UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Schlumberger Soundings and Total Field Measurements in the Raft River Geothermal Area, Idaho

By

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

SCHLUMBERGER SOUNDINGS AND TOTAL FIELD MEASUREMENTS IN THE RAFT RIVER GEOTHERMAL AREA, IDAHO

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In 1974, the U.S. Geological Survey in cooperation with the Energy Research Development Administration (formerly the U.S. Atomic Energy Commission) made d.c. current measurements in the Raft River geothermal area. Seventy nine symmetric Schlumberger soundings were made and 269 bipole-dipole total field stations were occupied about a current bipole 3.22 km (2 miles) in length. Included in these total field stations are seven repeat stations, and three other stations at which measurements could not be made.

Figure 1 shows the index map for the location, number, and azimuth of the Schlumberger sounding stations. The soundings were numbered from Raft #1 to Raft #43, then from Raft #101 to Raft #136. With the exception of Raft #107 (which was expanded to a maximum electrode spacing, AB/2, of 426 metres (1,400 feet)) the maximum electrode spacing ranged from AB/2 = 914 metres (3,000 feet) to AB/2 = 3,658 metres (12,000 feet). All the sounding curves were automatically processed and interpreted 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 obtained by shifting the various segments upwards or downwards generally with respect to the last segment on the segmented field curve (Zohdy and others, 1973)

(b) the digitized curve at the rate of six points per logarithmic cycle. Although the digitized points are not shown on the dashed curve, they were computed using a subroutine in a computer program for bicubic spline functions (Anderson, 1971). The digitized data were then fed into the automatic interpretation program (Zohdy, 1974a and 1975) to obtain the best fitting theoretical sounding curve for a horizontally layered medium.

(3) The theoretical best fitting sounding curve is 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 #40) to avoid cluttering the graphs. The D.Z. curves can be used to obtain equivalent and simpler solutions containing fewer number of layers and in which certain constraints are imposed on the layer thickness and resistivities (Zohdy, 1974b).

All these graphs were generated on a Hewlett Packard 7203A graphic plotter. The plotter driving subroutines were developed by G. I. Evenden of the U.S. Geological Survey.

Figure 2 shows the simple total-field bipole-dipole apparent resistivity map which is contoured at a logarithmic contour interval, in ohm-m values.

Figure 3 shows the theoretical simple total field bipole-dipole apparent resistivity map that should have been obtained had the ground been horizontally layered over the entire survey area. The calculations (Zohdy and Stanley, 1974) are based on the sounding data obtained at sounding Raft #1 which was made at the center of the current bipole.

Figure 4 shows the normalized (or reduced) apparent resistivity map which is obtained by finding the ratio between the observed values in figure 2 and the theoretical values shown in figure 3. Had the ground been horizontally layered over the entire survey area, all the normalized values should have been equal to unity. In general, areas outlined by values greater than unity indicate that the section contains more resistive materials or that basement rocks are shallower than at Raft #1 sounding. Conversely areas outlined by contour values less than unity designate the opposite. It should be noted, however, that false lows and highs may be caused by the presence of near vertical faulting separating media of large differences in resistivity. The major use of the normalized apparent resistivity map is that it emphasises lateral variations in the subsurface resistivity and thus outline more clearly the trend of possible faulting.

References cited

Anderson, W. L., 1971, Application of bicubic spline functions to two dimentipial guided data: NTIS (National Technical Information Service), No. PB-203579, Springfield, Virginia.

Zohdy, Adel A. R., 1974a, A computer program for the automatic interpretation of Schlumberger sounding curves over horizontally stratified media: NTIS (National Tech. Inform. Service) PB-232703/AS, 25 p., Springfield, Virginia.

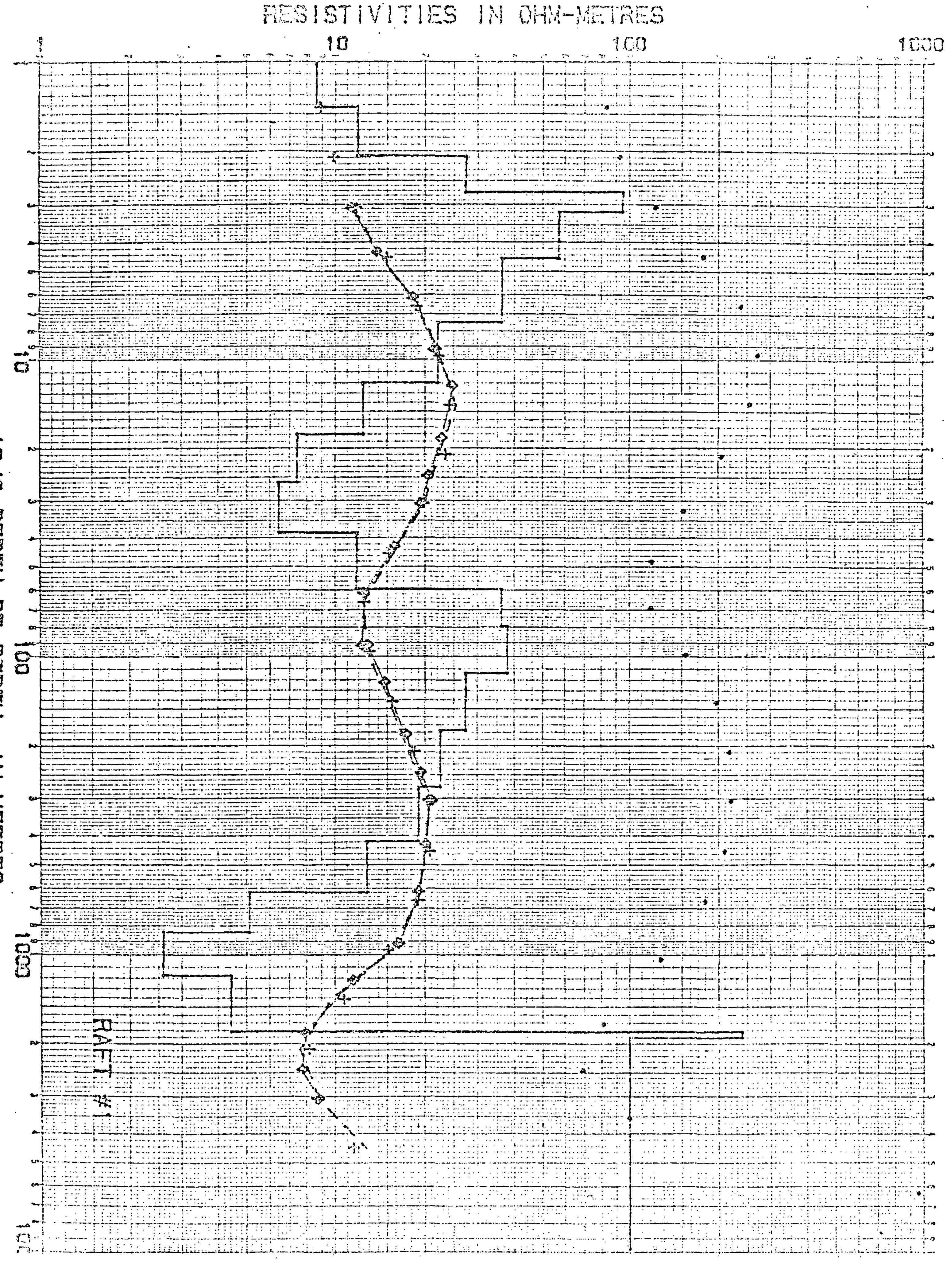
Zohdy, Adel A. R., 1974b, The use of Dar-Zarrouk curves in the interpretation of VES data: U.S. Geol. Survey Bull. 1313-D, 41 p.

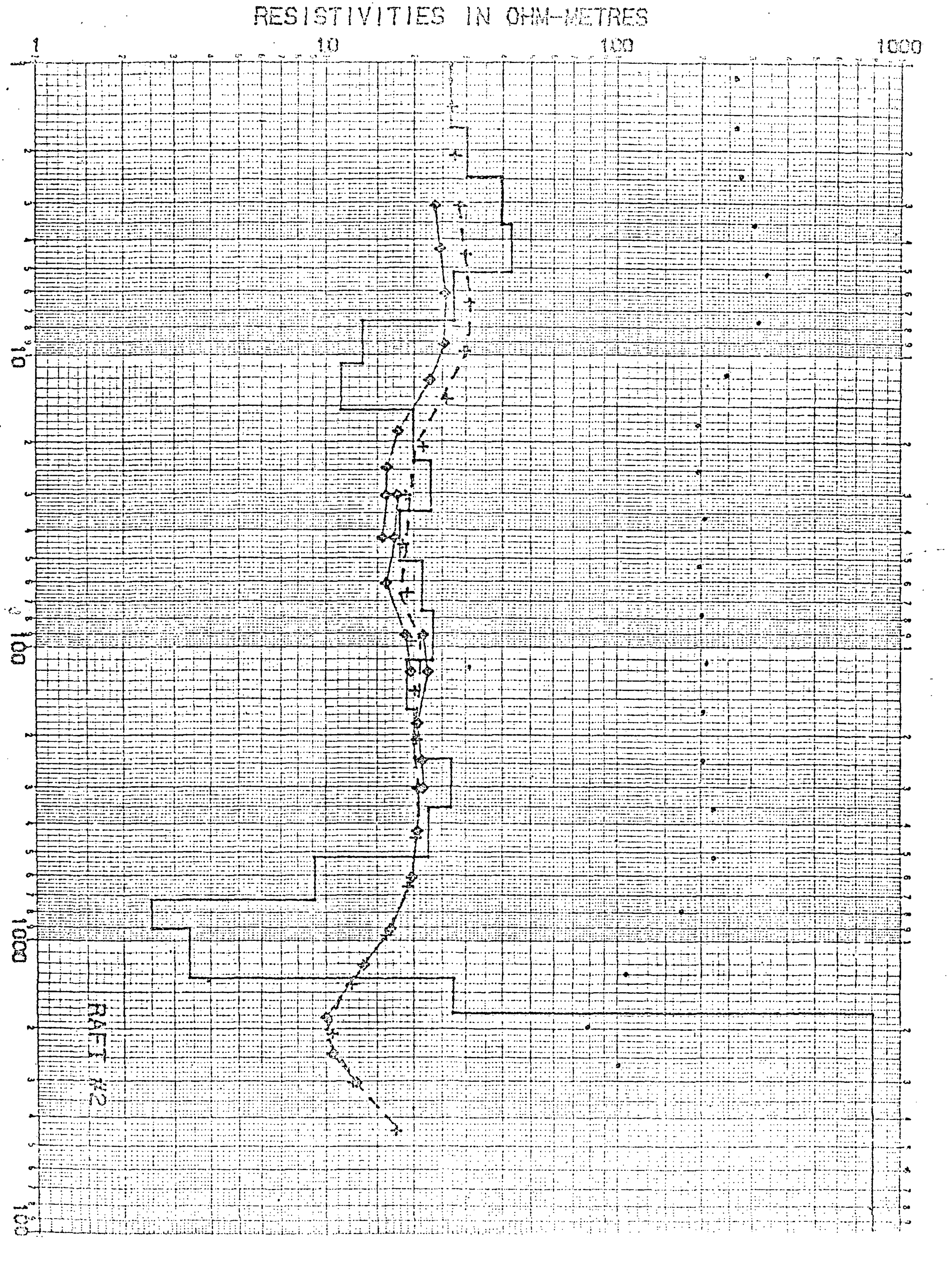
Zohdy, A. A. R., (in press), Automatic interpretation of Schlumberger sounding curves using modified Dar-Zarrouk functions: U.S. Geol. Survey Bull. 1313-E.

Zohdy, Adel A. R., and Stanley, William D., 1974, A computer program for the calculation of bipole-dipole apparent resistivity maps over horizontally stratified media: NTIS (National Tech. Inform. Service) PB-232727/AS, 10 p., Springfield, Virginia.

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.

APPENDIX


RESISTIVITIES IN OHM-METRES
10
100
1000
RAFT #1
10
100
1000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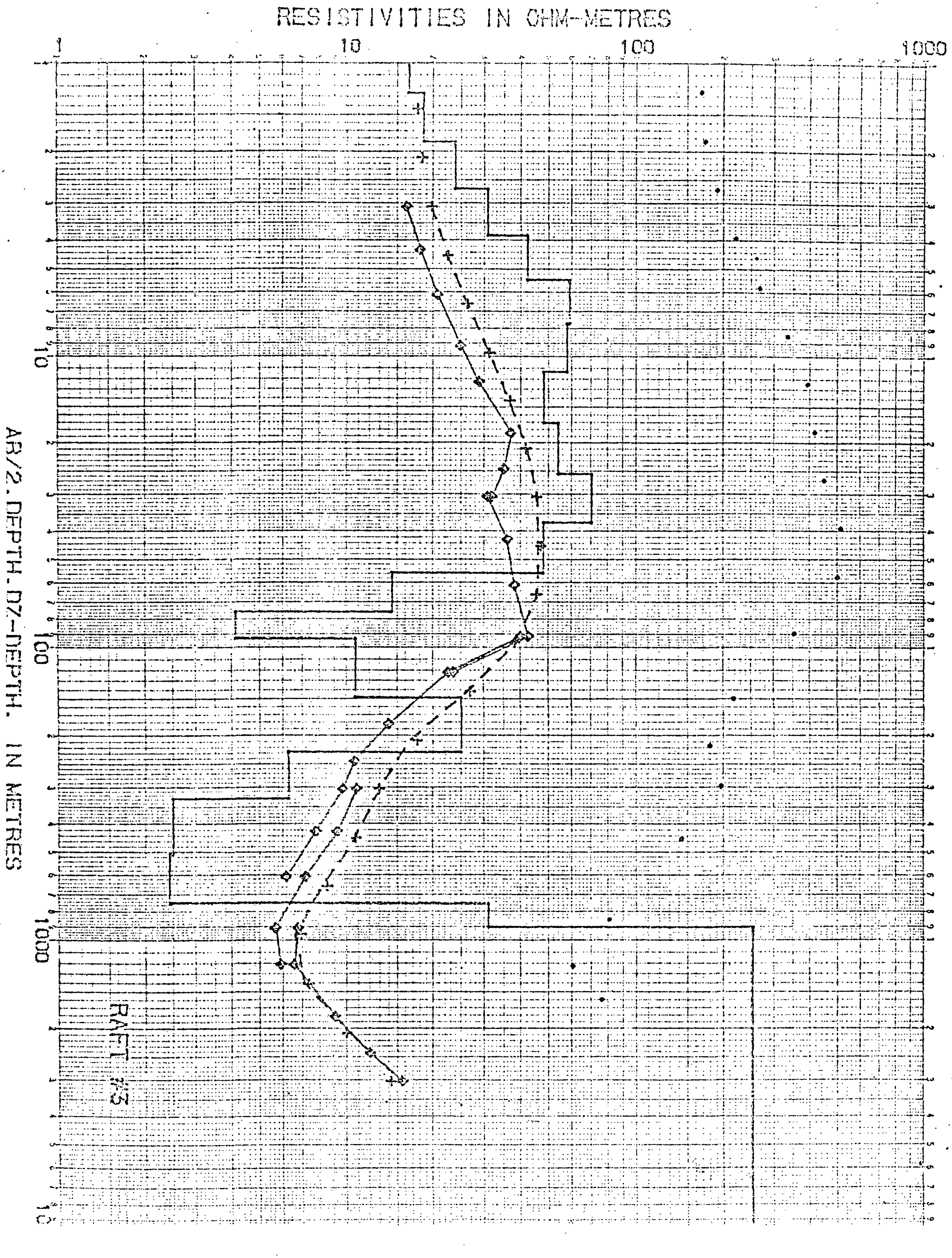
1
10
100
1000
RAFT #2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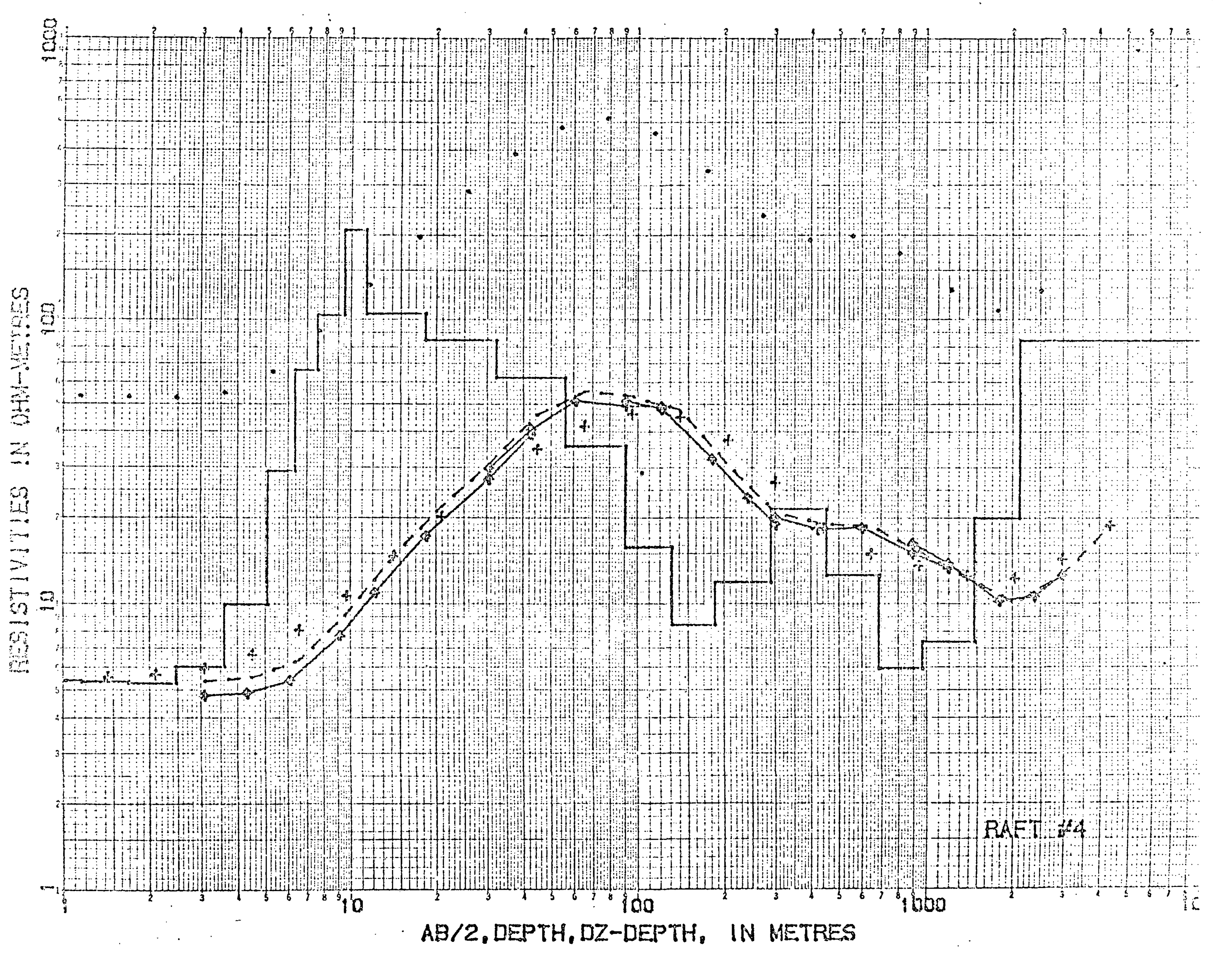
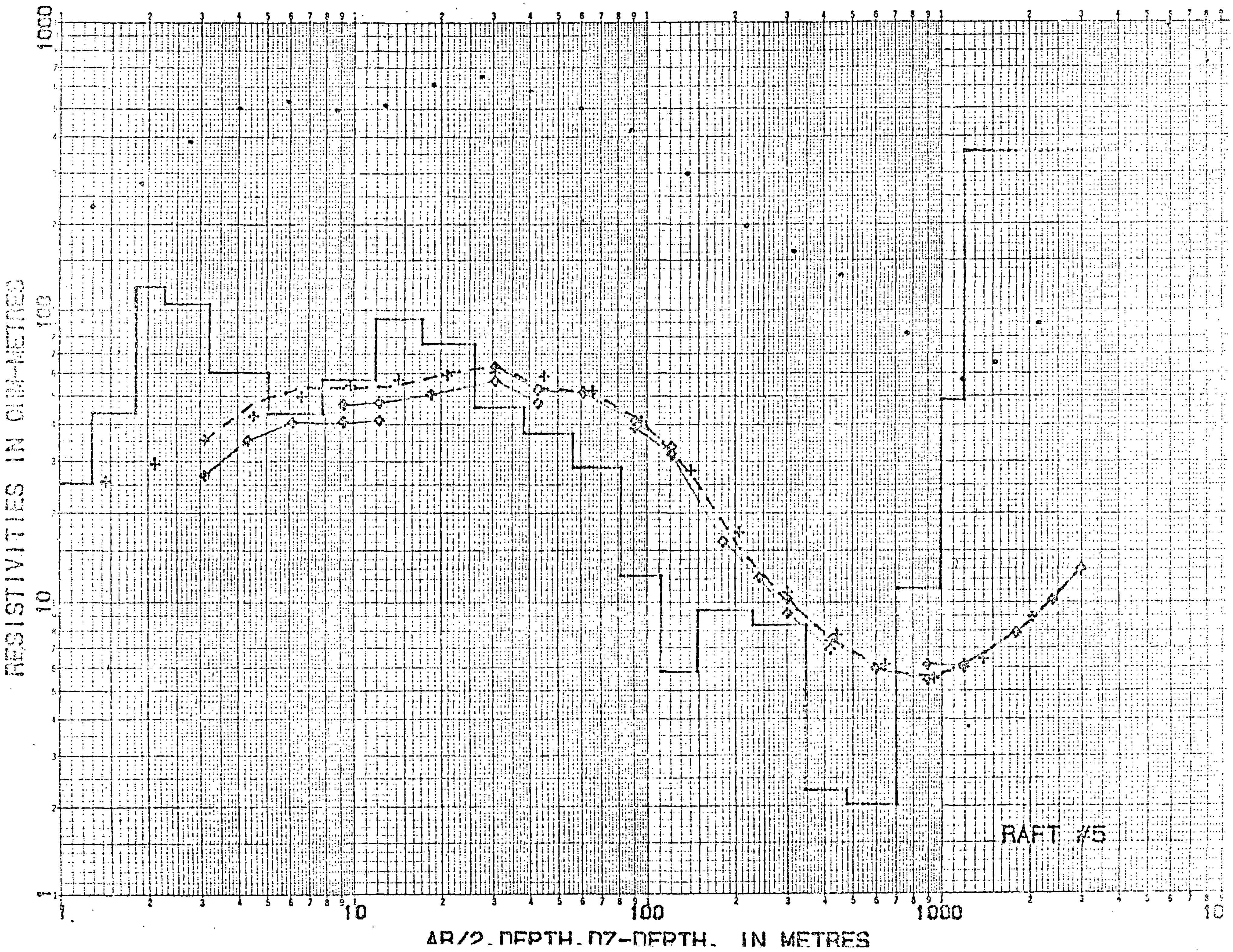
1
10
100
1000
AB/2.DEPTH.DZ-DEPTH. IN METRES
10
100
1000
RAFT #3



RAFT #4
RESISTIVITIES IN OHM-METRES
AB/2, DEPTH, DZ-DEPTH, IN METRES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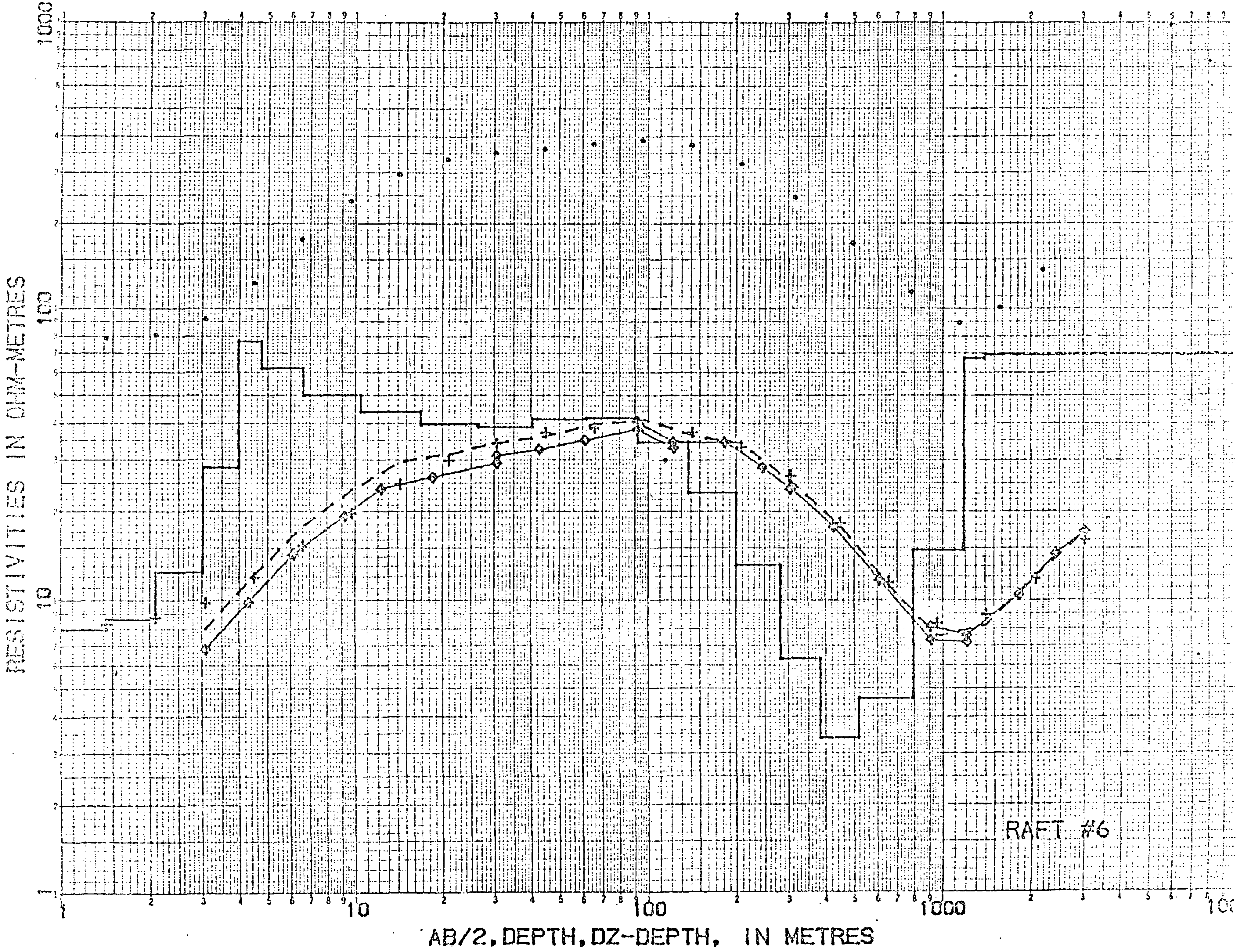
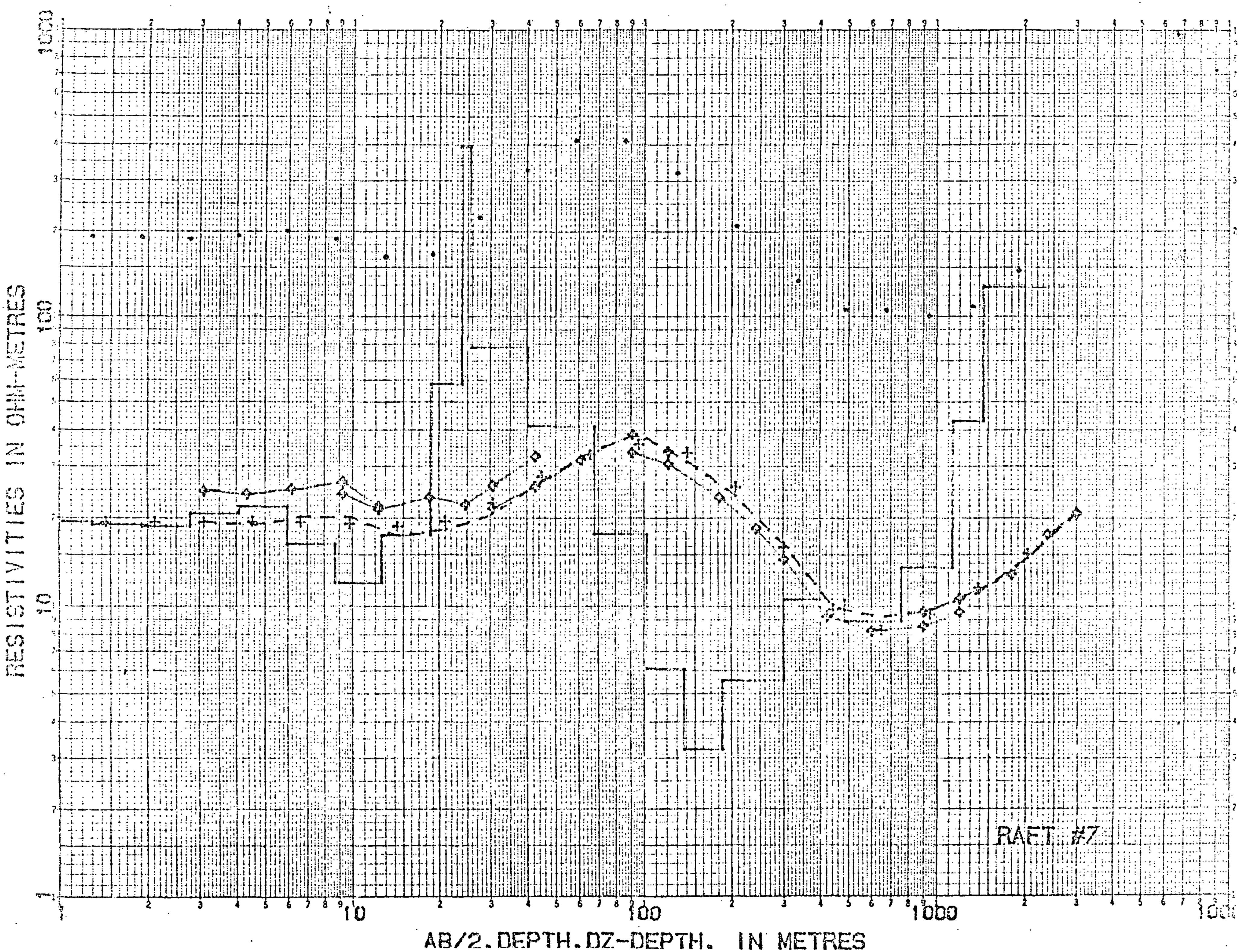
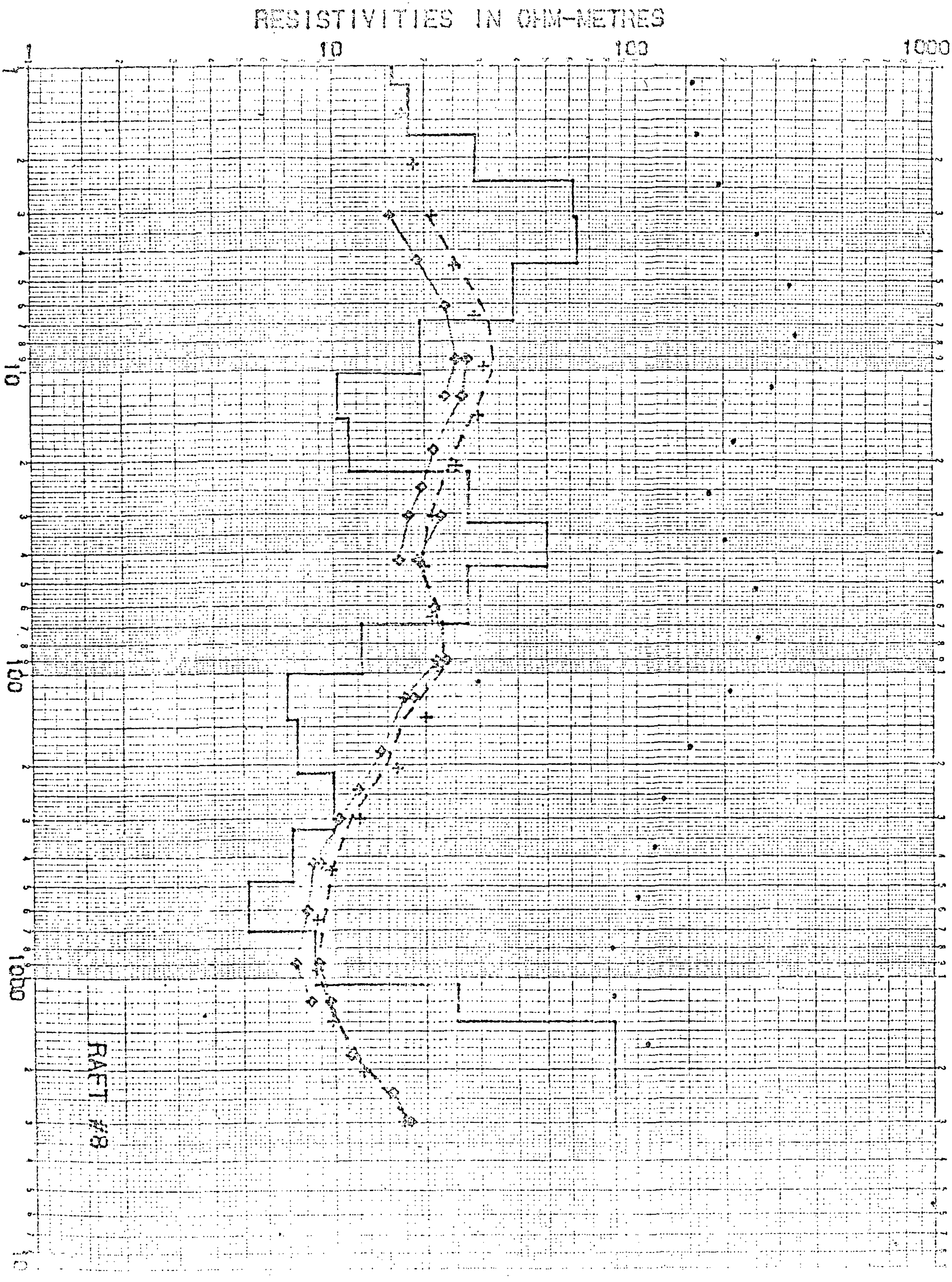
AB/2 DEPTH DZ-DEPTH. IN METRES
1000
100
10
1
10
100
1000

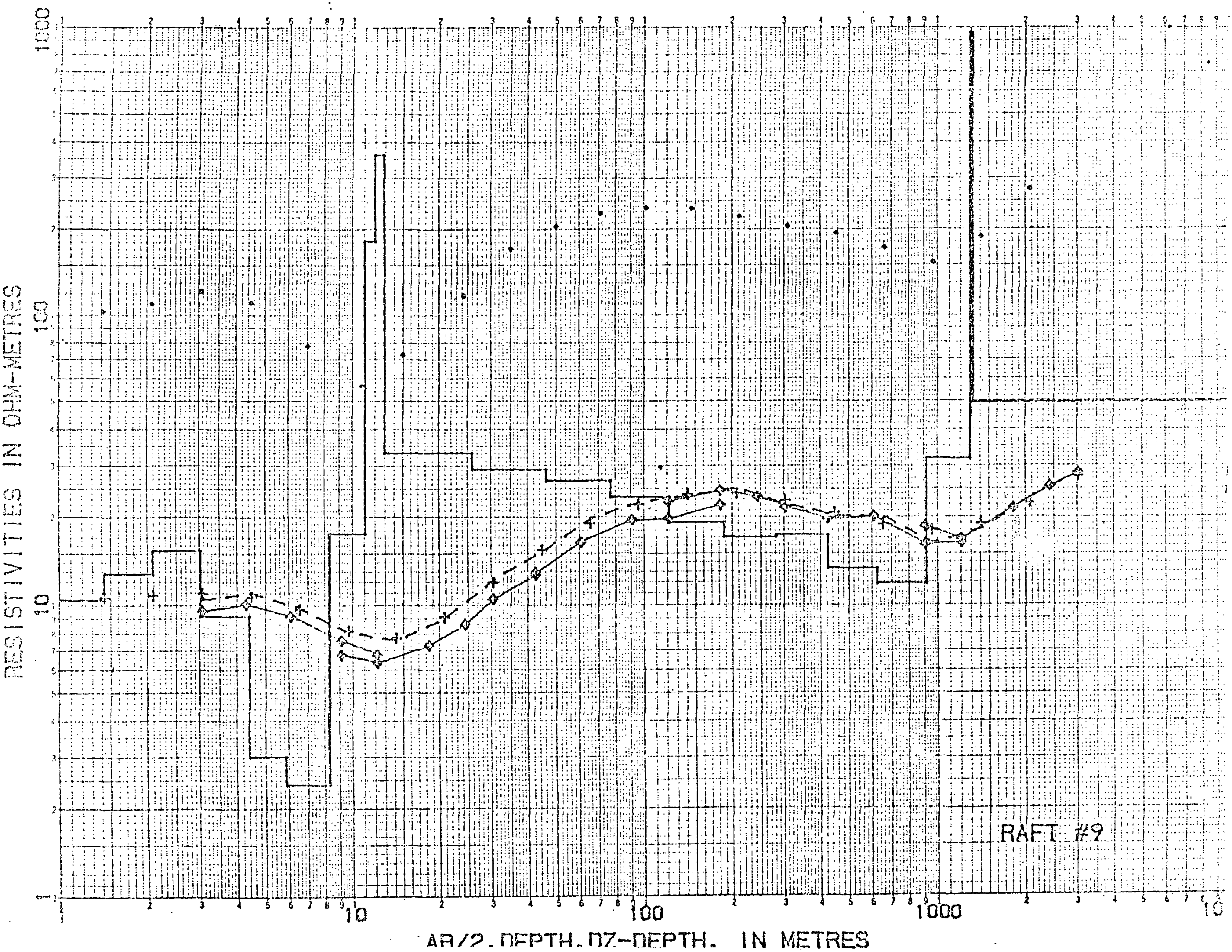

RESISTIVITIES IN OHM-METRES
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #6
1000
100
10
1
10
100
1000

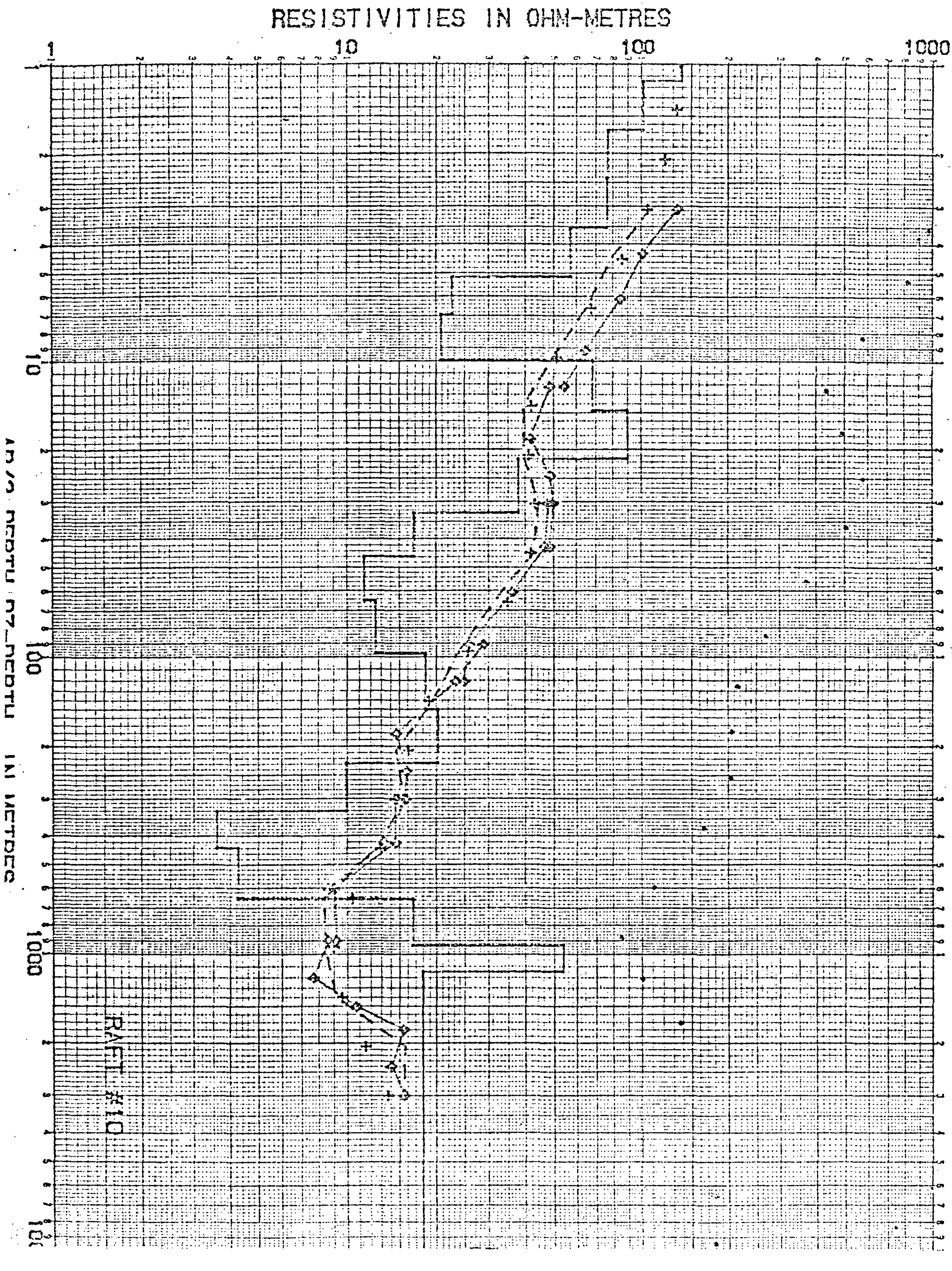


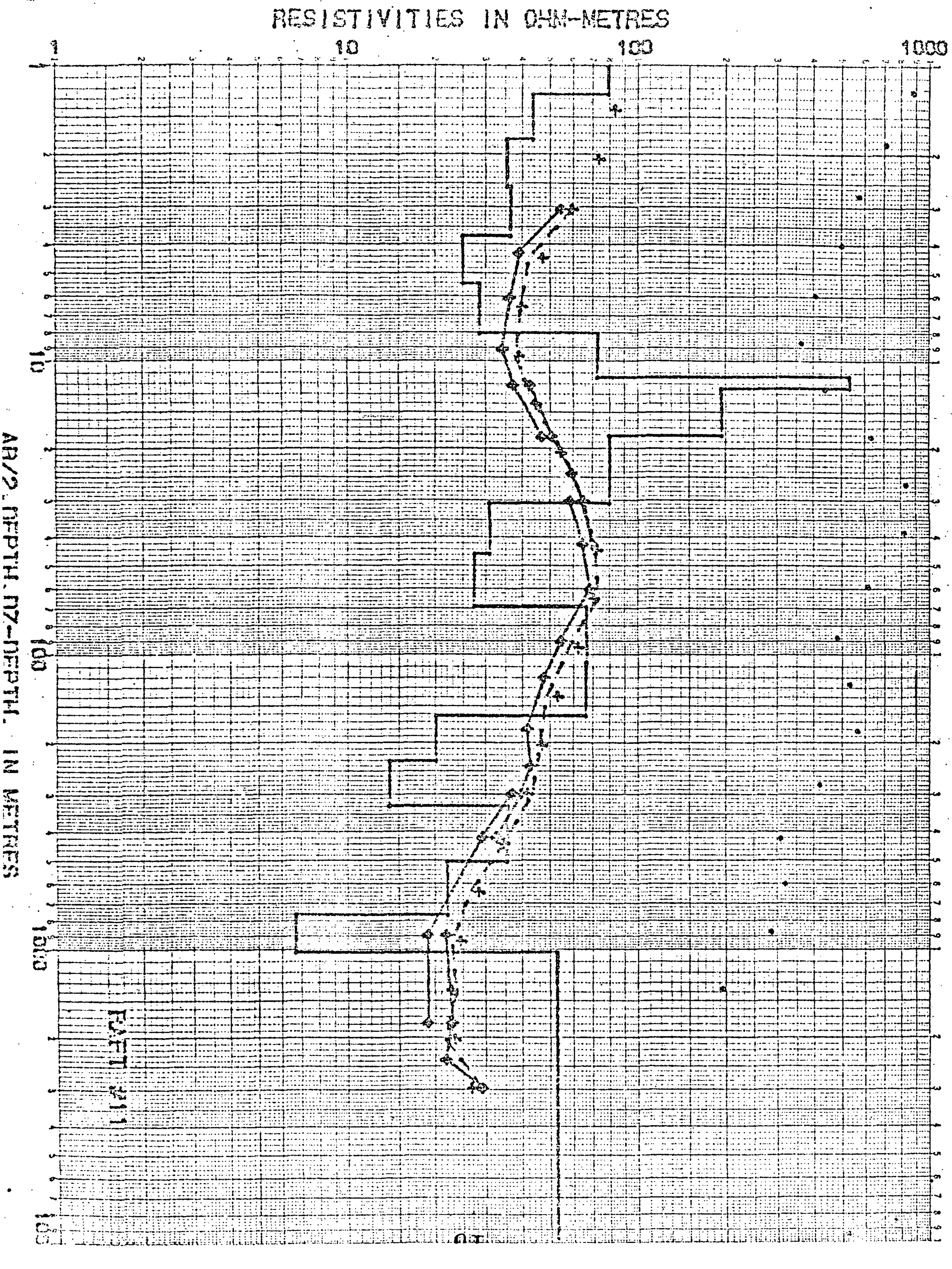
RESISTIVITIES IN OHM-METRES
1000
100
10
1
10
100
1000
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAET #7

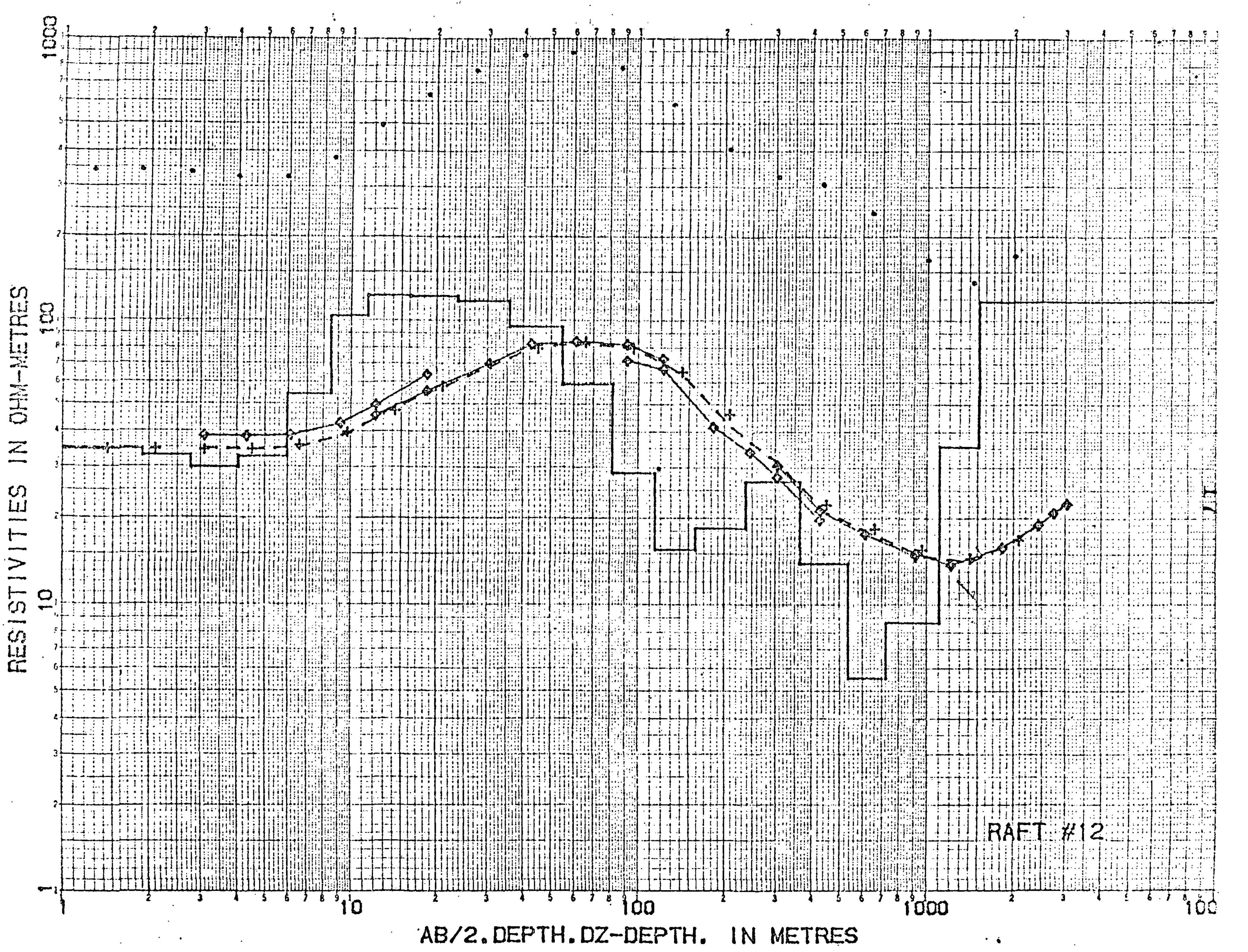


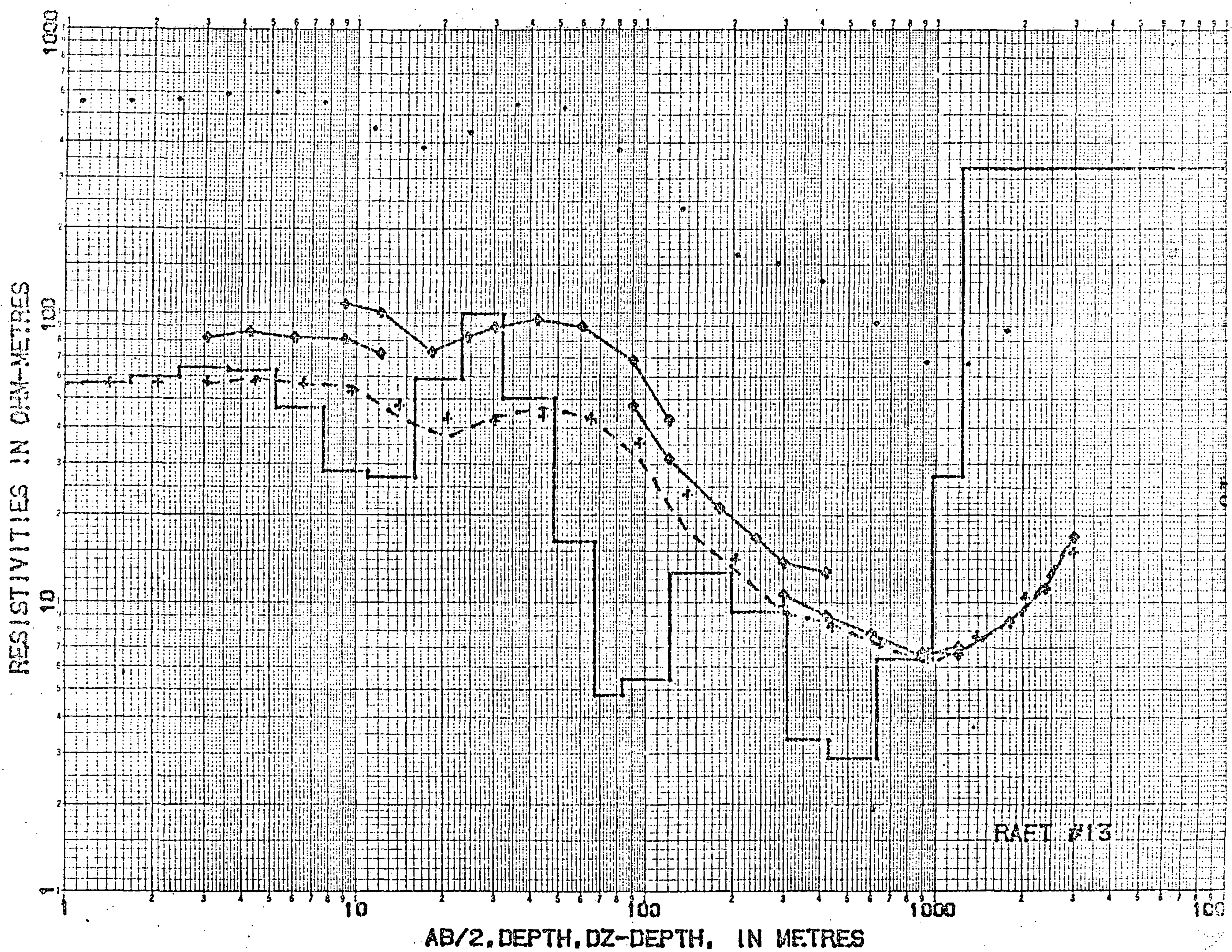
RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2 DEPTH, DZ-DEPTH, IN METRES
RAFT #8


RESISTIVITIES IN OHM-METRES
AB/2 DEPTH. DZ-DEPTH. IN METRES
RAFT #9
1000
100
10
1
1
10
100
1000
10

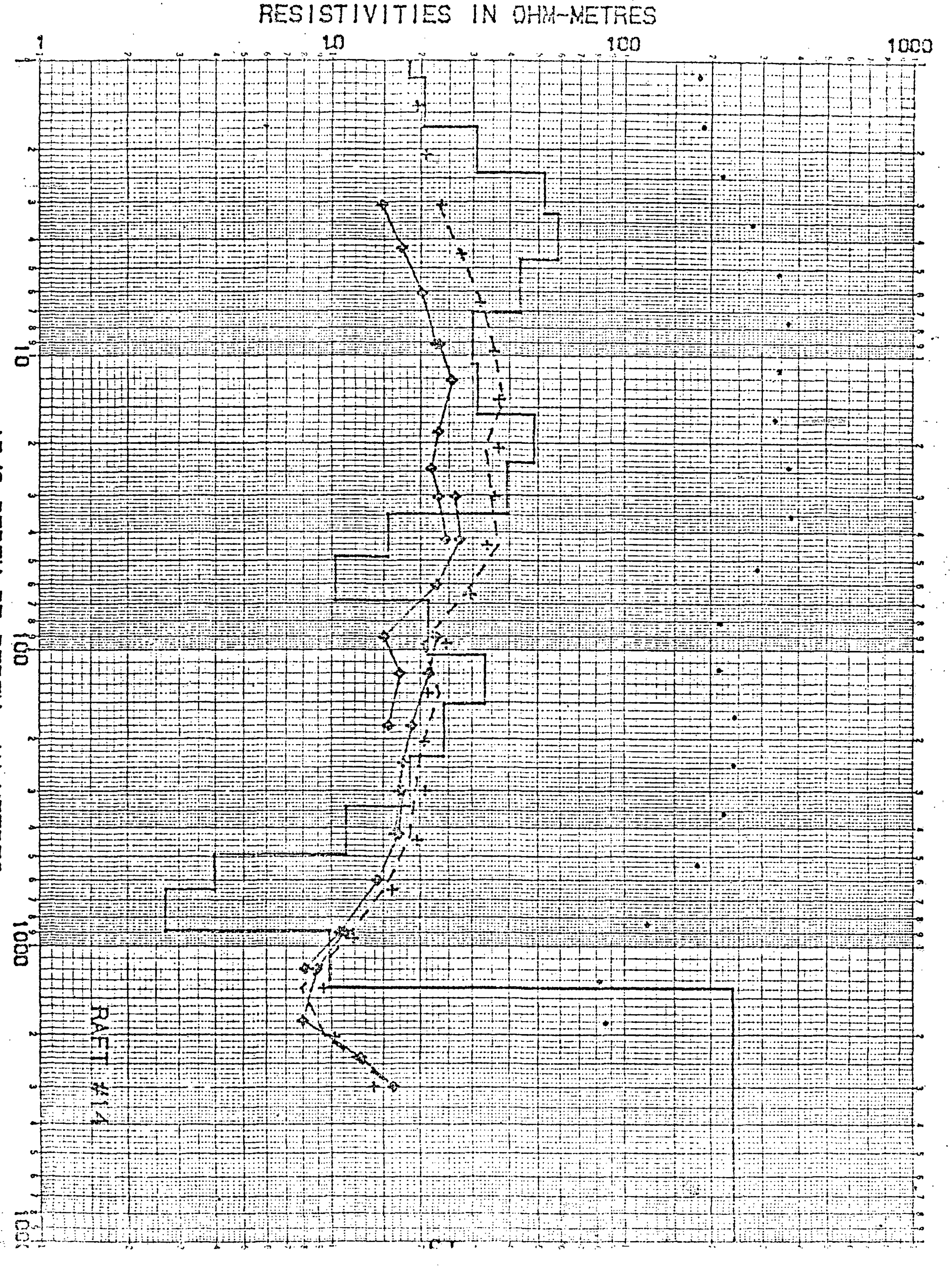

RESISTIVITIES IN OHM-METRES
1
10
100
1000
RAFT #10

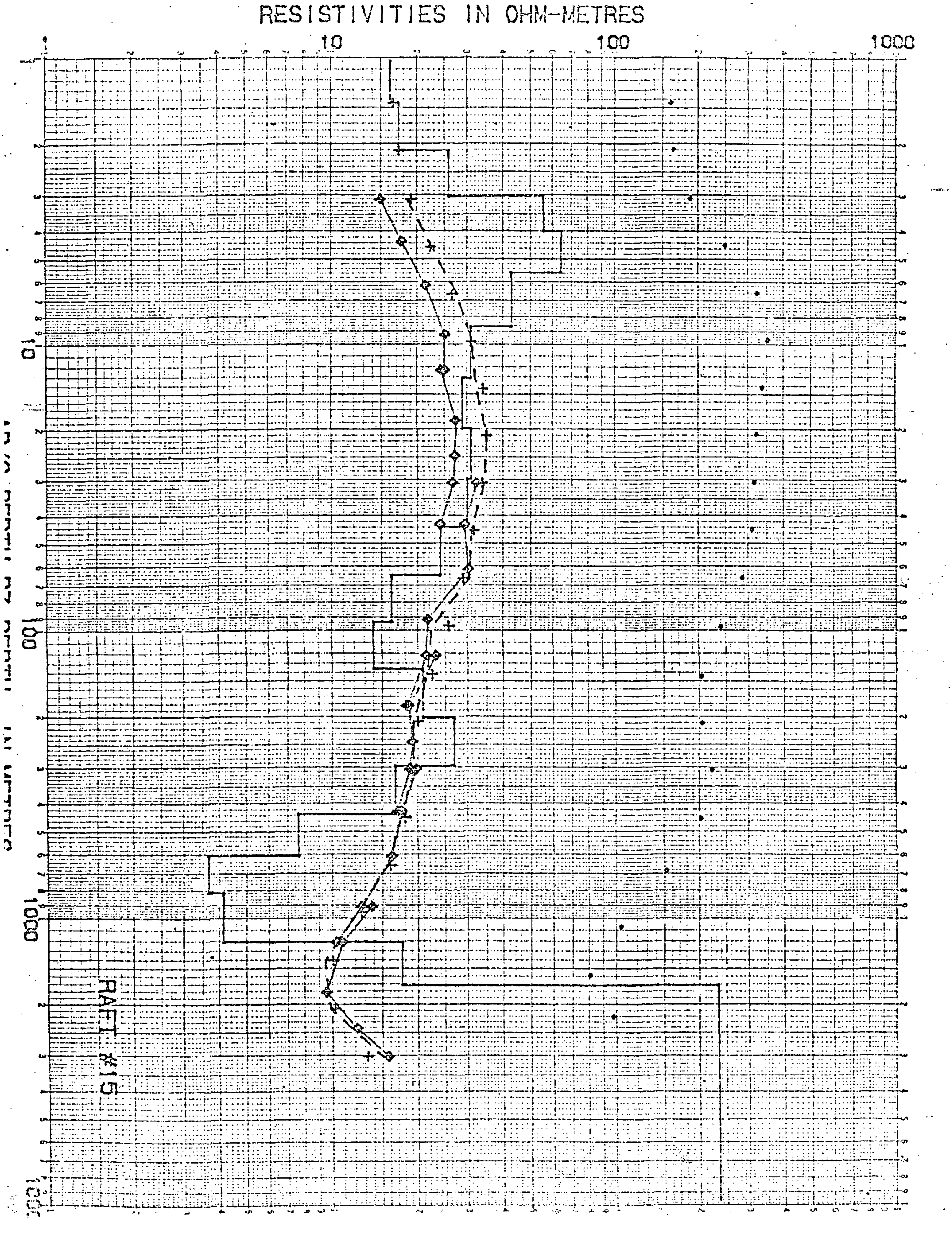

RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2 DEPTH, DZ-DEPTH, IN METRES
10
100
1000


RESISTIVITIES IN OHM-METRES
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAFT #12
1
10
100
1000

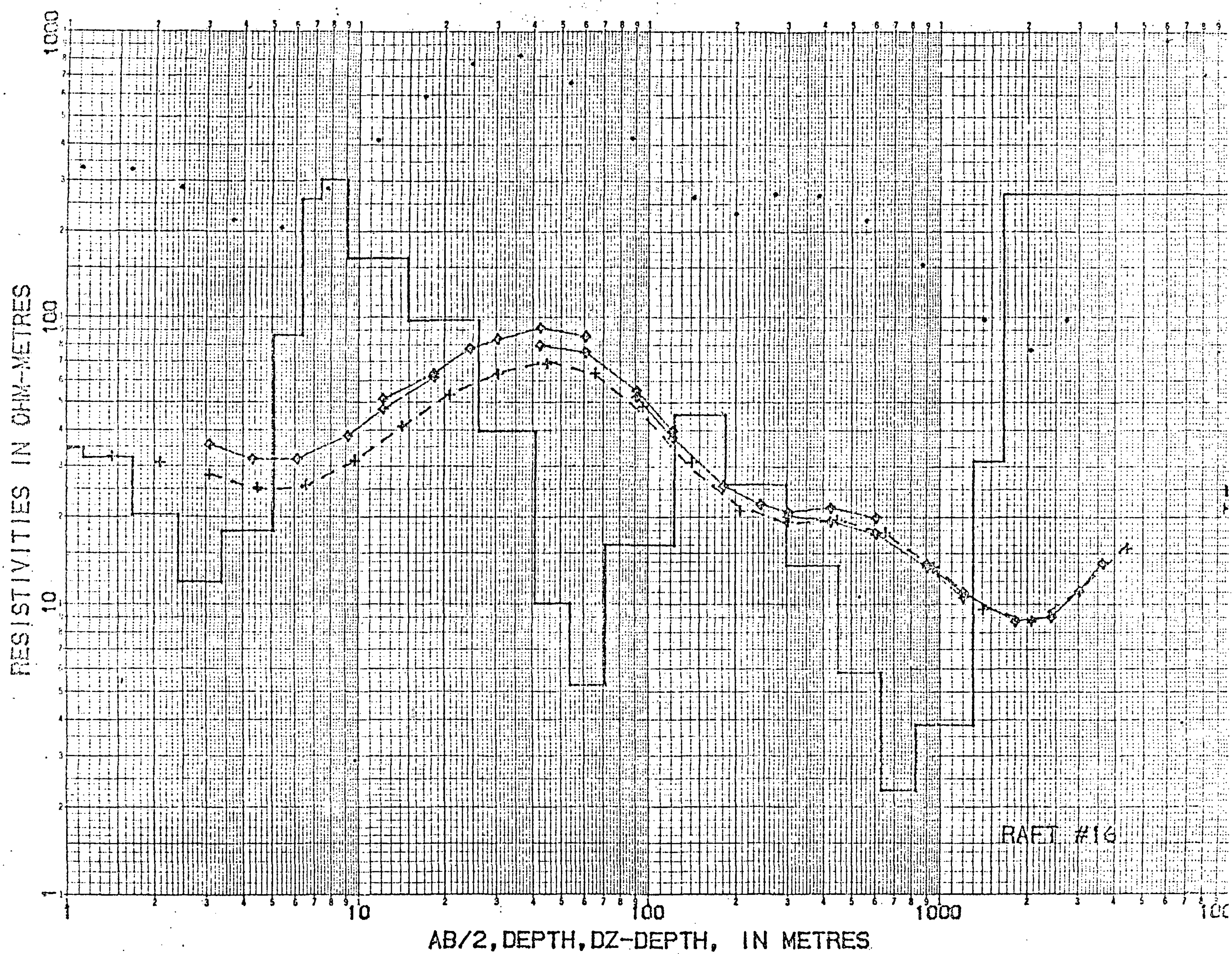


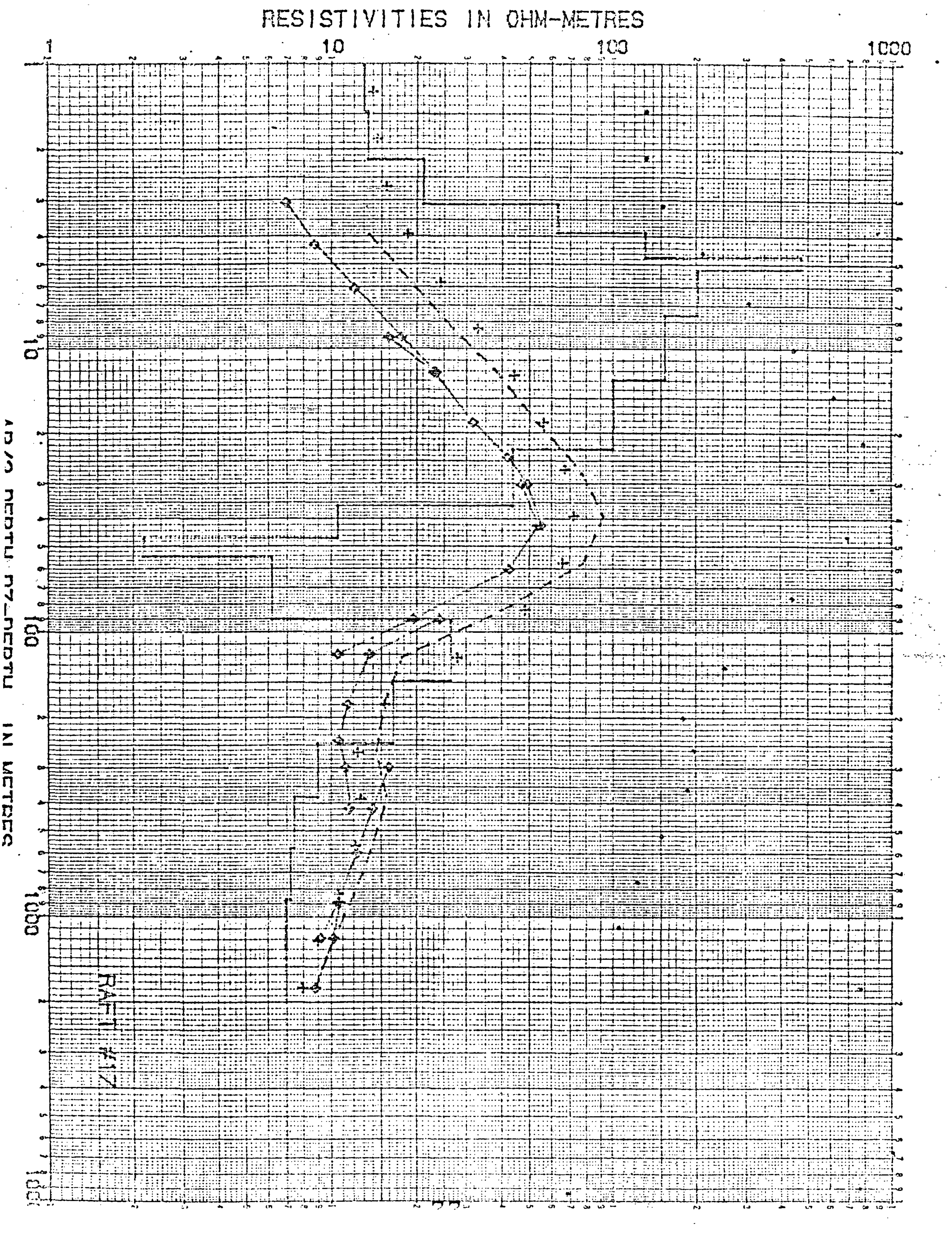
RESISTIVITIES IN OHM-METRES
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #13


RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2 DEPTH D7-DEPTH IN METRES
10
100
1000
RAFT #14

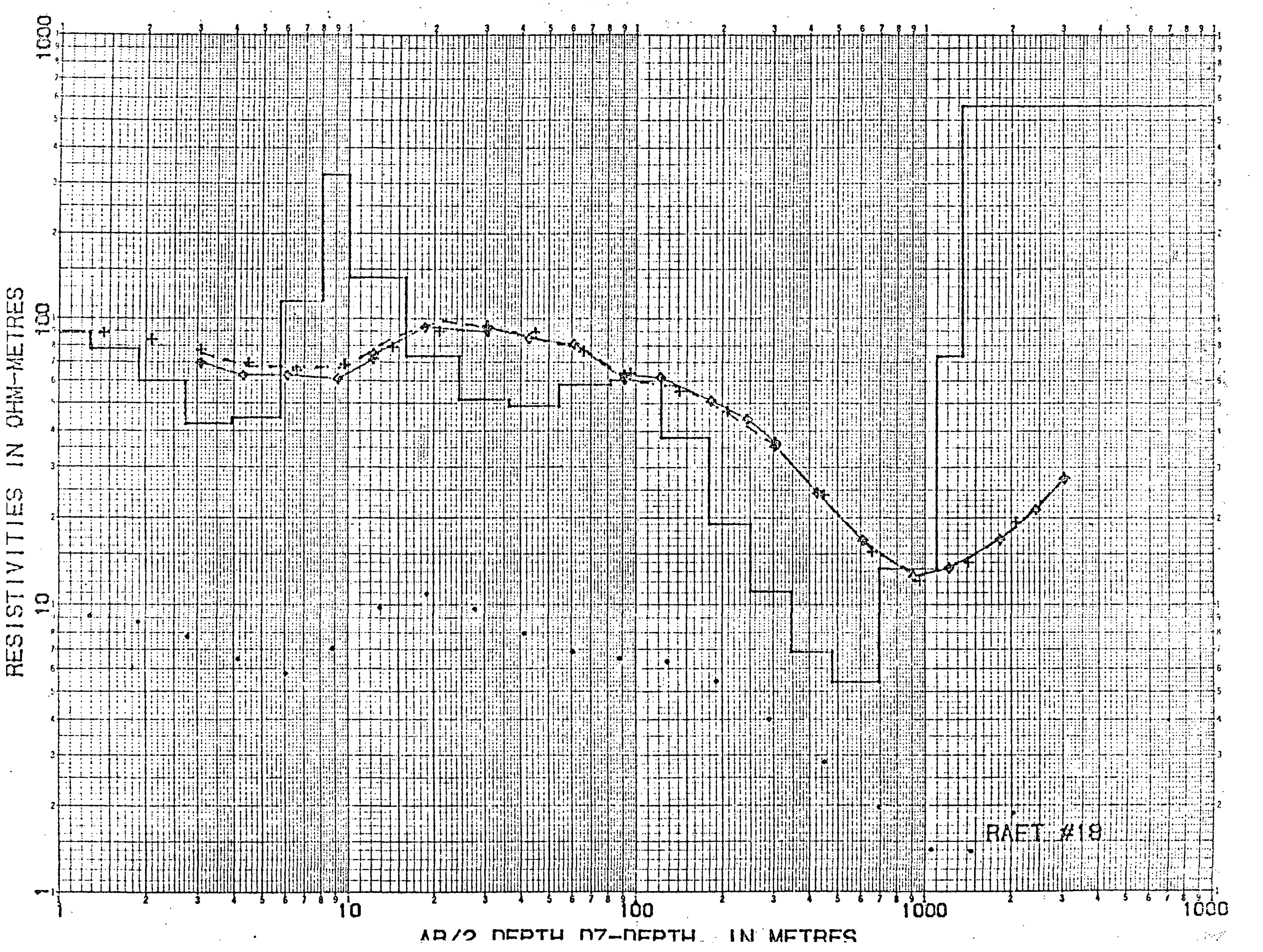


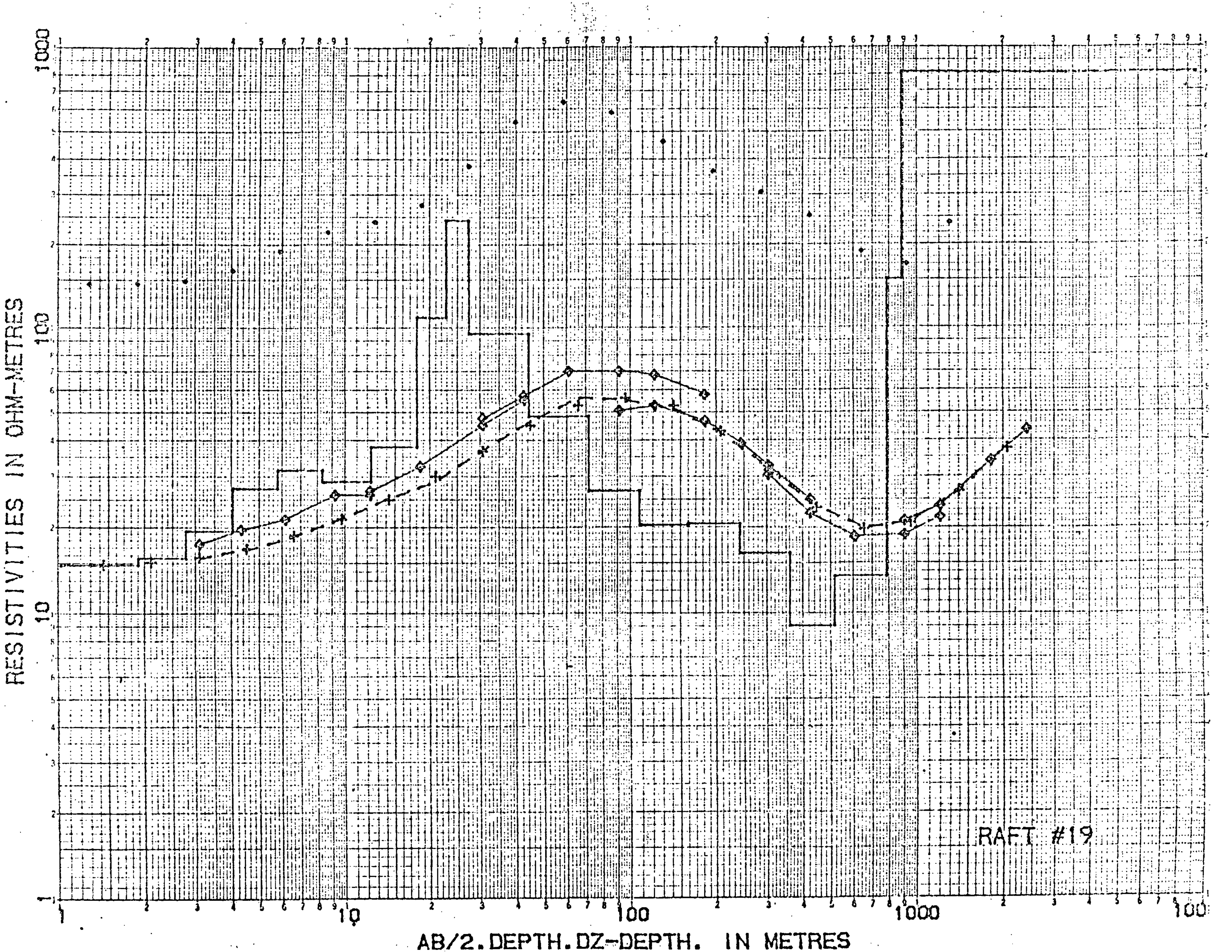
RESISTIVITIES IN OHM-METRES
10
100
1000
AB/2 DEPTH OR DEPTH IN METRES
10
100
1000
RAFT #15

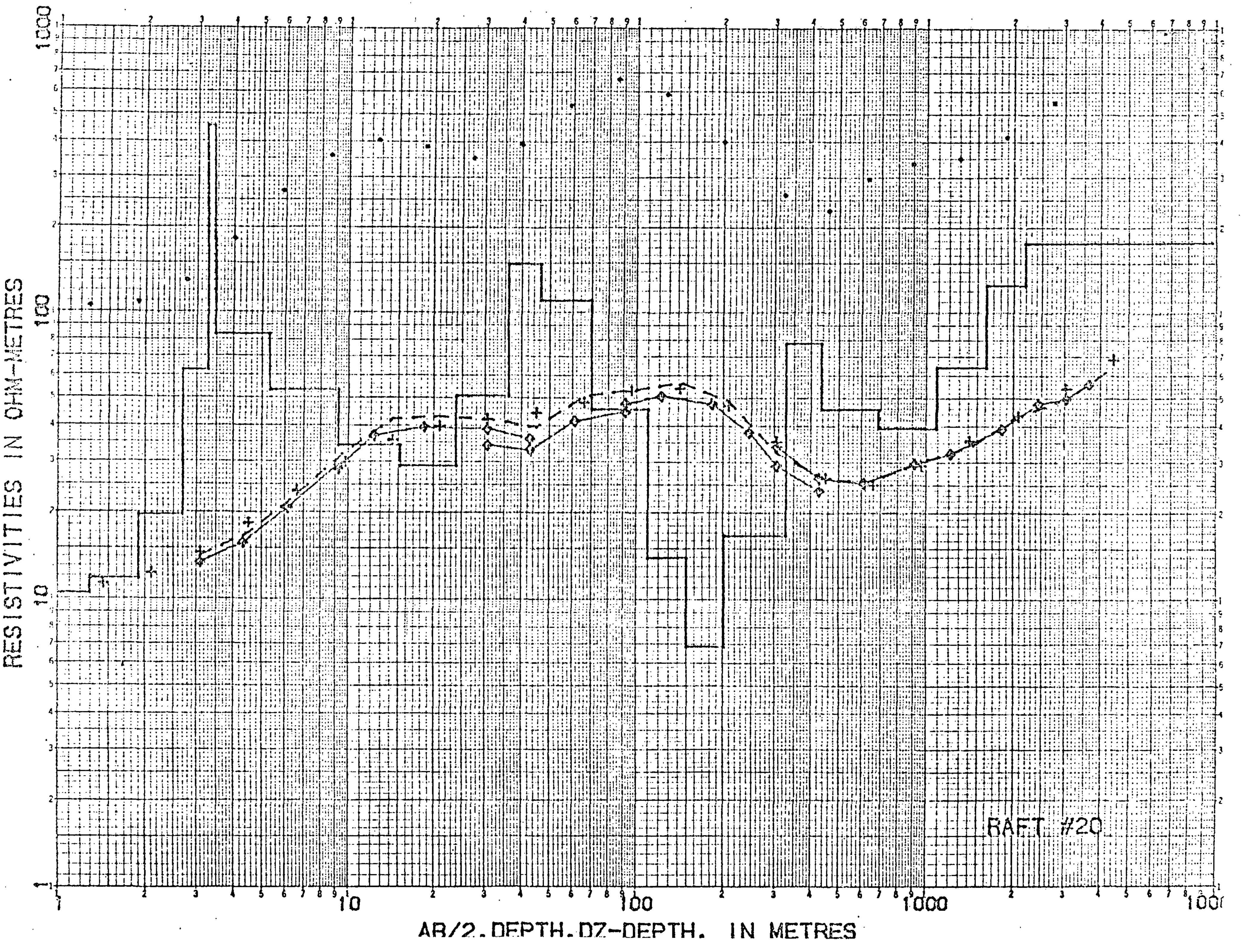

RESISTIVITIES IN OHM-METRES
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #16
1000
100
10
1
10
100
1000

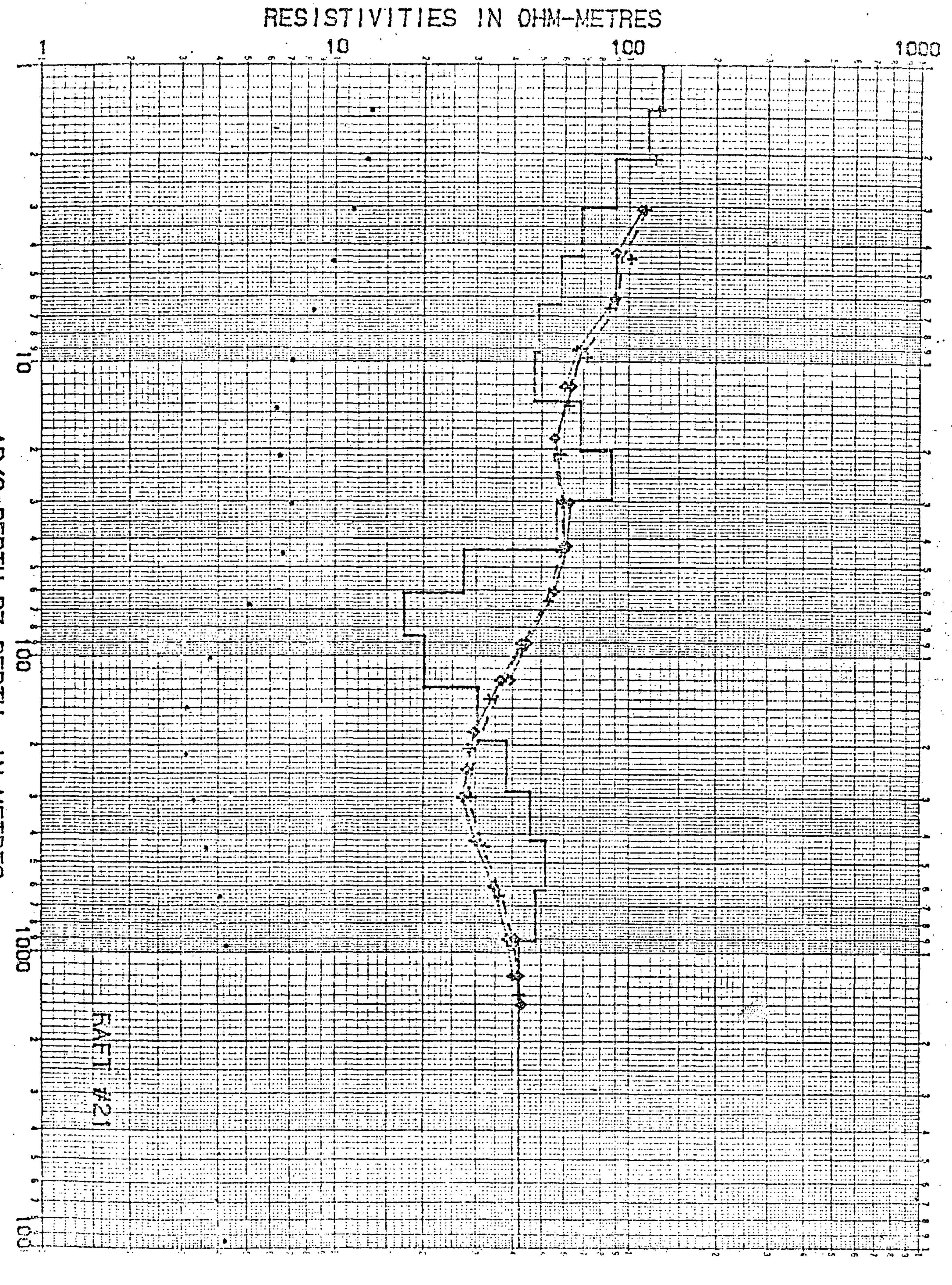


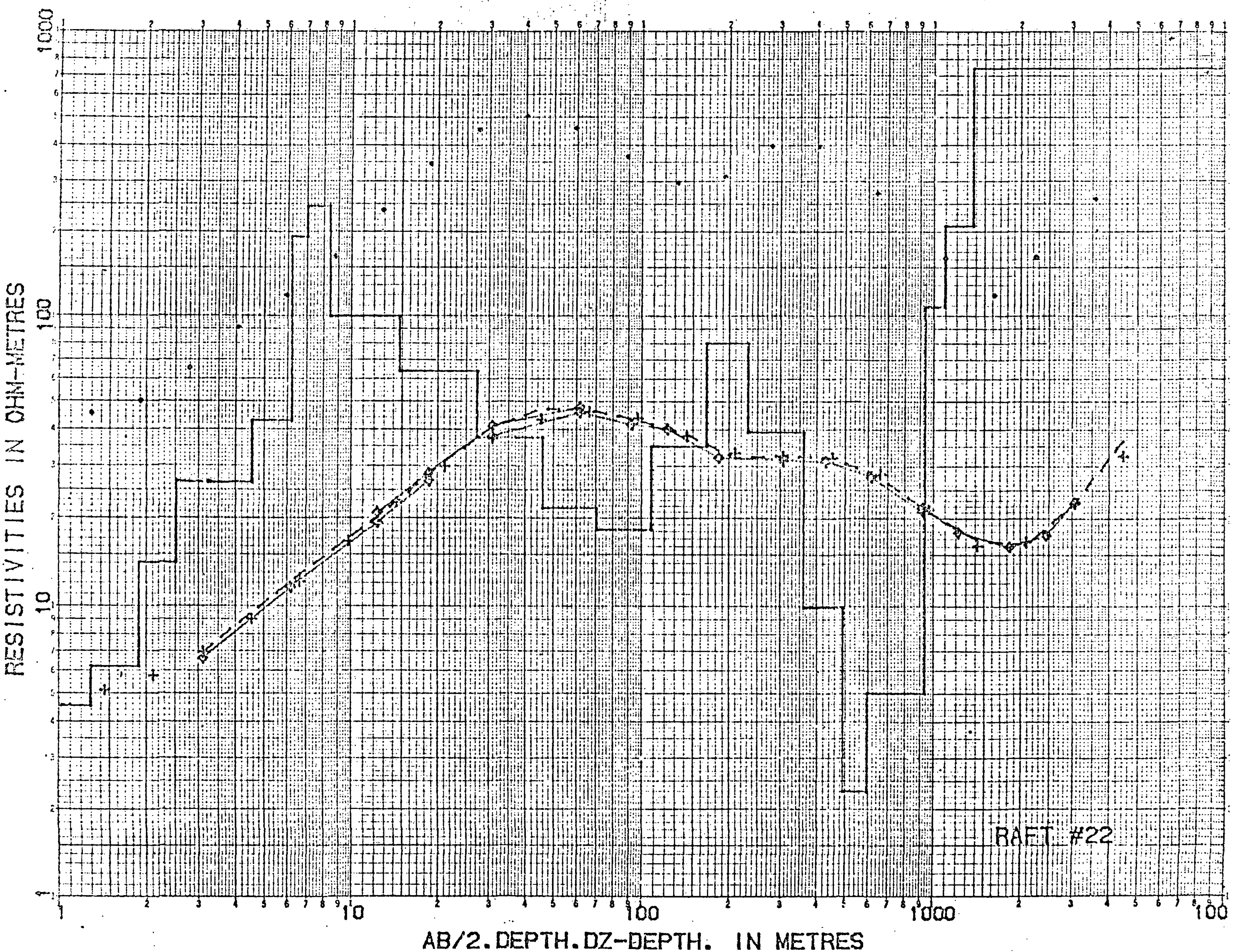
RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2 DEPTH DZ-DEPTH IN METRES
RAFT #17


RESISTIVITIES IN OHM-METRES
1000
100
10
1
10
100
1000
1000
RAET #18

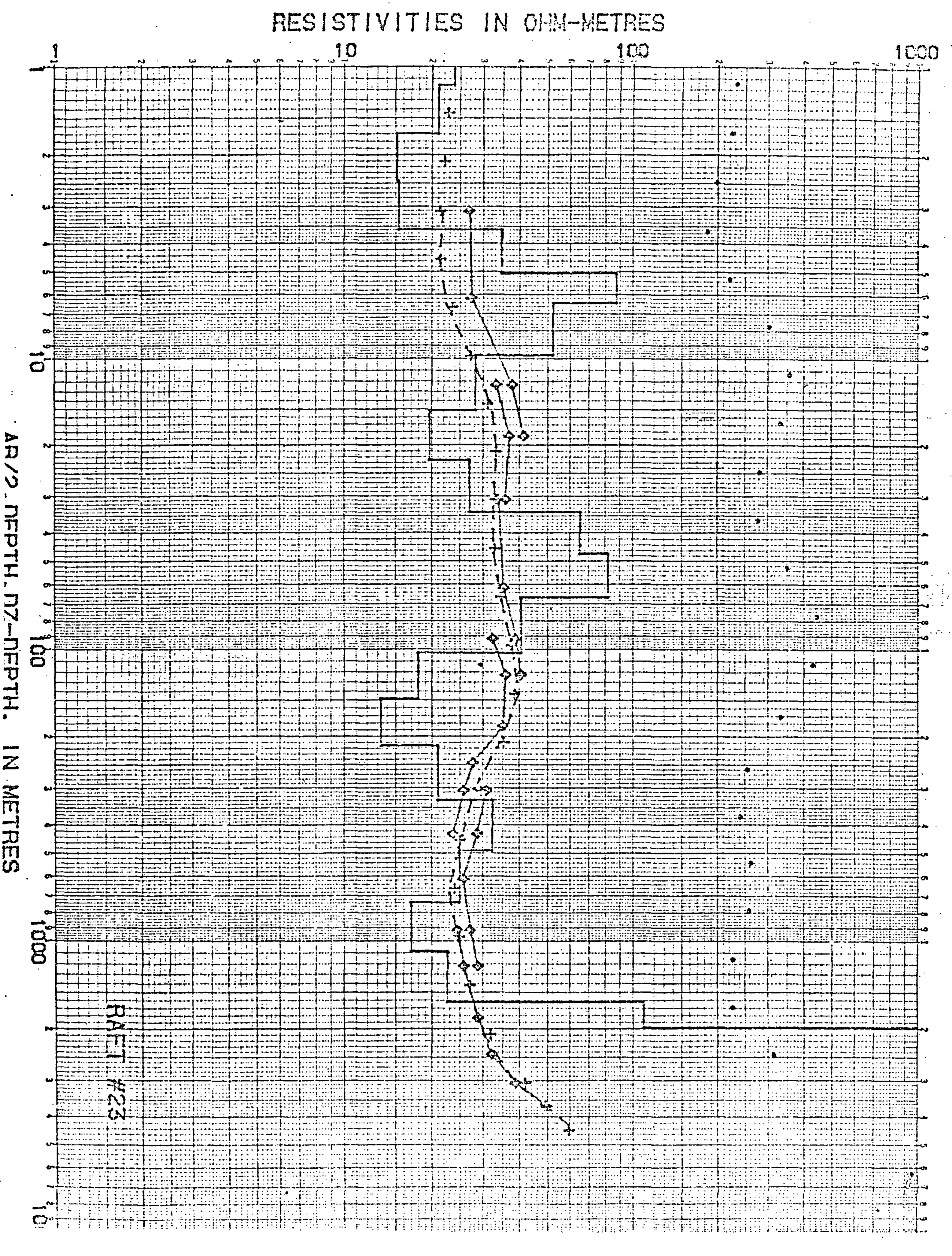

RESISTIVITIES IN OHM-METRES
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAFT #19
1
10
100
1000


RESISTIVITIES IN OHM-METRES
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #20
1000
100
10
1
10
100
1000
10000

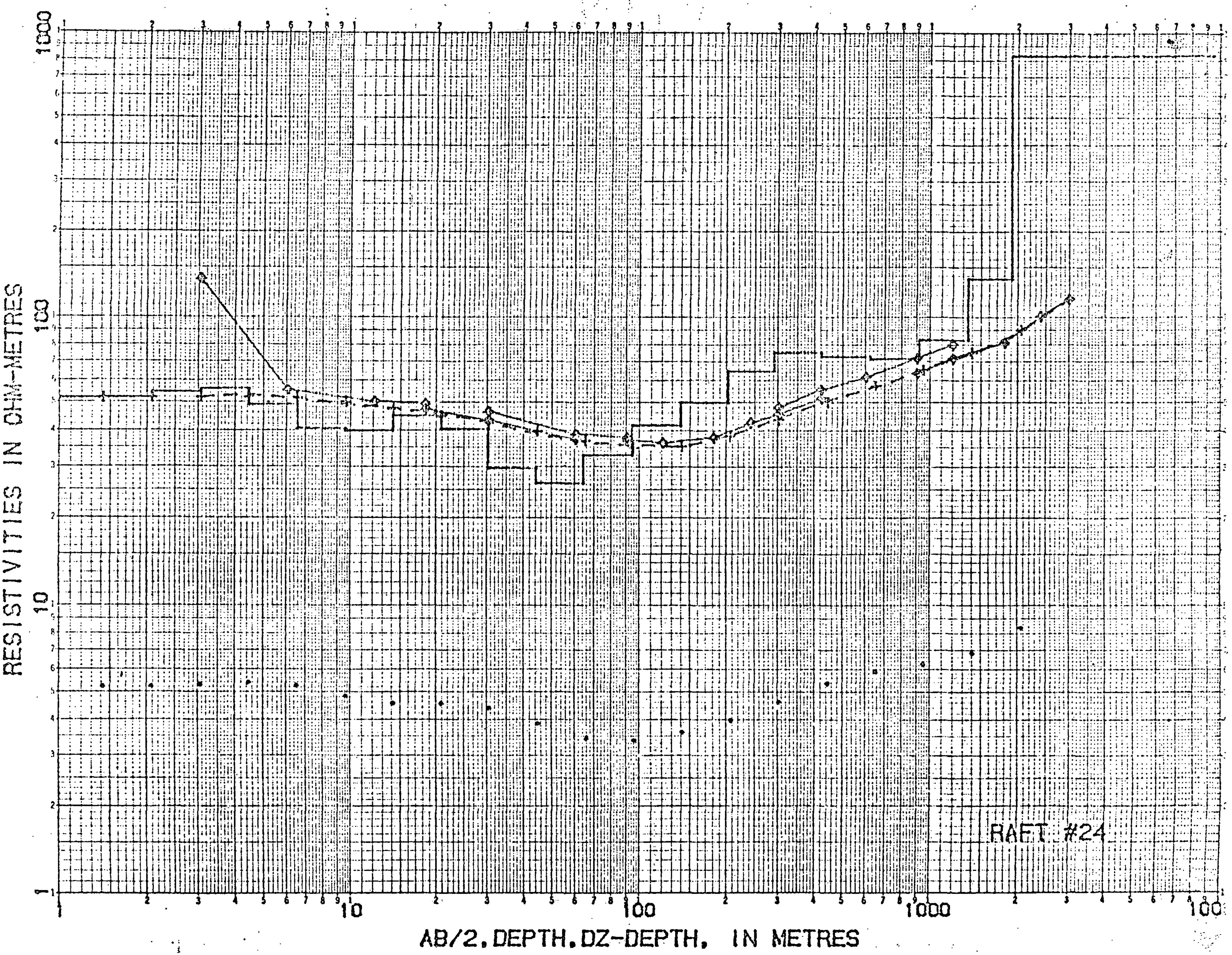

RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2 DEPTH RZ-DEPTH IN METRES
10
100
1000
100

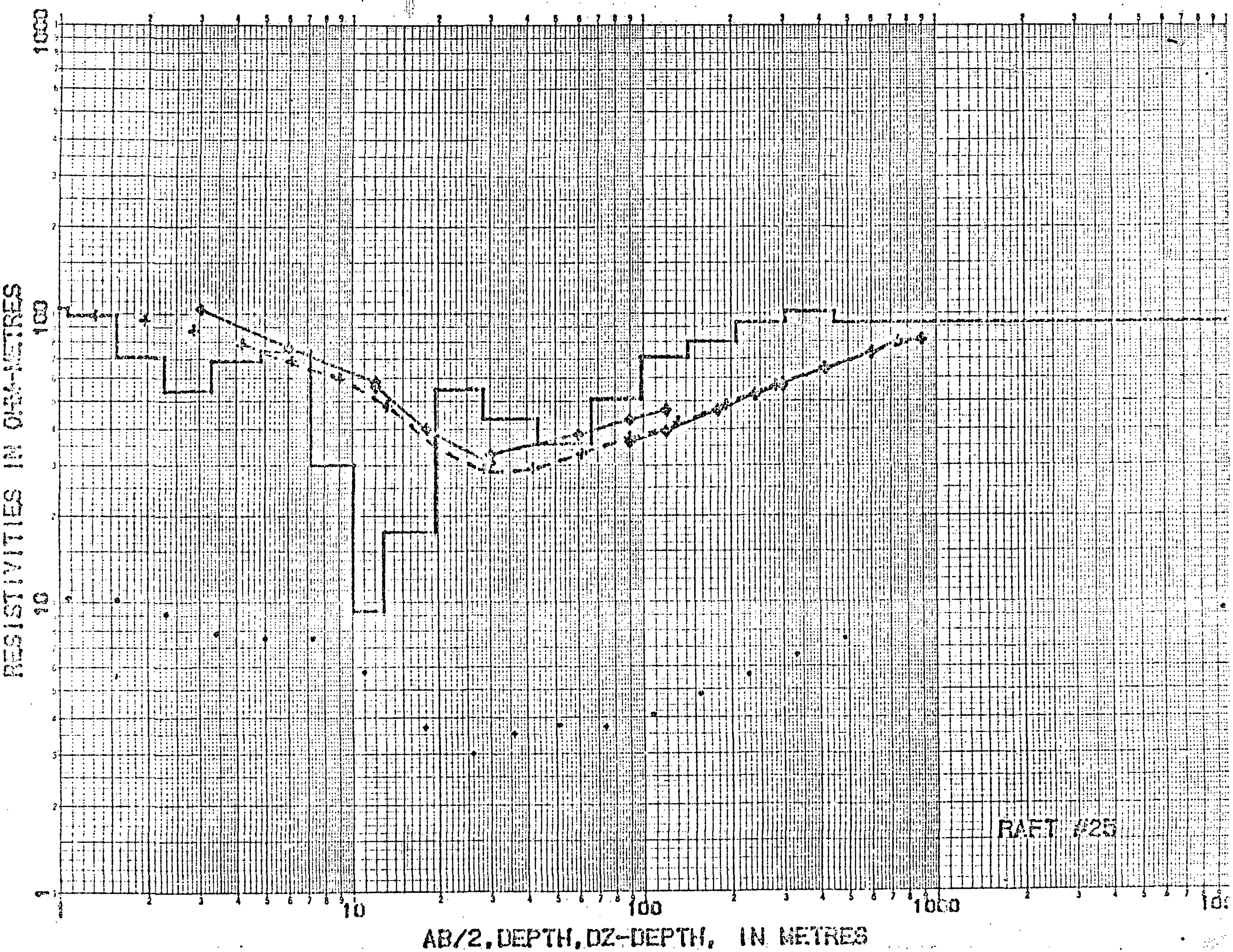


RESISTIVITIES IN OHM-METRES
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAFT #22

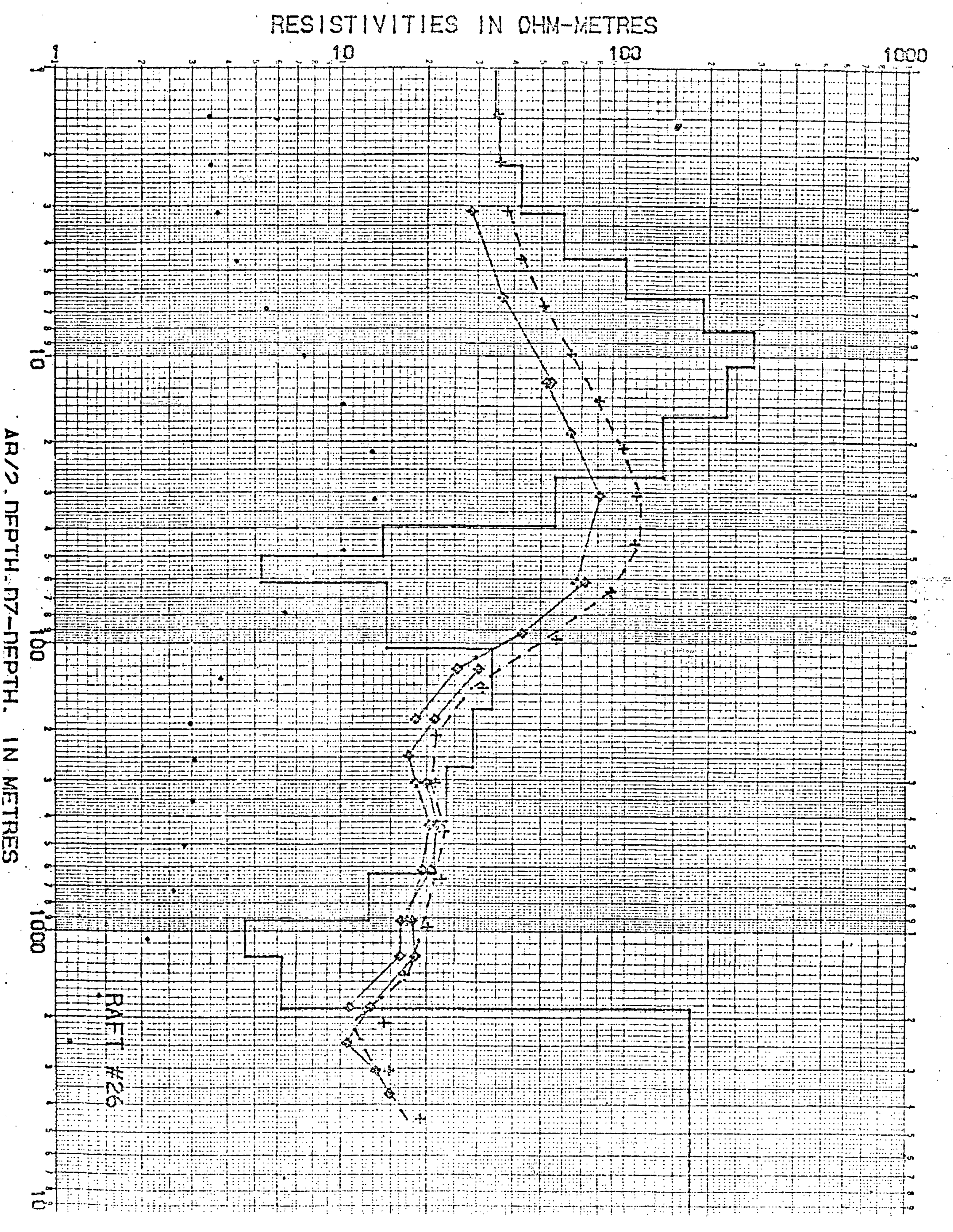


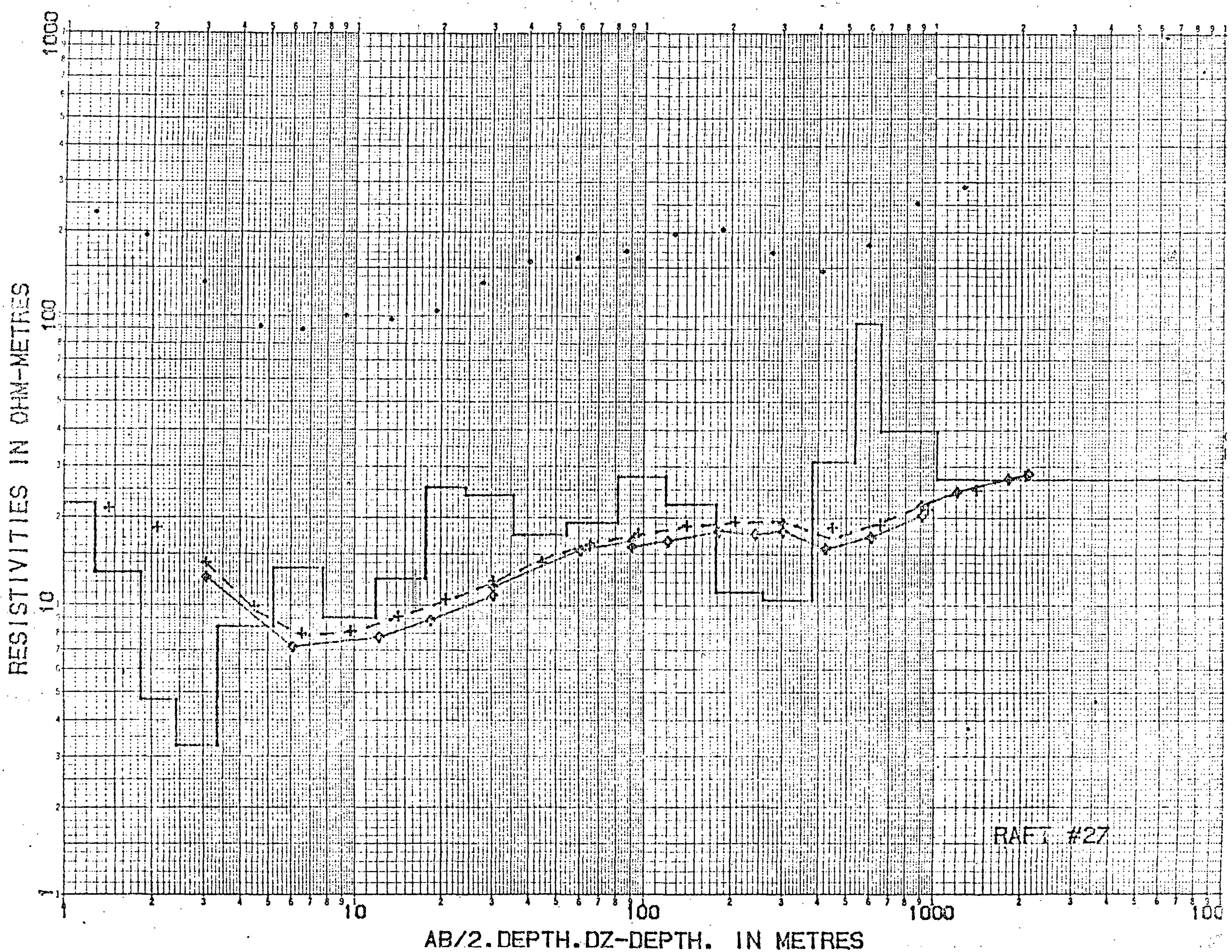
RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAFT #23


RESISTIVITIES IN OHM-METRES
1000
100
10
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #24

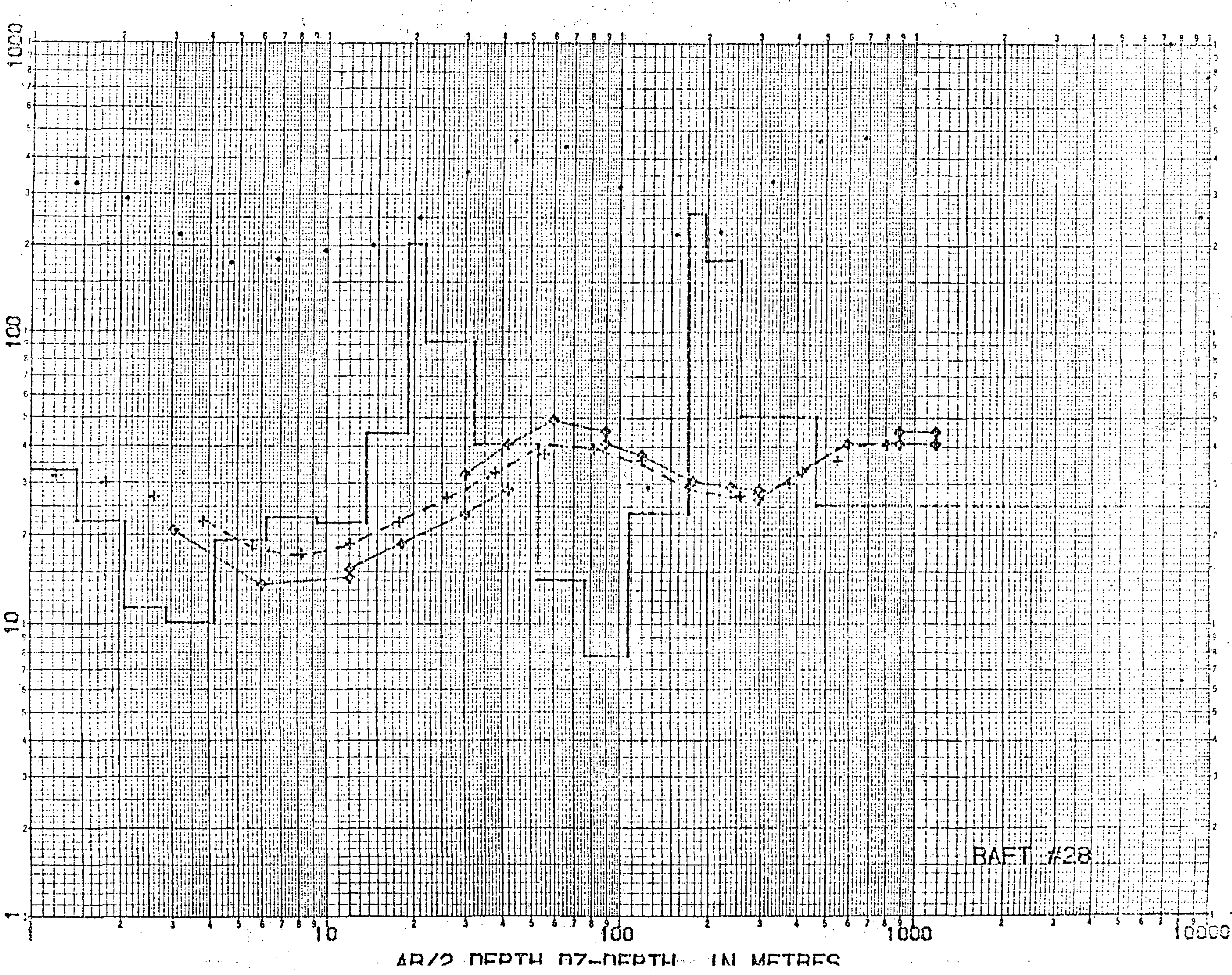


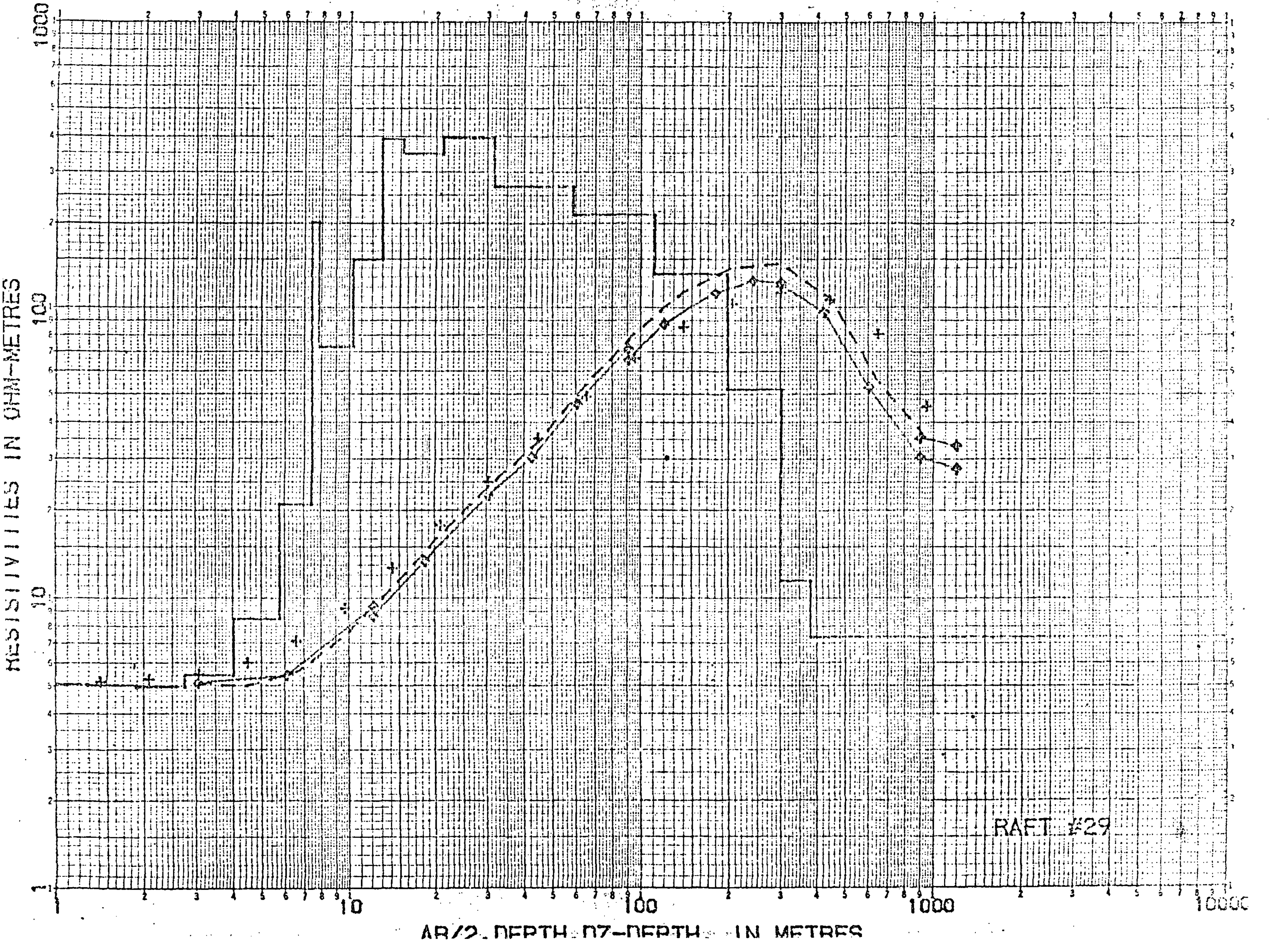
RESISTIVITIES IN OHM-METRES
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #25

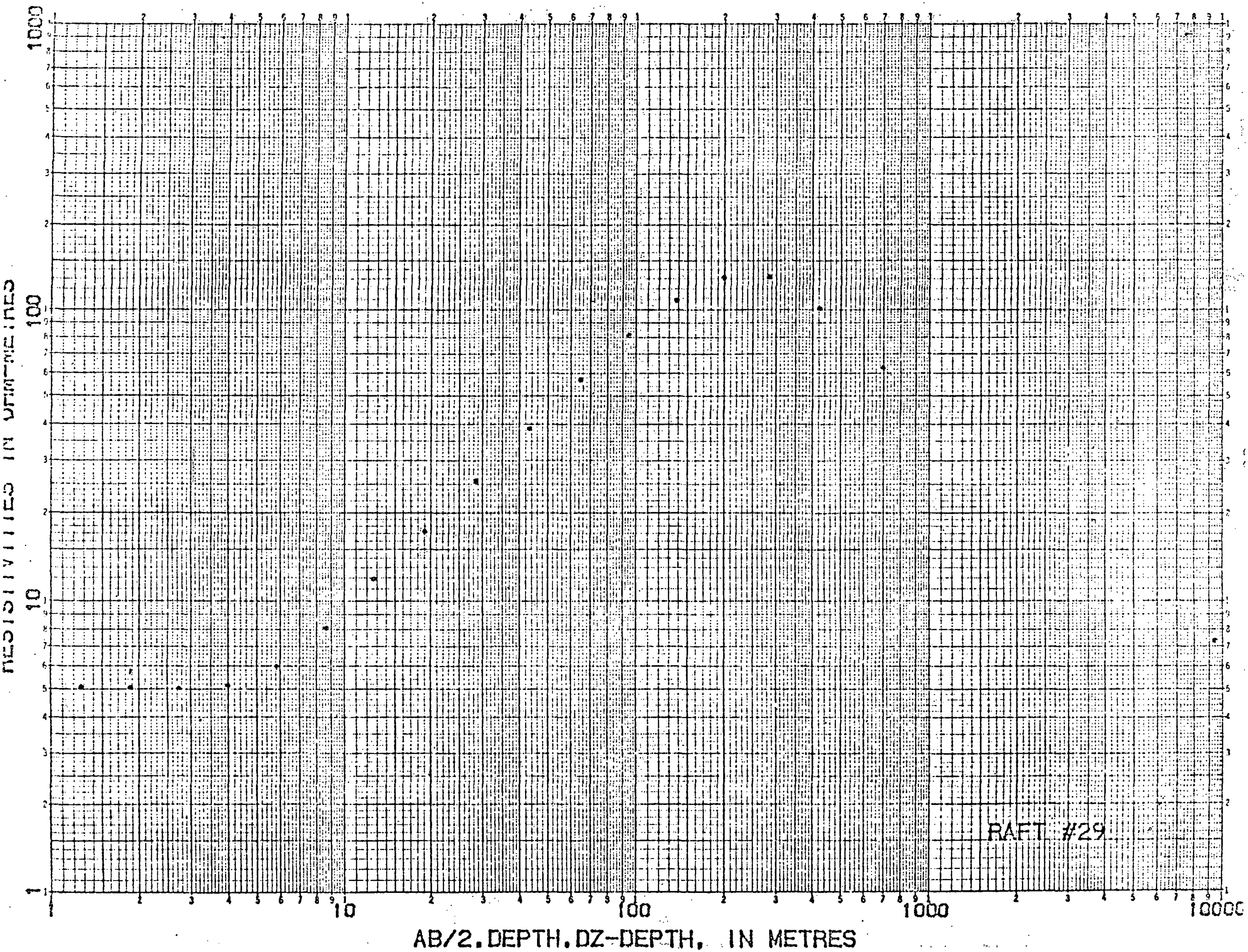

RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2 DEPTH, DZ-DEPTH, IN METRES
10
100
1000
RAFT #26

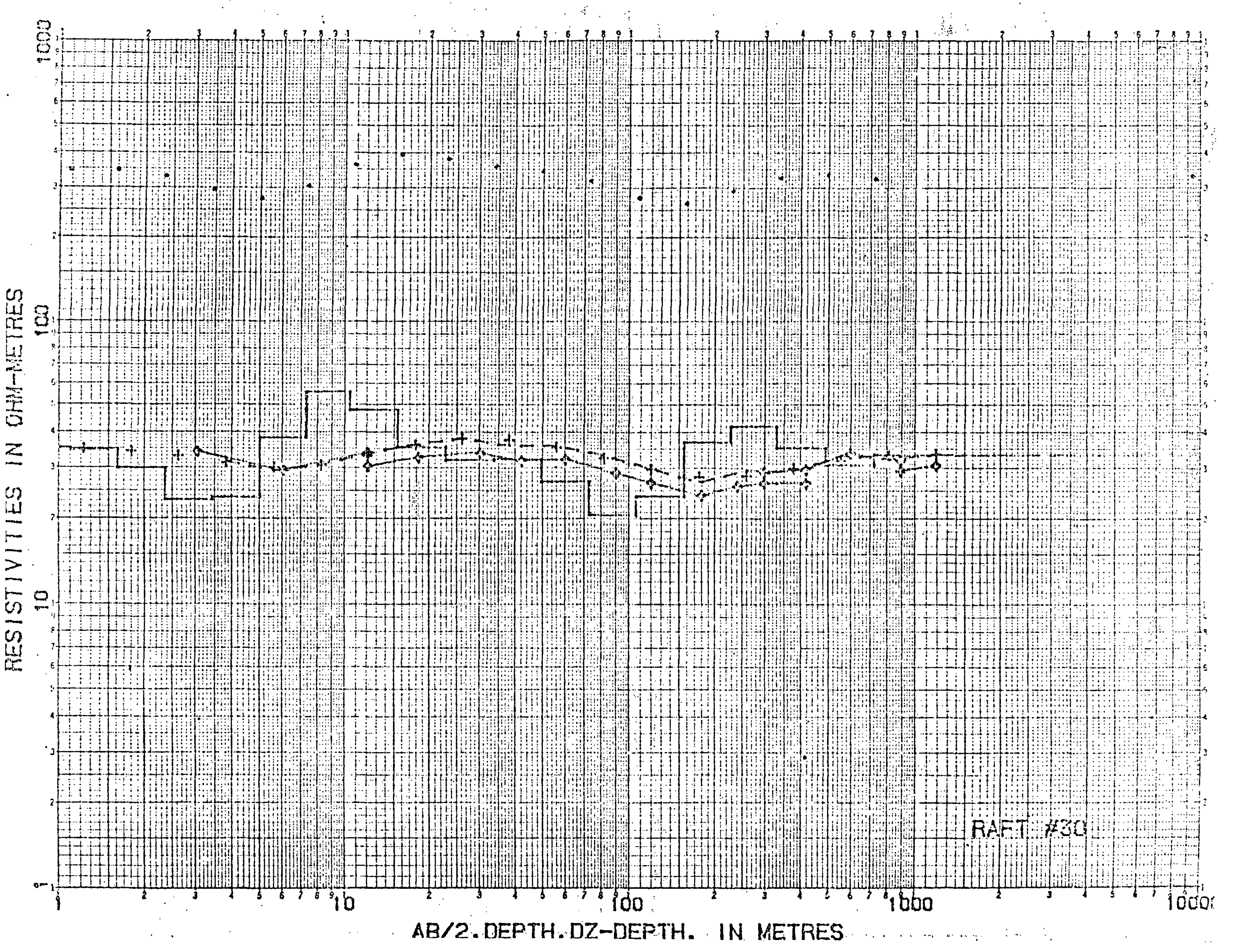


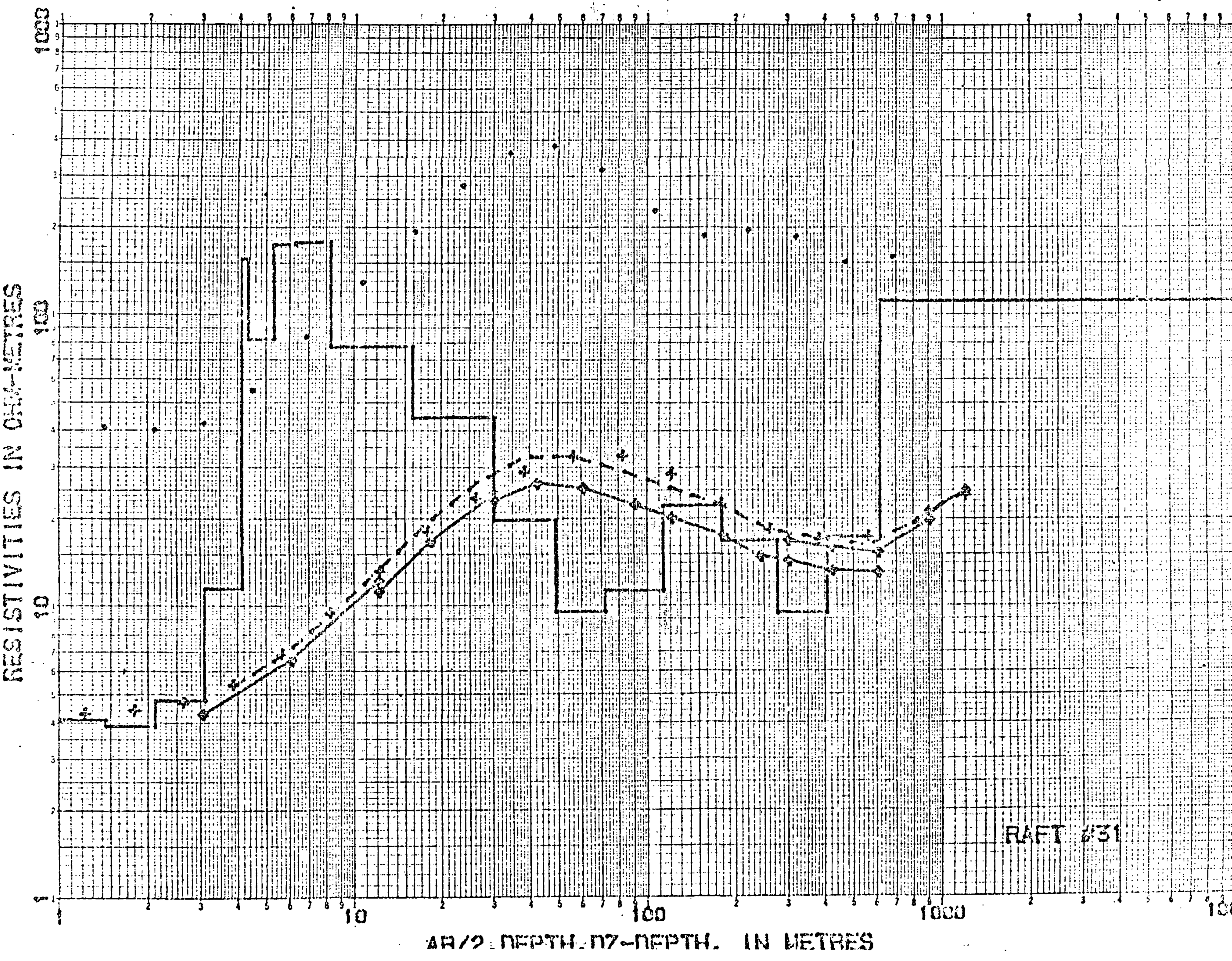
RESISTIVITIES IN OHM-METRES
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAFT #27
1
10
100
1000


RESISTIVITIES IN OHM-METRES
AB/2 DEPTH BZ-DEPTH IN METRES
RAFT #28
1000
100
10
1
10
100
1000
10000

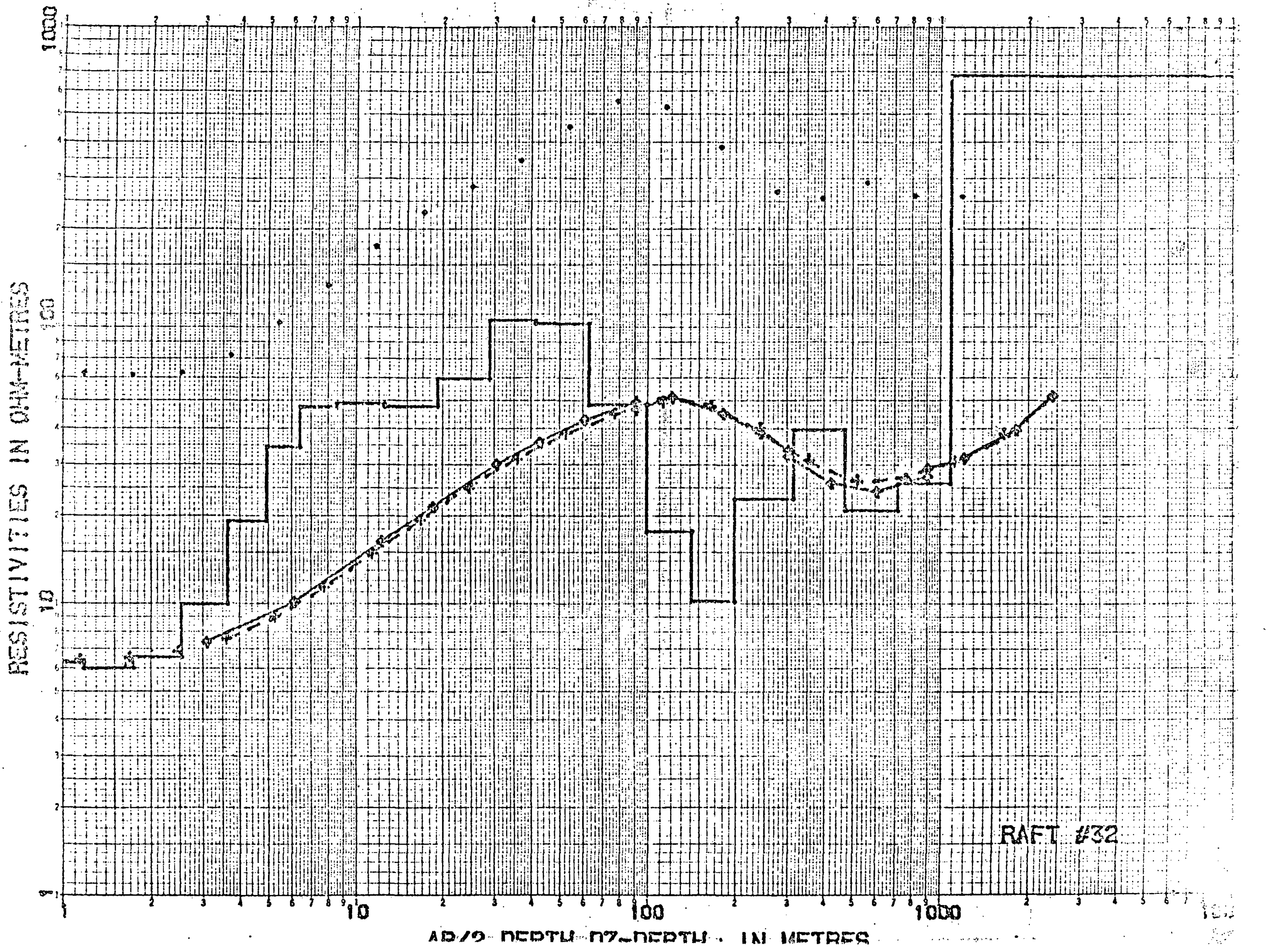

RESISTIVITIES IN OHM-METRES
1000
100
10
1
10
100
1000
10000
RAFT #29
AB/2-DEPTH DZ-DEPTH IN METRES

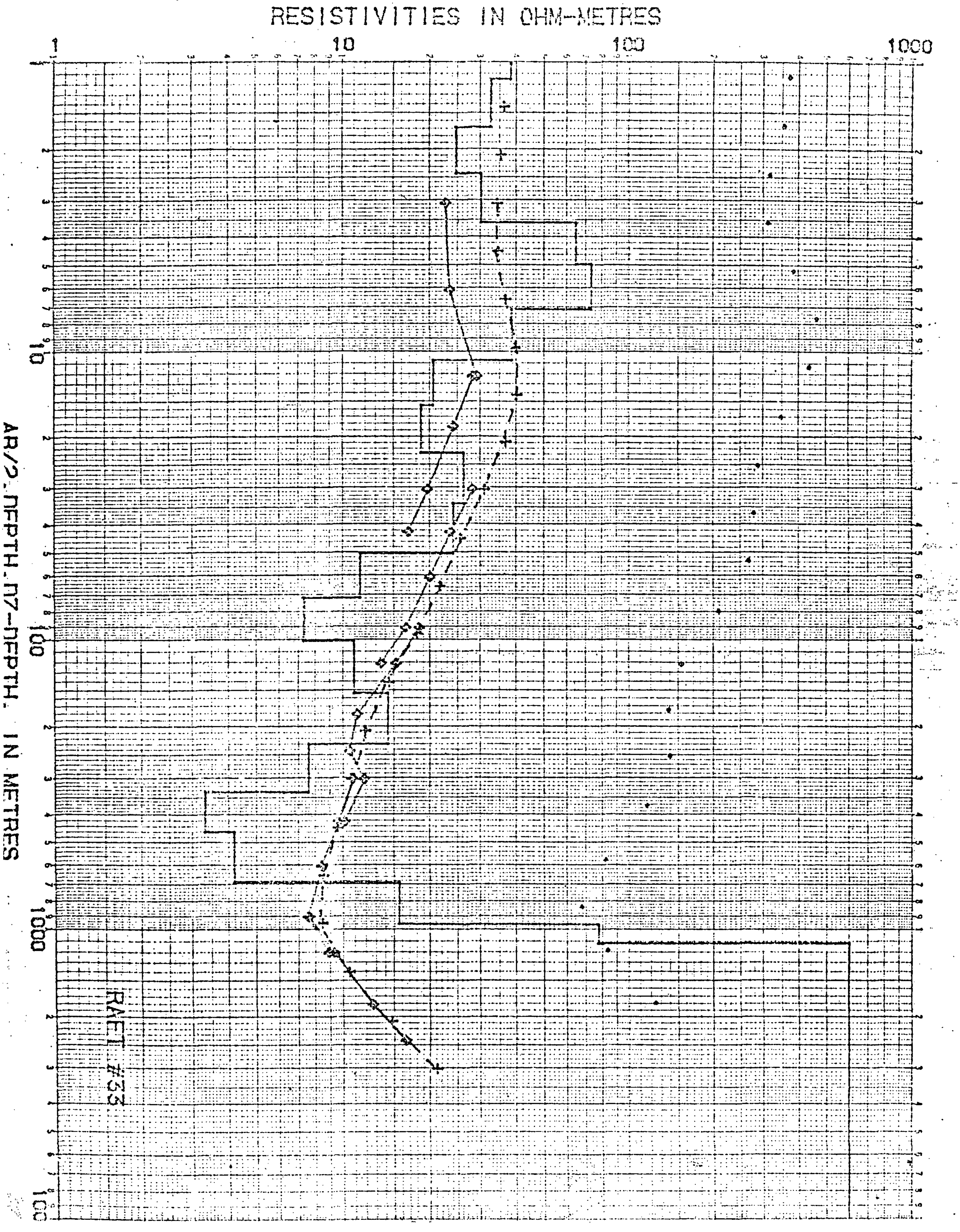

1000
100
10
1
10
100
1000
10000
AB/2.DEPTH.DZ-DEPTH, IN METRES
RAFT #29

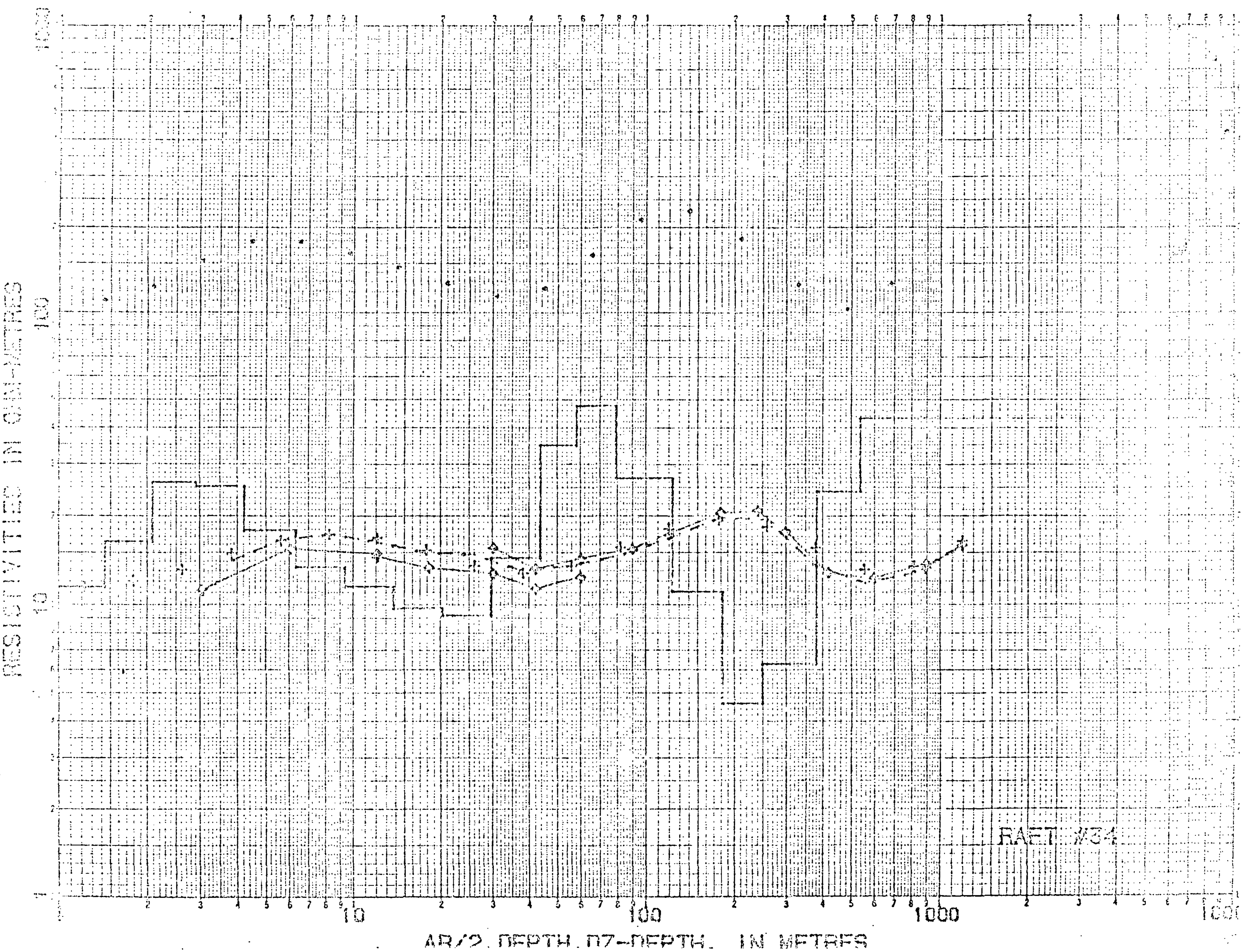

RESISTIVITIES IN OHM-METRES
1000
100
10
1
10
100
1000
10000
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAFT #30



RAFT #31
RESISTIVITIES IN OHM-METRES
AB/2 DEPTH-DZ-DEPTH. IN METRES
1
10
100
1000

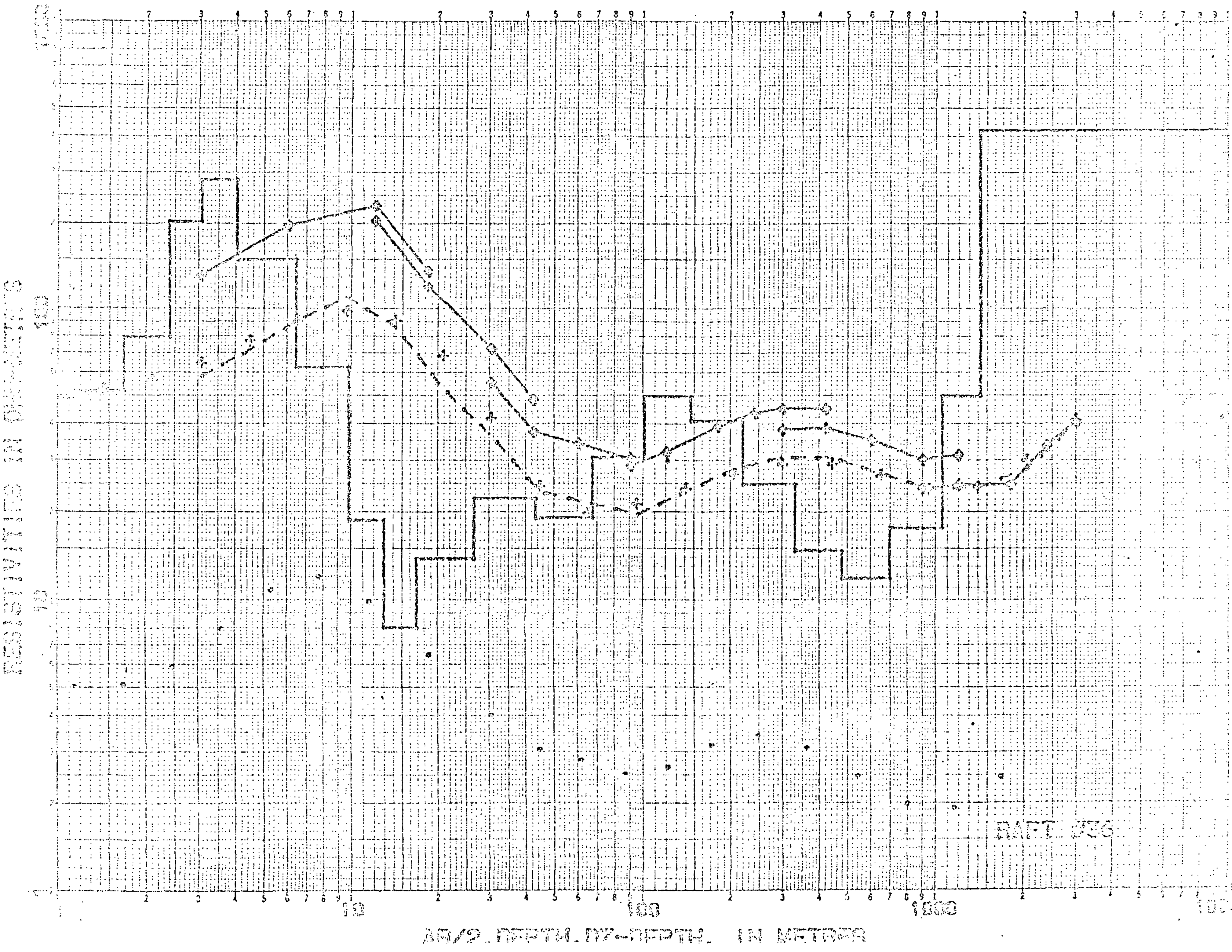

RESISTIVITIES IN OHM-METRES
AB/2-DEPTH-DZ-DEPTH, IN METRES
RAFT #32
1
10
100
1000


RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2 .DEPTH.D7-DEPTH. IN METRES
RAET #33

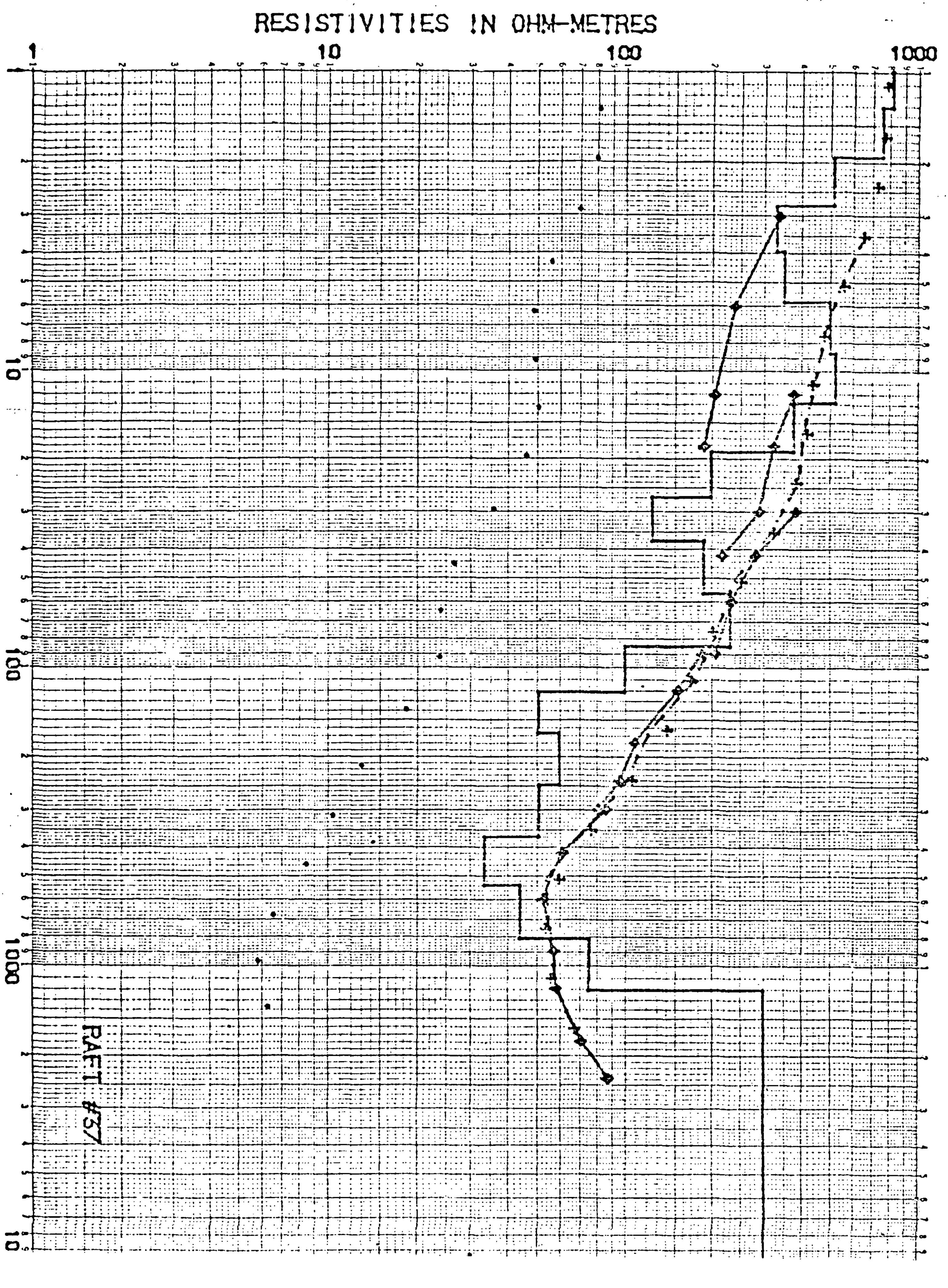


RESISTIVITIES IN OHM-METRES
10
100
1000
AB/2 DEPTH DZ-DEPTH IN METRES
RAET #34

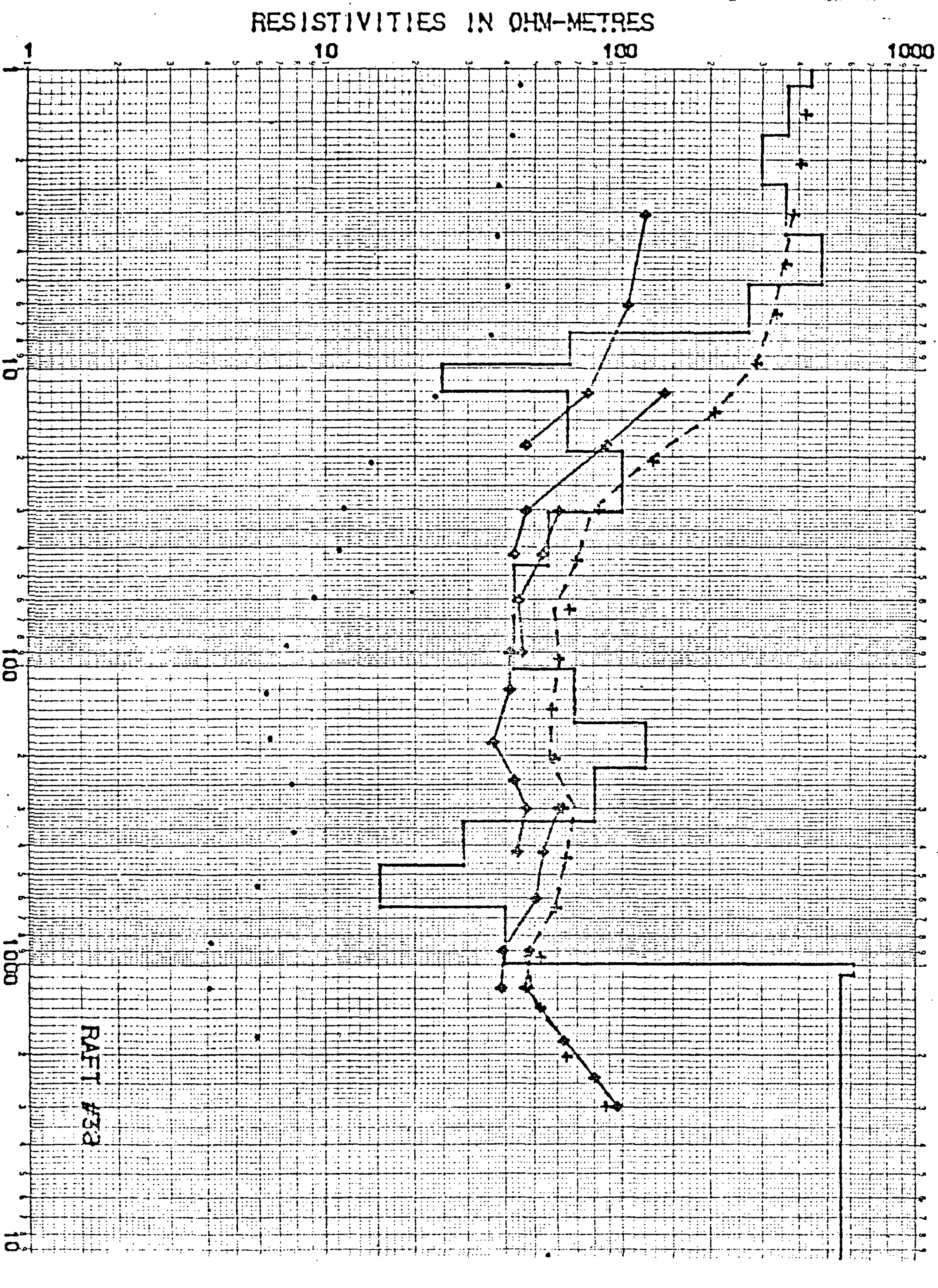
1000
100
10
1000
RAFT



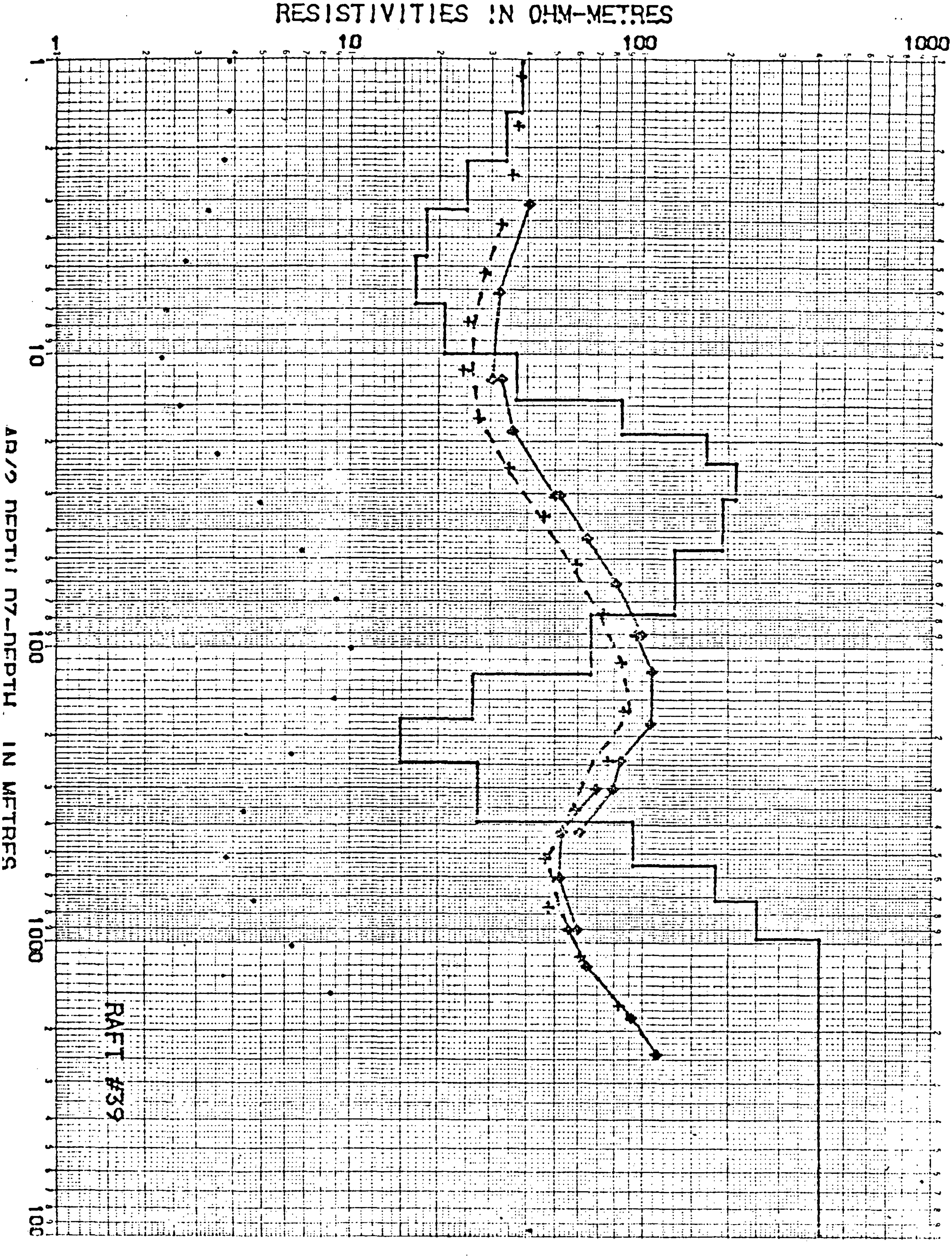
RAFT
10
100
1000

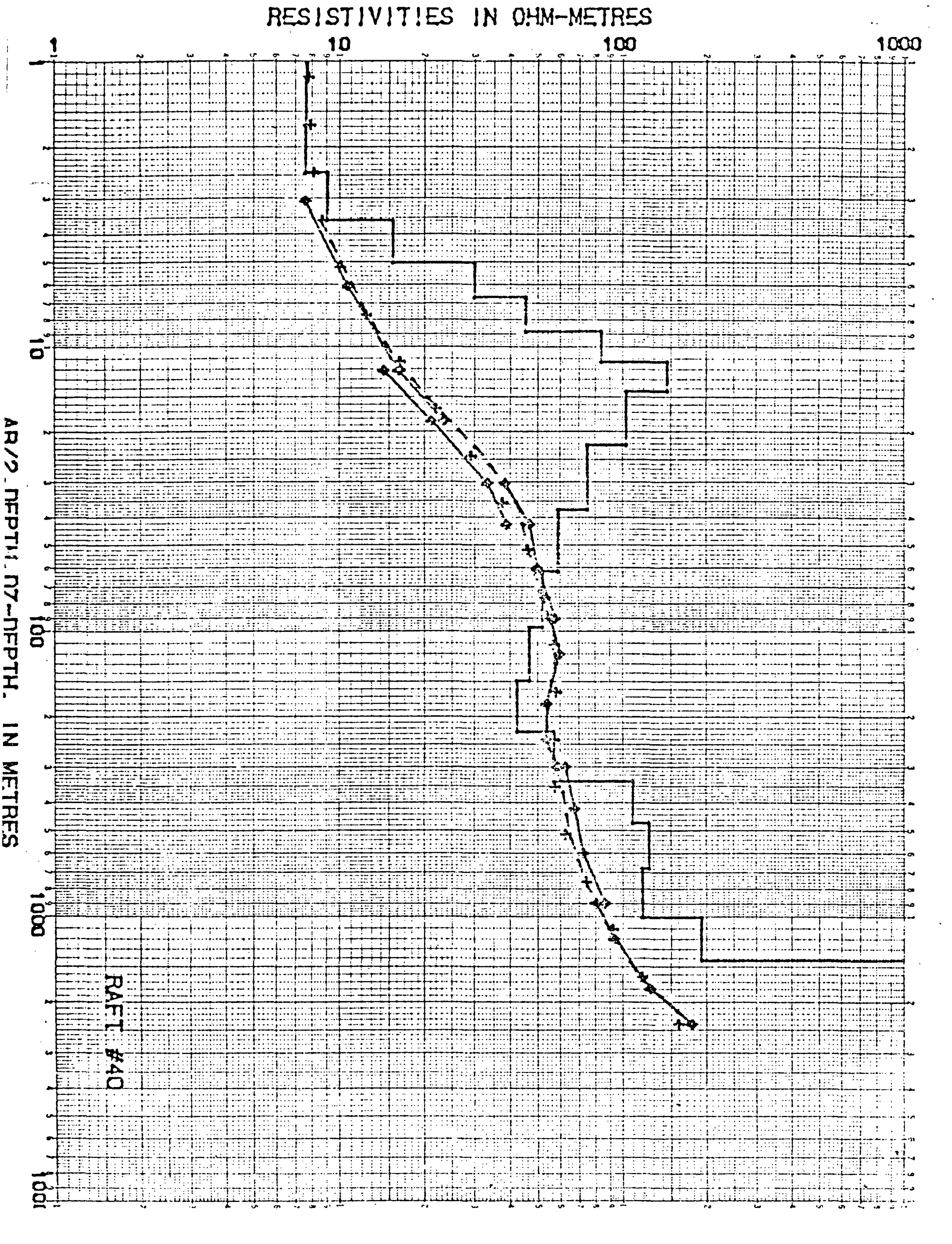


RESISTIVITIES IN OHM-METRES
1
10
100
1000
10
100
1000
10
RAFT #37

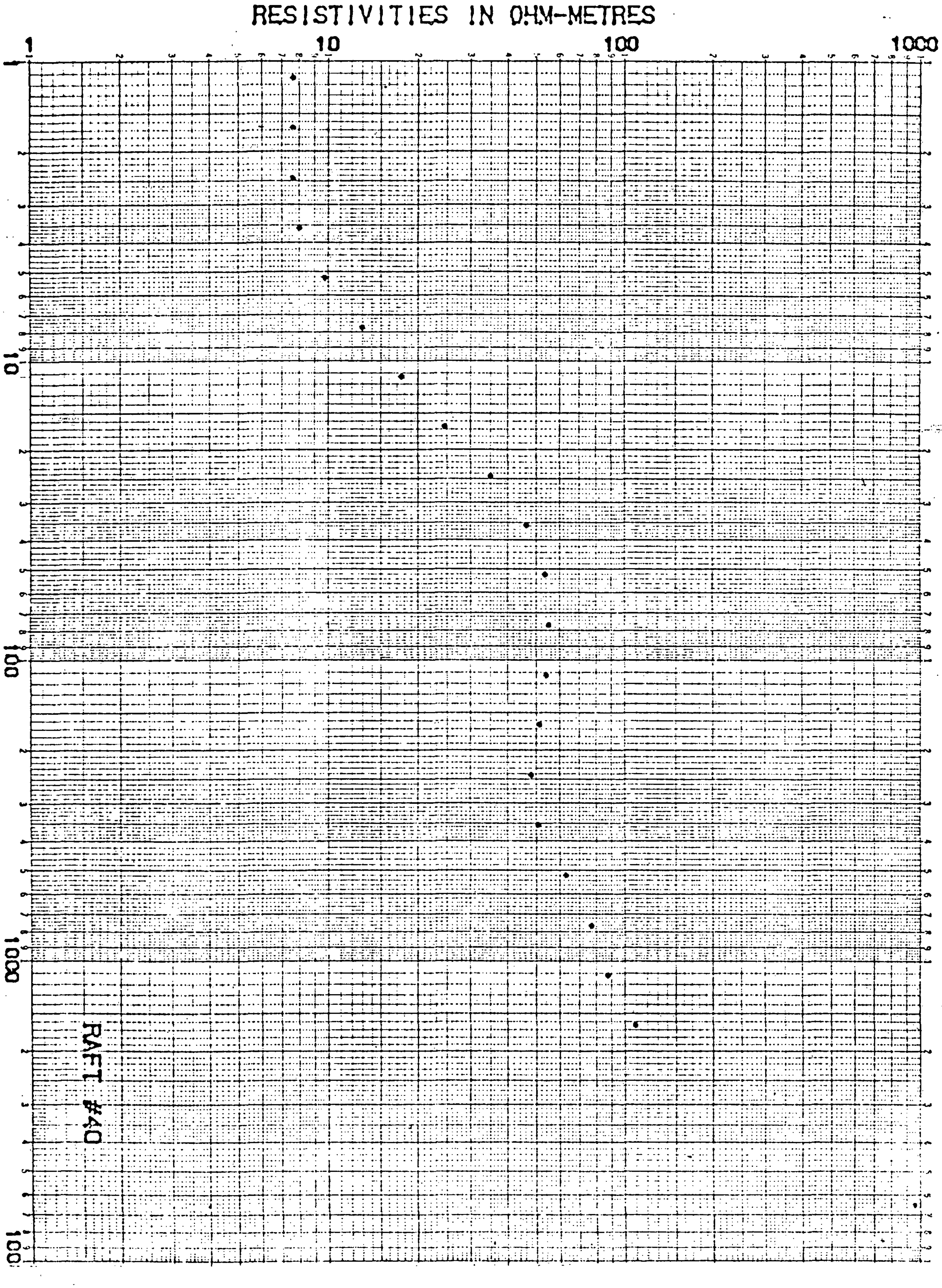


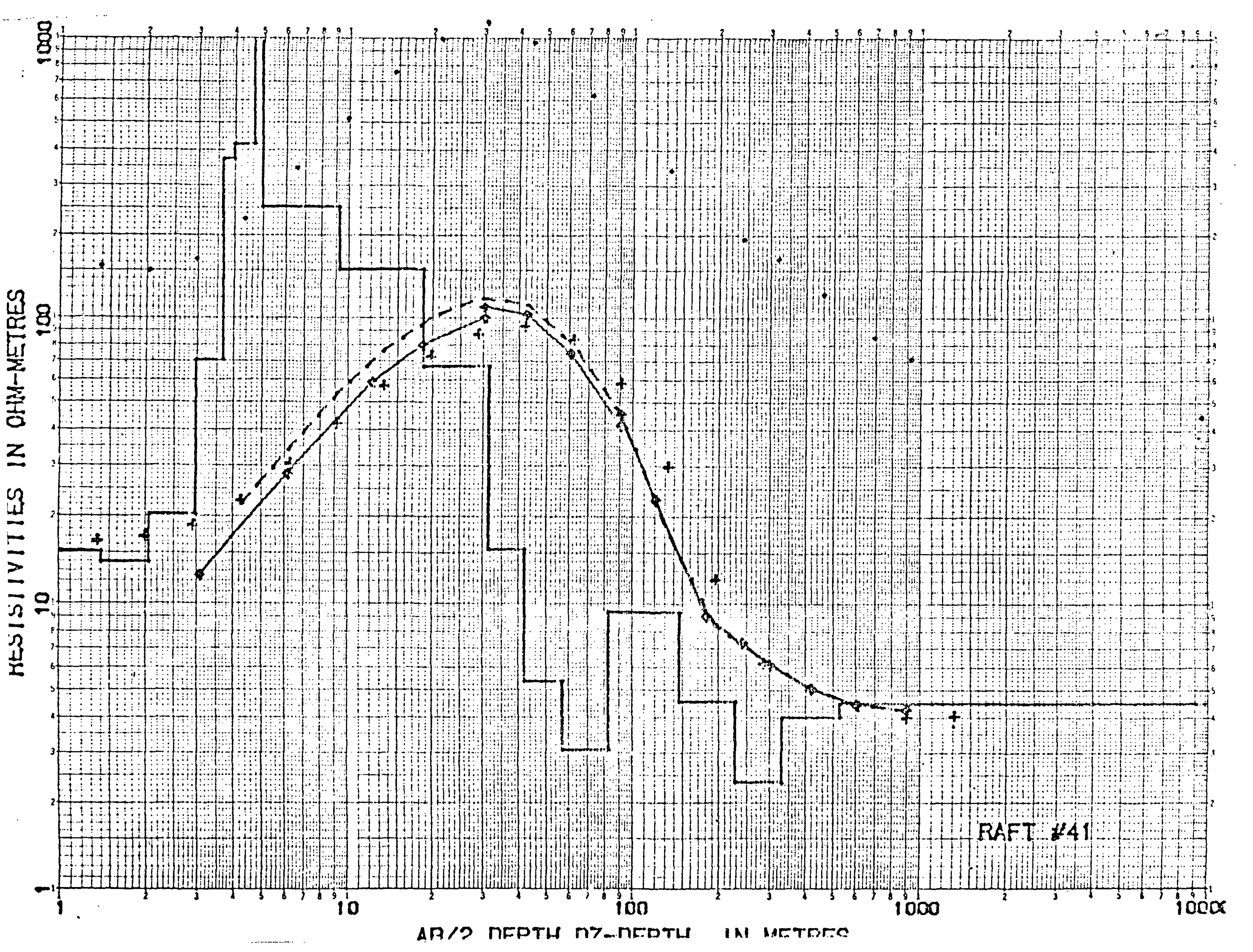
RESISTIVITIES IN OHM-METRES
1
10
100
1000
10
100
1000
RAFT #33

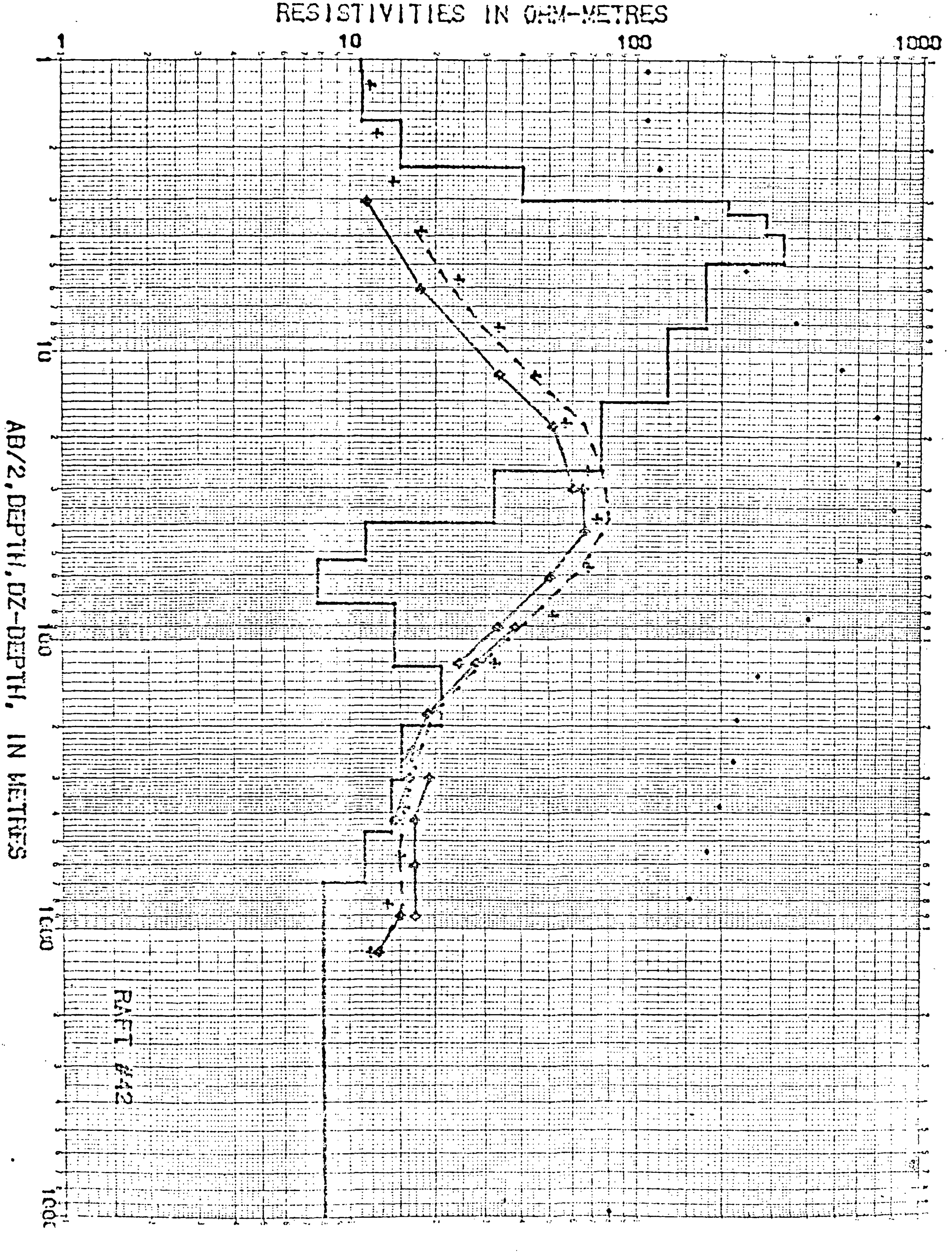

RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2 DEPTH D7-DEPTH IN METRES
RAFT #39



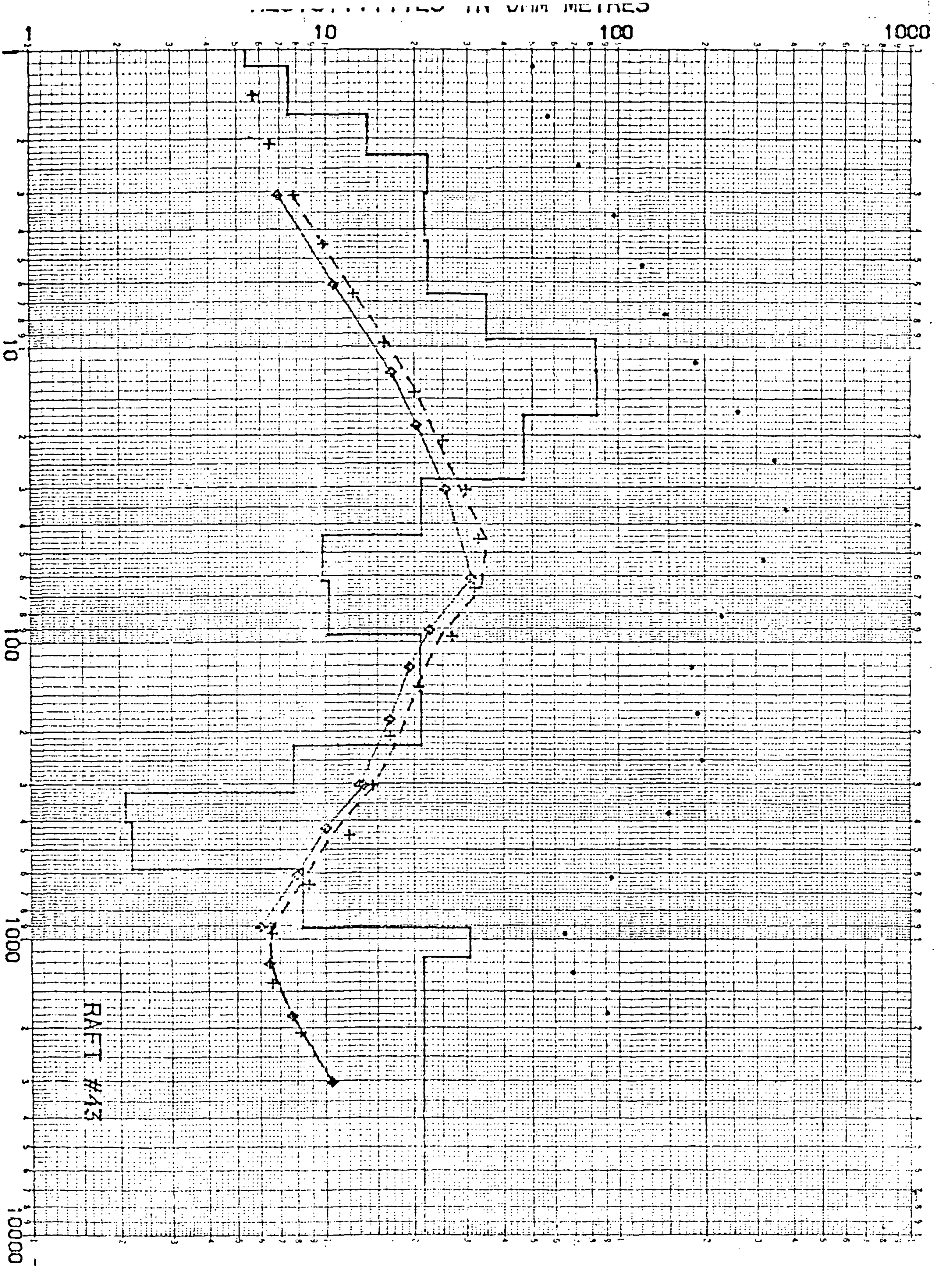
RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2 DEPTH, DZ-DEPTH, IN METRES
RAFT #40


RESISTIVITIES IN OHM-METRES
1
10
100
1000
10
100
1000
RAFT #40

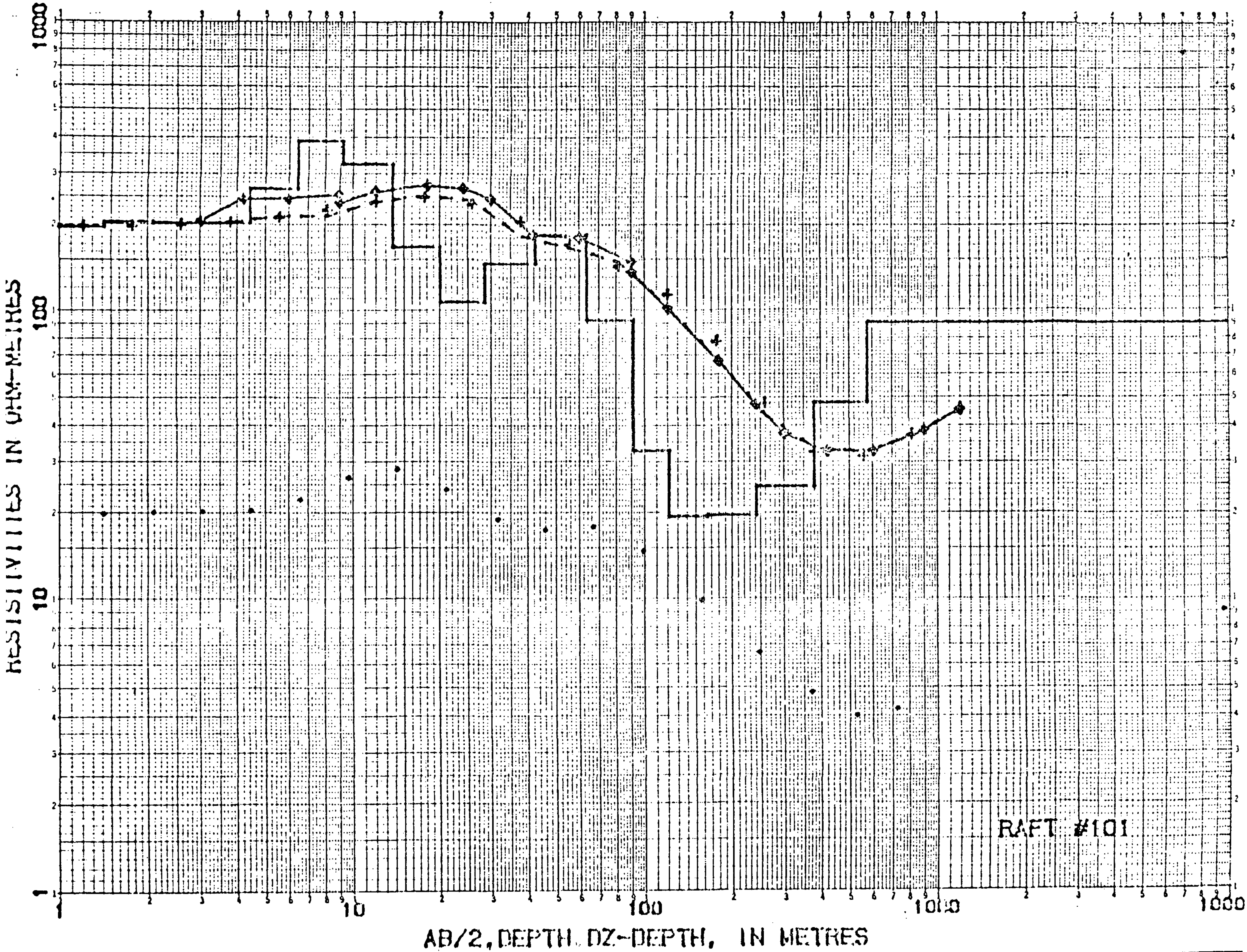

RESISTIVITIES IN OHM-METRES
RAFT #41
AB/2 DEPTH DZ-DEPTH IN METRES

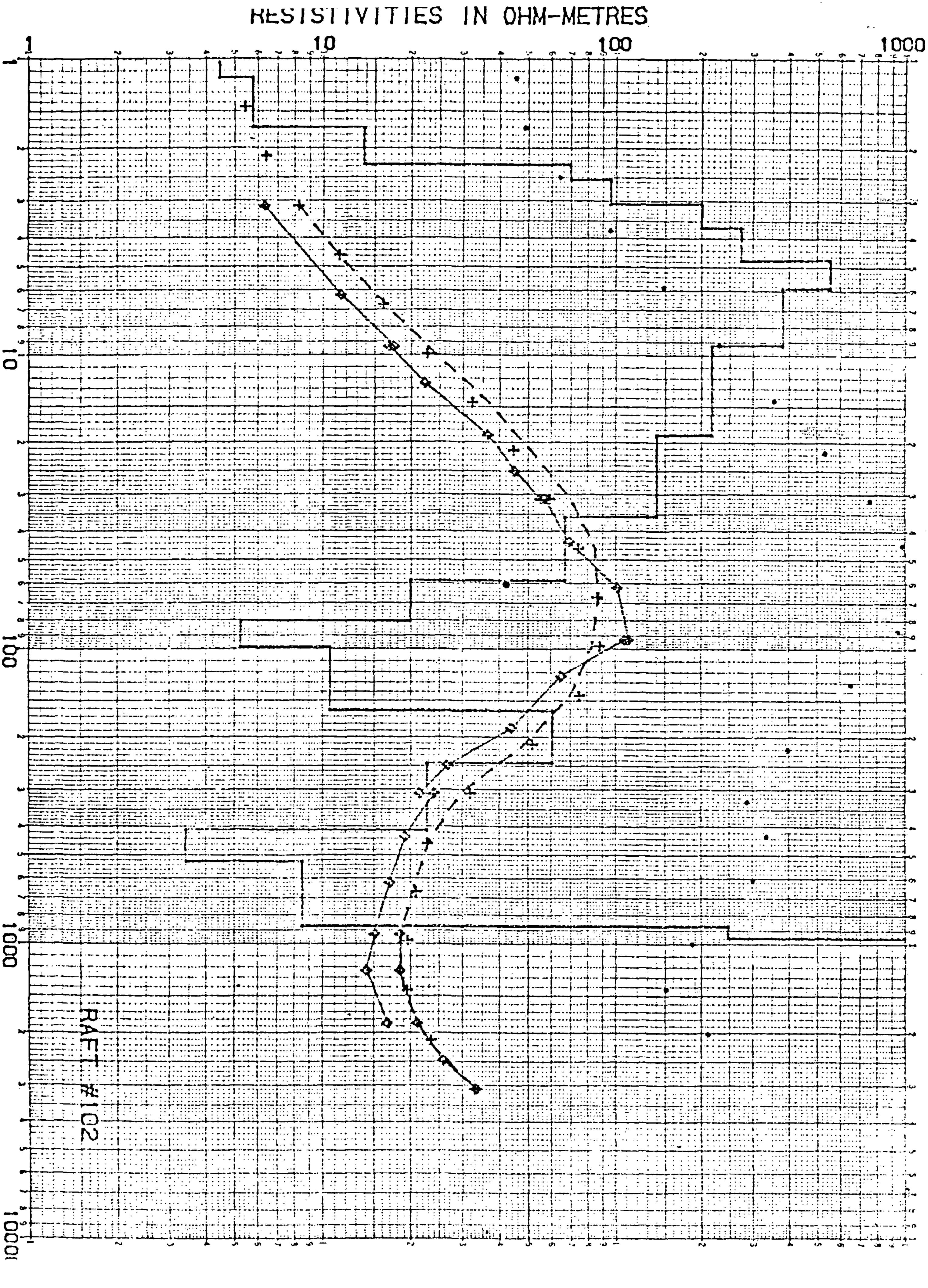


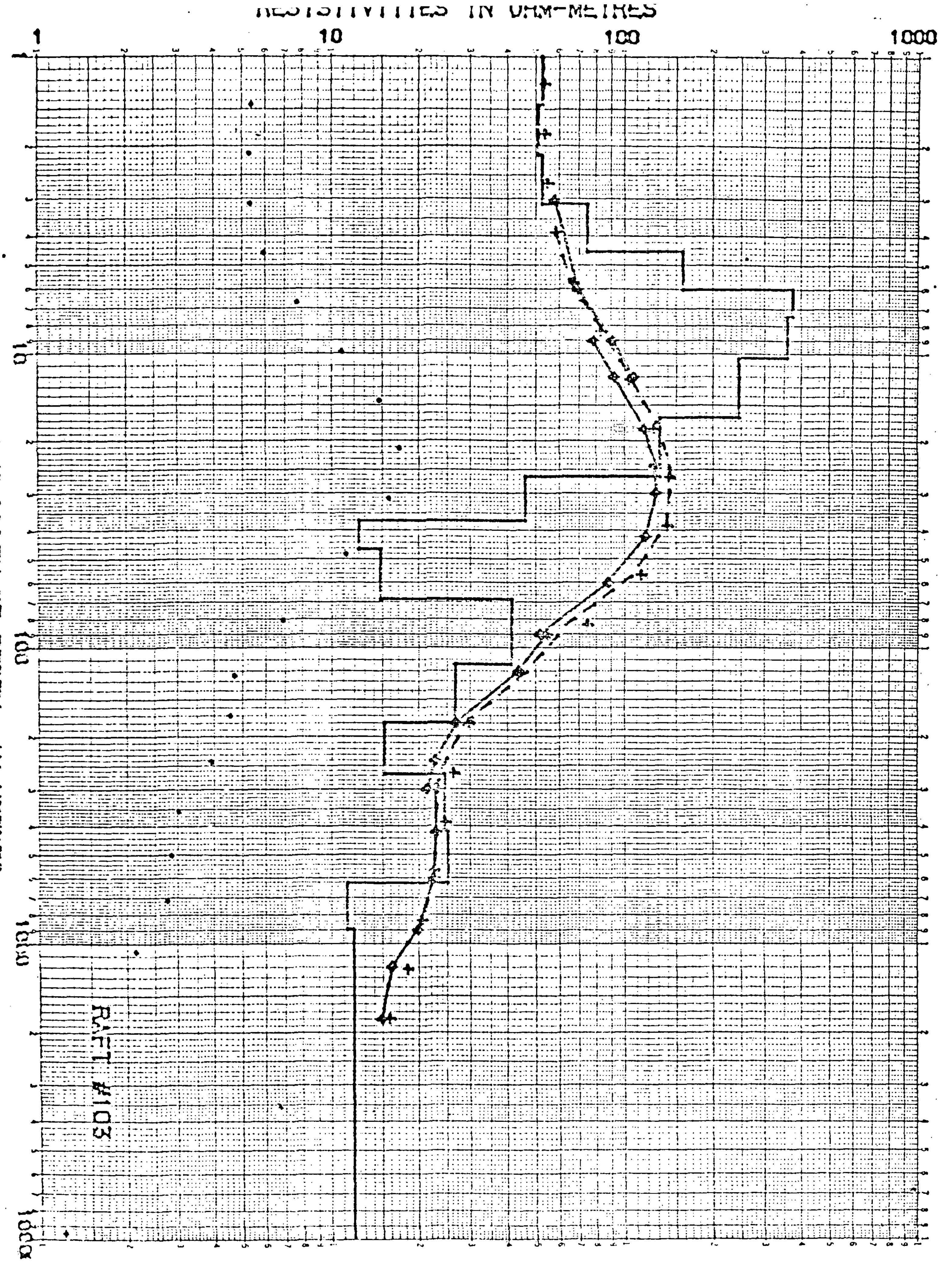
RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #42

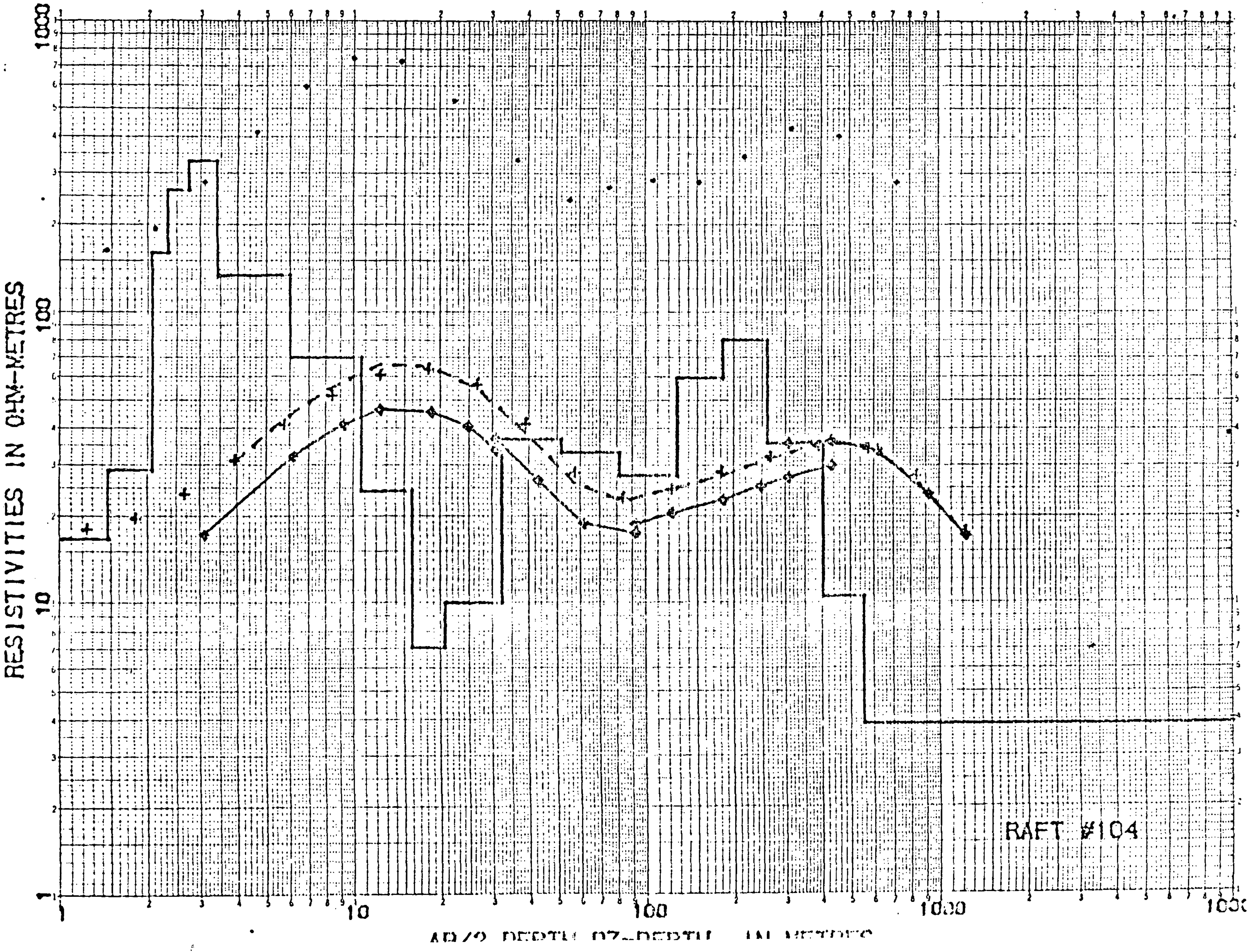


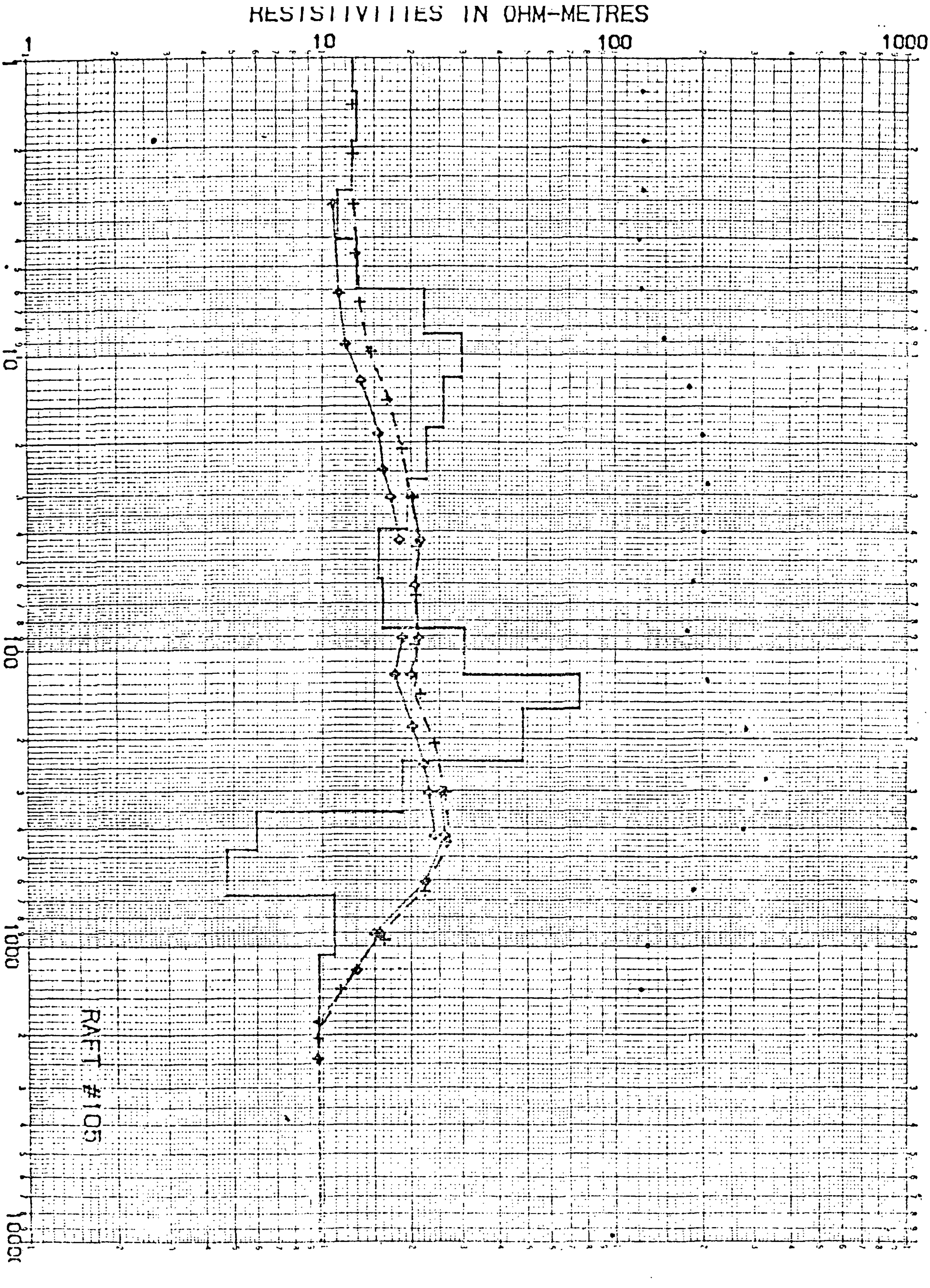
1
10
100
1000
RAFT #43


RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2, DEPTH, DZ-DEPTH, IN METRES
RAFT #101

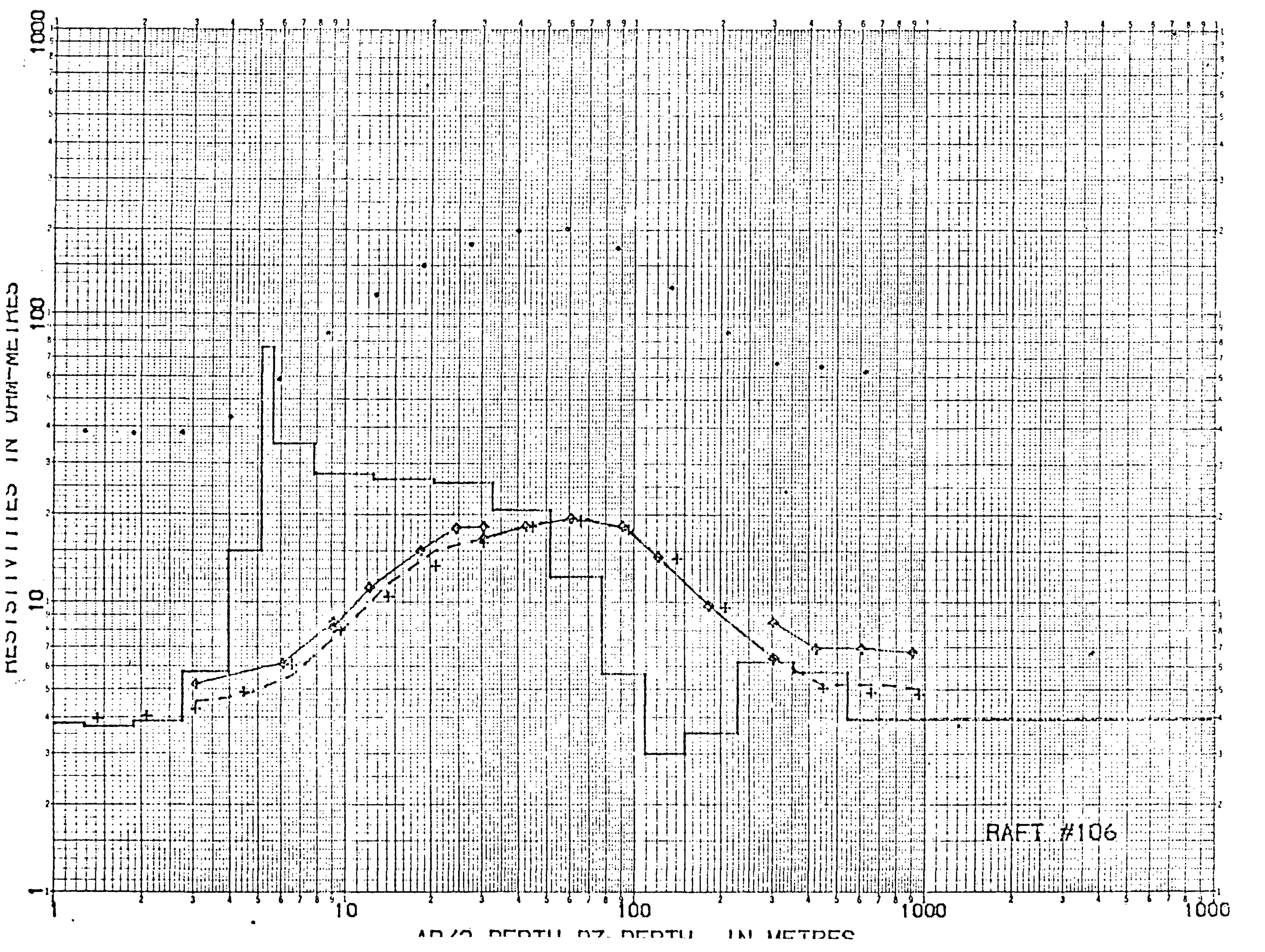

RESISTIVITIES IN OHM-METRES
AB/2 DEPTH OR DEPTH IN METRES
1
10
100
1000
RAFT #102


RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2, DEPTH, D7-DEPTH, IN METRES
RAFT #103

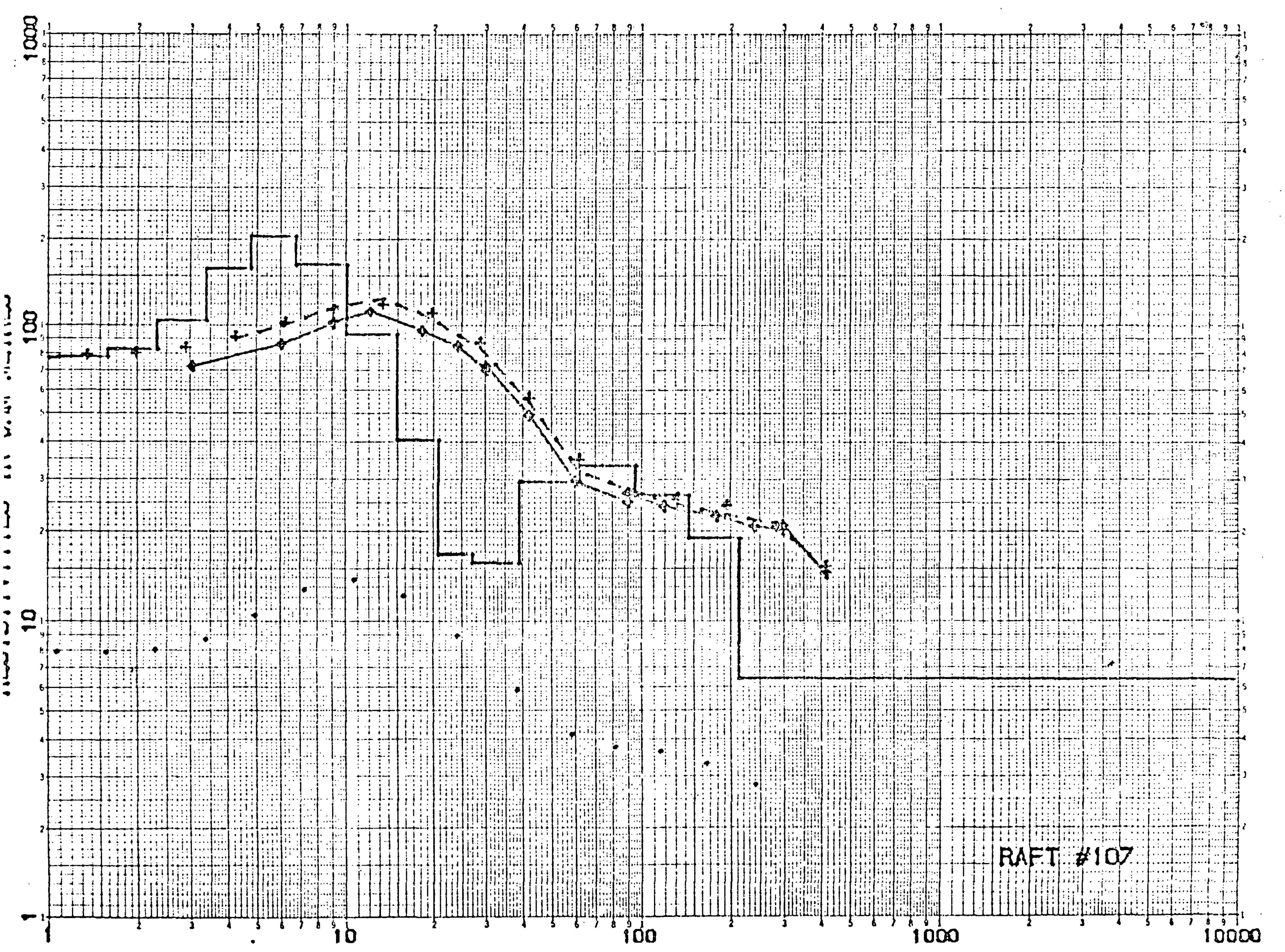

RESISTIVITIES IN OHM-METRES
1000
100
10
1
10
100
1000
1000
RAFT #104

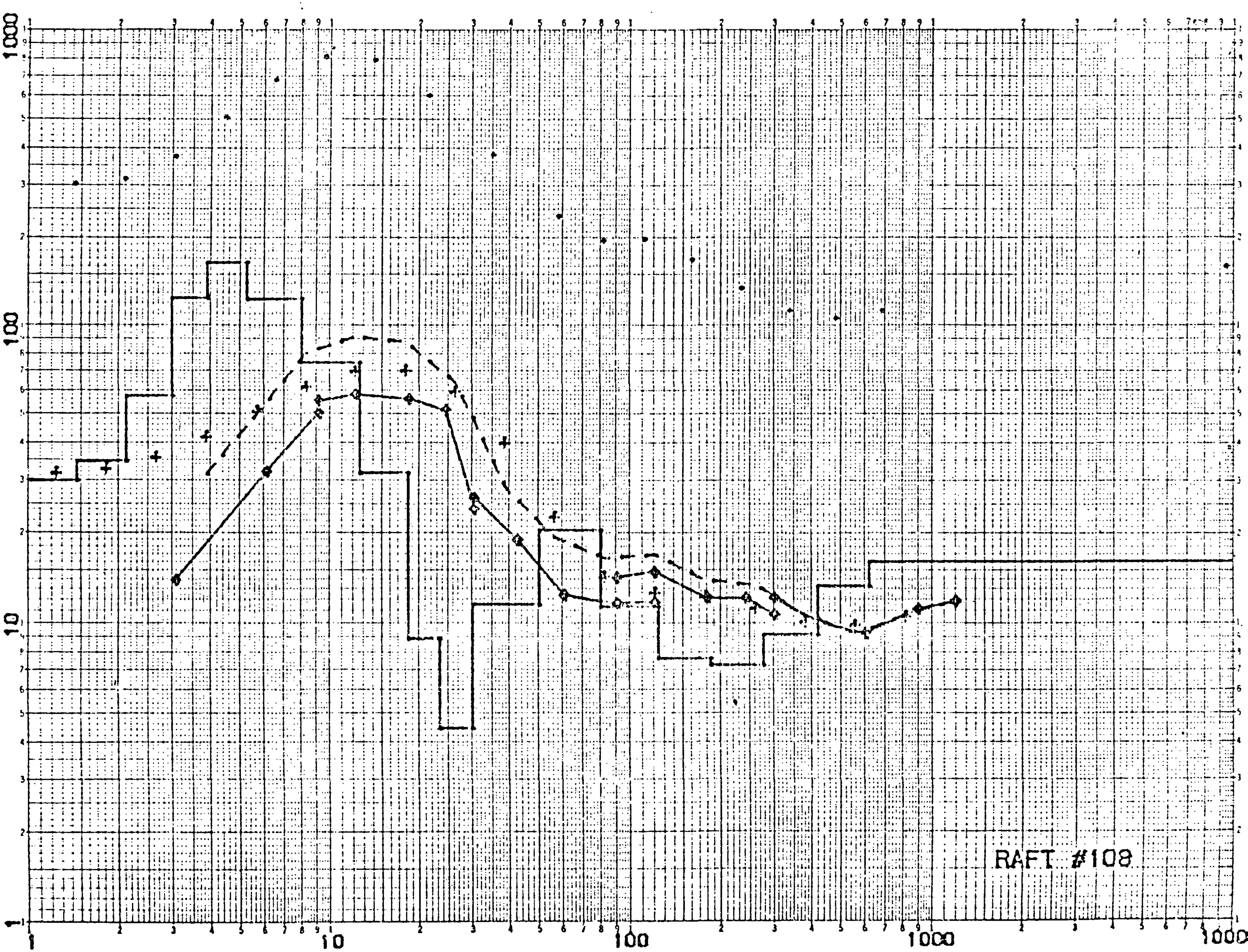


RESISTIVITIES IN OHM-METRES
1
10
100
1000
10
100
1000
10000
RAFT #105

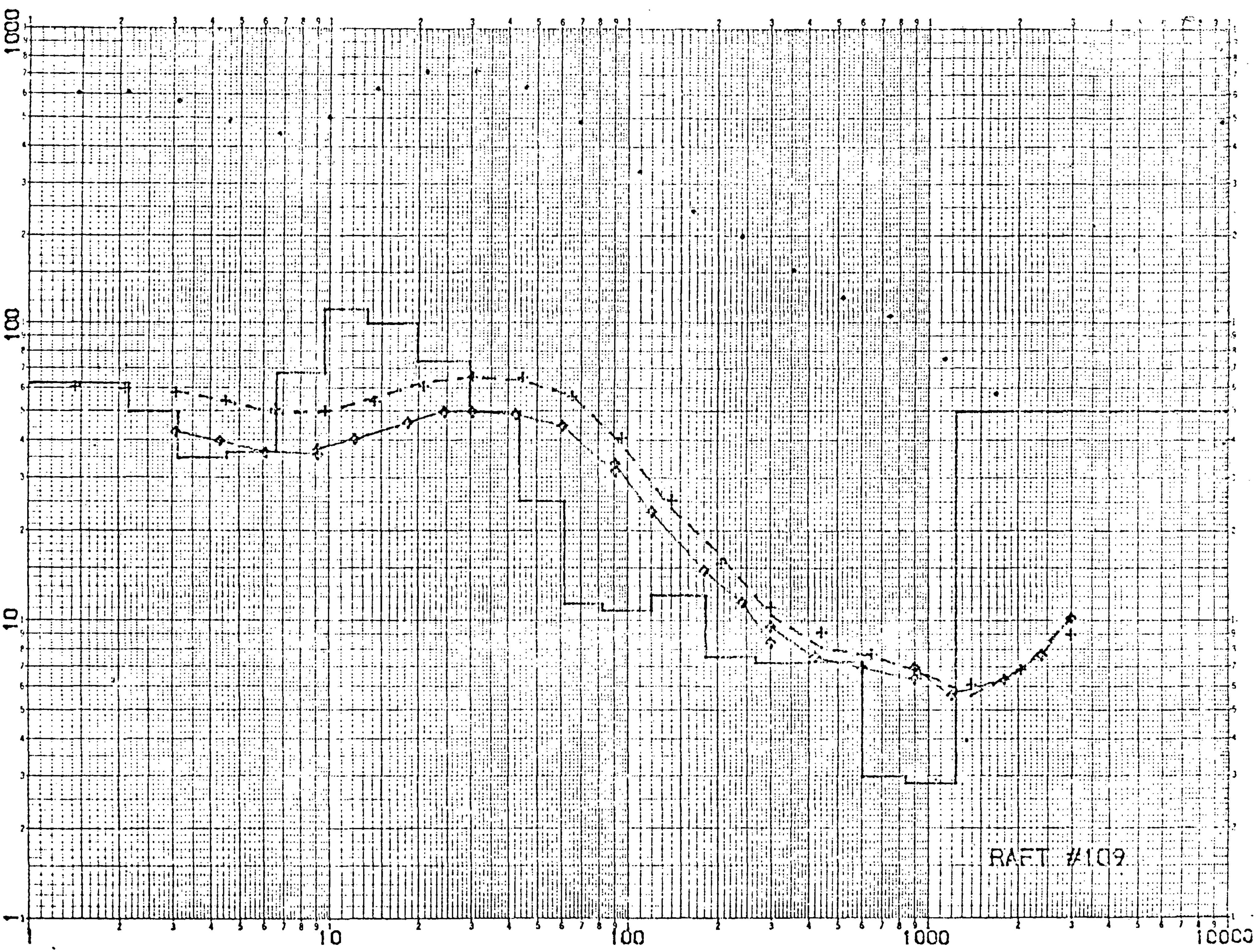


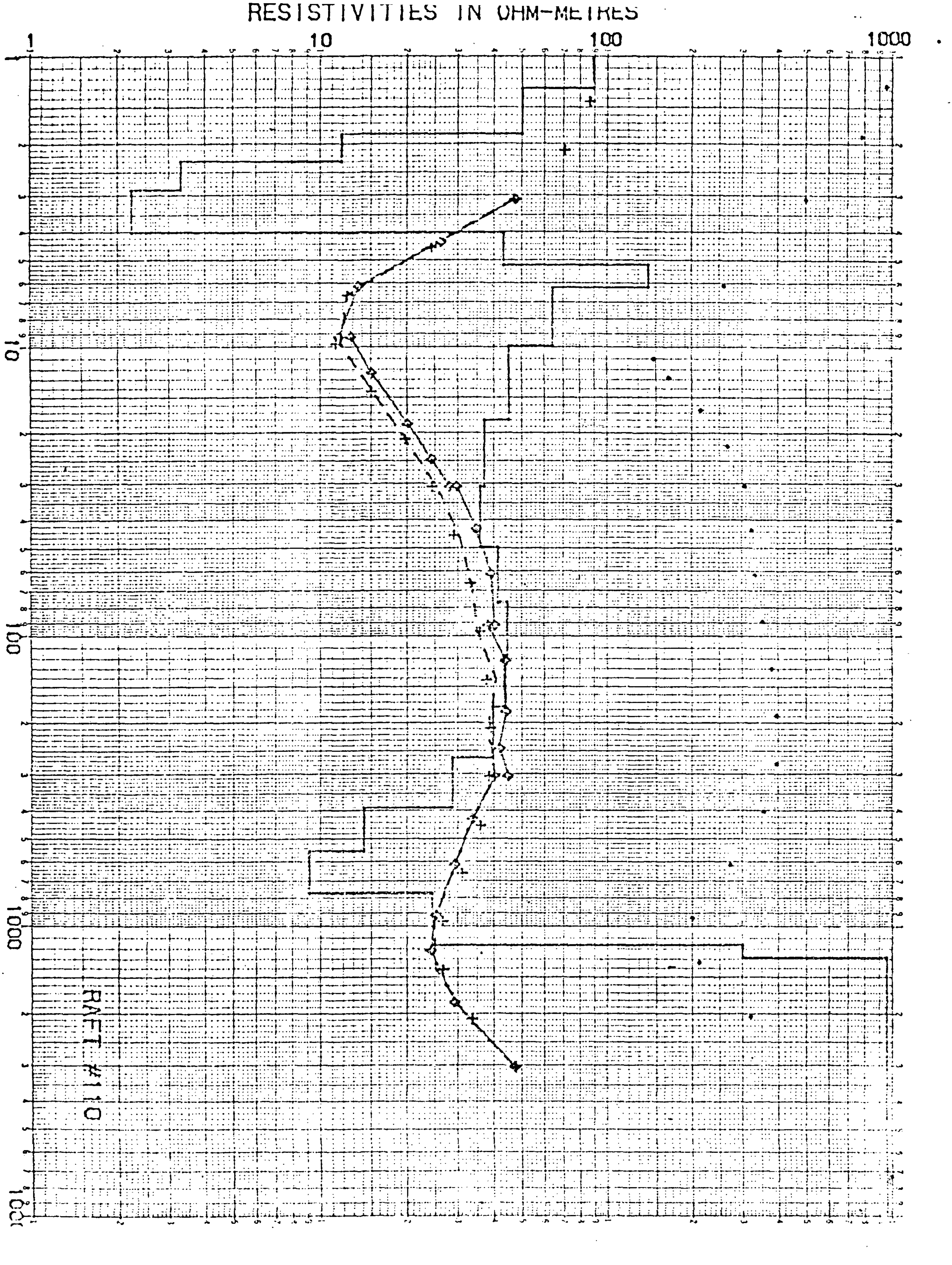
RESISTIVITIES IN OHM-METRES
RAFT #106
AB/2 DEPTH DZ DEPTH IN METRES


RAFT #107
1
10
100
1000
10000

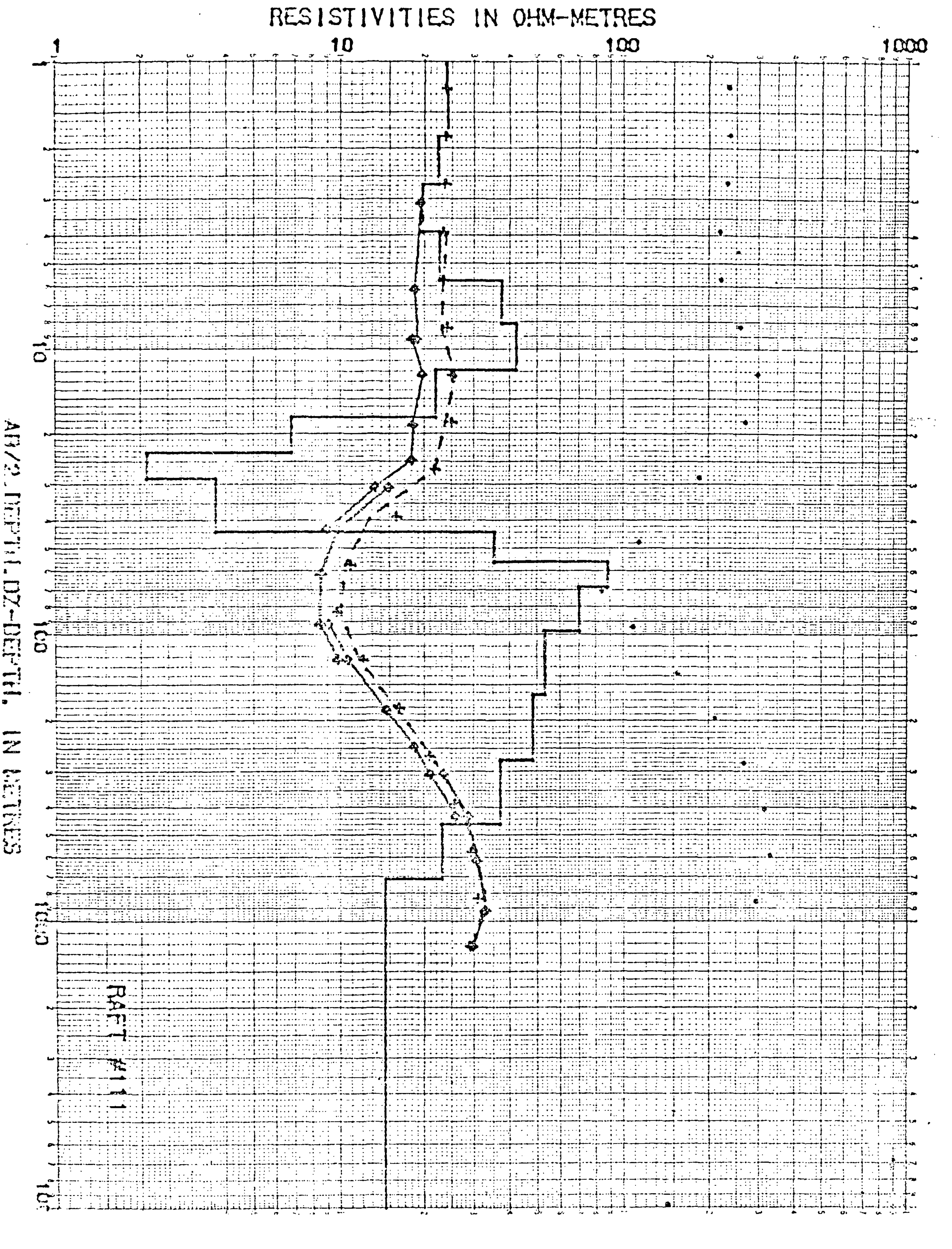


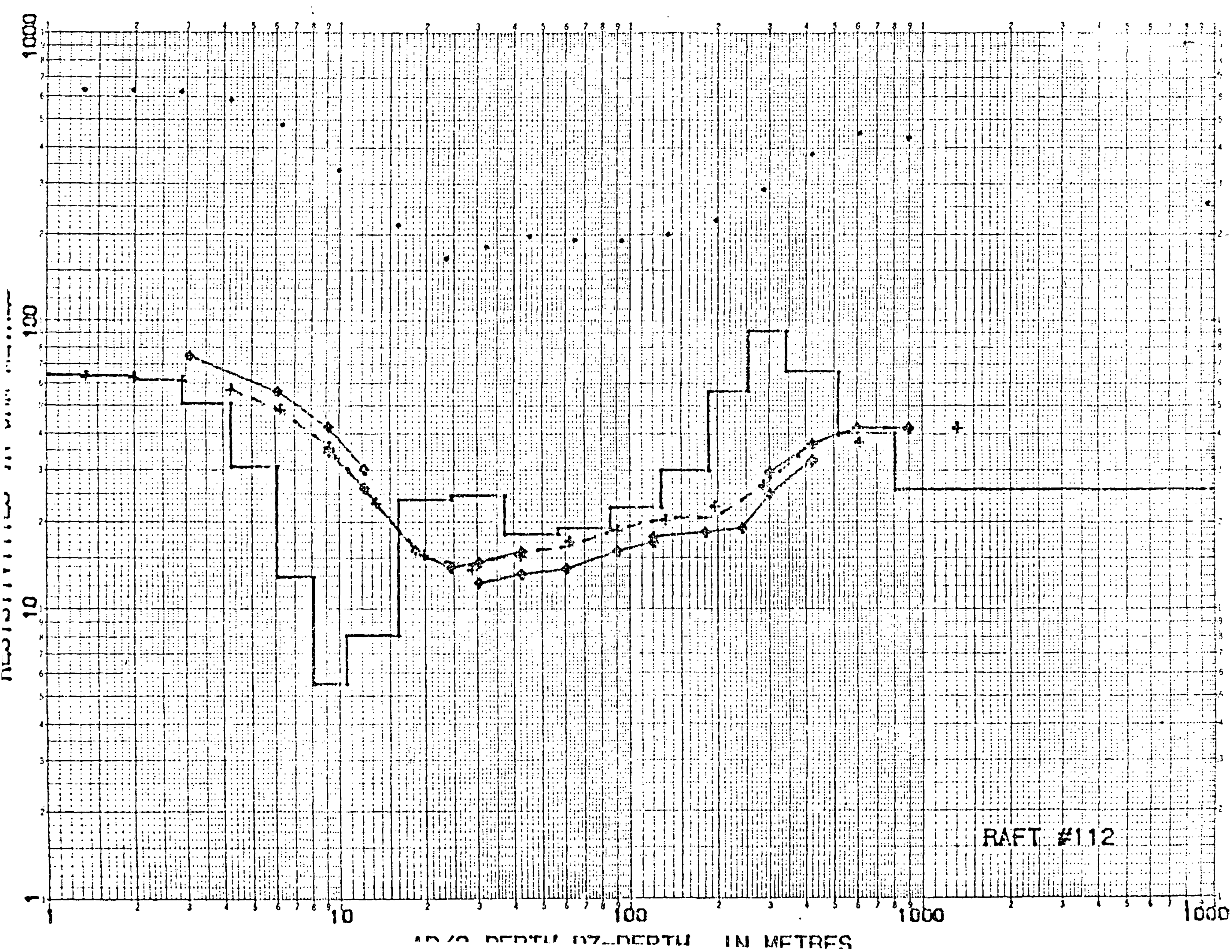
RAFT #108
1
10
100
1000
10000

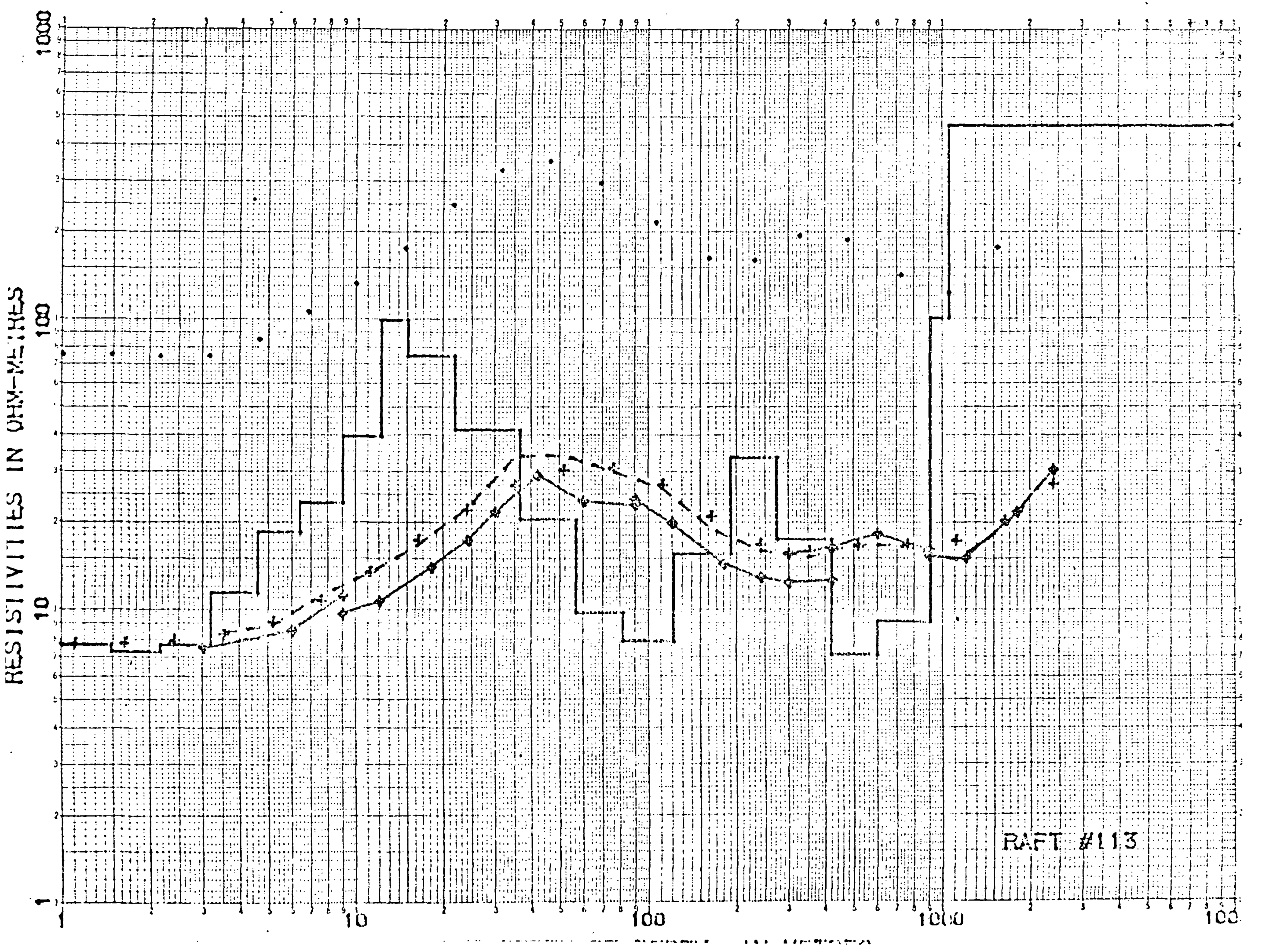

RAFT #109
1
10
100
1000
10000



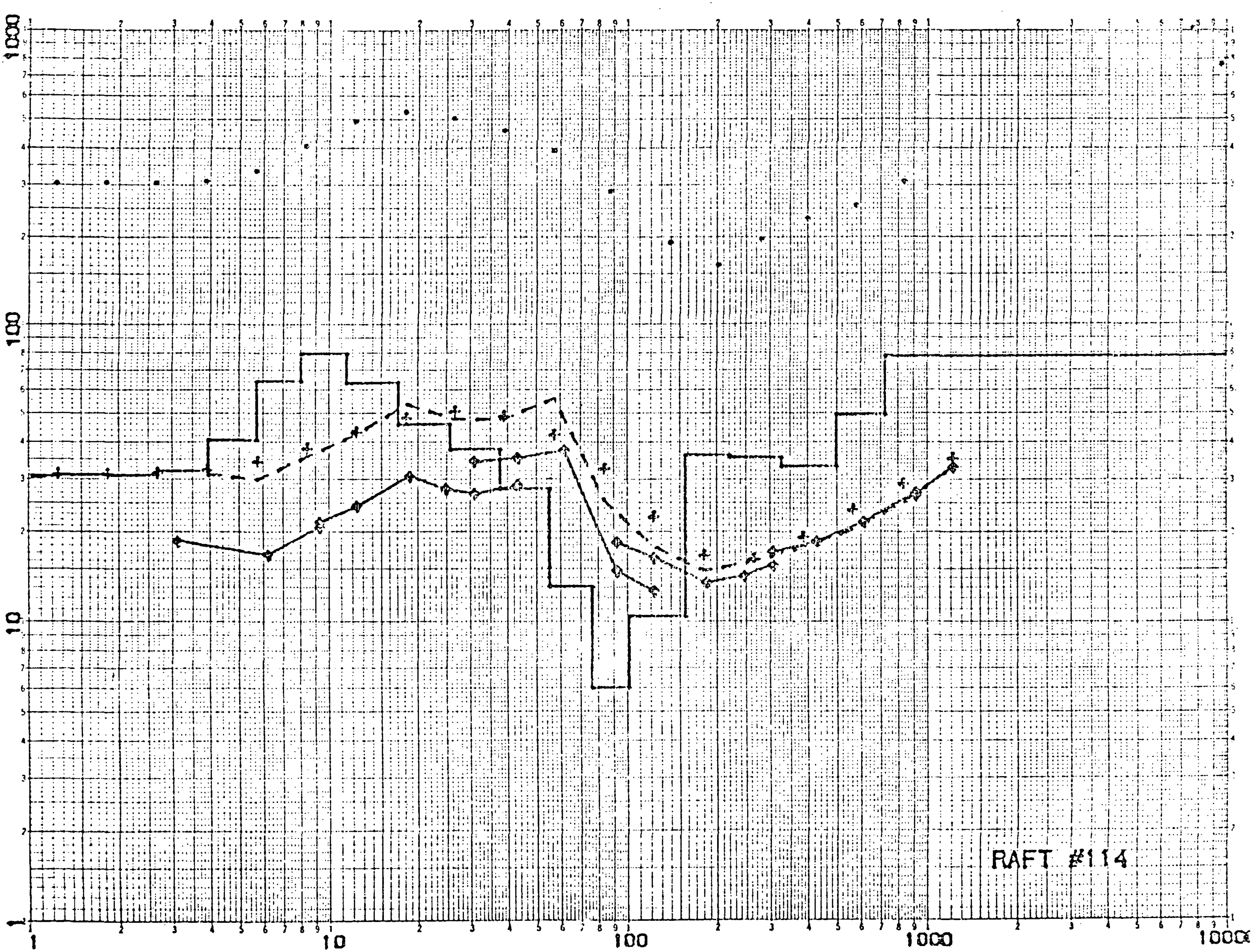
RESISTIVITIES IN OHM-METRES
1
10
100
1000
10
100
1000
RAFT #110

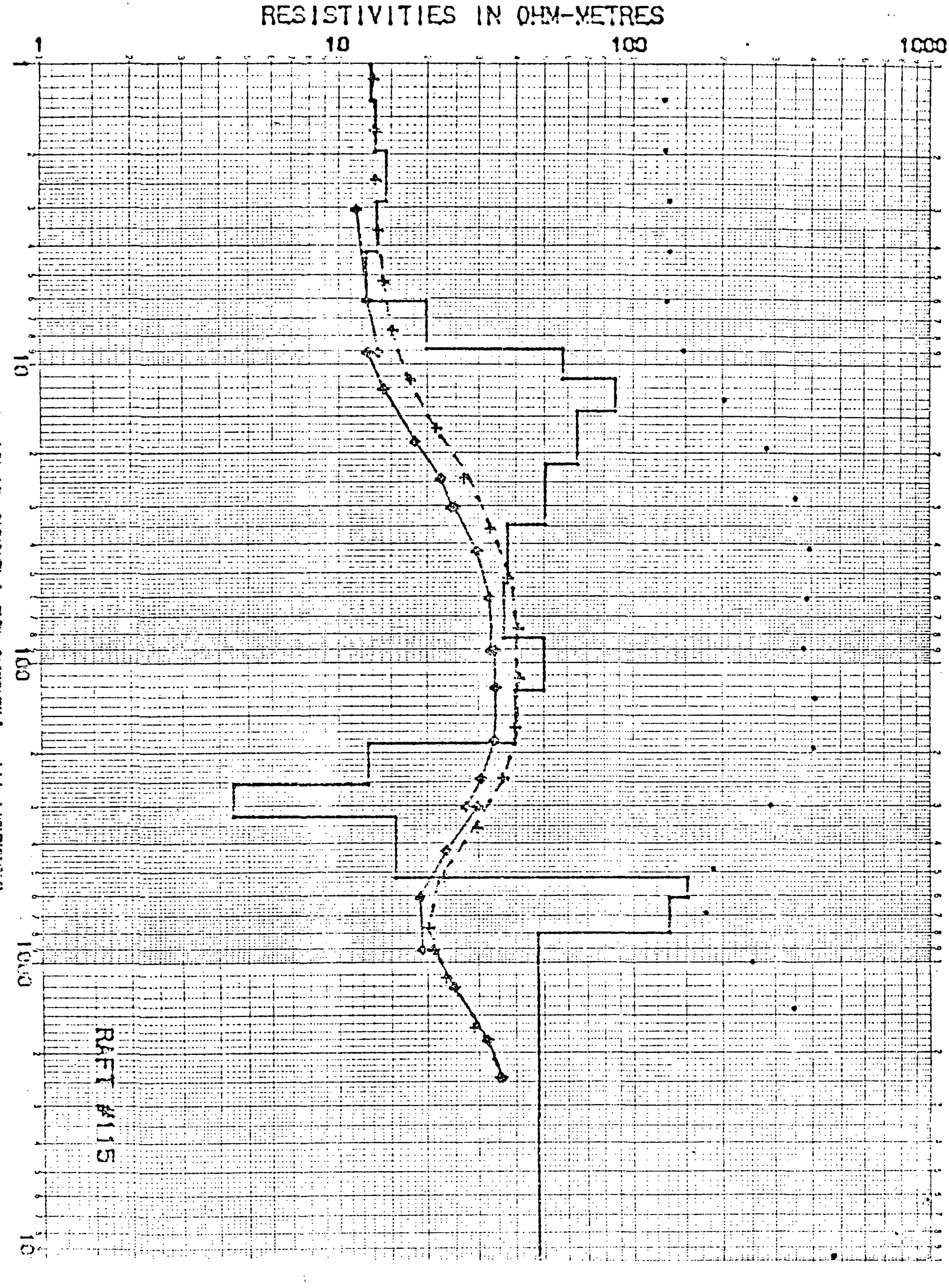

RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2.DEPTH,DZ-DEPTH, IN METRES
RAFT #111


RAFT #112
1000
100
10
1
1
10
100
1000
AB/2 DEPTH DZ-DEPTH IN METRES

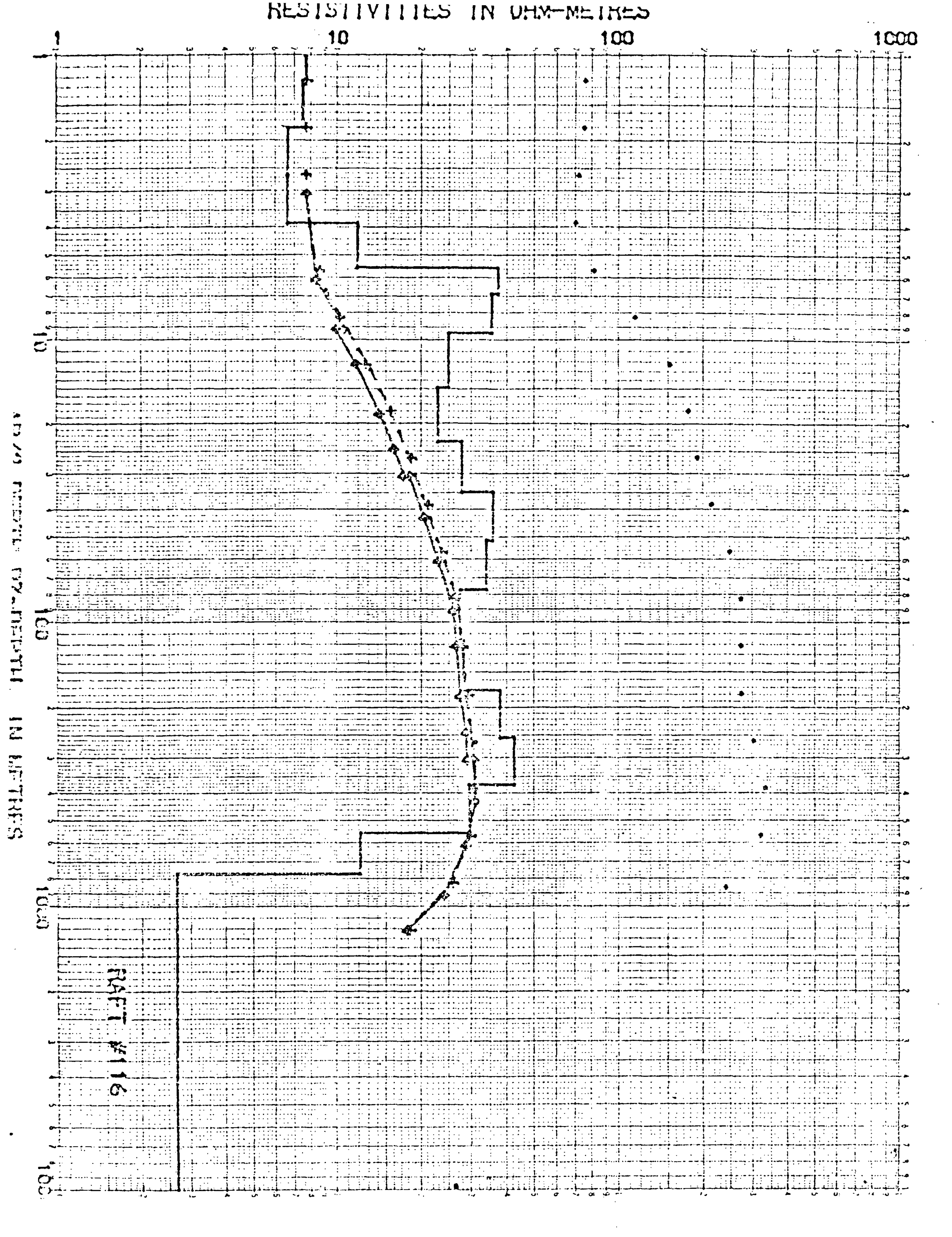


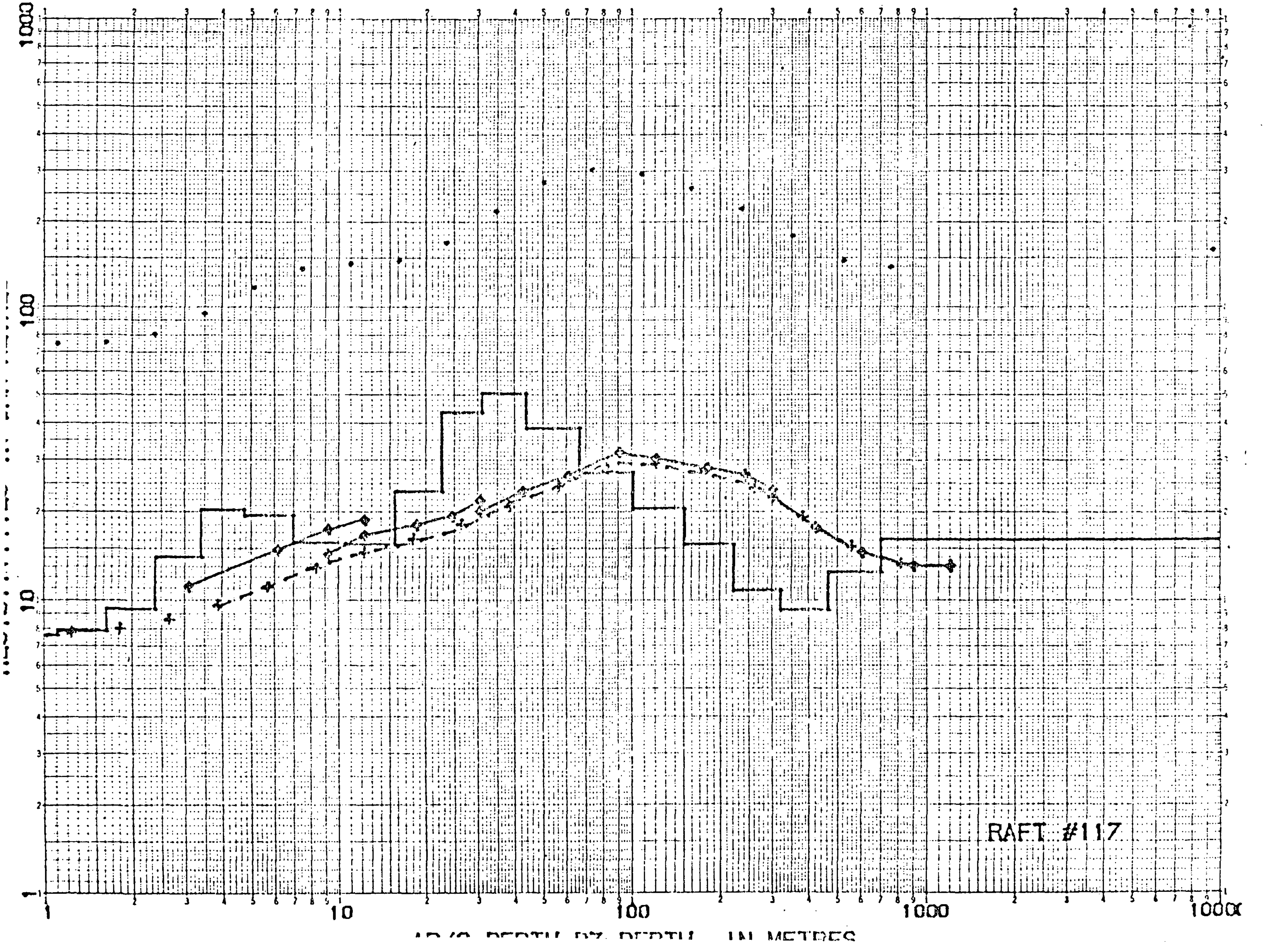
RESISTIVITIES IN OHM-METRES
RAFT #113
1000
100
10
1
1
10
100
1000


RAFT #114
1
10
100
1000
10000
RESISTIVITIES IN OHM-METRES

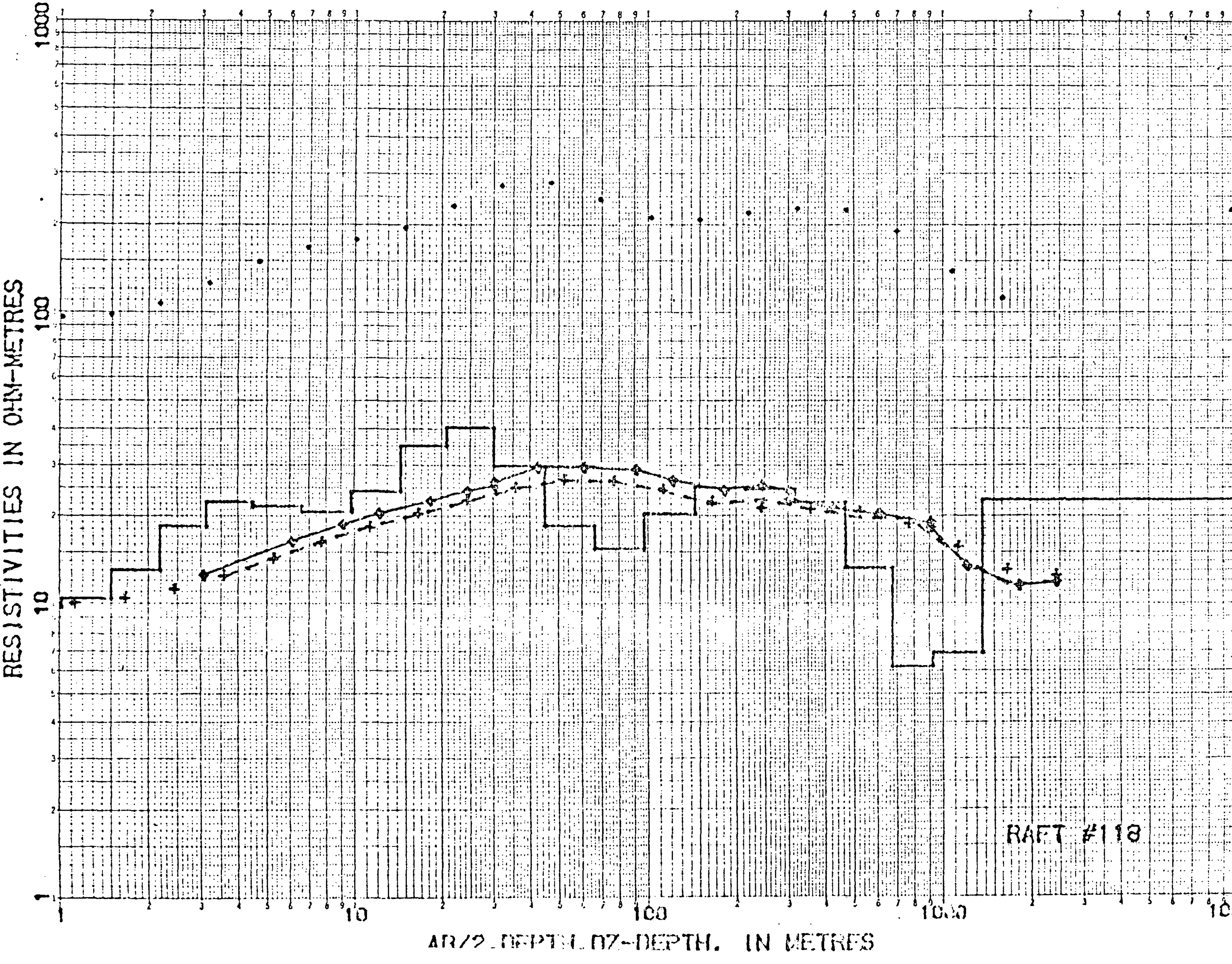


RESISTIVITIES IN OHM-METRES
1
10
100
1000
10
100
1000
RAFT #115

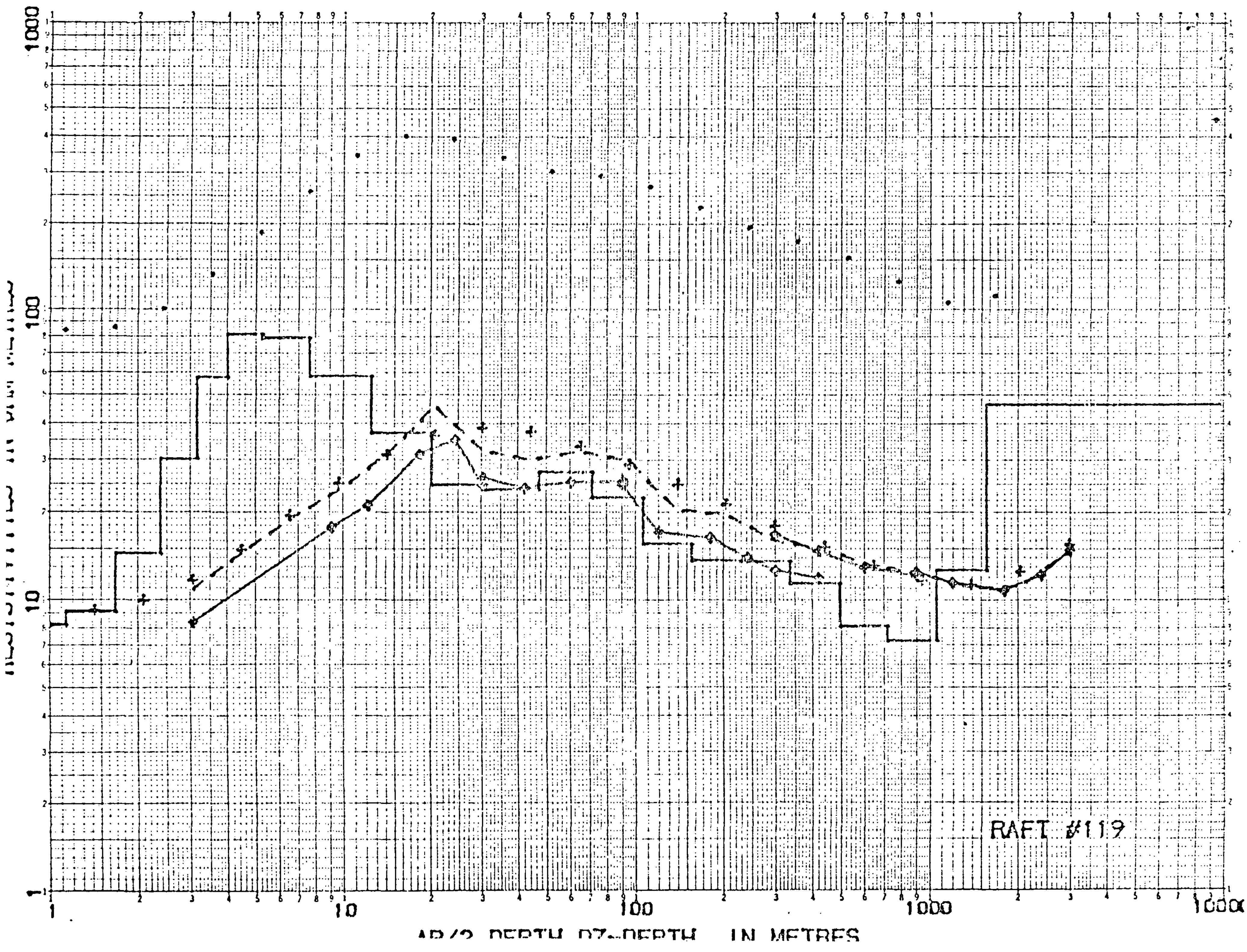

RESISTIVITIES IN OHM-METRES
1
10
100
1000
DZ-DEPTH IN METRES
RAFT #116



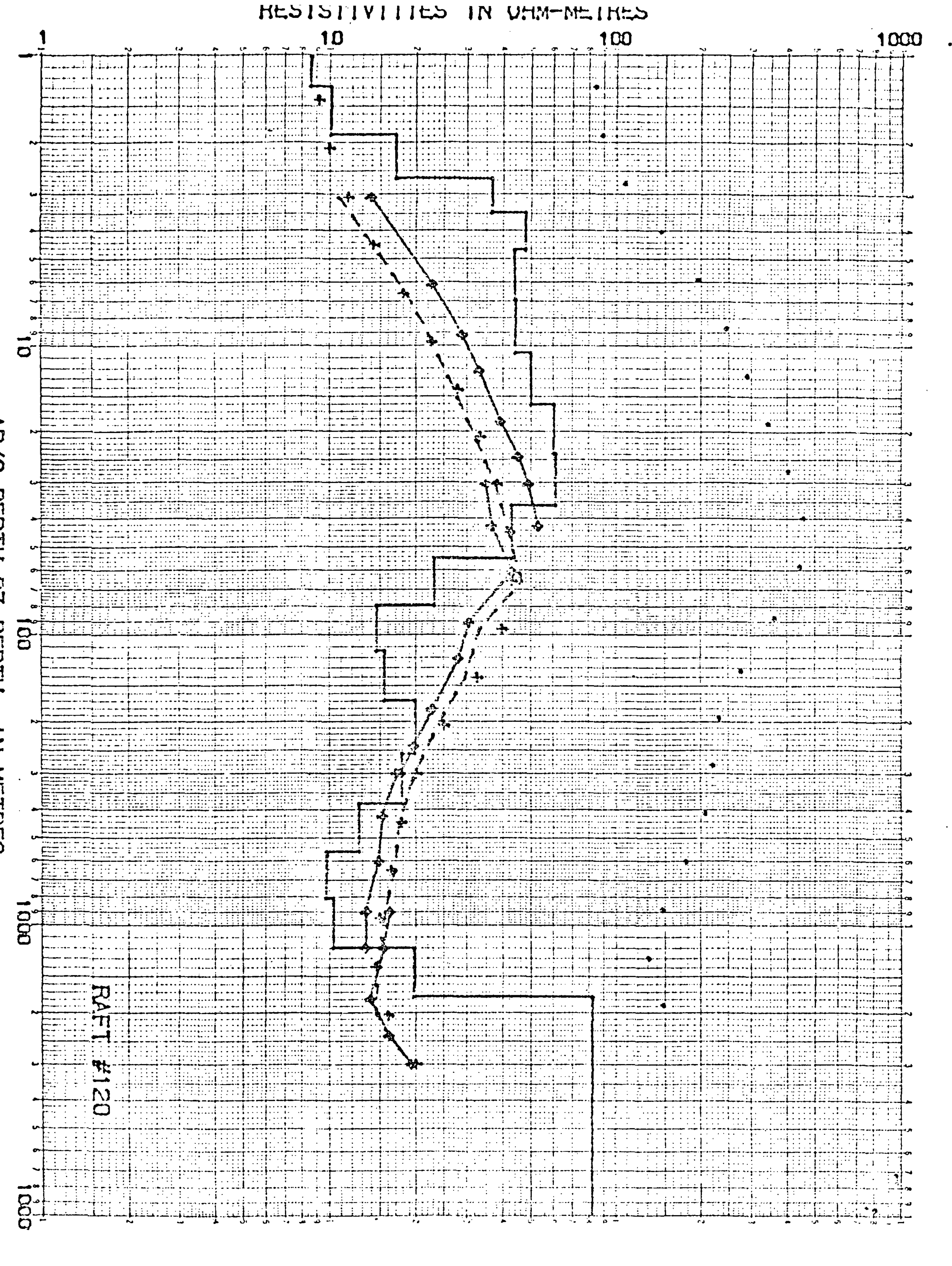
RAFT #117
1
10
100
1000
10000

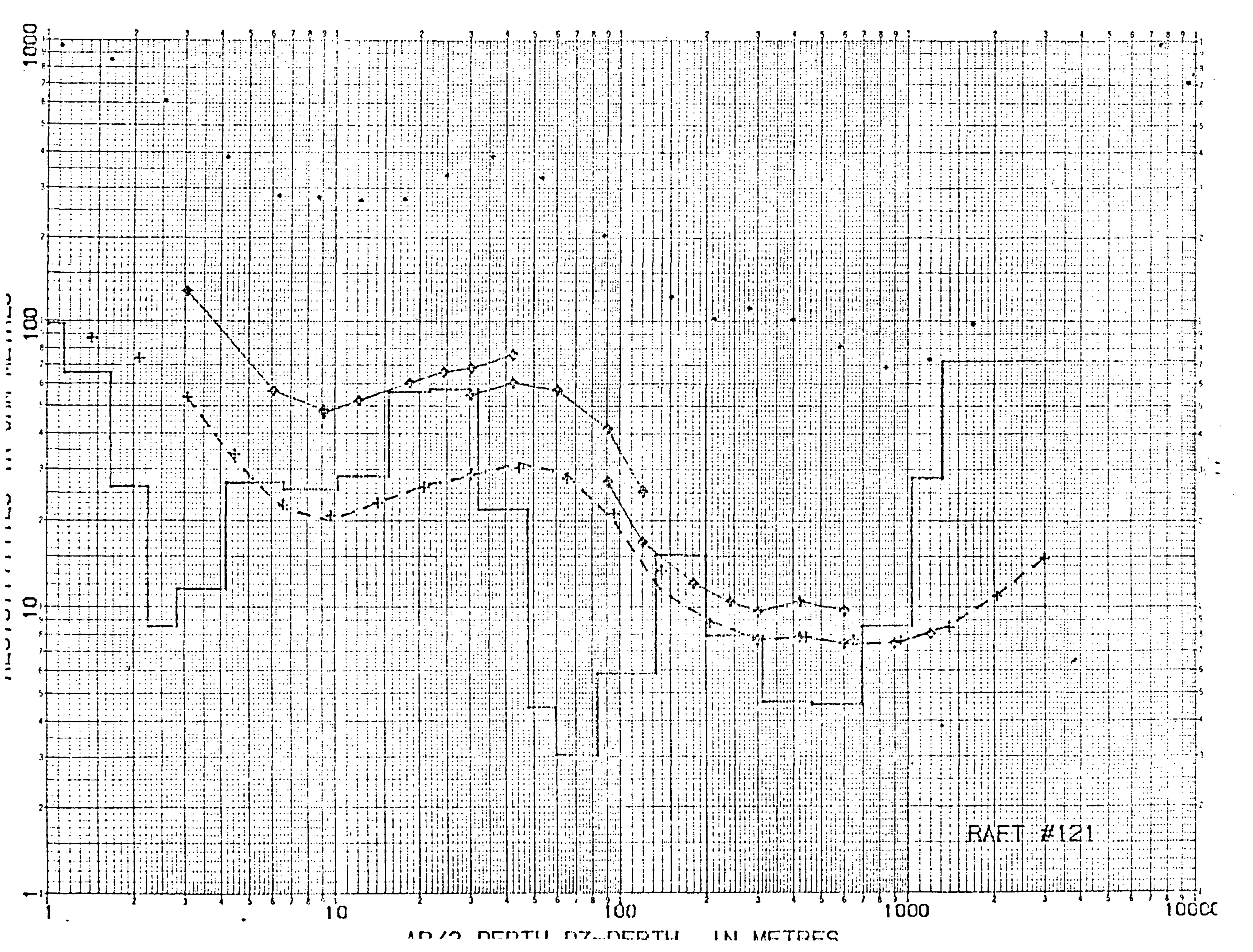


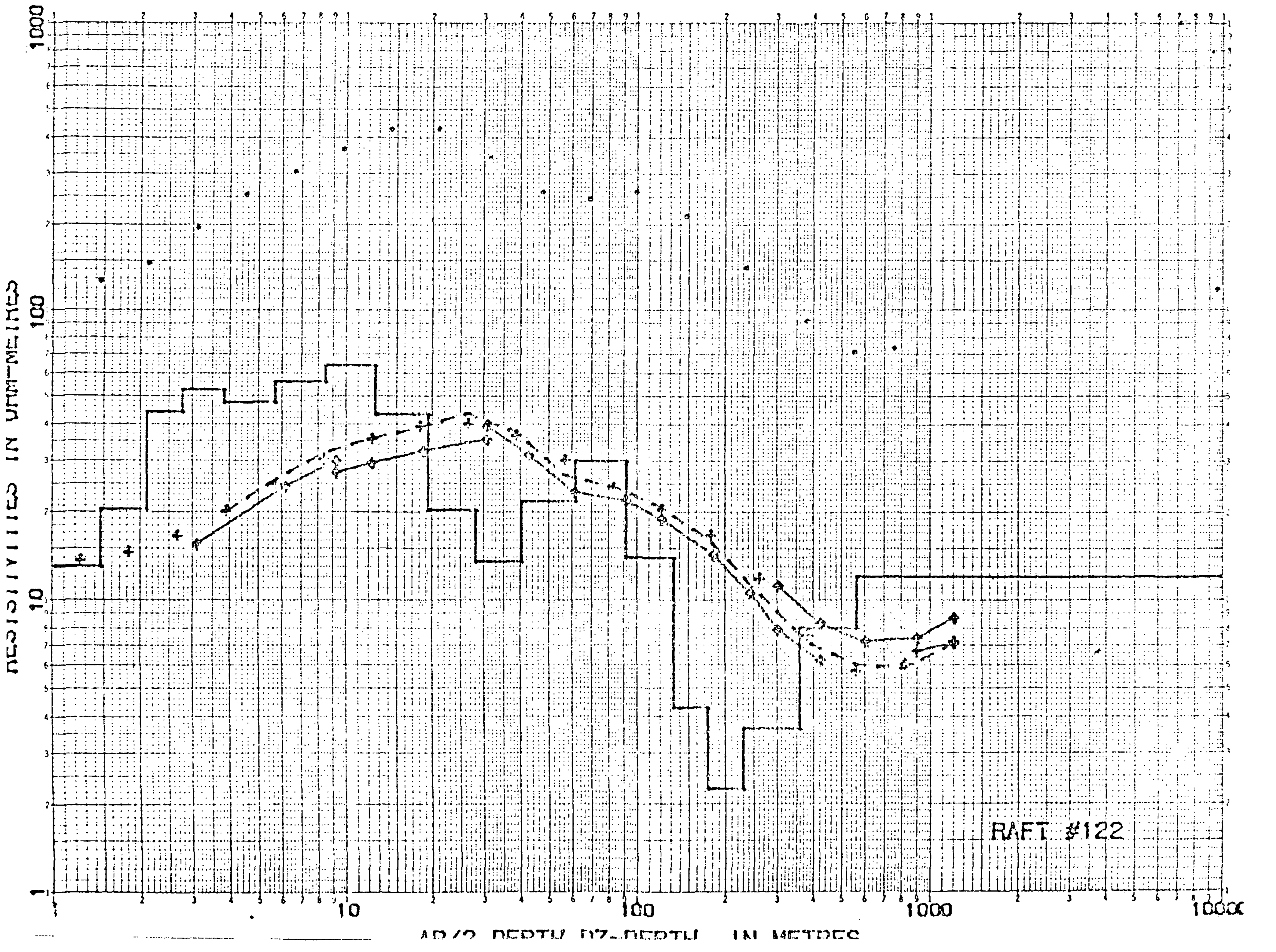
RESISTIVITIES IN OHM-METRES
1000
100
10
1
1
10
100
1000
AB/2-DEPTH, DZ-DEPTH, IN METRES
RAFT #118

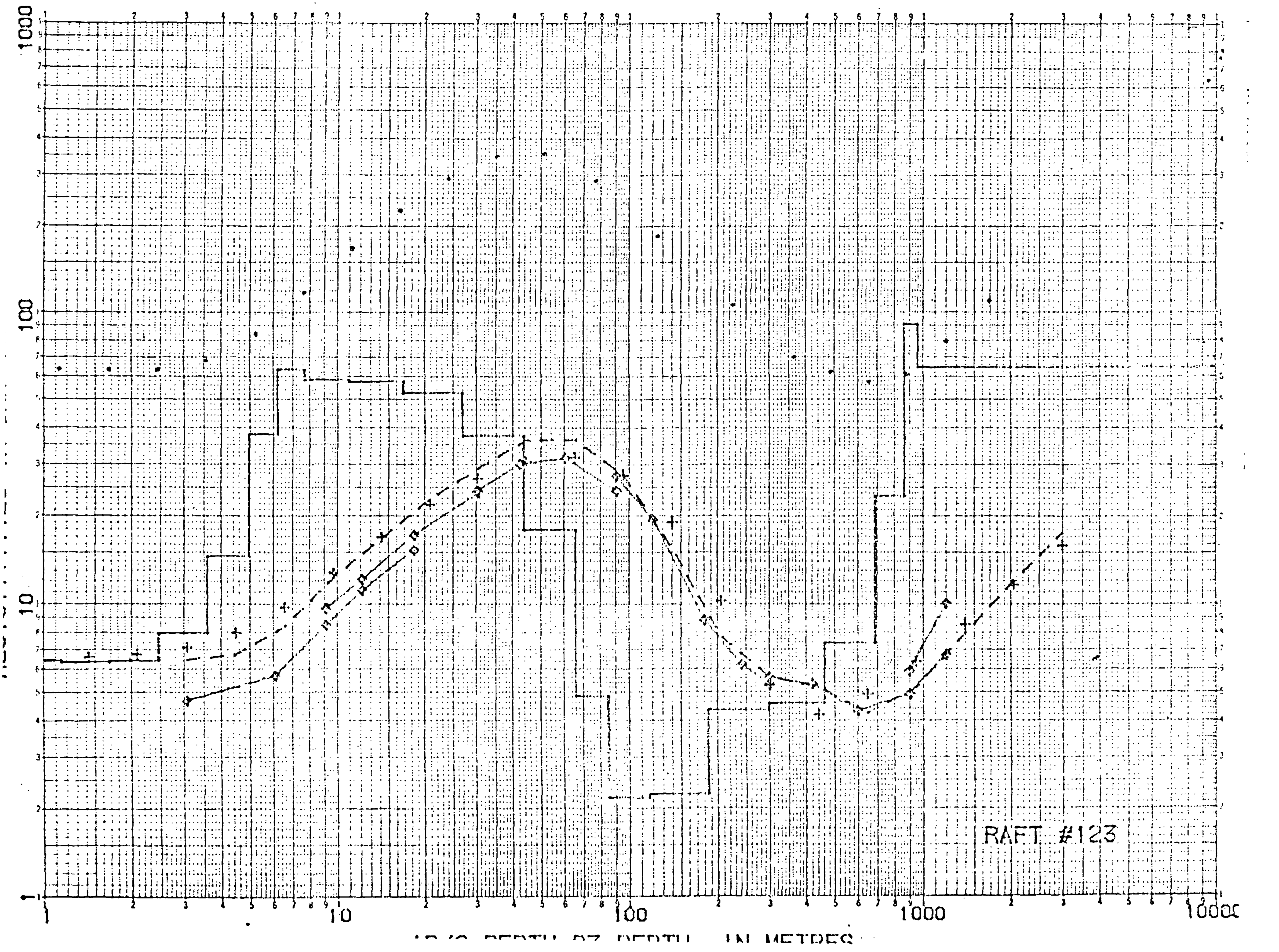


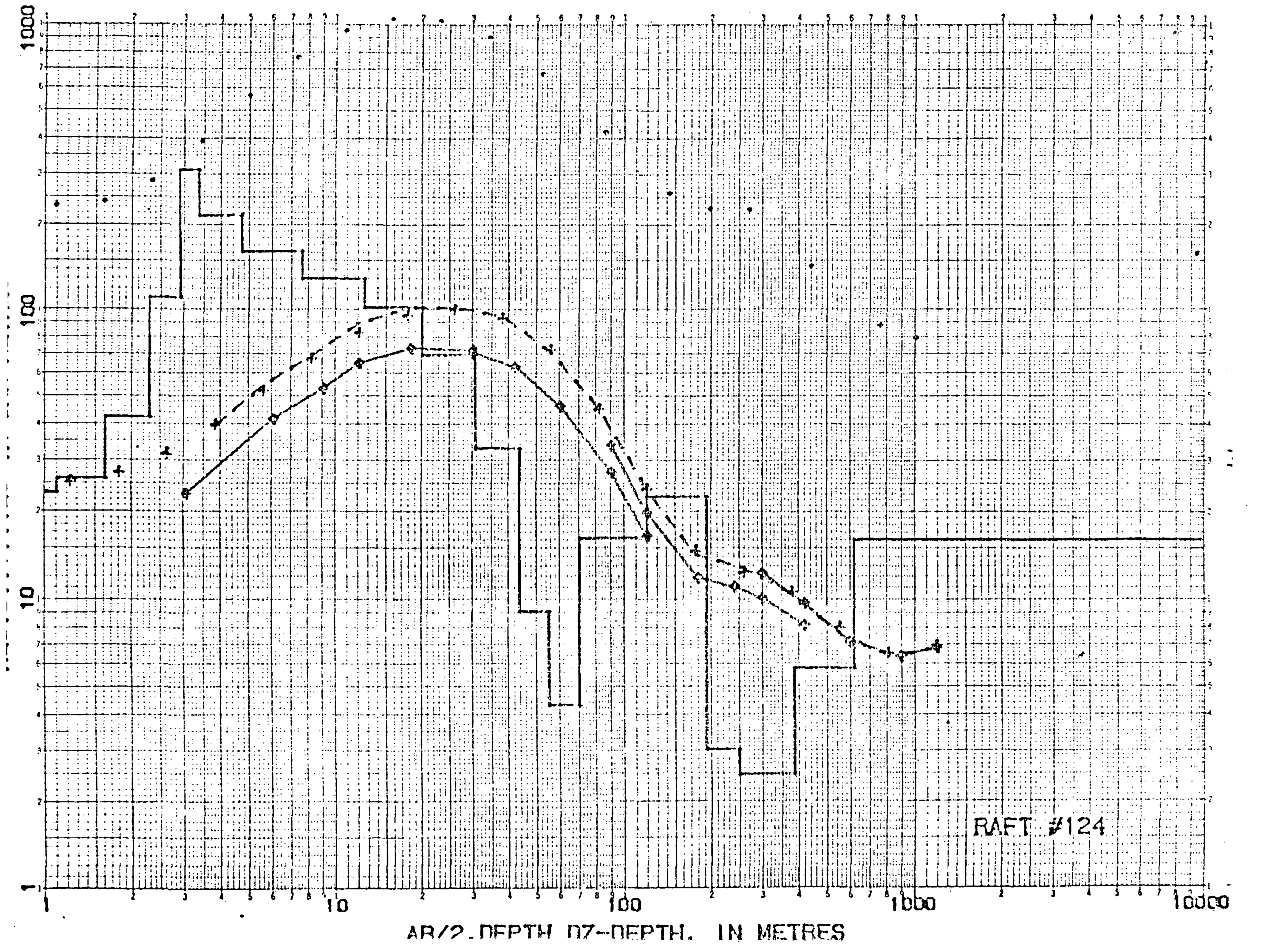
RAFT #119
AB/2 DEPTH DZ-DEPTH IN METRES
1
10
100
1000
10000
1000
100
10
1


RESISTIVITIES IN OHM-METRES
1
10
100
1000
10
100
1000
IN METRES
RAFT #120

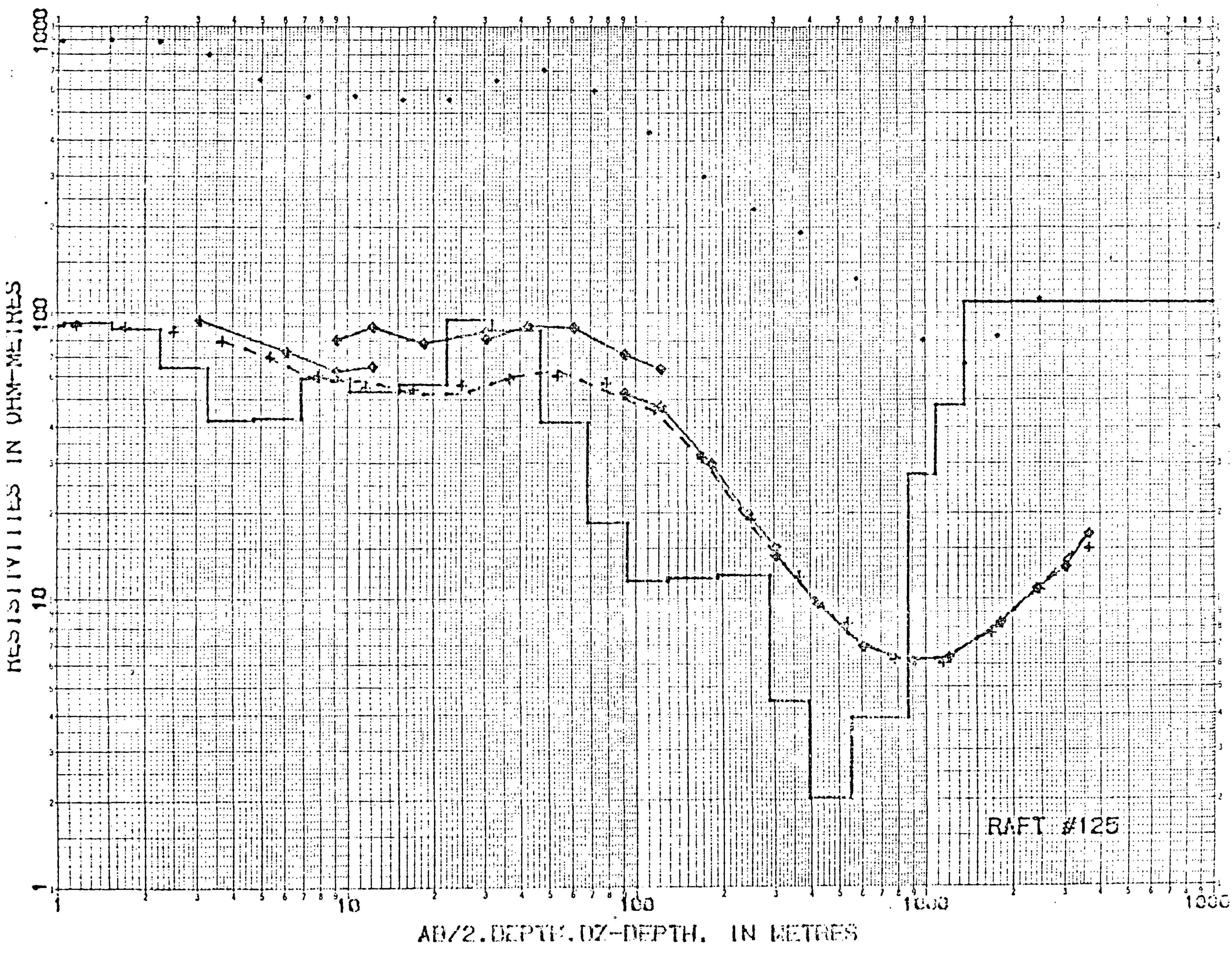

RAFT #121
AB/2 DEPTH DZ-DEPTH IN METRES
1
10
100
1000
10000
10
100
1000

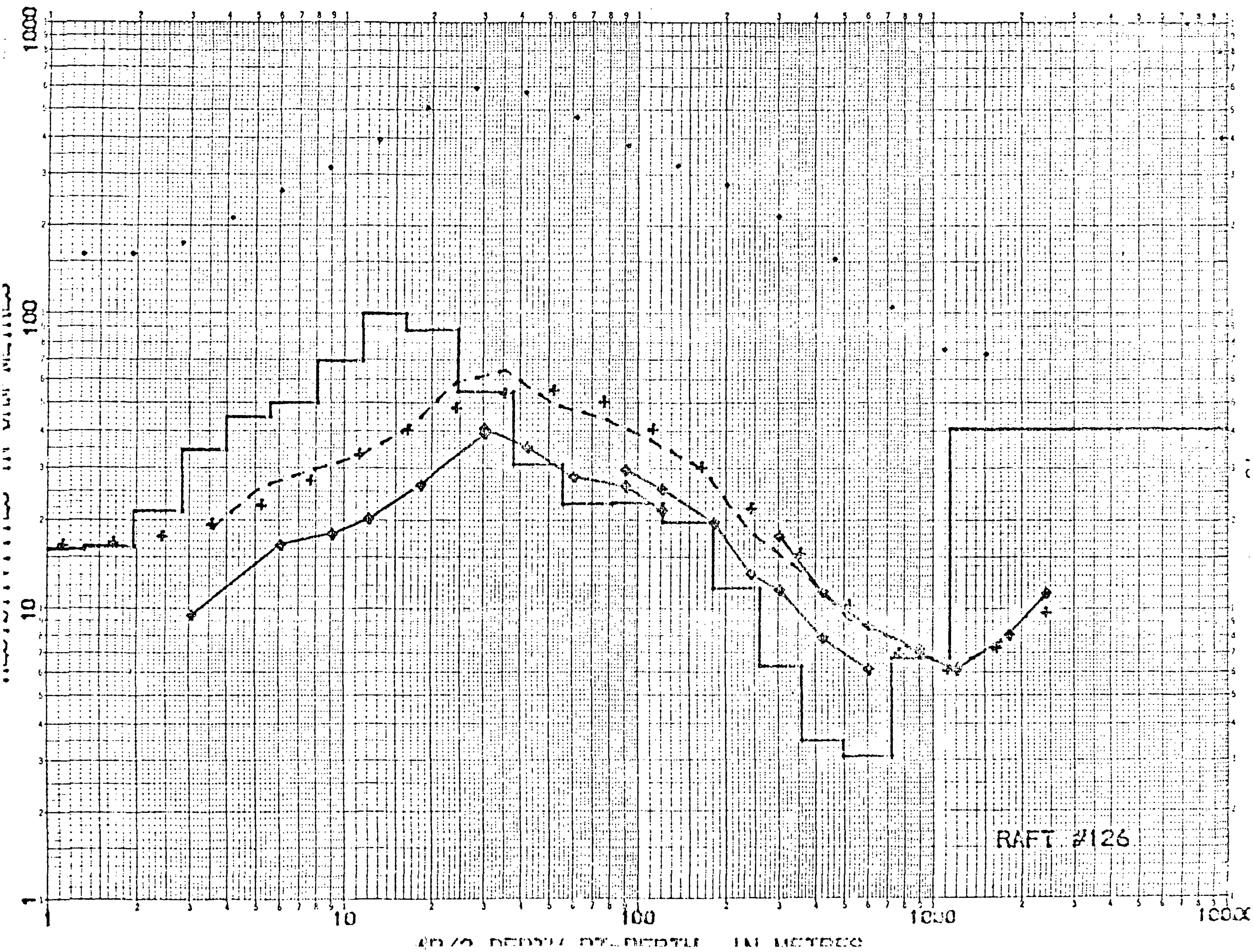

RESISTIVITIES IN OHM-METRES
RAFT #122
AB/2 DEPTH DZ-DEPTH IN METRES
1
10
100
1000
10000

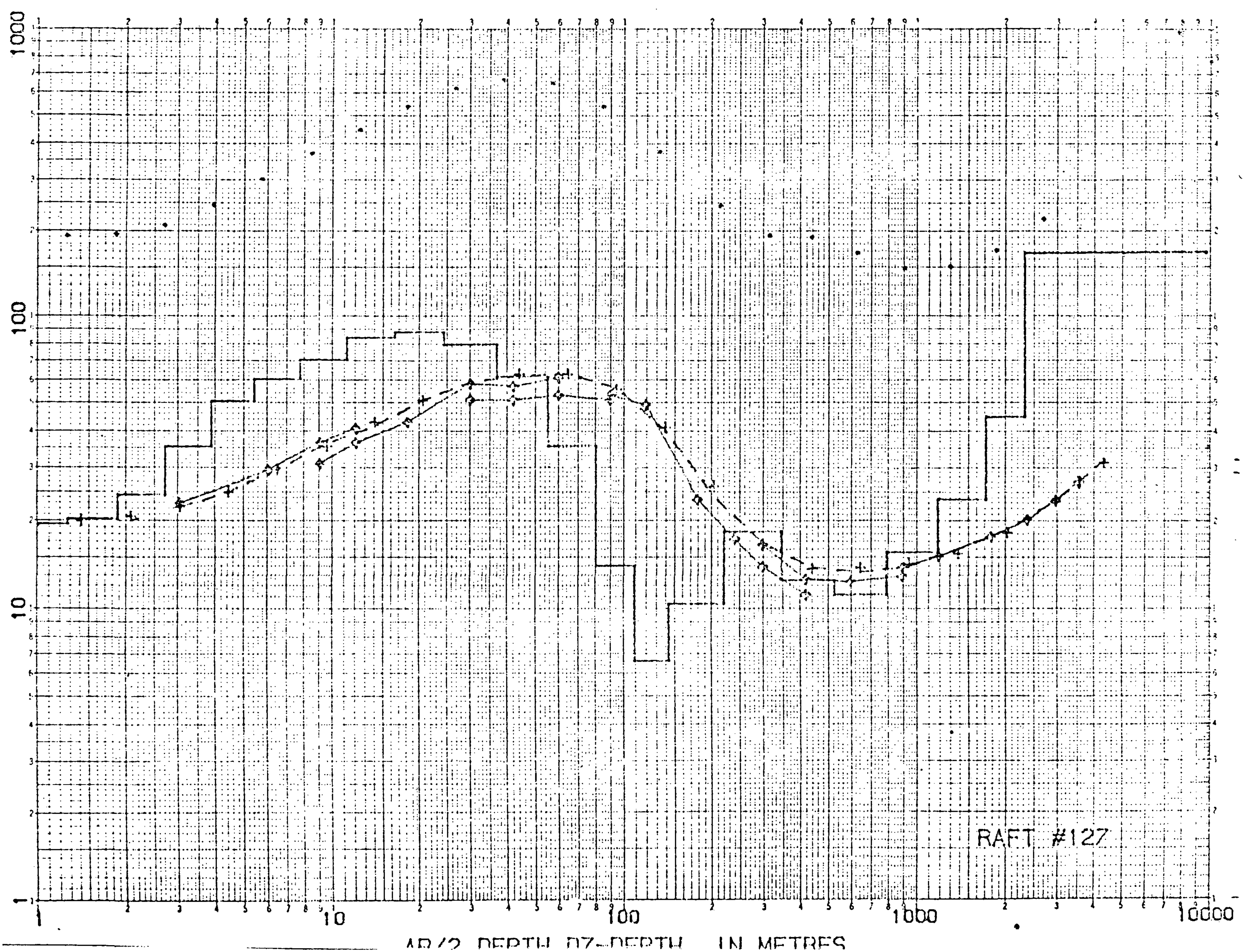

RAFT #123
1
10
100
1000
10000



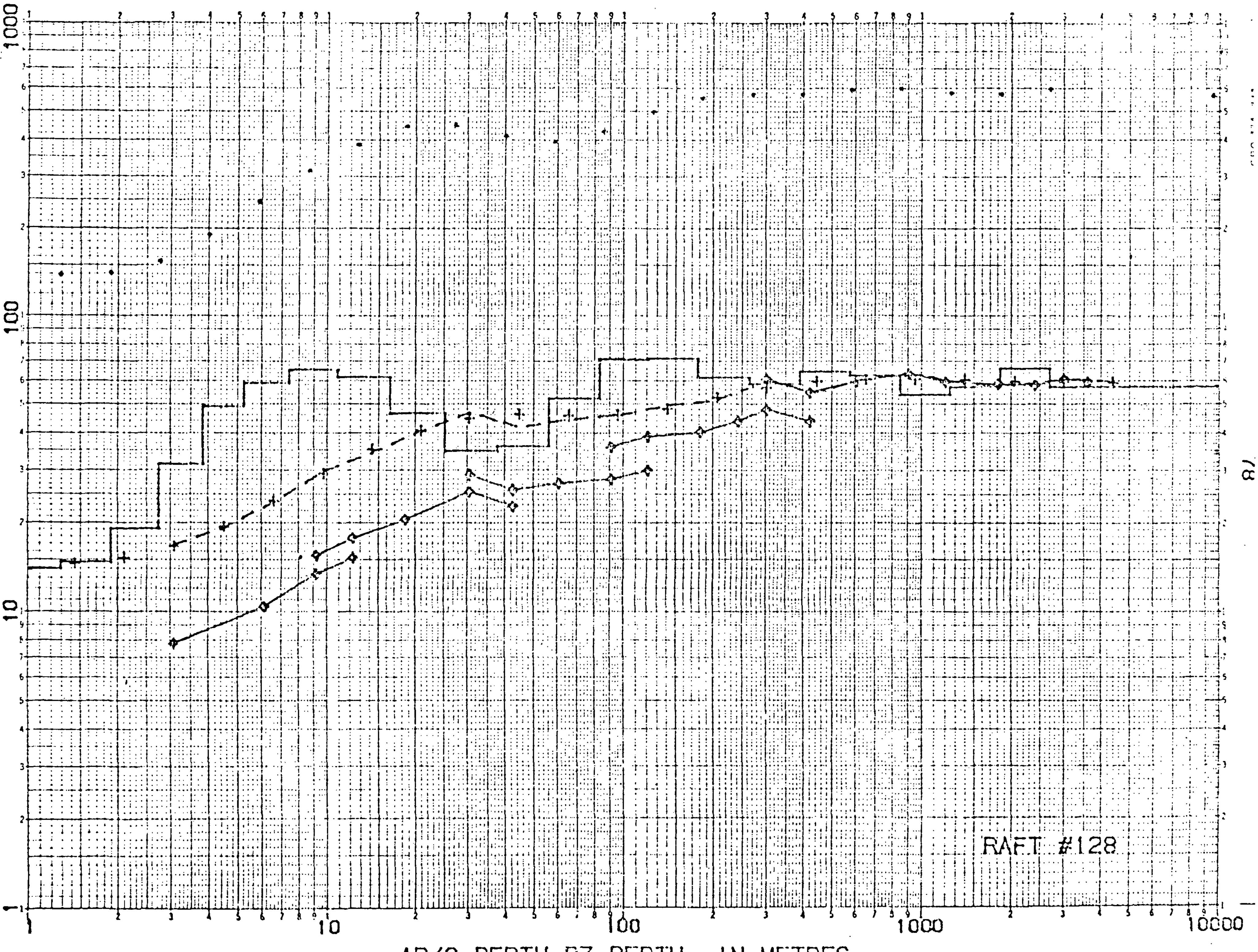
1000
100
10
1
1
10
100
1000
10000
RAFT #124
AB/2-DEPTH DZ-DEPTH, IN METRES


RESISTIVITIES IN OHM-METRES
AB/2.DEPTH.DZ-DEPTH. IN METRES
RAFT #125
1
10
100
1000


1000
100
10
1
10
100
1000
10000
RAFT #126

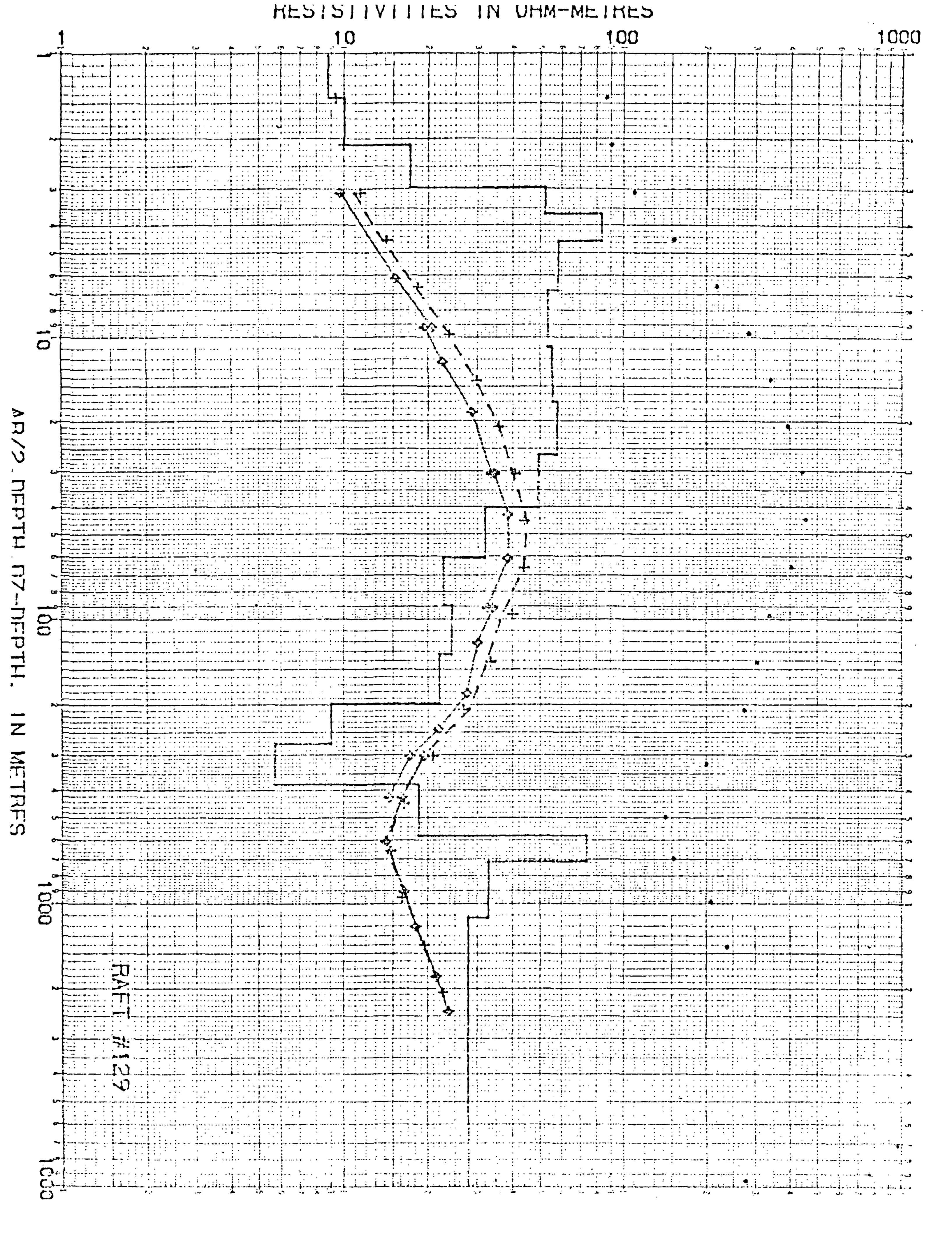


RAFT #127
1
10
100
1000
1
10
100
1000
10000
AB/2 DEPTH DZ-DEPTH IN METRES

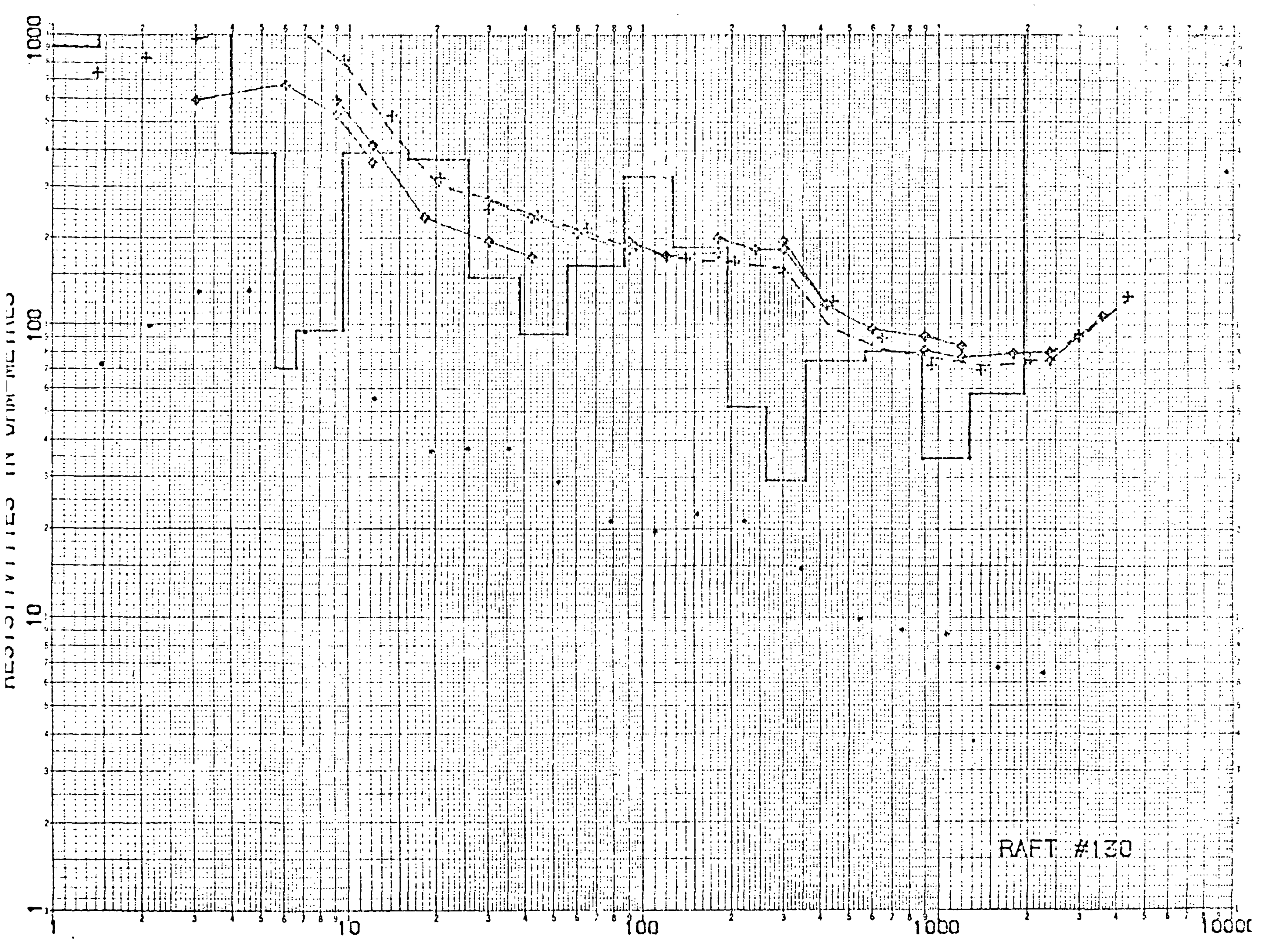


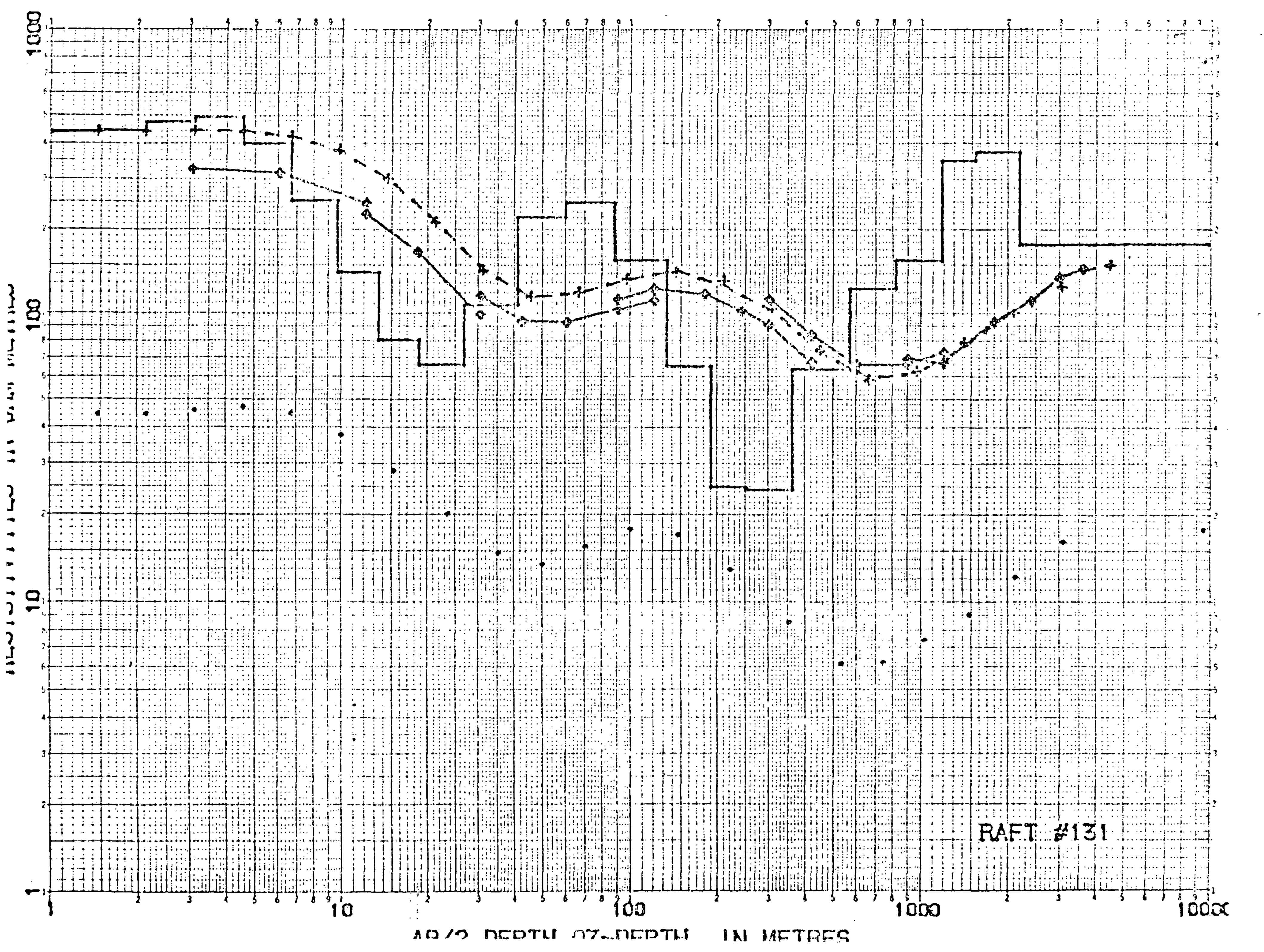
RAFT #128
1000
100
10
1
10
100
1000
10000
AB/2 DEPTH DZ-DEPTH IN METRES

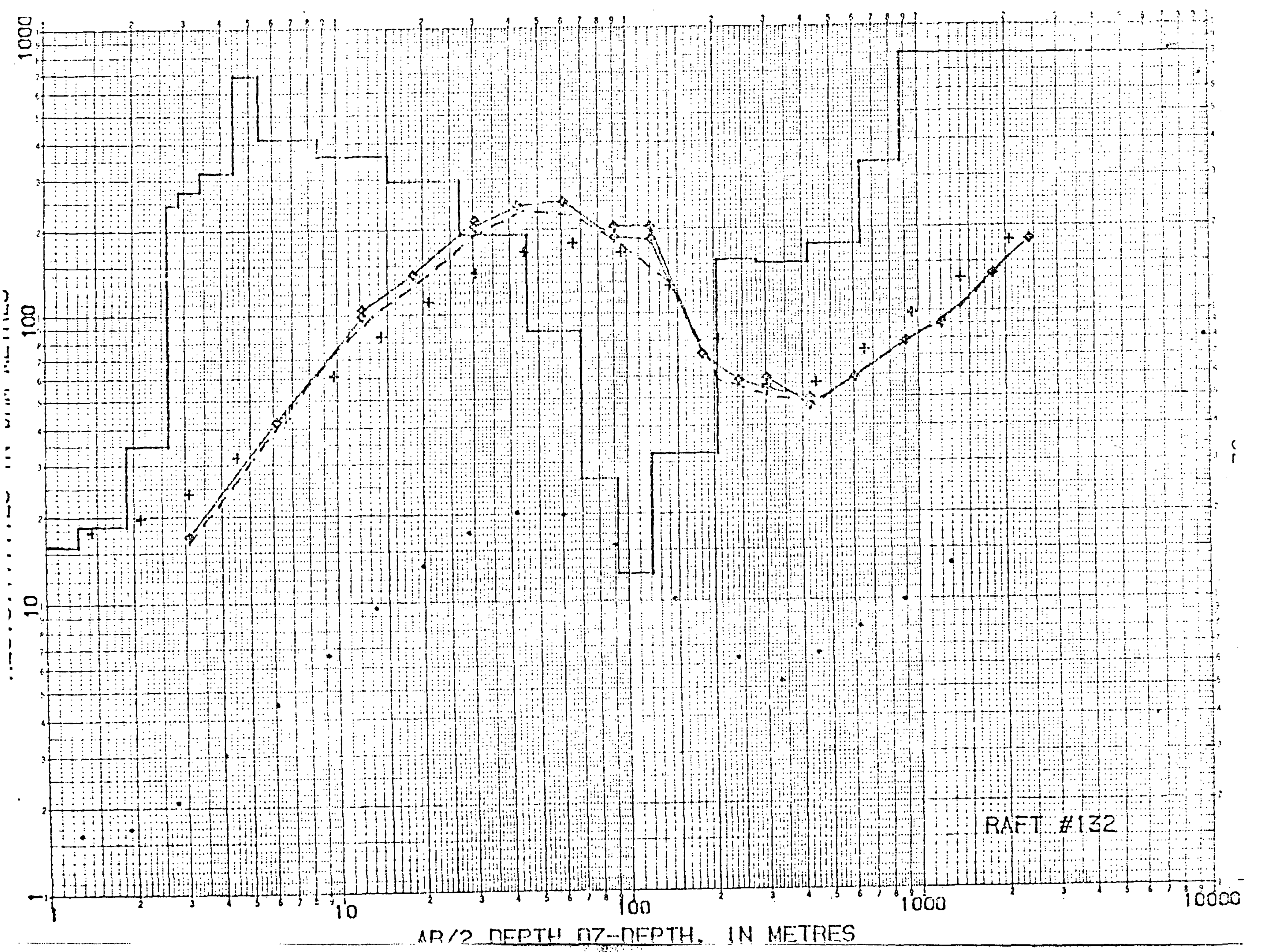
87



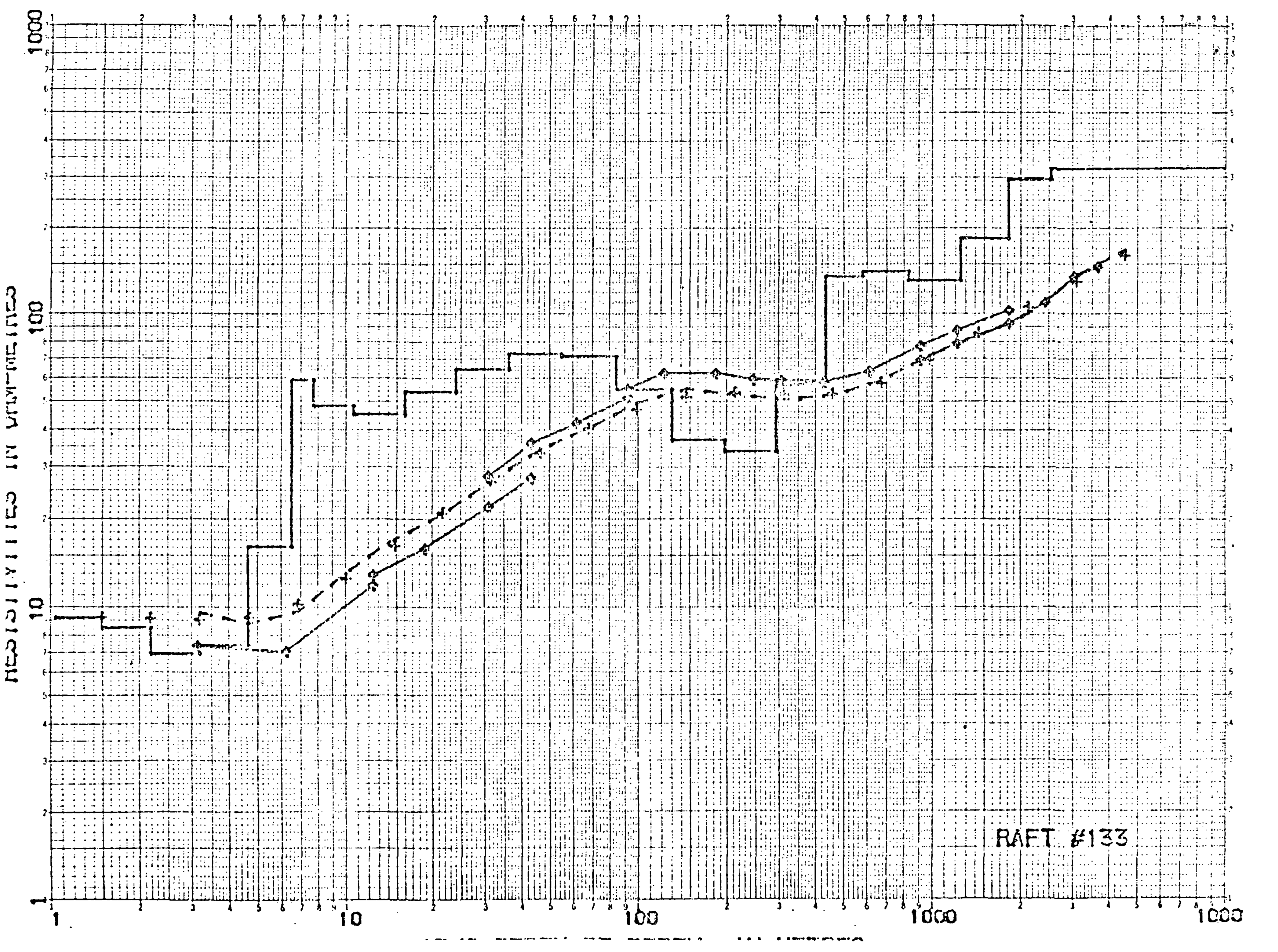
RESISTIVITIES IN OHM-METRES
1
10
100
1000
AB/2 DEPTH, DZ-DEPTH, IN METRES
10
100
1000
RAFT #129


RAFT #130
1000
100
10
1
1
10
100
1000
10000

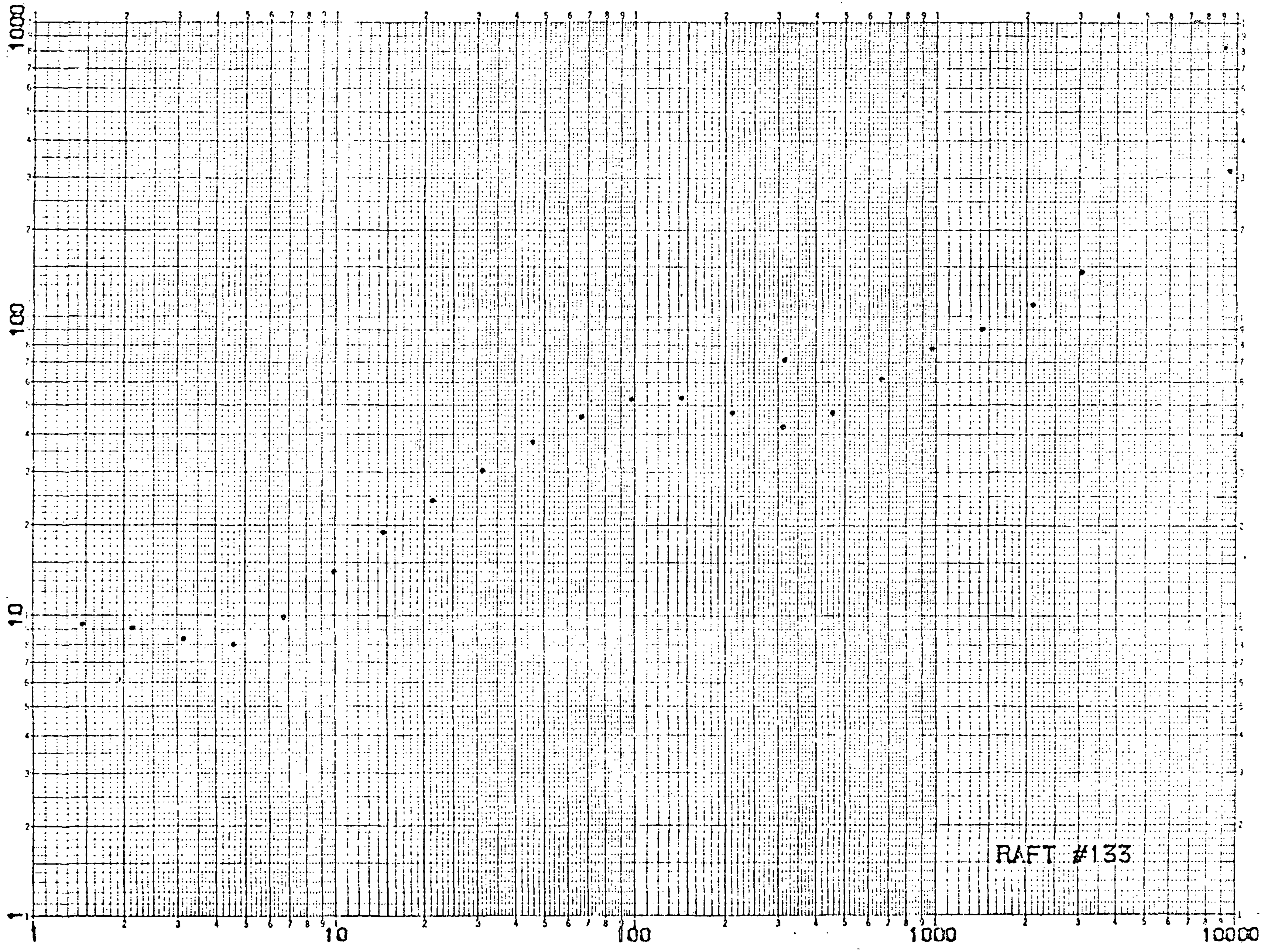

RAFT #131
1000
100
10
1
1
10
100
1000
10000
AB/2 DEPTH OZ-DEPTH IN METRES

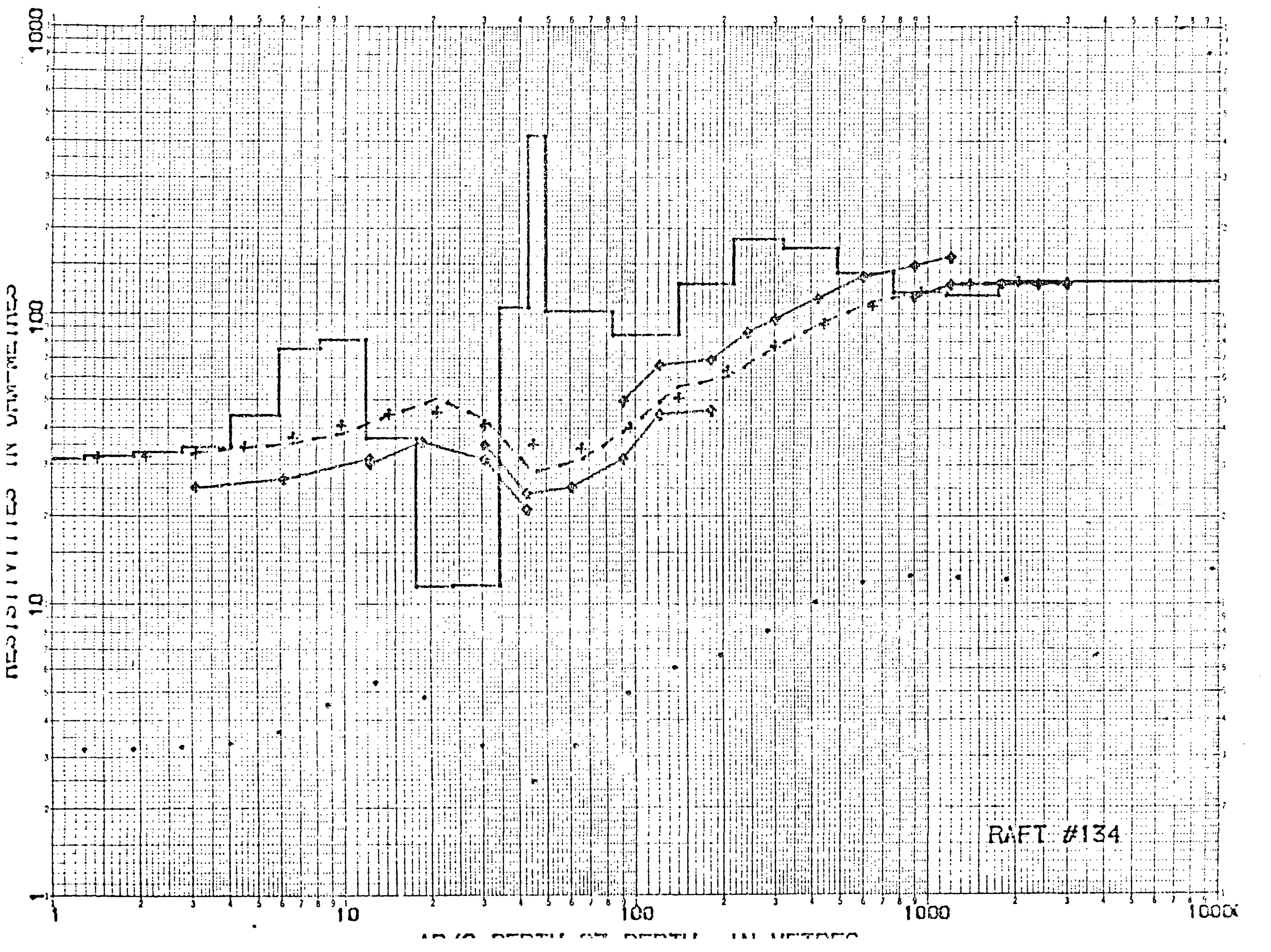


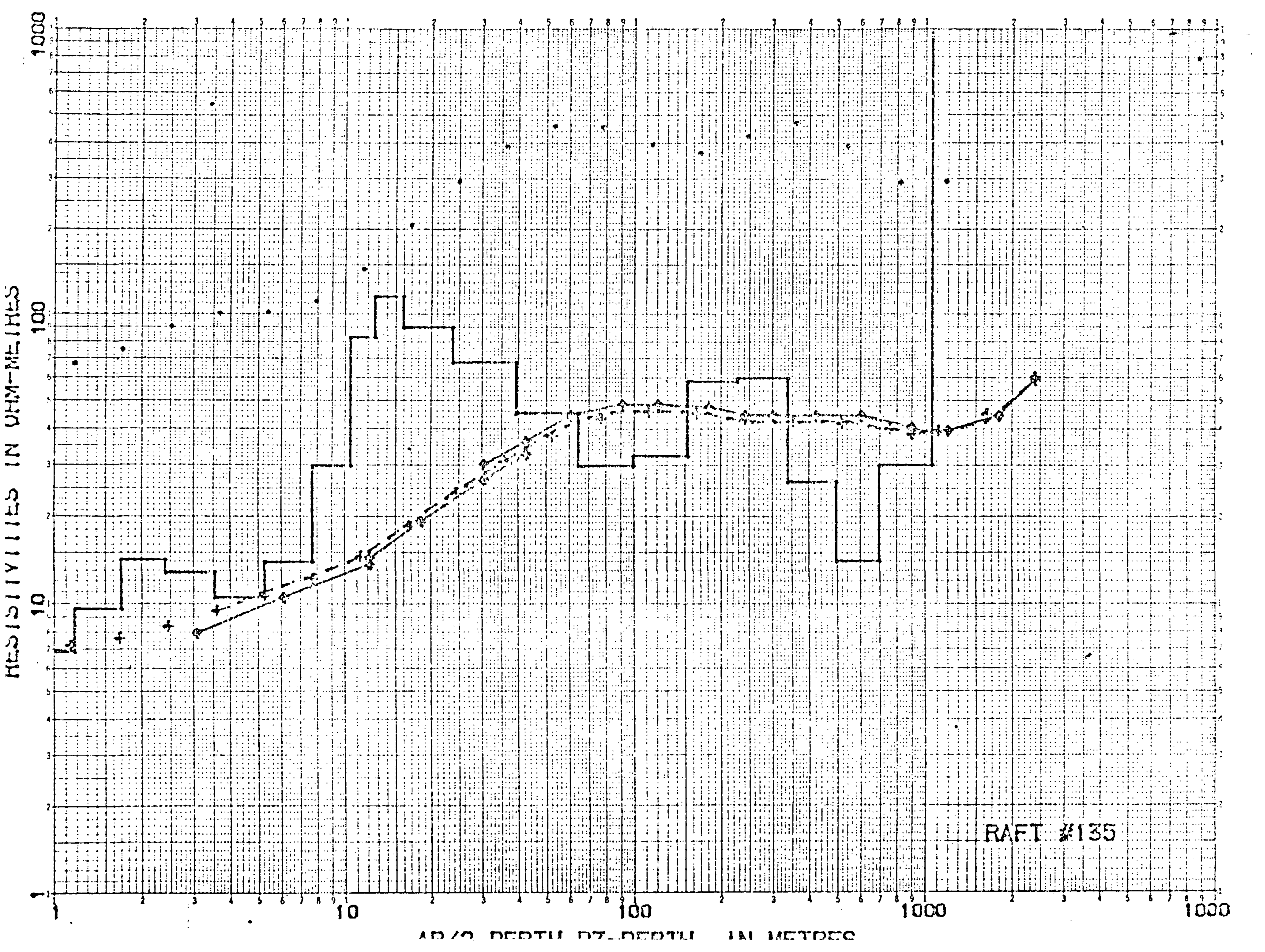
RAFT #132
1
10
100
1000
10000
AB/2 DEPTH DZ-DEPTH, IN METRES

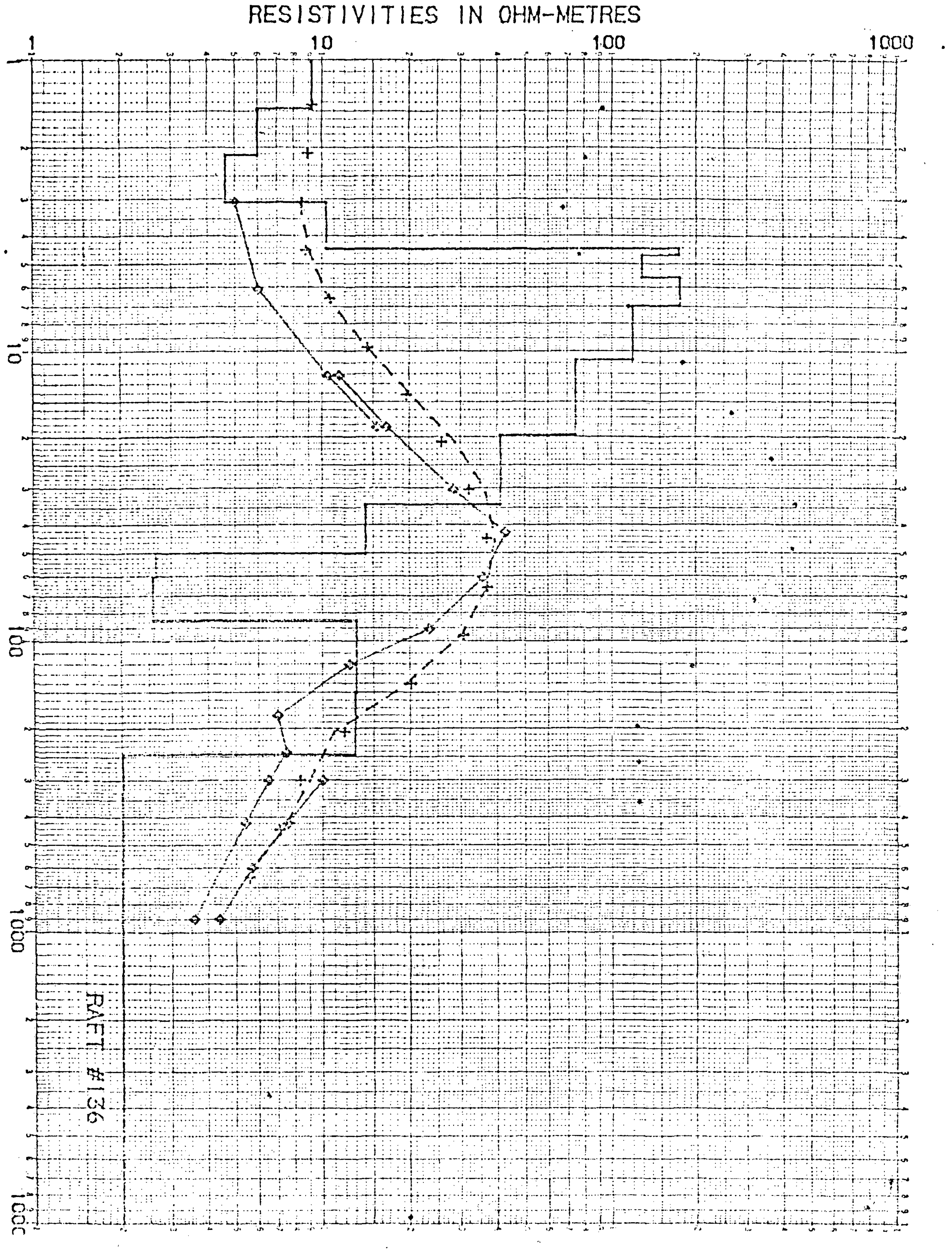


RESISTIVITIES IN OHM-METRES
RAFT #133
1
10
100
1000


RAFT #133
1
10
100
1000
10000
1000
100
10


RESISTIVITIES IN OHM-METRES
AB/2 DEPTH OR DEPTH IN METRES
1
10
100
1000
10000
RAFT #134


RESISTIVITIES IN OHM-METRES
AB/2 DEPTH DZ-DEPTH IN METRES
RAFT #135
1
10
100
1000


RESISTIVITIES IN OHM-METRES
1
10
100
1000
10
100
1000
IN METRES
RAFT #136