

UNITED STATES DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY

SCHLUMBERGER SOUNDINGS IN THE UPPER RAFT RIVER
AND RAFT RIVER VALLEYS, IDAHO AND UTAH

BY

Adel A.R. Zohdy and Robert J. Bisdorf

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This report is preliminary and has not been
edited or revised for conformity with U. S.
Geological Survey standards and nomenclature.

SCHLUMBERGER SOUNDINGS IN THE UPPER RAFT RIVER
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In 1975, the U. S. Geological Survey made seventy Schlumberger resistivity soundings in the Upper Raft River Valley and in parts of the Raft River Valley. These soundings compliment the seventy nine soundings made previously in the Raft River Valley (Zohdy and others, 1975) and bring the total number of soundings to 149. This work was done as part of a hydrogeologic study of the area.

Plate 1 shows the location, number, and azimuth of all 149 Schlumberger sounding stations. The location of the new stations are shown with solid circles, whereas the location of the previous stations (Zohdy and others, 1975) are shown with open circles. The new stations are numbered from 201 to 270. In the following, we present the data and interpretation of only the new soundings (Raft #201 through Raft #270).

The maximum symmetric electrode spacing, $AB/2$, used for some of the soundings reached 4,877 metres (16,000 feet). For a few soundings, (#202, #211, #214, #254, and #267) standard Schlumberger apparent resistivities were calculated for standard Schlumberger electrode spacings ($AB/2$) that are larger than the maximum possible symmetric spacing for the given location of these soundings. This was done by making measurements with asymmetric electrode spacings then using a correction formula. For example, with one current electrode remaining stationary at 1,829 metres

(6,000 feet), the second current electrode was moved to larger spacings of 2,438 metres (8,000 feet) and 3,048 metres (10,000 feet), respectively. The Schlumberger apparent resistivity at the larger electrode spacings was calculated from the formula

$$\bar{\rho}_S(BO) = BO^2 \left[\frac{2\pi}{MN} \cdot \frac{\Delta V}{I} \cdot (0.3048) - \frac{\bar{\rho}_S(AO)}{AO^2} \right],$$

where

$\bar{\rho}_S(BO)$ = Schlumberger apparent resistivity at the larger electrode spacing BO, in ohm-metres,

BO = distance from center of potential electrodes, O, to farthest current electrode, B, in feet,

AO = distance from center of potential electrodes, O, to nearest current electrode, A, in feet,

ΔV = potential difference measured with asymmetric array, in millivolts,

I = intensity of electric current, in milliamperes,

0.3048 = conversion factor from feet to metres,

$\bar{\rho}_S(AO)$ = last Schlumberger apparent resistivity measured with the symmetric array at $AB/2 = AO$, in ohm-metres.

This formula was derived by the senior author and theoretically is valid for horizontally layered laterally homogeneous media. In practice, errors in measurements are not substantially magnified provided that:

- a) The subsurface is laterally homogeneous,
- b) the asymmetric measurements are made to extend an ascending portion of the sounding curve, and
- c) the ratio of $BO/AO \leq 1.7$.

- For extending descending portions of a sounding curve, the limiting ratio of B_0/A_0 should be made smaller, for example about 1.3.

All the sounding curves were automatically processed and interpreted (Zohdy, 1973 and 1975) as shown in the graphs given in the appendix.

Each graph shows the following:

- (1) Field data designated by a segmented solid-line curve with diamond symbols for observed data.
- (2) A continuous-dashed curve which represents:
 - (a) The continuous "field" curve which is generally obtained by maintaining the position of the last segment and shifting each of the previous segments, up or down so that the last point on each segment coincides with the corresponding point on the following segment (Zohdy and others, 1973).
 - (b) The digitized curve at the rate of six points per logarithmic cycle. Although the individual digitized points are not depicted on the dashed curve (to avoid cluttering the graphs) they were computed using a subroutine in a computer program for bicubic spline functions (Anderson, 1971). The digitized data from the continuous dashed curve were then fed into the automatic interpretation program (Zohdy, 1973) to obtain the best fitting theoretical sounding curve for a horizontally layered medium. The automatic interpretation program used here was slightly modified from the one referred to in the above reference. The modifications are identical to those

used in another program recently written for inverting Wenner sounding curves (Zohdy and Bisdorf, 1975a).

- (3) The theoretical best fitting sounding curve plotted as (+) signs.
- (4) The detailed layering for which the theoretical curve is calculated.
- (5) The D.Z. (Dar Zarrouk) curve for the detailed layering. The ordinate values for the D.Z. curves are shifted upward or downward by one logarithmic cycle or they are plotted on a separate sheet of graph paper (as for Raft #250) to avoid cluttering the graphs. The D.Z. curves can be used to obtain equivalent and simpler solutions containing fewer number of layers. In addition, they can be used to impose certain constraints on the layer thicknesses and resistivities (Zohdy, 1974).

All these graphs were generated on a graphic plotter. The plotter-driving subroutines were developed by G. I. Evenden of the U.S. Geological Survey.

References

- Anderson, W. L., 1971, Application of bicubic spline functions to two dimensional grided data: NTIS (National Technical Information Service), No. PB-203579, Springfield, Virginia.
- Zohdy, Adel A. R., 1973, A computer program for the automatic interpretation of Schlumberger sounding curves over horizontally stratified media: NTIS (Natl. Tech. Inf. Service) PB-232703/AS, 25 p. Springfield, Virginia.
- Zohdy, Adel A. R., 1974, The use of Dar-Zarrouk curves in the interpretation of VES data: U.S. Geol. Survey Bull. 1313-D, 41 p.
- Zohdy, A. A. R., 1975, Automatic interpretation of Schlumberger sounding curves using modified Dar-Zarrouk functions: U.S. Geol. Survey Bull. 1313-E, 39 p.
- Zohdy, A. A. R., Anderson, L. A., and Muffler, L. J. P., 1973, Resistivity self potential, and induced polarization surveys of a vapor-dominated geothermal system: Geophysics, v. 38, p. 1130-1144.
- Zohdy, A. A. R., Jackson, D. B., Bisdorf, R. J., 1975, Schlumberger soundings and total field measurements in the Raft River geothermal area, Idaho: U.S. Geol. Survey open-file report 75-130, 5 p., + 82 text figures + 4 pls.
- Zohdy, A. A. R., and Bisdorf, R. J., 1975, Computer programs for the forward calculation and automatic inversion of Wenner sounding curve: NTIS (Natl. Tech. Inf. Service) PB-247-265/AS, 47 p., Springfield, Virginia.

RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

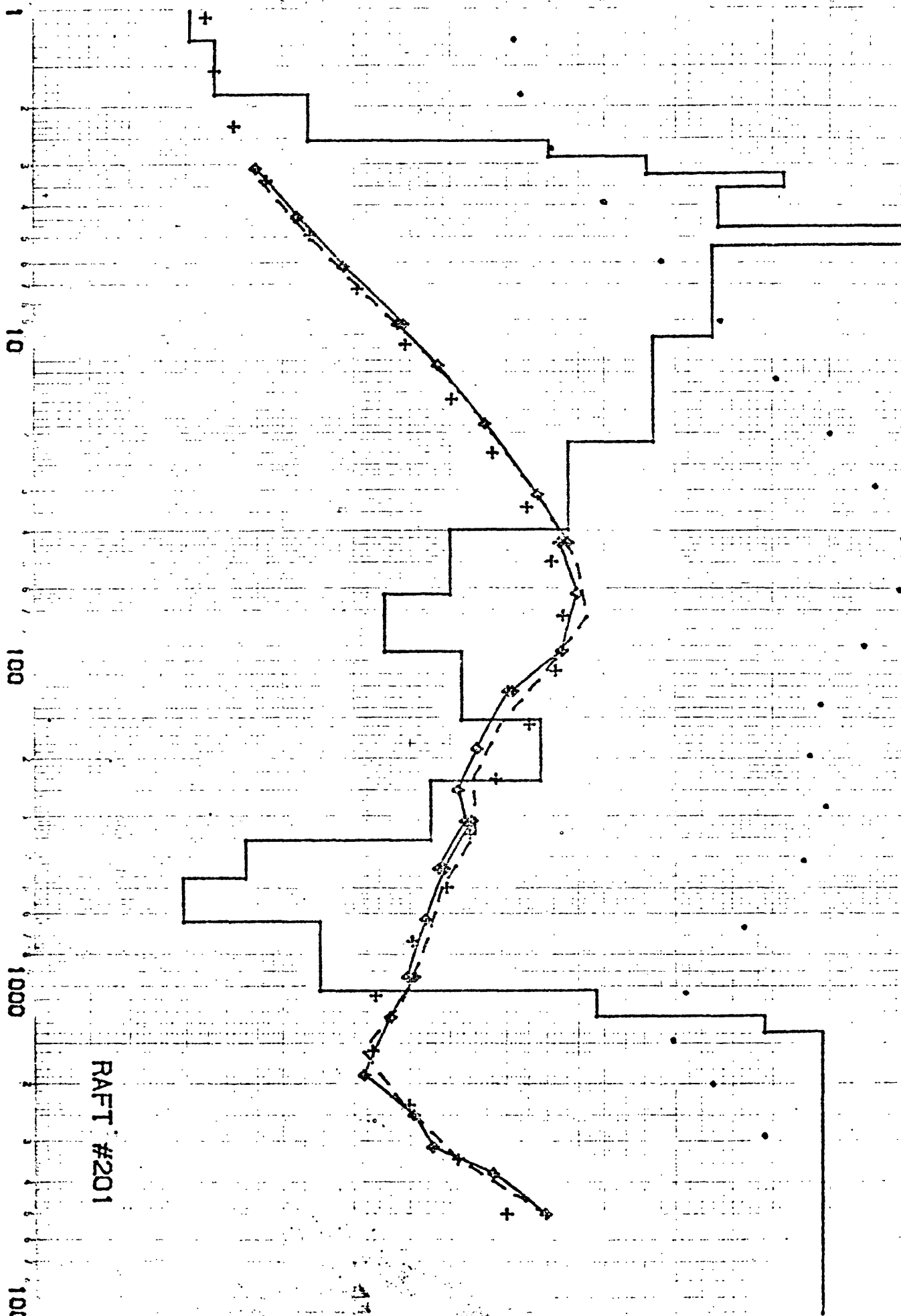
100

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10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #201



RESISTIVITIES IN OHM-METRES

1000

100

10

1

10

100

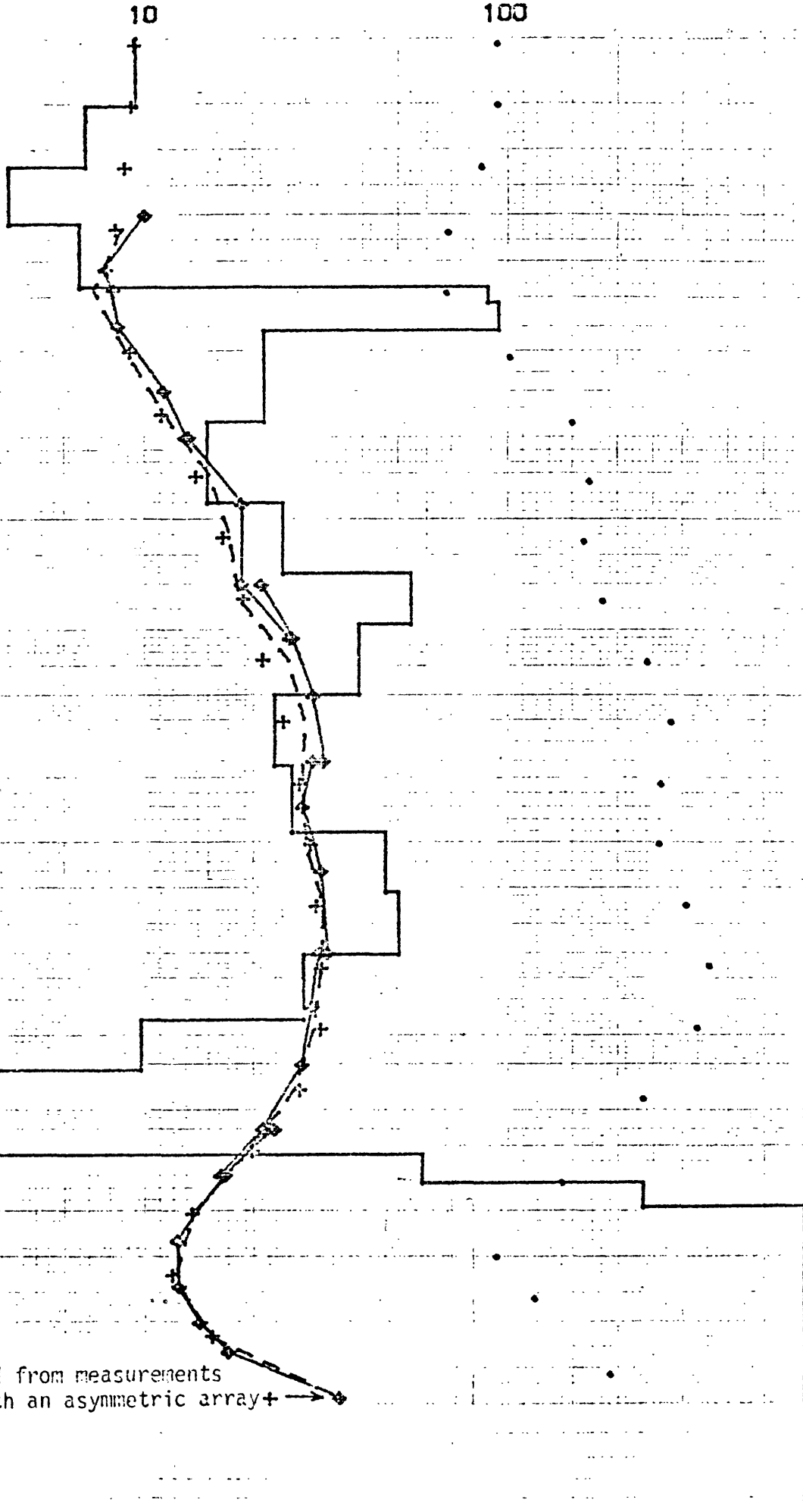
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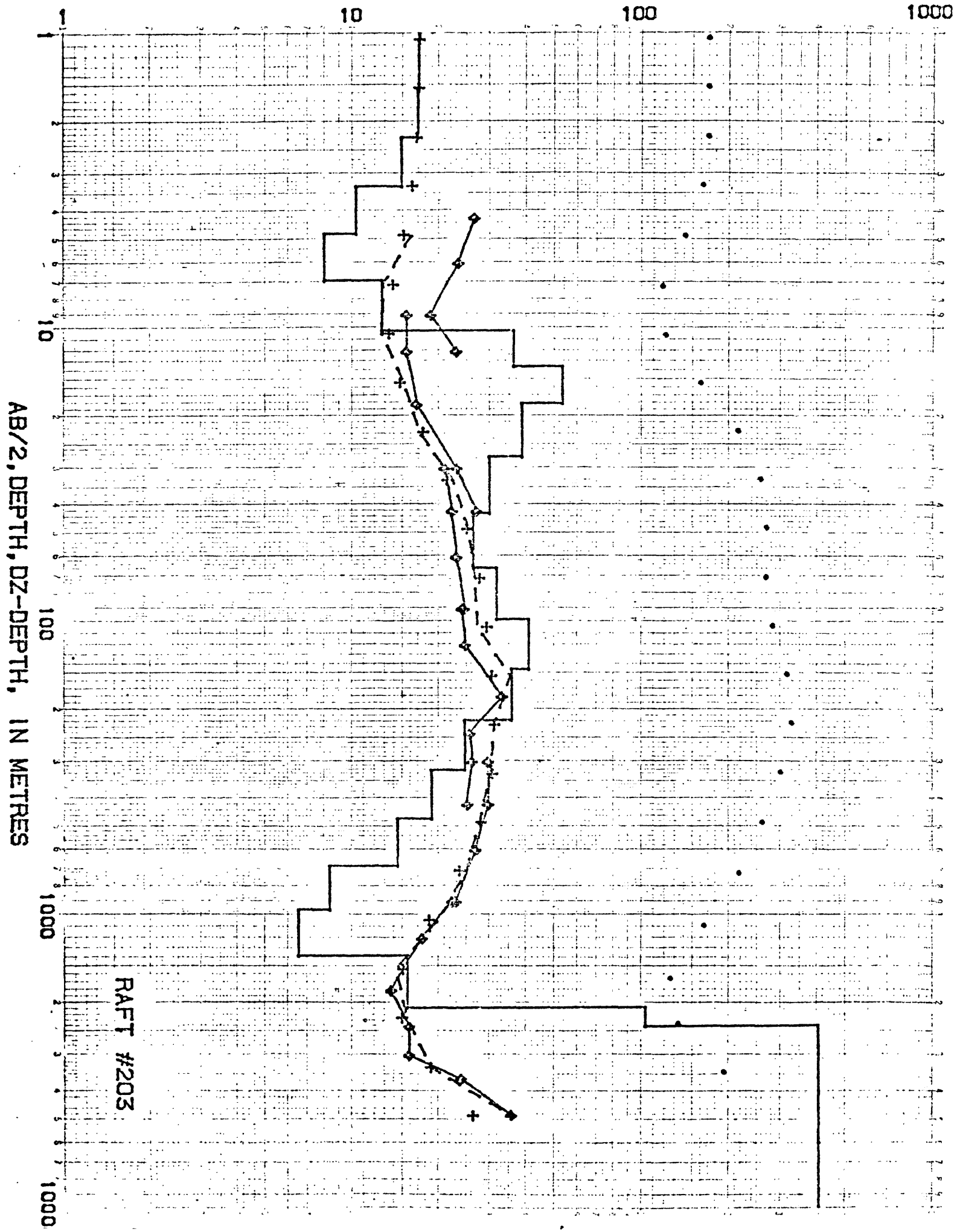
AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #202

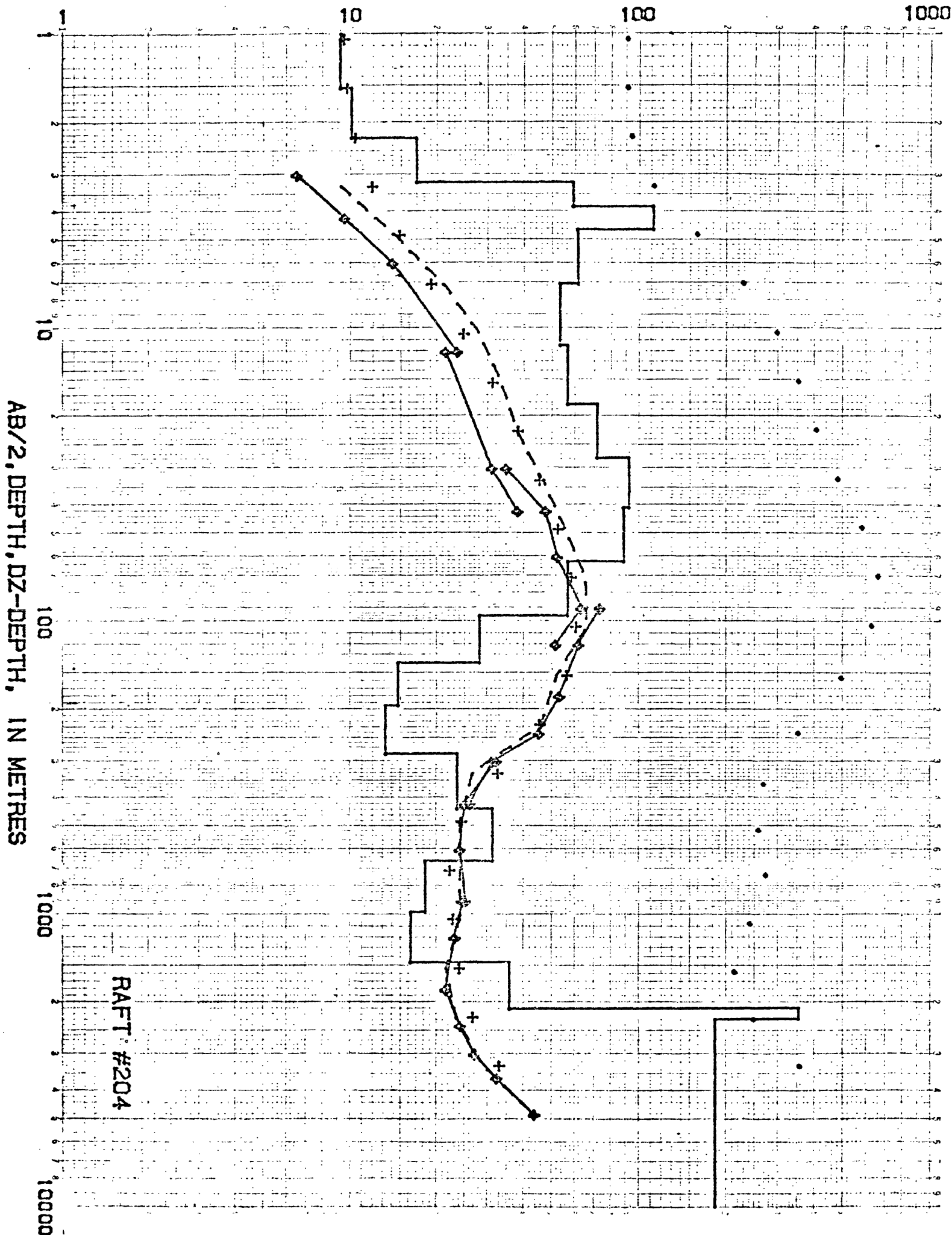
Computed from measurements
made with an asymmetric array +



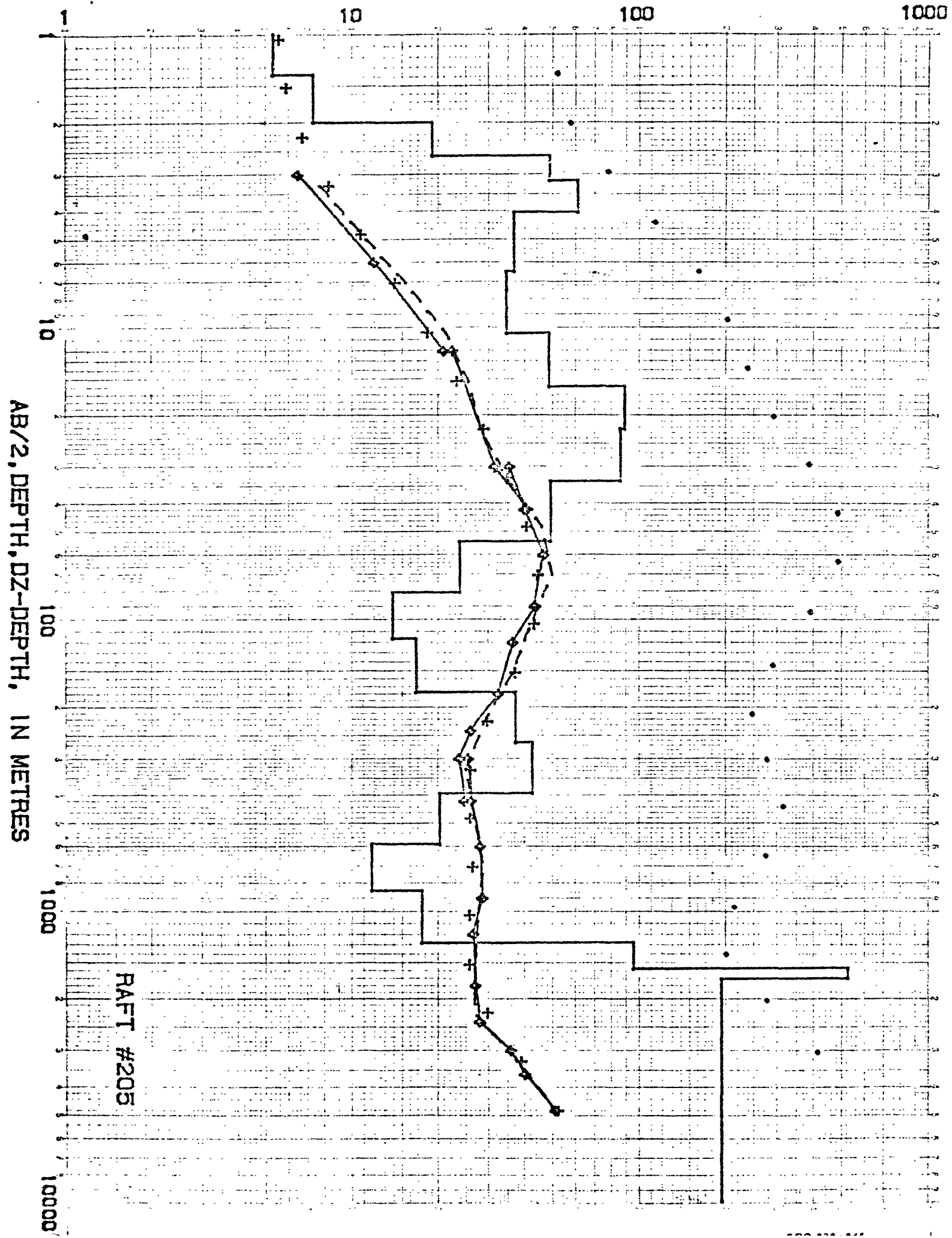
RESISTIVITIES IN OHM-METRES



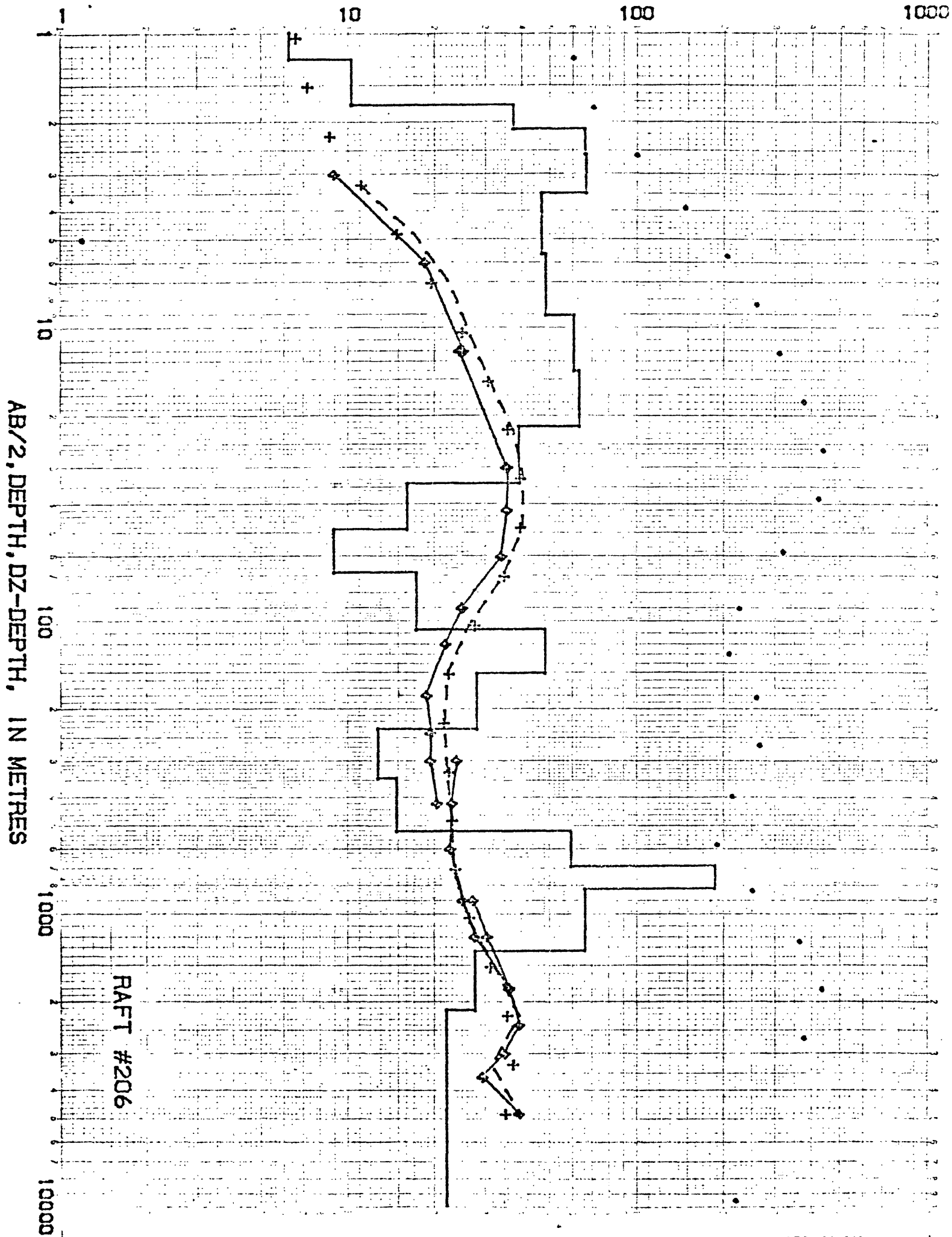
RESISTIVITIES IN OHM-METRES



RESISTIVITIES IN OHM-METRES



RESISTIVITIES IN OHM-METRES



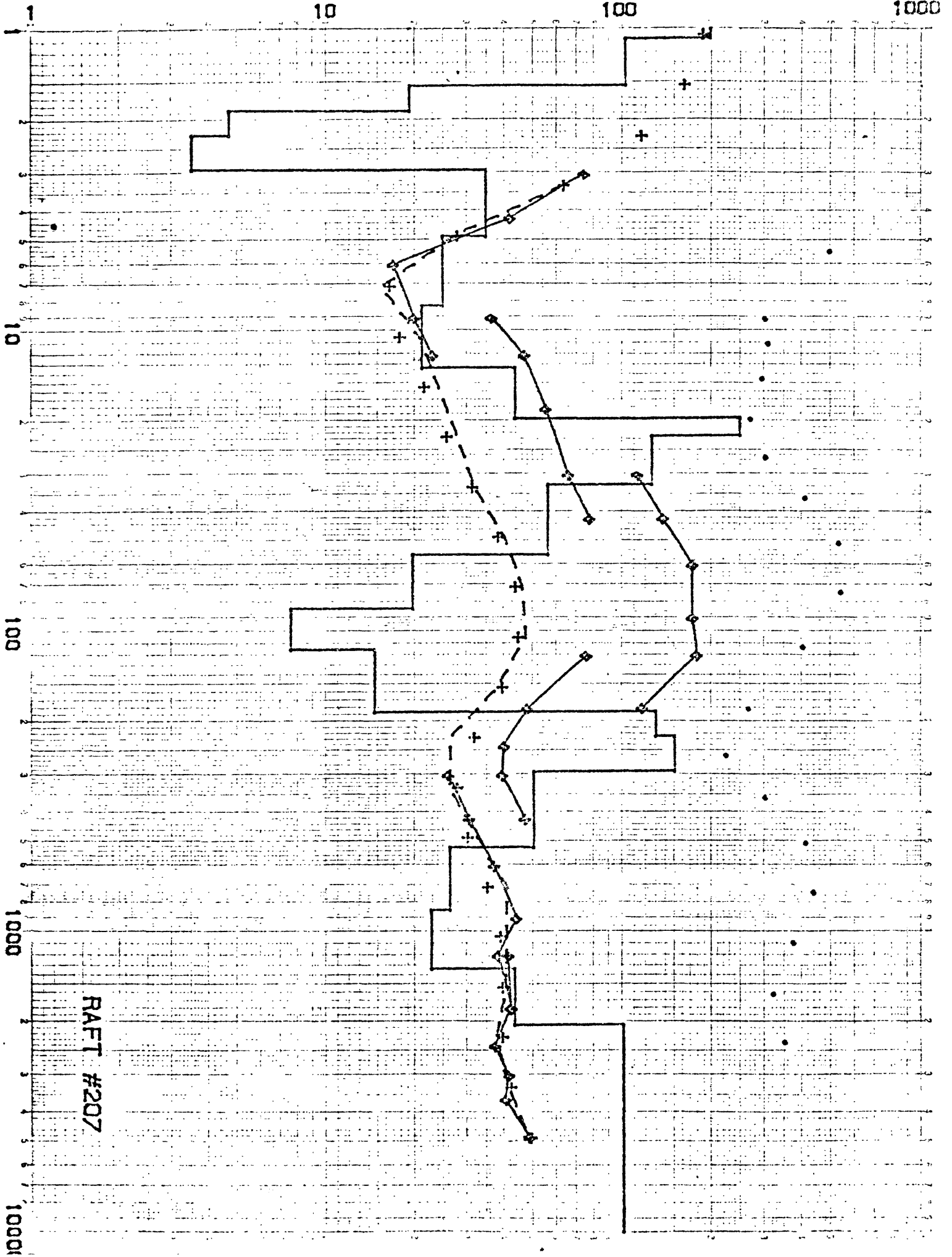
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RESISTIVITIES IN OHM-METRES

10

100

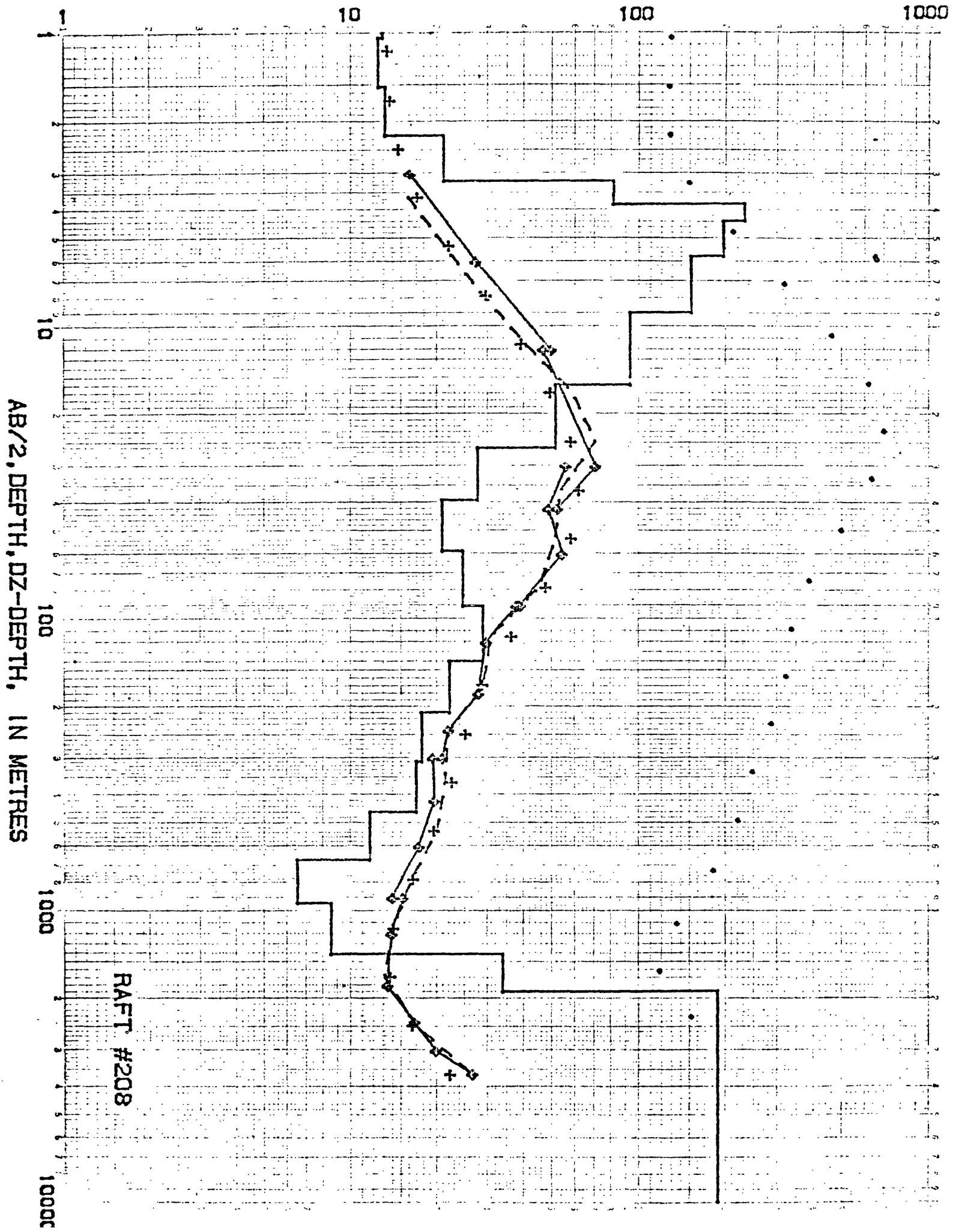
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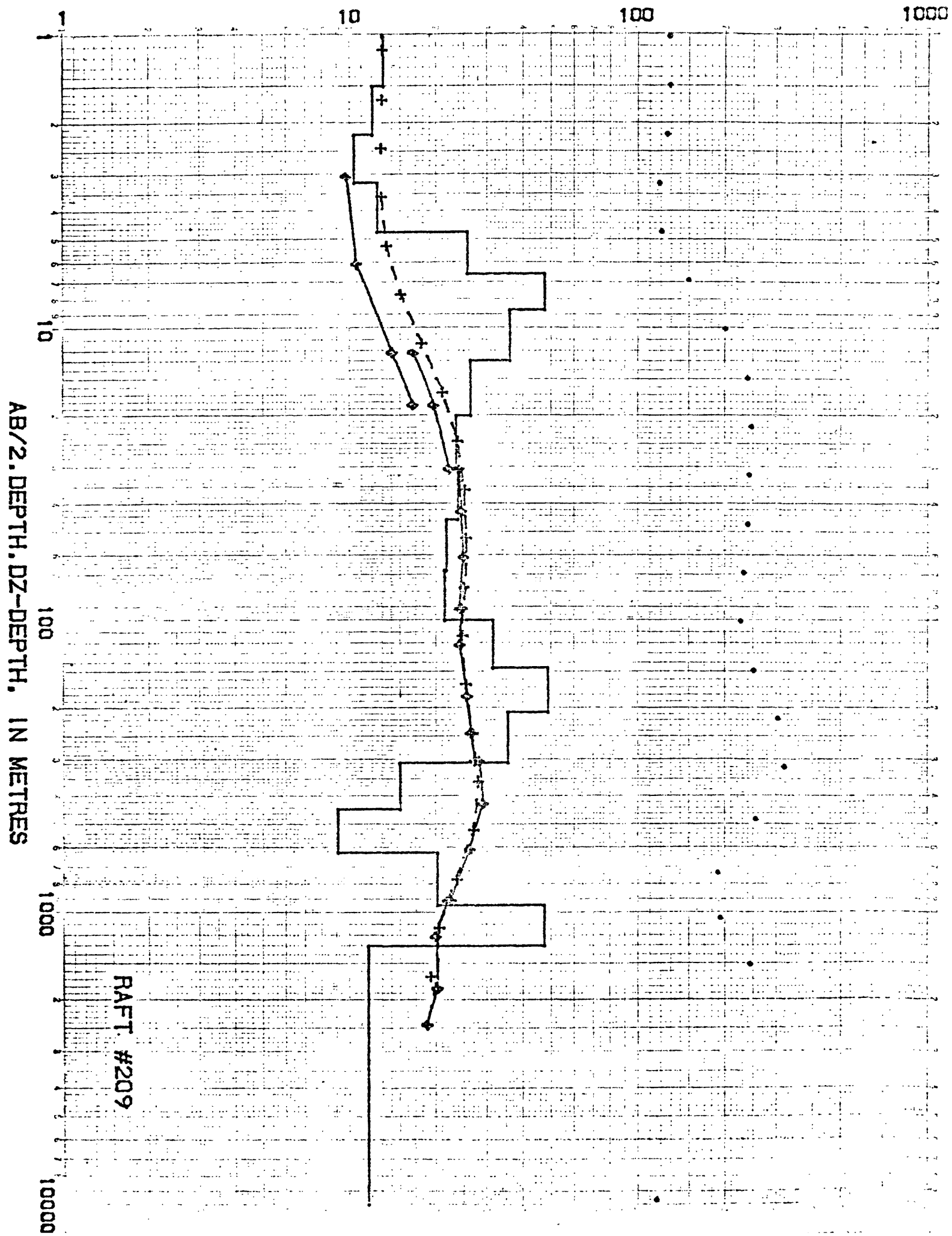
RAFT #207

AB/2, DEPTH, DZ-DEPTH, IN METRES

RESISTIVITIES IN OHM-METRES



RESISTIVITIES IN OHM-METRES

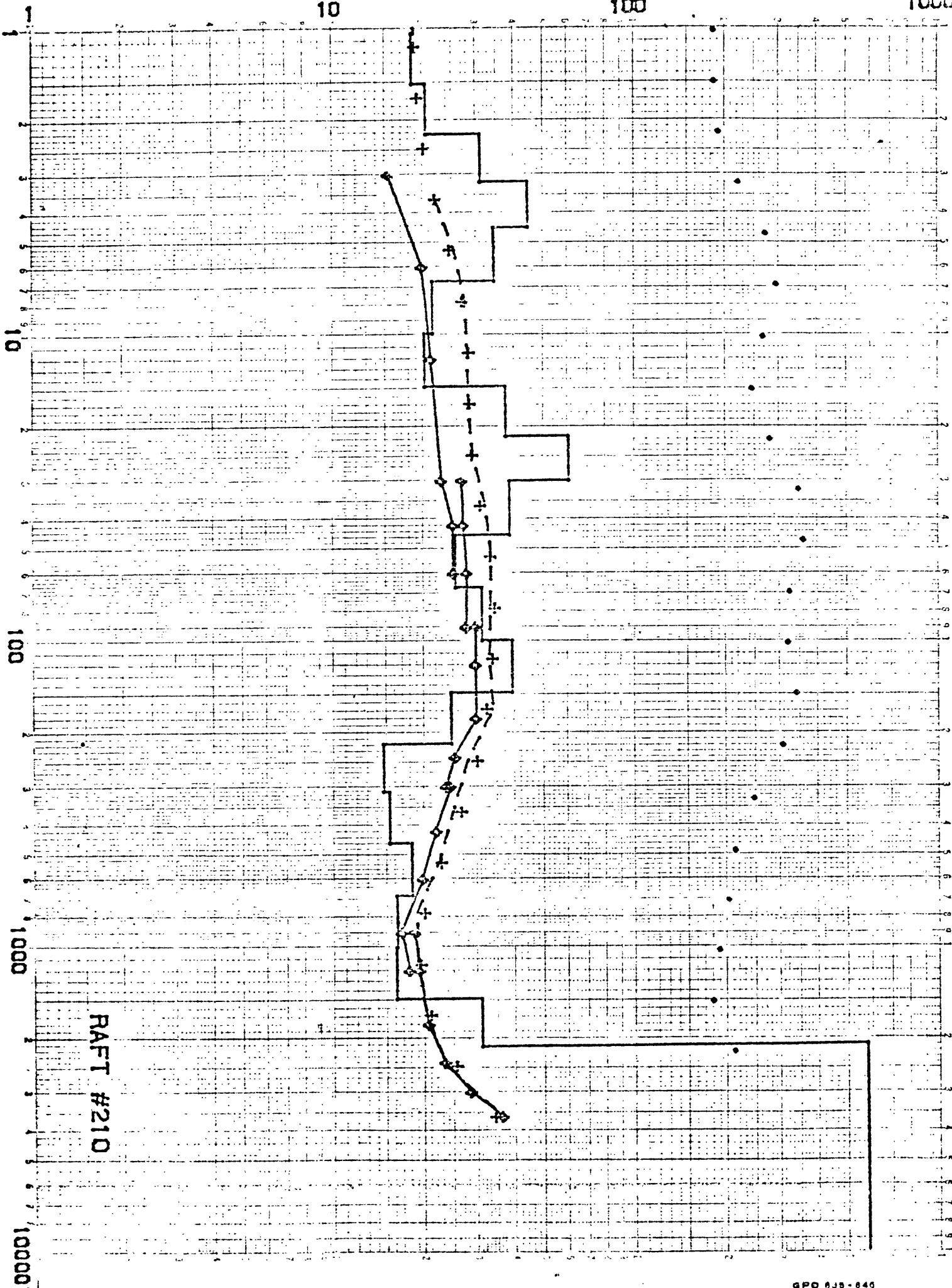


RESISTIVITIES IN OHM-METRES

10

100

1000



RAFT #210

RESISTIVITIES, IN OHM-METRES

10

100

1000

1

10

100

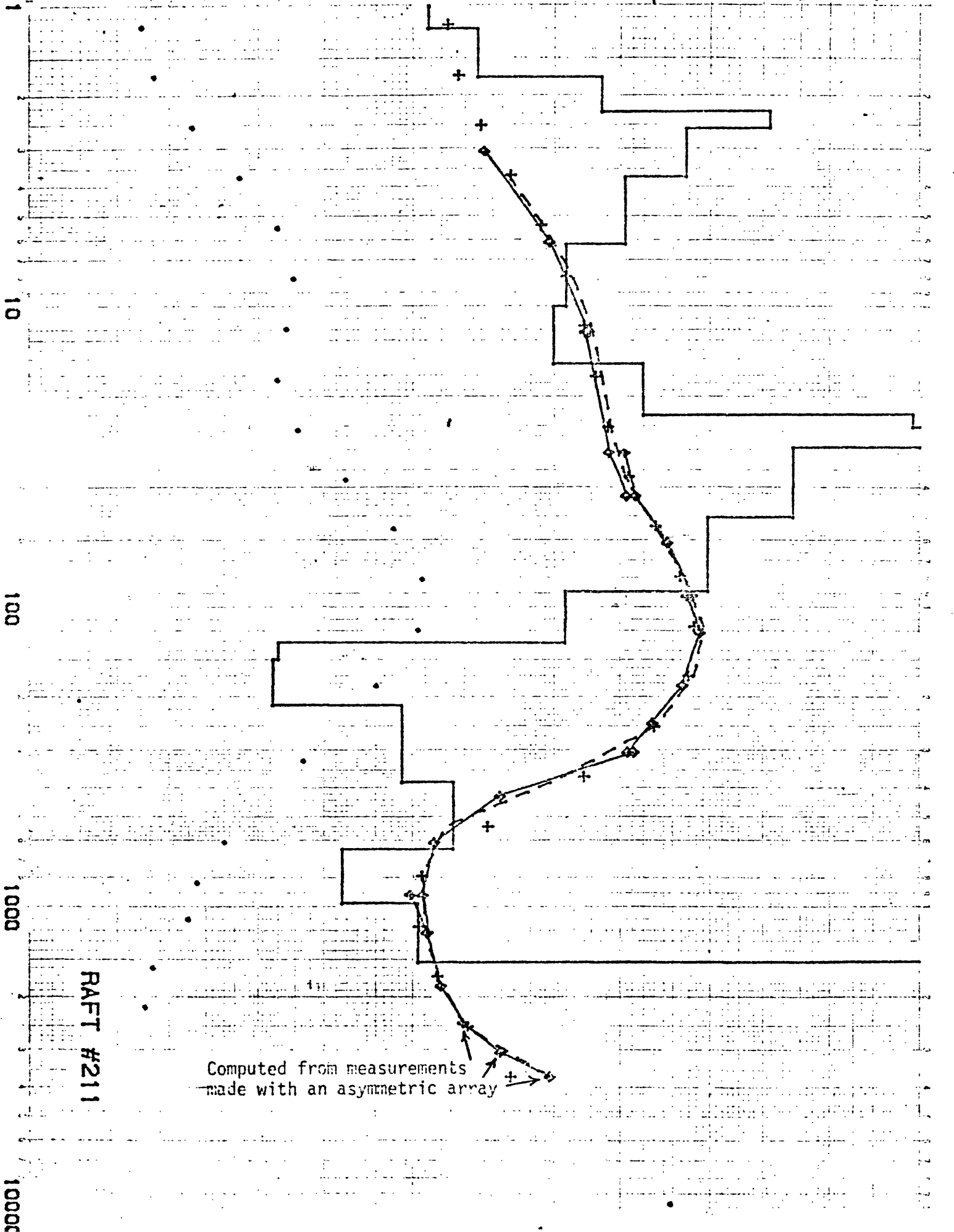
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AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #211

Computed from measurements
made with an asymmetric array



RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

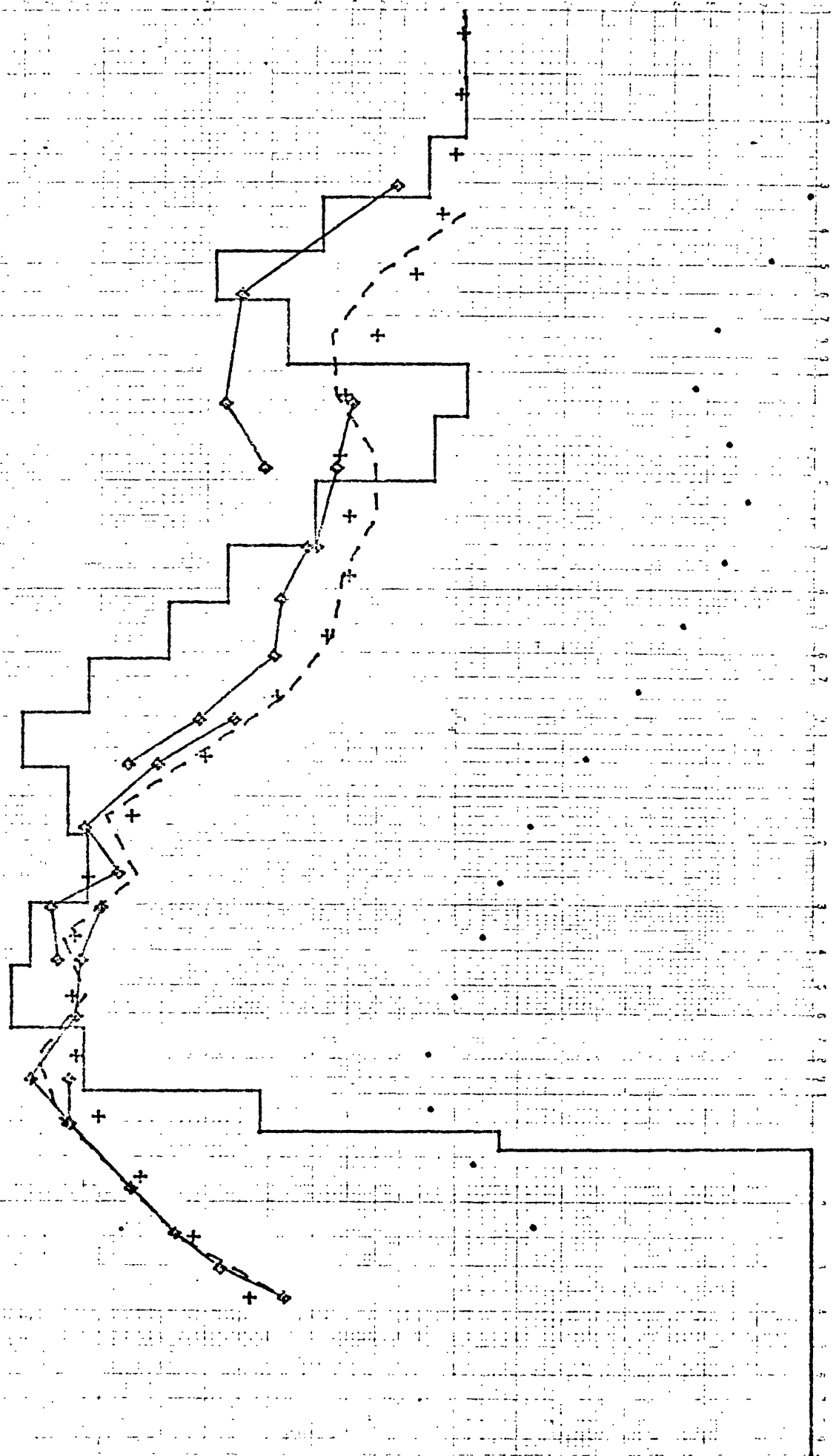
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AB/2, DEPTH, DZ-DEPTH, IN METRES

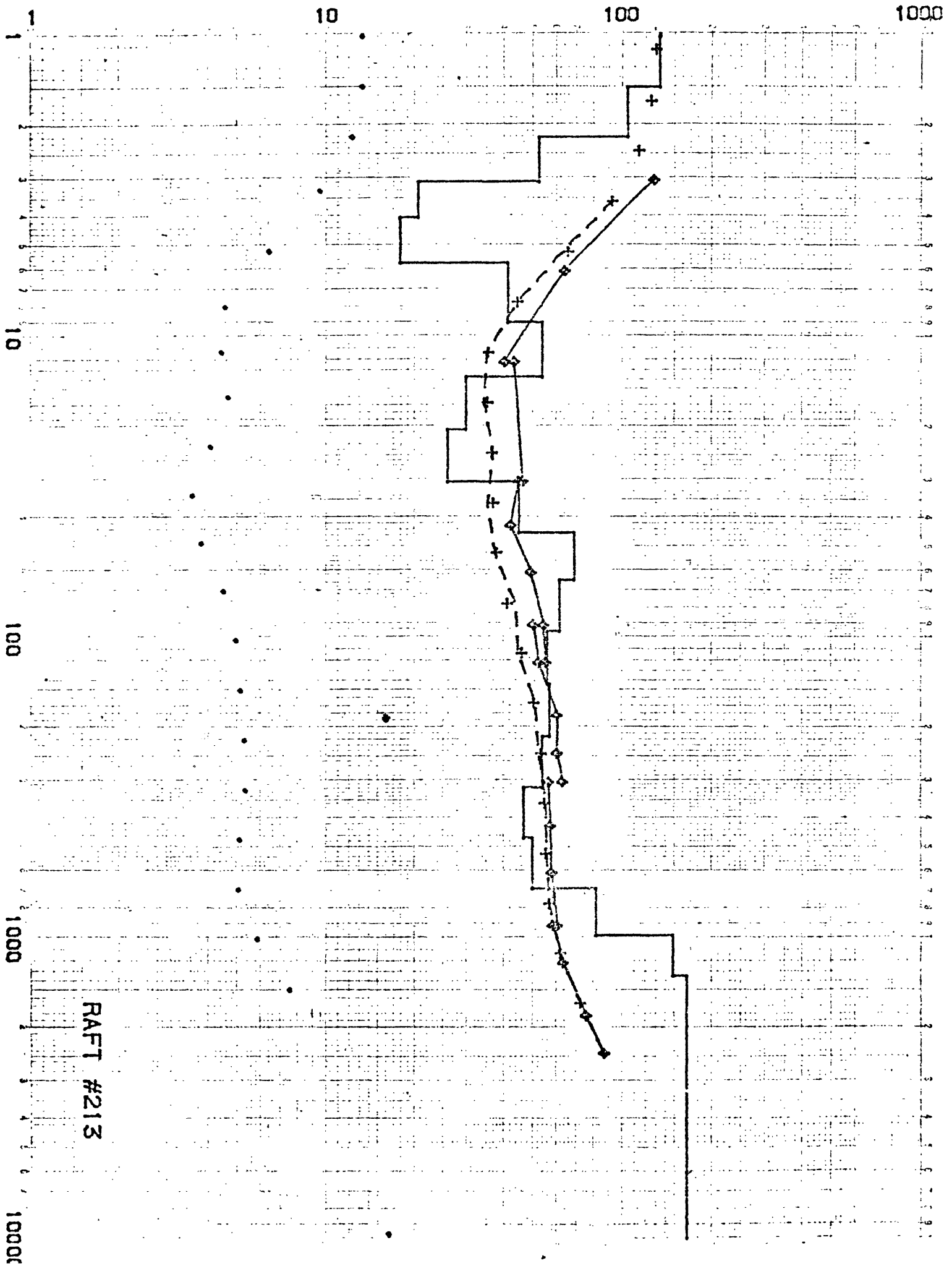
RAFT #212



RESISTIVITIES IN OHM-METRES

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #213

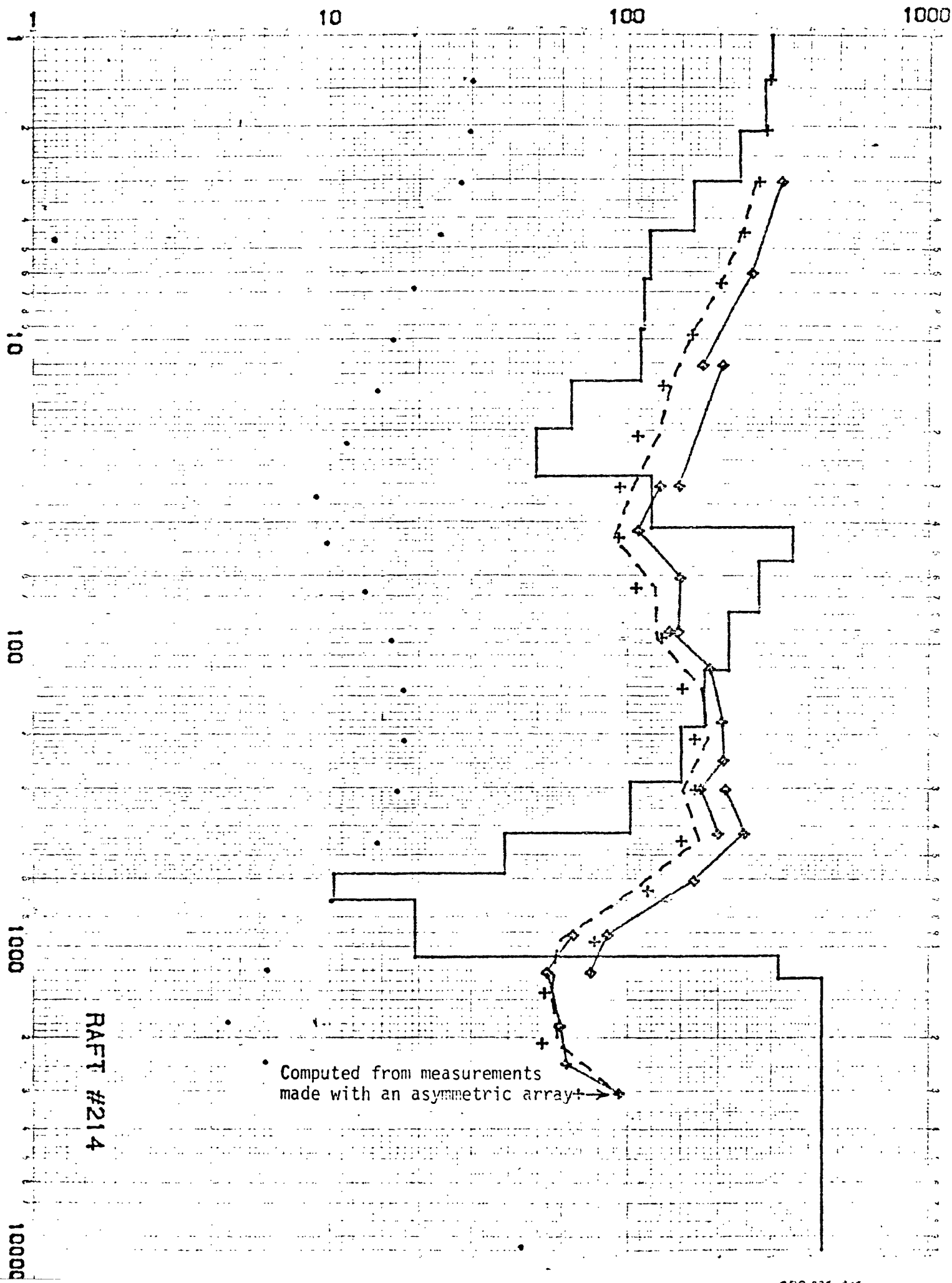


RESISTIVITIES IN OHM-METRES

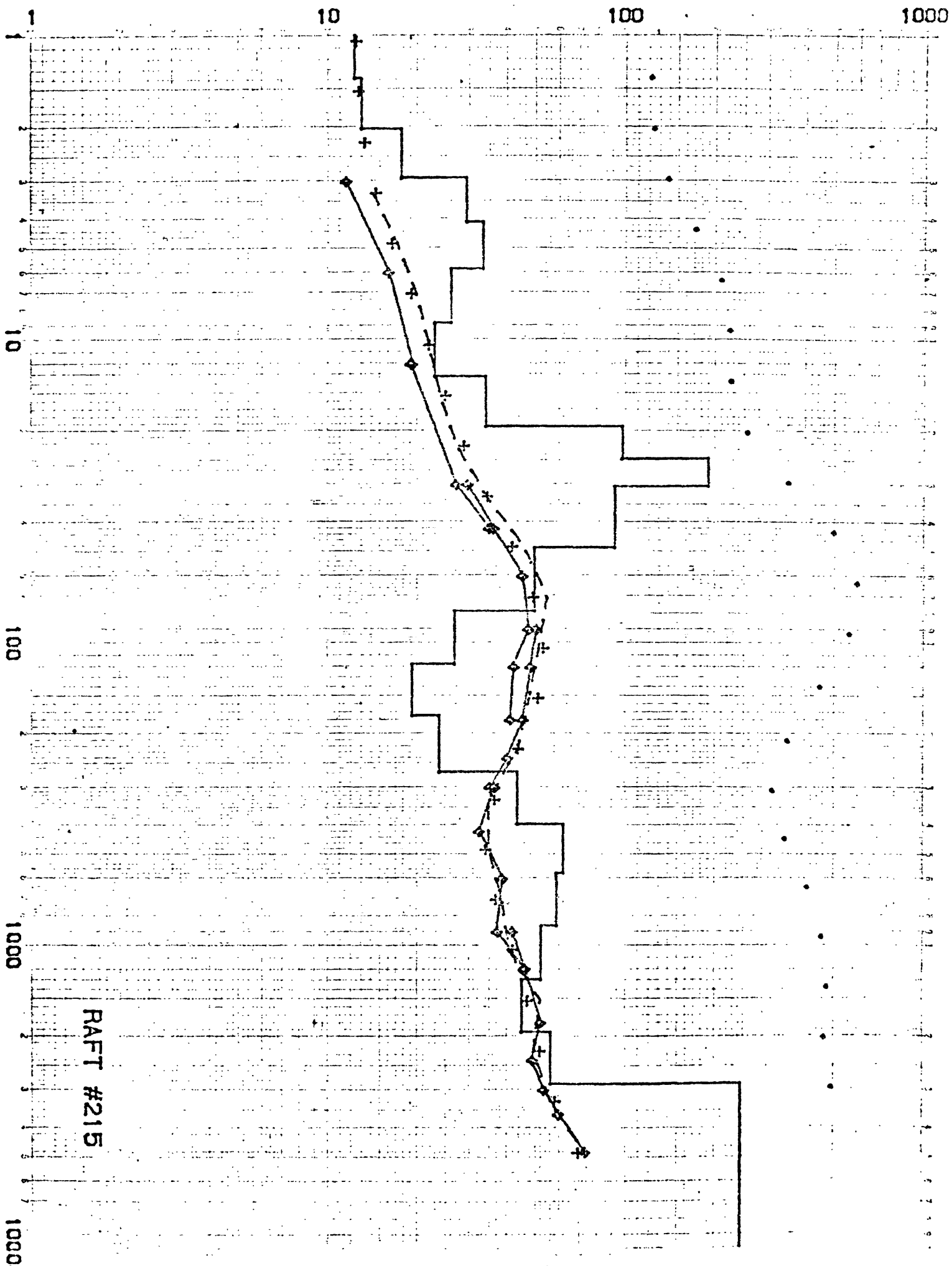
AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #214

Computed from measurements
made with an asymmetric array



RESISTIVITIES. IN OHM-METRES



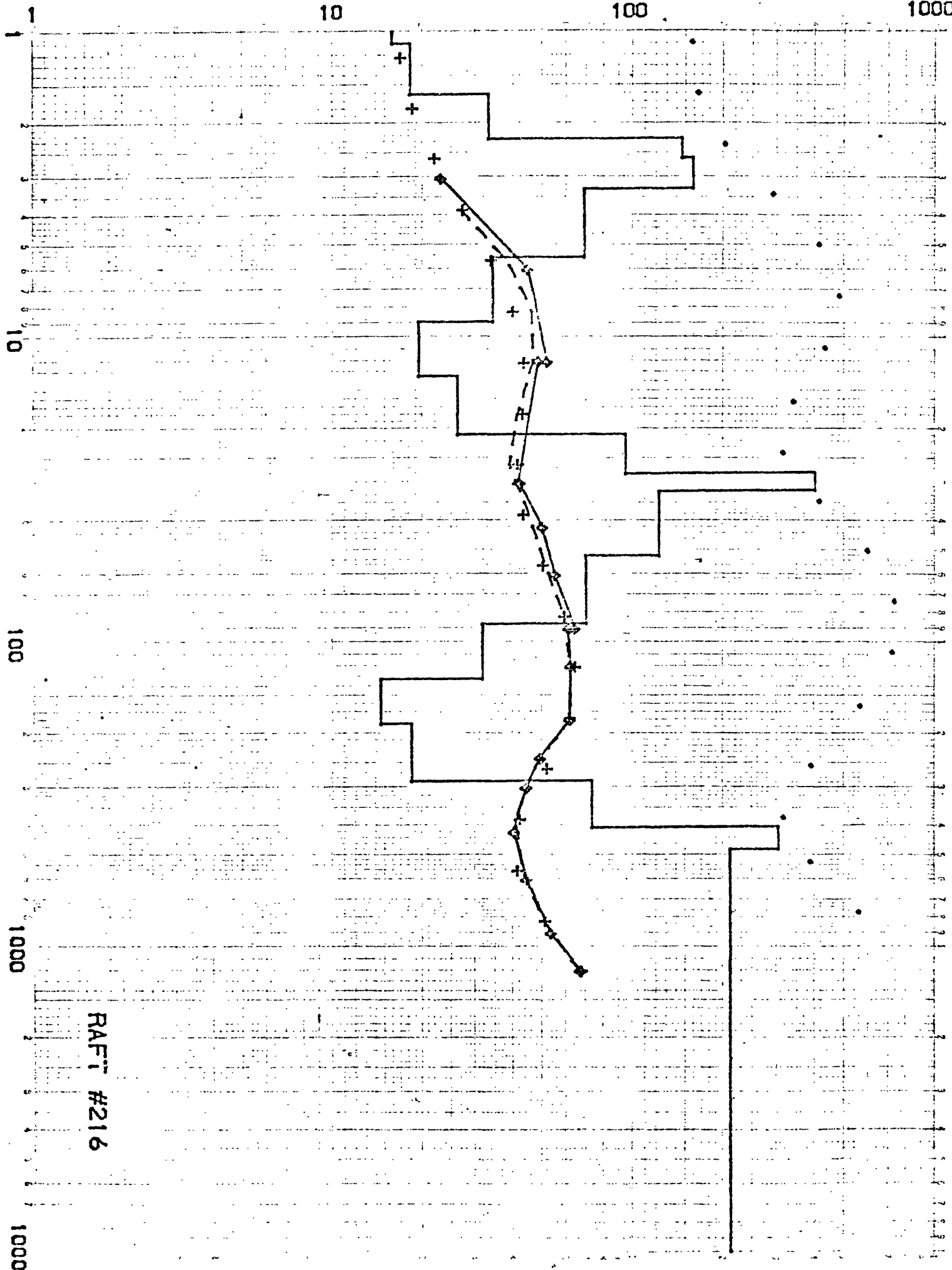
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RESISTIVITIES IN OHM-METRES

10

100

1000

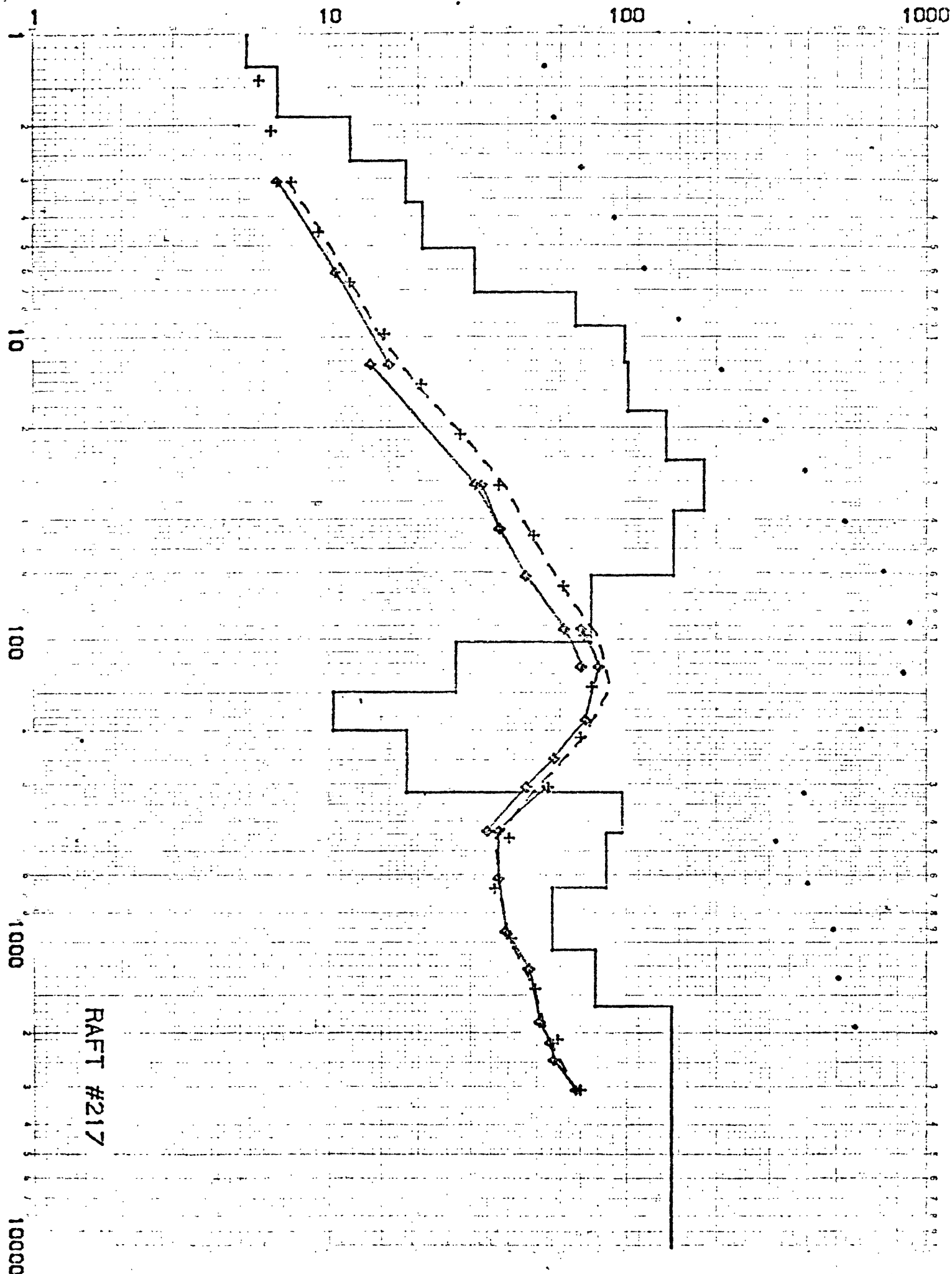


RESISTIVITIES IN OHM-METRES

10

100

1000



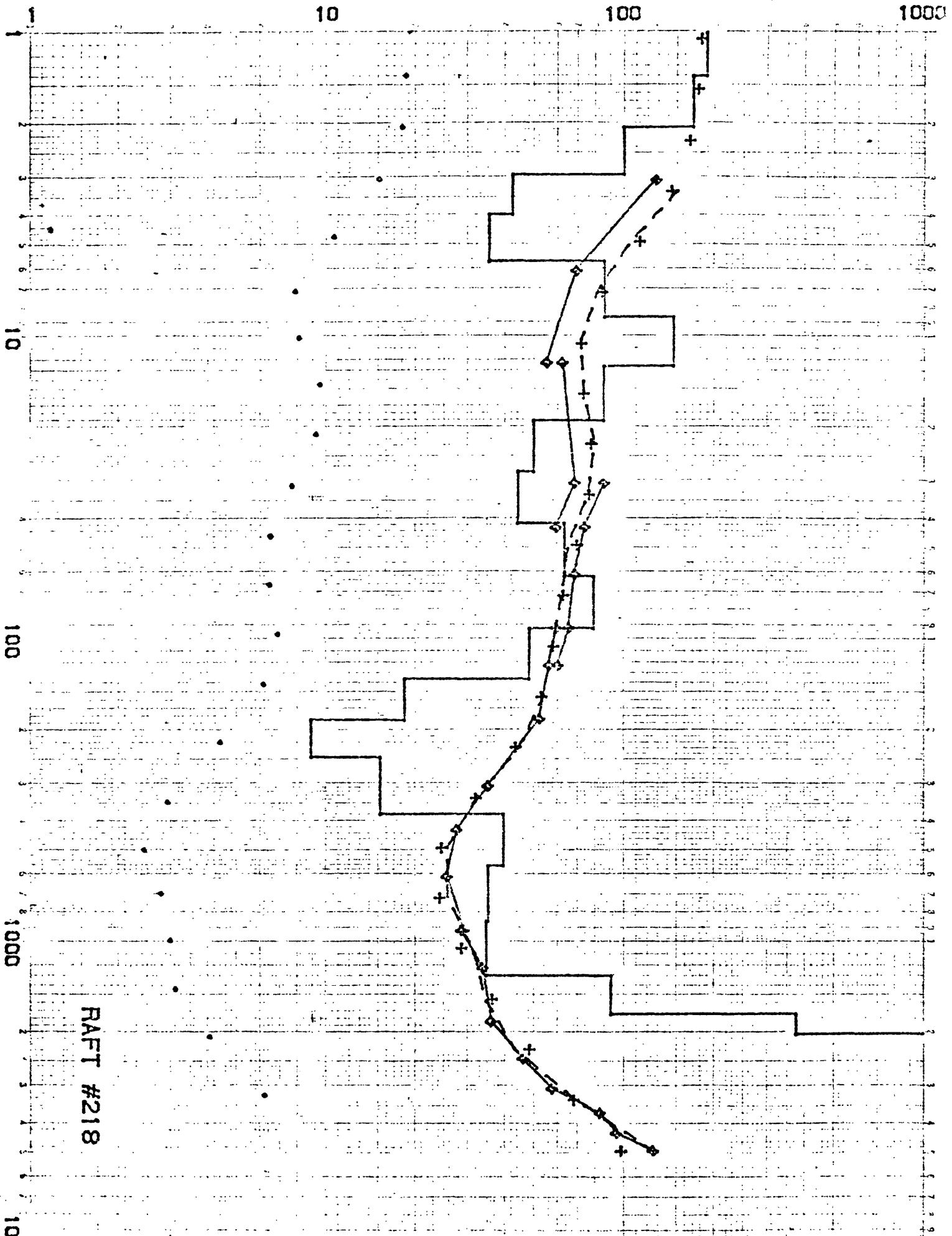
RAFT #217

AB/2, DEPTH, DZ-DEPTH, IN METRES

RESISTIVITIES IN OHM-METRES

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #218



RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

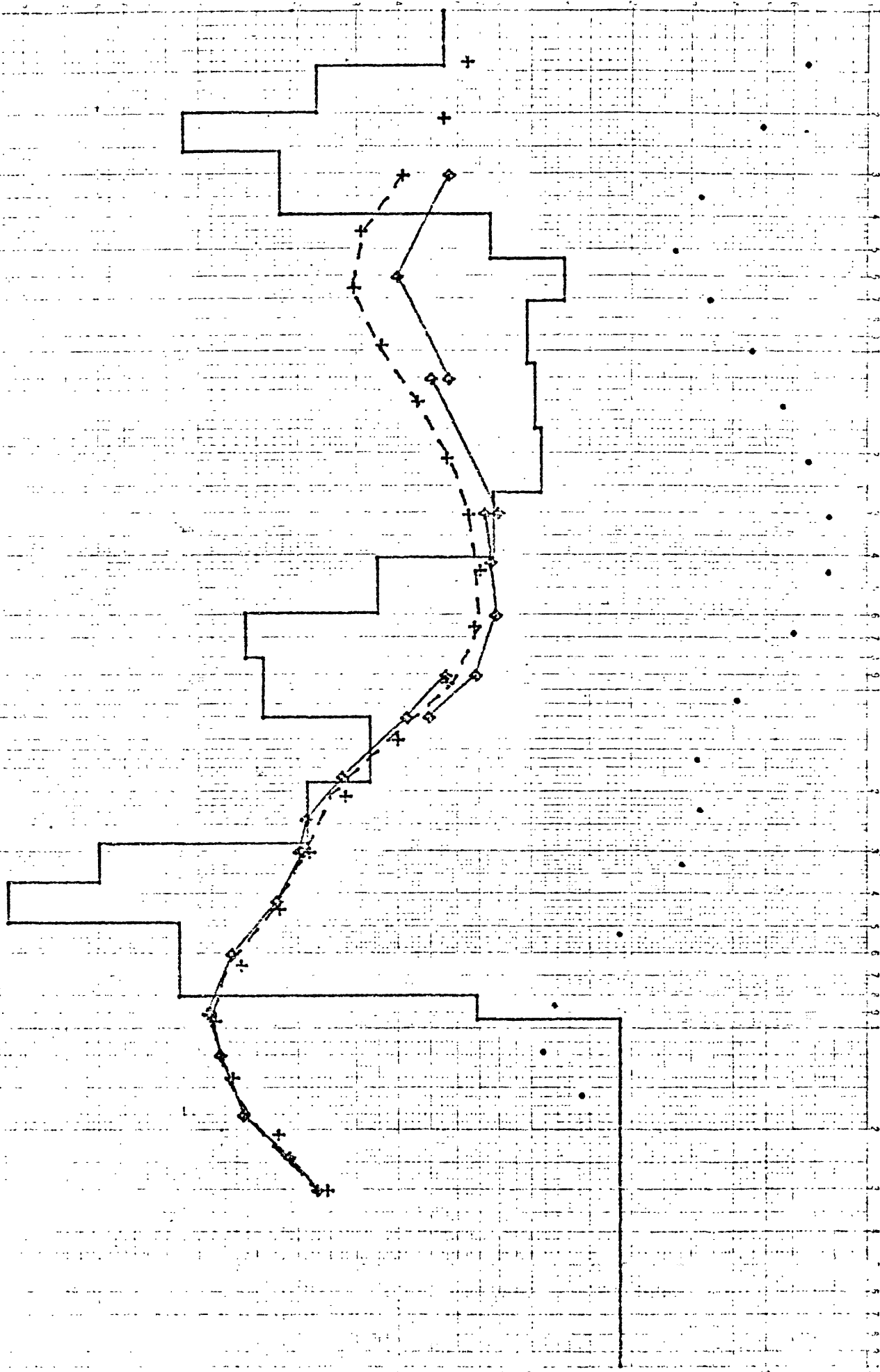
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AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFI #219



RESISTIVITIES IN OHM-METRES

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100

1000

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4

5

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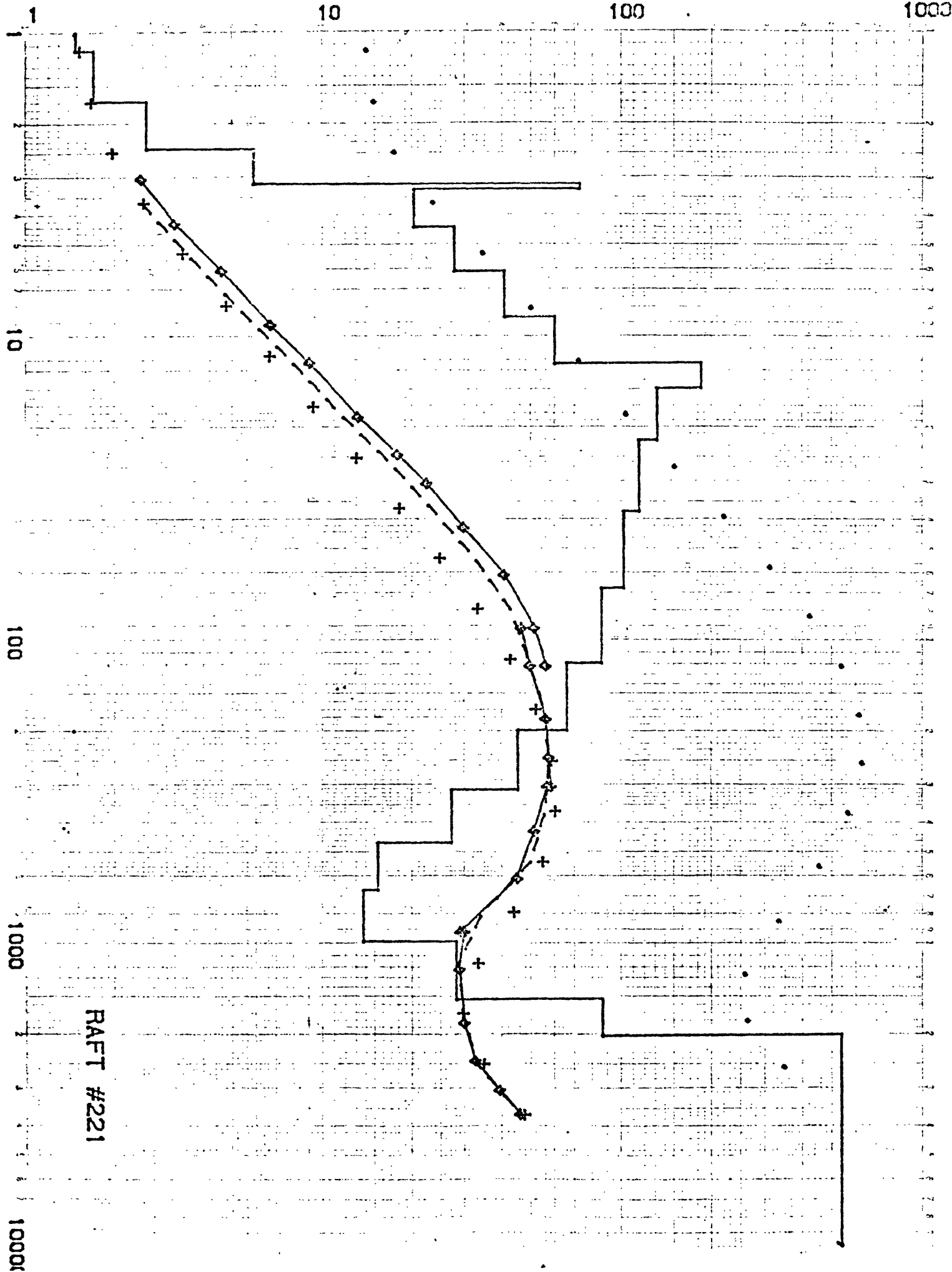
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RESISTIVITIES, IN OHM-METRES

10

100

1000



RAFT #221

10000

RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

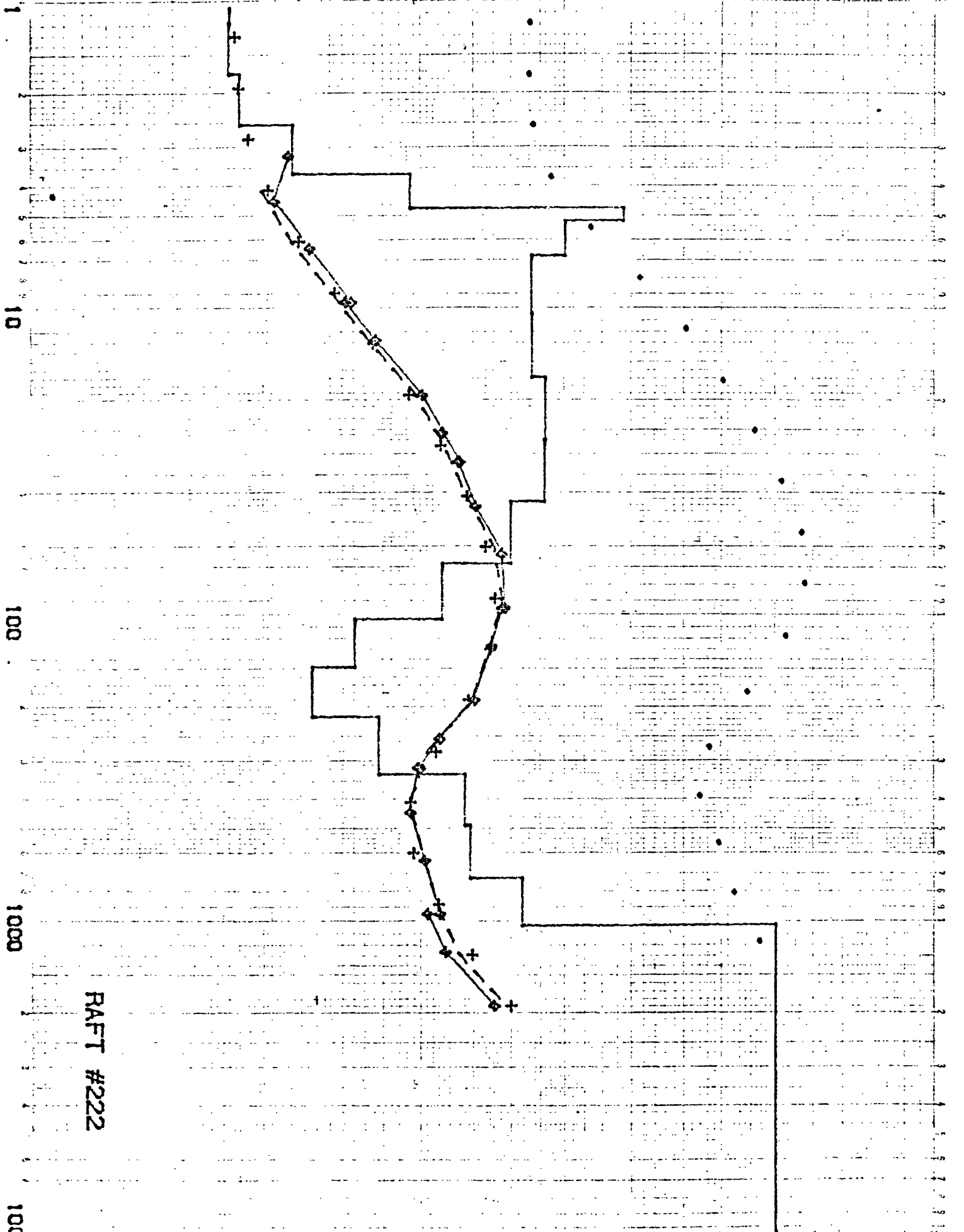
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AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #222



RESISTIVITIES IN OHM-METRES

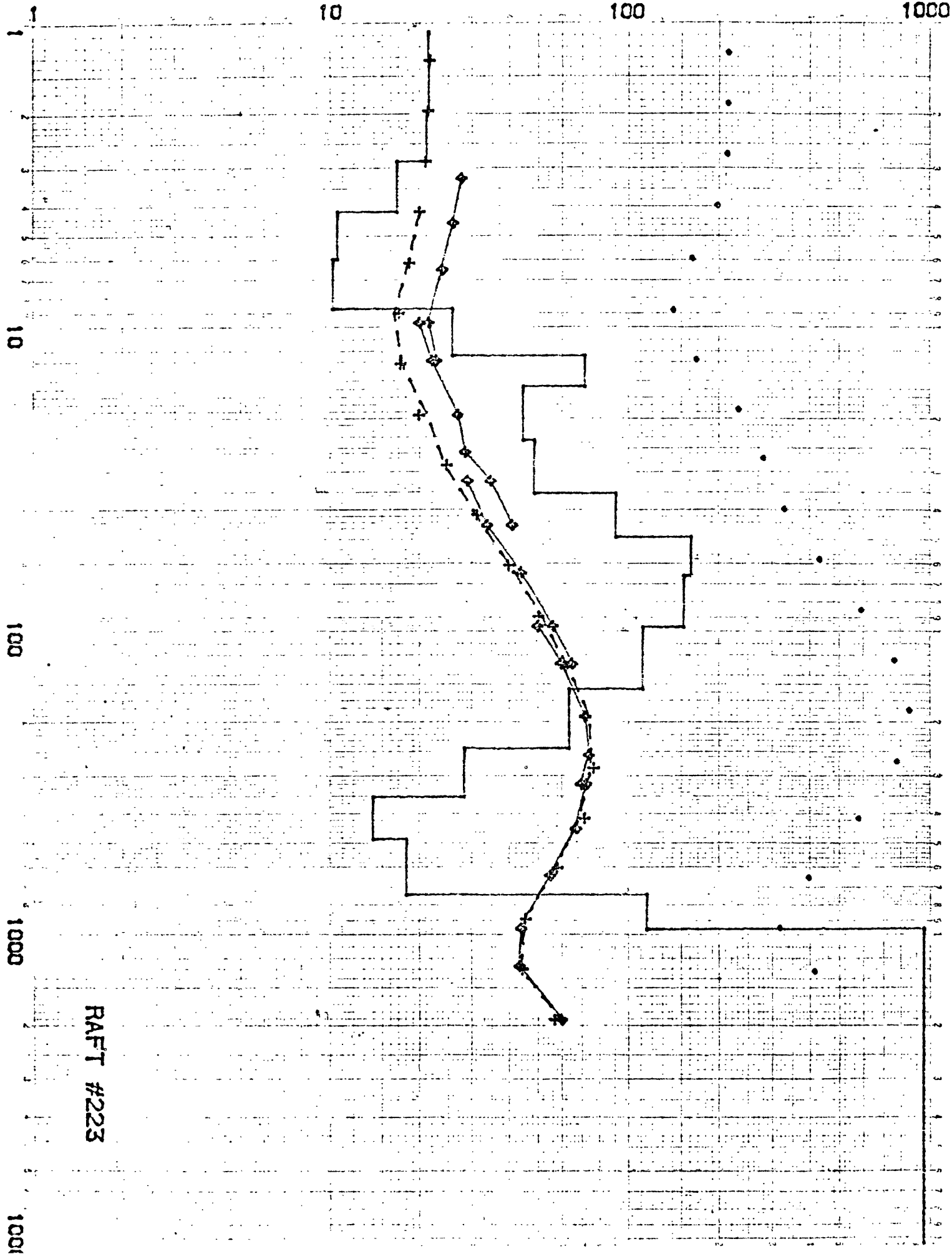
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AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #223



RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

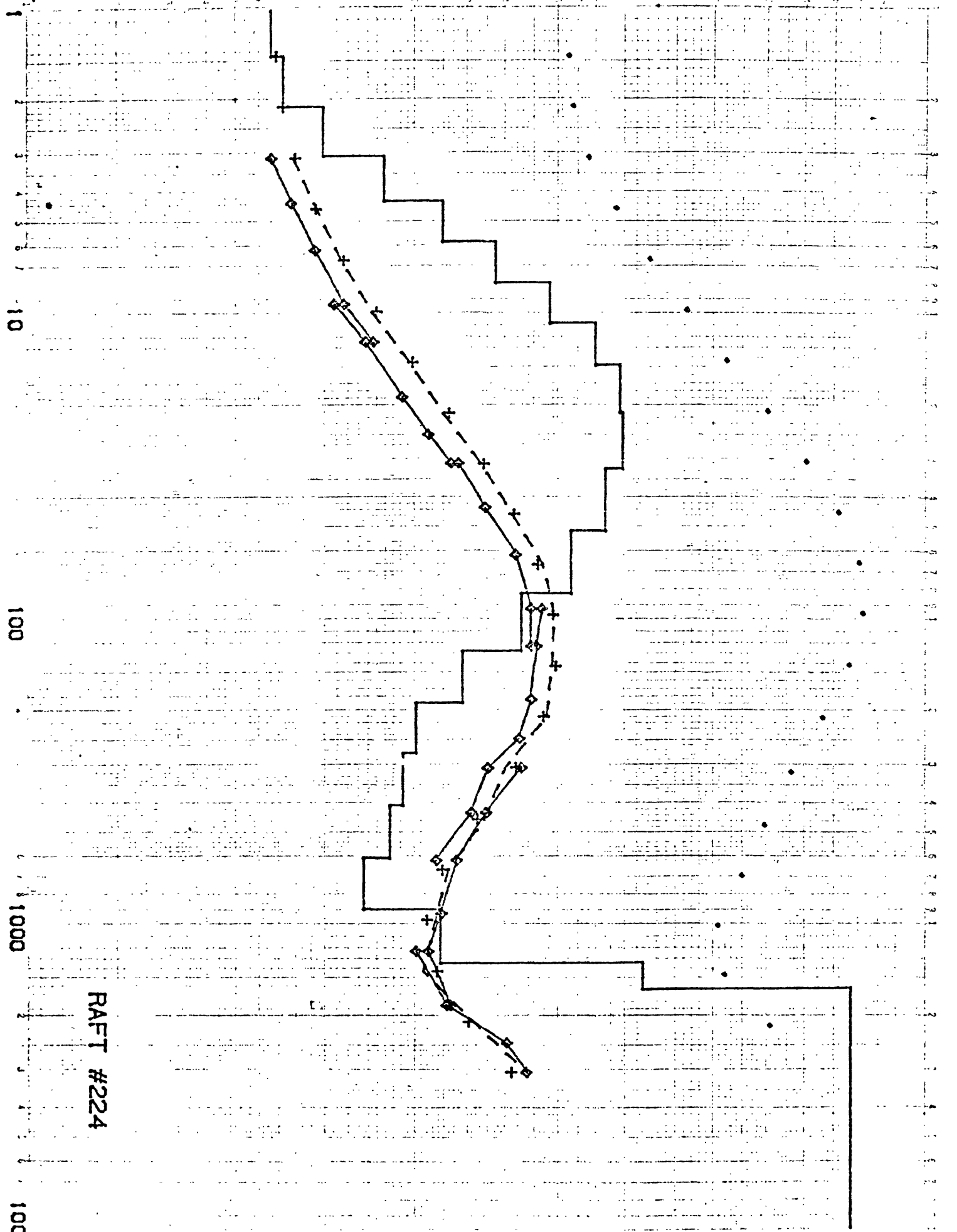
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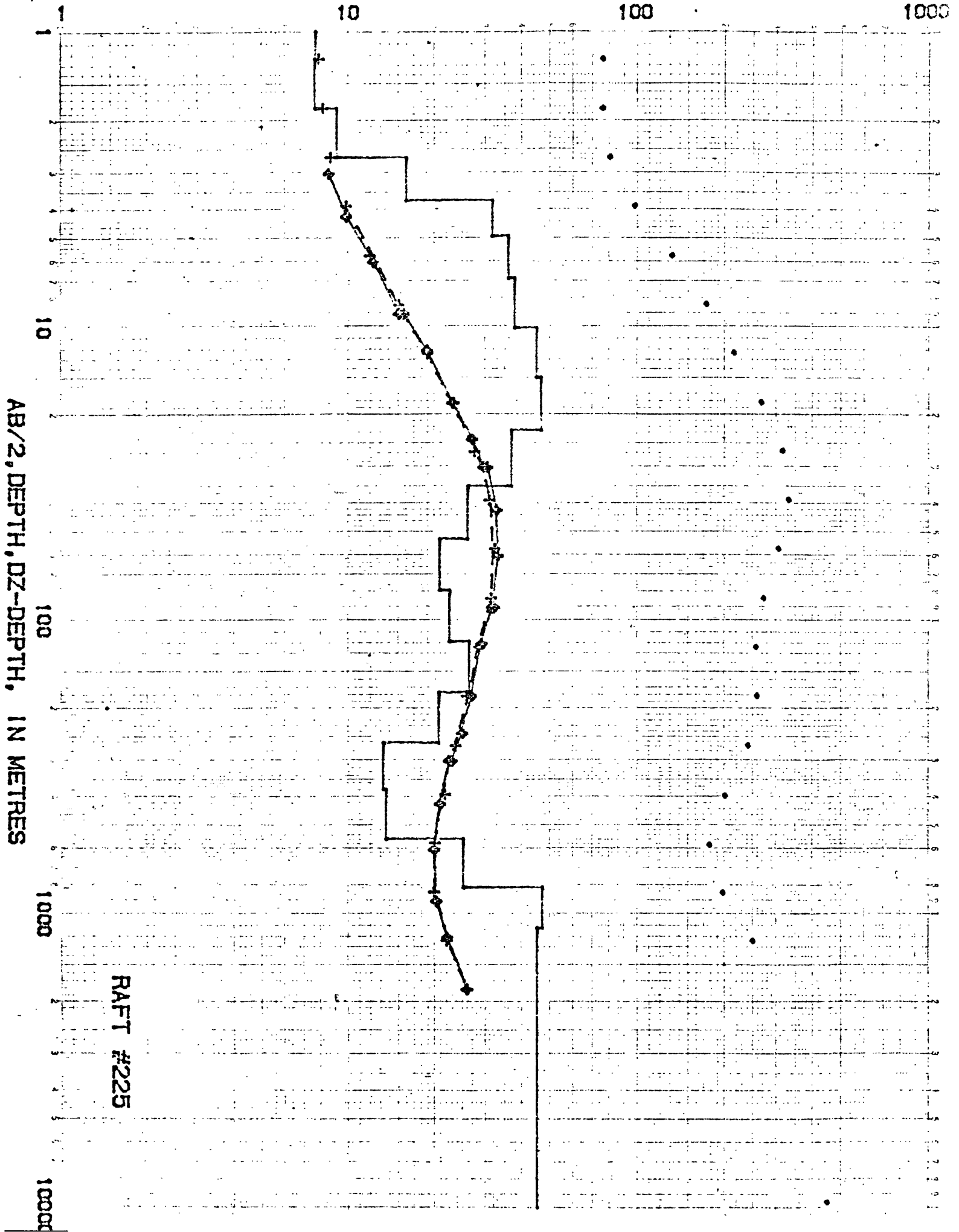
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AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #224



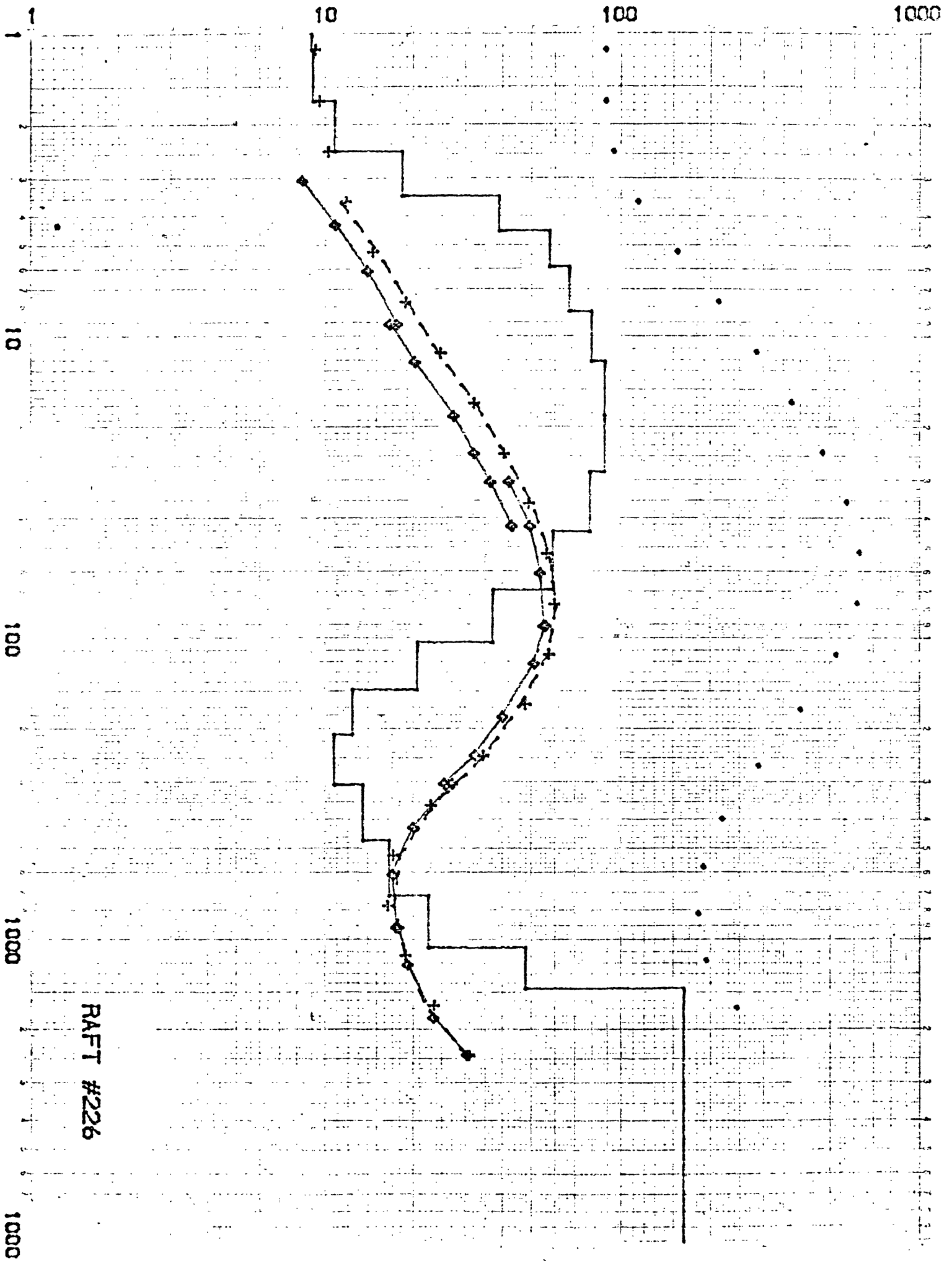
RESISTIVITIES. IN OHM-METRES



RESISTIVITIES IN OHM-METRES

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #226



RESISTIVITIES IN OHM-METRES

1000

100

10

1

10

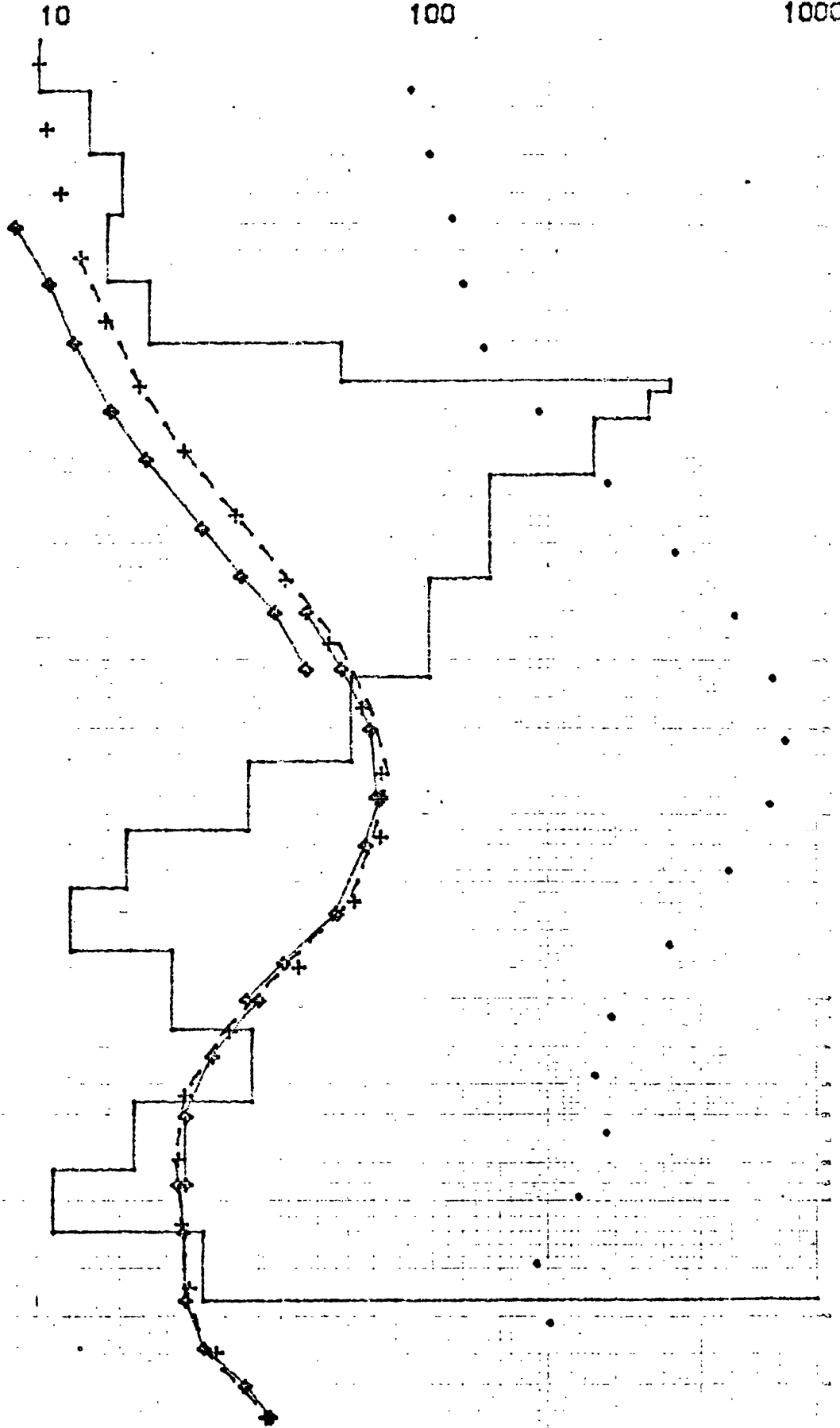
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AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #227



RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

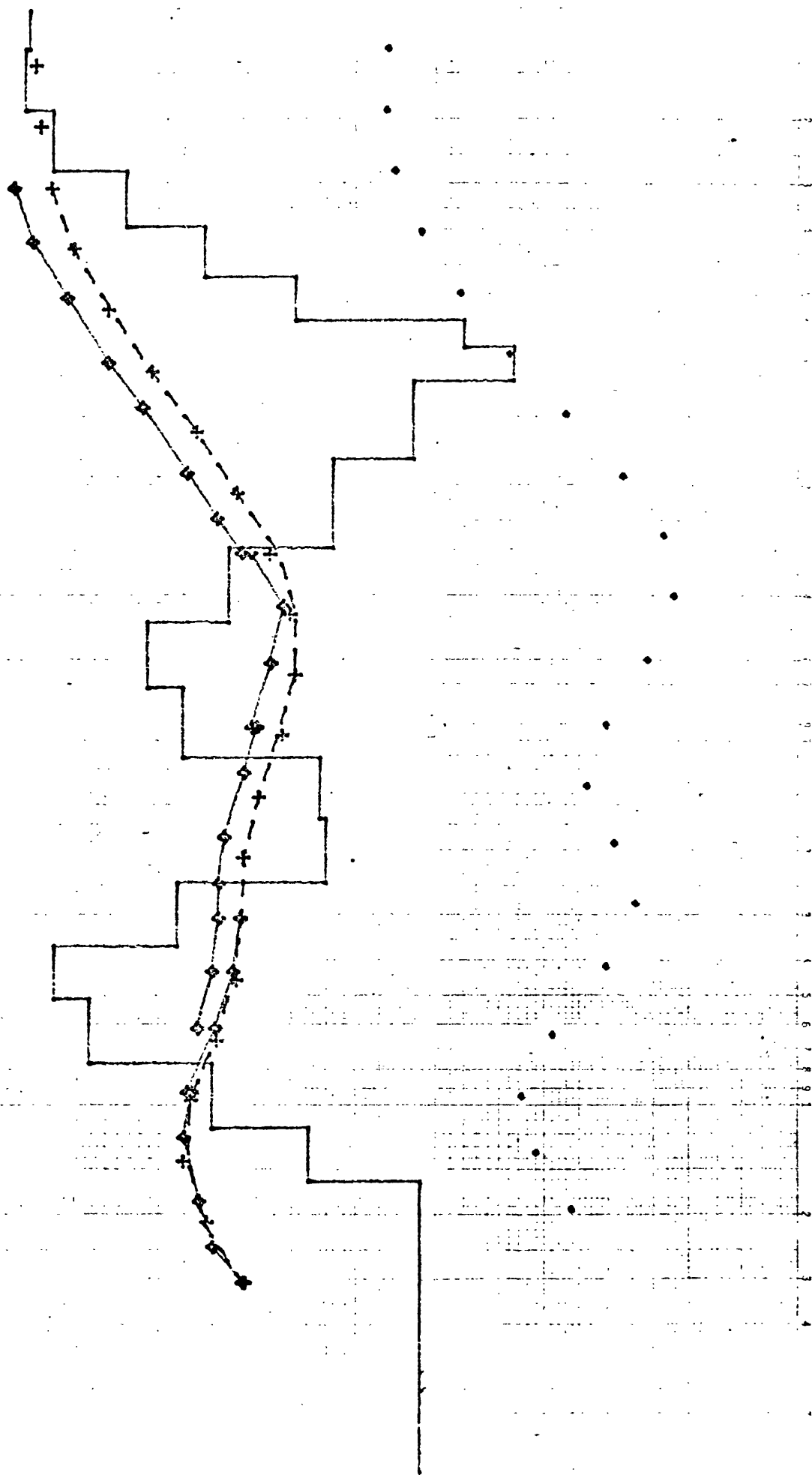
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AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #228



RESISTIVITIES. IN OHM-METRES

10

100

1000

1

10

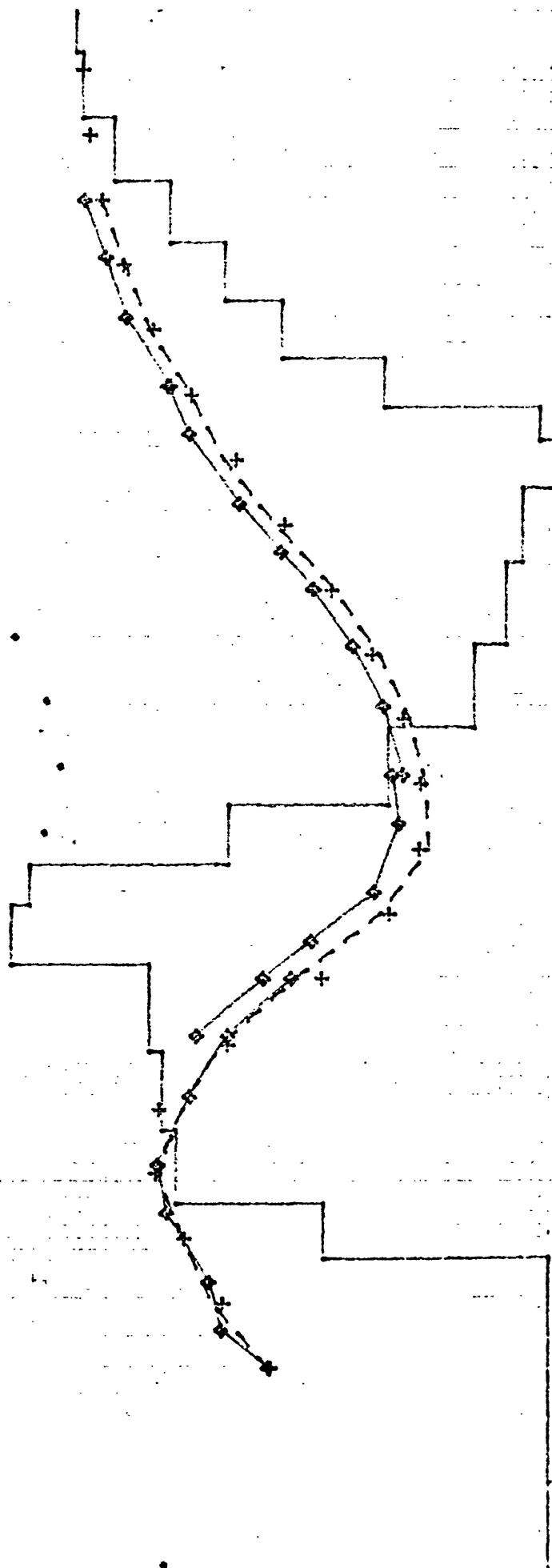
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1000

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AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #229

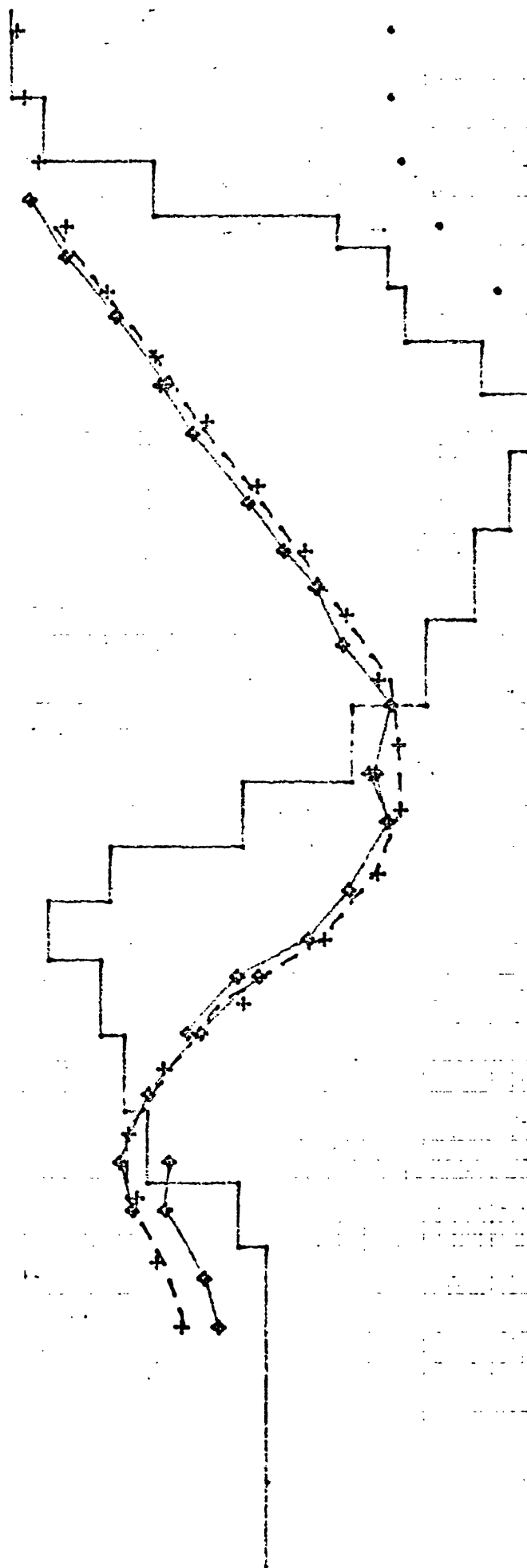


RESISTIVITIES IN OHM-METRES

10

100

1000



RAFT #230

1

10

100

1000

10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

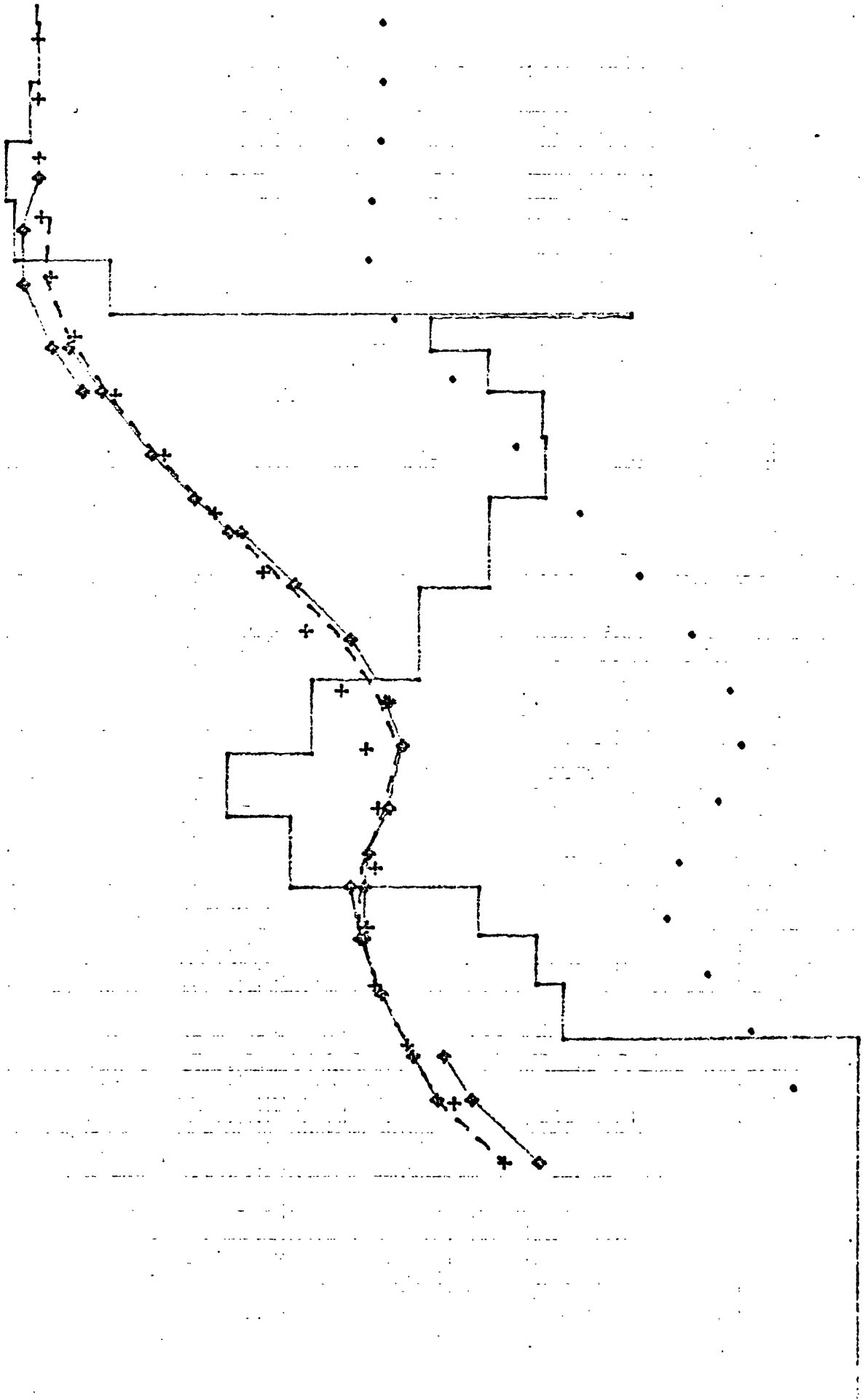
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10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #231



RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

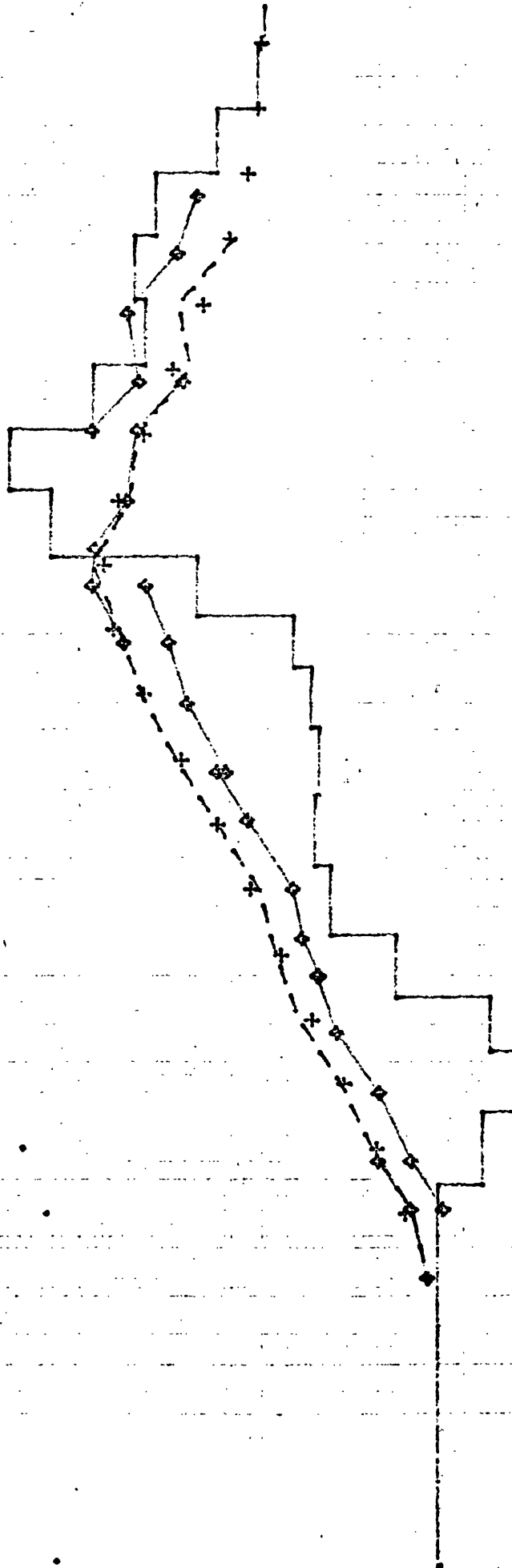
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1000

1000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #232

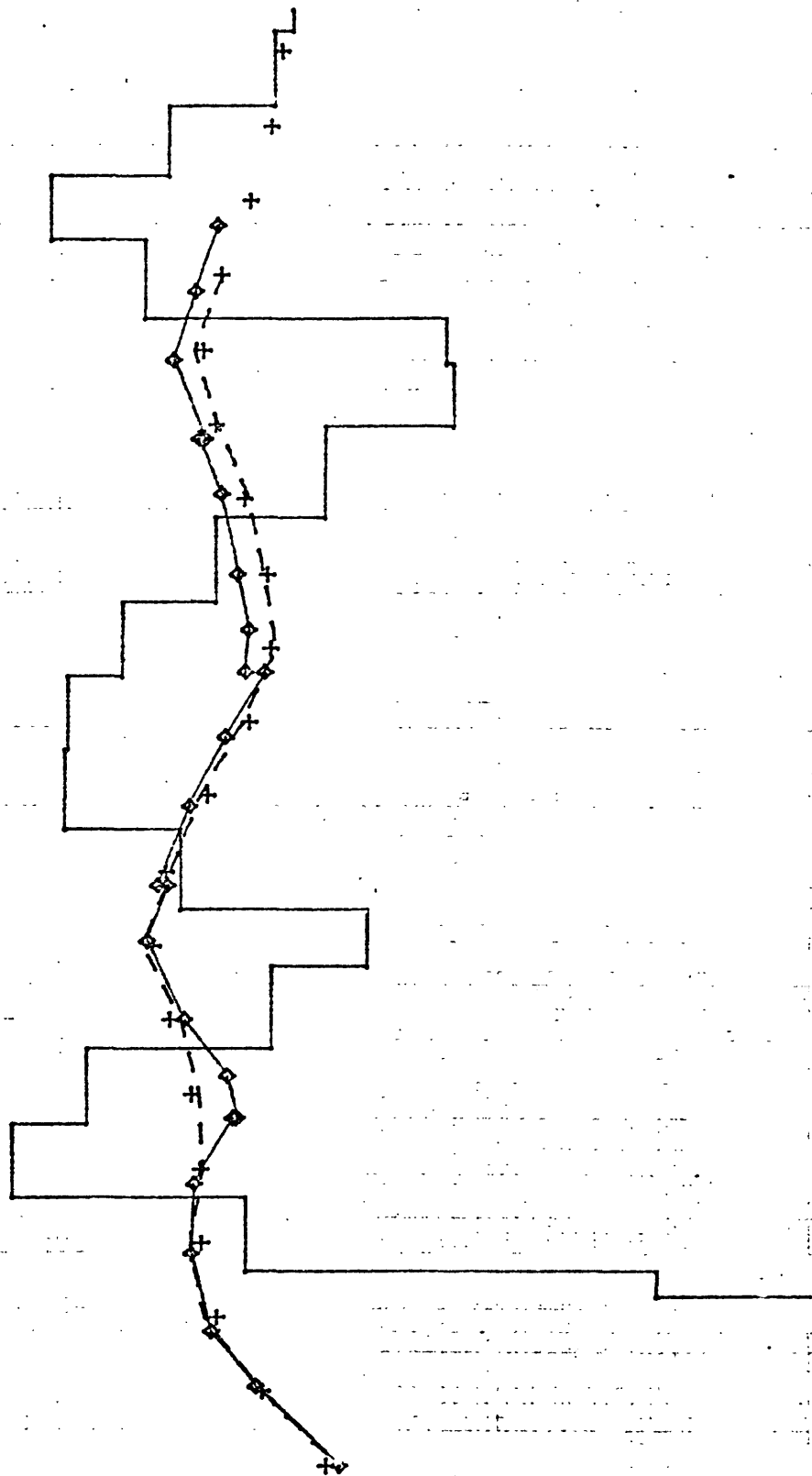


RESISTIVITIES, IN OHM-METRES

10

100

1000



RAFT #233

AB/2, DEPTH, DZ-DEPTH, IN METRES

10

100

1000

10000

RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

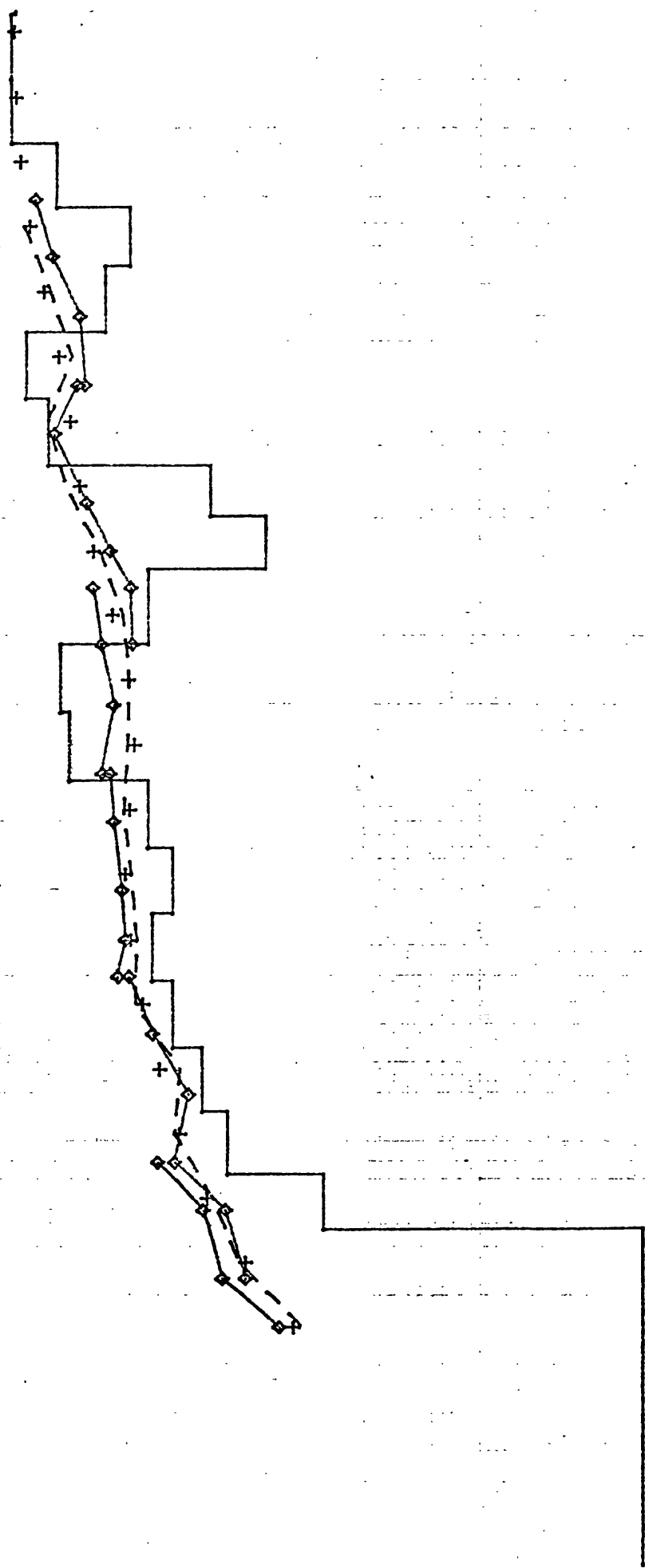
100

1000

10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #234



RESISTIVITIES, IN OHM-METRES

10

100

1000

1

10

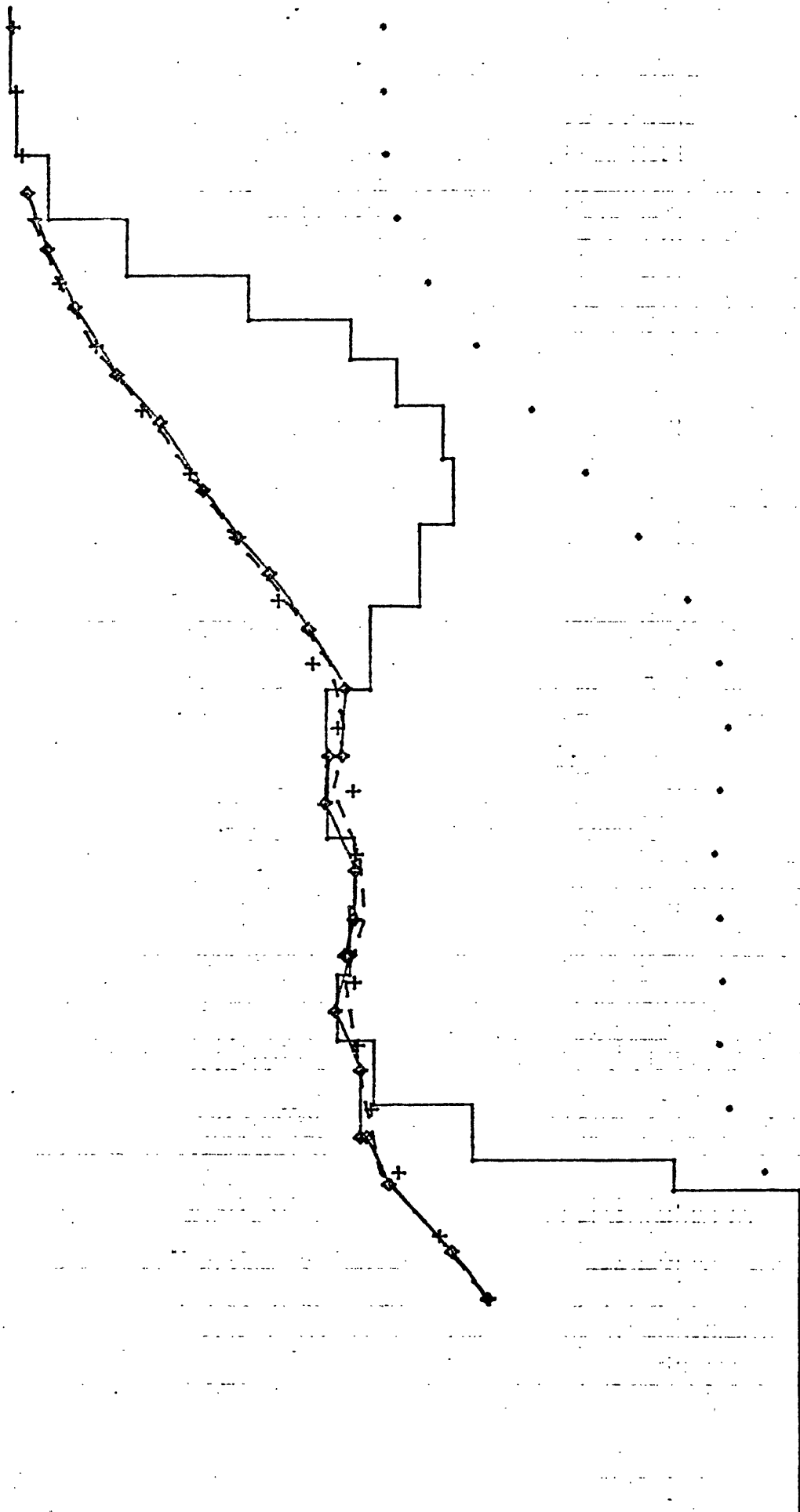
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10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #235

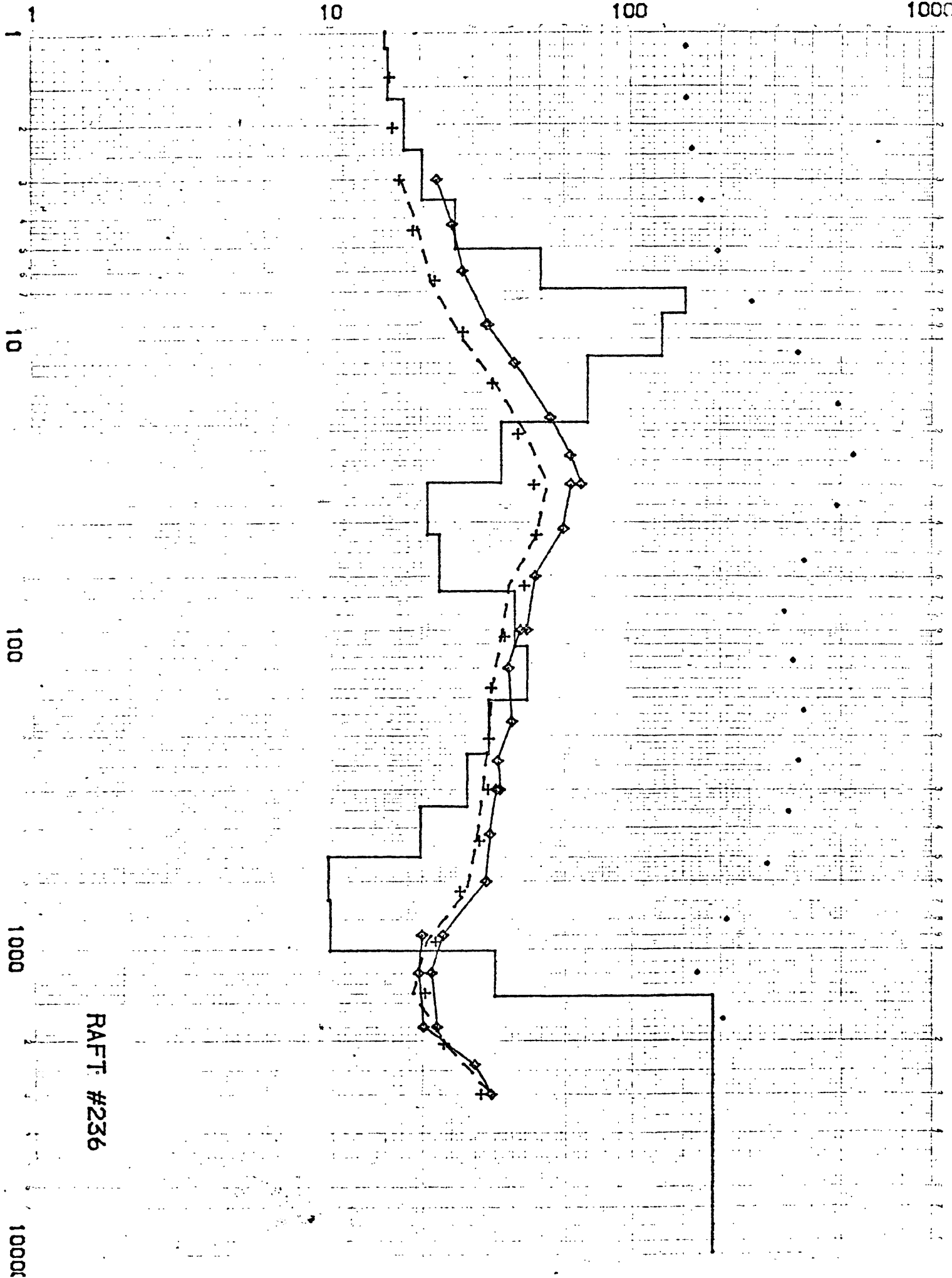


RESISTIVITIES IN OHM-METRES

10

100

1000



10

100

1000

10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #236

RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

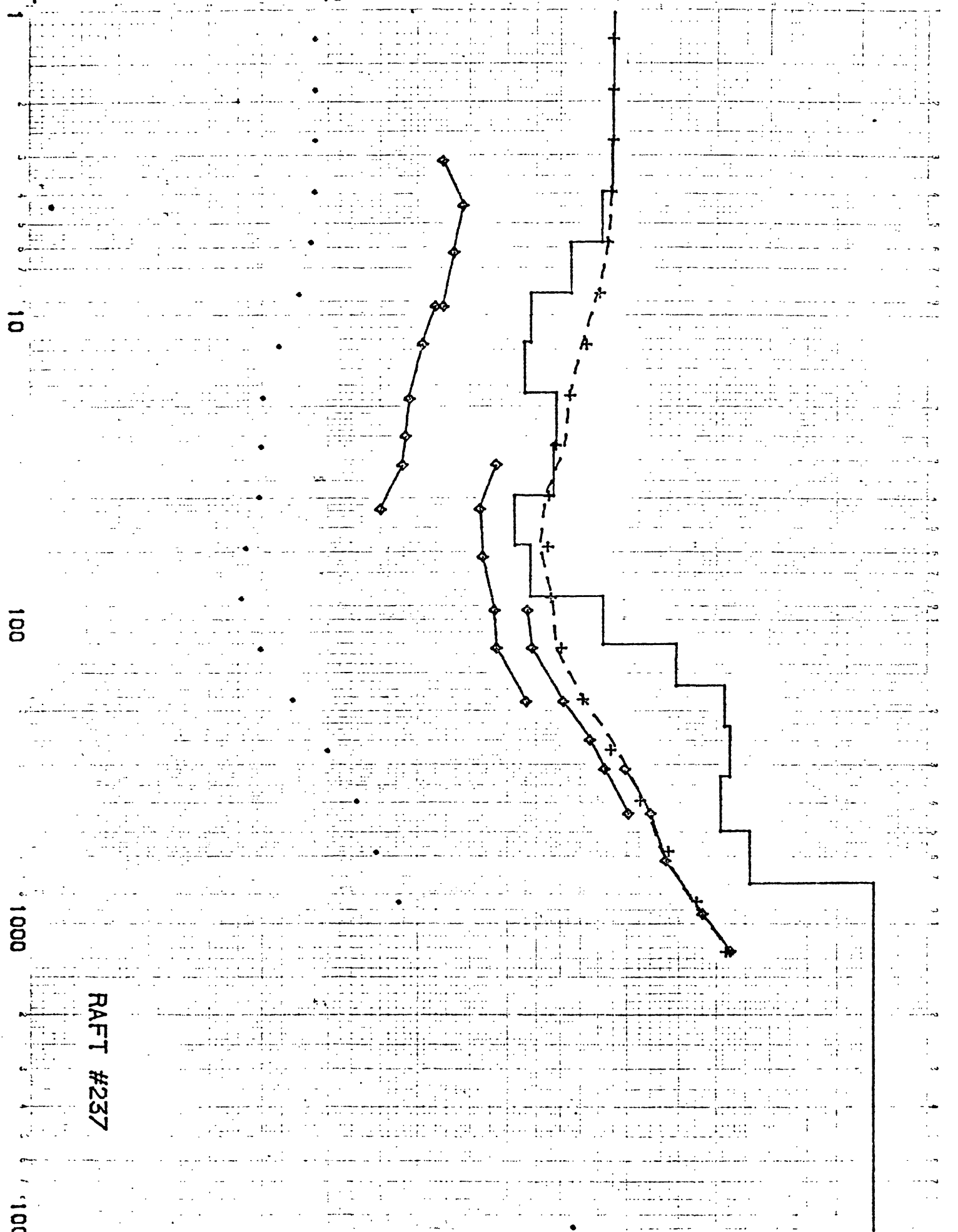
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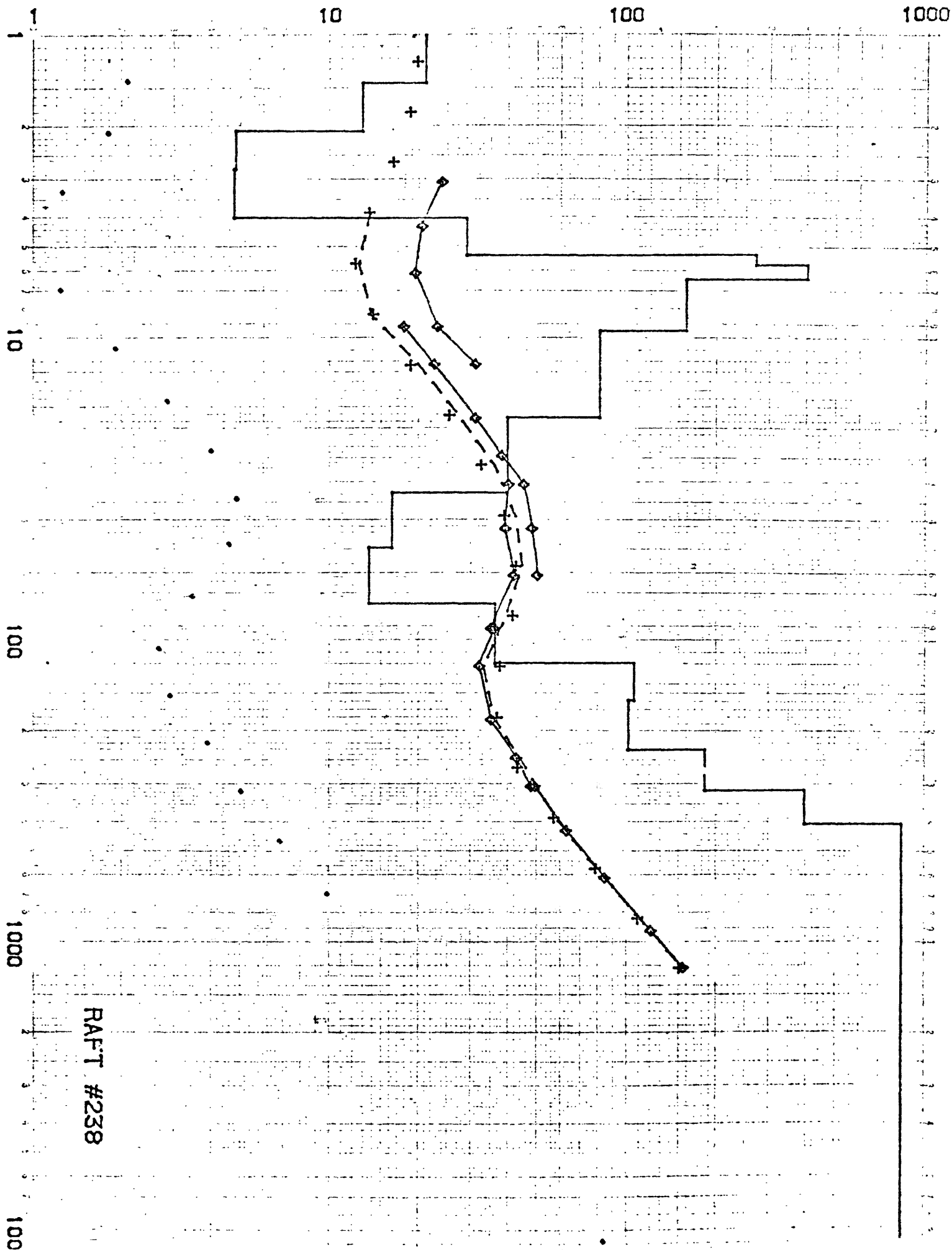
AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #237



RESISTIVITIES IN OHM-METRES

AB/2, DEPTH, DZ-DEPTH, IN METRES

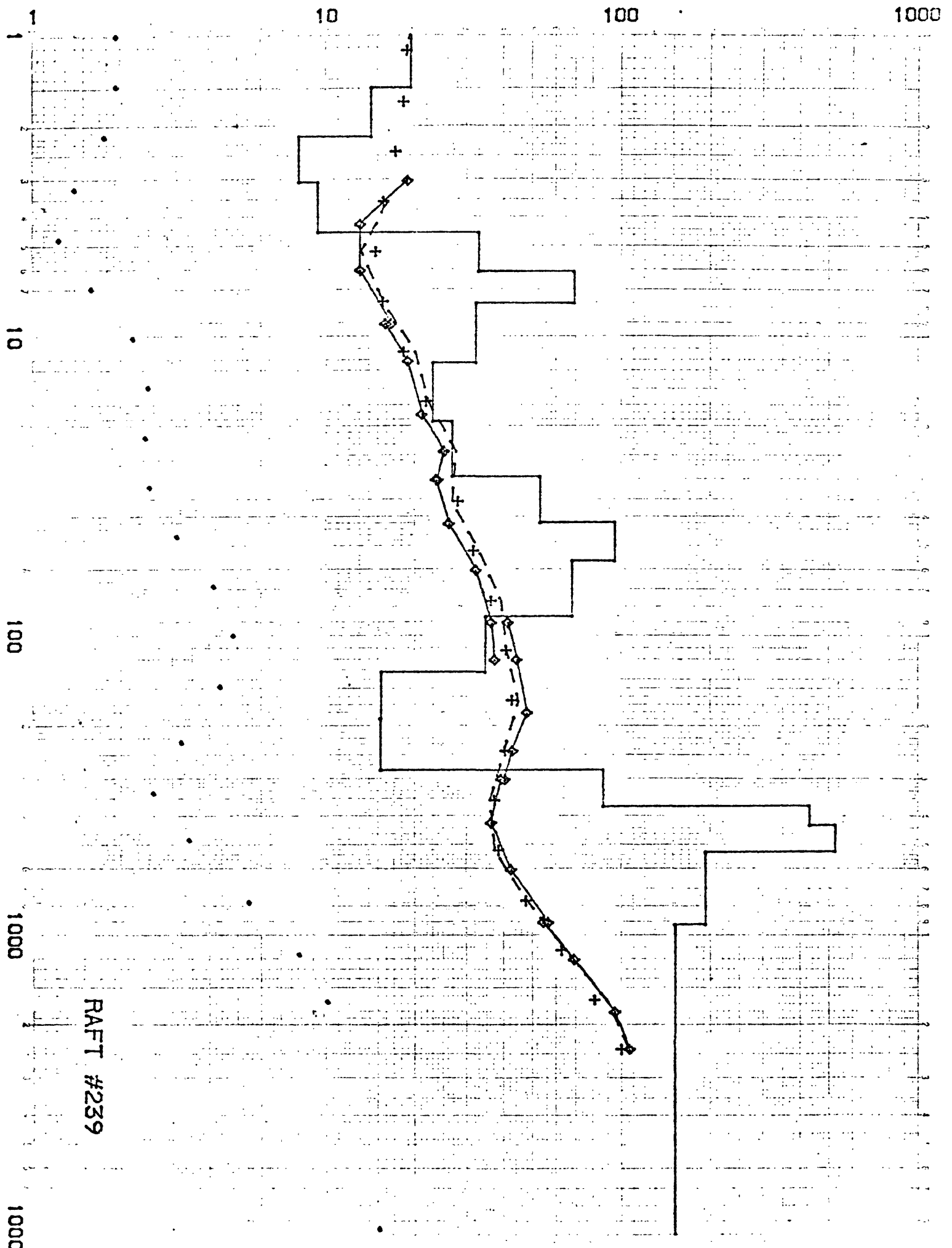


RAFT #238

RESISTIVITIES. IN OHM-METRES

AB/2. DEPTH, DZ-DEPTH, IN METRES

RAFT #239



RESISTIVITIES IN OHM-METRES

10

100

1000

1

2

10

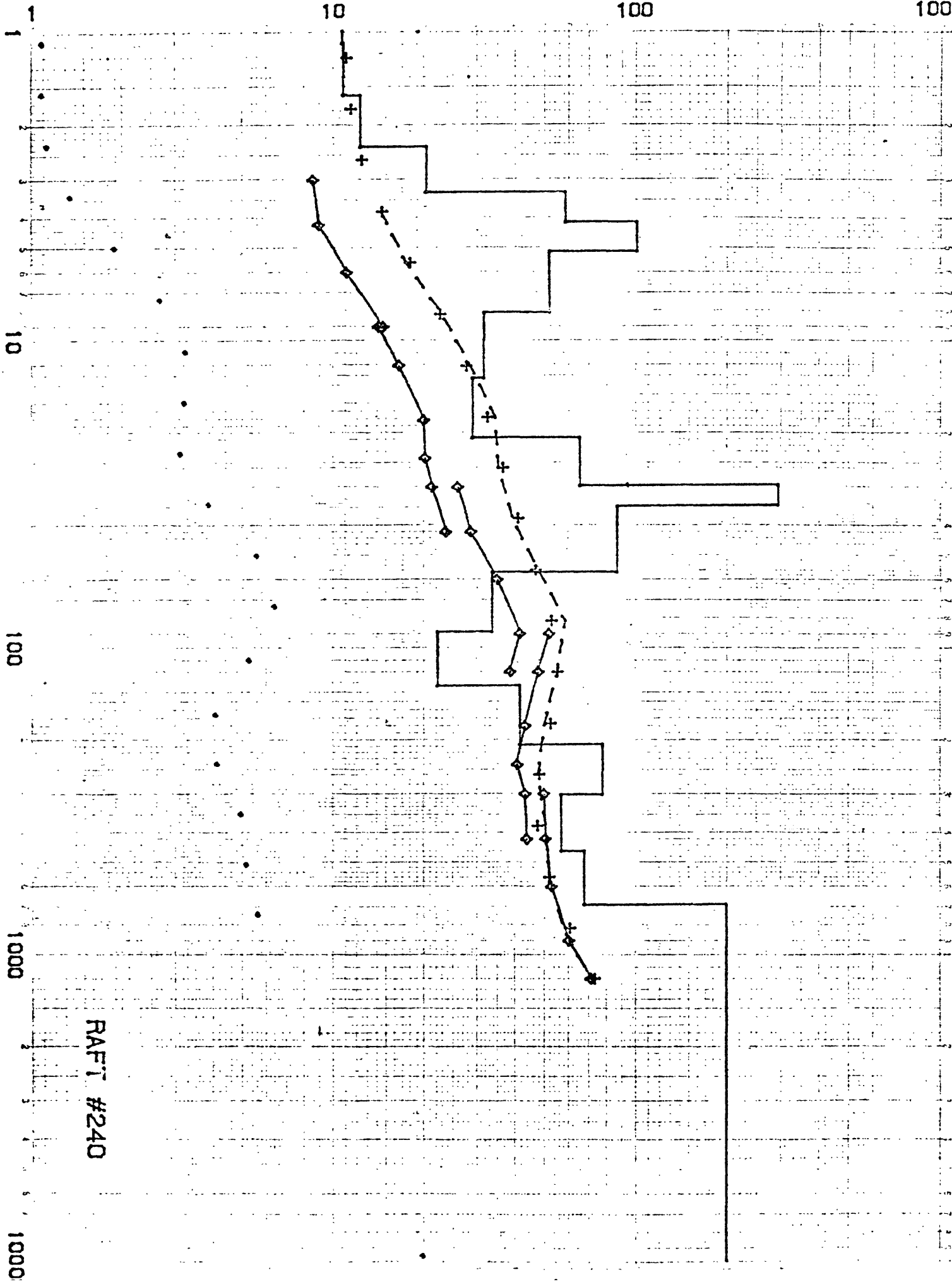
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10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #240



RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

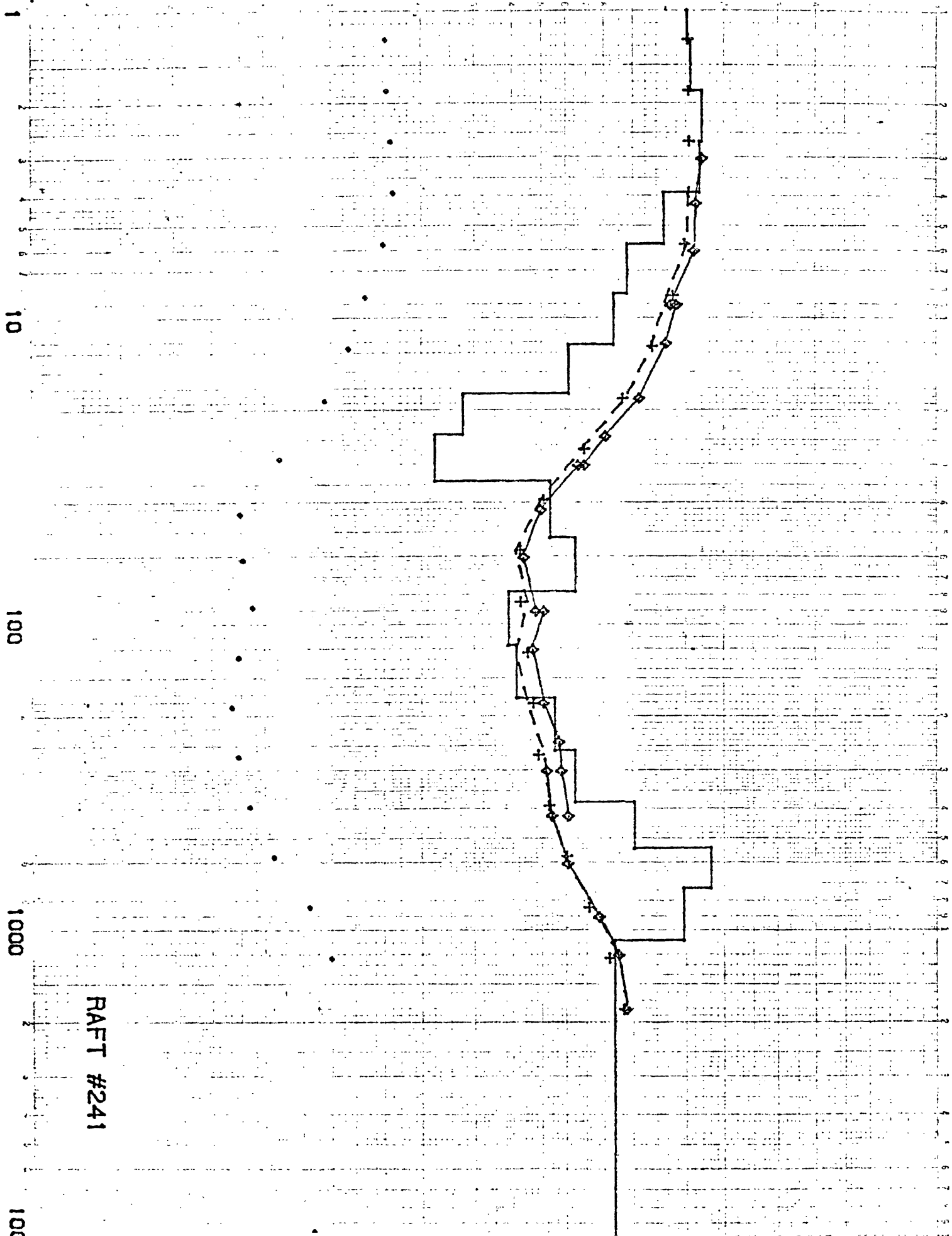
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1000

AB/2. DEPTH. DZ-DEPTH. IN METRES

RAFT #241

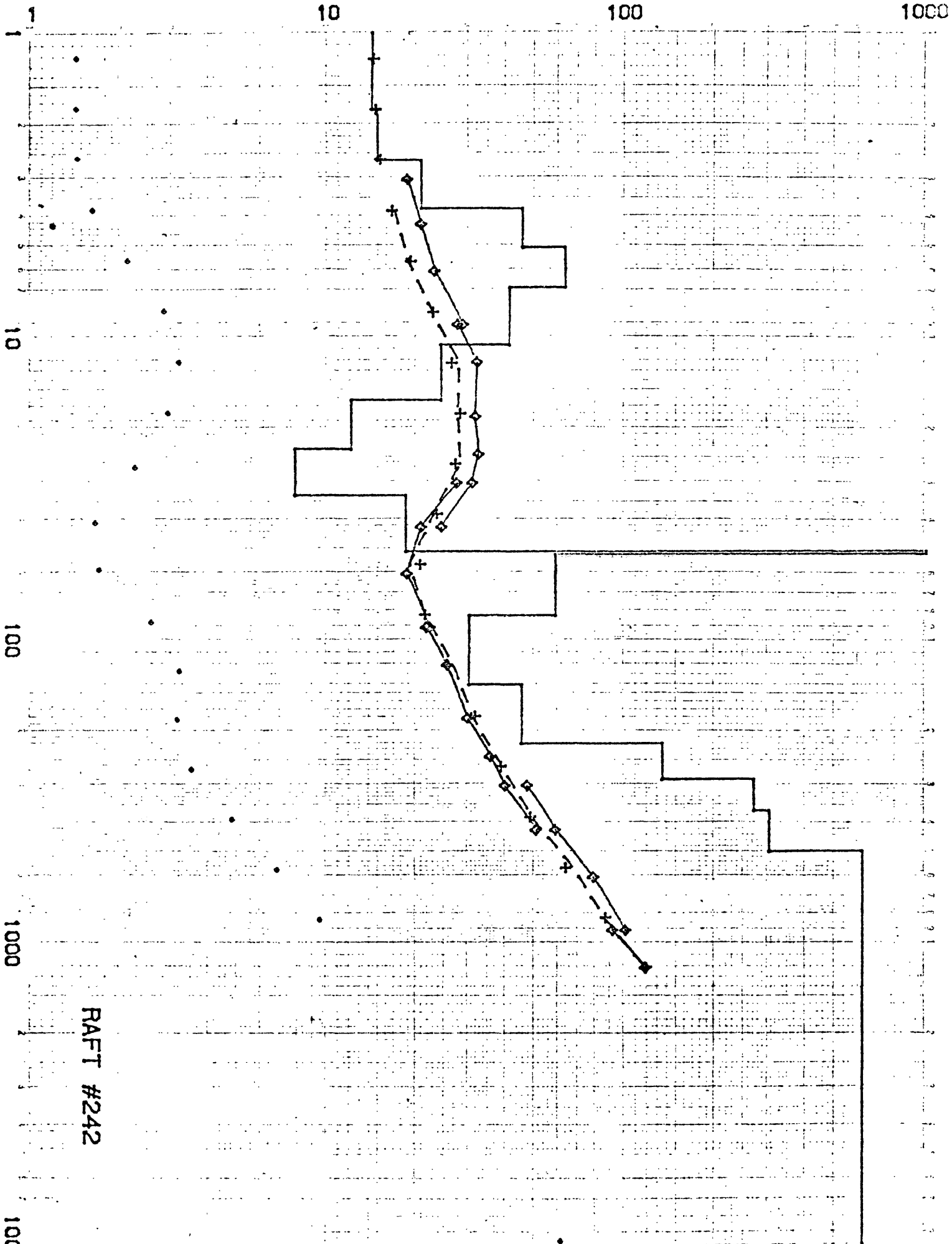


RESISTIVITIES IN OHM-METRES

10

100

1000



RAFT #242

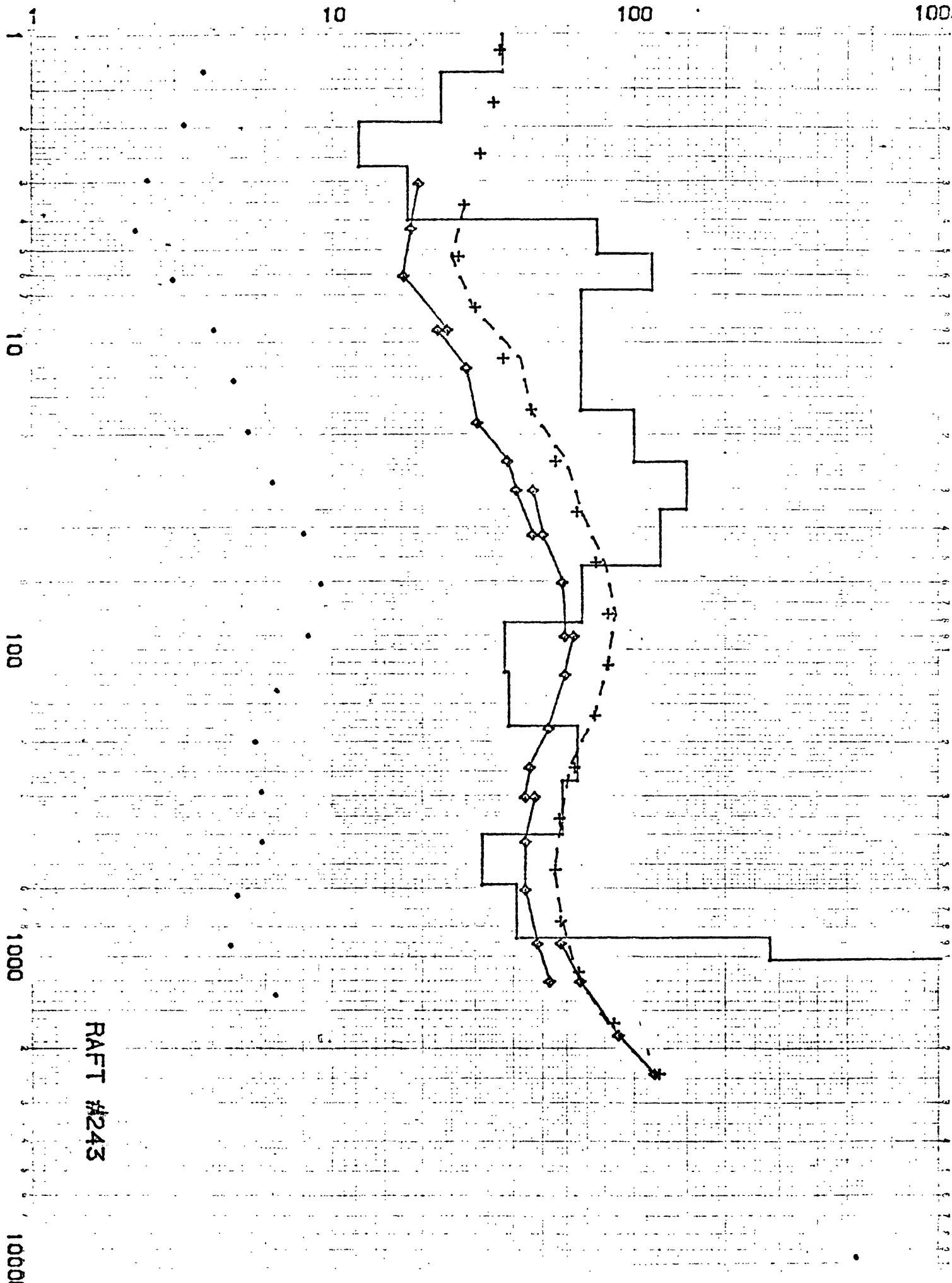
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RESISTIVITIES. IN OHM-METRES

10

100

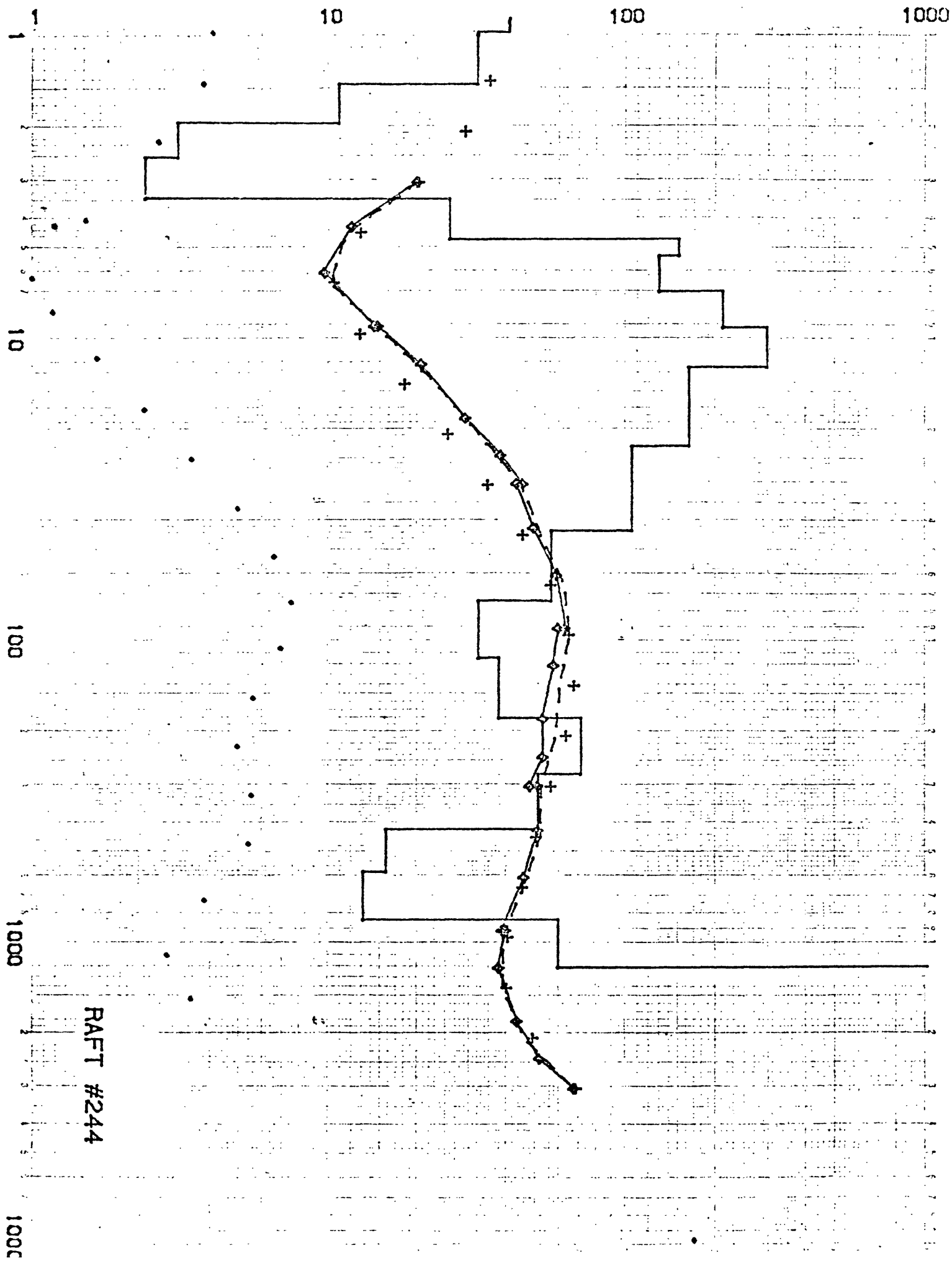
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RESISTIVITIES IN OHM-METRES

AB/2, DEPTH, DZ-DEPTH, IN METRES

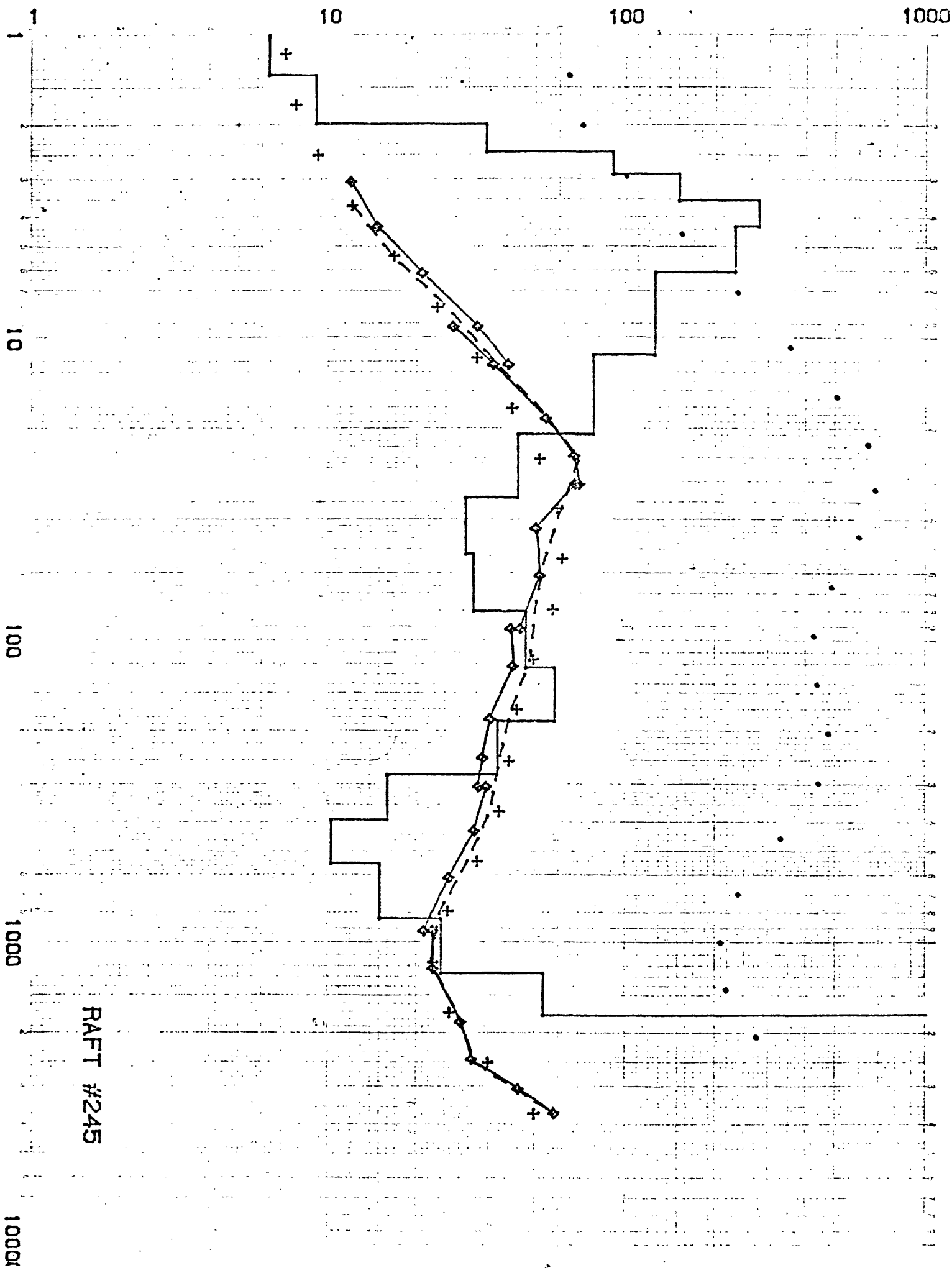
RAFT #244



RESISTIVITIES IN OHM-METRES

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #245



RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

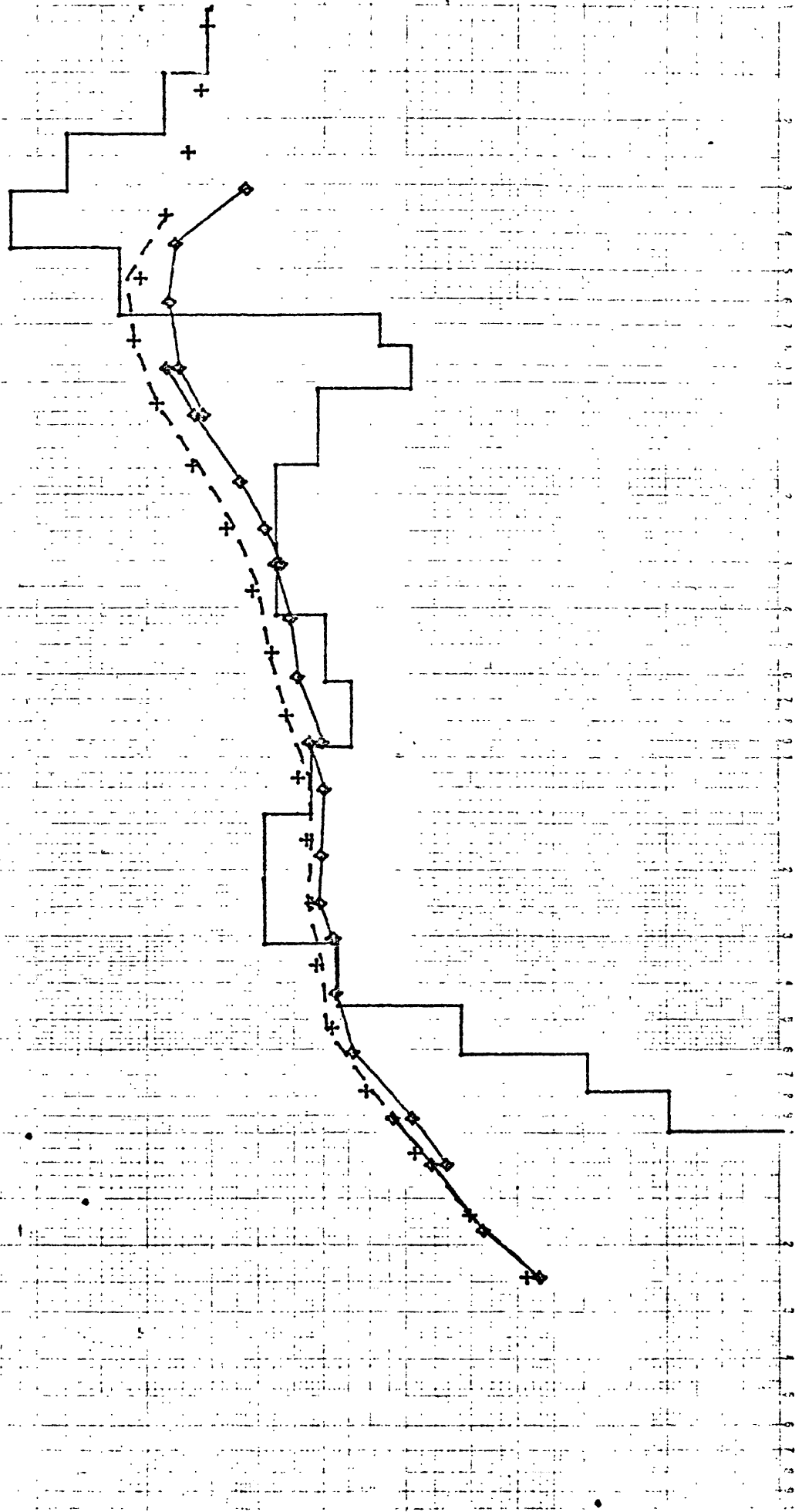
100

1000

10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #246



RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

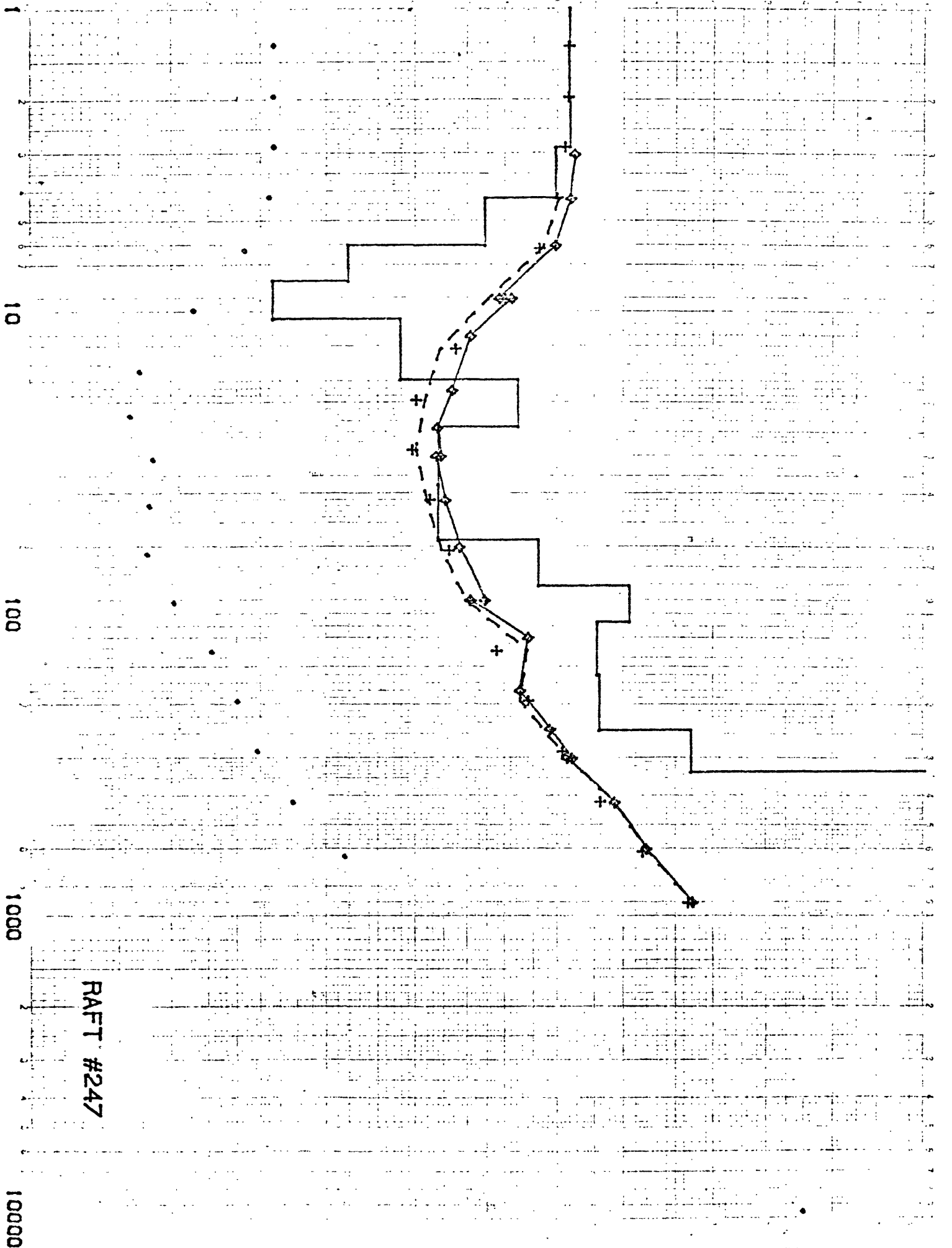
100

1000

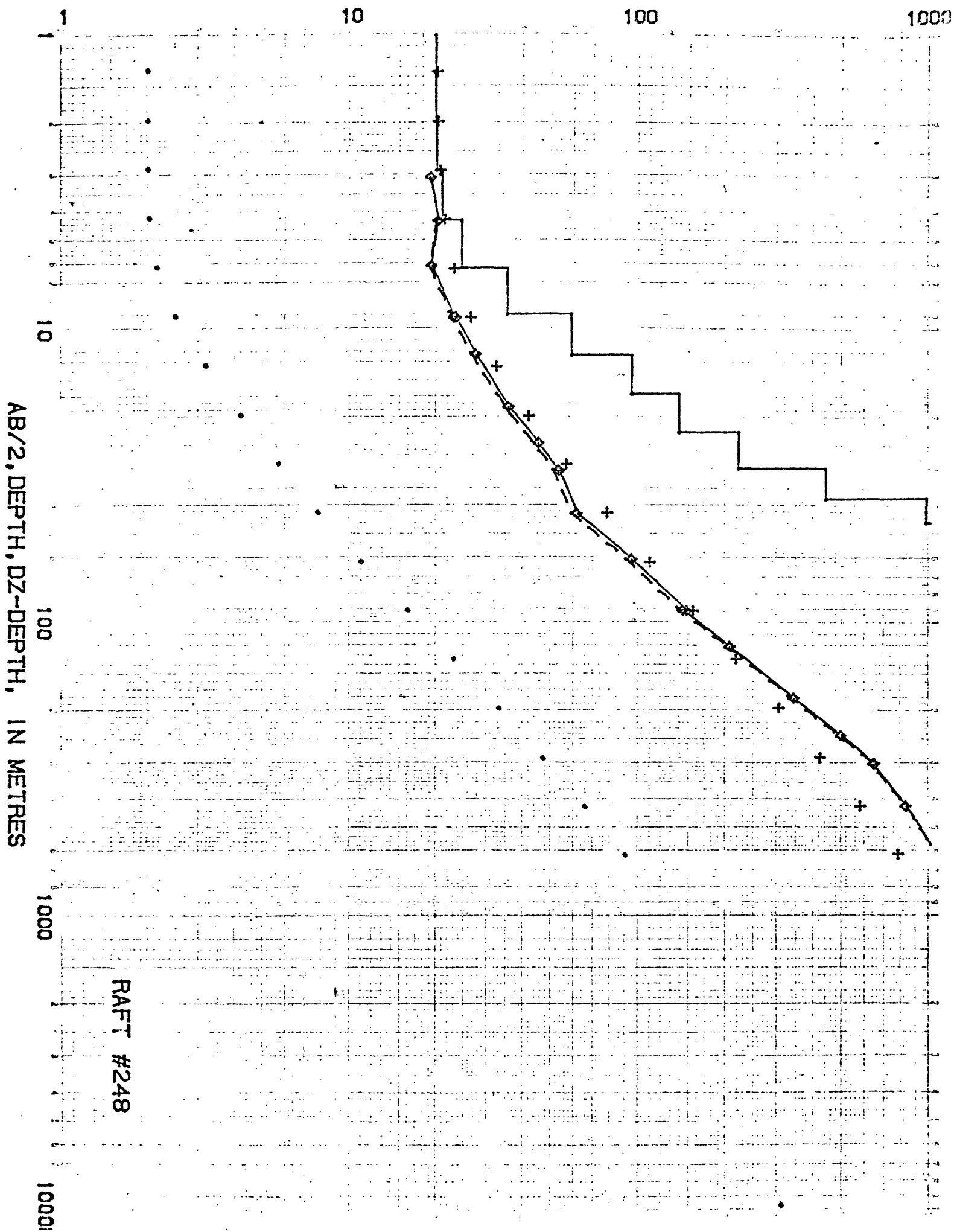
10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #247



RESISTIVITIES IN OHM-METRES

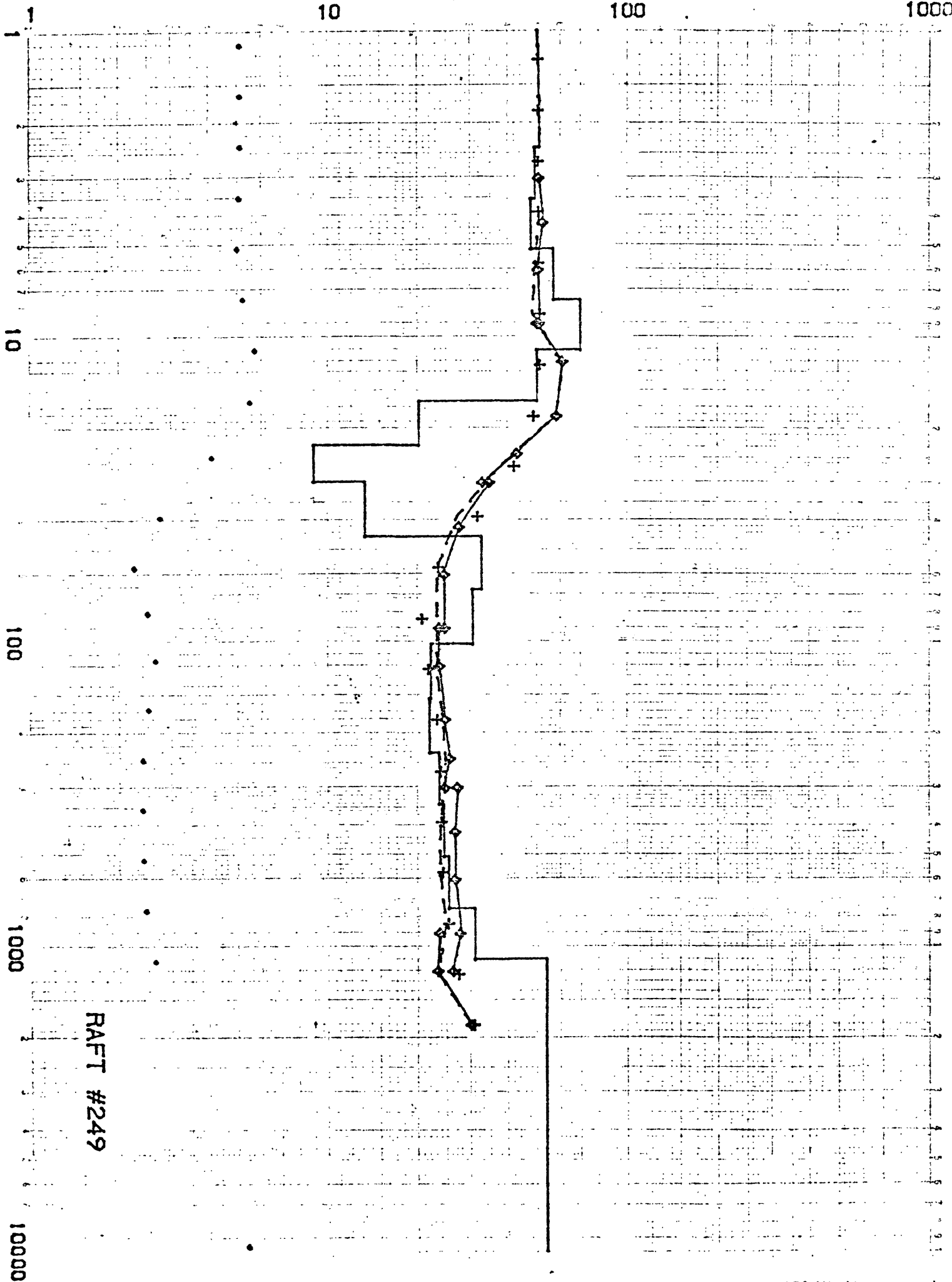


RESISTIVITIES IN OHM-METRES

10

100

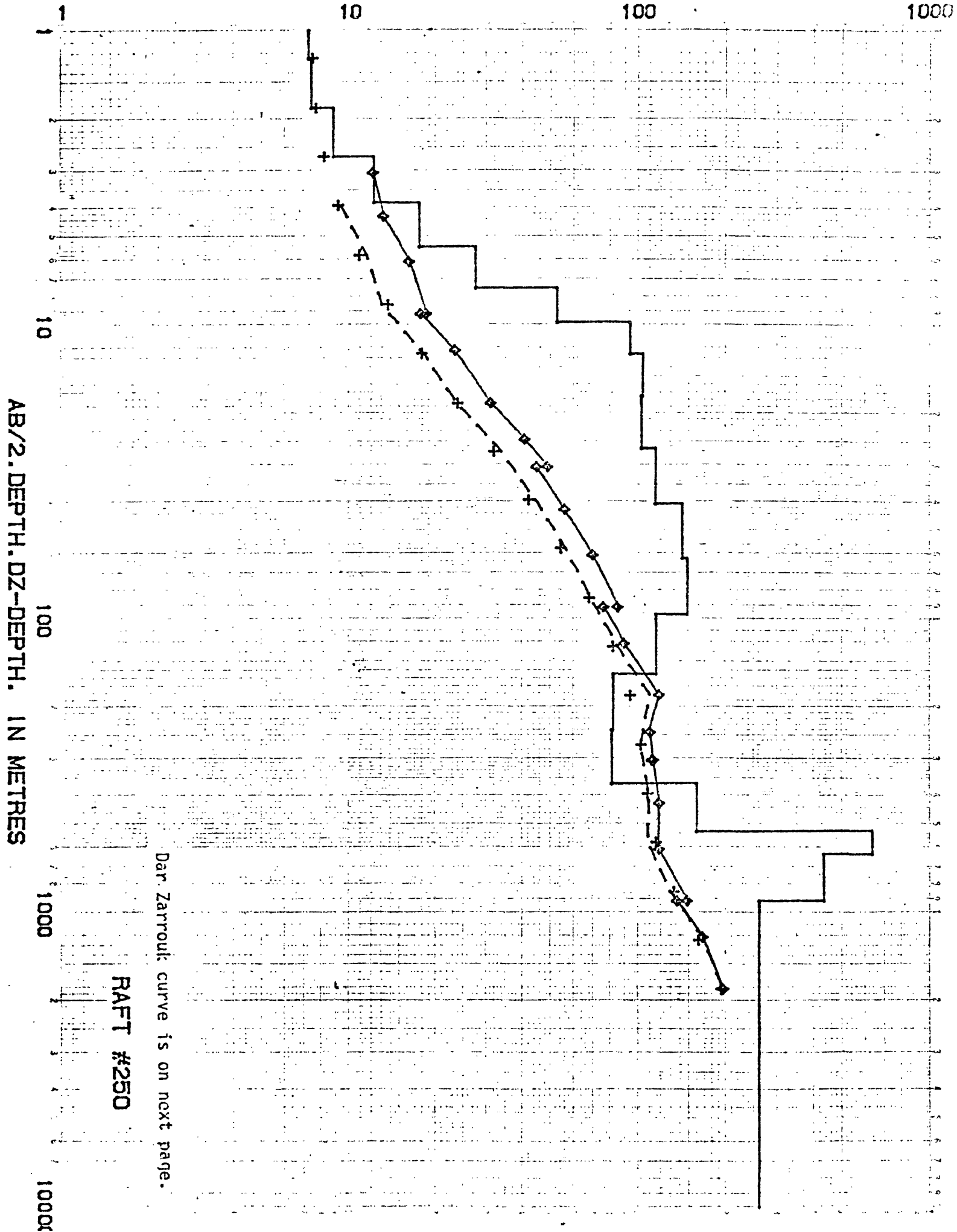
1000



AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #249

RESISTIVITIES. IN OHM-METRES



Dar Zarroui: curve is on next page.

RAFT #250

AB/2. DEPTH. DZ-DEPTH. IN METRES

RESISTIVITIES IN OHM-METRES

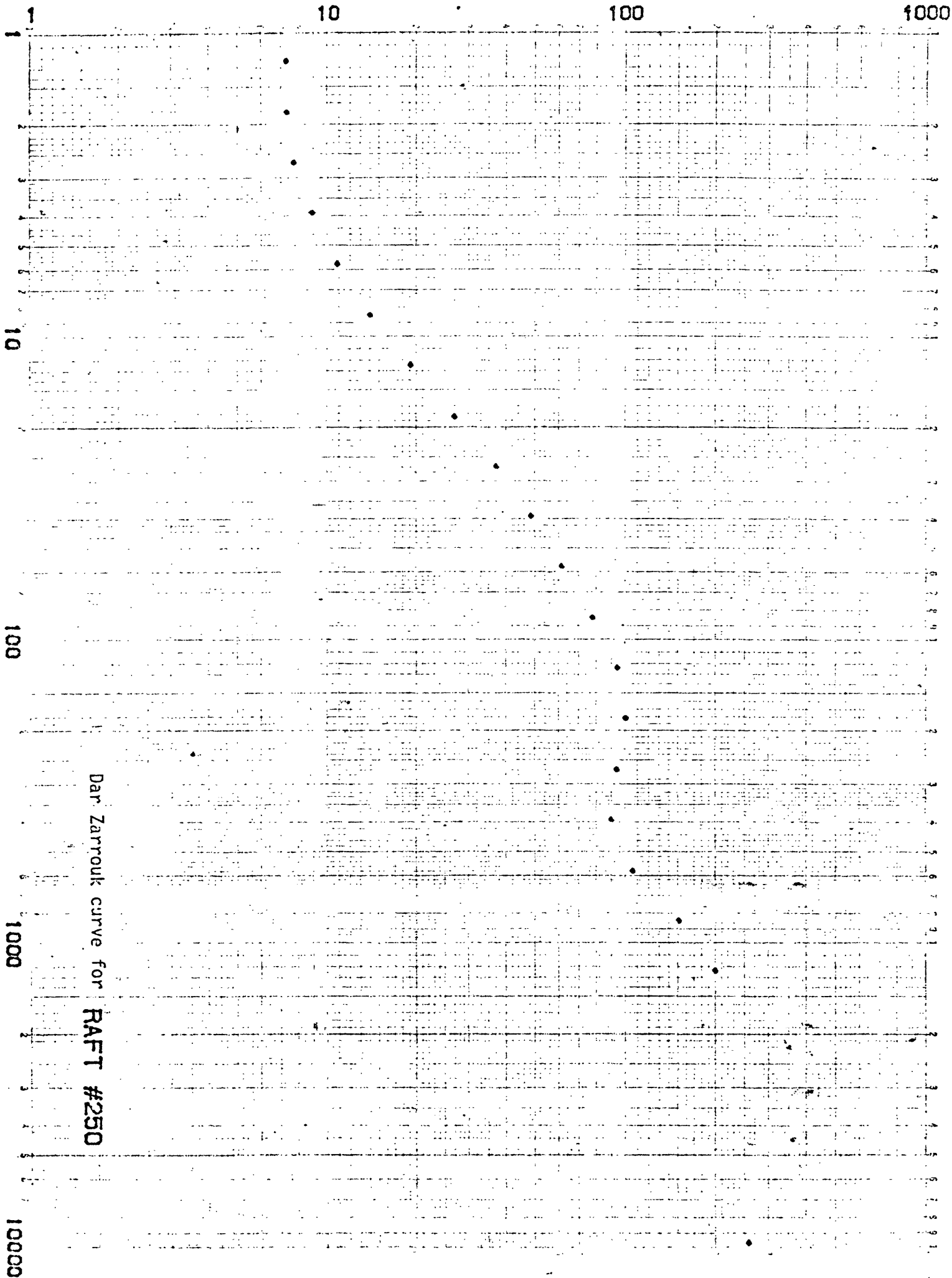
10

100

1000

Bar Zarrouk curve for RAFT #250

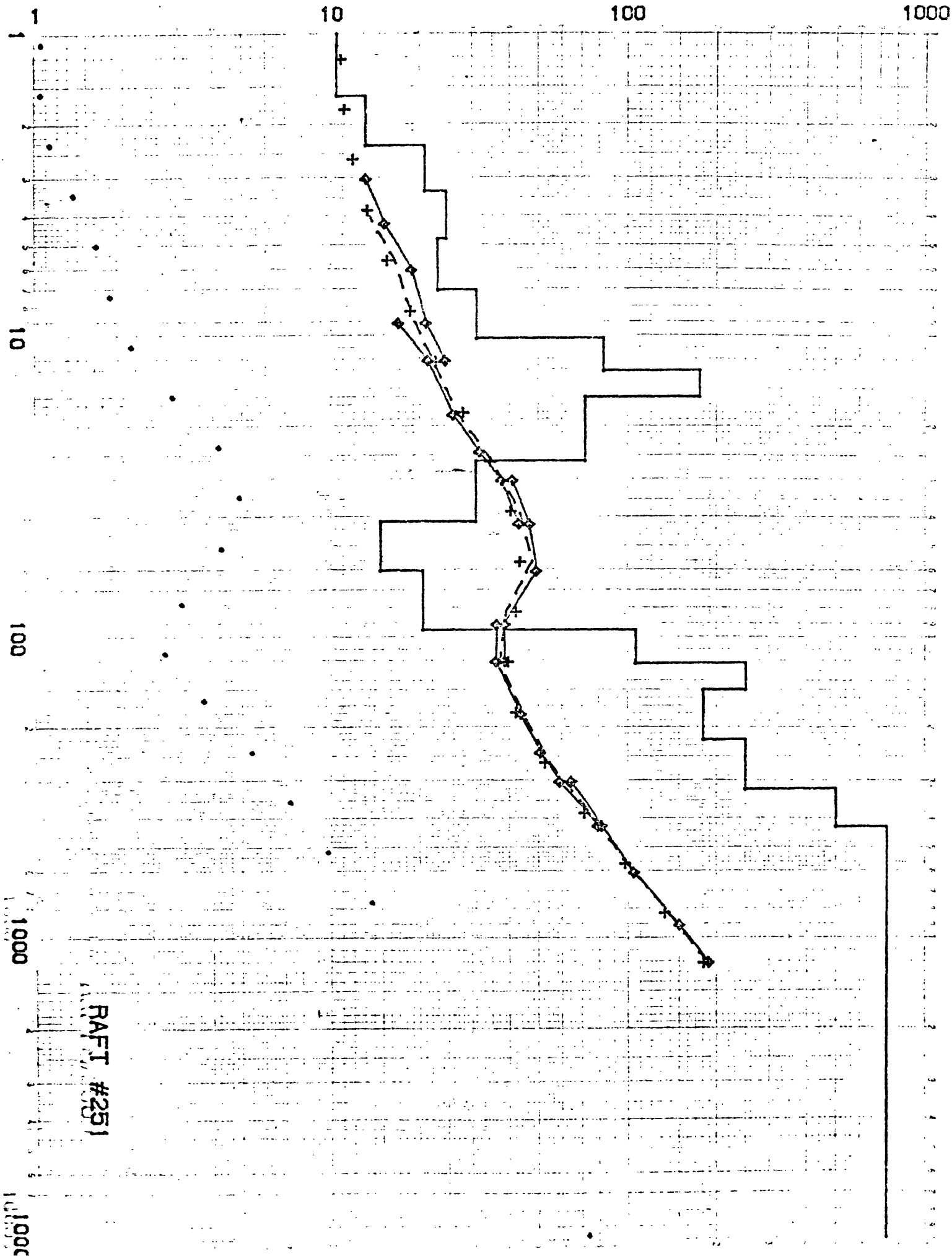
AB/2, DEPTH, DZ-DEPTH, IN METRES



RESISTIVITIES IN OHM-METRES

AB/2, DEPTH, DZ-DEPTH, IN METRES

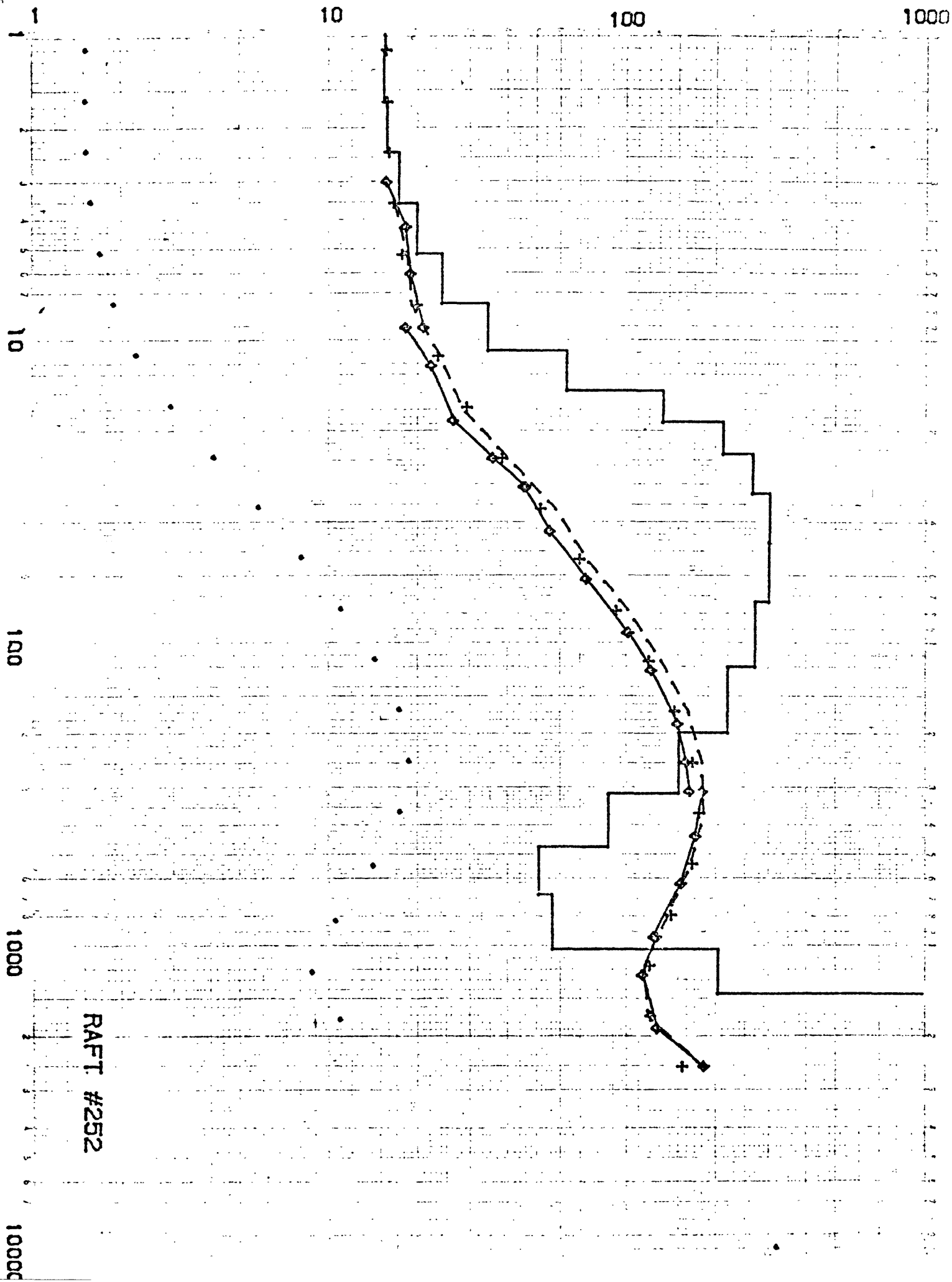
RAFT #251



RESISTIVITIES IN OHM-METRES.

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #252

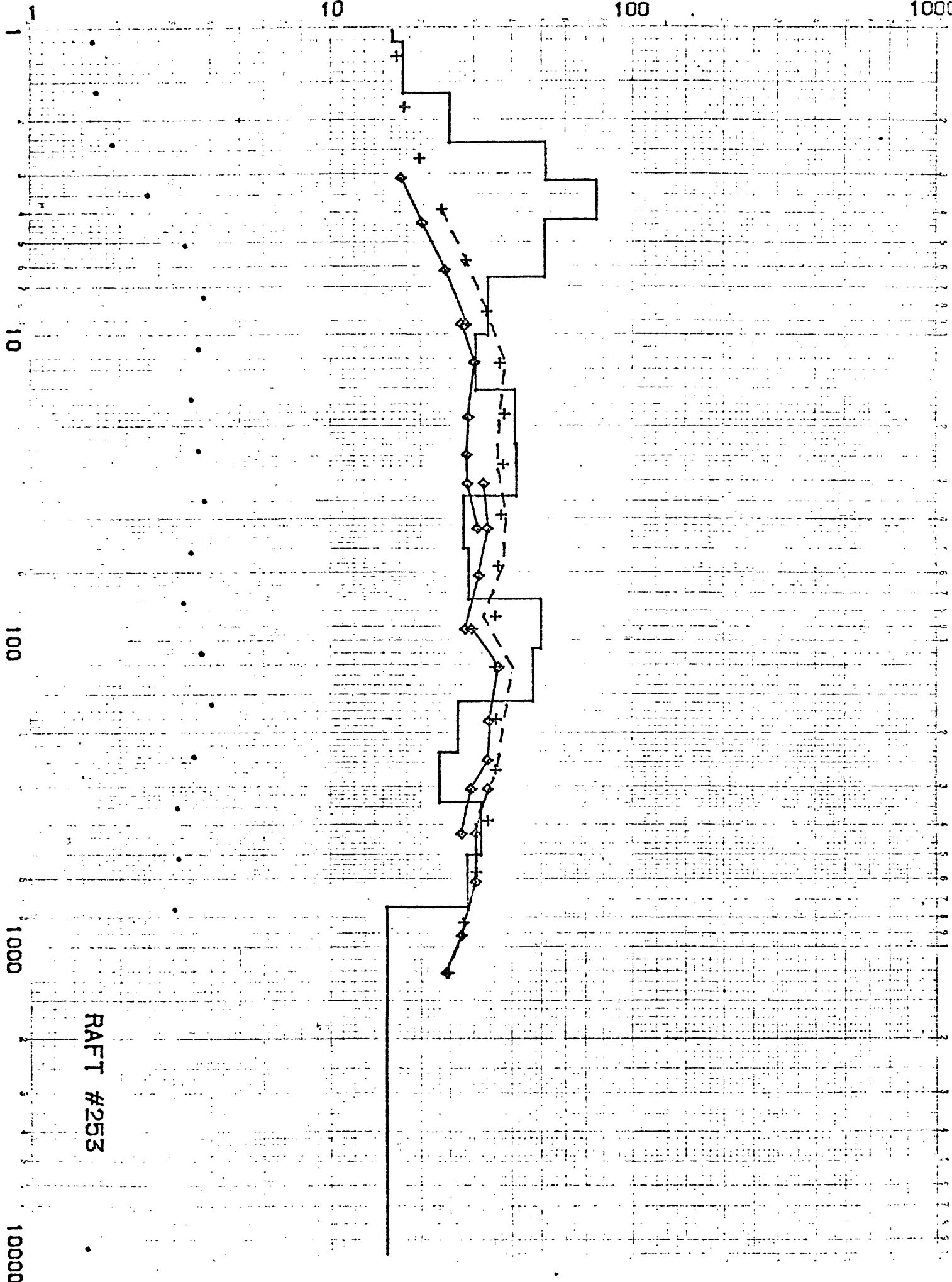


RESISTIVITIES, IN OHM-METRES

10

100

1000



RAFT #253

AB/2, DEPTH, DZ-DEPTH, IN METRES

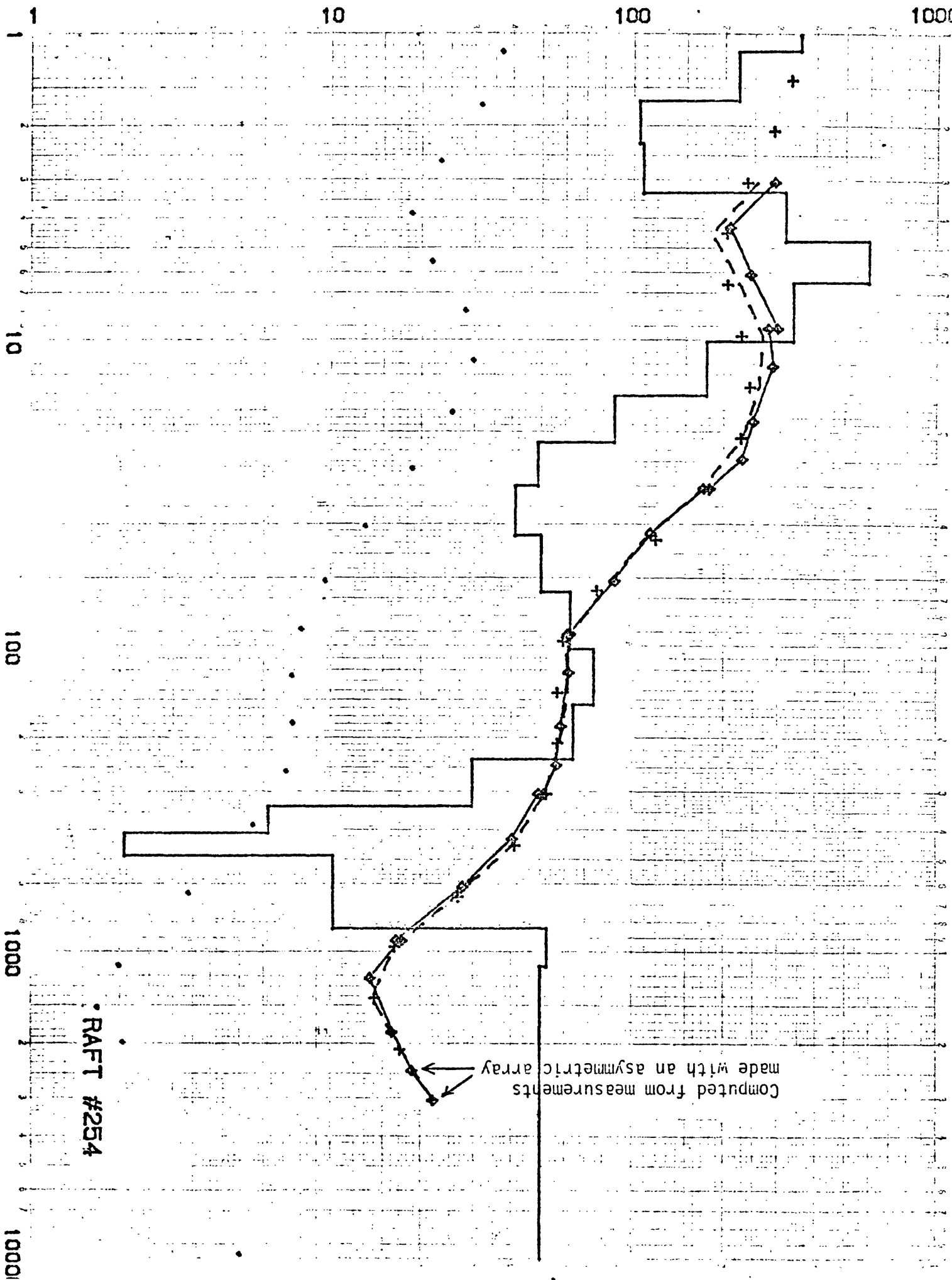
10000

RESISTIVITIES IN OHM-METRES

10

100

1000



RAFT #254

Computed from measurements
made with an asymmetric array

AB/2, DEPTH, DZ-DEPTH, IN METRES

RESISTIVITIES IN OHM-METRES

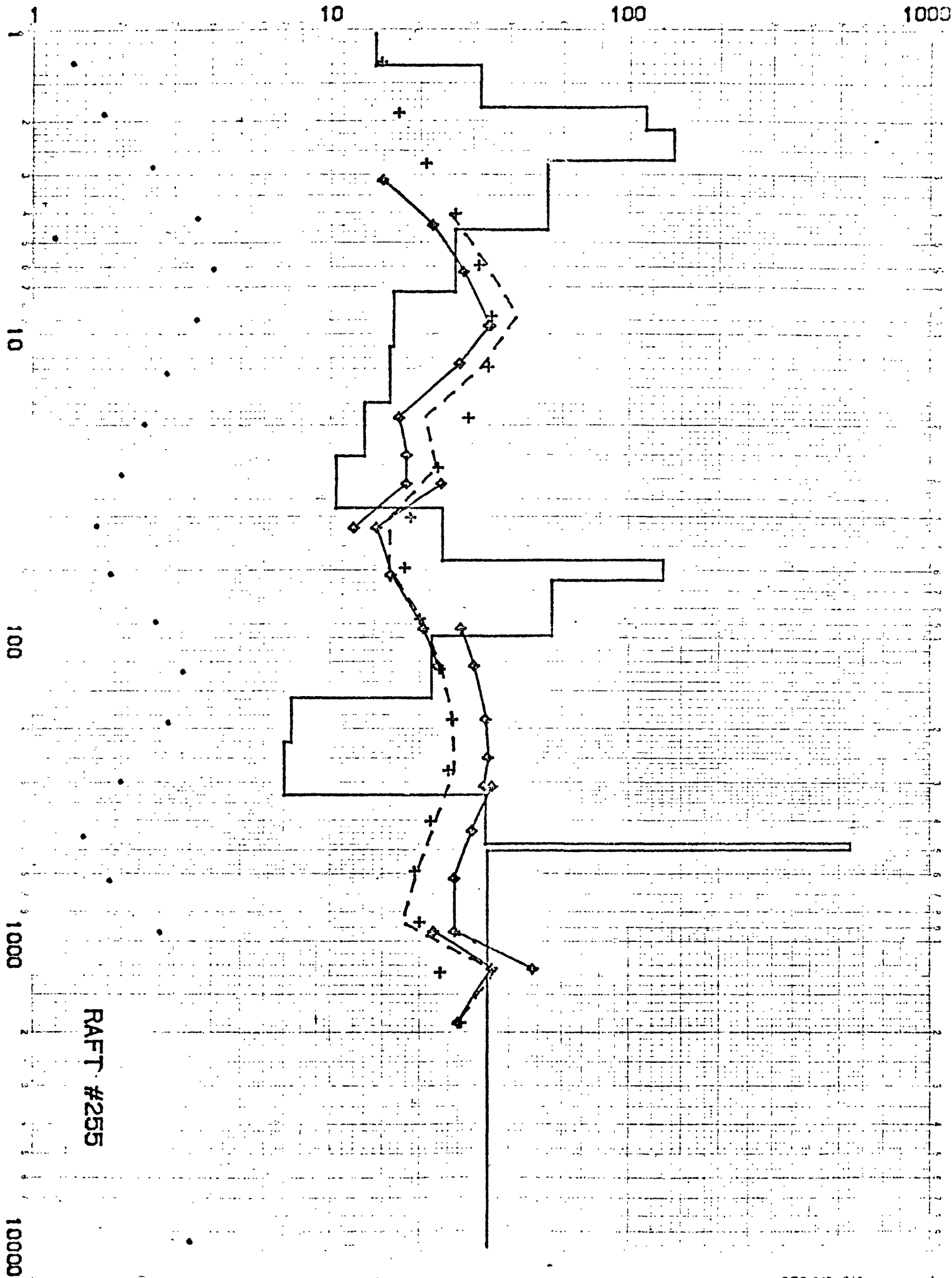
10

100

1000

RAFT #255

AB/2, DEPTH, DZ-DEPTH, IN METRES

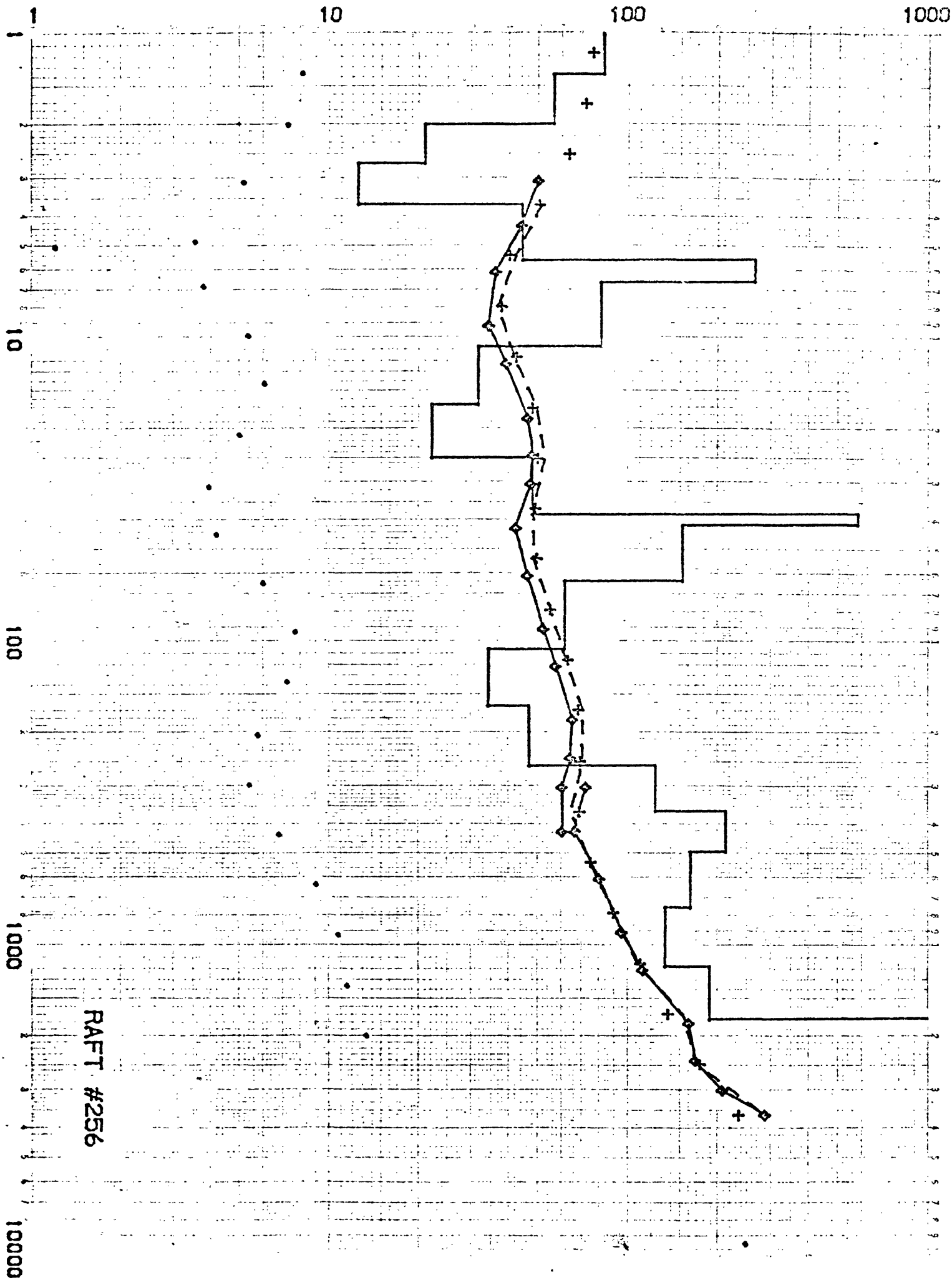


RESISTIVITIES IN OHM-METRES

10

100

1000



AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #256

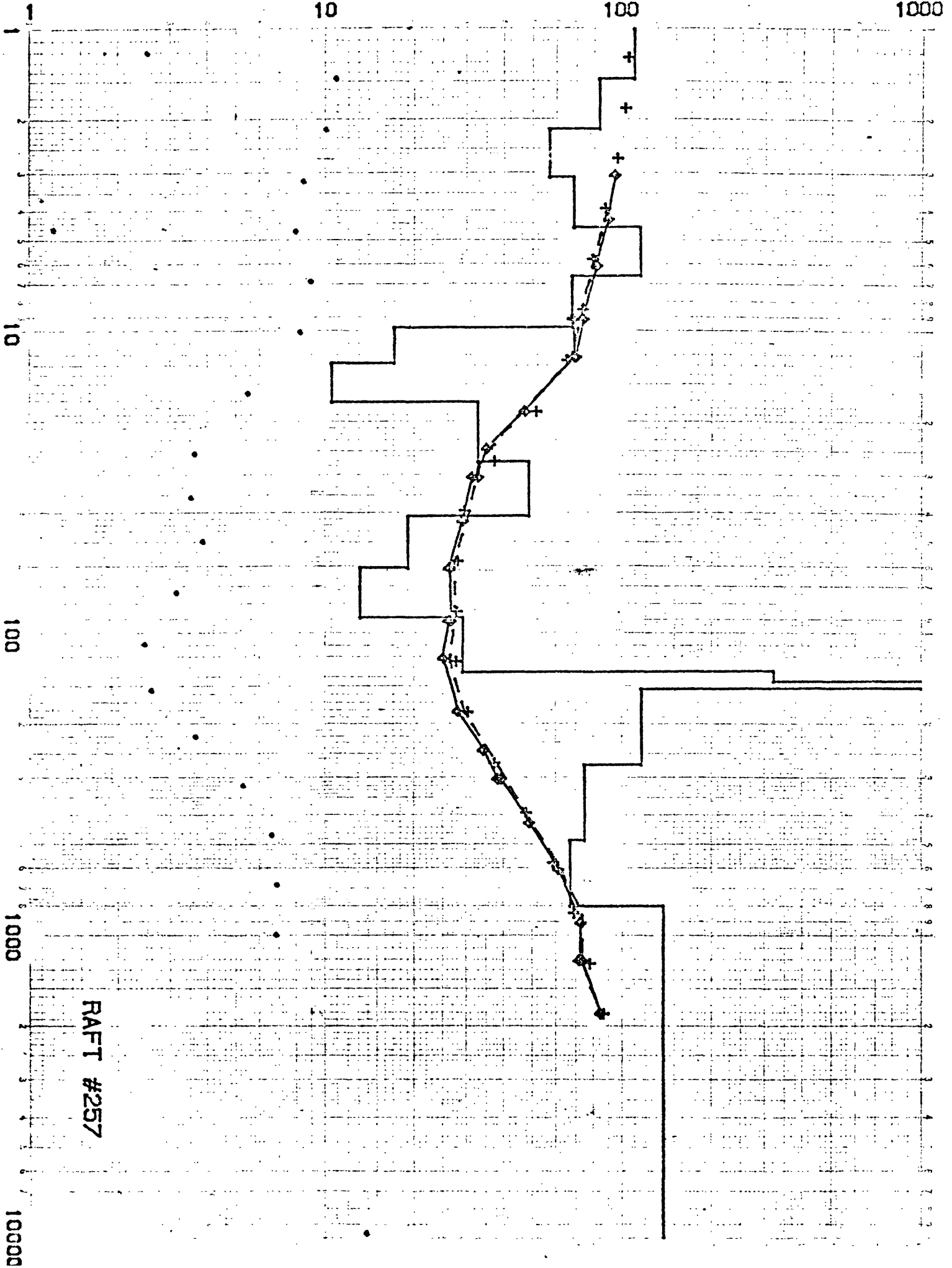
RESISTIVITIES IN OHM-METRES

10

100

1000

AB/2, DEPTH, DZ-DEPTH, IN METRES



RAFT #257

RESISTIVITIES IN OHM-METRES

1 10 100 1000

10

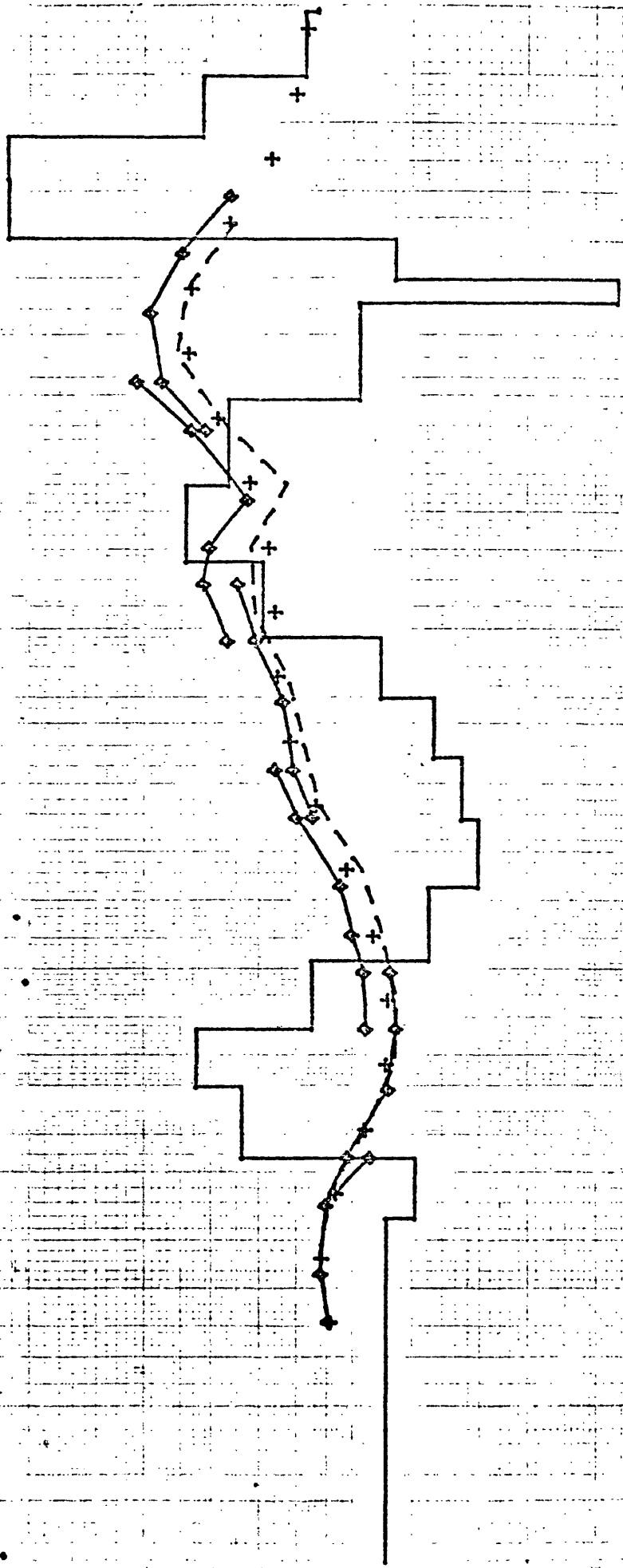
100

1000

10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #258



RESISTIVITIES IN OHM-METRES

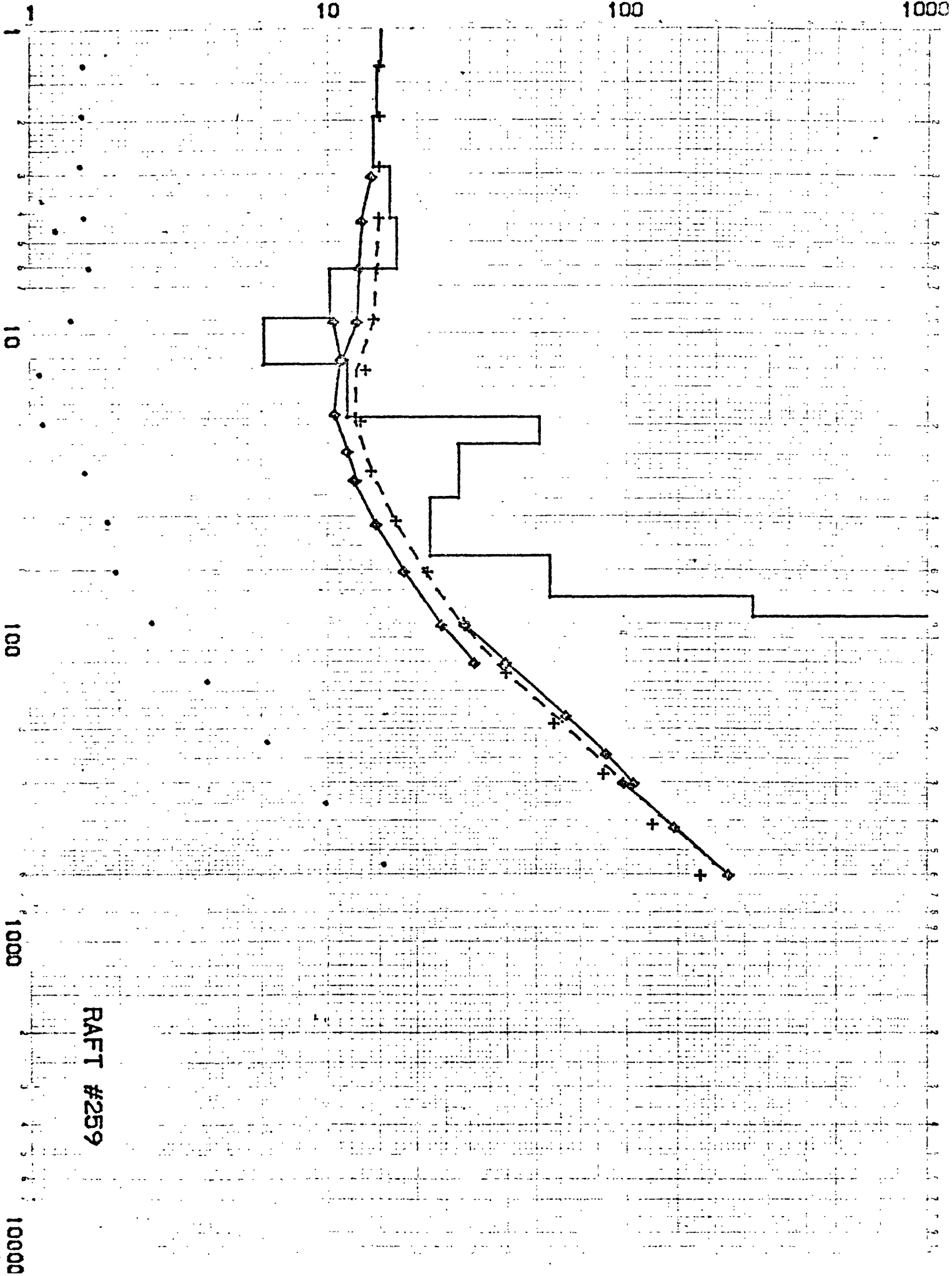
10

100

1000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #259



RESISTIVITIES IN OHM-METRES

10

100

1000

1

2

3

4

5

6

7

8

10

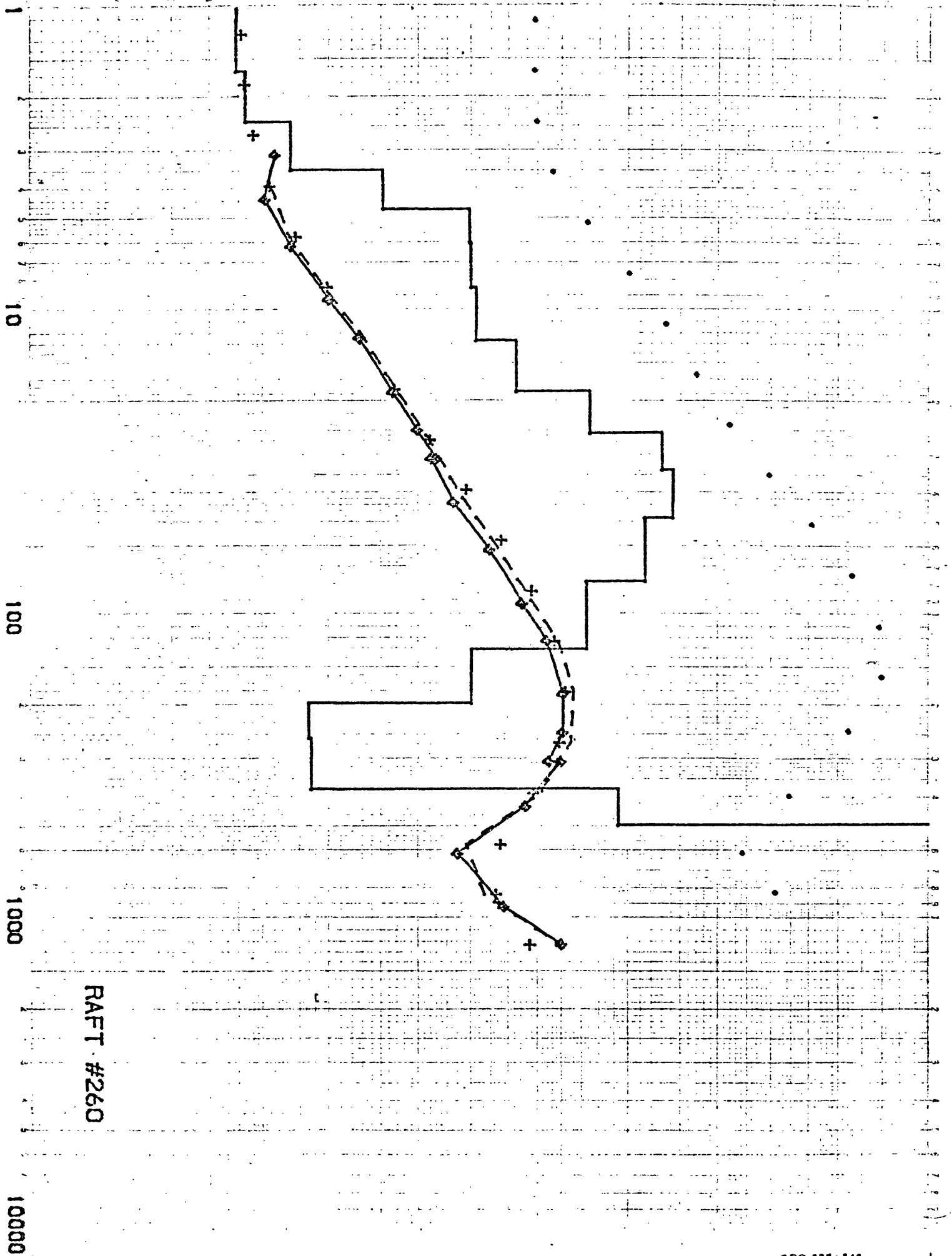
100

1000

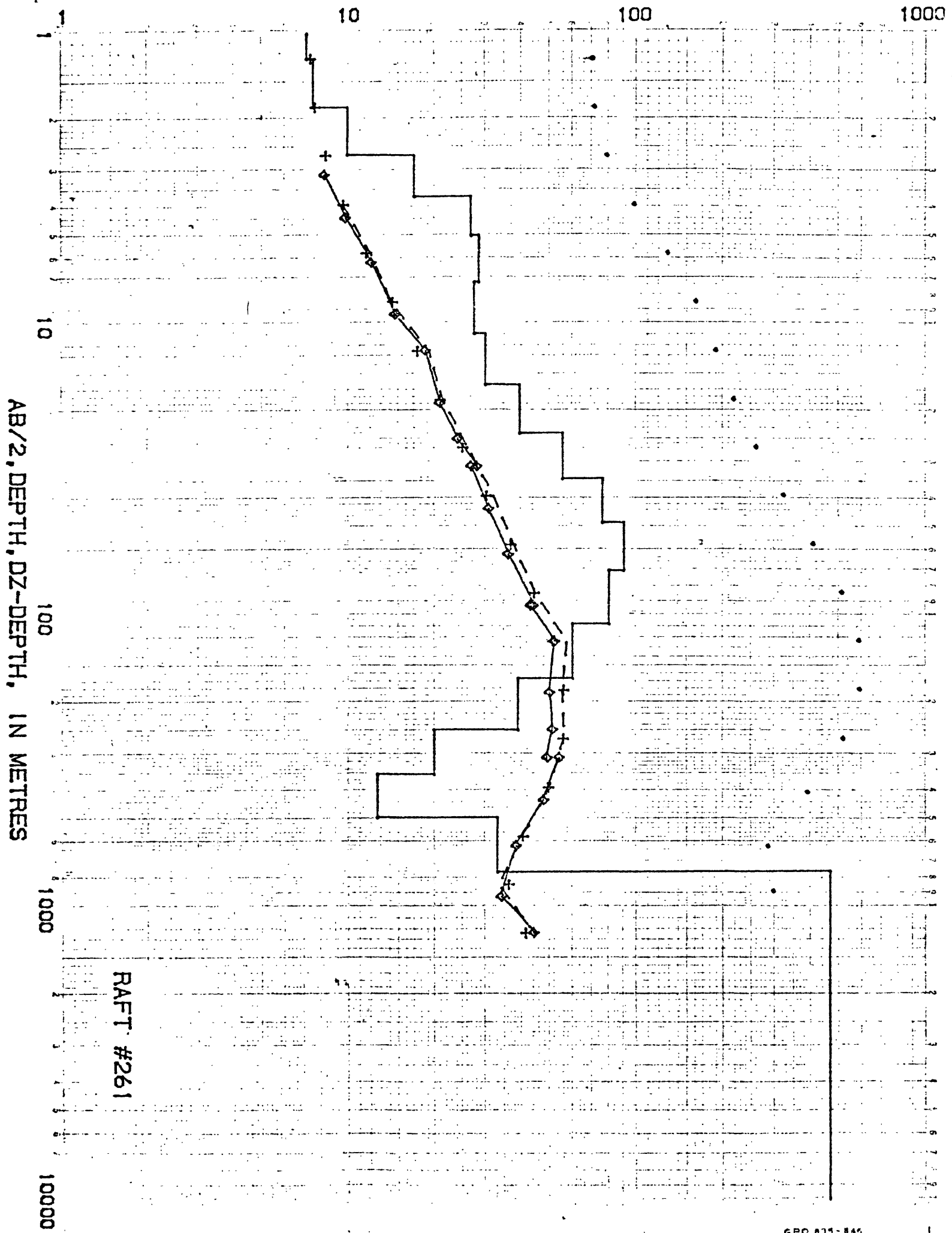
10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #260



RESISTIVITIES IN OHM-METRES



RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

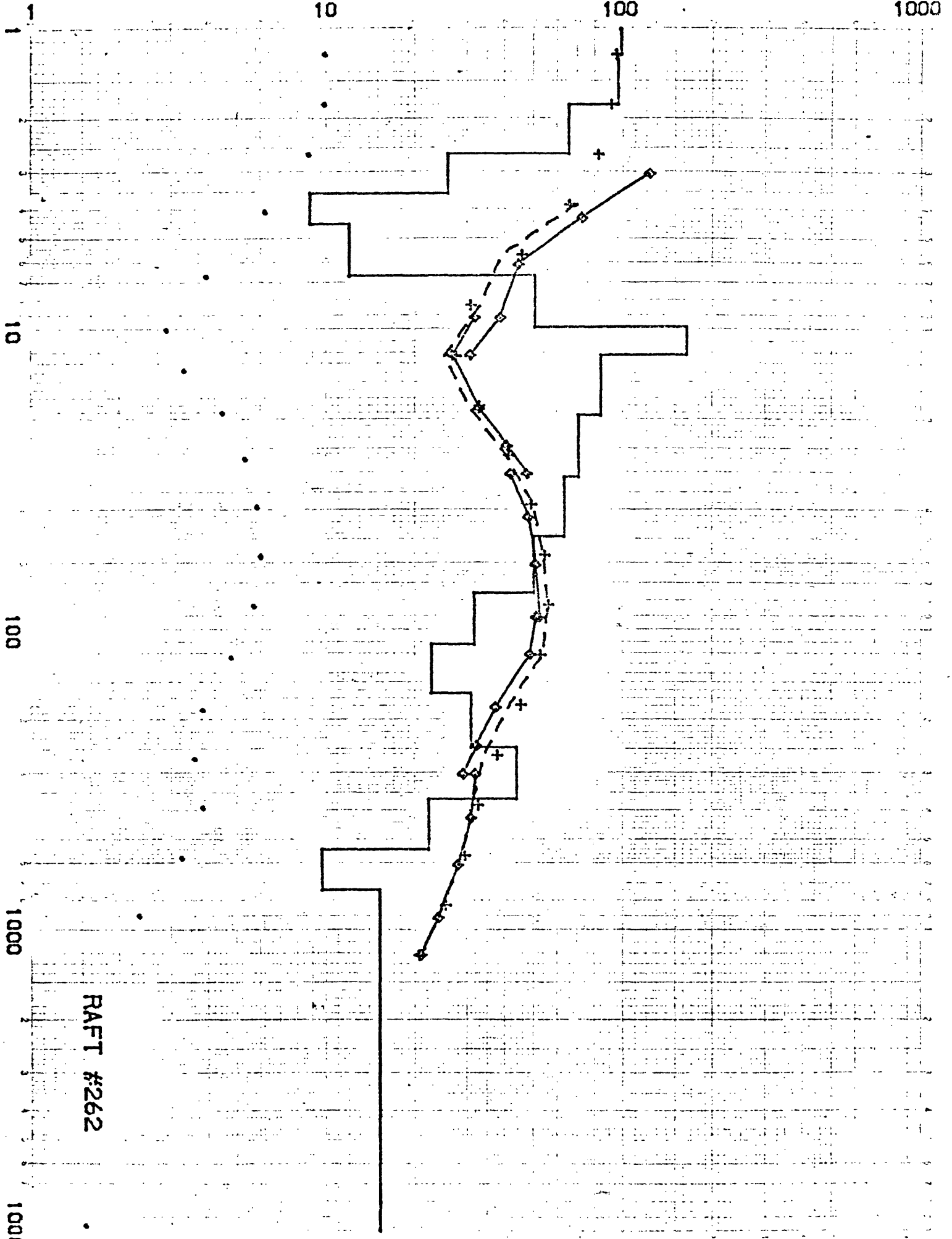
100

1000

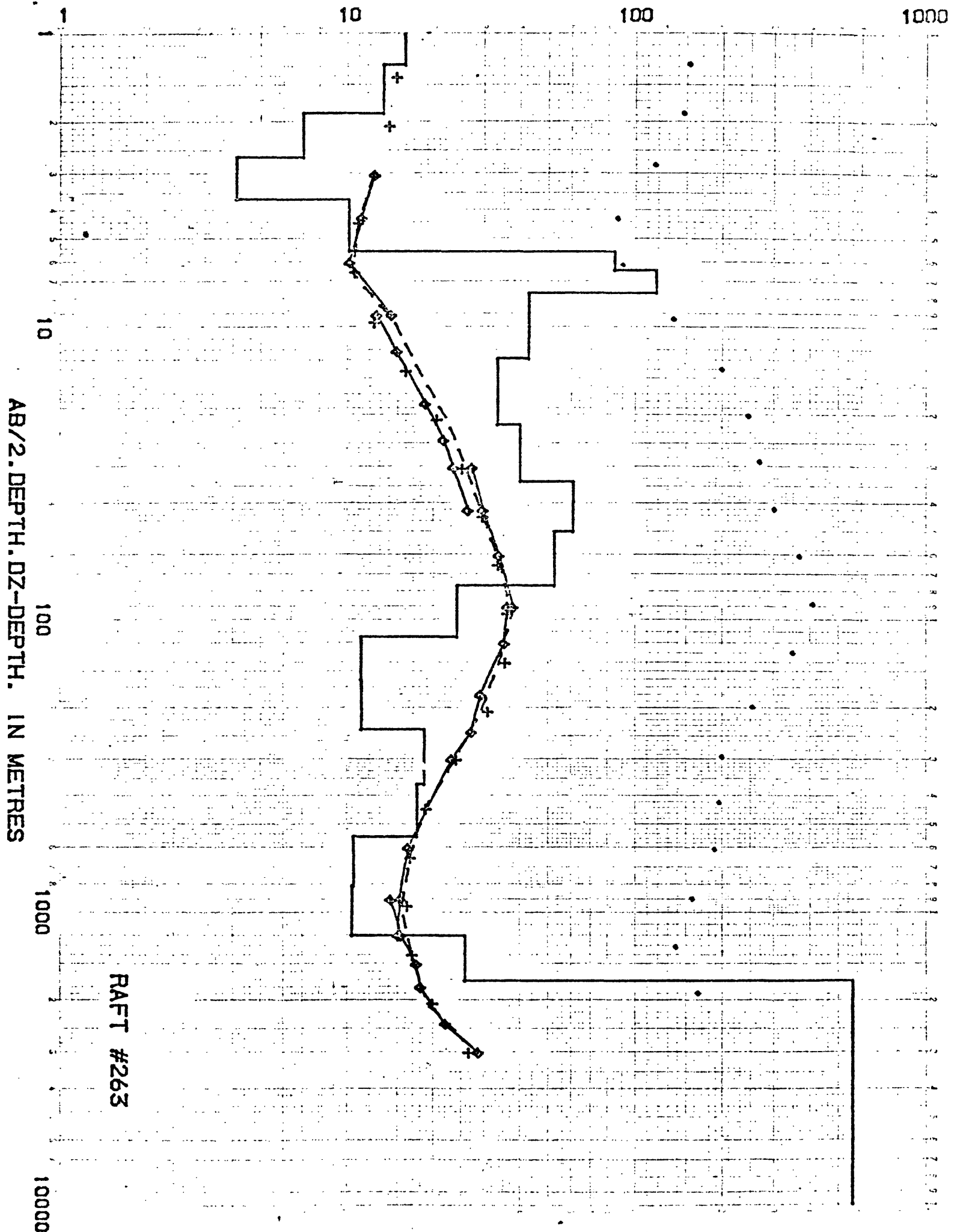
10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #262



RESISTIVITIES IN OHM-METRES



RAFT #263

AB/2. DEPTH. DZ-DEPTH. IN METRES

RESISTIVITIES IN OHM-METRES



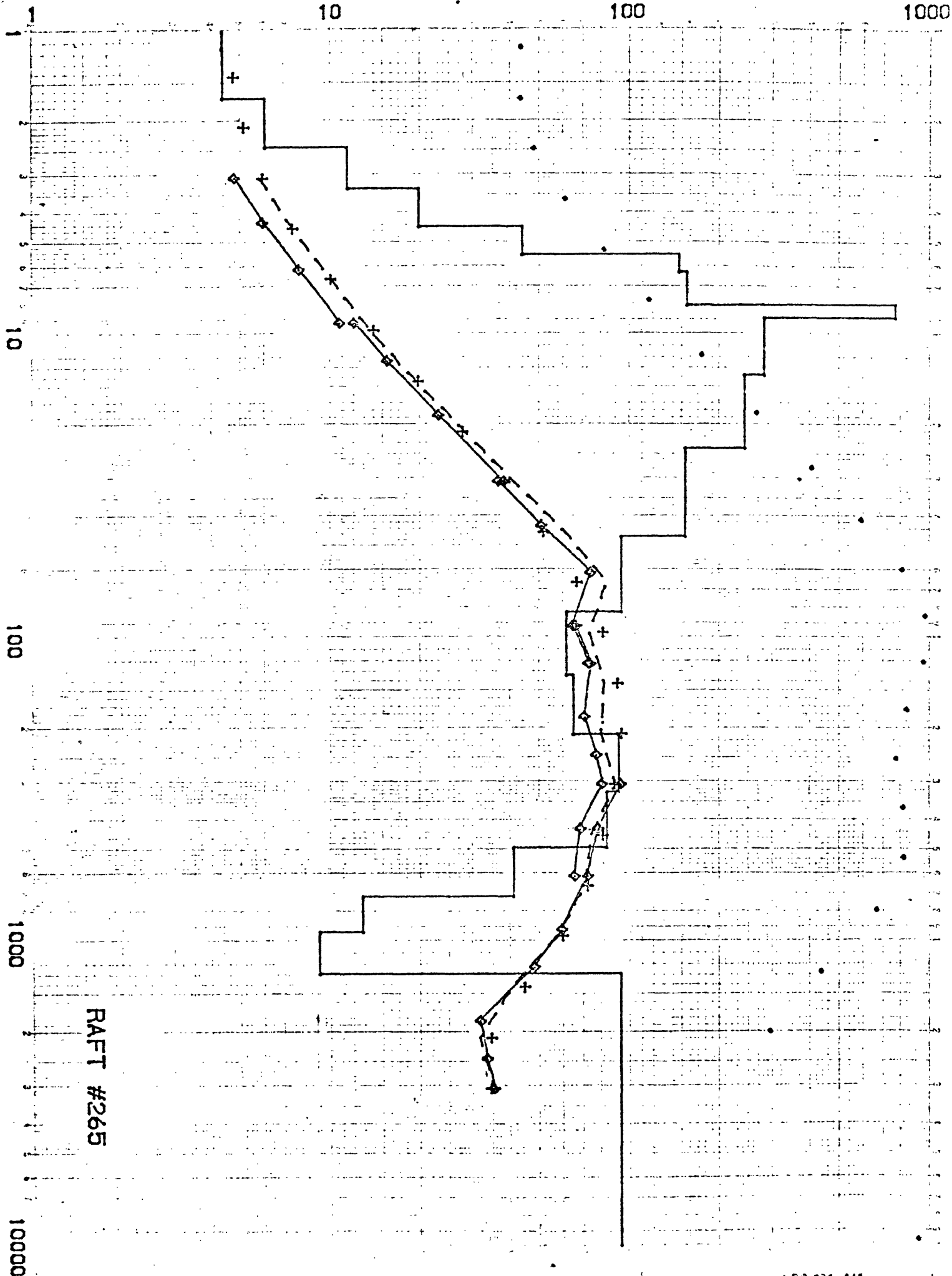
RAFT #264

RESISTIVITIES IN OHM-METRES

10

100

1000



RESISTIVITIES IN OHM-METRES

10

100

1000

AB/2, DEPTH, DZ-DEPTH, IN METRES

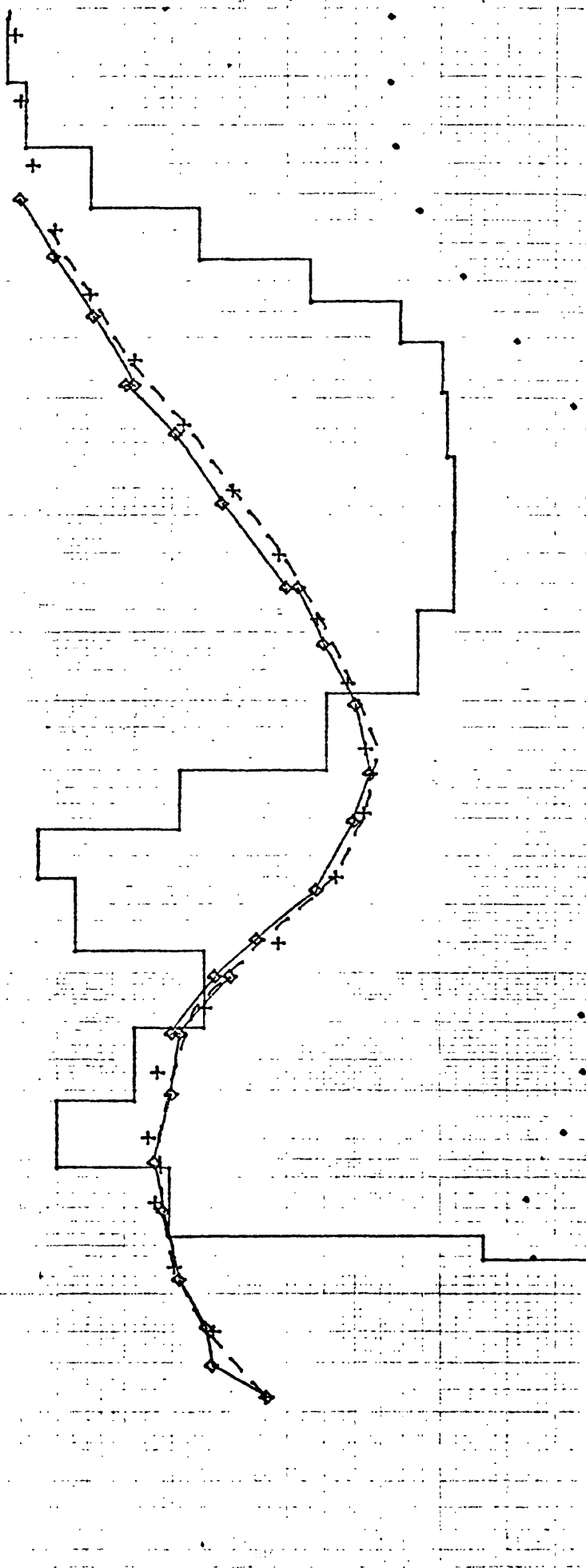
RAFT #266

10

100

1000

10000

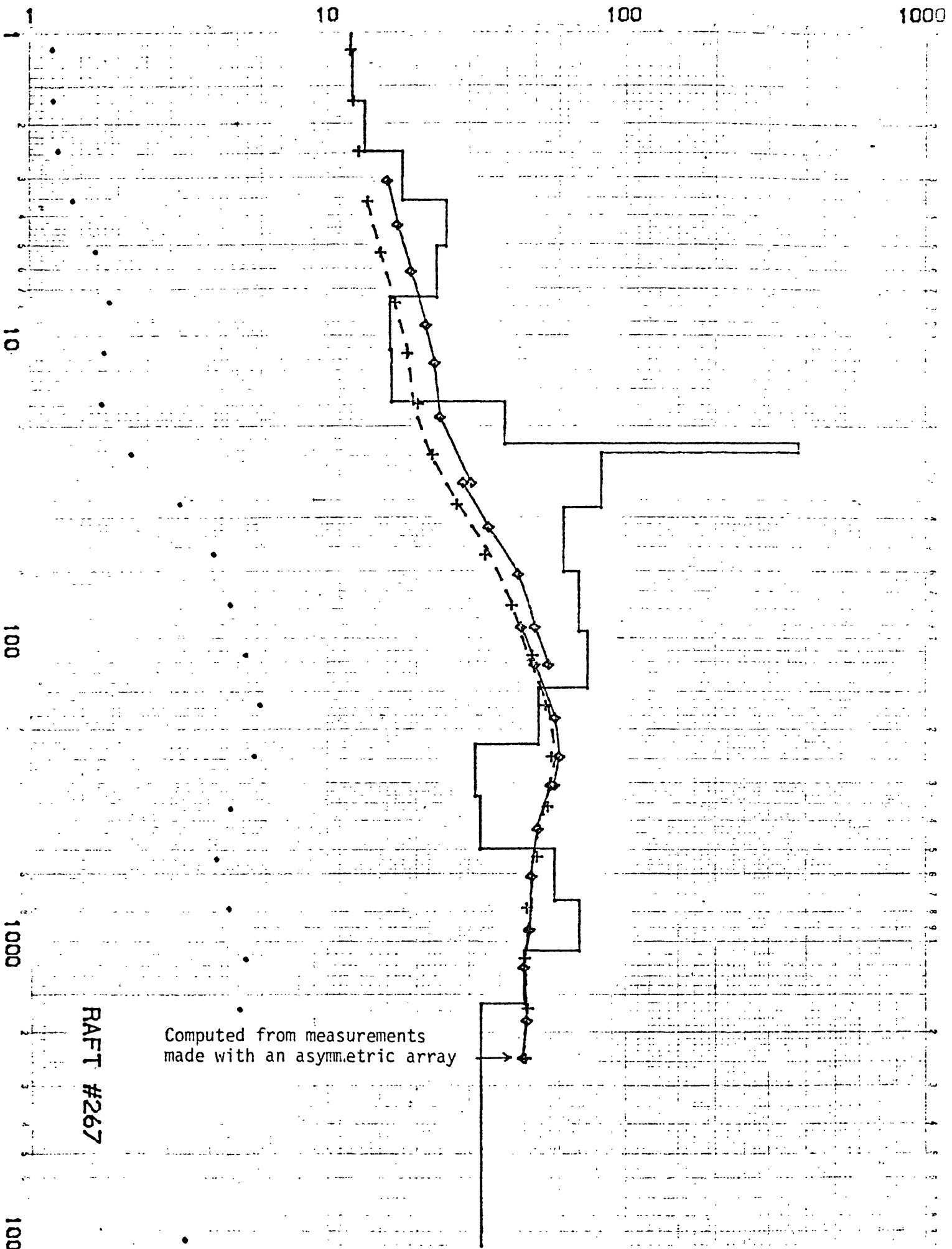


RESISTIVITIES IN OHM-METRES

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #267

Computed from measurements
made with an asymmetric array



RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

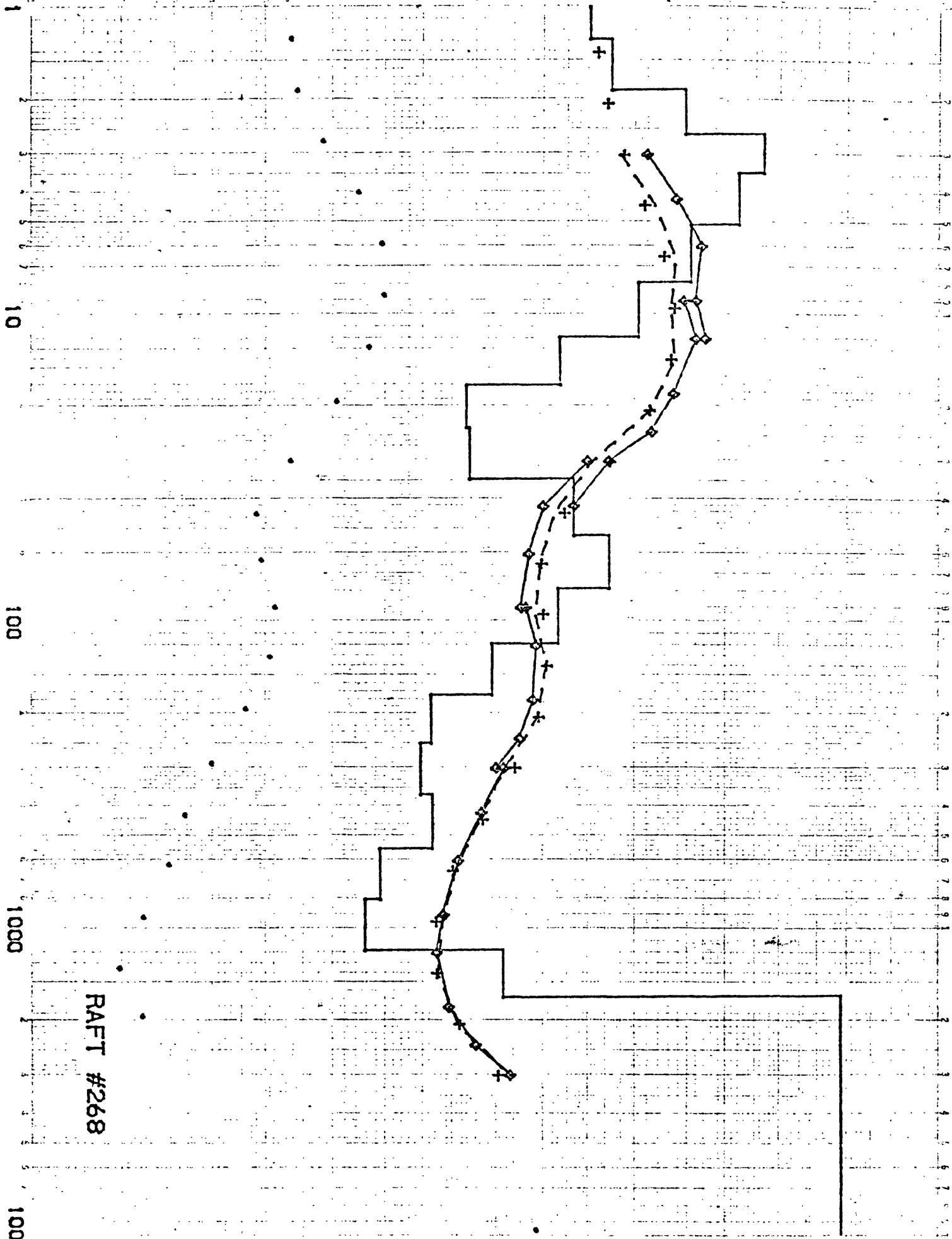
100

1000

10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #268



RESISTIVITIES IN OHM-METRES

10

100

1000

1

10

100

1000

10000

AB/2, DEPTH, DZ-DEPTH, IN METRES

RAFT #269

