LABORATORIUM VOOR TOEGEPASTE GEOLOGIE EN HYDROGEOLOGIE

GROUNDWATER INVESTIGATION

LANDFALL INTERCONNECTOR PIPELINE

BACTON - ZEEBRUGGE

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Laboratorium
voor
Toegepaste Geologie
en
Hydrogeologie

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PIPELINE BACTON - ZEEBRUGGE

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I INTRODUCTION

By order of Haecon NV the Laboratory of Applied Geology and Hydrogeology of the University of Ghent carried out a surface geophysical investigation nearby the site for the landfall of the Gas Interconnector Pipeline Bacton-Zeebrugge.

The fieldwork consisted of:
- 5 resistivity soundings (Wenner)
- 1000 m resistivity traversing
- all points levelled (by Haecon)

This report contains the results and interpretation of the prospection.

II SITE DESCRIPTION

The land-fall of the interconnector pipeline Bacton-Zeebrugge is planned west of Zeebrugge-harbour in the proximity of the dune belt. The projected trajectory from the beach to the polders Evendijk (towards the reception terminal) follows a NS direction.

In the study area from north to south the following zones can be distinguished:
- the beach
- the dune belt with a seawall
- road N34 ("Koninklijke Baan")
- the polders

The beach is between 500 and 700 m wide at the landfall point (distance to low water line); the dune area before the water pond is approximative 50 m wide; the water pond is about 60 m wide and is separated from the road (N34) by a about 50 metres of dunes. The polders extend several kilometres inland. The top of the dune area lies approximative 13 m above the reference level (T.A.W.); 8 m above the water surface in the pond and 7 m above the beach (near the seawall). The surface level of the polders is about +3.4 m T.A.W.

III GEOLOGY

The local geology is illustrated in figure 1. The generalised section shows the sequence of Quaternary lithological units as well as the Tertiary substratum. From top to bottom following units can be distinguished:

Name	lithology	thickness (m)
D	sand (dune/beach)	7
K8.3	clay and loam	3
K7	peat	2
K6	loamy clay	1
K5.2	sand	1
K5.1	peat and loam	1
K4.1	fine sand	9
K3	gravel and sand	2
K2.1	fine to medium sand	13
K1	gravel and sand	0.5
T4	glauconitic clayey very fine sand	1
T5	sandy clay to clay	7

IV FIELD WORK

IV.1 Location and type

The geo-electrical fieldwork was performed along a NS-profile parallel to the pipeline projected trajectory. The locations of the resistivity soundings, the resitivity traverses and the location of the pipeline are shown in figure 2.

IV. 1.1 Resistivity sounding

At 6 sites resistivity soundings were carried out with direct current and the electrodes in Wenner arrangement. The apparent resistivity was measured for electrode separations varying between 1 and 100 metres and plotted versus the distance on a double logarithmic scale. The results are shown in figures 3 to 8. Each graph is interpreted for resistivity and thickness of the geo-electrical layers.

Sounding 1 lies on the beach at the foot of the dune belt, soundings 2, 3 and 2'are located respectively along the northern and southern border of the water pond and in the dune area; sounding 4 lies between the polders and the road N34 and sounding 5 is located near the southern end of the resistivity traverse.

IV.1.2 Resistivity traversing

A total of 1000 m of resistivity traversing was made along a NS profile by means of a longitudinal Wenner arrangement. The interval between successive mesurements and the electrode spacing were 20 m. The resistivity thus obtained is allocated to the centre of the measuring arrangement. Figure 9a shows the results of 300 m resistivity traversing on the beach, starting from the seawall towards the sea; the results of the measurements along the Londenstraat (dune belt and water pond) and in the polders are shown in figure 9b.

IV.2 Results

IV.2.1 Resistivity soundings

The interpretation of the resistivities in terms of litology and salinization is based upon data from earlier geo-electrical prospections.

litology/salinization	resistivity Ωm	litology/salinazation	resistivity in Ωm
brackish/salt water	1.2 - 10	heavy clay/loamy clay/clay	6 - 12
clay	7 -15	peat-clay/heavy loam	12 - 20
sandy clay	15 - 30	sandy clay/light clay	15 - 25
loam	25 - 30	sandy loam/loam/clayey sand	25 - 35
sand	40 - 100	fine loamy sand	35 - 50
dry sand	100 - 1000	moderate sand	50 - 80

Sounding 1 (beach)
The resistivity of the top layer corresponds with sand filled with salty water. The resistivity of the underlying indicates the presence of a clay, loam and /or peat complex. The values for the third and fifth layer are typical for sand with brackish pore water, whereas the resistivity values measured inbetween match those of a layer with fresh pore water. The latter is located between 8 and 9.5 m depth.

Sounding 2 (dune area, north of pond)
The resistivity sounding gives following result. Under 1 m of dry sands lies a sandy layer filled with fresh pore water. The third layer consists of clay, loam and peat; below 10 m of sand with fresh pore water is found. The fresh-/salt-water interface is located at 17.5 m depth.

Sounding 2' (dune area)
The high resistivities (between 800 and 1750 Ω.m) of the upper two layers indicate dry sand (10.3 m). Below one finds 3.5 m of clay and peat on top of 26 m of sand saturated with brackish pore water. The fifth layer detected is the Tertiary sandy substratum. The fresh-/salt-water interface is located at 14 m depth.

Sounding 3 (south of the pond)
The resistivity of the top layer corresponds with a sandy horizon (0.9 m thick) with fresh pore water overlying a loamy, clayey and/or peaty layer of low resistivity (4 m thick). Below this complex one finds 8 m of sand with fresh pore water. Below this depth the sand contains brackish pore water. The fresh-/salt-water interface is located at 13 m depth.

Sounding 4 (between road and polder area)
The medium-high resistivities of layers 1 and 2 correspond to sandy material (2.8 m thick) with fresh pore water. The third layer, with lower resistivity values, corresponds to clay and peat. The fourth layer is composed of sand with brackish pore water and the fresh-/salt-water interface is located at 23 m depth.

Sounding 5 (near the end of the profile)
A layer with moderate resistivity (38 Ω.m) overlies a clayey, loamy and/or peaty layer with a mean resistivity of 13 Ω.m. The third layer has a resistivity value which correspond to sand with fresh pore water. The fresh-/salt-water interface is located at 19 m depth.

Depth and level of the fresh-/salt-water interface.

sounding n°and surface level (m T.A.W.)	depth to interface in m	level of interface in m
1 / +5.94	9.5	-3.6
2 / +7.20	14	-6.8
2'/ +14.15	17.5	-3.0
3 / +7.20	13	-5.8
4 / +5.34	23	-7.7
5 / +3.40	19	-15.6

Figure 10 shows the position of the interface along the projected trajectory (alternative 2).

With the exception of the sounding at the beach (near the dune area) where a fresh water zone is enclosed in between saline groundwater, resisitivity soundings show the interface to be at more than 10 metres depth. These values are in agreement with the results of earlier investigations in the area.

IV.2.2 Resistivity traversing

Figure 9a shows the apparent resistivities along traverse I (beach), figure 9b the values along traverse IIa (dune area and pond) and IIb (polder area).

IV.2.2.1 Traverse I

The resistivity traverse was carried out on the 13th of February at low tide and freezing temperature. The small resisivity values (mostly between 5 and 2.5 Ω.m) are due to the presence of (brackish) salt pore water near the surface. The fresh water lens is not detected. The high resistivity (up to 95 Ω.m) at the start is likely caused by a pipe buried in the beach. The resistivity decreases gradually towards the sea from 4.8 Ω.m to 2.5 Ω.m at the end of the traverse.

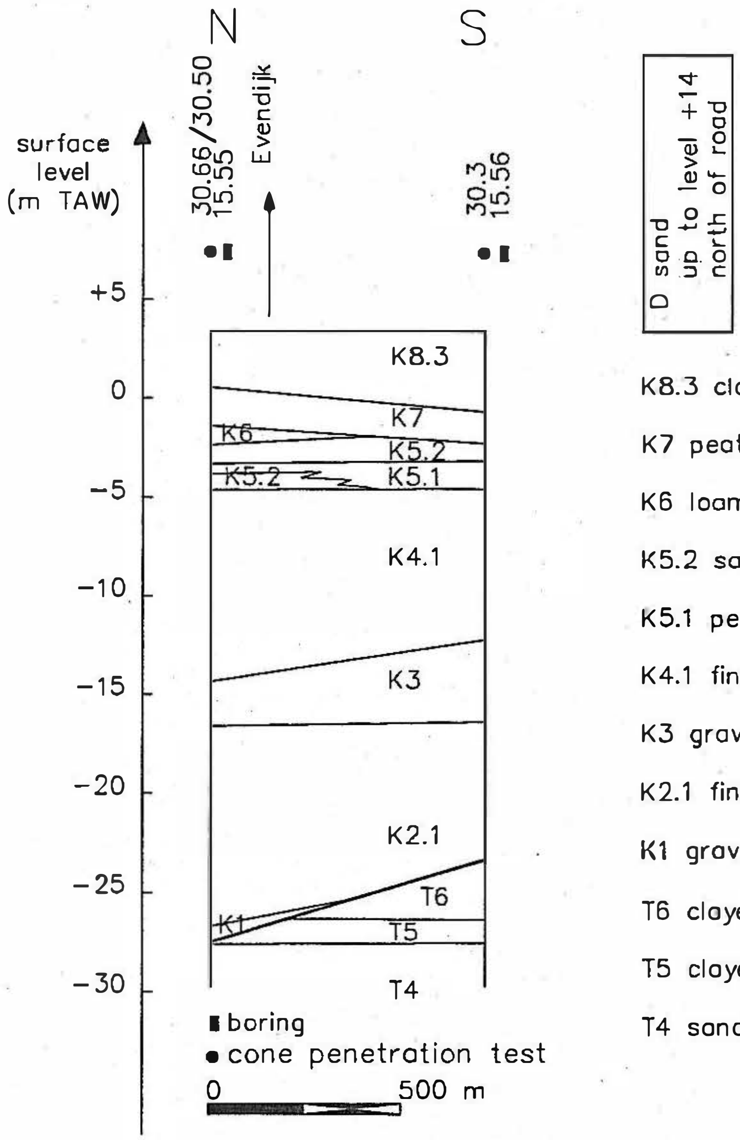
IV.2.2.2 Traverse IIa and IIb

The soundings 2, 2' and 3 indicate the presence of a loam-clay-peat complex. From the road N34 (Koninklijke Baan) to the end of traverse IIb apparent resistivities increase from 5.5 to 11.5 Ω.m. The higher values may be due to weather conditions, a reduction of the thickness of the clay-loam-peat layer or the presence of mains and wiring (Londenstraat).

V Conclusion

The resistivity soundings provide a fairly good picture of the lithology of and the fresh and salt water distribution in the unconfined aquifer.

The landward traverses confirm the presence of the clay-loam-peat layer. Because of the litological heterogeneity of the Quaternary reservoir it is not possible to derive the depth of the interface between fresh and salt water.



K8.3 clay and loam

K7 peat

K6 loamy clay

K5.2 sand

K5.1 peat and loam

K4.1 fine sand

K3 gravel and sand

K2.1 fine to medium sand

K1 gravel and sand

T6 clayey sand

T5 clayey very fine sand

T4 sandy clay to clay

Figure 1 Geological cross-section near the Evendijk (southern end of resistivity traverse IIb).

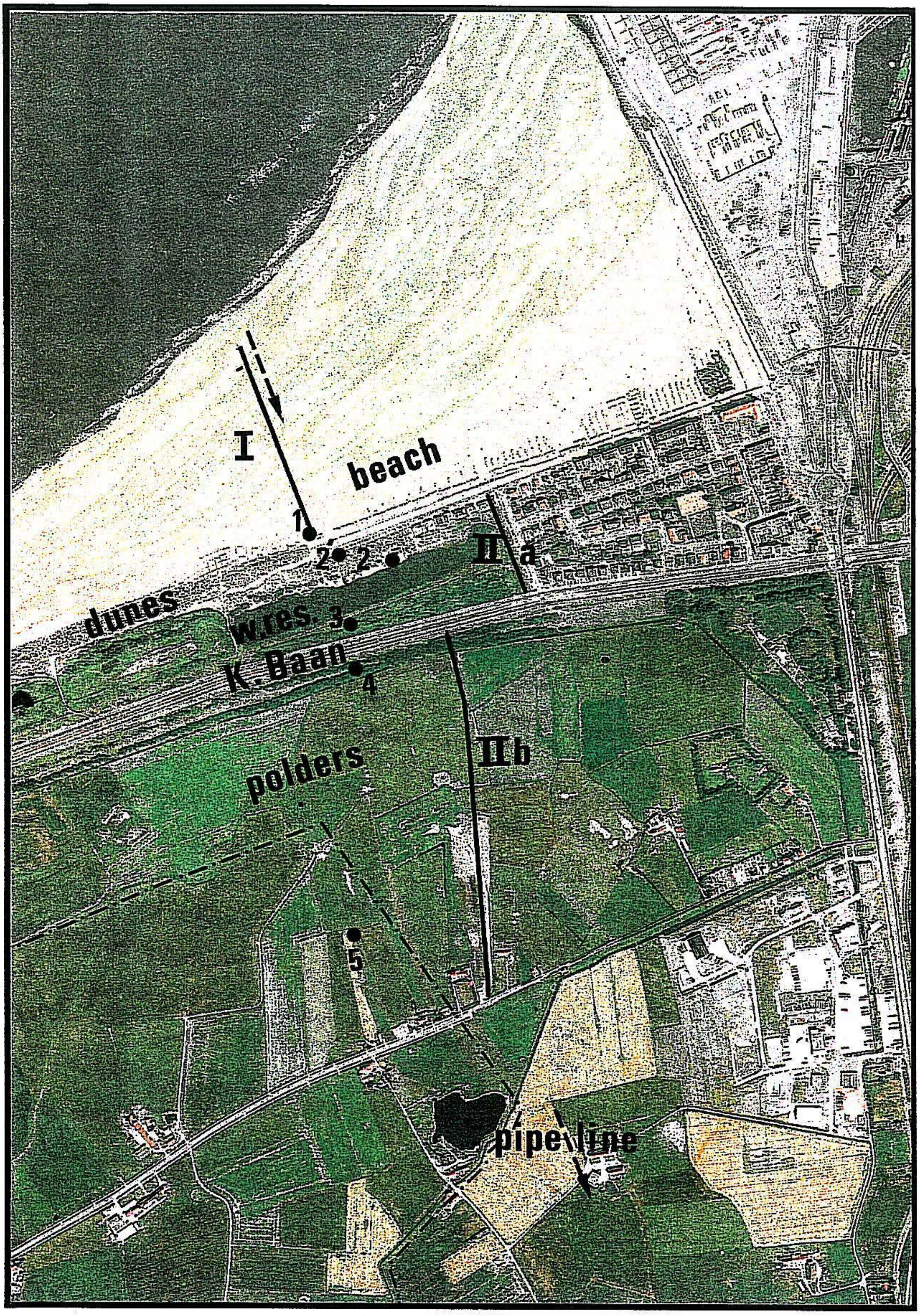


Figure 2 Study area and location of field works

——— resistivity traverse

• resistivity sounding

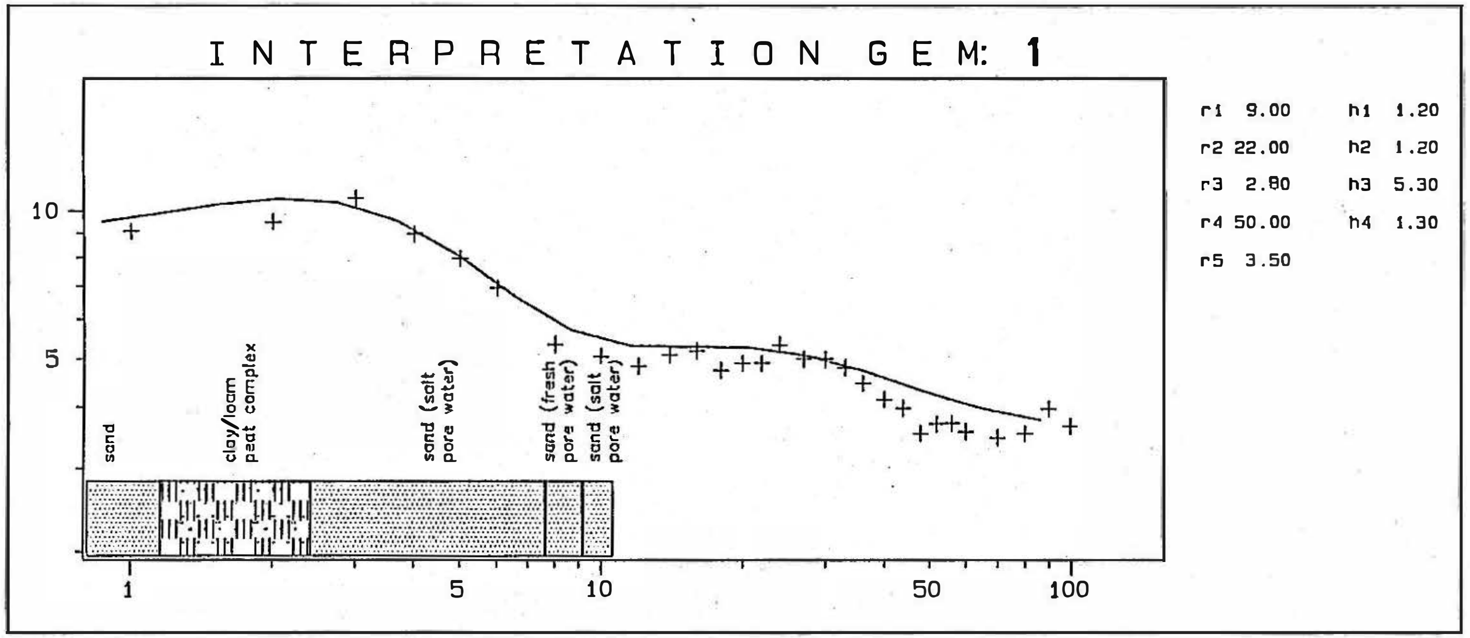


Figure 3 - Resistivity sounding 1

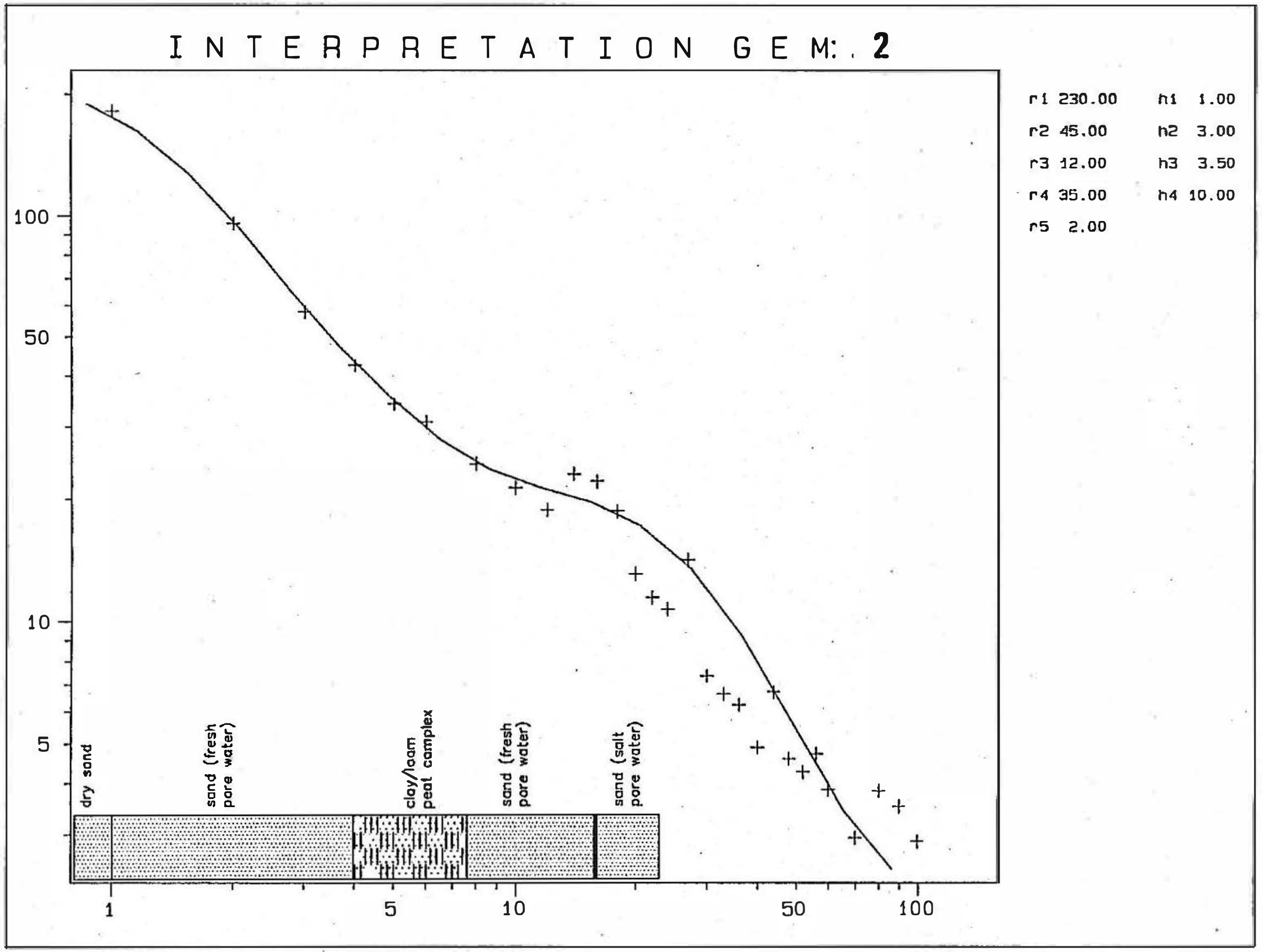


Figure 4 - Resistivity sounding 2

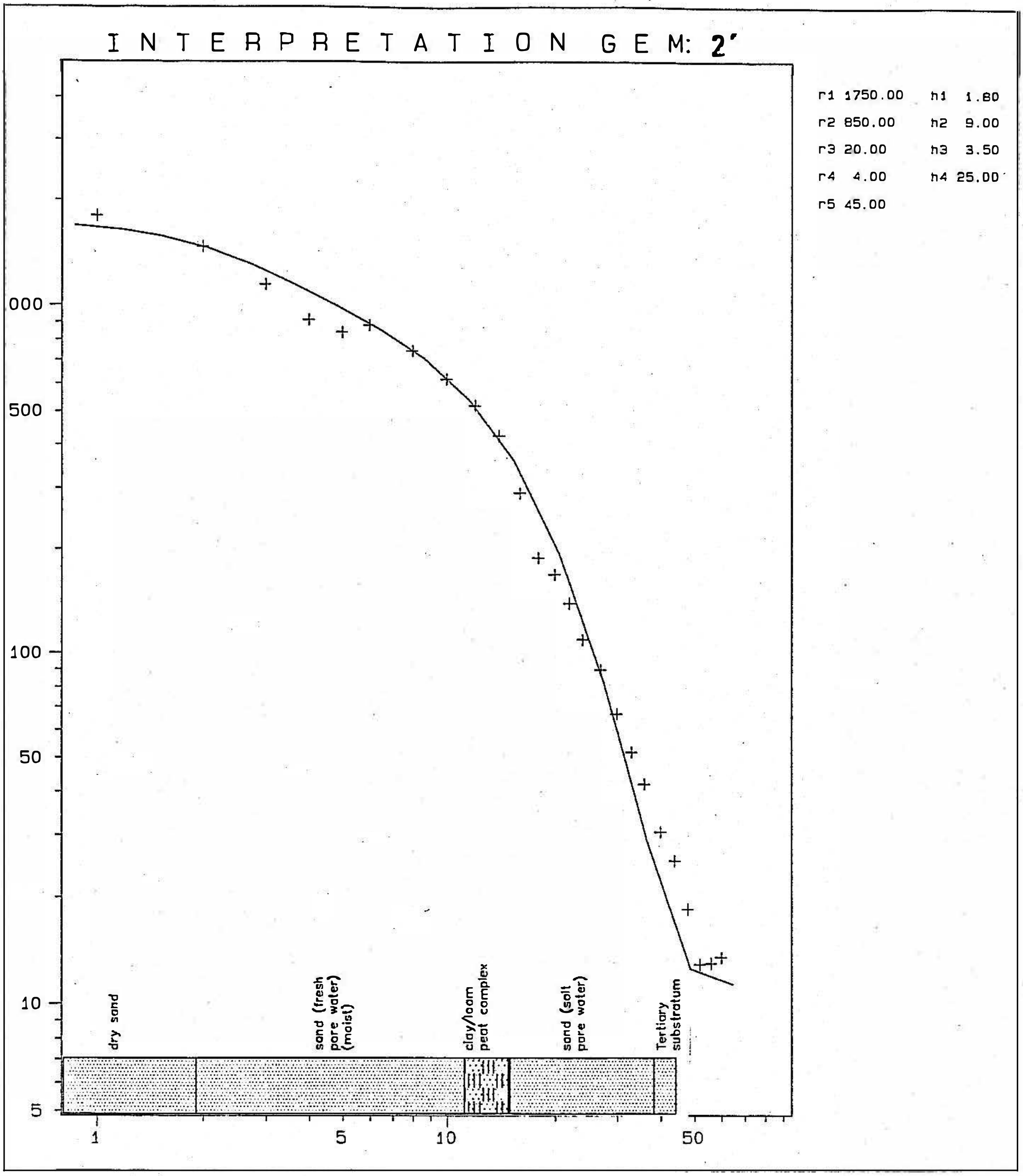


Figure 5 - Resistivity sounding 2'

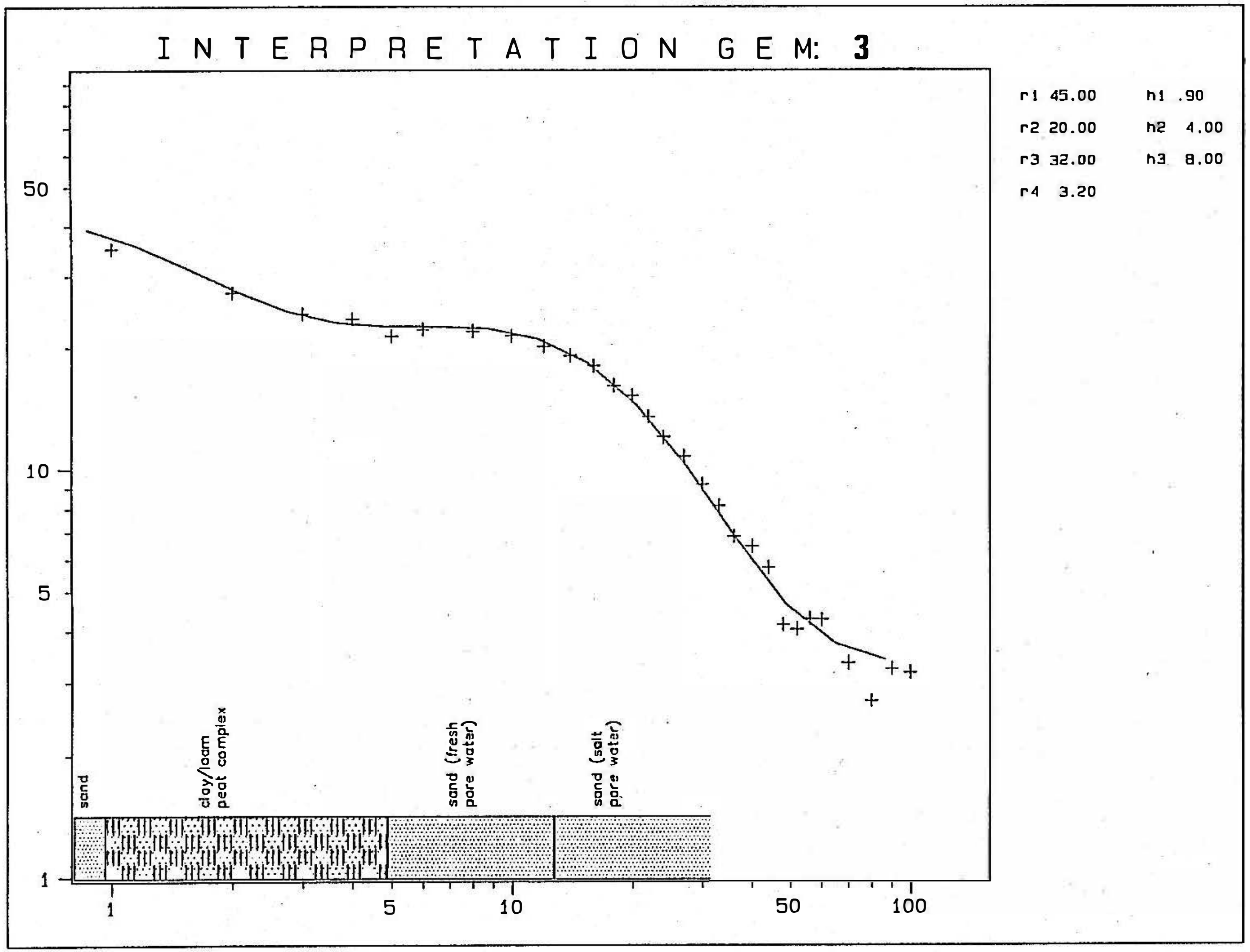


Figure 6 - Resistivity sounding 3

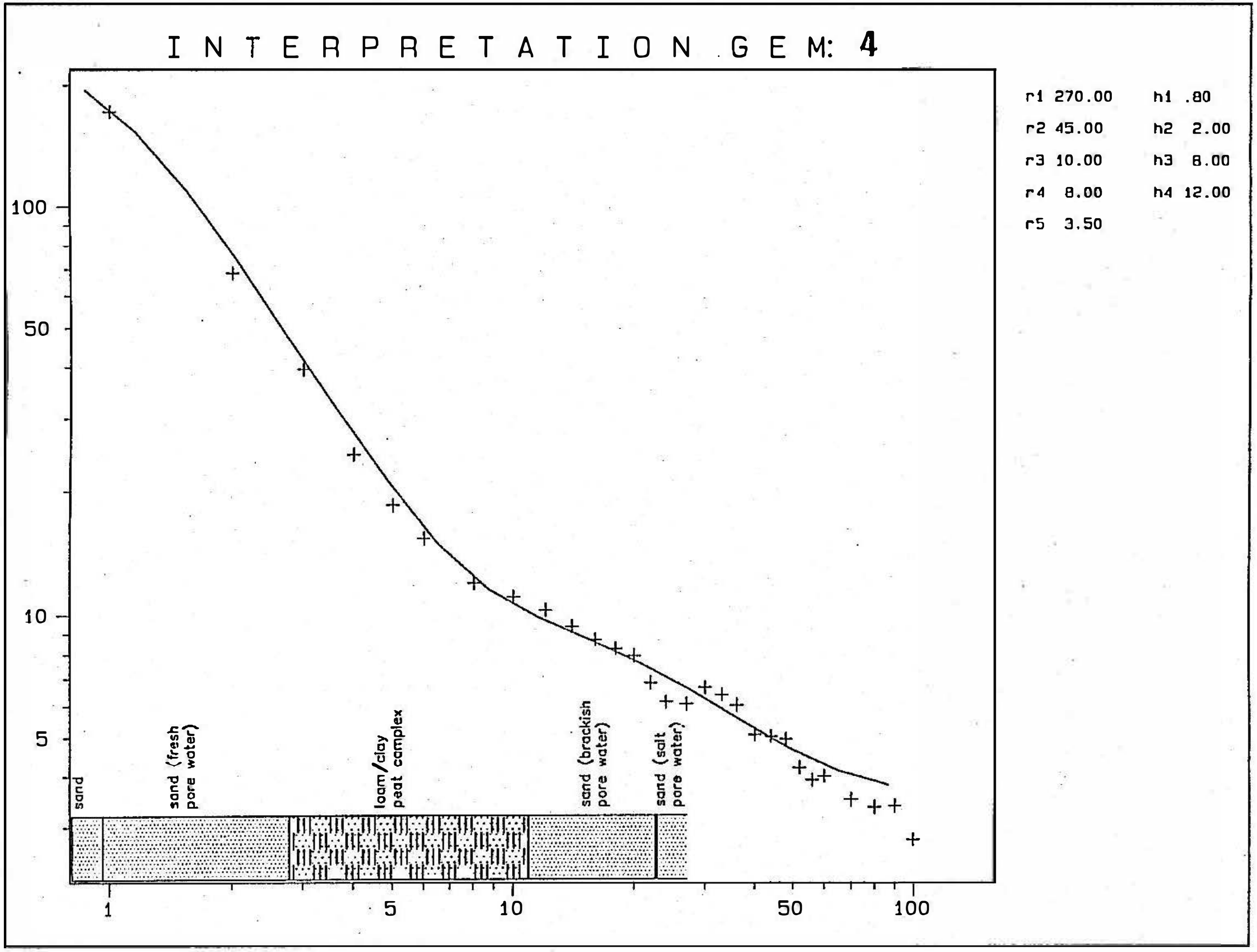


Figure 7 - Resistivity sounding 4

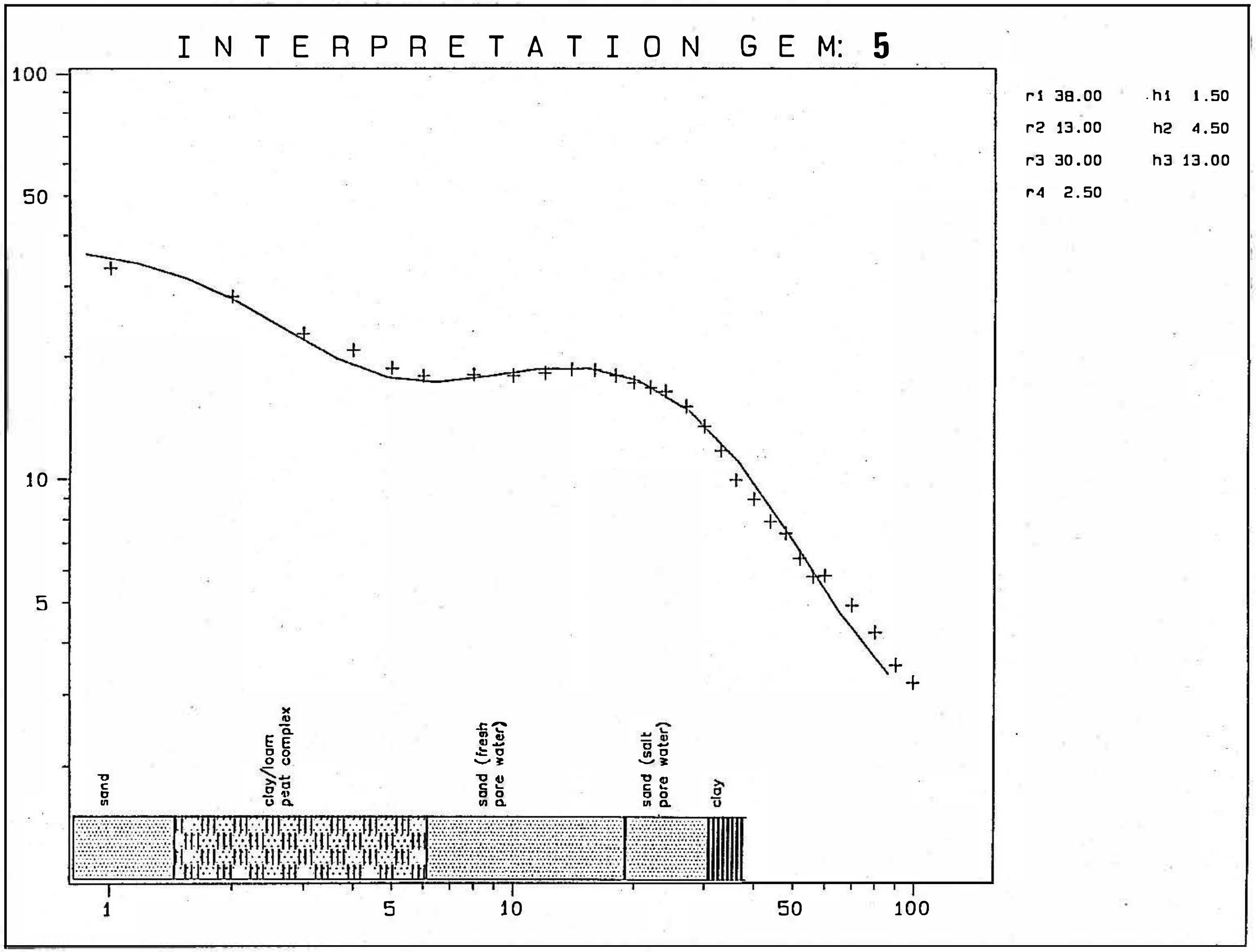


Figure 8 - Resistivity sounding 5

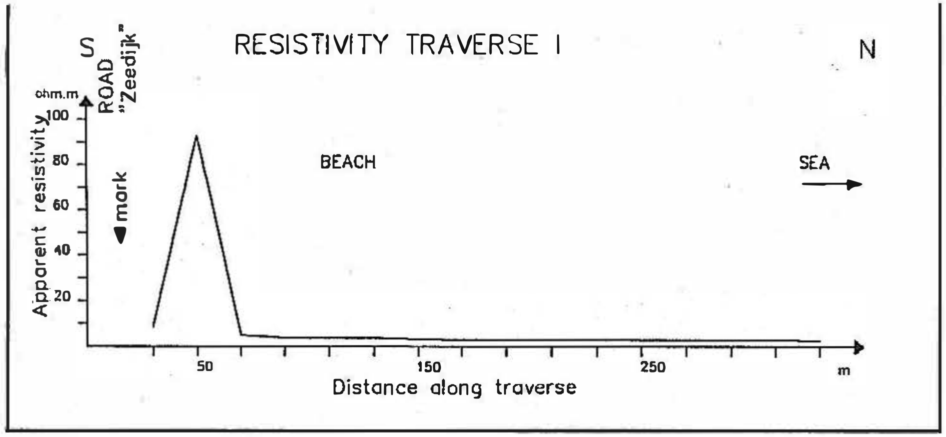


Figure 9a Apparent resistivity along traverse I.

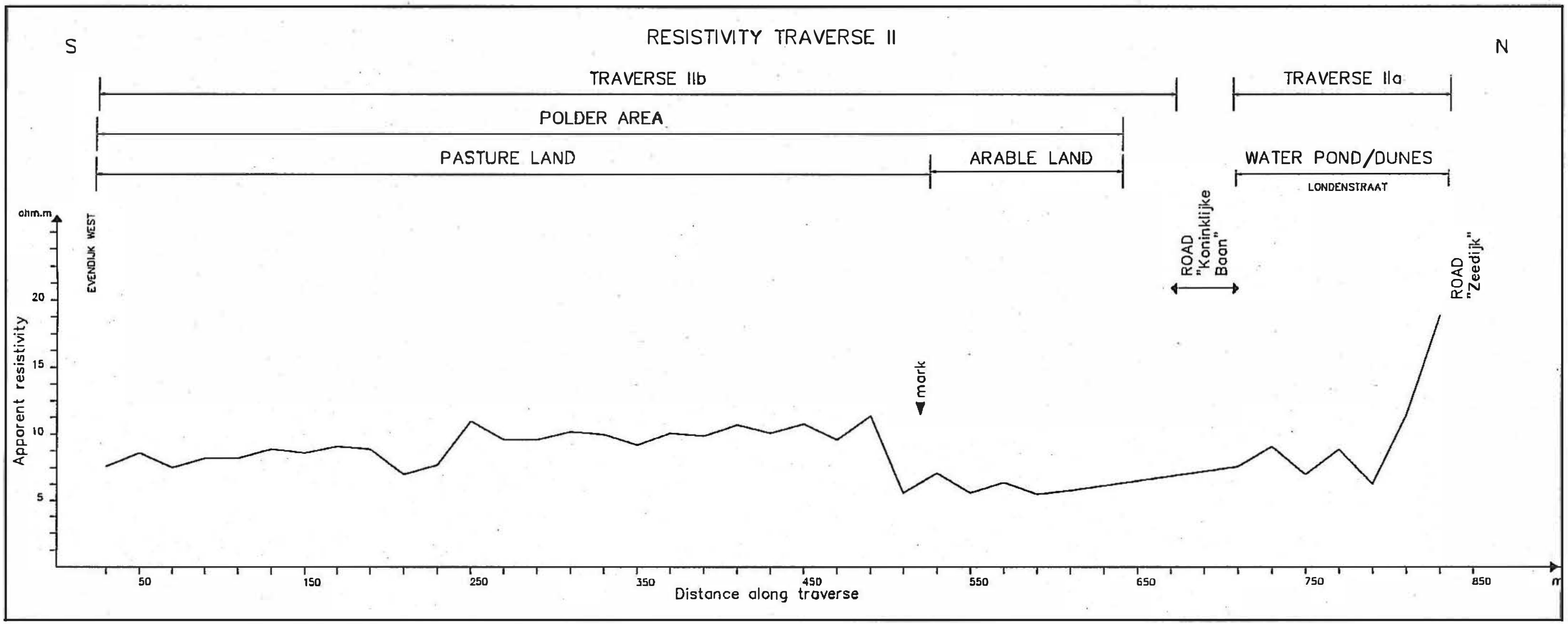


Figure 9b Apparent resistivity along traverse IIa and b.

Figure 10 FRESH-/SALT-WATER INTERFACE