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

Open-File Report 76-92
1976

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 AND RAFT RIVER VALLEYS, IDAHO AND UTAH

By Adel A.R. Zohdy and Robert J. Bisdorf

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

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

where

$\overline{\rho}_s(BO)$ = 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,

$\overline{\rho}_s(AO)$ = 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 BO/AO 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 continous-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 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.

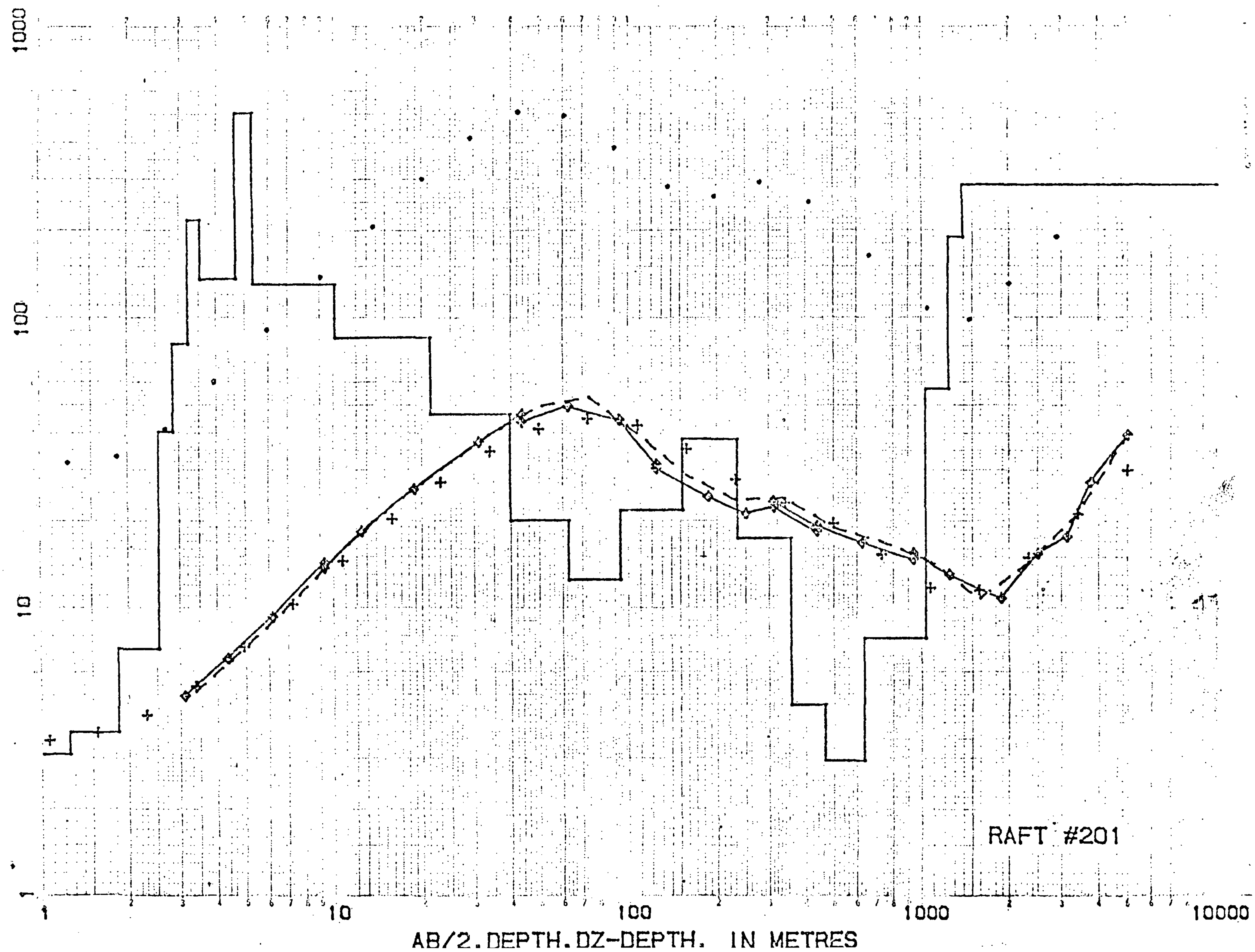
Zohdy, A. A. R., 1975, Automatic interpretation of Schlumberger sounding curves using modified Dar-Zarrouk functions: U.S. Geol. Survey Bull. 1313-E, 39 p.

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.

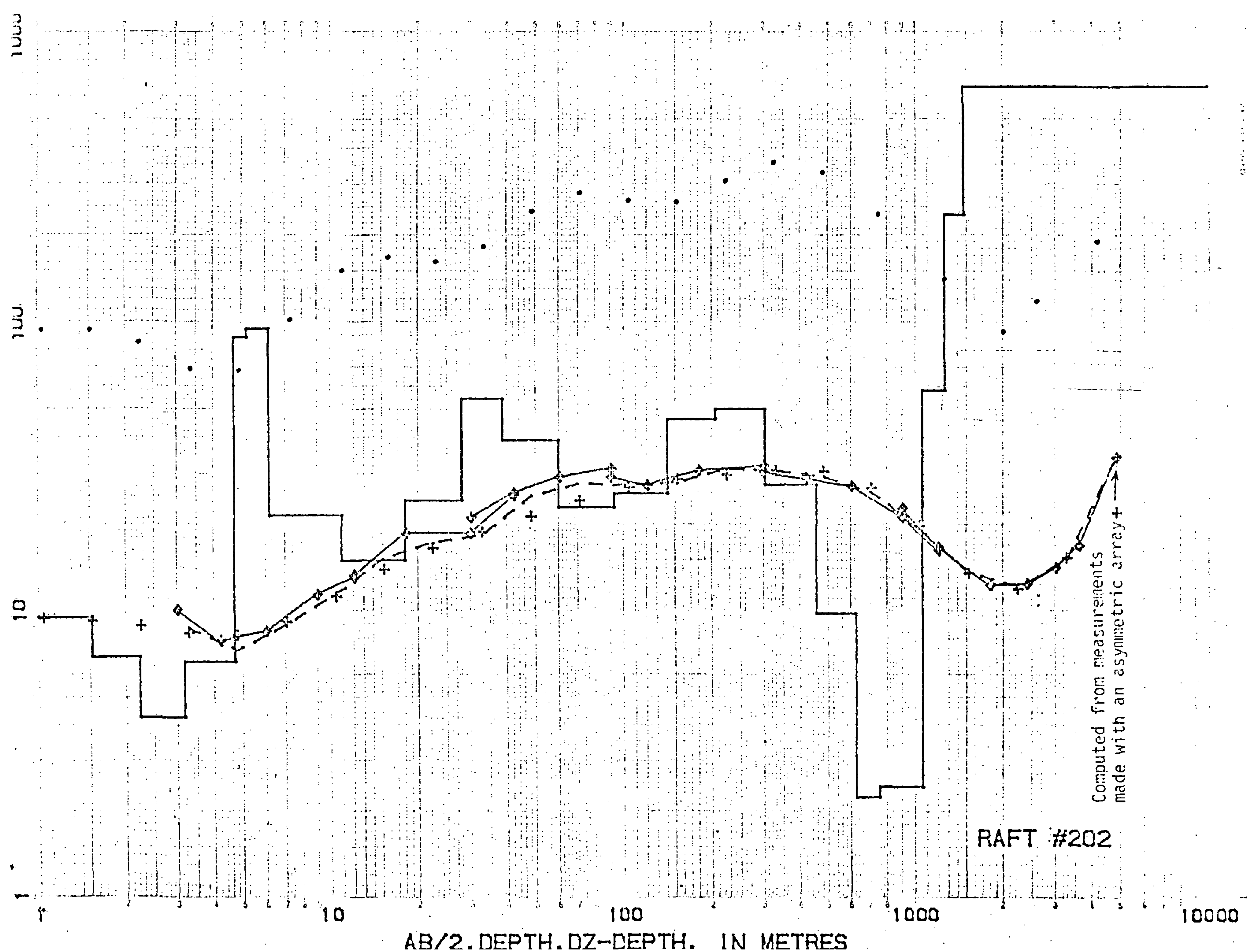
Zohdy, A. A. R., Jackson, D. B., Bisdorf, R. J., 1975, Schlumberger soundings and total field measurements in the Raft River geothermal area, Idaho: U.S. Geol. Survey open-file report 75-130, 5 p., + 82 text figures + 4 pls.

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.

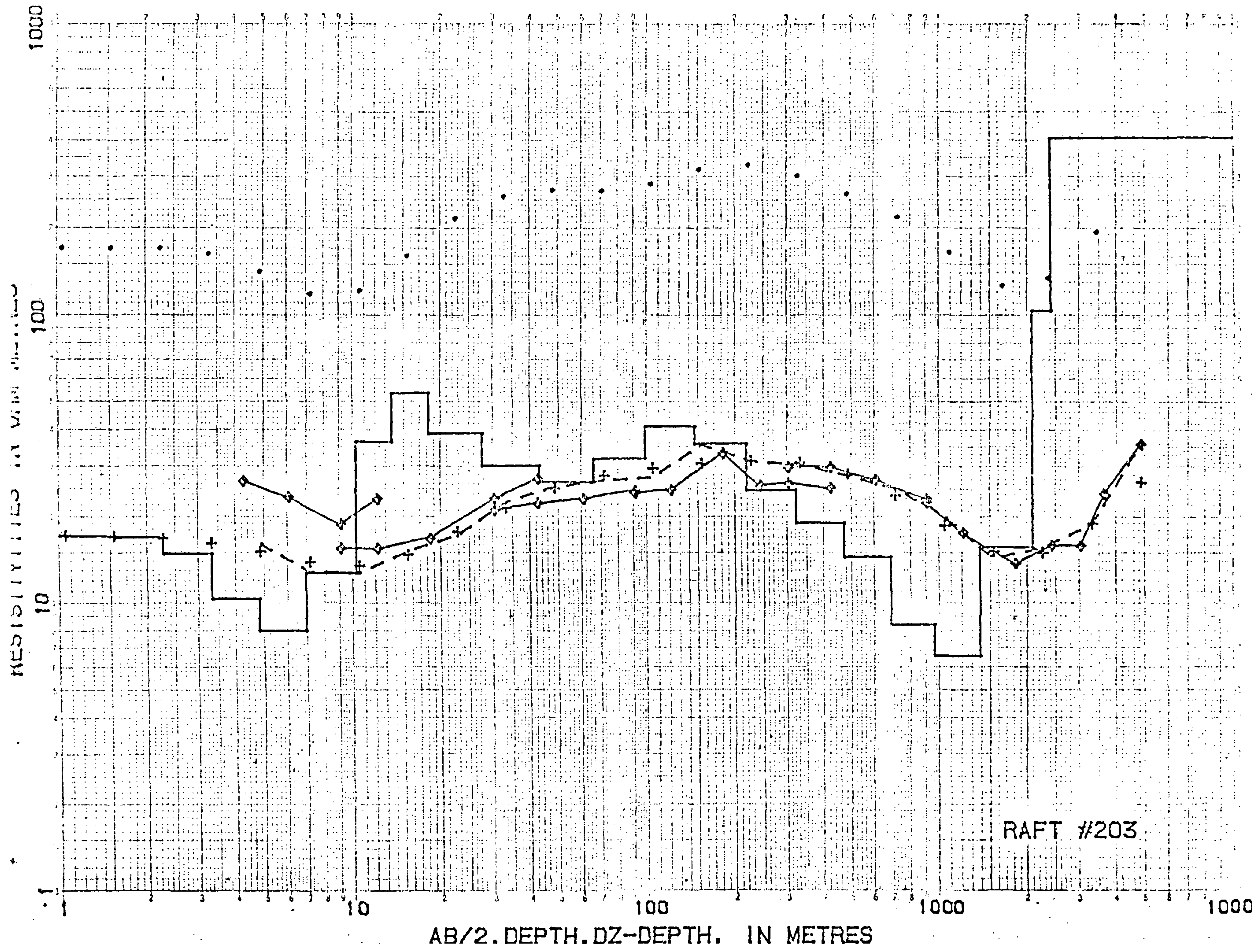
APPENDIX



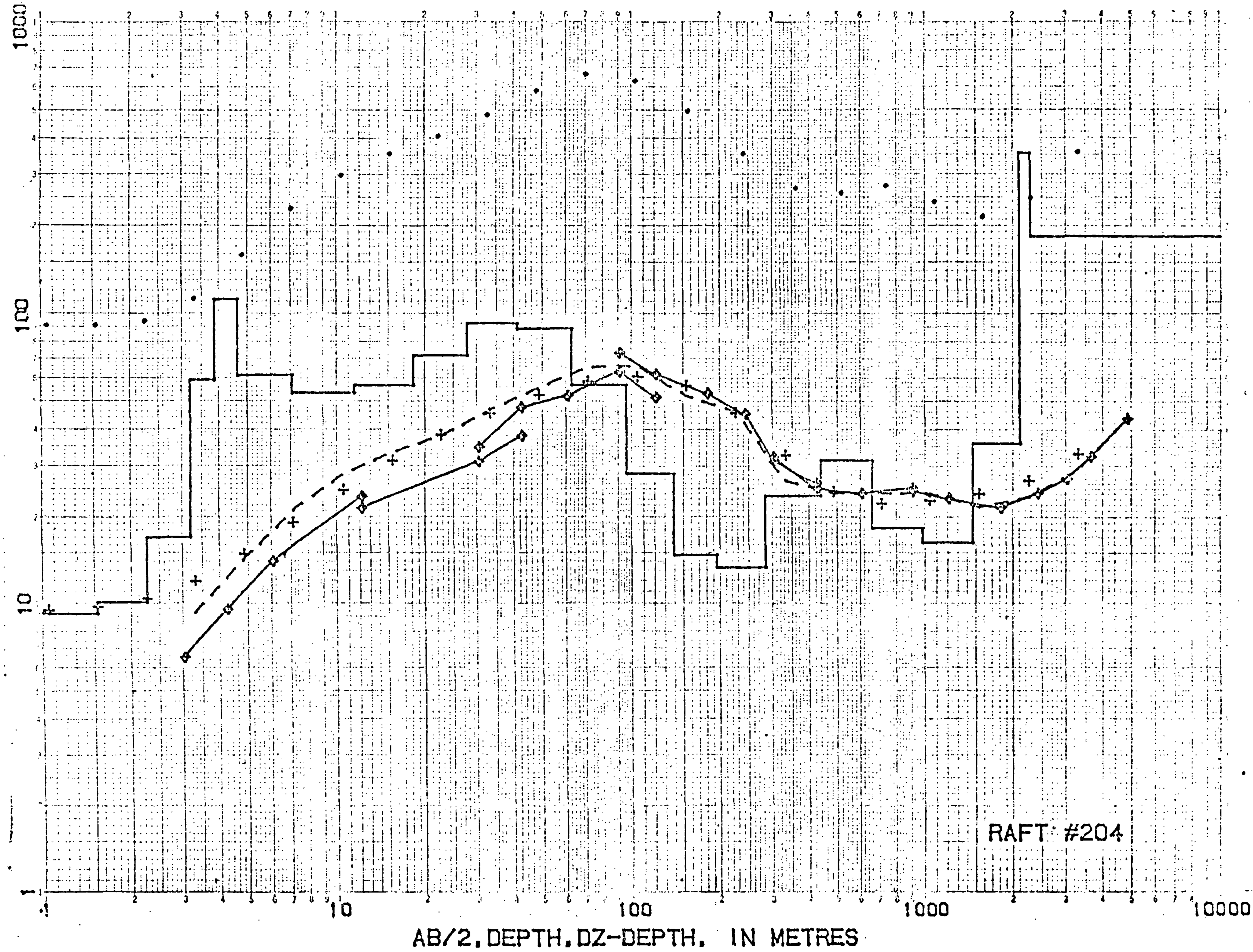
1000
100
10
1
1
10
100
1000
10000
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAFT #201



1000
100
10
1
1
10
100
1000
10000
AB/2.DEPTH.DZ-DEPTH. IN METRES
Computed from measurements made with an asymmetric array +
RAFT #202

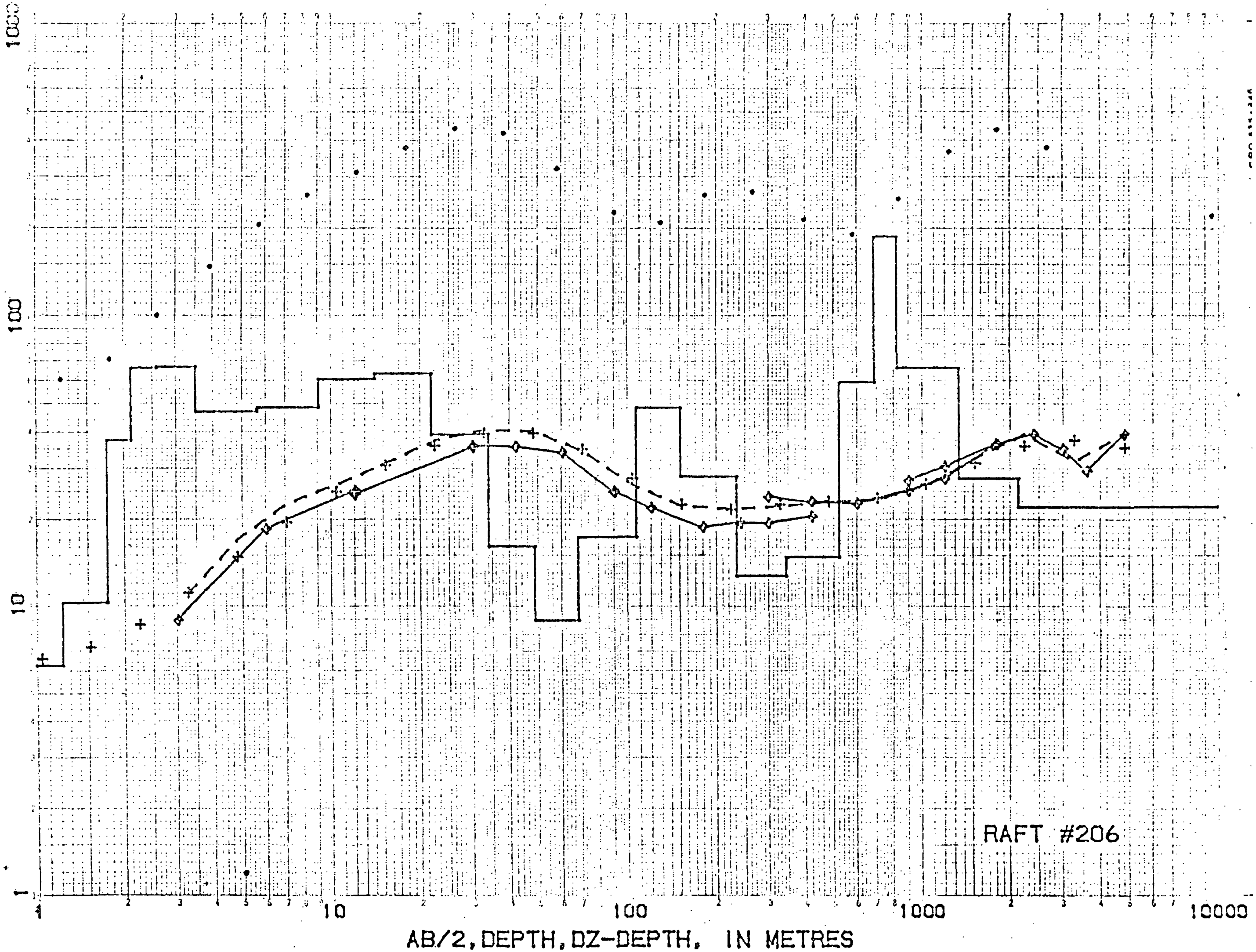


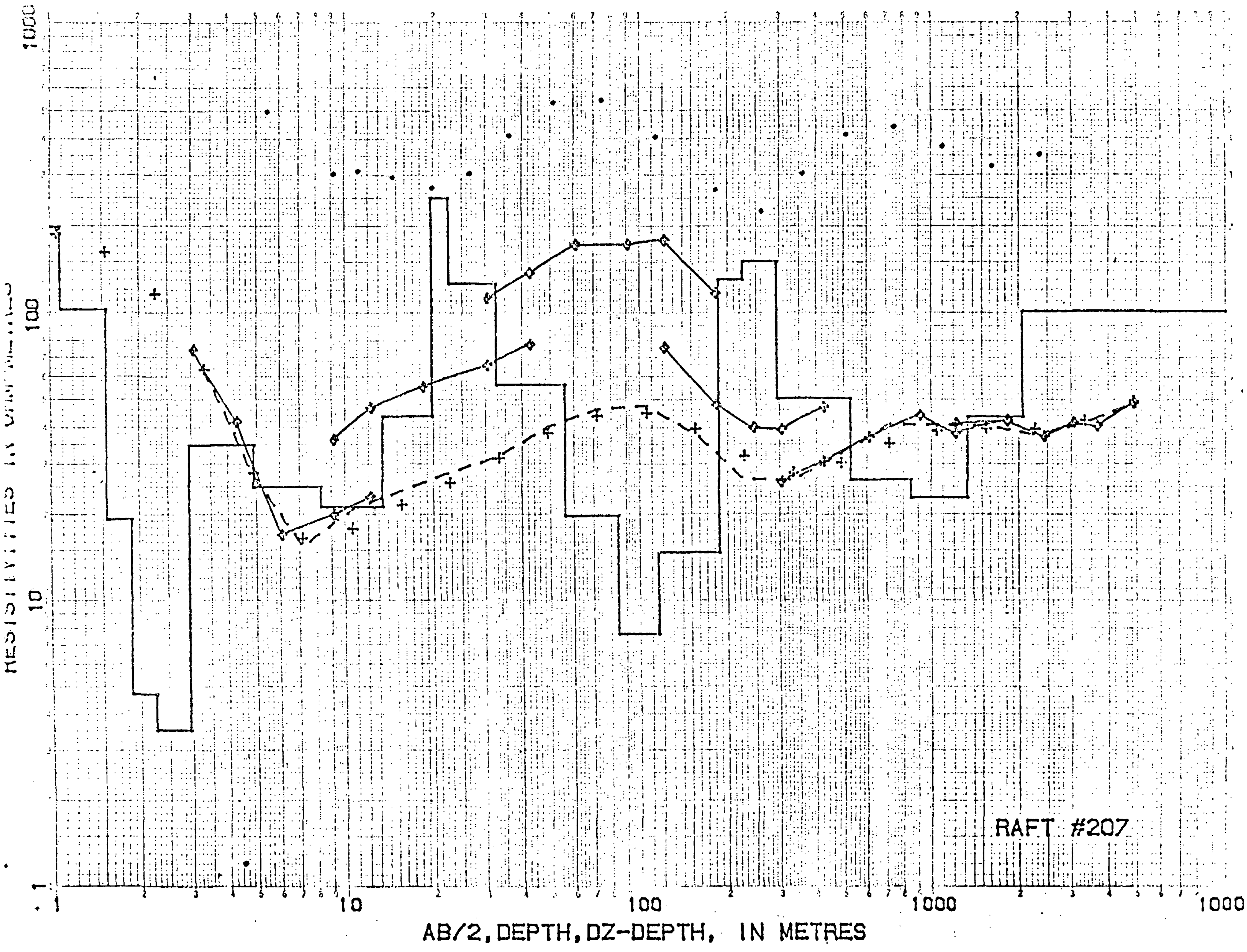
1000
100
10
1
10
100
1000
1000
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAFT #203



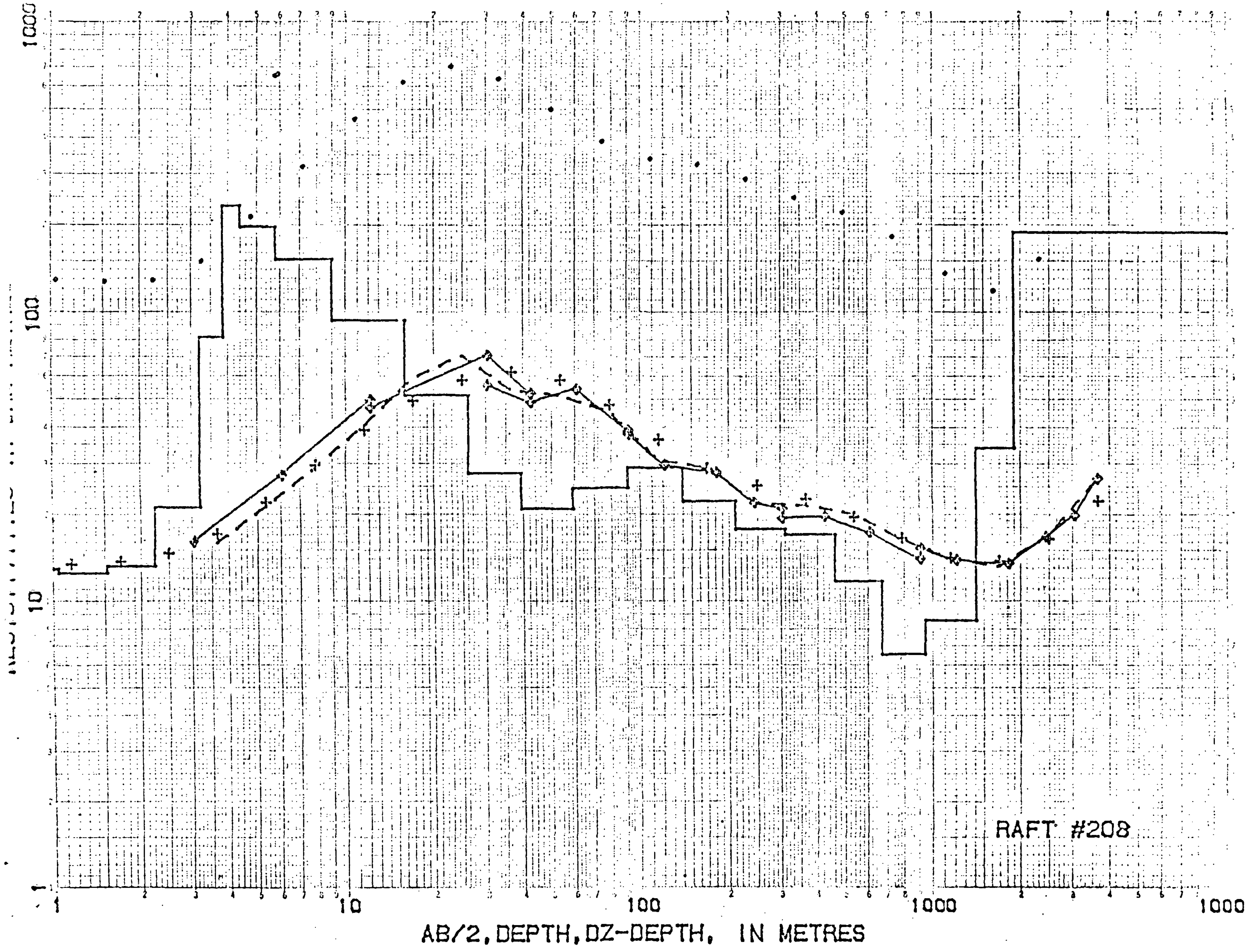
1000
100
10
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #204

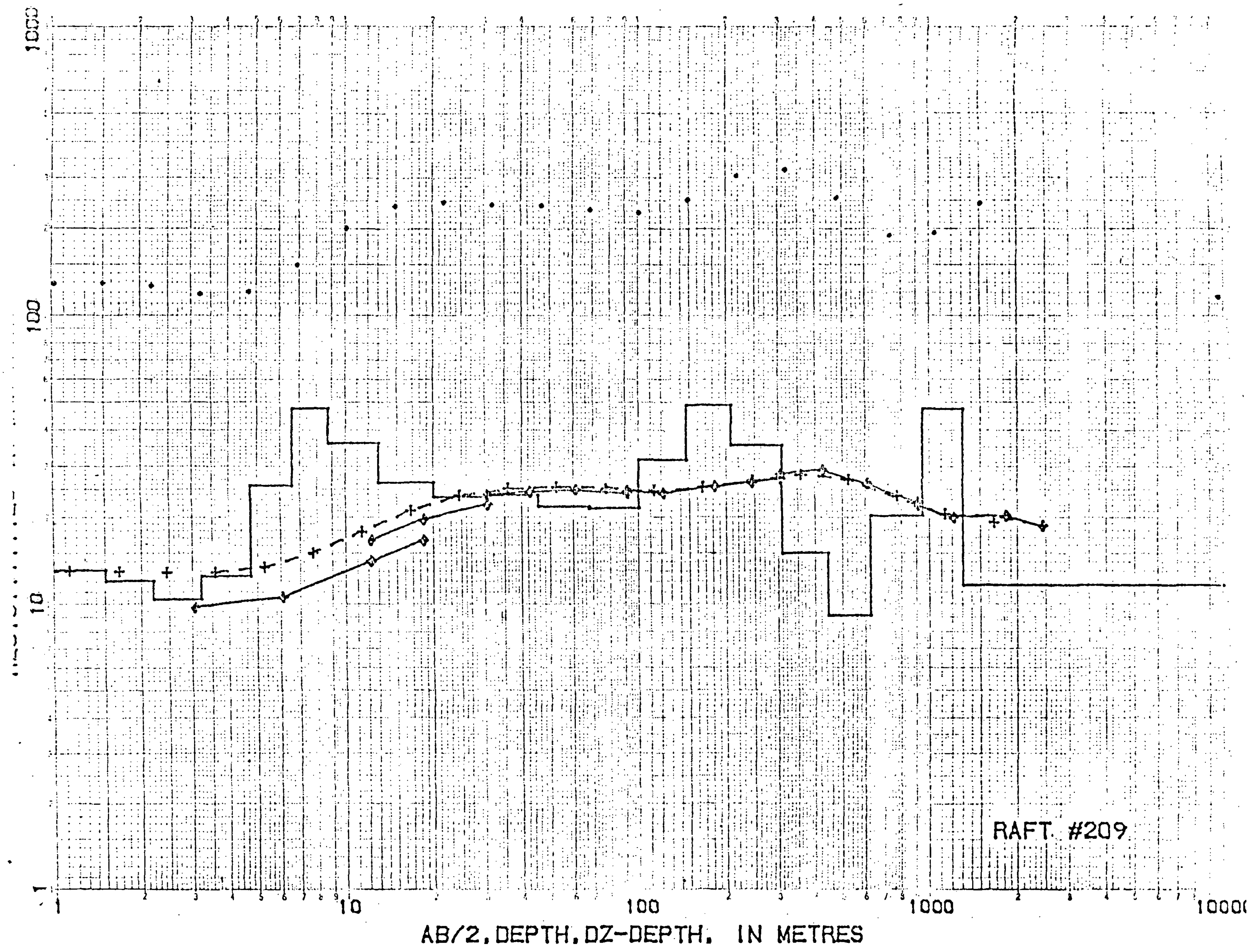

1000
100
10
1
1
10
100
1000
10000
RAFT #205
AB/2.DEPTH.DZ-DEPTH. IN METRES


1000
100
10
1
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #206

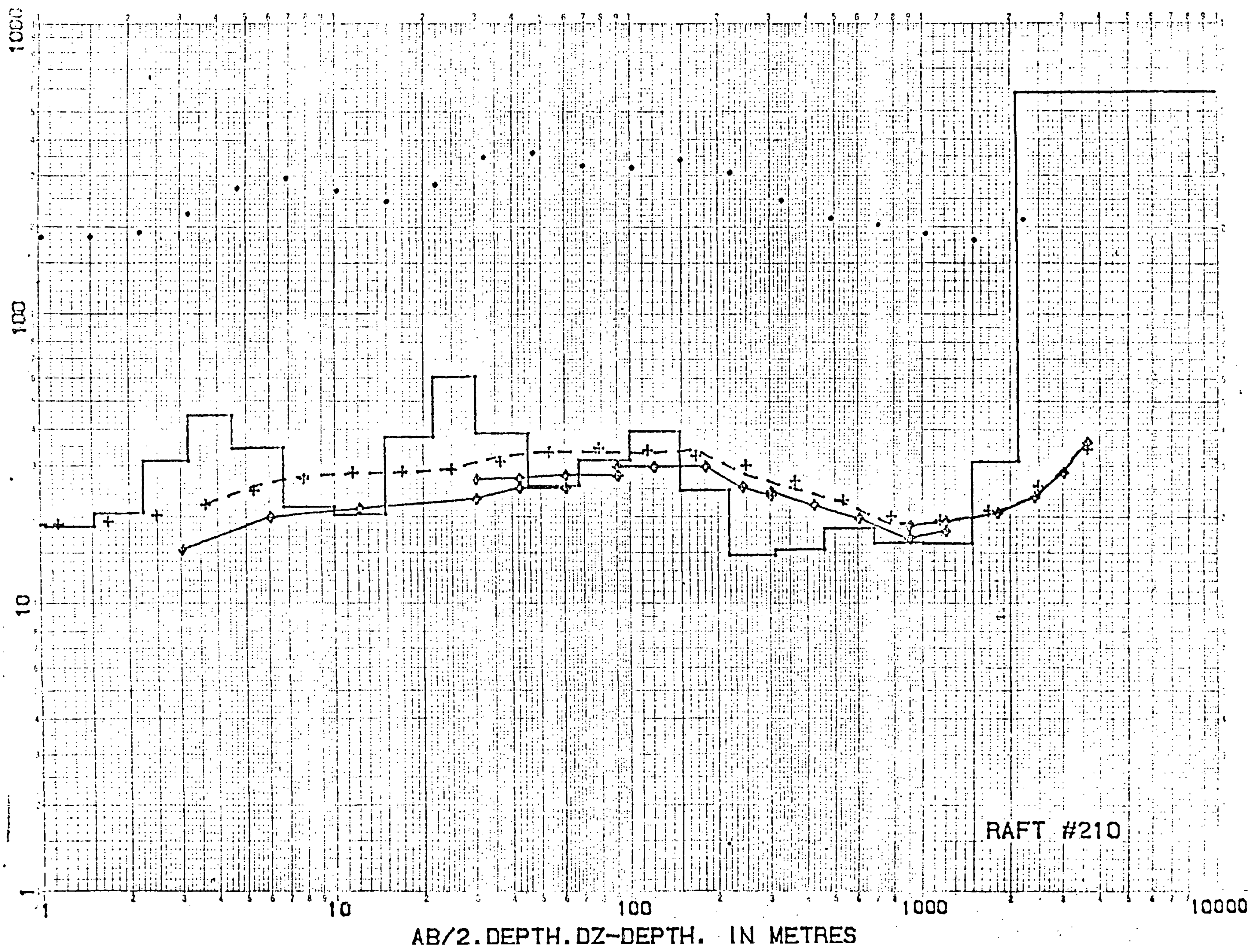


1000
100
10
1
RESISTIVITIES IN OHM METRES
10
100
1000
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #207

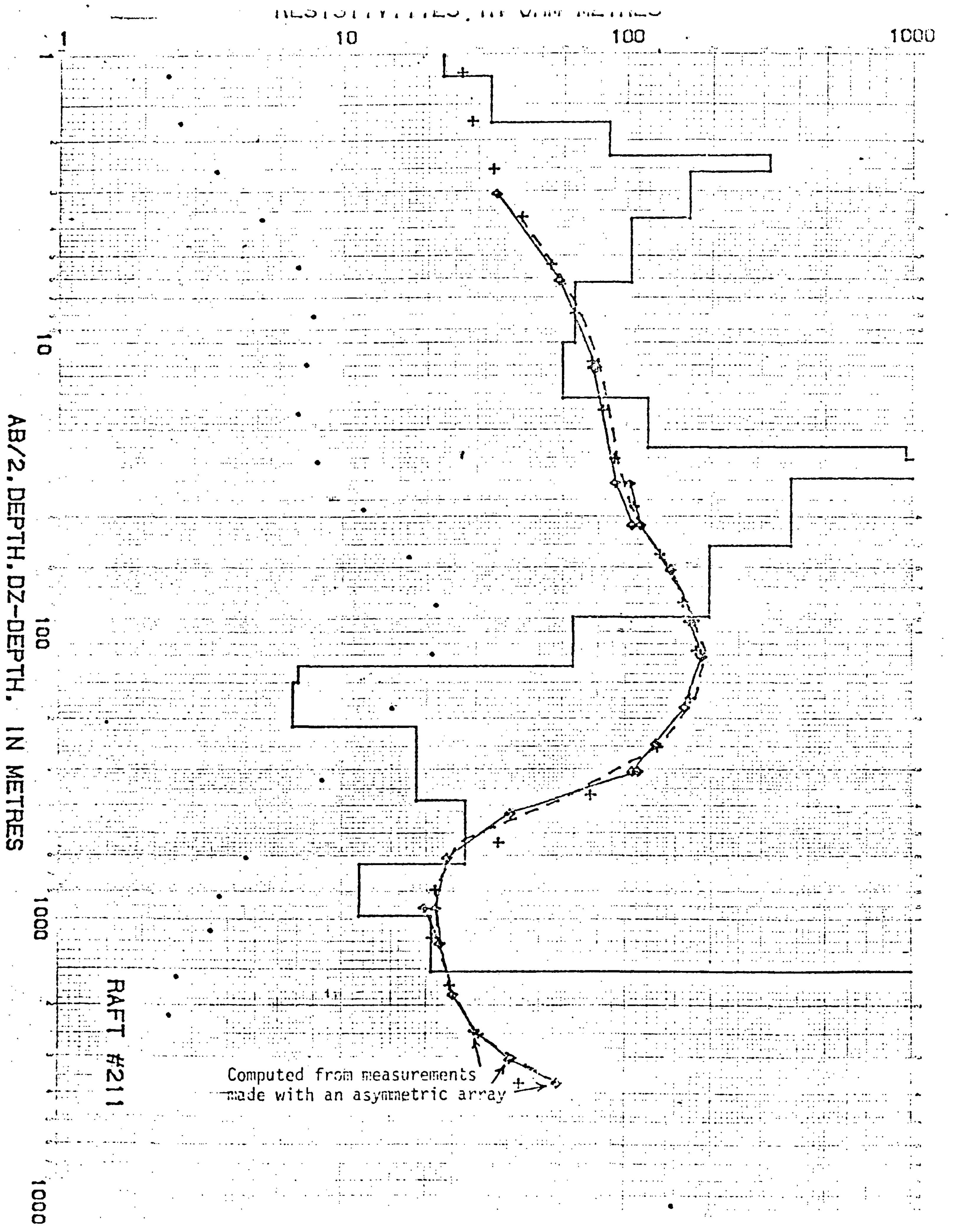

1000
100
10
1
1
10
100
1000
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #208



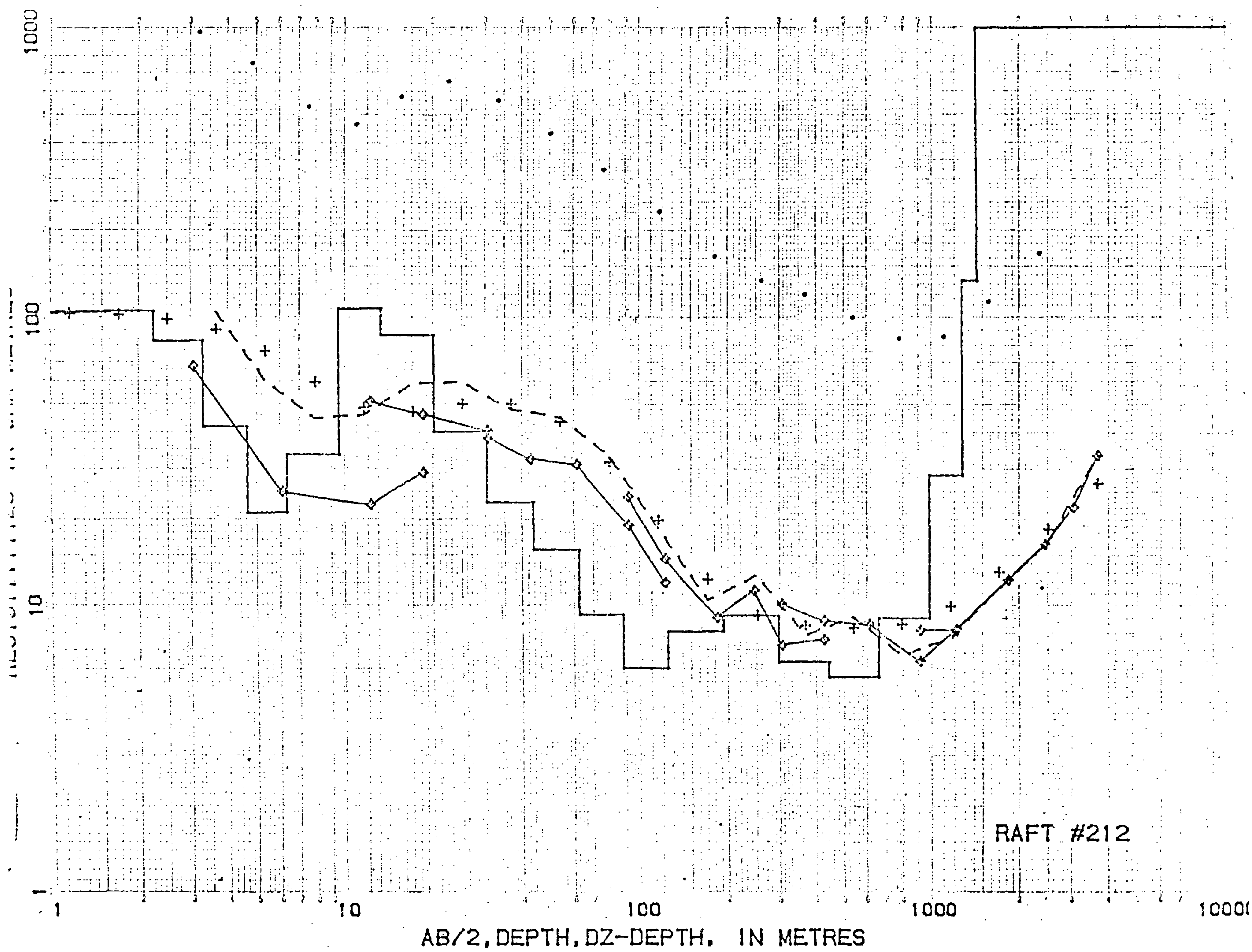
1000
100
10
1
1
10
100
1000
10000
RAFT. #209
AB/2, DEPTH, DZ-DEPTH, IN METRES

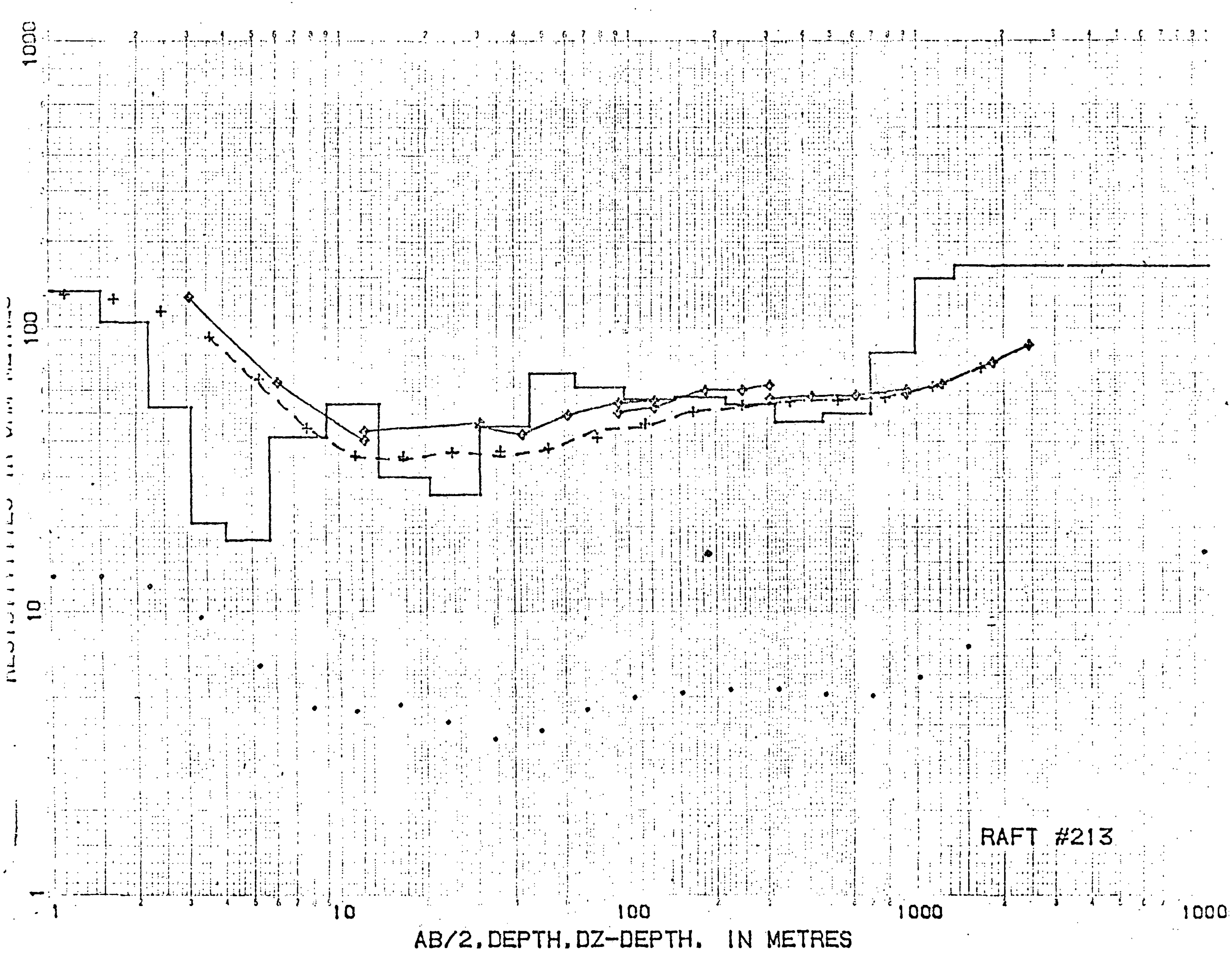


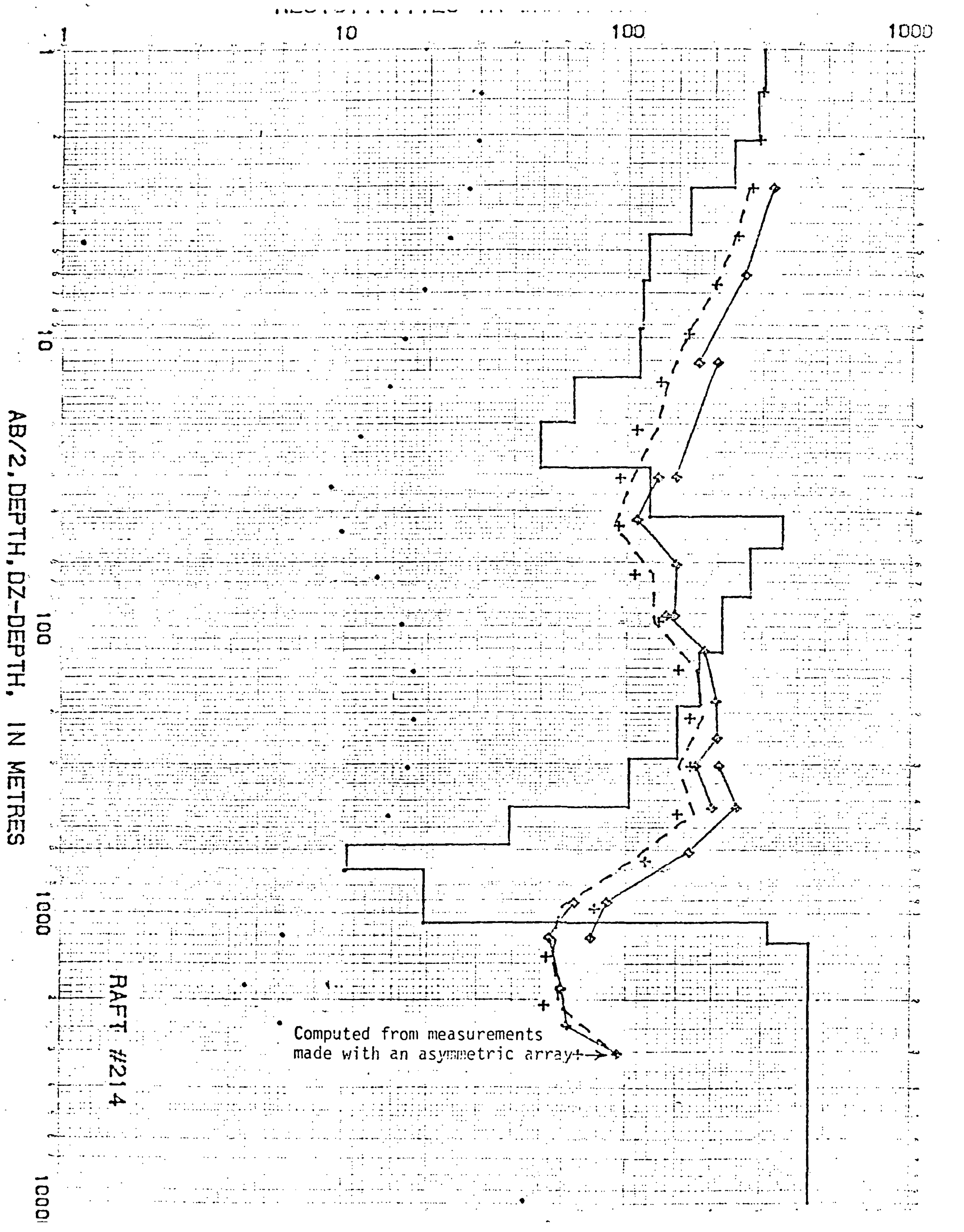
1000
100
10
1
1
10
100
1000
10000
RAFT #210
AB/2.DEPTH.DZ-DEPTH. IN METRES



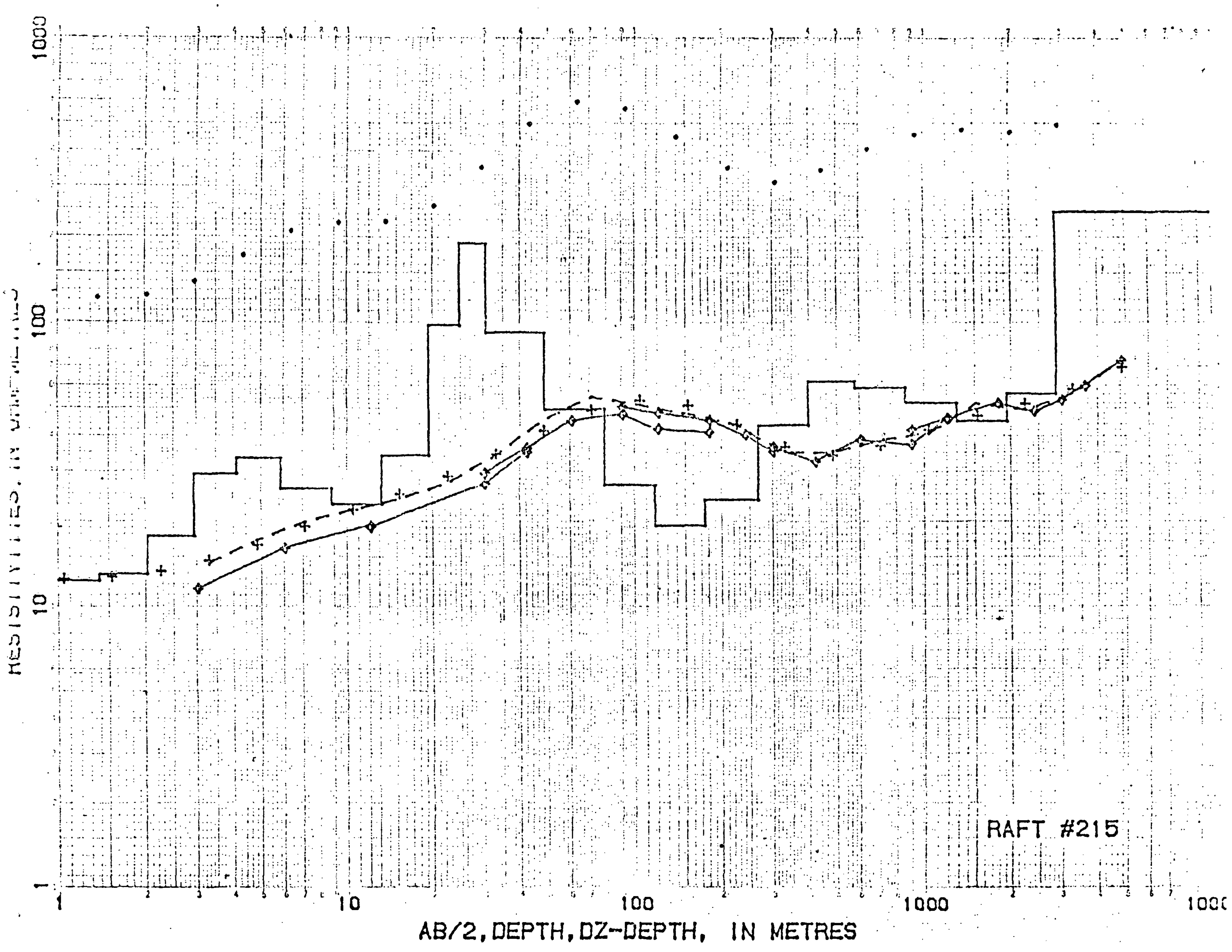
1
10
100
1000
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAFT #211
Computed from measurements
made with an asymmetric array


1000
100
10
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #212

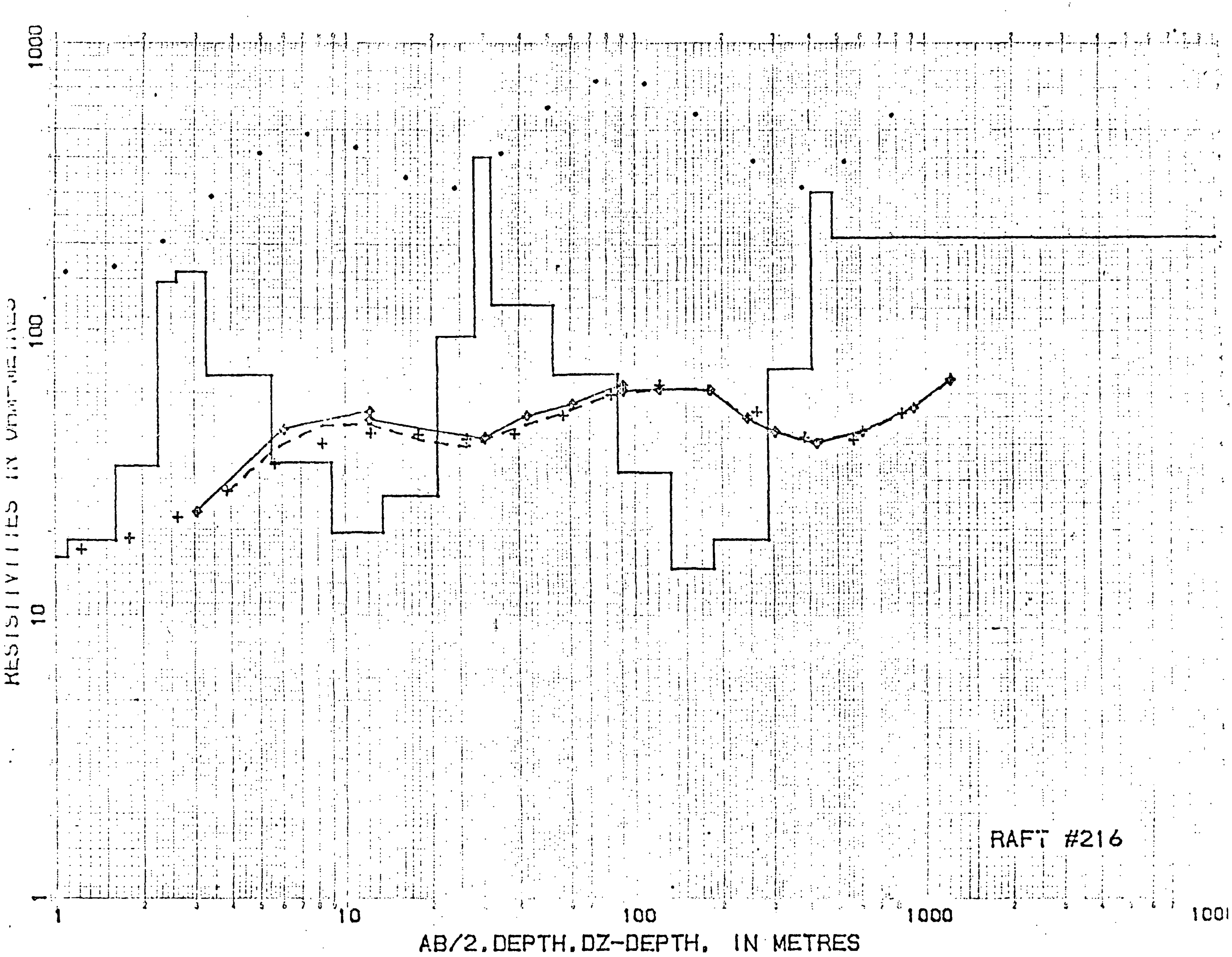

1000
100
10
1
1
10
100
1000
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #213

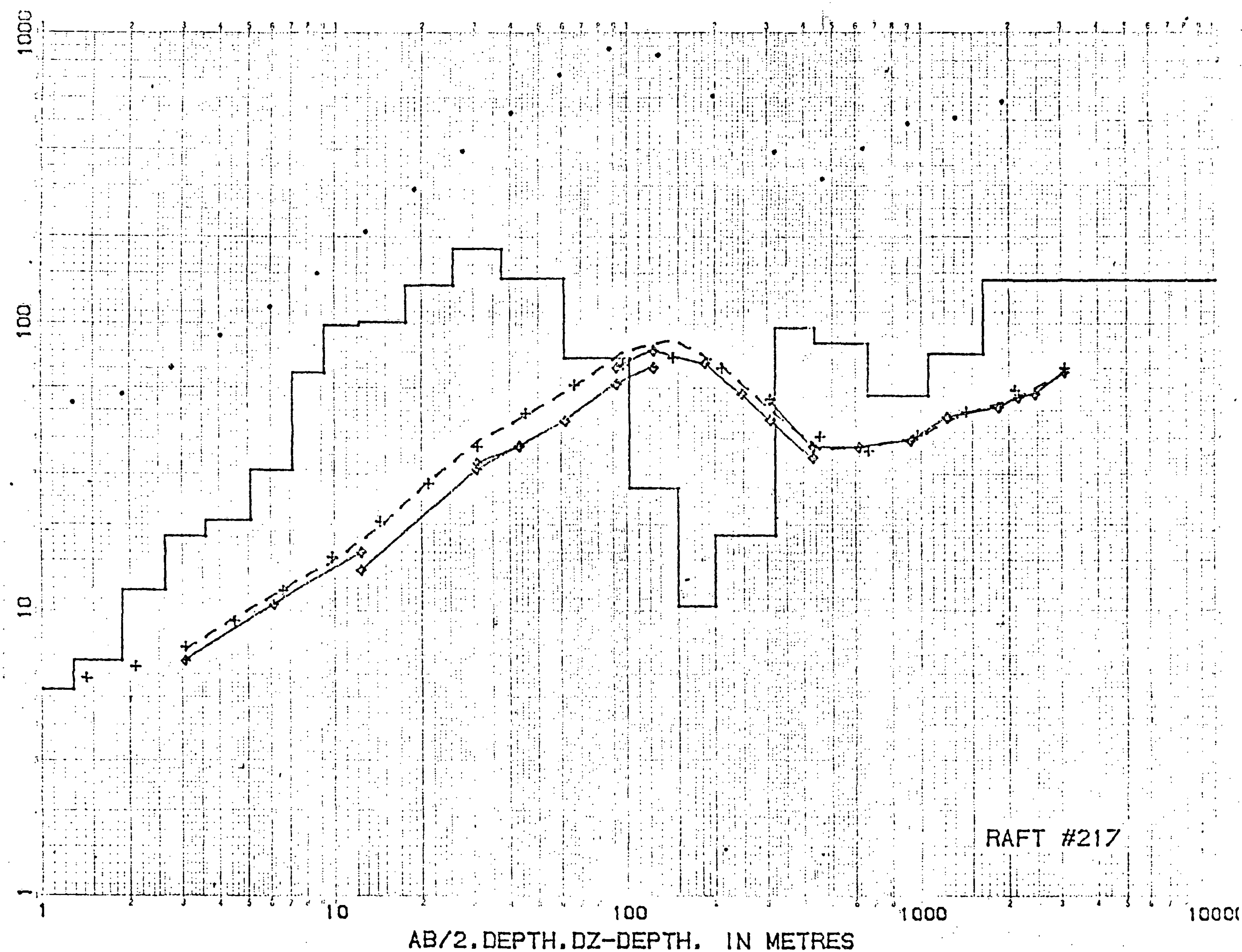


1
10
100
1000
AB/2,DEPTH,DZ-DEPTH, IN METRES
RAFT #214
Computed from measurements
made with an asymmetric array

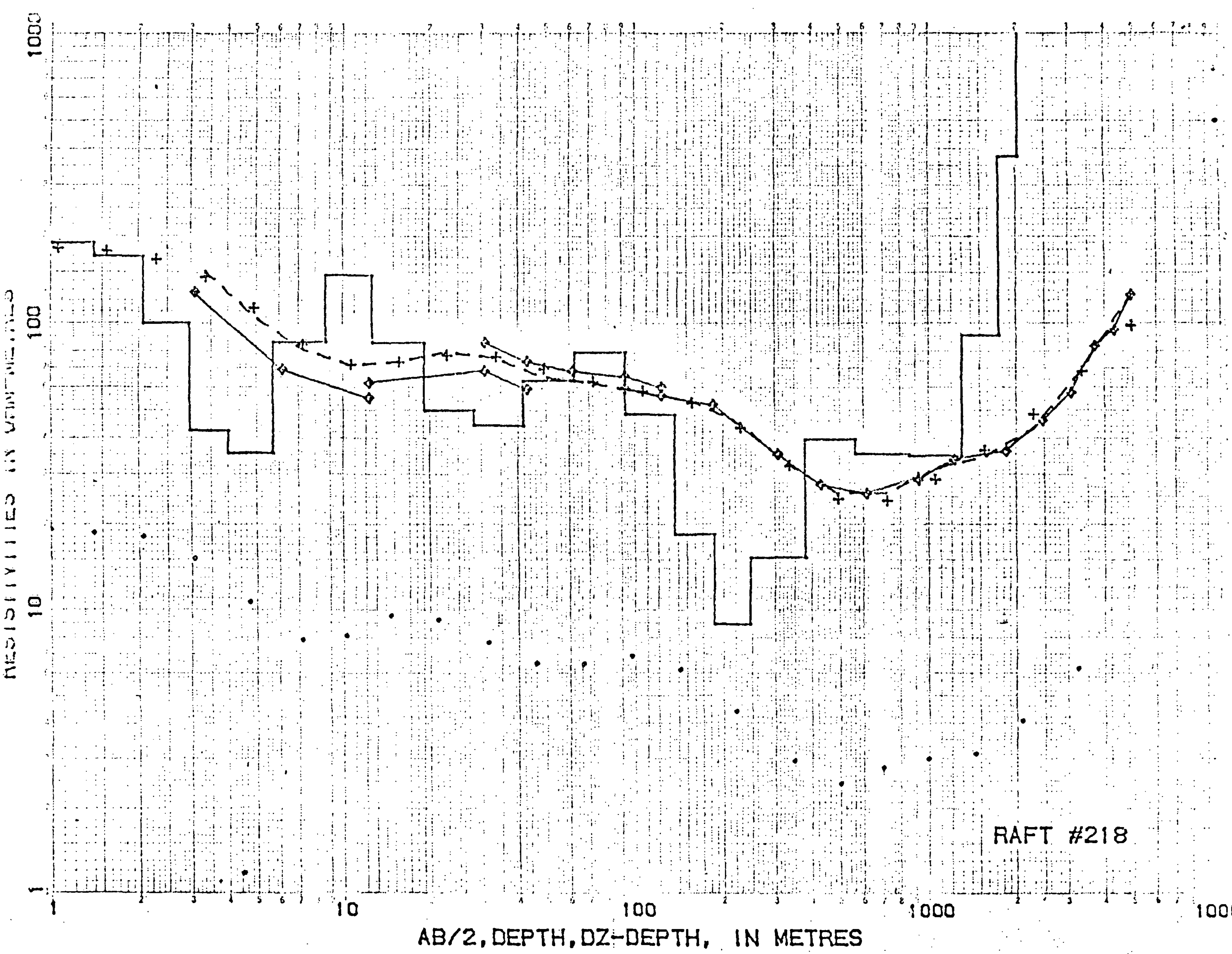


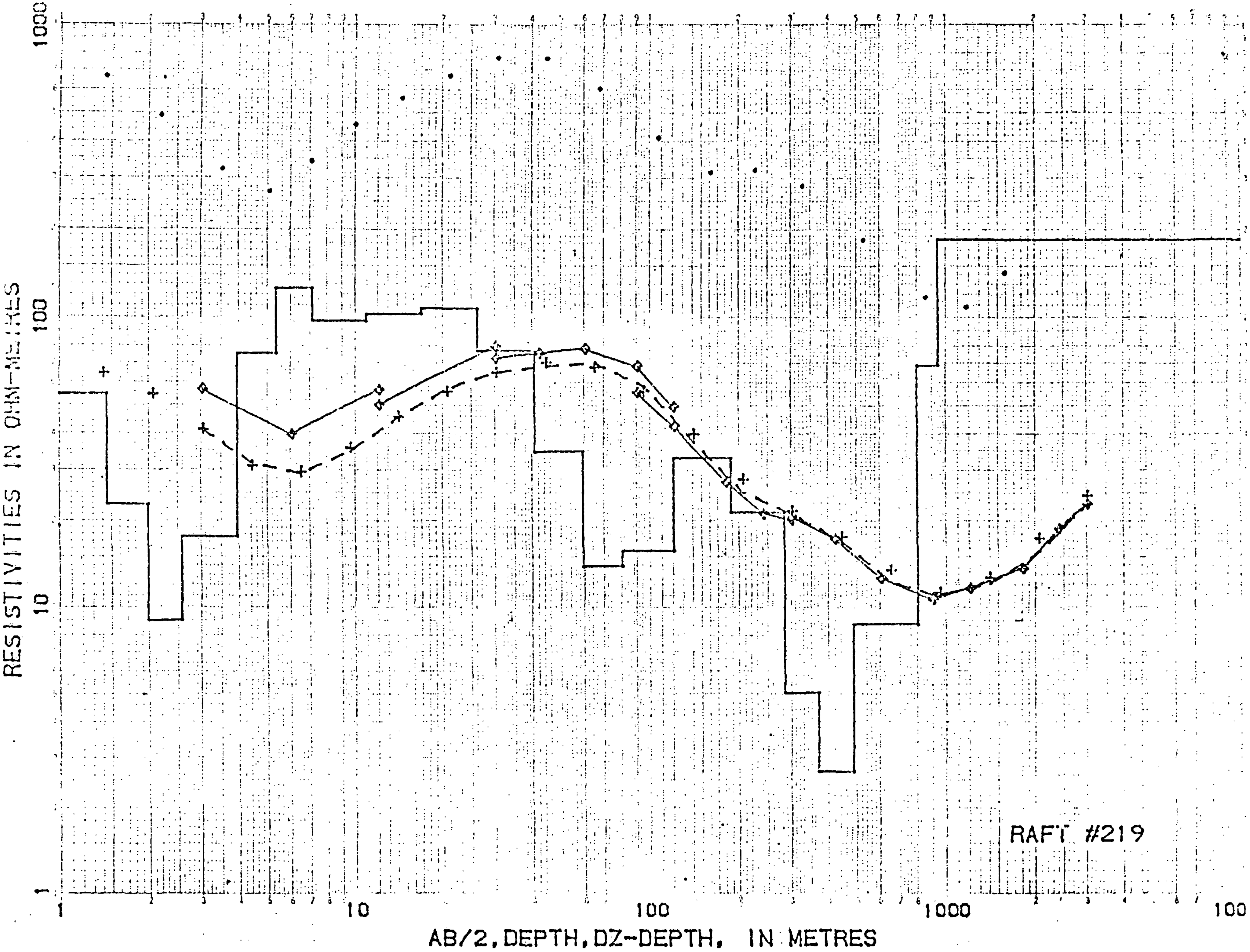
RAFT #215
AB/2, DEPTH, DZ-DEPTH, IN METRES
1
10
100
1000
1000
100
10
1


RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #216

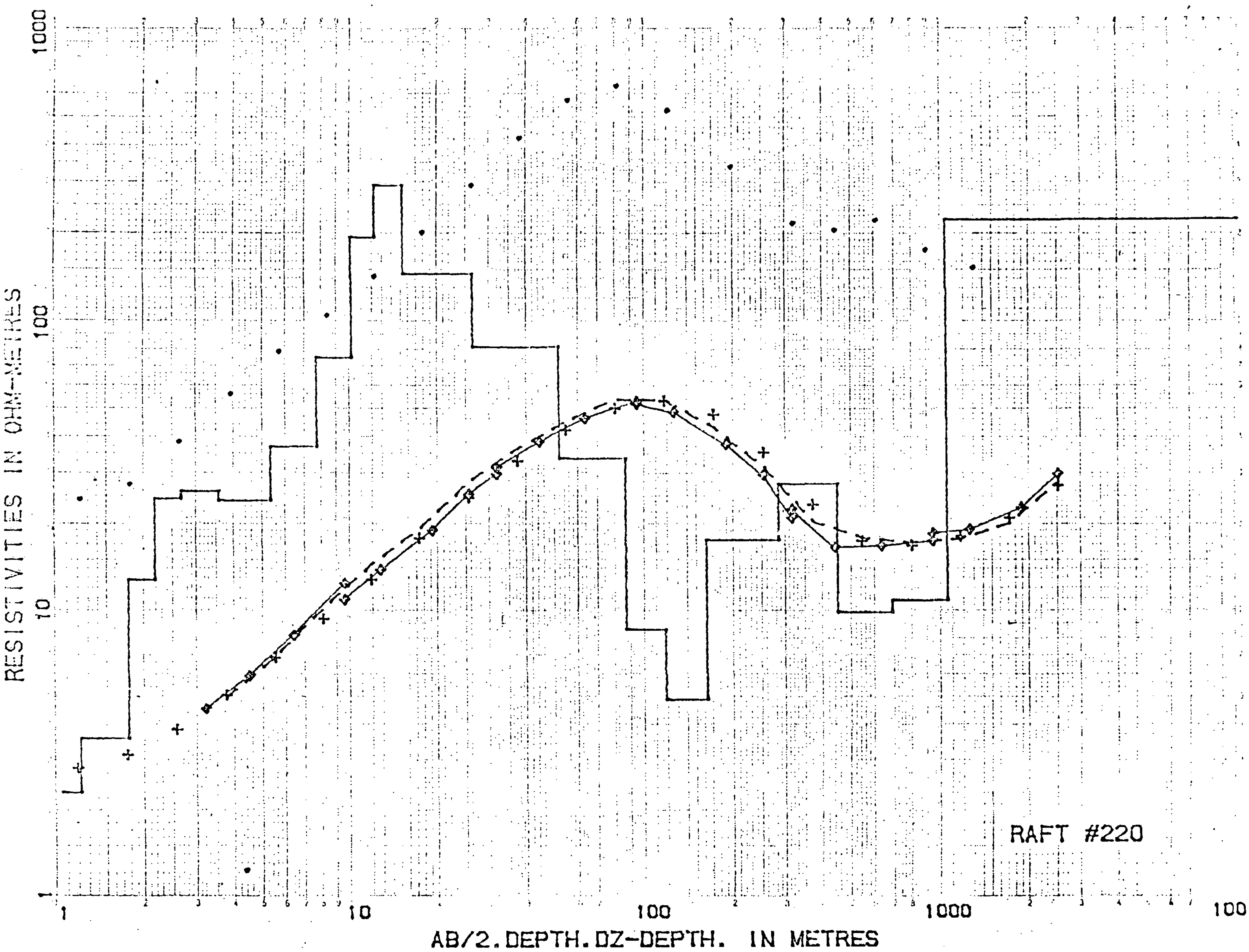


1000
100
10
1
1
10
100
1000
10000
RAFT #217
AB/2.DEPTH.DZ-DEPTH. IN METRES

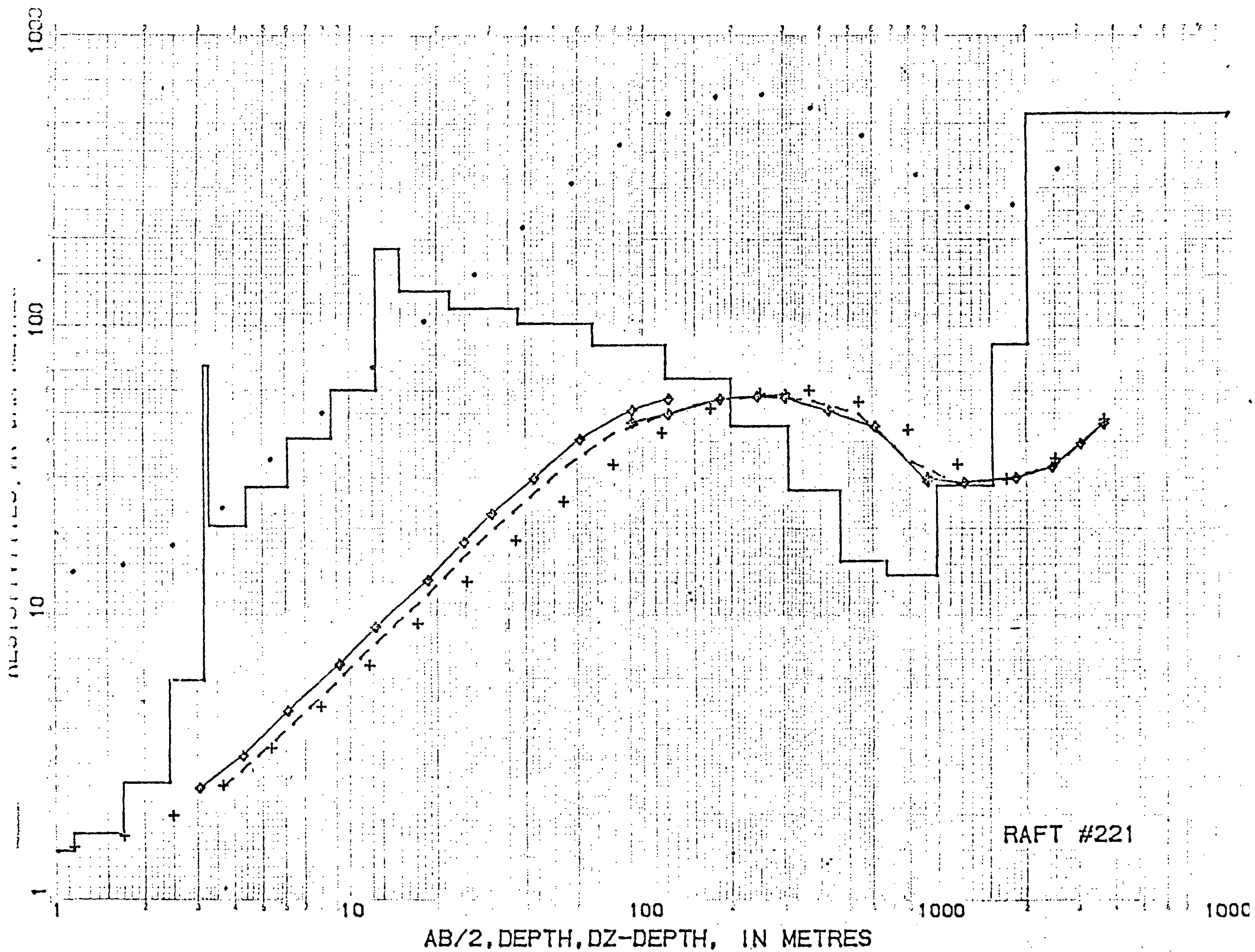

RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #218



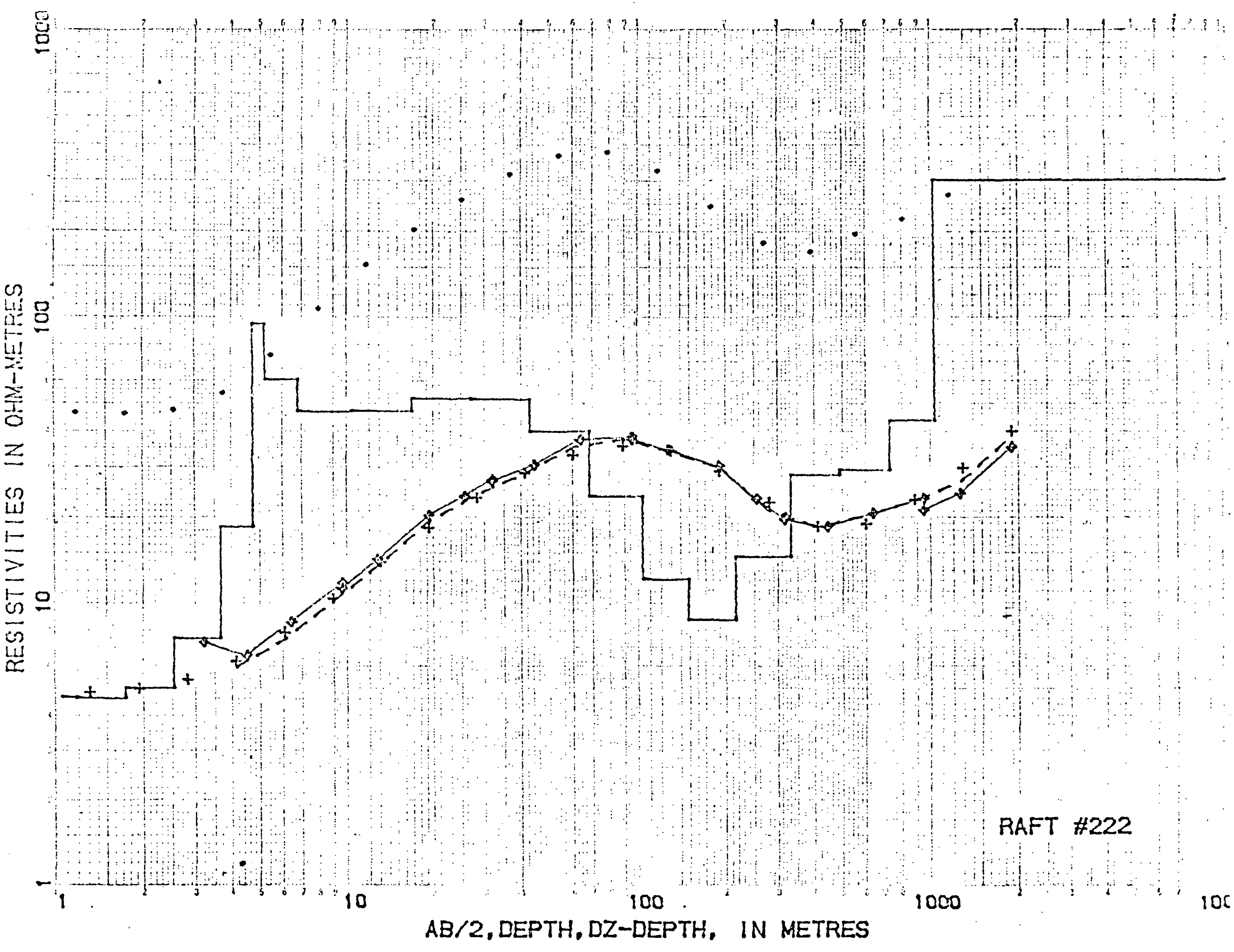
RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
100
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #219



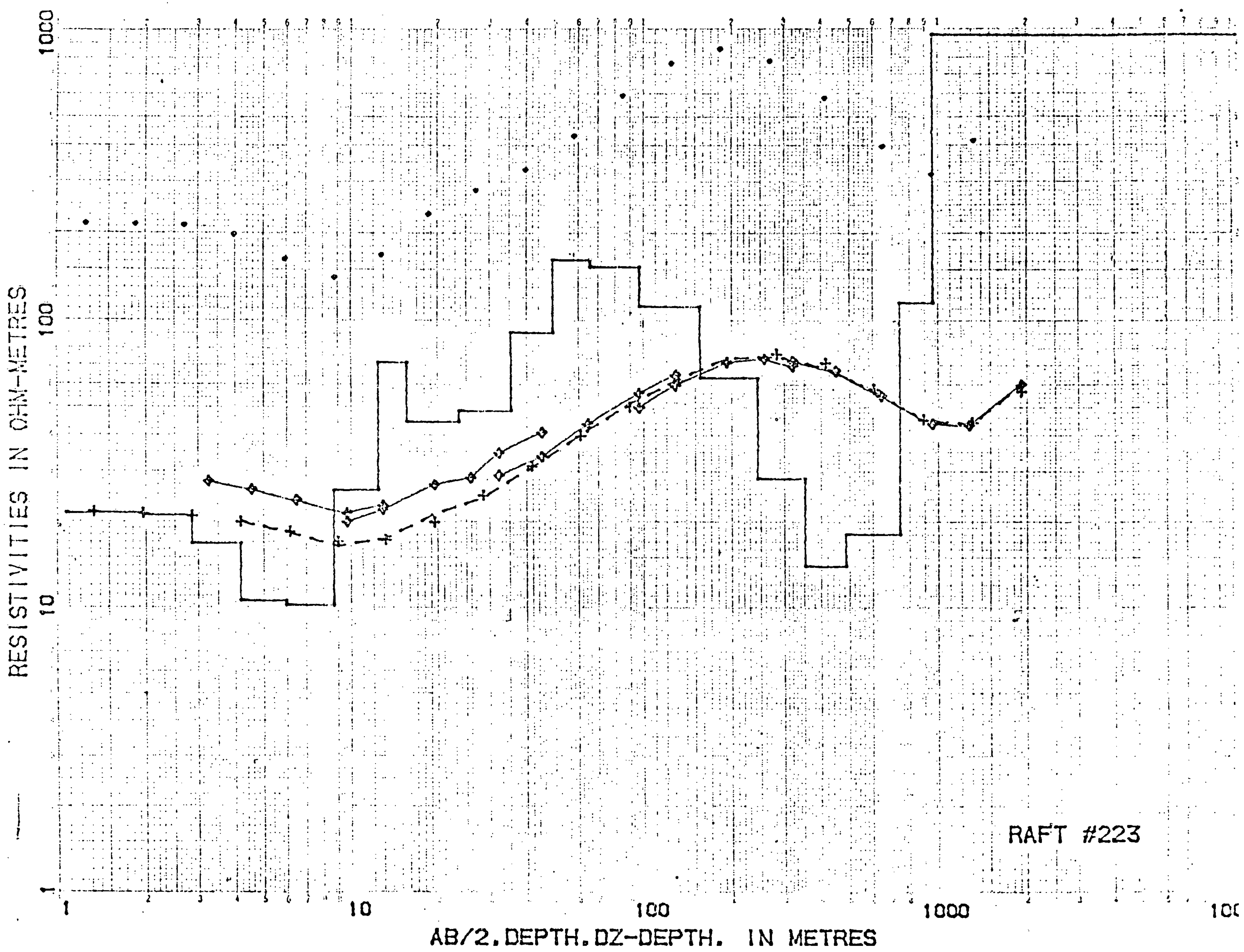
1000
100
10
1
RESISTIVITIES IN OHM-METRES
1
10
100
1000
100
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAFT #220



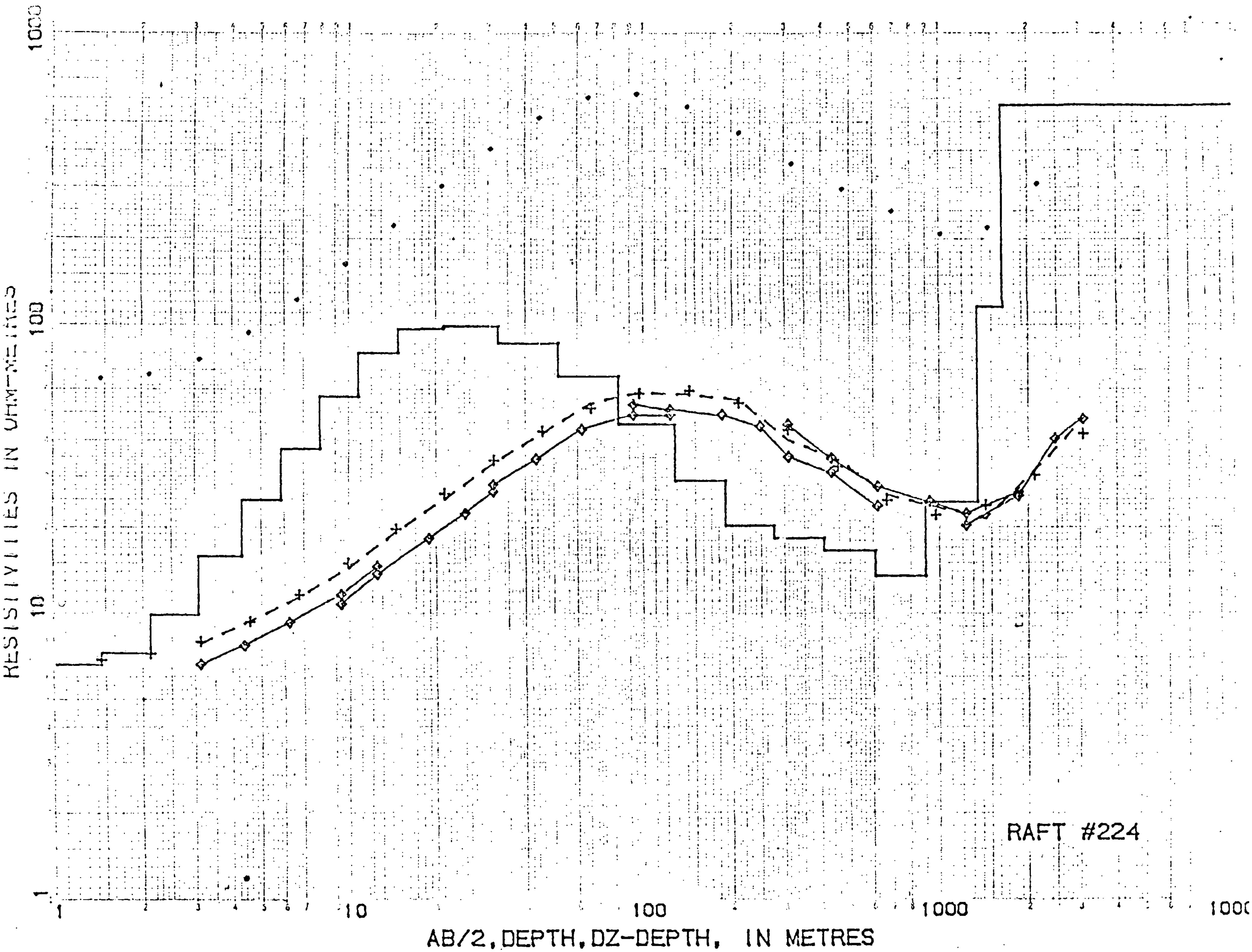
1000
100
10
1
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #221



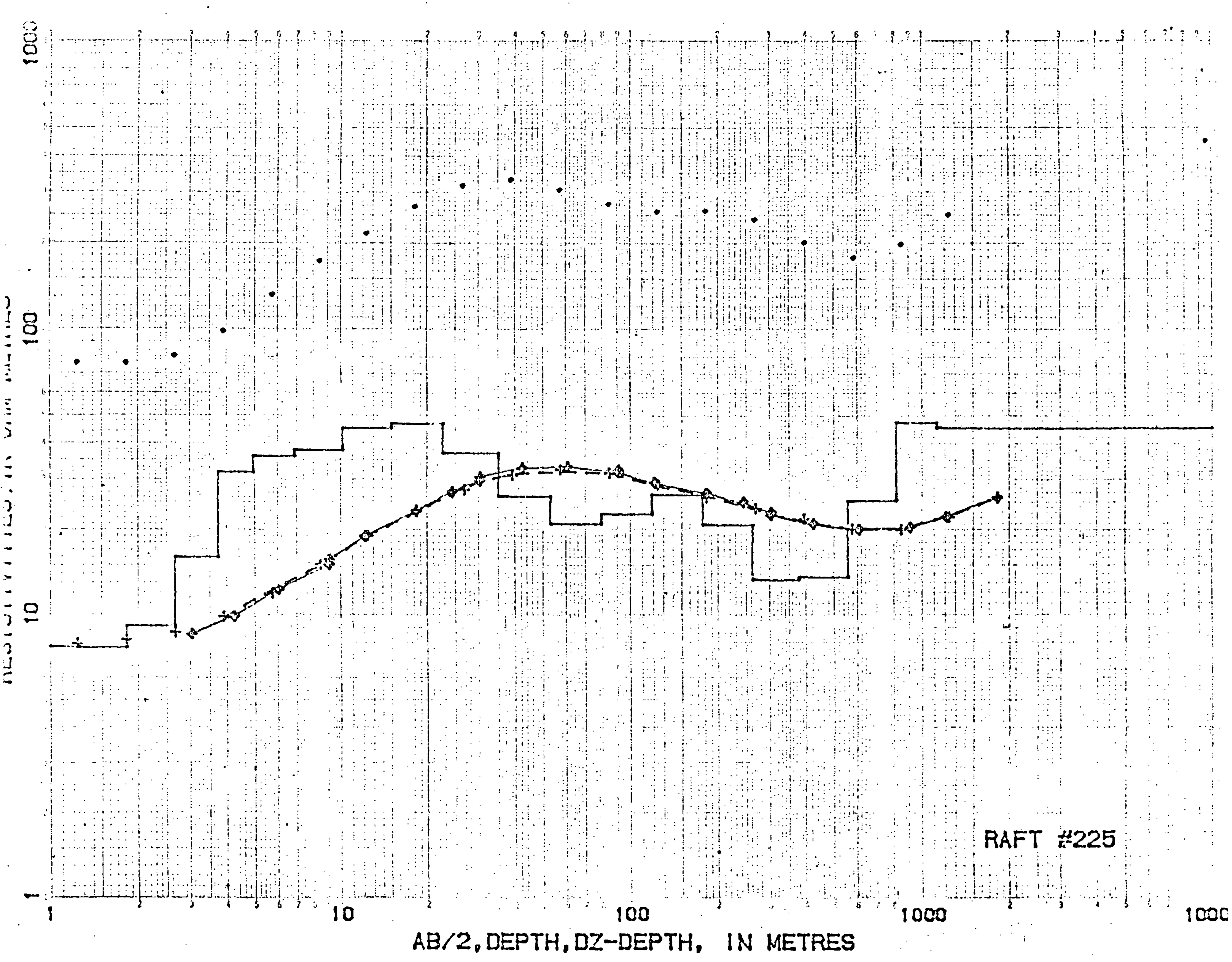
RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #222



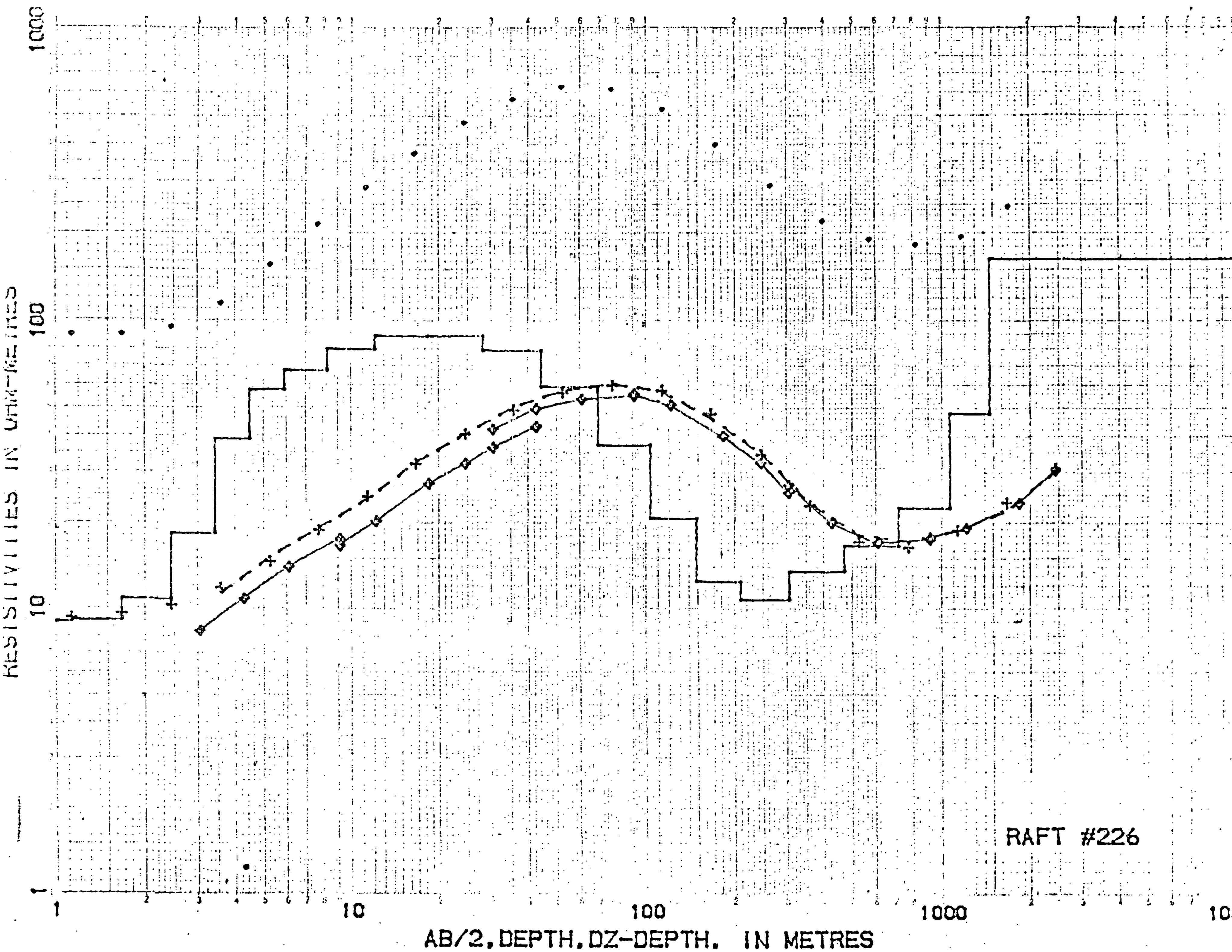
RESISTIVITIES IN OHM-METRES
1000
100
10
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #223



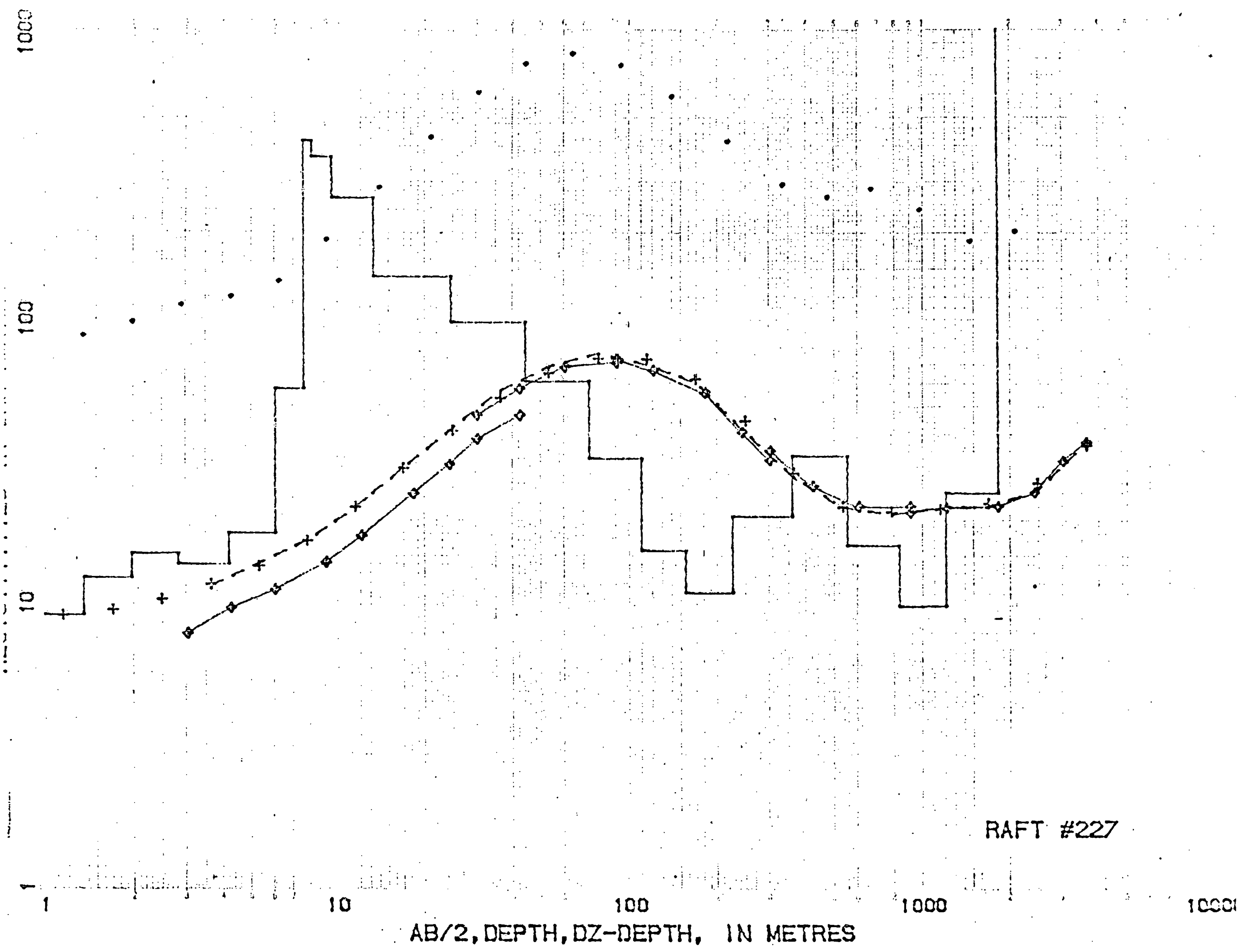
RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #224

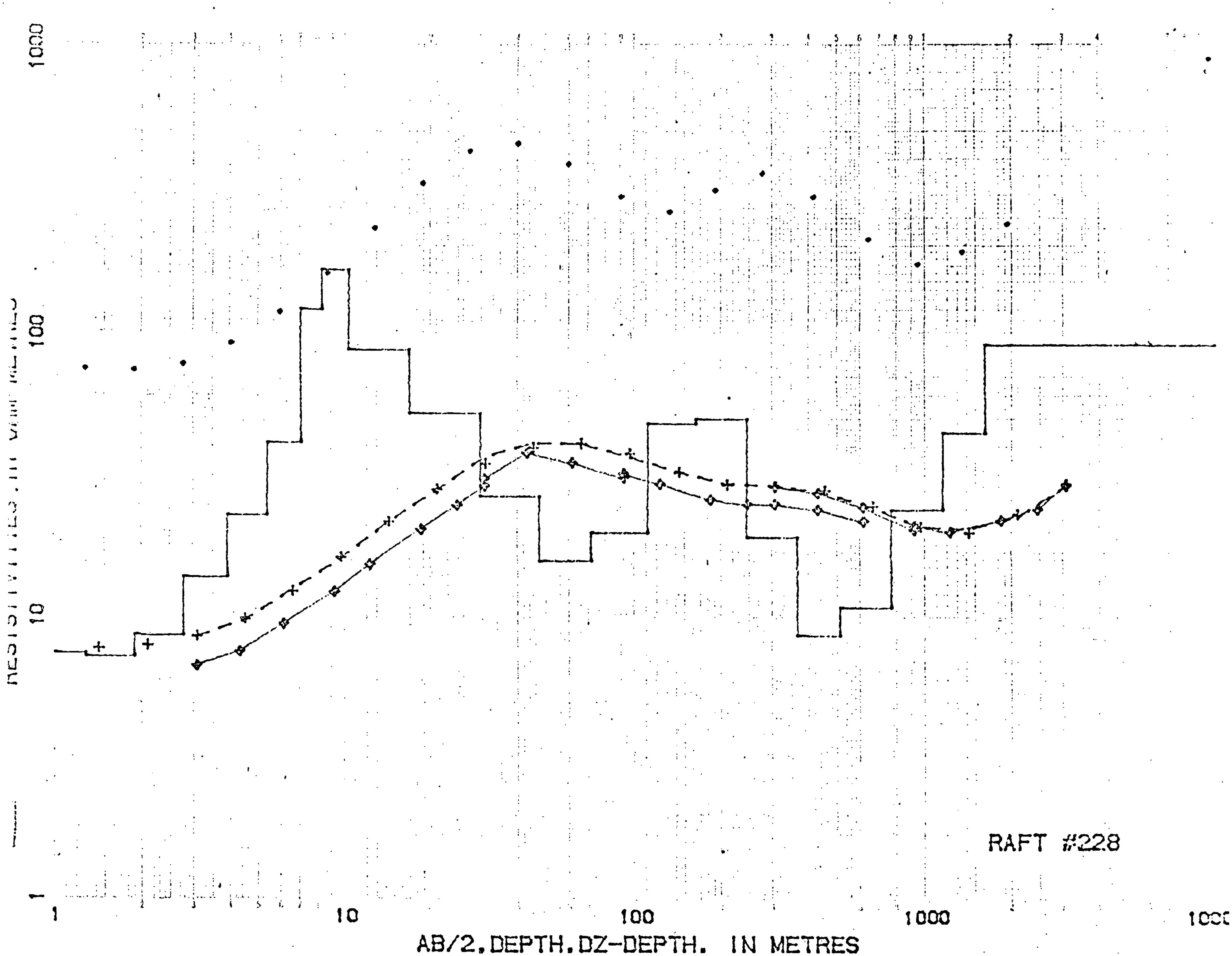


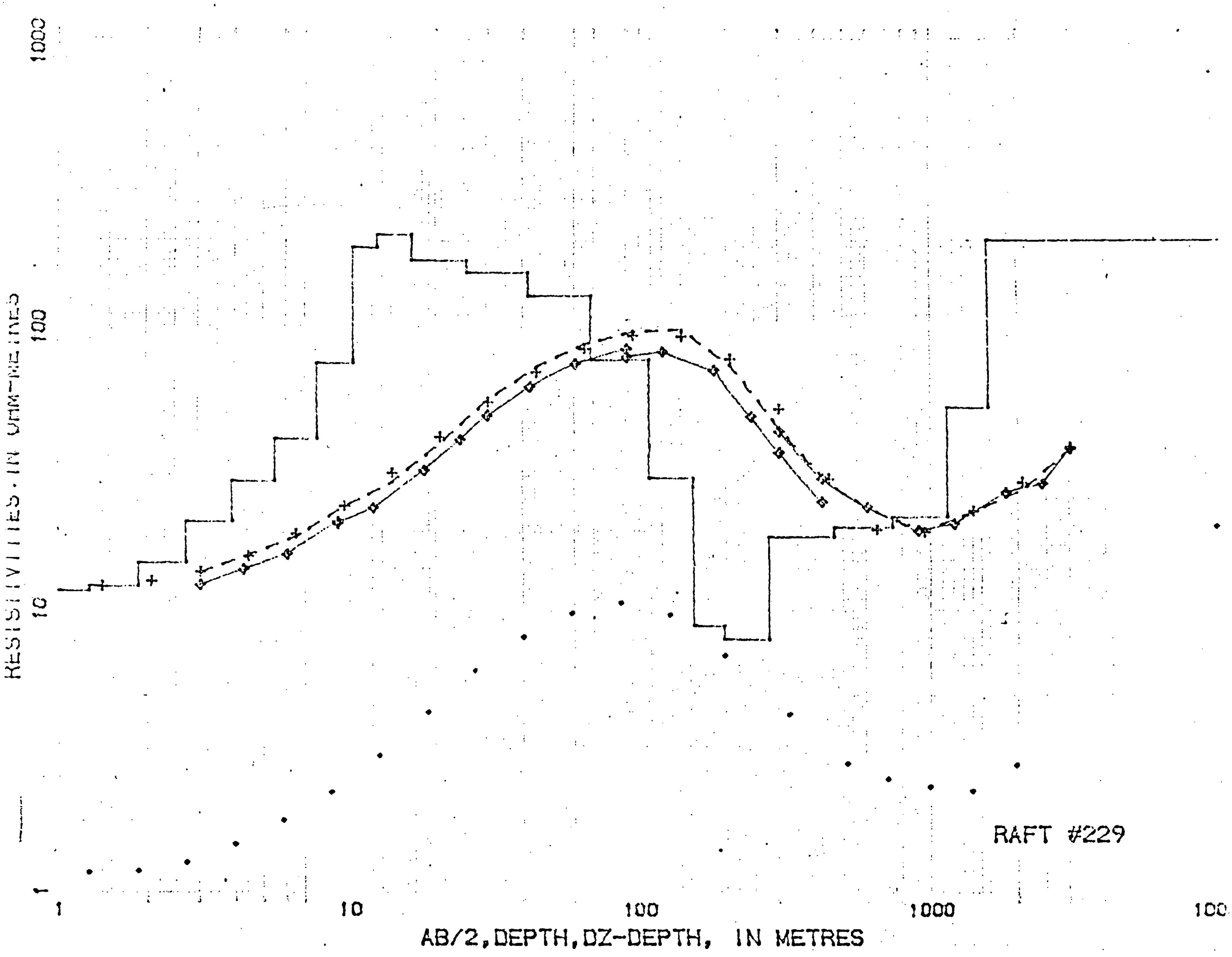
1000
100
10
1
1
10
100
1000
RAFT #225
AB/2, DEPTH, DZ-DEPTH, IN METRES



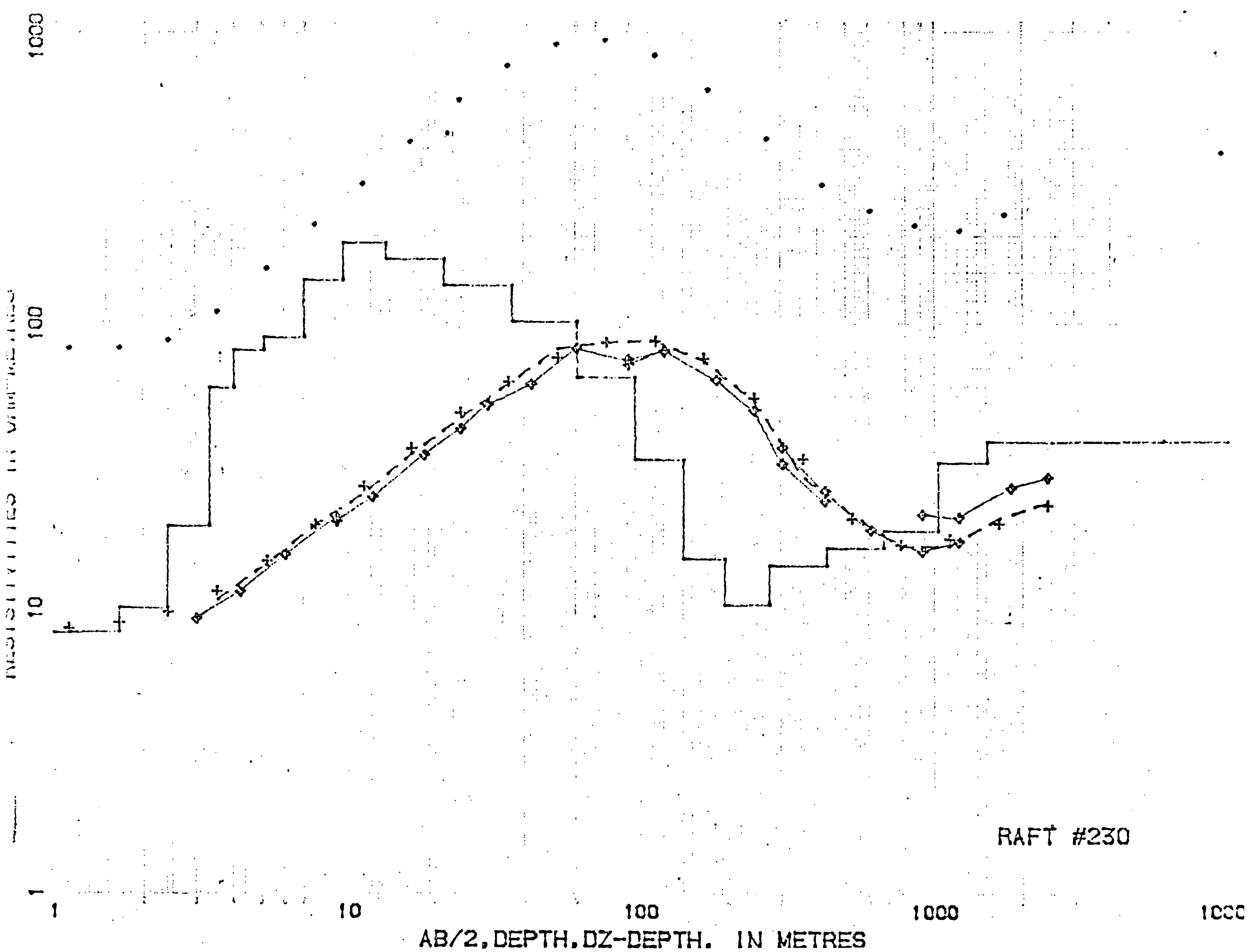
RESISTIVITIES IN OHM-METRES
1000
100
10
1
10
100
1000
RAFT #226
AB/2, DEPTH, DZ-DEPTH, IN METRES

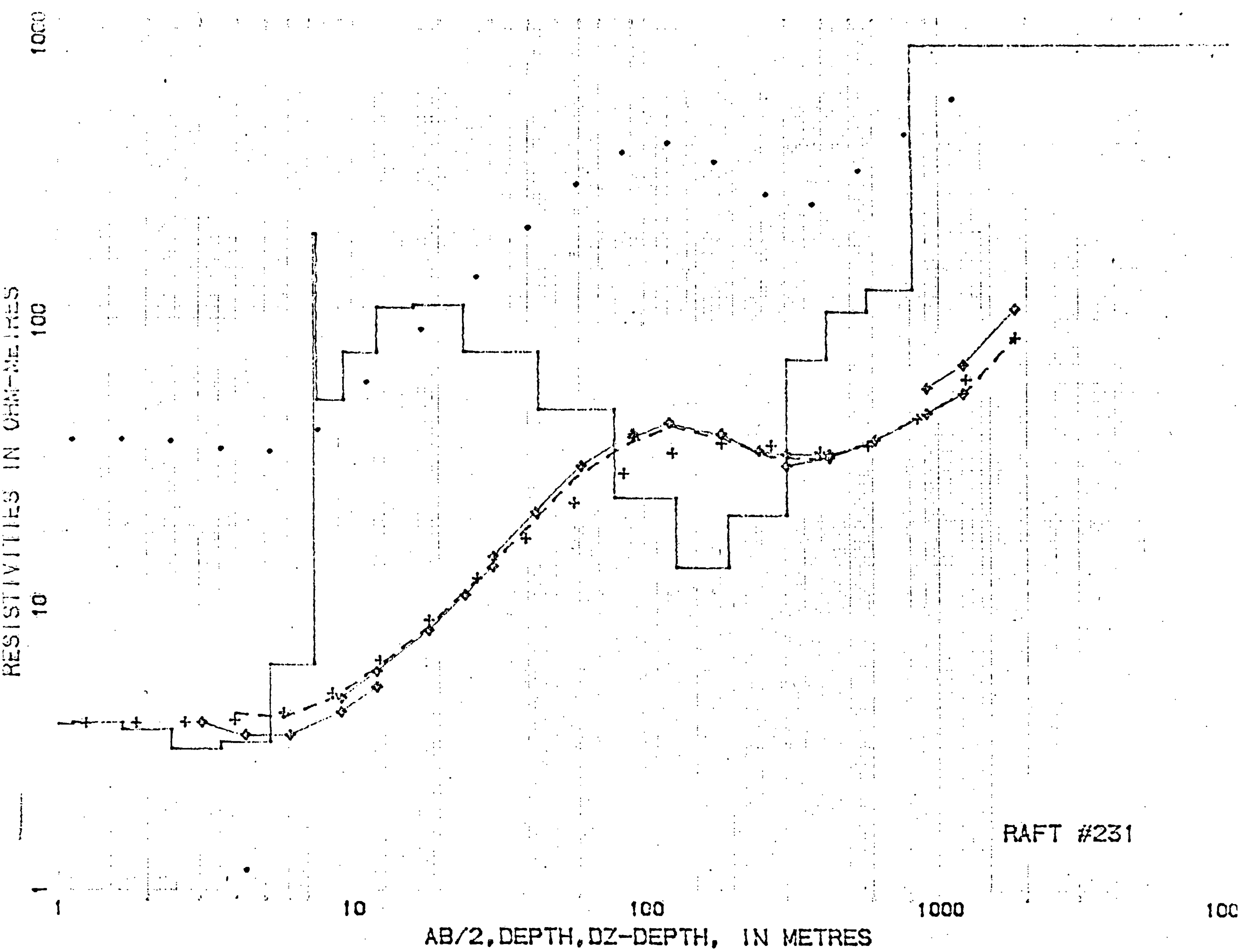

1000
100
10
1
10
100
1000
10000
AB/2,DEPTH,DZ-DEPTH, IN METRES
RAFT #227


1000
100
10
1
1
10
100
1000
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAFT #228

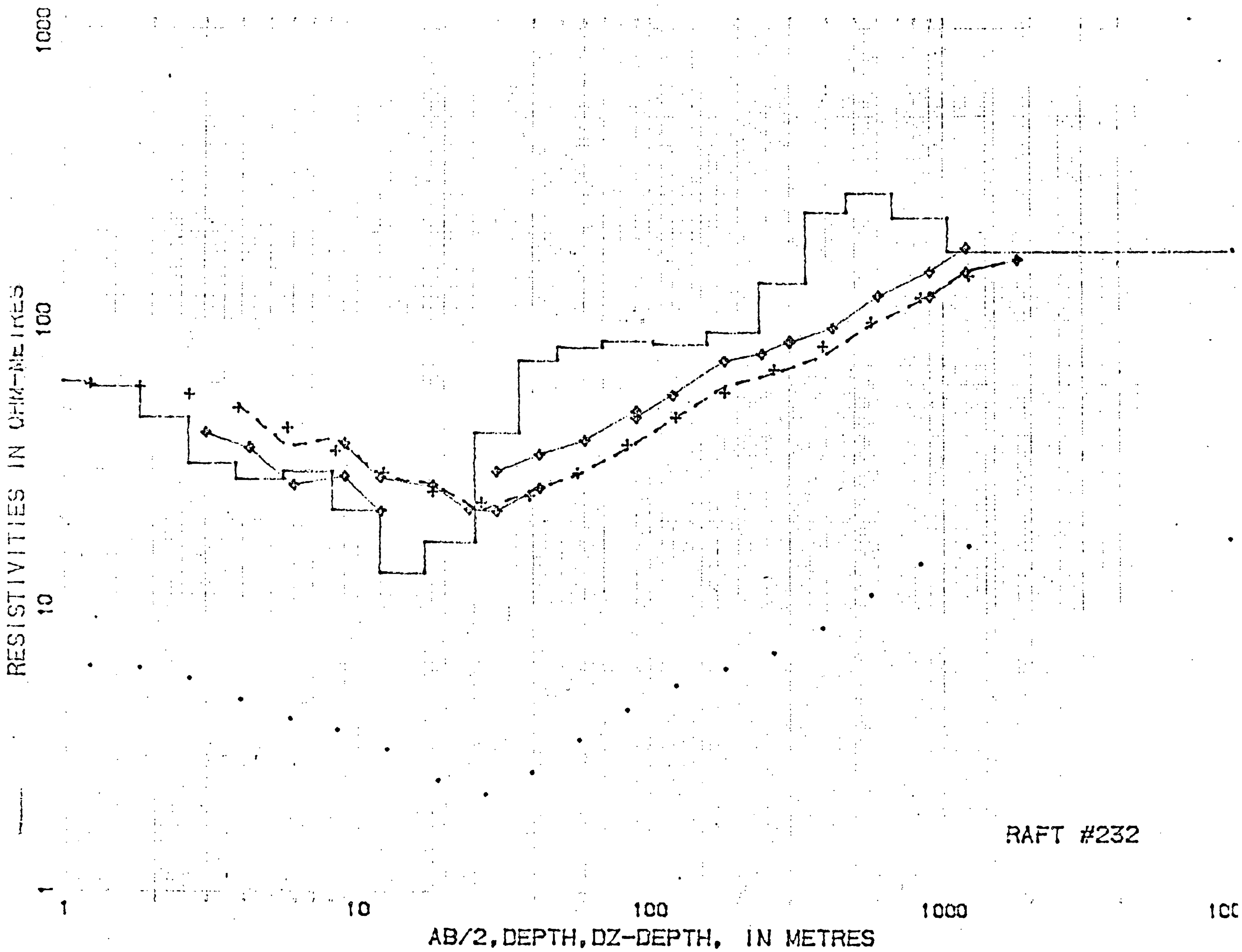


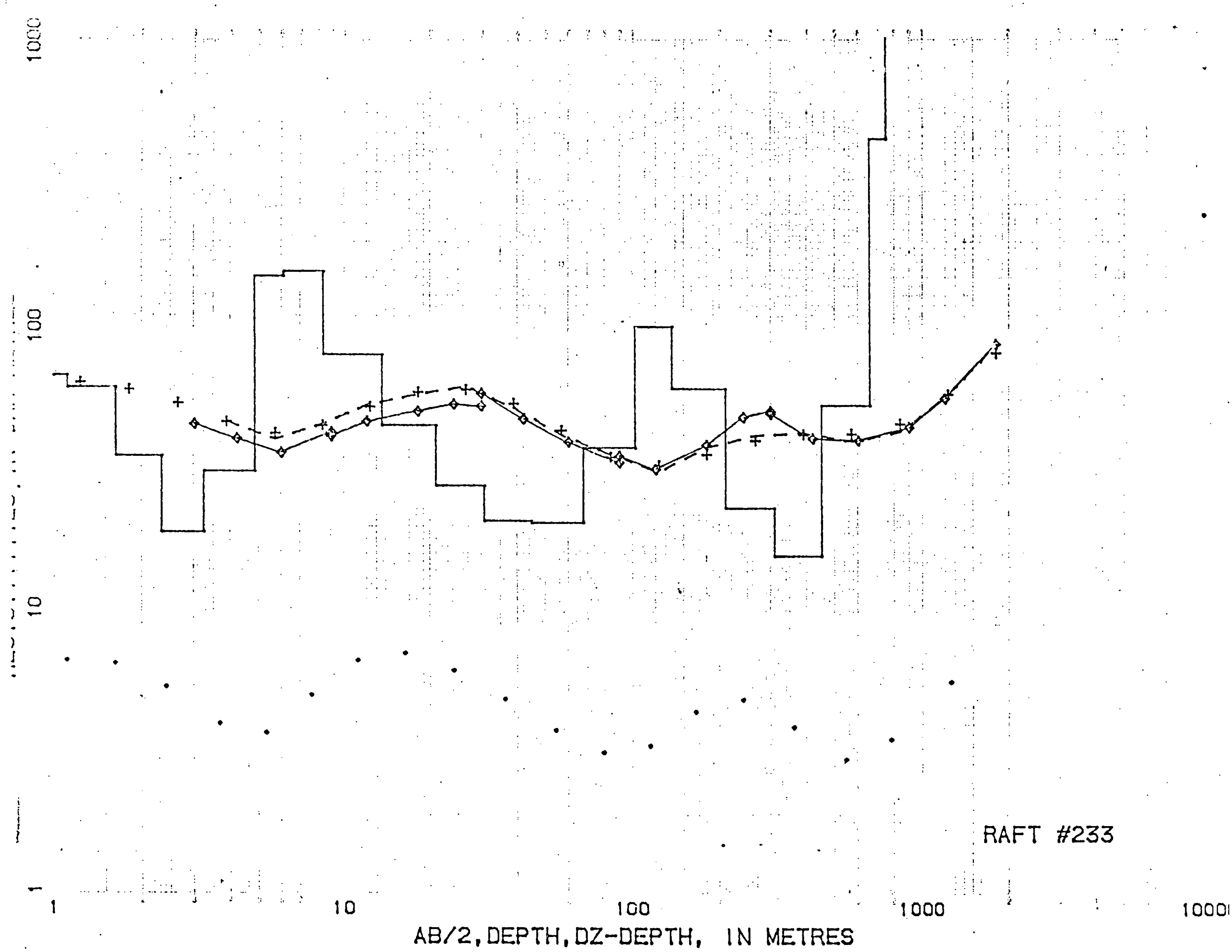
1000
100
10
1
RESISTIVITIES IN OHM-METRES
1
10
100
1000
100
AB/2,DEPTH,DZ-DEPTH, IN METRES
RAFT #229


1000
100
10
1
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH. IN METRES
RAFT #230

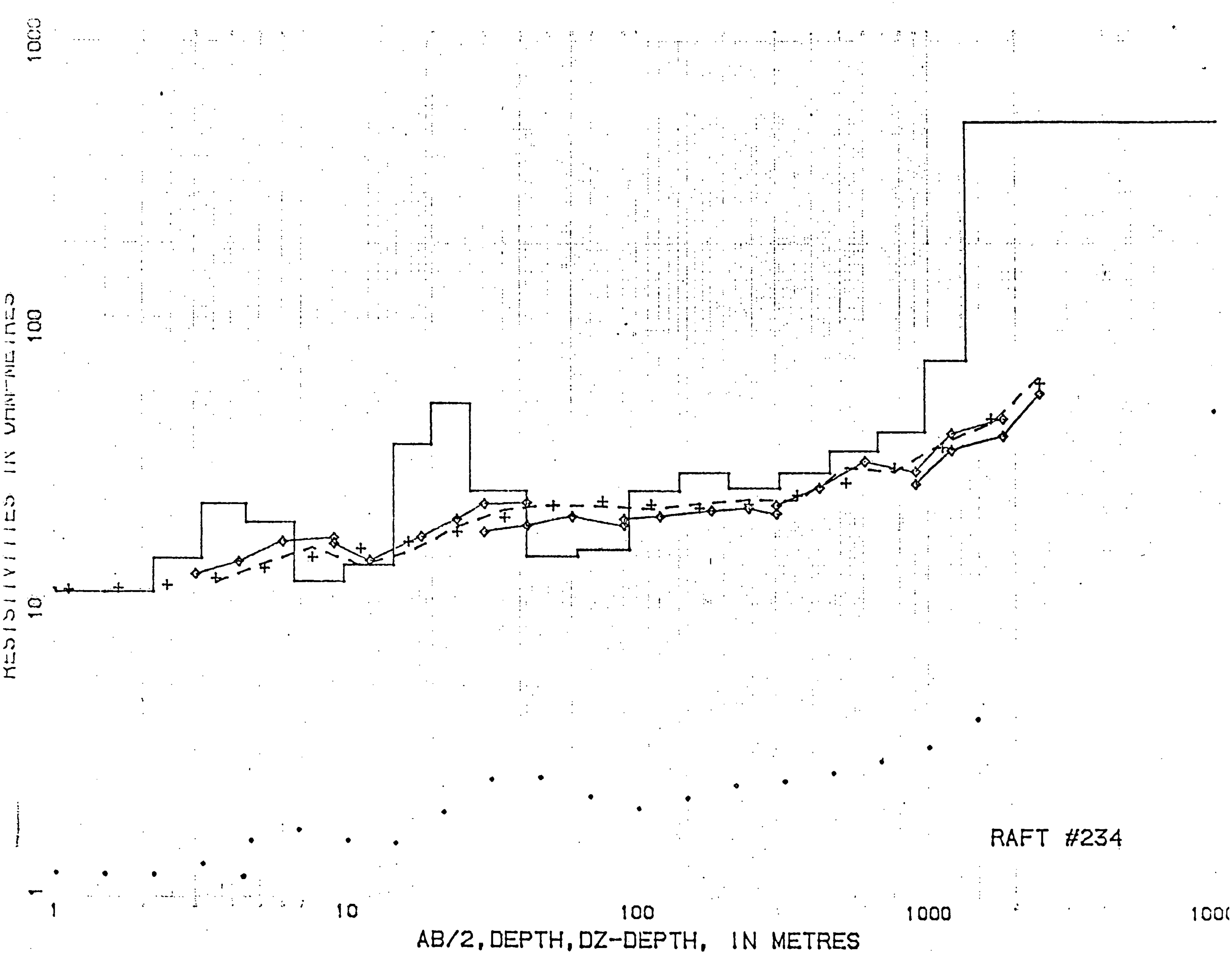


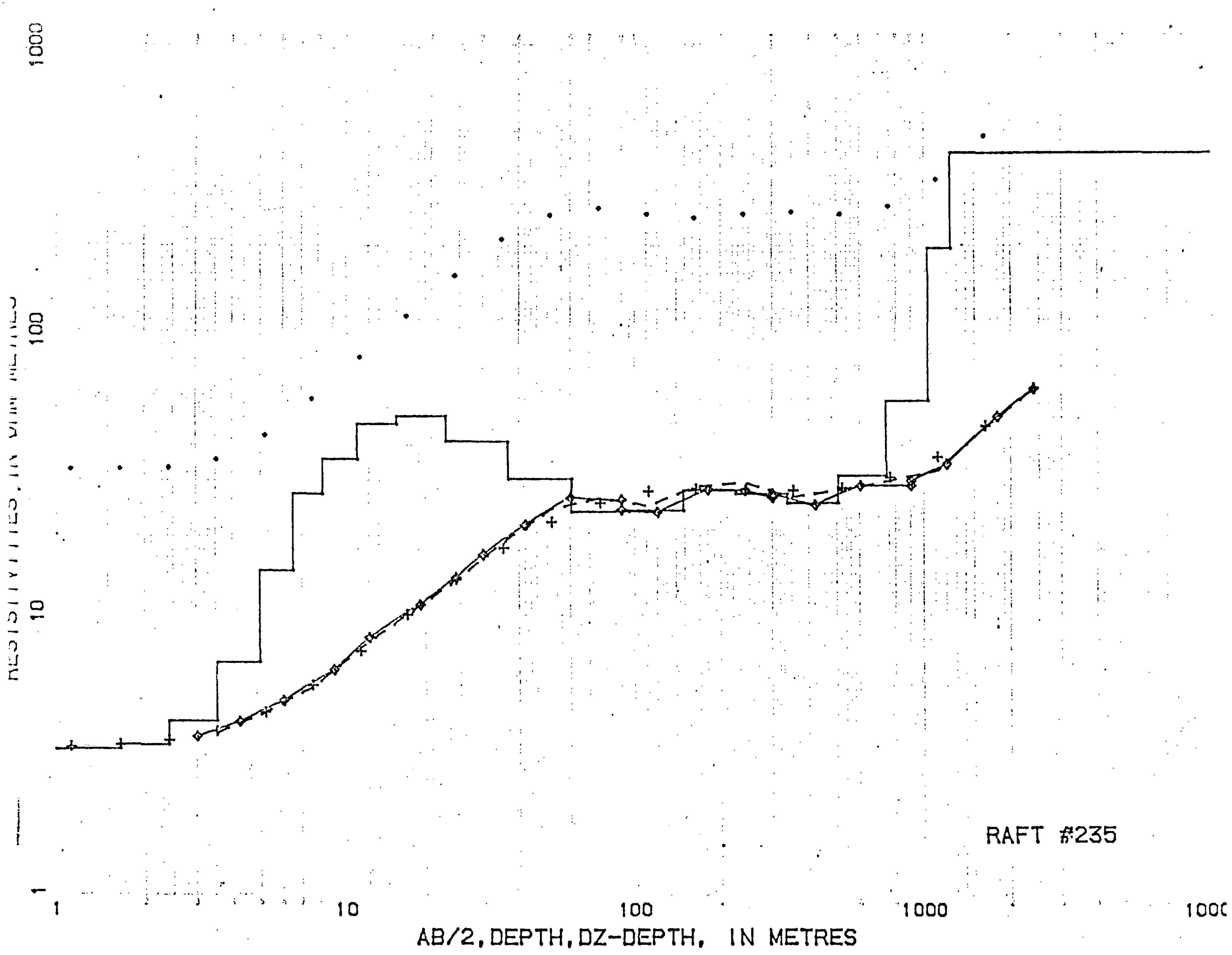
1000
100
10
1
RESISTIVITIES IN OHM-METRES
1
10
100
1000
100
AB/2,DEPTH,DZ-DEPTH, IN METRES
RAFT #231


RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #232

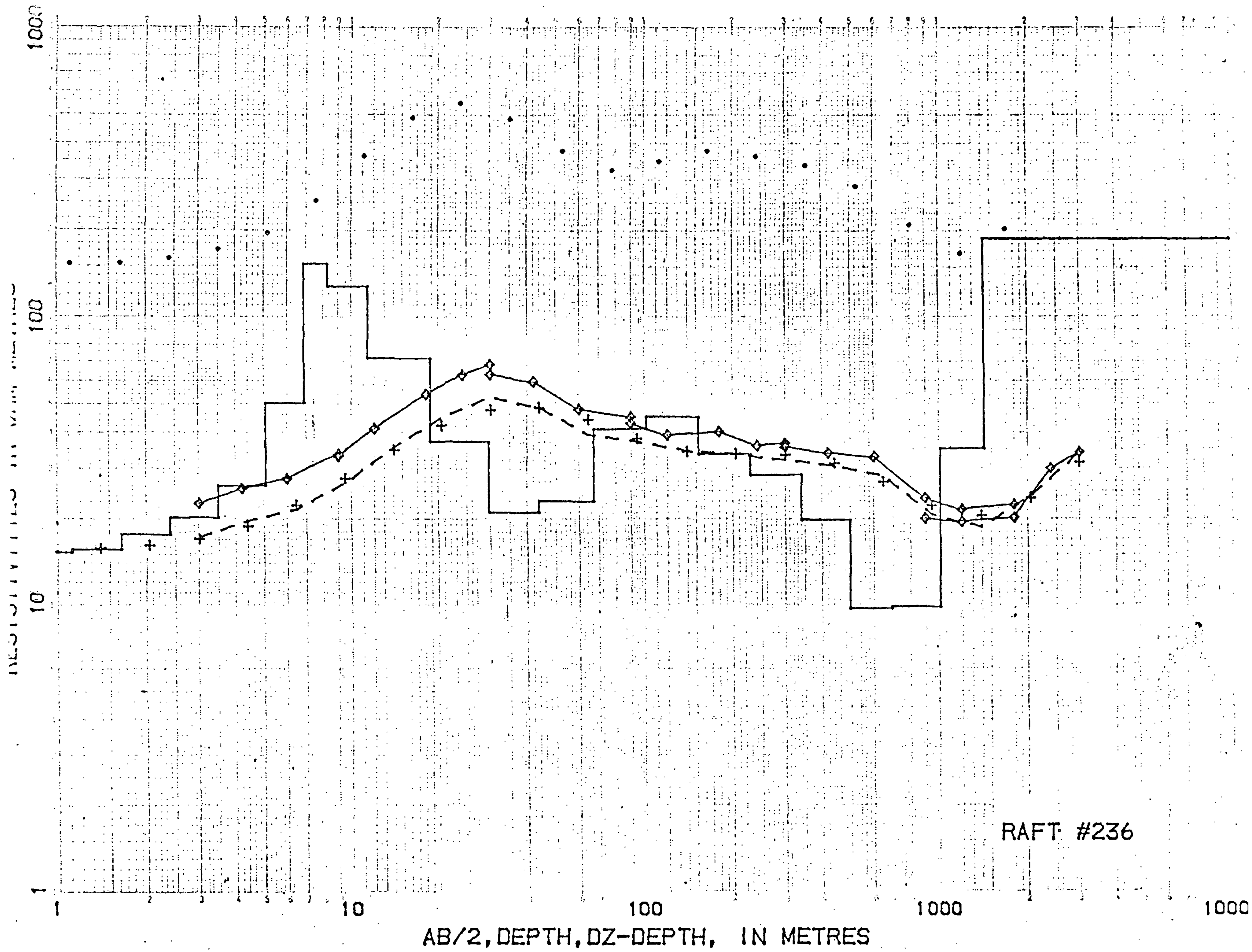


1000
100
10
1
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #233

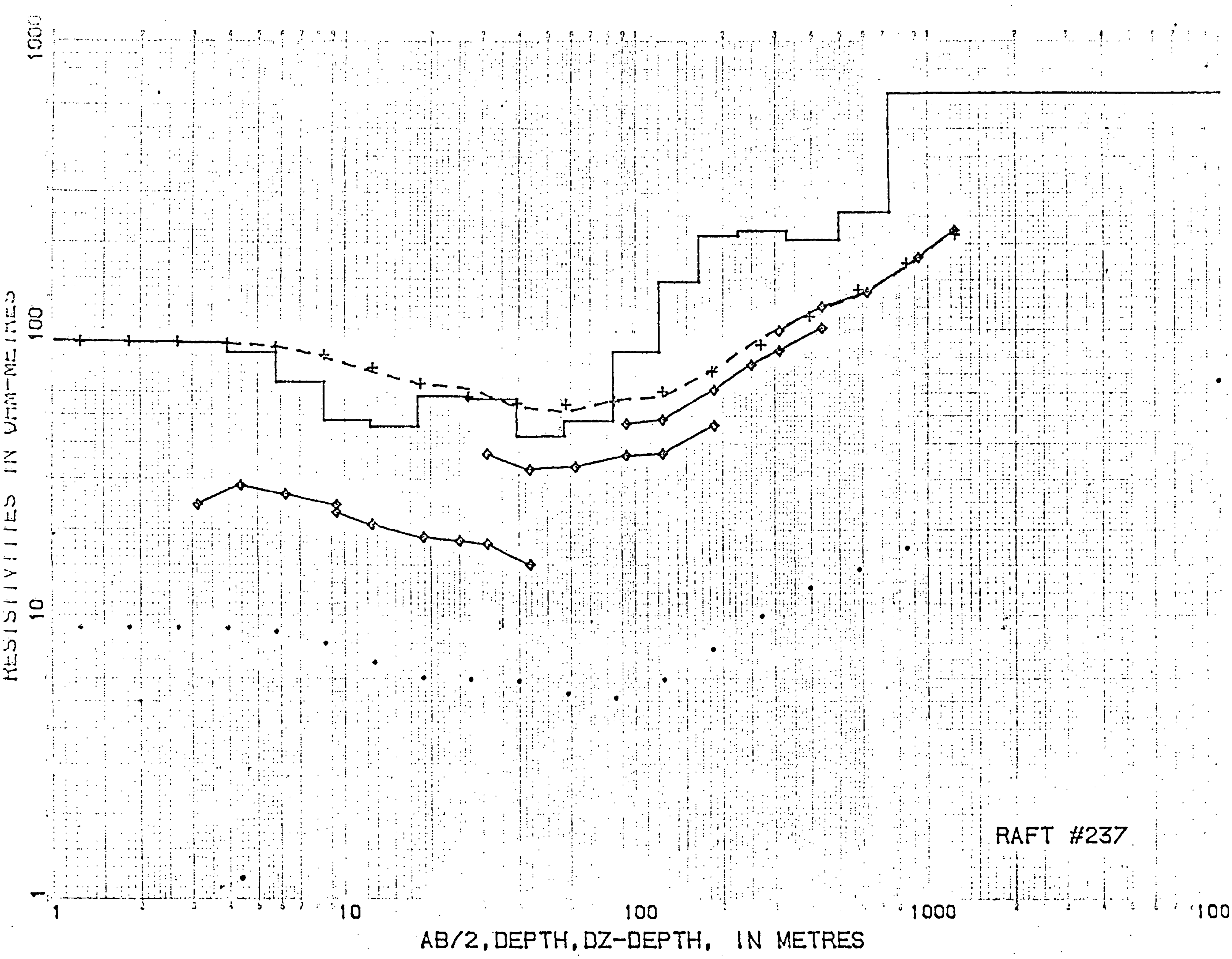

RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #234



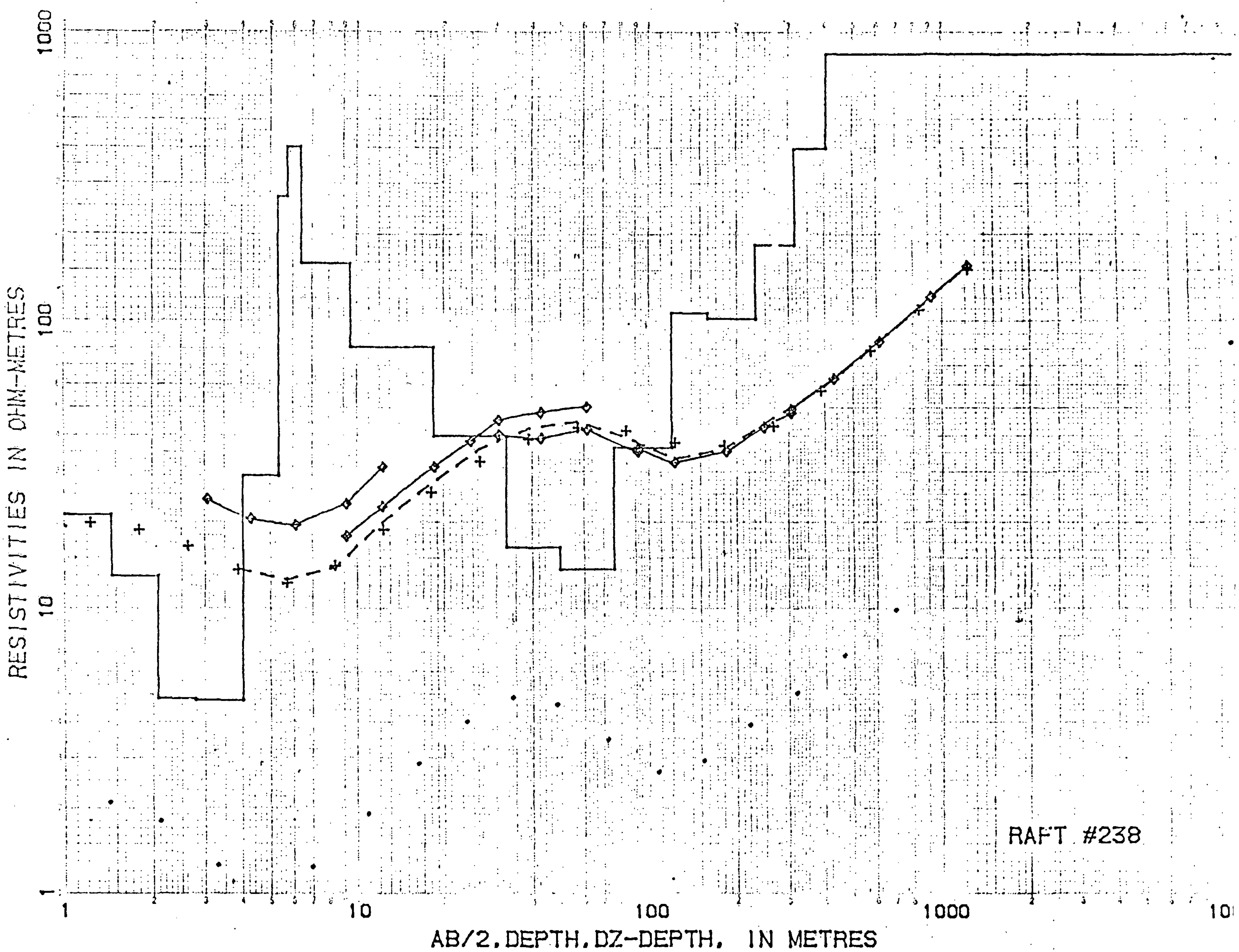
1000
100
10
1
RESISTIVITIES, IN OHM METRES
1
10
100
1000
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #235



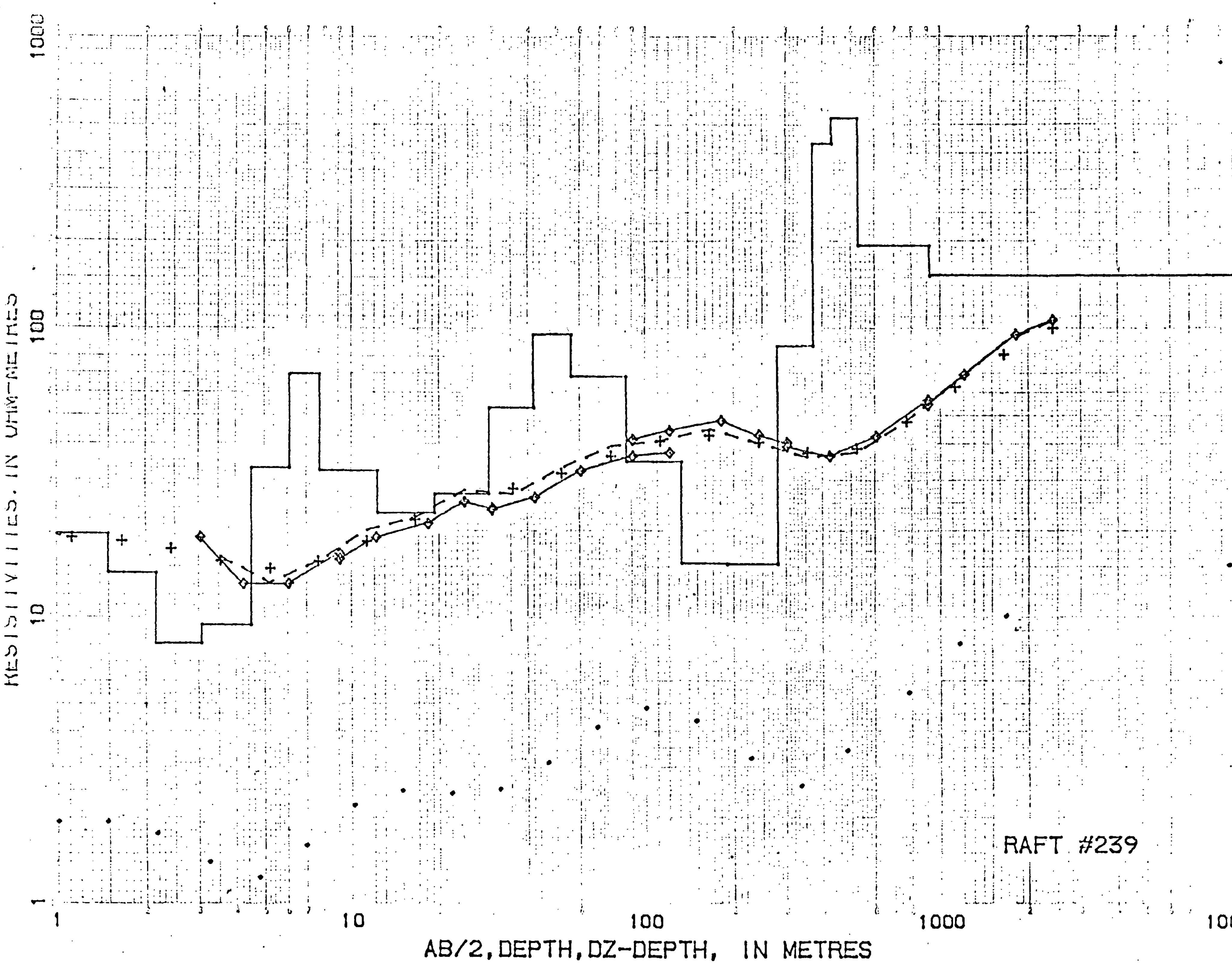
1000
100
10
1
1
10
100
1000
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #236



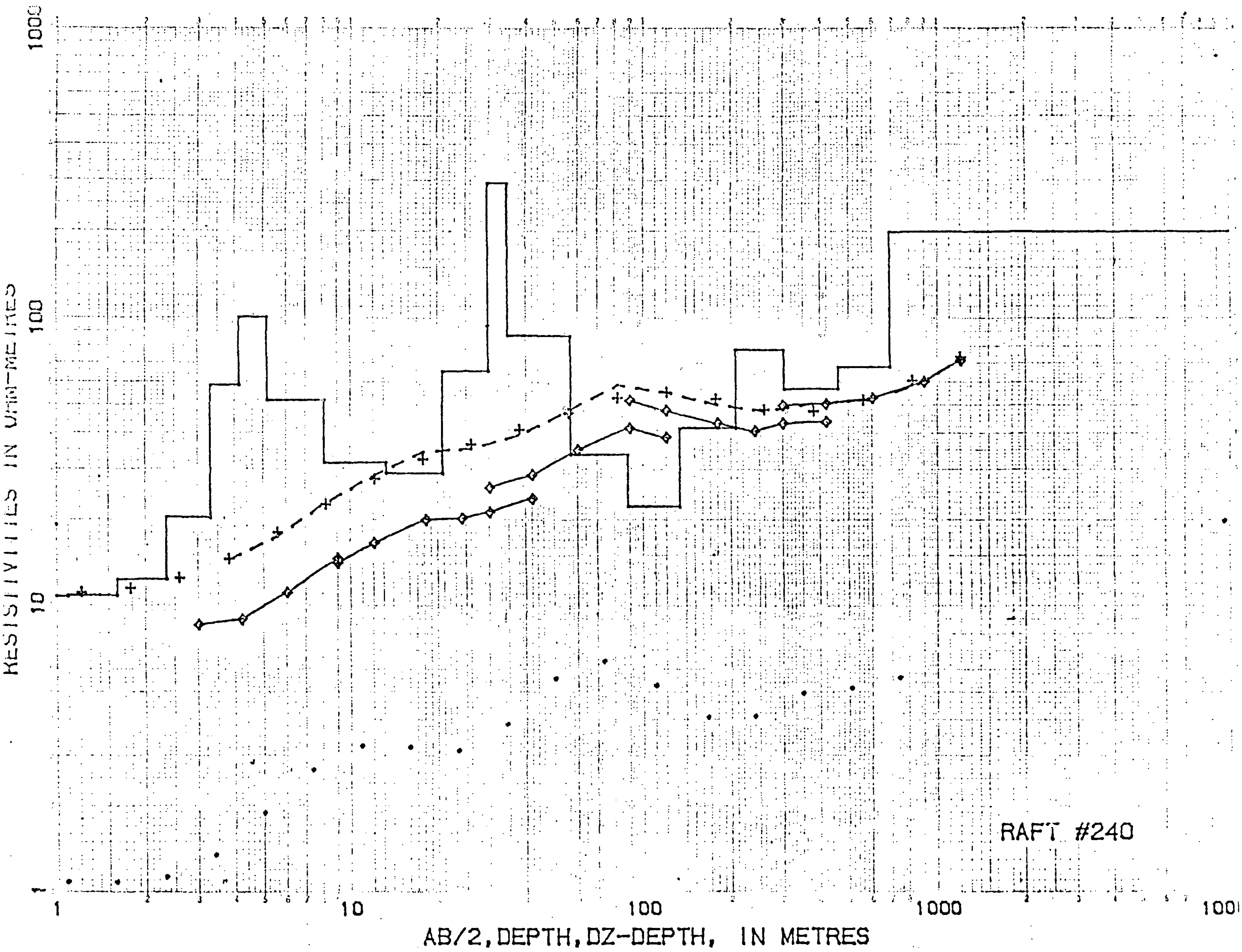
RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
100
RAFT #237
AB/2, DEPTH, DZ-DEPTH, IN METRES



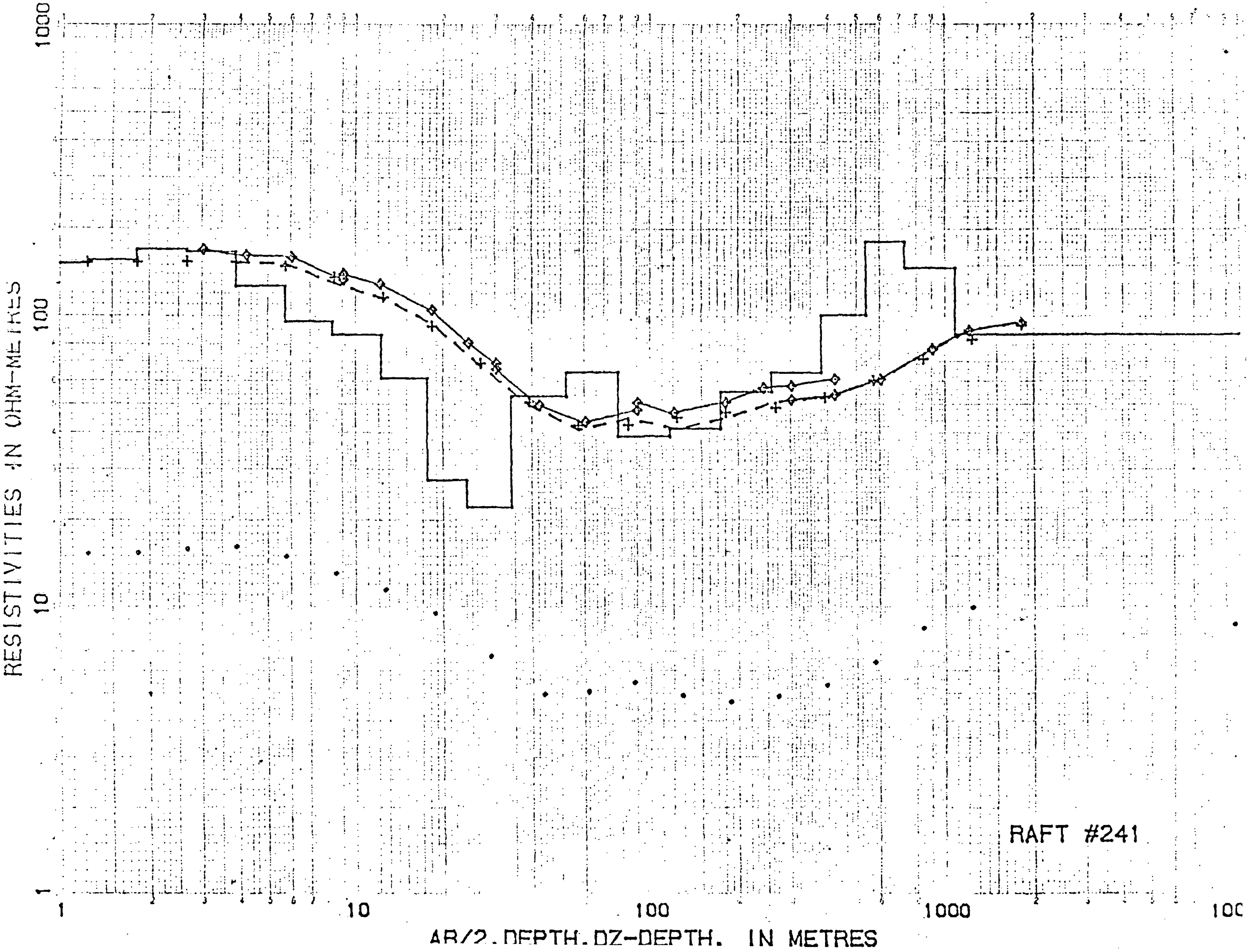
RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #238



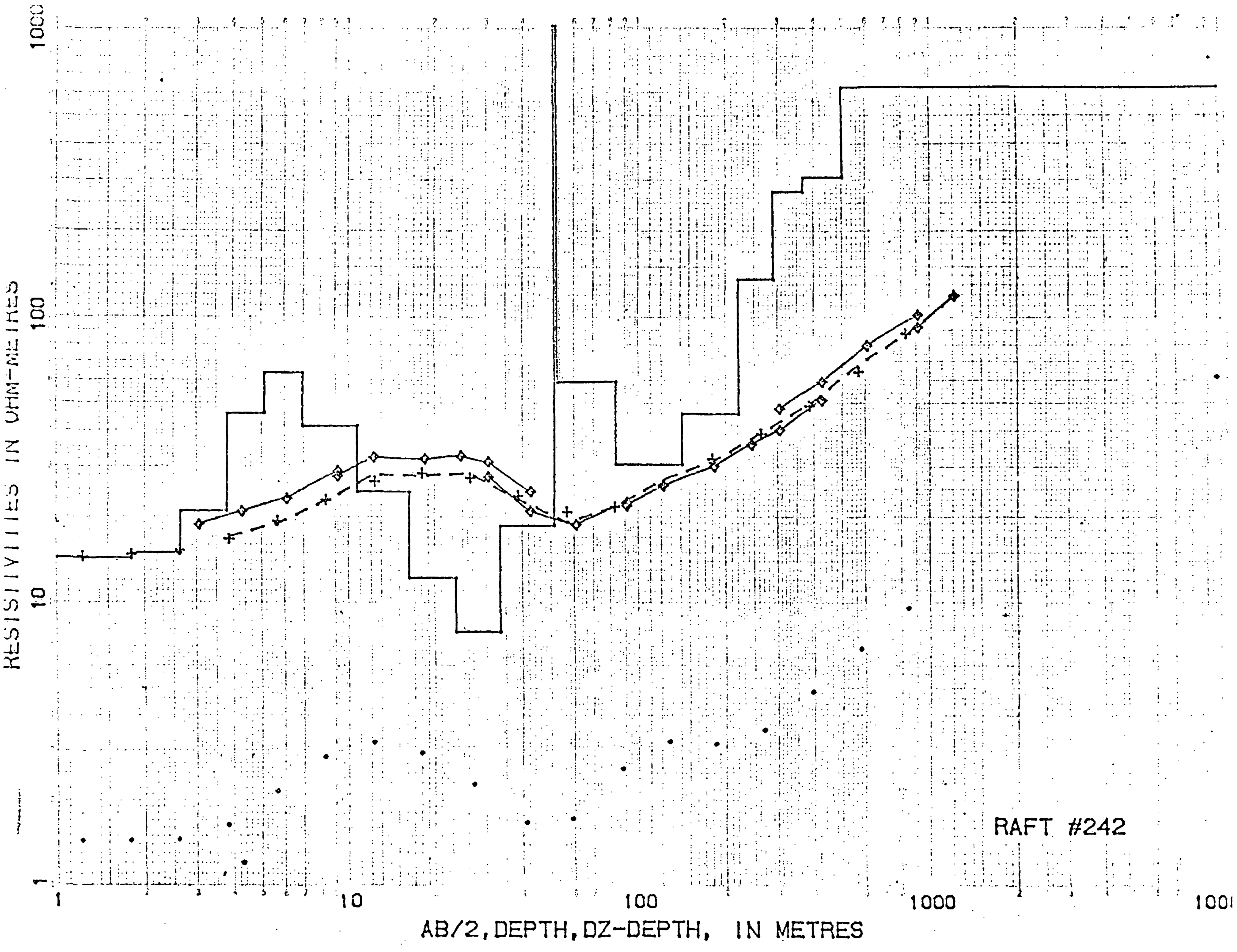
RESISTIVITIES, IN OHM-METRES
1000
100
10
1
1
10
100
1000
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #239

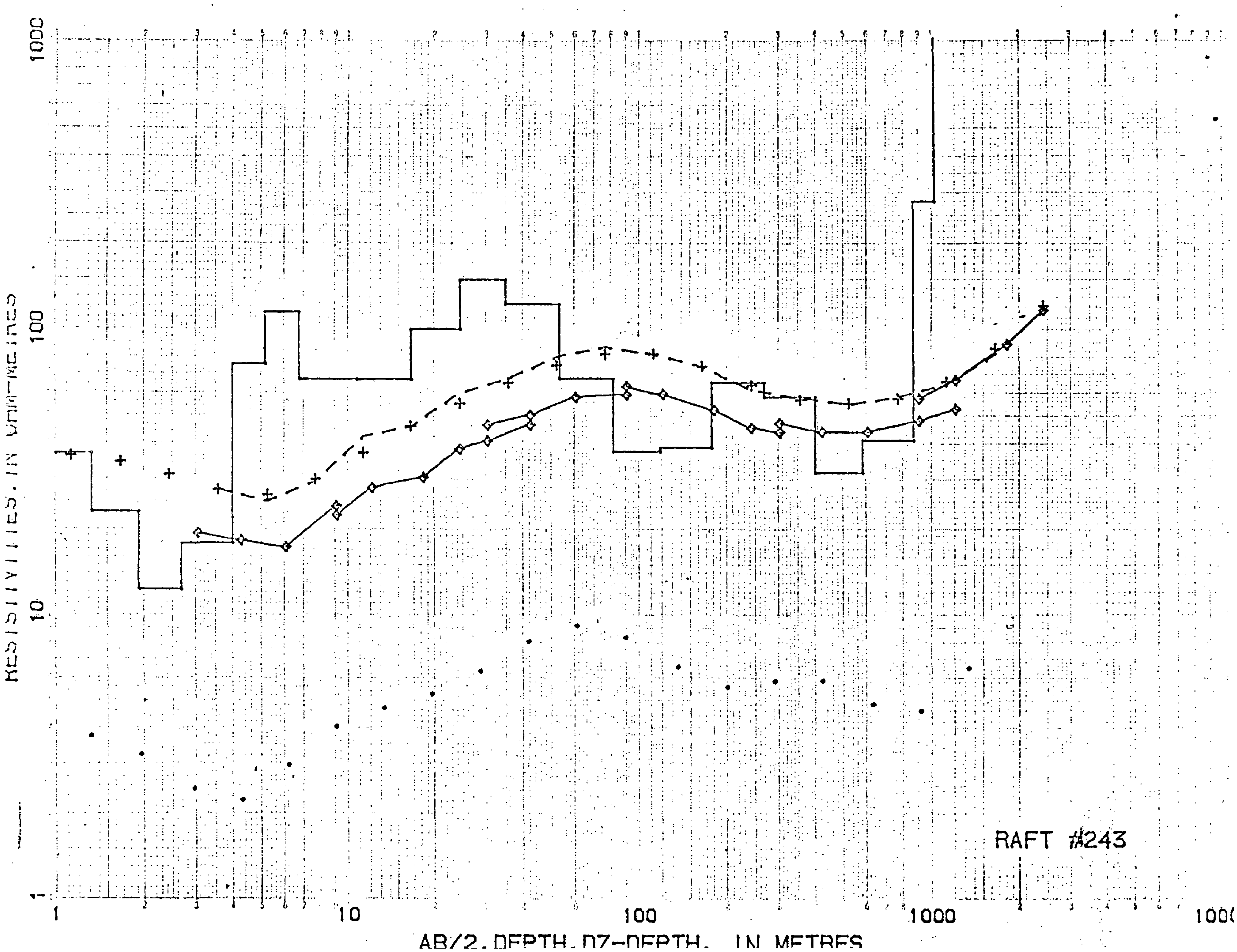


RESISTIVITIES IN OHM-METRES
1000
100
10
1
10
100
1000
RAFT #240
AB/2, DEPTH, DZ-DEPTH, IN METRES

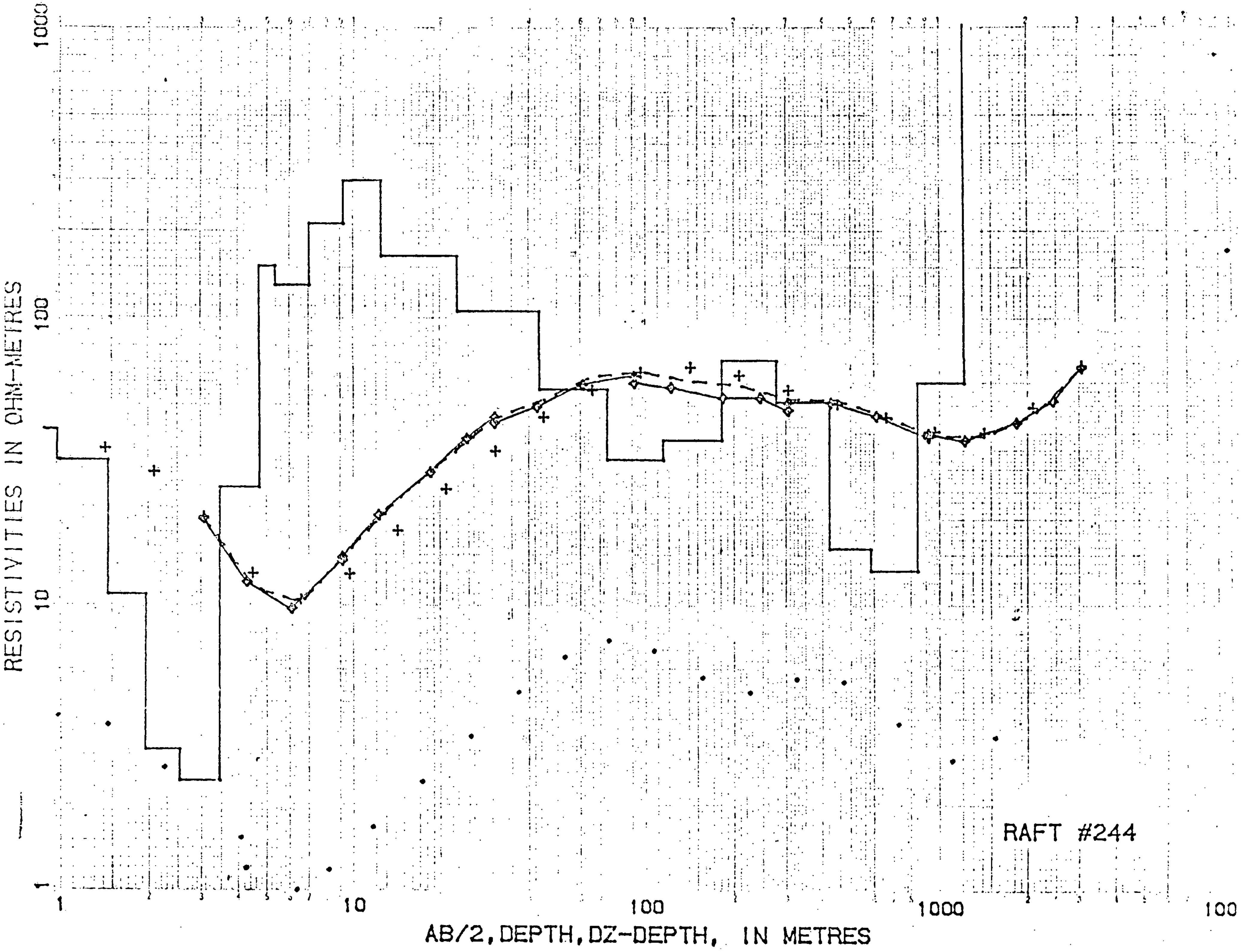


RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #241

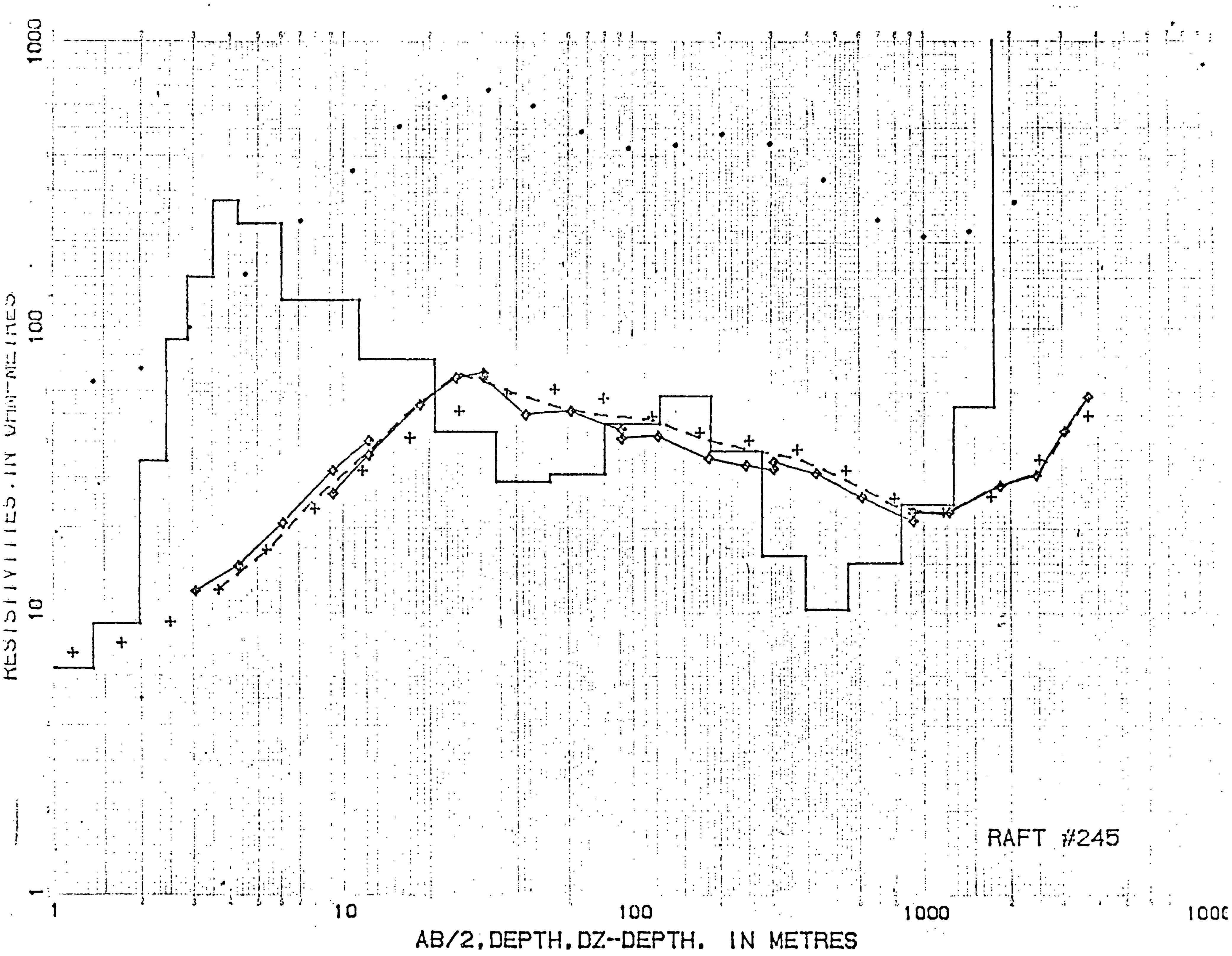

RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #242



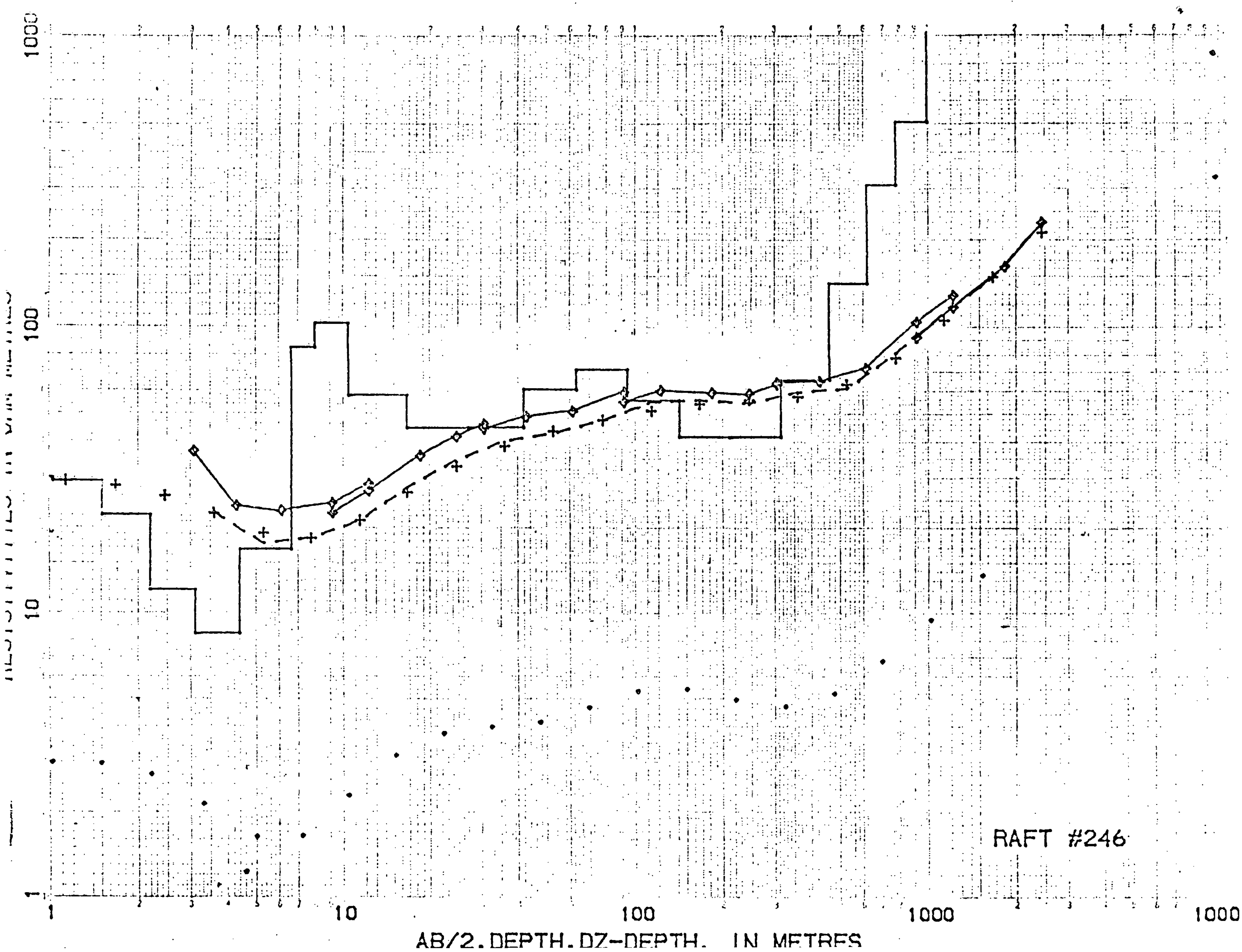
1000
100
10
RESISTIVITIES, IN OHM-METRES
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #243



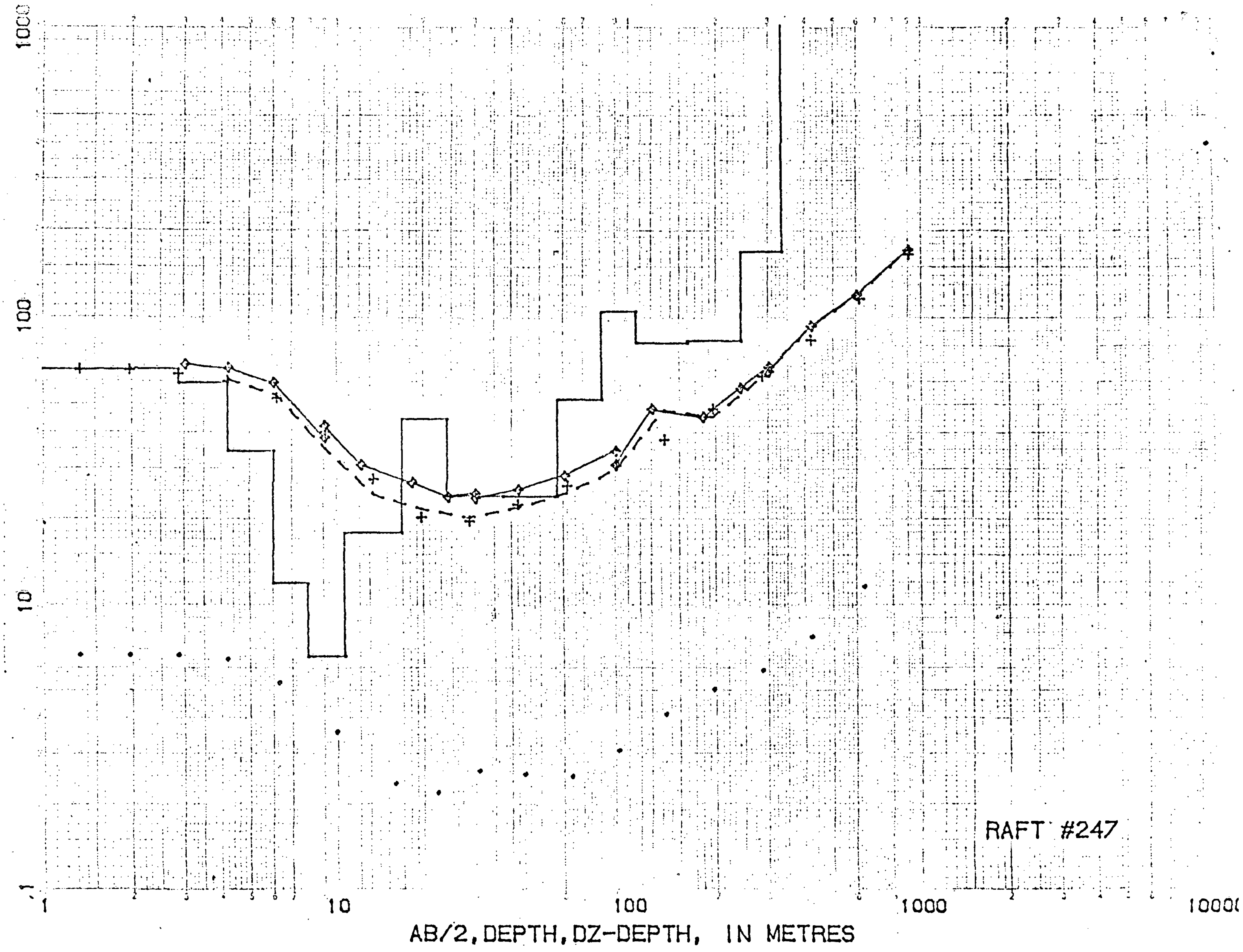
1000
100
10
1
RESISTIVITIES IN OHM-METRES
1
10
100
1000
100
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #244



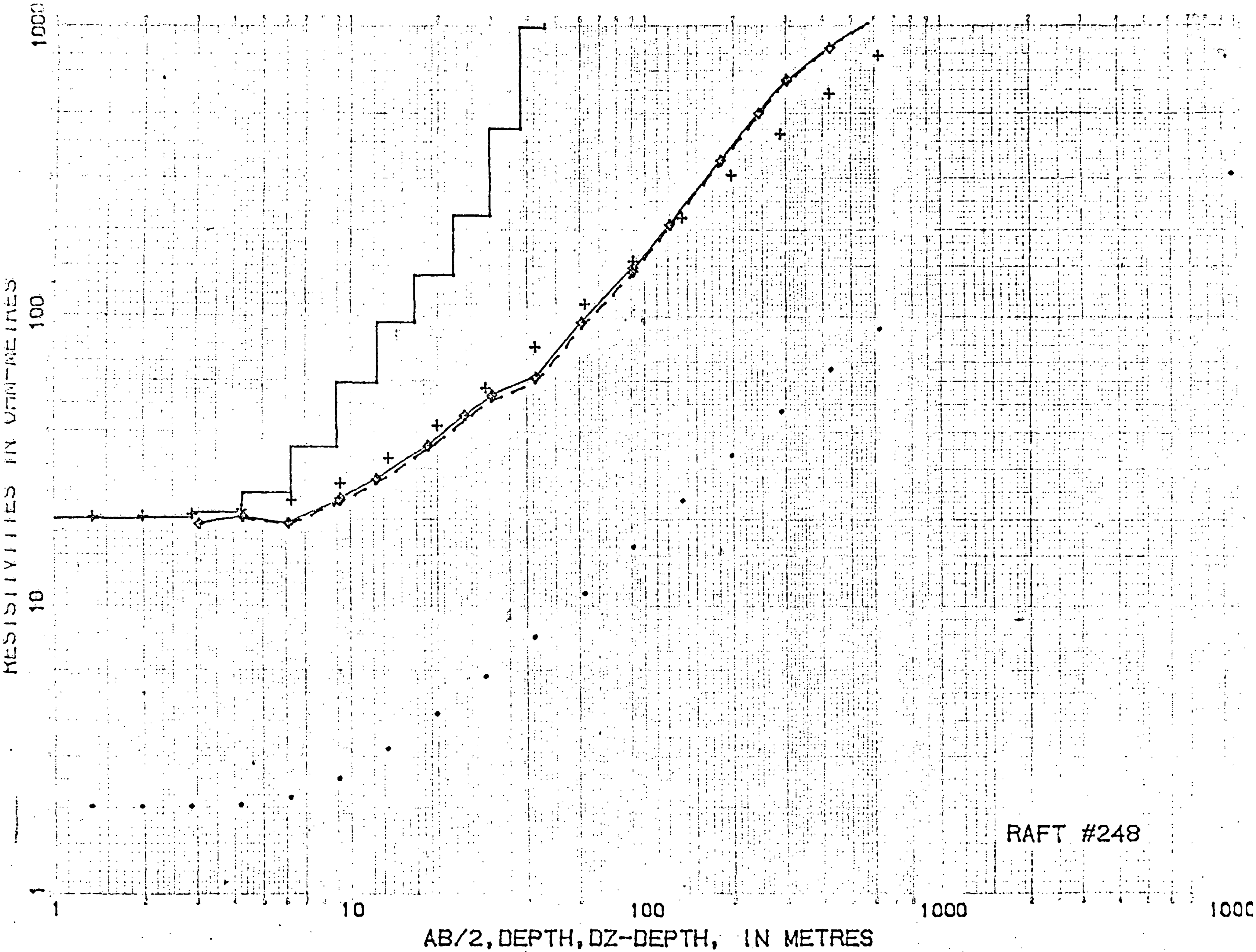
RESISTIVITIES, IN OHM-METRES
1000
100
10
1
1
10
100
1000
10000
RAFT #245
AB/2, DEPTH, DZ-DEPTH, IN METRES



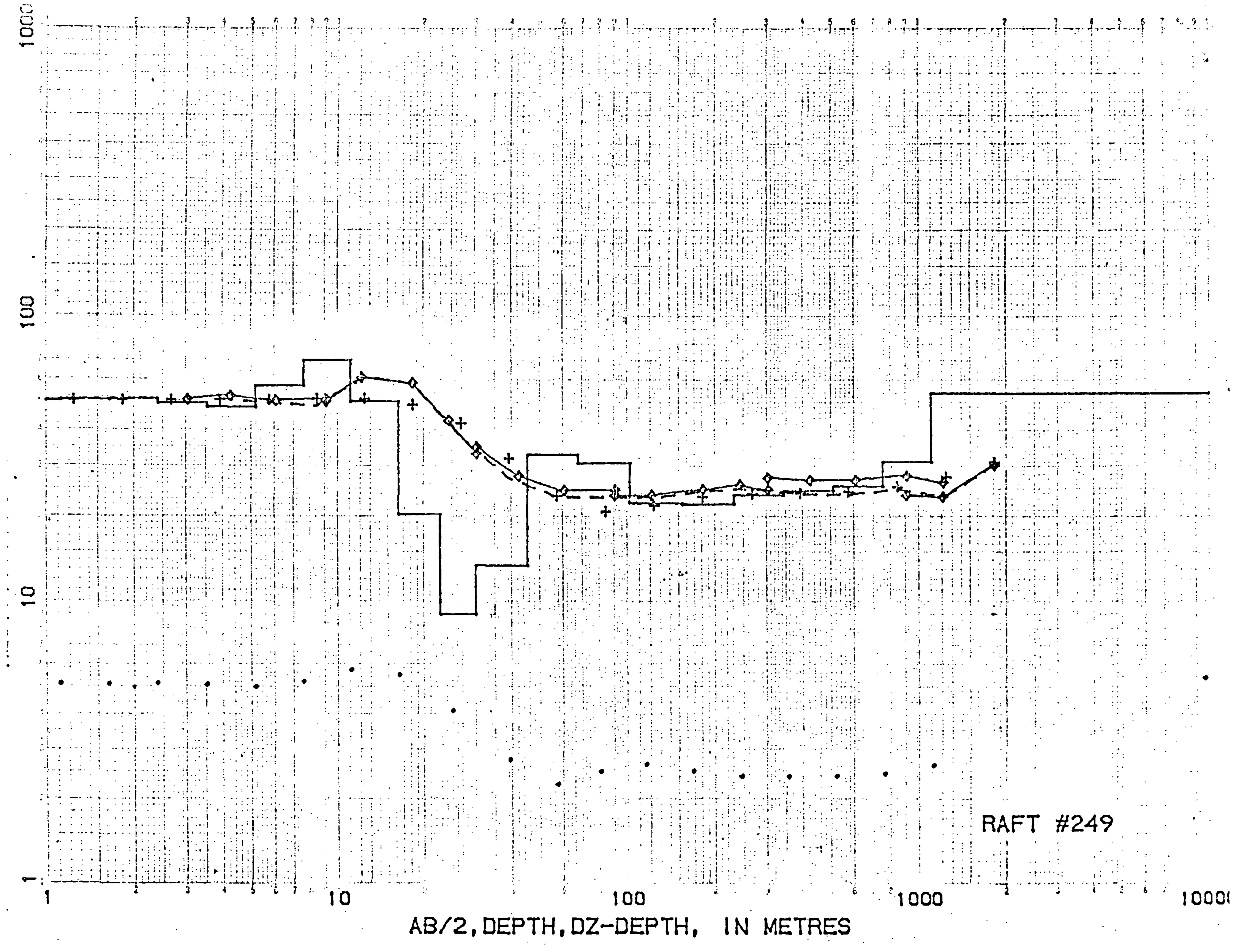
1000
100
10
1
1
10
100
1000
1000
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAFT #246



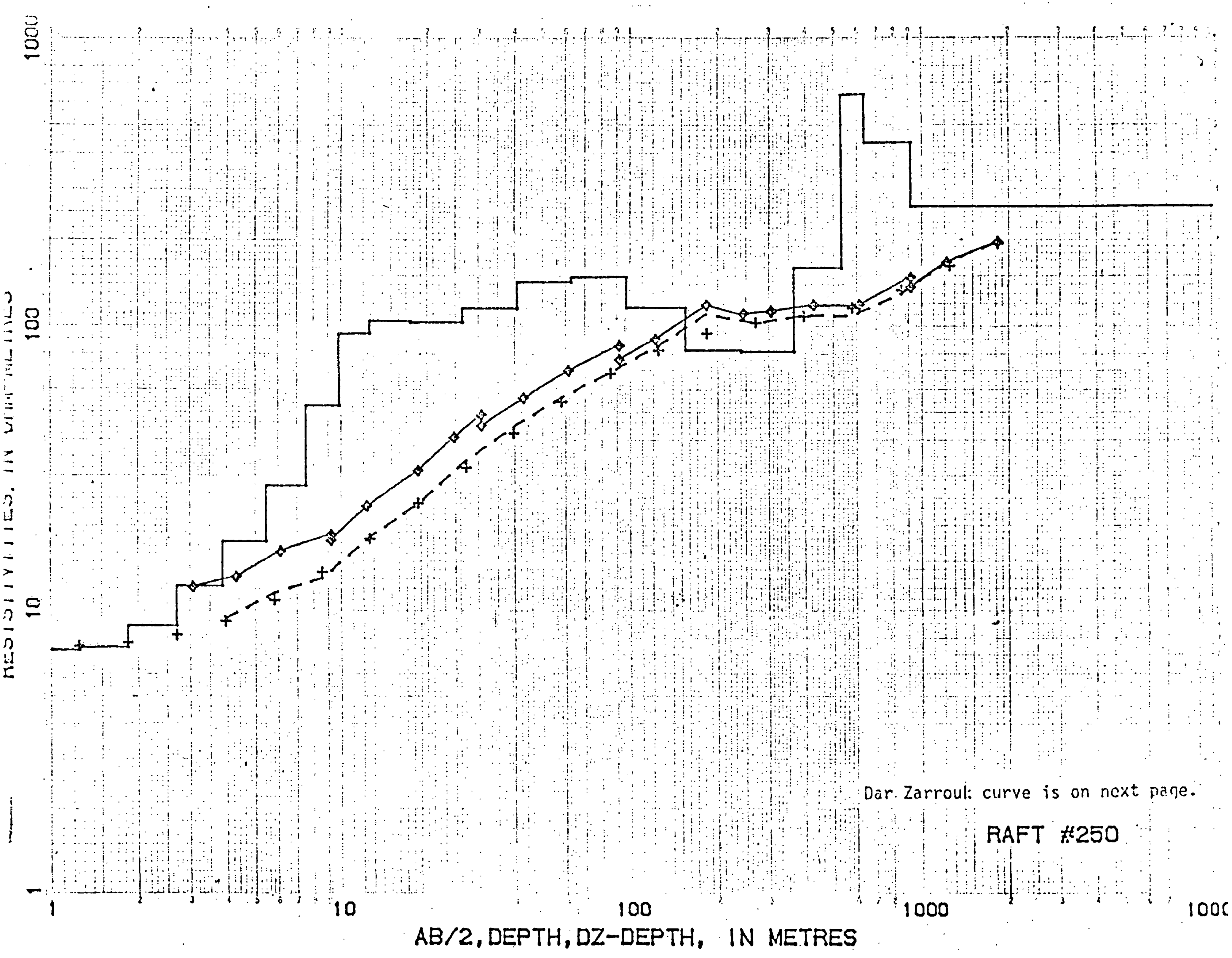
1000
100
10
1
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #247



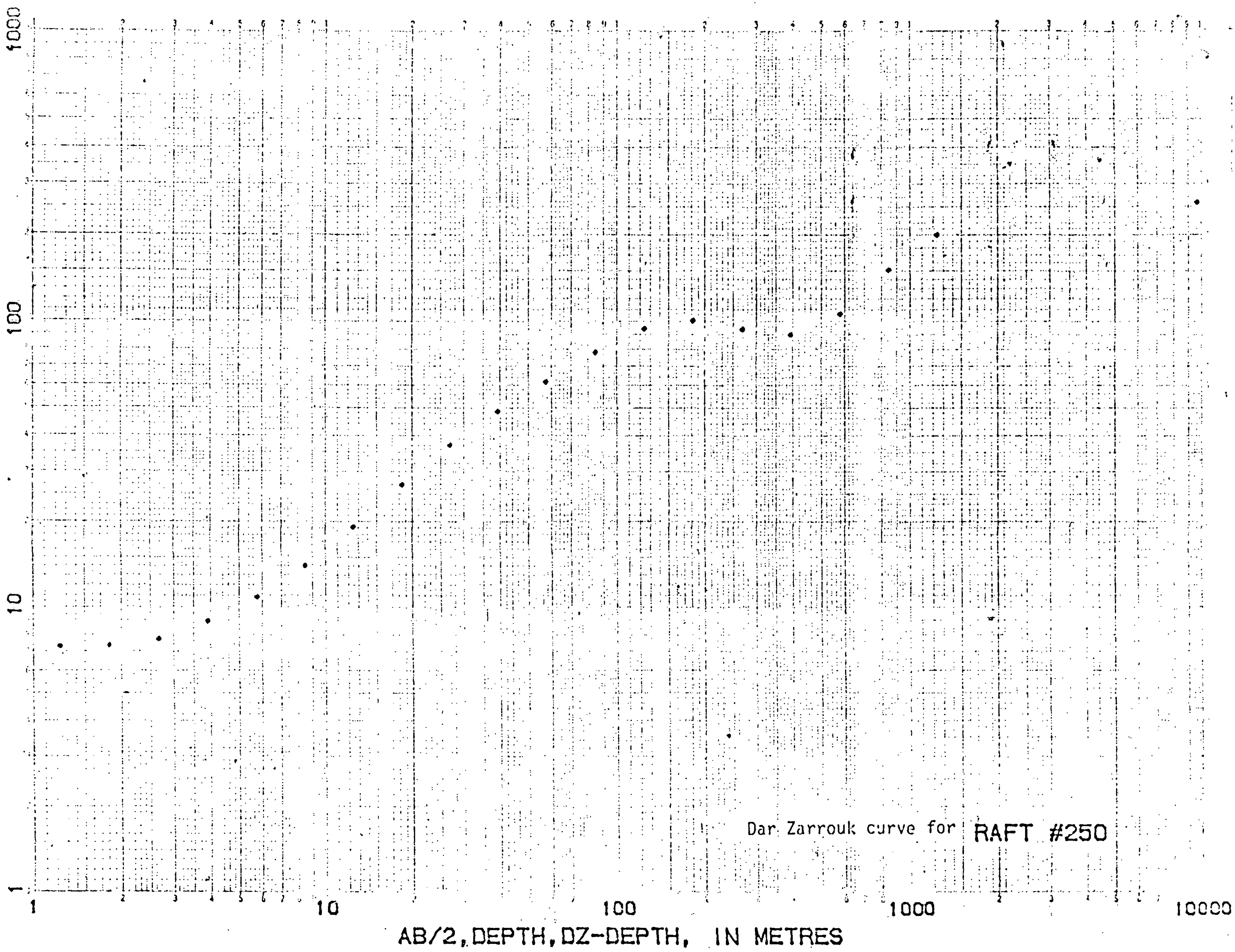
RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #248



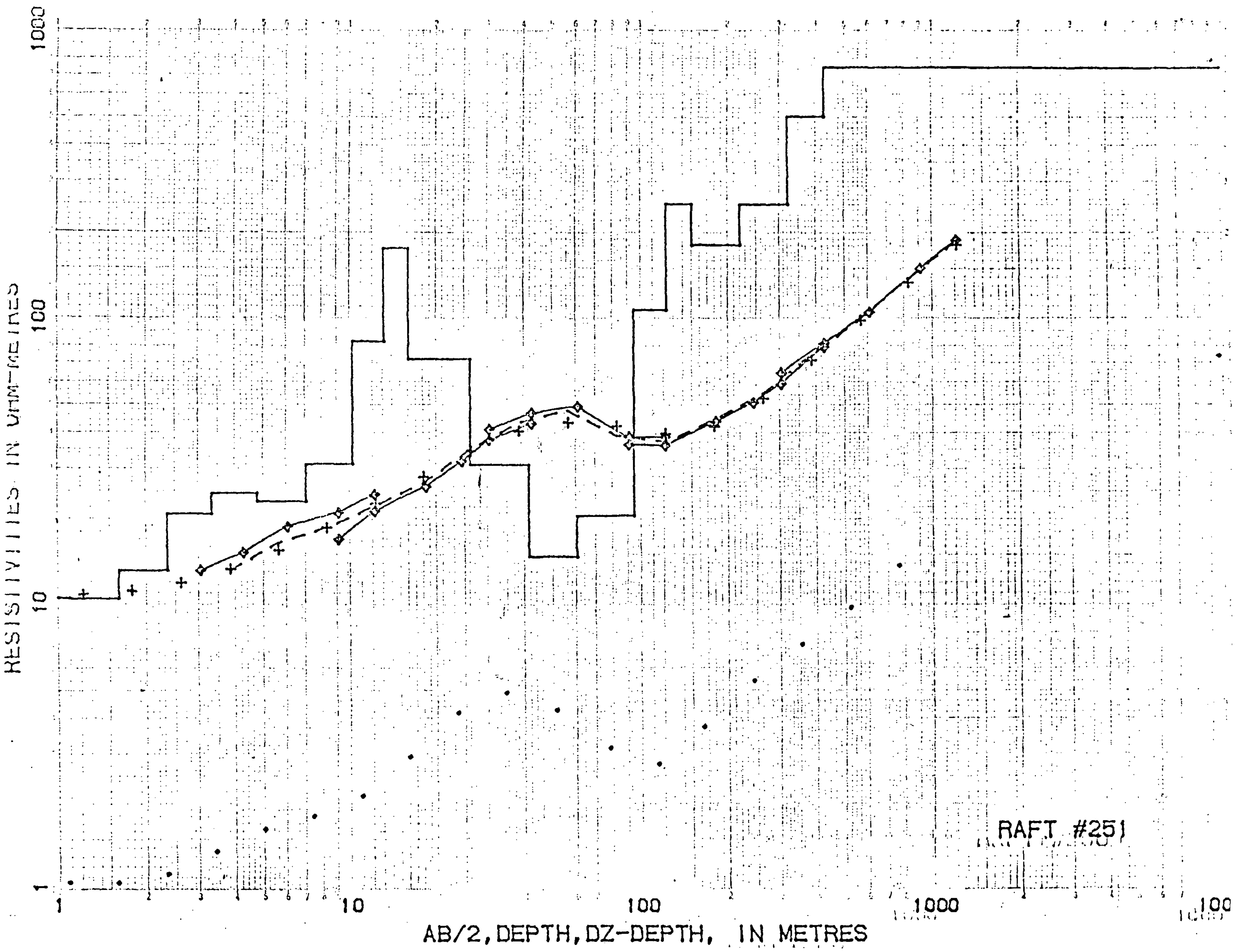
1000
100
10
1
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #249



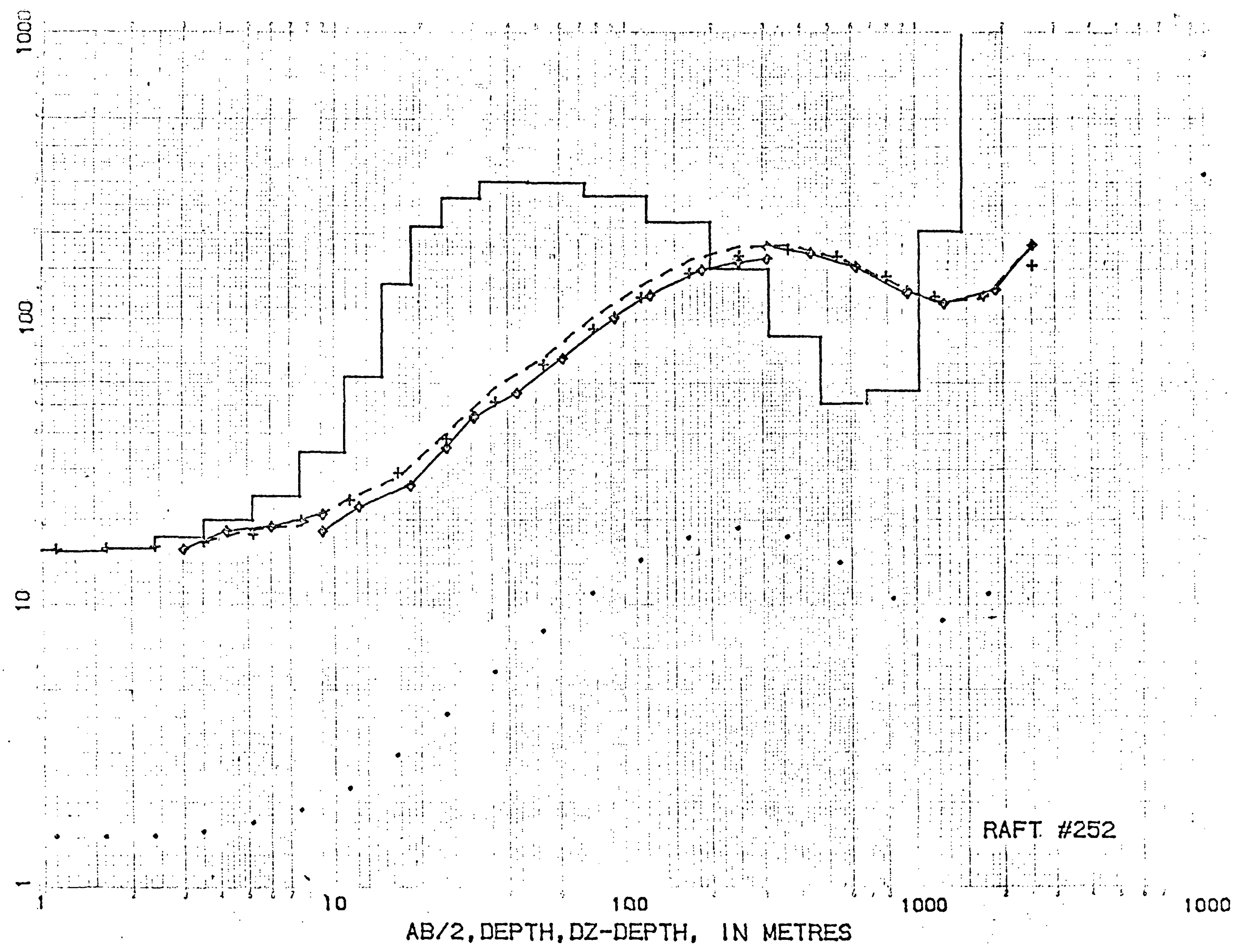
1000
100
10
1
RESISTIVITIES, IN OHM-METRES
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
Dar Zarrouk curve is on next page.
RAFT #250



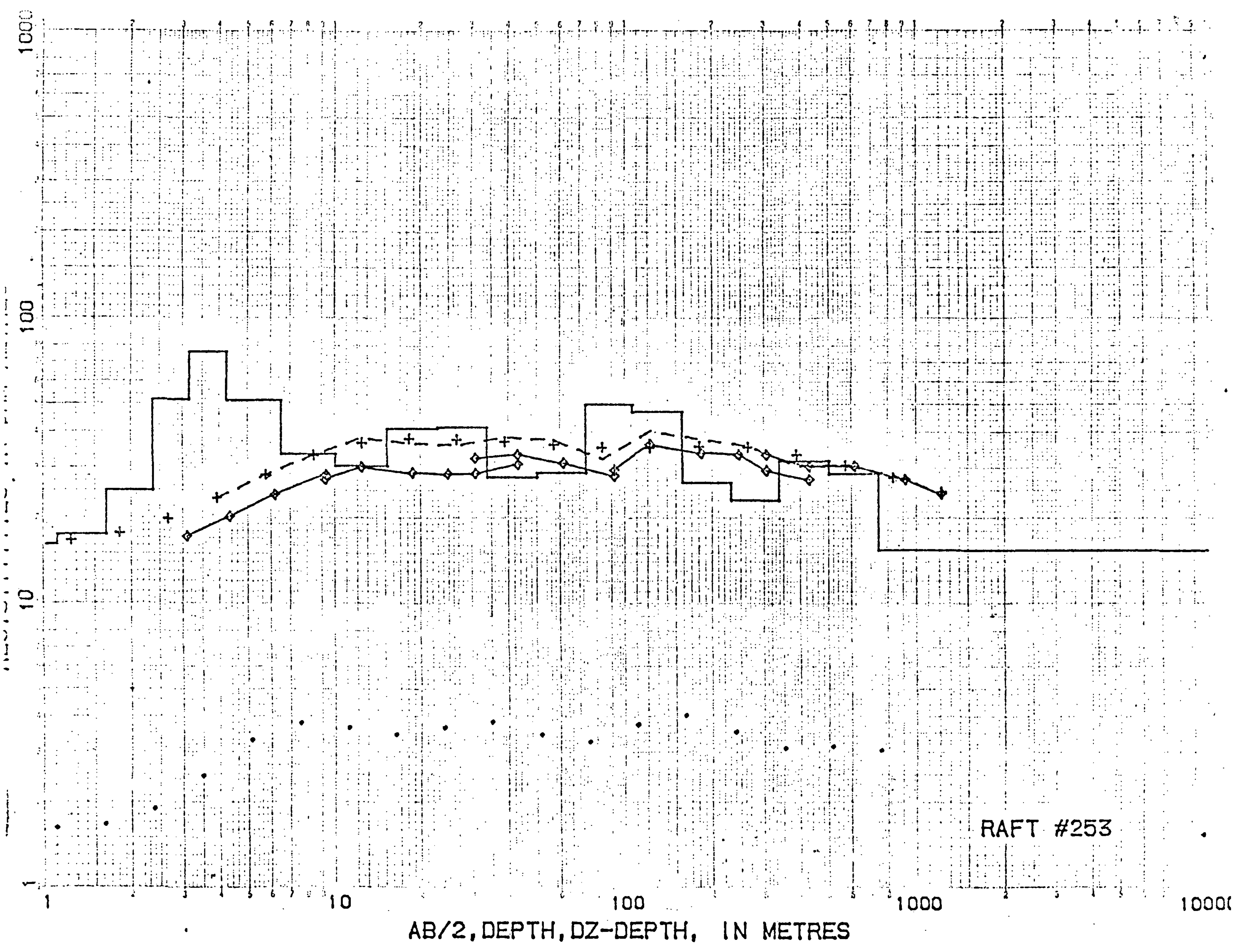
1000
100
10
1
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
Dar Zarrouk curve for RAFT #250

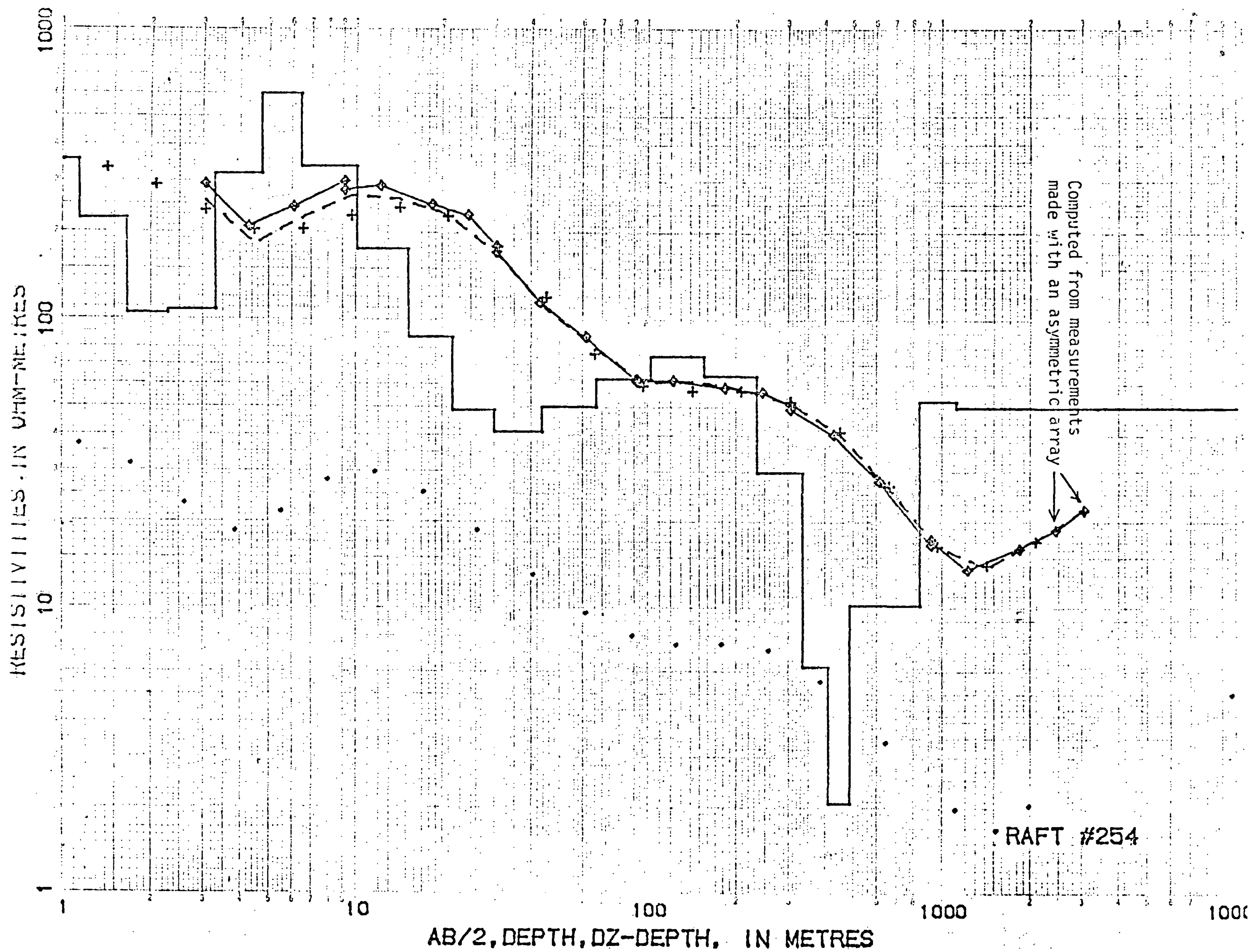


RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #251

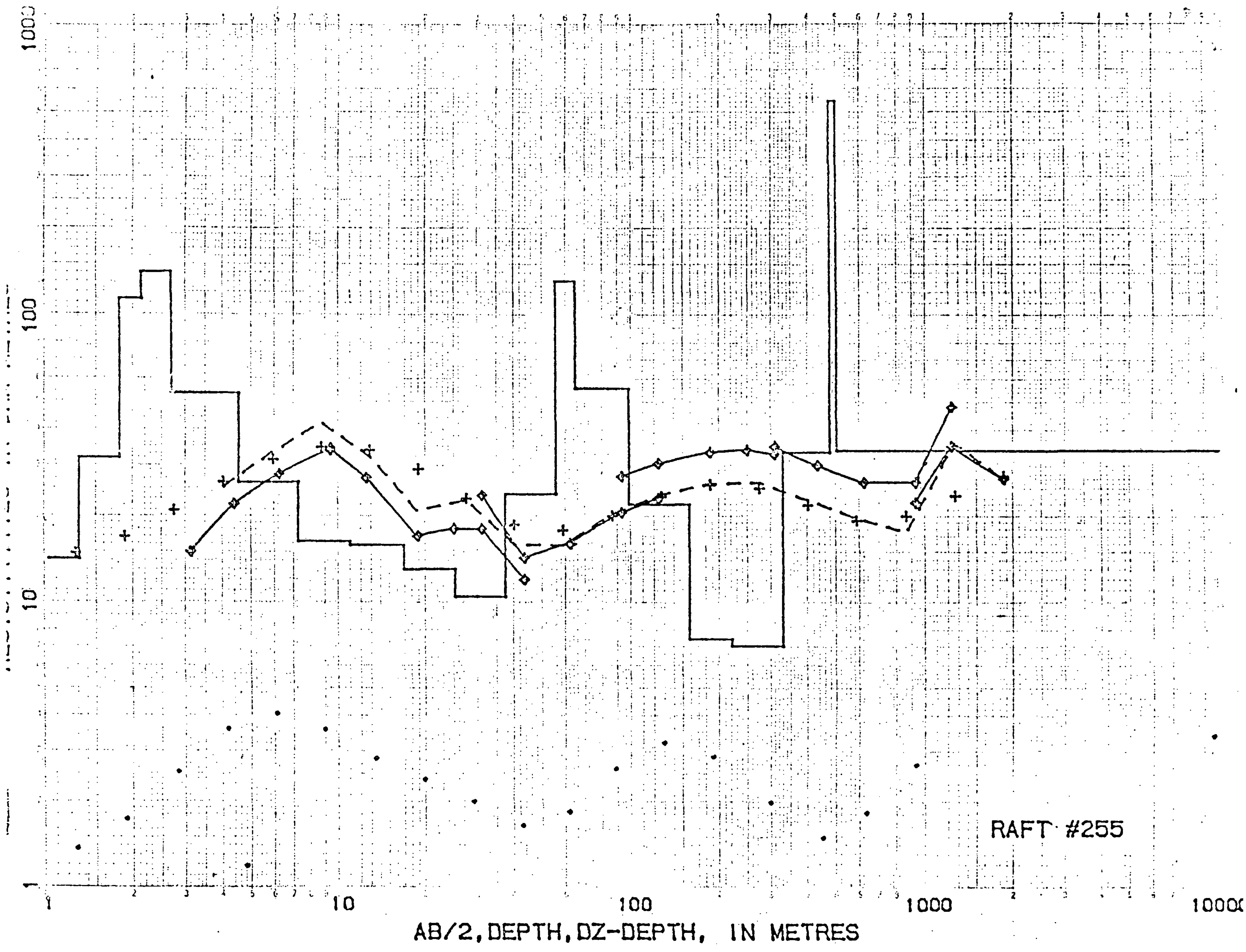


1000
100
10
1
1
10
100
1000
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #252

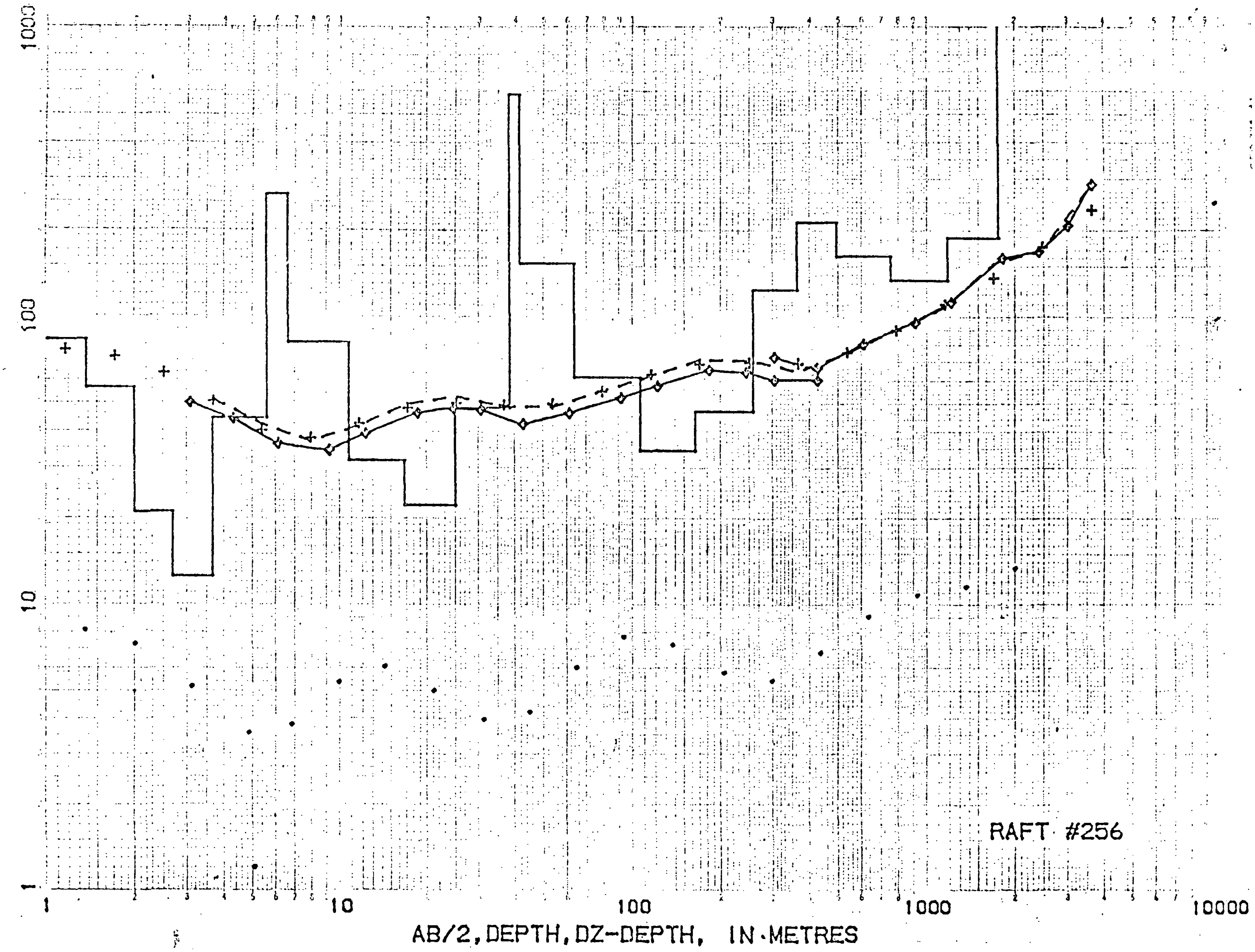

1000
100
10
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #253



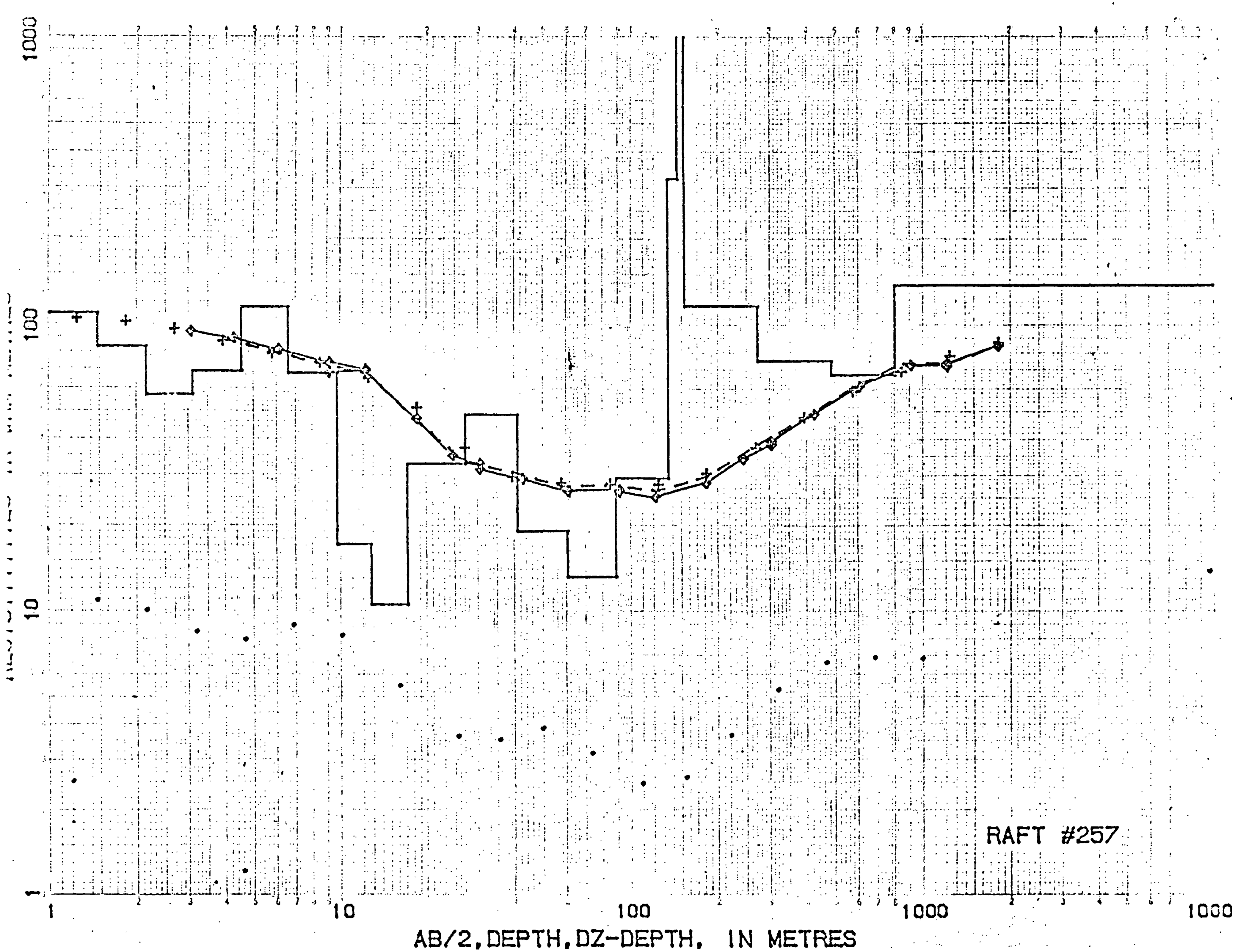
RESISTIVITIES IN OHM-METRES
1000
100
10
1
AB/2, DEPTH, DZ-DEPTH, IN METRES
1
10
100
1000
Computed from measurements
made with an asymmetric array
RAFT #254



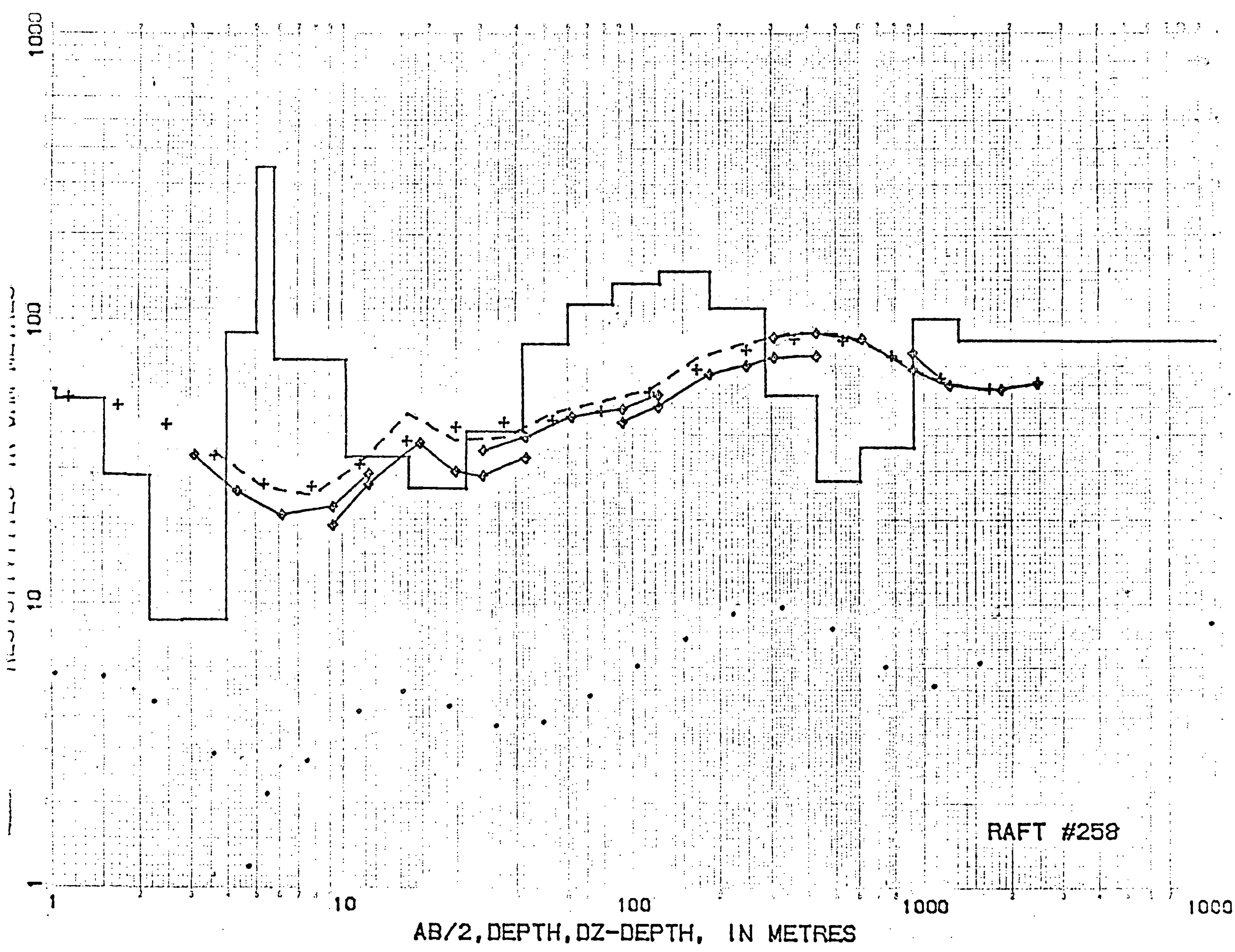
1000
100
10
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #255

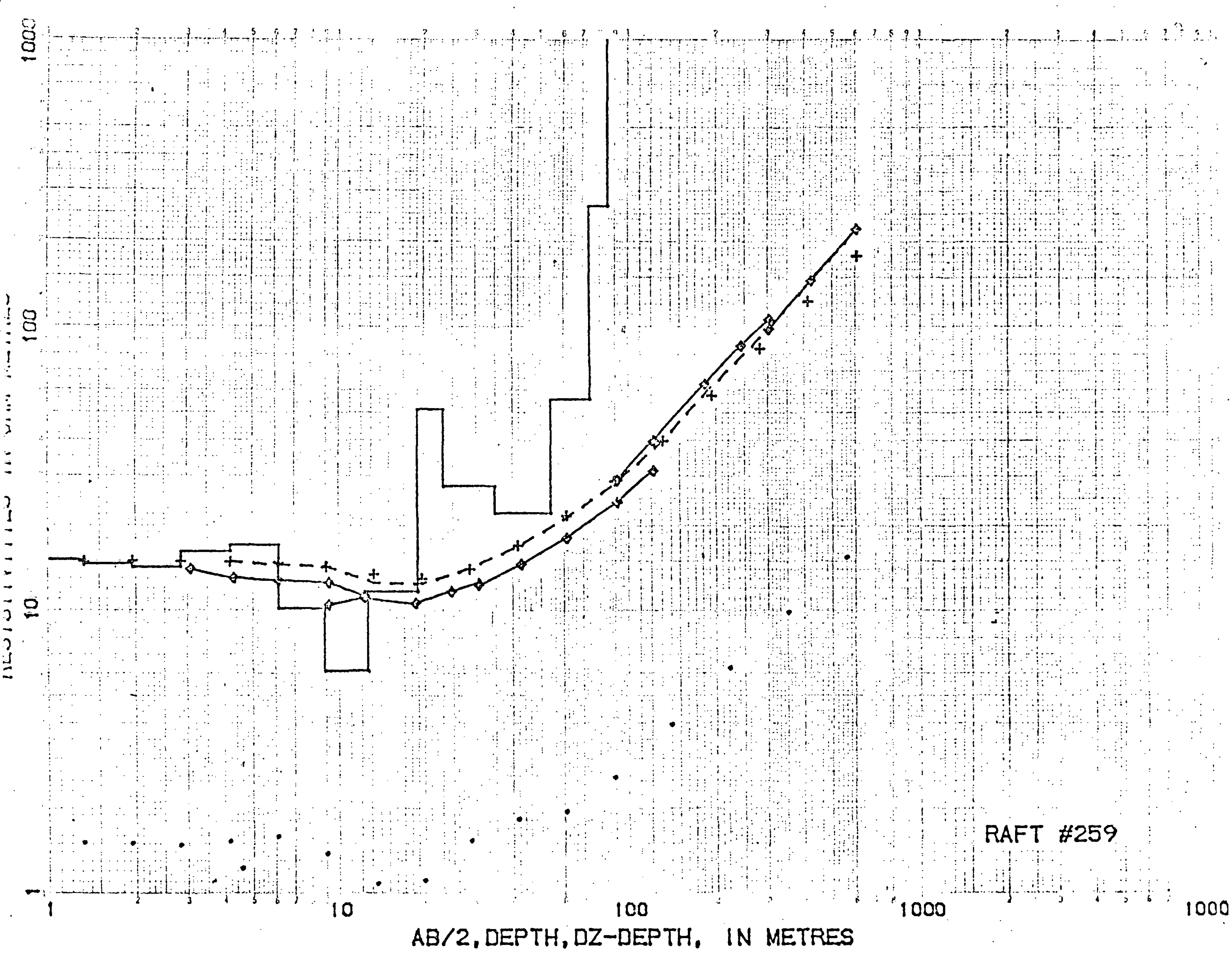


1000
100
10
1
1
10
100
1000
10000
RAFT #256
AB/2, DEPTH, DZ-DEPTH, IN METRES

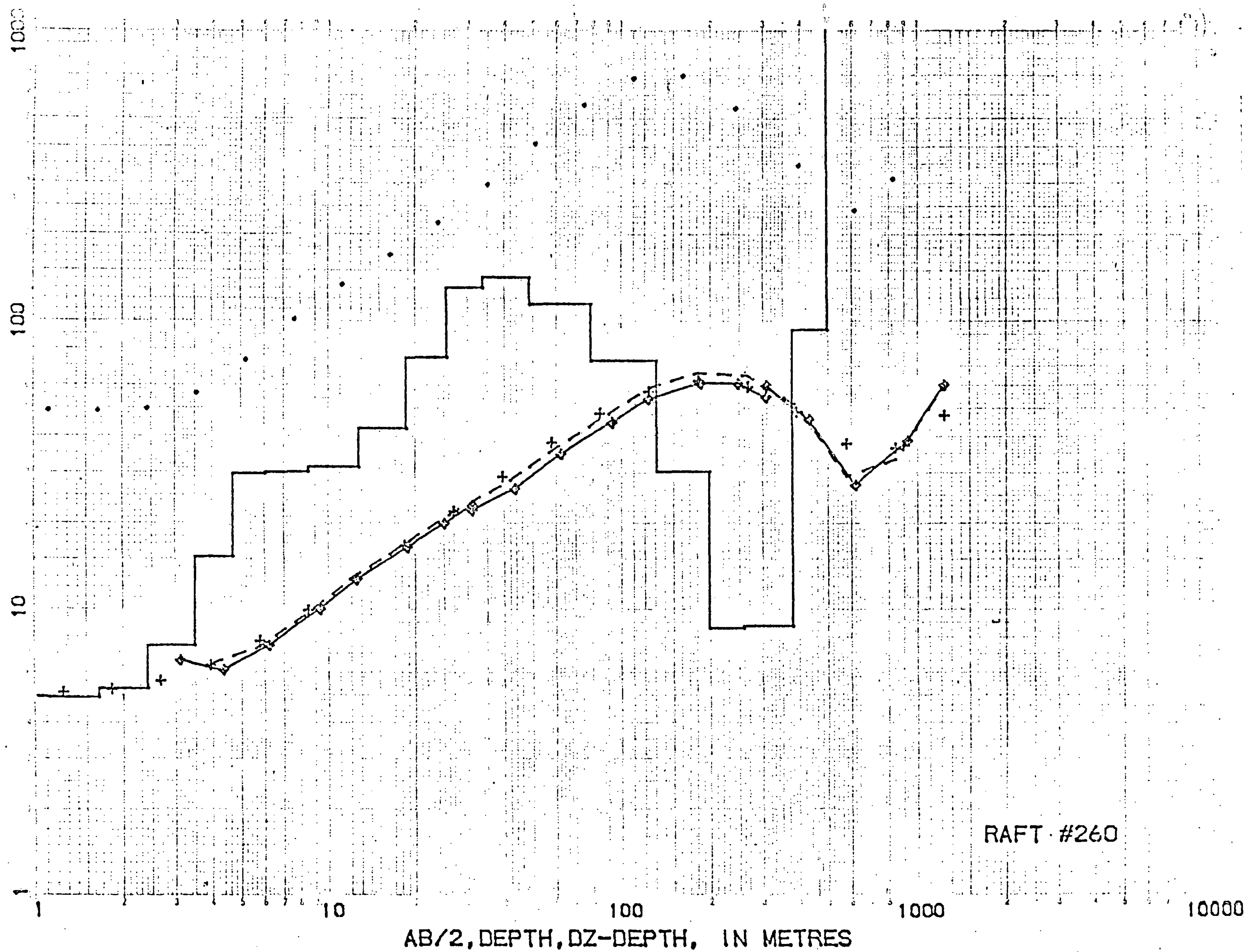


1000
100
10
1
RAFT #257
1
10
100
1000
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES

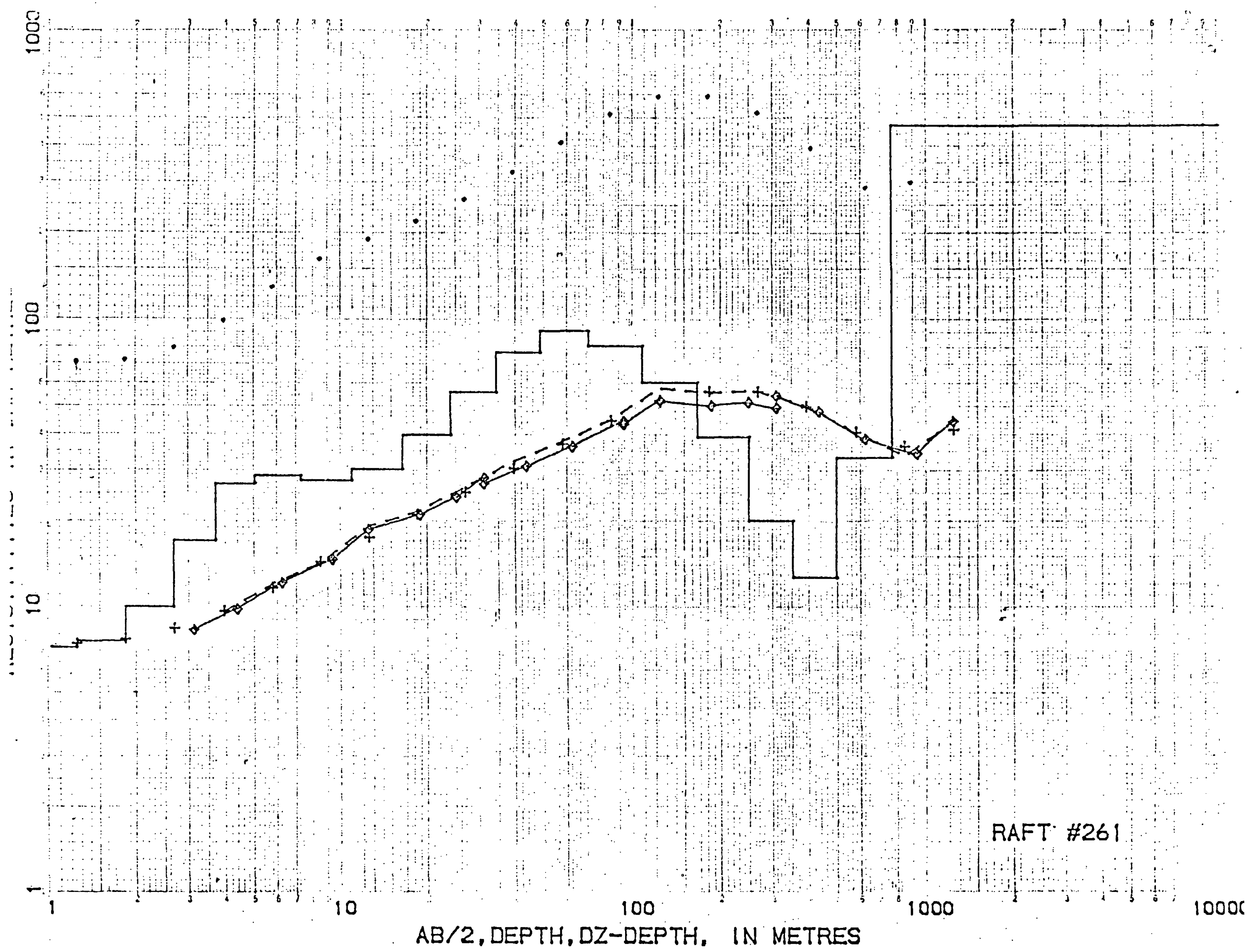

1000
100
10
1
1
10
100
1000
1000
AB/2,DEPTH,DZ-DEPTH, IN METRES
RAFT #258



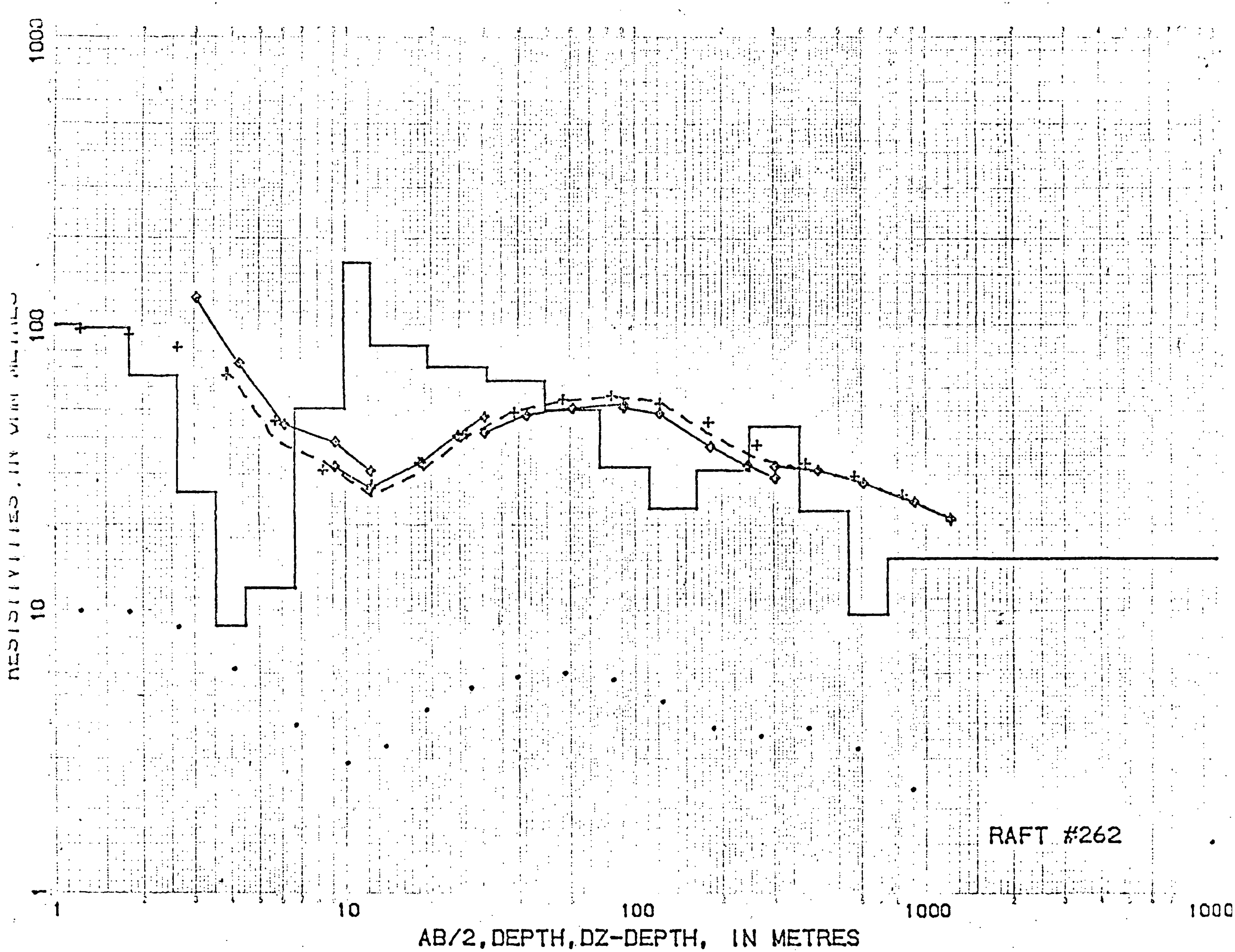
RAFT #259
AB/2, DEPTH, DZ-DEPTH, IN METRES
1
10
100
1000
10
100
1000

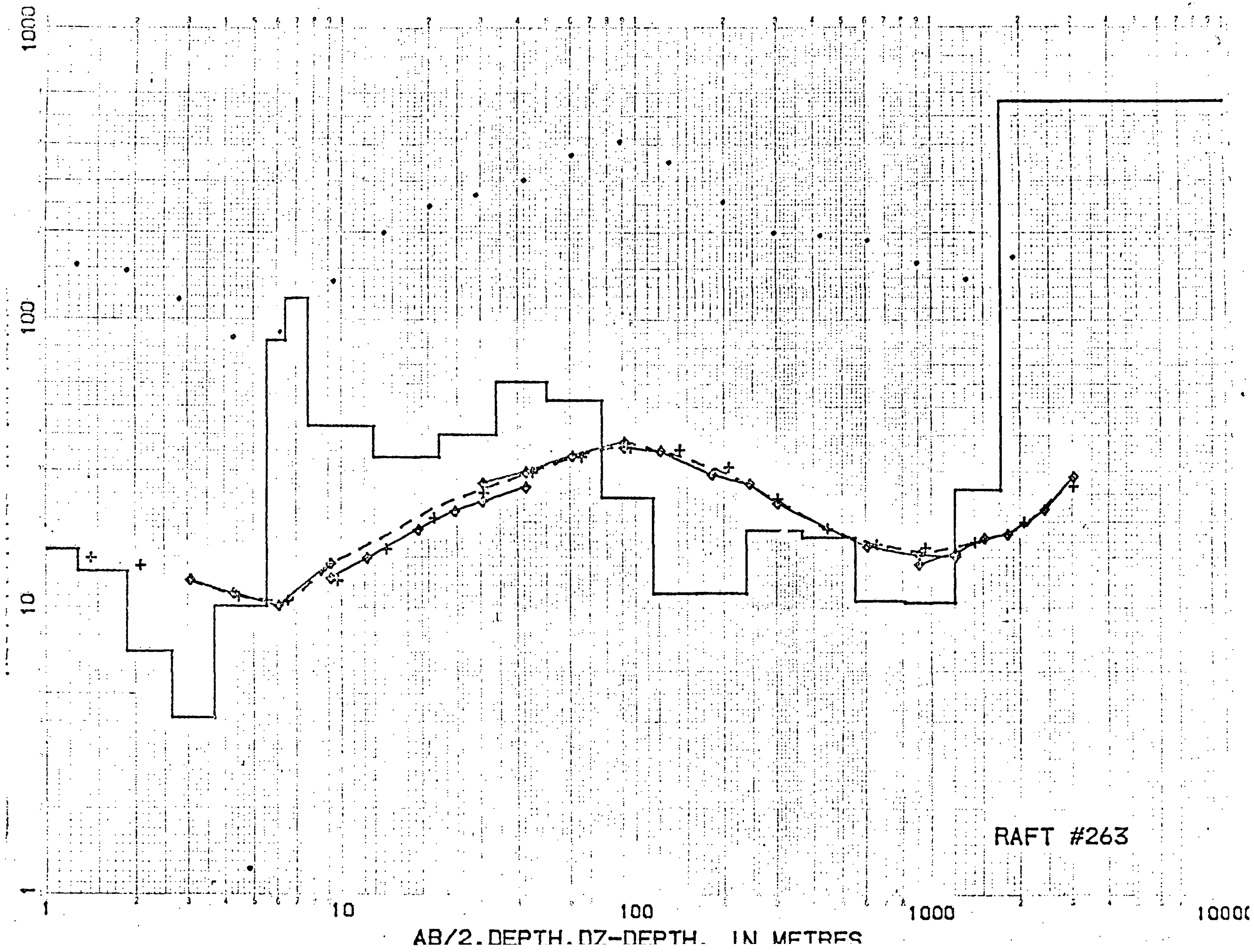


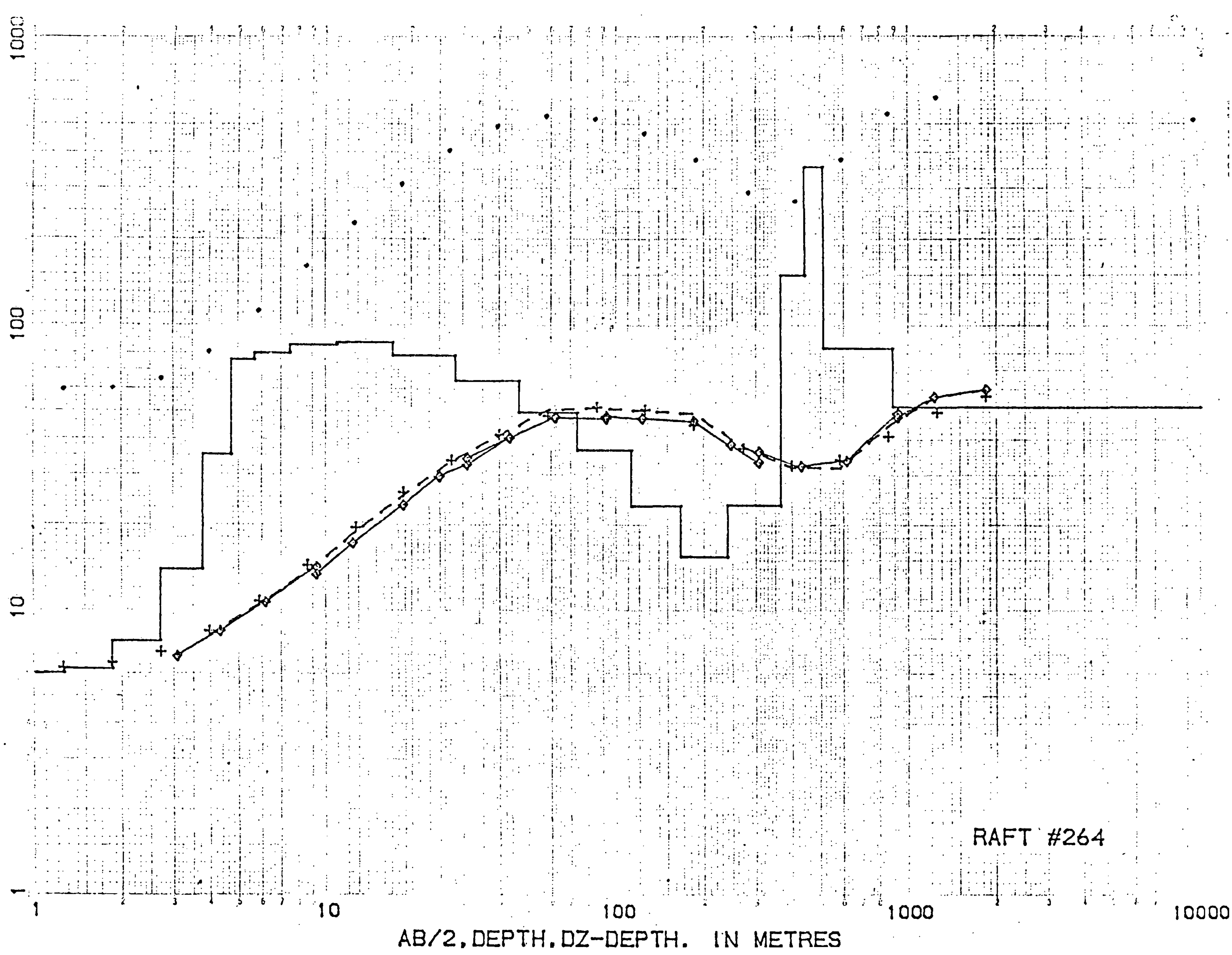
1000
100
10
1
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #260



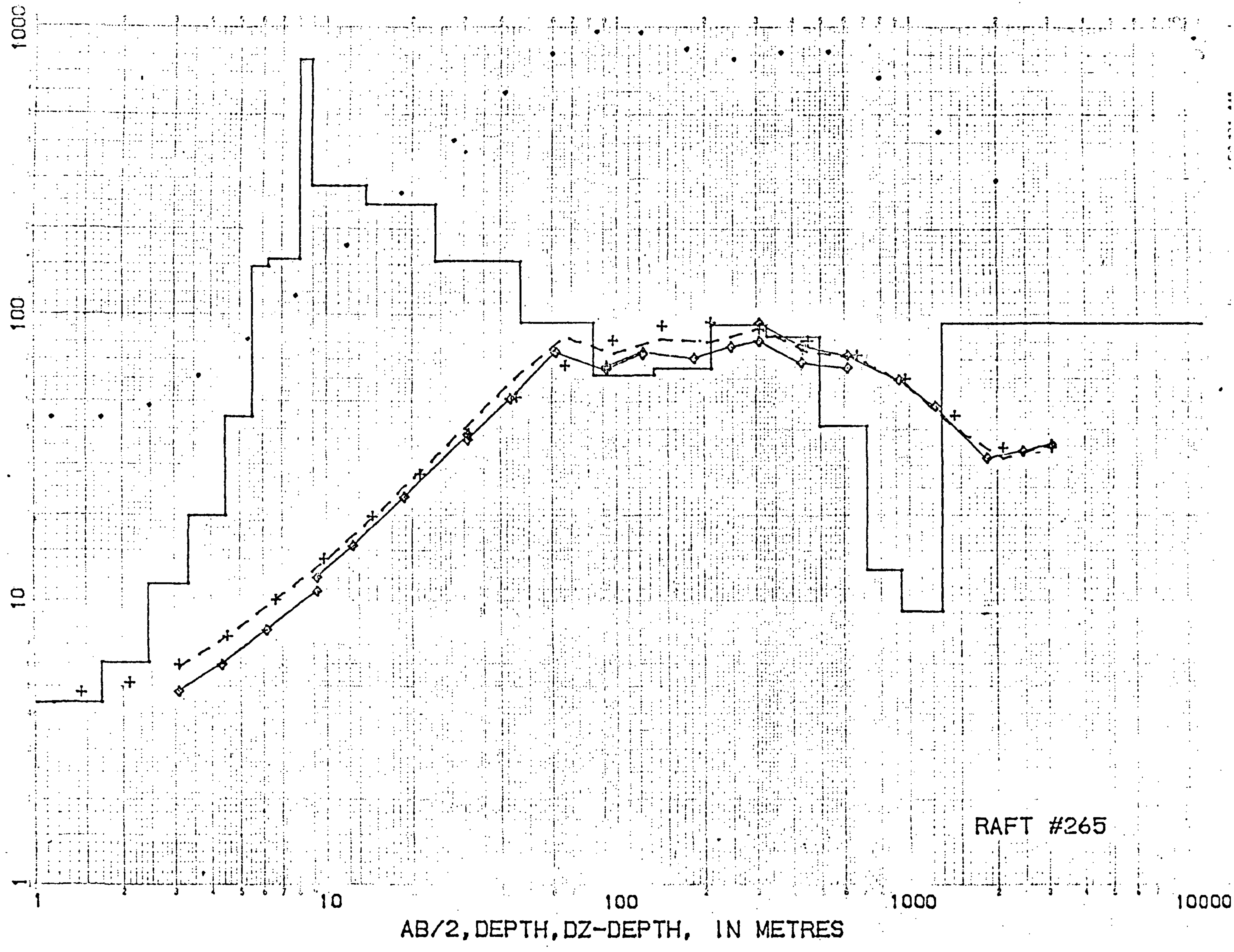
1000
100
10
1
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #261


RAFT #262
AB/2, DEPTH, DZ-DEPTH, IN METRES
RESISTIVITIES IN OHM METRES
1
10
100
1000
10000

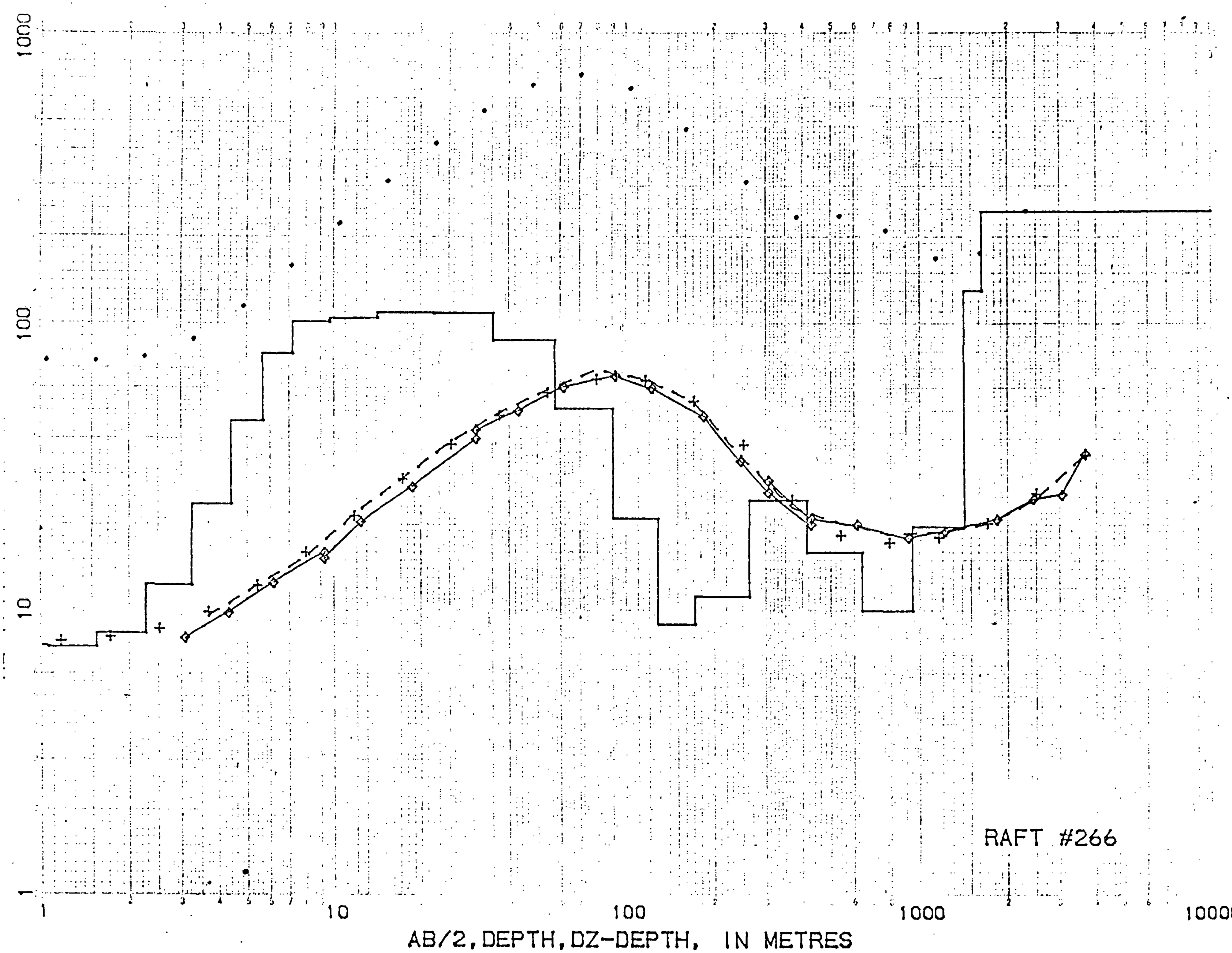

1000
100
10
1
10
100
1000
10000
RAFT #263
AB/2, DEPTH, DZ-DEPTH, IN METRES



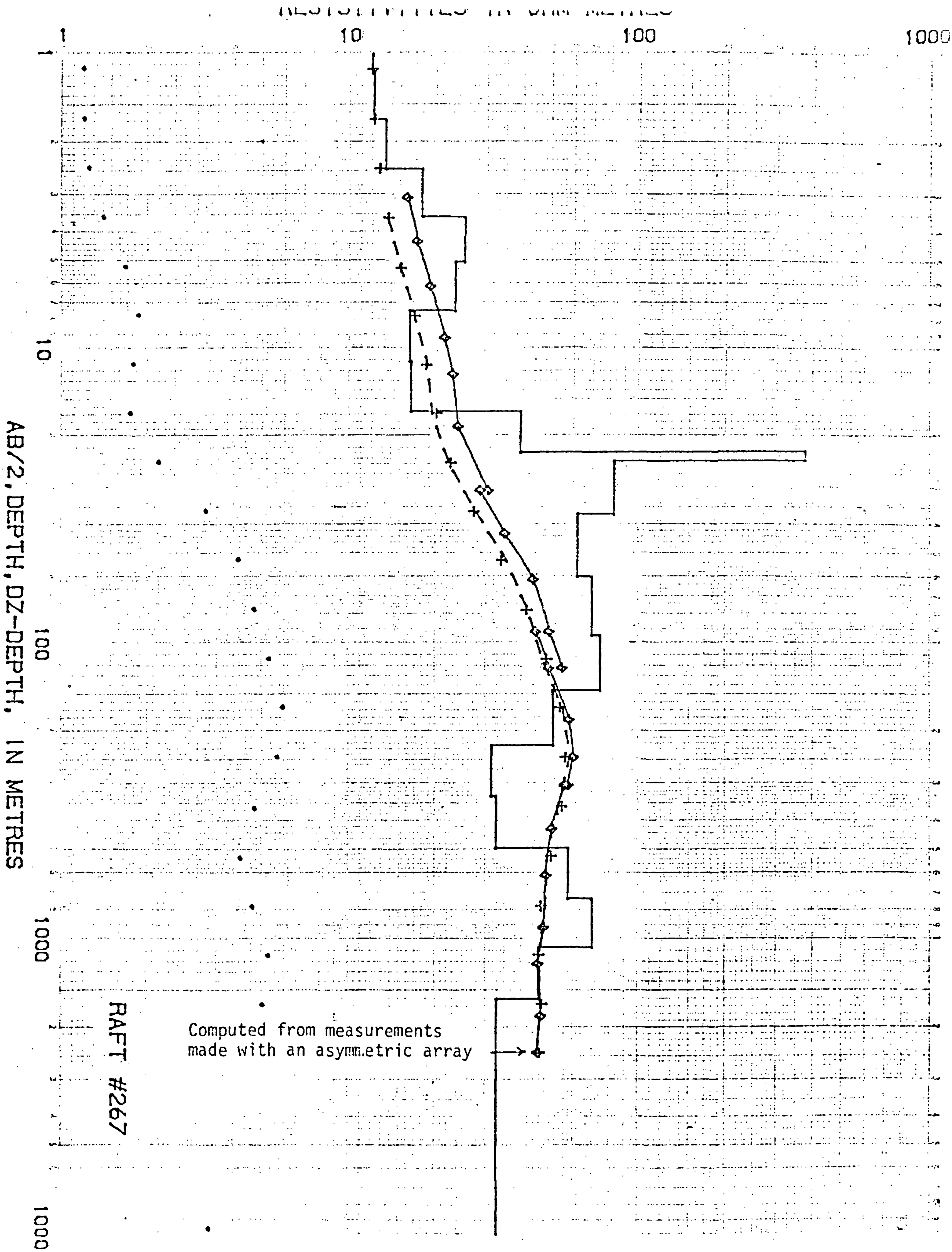
1000
100
10
1
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH. IN METRES
RAFT #264



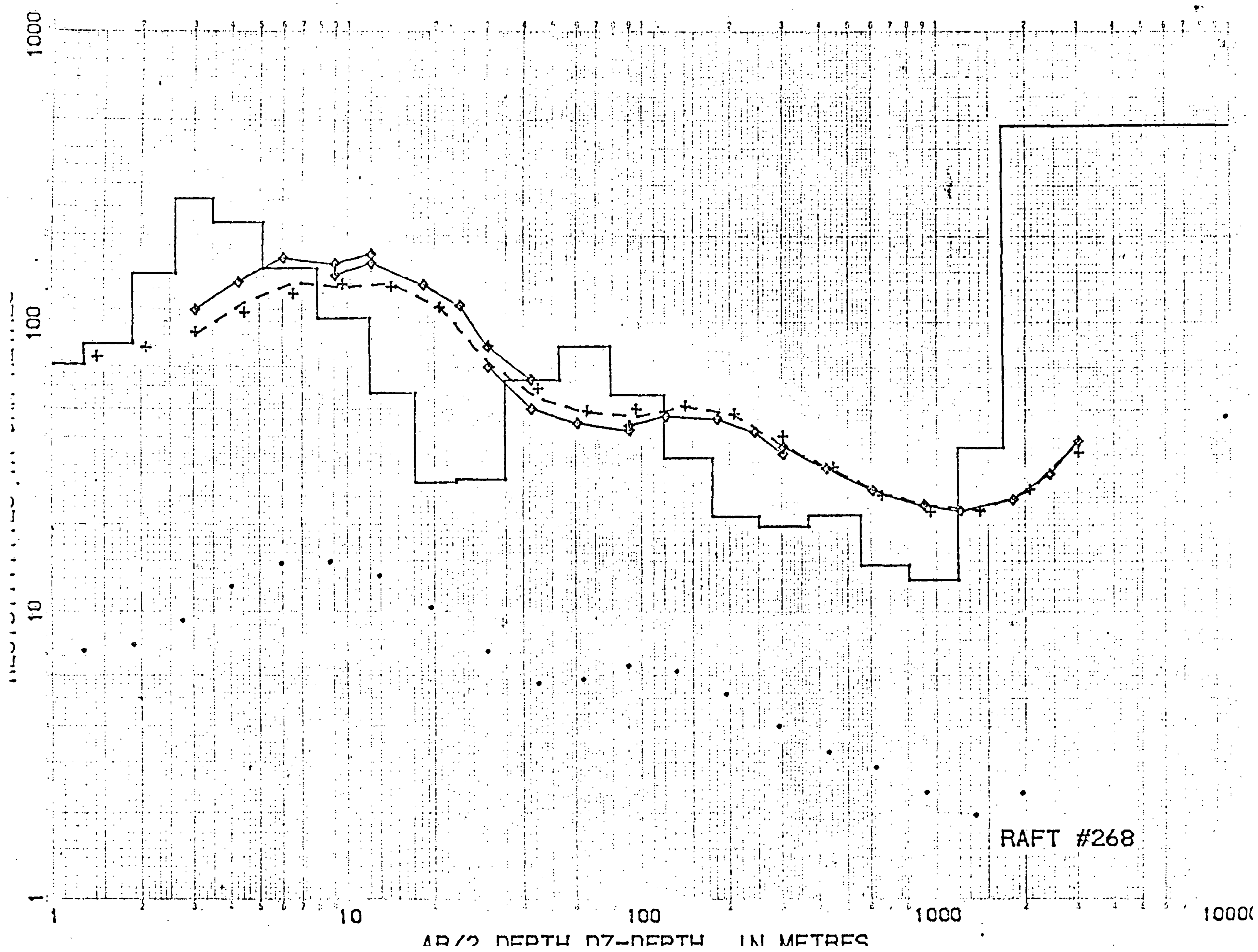
1000
100
10
1
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #265



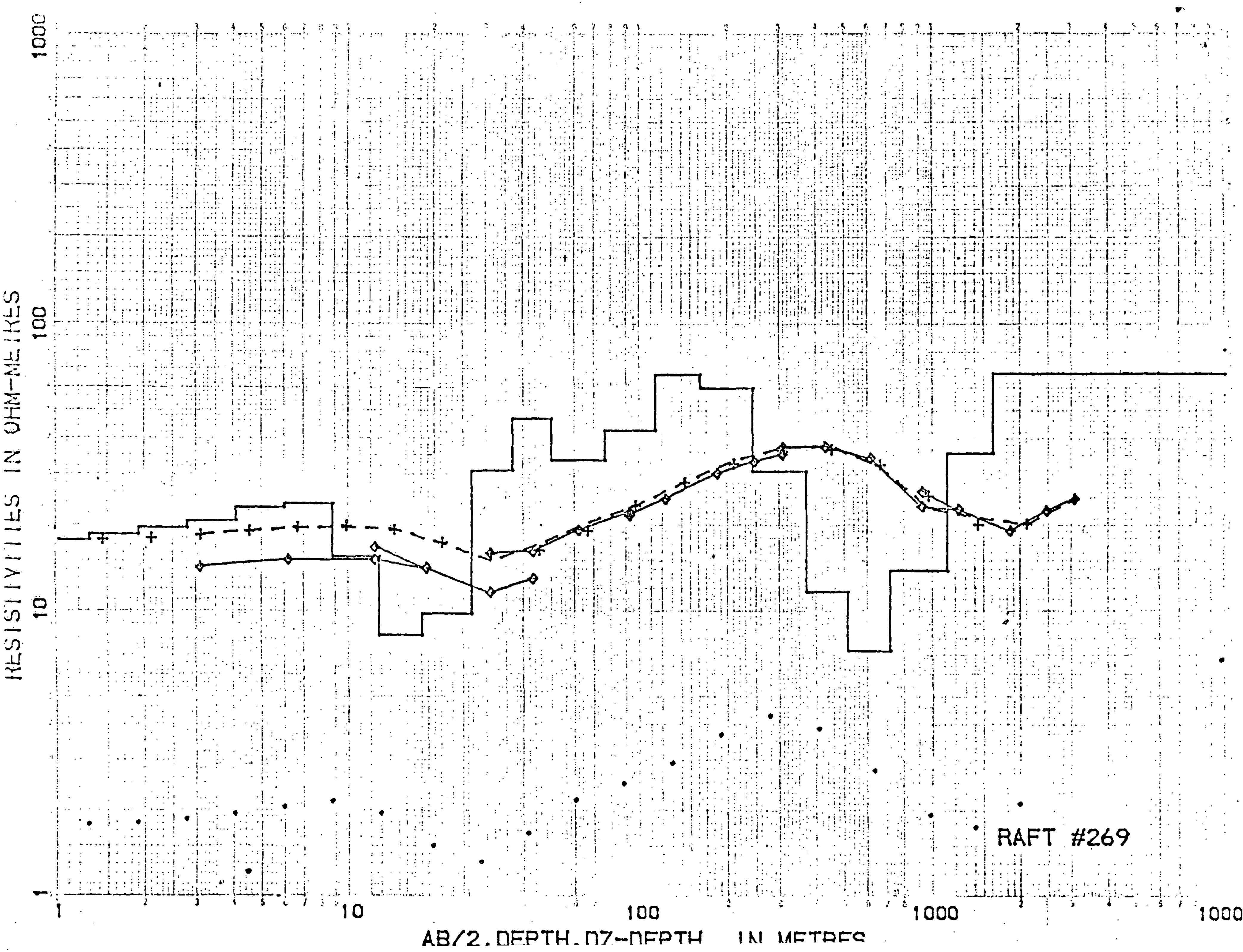
1000
100
10
1
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #266



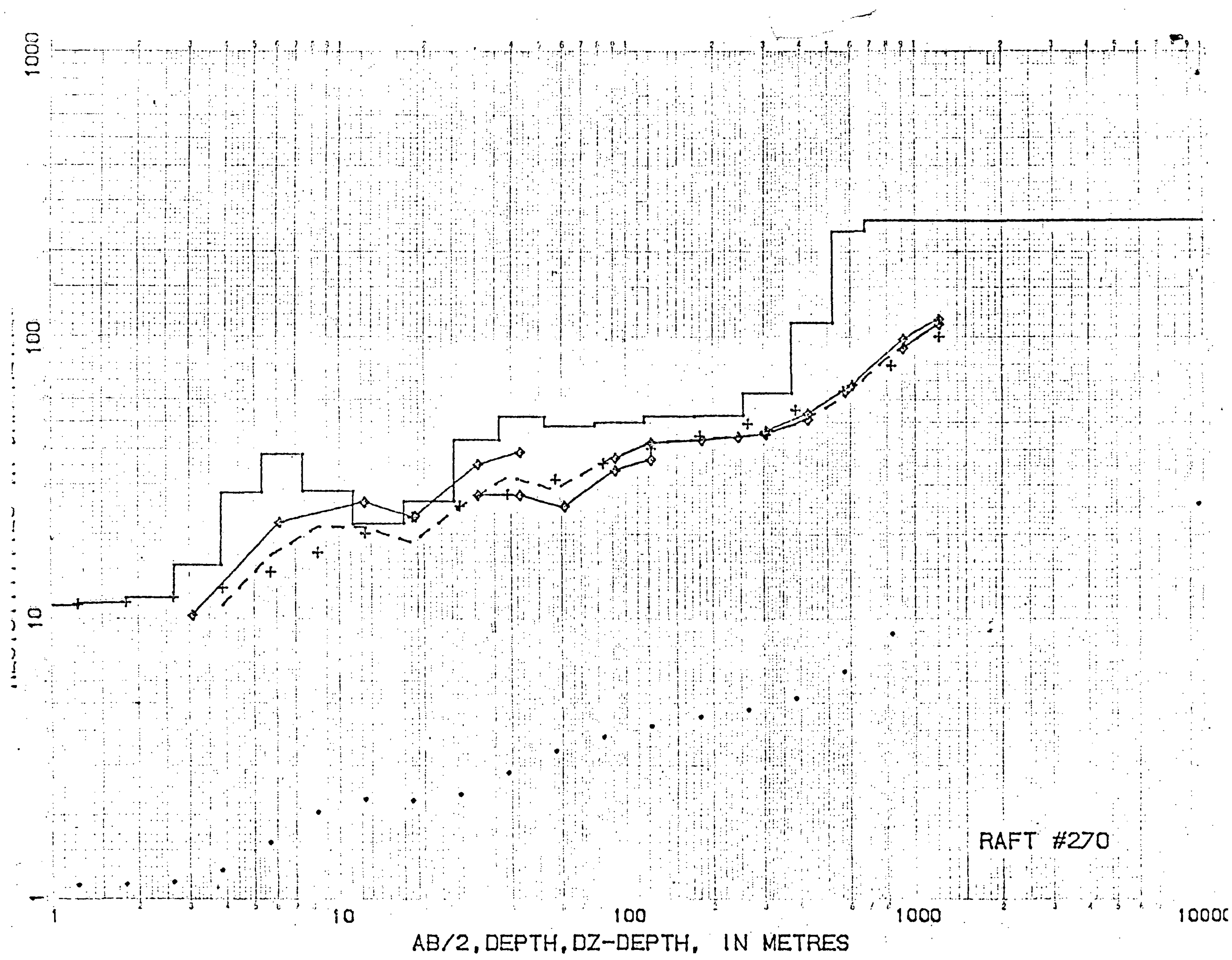
RESISTIVITIES IN OHM METRES
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
10
100
1000
RAFT #267
Computed from measurements
made with an asymmetric array



1000
100
10
1
1
10
100
1000
10000
RAFT #268



RESISTIVITIES IN OHM-METRES
1000
100
10
1
10
100
1000
1000
AB/2.DEPTH.DZ-DEPTH IN METRES
RAFT #269



1000
100
10
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #270