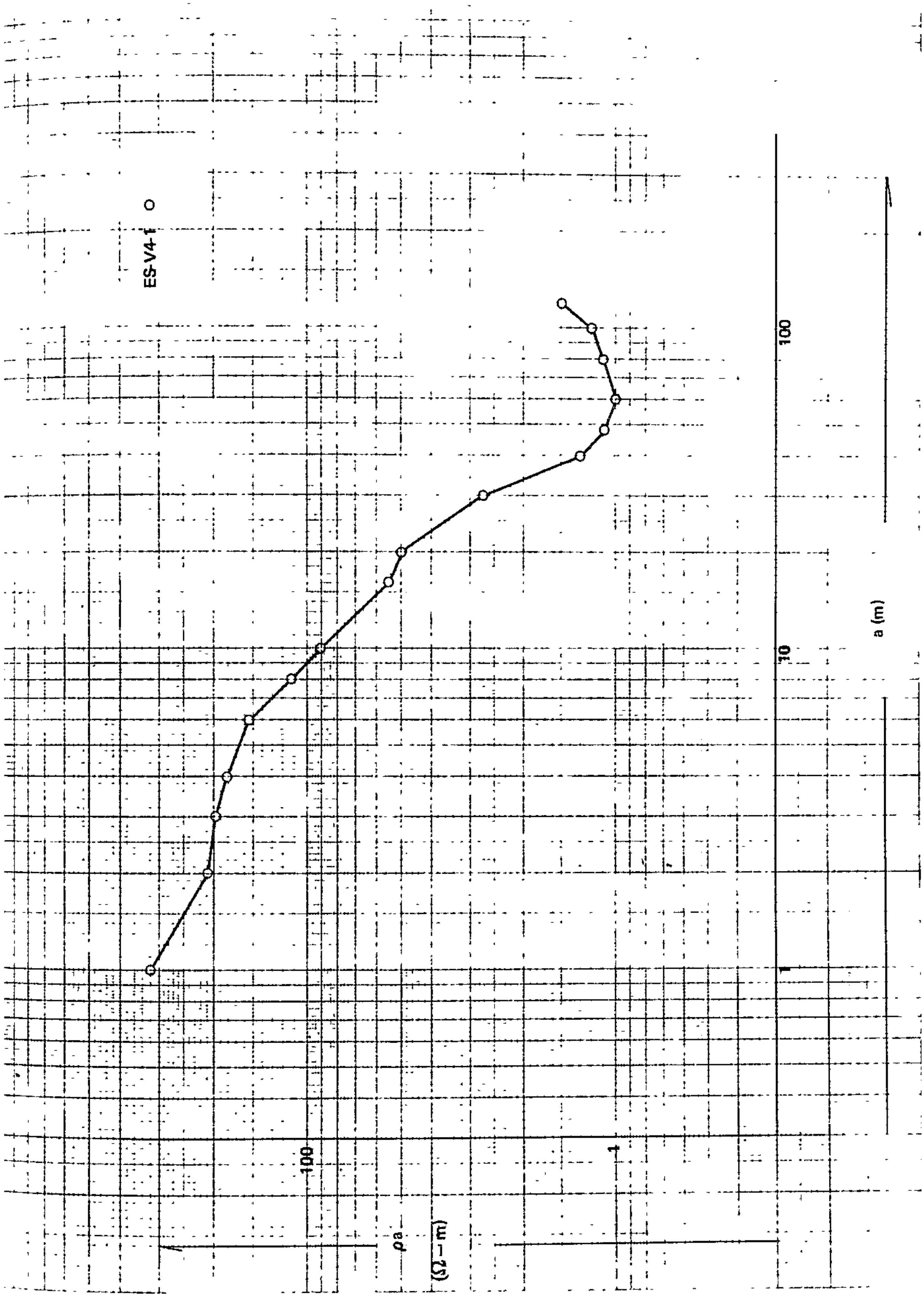
ES-V2-3
EX-V2-4
100
10
a (m)
1,000
100
ρa (Ω-m)

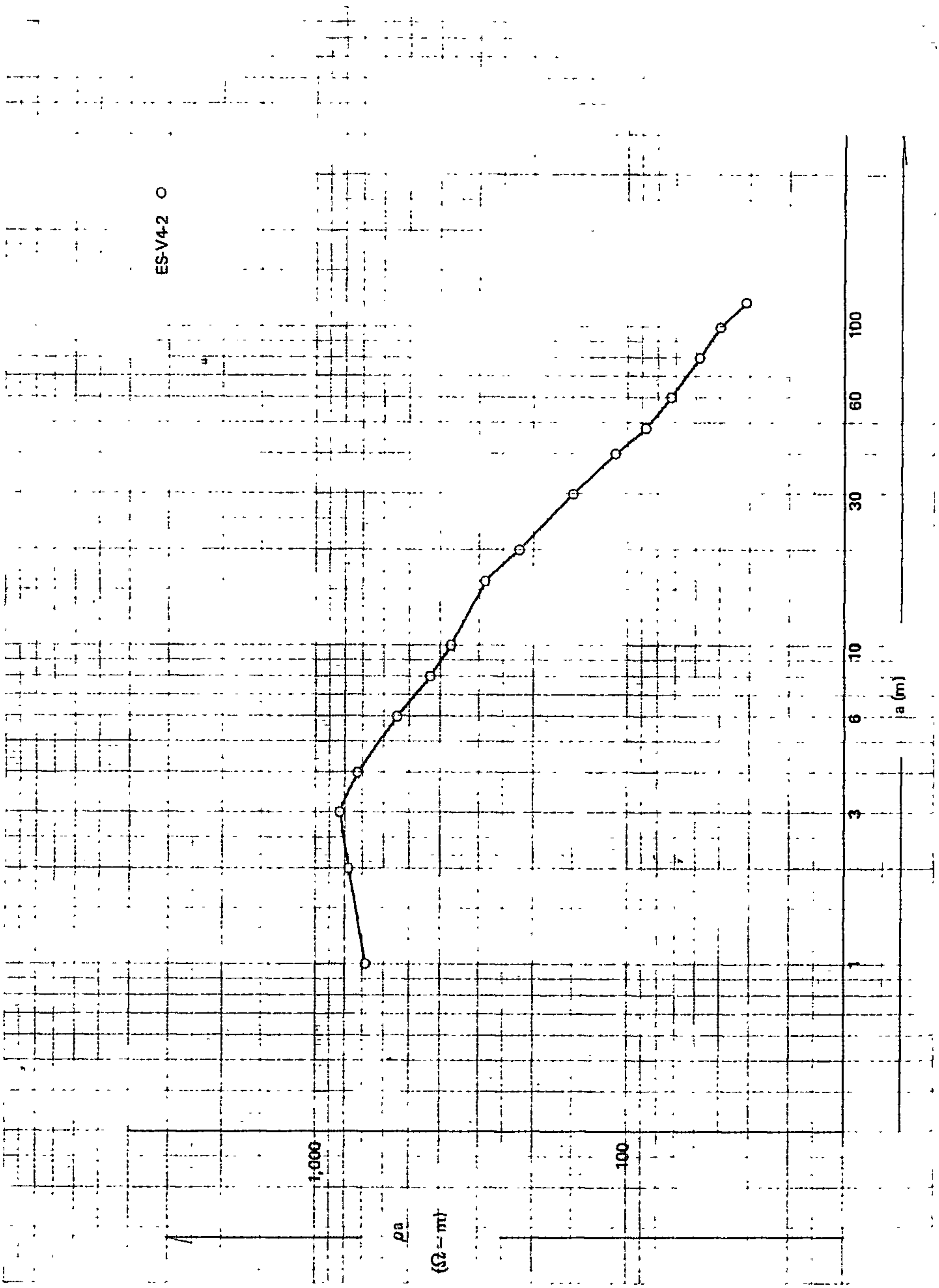

ES-V2-5
100
30
10
3
1
a (m)
10
100
ρa
(Ω−m)

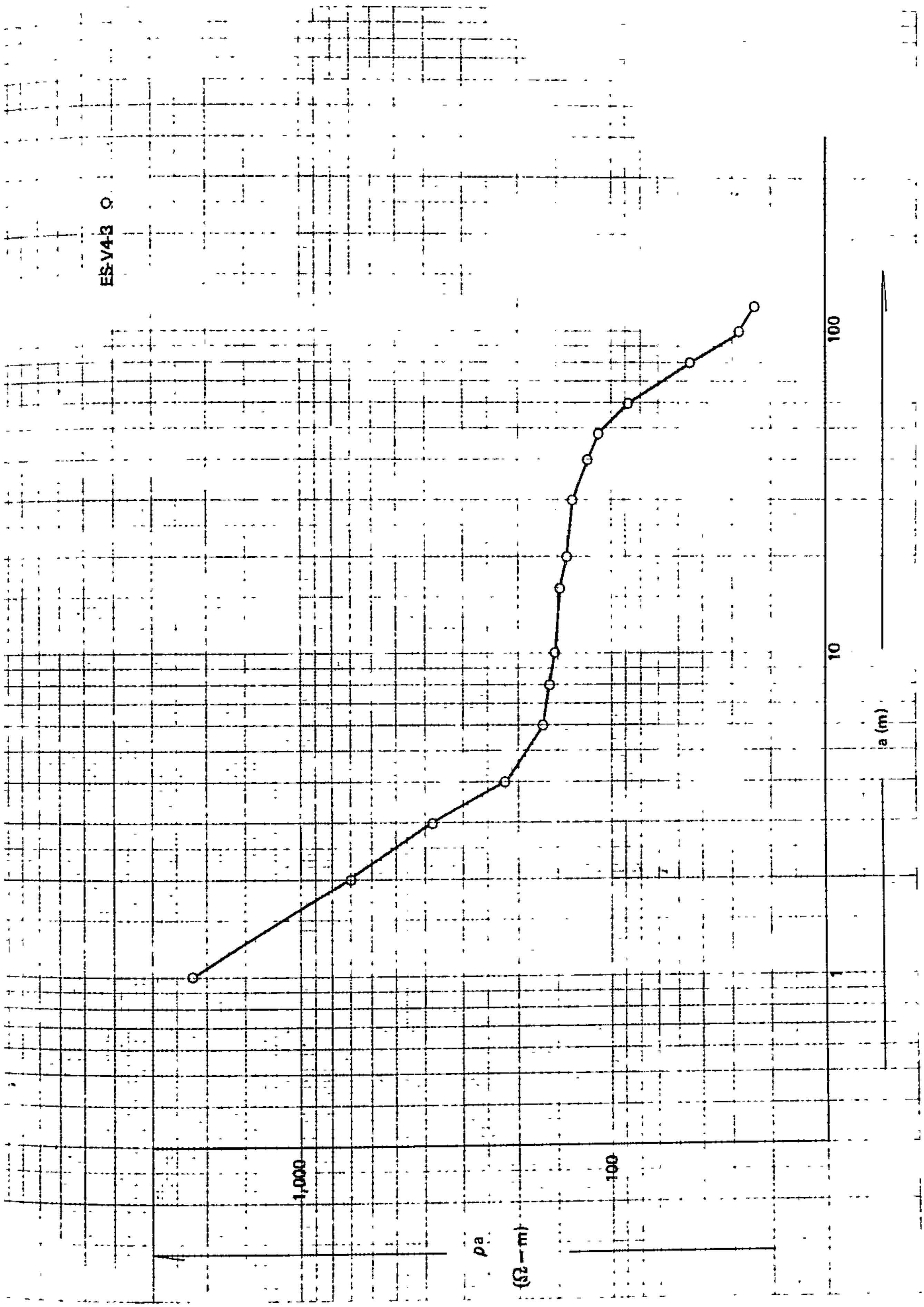

ES-V2-6
100
10
1
a (m)
1,000
100
ρa
(Ω-m)

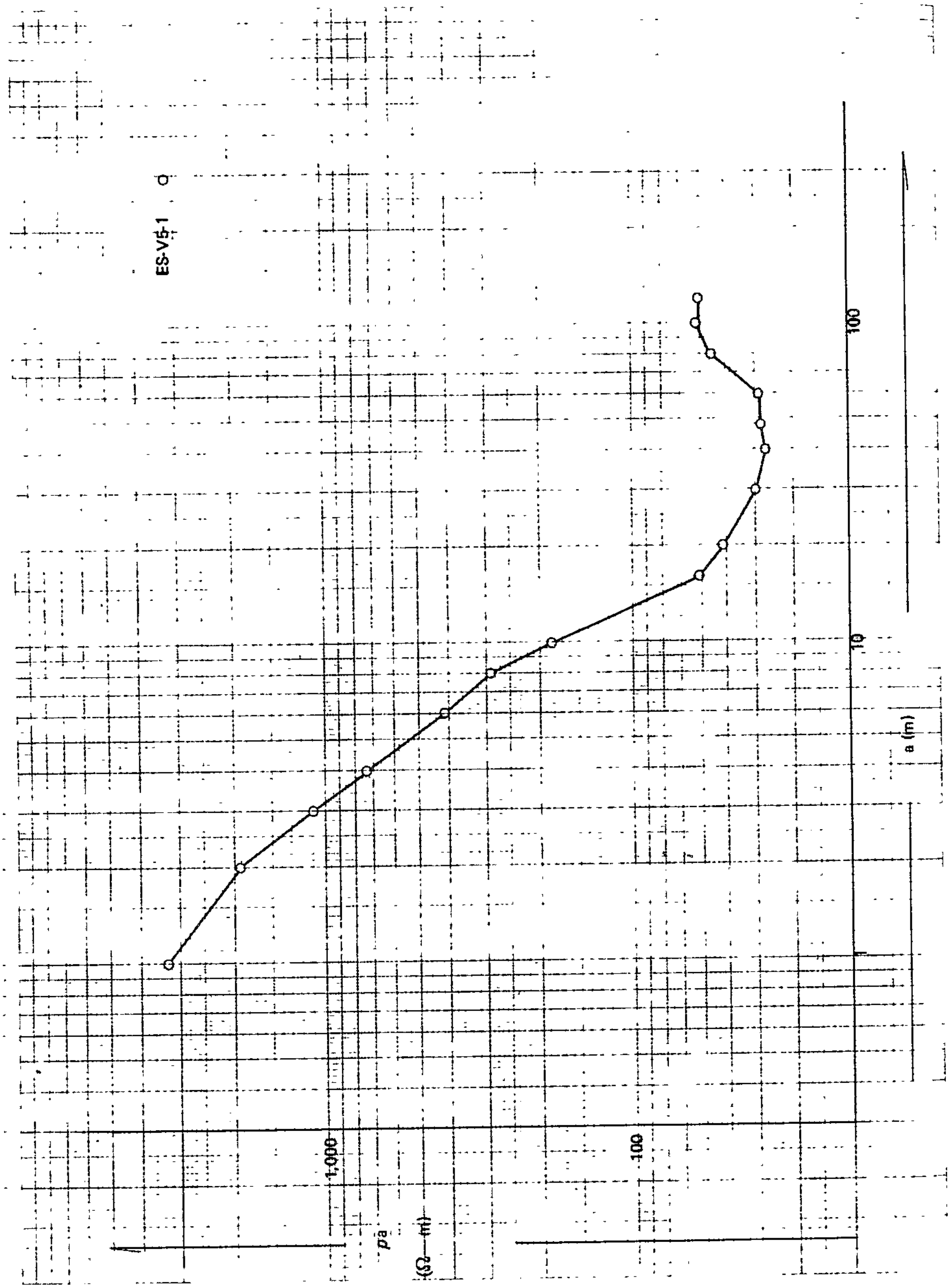

ES-V2-7 △
ES-V2-8 ○
1
3
6
10
30
60
100
a (m)
100
10
ρa
(Ω−m)


ρa
(Ω−m)
100
1,000
a (m)
1
3
6
10
30
60
100
ES-V3-1 △
ES-V3-2 ○


ES-V4-1 o
100
10
1
a (m)
100
1
ρa
(Ω−m)


ES-V4-2 ○
ρa
(Ω - m)
1,000
100
a (m)
1
3
6
10
30
60
100

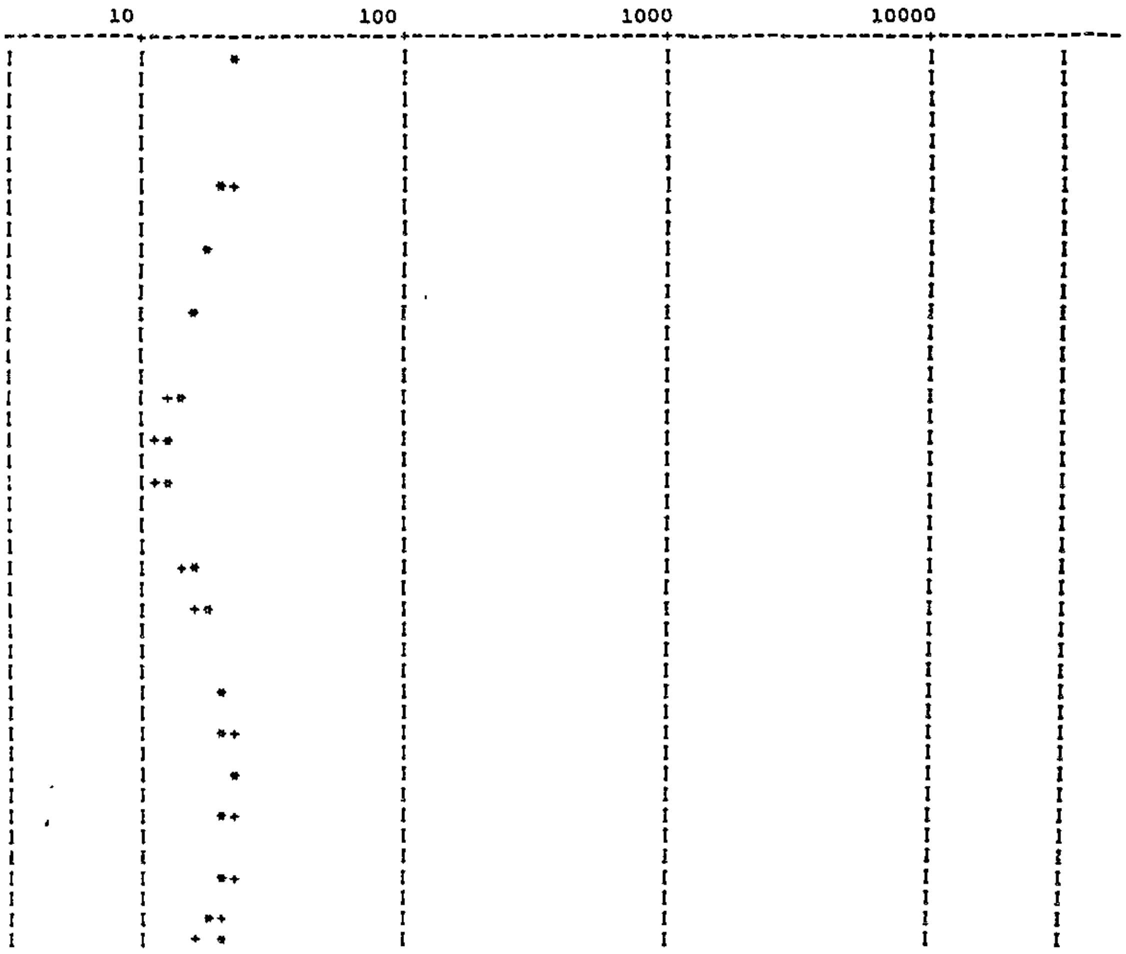

ES V4-3
1
10
100
a (m)
1,000
100
ρa
(Ω−m)


ES-V5-1
100
10
a (m)
1,000
100
ρa
(Ω—m)

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V1-1

------APPARENT RESISTIVITY:OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9850	24.626	23.100
2.00	0.9098	22.746	22.200
3.00	0.7912	19.780	17.900
4.00	0.6722	16.804	16.600
6.00	0.5142	12.856	15.800
8.00	0.4630	11.575	14.100
10.00	0.4737	11.842	13.800
16.00	0.6108	15.271	17.000
20.00	0.7039	17.598	18.900
30.00	0.8711	21.778	22.000
40.00	0.9583	23.958	22.100
48.00	0.9869	24.674	22.500
60.00	0.9840	24.599	22.100
80.00	0.9107	22.767	21.200
100.00	0.8045	20.112	19.800
120.00	0.6964	17.409	21.500



+:CALCALATED VALUE

*:MEASUREMENT VALUE

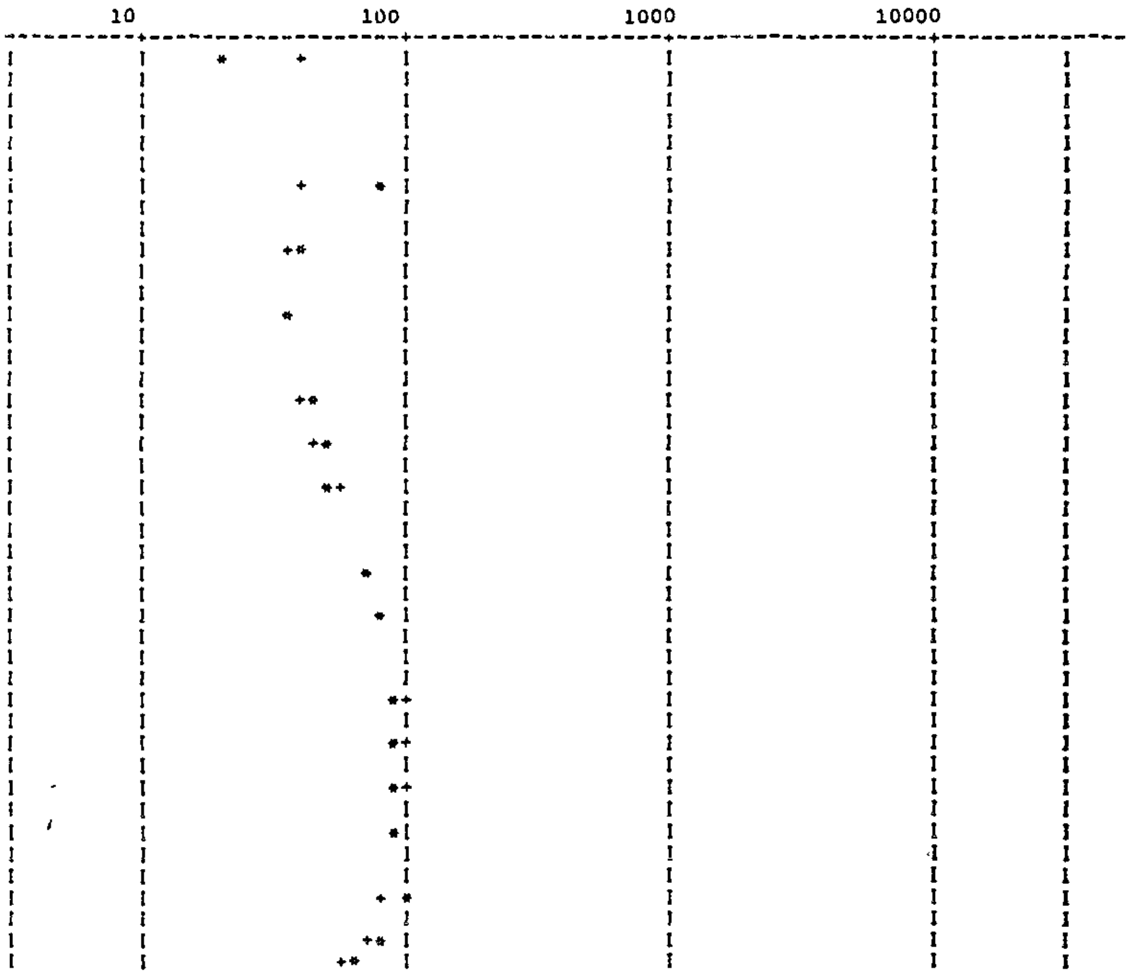
SPECIFIC RESISTIVITY:OHM-METER

LAYER 1:	25.0	
		3M
LAYER 2:	5.0	
		8M
LAYER 3:	70.0	
		25M
LAYER 4:	20.0	
		70M
LAYER 5:	5.0	

APPARENT RESISTIVITY-DEPTH CURVE;STATION NO.OMAN ES-V1-2

------APPARENT RESISTIVITY;OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9762	43.931	21.500
2.00	0.8940	40.229	80.000
3.00	0.8250	37.124	41.000
4.00	0.8088	36.395	39.000
6.00	0.9033	43.648	49.000
8.00	1.0716	48.224	53.000
10.00	1.2517	56.374	56.000
16.00	1.7101	76.956	75.000
20.00	1.9316	86.920	86.000
30.00	2.2462	101.076	98.000
40.00	2.3254	104.642	96.000
48.00	2.2894	103.021	96.000
60.00	2.1521	96.843	100.000
80.00	1.8595	93.679	104.000
100.00	1.5972	71.872	64.000
120.00	1.3969	62.850	68.000



+:CALCALATED VALUE

*:MEASUREMENT VALUE

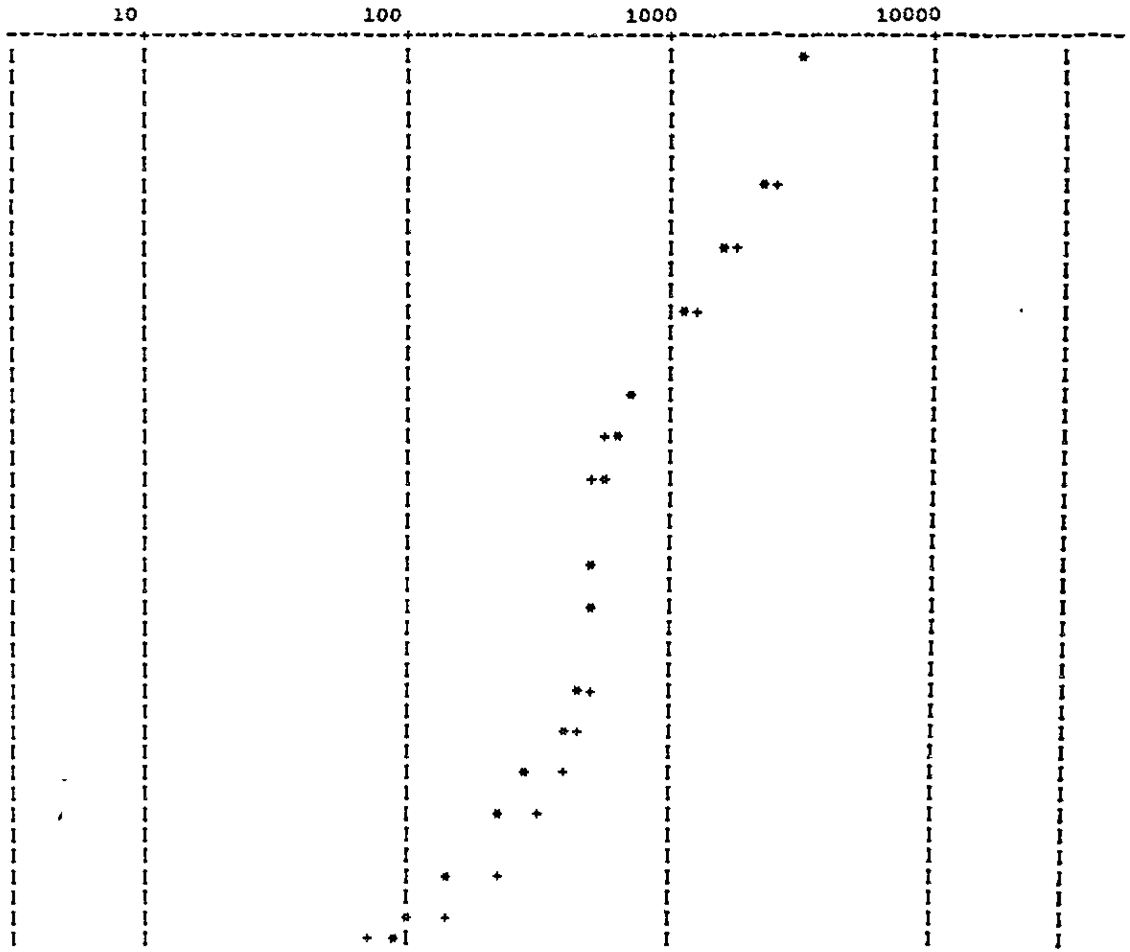
SPECIFIC RESISTIVITY;OHM-METER

LAYER 1:	45.0	
	------	2M
LAYER 2:	20.0	
	------	5M
LAYER 3:	250.0	
	------	25M
LAYER 4:	40.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V1-3

------APPARENT RESISTIVITY:OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9478	3317.229	3480.000
2.00	0.7510	2628.543	2400.000
3.00	0.5347	1371.385	1650.000
4.00	0.3771	1319.720	1190.000
6.00	0.2223	778.199	730.000
8.00	0.1720	601.907	631.000
10.00	0.1559	545.583	585.000
16.00	0.1490	521.538	560.000
20.00	0.1493	522.434	540.000
30.00	0.1445	505.844	460.000
40.00	0.1310	458.565	405.000
48.00	0.1171	409.990	310.000
60.00	0.0959	335.691	241.000
80.00	0.0656	229.759	152.000
100.00	0.0418	146.285	111.000
120.00	0.0206	72.232	98.000



+:CALCALATED VALUE

*:MEASUREMENT VALUE

SPECIFIC RESISTIVITY:OHM-METER

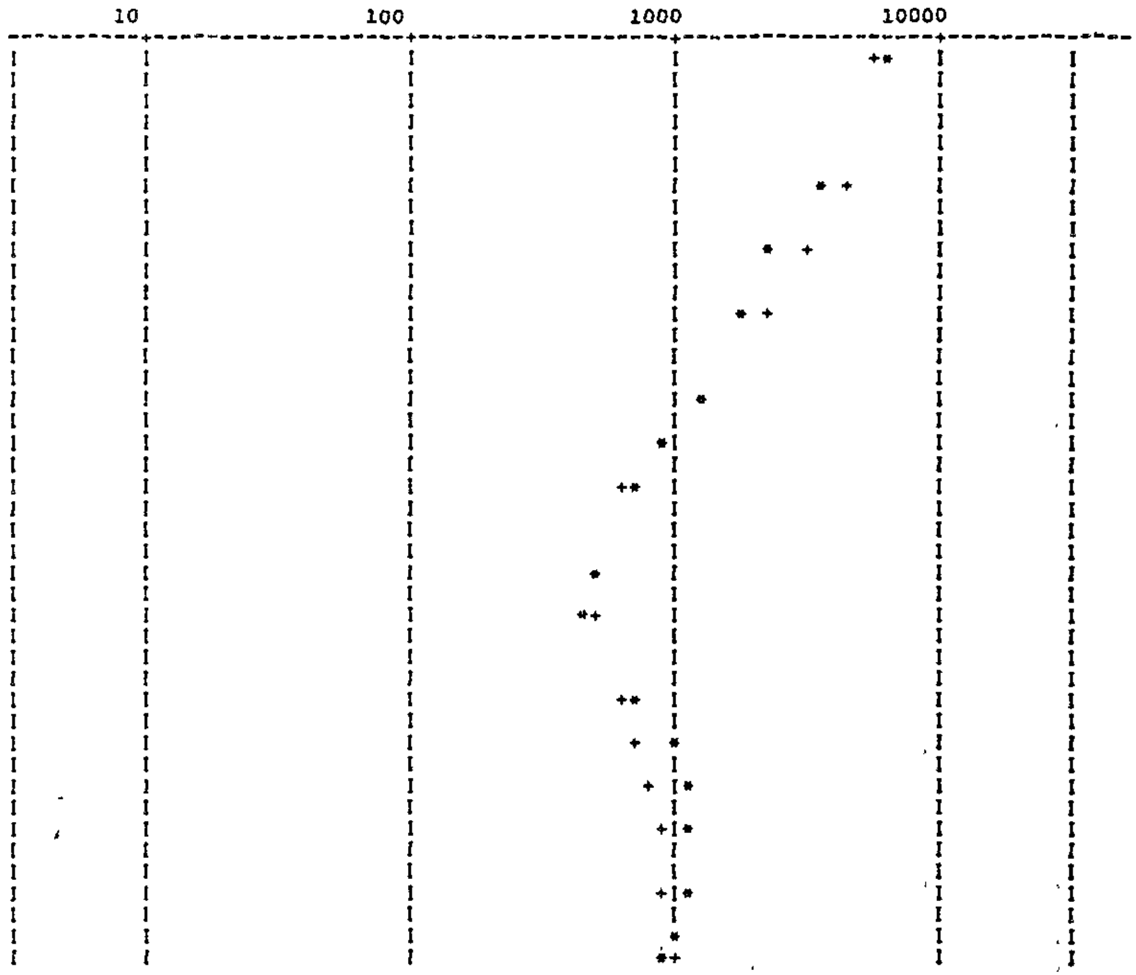
LAYER 1:	3500.0	
		2M
LAYER 2:	480.0	
		20M
LAYER 3:	850.0	
		30M
LAYER 4:	20.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V1-4

------APPARENT RESISTIVITY:OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9490	6168.594	6700.000
2.00	0.7557	4911.820	3750.000
3.00	0.5398	3508.837	2500.000
4.00	0.3779	2456.283	1820.000
6.00	0.2062	1340.426	1310.000
8.00	0.1380	897.107	980.000
10.00	0.1082	703.538	760.000
16.00	0.0838	544.699	530.000
20.00	0.0839	545.298	489.000
30.00	0.0972	631.634	720.000
40.00	0.1136	738.185	1010.000
48.00	0.1252	813.699	1160.000
60.00	0.1388	901.866	1250.000
80.00	0.1517	986.356	1210.000
100.00	0.1557	1012.373	1040.000
120.00	0.1540	1001.137	900.000

DEPTH*METER*



+:CALCALATED VALUE

*:MEASUREMENT VALUE

SPECIFIC RESISTIVITY:OHM-METER

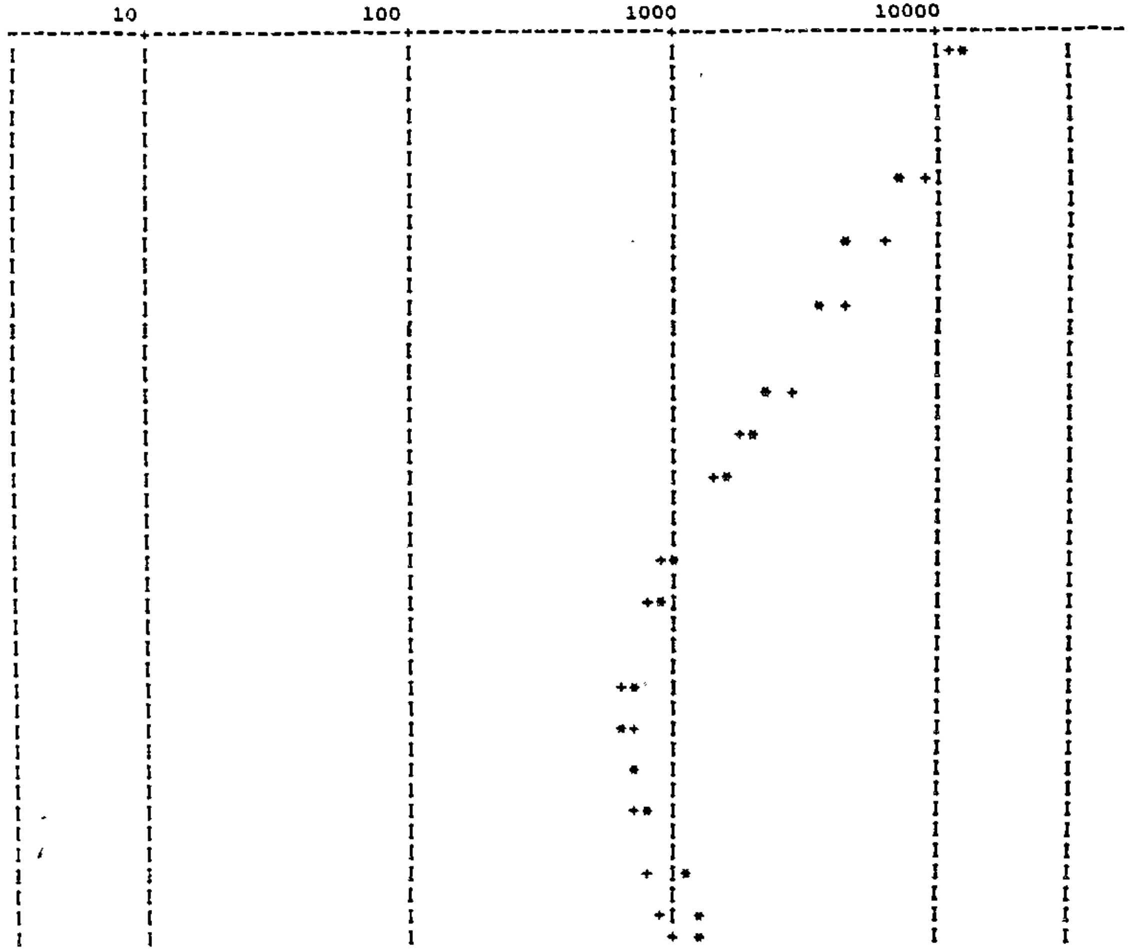
LAYER 1:	6500.0	
		2M
LAYER 2:	1000.0	
		6M
LAYER 3:	400.0	
		27M
LAYER 4:	3500.0	
		60M
LAYER 5:	400.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V1-5

------APPARENT RESISTIVITY:OHM-METER------

DEPTH*METER*

A	R(A)	CAR(A)	MAR(A)
1.00	0.9492	12339.695	13000.000
2.00	0.7570	9941.055	7080.000
3.00	0.5435	7055.363	4620.000
4.00	0.3845	4999.402	3710.000
6.00	0.2174	2926.209	2250.000
8.00	0.1495	1943.755	2005.000
10.00	0.1163	1511.536	1710.000
16.00	0.0740	961.839	1105.000
20.00	0.0629	818.298	920.000
30.00	0.0544	707.370	742.000
40.00	0.0545	708.289	706.000
48.00	0.0564	732.816	765.000
60.00	0.0605	765.894	880.000
80.00	0.0685	890.917	1207.000
100.00	0.0767	996.824	1405.000
120.00	0.0839	1091.296	1370.000



+:CALCALATED VALUE

*:MEASUREMENT VALUE

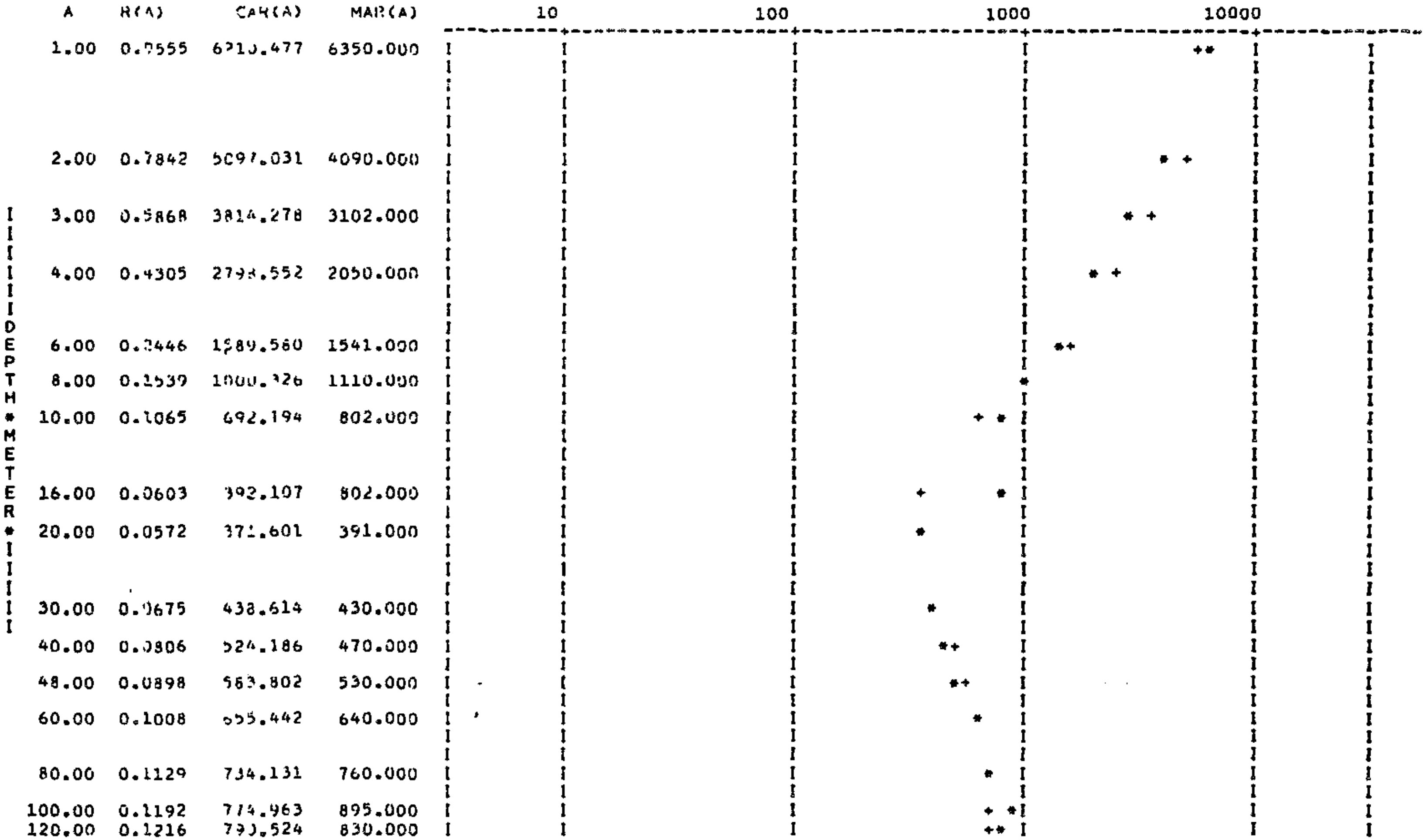
SPECIFIC RESISTIVITY:OHM-METER

LAYER 1:	13000.0	
		2M
LAYER 2:	2000.0	
		8M
LAYER 3:	600.0	
		35M
LAYER 4:	700.0	
		80M
LAYER 5:	3000.0	
		100M
LAYER 6:	300.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V1-6

------APPARENT RESISTIVITY:OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.0555	6210.477	6350.000
2.00	0.7842	5097.031	4090.000
3.00	0.5868	3814.278	3102.000
4.00	0.4305	2798.552	2050.000
6.00	0.3446	1589.560	1541.000
8.00	0.1539	1000.326	1110.000
10.00	0.1065	692.194	802.000
16.00	0.0603	392.107	802.000
20.00	0.0572	371.601	391.000
30.00	0.0675	438.614	430.000
40.00	0.0806	524.186	470.000
48.00	0.0898	583.802	530.000
60.00	0.1008	655.442	640.000
80.00	0.1129	734.131	760.000
100.00	0.1192	774.963	895.000
120.00	0.1216	790.524	830.000



+:CALCALATED VALUE

*:MEASUREMENT VALUE

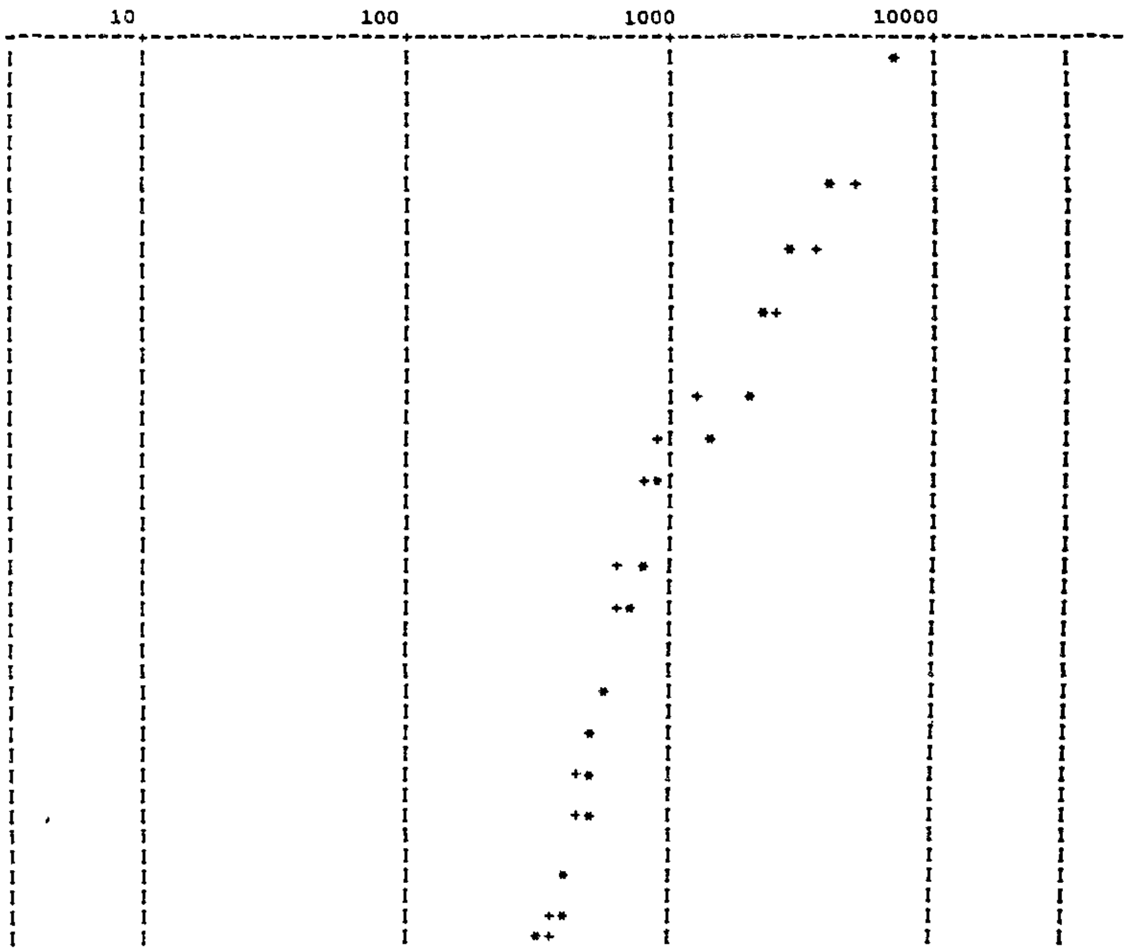
SPECIFIC RESISTIVITY:OHM-METER

LAYER 1:	6500.0	
		2M
LAYER 2:	1500.0	
		6M
LAYER 3:	220.0	
		22M
LAYER 4:	1800.0	
		70M
LAYER 5:	[illegible]	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V1-7

------APPARENT RESISTIVITY:OHM-METER------

A	P(A)	CAR(A)	MAR(A)
1.00	0.9447	7085.406	7567.000
2.00	0.7369	5526.176	4200.000
3.00	0.5092	3818.963	3050.000
4.00	0.3442	2581.751	2400.000
6.00	0.1832	1373.646	2051.000
8.00	0.1298	973.436	1482.000
10.00	0.1107	950.140	990.000
16.00	0.0936	702.303	825.000
20.00	0.0884	662.706	725.000
30.00	0.0787	590.211	611.000
40.00	0.0711	533.594	530.000
48.00	0.0663	467.207	551.000
60.00	0.0608	455.876	505.000
80.00	0.0551	413.112	421.000
100.00	0.0520	399.946	400.000
120.00	0.0503	376.924	353.000



+:CALCALATED VALUE

*:MEASUREMENT VALUE

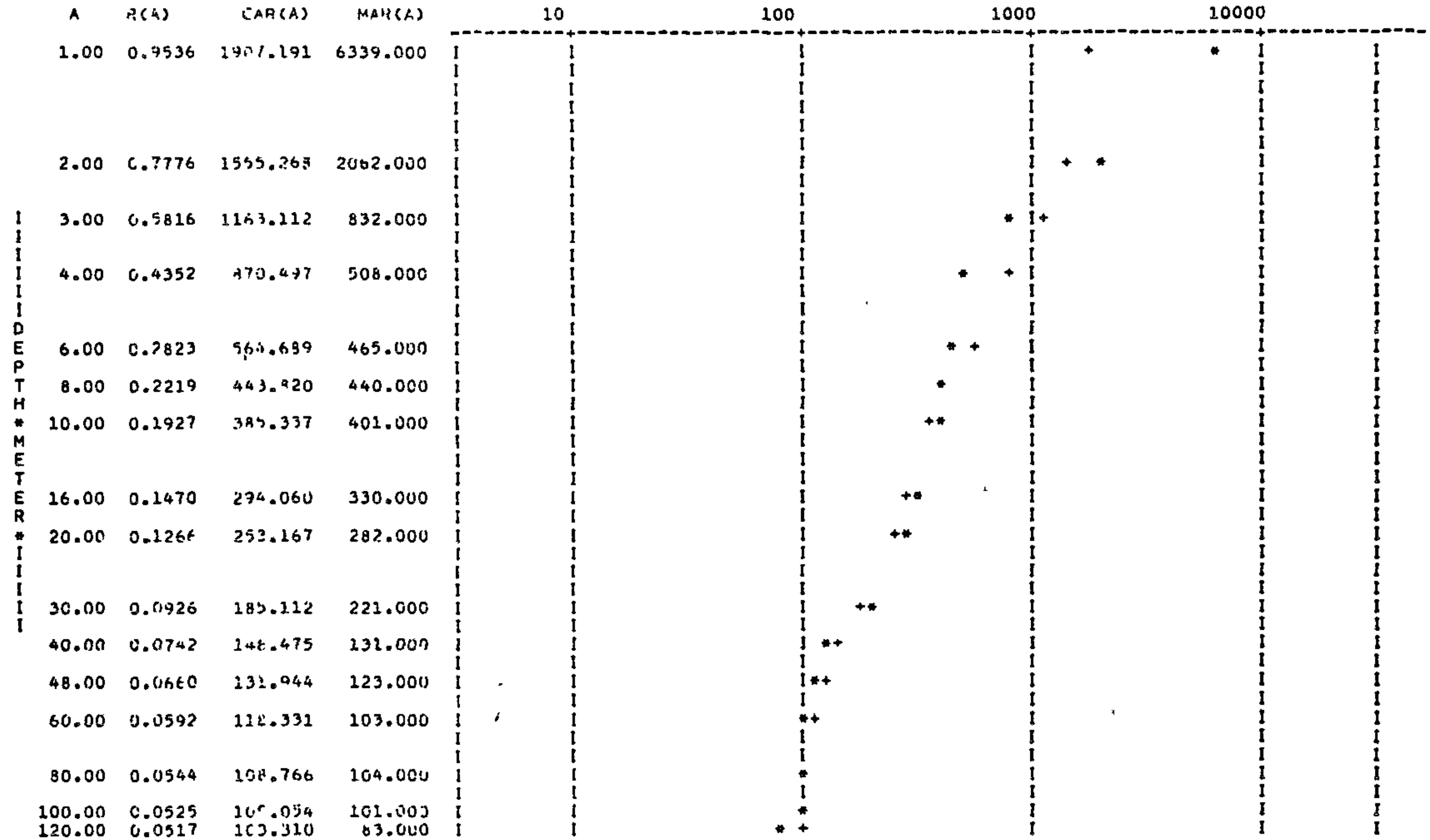
SPECIFIC RESISTIVITY:OHM-METER

LAYER 1:	7500.0	
		2M
LAYER 2:	800.0	
		8M
LAYER 3:	650.0	
		30M
LAYER 4:	350.0	

APPARENT RESISTIVITY-DEPTH CURVE;STATION NO.OMAN ES-V1-8

------APPARENT RESISTIVITY;OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9536	1907.191	6339.000
2.00	0.7776	1555.263	2062.000
3.00	0.5816	1163.112	832.000
4.00	0.4352	870.497	508.000
6.00	0.2823	564.689	465.000
8.00	0.2219	443.820	440.000
10.00	0.1927	385.337	401.000
16.00	0.1470	294.060	330.000
20.00	0.1266	253.167	282.000
30.00	0.0926	185.112	221.000
40.00	0.0742	148.475	131.000
48.00	0.0660	131.944	123.000
60.00	0.0592	112.331	103.000
80.00	0.0544	108.766	104.000
100.00	0.0525	105.054	101.000
120.00	0.0517	103.310	83.000



+;CALCALATED VALUE

*;MEASUREMENT VALUE

SPECIFIC RESISTIVITY;OHM-METER

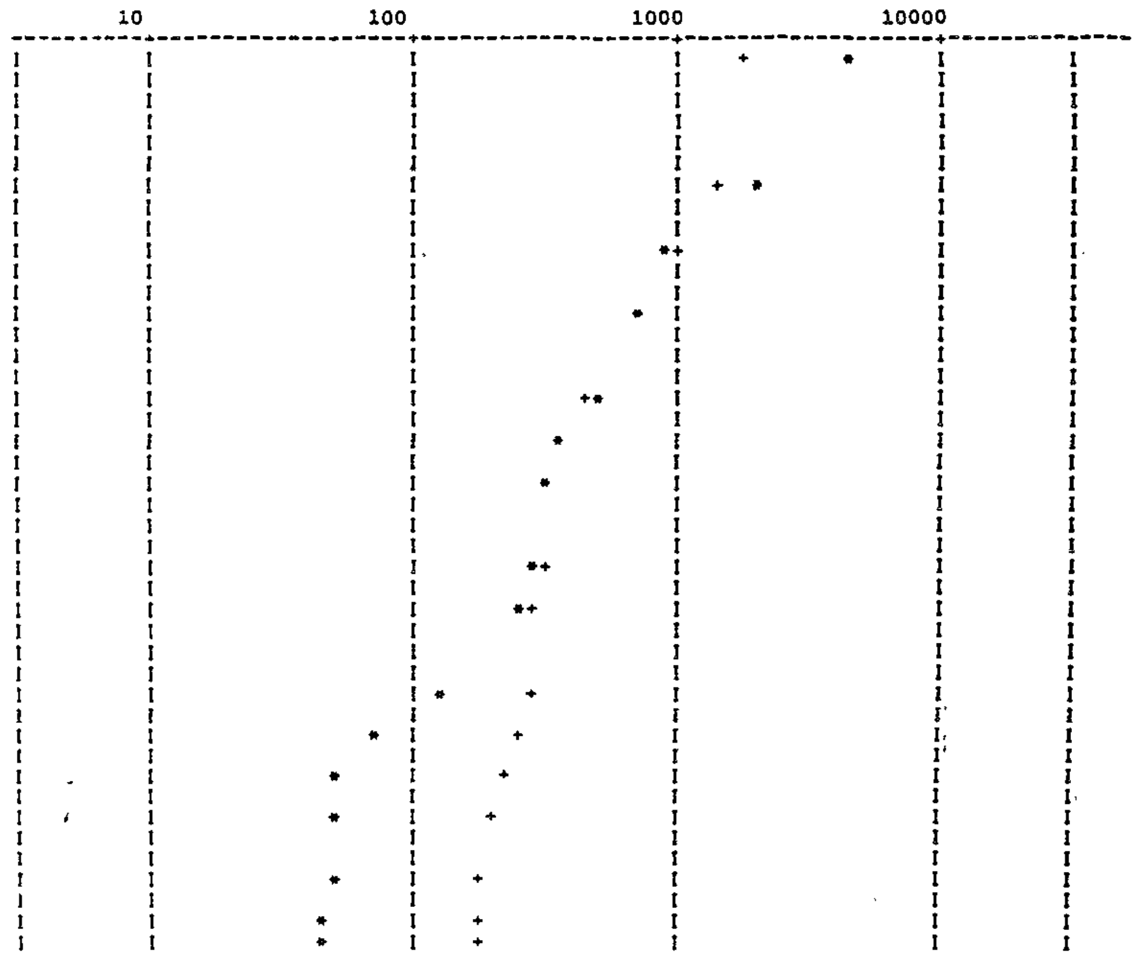
LAYER 1;	2000.0	
		2M
LAYER 2;	400.0	
		10M
LAYER 3;	250.0	
		20M
LAYER 4;	100.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V1-9

------APPARENT RESISTIVITY:OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9490	1996.071	4891.000
2.00	0.7569	1513.506	2222.000
3.00	0.5449	1019.805	983.000
4.00	0.3900	740.071	792.000
6.00	0.2370	473.999	545.000
8.00	0.1864	372.828	392.000
10.00	0.1697	339.333	335.000
16.00	0.1593	318.533	302.000
20.00	0.1560	312.098	260.000
30.00	0.1440	283.045	140.000
40.00	0.1301	260.255	75.300
48.00	0.1205	240.928	55.000
60.00	0.1095	218.997	52.000
80.00	0.0987	197.380	54.000
100.00	0.0933	186.502	49.800
120.00	0.0904	130.756	50.100

DEPTH*METER*



+:CALCALATED VALUE

*:MEASUREMENT VALUE

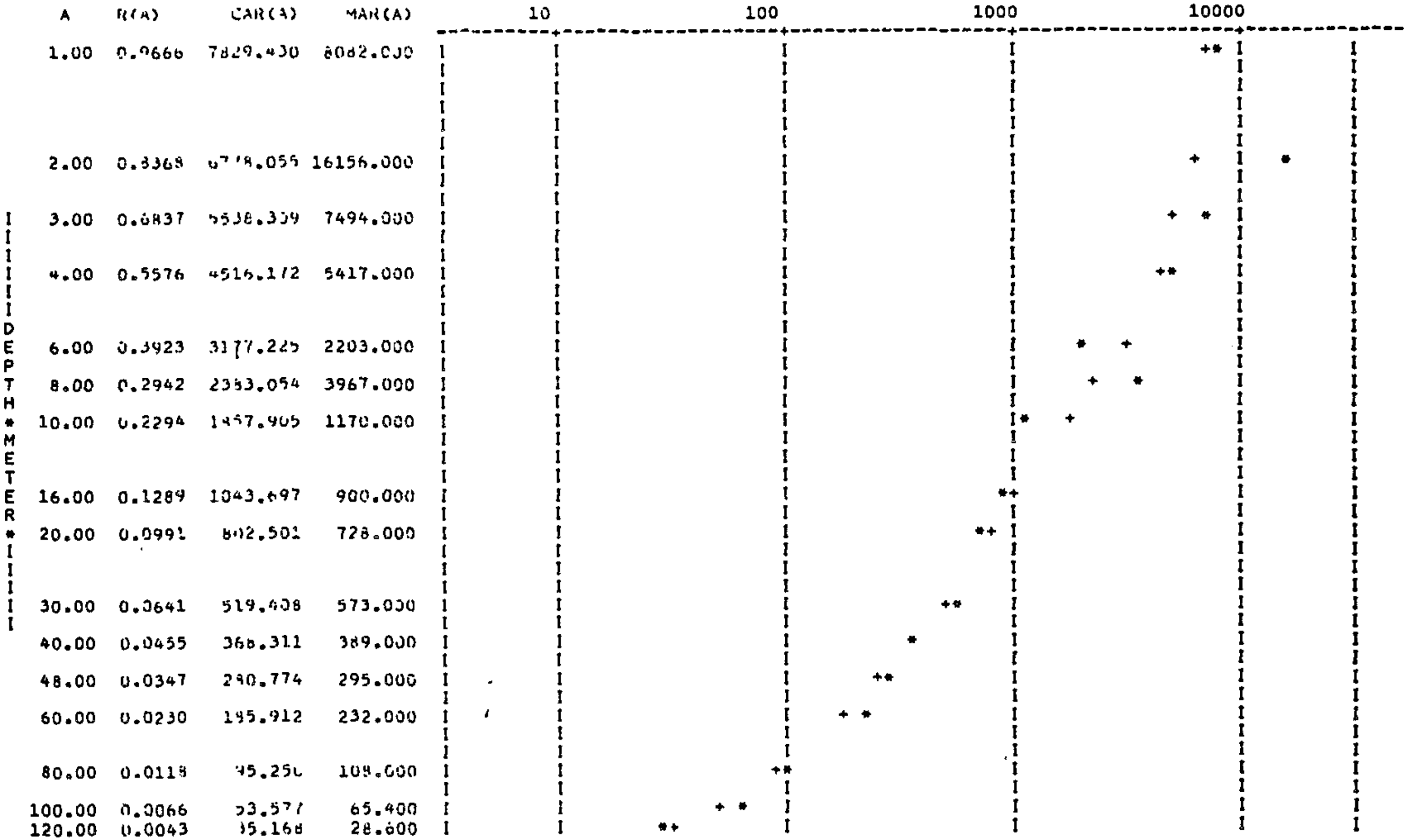
SPECIFIC RESISTIVITY:OHM-METER

LAYER 1:	2000.0	
	------	2M
LAYER 2:	300.0	
	------	16M
LAYER 3:	600.0	
	------	20M
LAYER 4:	100.0	

APPARENT RESISTIVITY-DEPTH CURVE;STATION NO.OMAN ES-V1-10

------APPARENT RESISTIVITY;OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9666	7829.430	8082.000
2.00	0.3368	6778.055	16156.000
3.00	0.6837	5538.339	7494.000
4.00	0.5576	4516.172	5417.000
6.00	0.3923	3177.225	2203.000
8.00	0.2942	2383.054	3967.000
10.00	0.2294	1857.905	1170.000
16.00	0.1289	1043.697	900.000
20.00	0.0991	802.501	728.000
30.00	0.0641	519.408	573.000
40.00	0.0455	368.311	389.000
48.00	0.0347	290.774	295.000
60.00	0.0230	195.912	232.000
80.00	0.0118	95.250	108.000
100.00	0.0066	53.577	65.400
120.00	0.0043	35.168	28.600



+;CALCALATED VALUE

*;MEASUREMENT VALUE

SPECIFIC RESISTIVITY;OHM-METER

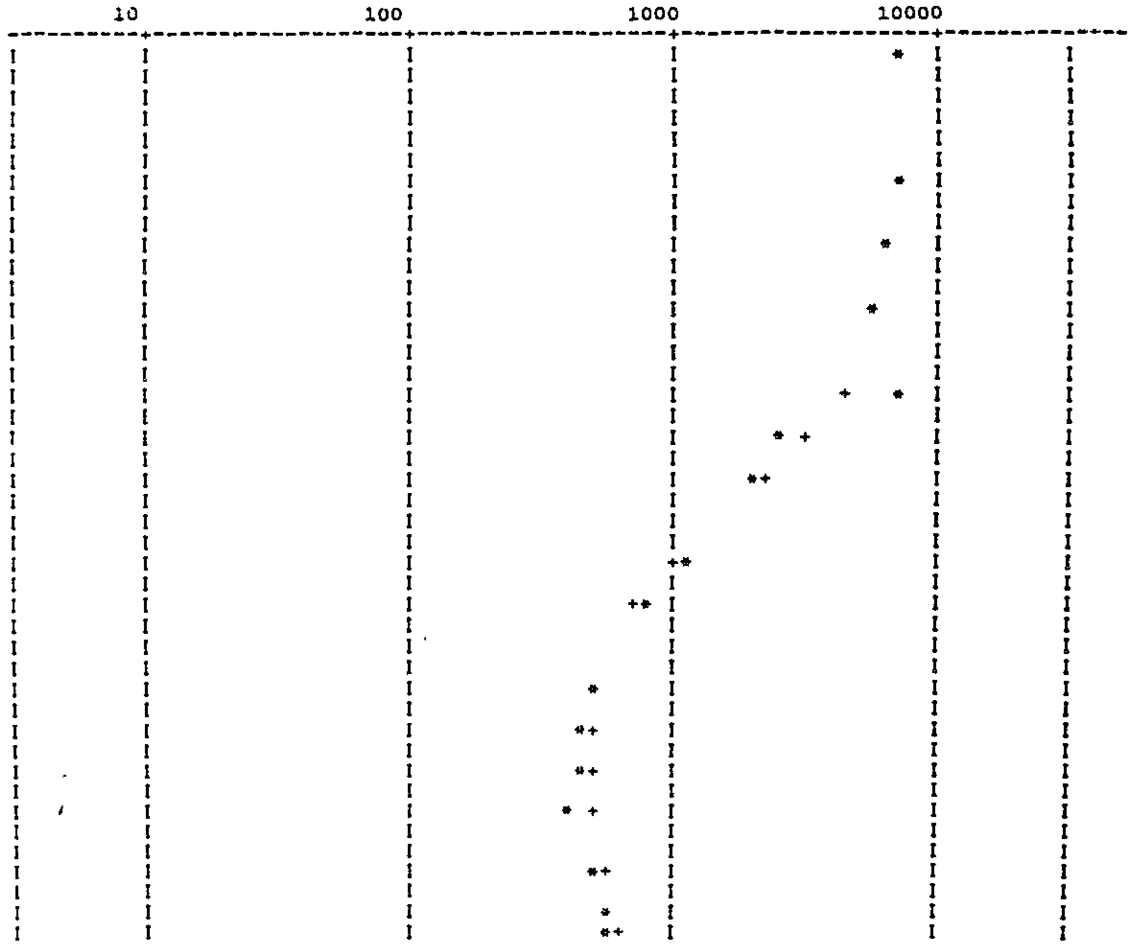
LAYER 1;	8100.0	
		2M
LAYER 2;	3000.0	
		7M
LAYER 3;	700.0	
		19M
LAYER 4;	500.0	
		40M
LAYER 5;	20.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V1-11

------APPARENT RESISTIVITY:OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9908	7926.371	7900.000
2.00	0.9421	7546.414	7500.000
3.00	0.8567	6953.395	6900.000
4.00	0.7558	6046.453	6100.000
6.00	0.5627	4501.309	7248.000
8.00	0.4104	3233.464	2688.000
10.00	0.3002	2401.456	2055.000
16.00	0.1355	1073.873	1211.000
20.00	0.0961	768.607	872.000
30.00	0.0688	550.511	547.000
40.00	0.0659	527.506	458.000
48.00	0.0668	534.176	459.000
60.00	0.0693	554.046	441.000
80.00	0.0739	591.386	535.000
100.00	0.0780	623.673	580.000
120.00	0.0813	650.144	581.000

DEPTH*METER*



+:CALCALATED VALUE

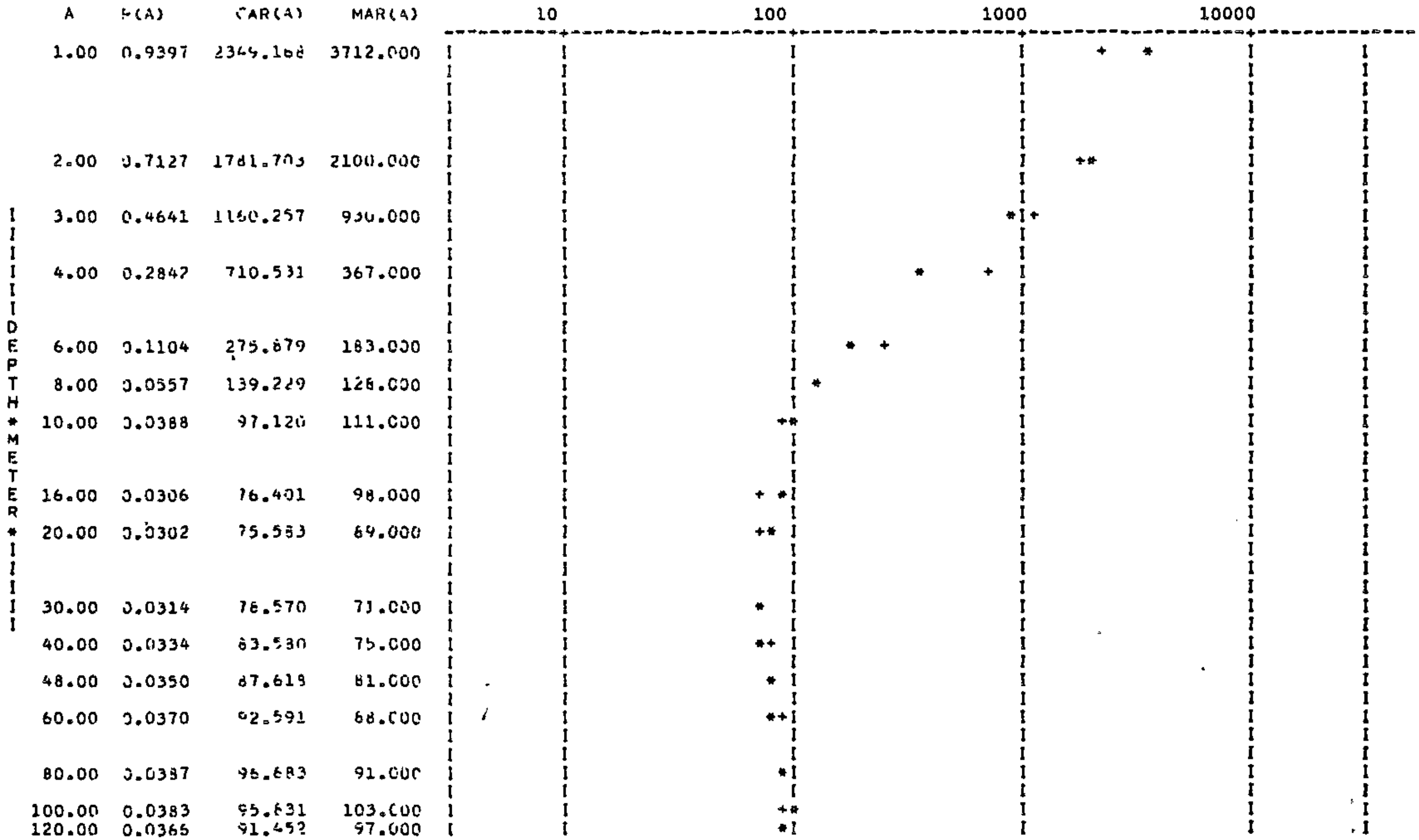
*:MEASUREMENT VALUE

SPECIFIC RESISTIVITY:OHM-METER

LAYER 1:	8000.0	
		3M
LAYER 2:	4000.0	
		6M
LAYER 3:	2500.0	
		8M
LAYER 4:	700.0	
		50M
LAYER 5:	1200.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V2-1

A	F(A)	CAR(A)	MAR(A)
1.00	0.9397	2349.168	3712.000
2.00	0.7127	1781.703	2100.000
3.00	0.4641	1160.257	930.000
4.00	0.2847	710.531	367.000
6.00	0.1104	275.879	183.000
8.00	0.0557	139.229	128.000
10.00	0.0388	97.120	111.000
16.00	0.0306	76.401	98.000
20.00	0.0302	75.553	89.000
30.00	0.0314	78.570	73.000
40.00	0.0334	83.530	75.000
48.00	0.0350	87.619	81.000
60.00	0.0370	92.591	88.000
80.00	0.0387	96.683	91.000
100.00	0.0383	95.831	103.000
120.00	0.0365	91.452	97.000



+:CALCALATED VALUE

*:MEASUREMENT VALUE

SPECIFIC RESISTIVITY:OHM-METER

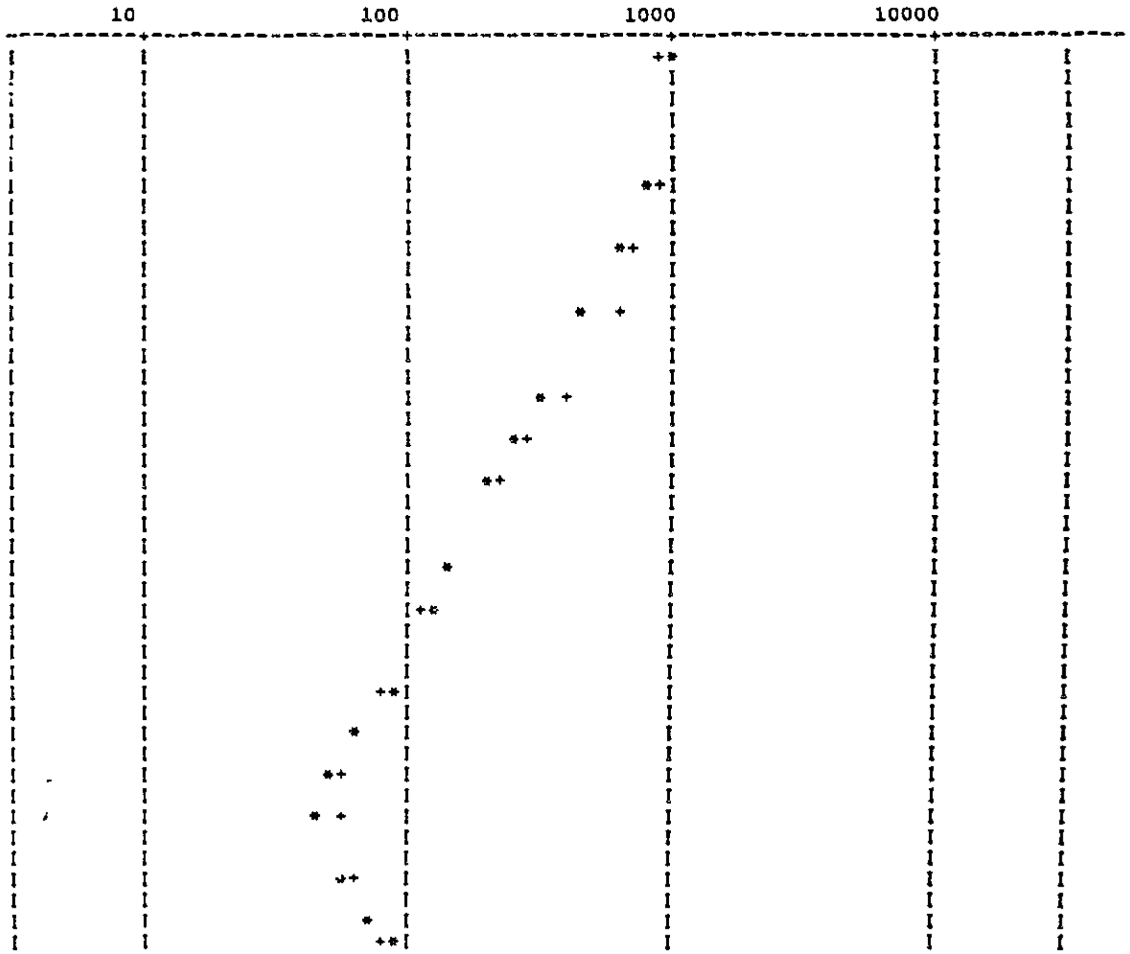
LAYER 1:	2500.0	
		2M
LAYER 2:	160.0	
		4M
LAYER 3:	70.0	
		40M
LAYER 4:	200.0	
		100M
LAYER 5:	10.0	

APPARENT RESISTIVITY-DEPTH CURVE;STATION NO.OMAN ES-V2-2

------APPARENT RESISTIVITY;OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9844	994.429	1007.000
2.00	0.9051	905.115	875.000
3.00	0.7763	776.311	690.000
4.00	0.6399	639.947	485.000
6.00	0.4273	427.316	345.000
8.00	0.3034	303.410	263.000
10.00	0.2343	234.293	218.000
16.00	0.1466	146.621	158.000
20.00	0.1189	118.901	134.000
30.00	0.0807	80.692	99.000
40.00	0.0648	64.807	67.000
48.00	0.0604	60.359	54.000
60.00	0.0605	60.454	50.000
80.00	0.0676	67.588	62.000
100.00	0.0769	76.756	74.000
120.00	0.0857	85.687	90.000

DEPTH*METER*



+;CALCALATED VALUE

*;MEASUREMENT VALUE

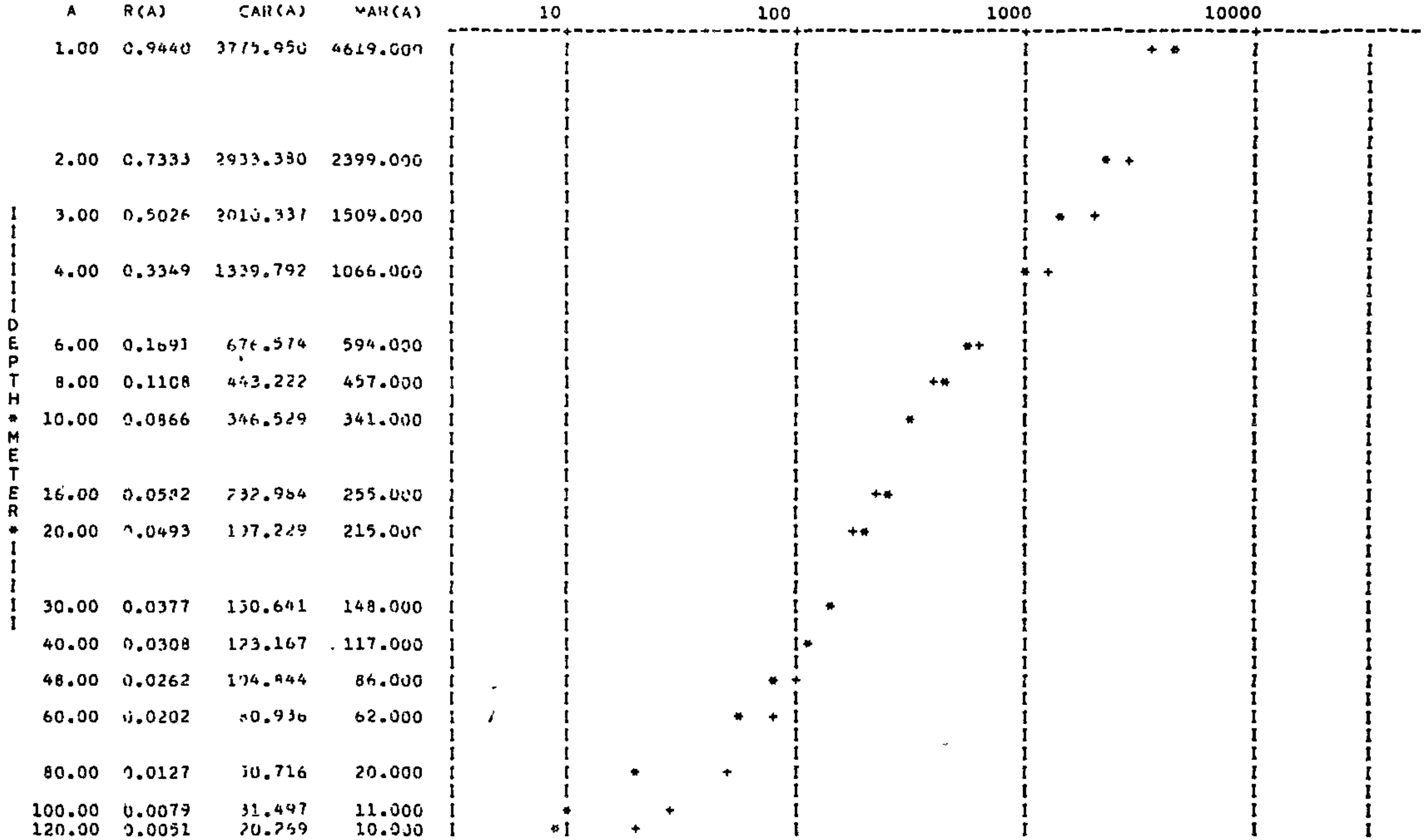
SPECIFIC RESISTIVITY;OHM-METER

LAYER 1;	1000.0	
		3M
LAYER 2;	200.0	
		10M
LAYER 3;	120.0	
		20M
LAYER 4;	35.0	
		60M
LAYER 5;	200.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V2-3

------APPARENT RESISTIVITY:OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9440	3775.950	4619.000
2.00	0.7333	2933.380	2399.000
3.00	0.5026	2010.337	1509.000
4.00	0.3349	1339.792	1066.000
6.00	0.1691	676.574	594.000
8.00	0.1108	443.222	457.000
10.00	0.0866	346.529	341.000
16.00	0.0582	232.964	255.000
20.00	0.0493	197.229	215.000
30.00	0.0377	130.641	148.000
40.00	0.0308	123.167	117.000
48.00	0.0262	104.844	86.000
60.00	0.0202	80.936	62.000
80.00	0.0127	30.716	20.000
100.00	0.0079	31.497	11.000
120.00	0.0051	20.259	10.000



+:CALCALATED VALUE

*:MEASUREMENT VALUE

SPECIFIC RESISTIVITY:OHM-METER

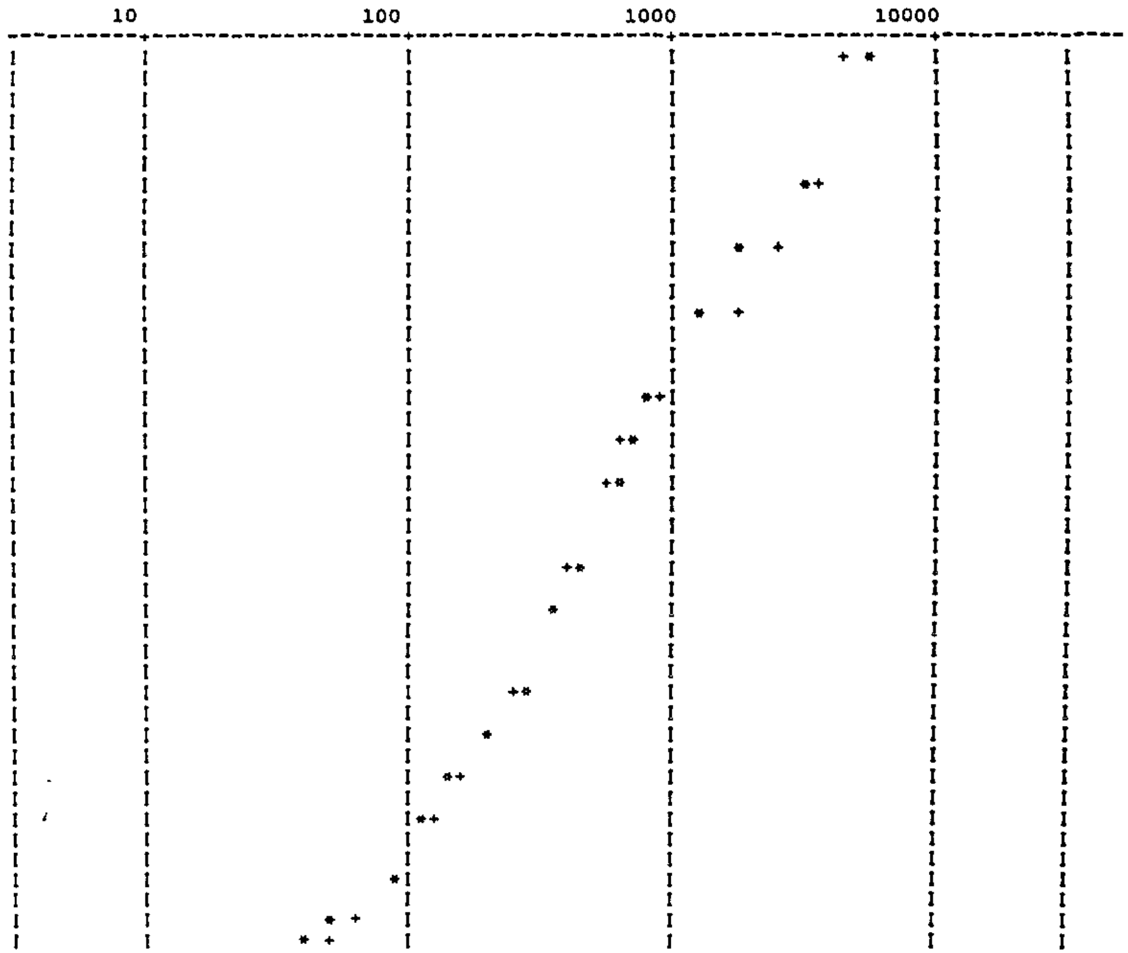
LAYER 1:	4000.0	
		2M
LAYER 2:	400.0	
		9M
LAYER 3:	150.0	
		50M
LAYER 4:	5.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V2-4

------APPARENT RESISTIVITY:OHM-METER------

DEPTH*METER

A	R(A)	CAR(A)	MAR(A)
1.00	0.9460	4730.231	5724.000
2.00	0.7429	3714.267	3415.000
3.00	0.5196	2598.220	1872.000
4.00	0.3569	1784.462	1337.000
6.00	0.1951	975.501	876.000
8.00	0.1380	689.760	740.000
10.00	0.1142	570.956	640.000
16.00	0.0841	420.747	453.000
20.00	0.0725	362.646	389.000
30.00	0.0536	267.897	295.000
40.00	0.0415	207.649	213.000
48.00	0.0345	172.696	153.000
60.00	0.0269	134.437	117.000
80.00	0.0188	93.941	92.000
100.00	0.0139	69.489	56.000
120.00	0.0108	53.833	43.000



+:CALCALATED VALUE

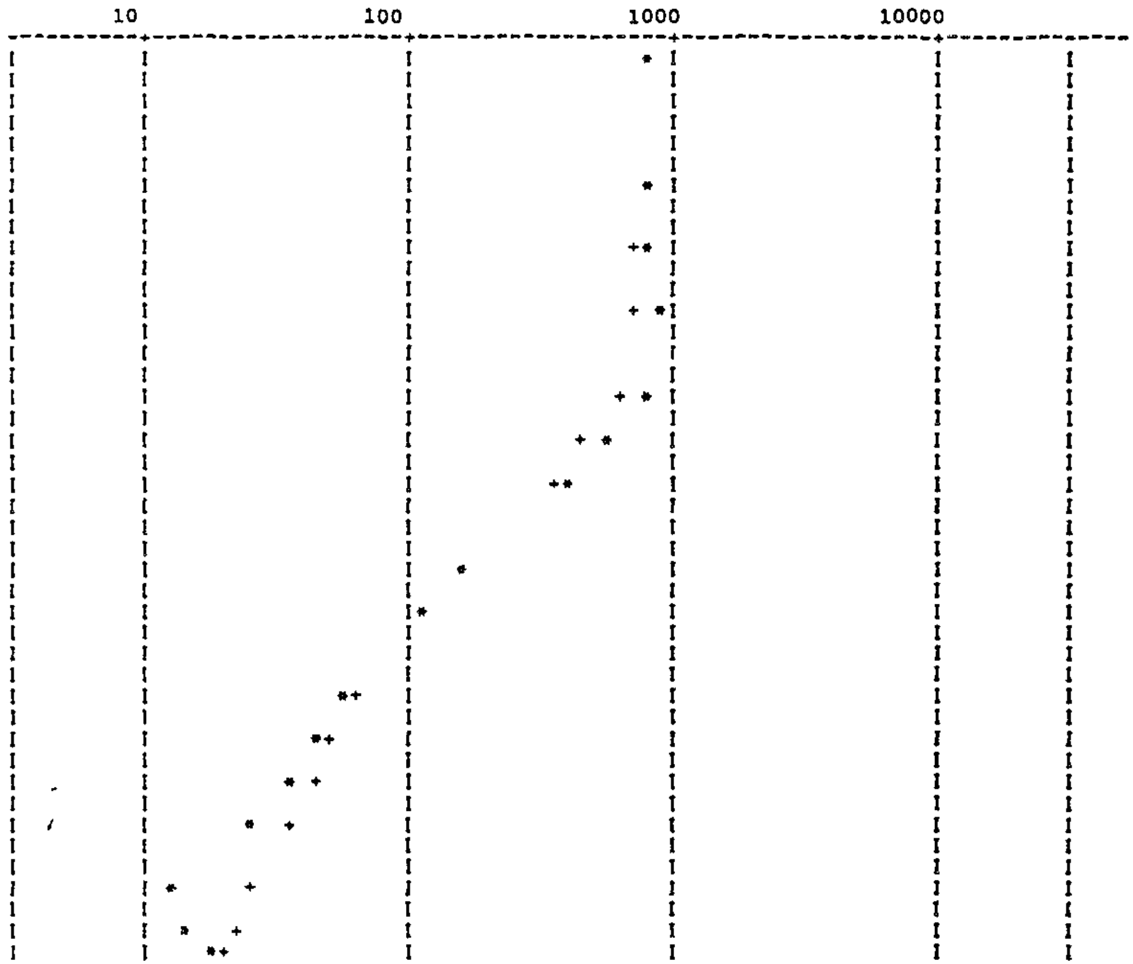
*:MEASUREMENT VALUE

SPECIFIC RESISTIVITY:OHM-METER

LAYEP 1:	5000.0	
		2M
LAYER 2:	600.0	
		10M
LAYER 3:	300.0	
		30M
LAYER 4:	100.0	
		80M
LAYER 5:	20.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V2-5

A	R(A)	CAR(A)	MAR(A)
1.00	1.0017	801.343	798.000
2.00	1.0017	801.321	805.000
3.00	0.9823	755.862	860.000
4.00	0.9368	749.414	900.000
6.00	0.7903	632.223	795.000
8.00	0.6234	498.729	618.000
10.00	0.4760	340.827	435.000
16.00	0.2160	172.825	169.000
20.00	0.1450	116.012	114.000
30.00	0.0856	68.472	58.000
40.00	0.0665	53.202	48.000
48.00	0.0565	45.222	36.000
60.00	0.0454	36.310	28.000
80.00	0.0343	27.432	13.000
100.00	0.0294	23.485	15.000
120.00	0.0277	22.146	18.000



+:CALCALATED VALUE

*:MEASUREMENT VALUE

SPECIFIC RESISTIVITY:OHM-METER

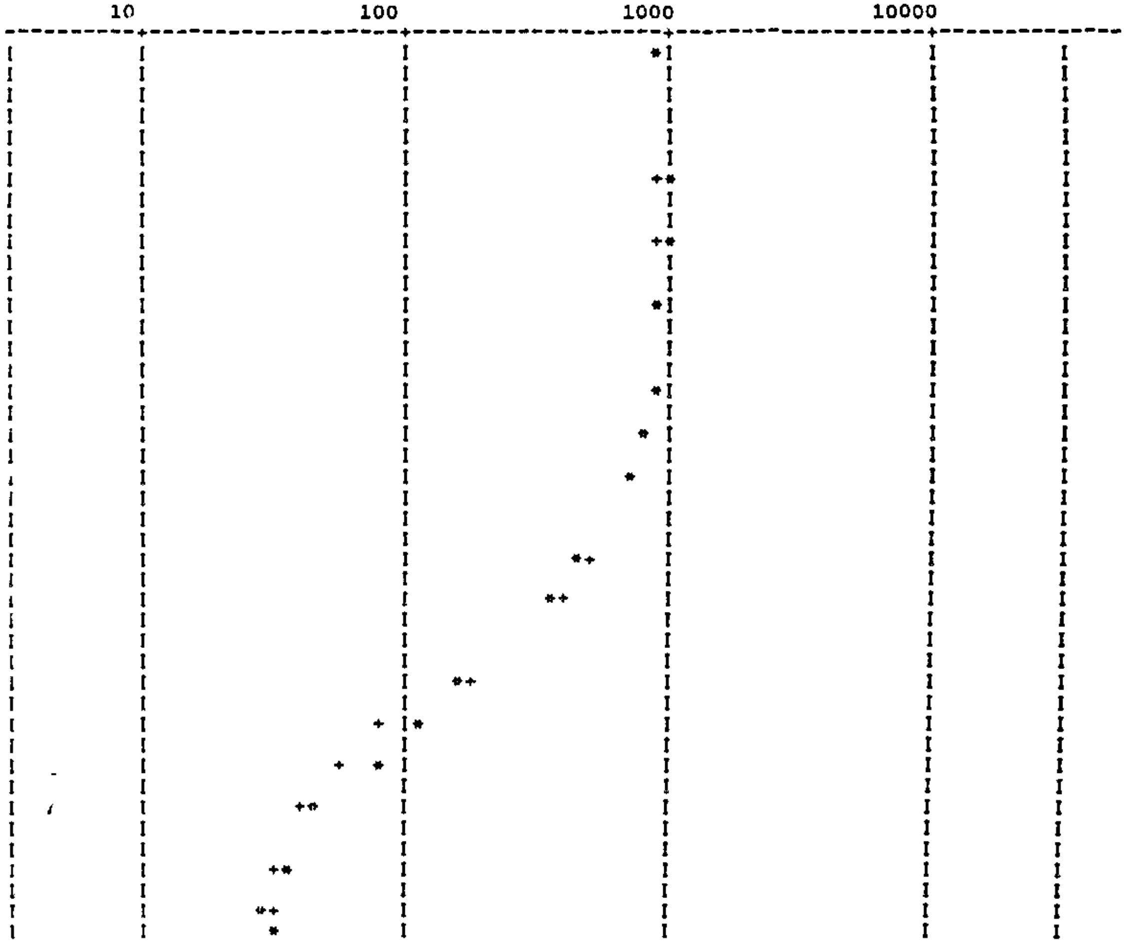
LAYER 1:	800.0	
		2M
LAYER 2:	900.0	
		6M
LAYER 3:	70.0	
		40M
LAYER 4:	10.0	
		80M
LAYER 5:	30.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V2-6

------APPARENT RESISTIVITY:OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	1.0065	905.812	924.000
2.00	1.0295	926.515	1032.000
3.00	1.0497	944.726	1028.000
4.00	1.0549	949.374	940.000
6.00	1.0218	919.619	893.000
8.00	0.9530	857.696	876.000
10.00	0.8673	780.538	764.000
16.00	0.5970	537.321	462.000
20.00	0.4443	399.497	364.000
30.00	0.2020	111.803	170.000
40.00	0.0989	89.022	119.000
48.00	0.0645	58.091	82.000
60.00	0.0449	40.392	50.000
80.00	0.0377	33.906	37.000
100.00	0.0370	33.794	29.000
120.00	0.0374	33.621	32.000

DEPTH*METER*



+:CALCALATED VALUE

*:MEASUREMENT VALUE

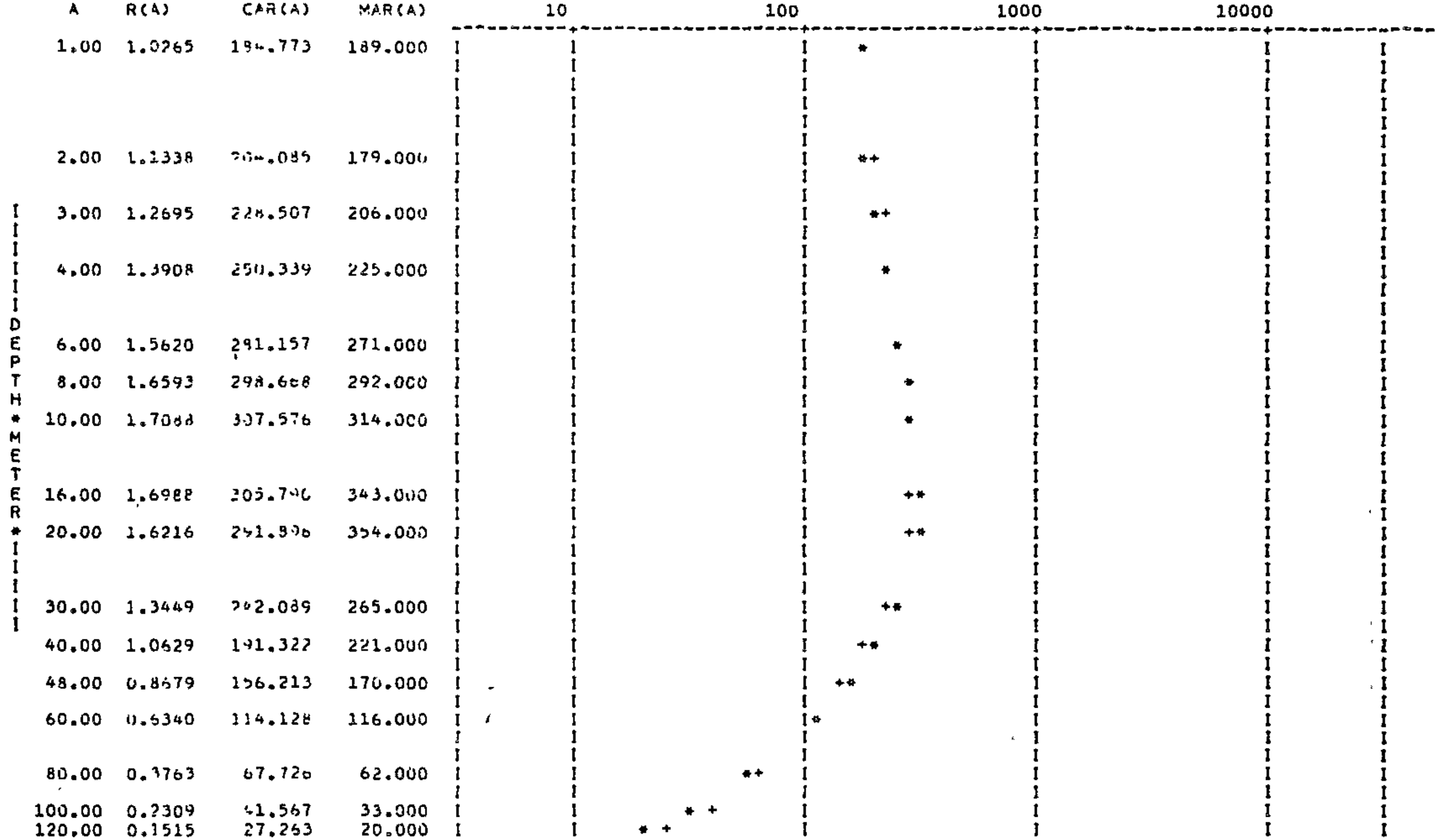
SPECIFIC RESISTIVITY:OHM-METER

LAYER 1:	900.0	
		2M
LAYER 2:	1100.0	
		5M
LAYER 3:	800.0	
		14M
LAYER 4:	30.0	
		100M
LAYER 5:	40.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V2-7

------APPARENT RESISTIVITY:OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	1.0265	194.773	189.000
2.00	1.1338	204.085	179.000
3.00	1.2695	228.507	206.000
4.00	1.3908	250.339	225.000
6.00	1.5620	291.157	271.000
8.00	1.6593	298.668	292.000
10.00	1.7088	307.576	314.000
16.00	1.6988	305.790	343.000
20.00	1.6216	291.896	354.000
30.00	1.3449	262.089	265.000
40.00	1.0629	191.322	221.000
48.00	0.8679	156.213	170.000
60.00	0.6340	114.128	116.000
80.00	0.3763	67.726	62.000
100.00	0.2309	41.567	33.000
120.00	0.1515	27.263	20.000



+:CALCALATED VALUE

*:MEASUREMENT VALUE

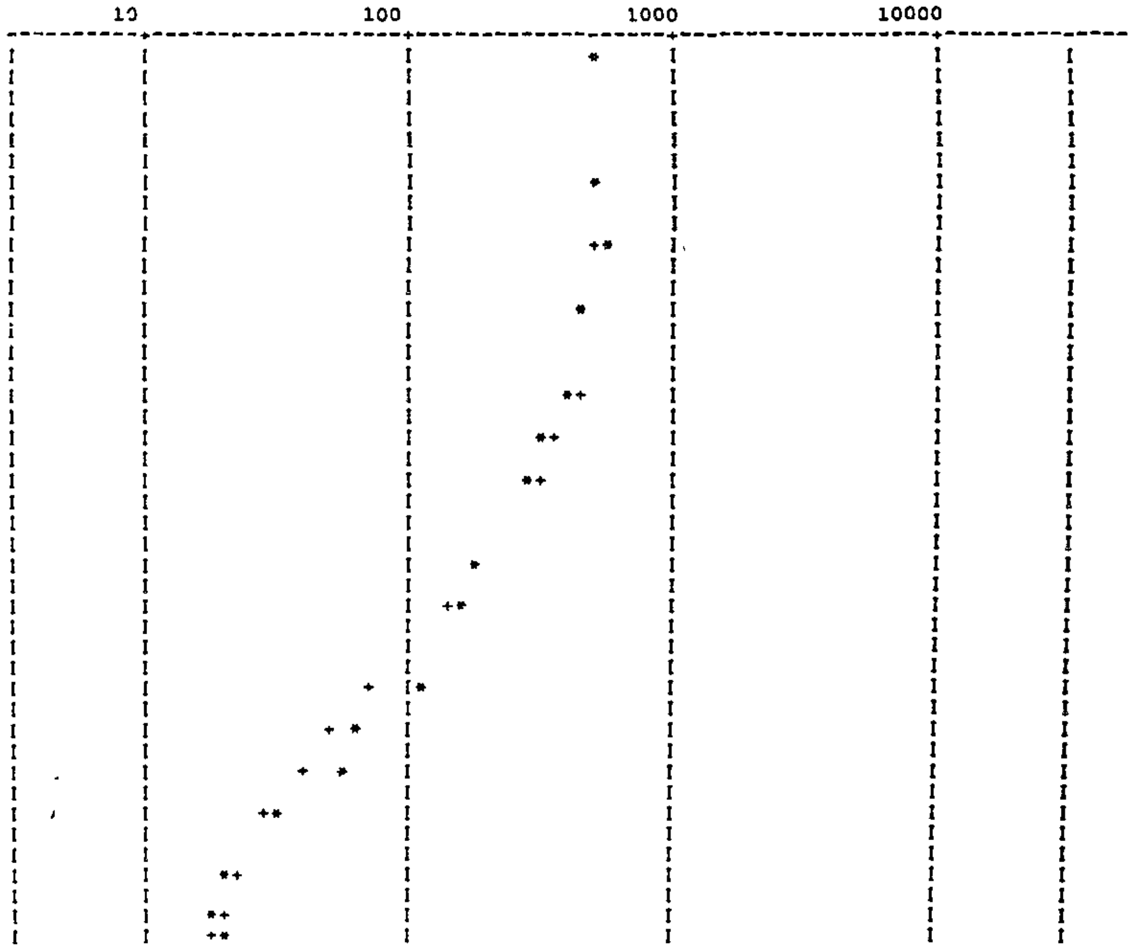
SPECIFIC RESISTIVITY:OHM-METER

LAYER 1:	180.0	
		2M
LAYER 2:	360.0	
		20M
LAYER 3:	140.0	
		50M
LAYER 4:	10.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V2-8

------APPARENT RESISTIVITY:OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9996	519.732	518.000
2.00	0.9956	517.708	550.000
3.00	0.9825	510.895	578.000
4.00	0.9566	497.426	500.000
6.00	0.8694	452.107	426.000
8.00	0.7567	393.469	352.000
10.00	0.6424	334.033	296.000
16.00	0.3819	196.608	190.000
20.00	0.2785	154.844	164.000
30.00	0.1497	77.819	116.000
40.00	0.0979	50.914	70.000
48.00	0.0772	40.140	58.000
60.00	0.0605	31.466	35.000
80.00	0.0475	24.715	21.000
100.00	0.0411	21.367	18.000
120.00	0.0373	19.392	20.000



+:CALCALATED VALUE

*:MEASUREMENT VALUE

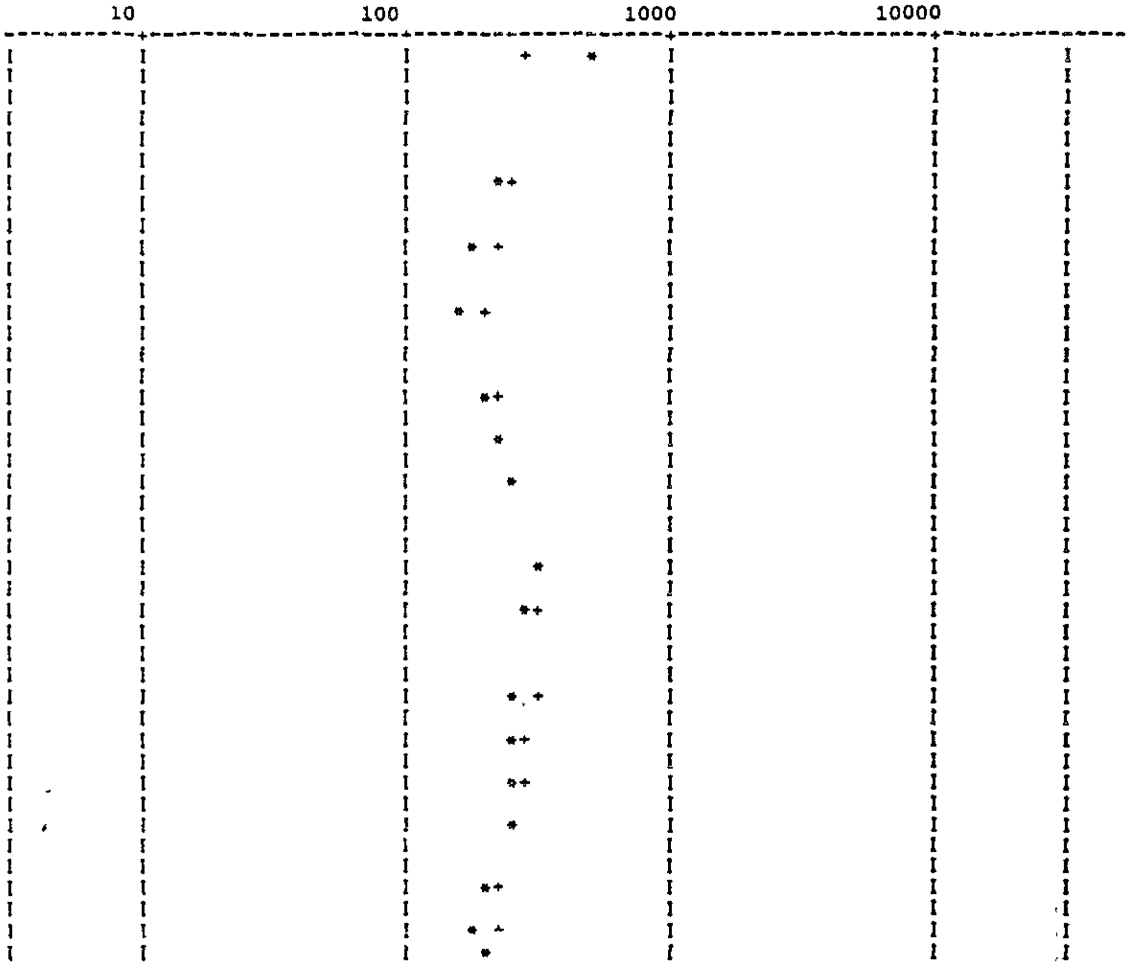
SPECIFIC RESISTIVITY:OHM-METER

LAYER 1:	520.0	
		3M
LAYER 2:	560.0	
		7M
LAYER 3:	120.0	
		20M
LAYER 4:	30.0	
		60M
LAYER 5:	15.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V3-1

------APPARENT RESISTIVITY:OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9695	290.860	510.000
2.00	0.8629	258.859	235.000
3.00	0.7662	229.847	187.000
4.00	0.7232	216.946	170.000
6.00	0.7528	225.454	205.000
8.00	0.8351	250.523	245.000
10.00	0.9153	274.592	278.000
16.00	1.0656	319.680	318.000
20.00	1.1062	331.873	290.000
30.00	1.1053	331.580	268.000
40.00	1.0485	314.562	260.000
48.00	0.9959	298.767	275.000
60.00	0.9225	276.743	263.000
80.00	0.8277	245.302	213.000
100.00	0.7631	228.922	189.000
120.00	0.7194	215.834	200.000



+:CALCALATED VALUE

*:MEASUREMENT VALUE

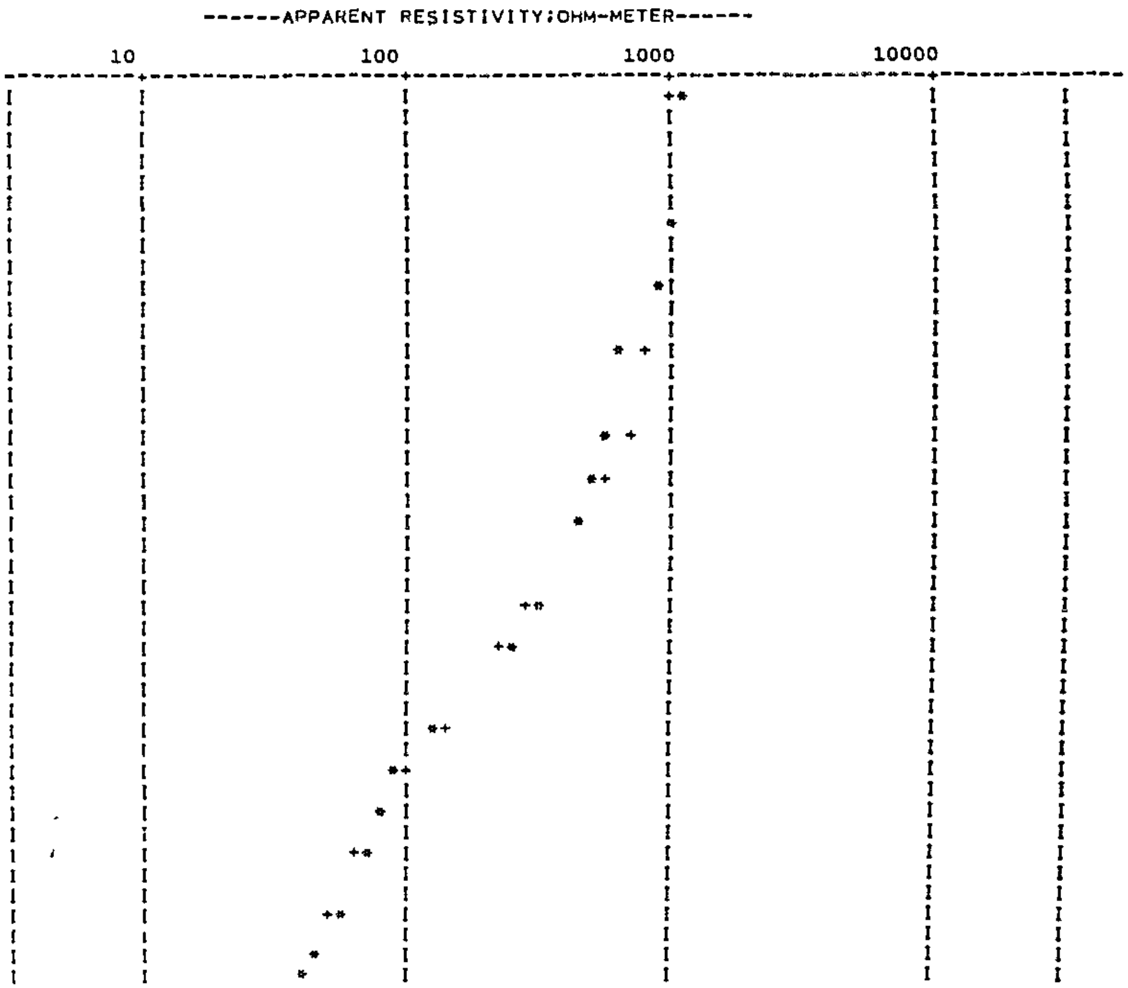
SPECIFIC RESISTIVITY:OHM-METER

LAYER 1:	300.0	
		2M
LAYER 2:	100.0	
		4M
LAYER 3:	500.0	
		17M
LAYER 4:	260.0	
		50M
LAYER 5:	180.0	

APPARENT RESISTIVITY-DEPTH CURVE;STATION NO.OMAN ES-V3-2

A	R(A)	CAR(A)	MAR(A)
1.00	0.9920	1041.164	1242.000
2.00	0.9501	1045.162	1095.000
3.00	0.8791	967.031	905.000
4.00	0.7983	878.140	692.000
6.00	0.6506	715.619	611.000
8.00	0.5356	589.125	558.000
10.00	0.4473	492.040	472.000
16.00	0.2814	309.490	326.000
20.00	0.2195	241.456	257.000
30.00	0.1389	152.735	134.000
40.00	0.1000	109.934	97.000
48.00	0.0809	89.036	86.000
60.00	0.0631	69.403	75.000
80.00	0.0486	53.460	59.000
100.00	0.0427	46.935	49.000
120.00	0.0401	44.658	40.000

DEPTH*METER



+;CALCALATED VALUE

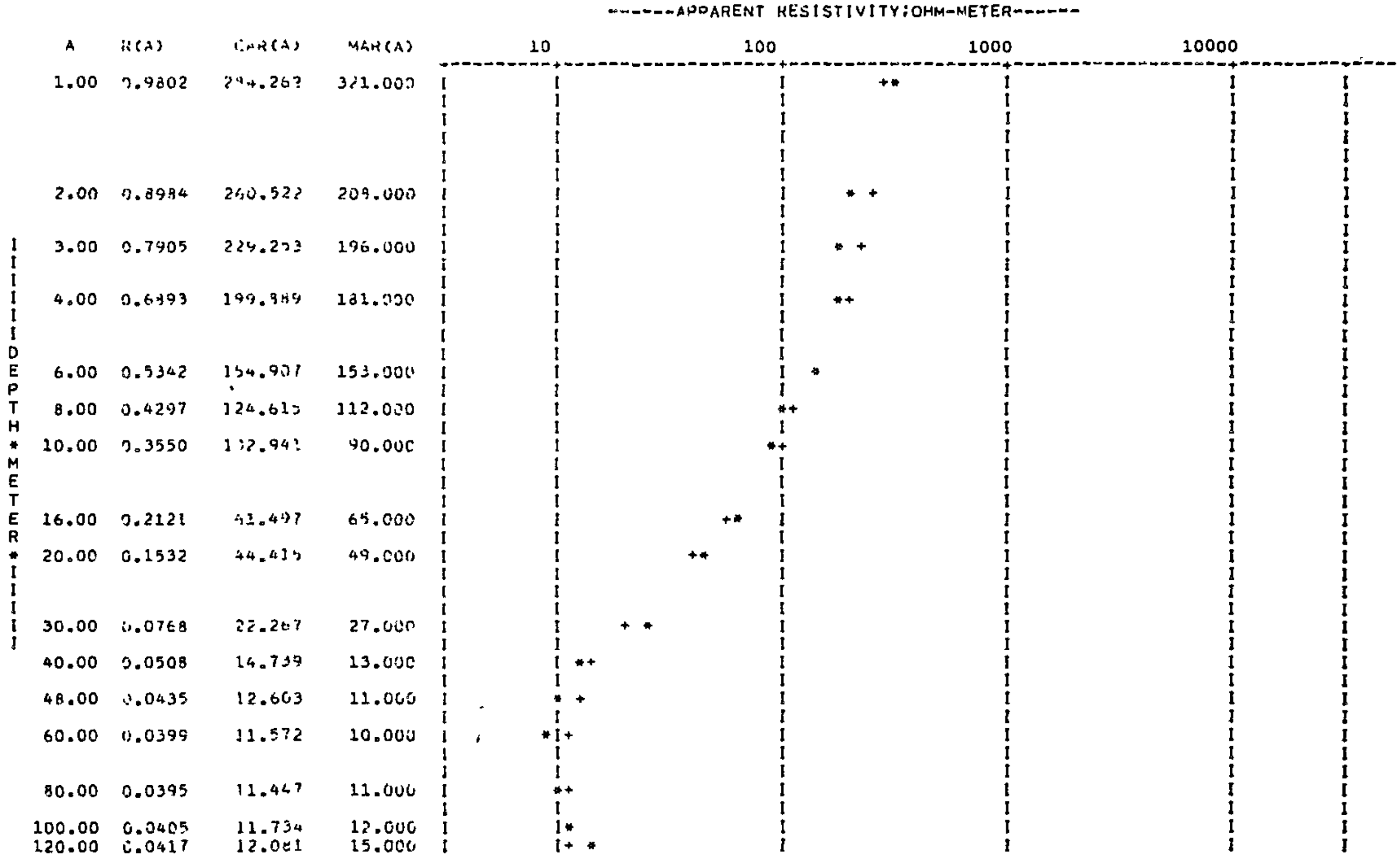
*;MEASUREMENT VALUE

SPECIFIC RESISTIVITY;OHM-METER

LAYER 1;	1100.0	
		3M
LAYER 2;	570.0	
		9M
LAYER 3;	170.0	
		30M
LAYER 4;	40.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V4-1

A	R(A)	CAR(A)	MAR(A)
1.00	0.9802	294.263	321.000
2.00	0.8984	260.522	209.000
3.00	0.7905	229.253	196.000
4.00	0.6893	199.389	181.000
6.00	0.5342	154.907	153.000
8.00	0.4297	124.615	112.000
10.00	0.3550	102.941	90.000
16.00	0.2121	61.497	65.000
20.00	0.1532	44.415	49.000
30.00	0.0768	22.267	27.000
40.00	0.0508	14.739	13.000
48.00	0.0435	12.603	11.000
60.00	0.0399	11.572	10.000
80.00	0.0395	11.447	11.000
100.00	0.0405	11.734	12.000
120.00	0.0417	12.081	15.000



+:CALCALATED VALUE

*:MEASUREMENT VALUE

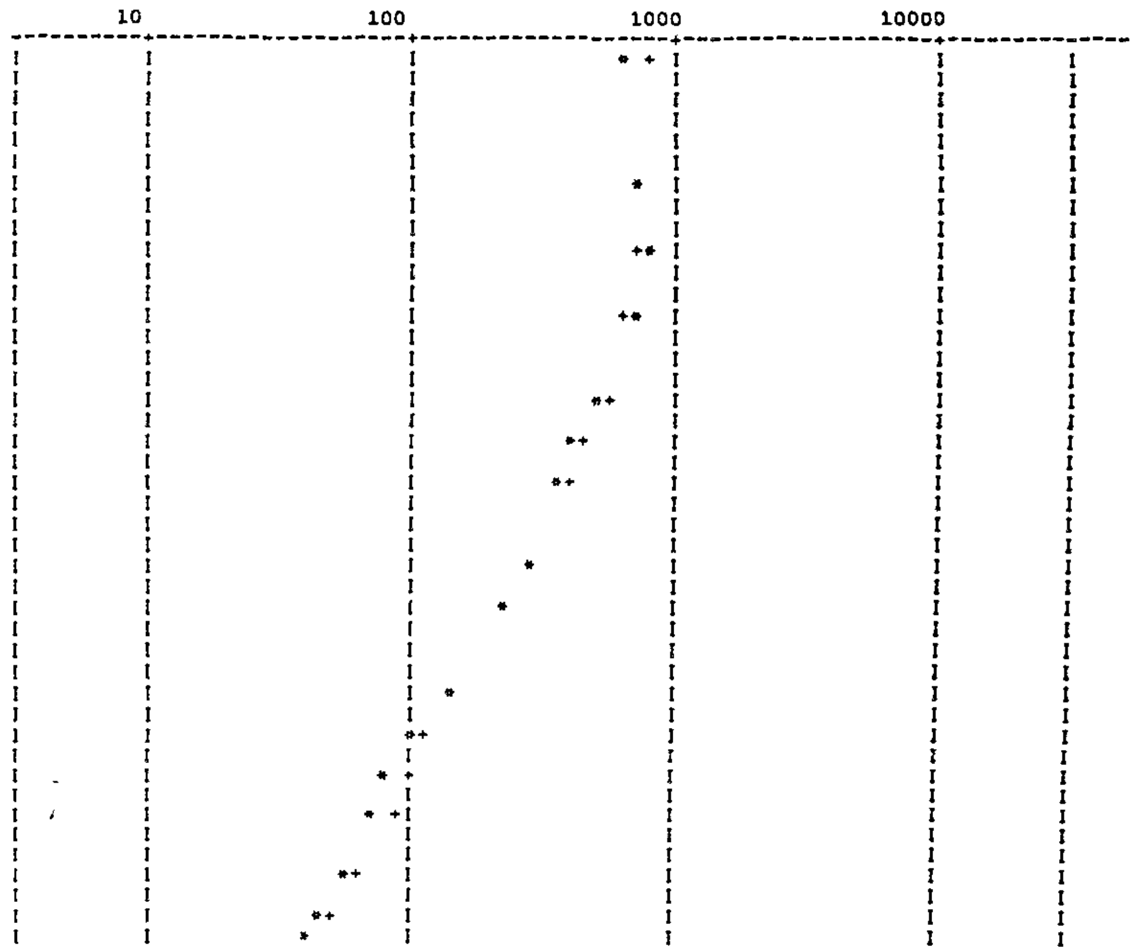
SPECIFIC RESISTIVITY:OHM-METER

LAYER 1:	290.0	
		2M
LAYER 2:	180.0	
		4M
LAYER 3:	100.0	
		13M
LAYER 4:	10.0	
		80M
LAYER 5:	15.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V4-2

A	R(A)	CAR(A)	MAP(A)
1.00	0.9940	755.226	686.000
2.00	0.9628	770.241	776.000
3.00	0.9091	727.276	814.000
4.00	0.8467	677.373	722.000
6.00	0.7271	551.660	540.000
8.00	0.6256	500.448	437.000
10.00	0.5400	432.029	372.000
16.00	0.3567	285.336	286.000
20.00	0.2820	225.572	232.000
30.00	0.1889	151.091	151.000
40.00	0.1514	121.114	110.000
48.00	0.1334	106.755	88.000
60.00	0.1129	90.340	73.000
80.00	0.0863	69.042	59.000
100.00	0.0668	53.426	50.000
120.00	0.0533	42.574	41.000

DEPTH*METER



+:CALCALATED VALUE

*:MEASUREMENT VALUE

SPECIFIC RESISTIVITY:OHM-METER

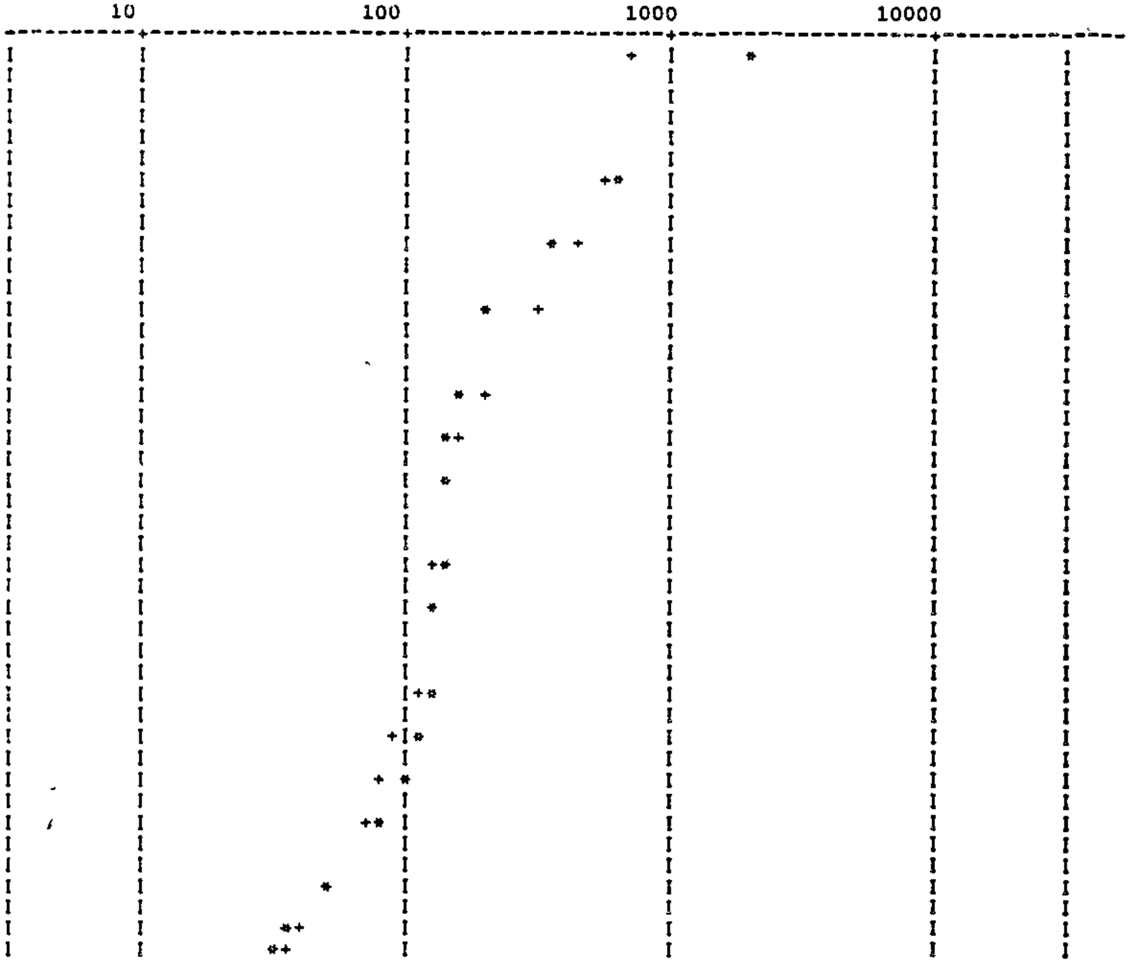
LAYER 1:	800.0	
	------	3M
LAYER 2:	500.0	
	------	10M
LAYER 3:	120.0	
	------	60M
LAYER 4:	20.0	

APPARENT RESISTIVITY-DEPTH CURVE;STATION NO.OMAN ES-V4-3

------APPARENT RESISTIVITY;OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9514	761.101	2214.000
2.00	0.7675	614.026	695.000
3.00	0.5640	451.239	377.000
4.00	0.4141	331.317	220.000
6.00	0.2633	210.633	168.000
8.00	0.2107	164.584	158.000
10.00	0.1911	152.855	152.000
16.00	0.1720	137.602	148.000
20.00	0.1640	131.206	140.000
30.00	0.1432	114.550	133.000
40.00	0.1224	97.903	118.000
48.00	0.1075	95.980	112.000
60.00	0.0890	71.212	87.000
80.00	0.0675	53.964	54.000
100.00	0.0539	43.119	38.000
120.00	0.0452	36.127	34.000

DEPTH*METER*



+;CALCALATED VALUE

*;MEASUREMENT VALUE

SPECIFIC RESISTIVITY;OHM-METER

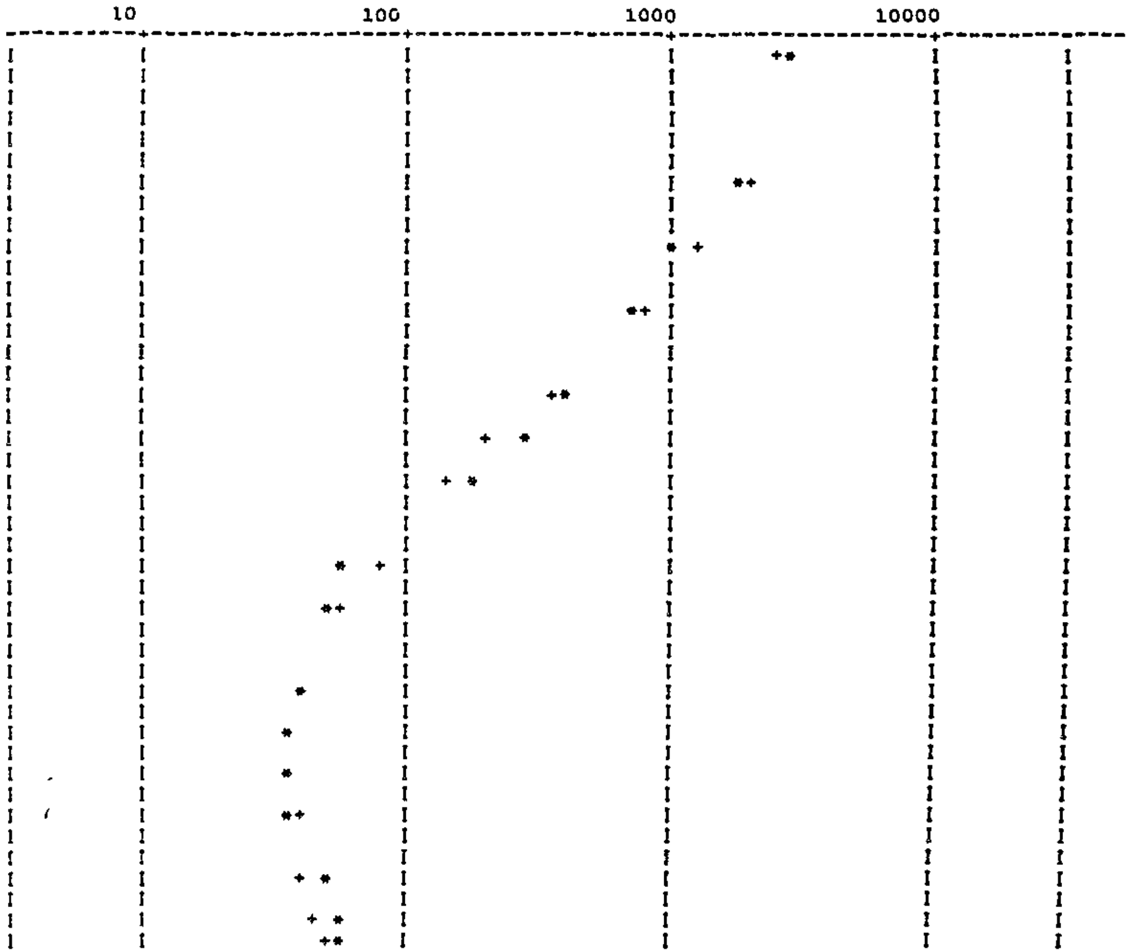
LAYER 1:	800.0	
		2M
LAYER 2:	140.0	
		30M
LAYER 3:	50.0	
		75M
LAYER 4:	20.0	

APPARENT RESISTIVITY-DEPTH CURVE:STATION NO.OMAN ES-V5-1

------APPARENT RESISTIVITY:OHM-METER------

A	R(A)	CAR(A)	MAR(A)
1.00	0.9402	2632.646	3150.000
2.00	0.7162	2005.495	1920.000
3.00	0.4727	1323.526	1089.000
4.00	0.2980	834.450	728.000
6.00	0.1300	363.957	403.000
8.00	0.0745	206.604	296.000
10.00	0.0532	145.987	183.000
16.00	0.0293	81.955	62.000
20.00	0.0220	61.527	52.000
30.00	0.0148	41.394	40.000
40.00	0.0135	37.674	37.000
48.00	0.0136	38.010	38.000
60.00	0.0143	40.116	39.000
80.00	0.0159	44.611	56.000
100.00	0.0175	48.383	62.000
120.00	0.0188	52.622	61.000

DEPTH*METER*



+:CALCALATED VALUE

*:MEASUREMENT VALUE

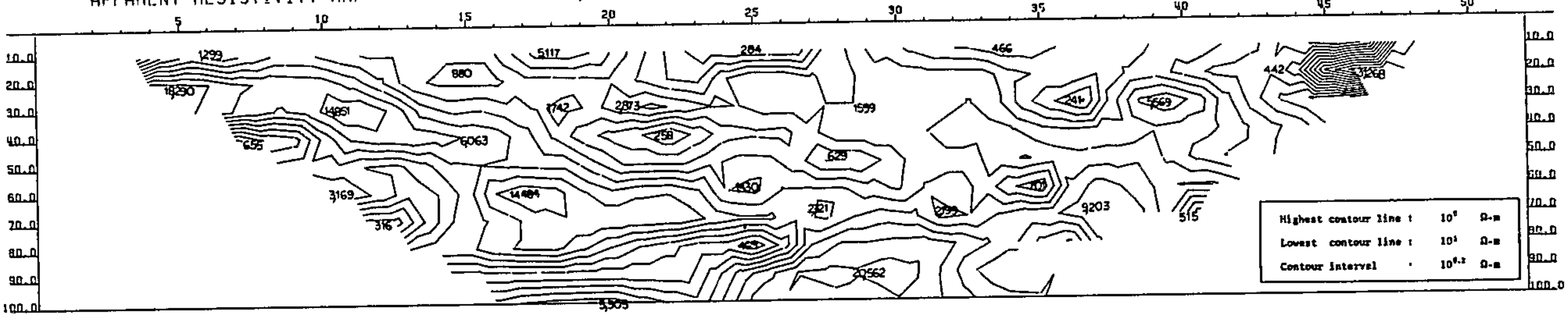
SPECIFIC RESISTIVITY:OHM-METER

LAYER 1:	2800.0	
		2M
LAYER 2:	180.0	
		10M
LAYER 3:	30.0	
		55M
LAYER 4:	80.0	

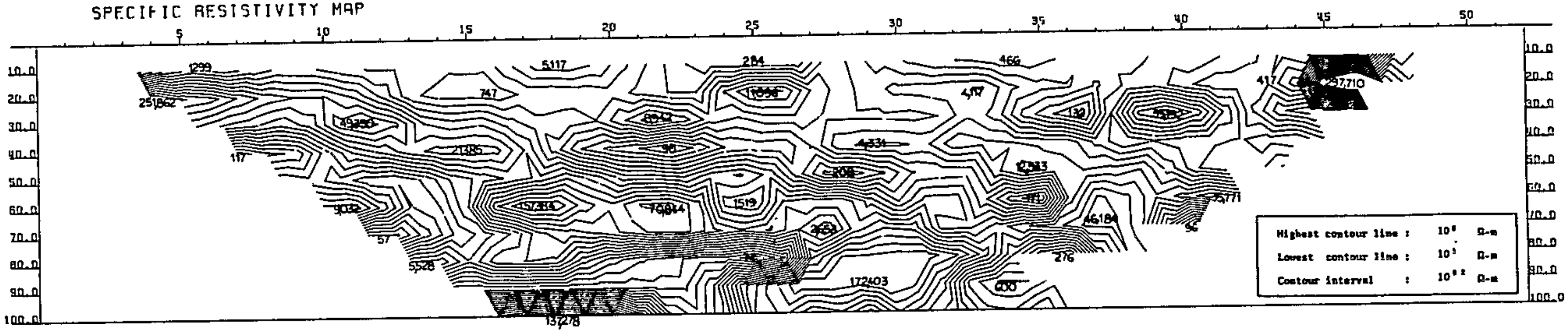
END OF GO,SEVERITY CODE=10

LINE 1 ARRANGEMENT 1

APPARENT RESISTIVITY MAP

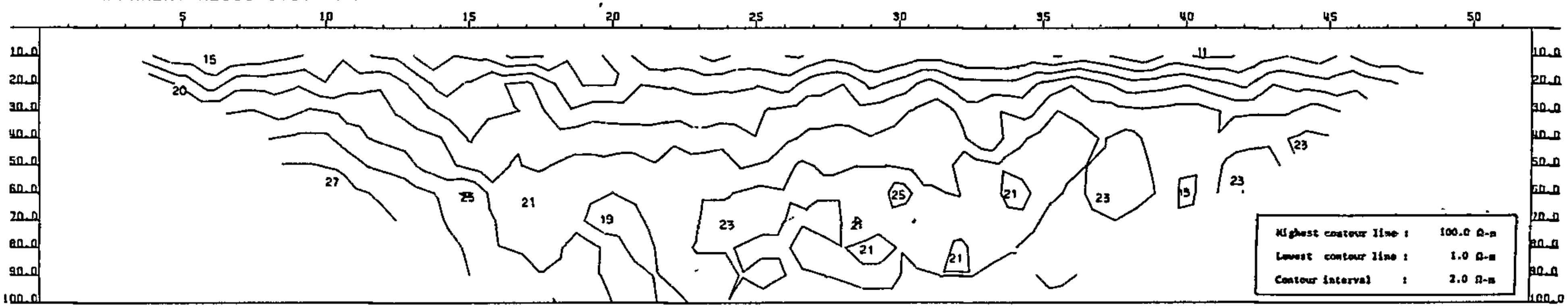


SPECIFIC RESISTIVITY MAP

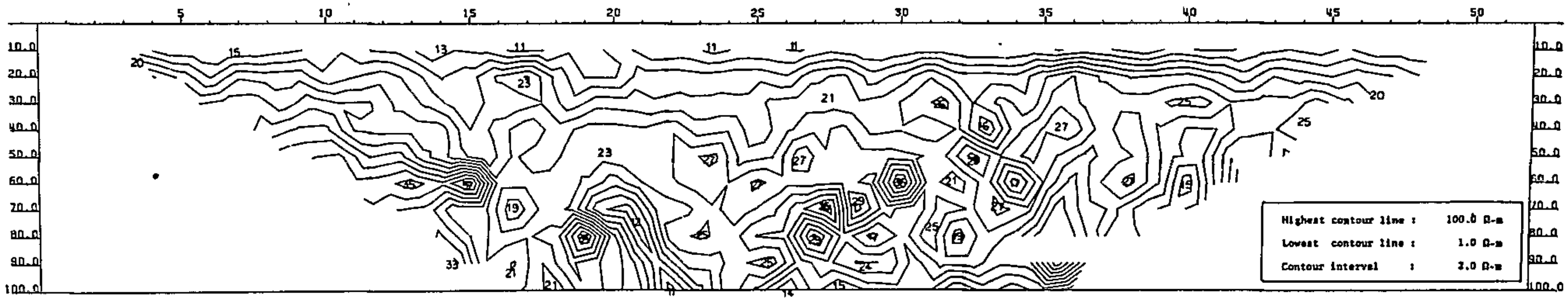


LINE 2 ARRANGEMENT 1

APPARENT RESISTIVITY MAP

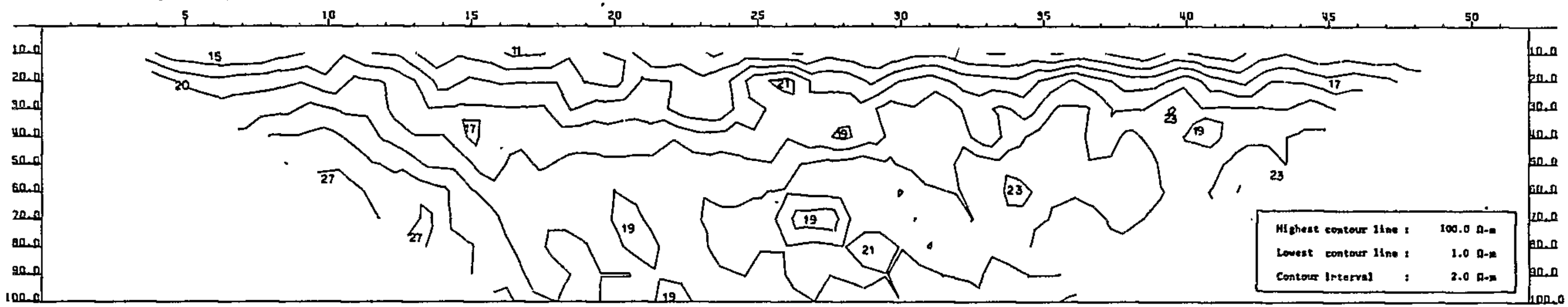


SPECIFIC RESISTIVITY MAP

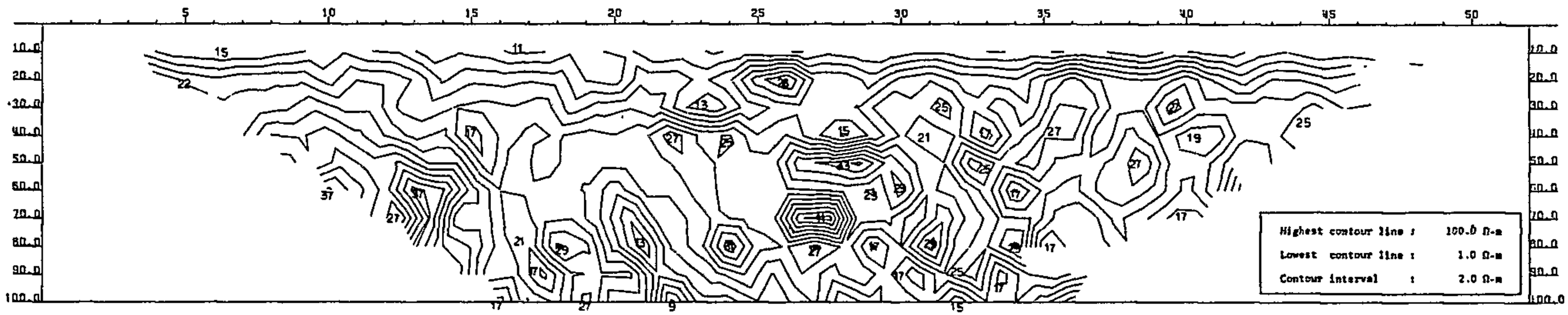


LINE 2 ARRANGEMENT 2

APPARENT RESISTIVITY MAP

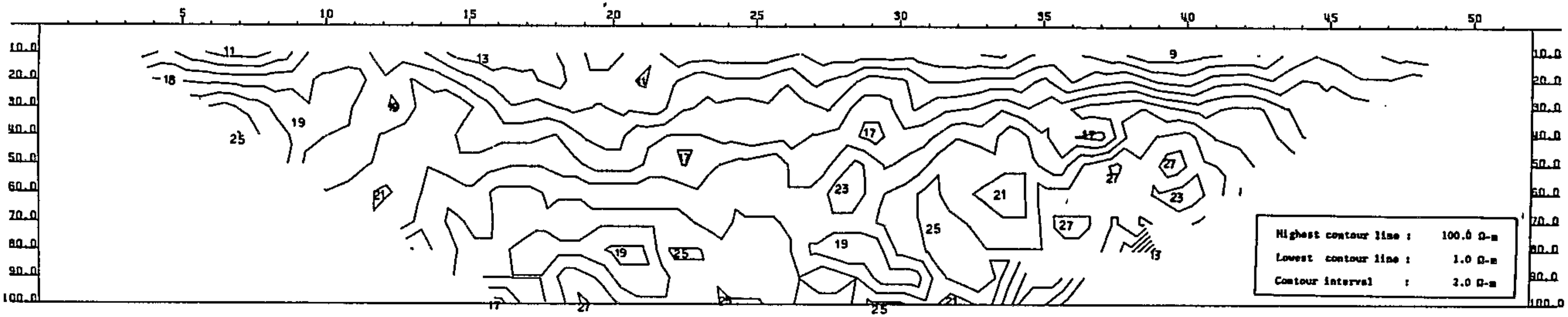


SPECIFIC RESISTIVITY MAP

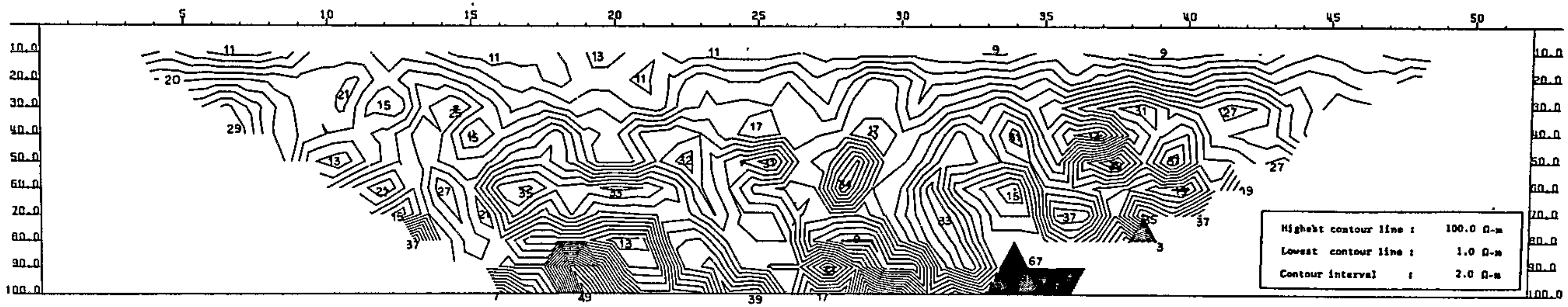


LINE 2 ARRANGEMENT 3

APPARENT RESISTIVITY MAP

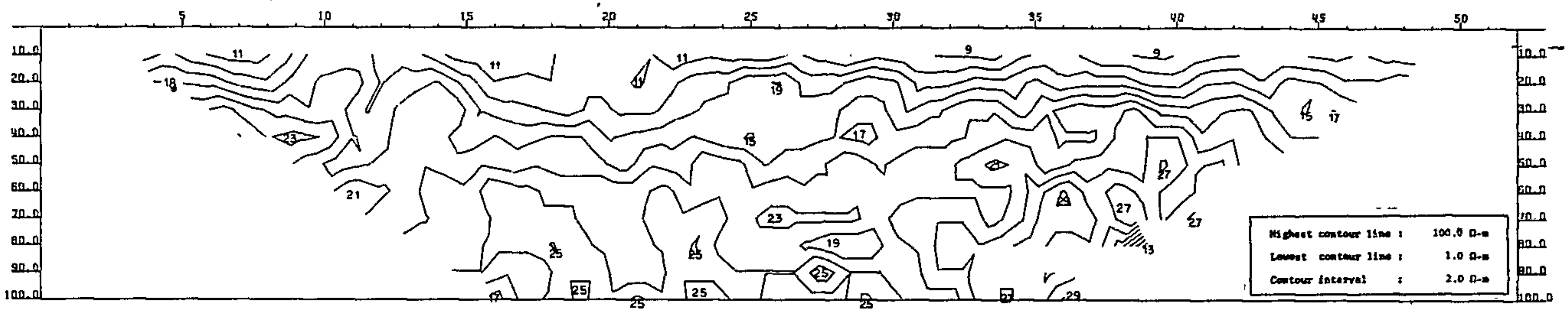


SPECIFIC RESISTIVITY MAP

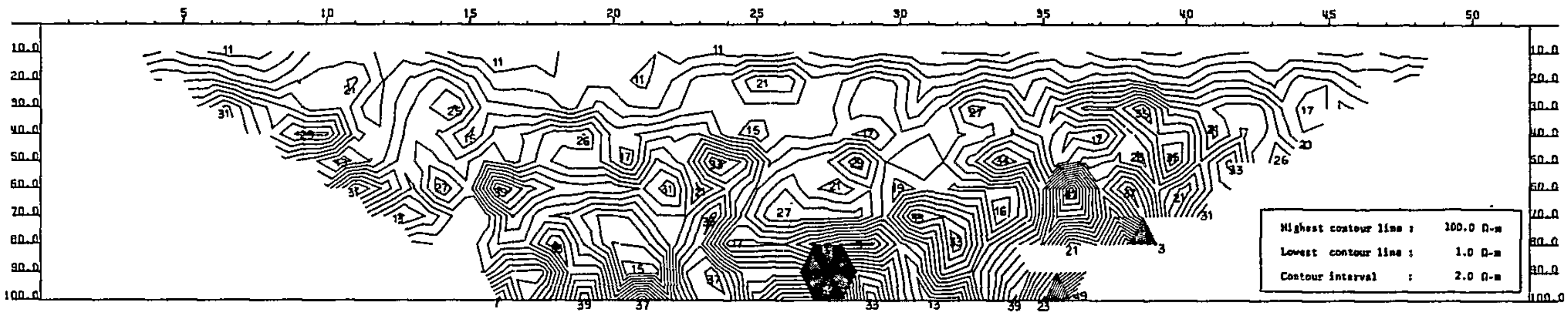


LINE 2 ARRANGEMENT 4

APPARENT RESISTIVITY MAP

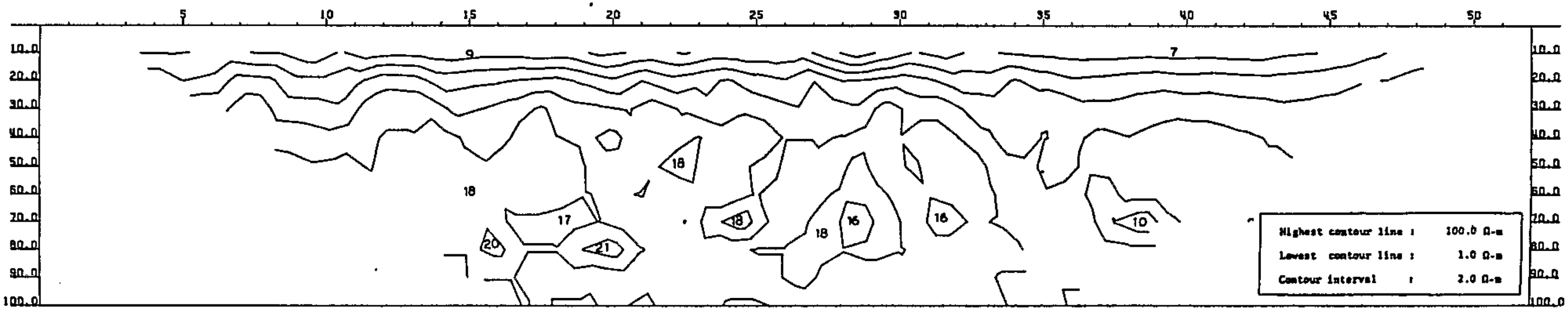


SPECIFIC RESISTIVITY MAP

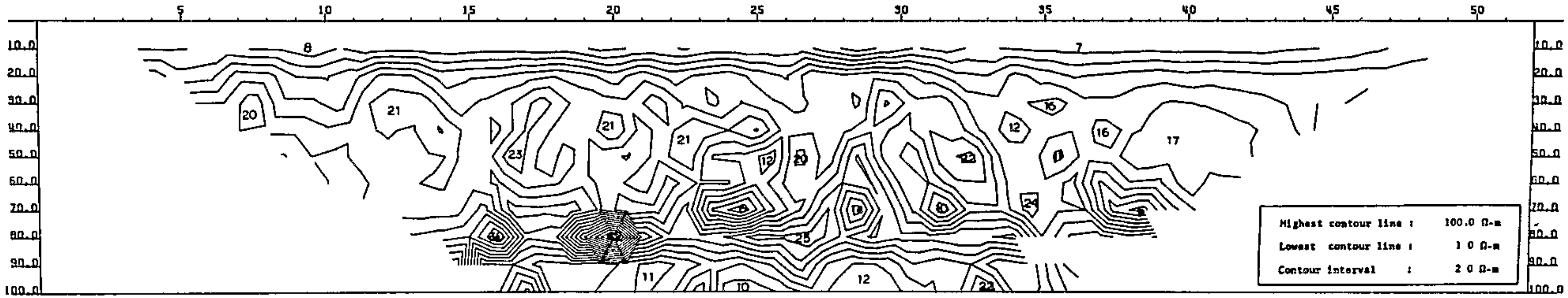


LINE 3 ARRANGEMENT 1

APPARENT RESISTIVITY MAP

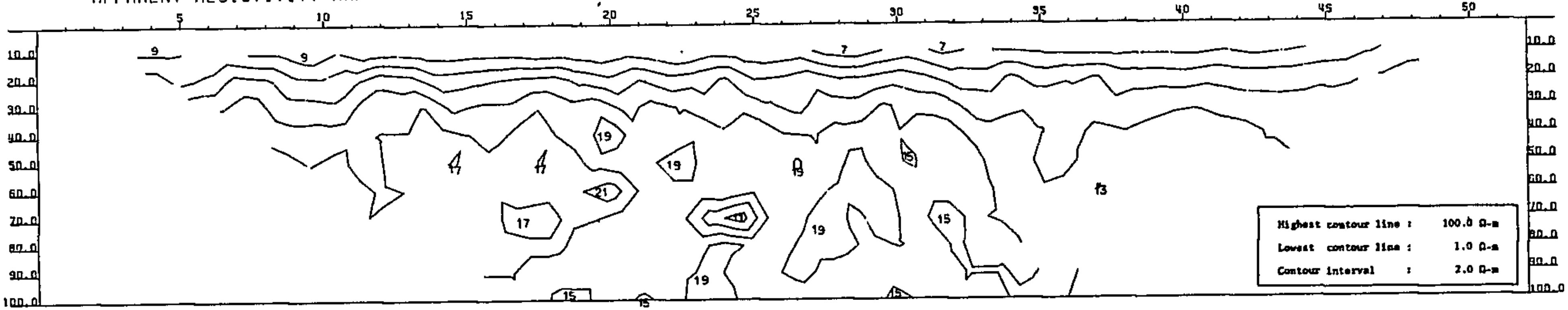


SPECIFIC RESISTIVITY MAP

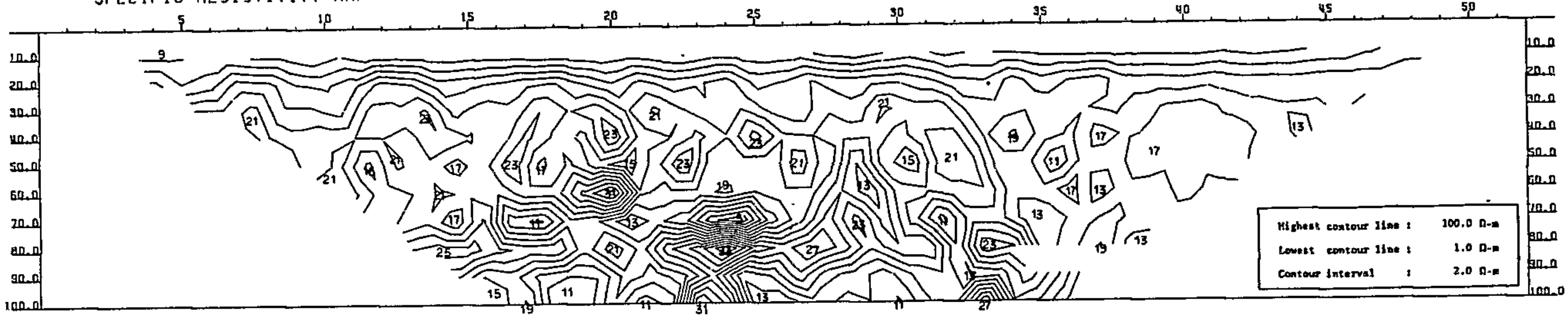


LINE 3 ARRANGEMENT 2

APPARENT RESISTIVITY MAP

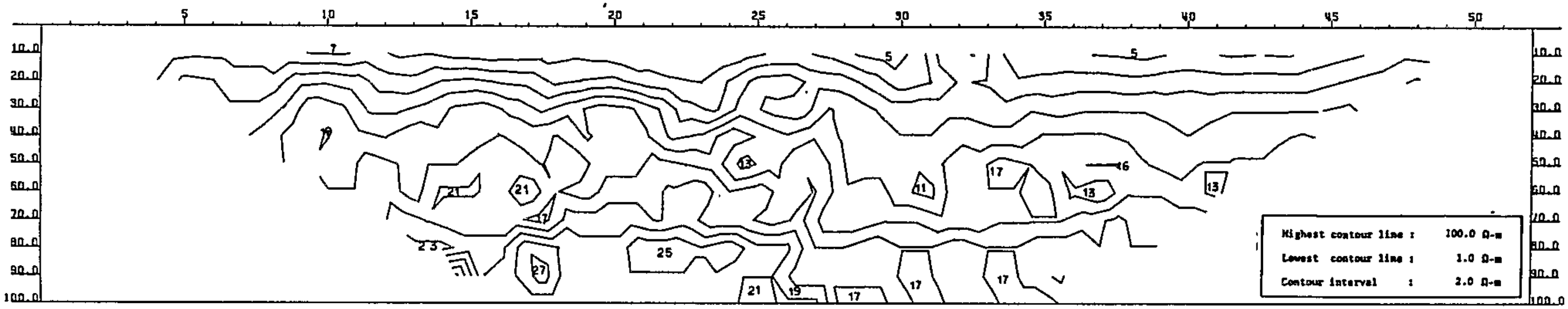


SPECIFIC RESISTIVITY MAP

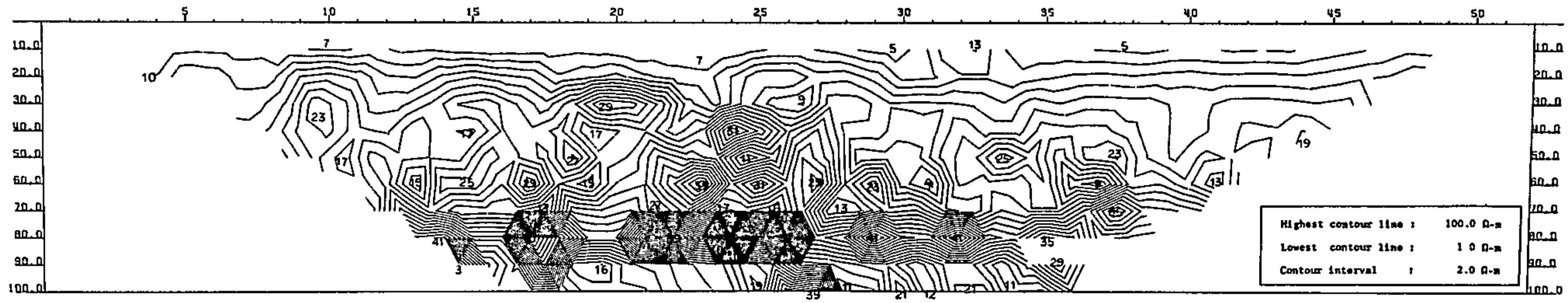


LINE 3 ARRANGEMENT 3

APPARENT RESISTIVITY MAP

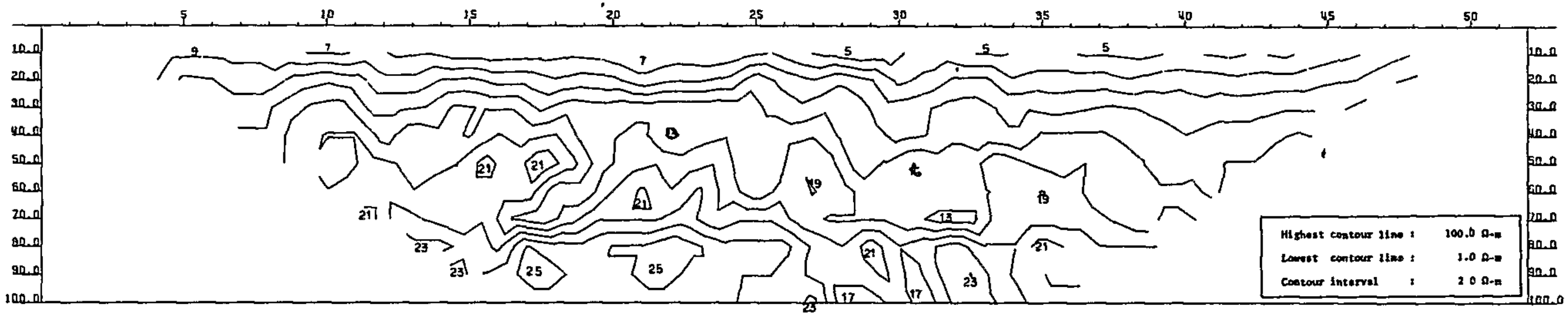


SPECIFIC RESISTIVITY MAP

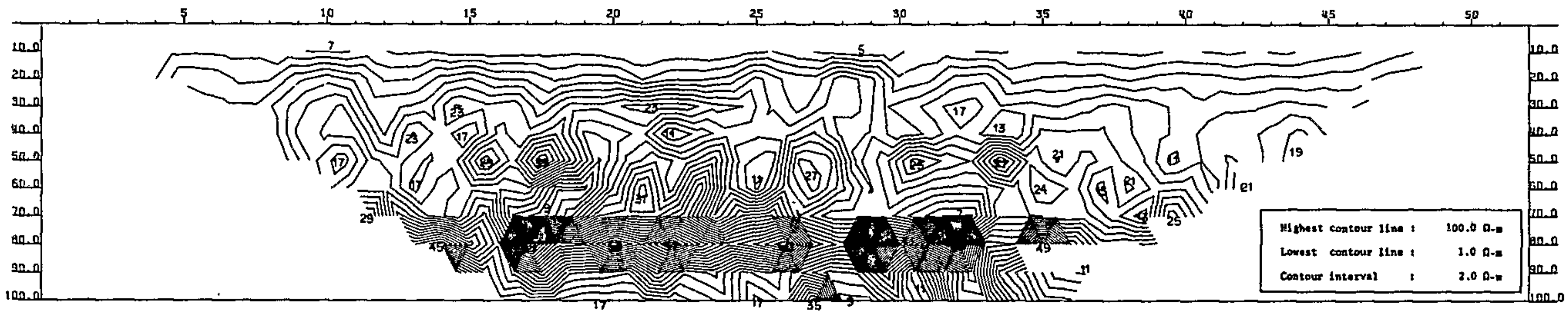


LINE 3 ARRANGEMENT 4

APPARENT RESISTIVITY MAP

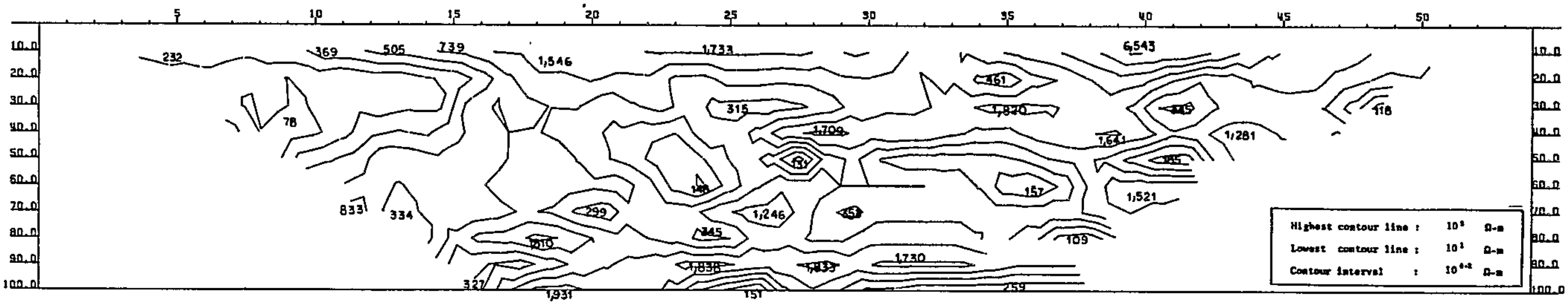


SPECIFIC RESISTIVITY MAP

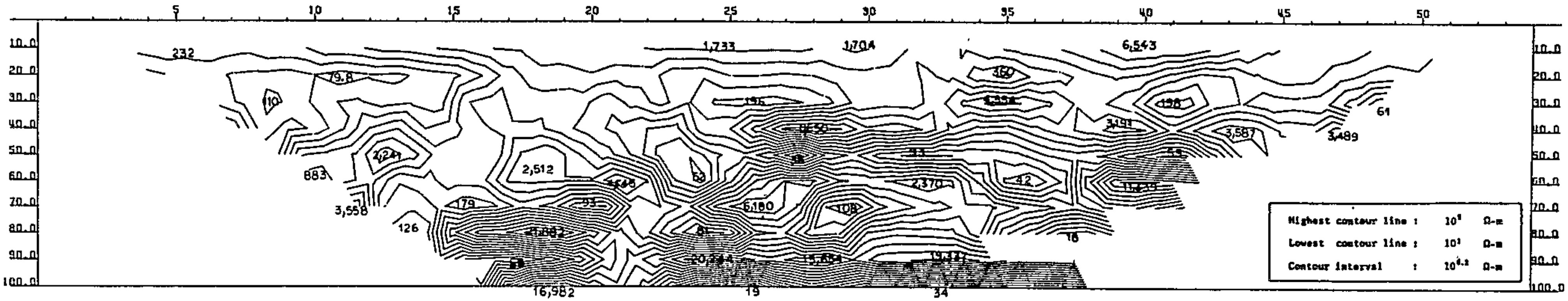


LINE 4 ARRANGEMENT 1

APPARENT RESISTIVITY MAP

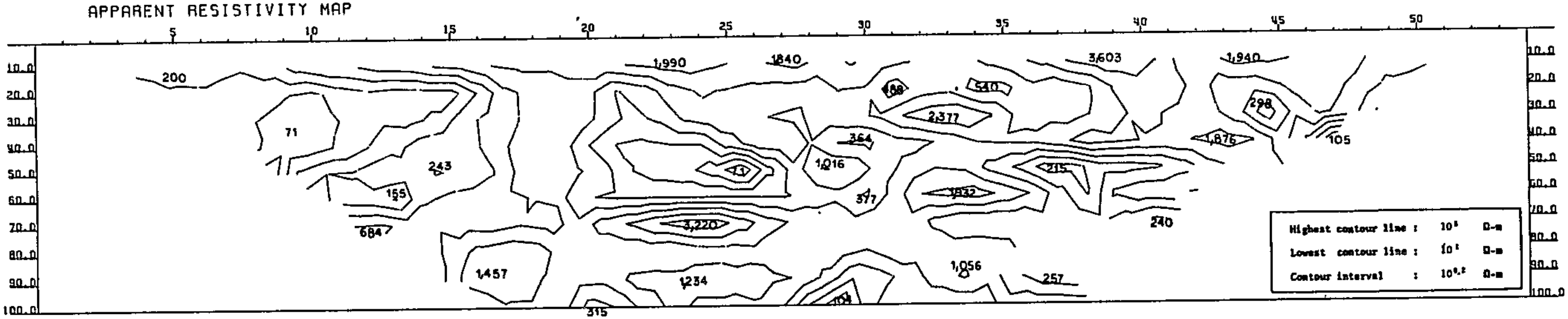


SPECIFIC RESISTIVITY MAP

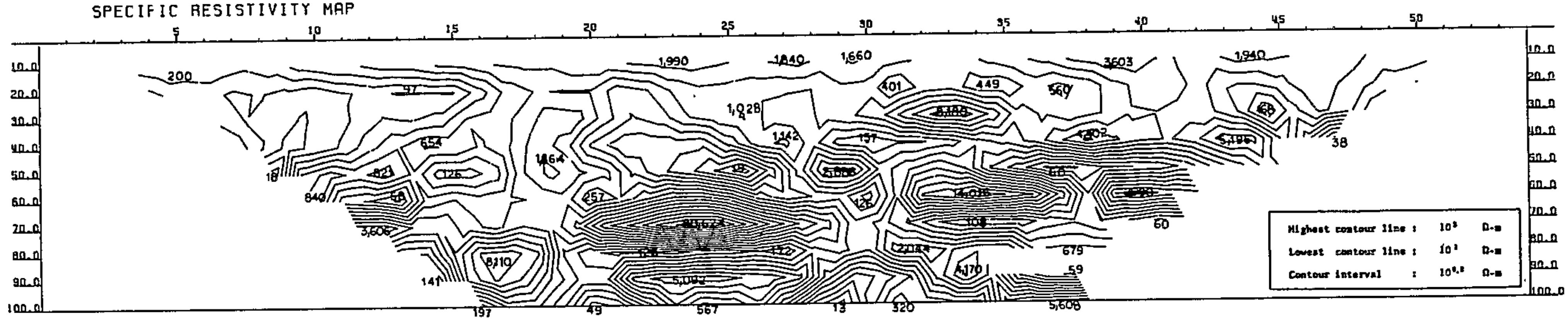


LINE 4 ARRANGEMENT 2

APPARENT RESISTIVITY MAP

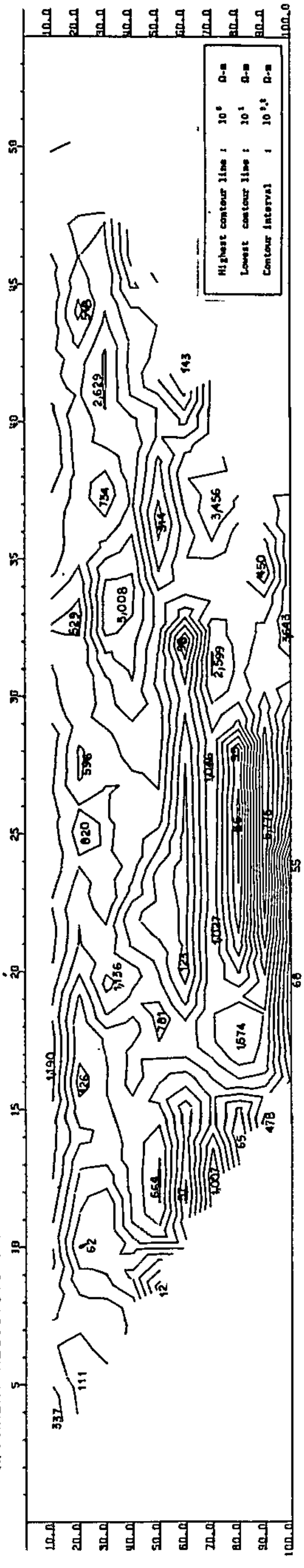


SPECIFIC RESISTIVITY MAP

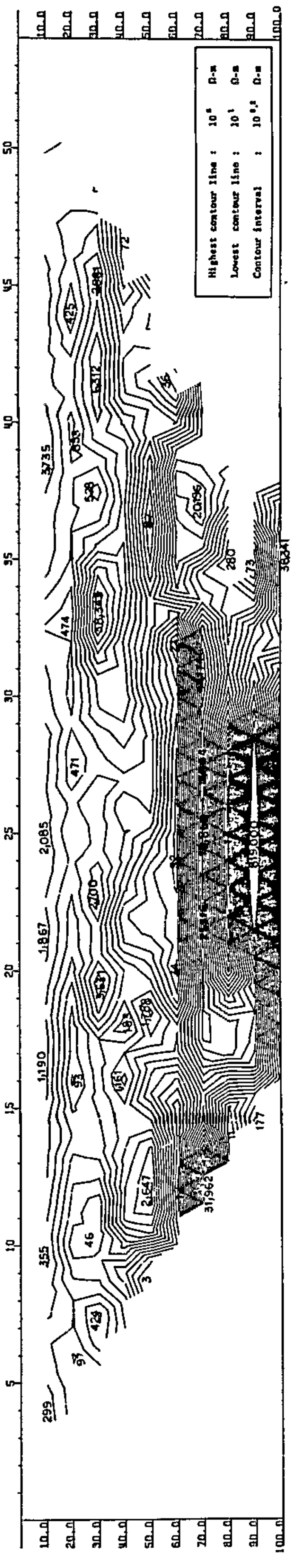


LINE 4 ARRANGEMENT 3

APPARENT RESISTIVITY MAP

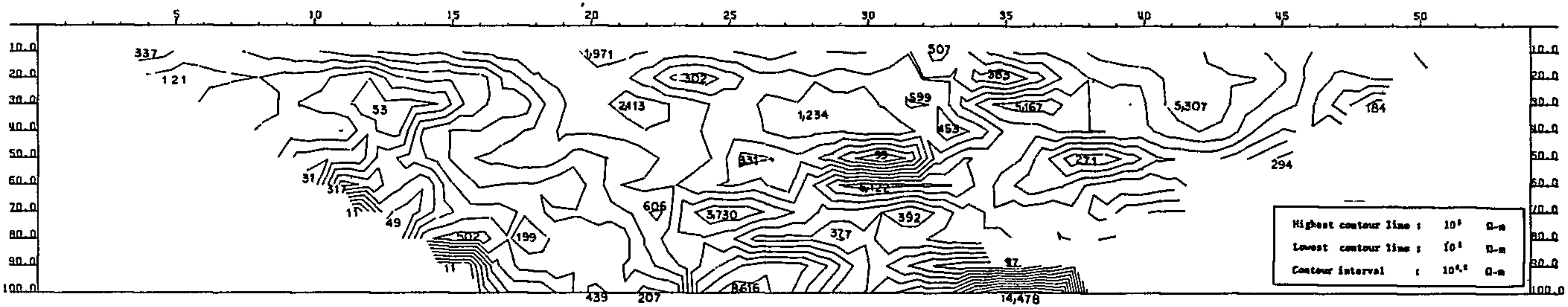


SPECIFIC RESISTIVITY MAP

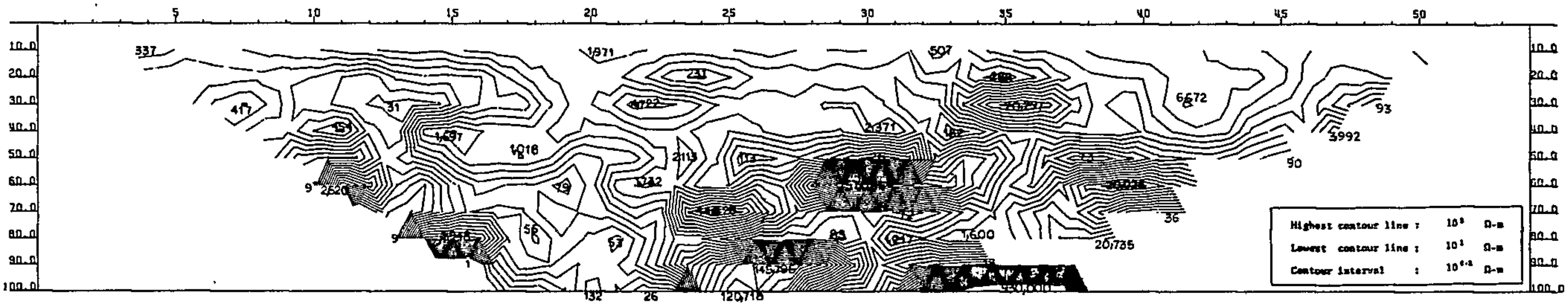


LINE 4 ARRANGEMENT 4

APPARENT RESISTIVITY MAP

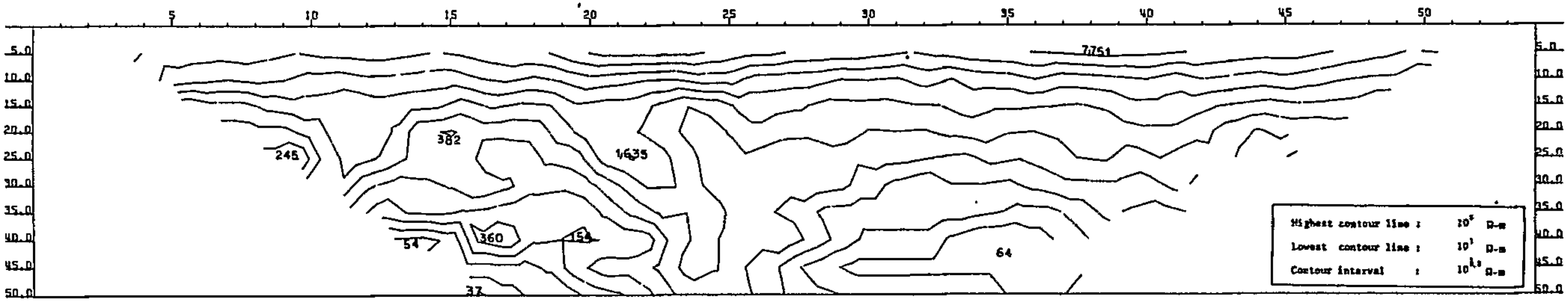


SPECIFIC RESISTIVITY MAP

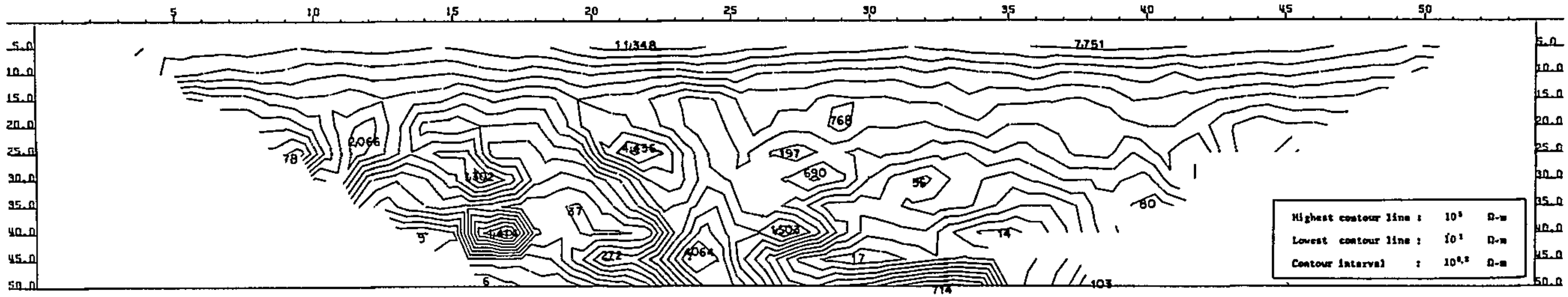


LINE 5 ARRANGEMENT 1

APPARENT RESISTIVITY MAP

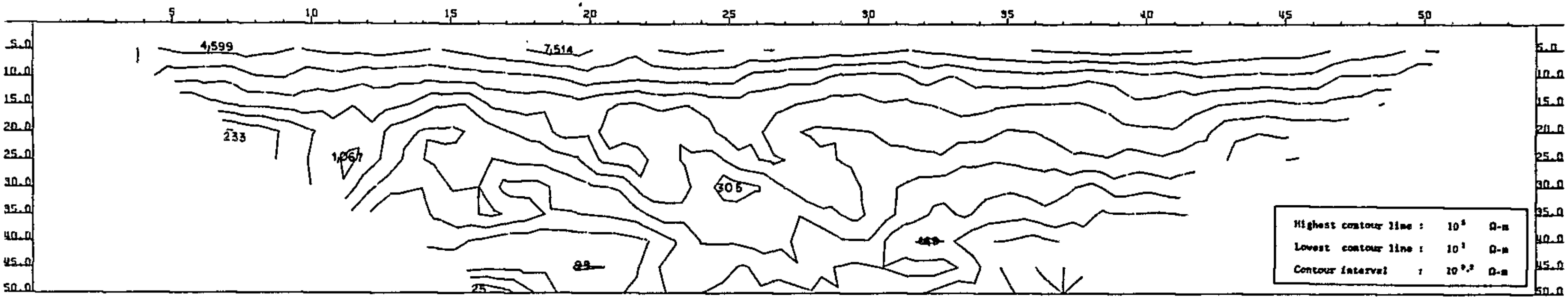


SPECIFIC RESISTIVITY MAP

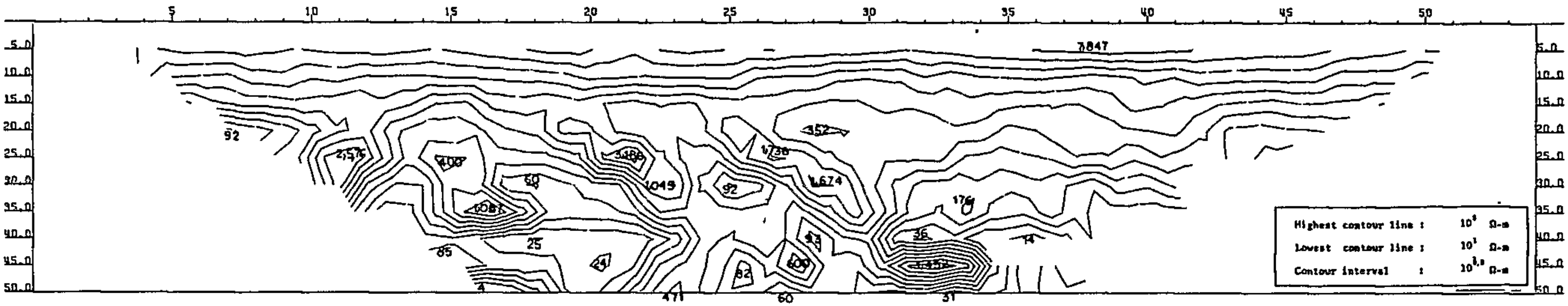


LINE 5 ARRANGEMENT 2

APPARENT RESISTIVITY MAP

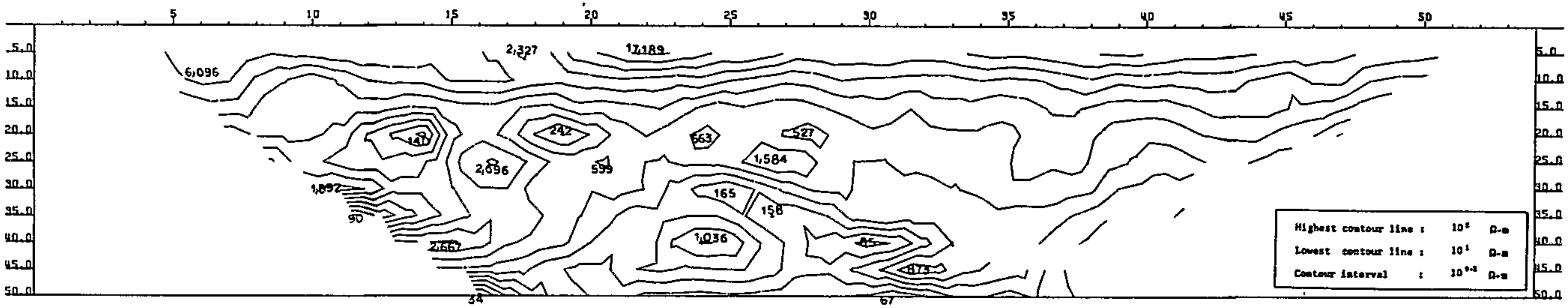


SPECIFIC RESISTIVITY MAP

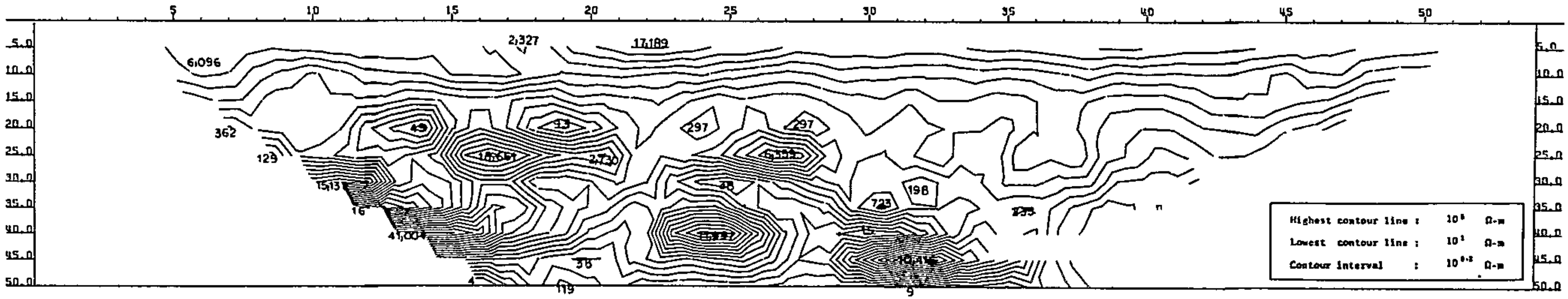


LINE 5 ARRANGEMENT 3

APPARENT RESISTIVITY MAP

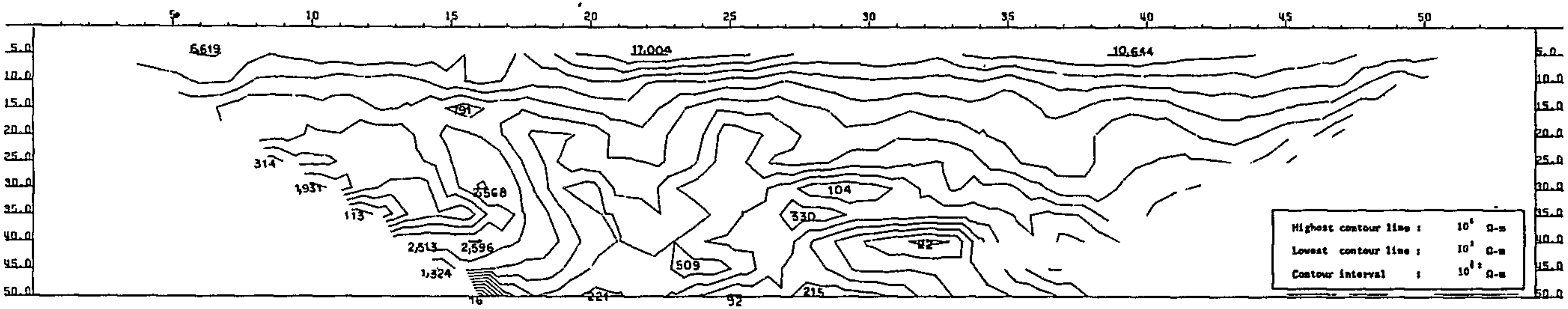


SPECIFIC RESISTIVITY MAP

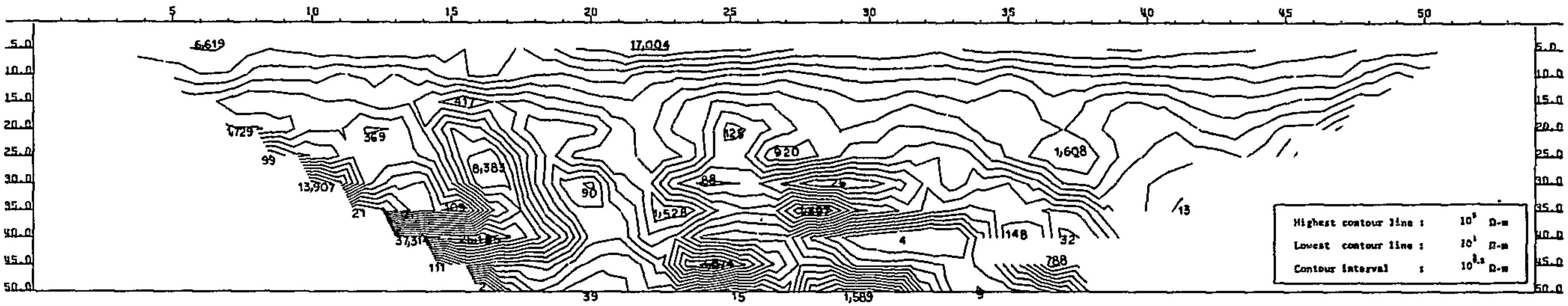


LINE 5 ARRANGEMENT 4

APPARENT RESISTIVITY MAP

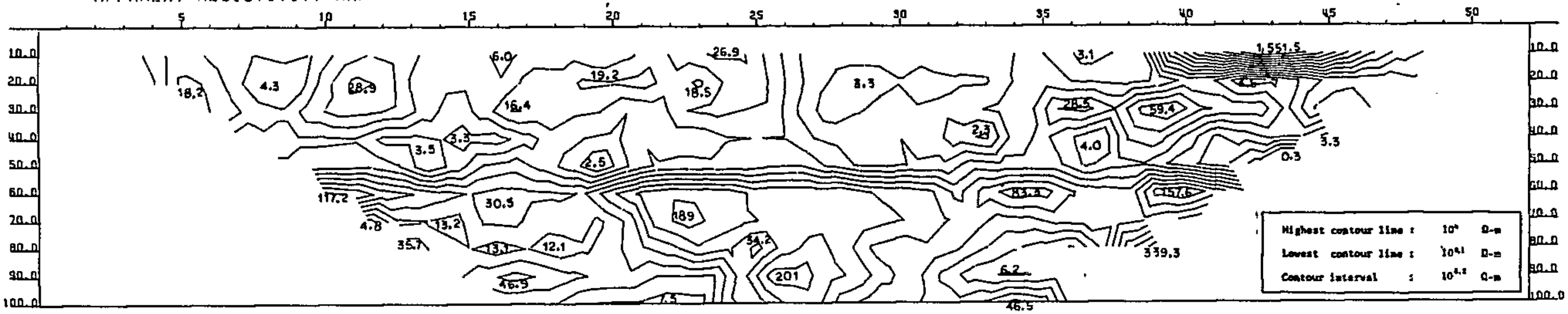


SPECIFIC RESISTIVITY MAP

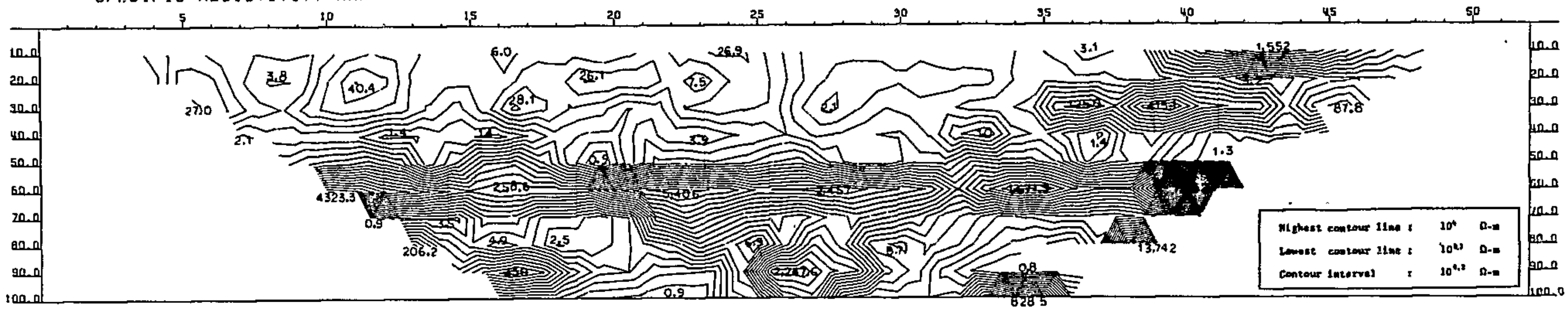


LINE 6 ARRANGEMENT 1

APPARENT RESISTIVITY MAP

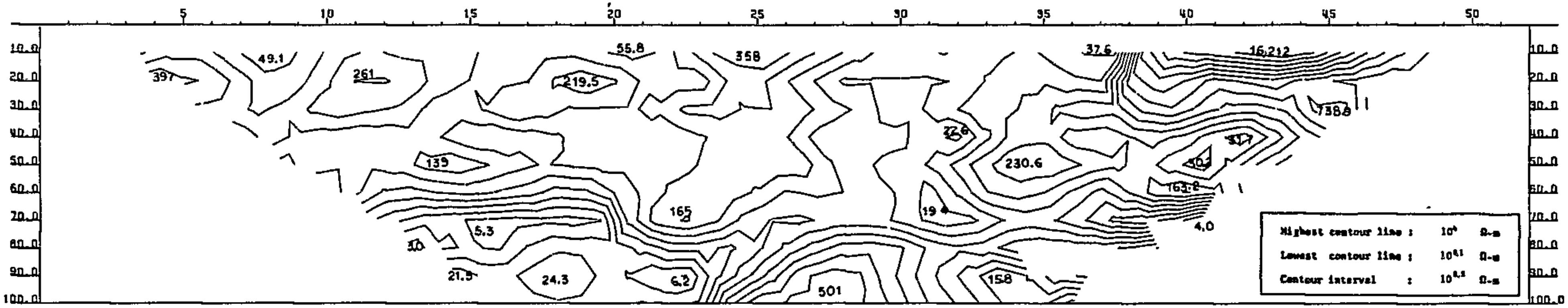


SPECIFIC RESISTIVITY MAP

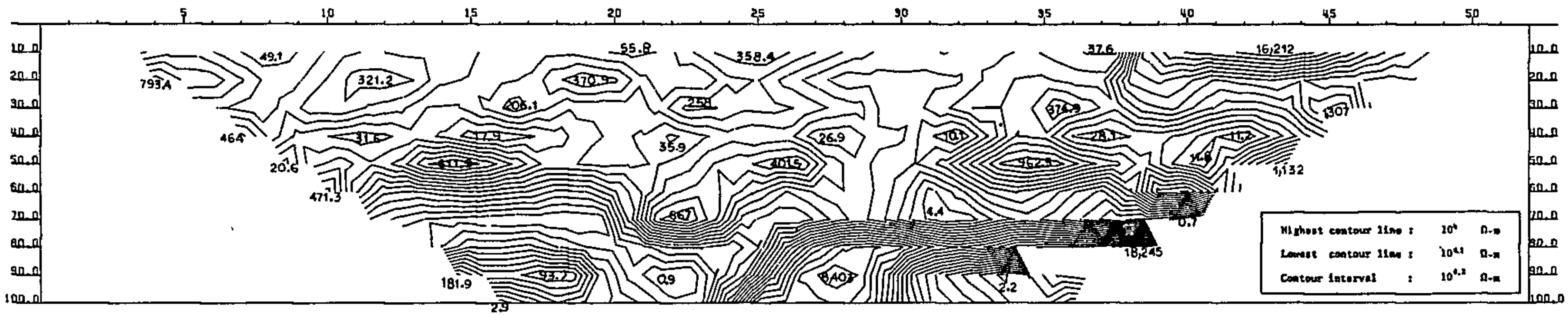


LINE 6 ARRANGEMENT 2

APPARENT RESISTIVITY MAP

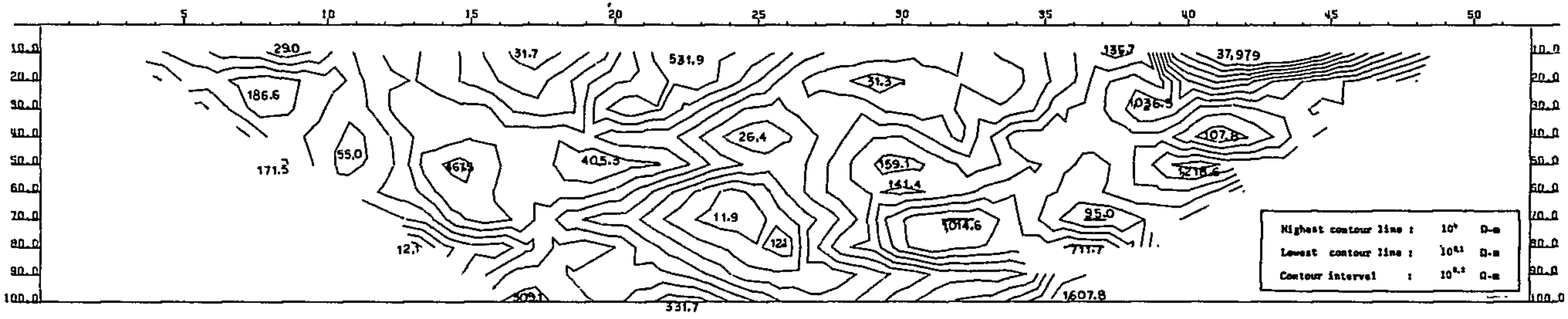


SPECIFIC RESISTIVITY MAP

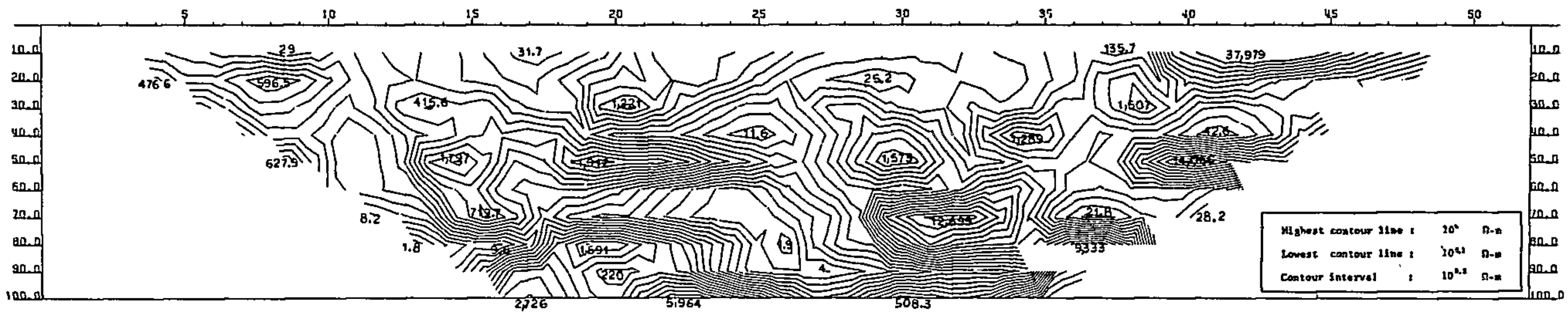


INE 6 ARRANGEMENT 3

APPARENT RESISTIVITY MAP

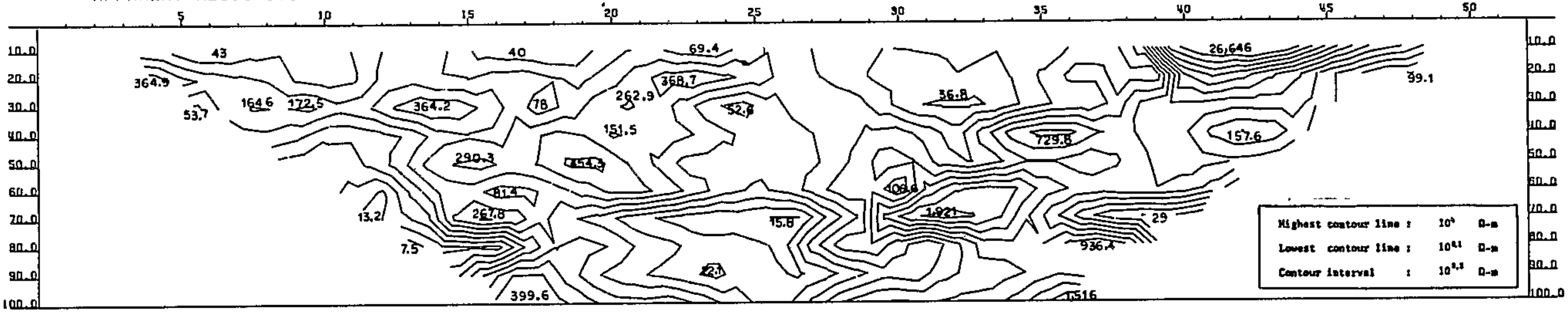


SPECIFIC RESISTIVITY MAP

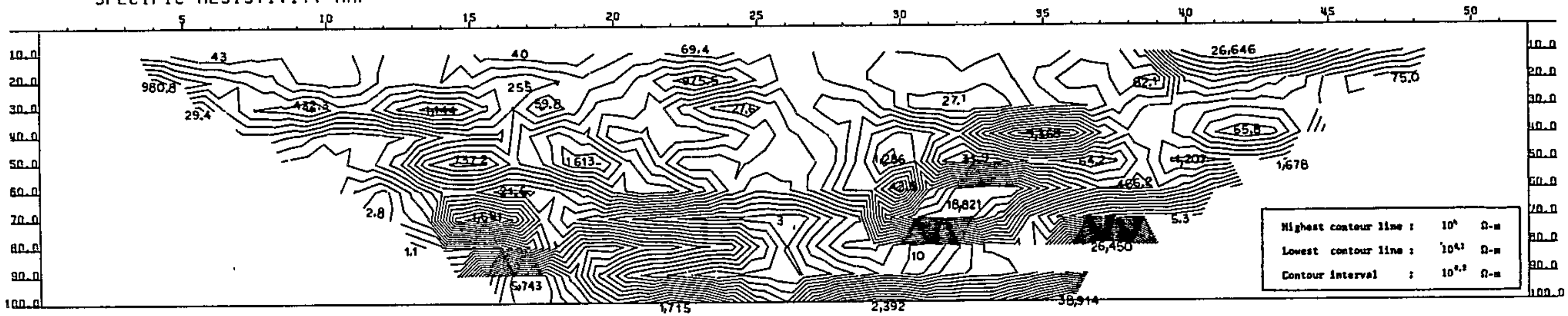


LINE 6 ARRANGEMENT 4

APPARENT RESISTIVITY MAP

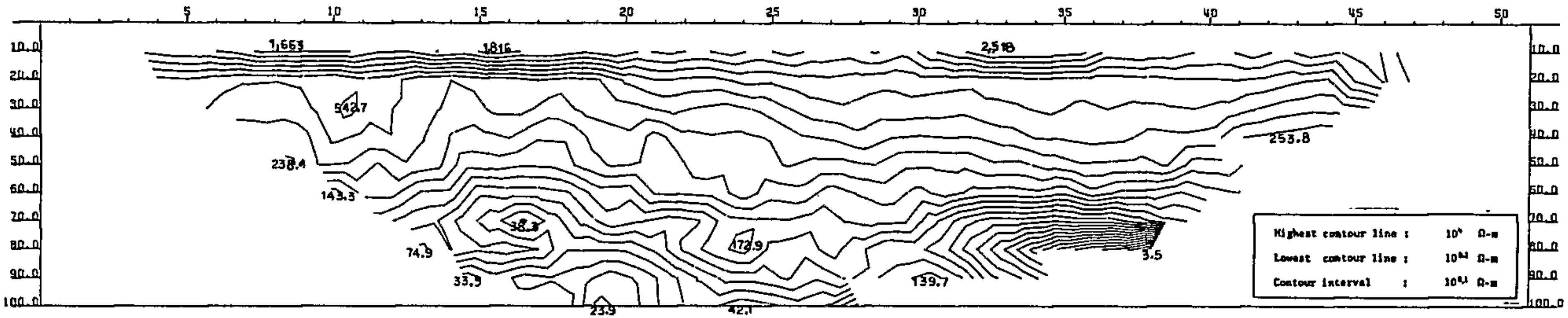


SPECIFIC RESISTIVITY MAP

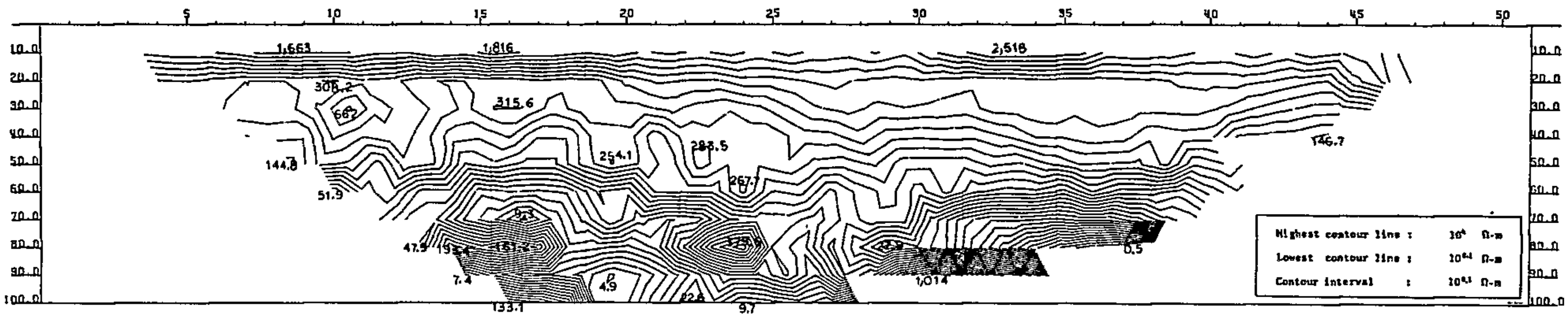


LINE 7 ARRANGEMENT 1

APPARENT RESISTIVITY MAP

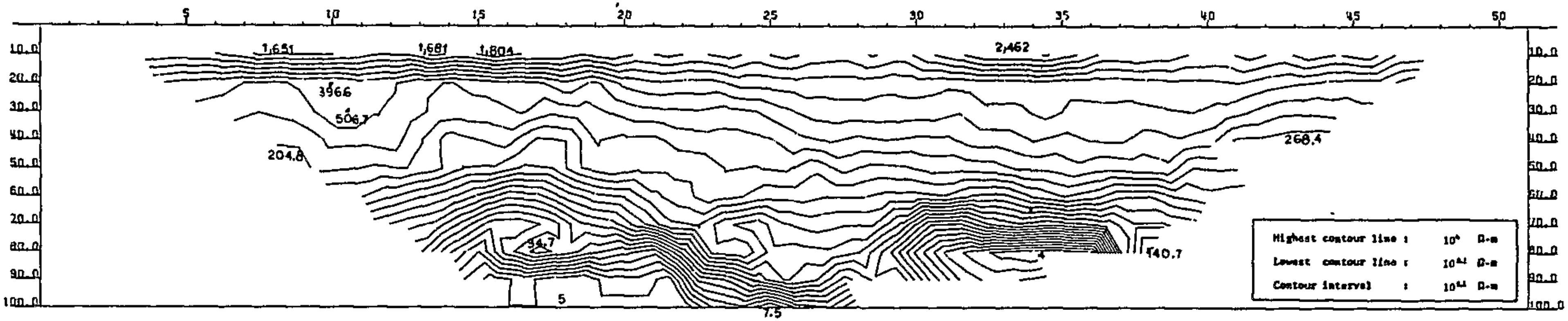


SPECIFIC RESISTIVITY MAP

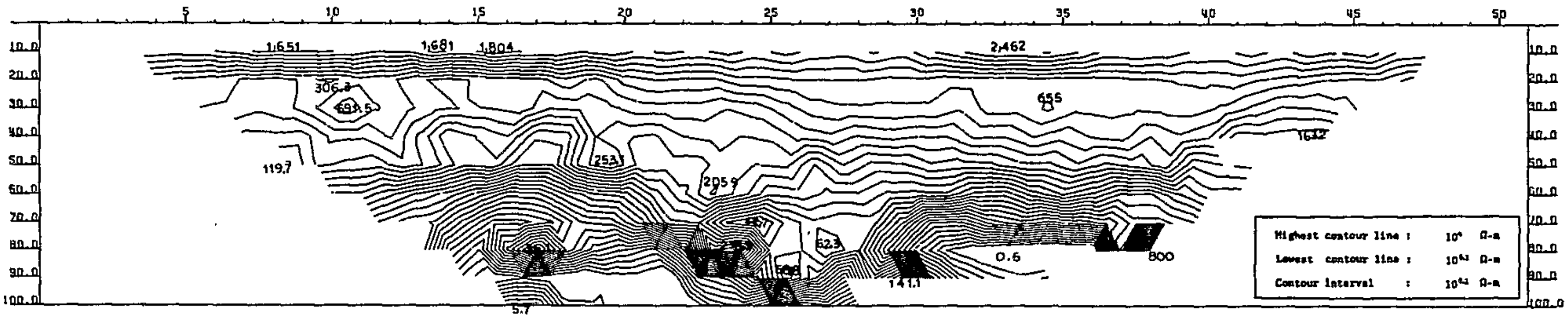


LINE 7 ARRANGEMENT 2

APPARENT RESISTIVITY MAP

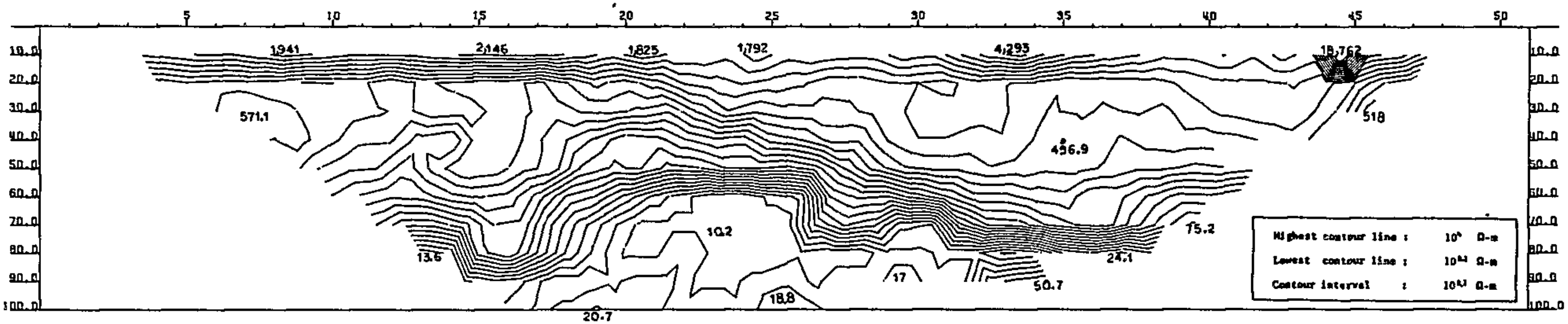


SPECIFIC RESISTIVITY MAP

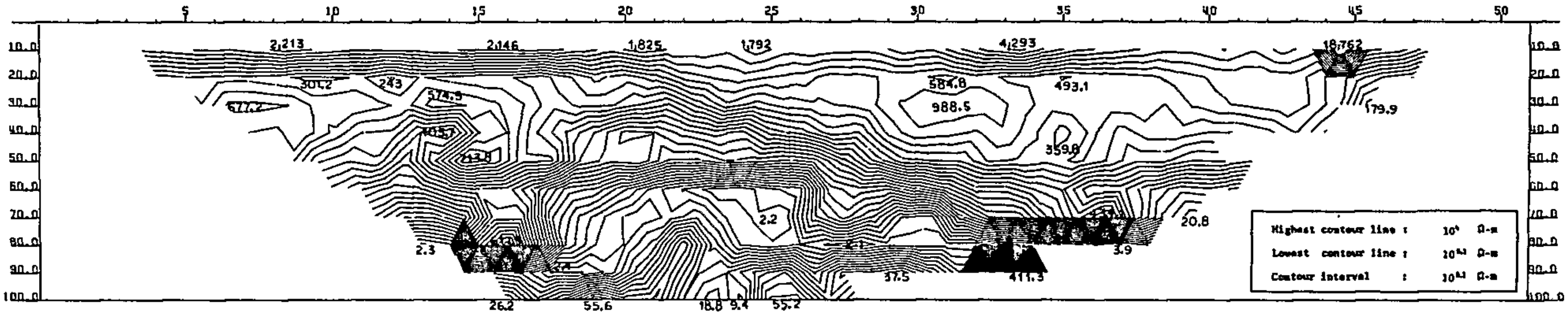


LINE 7 ARRANGEMENT 3

APPARENT RESISTIVITY MAP

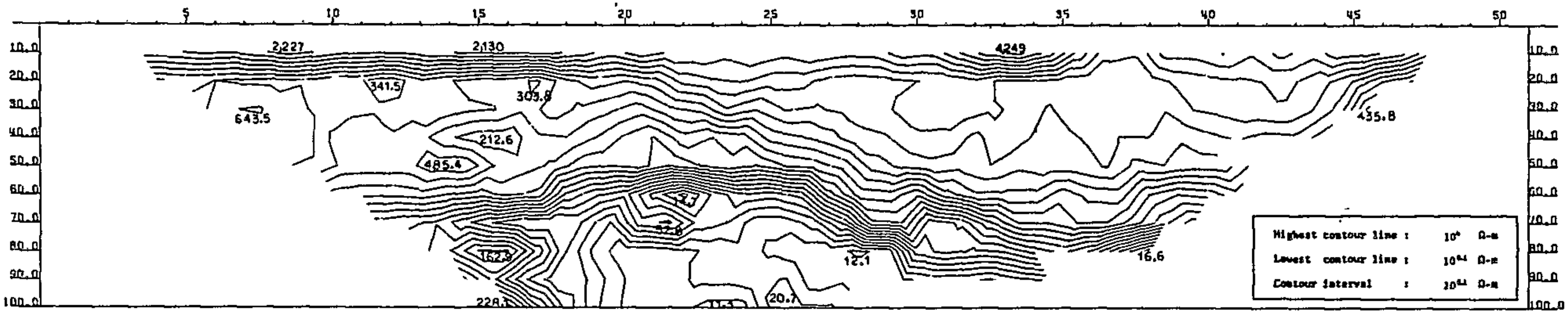


SPECIFIC RESISTIVITY MAP

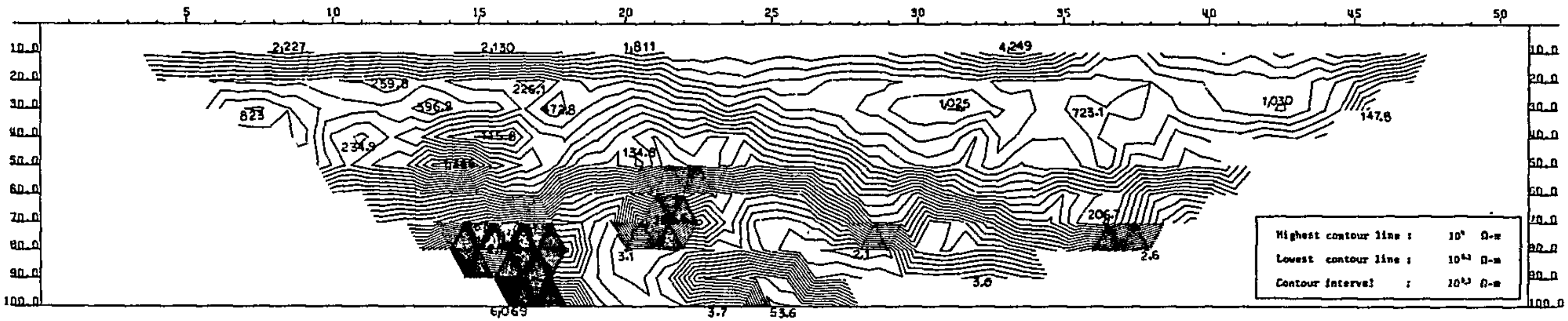


LINE 7 ARRANGEMENT 4

APPARENT RESISTIVITY MAP

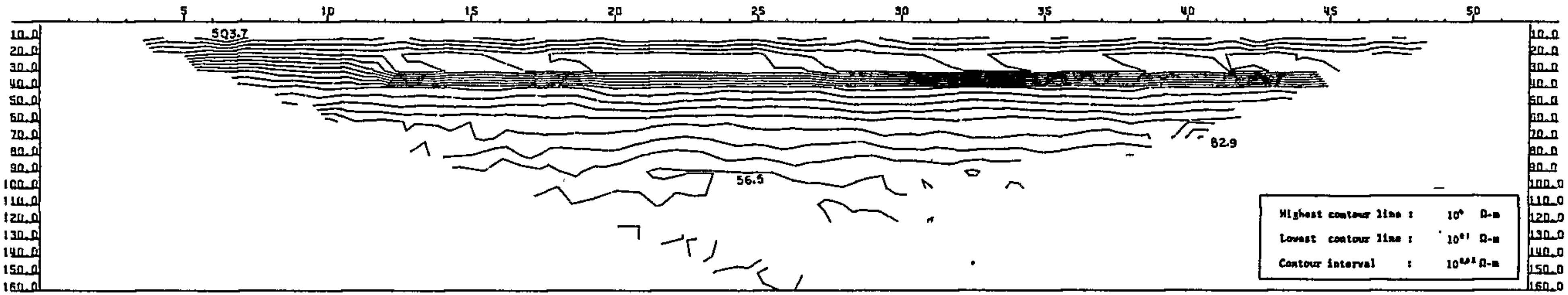


SPECIFIC RESISTIVITY MAP

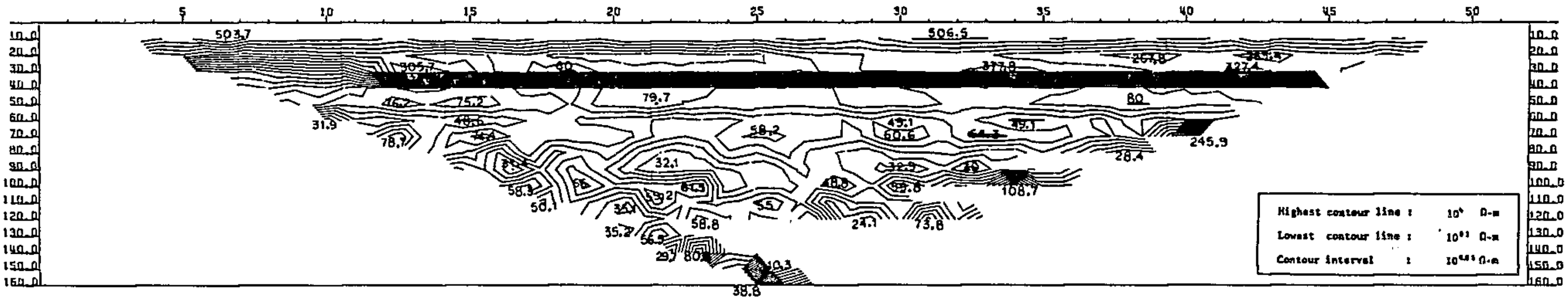


LINE 8 ARRANGEMENT 1

APPARENT RESISTIVITY MAP

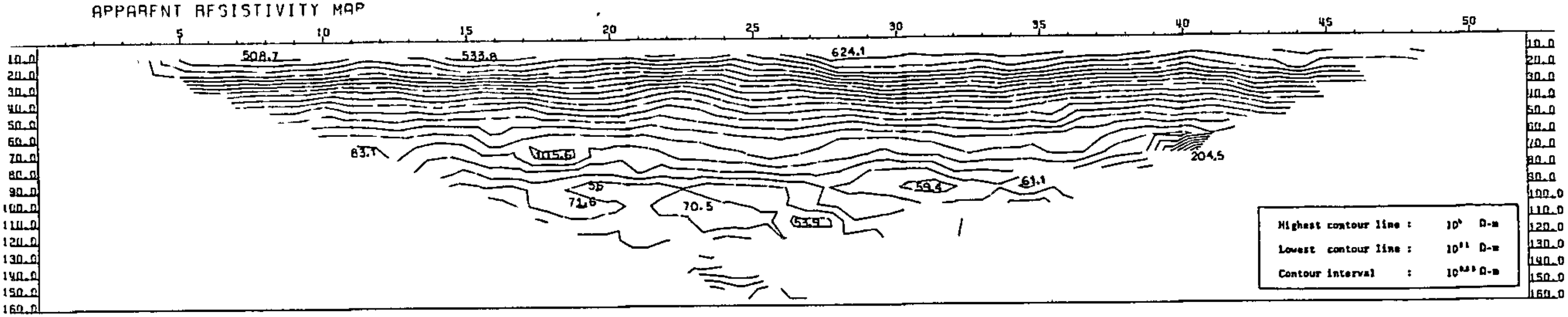


SPECIFIC RESISTIVITY MAP



LINE 8 ARRANGEMENT 3

APPARENT RESISTIVITY MAP



SPECIFIC RESISTIVITY MAP