UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

SCHLUMBERGER SOUNDING INVESTIGATIONS IN THE DATE CREEK BASIN, ARIZONA.

by

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INTRODUCTION

In 1979 the U.S. Geological Survey made 40 Schlumberger soundings in the Date Creek Basin of western Arizona (fig. 1). The purpose of this study was to trace fine grained lacustrine sediments known to contain uranium, from their surface exposures into the subsurface beneath younger sedimentary rocks. Structural information on the basin fill, the location and nature of the bounding faults, and the basement topography was also desired.

The Date Creek Basin is underlain primarily by a thin veneer of Quaternary alluvium which in turn overlies older basinal sedimentary rocks. On the northern side of the basin the Miocene Chapin Wash Formation crops out (Otton, 1981). This formation consists of fine grained lacustrine and alluvial fan deposits. The lacustrine facies contains uranium that can occur in economic concentrations.

Two types of basement rocks are believed to underly the basin. On the north side of the basin Precambrian granitic rocks crop out. On the south side of the basin outcrops of Mesozoic mylonite occur. West of the basin these two terranes are seperated by a low angle detachment surface which can be

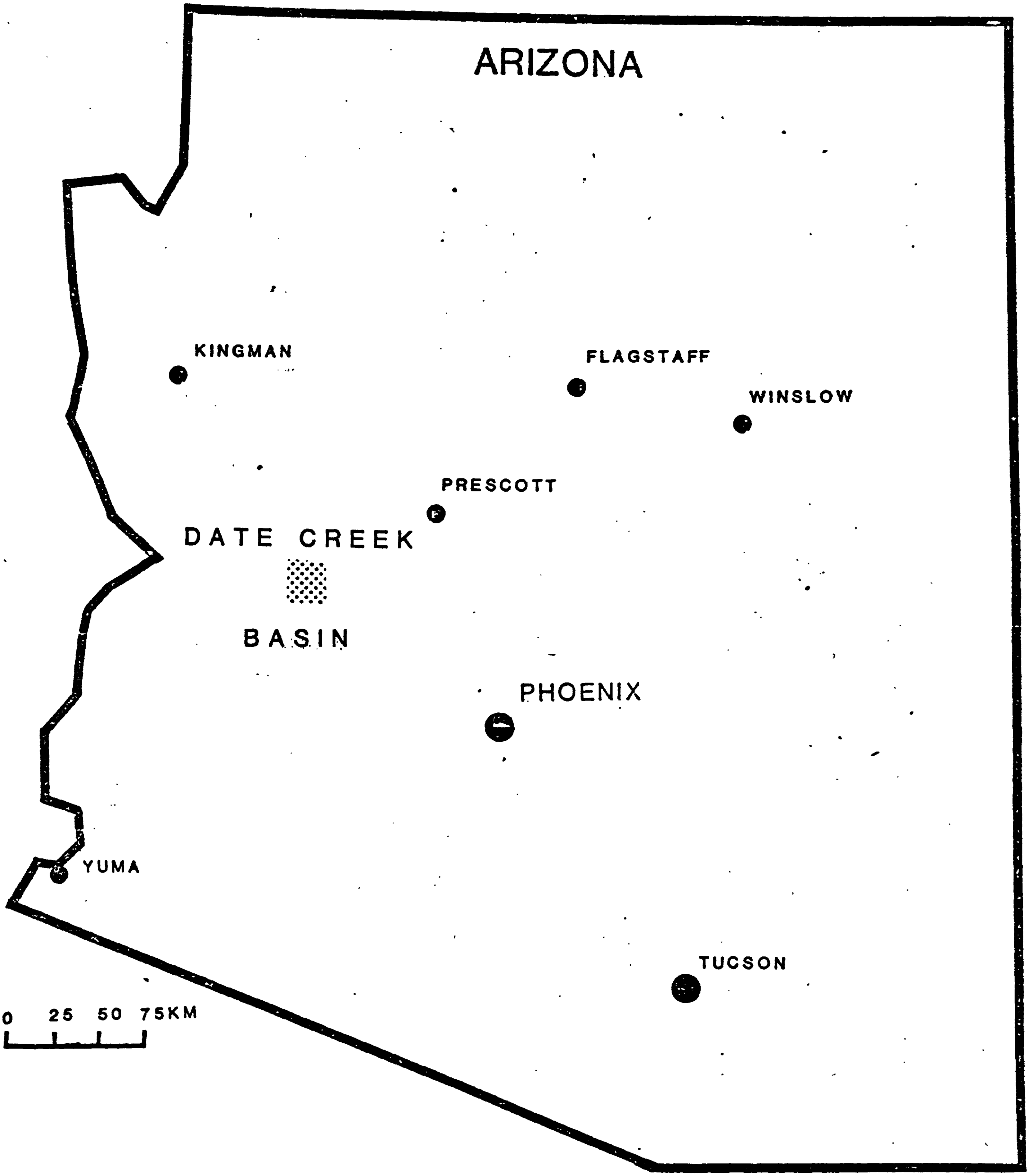


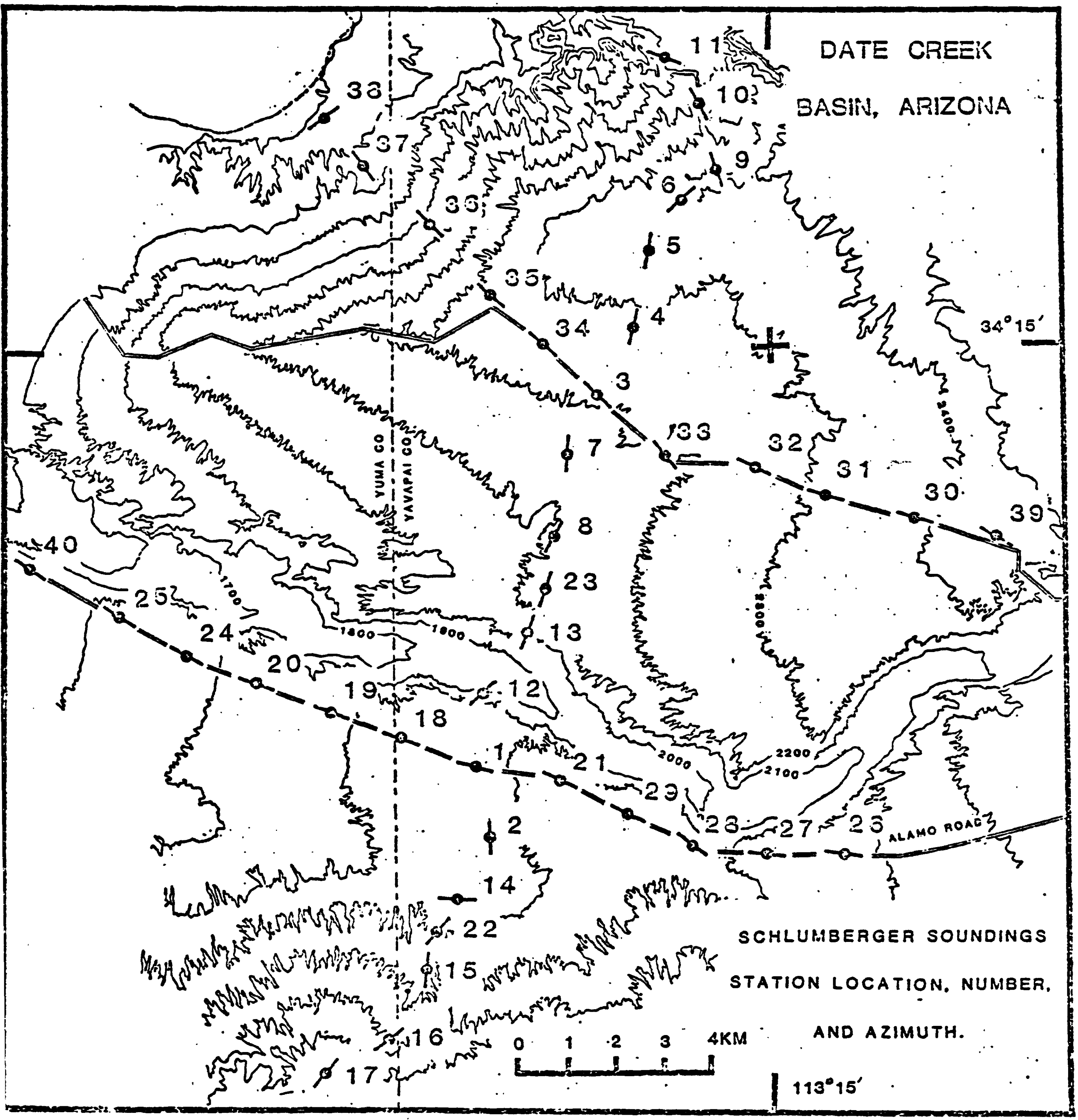
FIGURE 1. Map of Arizona showing the location of the Date Creek Basin.

projected into the basin area.

SCHLUMBERGER SOUNDINGS

Figure 2 shows the Schlumberger sounding locations and their direction of expansion. All sounding measurements were made with a symmetric Schlumberger array. All the sounding curves were automatically processed and interpreted using a slightly modified version of Zohdy's inversion program (Zohdy, 1973). The soundings, labeled and numbered from DATE CREEK 1 to DATE CREEK 40, are shown in the appendix. Each graph shows the following:

1. Field data designated by a segmented, solid-line curve, with diamond symbols for the observed data points.
2. A shifted and digitized field curve designated by a dashed line. The shifted field curve is obtained by shifting the various segments upward or downward generally with respect to the last segment on the segmented field curve (Zohdy and others, 1973). This shifted curve is then digitized at the rate of six points per logarithmic cycle. These points, obtained using a subroutine for the computation of cubic spline functions (Anderson, 1971), are not explicitly shown.
3. The detailed layering shown as a solid-line step function of interpreted true resistivity versus depth.
4. The theoretical best fitting sounding curve calculated from the detailed layering. This curve is designated by plus "+" symbols and is presented to show how well the detailed layering represents the shifted-digitized version of the sounding.
5. The D.Z. (Dar Zarrouk) curve for the detailed layering. The



DATE CREEK
BASIN, ARIZONA
34°15′
YUMA CO
YAVAPAI CO
ALAMO ROAD
1700
1800
1800
2000
2100
2200
2400
SCHLUMBERGER SOUNDINGS
STATION LOCATION, NUMBER,
AND AZIMUTH.
0 1 2 3 4KM
113°15′

FIGURE 2

ordinate values for the D.Z. curve are shifted upward or downward by one logarithmic cycle or are plotted on a seperate page to avoid cluttering the graph. The D.Z. curve can be used to obtain equivalent and simpler solutions containing fewer number of layers and in which certain constaints can be imposed on the layer thicknesses and resistivities (Zohdy, 1974).

COLOR GEOELECTRIC CROSSECTIONS

Computer generated color geoelectric cross sections were created for each of the three traverse lines in figure 2. Each cross section consists of two representations of the same cross section, one with no vertical exaggeration and one vertically exaggerated four times. The cross sections were constructed in the following manner.

For each sounding in a traverse the detailed layering is converted to a smooth curve representing a continuous variation of resistivity with depth. This conversion is made by determining the coordinates of the logarithmic mid-point of each horizontal and vertical segment as shown on figure 3. The logarithms of these points are splined (Anderson, 1971) to form a continuous curve. Then the computed spline coefficients are used to digitize this continuous curve at equal linear intervals. After this is done for each sounding interpretation, the digitized resistivity-depth curves generated in this manner are spline-interpolated in the horizontal direction to generate 100 equally spaced points. This produces a data set in the form of a mesh suitable for contouring. Contouring is done with a contour program supplied by the plotter manufacturer.

Because the minimum resolution of the color plotter in the

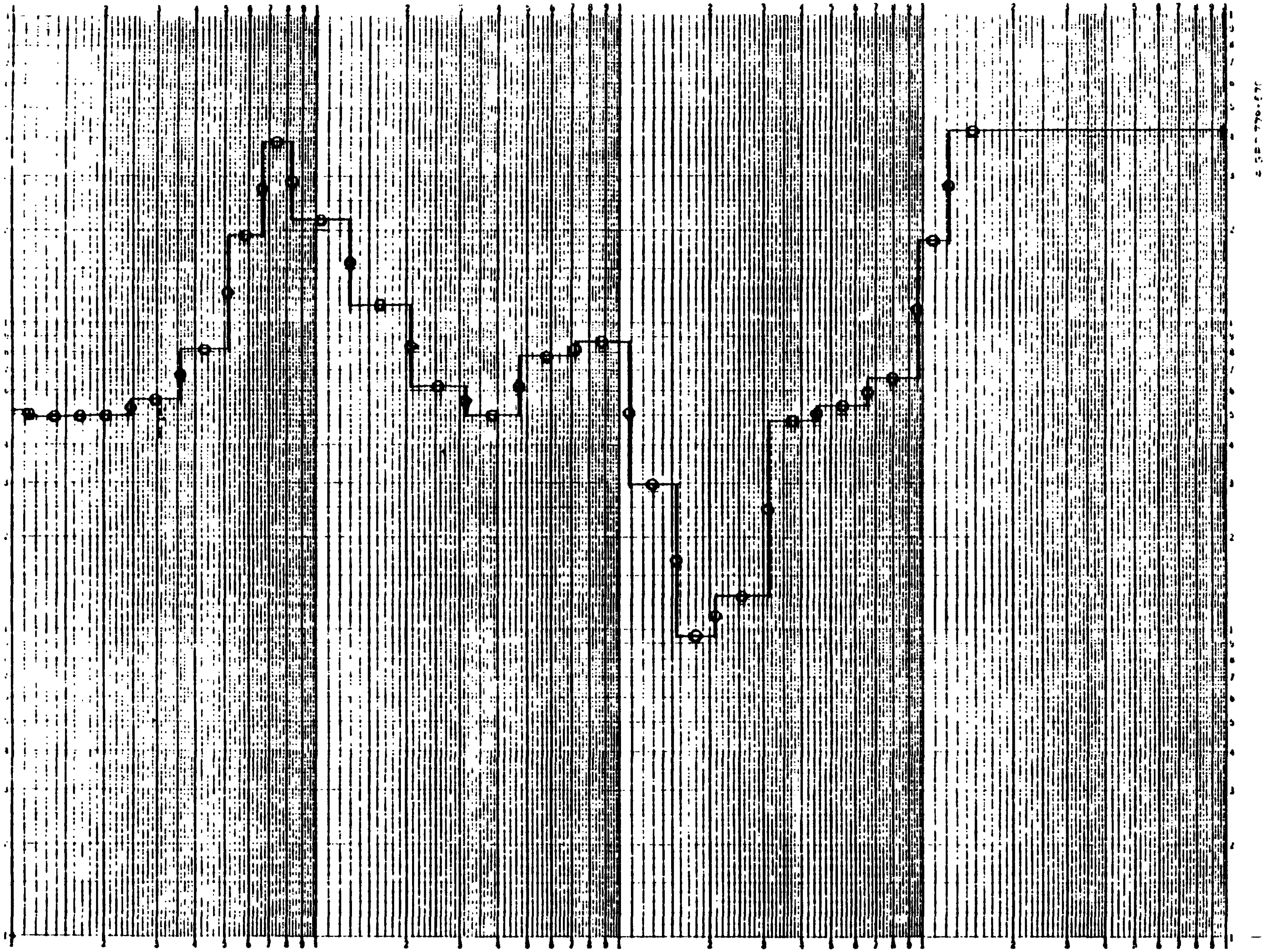


Figure 3. Detailed layering and coordinates of the logorithmic midpoint of each horizontal and vertical segment (represented by circles).

contour mode is 1.6 mm, the number of points digitized vertically from the continuous variation is different for each vertical exaggeration. The times one vertically exaggerated cross section has 47 vertical points and the times four vertically exaggerated cross section has 100 vertical points. Both the vertical exaggerations contain 100 horizontal points.

It should be noted that even though the logarithms of the resistivities and depths were used for splining, some significant anomalies may still be generated between sounding locations. Thus although the automatic contouring method used is faithful to the interpreted resistivity values beneath each station, there are other acceptable methods of contouring these resistivity values. The reader is cautioned that anamolies generated between soundings may not be real.

Each color cross section has a color scale which relates resistivity ranges to colors. The resistivity ranges selected are quasi-equally spaced logarithmically at 2, 3, 4.5, 7, 10, 15, 20, ... , 200, 300, and 450 ohm-meters. To produce a uniform lower layer, most of the sounding interpretations had the last layer resistivity forced to be 1000 ohm-m. This tends to produce a "prettier" picture without unduly altering the general interpretation, at least on curves with ascending terminal branches. Due to logistical problems, soundings 6 and 9 could not be expanded far enough to detect a rising terminal branch. For these soundings a rising terminal branch was manually added to present a more pleasing cross section. This was done in such a manner so that the terminal branches added would be similar to those of adjacent soundings 5 and 10. Basement depths interpreted for soundings 6 and 9 represent minimum depths for the interpretation scheme used. Other schemes which might include larger resistivity contrasts could certainly result in a shallower basement. Modified versions of soundings 6 and 9 are shown in the appendix as DATE CREEK 6-EXT and DATE CREEK 9-EXT respectively.

DISCUSSION

Since sounding 11 was made in the Anderson mine, the resistivity values interpreted from this sounding should be indicative of the resisitivity values of the fine grained lacustrine facies of the Chapin Wash Formation. The interpretation of sounding 11 (see the Appendix) indicates a resistivity range of 10 to 30 ohm-m for this facies. The following correlates resistivity ranges to probable lithologies:

RESISTIVITY (ohm-m)	PROBABLE LITHOLOGY
<10	clays, clayey sand, or salt water saturated sediments
10-30	fine grained sediments
30-70	sands
70-300	coarse sands, or gravels
>300	crystalline or metamorphic basement material

Figure 4 shows the north-south geoelectric cross section.

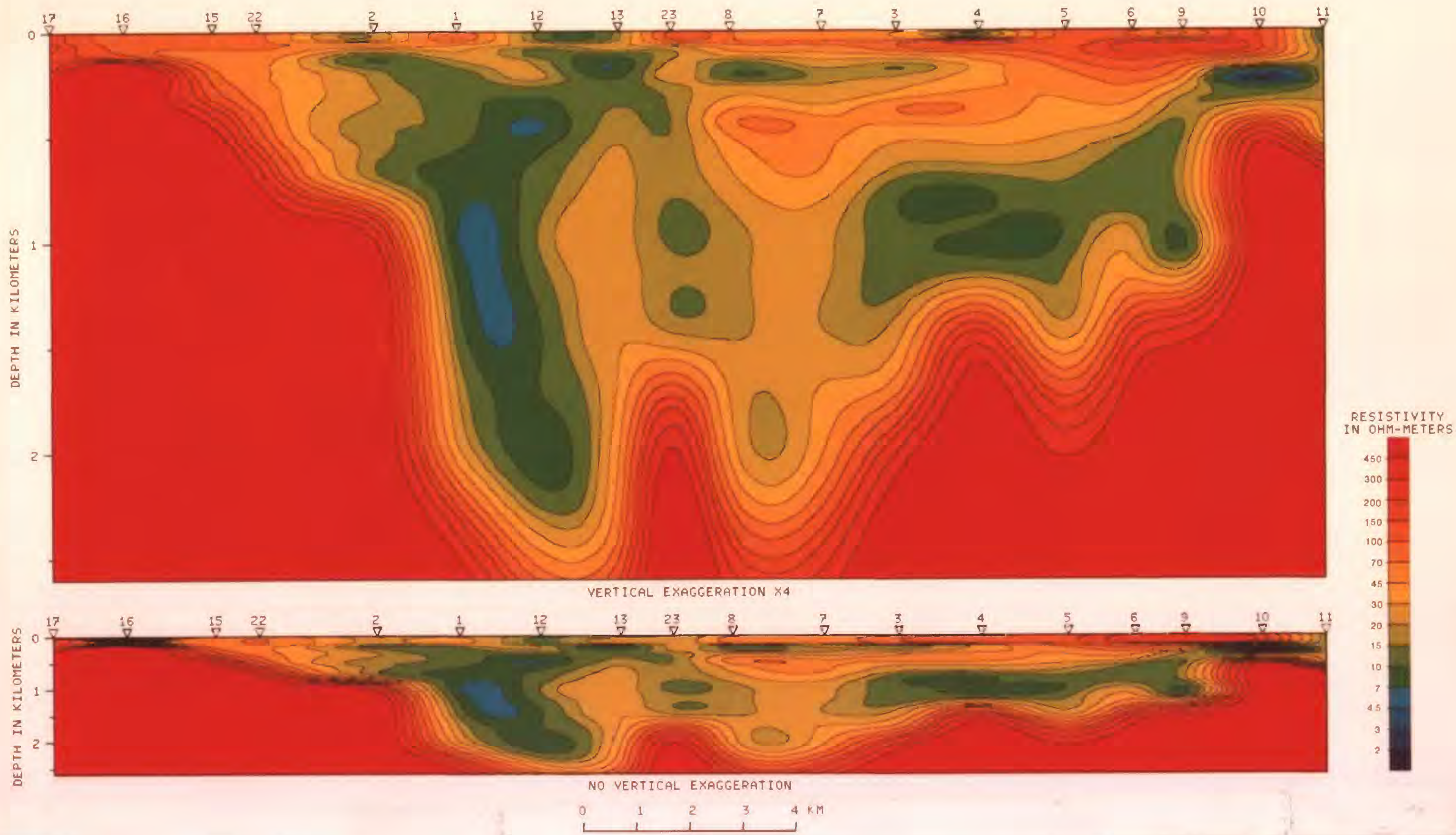


Figure 4. Computer-generated color geoelectric cross section. Top and Bottom parts are vertically exaggerated 4 and 1 times respectively.

The Anderson mine and sounding 11 are at the right. Basement is well defined along the cross section. A major fault, which appears to have a vertical offest of about 1 km, is indicated in the vicinity of sounding 2. A horst like feature in the basement material is indicated under soundings 13, 23, and 8. This feature appears to be a block of basement material uplifted about 500 m. A fault with a vertical offset of about 500 m is present between soundings 9 and 10. This fault appears to have cut the Chapin Wash Formation during deposition in that the formation on the downthrown side appears to be thicker than on the upthrown side.

A low resistivity layer of less than 30 ohm-m extends from the vicinity of sounding 11 into the basin. This layer has a section of lower resistivity than that indicated for the Chapin Wash Formation. This could be due to the presence of water in the sediments or of a different lithology. Surface reisitivities are variable and probably reflect changes in grain size with the finest grained material having the lowest resitivities.

Beneath soundings 1 and 12 there exists a zone characterized by resistivities of less than 10 ohm-m. This zone could indicate the presence of a large column of saline water or a large column of clays. The latter explanation could be indicative of a geothermal system with the clays being the result of hydrothermal alteration.

Figure 5 shows the northernmost east-west geoelectric cross section. Basement is well defined along this cross section. Possible faults with offsets of less than 500 m of vertical offset are indicated between soundings 30, 31 and soundings 36, 37. In the basin fill deposits a layer with resistivities of less than 30 ohm-m exists. This layer may correlate with the Chapin Wash Formation.

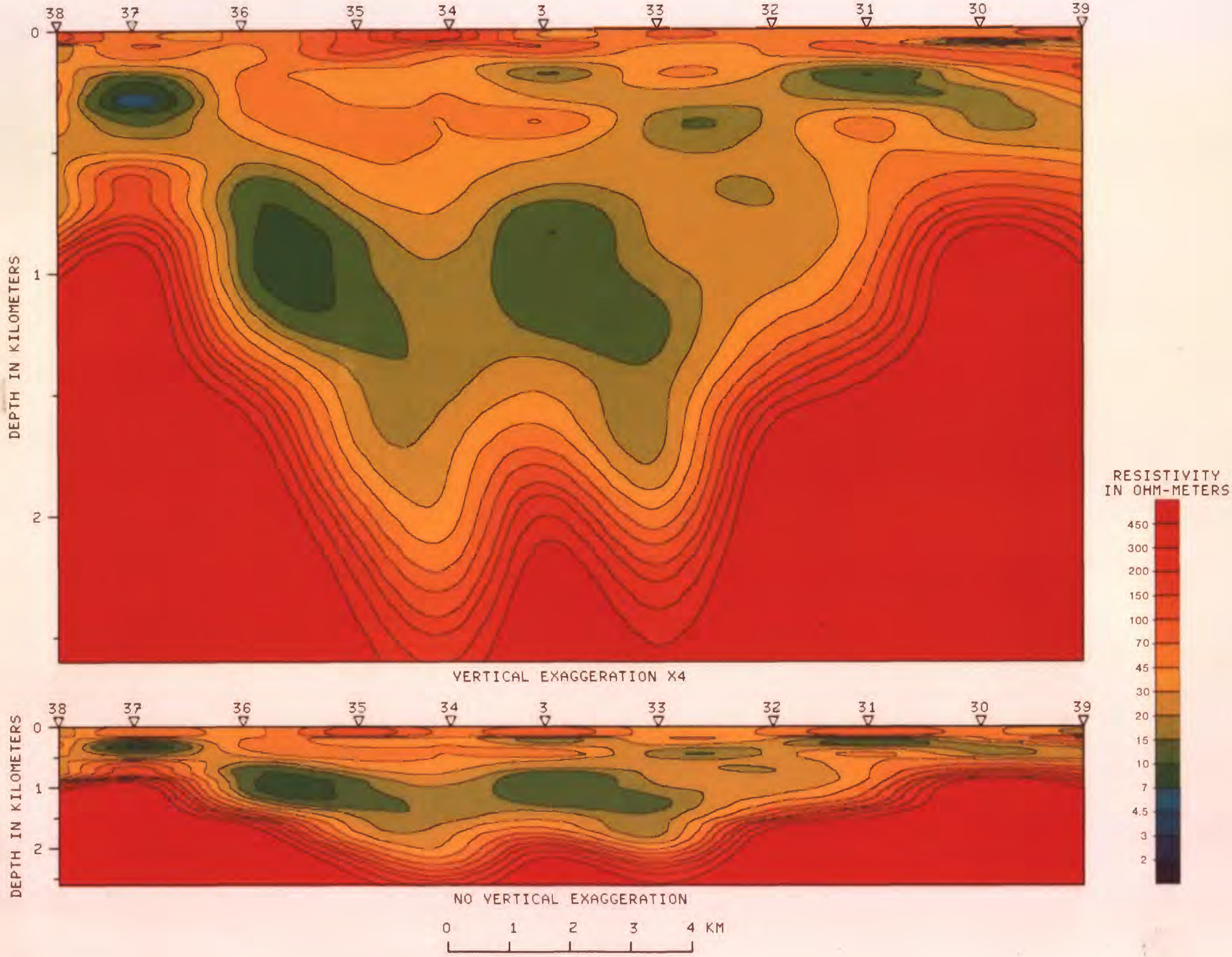


Figure 5. Computer-generated color geoelectric cross section. Top and Bottom parts are vertically exaggerated 4 and 1 times respectively.

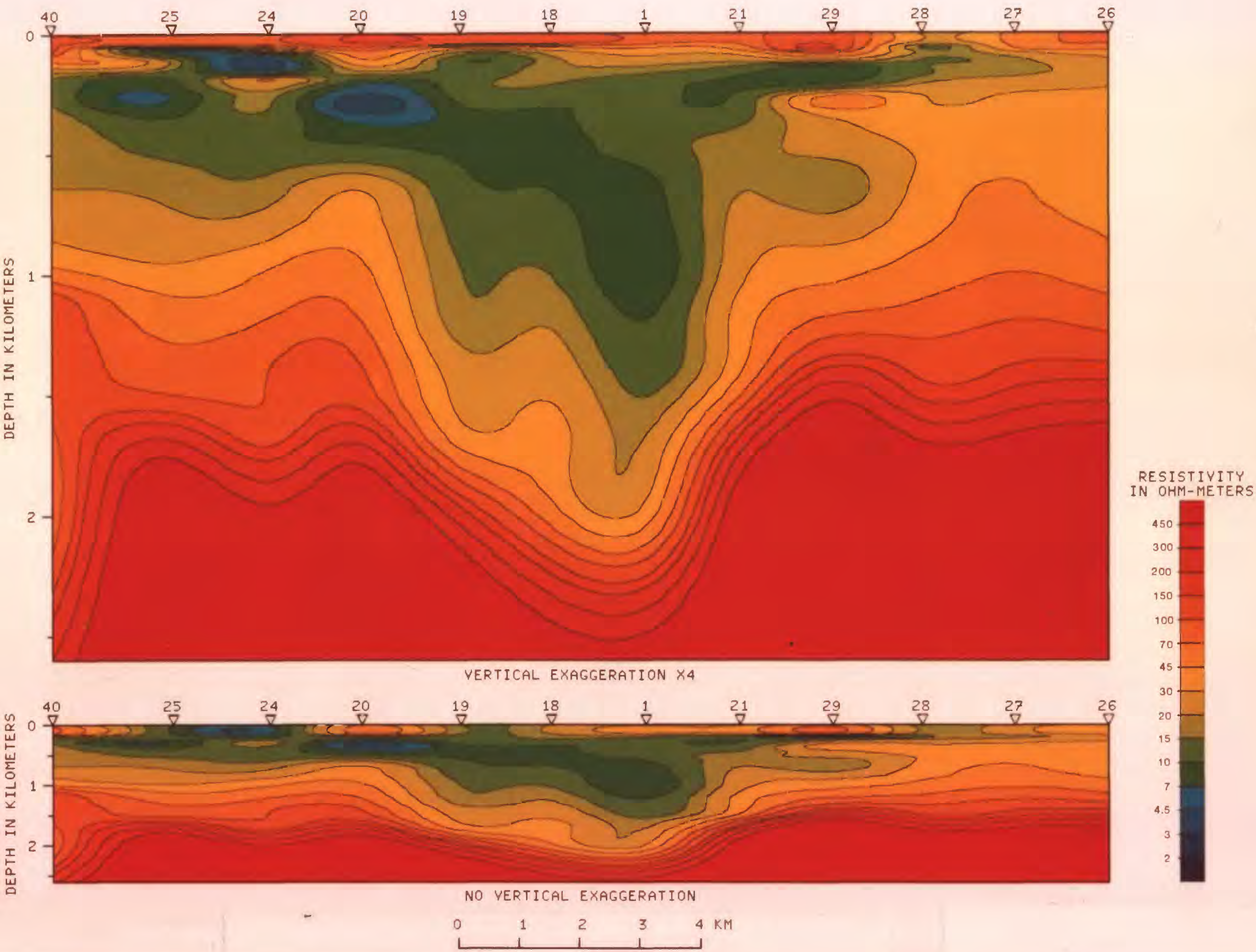


Figure 6. Computer-generated color geoelectric cross section. Top and Bottom parts are vertically exaggerated 4 and 1 times respectively.

Figure 6 show the southernmost east-west geoelectric cross section. Basement is well defined along this cross section with the exception of sounding 40 which was distorted due to some unknown lateral feature possibly a fault. The layer with resistivities of less than 30 ohm-m is present in the basin, but resistivities are generally lower than those indicated for the Chapin Wash Formation. This probably indicates that this unit is different, either containing more clays or saltier water.

In summary: The resistivity data provided a good picture of the basement configuration. A low resistivity unit that could be correlatable to the mineralized Chapin Wash Formation was detected within the basin. Faults with vertical offsets of up to 1 km were detected in the basement material and in one instance a fault with significant displacement cuts the basin fill.

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Anderson, W. L., 1971, Application of bicubic spline functions to two dimensional gridded data: available only from U.S. Dept. Commerce, Natl. Tech. Inf. Service Springfield, Va. 22161, as U.S. Geol. Survey Rept. USGS-GD-71-022, PB-203 579.

Otton, J. K., 1981, Stuctural Geology of the Date Creek Basin area, west central Arizona, in Howard, K. A., Carr, N. D., and Miller, D. M., editors Tectonic framework of the Mojave and Sonoran deserts, California and Arizona: U. S. Geol. Survey Open-File Report 81-503, p. 82-84.

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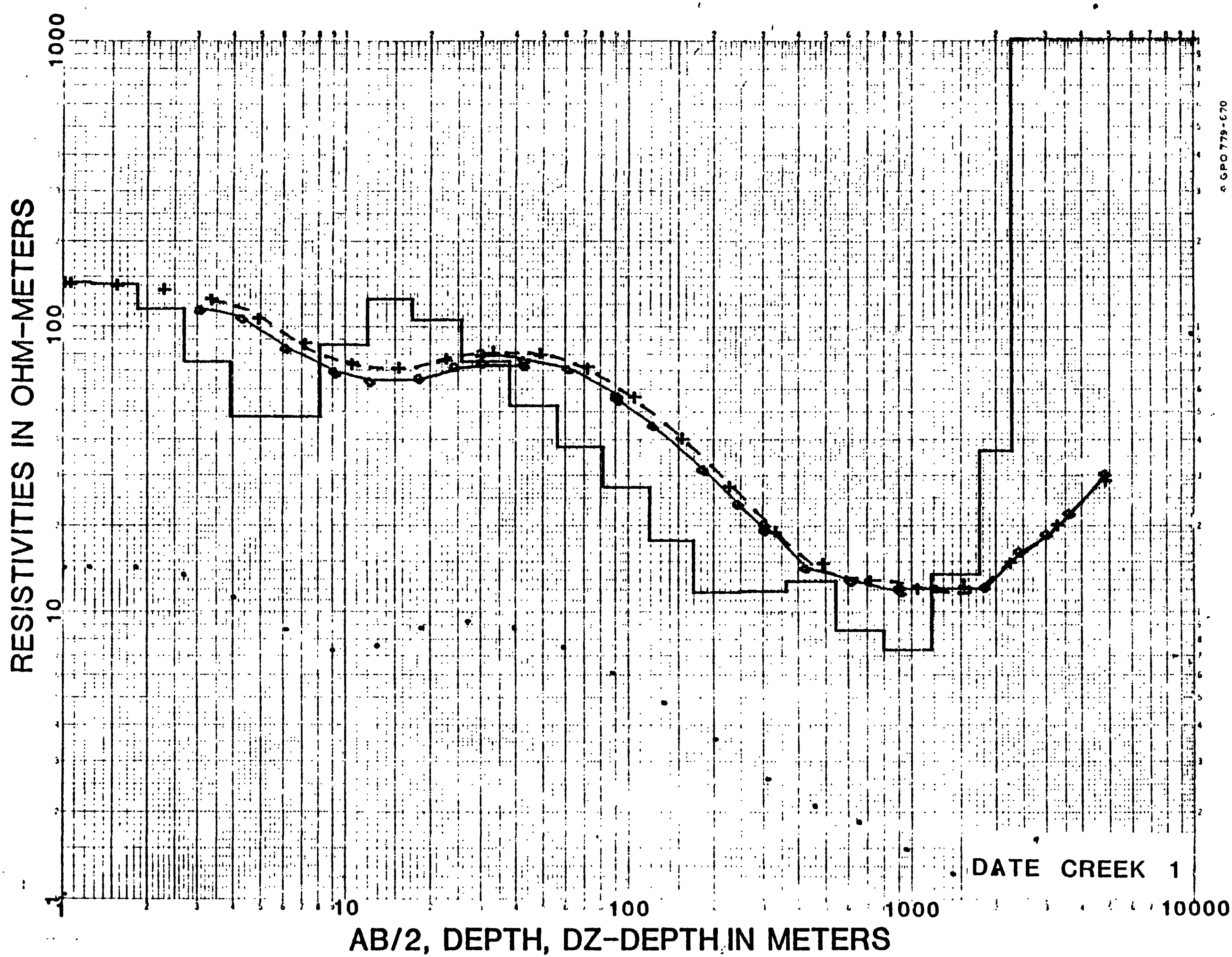
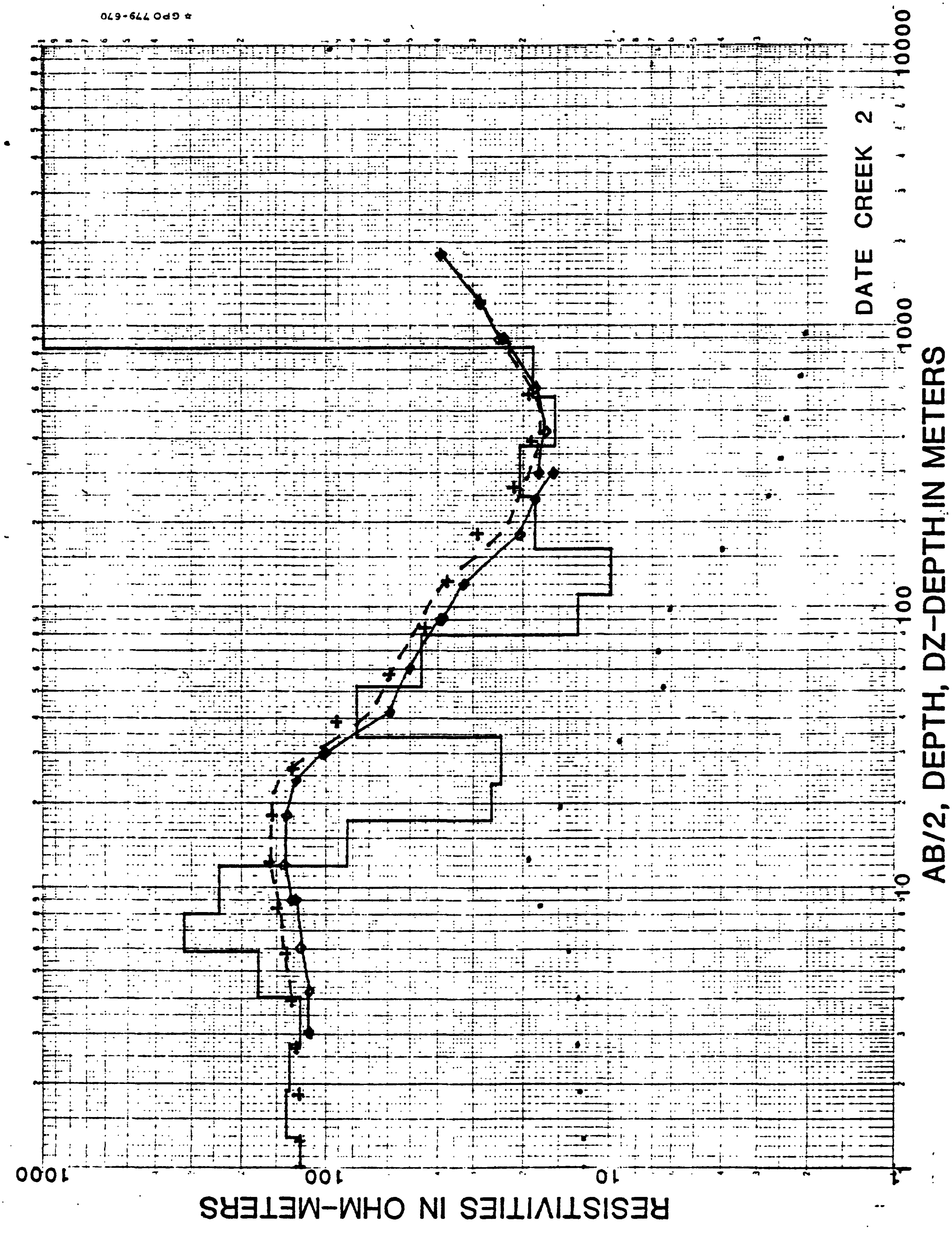
______, 1974, Use of Dar Zarrouk curves in the intereprretation of vertical electrical sounding data: U.S. Geol. Survey Bull. 1313-D, 41 p.

Zohdy, A. A. R., Anderson, L. A., and Muffler, L. J. P., 1973, Resistivity, self potential, and induced polarization surveys of a vapor dominated system: Geophysics, v.38, p. 1130-1144.

APPENDIX


DATE CREEK 1
RESISTIVITIES IN OHM-METERS
AB/2, DEPTH, DZ-DEPTH IN METERS
1000
100
10
1
10
100
1000
10000
GPO 779-670


DATE CREEK 2
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
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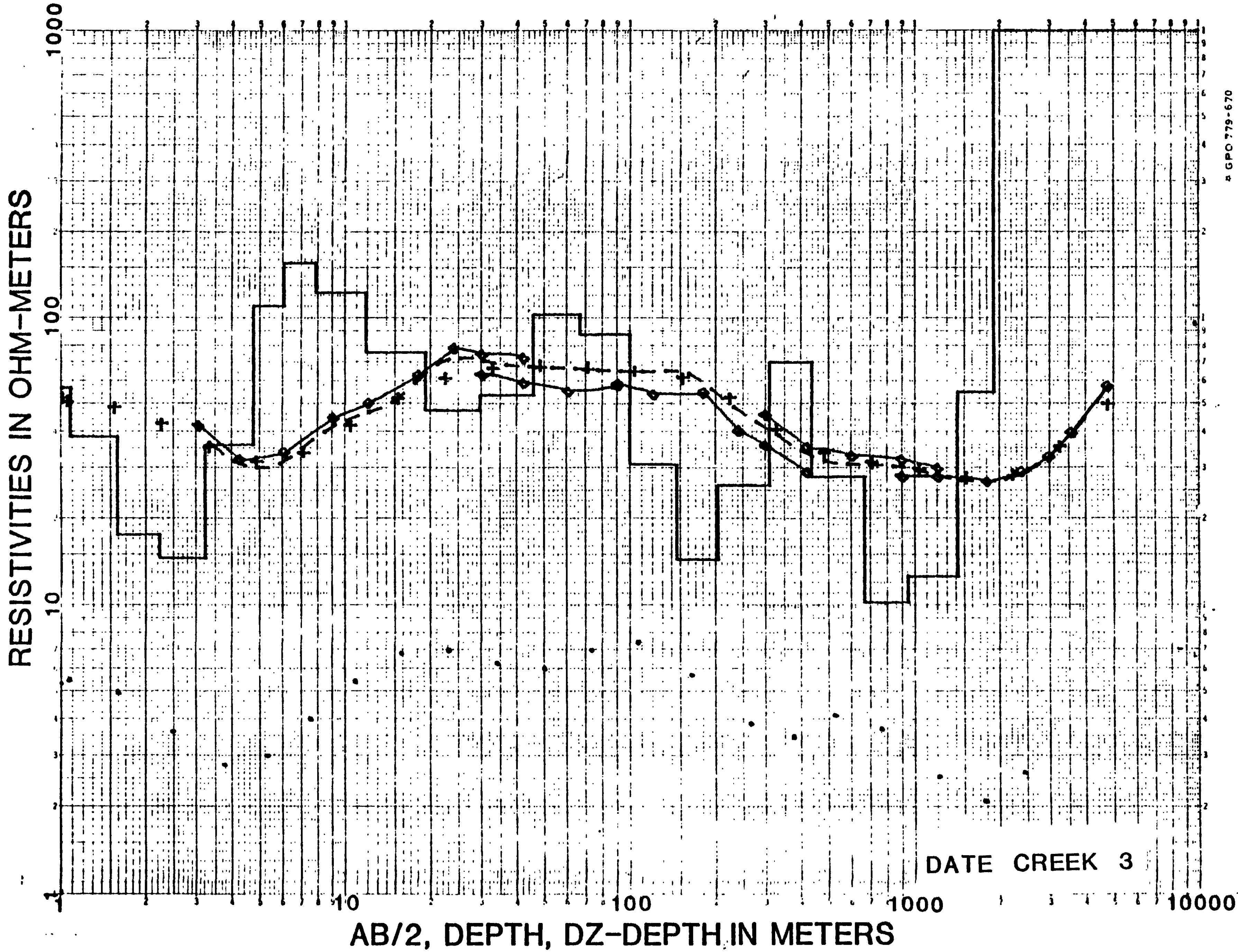
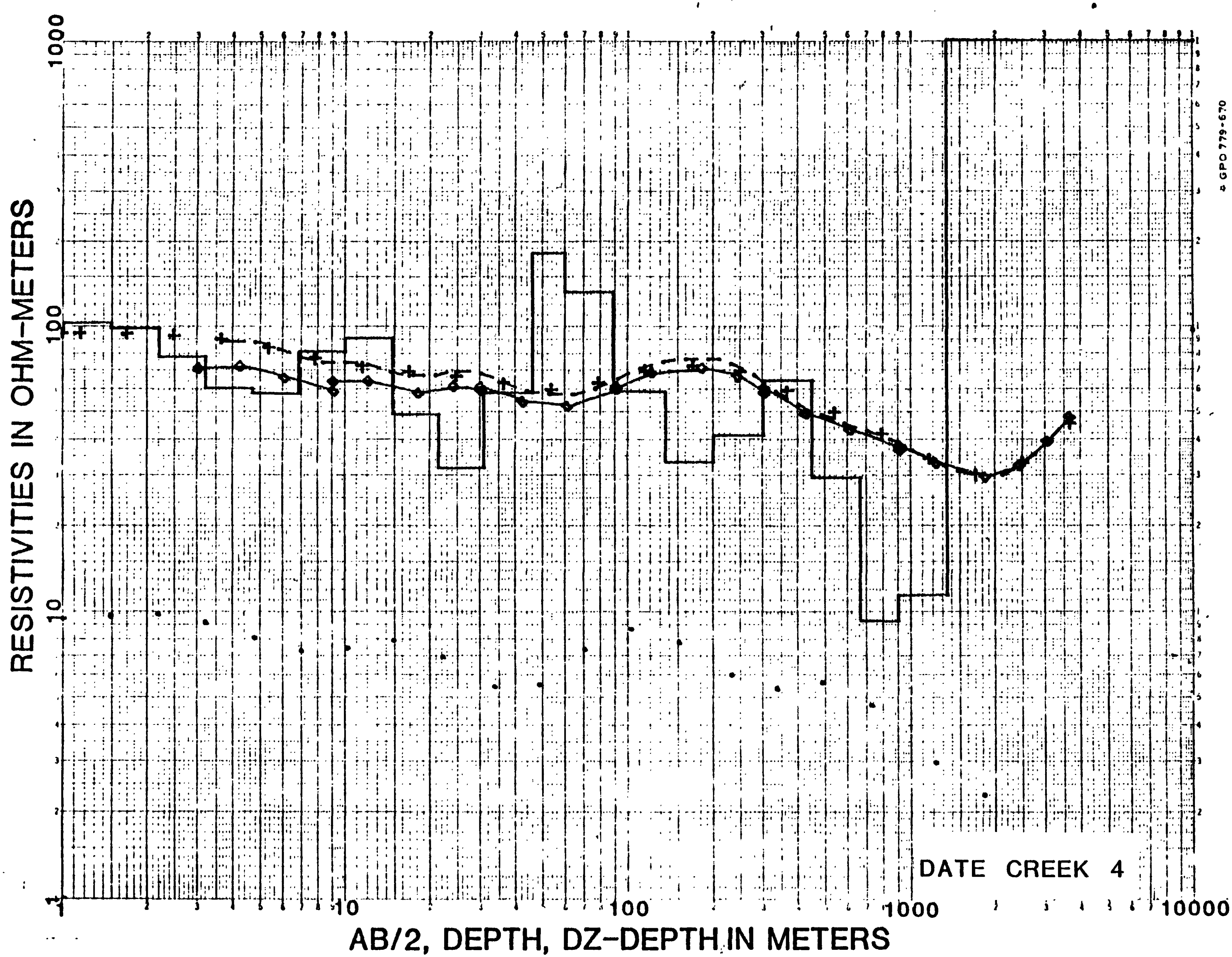
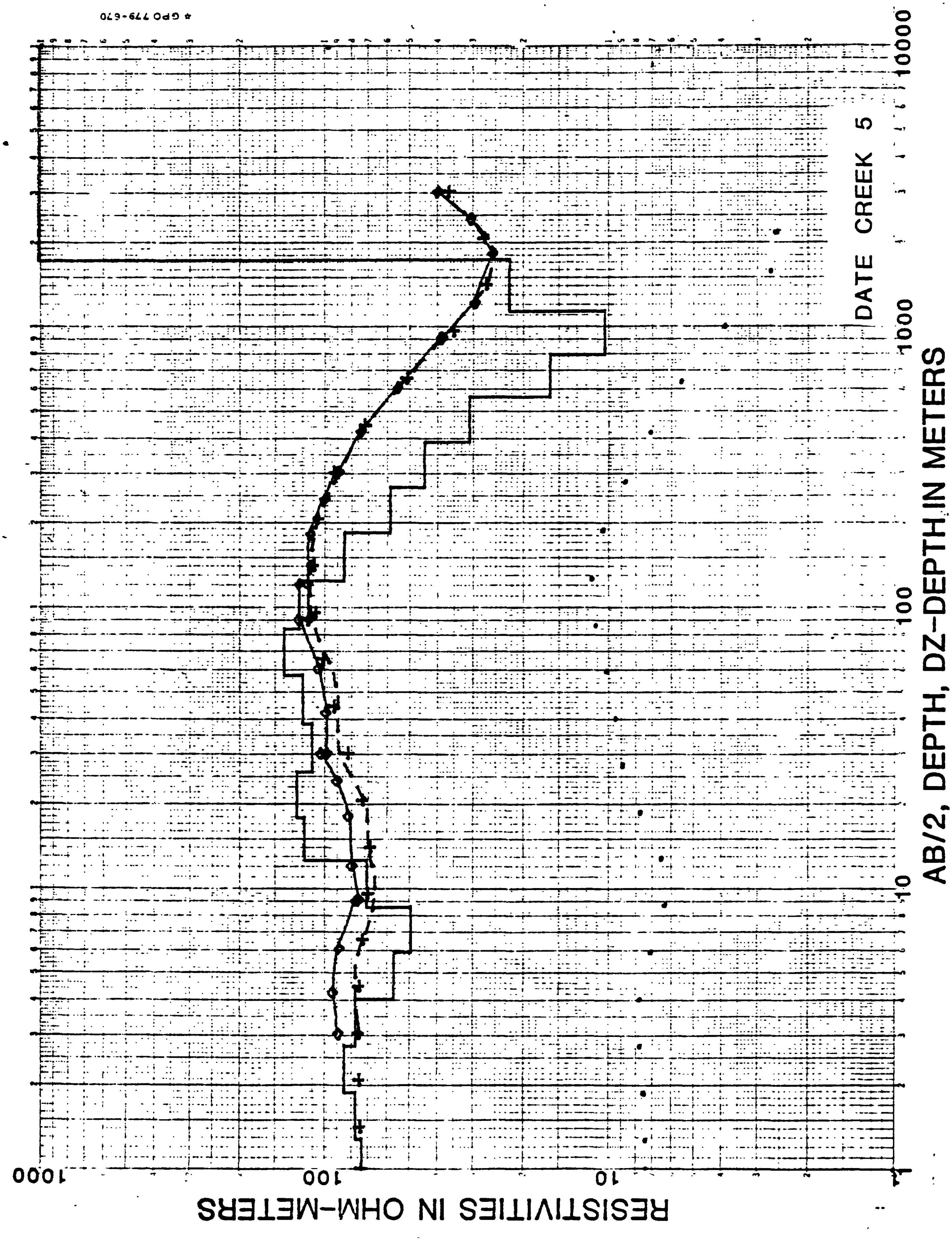
100
10
1
10000
GPO 779-670

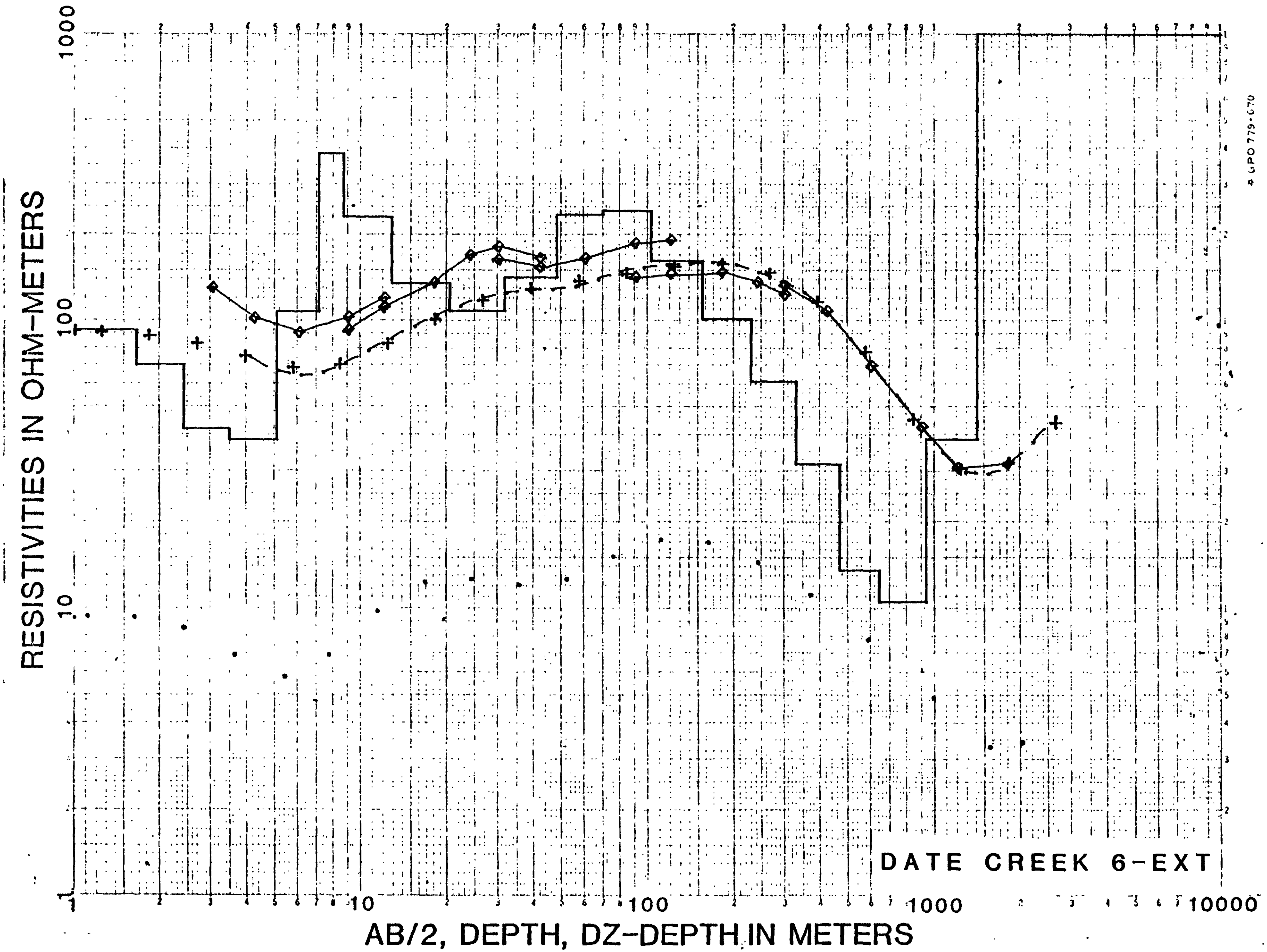


RESISTIVITIES IN OHM-METERS
1000
100
10
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH IN METERS
DATE CREEK 3
GPO 779-670

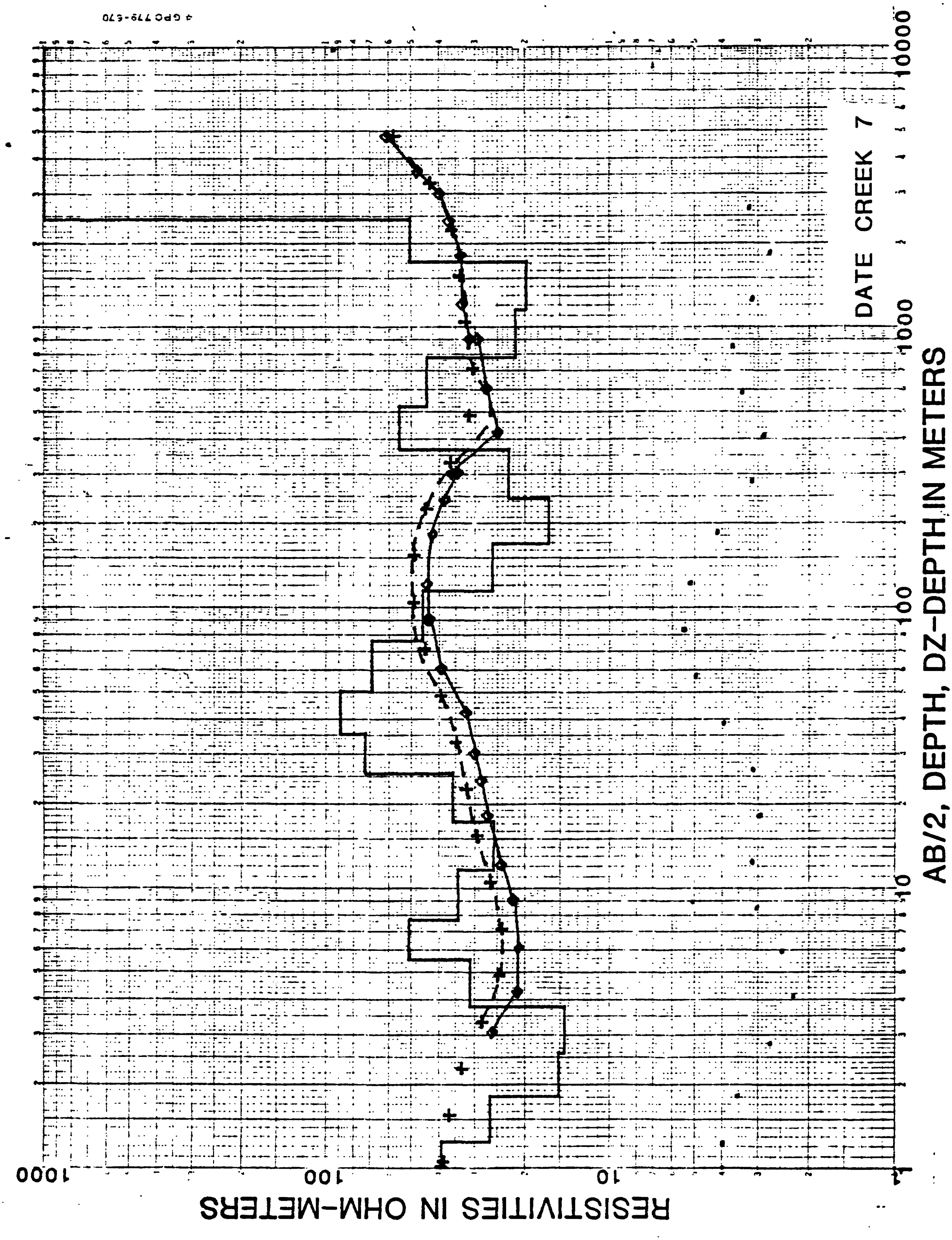


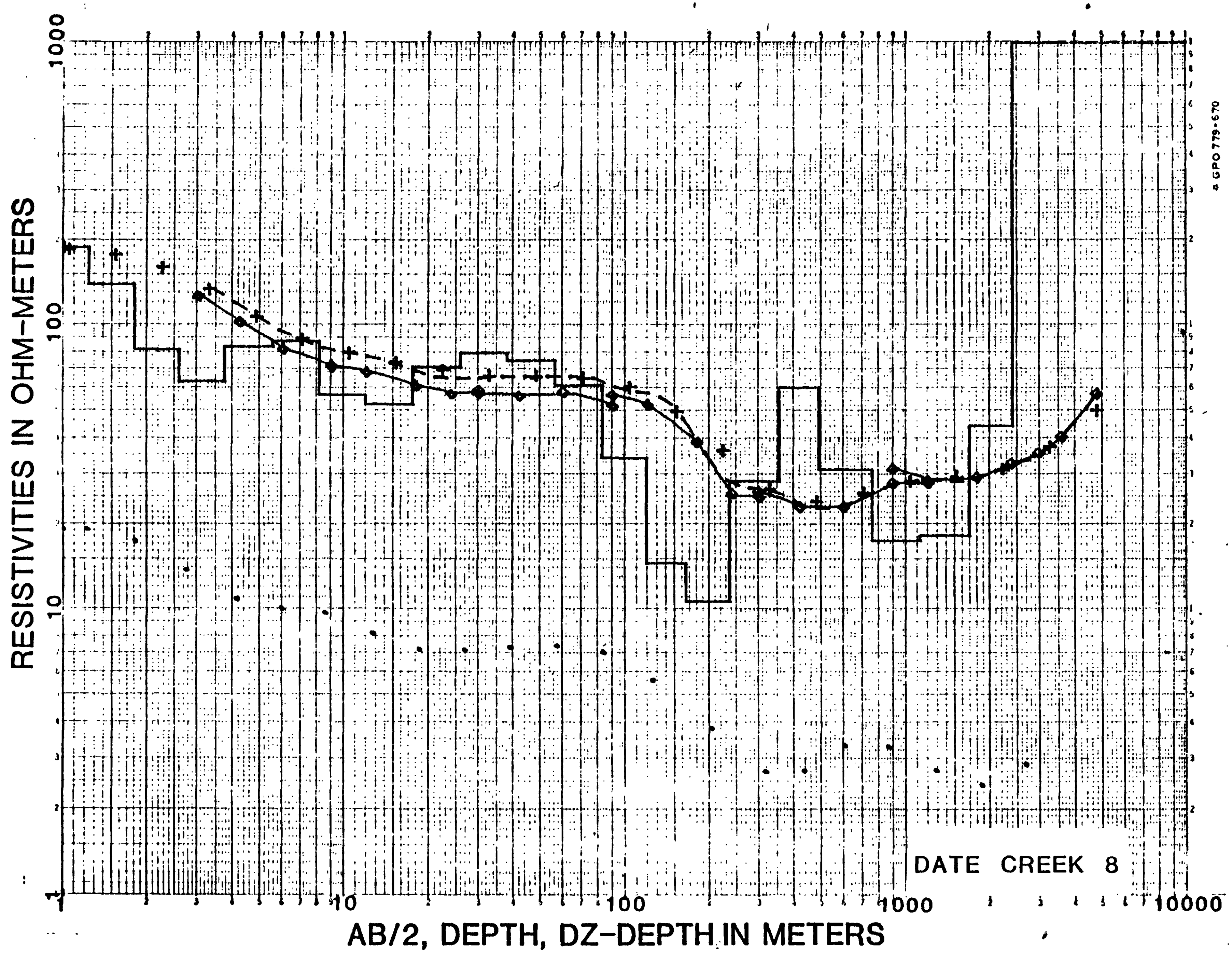
DATE CREEK 4
RESISTIVITIES IN OHM-METERS
AB/2, DEPTH, DZ-DEPTH IN METERS
1000
100
10
1
10
100
1000
10000
GPO 779-670


DATE CREEK 5
AB/2, DEPTH, DZ-DEPTH IN METERS
10
100
1000
10000
RESISTIVITIES IN OHM-METERS
1000
100
10
1

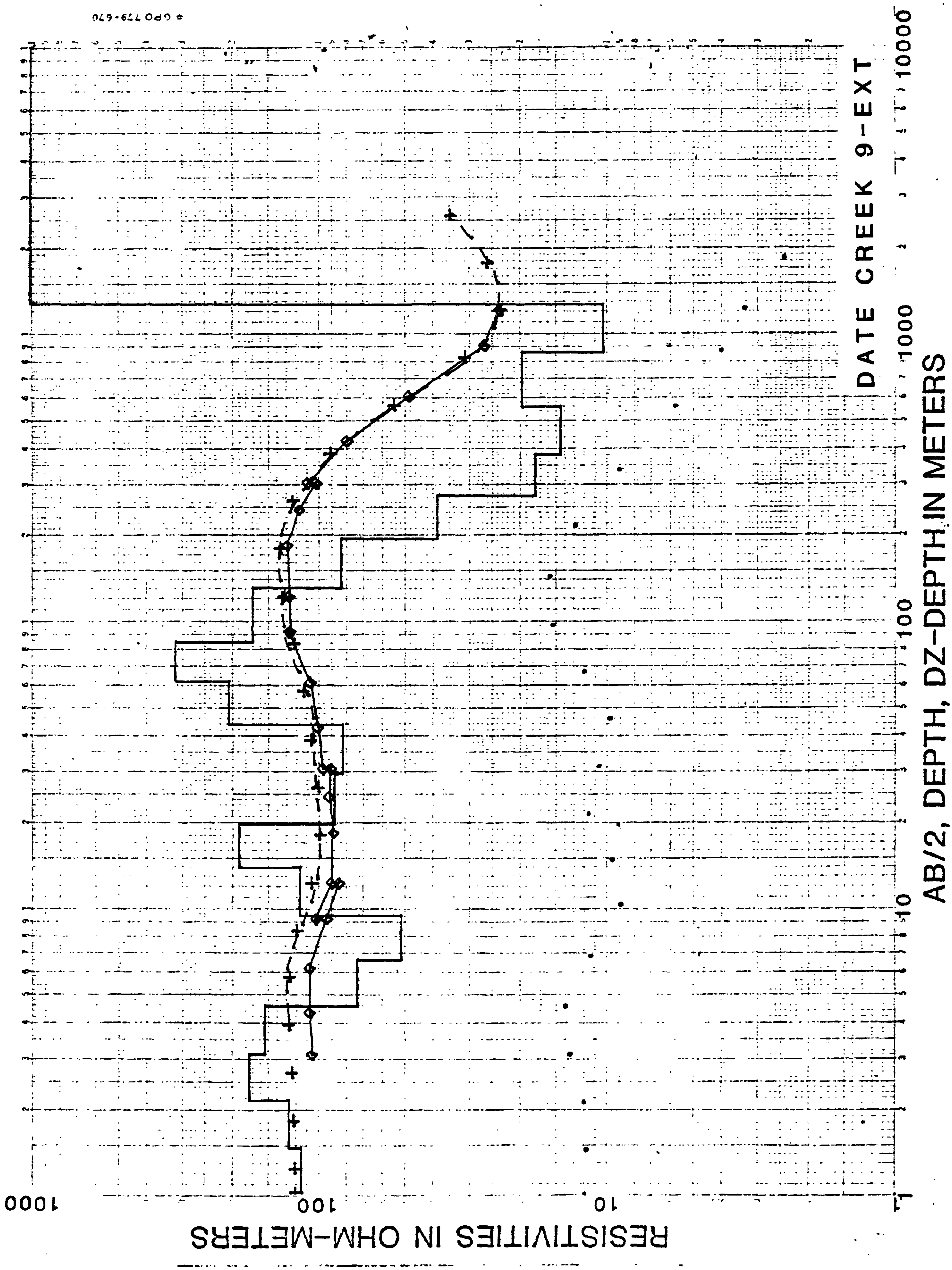


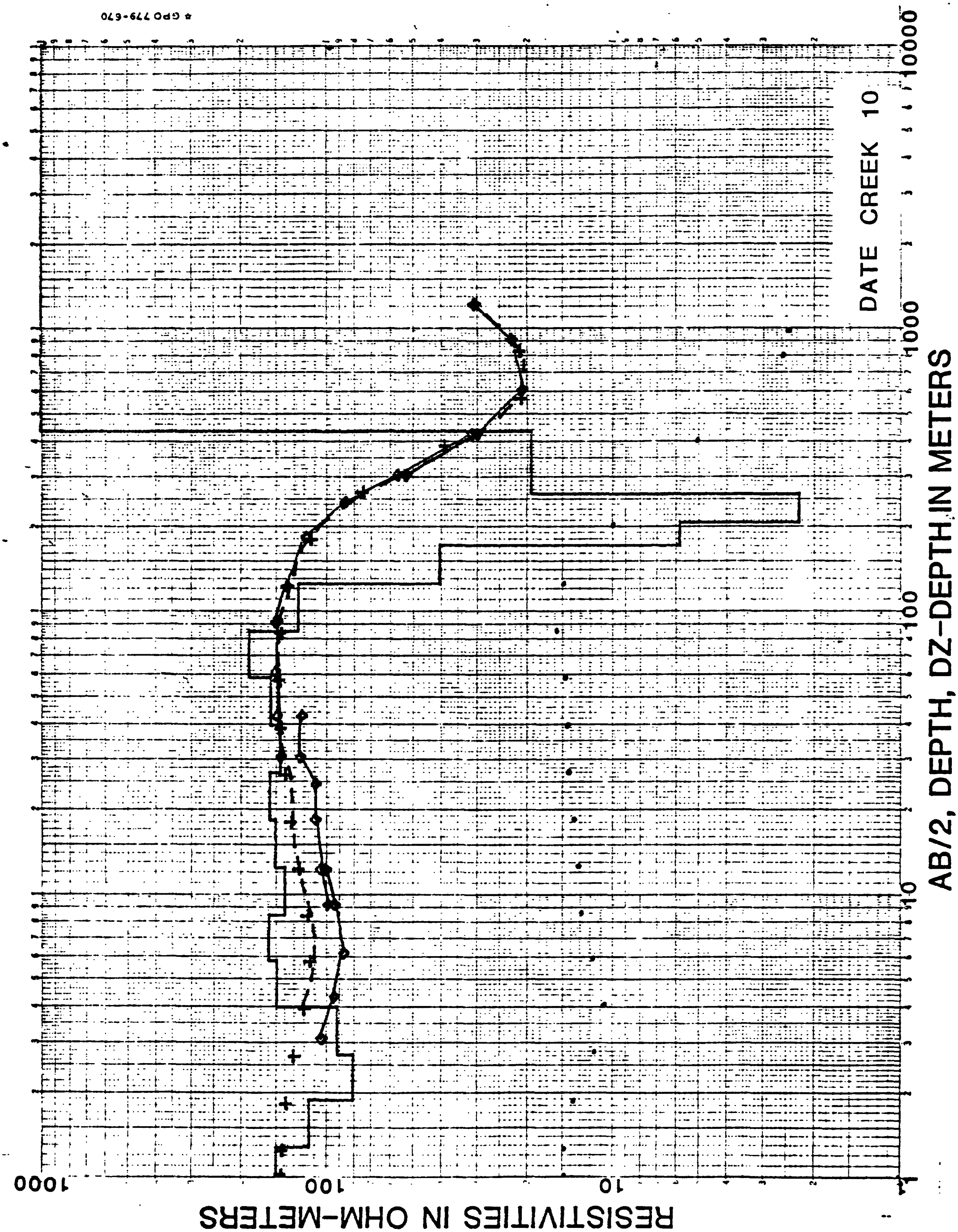
RESISTIVITIES IN OHM-METERS
1000
100
10
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH IN METERS
DATE CREEK 6-EXT
GPO 779-070

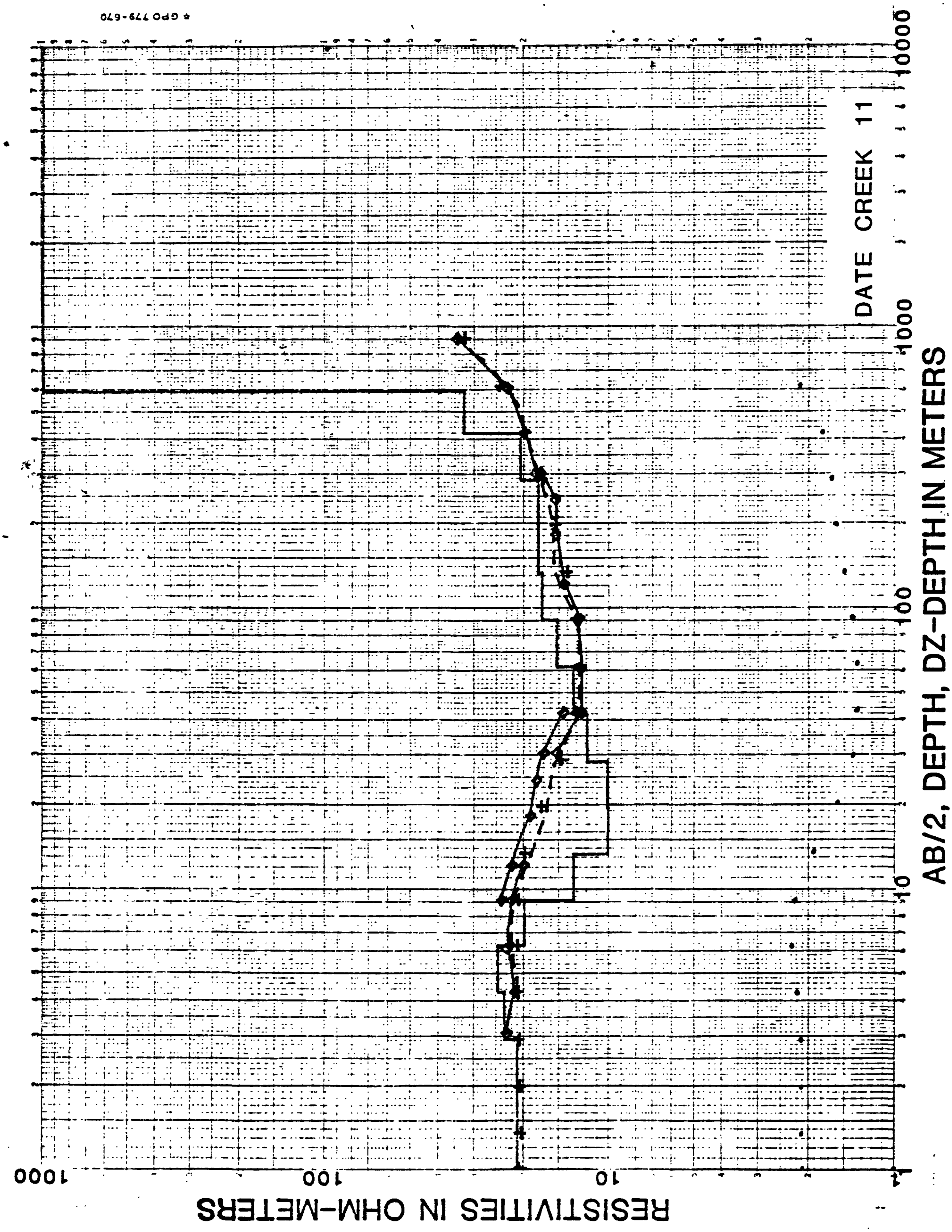

DATE CREEK 7
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
10000
1000
100
10
1
1000
100
10
1



RESISTIVITIES IN OHM-METERS
1000
100
10
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH IN METERS
DATE CREEK 8
GPO 779-670


DATE CREEK 9-EXT
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
1
10
100
1000
10000
1000
100
10


DATE CREEK 10
AB/2, DEPTH, DZ-DEPTH IN METERS
10
100
1000
10000
RESISTIVITIES IN OHM-METERS
1000
100
10
GPO 779-670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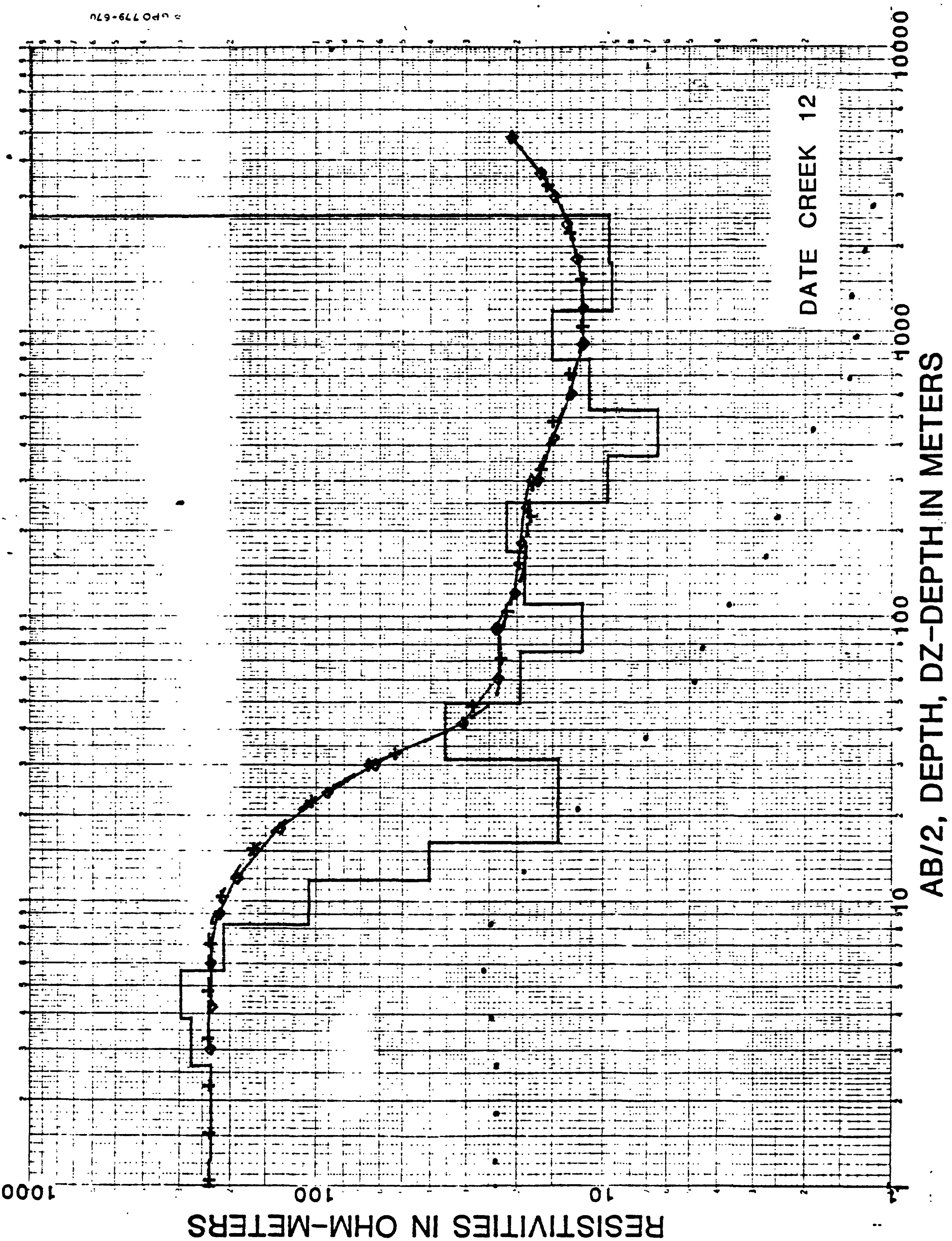
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
1000
100
10
1
10
100
1000
10000
GPO 779-670



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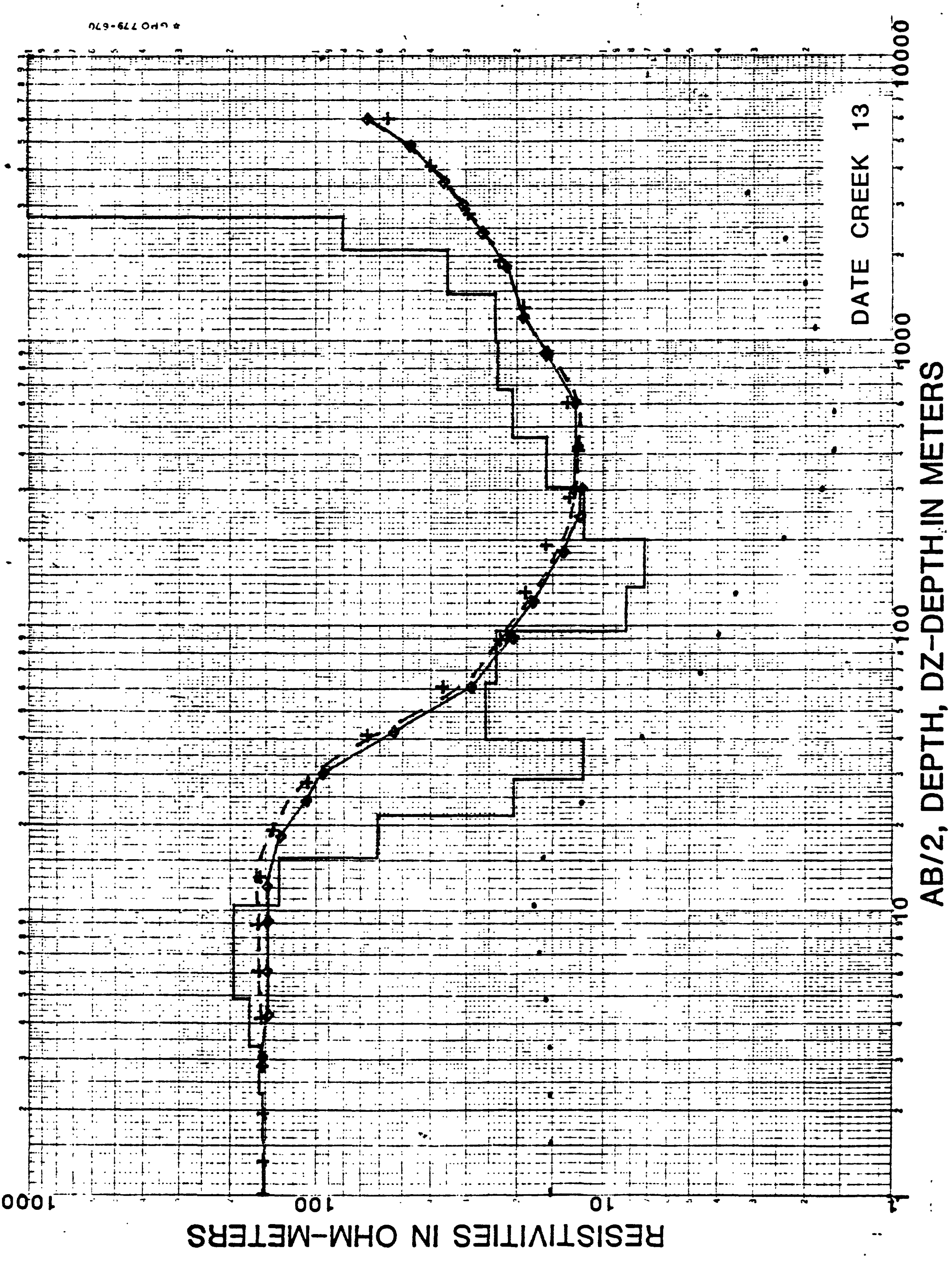
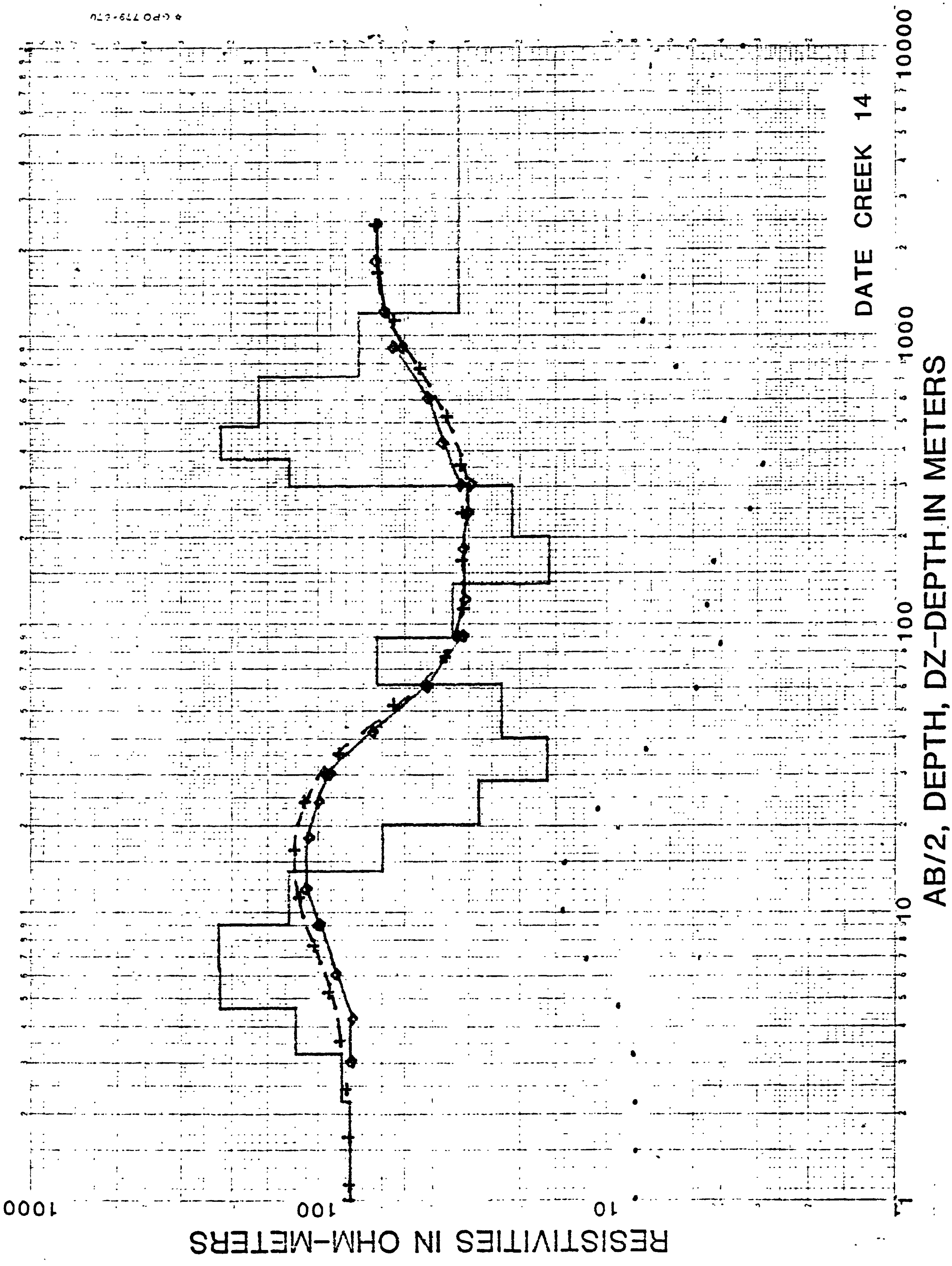
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
1000
100
10
1
10
100
1000
10000


DATE CREEK 13
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
1
10
100
1000
10000
1000
100
10
1
GPO 779-670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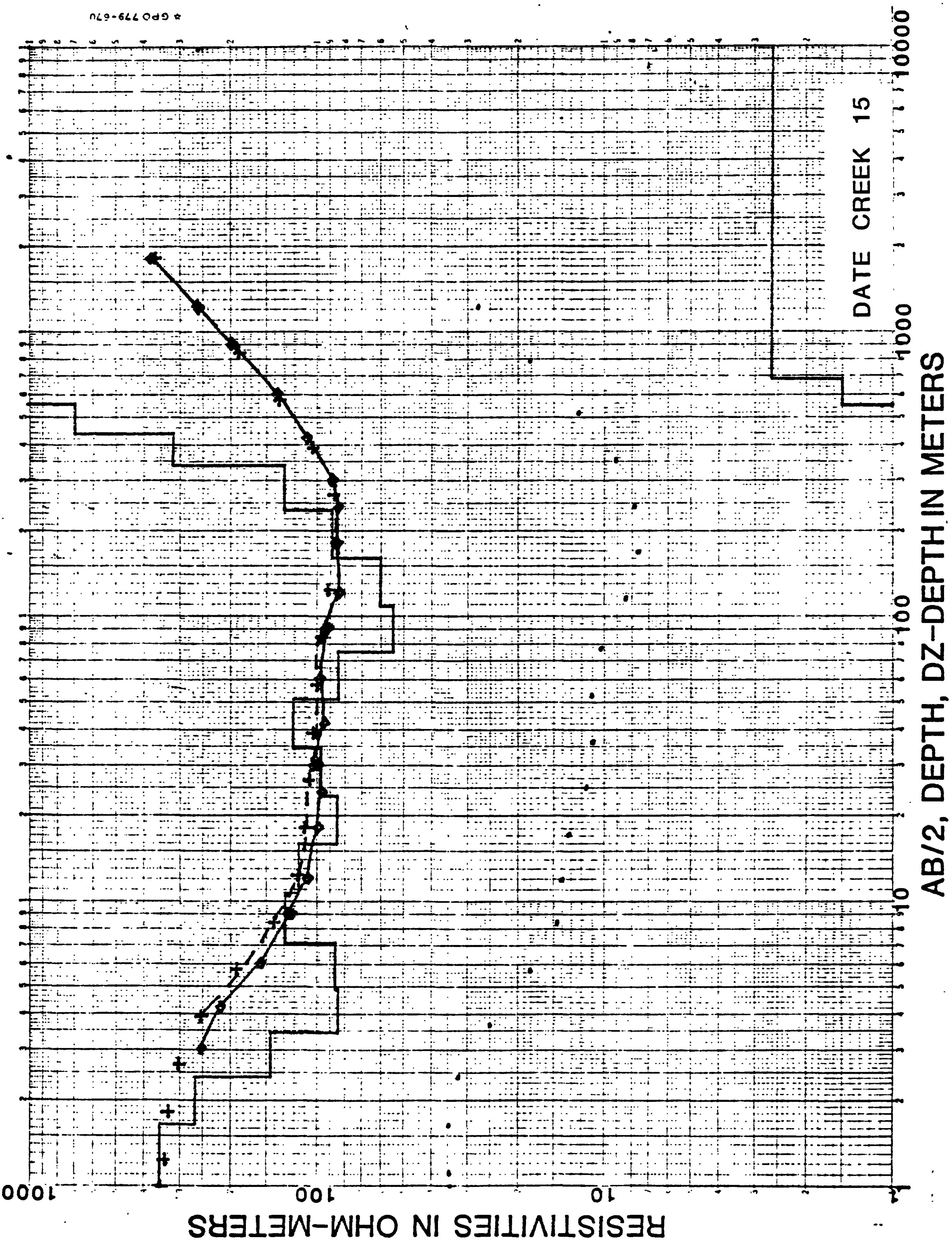
AB/2, DEPTH, DZ-DEPTH IN METERS
1
10
100
1000
10000
RESISTIVITIES IN OHM-METERS
1000
100
10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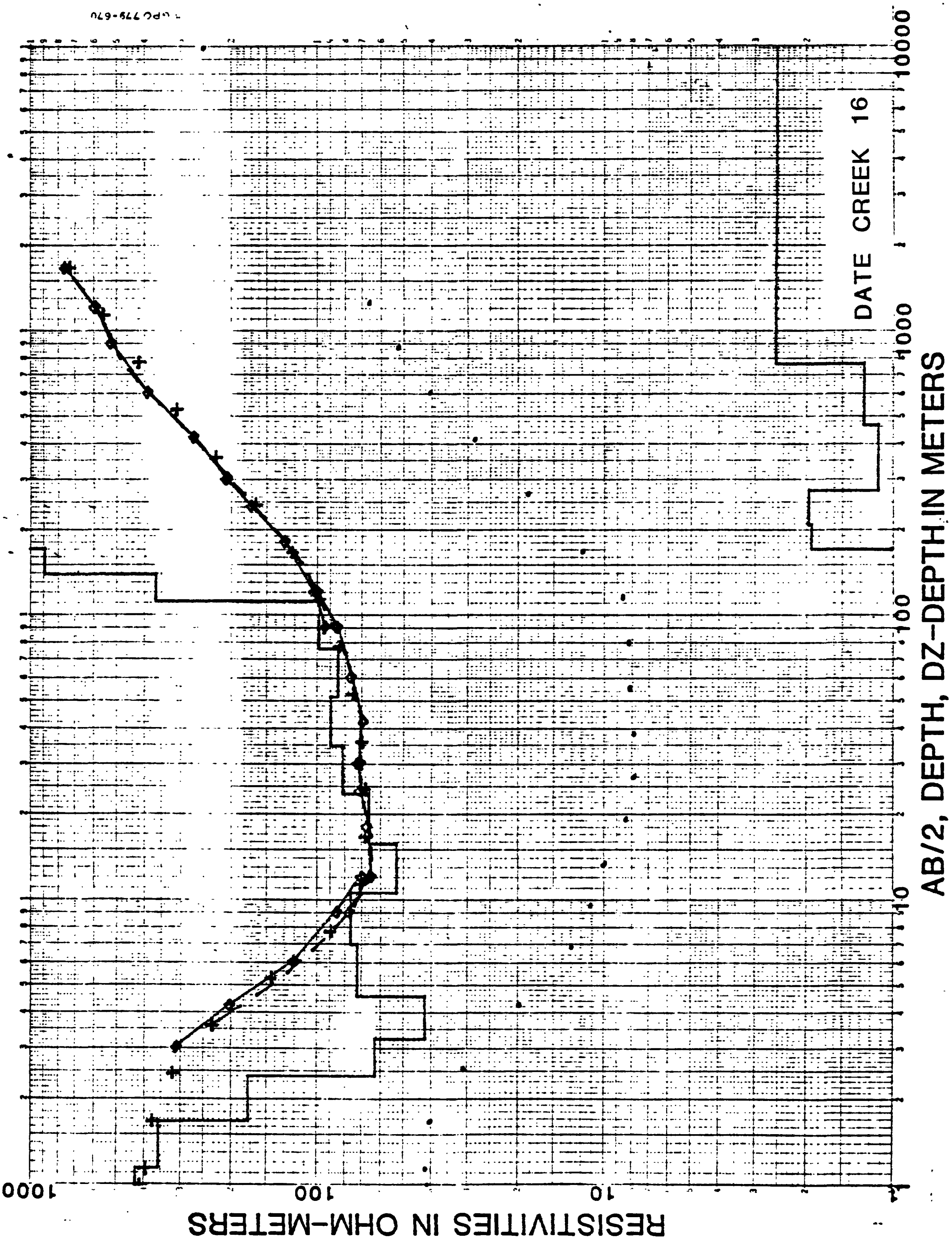
AB/2, DEPTH, DZ-DEPTH IN METERS
10
100
1000
10000
RESISTIVITIES IN OHM-METERS
1000
100
10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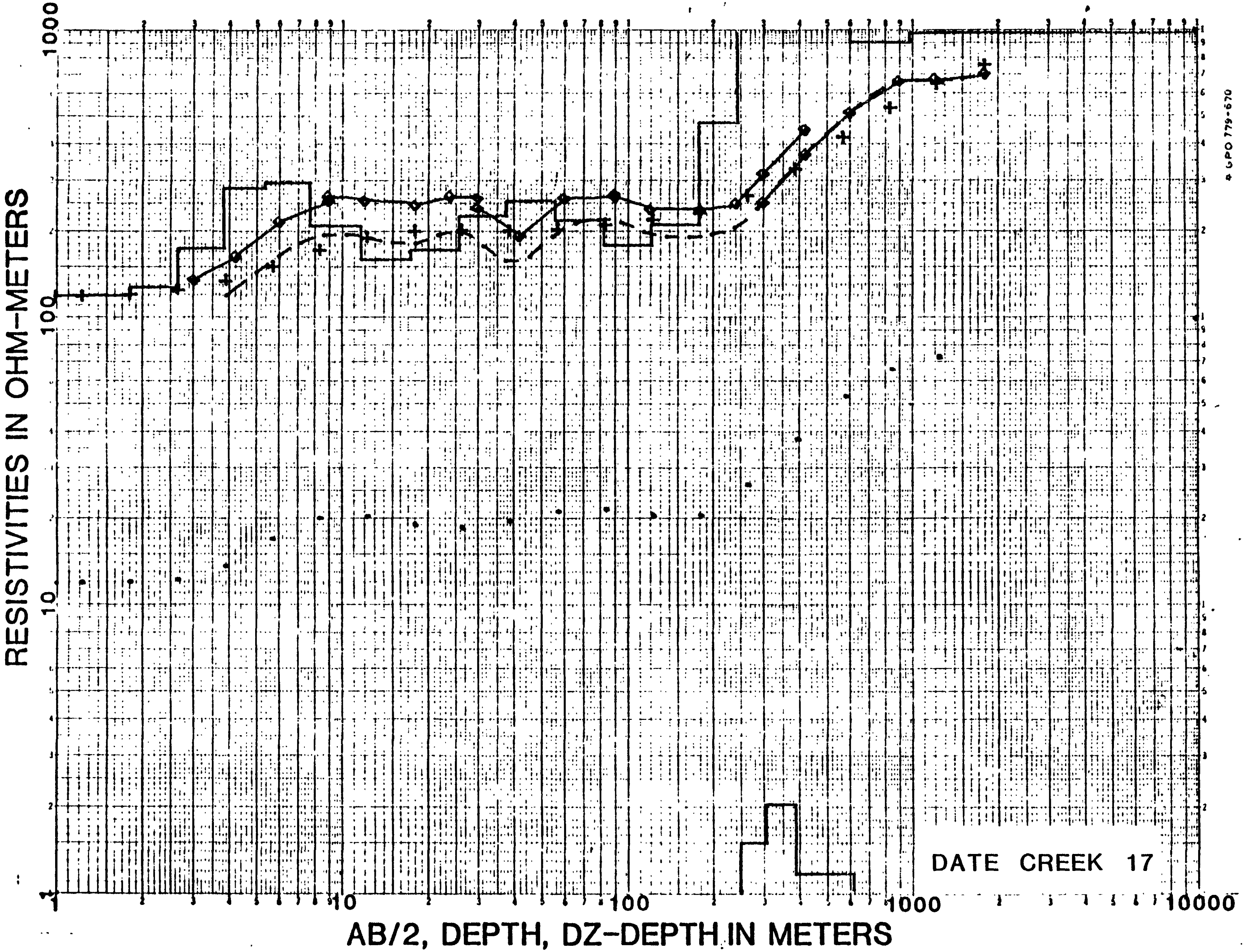
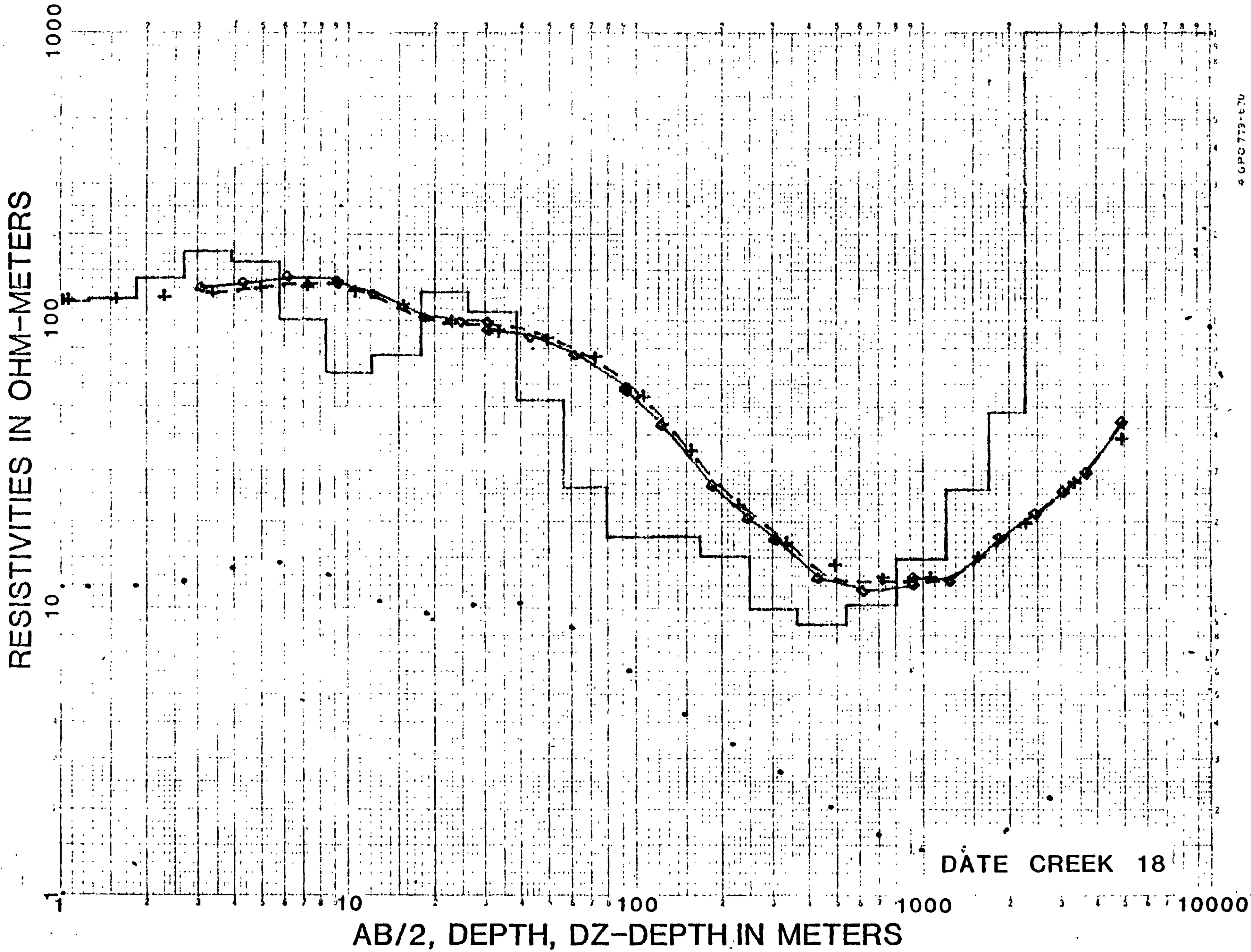
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
1
10
100
1000
10000



DATE CREEK 17
RESISTIVITIES IN OHM-METERS
AB/2, DEPTH, DZ-DEPTH IN METERS
1000
100
10
1
10
100
1000
10000
GPO 779-670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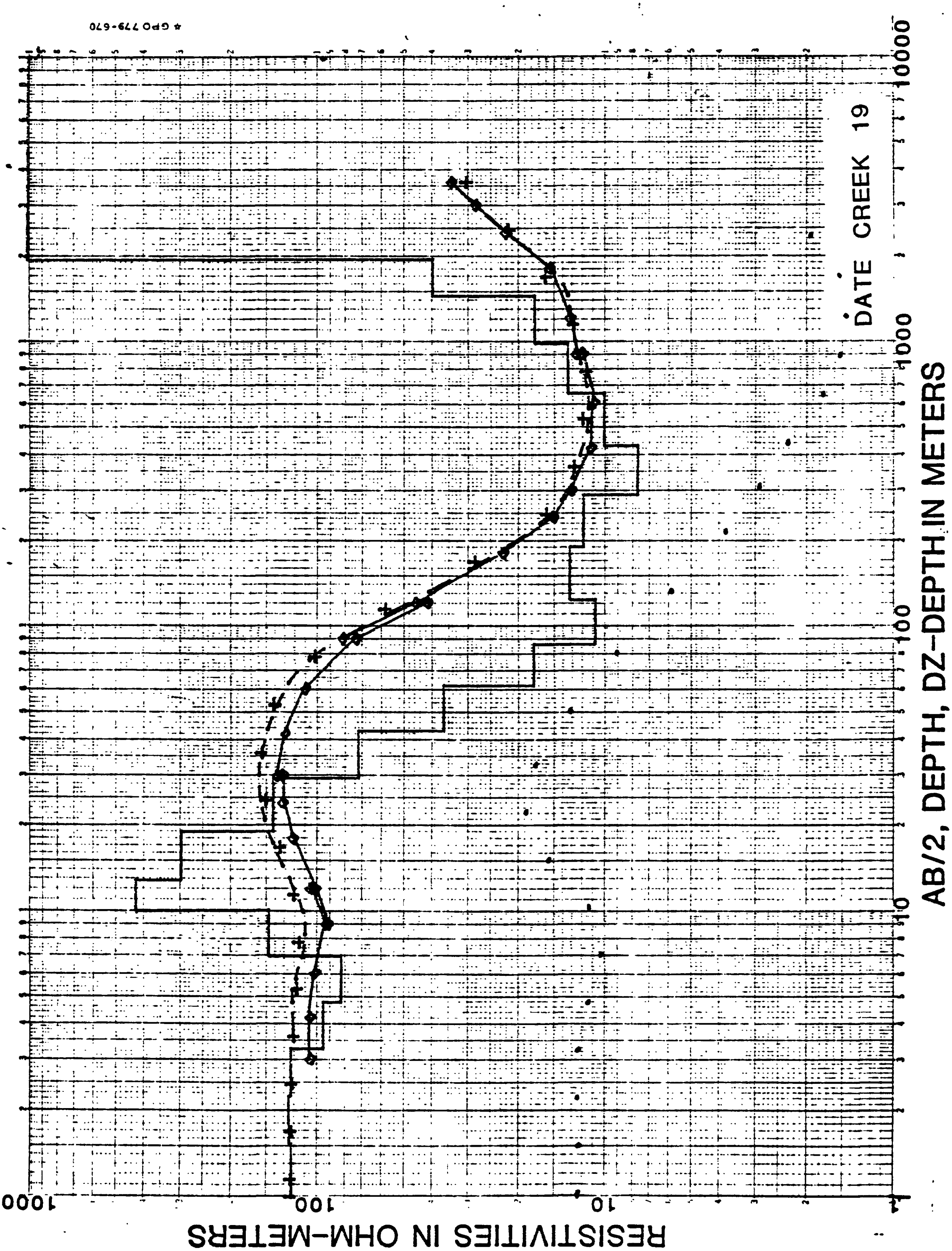
100
10
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH IN METERS
DATE CREEK 18


DATE CREEK 19
AB/2, DEPTH, DZ-DEPTH IN METERS
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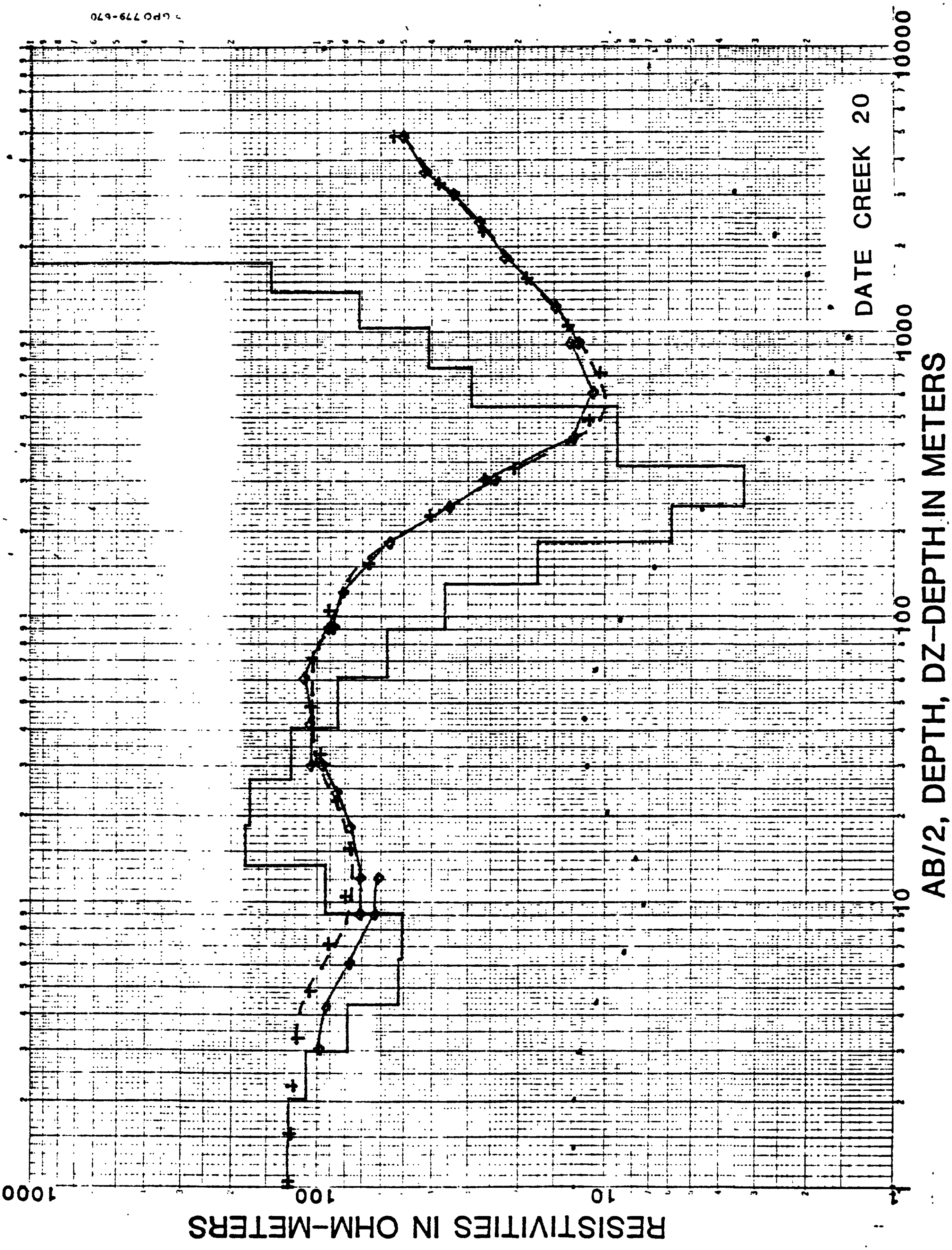
100
1000
10000
RESISTIVITIES IN OHM-METERS
1000
100
10
GPO 779-670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AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
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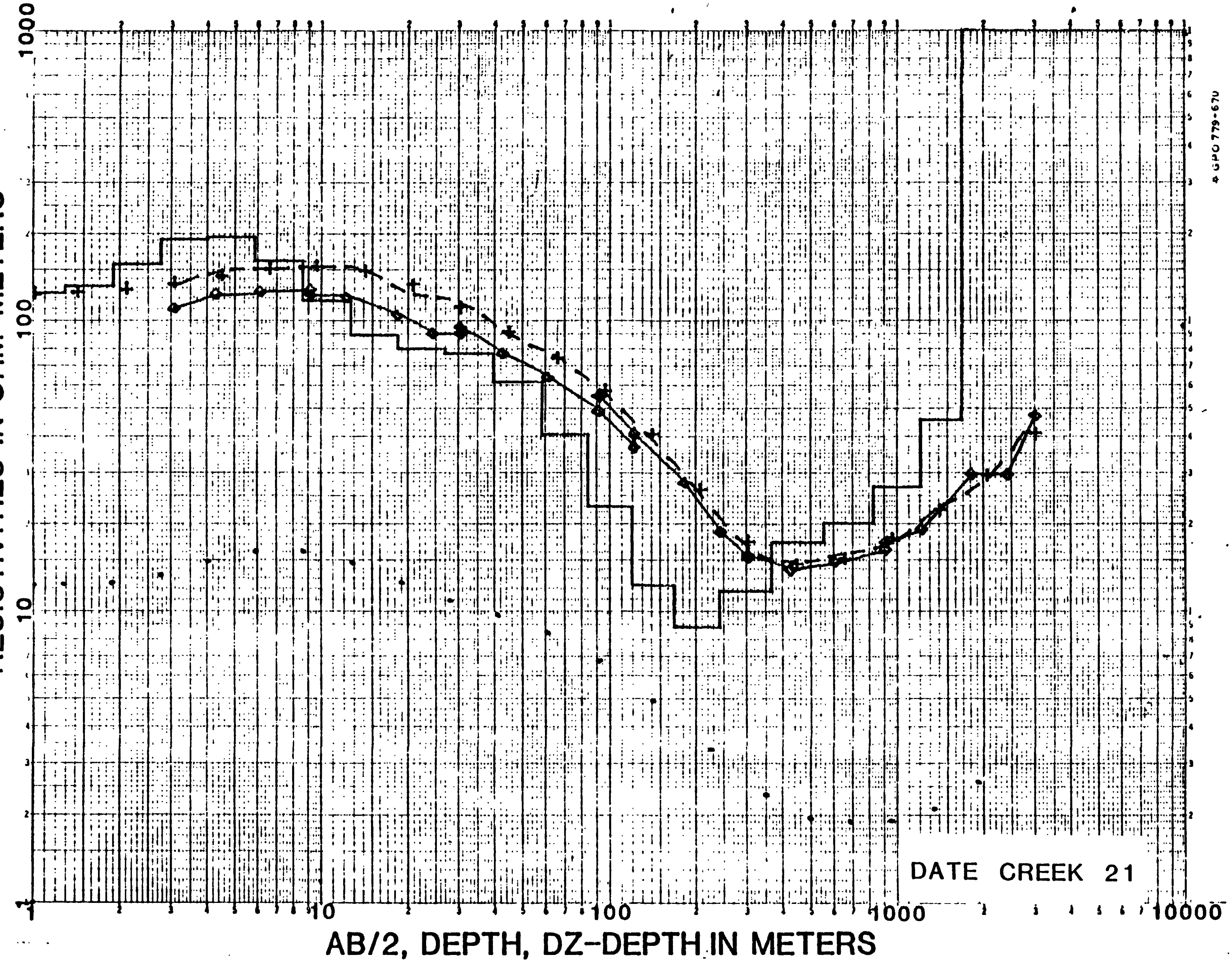
100
10
1
10000
1000
100
10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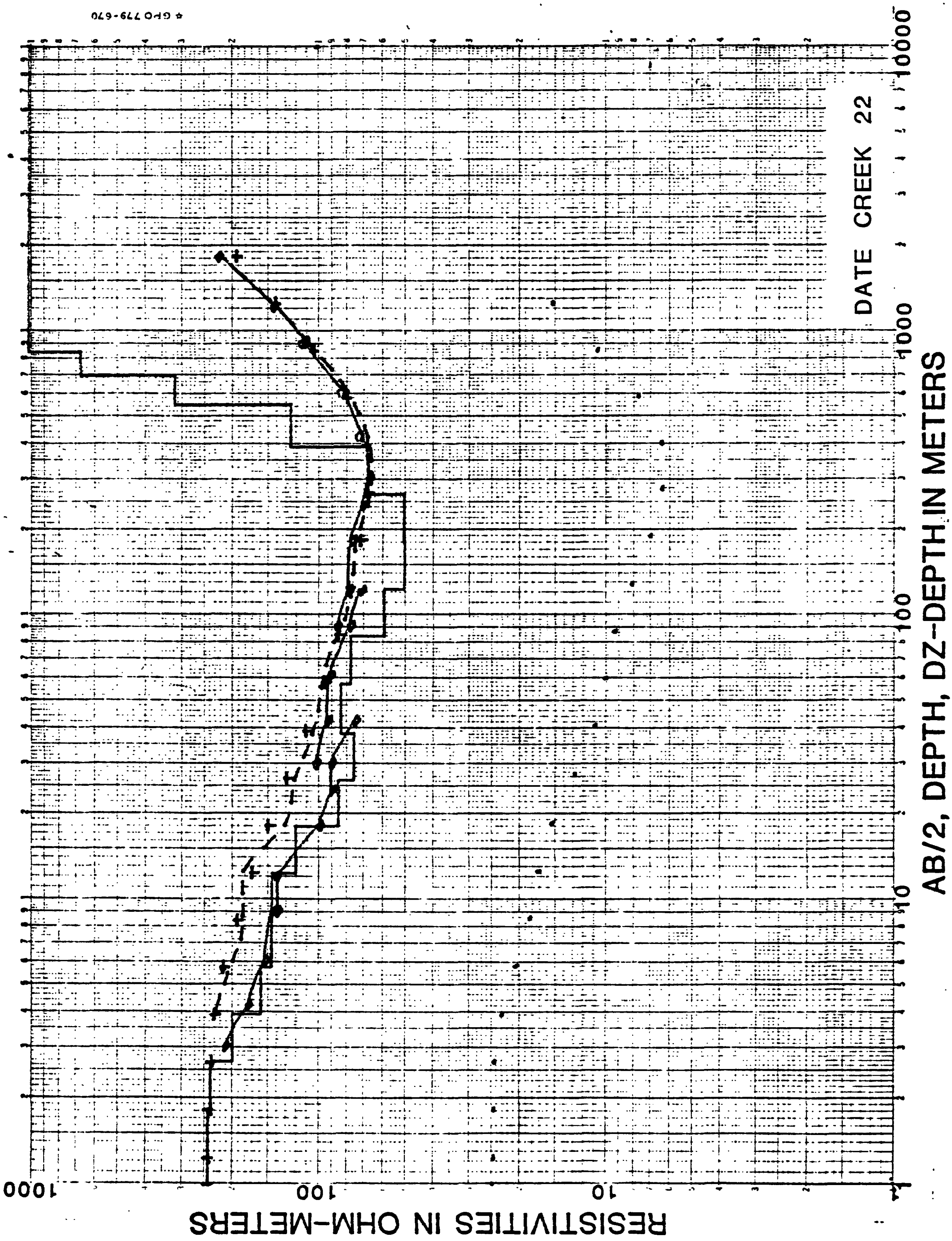
AB/2, DEPTH, DZ-DEPTH IN METERS
1000
100
10
1
10000
GPO 779-670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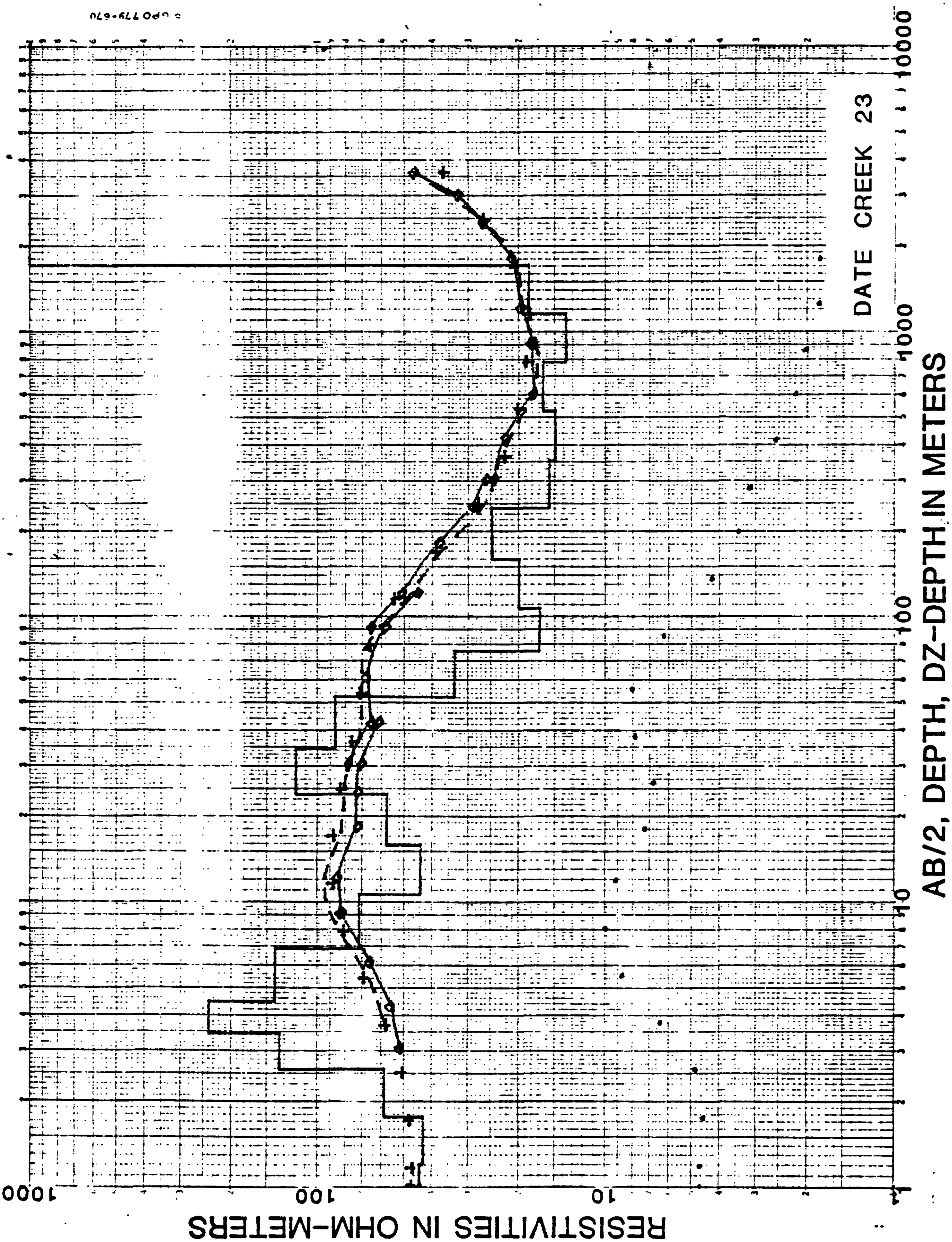
1
10
100
1000
10000
GPO 779-670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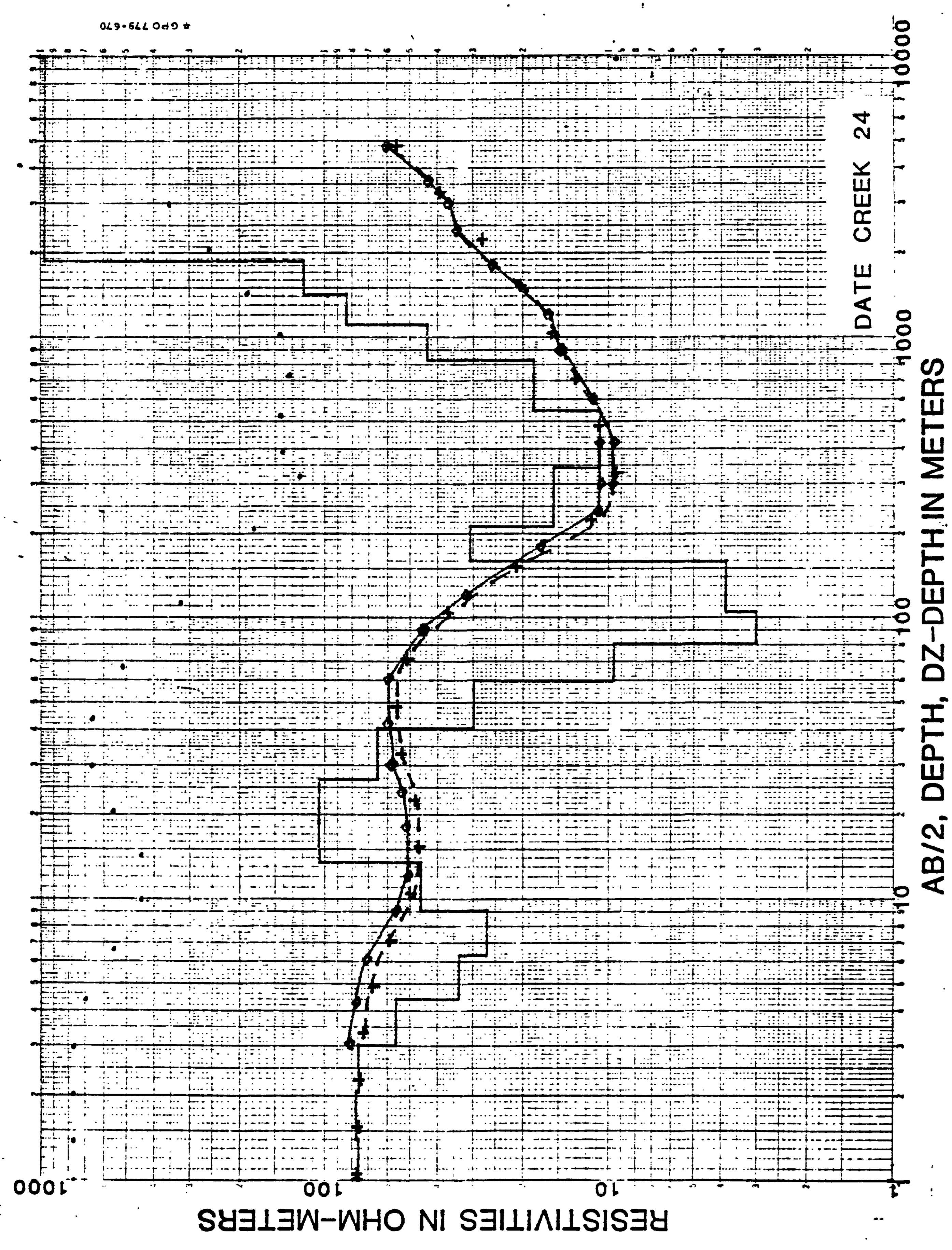
RESISTIVITIES IN OHM-METERS
1000
100
10
1
10000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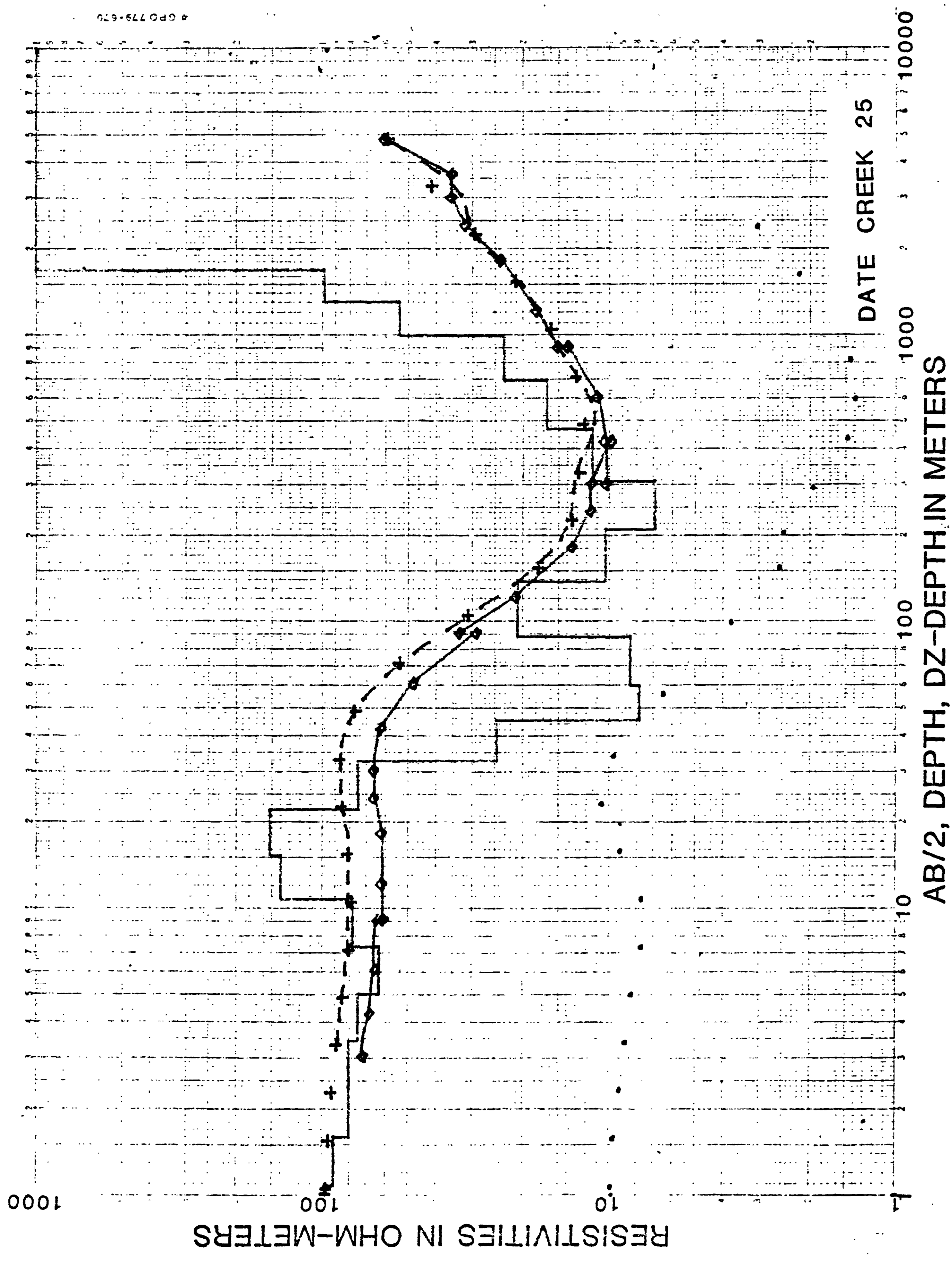
RESISTIVITIES IN OHM-METERS
1
10
100
1000
10000
GPO 779-670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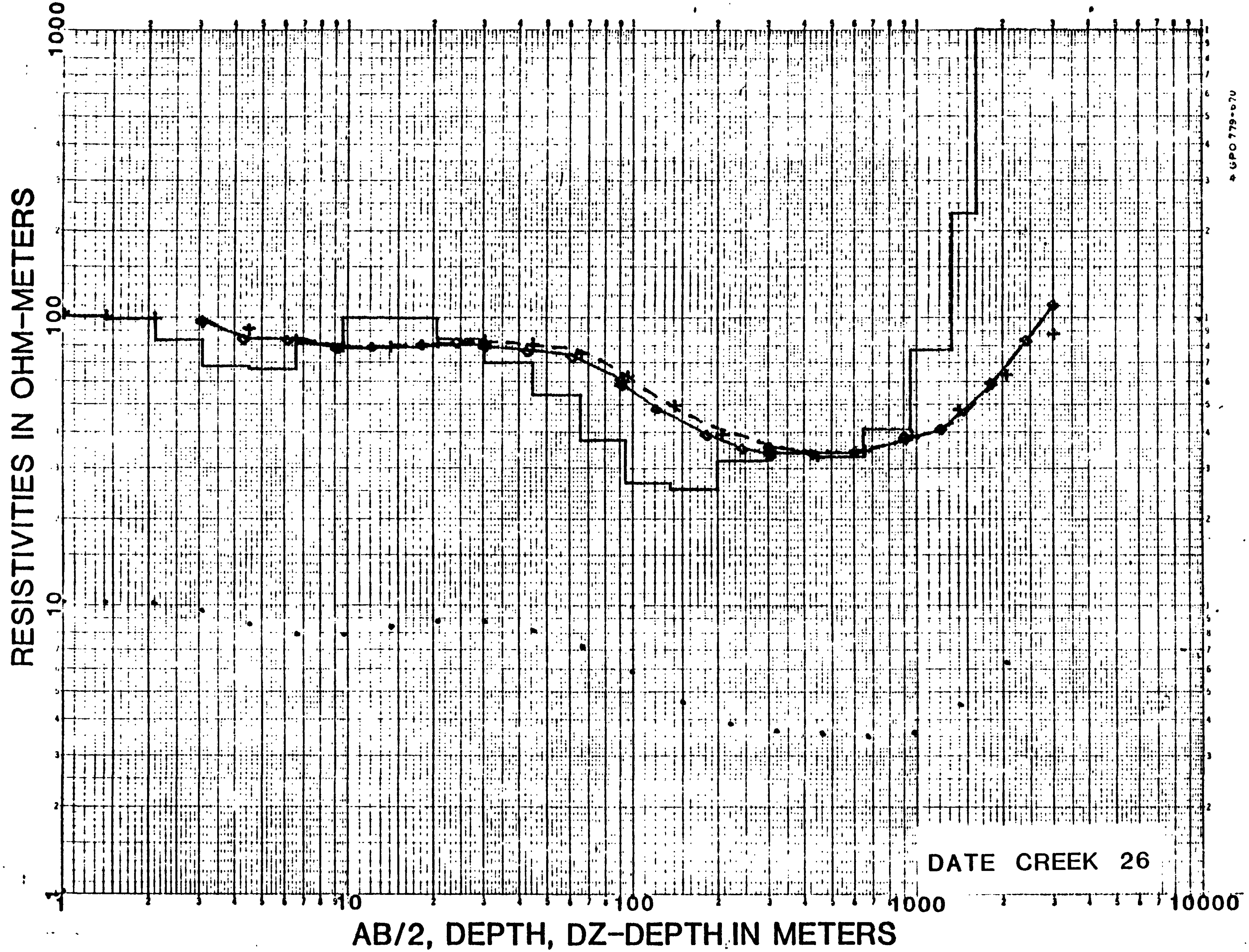
10
100
1000
10000
1000
100
10
1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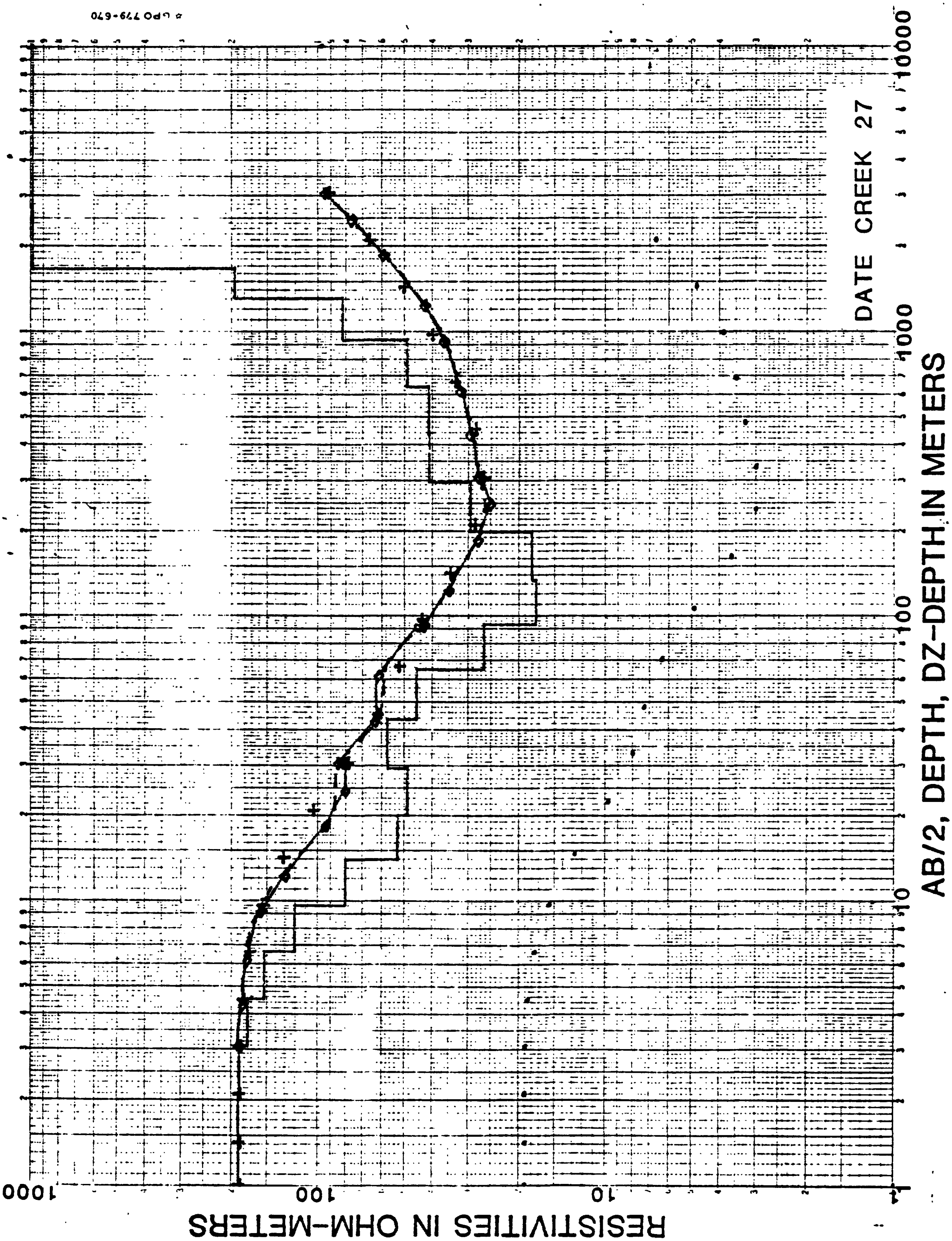
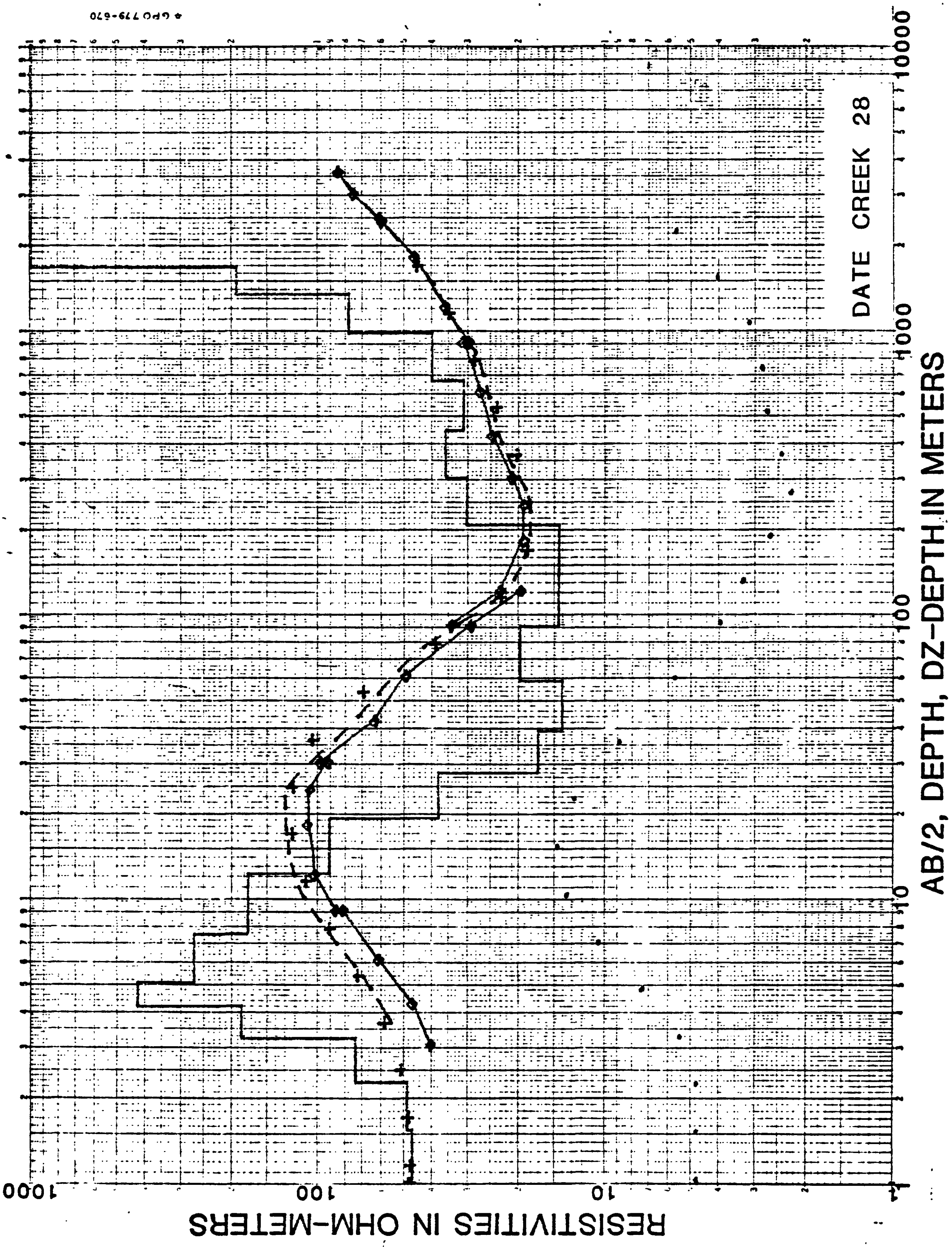
RESISTIVITIES IN OHM-METERS
AB/2, DEPTH, DZ-DEPTH IN METERS
1000
100
10
1
10000
GPO 779-670


DATE CREEK 27
AB/2, DEPTH, DZ-DEPTH IN METERS
1
10
100
1000
10000
RESISTIVITIES IN OHM-METERS
1000
100
10
1
GPO 779-670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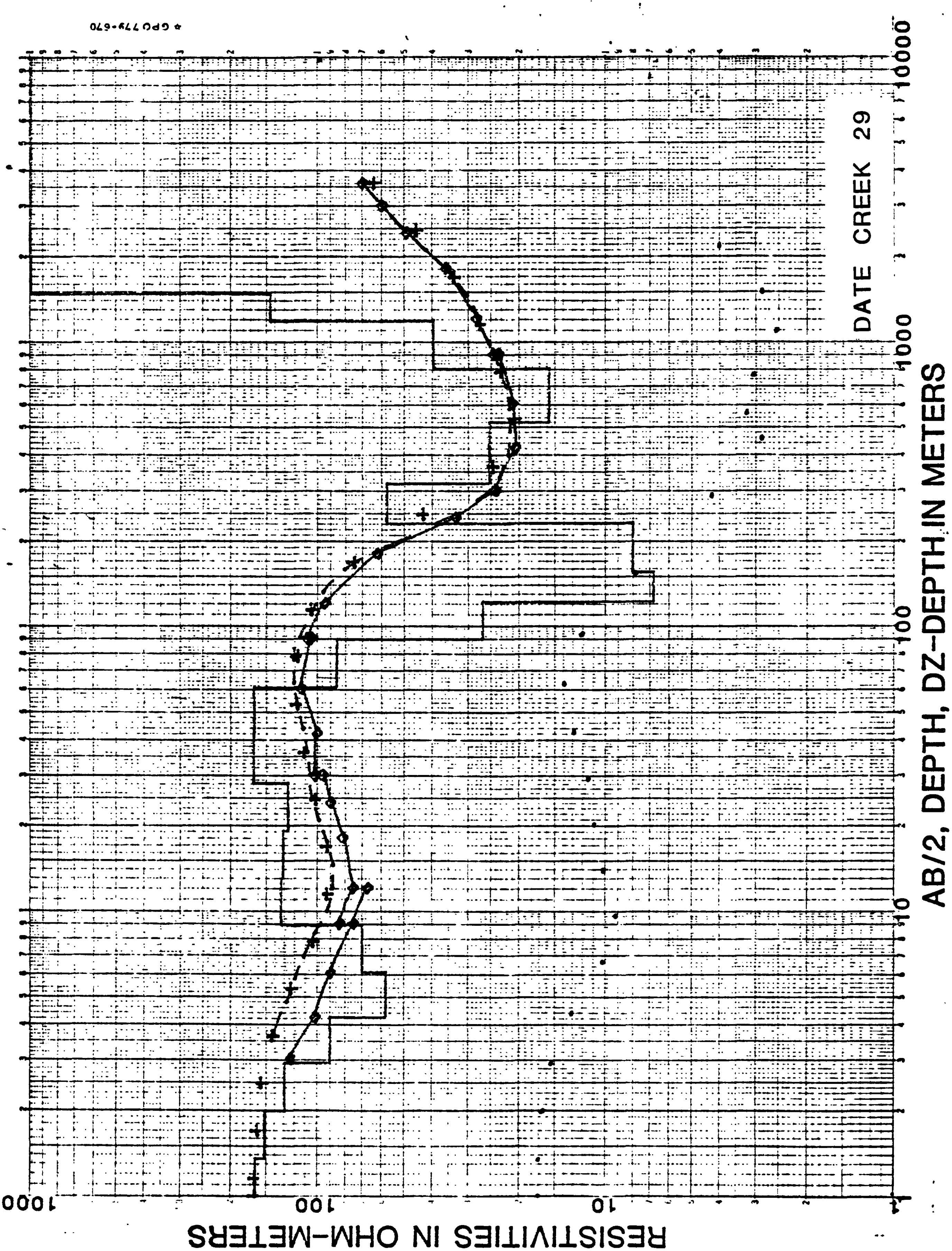
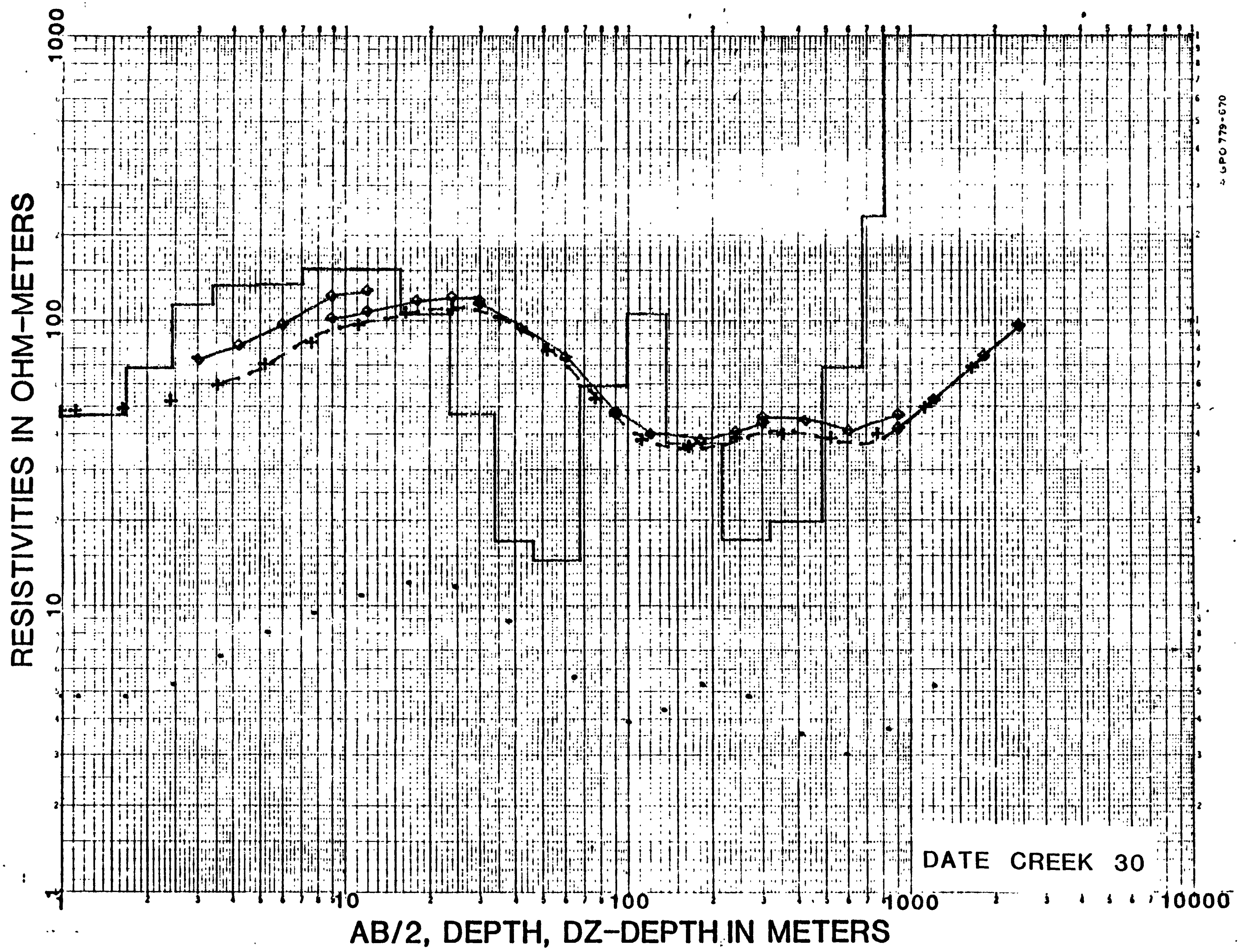
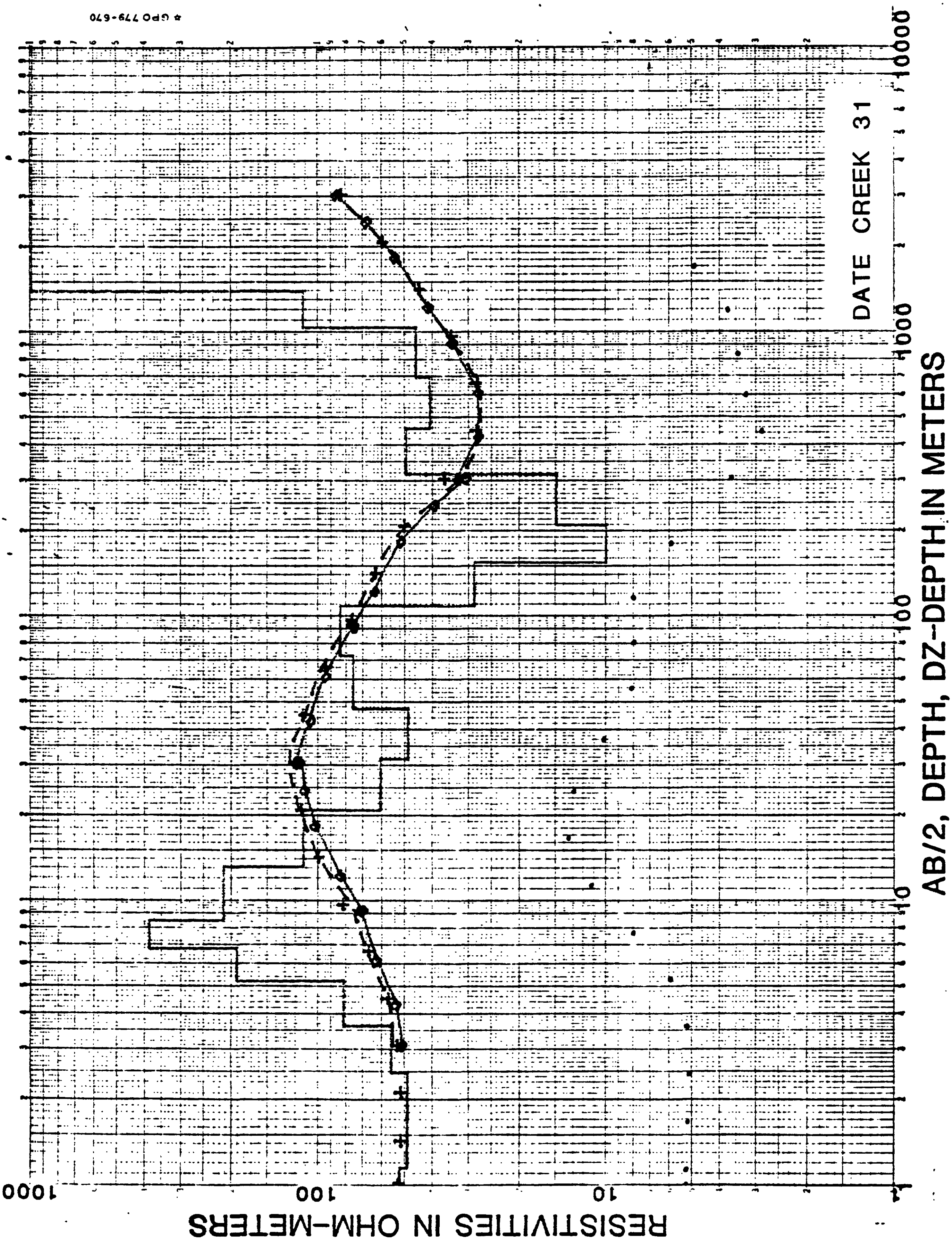
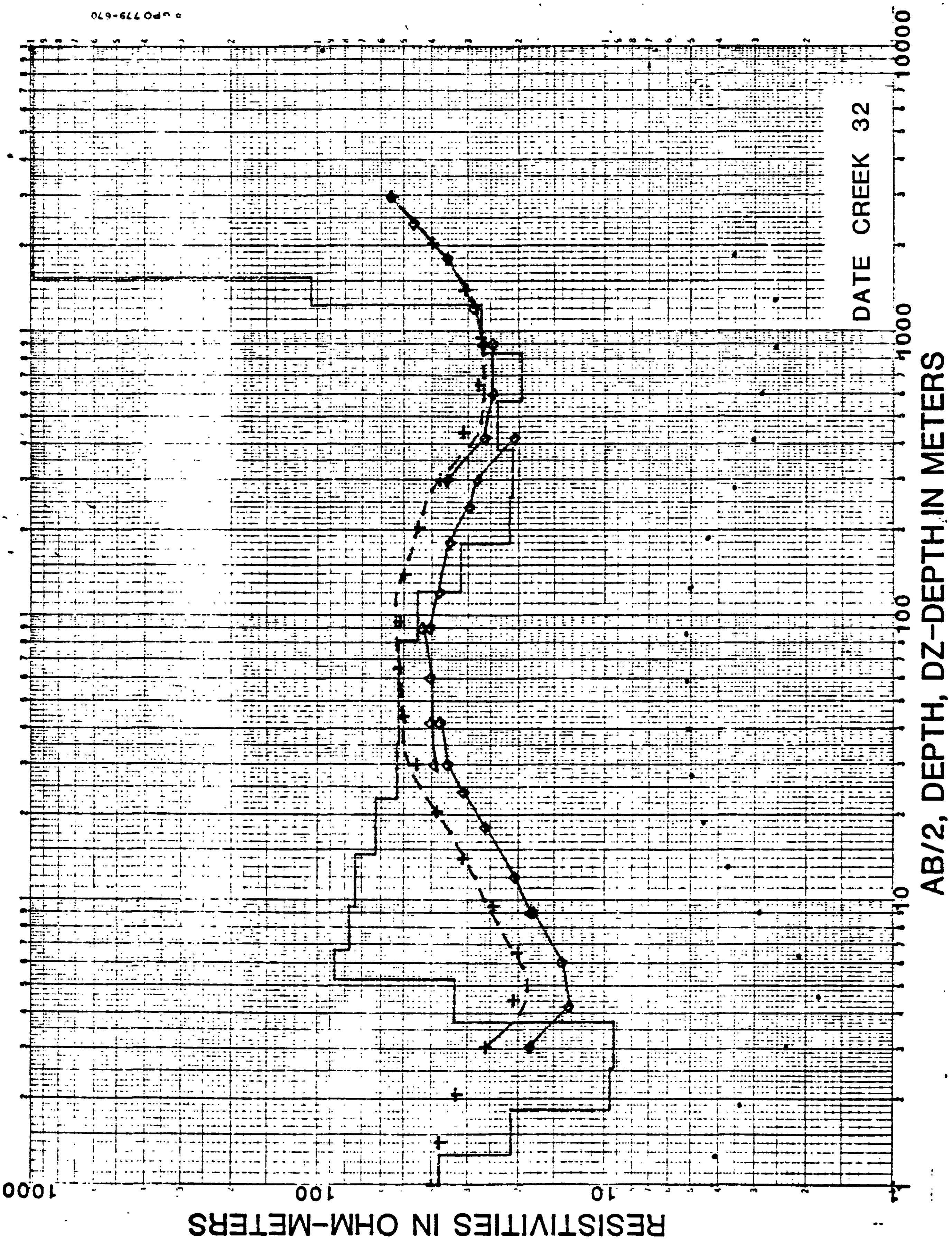
AB/2, DEPTH, DZ-DEPTH IN METERS
10
100
1000
10000
RESISTIVITIES IN OHM-METERS
1000
100
10
1



DATE CREEK 29
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
1000
100
10


DATE CREEK 30
RESISTIVITIES IN OHM-METERS
1000
100
10
1
10
100
1000
10000
AB/2, DEPTH, DZ-DEPTH IN METERS
GPO 779-670


DATE CREEK 31
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
1000
100
10
1
10
100
1000
10000
GPO 779-670


DATE CREEK 32
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
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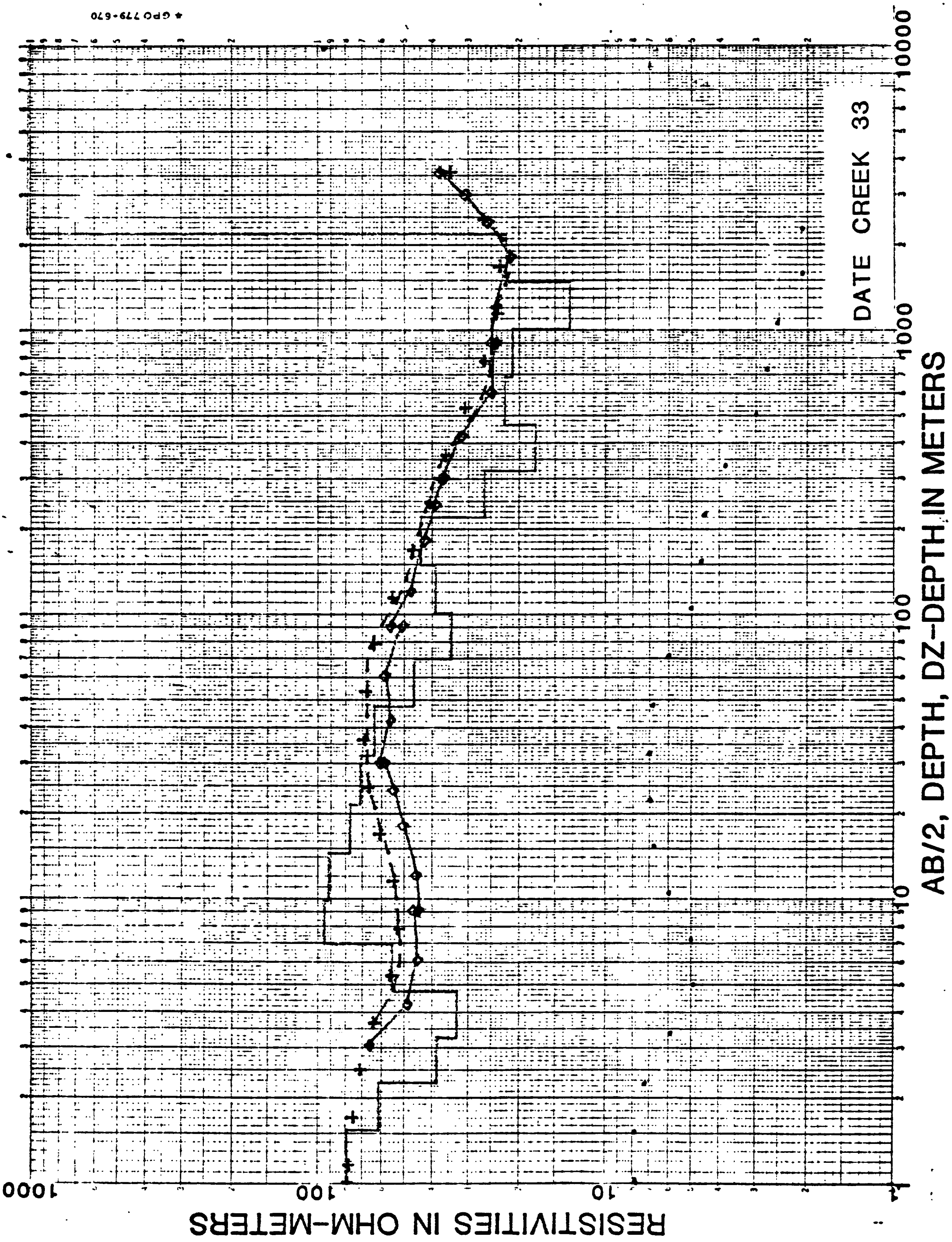
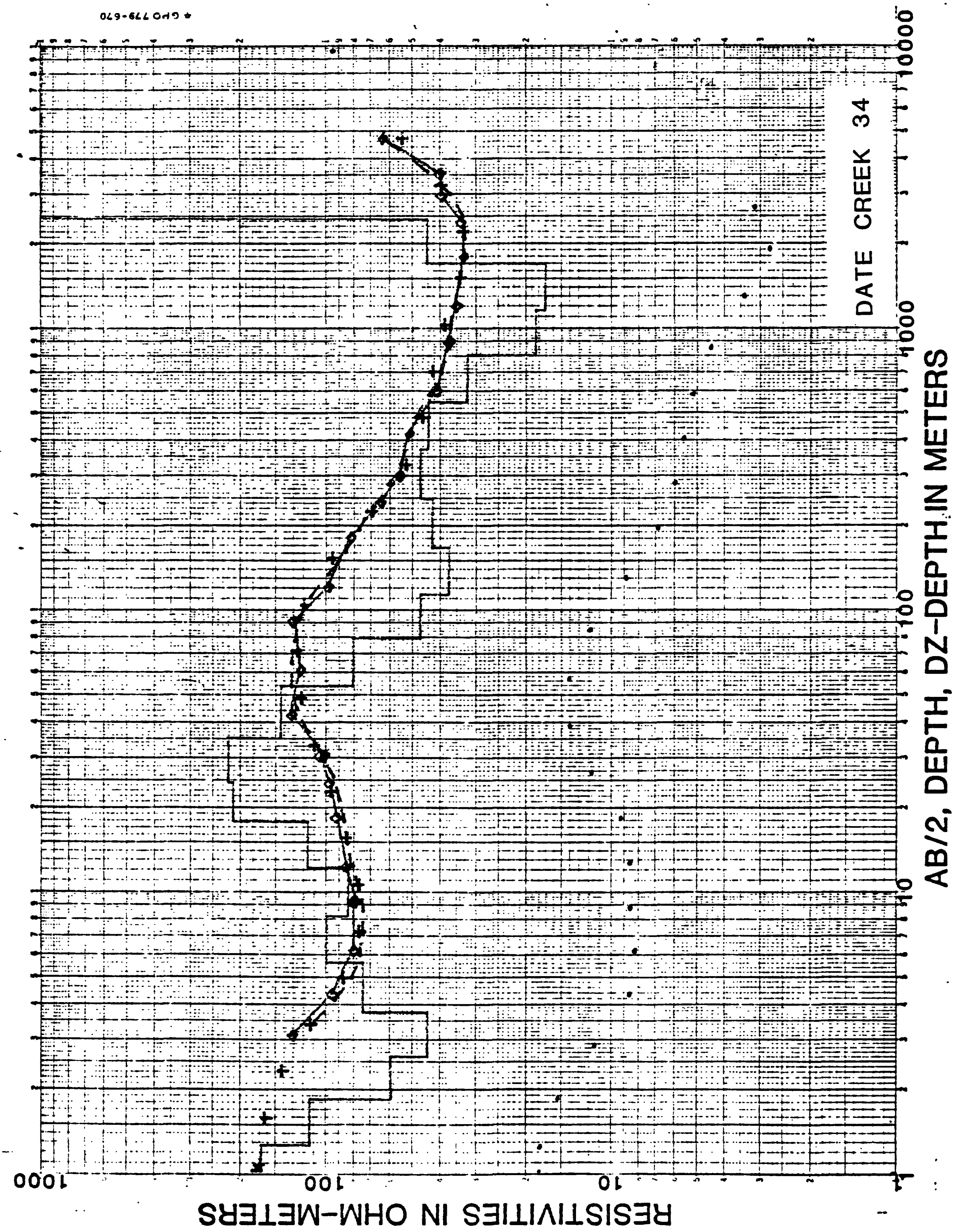
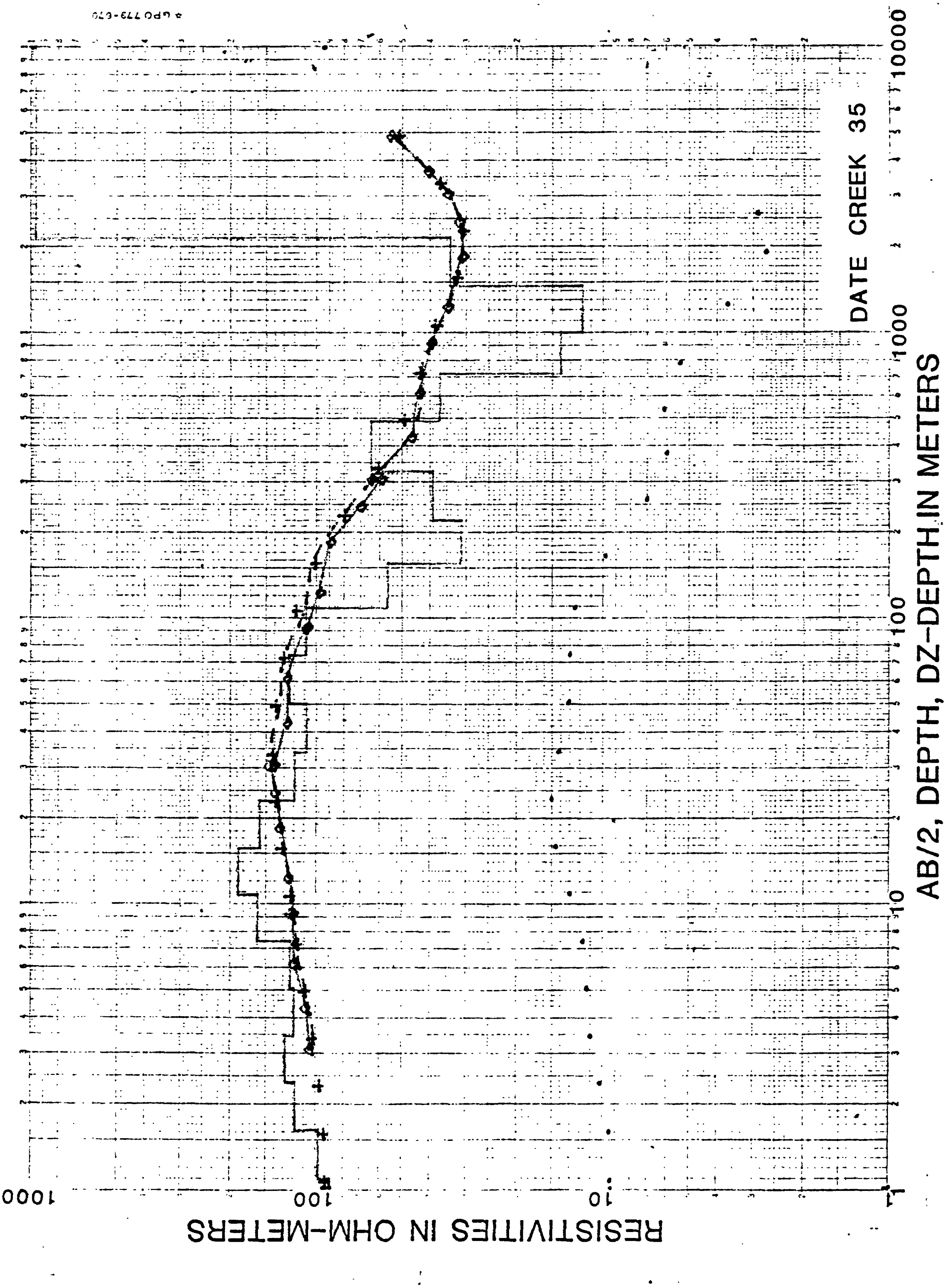
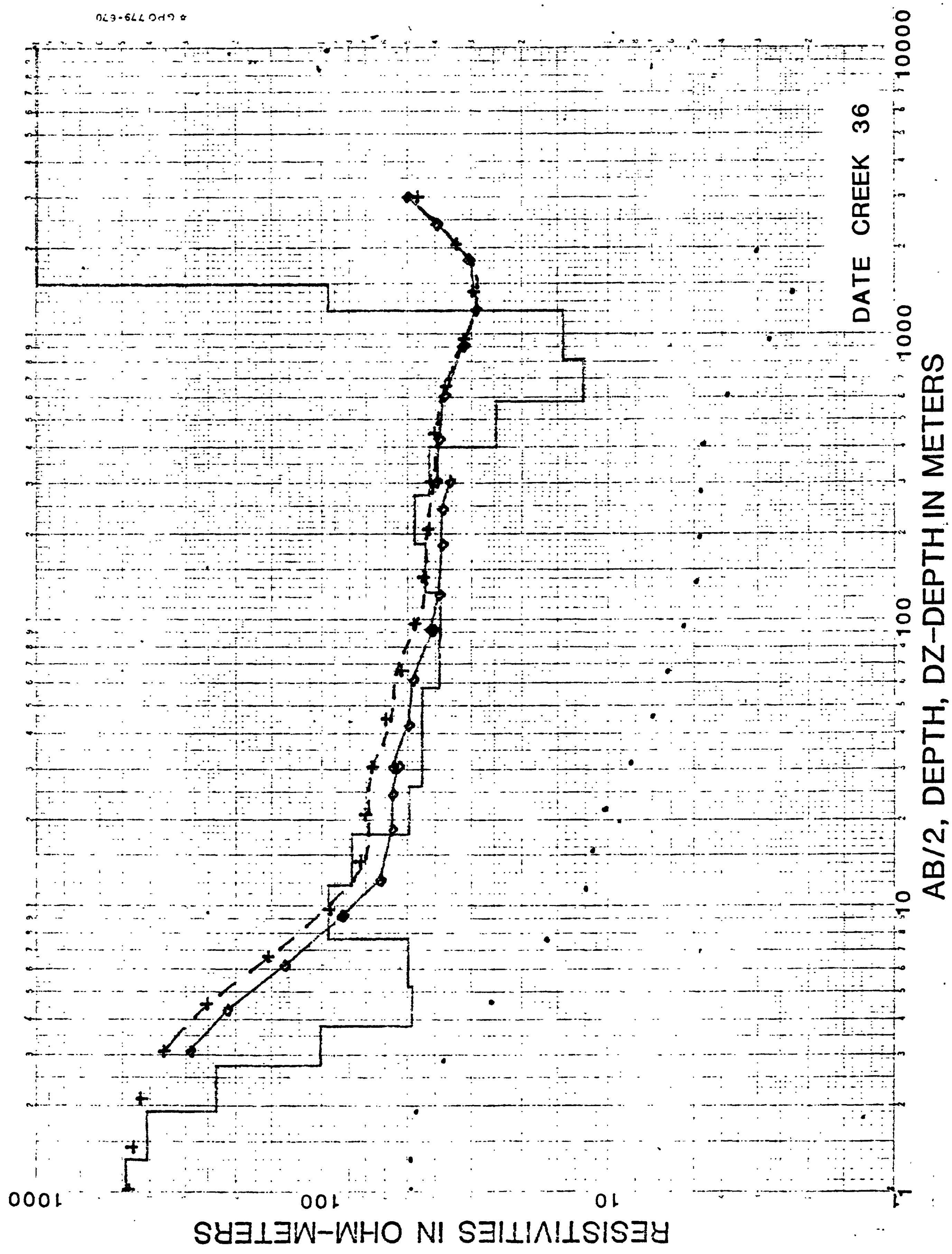
100
10
1
10
100
1000
10000



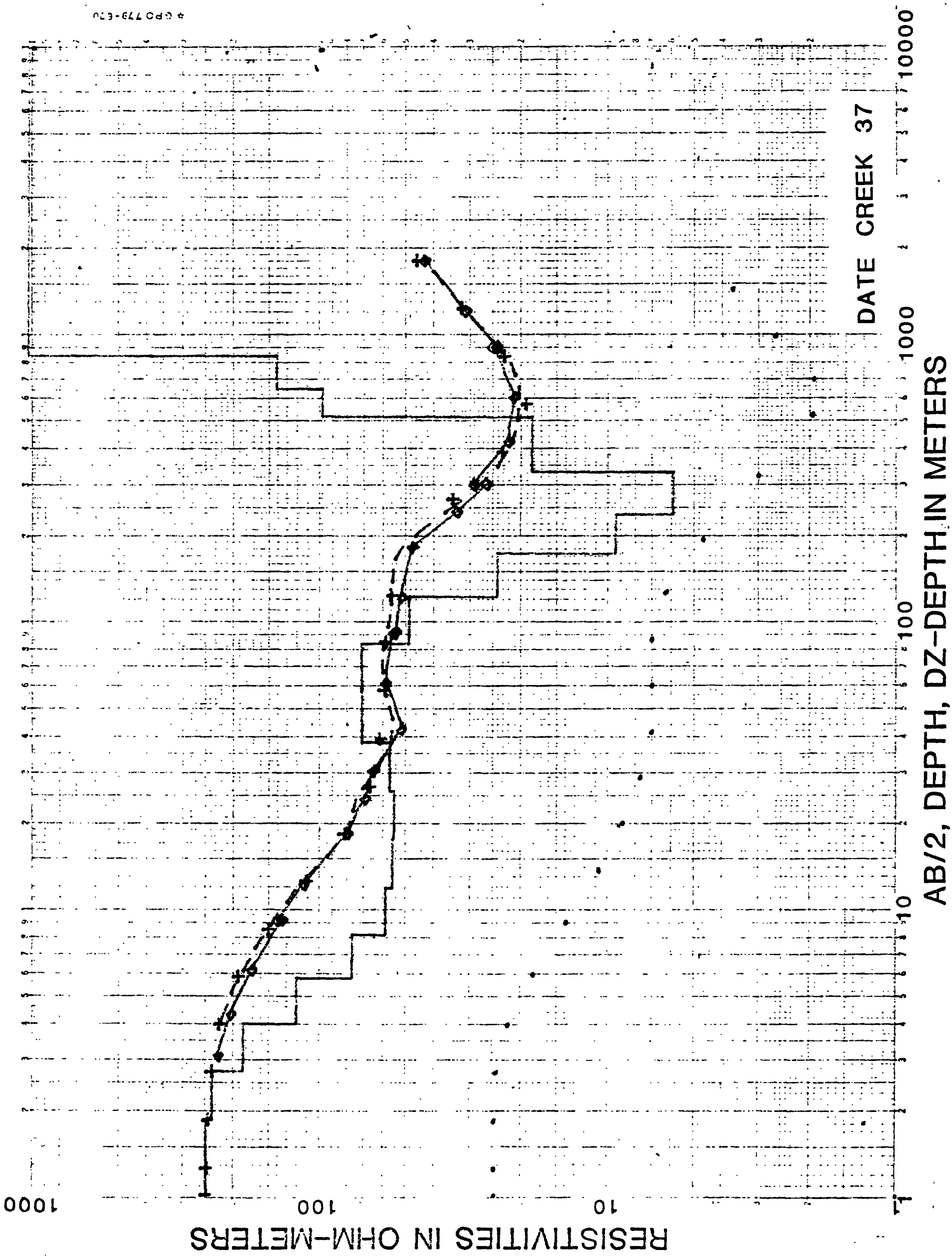
DATE CREEK 33
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
1
10
100
1000
10000
1000
100
10
GPO 779-670

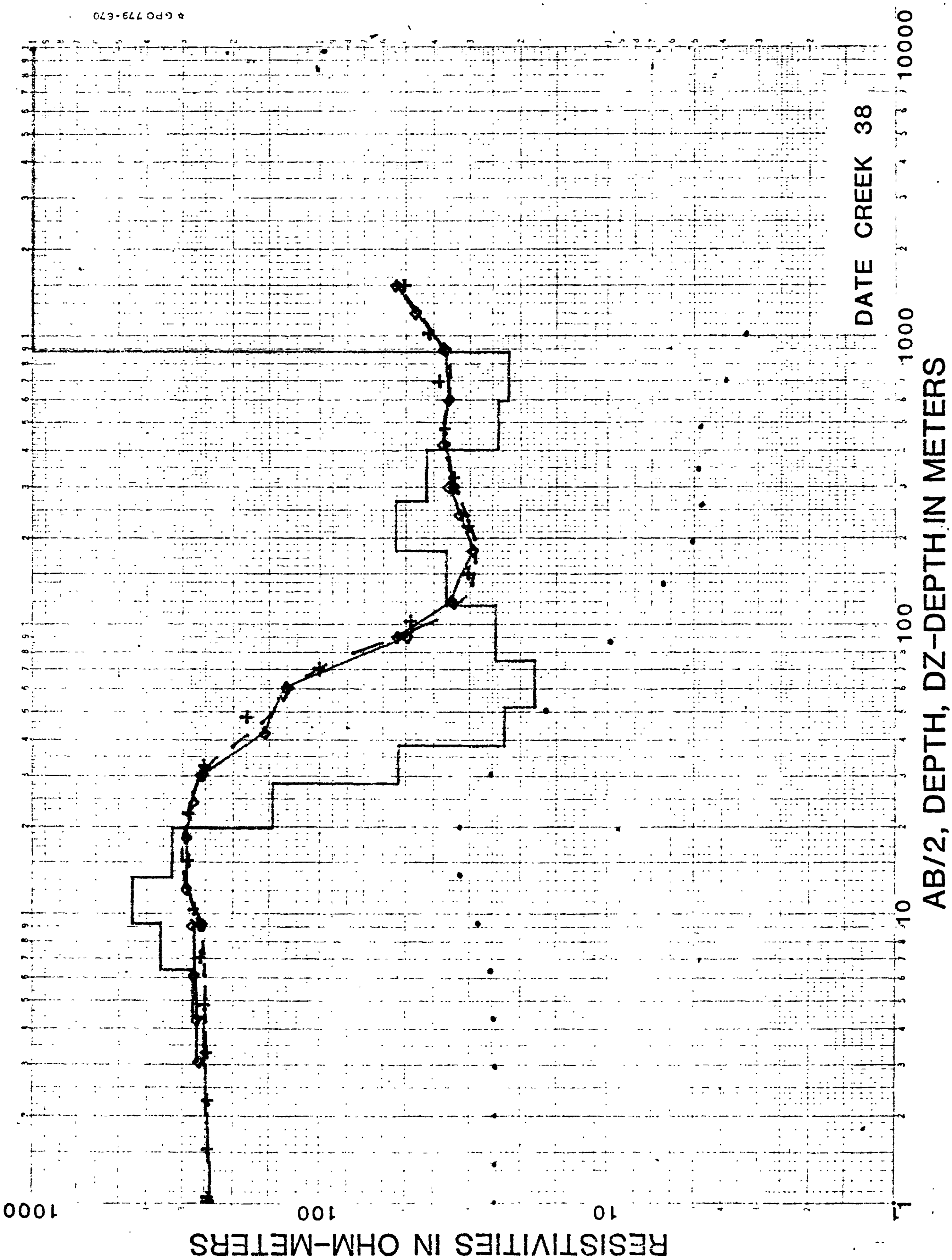

DATE CREEK 34
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
1000
100
10
1
10
100
1000
10000

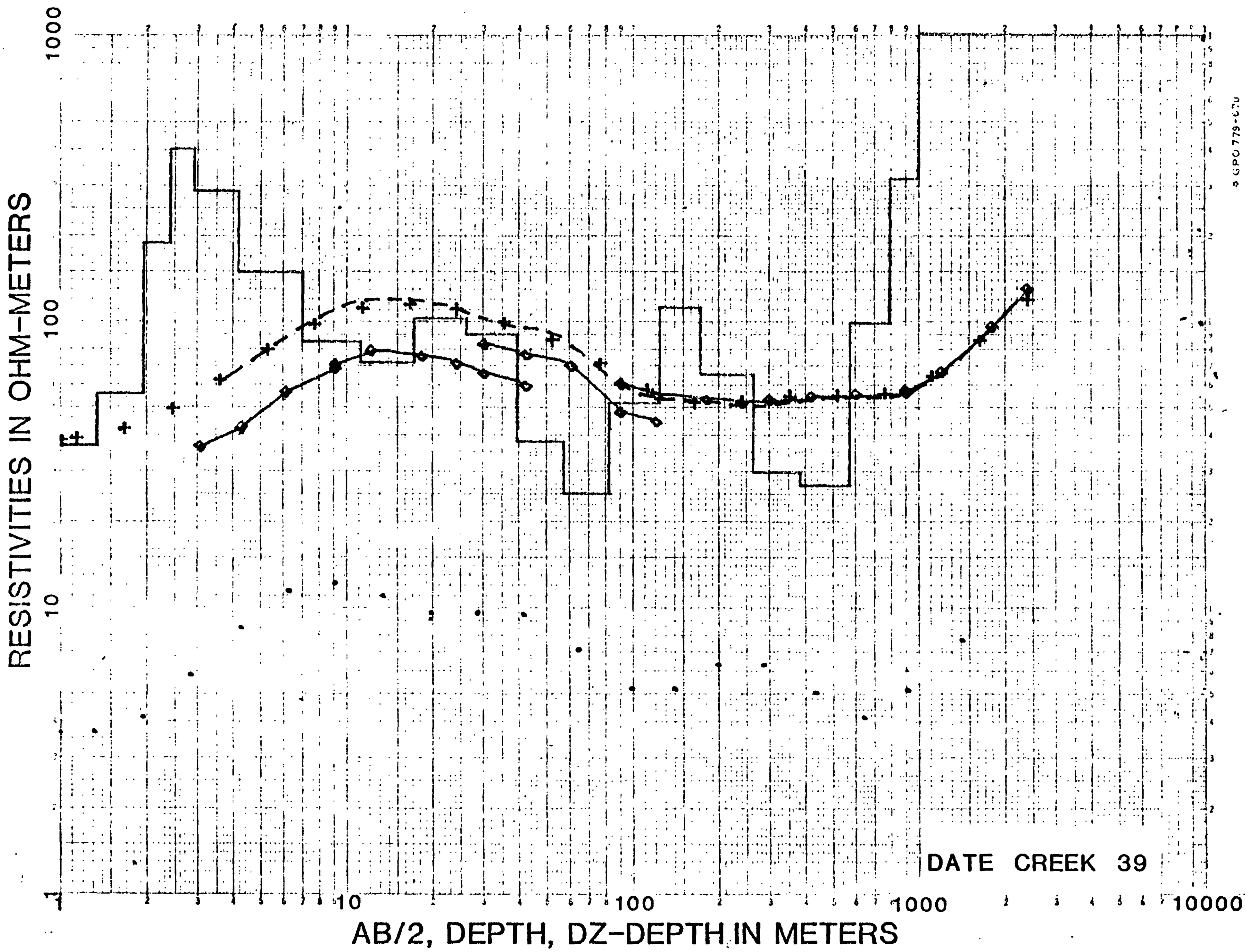

DATE CREEK 35
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
1
10
100
1000
10000



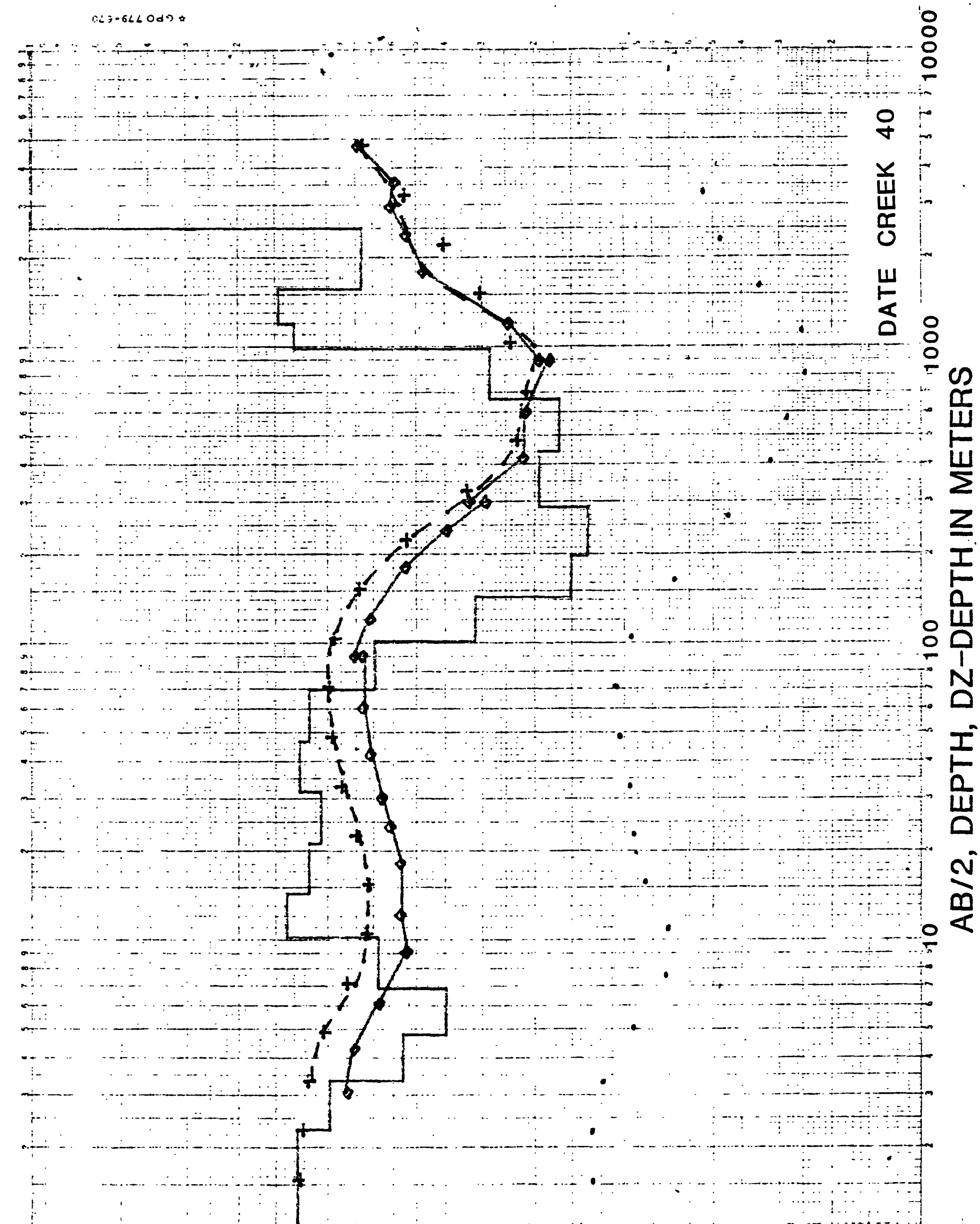
DATE CREEK 36
AB/2, DEPTH, DZ-DEPTH IN METERS
1
10
100
1000
10000
RESISTIVITIES IN OHM-METERS
1000
100
10
1
GPO 779-670


DATE CREEK 37
AB/2, DEPTH, DZ-DEPTH IN METERS
1
10
100
1000
10000
RESISTIVITIES IN OHM-METERS
10
100
1000


DATE CREEK 38
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
1
10
100
1000
10000
GPO 779-670



DATE CREEK 39
RESISTIVITIES IN OHM-METERS
AB/2, DEPTH, DZ-DEPTH IN METERS
1000
100
10
1
10
100
1000
10000


DATE CREEK 40
AB/2, DEPTH, DZ-DEPTH IN METERS
RESISTIVITIES IN OHM-METERS
1
10
100
1000
10000
1000
100
10
1