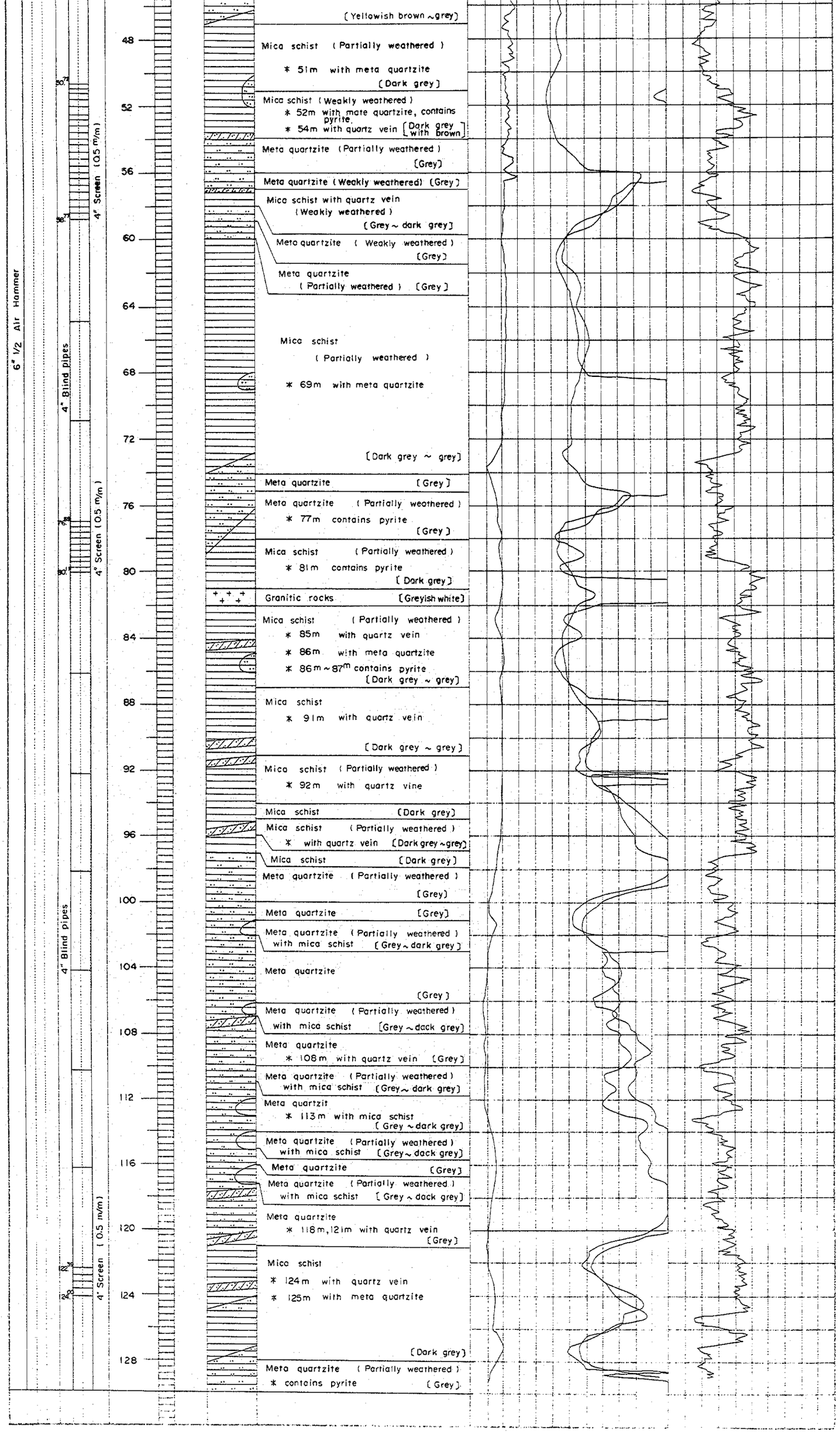
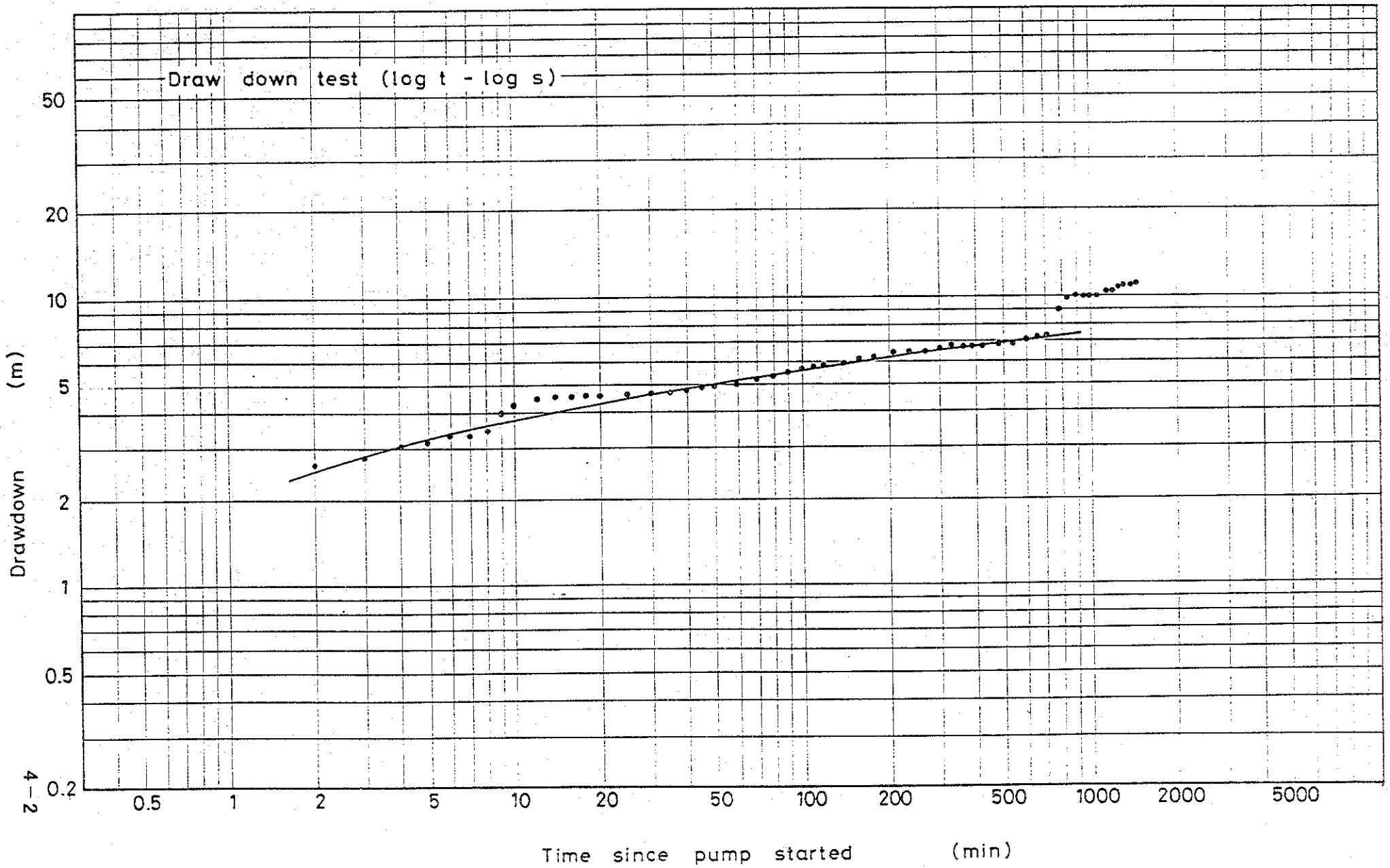
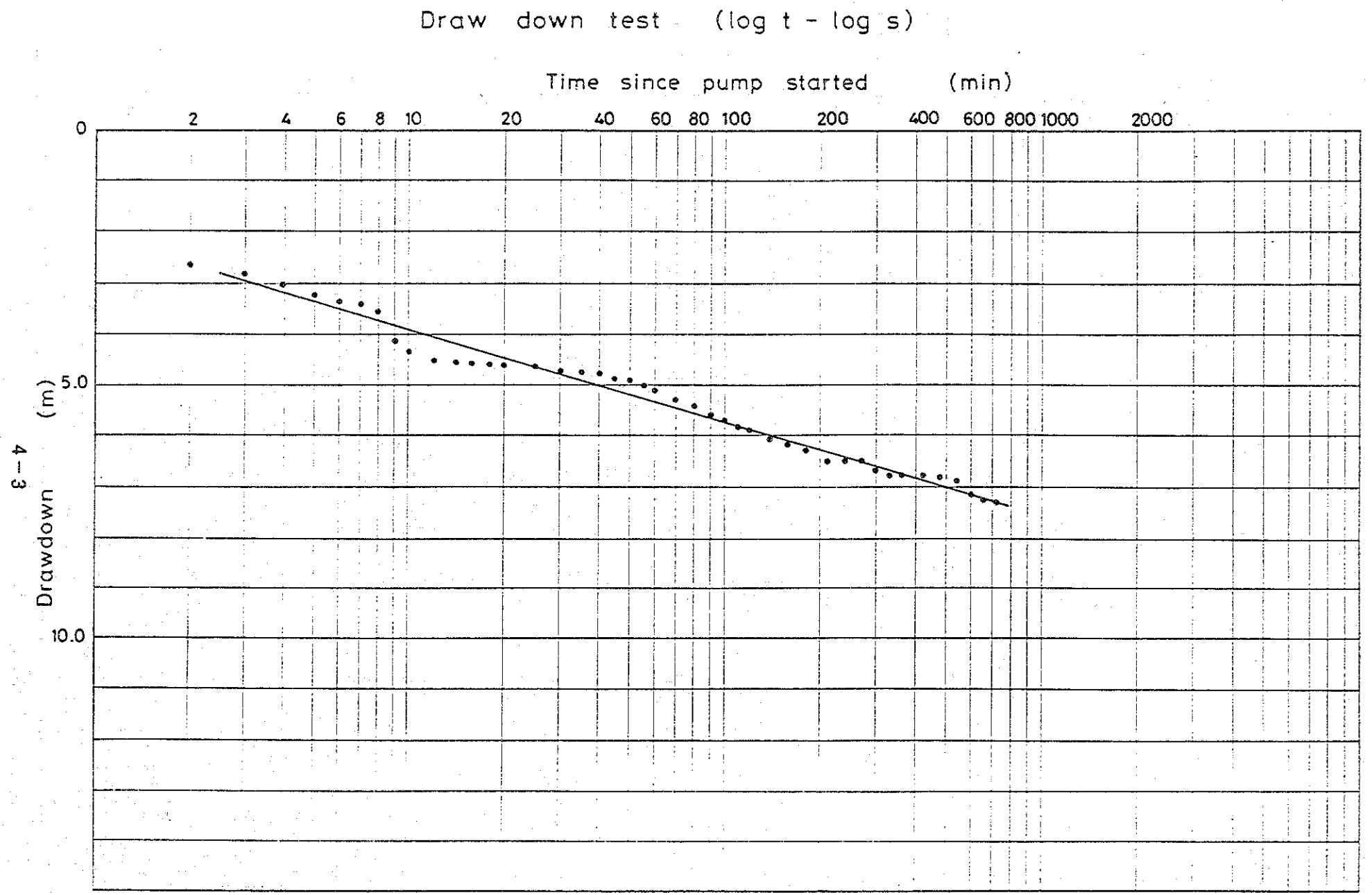
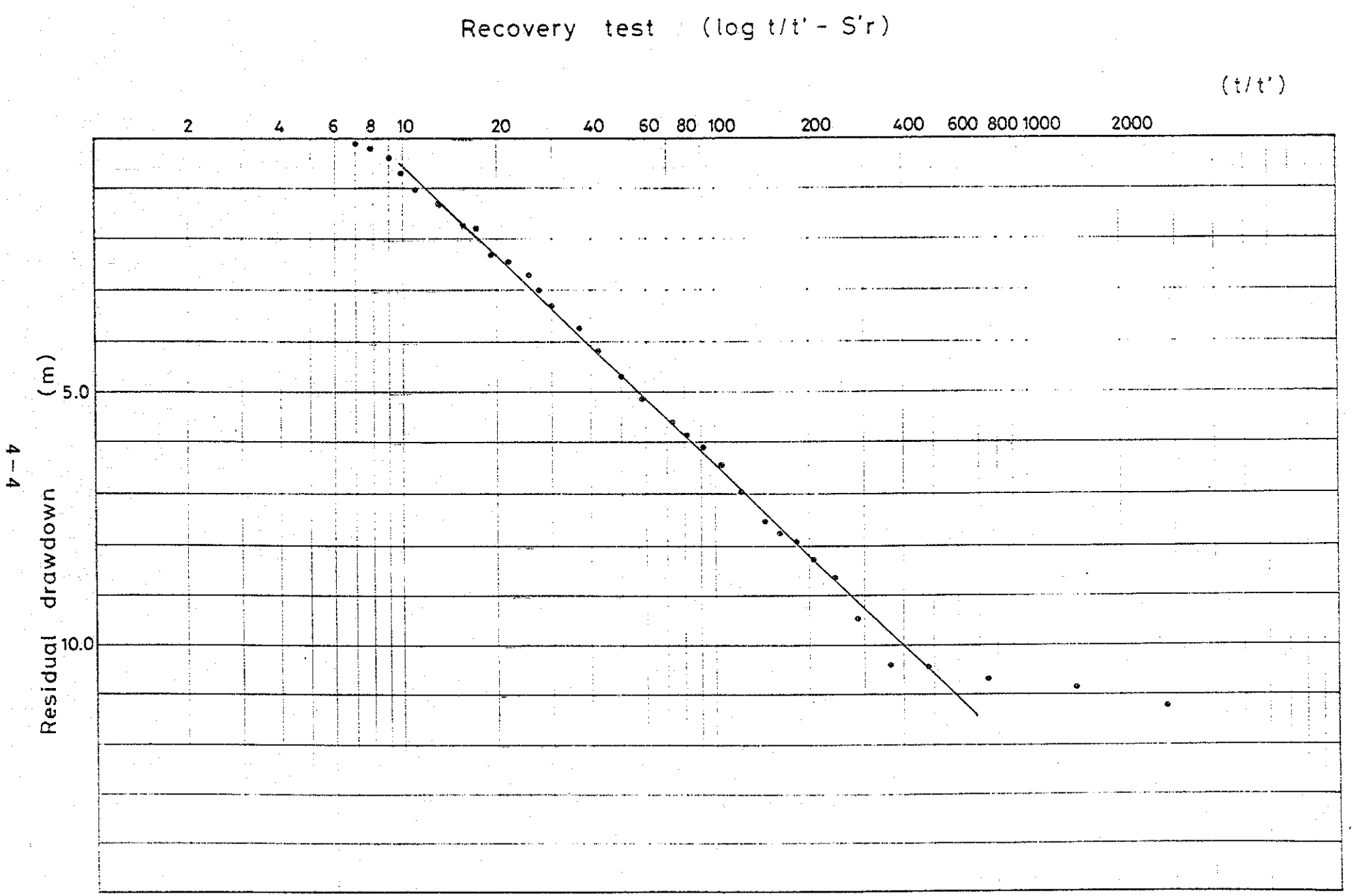

6" 1/2 Air Hammer
4" Blind pipes
4" Screen (0.5 m/m)
4" Blind pipes
4" Screen (0.5 m/m)
4" Screen (0.5 m/m)
48
52
56
60
64
68
72
76
80
84
88
92
96
100
104
108
112
116
120
124
128
(Yellowish brown ~ grey)
Mica schist (Partially weathered)
* 51m with meta quartzite
(Dark grey)
Mica schist (Weakly weathered)
* 52m with mate quartzite, contains pyrite.
* 54m with quartz vein (Dark grey with brown)
Meta quartzite (Partially weathered)
(Grey)
Meta quartzite (Weakly weathered) (Grey)
Mica schist with quartz vein
(Weakly weathered)
(Grey ~ dark grey)
Meta quartzite (Weakly weathered)
(Grey)
Meta quartzite
(Partially weathered) (Grey)
Mica schist
(Partially weathered)
* 69m with meta quartzite
(Dark grey ~ grey)
Meta quartzite (Grey)
Meta quartzite (Partially weathered)
* 77m contains pyrite
(Grey)
Mica schist (Partially weathered)
* 81m contains pyrite
(Dark grey)
Granitic rocks (Greyish white)
Mica schist (Partially weathered)
* 85m with quartz vein
* 86m with meta quartzite
* 86m ~ 87m contains pyrite
(Dark grey ~ grey)
Mica schist
* 91m with quartz vein
(Dark grey ~ grey)
Mica schist (Partially weathered)
* 92m with quartz vine
Mica schist (Dark grey)
Mica schist (Partially weathered)
* with quartz vein (Dark grey ~ grey)
Mica schist (Dark grey)
Meta quartzite (Partially weathered)
(Grey)
Meta quartzite (Grey)
Meta quartzite (Partially weathered)
with mica schist (Grey ~ dark grey)
Meta quartzite
(Grey)
Meta quartzite (Partially weathered)
with mica schist (Grey ~ dack grey)
Meta quartzite
* 108m with quartz vein (Grey)
Meta quartzite (Partially weathered)
with mica schist (Grey ~ dark grey)
Meta quartzit
* 113m with mica schist
(Grey ~ dark grey)
Meta quartzite (Partially weathered)
with mica schist (Grey ~ dack grey)
Meta quartzite (Grey)
Meta quartzite (Partially weathered)
with mica schist (Grey ~ dack grey)
Meta quartzite
* 118m, 121m with quartz vein
(Grey)
Mica schist
* 124m with quartz vein
* 125m with meta quartzite
(Dark grey)
Meta quartzite (Partially weathered)
* contains pyrite (Grey)

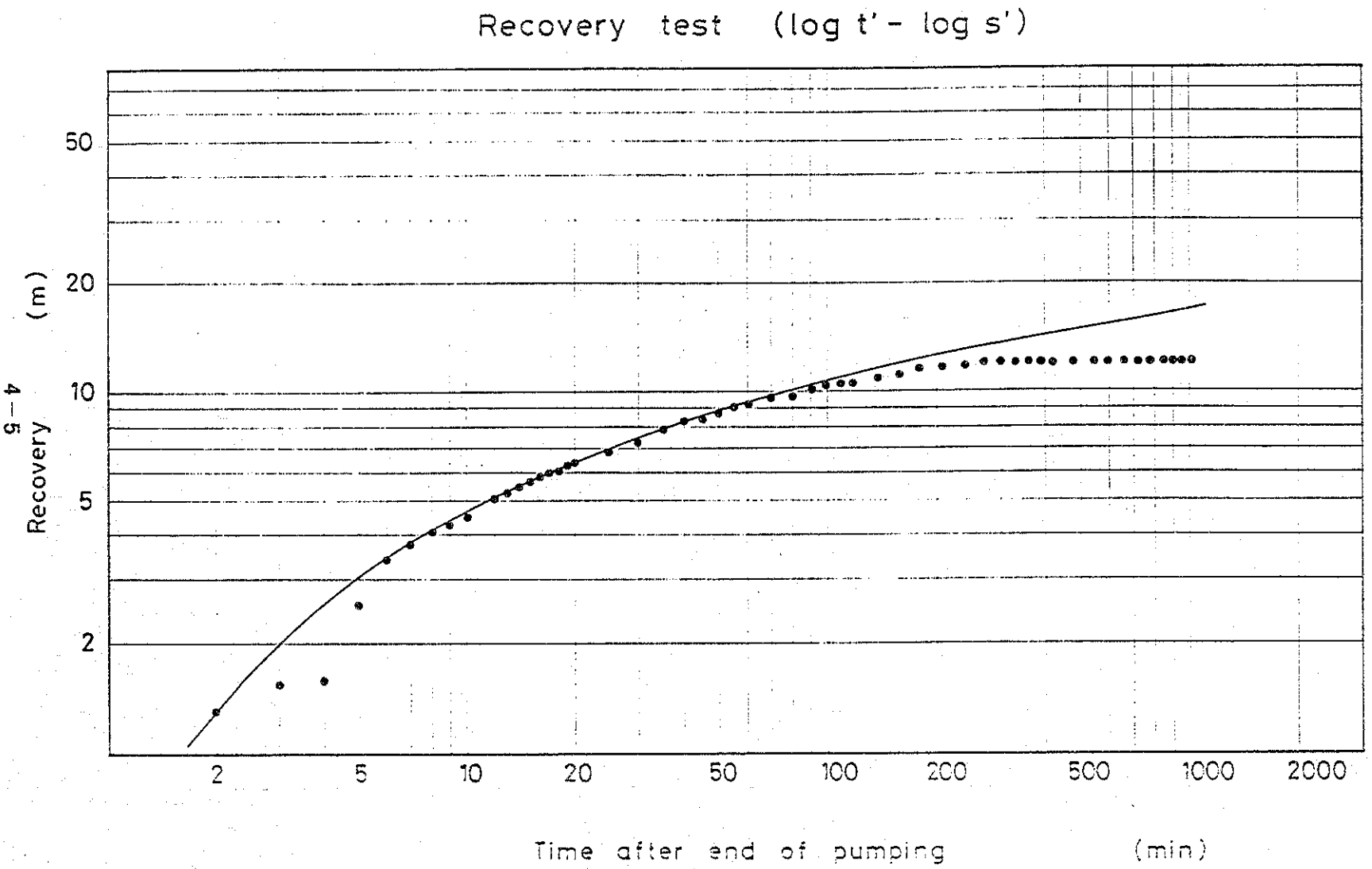
4. RESULT OF PUMPING TEST ANALYSIS

Tunga Ardo

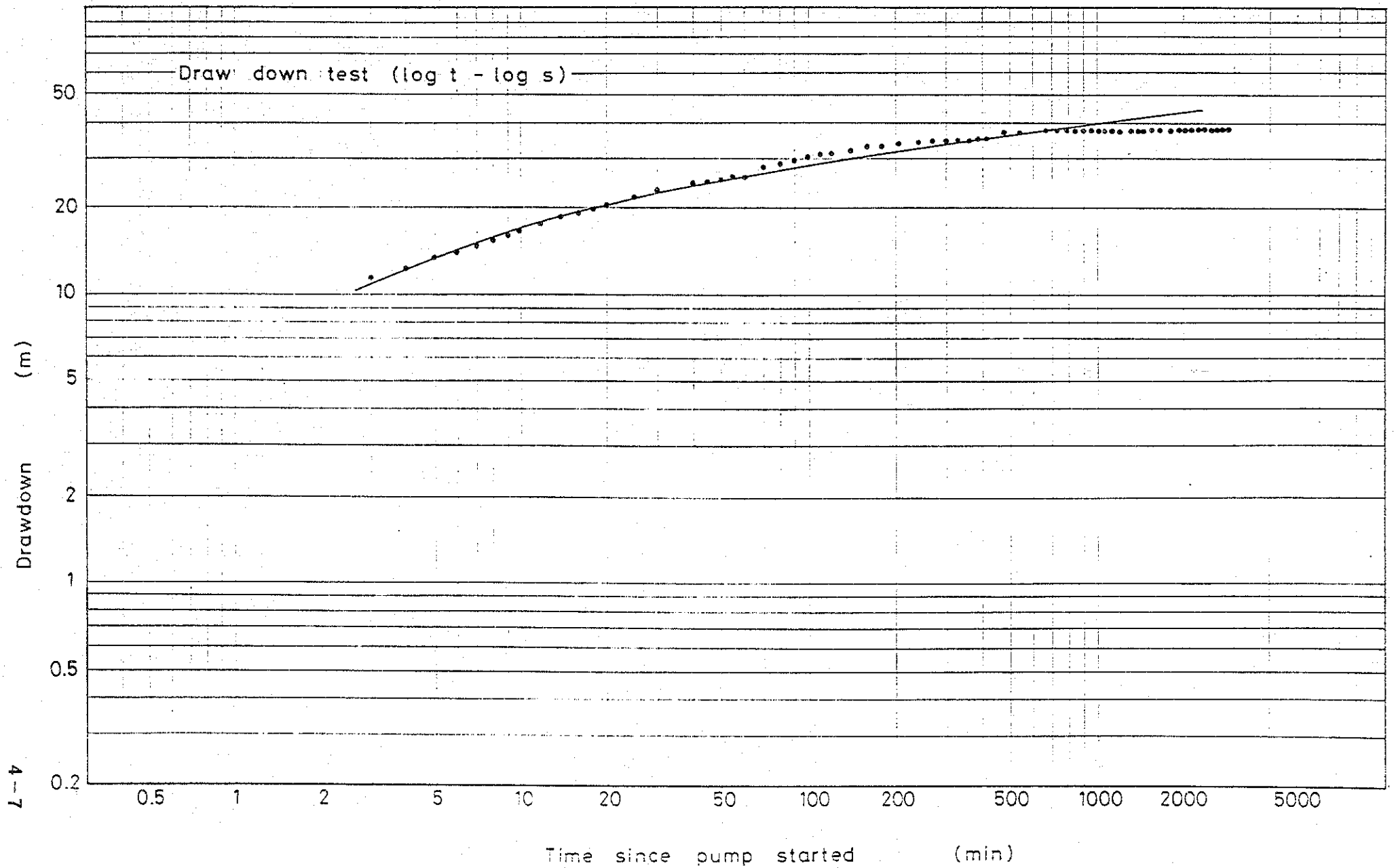

Draw down test (log t - log s)
Drawdown (m)
50
20
10
5
2
1
0.5
0.2
0.5
1
2
5
10
20
50
100
200
500
1000
2000
5000
Time since pump started (min)

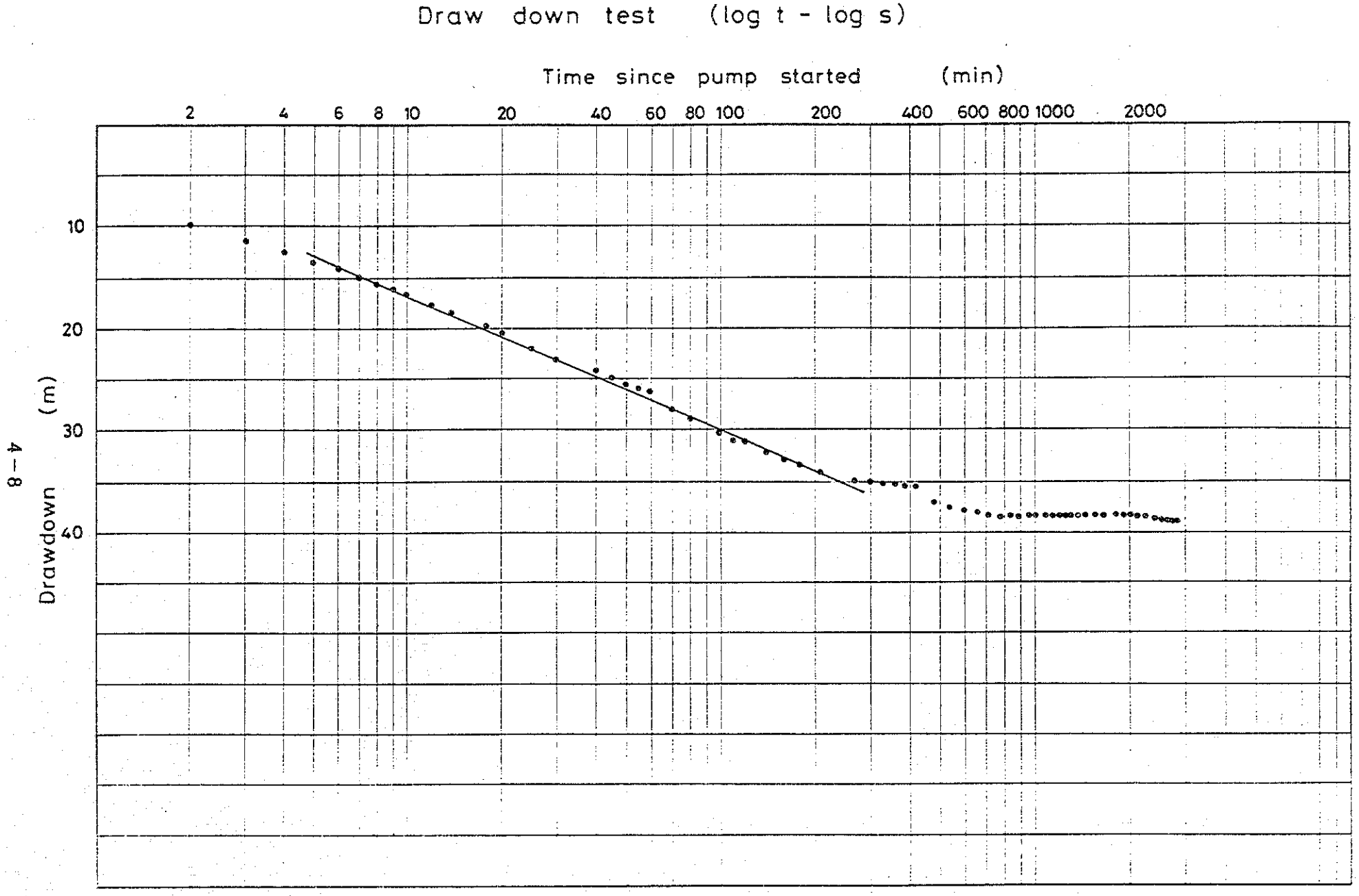

Draw down test (log t - log s)
Time since pump started (min)
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
0
5.0
10.0
Drawdown (m)

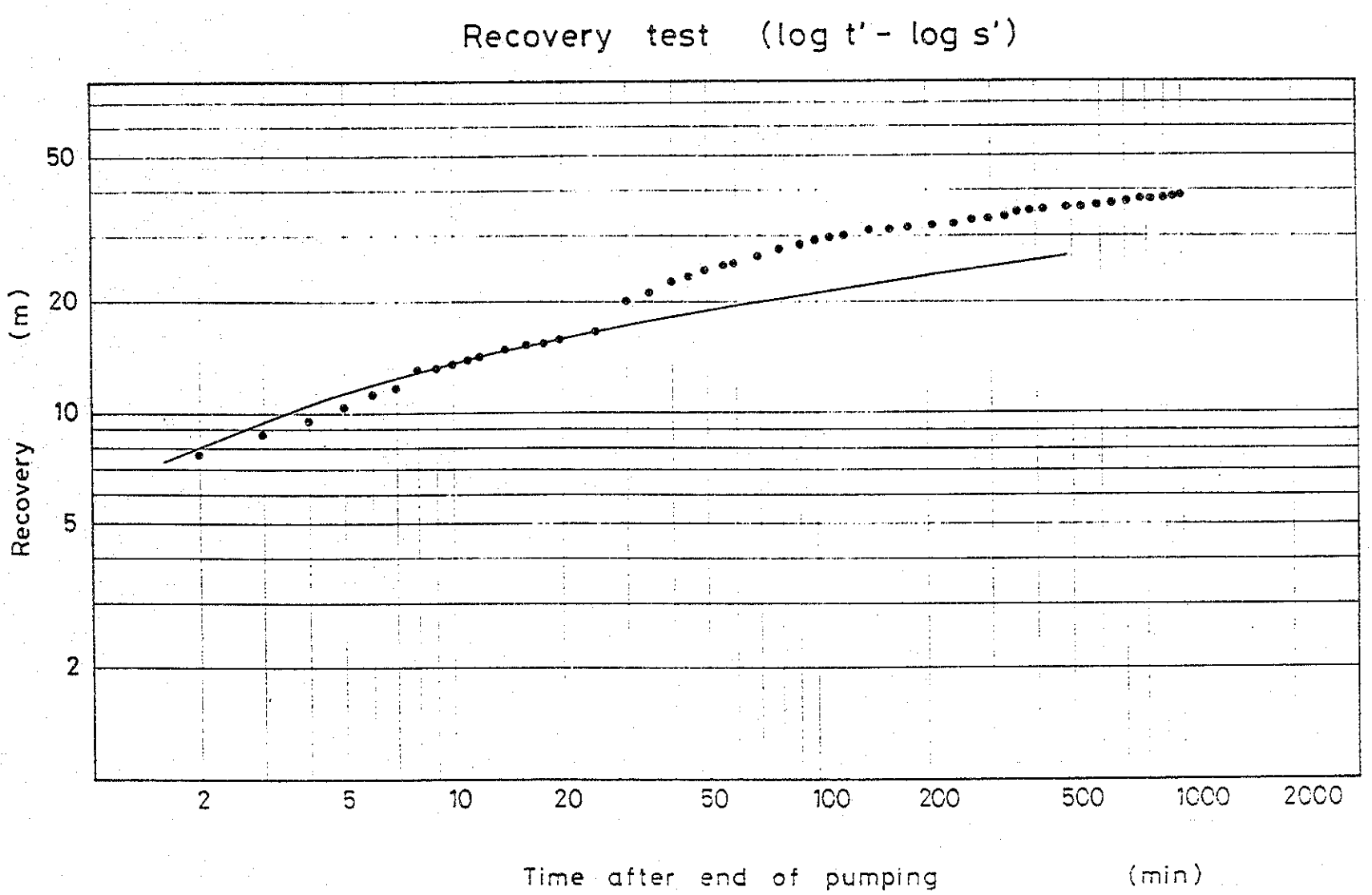

Recovery test (log t/t' - S'r)
(t/t')
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
Residual drawdown (m)
5.0
10.0

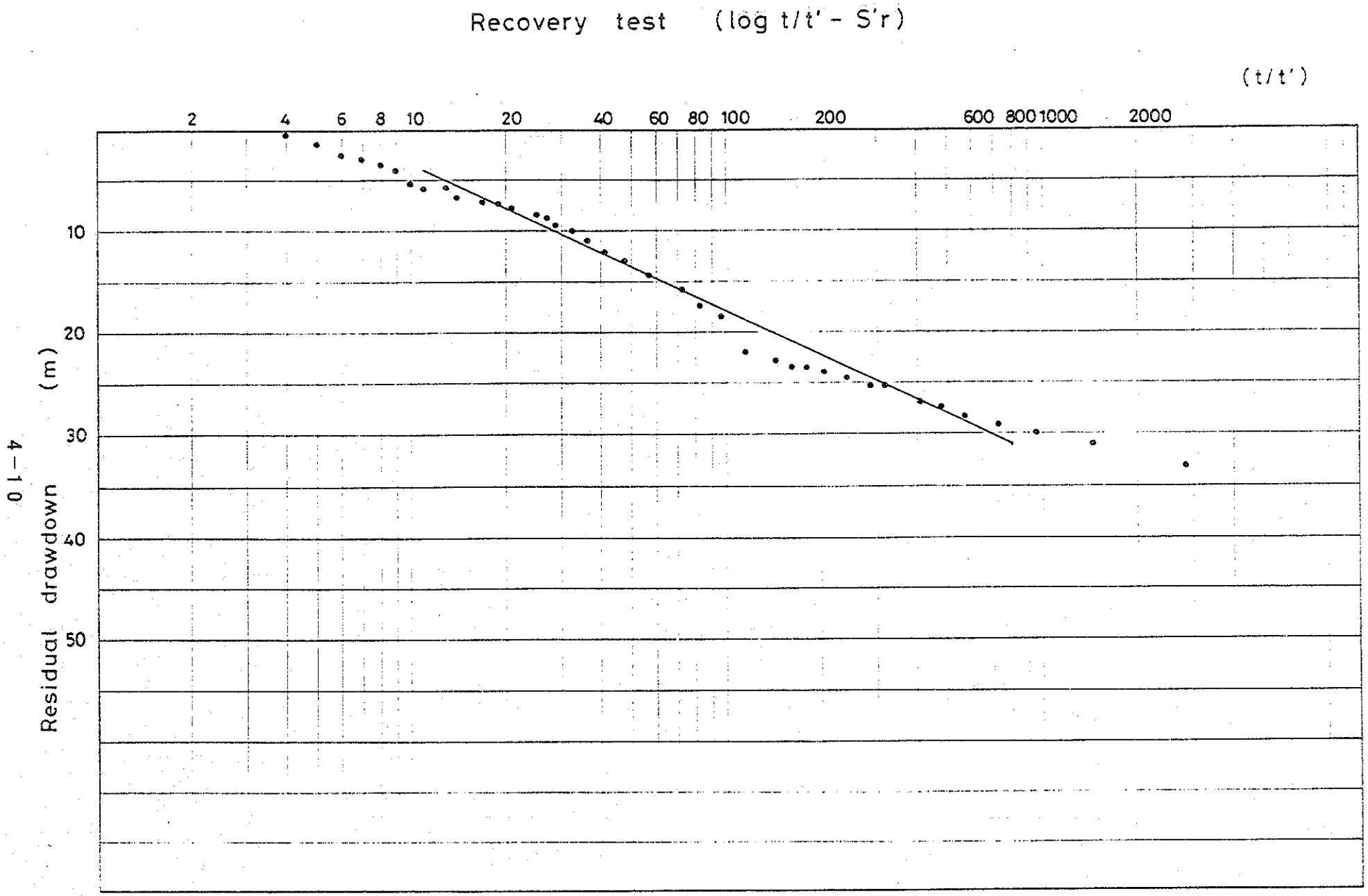

Recovery test (log t' - log s')
Recovery (m)
4 - 5
50
20
10
5
2
2
5
10
20
50
100
200
500
1000
2000
Time after end of pumping (min)

Ruwan Bore

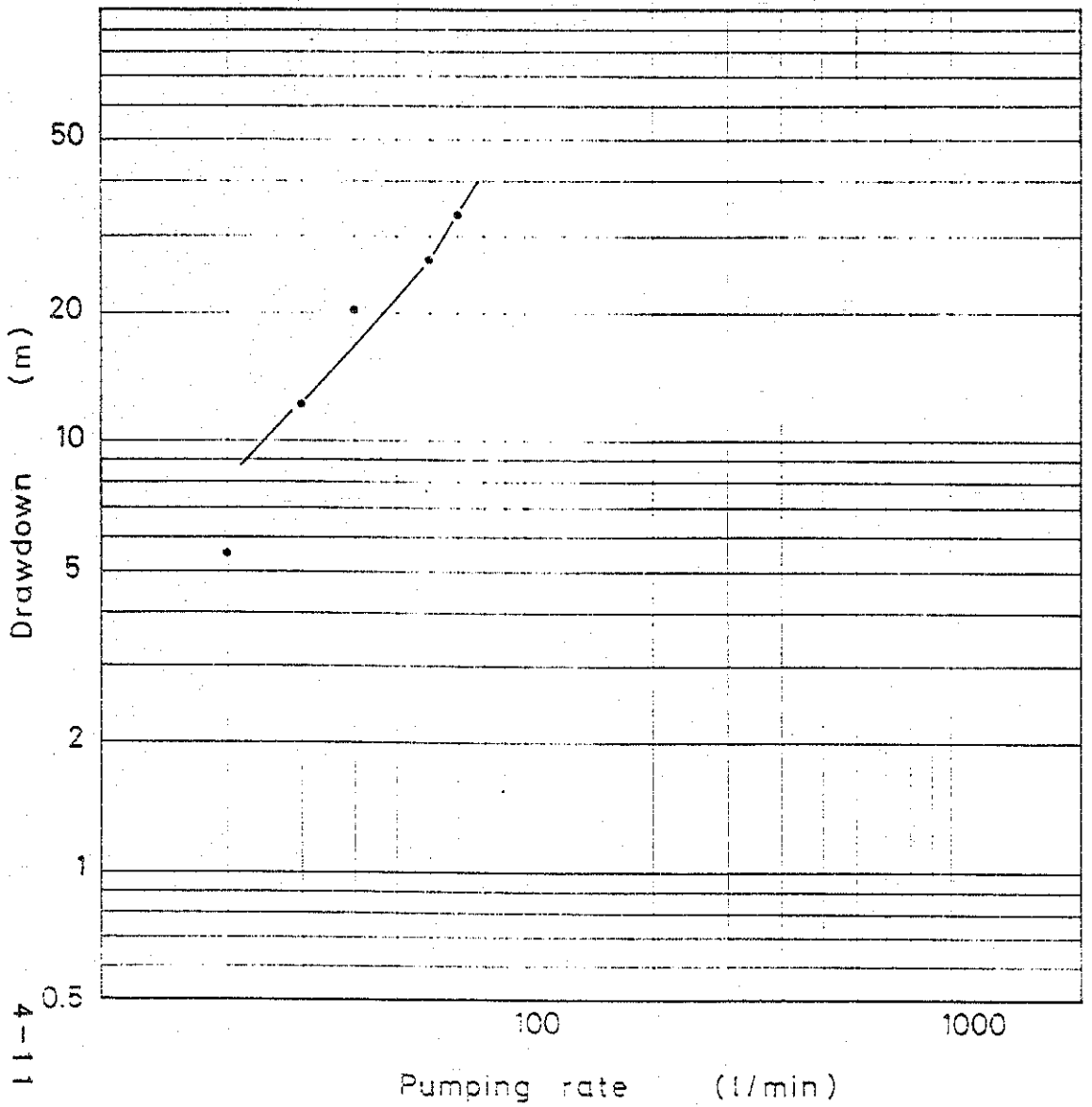

Draw down test (log t - log s)
50
20
10
5
2
1
0.5
0.2
Drawdown (m)
0.5
1
2
5
10
20
50
100
200
500
1000
2000
5000
Time since pump started (min)


Draw down test (log t - log s)
Time since pump started (min)
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
10
20
30
40
Drawdown (m)


Recovery test (log t' - log s')
Recovery (m)
50
20
10
5
2
2
5
10
20
50
100
200
500
1000
2000
Time after end of pumping (min)

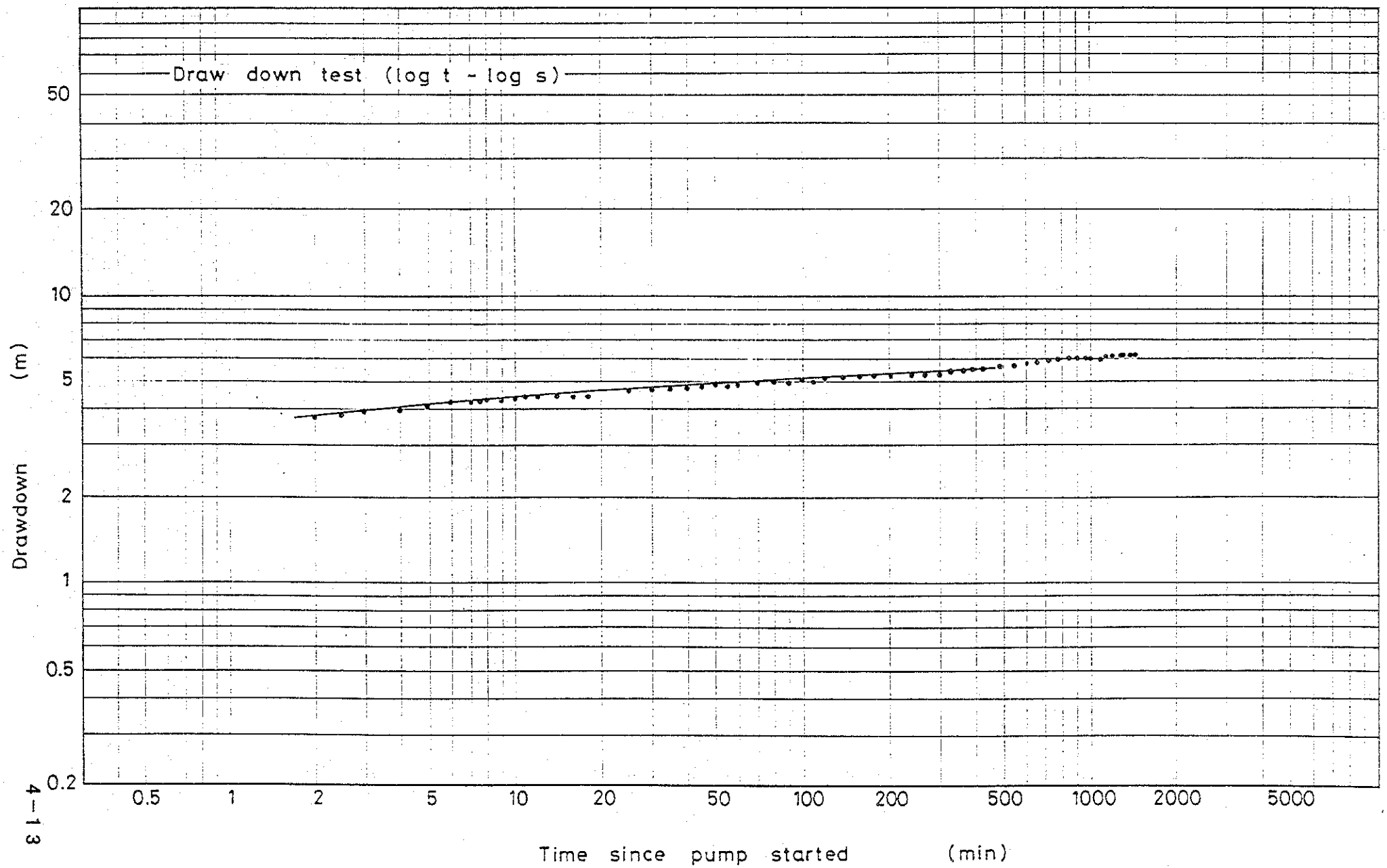

Recovery test (log t/t' - S'r)
(t/t')
2
4
6
8
10
20
40
60
80
100
200
600
800
1000
2000
10
20
30
40
50
Residual drawdown (m)

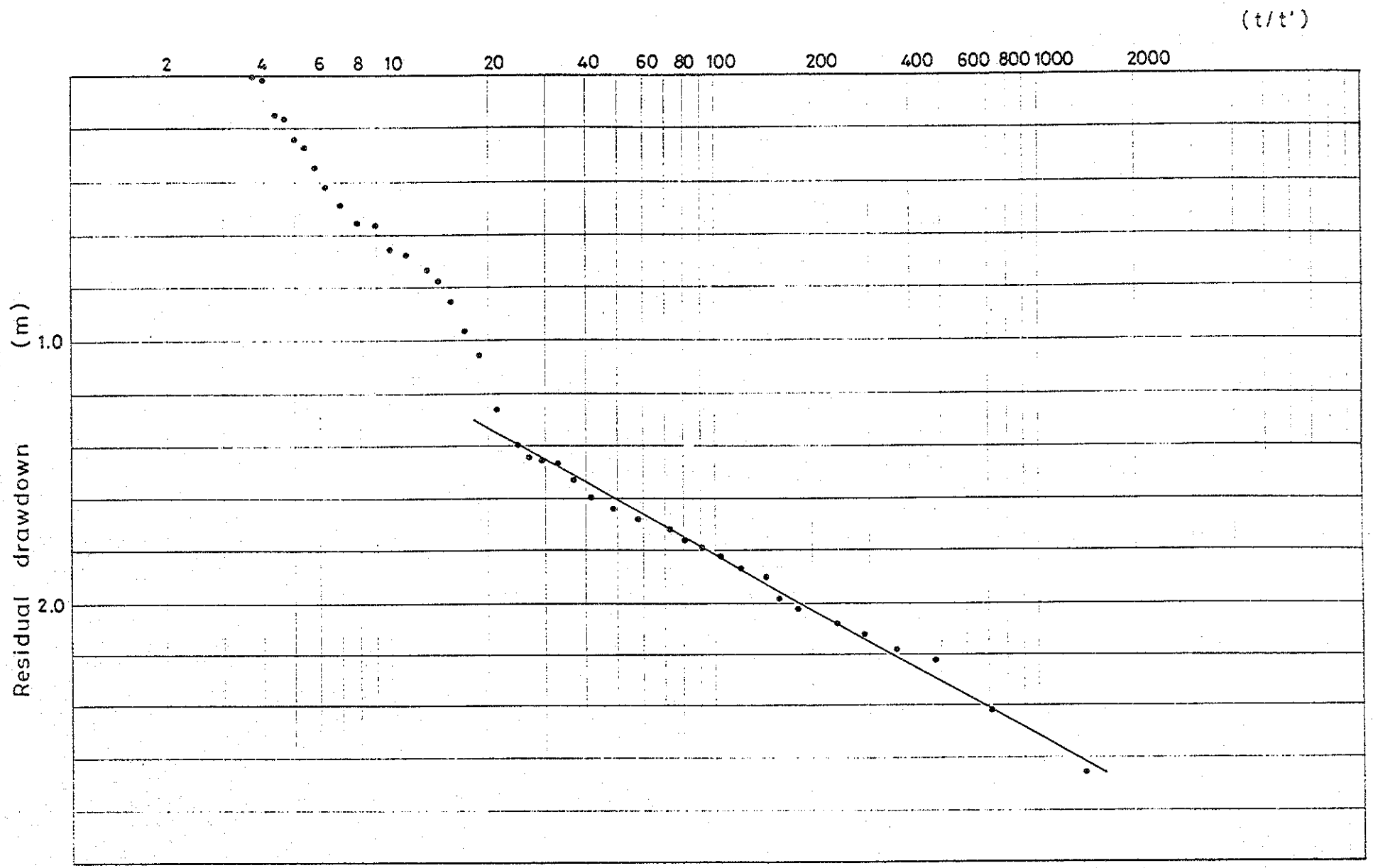
Step drawdown test (log Q - log S)

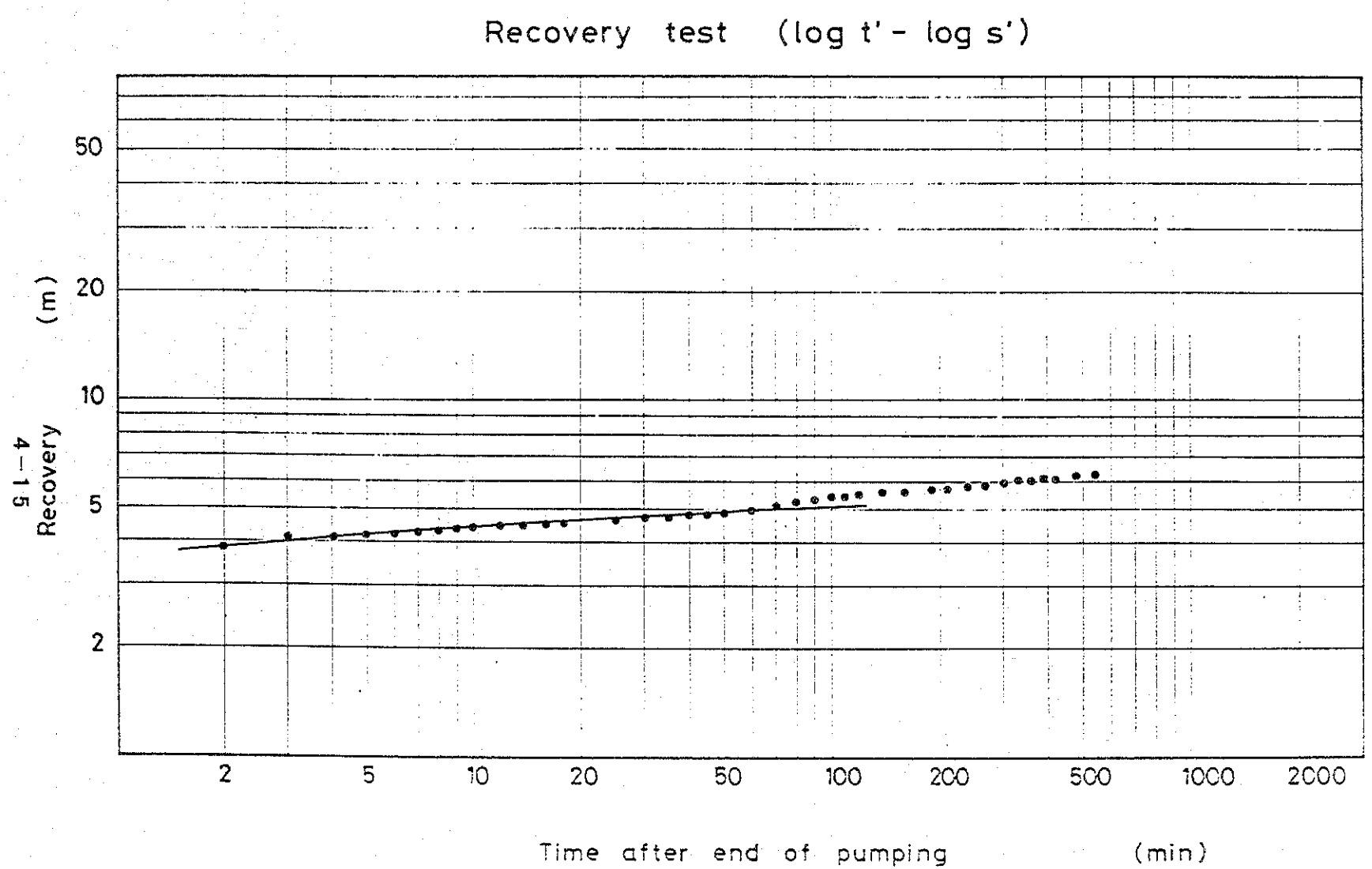


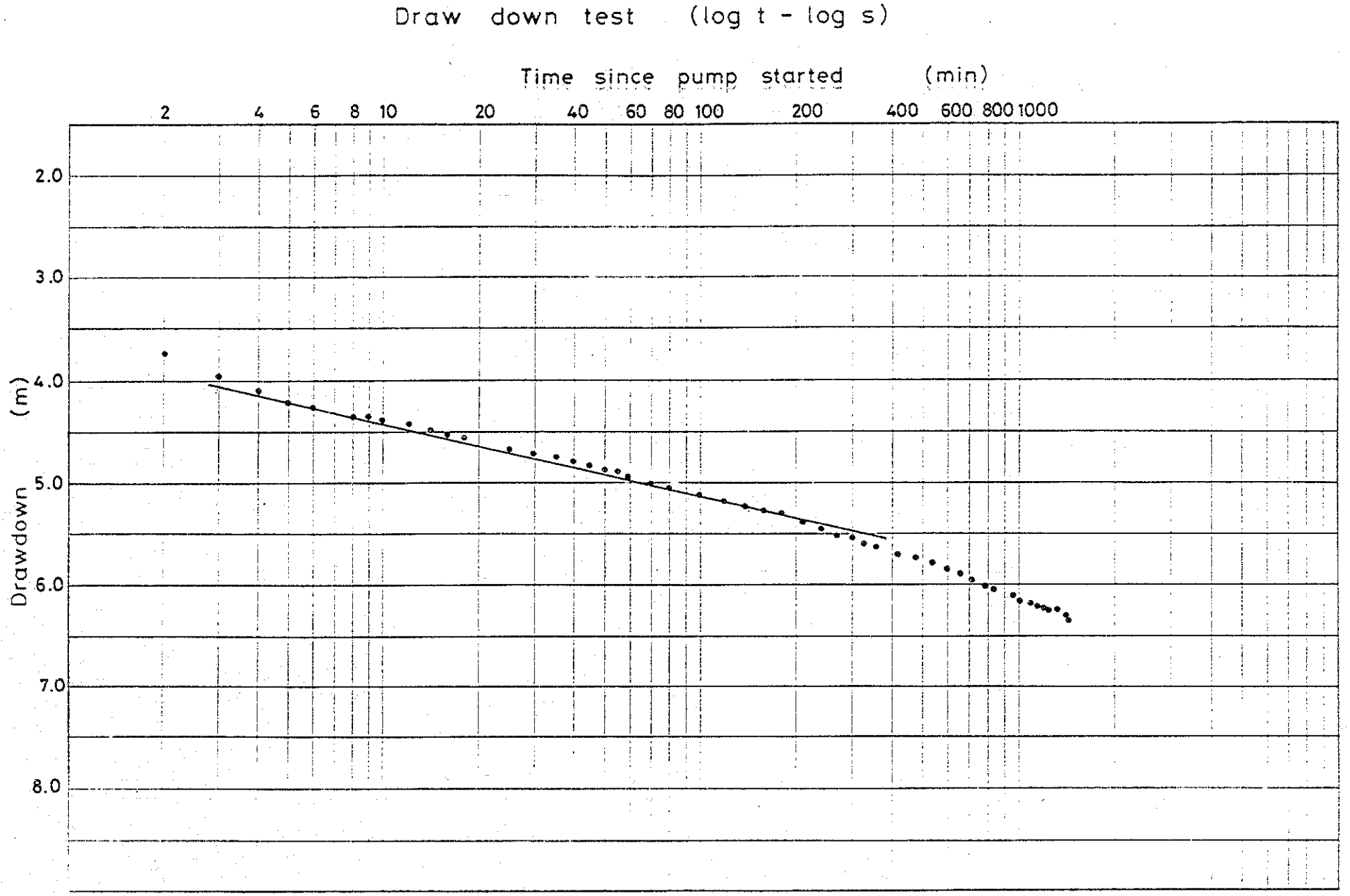
	Pumping rate Q (m³/min)	Drawdown ⊿S (m)	Specific capacity m²/min/m
1	0.02	5.49	0.004
2	0.03	12.28	0.002
3	0.04	20.85	0.002
4	0.06	26.78	0.002
5	0.07	33.83	0.002

Dauran

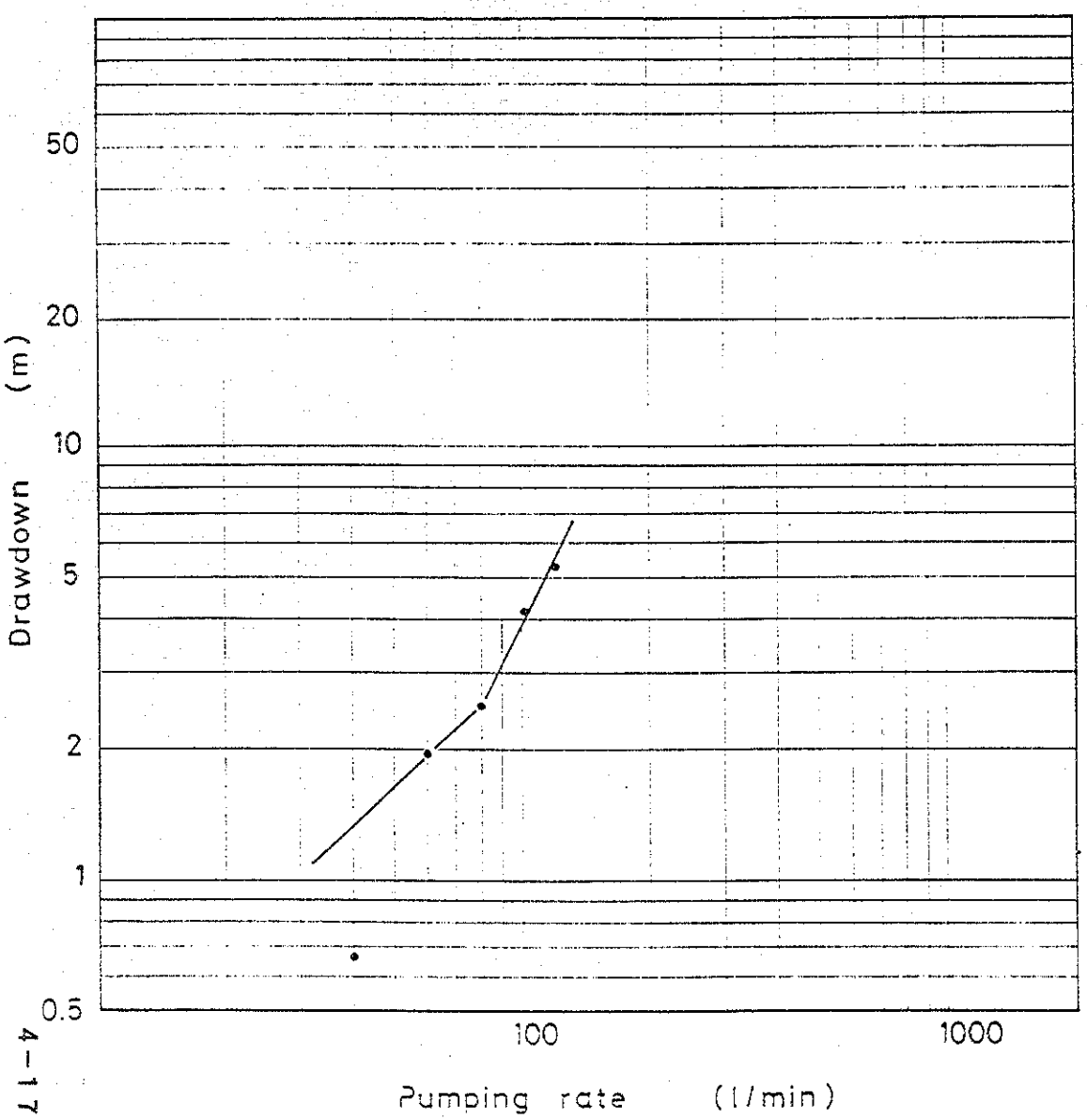

Draw down test (log t - log s)
Drawdown (m)
50
20
10
5
2
1
0.5
0.2
0.5
1
2
5
10
20
50
100
200
500
1000
2000
5000
Time since pump started (min)


Recovery test (log t/t' - S'r)
(t/t')
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
Residual drawdown (m)
1.0
2.0


Recovery test (log t' - log s')
50
20
10
5
2
(m)
Recovery
4 - 15
2
5
10
20
50
100
200
500
1000
2000
Time after end of pumping
(min)

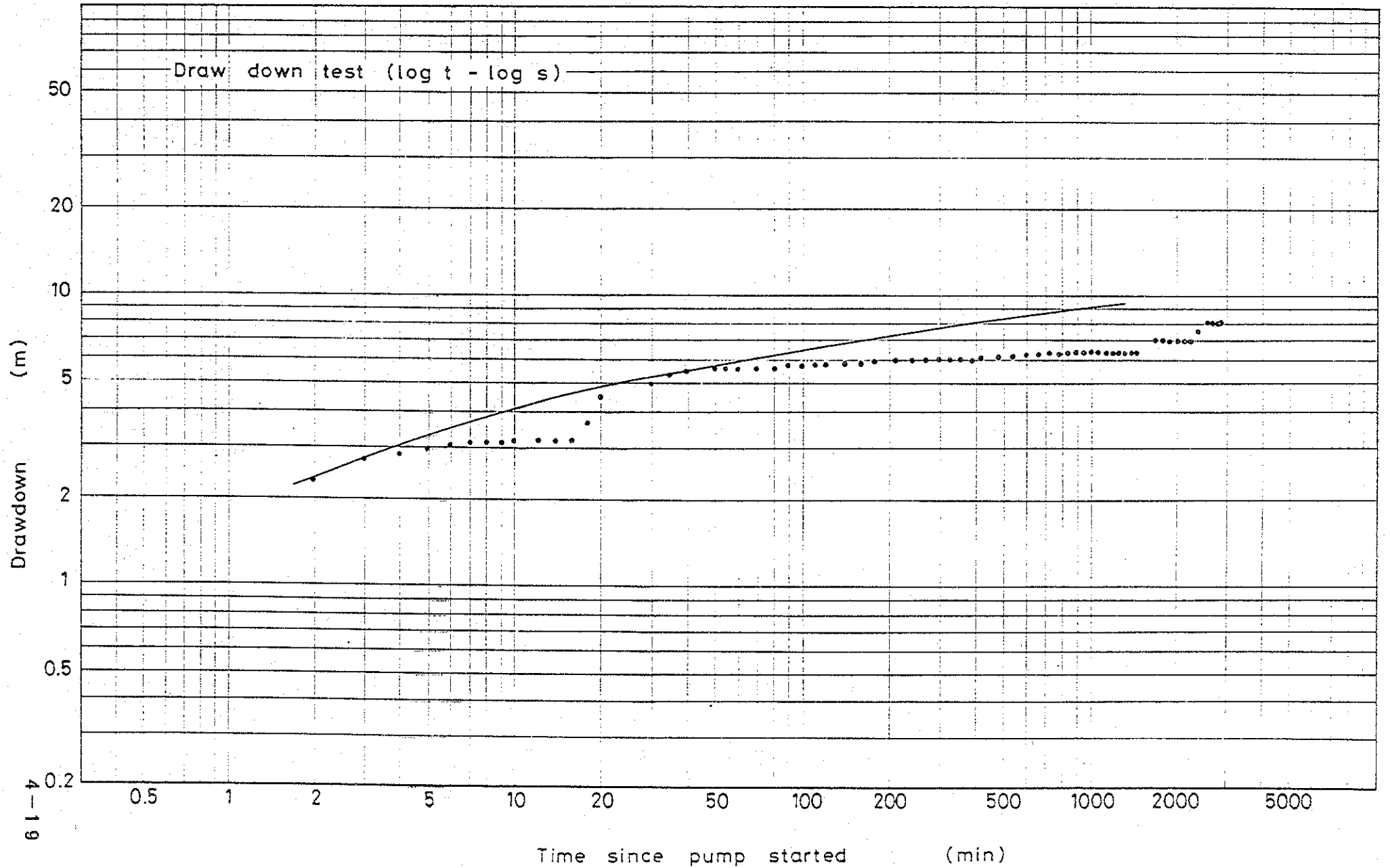

Draw down test (log t - log s)
Time since pump started (min)
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
Drawdown (m)
2.0
3.0
4.0
5.0
6.0
7.0
8.0

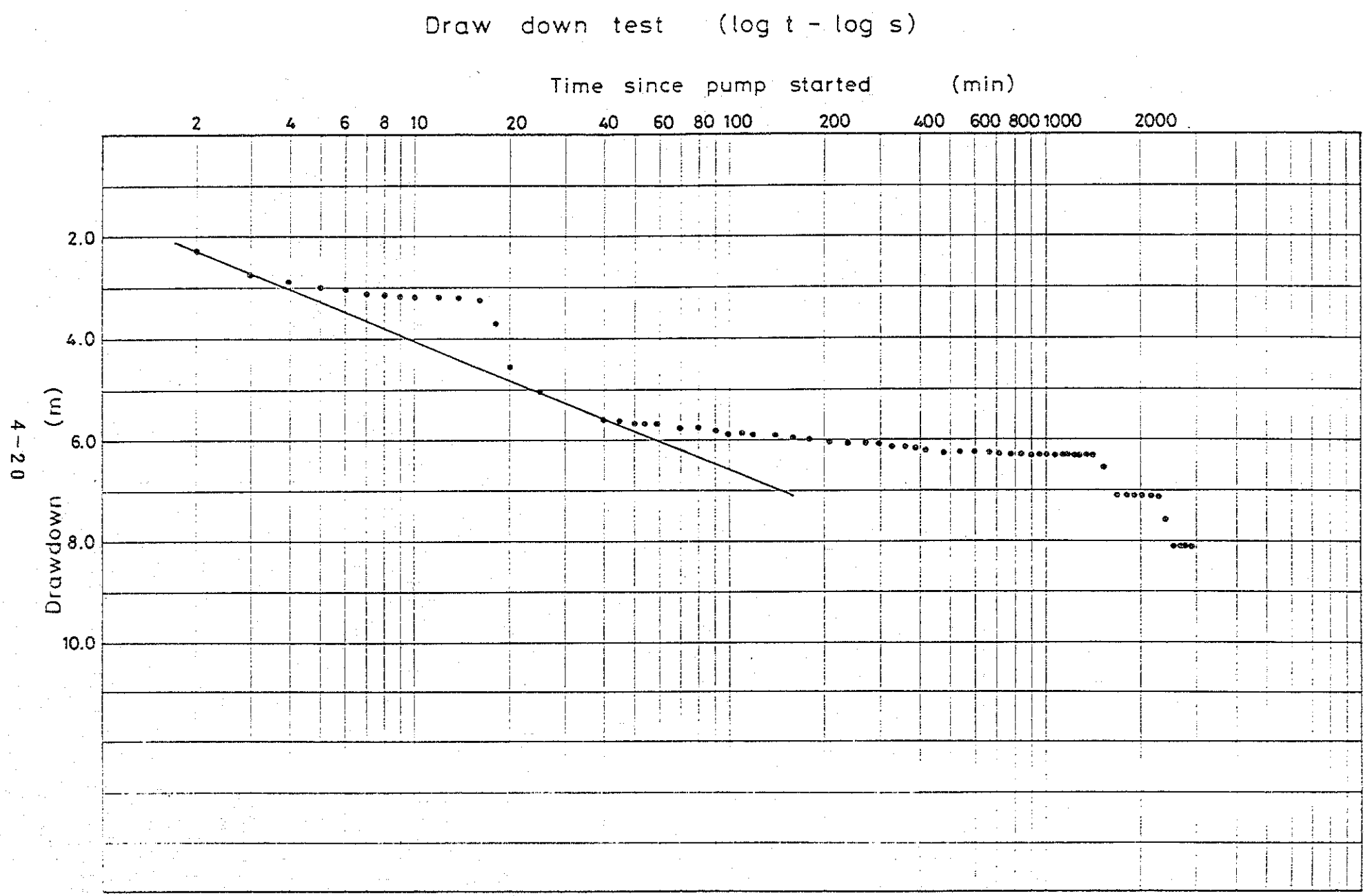
Step drawdown test (log Q - log S)

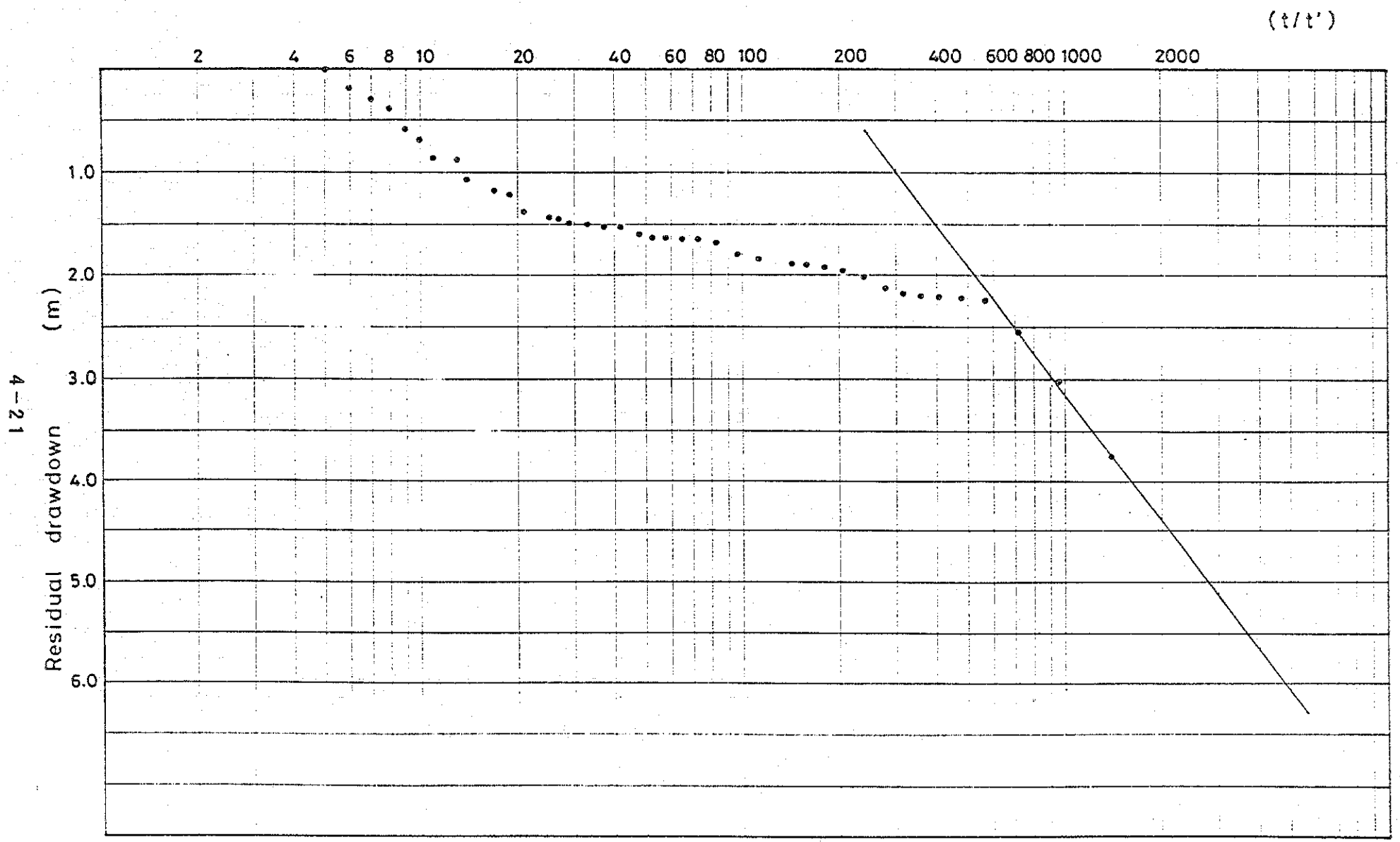


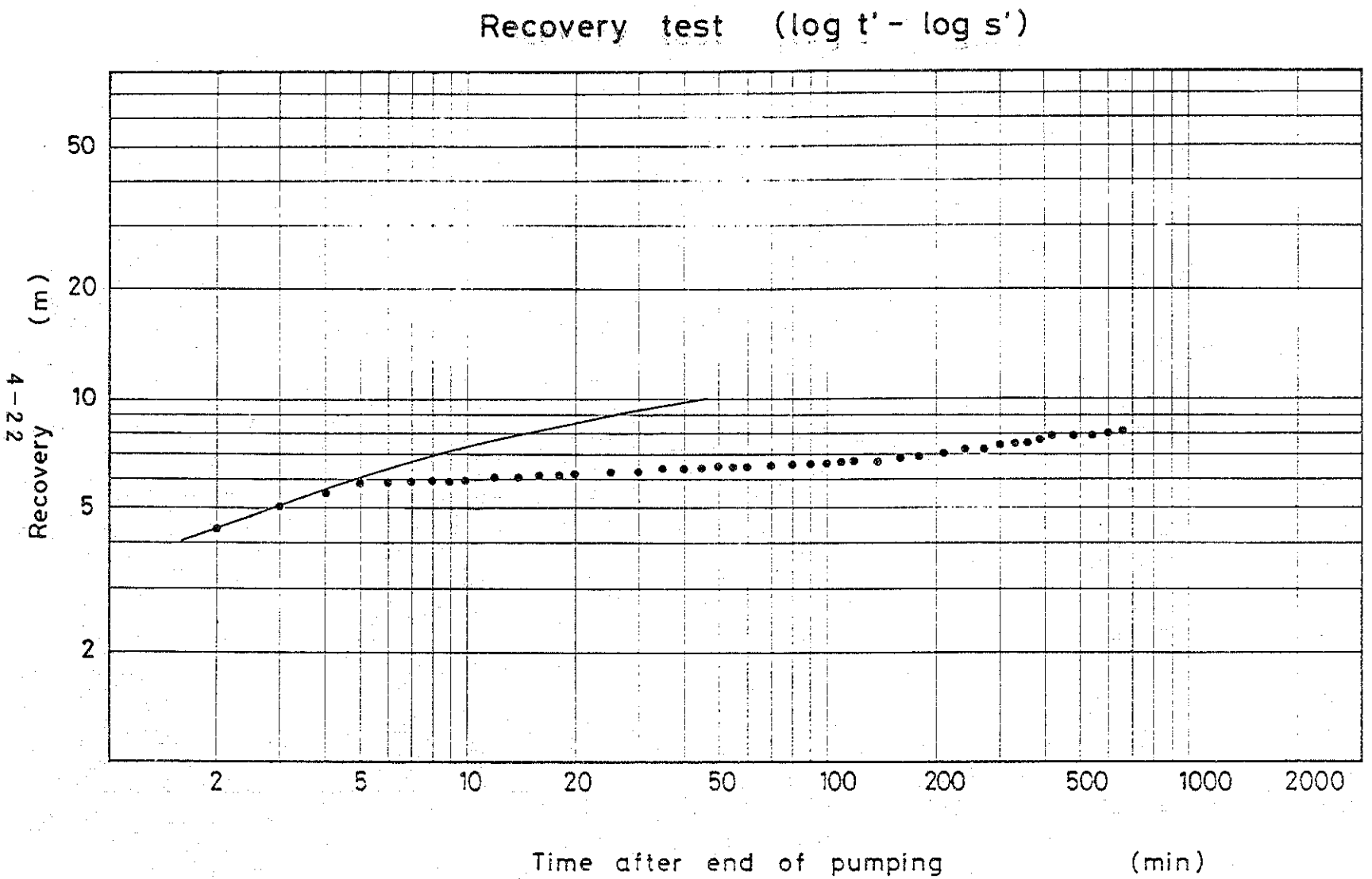
	Pumping rate Q (m³/min)	Drawdown ⊿S (m)	Specific capacity m³/min/m
1	0.04	0.66	0.061
2	0.06	1.95	0.031
3	0.08	2.51	0.032
4	0.10	4.22	0.024
5	0.12	5.31	0.023

Yambuki

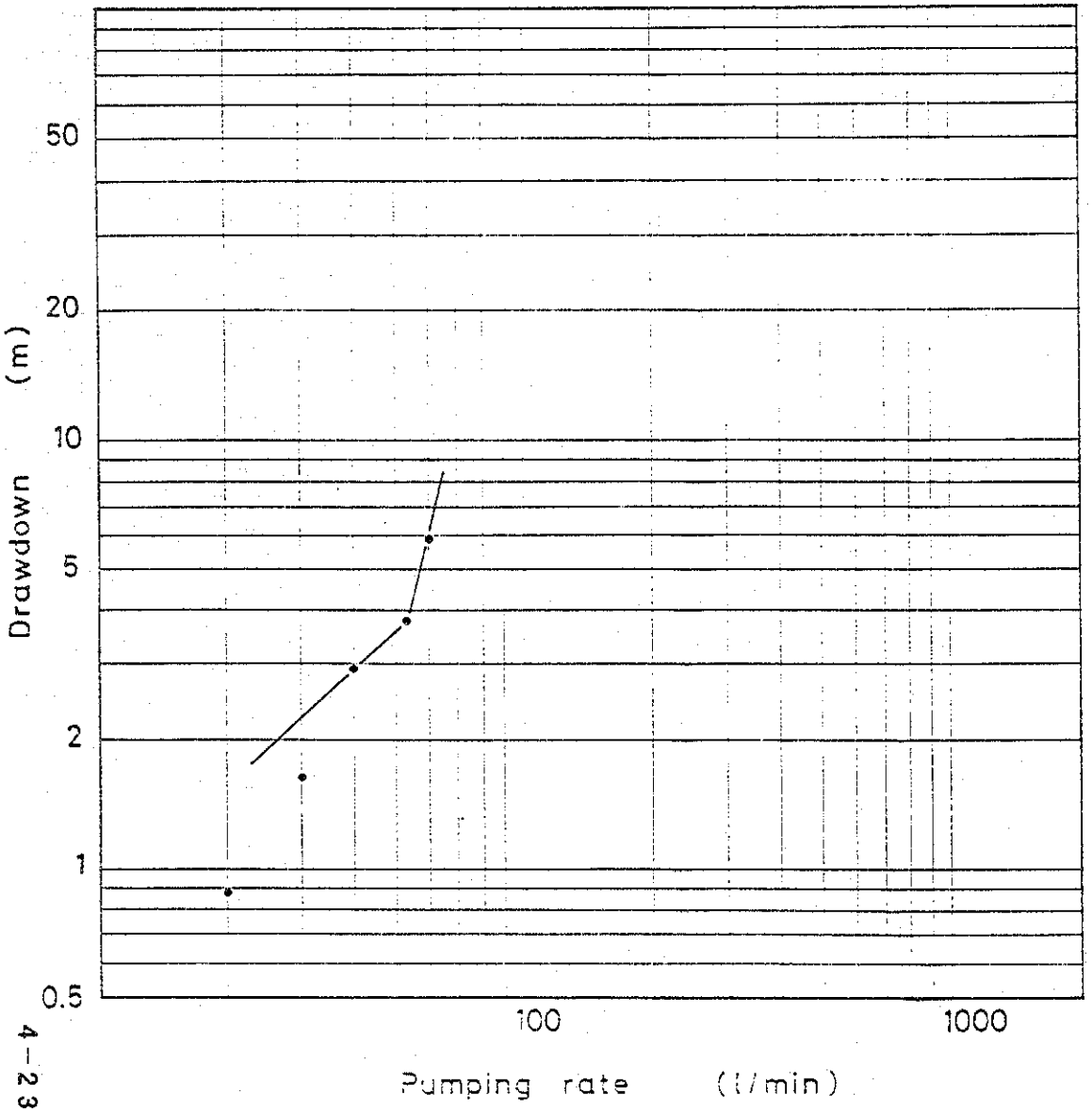

Draw down test (log t - log s)
Drawdown (m)
50
20
10
5
2
1
0.5
0.2
0.5
1
2
5
10
20
50
100
200
500
1000
2000
5000
Time since pump started (min)


Draw down test (log t - log s)
Time since pump started (min)
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
2.0
4.0
6.0
8.0
10.0
Drawdown (m)


Recovery test (log t/t' - S'r)
(t/t')
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
1.0
2.0
3.0
4.0
5.0
6.0
Residual drawdown (m)

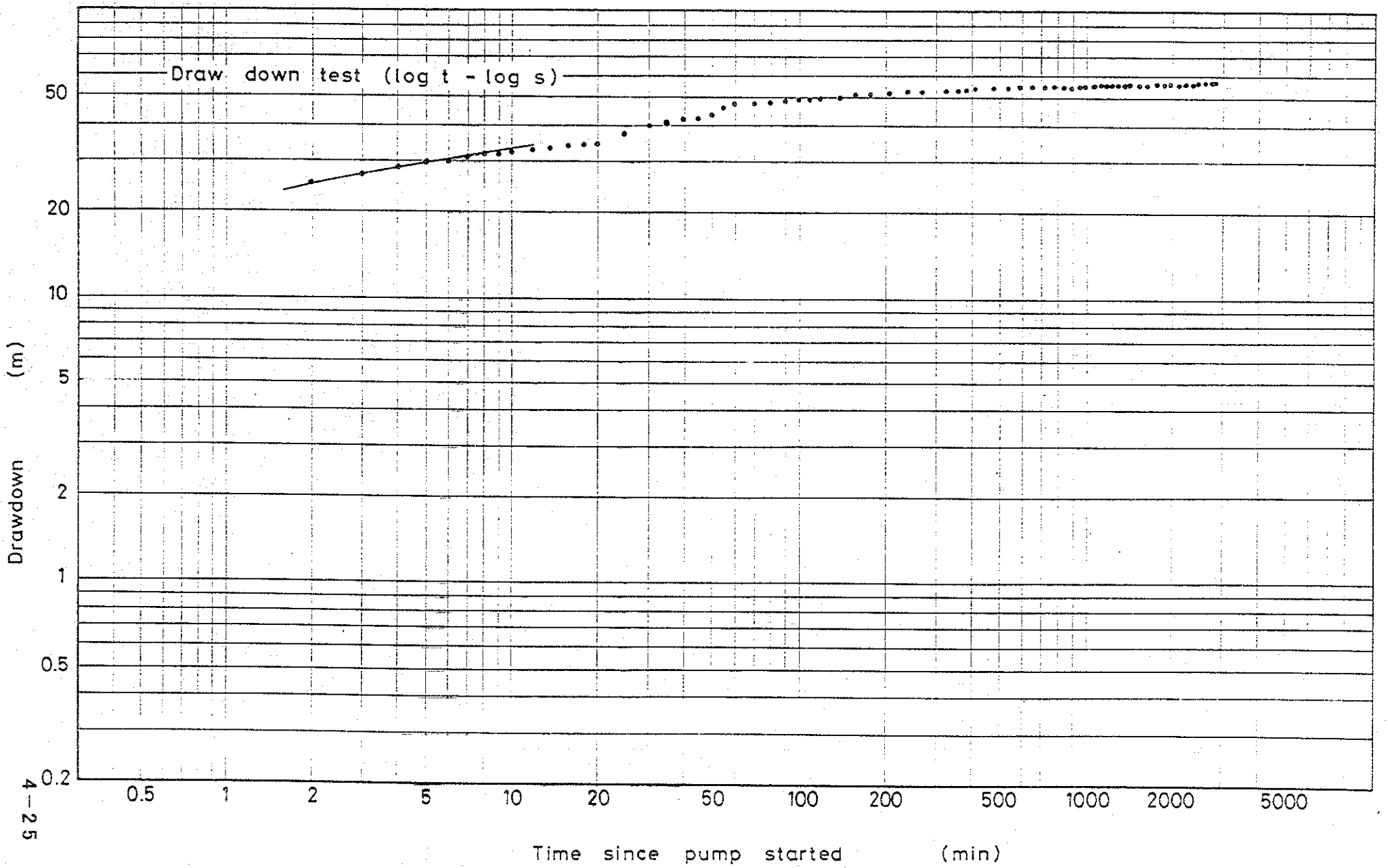

Recovery test (log t' - log s')
Recovery (m)
4 - 22
50
20
10
5
2
2
5
10
20
50
100
200
500
1000
2000
Time after end of pumping (min)

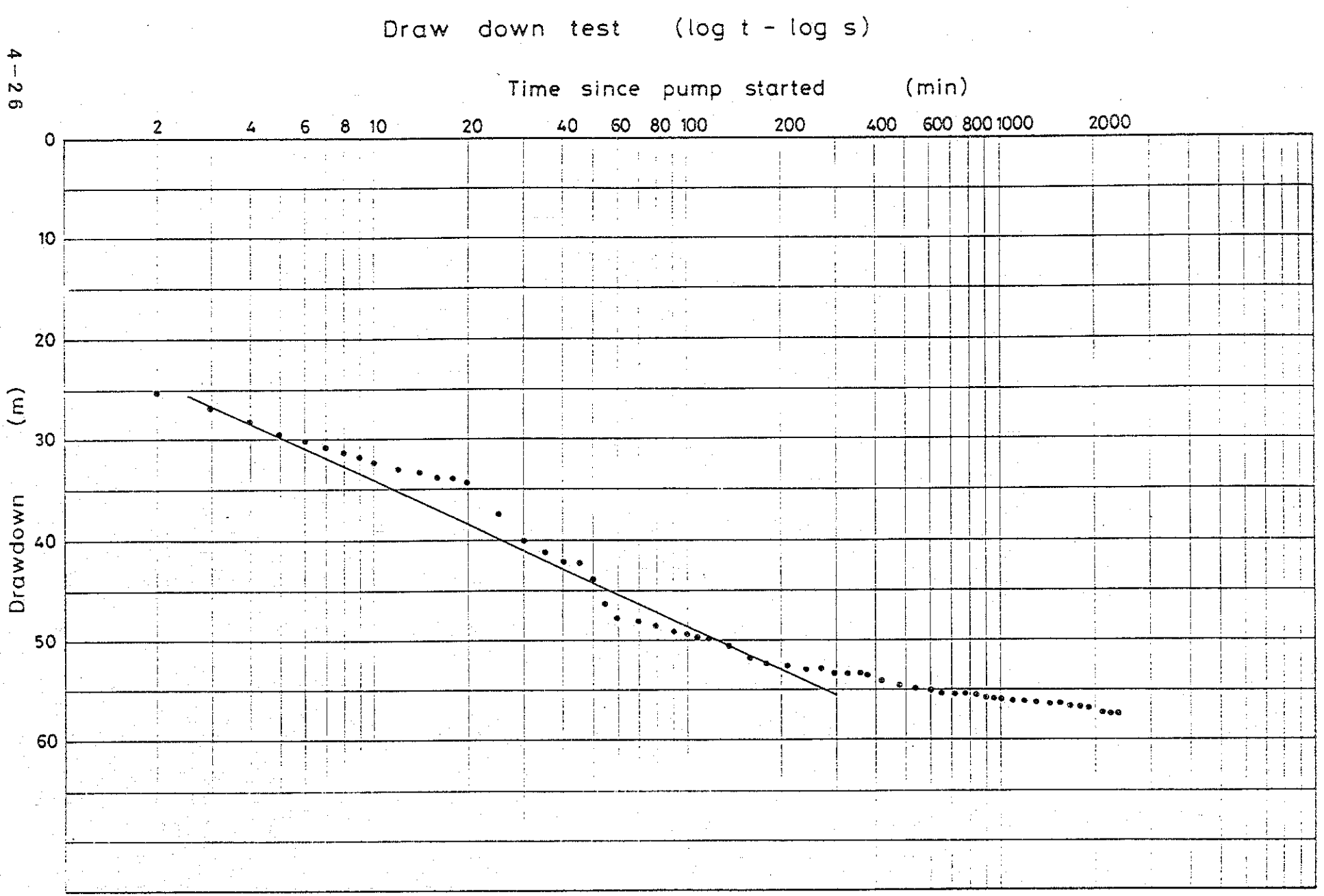
Step drawdown test (log Q - log S)

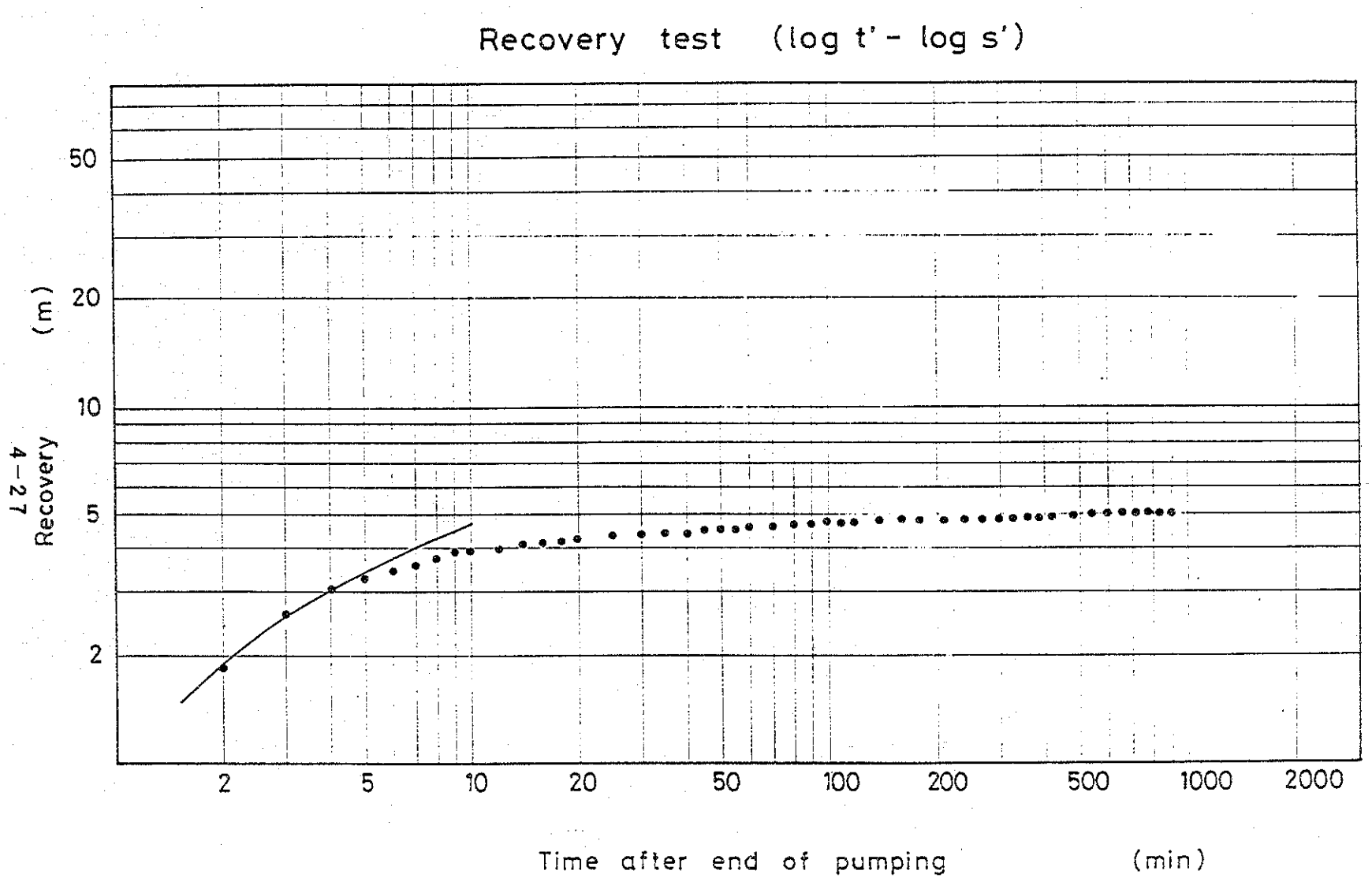


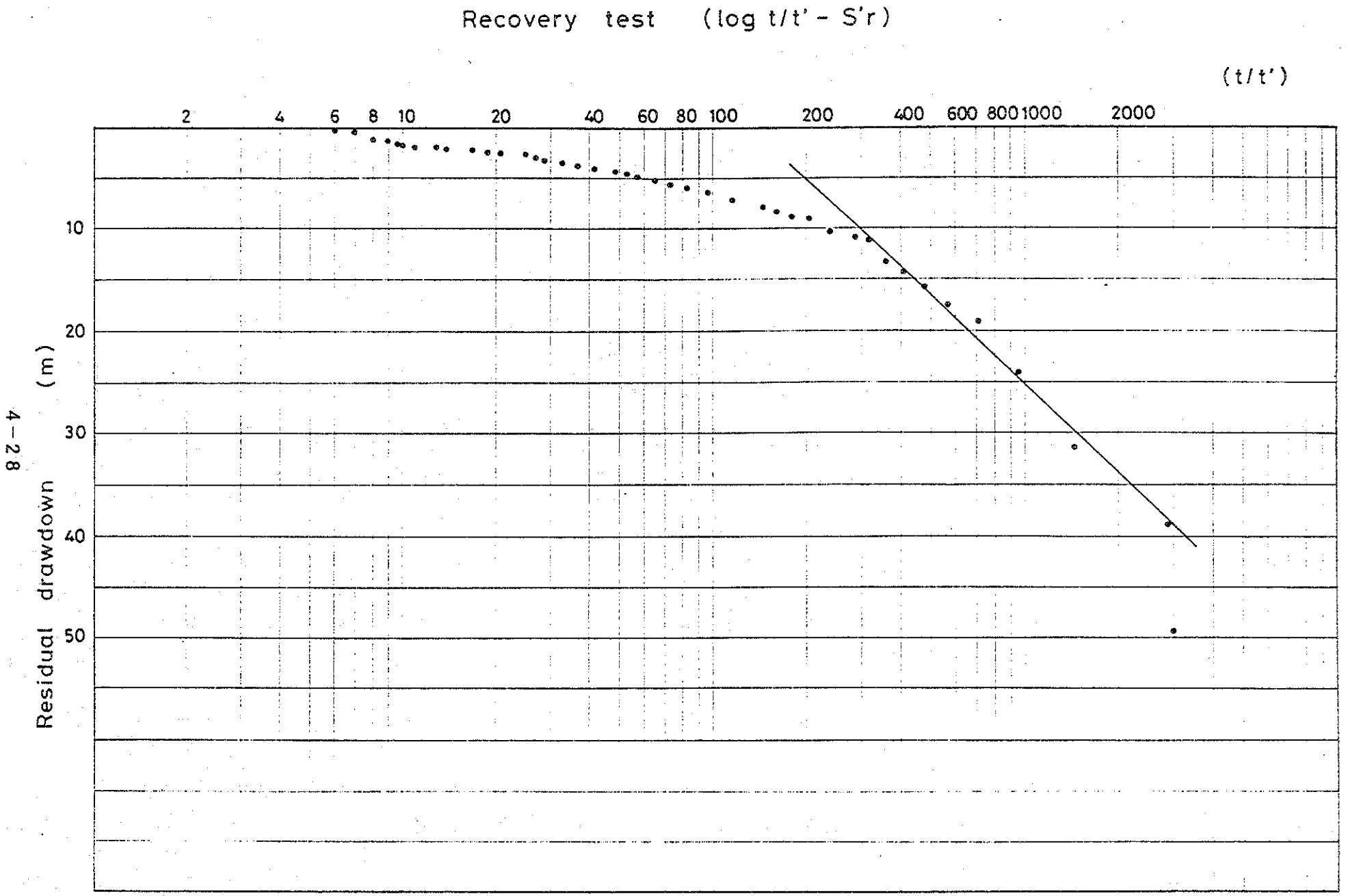
	Pumping rate Q (m³/min)	Drawdown Δ S (m)	Specific capacity m³/min/m
1	0.02	0.88	0.023
2	0.03	1.63	0.018
3	0.04	2.92	0.014
4	0.053	3.78	0.014
5	0.06	5.88	0.010

Maga

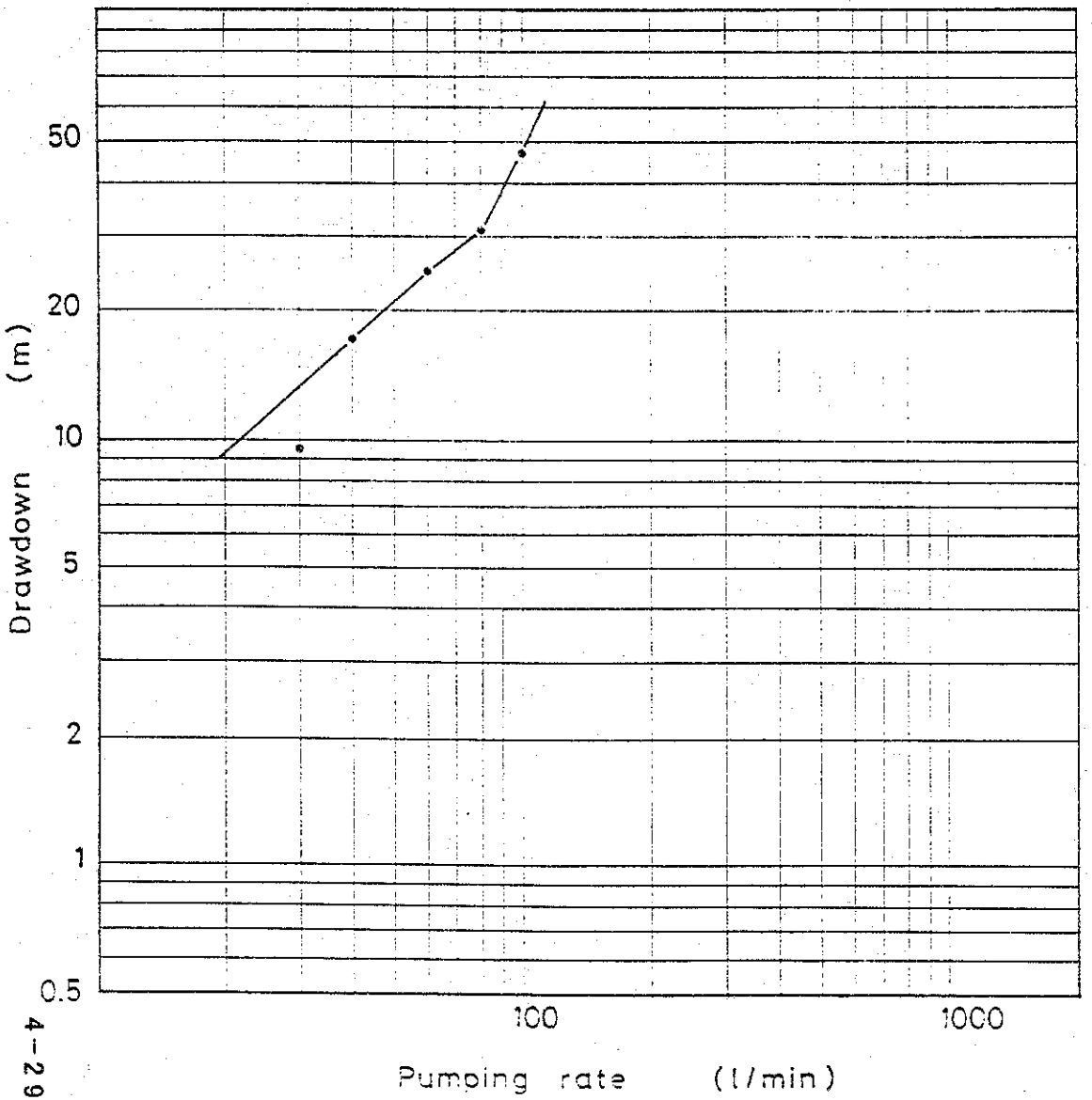

Draw down test (log t - log s)
Drawdown (m)
50
20
10
5
2
1
0.5
0.2
0.5
1
2
5
10
20
50
100
200
500
1000
2000
5000
Time since pump started (min)


Draw down test (log t - log s)
Time since pump started (min)
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
0
10
20
30
40
50
60
Drawdown (m)


Recovery test (log t' - log s')
Recovery (m)
50
20
10
5
2
2
5
10
20
50
100
200
500
1000
2000
Time after end of pumping (min)

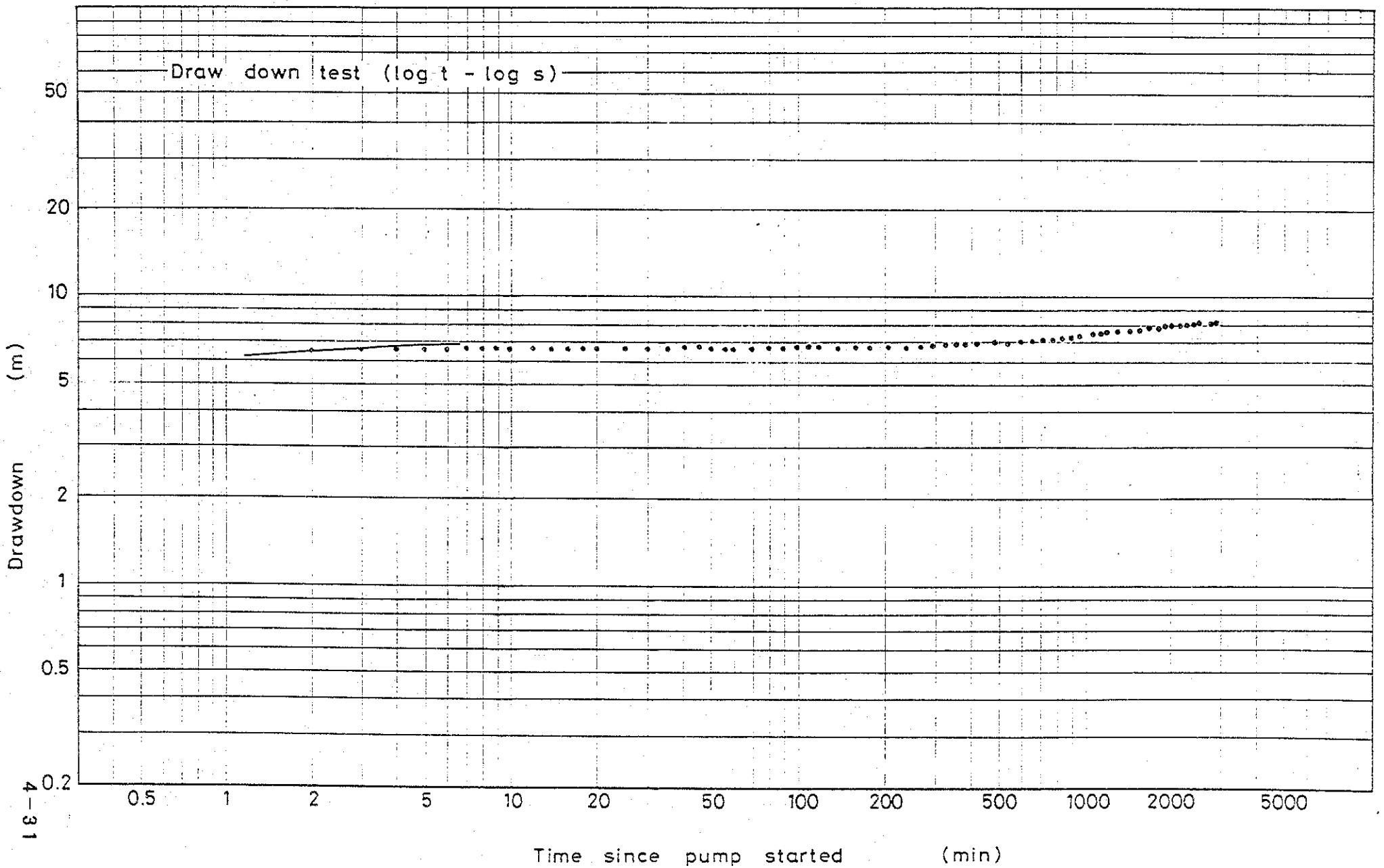

Recovery test (log t/t' - S'r)
(t/t')
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
10
20
30
40
50
Residual drawdown (m)

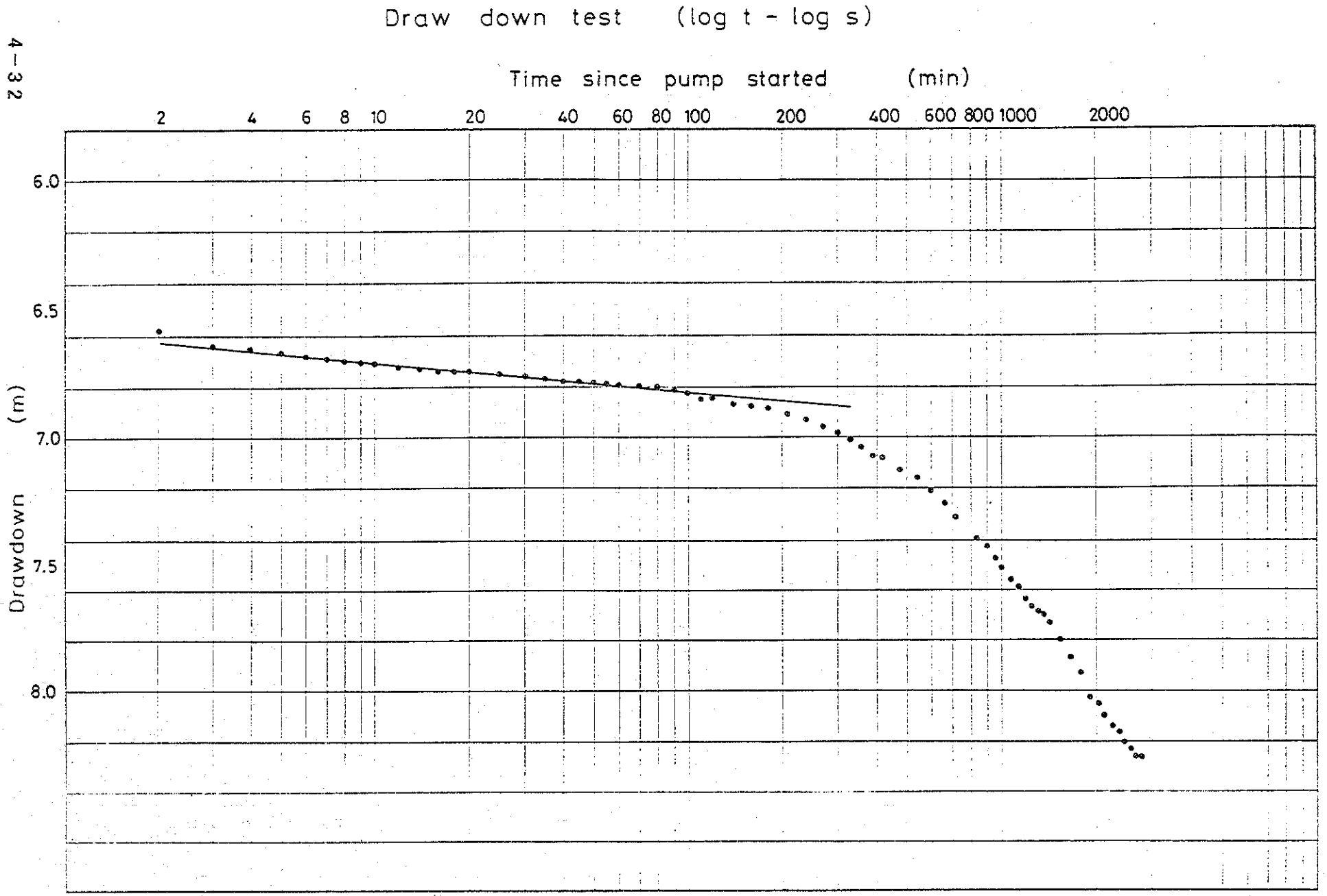
Step drawdown test (log Q - log S)

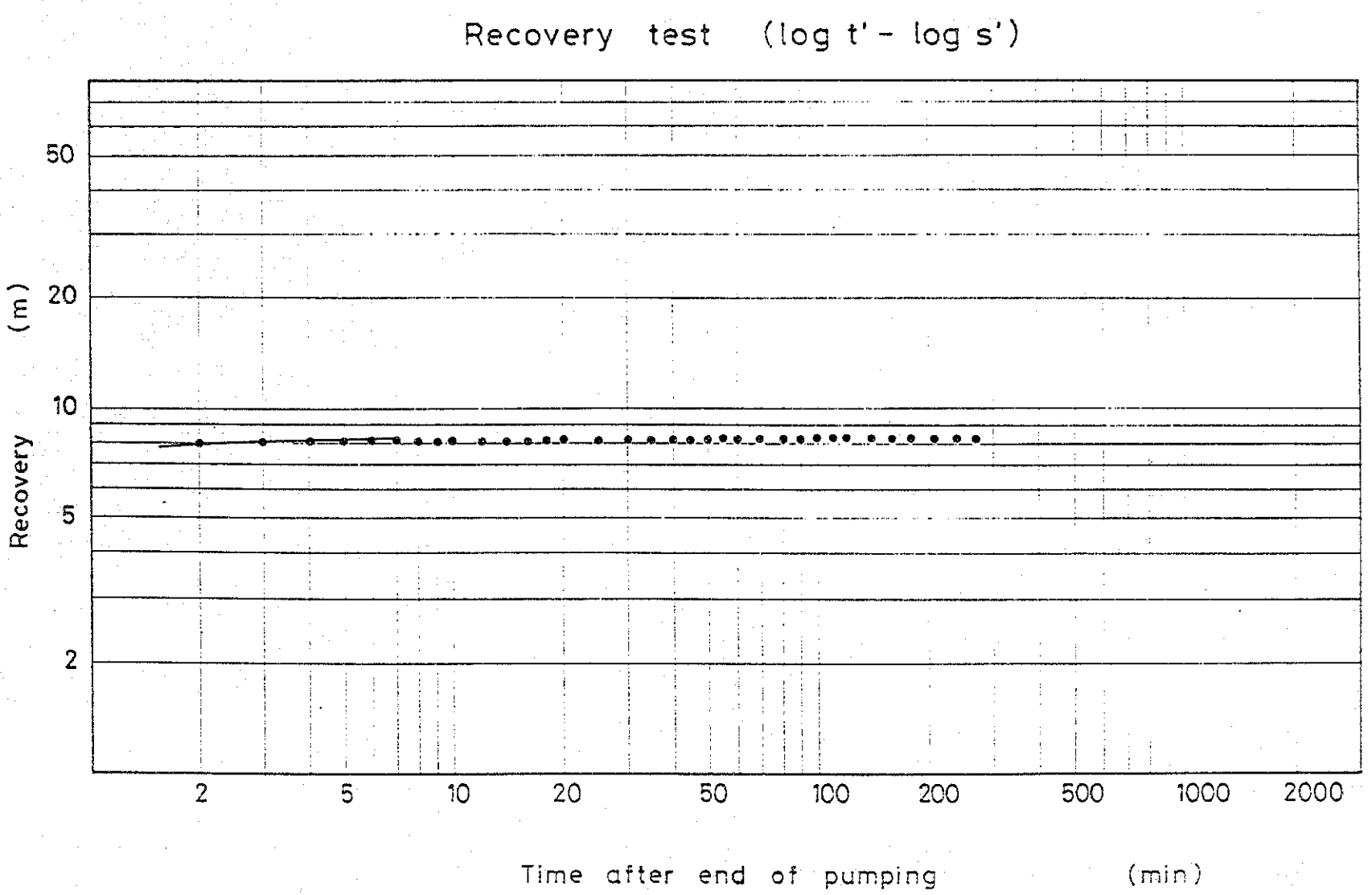


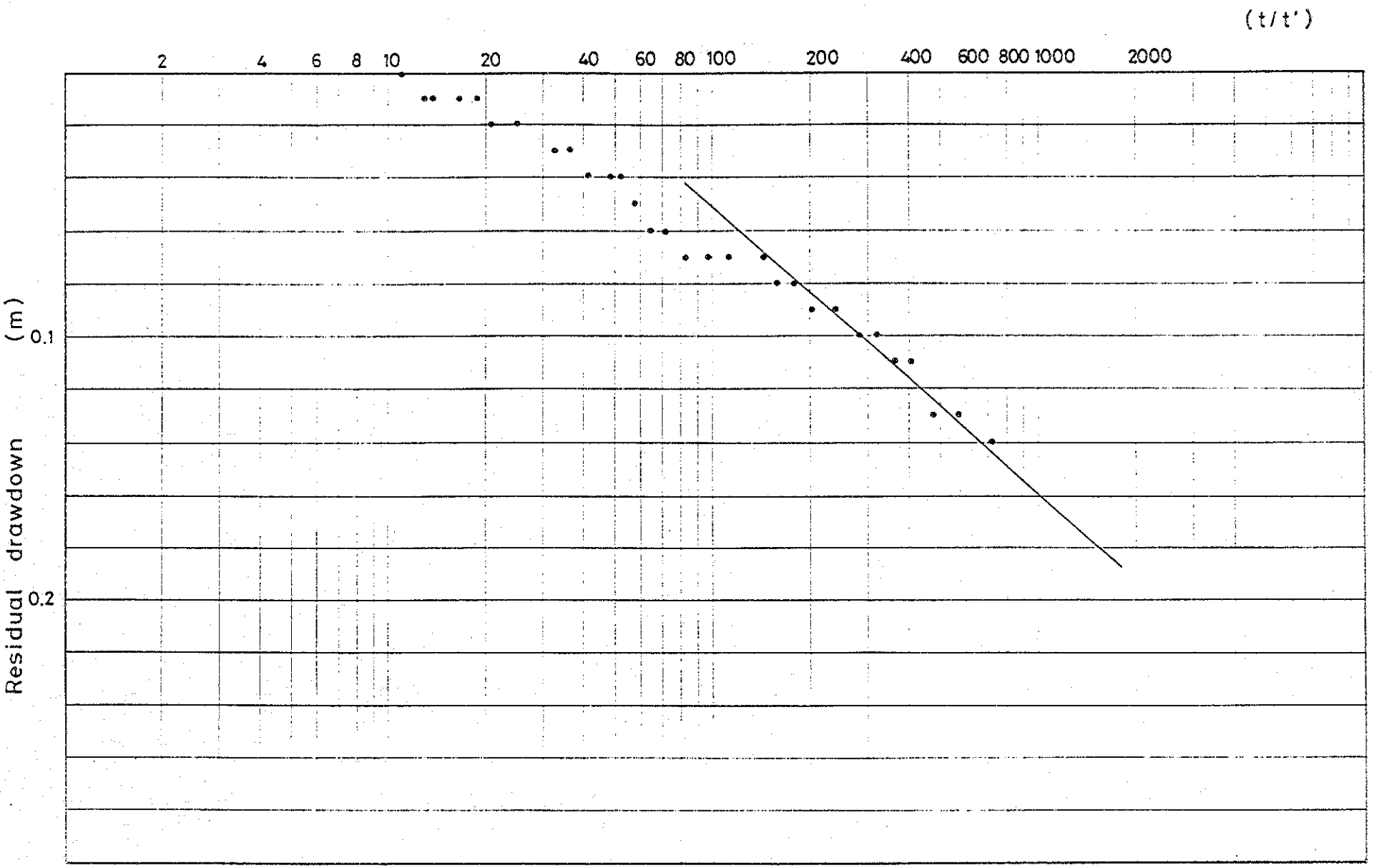
	Pumping rate Q (m³/min)	Drawdown ΔS (m)	Specific capacity m³/min/m
1	0.03	9.57	0.003
2	0.04	17.06	0.002
3	0.06	24.84	0.002
4	0.08	31.08	0.003
5	0.10	46.89	0.002

Horo Birni

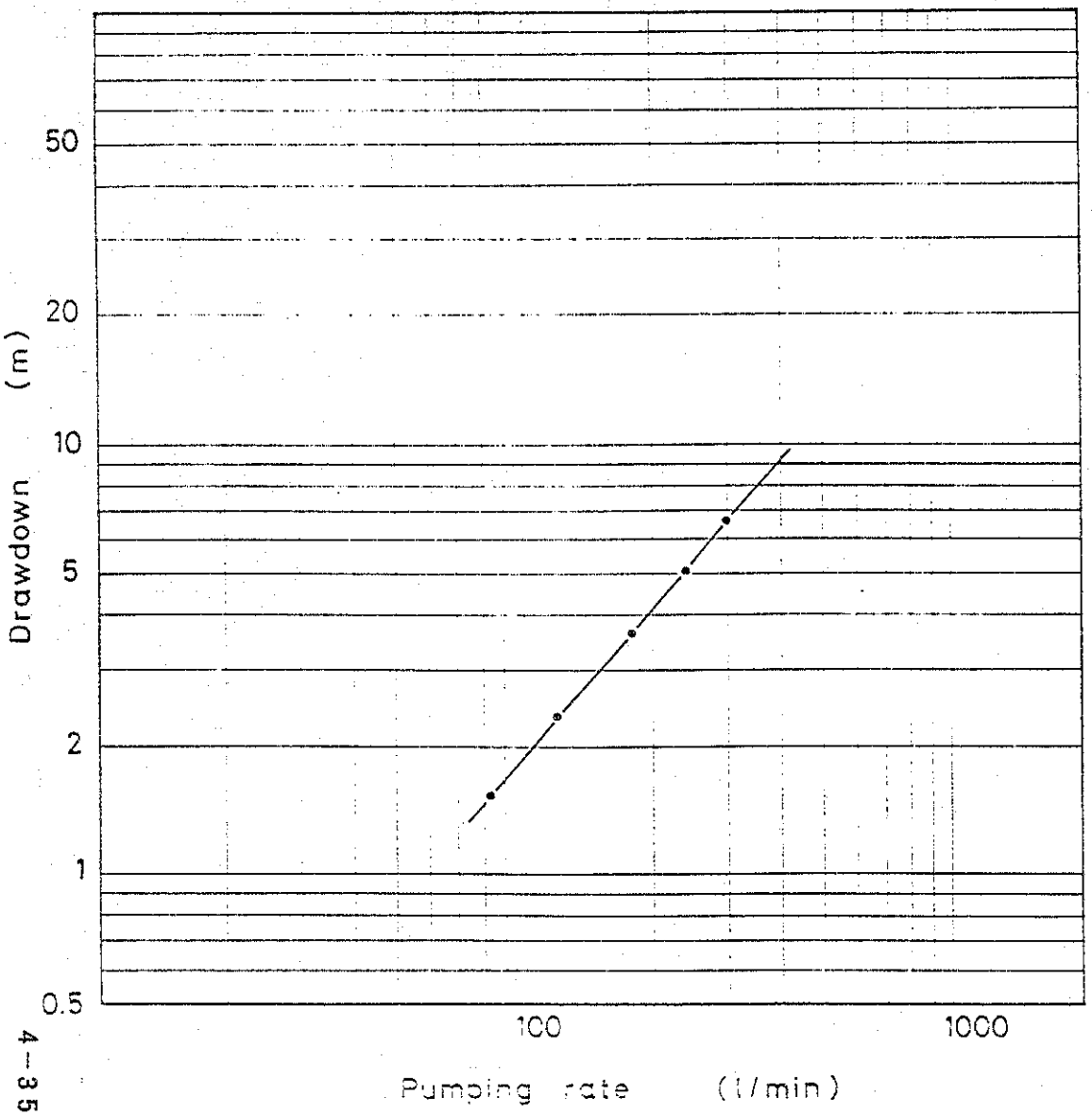

Draw down test (log t - log s)
Drawdown (m)
50
20
10
5
2
1
0.5
0.2
0.5
1
2
5
10
20
50
100
200
500
1000
2000
5000
Time since pump started (min)


Draw down test (log t - log s)
Time since pump started (min)
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
6.0
6.5
7.0
7.5
8.0
Drawdown (m)


Recovery test (log t' - log s')
Recovery (m)
50
20
10
5
2
2
5
10
20
50
100
200
500
1000
2000
Time after end of pumping (min)

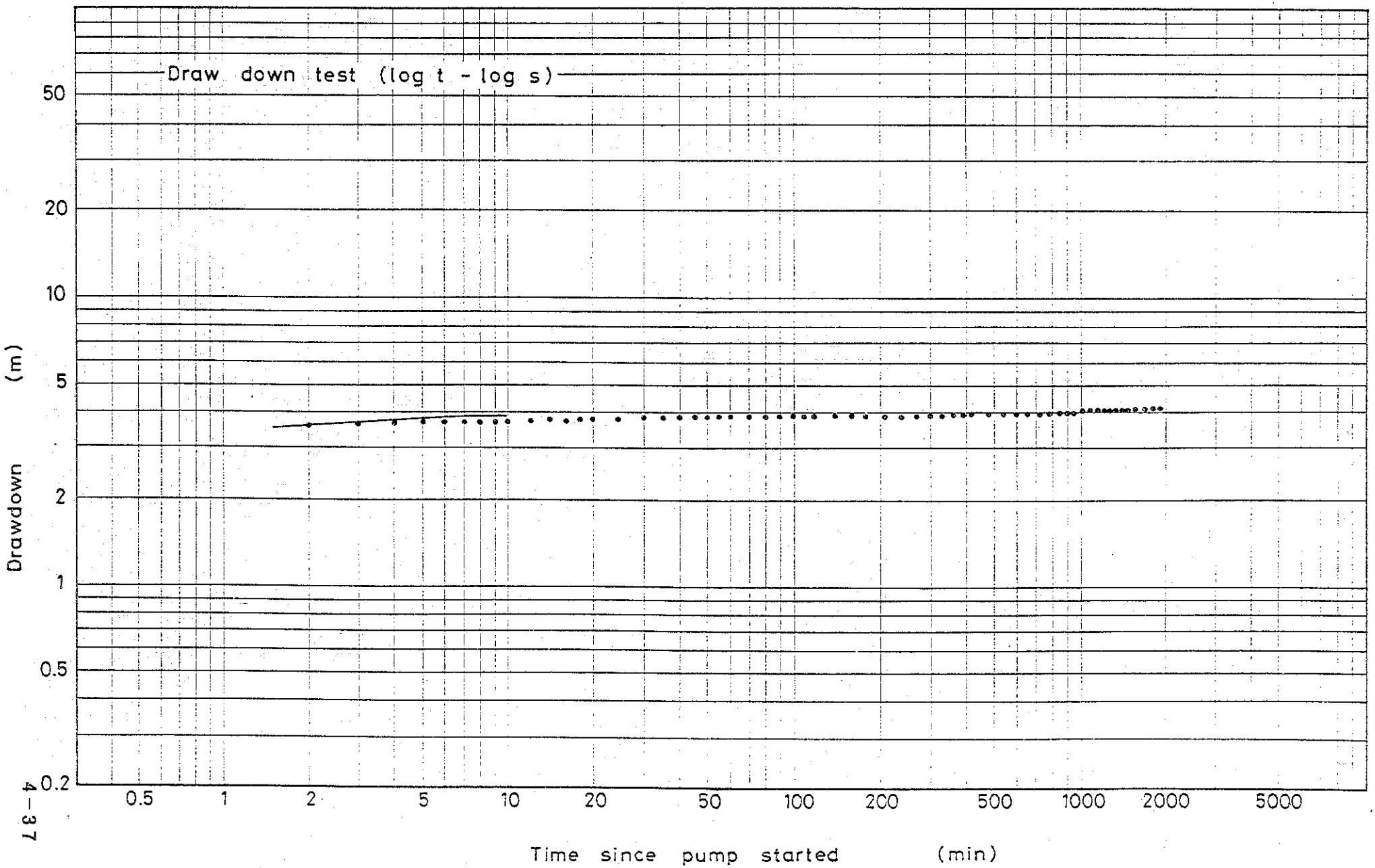

Recovery test (log t/t' - S'r)
(t/t')
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
Residual drawdown (m)
0.1
0.2

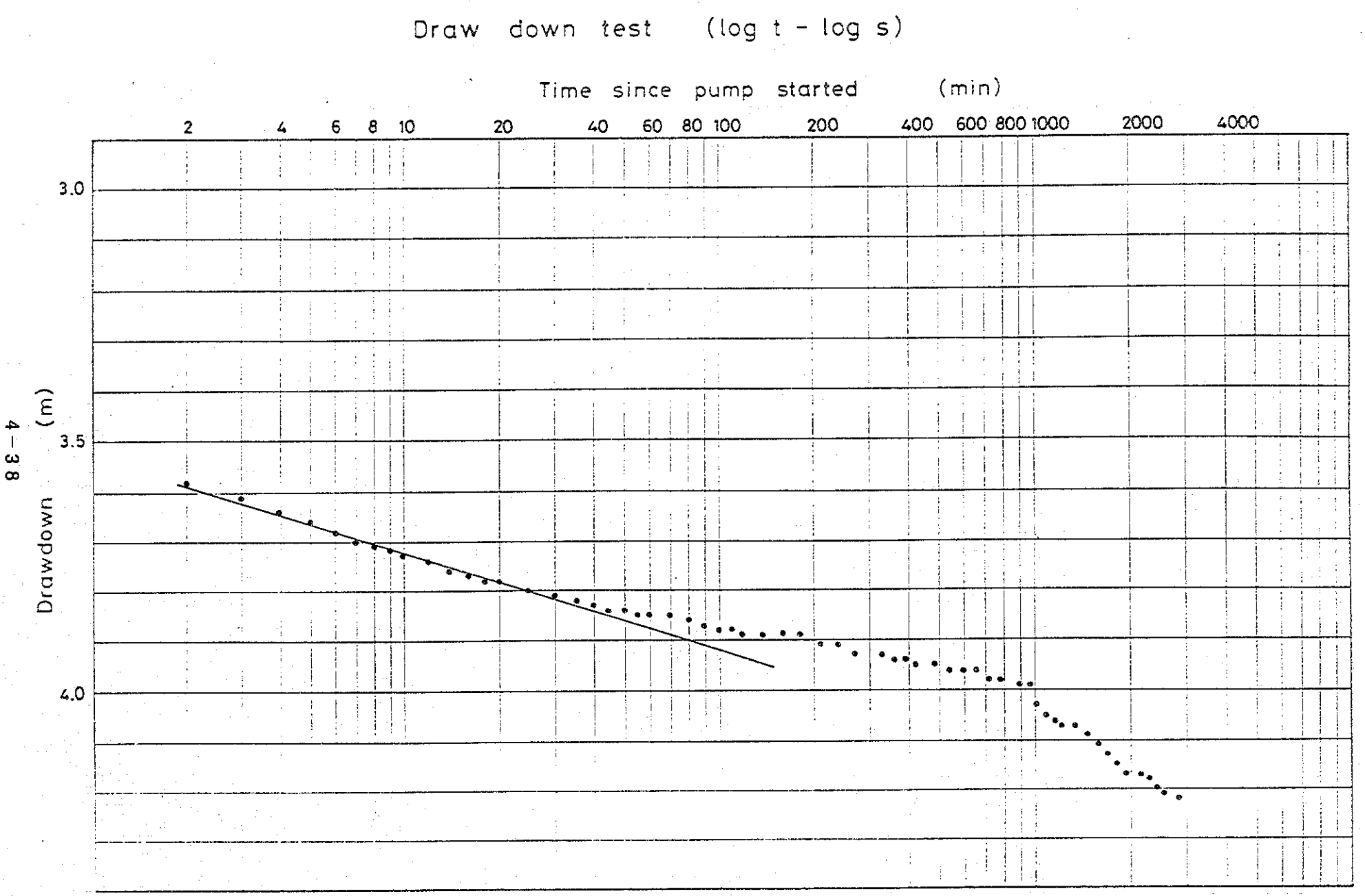
Step drawdown test (log Q - log S)

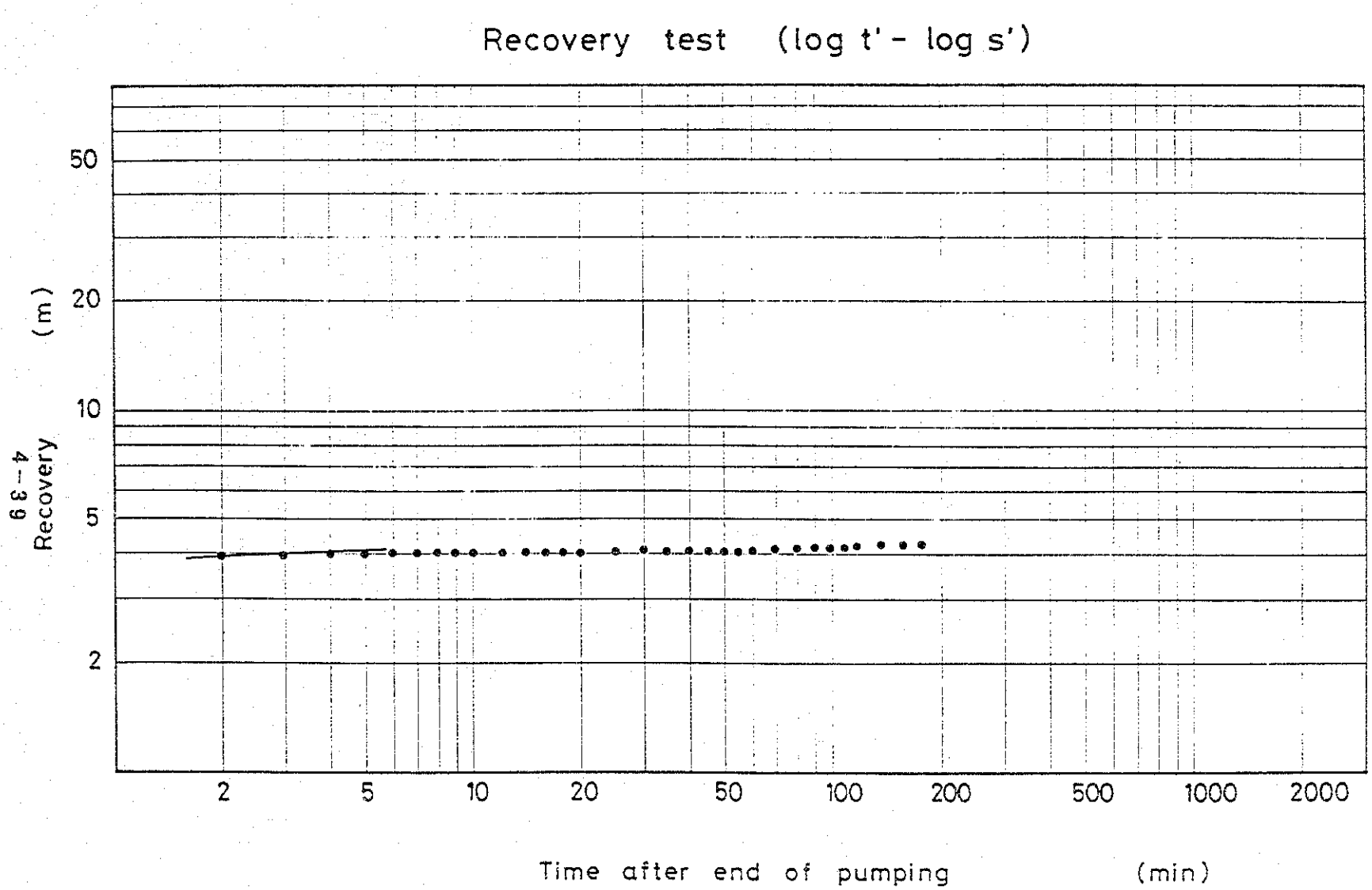


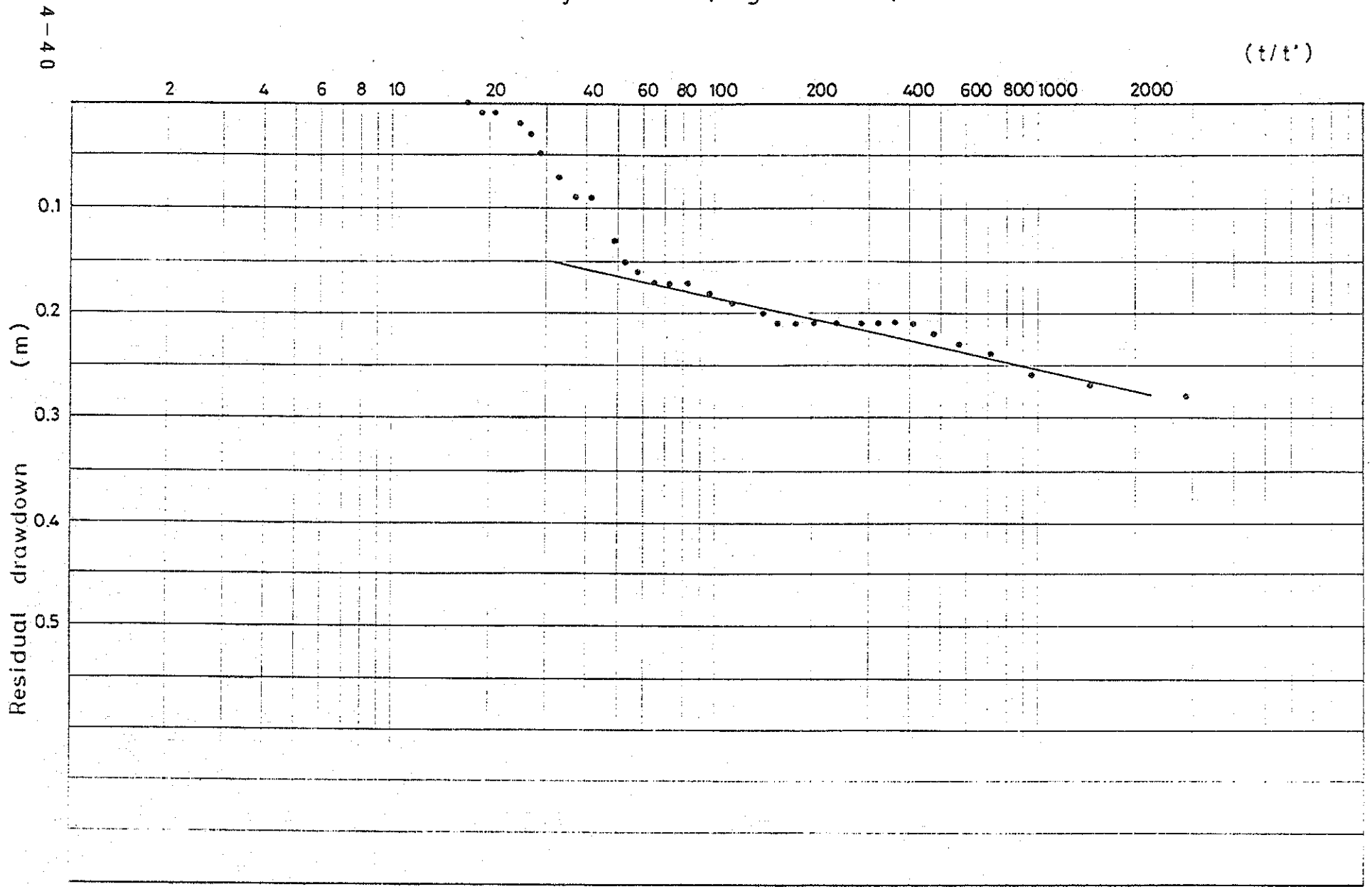
	Pumping rate Q (m³/min)	Drawdown ⊿S (m)	Specific capacity m³/min/m
1	0.083	1.52	0.055
2	0.120	2.34	0.051
3	0.180	3.81	0.047
4	0.240	5.07	0.047
5	0.300	6.61	0.045

Soro

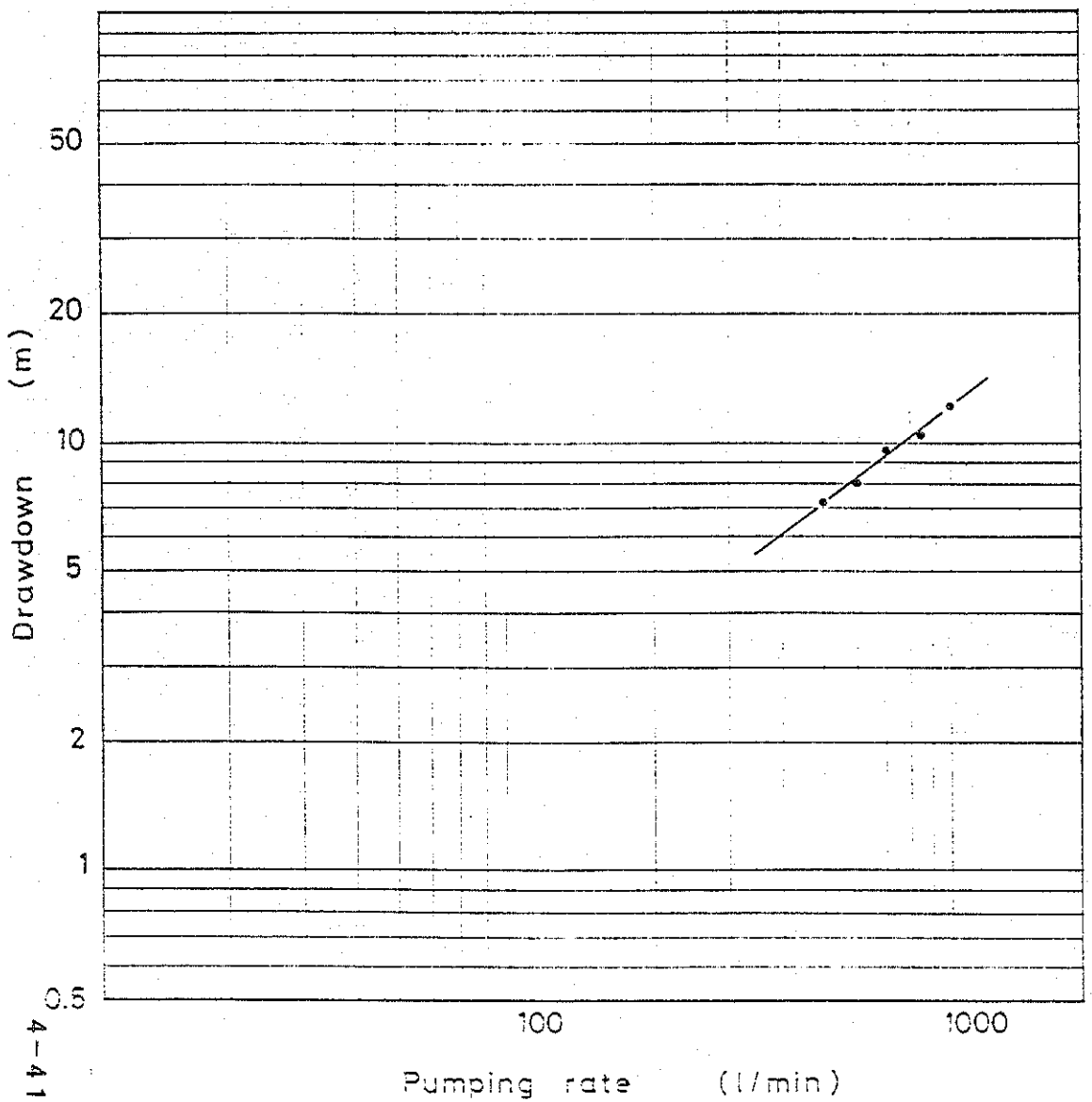

Draw down test (log t - log s)
Drawdown (m)
50
20
10
5
2
1
0.5
0.2
0.5
1
2
5
10
20
50
100
200
500
1000
2000
5000
Time since pump started (min)


Draw down test (log t - log s)
Time since pump started (min)
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
4000
3.0
3.5
4.0
Drawdown (m)


Recovery test (log t' - log s')
Recovery 4-39
(m)
50
20
10
5
2
2
5
10
20
50
100
200
500
1000
2000
Time after end of pumping (min)

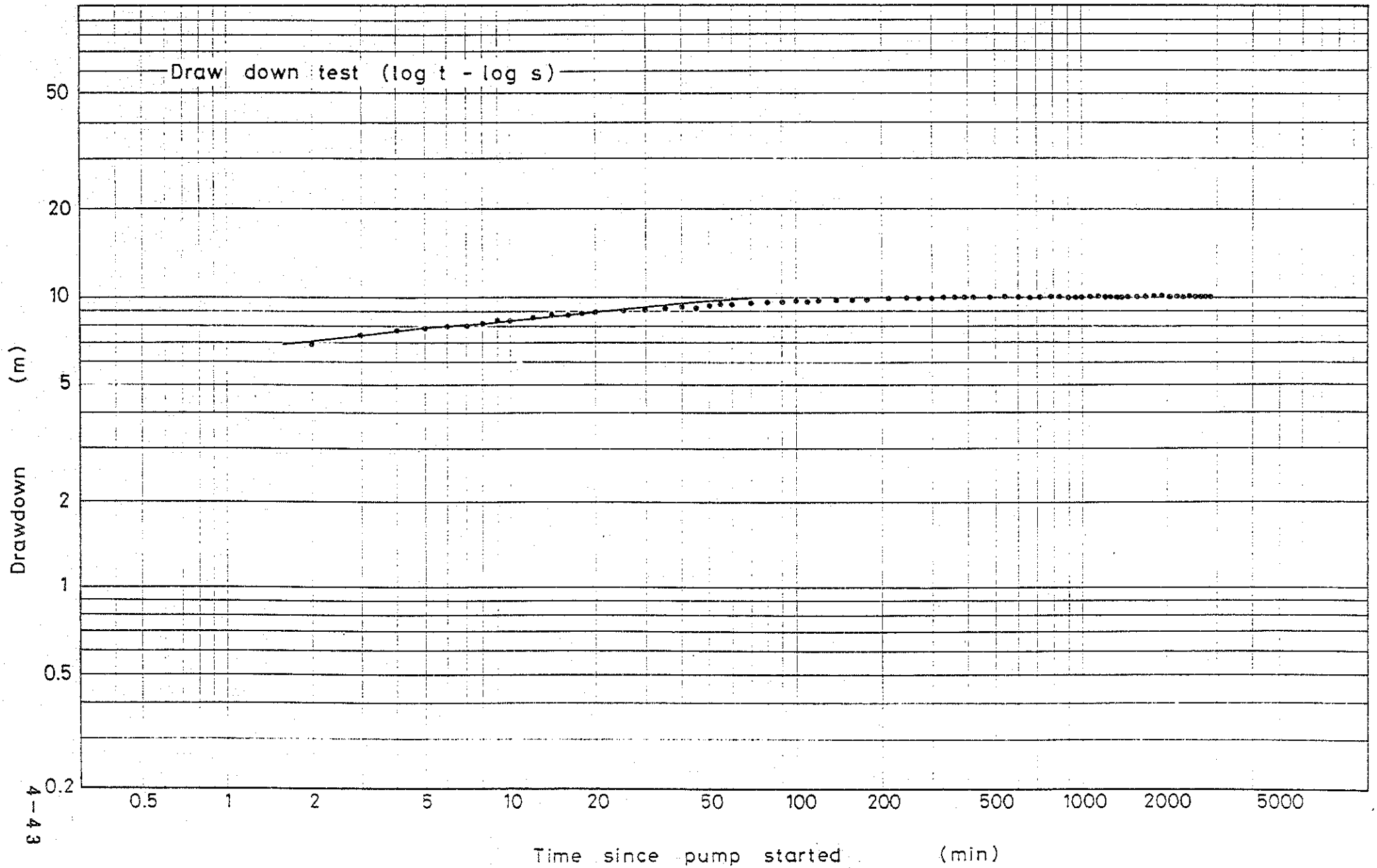

Recovery test (log t/t' - S'r)
4-40
(t/t')
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
0.1
0.2
0.3
0.4
0.5
Residual drawdown (m)

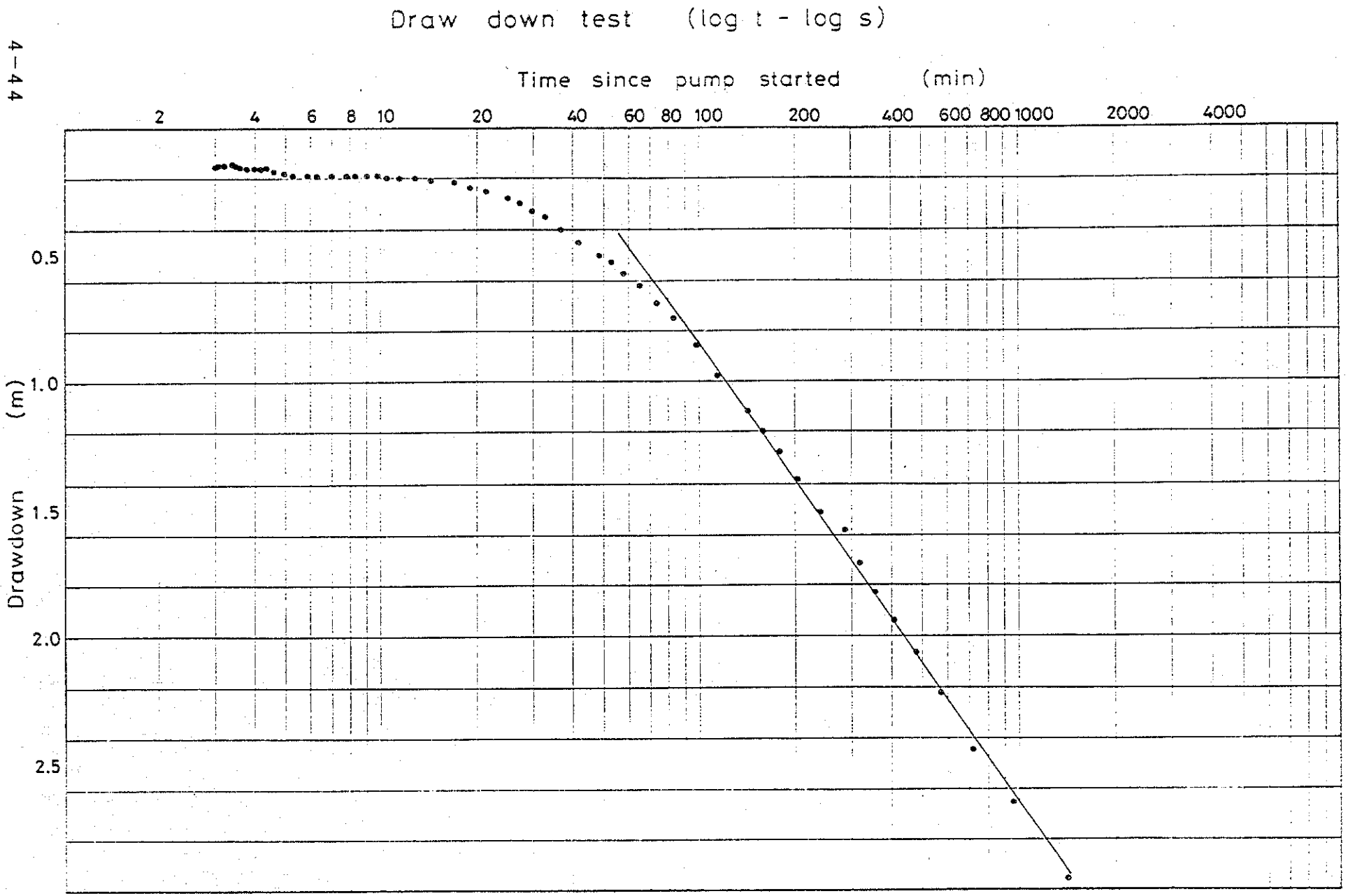
Step drawdown test (log Q - log S)

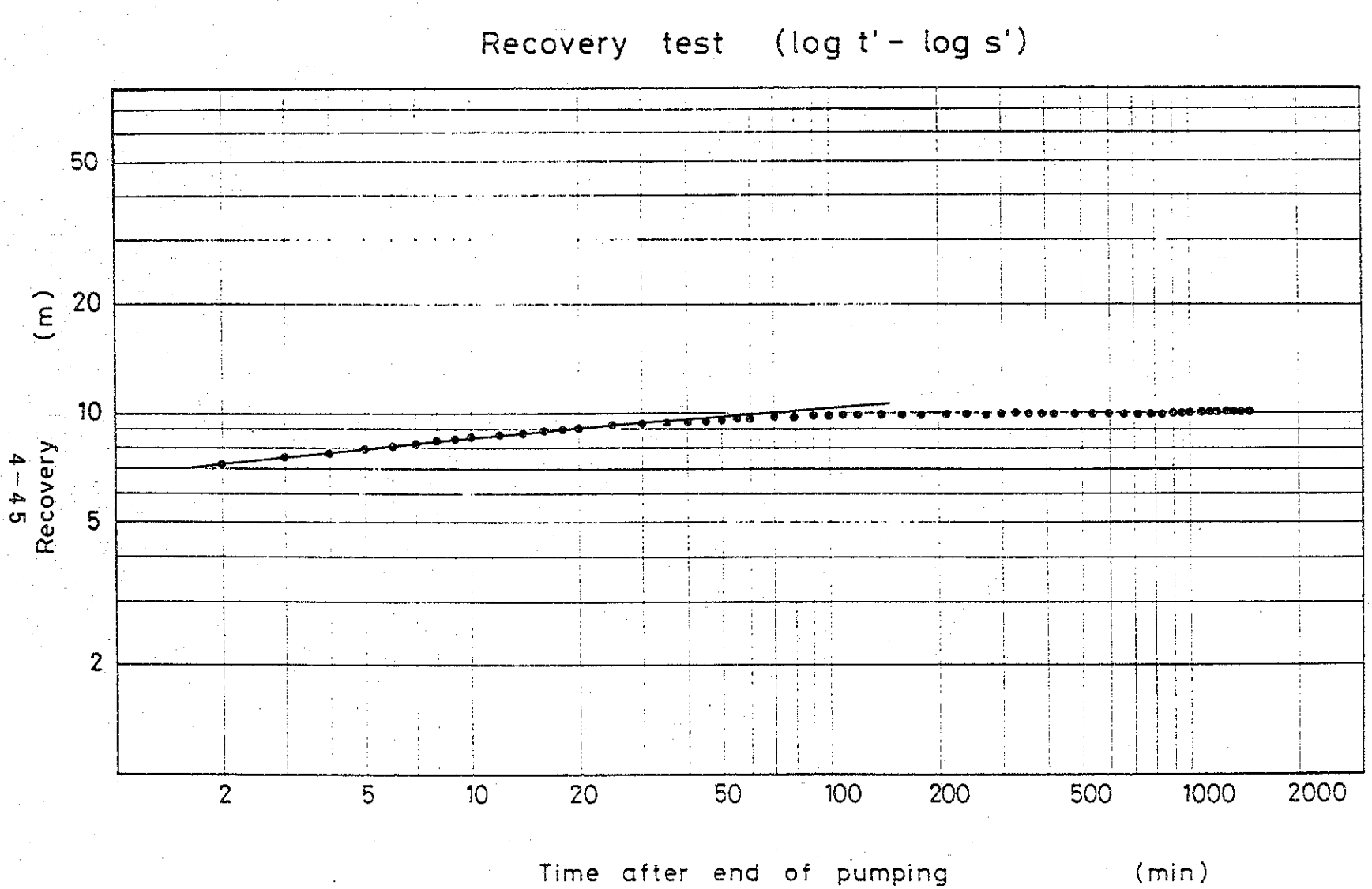


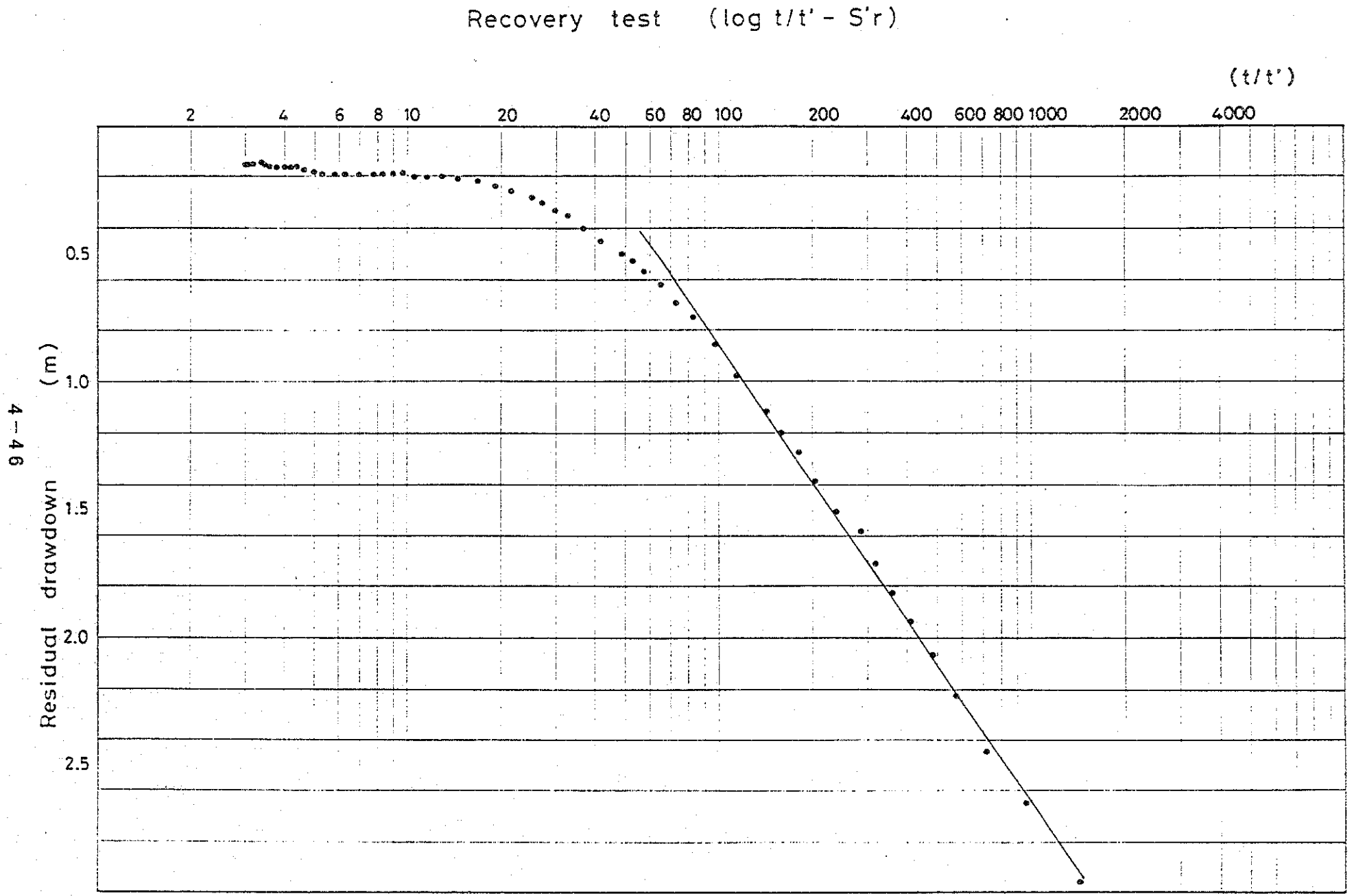
	Pumping rate Q (m^3/min)	Drawdown ΔS (m)	Specific capacity m^3/min/m
1	0.50	7.24	0.069
2	0.60	8.07	0.074
3	0.70	9.65	0.073
4	0.85	10.34	0.082
5	1.00	12.13	0.082

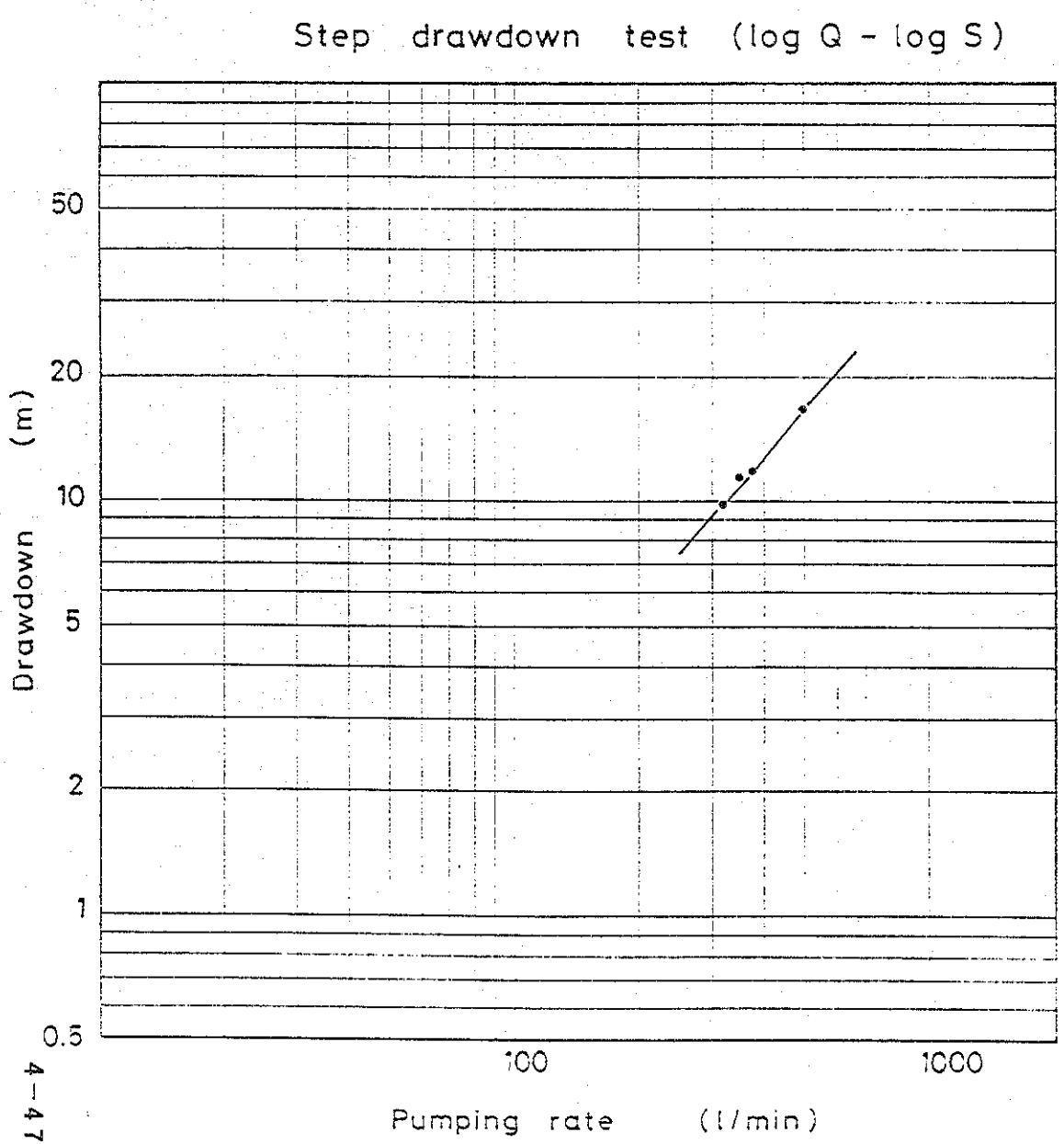
Kuka Kogo


Draw down test (log t - log s)
Drawdown (m)
50
20
10
5
2
1
0.5
0.2
0.5
1
2
5
10
20
50
100
200
500
1000
2000
5000
Time since pump started (min)


Draw down test (log t - log s)
Time since pump started (min)
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
4000
Drawdown (m)
0.5
1.0
1.5
2.0
2.5


Recovery test (log t' - log s')
Recovery (m)
50
20
10
5
2
2
5
10
20
50
100
200
500
1000
2000
Time after end of pumping (min)

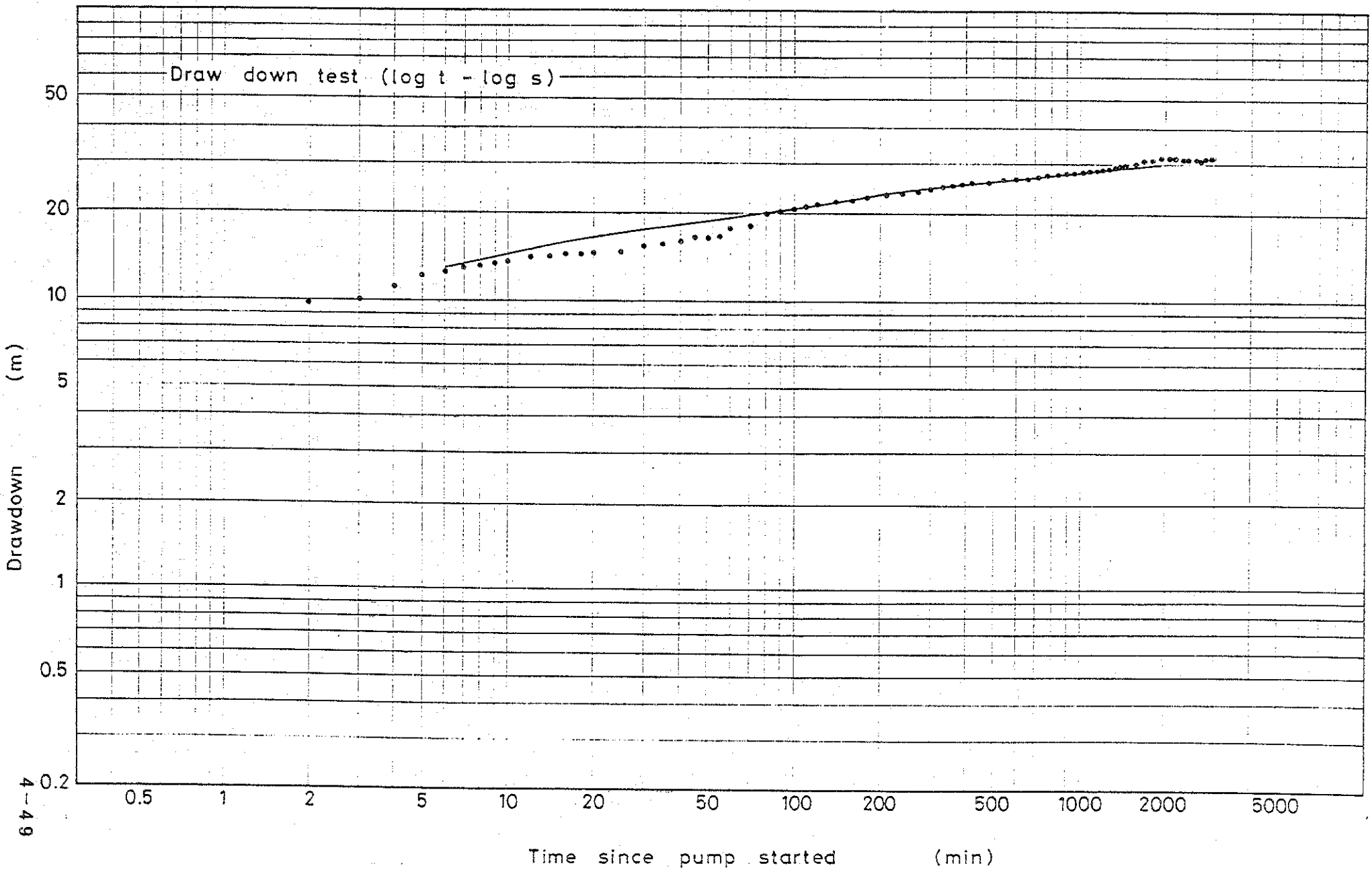

Recovery test (log t/t' - S'r)
(t/t')
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
4000
0.5
1.0
1.5
2.0
2.5
Residual drawdown (m)

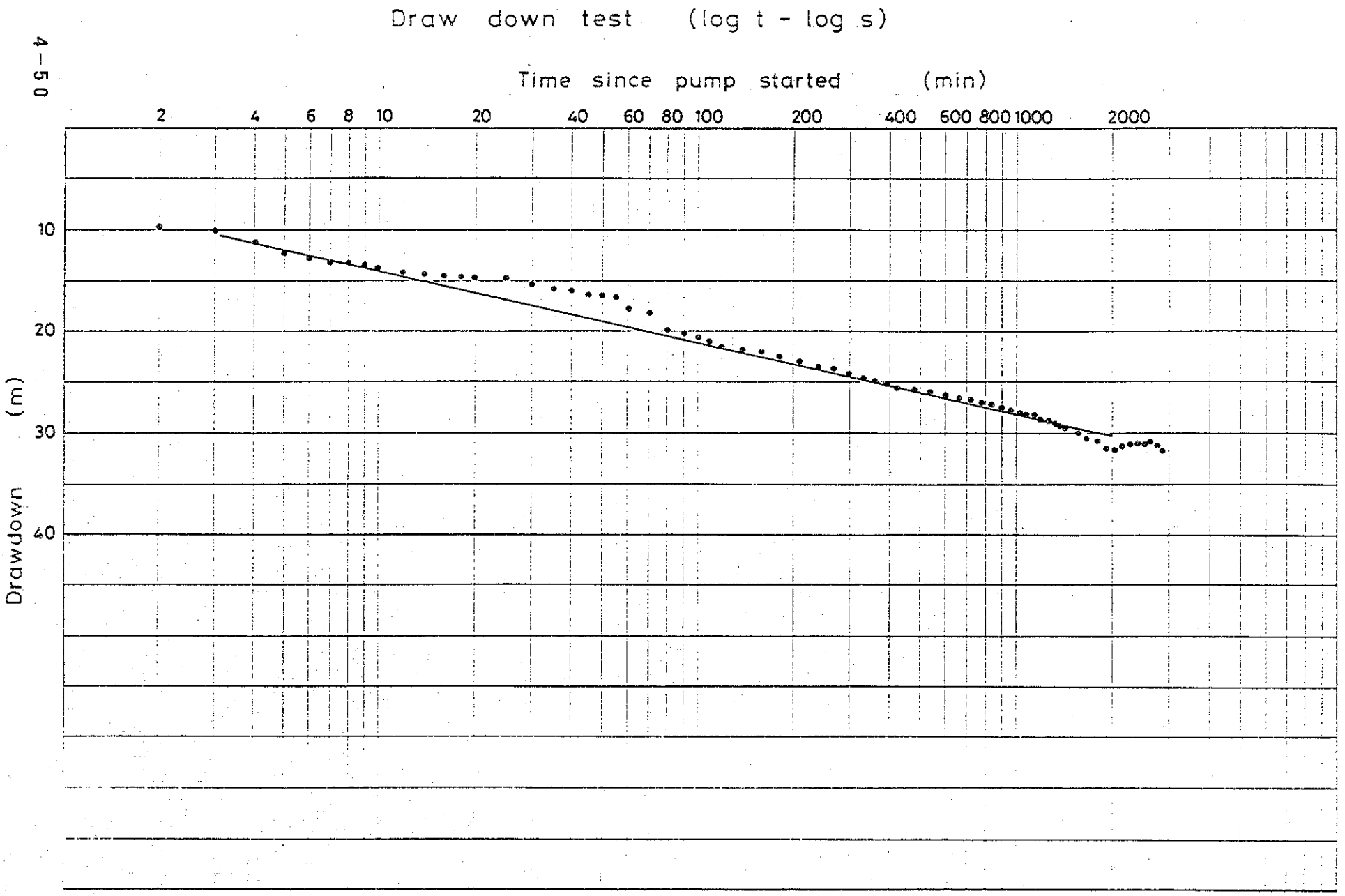


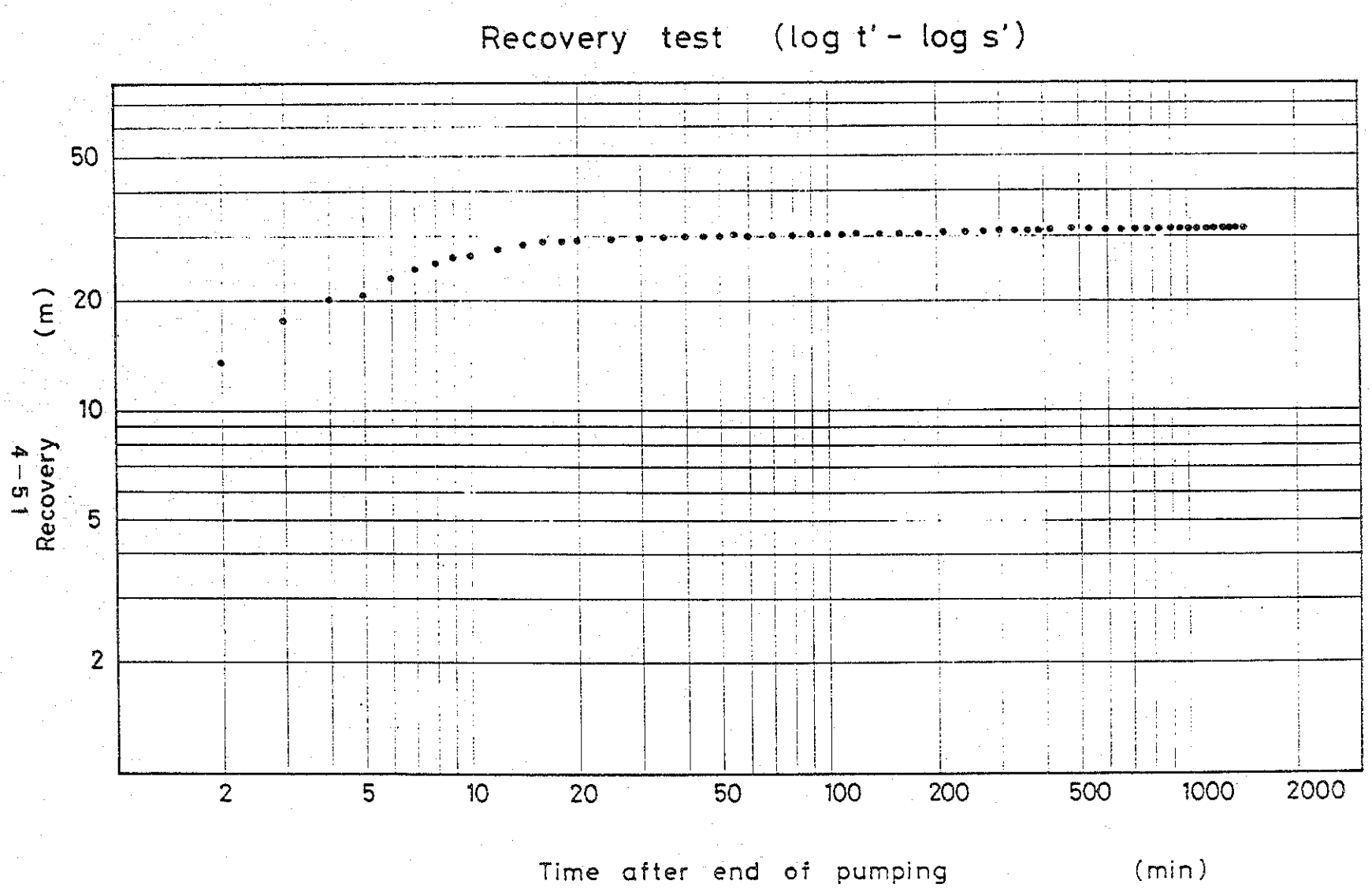
	Pumping rate Q (m³/min)	Drawdown ⊿S (m)	Specific capacity m³/min/m
1	0.500	16.92	0.030
2	0.353	11.65	0.030
3	0.375	11.87	0.032
(4)	0.316	9.89	0.032

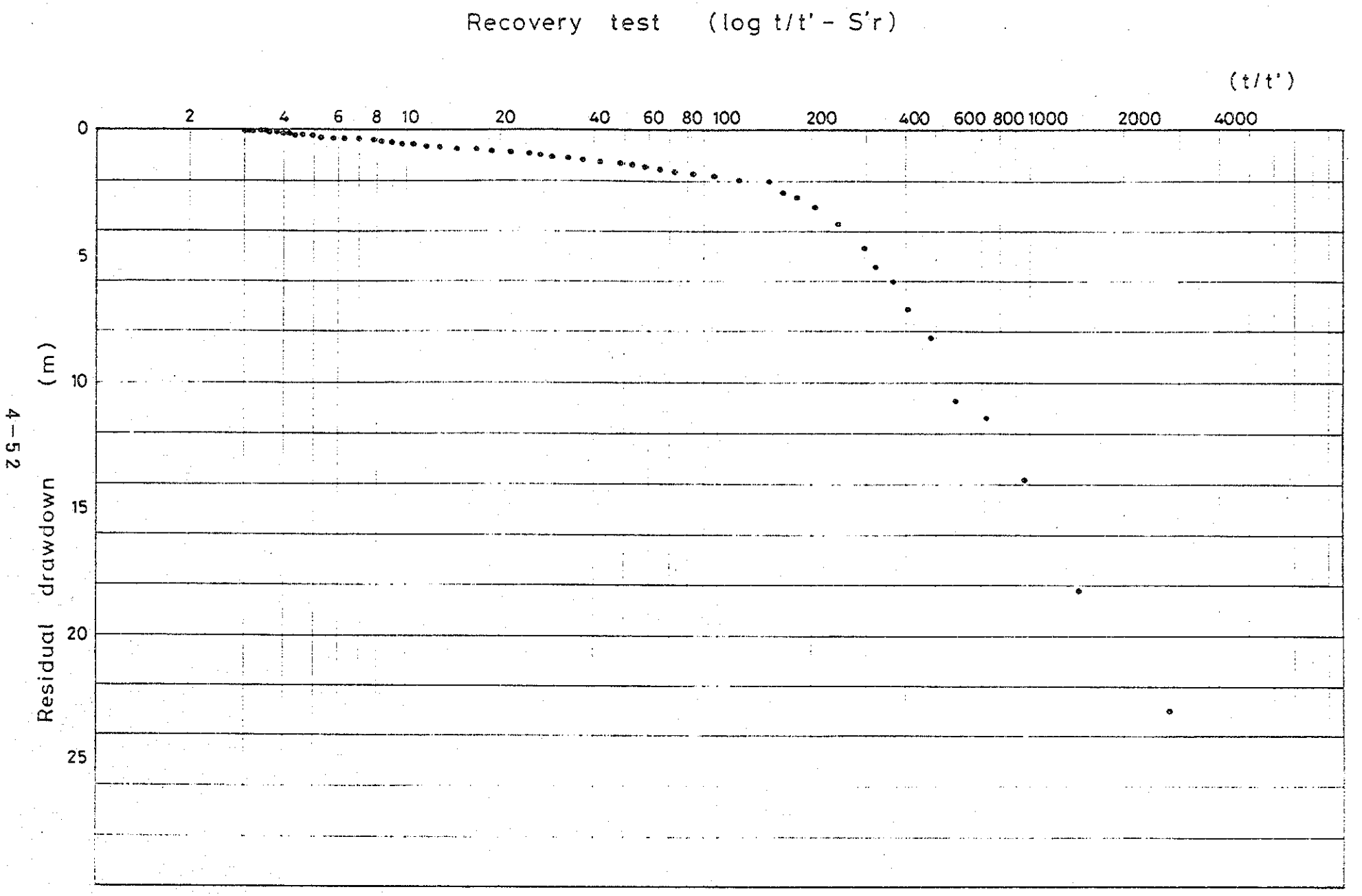
(4): result of pumping test at 180 min.

Zugu －1

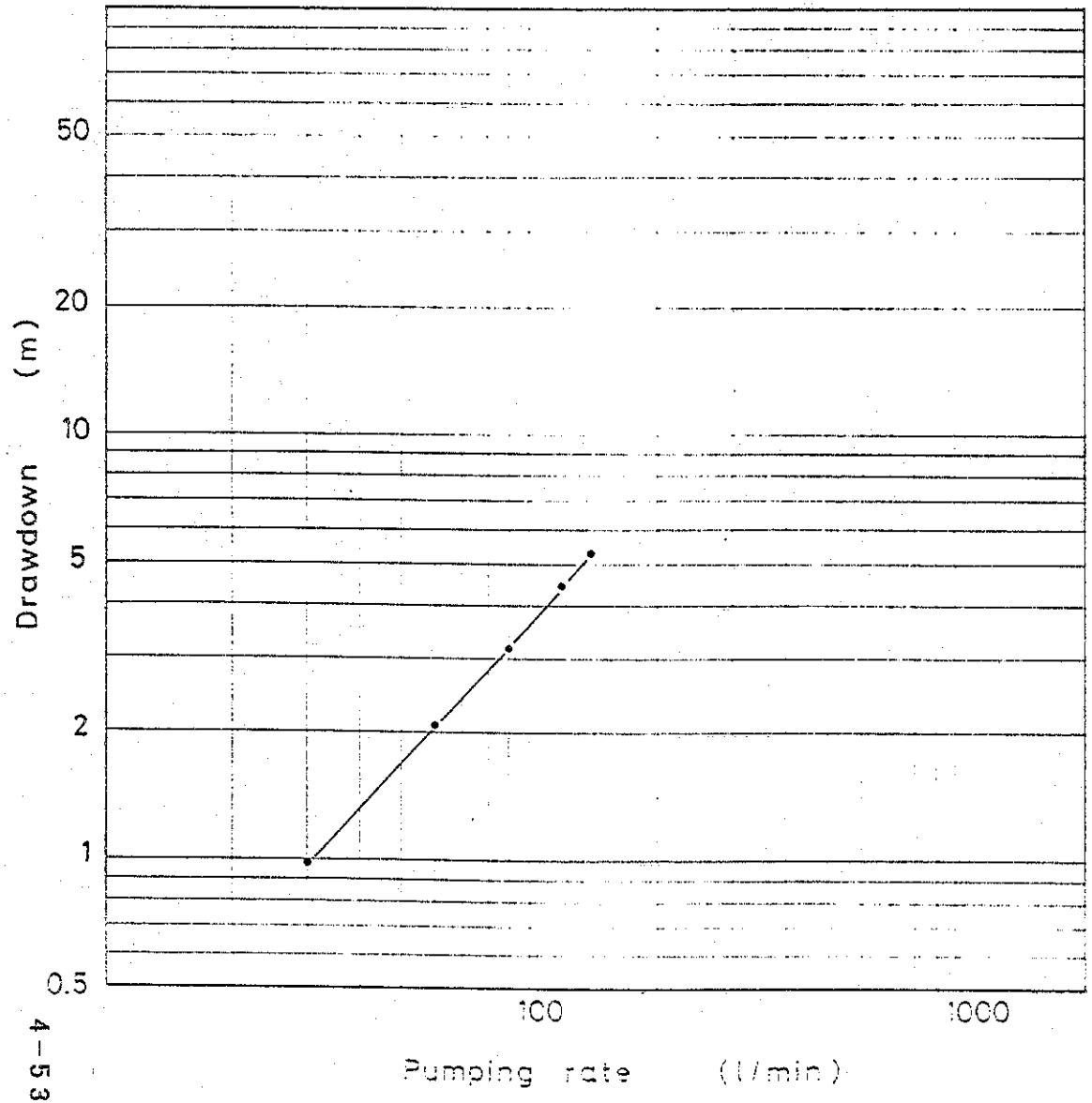

Draw down test (log t - log s)
50
20
10
5
2
1
0.5
0.2
Drawdown (m)
0.5
1
2
5
10
20
50
100
200
500
1000
2000
5000
Time since pump started (min)


Draw down test (log t - log s)
4 - 50
Time since pump started (min)
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
10
20
30
40
Drawdown (m)


Recovery test (log t' - log s')
Recovery 4 - 5 1 (m)
50
20
10
5
2
2
5
10
20
50
100
200
500
1000
2000
Time after end of pumping (min)

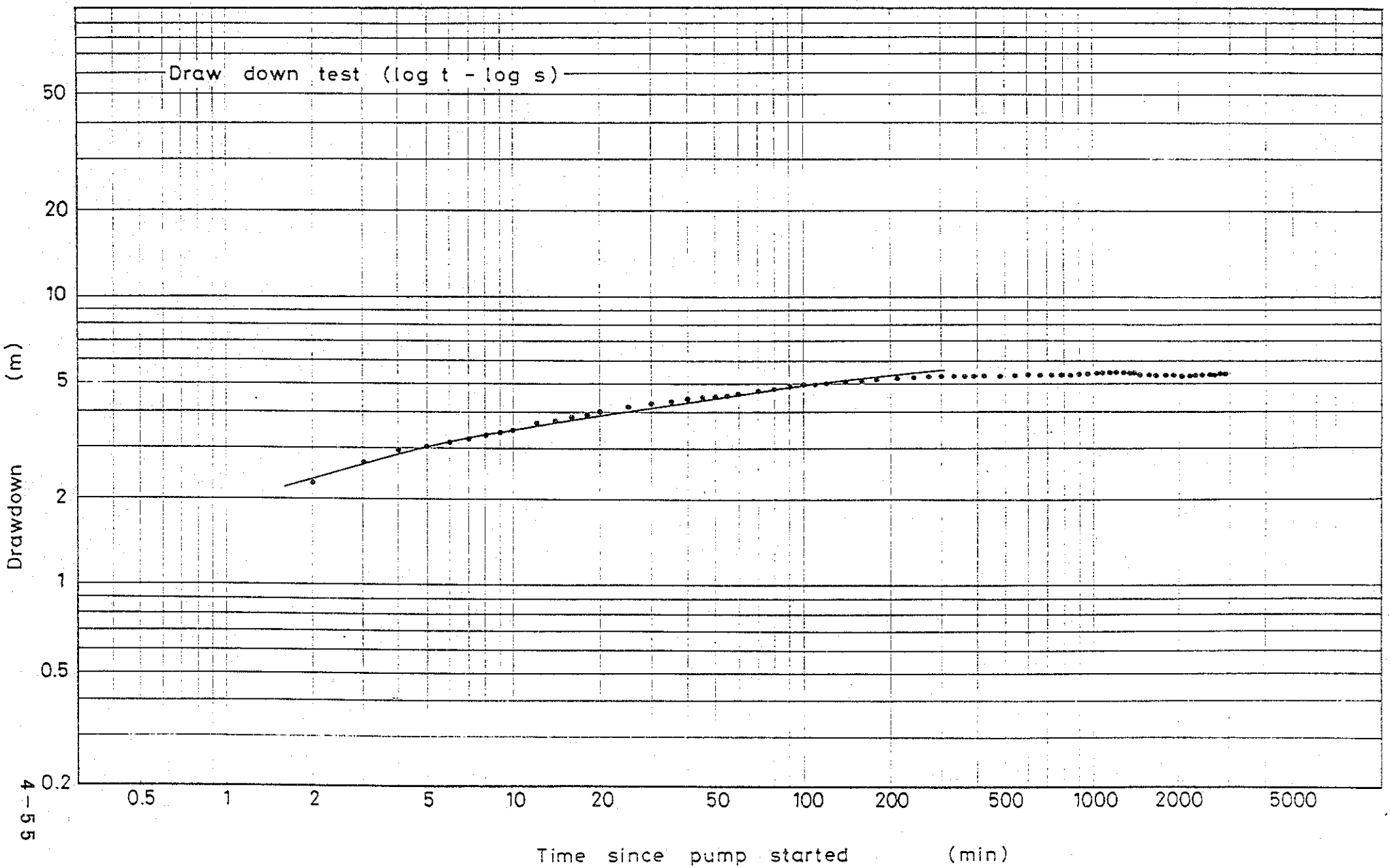

Recovery test (log t/t' - S'r)
(t/t')
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
4000
0
5
10
15
20
25
Residual drawdown (m)

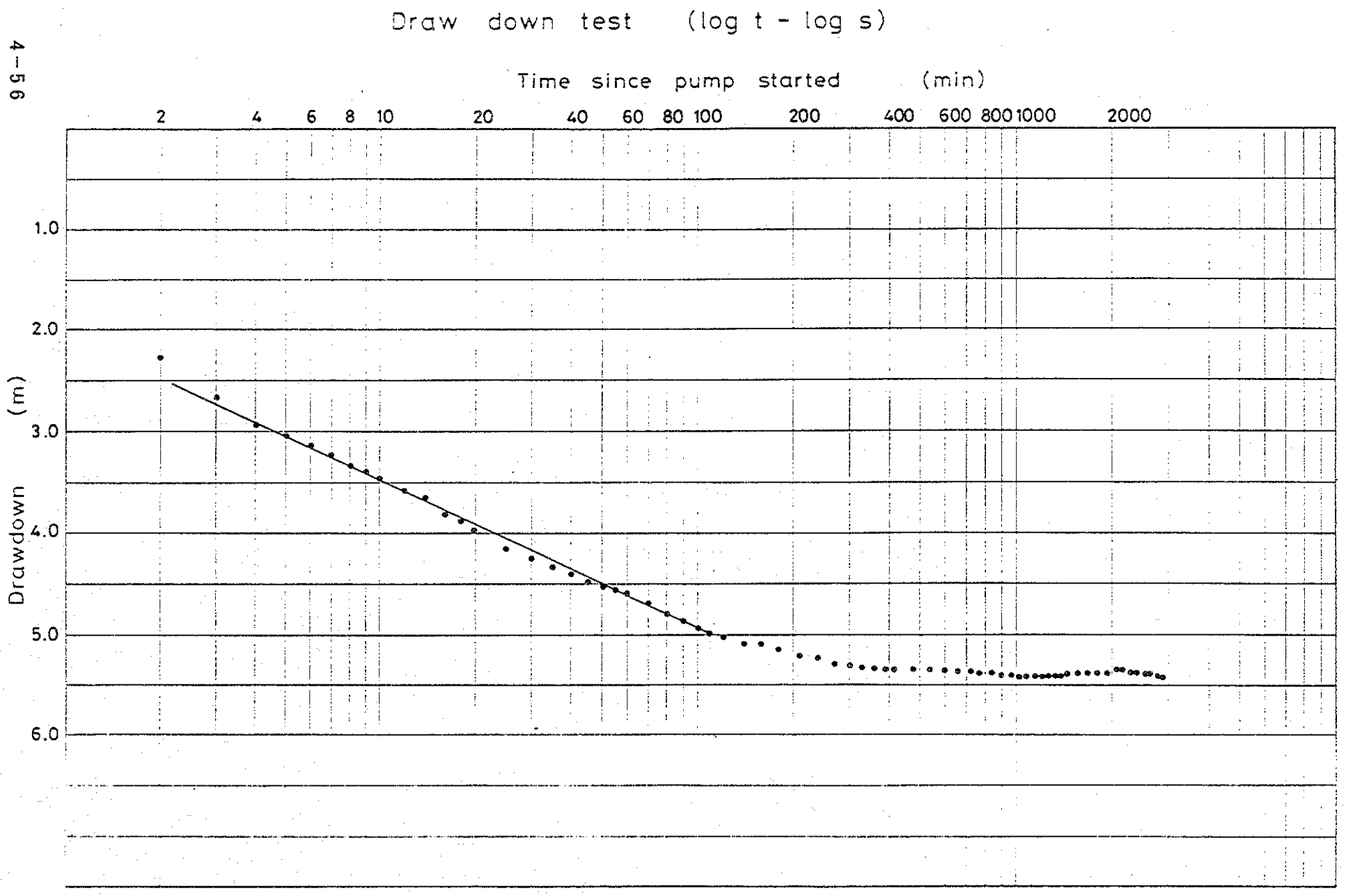
Step drawdown test (log Q - log S)

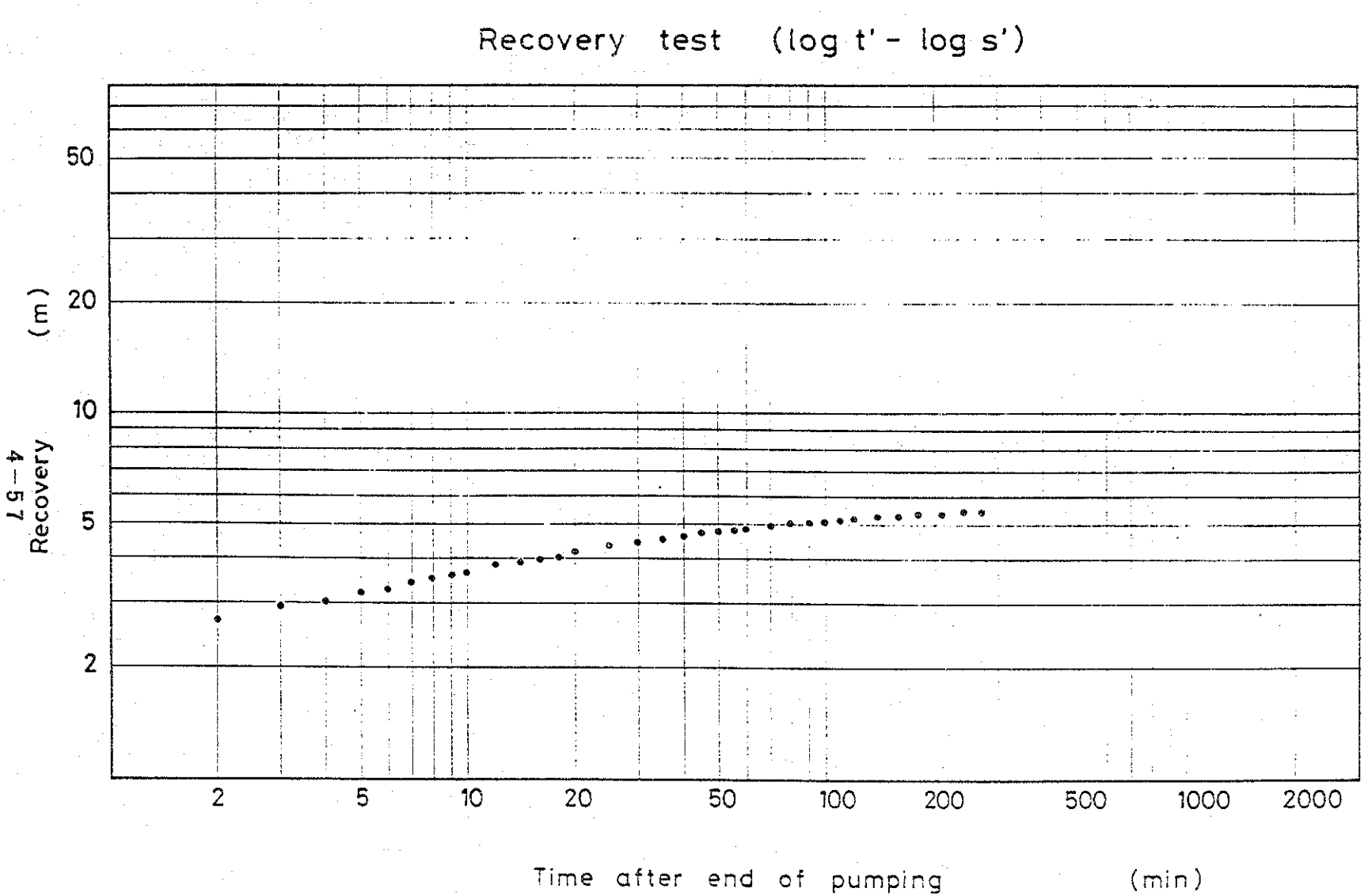


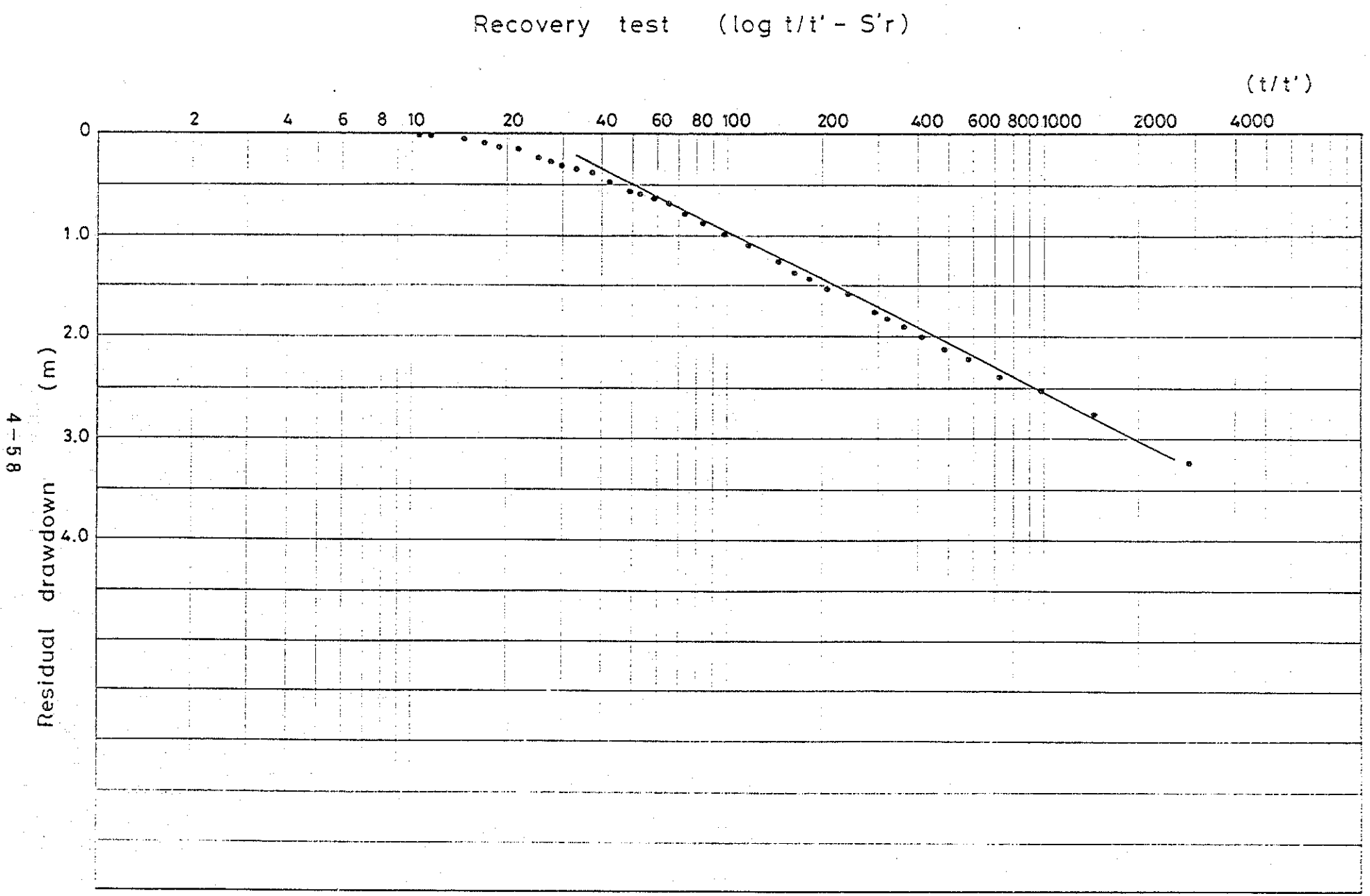
	Pumping rate Q (m³/min)	Drawdown ⊿S (m)	Specific capacity m³/min/m
1	0.030	0.98	0.031
2	0.060	2.08	0.029
3	0.090	3.18	0.028
4	0.120	4.43	0.027
5	0.140	5.23	0.027

Zugu − 2


Draw down test (log t - log s)
50
20
10
5
2
1
0.5
0.2
Drawdown (m)
0.5
1
2
5
10
20
50
100
200
500
1000
2000
5000
Time since pump started (min)


Draw down test (log t - log s)
Time since pump started (min)
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
Drawdown (m)
1.0
2.0
3.0
4.0
5.0
6.0


Recovery test (log t' - log s')
Recovery (m)
4-57
50
20
10
5
2
2
5
10
20
50
100
200
500
1000
2000
Time after end of pumping (min)


Recovery test (log t/t' - S'r)
(t/t')
2
4
6
8
10
20
40
60
80
100
200
400
600
800
1000
2000
4000
0
1.0
2.0
3.0
4.0
Residual drawdown (m)

5. MT SURVEY RESULTS

5. MT SURVEY RESULTS

Magnetotelluric method (MT method) with two different types of PL-MT and ELF-MT were carried out in 34 villages, 128 points. The location of this survey is shown on the location map (Fig. 5-1).

Resistivity values obtained through MT survey are tabulated in the table. Results of interpretation and an example analyzed by inversion using computer are shown in figures.

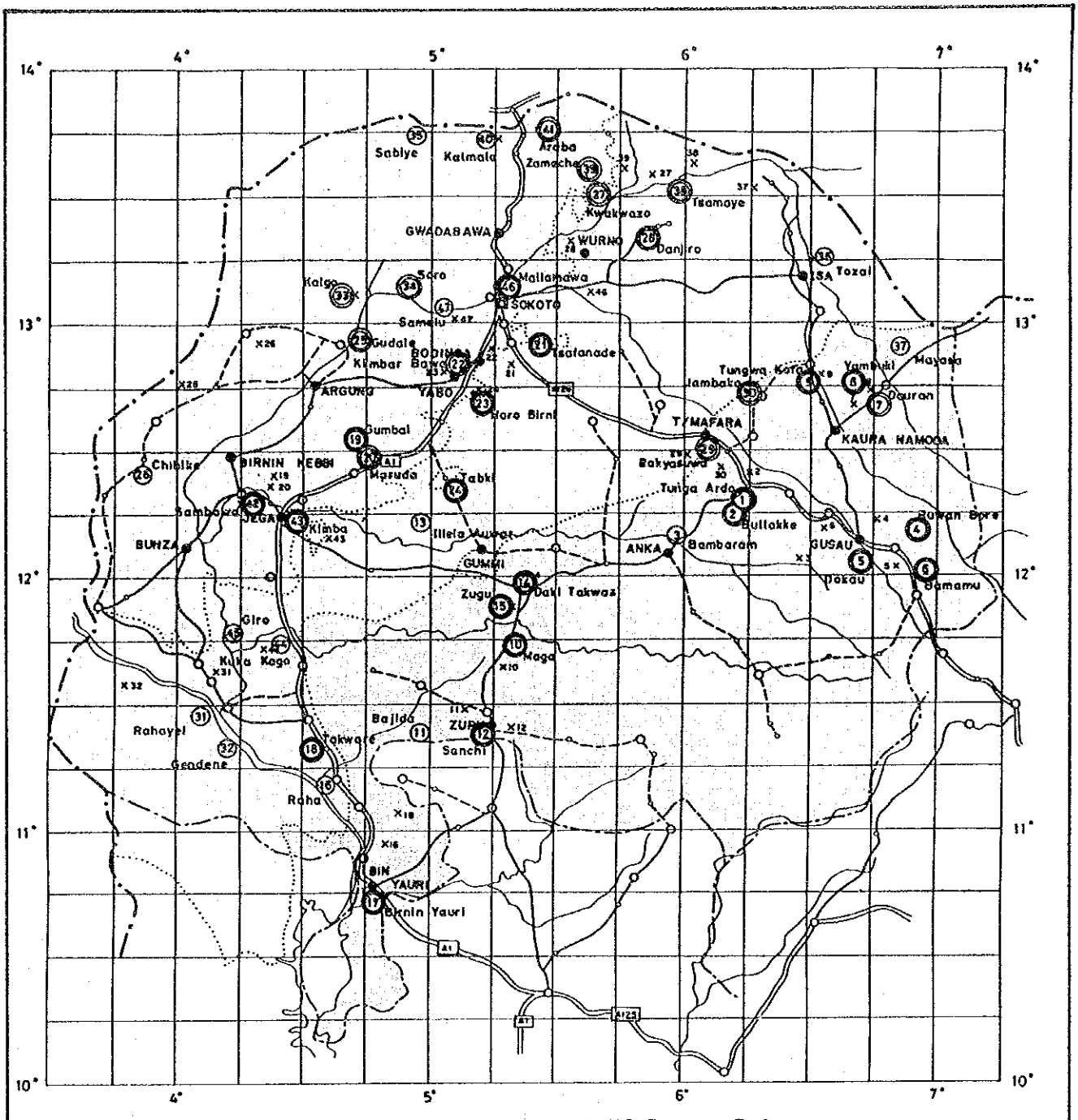


Fig. 5-1 Location Map of MT Survey Points

◎ : ELF-MT Survey Points

○ : ELF-MT and/or PL-MT Survey Points

Table 5-1 Apparent Resistivity Obtained through MT Survey (1/4)

NO.	Village Name	Station	NO.	PL MT 50Hz Raw date	PL MT 50Hz Mean value	PL MT 100Hz Raw date	PL MT 100Hz Mean value	PL MT 150Hz Raw date	PL MT 150Hz Mean value	NO.	ELF MT 8Hz Raw date	ELF MT 8Hz Mean value	ELF MT 14Hz Raw date	ELF MT 14Hz Mean value	ELF MT 20Hz Raw date	ELF MT 20Hz Mean value
1	Soro (34)	A								1	43	250	360	220	2,500	1,000
2		B								2	750		41		150	
3		C								3	260		650		4,900	
4		D								4	270		260		550	
5	Kalgo (33)	A								5	95	78	210	140	2,600	530
6		B								6	22		64		280	
7		C								7	19		45		220	
8		D								8	930		660		490	
9	Araba (41)	A								9	140	77	290	64	200	66
10		B								10	45		20		42	
11		C								11	96		90		92	
12		D								12	57		32		24	
13	Bakyaswwa (29)	A								13	16	24	8	13	12	10
14		B								14	20		8		12	
15		C								15	56		24		8	
16		D								16	20		16		8	
17	Kwakwago (27)	A								17	45	96	55	84	27	50
18		B								18	460		140		110	
19		C								19	49		59		33	
20		D								20	97		95		41	
21		E								21	81		99		75	
22	Sabuwer	A								22	24	19	20	19	4	9
23	Tsamaya (38)	B								23	16		28		16	
24		C								24	16		16		12	
25		D								25	20		16		8	
26	Zamache (39)	A								26	12	39	12	21	4	7
27		B								27	128		36		12	
28	Danjiro (28)	A	1							28	32	51	16	34	16	18
29		B	1	724,000	724,000	29,800	29,800	22,200	22,200	29	24		24		8	
30		C								30	310		120		71	
31		D								31	28		28		12	
32	Mallamawa (46)	A	2	586	586	900	900	75	75	32	36	52	16	20	12	11
33		B								33	60		24		12	
34		C								34	52		20		12	
35		D								35	64		20		8	

Table 5-1 Apparent Resistivity Obtained through MT Survey (2/4)

NO.	Village Name	Station	NO.	PL MT 50Hz Raw date	PL MT 50Hz Mean value	PL MT 100Hz Raw date	PL MT 100Hz Mean value	PL MT 150Hz Raw date	PL MT 150Hz Mean value	NO.	ELF MT 8Hz Raw date	ELF MT 8Hz Mean value	ELF MT 14Hz Raw date	ELF MT 14Hz Mean value	ELF MT 20Hz Raw date	ELF MT 20Hz Mean value
36	Sambawa (42)	A	3	49	66	55	71	23	29	36	16	18	16	12	12	9
37		B	4	46		45		22								
38		C	5	56		62		22		37	28		12		8	
39		D	6	148		170		65		38	12		8		8	
40	Kimba (43)	A	7	94	94					39	8	19	8	16	12	10
41		B								40	56		28		20	
42		C								41	16		20		4	
43	Gumbi (19)	A								42	48	32	16	15	16	13
44		B								43	24		16		12	
45		C	8	14	14	14	14			44	36		16		16	
46		D								45	24		12		8	
47	Maruda (20)	A								46	260	170	260	110	200	99
48		B								47	140		42		51	
49		C								48	140		130		96	
50	Gudale (25)	A								49	23	44	13	39	13	32
51		B								50	31		28		20	
52		C								51	57		59		46	
53		D								52	93		110		90	
54	Kimbar Bawa	A								53	73	160	81	72	33	52
55	(22)	B								54	240		27		32	
56		C								55	220		170		140	
57	Tabki (24)	A								56	210	290	200	230	170	210
58		B	9	83	99	62	16	142	21	57	420		270		210	
59		C	10	118		4				58	81		140		200	
60		D								59	320		180		180	
61		E								60	920		490		350	
62	Horo Biruni	A	11	9	12		14		17	61	21	13	9	13	4	12
63	(23)	B	12	11						62	3		7		11	
64		C	13	7				11		63	12		18		21	
65		D	14	33		14		27		64	38		22		19	
66	Tsafanade (21)	A	15	5	5	9	9			65	26	19	19	17	17	16
67		B								66	15		15		14	
68		C								67	15		15		14	
69		D								68	22		19		20	
70	Jam Bako (30)	A								69	5,800	5,800				

Table 5-1 Apparent Resistivity Obtained through MT Survey (3/4)

NO.	Village Name	Station	NO.	PL MT 50Hz Raw date	50Hz Mean value	100Hz Raw date	100Hz Mean value	150Hz Raw date	150Hz Mean value	NO.	ELF MT 8Hz Raw date	8Hz Mean value	14Hz Raw date	14Hz Mean value	20Hz Raw date	20Hz Mean value
71	Dauran (7)	A								70	13,000	8,700	9,300	6,900	4,300	5200
72		B								71	4,600		3,600		3,400	
73		C								72	11,000		10,000		6,500	
74		D								73	9,200		6,700		7,700	
75	Yambuki (8)	A	16	9,920	3,510	7,020	1,560	867	407	74	48,000	18,000	50,000	19,000	19,000	12,000
76		B	17	4,750		1,040		256		75	8,400		8,300		5,100	
77		C	18	4,820		1,390				76	24,000		23,000		23,000	
78		D	19	671		587		305		77	11,000		13,000		8,100	
79	Tungasa Kofa	A								78	5,500	4,000	5,100	3,600		2,700
80	(9)	B	20	2,010	2,010	558	558	506	506	79	3,400		3,100		2,900	
81		C								80	3,500		2,900		2,500	
82	Ruwan Bore	A	21	5,280	5,810	1,360	3,690	66	624							
83	(4)	B	22	8,530		4,000				81	4,100	12,000	3,900	10,000		
84		C	23	9,500		2,760		746		82	15,000		15,000		18,000	14,000
85		D	24	2,670		12,400		4,940		83	29,000		19,000		11,000	
86	Dokaw (5)	A	25	185	904	255	335	280	890	84	1,300	4,000	810	3,000	750	2,800
87		B	26	481		477										
88		C	27	433		331										
89		D	28	17,300				2,830		85	13,000		11,000		11,000	
90	Bullake (2)	A	29	637	489	73	93	61	54	86	430	2,300	460	1,800	210	1,300
91		B	30	285		188		107								
92		C	31	529				96		87	10,000		5,300		6,000	
93		D	32	596		59		14		88	2,800		2,200		1,800	
94	Bamamu (6)	A	33	20,700	25,700	3,080	7,030	809	1,580							
95		B	34	16,100		7,190		1,200								
96		C	35	134,000		31,800										
97		D	36	4,540		4,180			677							
98		E	37	55,100				9,580								
99	Tunga Ardo	A	38	7,490	14,200	1,780	10,400		26,800	89	20,000	20,000	24,000	24,000	12,000	12,000
100	(1)	B	39	18,800		16,300		27								
101		C	40	20,300		39,300		26,800								
102	Daki Takwas	A								90	2,900	3,900	2,500	3,000	2,300	2,300
103	(14)	B								91	1,300		800		660	
104		C	41	3,630	2,360	5,360	2,110		229							
105		D	42	1,530		828		229		92	17,000		13,000		8,400	

Table 5-1 Apparent Resistivity Obtained through MT Survey (4/4)

NO.	Village Name	Station	NO.	PL MT						NO.	ELF MT					
				50Hz		100Hz		150Hz			8Hz		14Hz		20Hz	
				Raw date	Mean value	Raw date	Mean value	Raw date	Mean value		Raw date	Mean value	Raw date	Mean value	Raw date	Mean value
106	Zugu (15)	A	43	2,430	2,230		532	480	196	93	15,000	19,000	14,000	16,000	9,300	10,000
107		B	44	985		475										
108		C	45	3,290		849		161		94	23,000		18,000		12,000	
109		D	46	3,100		373		98								
110	Maga (10)	A	47	3,930	1,250	5,980	1,020	649	243							
111		B	48	983		232		166		95	5,500	9,800	4,000	6,500	5,100	7,000
112		C	49	301		350		88								
113		D	50	2,120		2,270		365		96	17,000		11,000		9,700	
114	Sanchi (12)	A	51	41,700	76,100	7,020	7,390	5,580	5,290							
115		B	52	91,700				8,850								
116		C	53	86,700		12,300		4,770								
117		D	54	101,000		4,680		3,330								
118	Takware (18)	A	55	403	139	34	68		46							
119		B	56	51		49		16								
120		C	57	12		10		7								
121		D	58	1,530		1,270		867								
122	Birnin Yauri	A	59	122,000	71,200	144,000	69,700	40,700	21,200	97	52,000	52,000	47,000	47,000	42,000	42,000
123	(17)	B	60	51,700		52,600		17,900								
124		C	61	57,300		44,800		13,000								

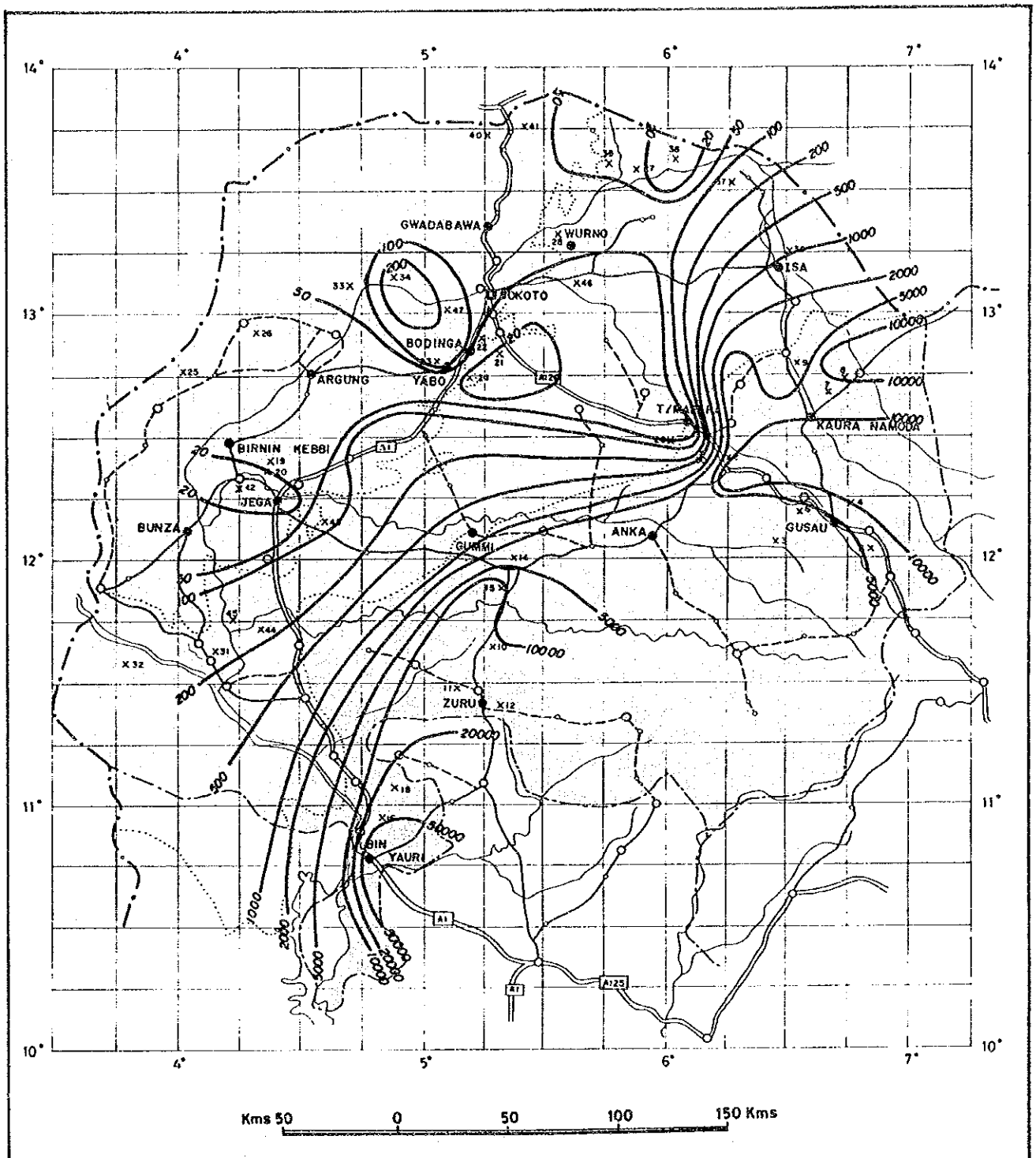


Fig. 5-2 Apparent Resistivity Distribution Surveyed by ELF-MT (Frequency Range : 8Hz) Method (Average Resistivity from Gs down to 600 ~1000m)

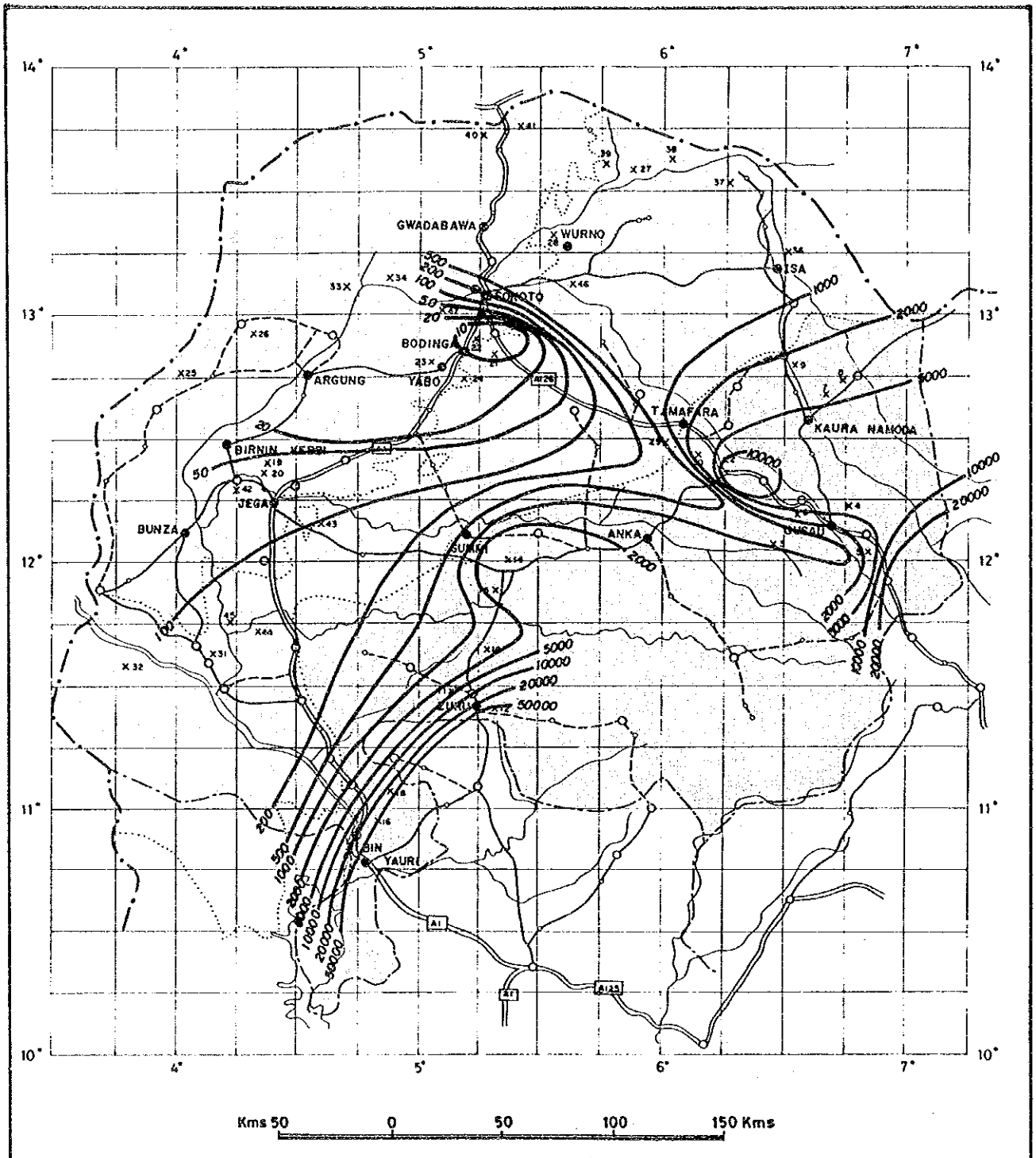


Fig. 5-3. Apparent Resistivity Distribution Surveyed by PL-MT (Frequency Range : 50Hz) Method (Average Resistivity from Gs down to 100 ～ 200m)

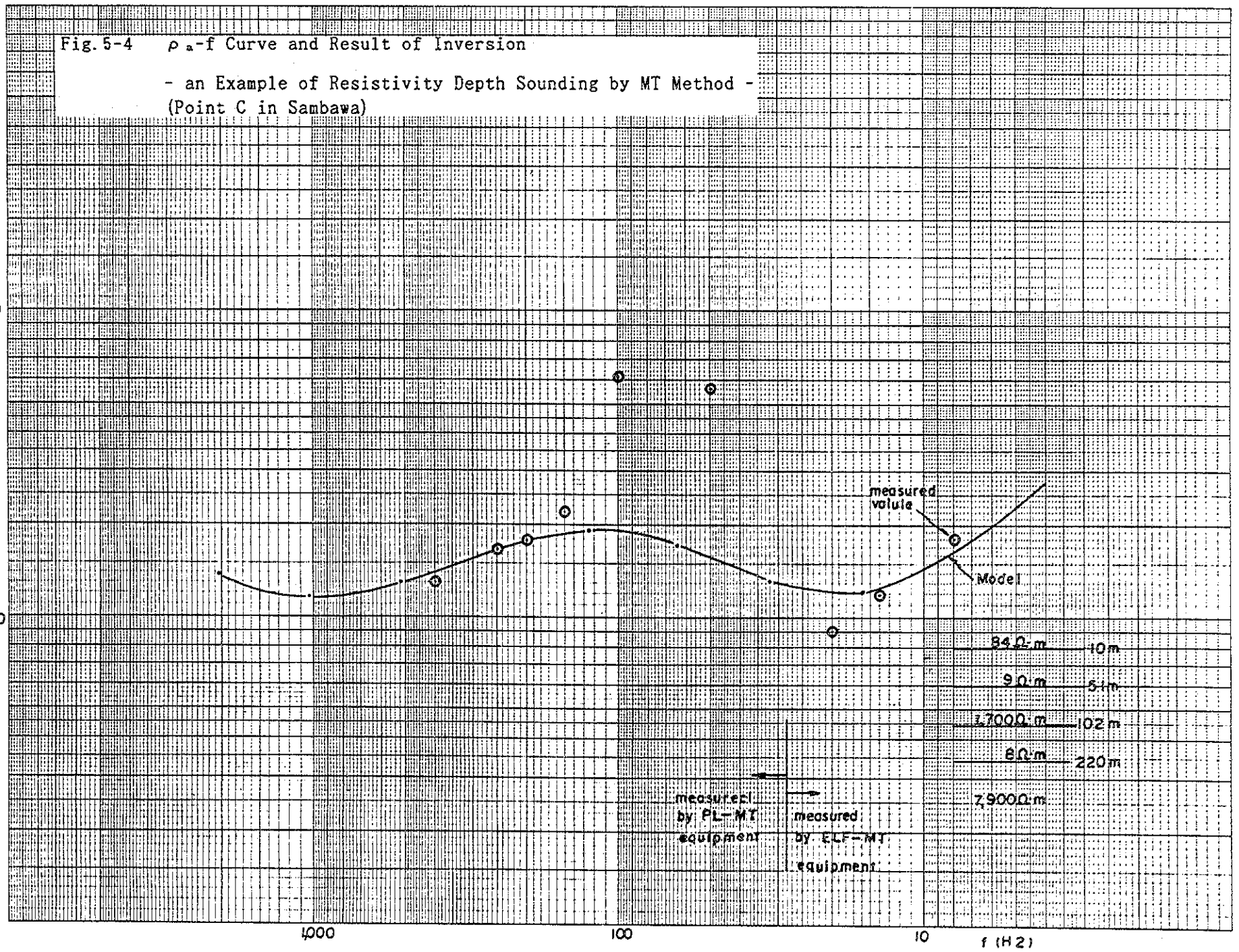


Fig. 5-4 ρa-f Curve and Result of Inversion
- an Example of Resistivity Depth Sounding by MT Method -
(Point C in Sambawa)
ρa Ωm
100
10
measured value
Model
34 Ω·m 10 m
9 Ω·m 5 m
1,700 Ω·m 102 m
8 Ω·m 220 m
7,900 Ω·m
measured by PL-MT equipment
measured by ELF-MT equipment
1000
100
10
f (Hz)

6. EM SURVEY RESULTS

6. EM SURVEY RESULTS

EM surveies were carried out in Ruwan Bore. Tunga Ardo and Zuru (Fig. 6-1).

Respectivery for these areas, the survey stations and the data obtained from them are shown in following figures. And the survey resuls are here as field record and the outputs of the TEMIX and MOTEM programs.

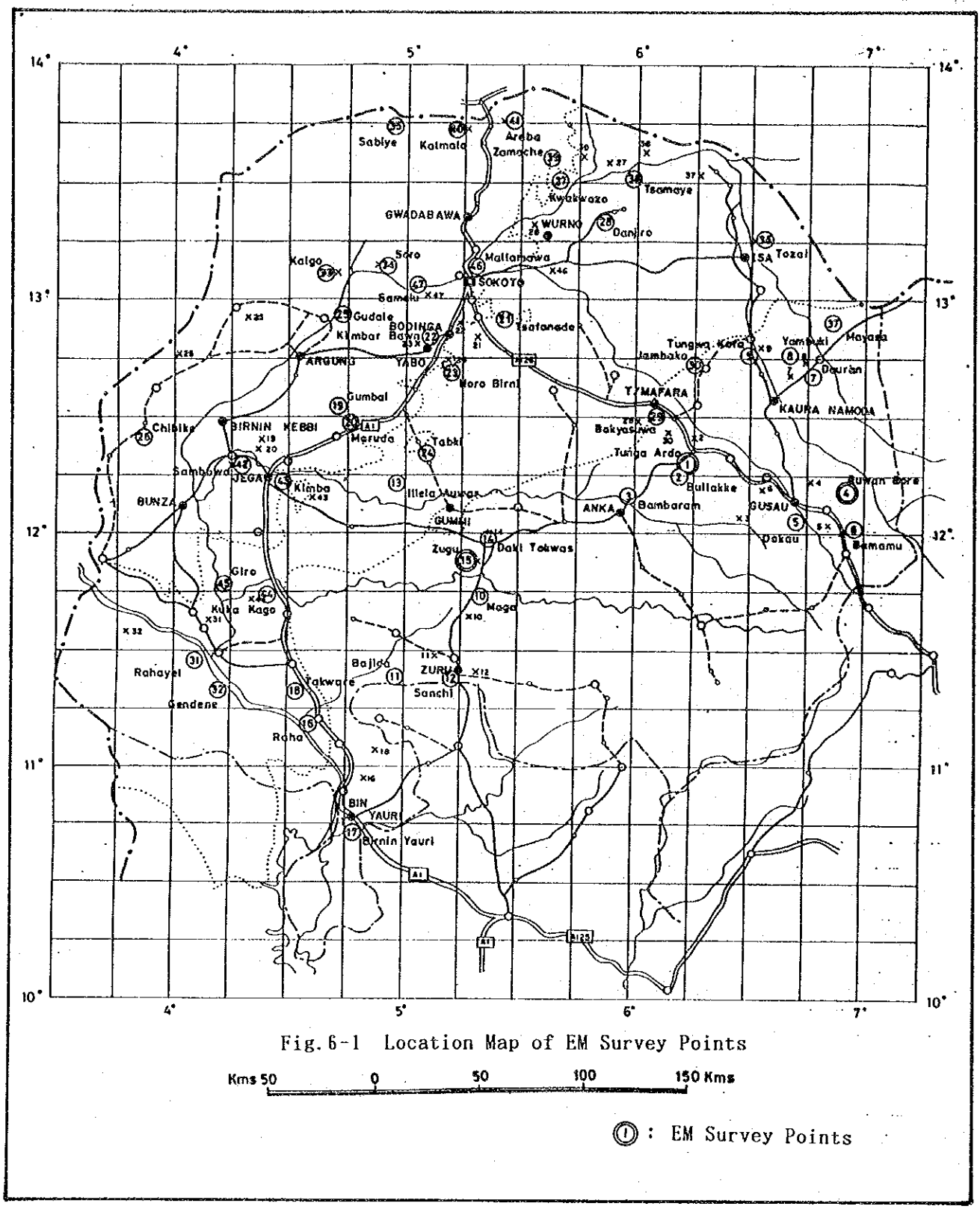
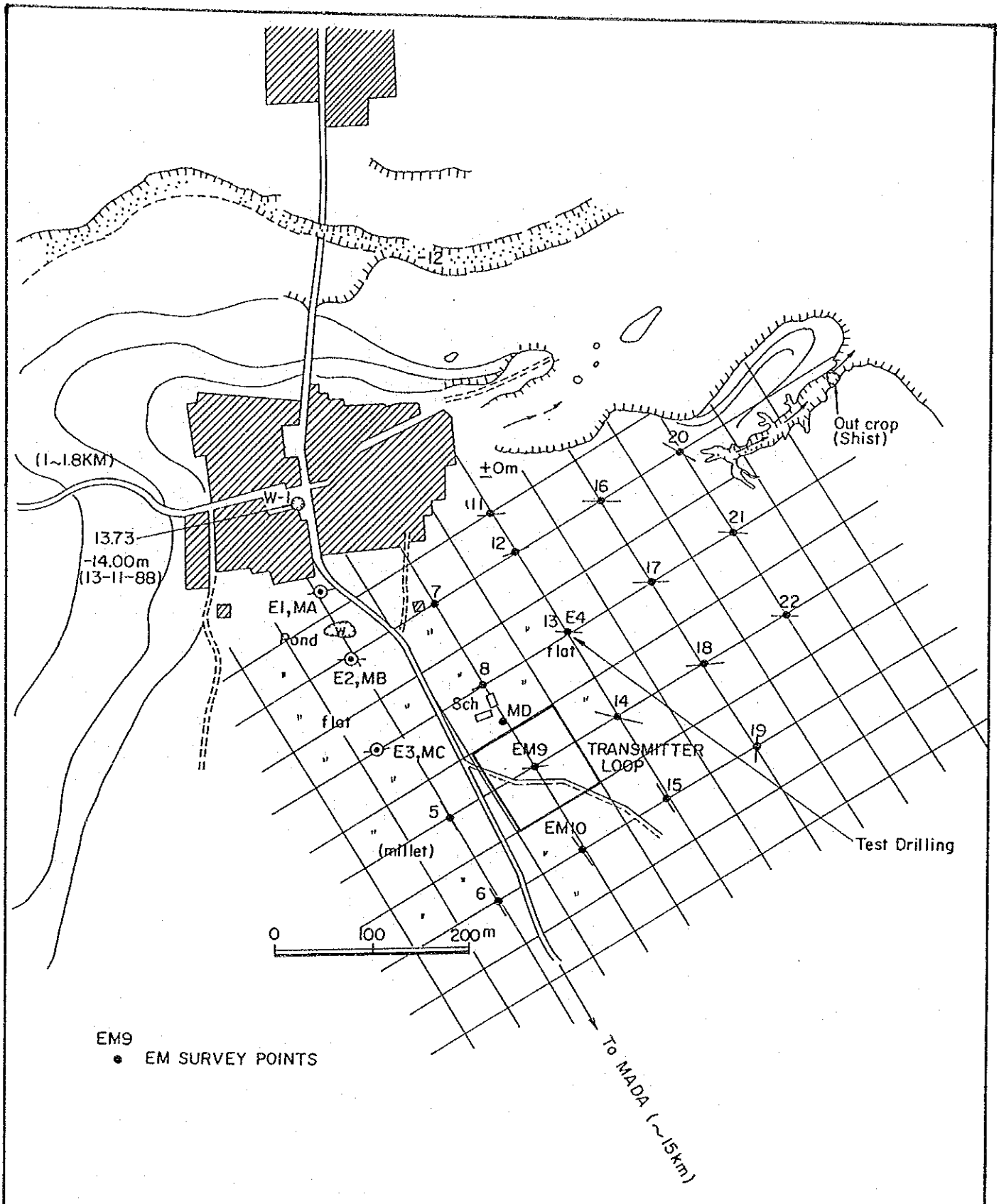


Fig. 6-1 Location Map of EM Survey Points

Result of interpretation of EM survey

- TEMIX RESULT -

(Ruwan Bore)



Location of the EM Survey Points (Ruwan Bore)

DATA SET: RUWAN9

CLIENT: JICA
LOCATION: Sokoto Nigeria
COUNTY: Gusau
PROJECT: Synthetic EM-37 Data
LOOP SIZE: 100.000 meters square
SOUNDING COORDINATES: X: 0.0000 Y: 0.0000

DATE: 14-NOV-88
SOUNDING: 1
ELEVATION: 0.00 m
EQUIPMENT: Geonics EM-37

FITTING ERROR: 24.784 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			0.0	
1	405.2	132.5	-132.5	0.326
2	31311.0			

ALL PARAMETERS ARE FREE

CURRENT: 11.00 AMPS
FREQUENCY: 25.00 Hz GAIN: 8

COIL AREA: 100.00 sq m.
RAMP TIME: 60.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0890	878.7	1011.7	-15.14
2	0.110	550.3	584.5	-6.21
3	0.140	302.9	302.2	0.220
4	0.177	166.4	153.1	7.96
5	0.220	86.97	79.94	8.07
6	0.280	41.61	37.51	9.85
7	0.355	15.74	17.31	-9.95
8	0.443	4.68	8.35	-78.37

CURRENT RESOLUTION MATRIX NOT AVAILABLE

DATA SET: RUWAN9

CLIENT: JICA
LOCATION: Sokoto Nigeria
COUNTY: Gusau
PROJECT: Synthetic EM-37 Data
LOOP SIZE: 100.000 meters square
SOUNDING COORDINATES: X: 0.0000 Y: 0.0000

DATE: 14-NOV-88
SOUNDING: 1
ELEVATION: 0.00 m
EQUIPMENT: Geonics EM-37

FITTING ERROR: 24.784 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			0.0	
1	405.2	132.5	-132.5	0.326
2	31311.0			

ALL PARAMETERS ARE FREE

CURRENT: 11.00 AMPS
FREQUENCY: 25.00 Hz GAIN: 8
COIL AREA: 100.00 sq m.
RAMP TIME: 60.00 muSEC

No.	TIME (ms)	Apparent Res (ohm-m) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0890	890.0	810.2	8.97
2	0.110	854.2	820.5	3.93
3	0.140	850.9	852.1	-0.147
4	0.177	858.0	906.8	-5.69
5	0.220	920.4	973.6	-5.77
6	0.280	1006.7	1078.8	-7.16
7	0.355	1295.6	1216.2	6.12
8	0.443	2009.5	1366.2	32.01

CURRENT RESOLUTION MATRIX NOT AVAILABLE

DATA SET: RUWAN9

CLIENT: JICA
LOCATION: Sokoto Nigeria
COUNTY: Gusau
PROJECT: Synthetic EM-37 Data
DATE: 14-NOV-88
SOUNDING: 1
ELEVATION: 0.00 m
EQUIPMENT: Geonics EM-37
LOOP SIZE: 100.000 meters square
SOUNDING COORDINATES: X: 0.0000 Y: 0.0000

FITTING ERROR: 24.784 PERCENT

Geonics EM-37 Data Worksheet
LOOP SIZE: 100.00 m PREAMP GAIN: 52.10
4x GAIN, CHANS 6-10,16,20: YES

	25.00 Hz GAIN: 8	6.25 Hz GAIN: 7	2.50 Hz GAIN: 7
	11.00 AMPS	11.00 AMPS	11.00 AMPS
	COIL: 100.0 m^2	COIL: 100.0 m^2	COIL: 100.0 m^2
	RAMP: 60.0 muSEC	RAMP: 60.0 muSEC	RAMP: 60.0 muSEC

CHNL	T (mSEC)	mVOLT	RHO-A	mVOLT	RHO-A	mVOLT	RHO-A
1	0.089	1172.00	890.08				
2	0.110	734.00	854.24				
3	0.140	404.00	850.93				
4	0.177	222.00	858.04				
5	0.220	116.00	920.49				
6	0.280	222.00	1006.71				
7	0.355	84.00	1295.70				
8	0.443	25.00	2009.57				

RWANDA
APPARENT RESISTIVITY (OHM-M)
TIME (msec)
DEPTH (M x 1E0)
RESISTIVITY (OHM-M)

DATA SET: RUWAN9N

CLIENT: JICA
LOCATION: Sokoto Nigeria
COUNTY: Gusau
PROJECT: Synthetic EM-37 Data
LOOP SIZE: 100.000 meters square
SOUNDING COORDINATES: X: 0.0000 Y: 0.0000

DATE: 15-NOV-88
SOUNDING: 2
ELEVATION: 0.00 m
EQUIPMENT: Geonics EM-37

FITTING ERROR: 112.915 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			0.0	
1	123.9	57.48	-57.48	0.463
2	2985.6	17.58	-75.06	0.00589
3	26359.0			

ALL PARAMETERS ARE FREE

CURRENT: 17.00 AMPS
FREQUENCY: 25.00 Hz GAIN: 8

COIL AREA: 100.00 sq m.
RAMP TIME: 70.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0890	4949.1	5861.1	-18.42
2	0.110	3316.1	3308.6	0.228
3	0.140	1834.6	1664.3	9.28
4	0.177	993.4	822.9	17.16
5	0.220	522.5	420.1	19.59
6	0.280	248.7	191.7	22.89
7	0.355	94.46	86.92	7.98
8	0.443	29.61	41.18	-39.05
9	0.564	1.87	16.89	-801.6

CURRENT RESOLUTION MATRIX NOT AVAILABLE

DATA SET: RUWAN9N

CLIENT: JICA
LOCATION: Sokoto Nigeria
COUNTY: Gusau
PROJECT: Synthetic EM-37 Data
LOOP SIZE: 100.000 meters square
SOUNDING COORDINATES: X: 0.0000 Y: 0.0000

DATE: 15-NOV-88
SOUNDING: 2
ELEVATION: 0.00 m
EQUIPMENT: Geonics EM-37

FITTING ERROR: 112.915 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			0.0	
1	123.9	57.48	-57.48	0.463
2	2985.6	17.58	-75.06	0.00589
3	26359.0			

ALL PARAMETERS ARE FREE

CURRENT: 17.00 AMPS
FREQUENCY: 25.00 Hz GAIN: 8
COIL AREA: 100.00 sq m.
RAMP TIME: 70.00 muSEC

No.	TIME (ms)	Apparent Res (ohm-m) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0890	375.8	335.7	10.66
2	0.110	344.8	345.3	-0.152
3	0.140	342.3	365.2	-6.71
4	0.177	348.5	395.1	-13.37
5	0.220	372.2	430.5	-15.65
6	0.280	408.5	485.9	-18.93
7	0.355	524.5	554.4	-5.70
8	0.443	785.8	630.7	19.73
9	0.564	3308.5	763.7	76.91

CURRENT RESOLUTION MATRIX NOT AVAILABLE

DATA SET: RUWAN9N

CLIENT: JICA
LOCATION: Sokoto Nigeria
COUNTY: Gusau
PROJECT: Synthetic EM-37 Data
LOOP SIZE: 100.000 meters square
SOUNDING COORDINATES: X: 0.0000 Y: 0.0000

DATE: 15-NOV-88
SOUNDING: 2
ELEVATION: 0.00 m
EQUIPMENT: Geonics EM-37

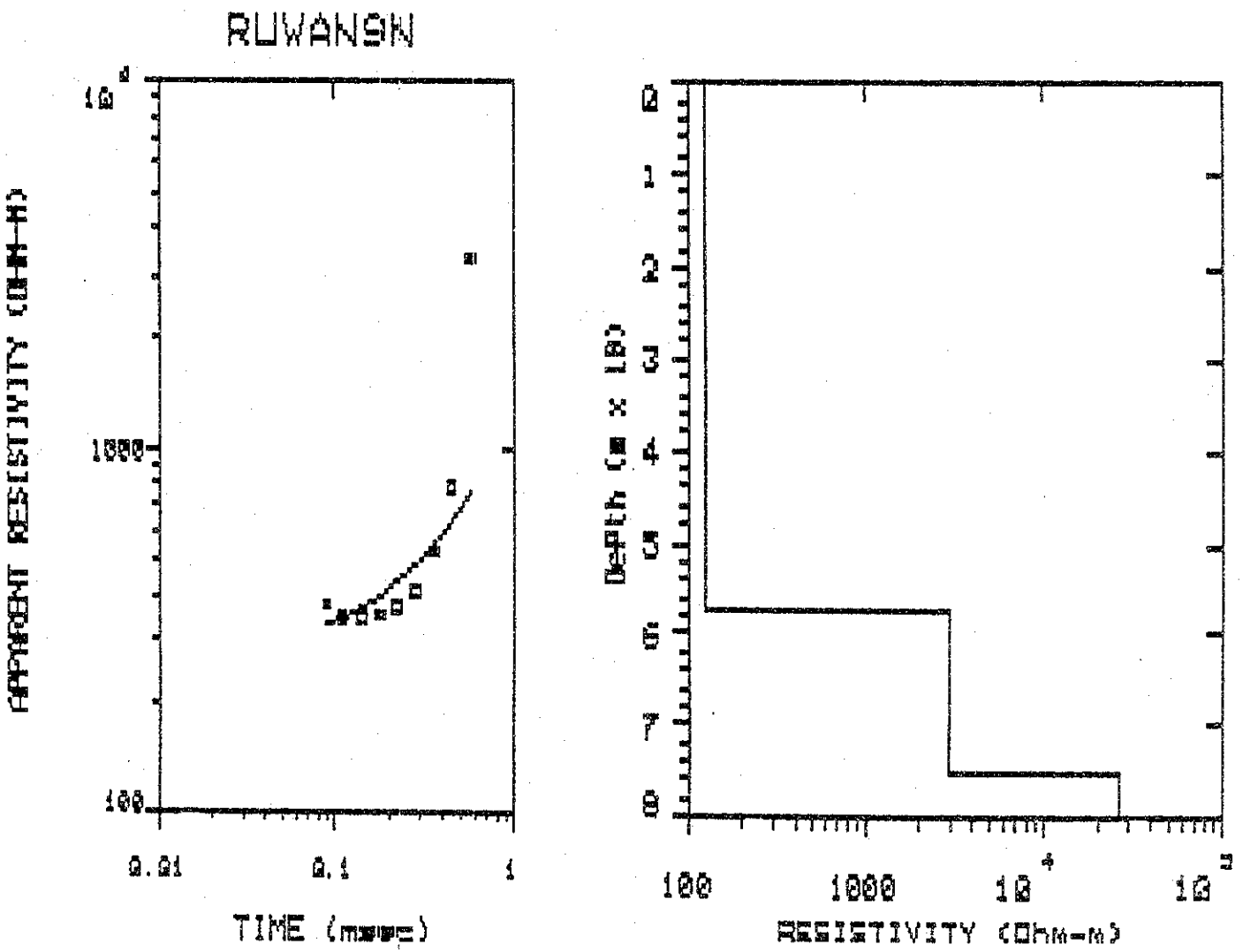
FITTING ERROR: 112.915 PERCENT

Geonics EM-37 Data Worksheet

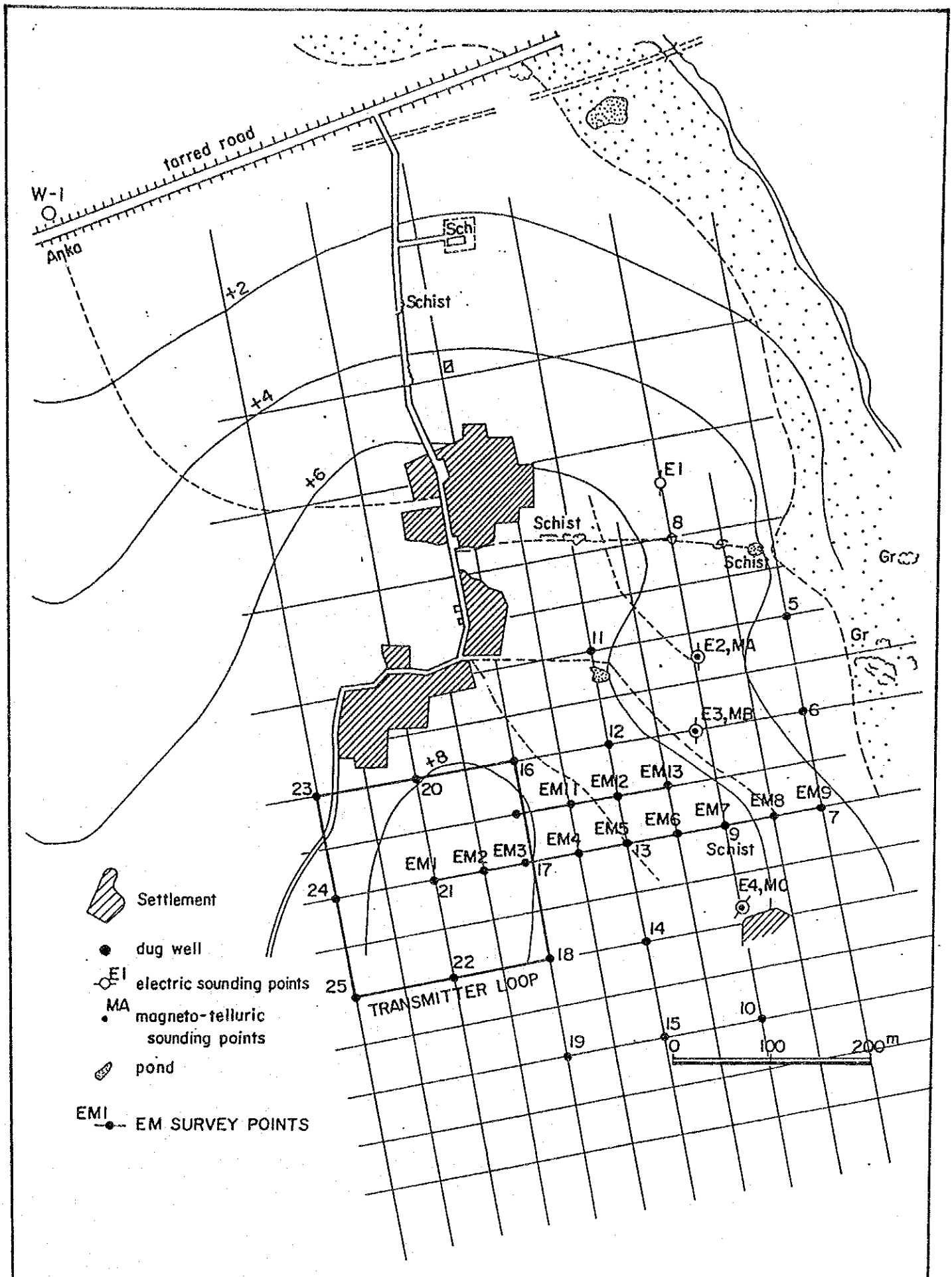
LOOP SIZE: 100.00 m PREAMP GAIN: 52.10
4x GAIN, CHANS 6-10,16,20: YES

25.00 Hz GAIN: 8	6.25 Hz GAIN: 8	2.50 Hz GAIN: 8
17.00 AMPS	17.00 AMPS	17.00 AMPS
COIL: 100.0 m^2	COIL: 100.0 m^2	COIL: 100.0 m^2
RAMP: 70.0 muSEC	RAMP: 70.0 muSEC	RAMP: 70.0 muSEC

CHNL	T (mSEC)	mVOLT	RHO-A	mVOLT	RHO-A	mVOLT	RHO-A
1	0.089	6601.00	375.85				
2	0.110	4423.00	344.83				
3	0.140	2447.00	342.32				
4	0.177	1325.00	348.58				
5	0.220	697.00	372.28				
6	0.280	1327.00	408.57				
7	0.355	504.00	524.53				
8	0.443	158.00	785.83				
9	0.564	10.00	3308.59				


RUWANSN
1000
100
0.01
0.1
1
TIME (msec)
100
1000
RESISTIVITY (OHM-M)
Depth (m x 10)
0
1
2
3
4
5
6
7
8

TUNGA ARDO



Location of the EM Survey Points (Tunga Ardo)

Result of interpretation of EM survey

- TEMIX RESULT -

(Tunga Ardo)

DATA SET: TUNGA1

CLIENT: JICA
DATE: 20-DEC-88
LOCATION: Sokoto Nigeria
SOUNDING: 3
COUNTY: Gusau
ELEVATION: 0.00 m
PROJECT: Synthetic EM-37 Data
EQUIPMENT: Geonics EM-37
LOOP SIZE: 200.000 meters square
SOUNDING COORDINATES: X: 0.0000 Y: 0.0000

FITTING ERROR: 164.153 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			0.0	
1	200.0	49.25	-49.25	0.246
2	175117.8	145.5	-194.8	8.313E-04
3	1.000E+06			

ALL PARAMETERS ARE FREE

CURRENT: 15.00 AMPS
COIL AREA: 100.00 sq m.
FREQUENCY: 25.00 Hz
GAIN: 8
RAMP TIME: 140.00 muSEC

No.	TIME (ms)	emf (nV/m sqrd) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0890	2259.7	2644.0	-17.00
2	0.110	1385.9	1474.2	-6.37
3	0.140	758.7	731.4	3.60
4	0.177	389.8	367.2	5.79
5	0.220	186.6	184.8	0.970
6	0.280	78.16	86.31	-10.42
7	0.355	25.67	38.34	-49.32
8	0.443	8.45	19.35	-128.9
9	0.564	2.24	6.86	-204.9
10	0.713	0.281	4.19	-1391.1

CURRENT RESOLUTION MATRIX NOT AVAILABLE

DATA SET: TUNGA1

CLIENT: JICA
DATE: 20-DEC-88
LOCATION: Sokoto Nigeria
SOUNDING: 3
COUNTY: Gusau
ELEVATION: 0.00 m
PROJECT: Synthetic EM-37 Data
EQUIPMENT: Geonics EM-37
LOOP SIZE: 200.000 meters square
SOUNDING COORDINATES: X: 0.0000 Y: 0.0000

FITTING ERROR: 164.153 PERCENT

L #	RESISTIVITY (ohm-m)	THICKNESS (meters)	ELEVATION (meters)	CONDUCTANCE (Siemens)
			0.0	
1	200.0	49.25	-49.25	0.246
2	175117.8	145.5	-194.8	8.313E-04
3	1.000E+06			

ALL PARAMETERS ARE FREE

CURRENT: 15.00 AMPS
COIL AREA: 100.00 sq m.
FREQUENCY: 25.00 Hz
GAIN: 8
RAMP TIME: 140.00 muSEC

No.	TIME (ms)	Apparent Res (ohm-m) DATA	SYNTHETIC	DIFFERENCE (percent)
1	0.0890	1469.3	1323.2	9.94
2	0.110	1429.9	1372.2	4.03
3	0.140	1429.5	1464.9	-2.47
4	0.177	1507.4	1568.6	-4.06
5	0.220	1714.0	1725.2	-0.652
6	0.280	2049.0	1917.9	6.39
7	0.355	2897.6	2217.9	23.45
8	0.443	4201.9	2418.6	42.43
9	0.564	6791.8	3229.4	52.45
10	0.713	18380.8	3034.0	83.49

CURRENT RESOLUTION MATRIX NOT AVAILABLE

DATA SET: TUNGA1

CLIENT: JICA
LOCATION: Sokoto Nigeria
COUNTY: Gusau
PROJECT: Synthetic EM-37 Data
LOOP SIZE: 200.000 meters square
SOUNDING COORDINATES: X: 0.0000 Y: 0.0000

DATE: 20-DEC-88
SOUNDING: 3
ELEVATION: 0.00 m
EQUIPMENT: Geonics EM-37

FITTING ERROR: 164.153 PERCENT

Geonics EM-37 Data Worksheet
LOOP SIZE: 200.00 m PREAMP GAIN: 52.10
4x GAIN, CHANS 6-10,16,20: YES

	25.00 Hz GAIN: 8	6.25 Hz GAIN: 8	2.50 Hz GAIN: 8
	15.00 AMPS	15.00 AMPS	15.00 AMPS
	COIL: 100.0 m^2	COIL: 100.0 m^2	COIL: 100.0 m^2
	RAMP: 140.0 muSEC	RAMP: 140.0 muSEC	RAMP: 140.0 muSEC

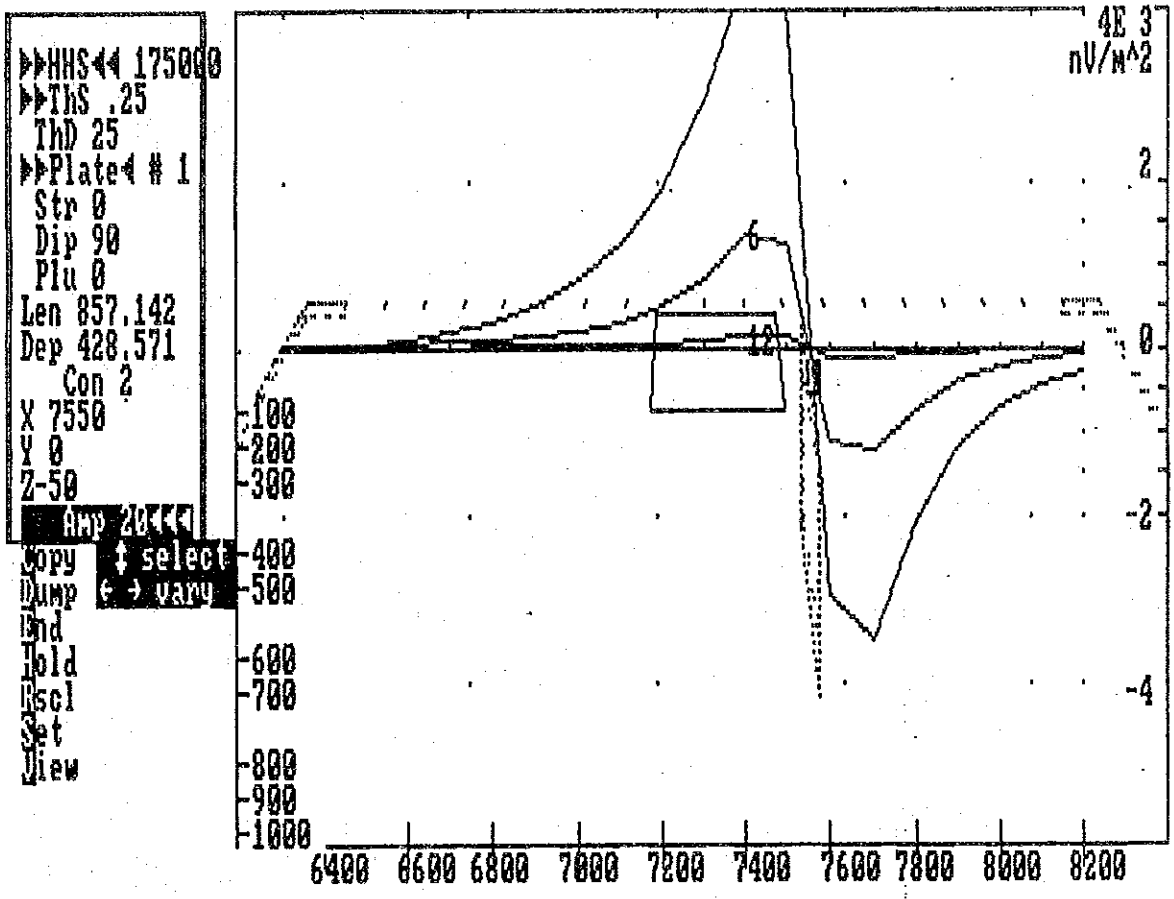
CHNL	T (mSEC)	mVOLT	RHO-A	mVOLT	RHO-A	mVOLT	RHO-A
1	0.089	3014.00	1469.34				
2	0.110	1848.50	1430.00				
3	0.140	1012.00	1429.56				
4	0.177	520.00	1507.46				
5	0.220	249.00	1714.08				
6	0.280	417.00	2049.06				
7	0.355	137.00	2897.67				
8	0.443	45.10	4201.96				
9	0.564	12.00	6791.88				
10	0.713	1.50	18380.87				

TUNGA1
TIME (msec)
RESISTIVITY (Ohm-m)
Depth (m x 100)

Result of interpretation of EM survey

- MOTEM RESULT -

(Tunga Ardo)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▶▶ThS .25
ThD 25
▶▶Plate◀ # 1
Str 0
Dip 90
Plu 0
Len 857.142
Dep 428.571
Con 2
X 7550
Y 0
Z-50
AMp 20000
Copy
Dump
Grid
Hold
Iscl
Set
View
↕ select
← → vary
4E 3
nV/m^2
2
0
-2
-4
-100
-200
-300
-400
-500
-600
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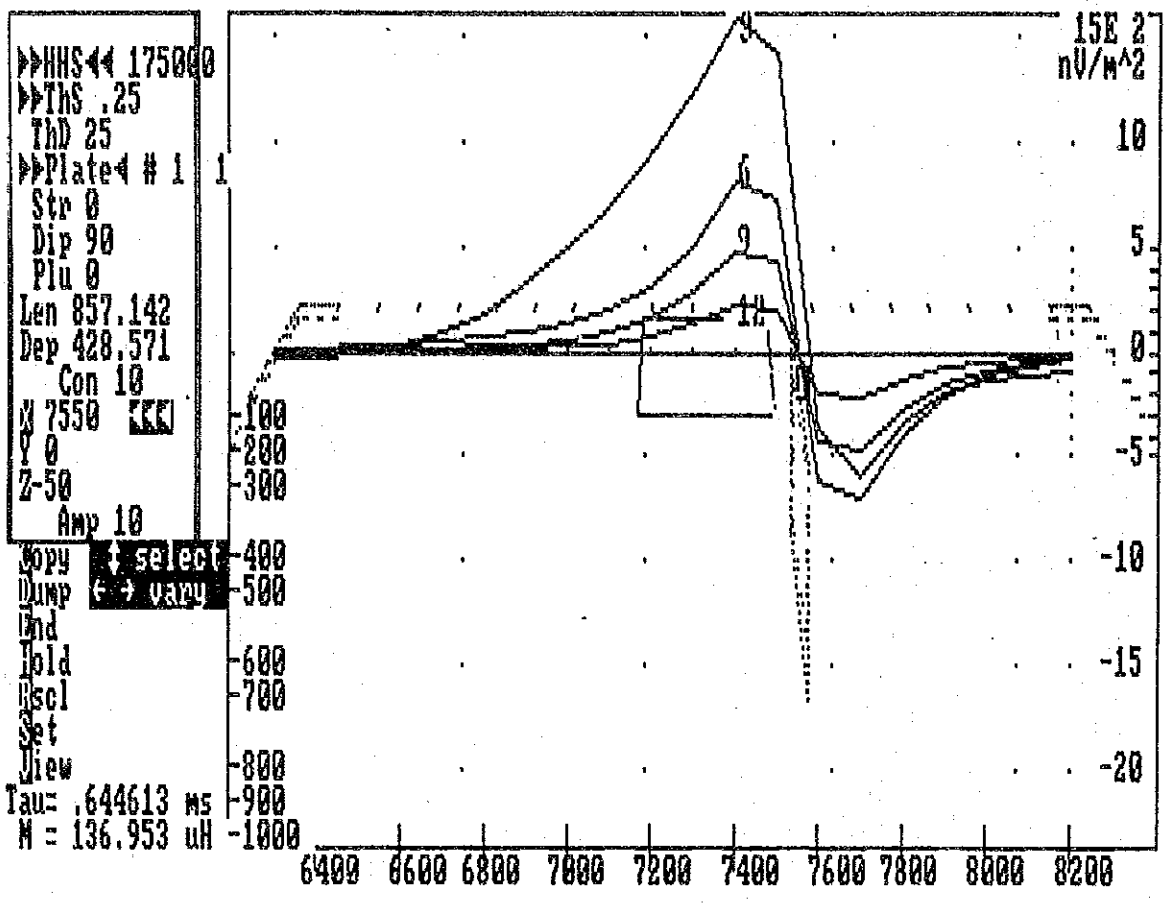
7000
7200
7400
7600
7800
8000
8200


▶▶MHS◀◀ 175000
▶▶ThS .25
ThD 25
▶▶Plate◀ # 1
Str 0
Dip 90
Plu 0
Len 857.142
Dep 428.571
Con 10
X 7550
Y 0
Z-50
Amp 10
Copy ↕ select
Dump ← → vary
Tau= .644613 ms
M = 136.953 uH
15E 2
nV/m^2
10
5
0
-5
-10
-15
-20
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
6400
6600
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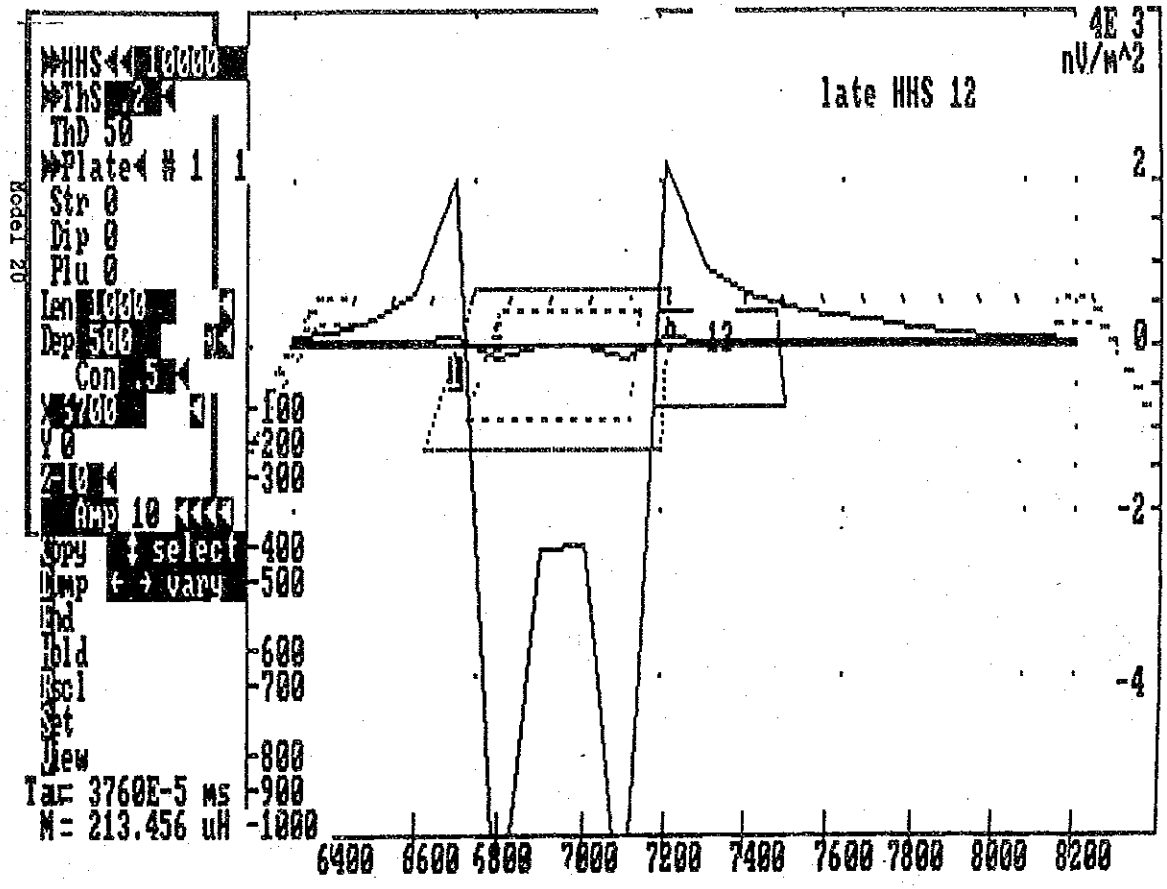
7000
7200
7400
7600
7800
8000
8200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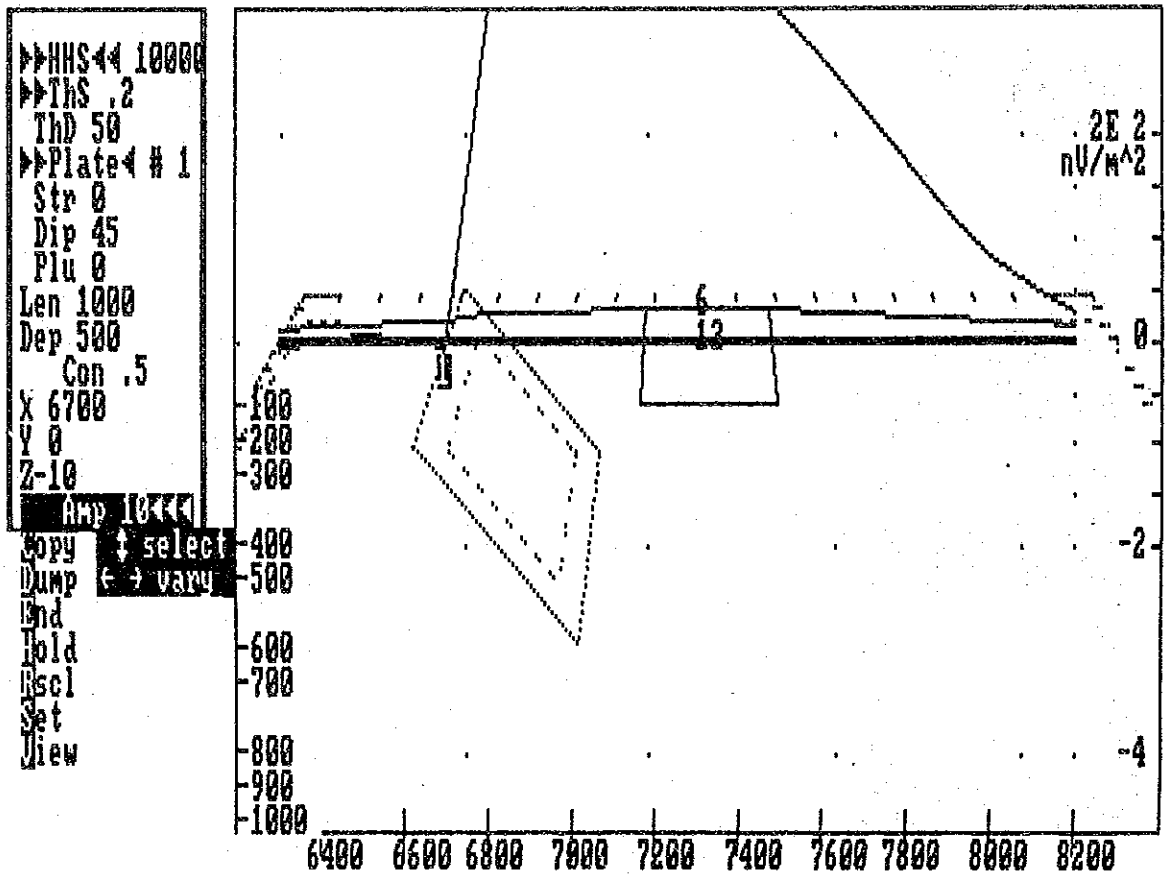
ThS .2
ThD 50
Plate # 1 1
Str 0
Dip 0
Plu 0
Len 1000
Dep 500
Con .5
X 5700
Y 0
Z 10
Amp 10
Cppy ↕ select
Jump ← → vary
Tau= 3760E-5 ms
M= 213.456 uH
late HHS 12
4E 3
nV/m^2
2
0
-2
-4
100
200
300
400
500
600
700
800
900
1000
6400
6600
6800
7000
7200
7400
7600
7800
8000
8200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▶▶ThS .2
ThD 50
▶▶Plate◀ # 1
Str 0
Dip 45
Plu 0
Len 1000
Dep 500
Con .5
X 6700
Y 0
Z-10
Amp 10◀◀
Copy ↕ select
Dump ← → vary
End
Hold
Rscl
Set
View
Model 245
2E 2
nV/m^2
0
-2
-4
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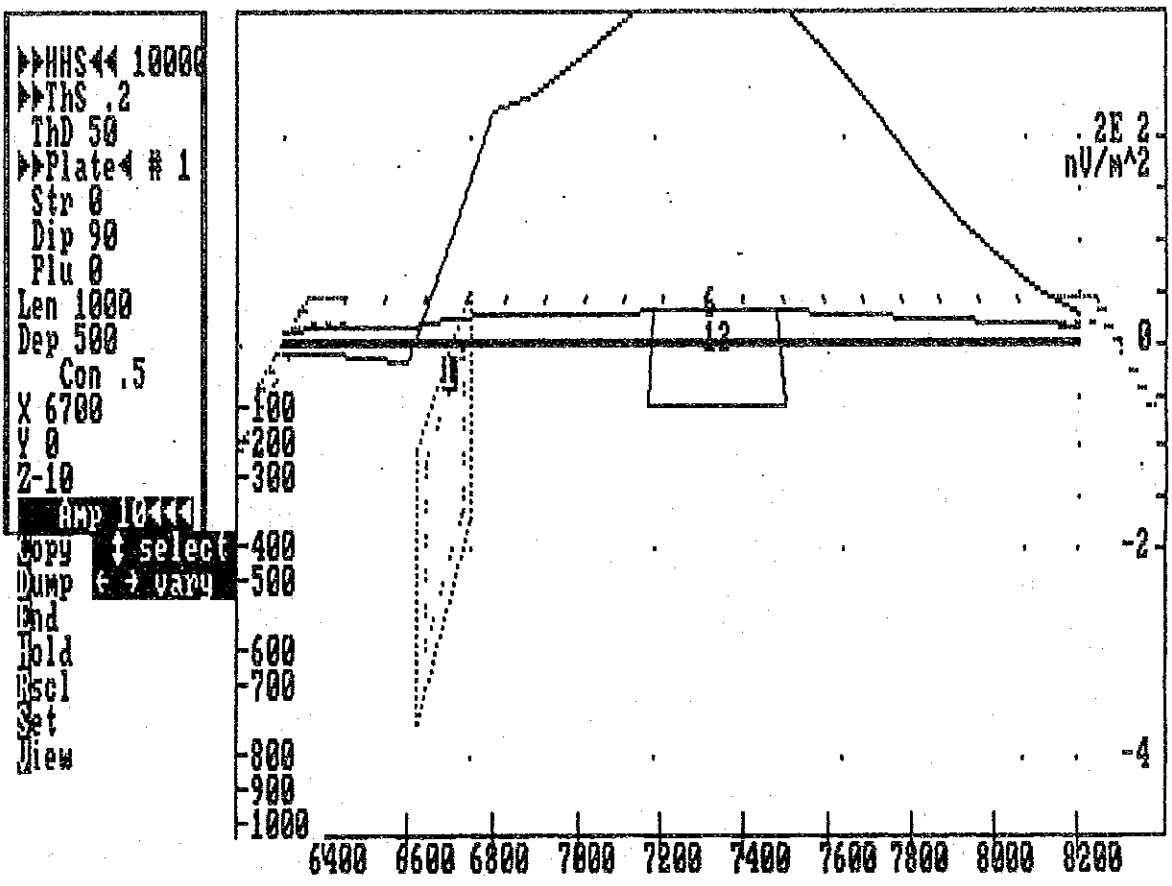
200
300
400
500
600
700
800
900
1000
6400 6600 6800 7000 7200 7400 7600 7800 8000 8200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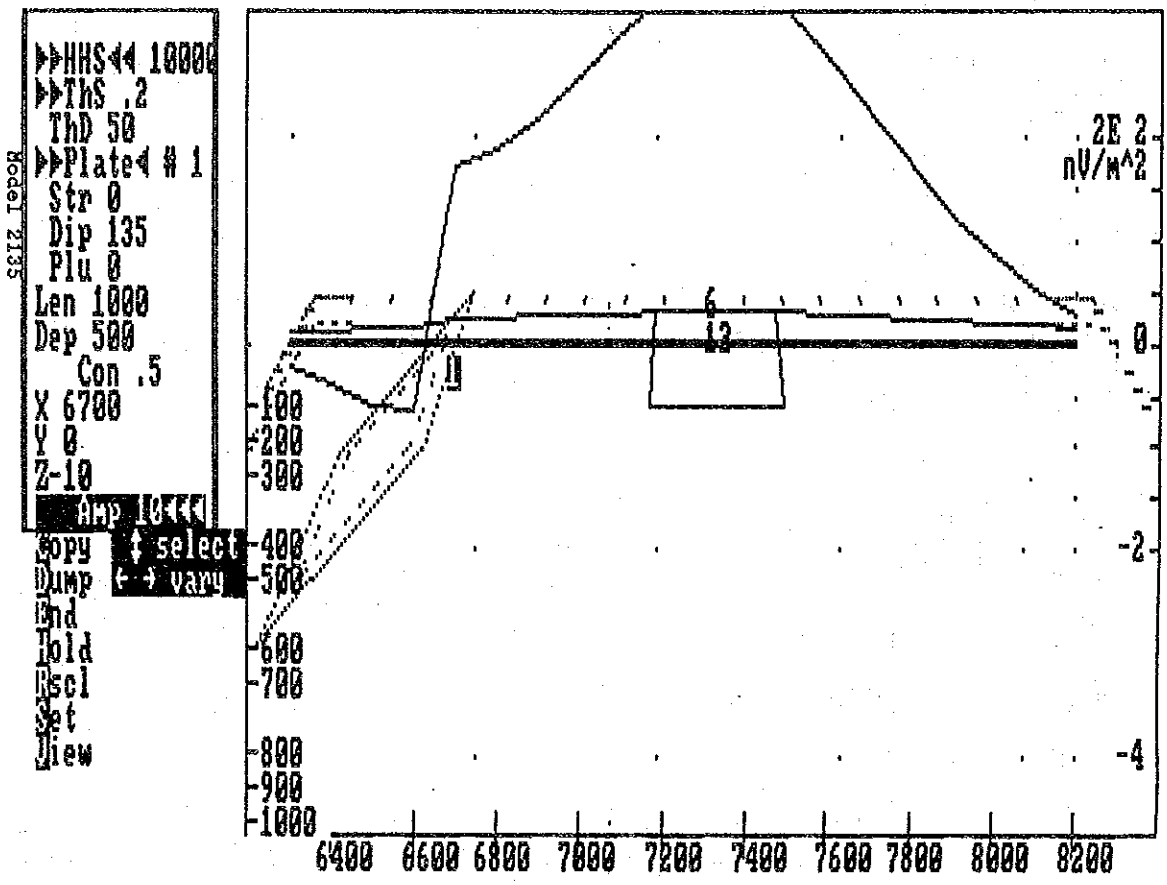
▶▶ThS .2
ThD 50
▶▶Plate◀ # 1
Str 0
Dip 90
Plu 0
Len 1000
Dep 500
Con .5
X 6700
Y 0
Z-10
Amp 10◀◀◀
Copy ↕ select
Dump ← → vary
Hold
Set
View
.2E 2
nV/m^2
0
-2
-4
100
200
300
400
500
600
700
800
900
1000
6400 6600 6800 7000 7200 7400 7600 7800 8000 8200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▶▶ThS .2
ThD 50
▶▶Plate◀ # 1
Str 0
Dip 135
Plu 0
Len 1000
Dep 500
Con .5
X 6700
Y 0
Z-10
Copy
Dump
Hold
Rscl
Set
View
Model 135
2E 2
nV/m^2
0
-2
-4
-100
-200
-300
-400
-500
-600
-700
-800
-900
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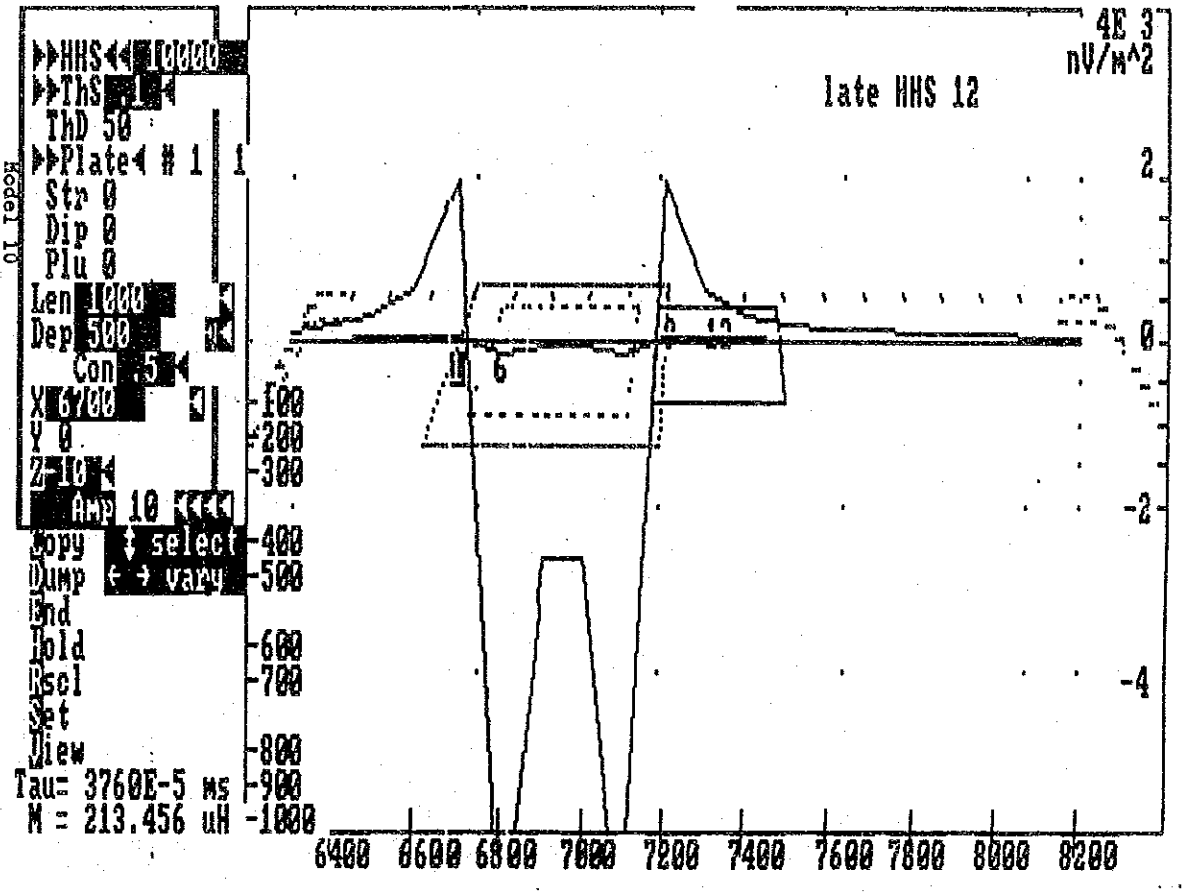
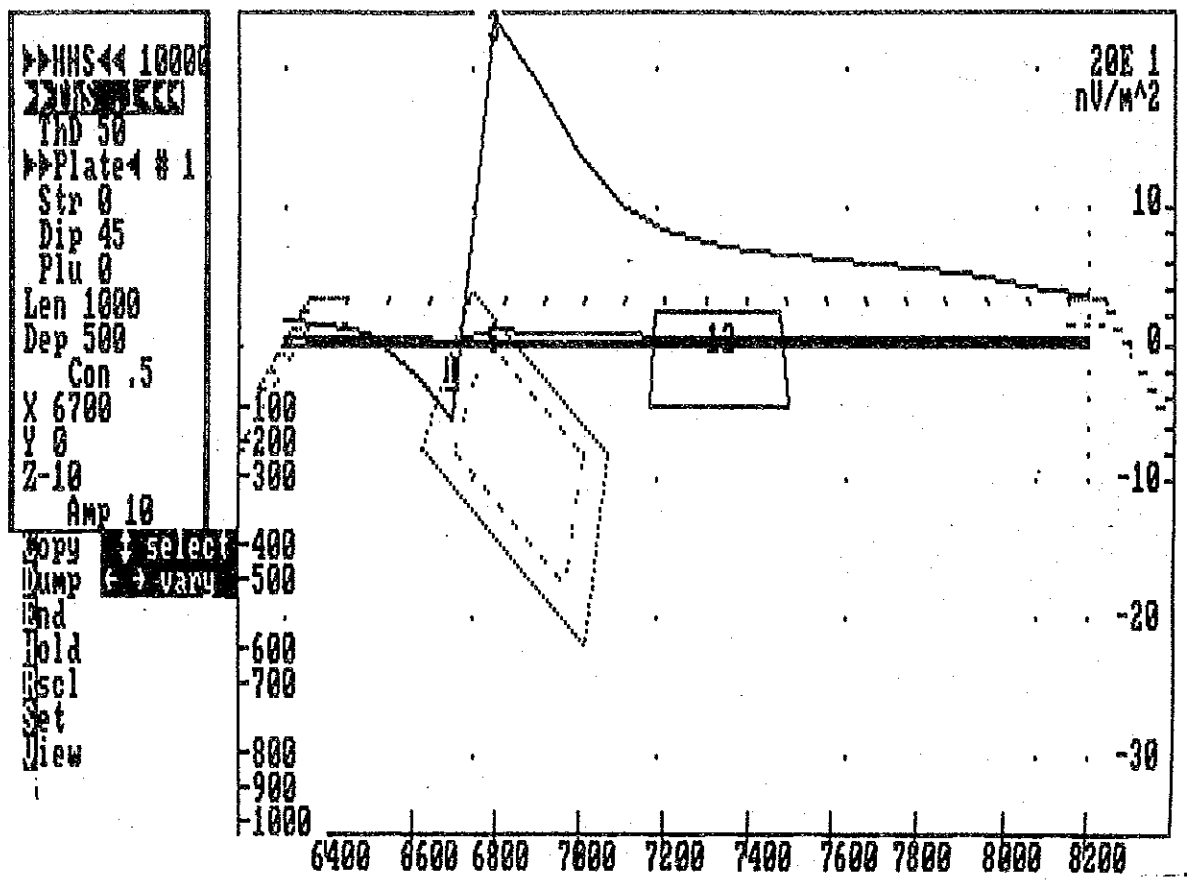
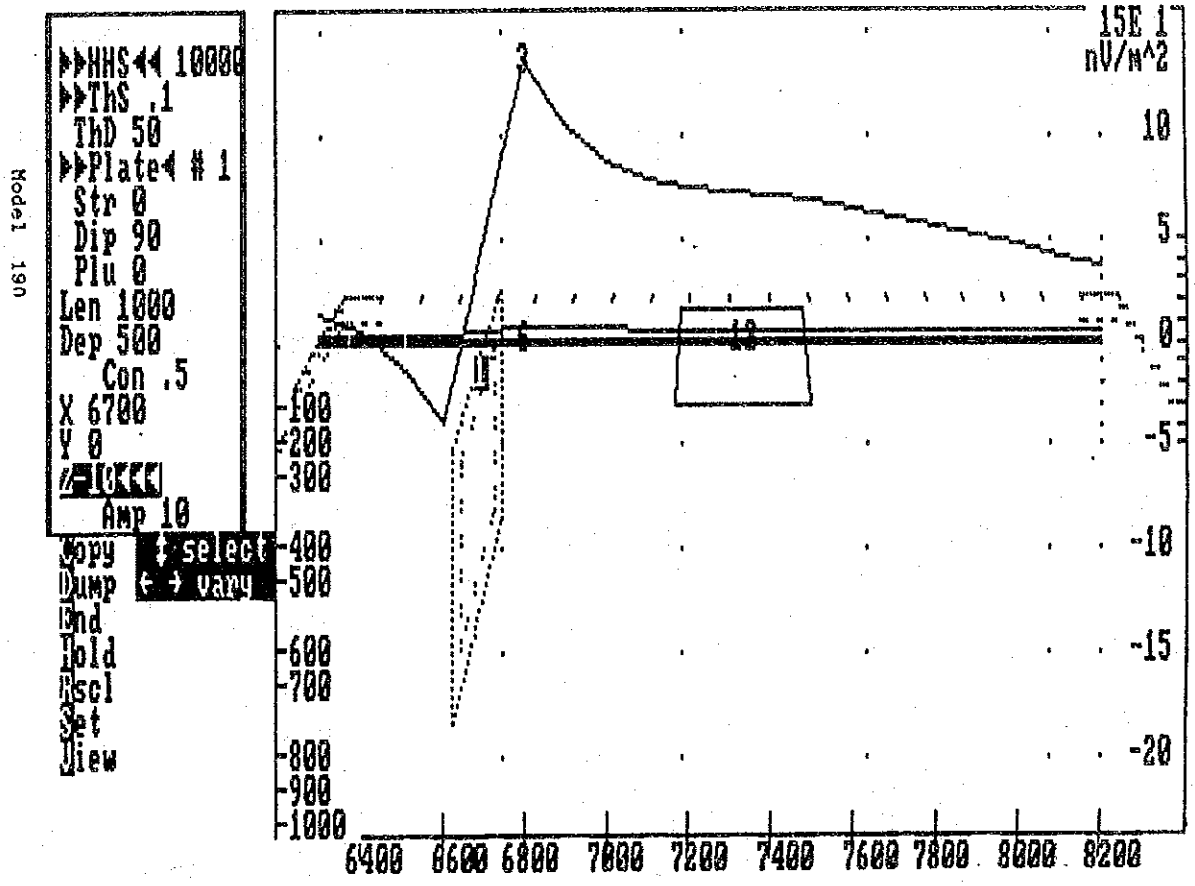
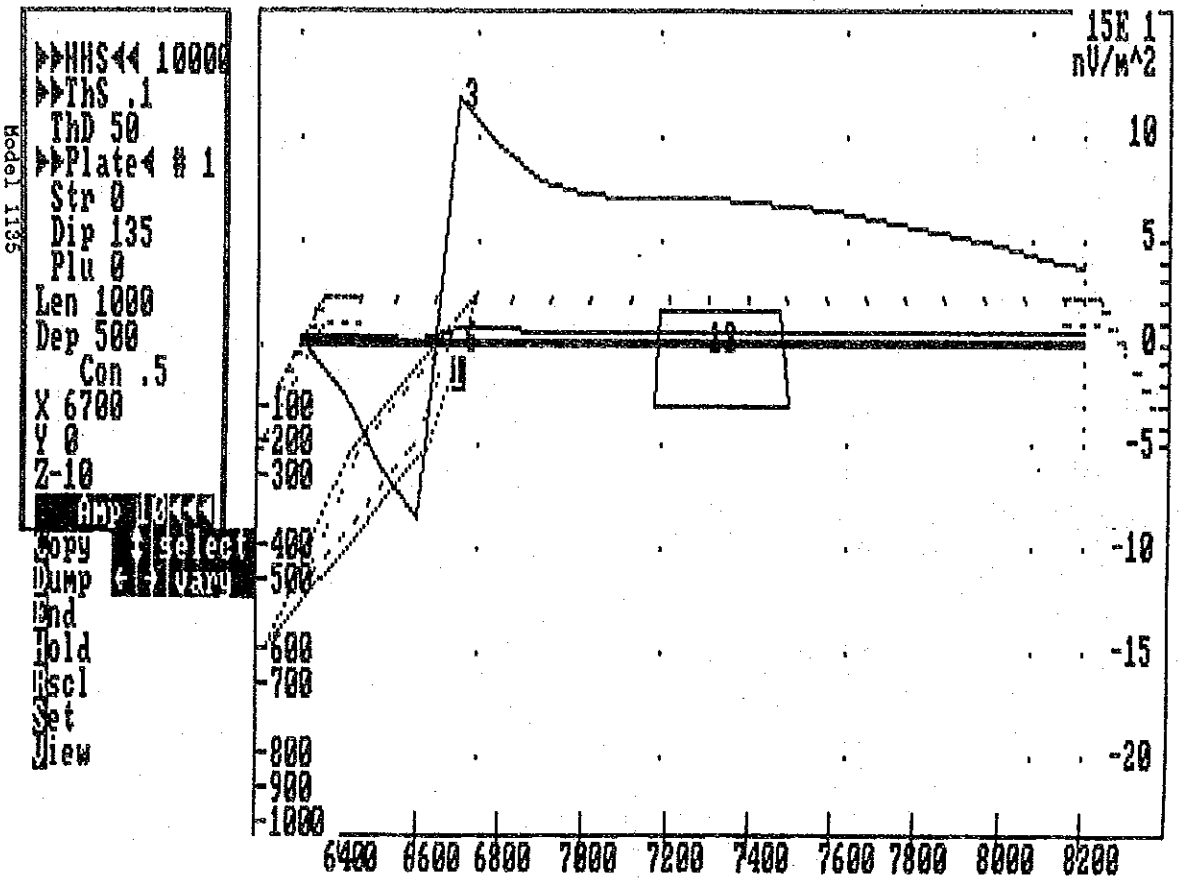
6800
7000
7200
7400
7600
7800
8000
8200


Late HHS 12
4E 3
nV/m^2
2
0
-2
-4
6400
6600
6800
7000
7200
7400
7600
7800
8000
8200
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
Model 10
Tau= 3760E-5 ms
M = 213.456 uH


▶▶HHS◀◀ 10000
ThD 50
▶▶Plate◀ # 1
Str 0
Dip 45
Plu 0
Len 1000
Dep 500
Con .5
X 6700
Y 0
Z-10
Amp 10
Copy
Dump
End
Hold
Escl
Set
View
20E 1
nV/m^2
10
0
-10
-20
-30
100
200
300
400
500
600
700
800
900
1000
6400
6600
6800
7000
7200
7400
7600
7800
8000
8200


Model 190
▶▶HHS◀◀ 10000
▶▶ThS .1
ThD 50
▶▶Plate◀ # 1
Str 0
Dip 90
Plu 0
Len 1000
Dep 500
Con .5
X 6700
Y 0
Amp 10
Copy
Dump
End
Hold
Escl
Set
View
select
vary
15E 1
nV/m^2
10
5
0
-5
-10
-15
-20
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
6400
6600
6800
7000
7200
7400
7600
7800
8000
8200


▶▶HHS◀◀ 10000
▶▶ThS .1
ThD 50
▶▶Plate◀ # 1
Str 0
Dip 135
Plu 0
Len 1000
Dep 500
Con .5
X 6700
Y 0
Z-10
Copy
Dump
End
Hold
Scl
Set
View
Model 1135
15E 1
nV/m^2
10
5
0
-5
-10
-15
-20
-100
-200
-300
-400
-500
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6400
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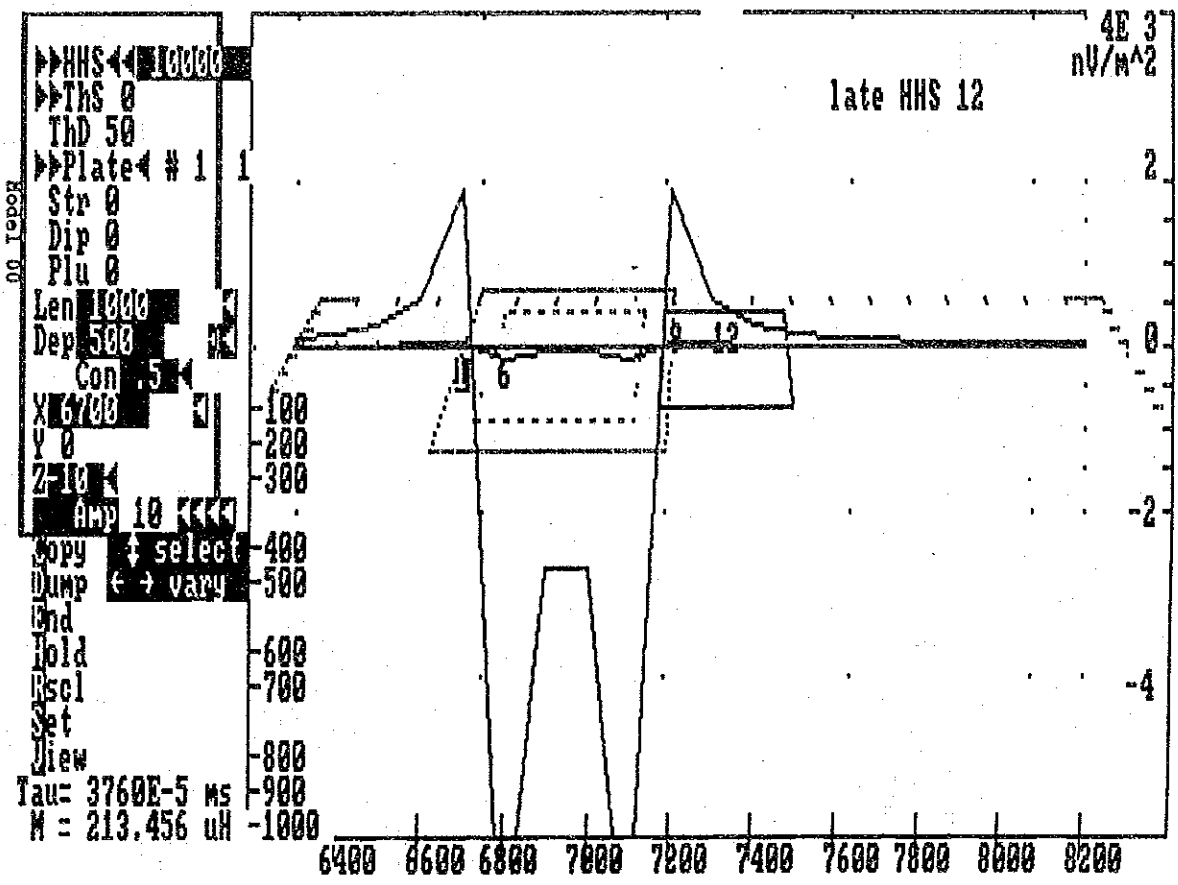
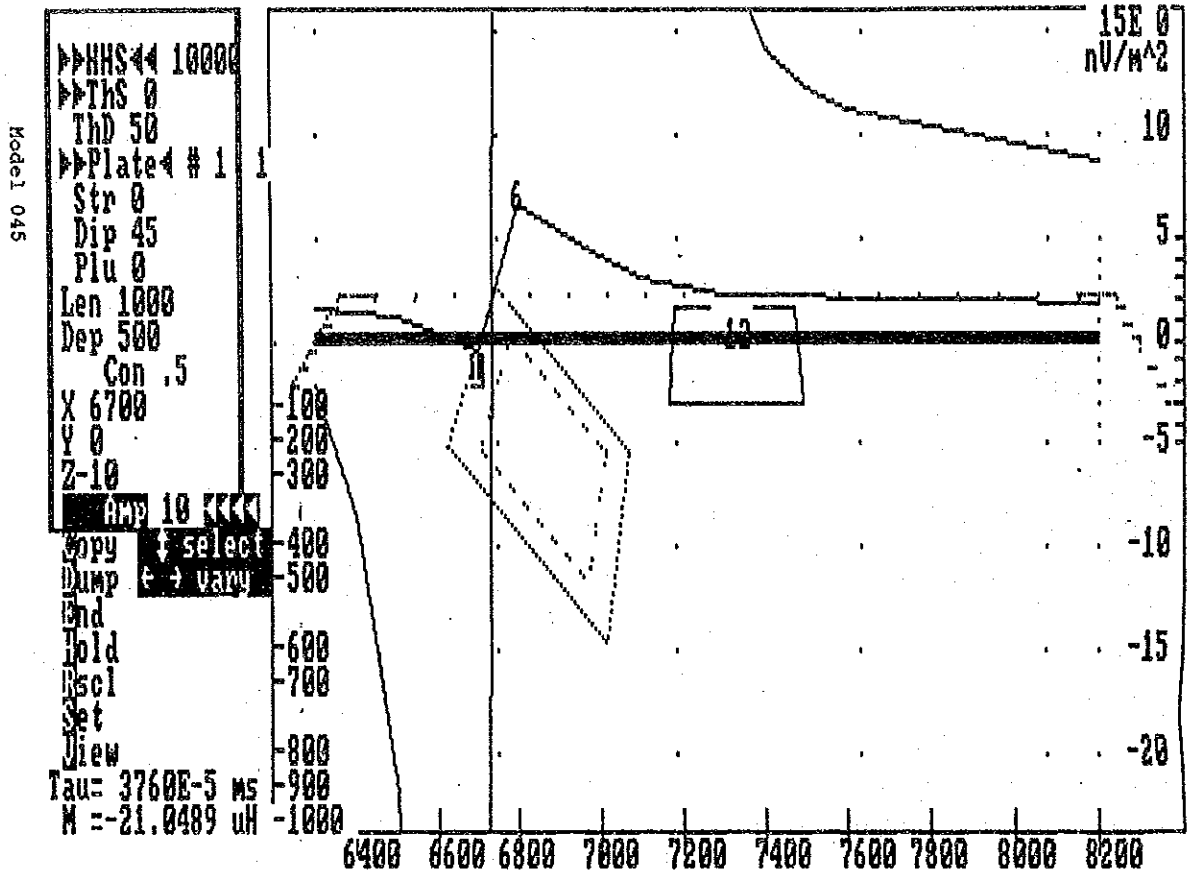
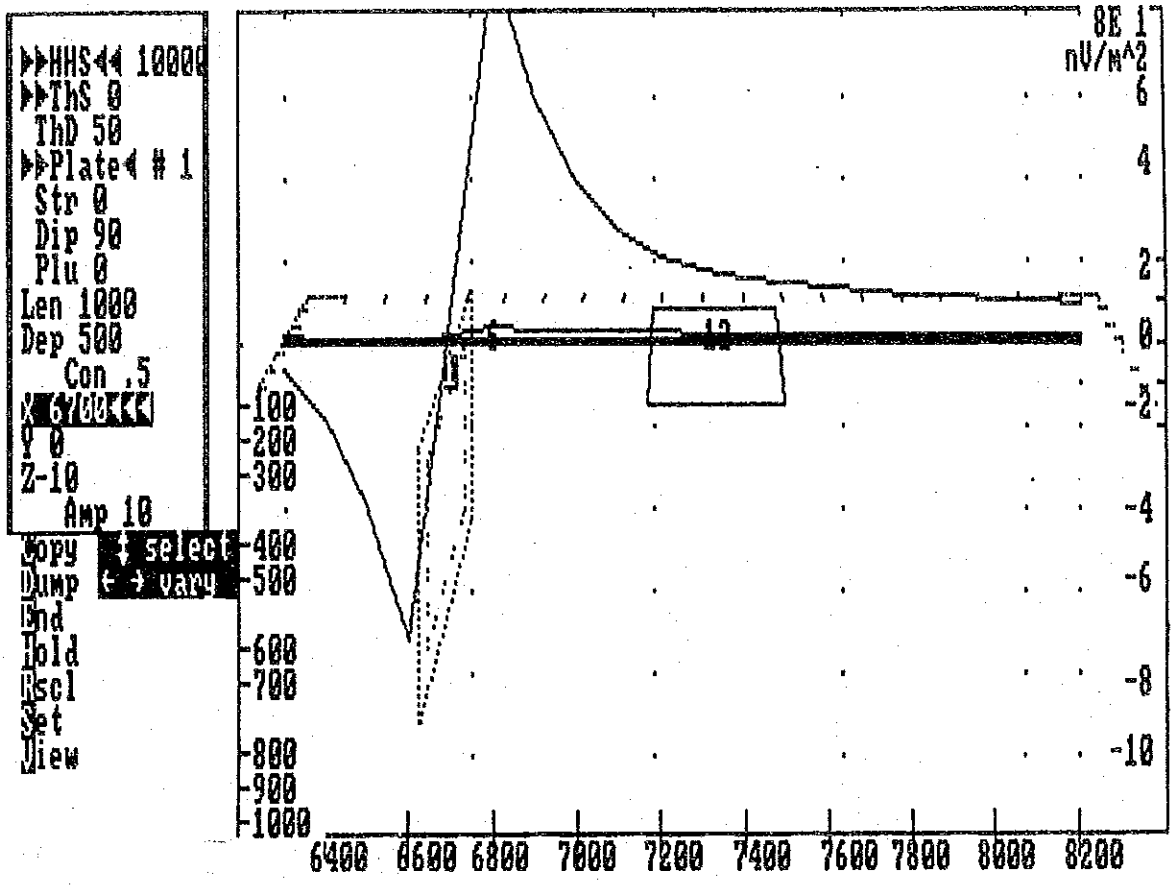
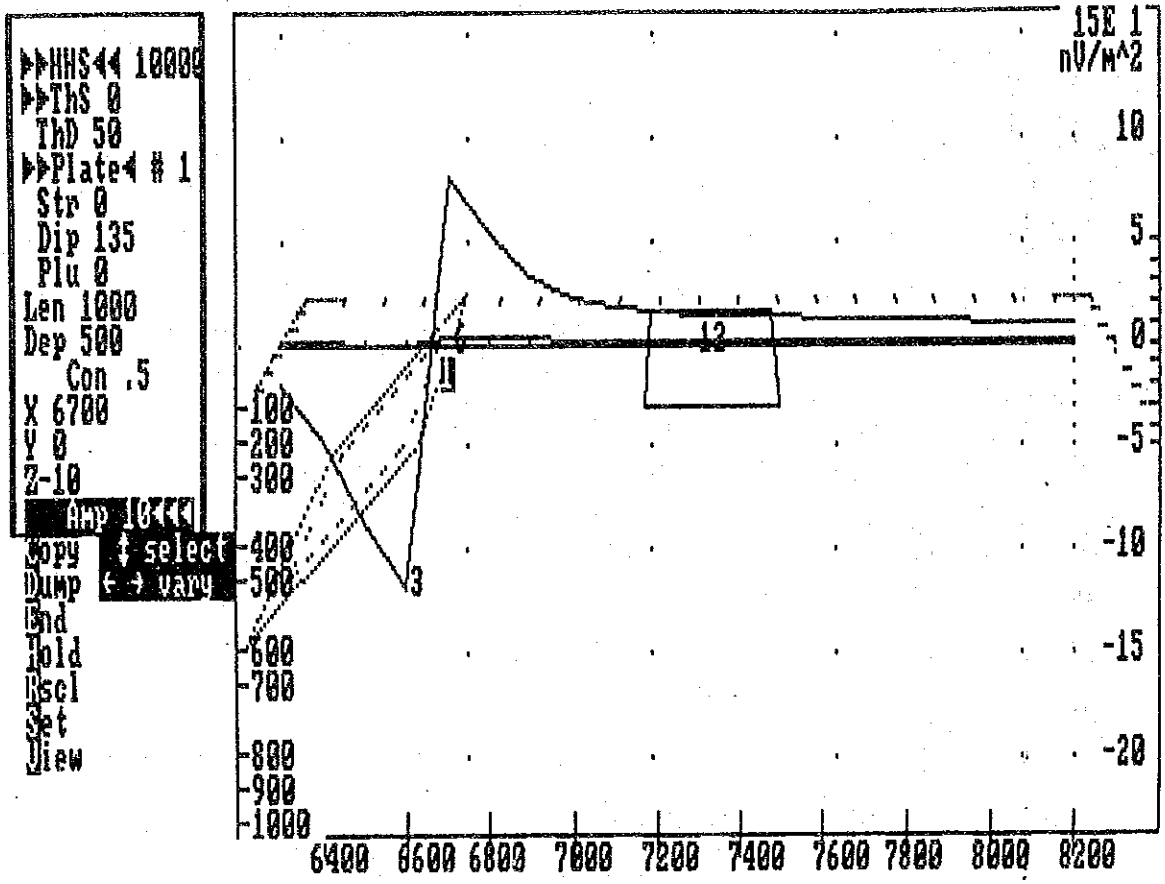
7000
7200
7400
7600
7800
8000
8200
3


HHS 10000
ThS 0
ThD 50
Plate # 1
Str 0
Dip 0
Plu 0
Len 1000
Dep 500
Con .5
X 6700
Y 0
Z-I0
Amp 10
Copy # select
Dump ← → vary
Hold
Rscl
Set
View
Tau= 3760E-5 ms
M = 213.456 uH
Model 60
late HHS 12
4E 3
nV/m^2
2
0
-2
-4
100
200
300
400
500
600
700
800
900
1000
6400
6600
6800
7000
7200
7400
7600
7800
8000
8200


▶▶HHS◀◀ 10000
▶▶ThS 0
ThD 50
▶▶Plate◀ # 1
Str 0
Dip 45
Plu 0
Len 1000
Dep 500
Con .5
X 6700
Y 0
Z-10
RMP 10
Copy
Dump
End
Hold
Escl
Set
View
Tau= 3760E-5 ms
M =-21.0489 uH
↕ select
← → vary
15E 0
nV/m^2
10
5
0
-5
-10
-15
-20
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
6400
6600
6800
7000
7200
7400
7600
7800
8000
8200

Model 045

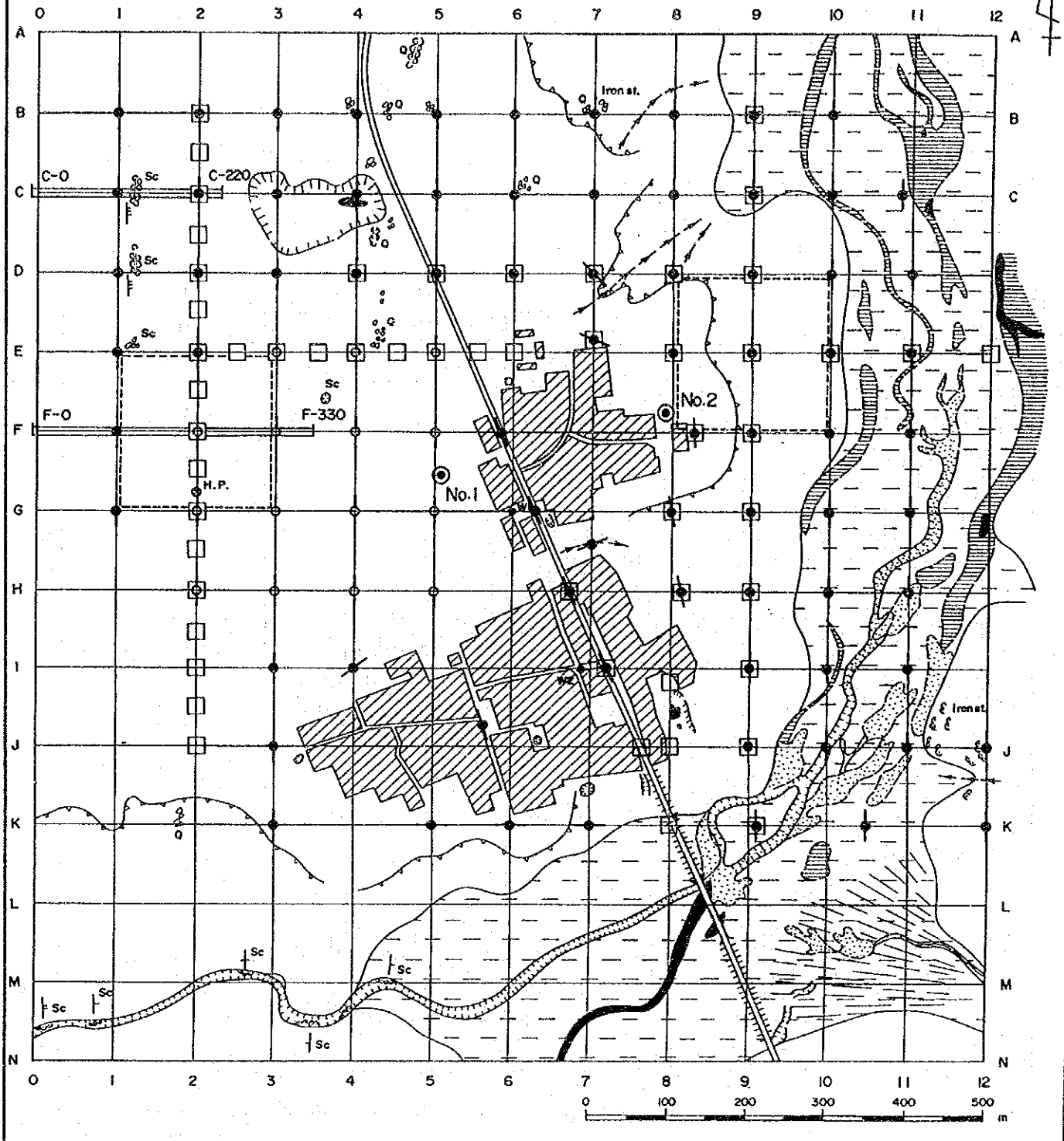

Model 090
▶▶HHS◀◀ 10000
▶▶ThS 0
ThD 50
▶▶Plate◀ # 1
Str 0
Dip 90
Plu 0
Len 1000
Dep 500
Con .5
X 6700
Y 0
Z-10
Amp 10
Copy ↕ select
Dump ← → vary
End
Hold
Rscl
Set
View
8E 1
nV/m^2
6
4
2
0
-2
-4
-6
-8
-10
100
200
300
400
500
600
700
800
900
1000
6400 6600 6800 7000 7200 7400 7600 7800 8000 8200


▶▶HHS◀◀ 10000
▶▶ThS 0
ThD 50
▶▶Plate◀ # 1
Str 0
Dip 135
Plu 0
Len 1000
Dep 500
Con .5
X 6700
Y 0
Z-10
AMP 10000
Copy ↕ select
Dump ← → vary
End
Hold
Rscl
Set
View
15E 1
nV/m^2
10
5
0
-5
-10
-15
-20
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
6400 6600 6800 7000 7200 7400 7600 7800 8000 8200
12
11
3

Model 0135

ZUGU

LOCATION OF THE SURVEY POINTS



Electlic Sounding

surveyed point

surveyed in previous stage

Seismic Refraction Survey

C-0 C-220 survey line

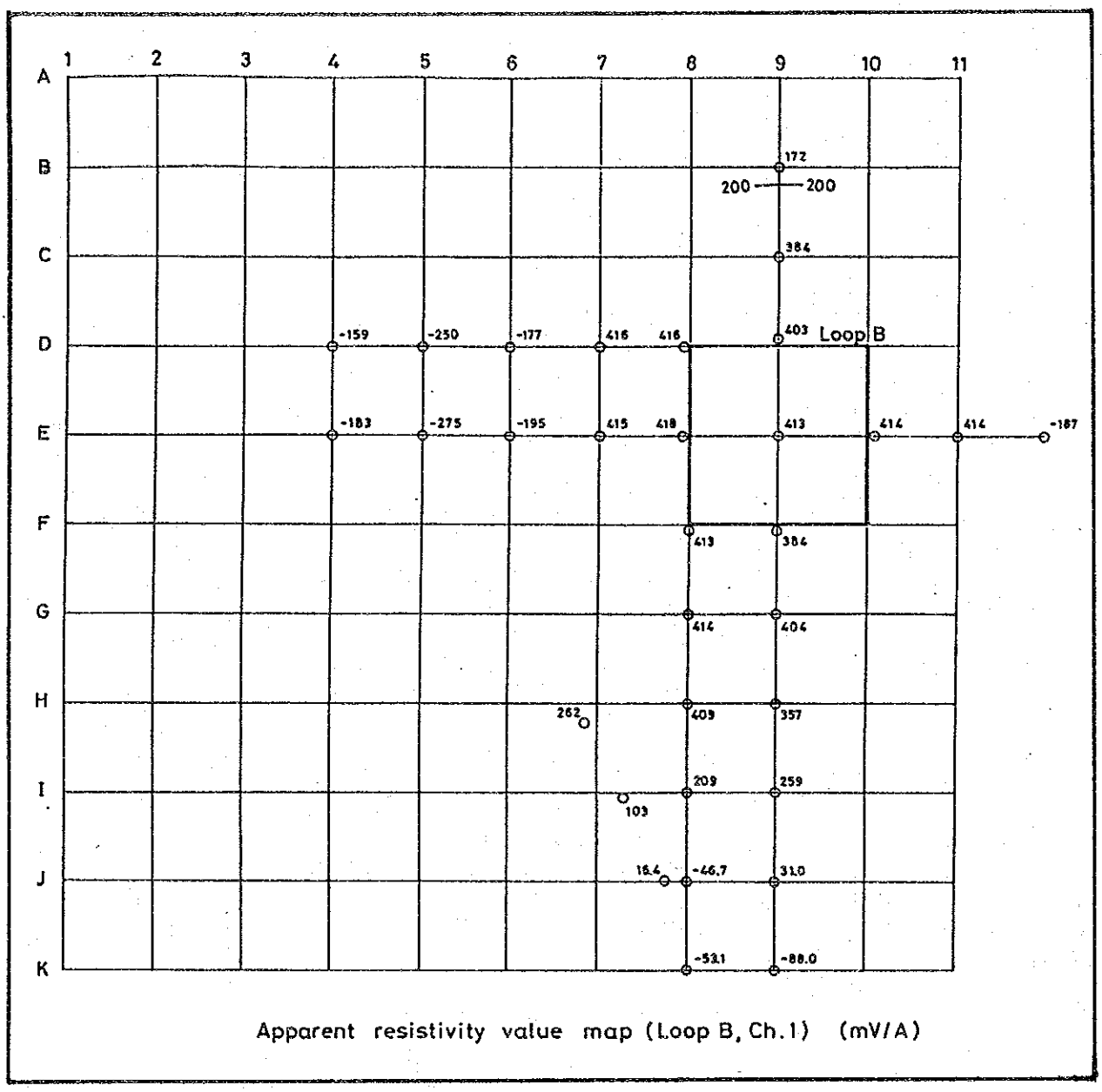
TEM Survey

measured point

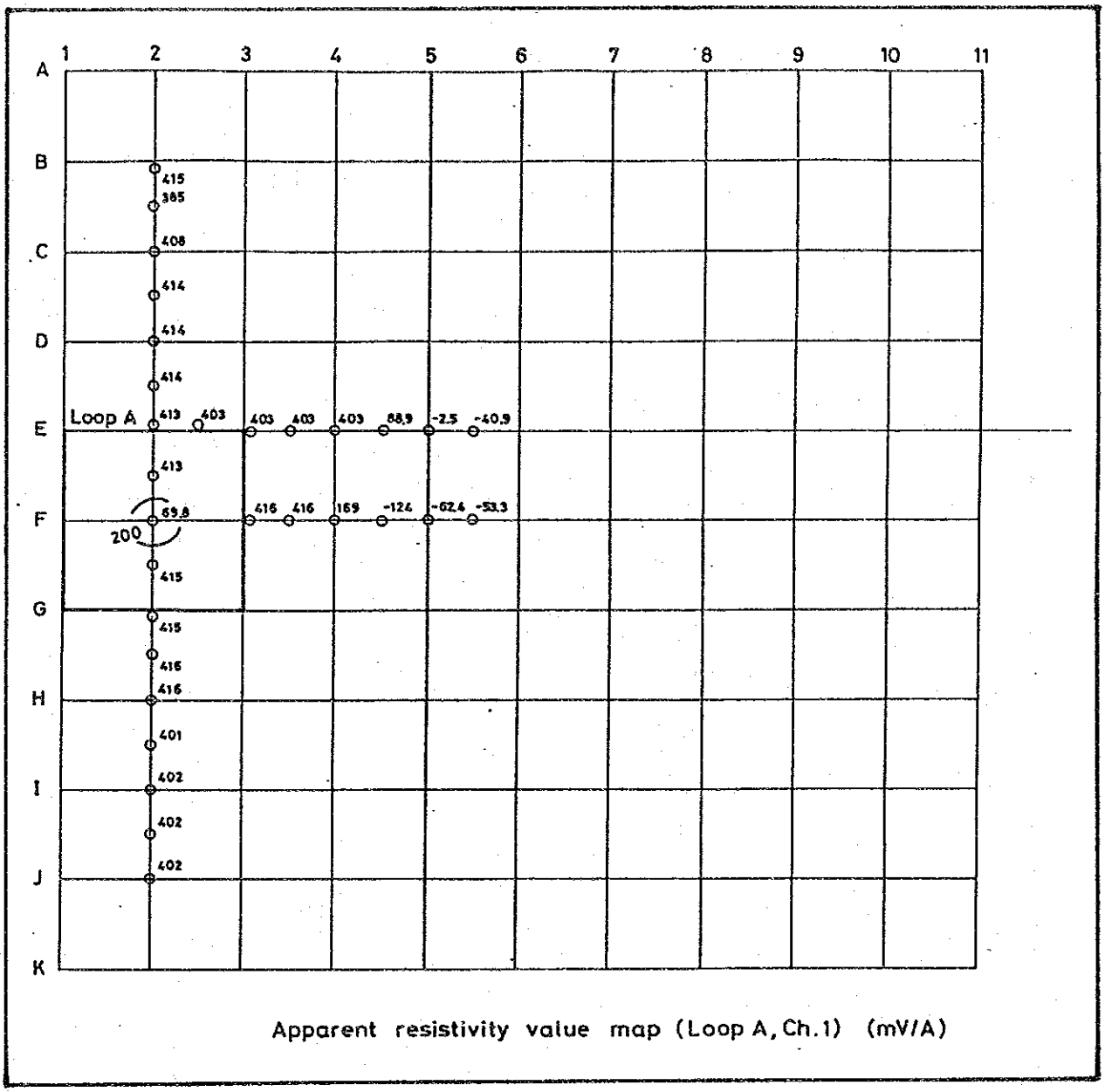
transmitting loop

Test Drilling

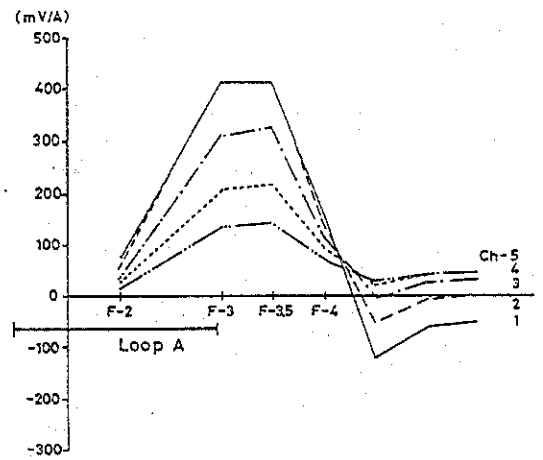
No.1,2 drilling point

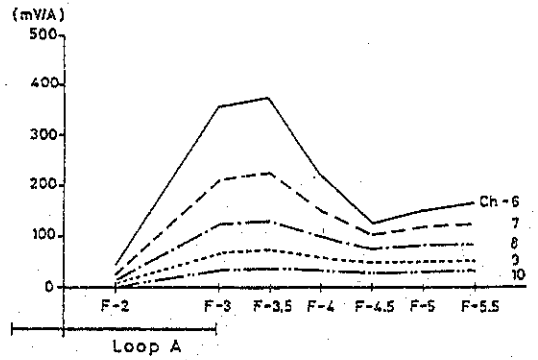


Apparent resistivity value map (Loop B, Ch.1) (mV/A)

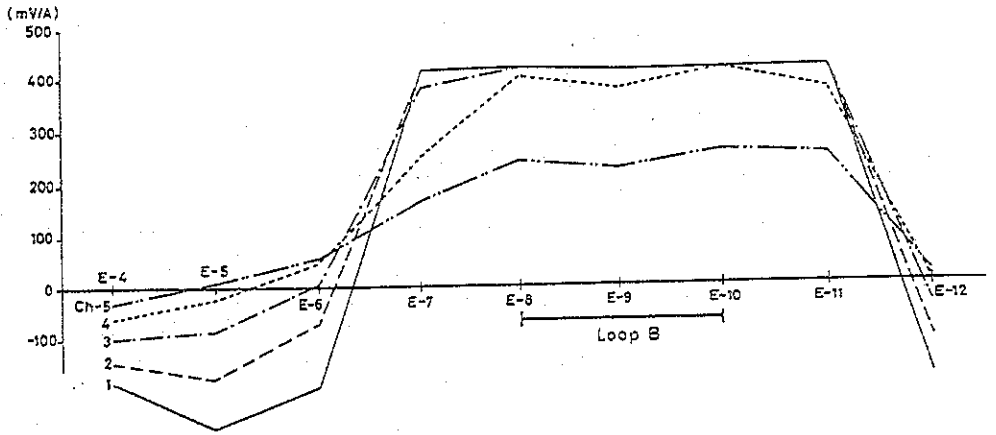


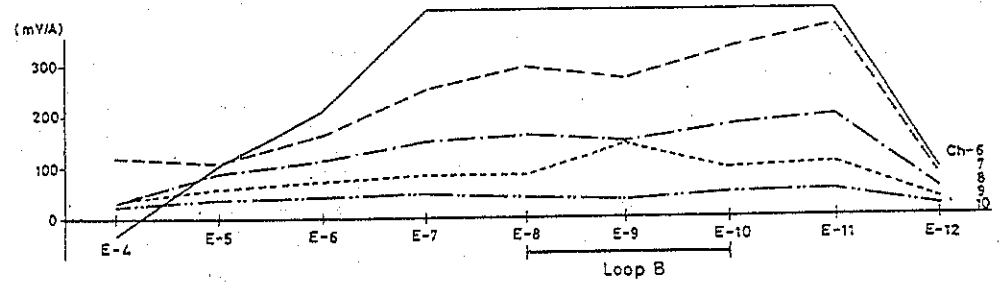
Apparent resistivity value map (Loop A, Ch.1) (mV/A)





TEM Profile along Line F above : Ch.1~5
based at F-2 (Loop A) below : Ch.6~10





TEM Profile along Line E above : Ch.1~5
based at E-9 (Loop B) below : Ch.6~10

The traverse data along Line E and F