

## CHAPTER 8

## A RESISTIVITY SURVEY AT EL-AMARNA

by

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## 8.1 Introduction

At the invitation of Mr. Barry J. Kemp, expedition director of the E.E.S. mission to el-Amarna and with the help and co-operation of Dr. Ali el-Khouli of the Egyptian Antiquities Organization and his staff at el-Amarna, a series of resistivity experiments was carried out. The objects of the experiments were, firstly, to see if the apparatus used would indicate the presence of hidden wells in the main city; secondly, to attempt to trace the edge of the ancient quarry now hidden beneath drift sand and debris from the Workmen's Village. If the results proved conclusive a considerable saving in exploratory digging and thereby expedition funds could be realised for further work.

Earlier in the season measurements were taken in the Memphis-Saqqara area and from the results obtained it appeared that we would be able to obtain conclusive results. The resistivity survey team consisting of Mr. I.J. Mathieson and Mrs. A.P. Mathieson arrived on Sunday 20th March, departing Saturday 26th. Under the general direction of Barry J. Kemp the team spent two days in the main city and two days at the Workmen's Village.

The procedure relies on the principle that different deposits beneath the ground offer different resistance to the passage of an electric current, depending largely on the amount of water present. A damp pit will offer less resistance than the surrounding soil, a brick wall more. The instrument consists of a source of electricity and a meter to record the results. The instrument used in this survey was a Strata-Scout, with a linear array of twenty-four copper rods or pins evenly spaced at two-metre intervals, with the instrument in the centre. The current is passed through the pins in paired sequences (the configuration being called the Wenner configuration), which provides a measure of the depths at which resistance is being measured. The results were later smoothed by computer enhancement.

In each of the resistivity profiles, the ground resistance, measured in ohms per metre on the vertical axis, can be followed along the length of the profile at different depths, as indicated by differently textured lines (Figure 8.1). Where lines rise, high resistance is being encountered; where they dip, a pocket of low resistance has been found. Because the method involves measuring current that passes down into the ground from one copper pin (the current electrode), and then back up again to another (the potential electrode), ever deeper levels of resistance measurement are progressively

confined to the centre of the fifty-metre line. Thus the deepest level plotted, at 14 metres, is available only for a limited length towards the centre of the line (between the 20 and 25 metre points).

Some initial difficulty was experienced in obtaining any readings, on account of the extreme dryness of the desert soil. This was overcome by pouring a small quantity of water down each of the holes in which the copper pins were to be placed, enabling the initial electrical contact between pin and soil to be made.

In interpreting the various profiles, comparison should be sought with nos. 7 and 9 (Figures 8.10 and 8.13). Both are control profiles, the former run over an excavated courtyard and completely excavated well, the latter over desert deposits apparently devoid of archaeological content. This latter provides a particularly valuable measure of control, showing the degree of background "noise" to be expected.

## 8.2 The well survey in the main city

A test area consisting of four pegs delineating an area containing probable well sites had been set out (see Figure 8.2) and traverses 1, 2 and 3 were observed in the directions indicated on the figure. The area measures 50 metres square, and the corner pegs are survey points 31-34. It lies in the 200-metre grid square P46, immediately behind, i.e. to the west, of the large estate Q46.1 of the German excavations (Borchardt and Rieke 1980: 23-27, the so-called "Weihnachtshaus"), and a group of smaller houses likewise excavated by the German expedition [Q46.19-23]. The housing block at the northern edge of Figure 8.2 belongs to the unpublished Griffith excavations of 1923-24 (see Chapter 7). The pegged-out area contains three conspicuous depressions amidst ancient house mounds.

**Traverse 1** (Figure 8.3) crosses two broad but shallow depressions. If we study the profile, we see high resistivity readings appearing at around 15 and 23 metres. High resistivity readings in areas of dry sandy conditions are an indication of back fill, structures, or man-made interference with the continuity of the strata. We can therefore say with conviction that between 15 to 23 metres and around 32 to 33 metres, there exist breaks in the even layering of the deposits. These positions are not near the centres of the depressions, and the high readings, therefore, may mark the presence of stone or brick structures surrounding a packed core of debris such as a midden-filled well shaft. Over the second depression centre (at 28 metres) a dip in resistivity is measured at the 4 and 6 metre depths. From the control profiles (especially no. 7) we know that these are depths at which sensitivity to moist well fillings is met.

**Traverse 2** (Figure 8.4). The results of this traverse are a series of high readings which may reflect the presence of walls. The centre of the depression also registers high readings. There is clearly something more here than just a surface feature, perhaps a well which has been filled with rubble and building

debris from the collapse of the sides.

**Traverse 3** (Figure 8.5). This crosses the line of Traverse 2, and ends on the line of Traverse 1. It is reassuring to find that at the crossing with Traverse 2, over a depression, the same high readings are obtained, consistent with a debris-filled area. The 4 and 6 metre readings also register a low point between 30 and 35 metres along the line. This corresponds less well with readings obtained for Traverse 1 at the point of intersection. This is a case where one or more further traverses are required to provide confirmation.

Traverses 4 to 7 were laid out over various adjacent parts of one of the excavated areas of the city (Figure 8.6) to provide an element of control. Most of the area lies within square P47.

**Traverse 4** (Figure 8.7). The line of this traverse was laid out to cross two depressions, one of them largely covered by an excavator's spoil heap. The latter was deliberately chosen to test the effectiveness of the method over such an obstacle. However, in order to avoid the walls of two houses, the line passes to the side of the centre of the other depression. Over the first depression only poor readings were obtained, but the high points registered at the 2 and 6 metre depths could be marking brick steps or some other structure attached to a well. Before the spoil heap, between 22 and 32 metres, a group of marked low readings occurs. As with Traverse 3, they are occurring before the site of the depression, rather than over it.

**Traverse 5** (Figure 8.8). This traverse begins close to the same spoil heap crossed by Traverse 4, and runs across an open area of ground containing one small depression. There are no significant lines at 6 to 8 metres to show that the disturbed area is a well at the start, but the second area at the end of the traverse definitely shows disturbed deposits to at least 6 metres, and this offers some grounds for thinking that a well is present. At least it makes a case for a further testing.

It should be noted that the German excavators accepted all three depressions as having been wells (Borchardt and Ricke 1980: 134, 138; Plan 33, 42).

**Traverse 6** (Figure 8.9). The line of this traverse covers two depressions on the surface, both identified as wells by the German expedition (Borchardt and Ricke 1980: 133; Plan 32). Both areas show impressive low resistance readings at considerable depths, so both could be wells.

**Traverse 7** (Figure 8.10). This profile was taken across the existing proved well at the house of the sculptor Thutmose (Borchardt and Ricke 1980: 91-94; Plan 27). When originally cleared in 1912, it was found to consist of an upper wider shaft, 4.40 metres deep, containing a mud brick staircase, and a narrower shaft in the centre dug out to a depth of 6.50 metres. The upper shaft was lined with bricks, and the separation into two parts may mark the division between looser sandier soil towards the top, requiring a retaining wall, and harder strata below, in which the narrower shaft was cut. Since 1912, the retaining wall seems to have collapsed inward, leaving now a broad

and deep bowl filled with drift sand. The resistivity line was laid directly on the dipping surface across the centre line of the well. Consequently, in the centre, the depth readings are likely to reflect resistivity changes at real depths below the desert surface slightly greater than with the other well depressions. In Figure 8.10, the fill, consisting of homogenous wind-blown sand, gives relatively constant readings as can be seen from the actual plot of the profile. It is reassuring to see that the lowest reading (i.e. least resistance/wet sand/good conductor) comes exactly at the centre point of this well at approximately 8 metres depth when checked against the topographic plot. At 10 and 12 metres the anomaly fades away, implying that by this time we are beneath the water table, in a hard bedrock feature with moisture-filled cracks.

This completed the work in the main city, and the survey team moved to the Workmen's Village.

### 8.3 The main quarry at the Workmen's Village site

The expedition had worked extensively at the Workmen's Village during the previous four seasons, and it had become apparent during the 1981 season that a large quarry existed at the edge of the village. To delineate the extent of the quarry by excavation would take considerable time and labour, because the fill of village debris and wind-blown sand had rendered the outline quite invisible on the ground. A considerable economy of expedition resources could be achieved if the quarry edge could be located by the resistivity meter.

To help with the plotting, all traverse lines followed the existing grid of five-metre squares. A total of eight profiles was taken, as shown on Figure 8.11, and in profiles 11 to 18 (Figures 8.13-8.20).

The survey team soon discovered that the infill of ash-midden-sand was of a high resistivity, being very dry with considerable aeration. However, this turned out to be a useful "non-event", as the bed-rock, gravels and sand were of low to medium resistivity, and the face of the quarry against the infill showed as clearly as if one had cut through the strata with a knife.

**Traverse 9** (Figure 8.13) turned out to be a useful test-run over what is assumed to be a fairly typical desert surface of rock and sand. It can be seen from the profile that there is a steady return of signal showing a matrix type of soil which could be interpreted as a wadi-bed of stratified layers of boulders and gravel to a considerable depth. It also shows that the quarry does not extend as far south as this line.

Profiles 10 to 15, shown in Figures 8.14 to 8.20, show clearly what happens when the stratified layers come suddenly to the ash-midden infill of the quarry. Plotting these contacts on the topographic plan gives a probable quarry-face line, as shown in Figure 8.12. There is, however, a difficult area to interpret at what could be the lowest point of the quarry excavation.

**Traverse 10** (Figure 8.14). The 2-metre line is the most important one to watch, since the excavated squares show that at this depth one is close to the maximum quarry depth. The quarry face appears between 30 and 35 metres. The second drop in resistance, between 10 and 15 metres, may mark the edge of the shallower cutting in the rock, picked up in the excavation of square L8. It should also be noted that there is a lateral change in the underlying geology, between the bedrock of the quarry, and the sands which were encountered in its place in the pit dug in the north-east corner of square J8. Possibly there is a natural buried channel in the bedrock here. Closer to the Walled Village trenches in front of the entrance failed to locate bedrock, which must here dip steeply westwards into a channel more or less on the line of the main entrance to the village.

**Traverse 11** (Figure 8.15). This is a particularly clear result, with high readings registering on several lines around the 30-metre mark.

**Traverse 12** (Figure 8.16). Again the quarry edge appears dramatically around the 30-metre mark.

**Traverse 13** (Figure 8.17). At the 2-metre depth, the quarry edge appears at 10 metres. The disturbances further along may be a consequence of the quarry face running roughly parallel to the line of the traverse.

**Traverse 14** (Figure 8.18). The quarry face appears at around 7 metres, with a high resistance peak further along, around 20 metres. This may mark the edge of the shallower cutting in the rock, picked up in the excavation of square L8, as mentioned above.

**Traverse 15** (Figure 8.19). According to other results (and especially traverse 13) the eastern quarry face should have appeared around 5 metres. From a subsequent examination of the results from 0 to 15 metres in the field notes, it appears that the eastern edge of the quarry was missed when the profile was plotted. An edge is just caught at 4-metres depth and definitely at 6-metres depth at approximately 5 to 9 metres in from the Pin 1 position. A sharp rise in resistance above the levels expected of desert sediments occurs between about 20 and 25 metres. This must mark the lowest part of the western quarry face in square M9, which was excavated only to the top of the lower midden deposit (see Chapter 6).

**Traverse 16** (Figure 8.20). This was run experimentally southwards from the excavated areas, towards the lowest point on the wadi-floor. At 30 to 35 metres a high resistivity anomaly is present at 2 to 4 metres depth.

It should be noted that there is no record for **Traverse 8**, or for any across the northern part of the quarry. Traverse 8 was run across the quarry along the line marking the division between the grid squares on the 13 and 14 lines. Despite the addition of water to the holes in which the copper pins were placed, the midden rubbish is so dry and aerated that no readings were obtained at all.

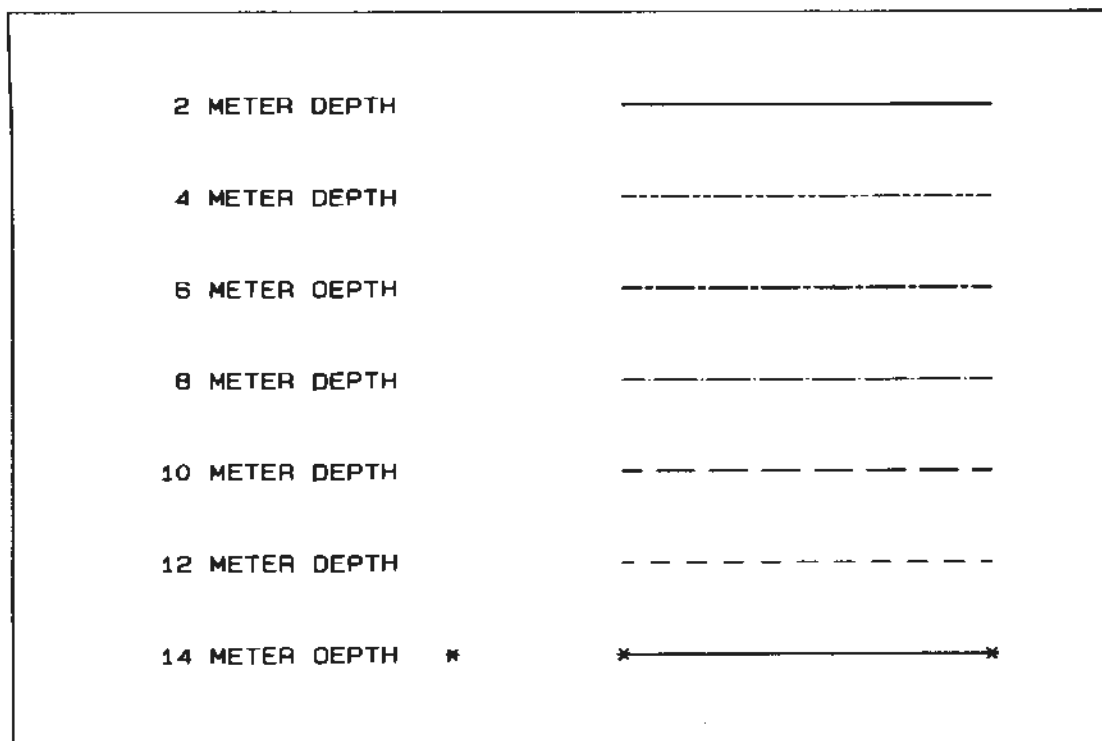
### 8.4 Conclusions

Observing for five days only was an extremely brief amount of time, as one could have utilised the whole five days in surveying comparative tests to locate the resistivity ohm/metre levels of the different types of strata. However, once again there is no doubt that here is a tool for archaeologists to use in the field as a valuable method of delineating the extent of an ancient excavation. We obviously found the wells we looked for, and the quarry face cannot be denied. However, it really requires several days work on any one location to prove conclusively that the plotting of the anomalies is correct.

### References

Borchardt, L. and H. Rieke (1980). *Die Wohnhäuser in Tell el-Amarna*. (91. Wissenschaftliche Veröffentlichung der Deutschen Orient-Gesellschaft). Berlin.

#### RESISTIVITY PROFILES (EGYPT 1983) - GRAPHIC LEGEND



PLOTTED IN JUBAIL / 23rd. MAY 1983

Figure 8.1. Key to the profiles in Figures 8.2 to 8.20.

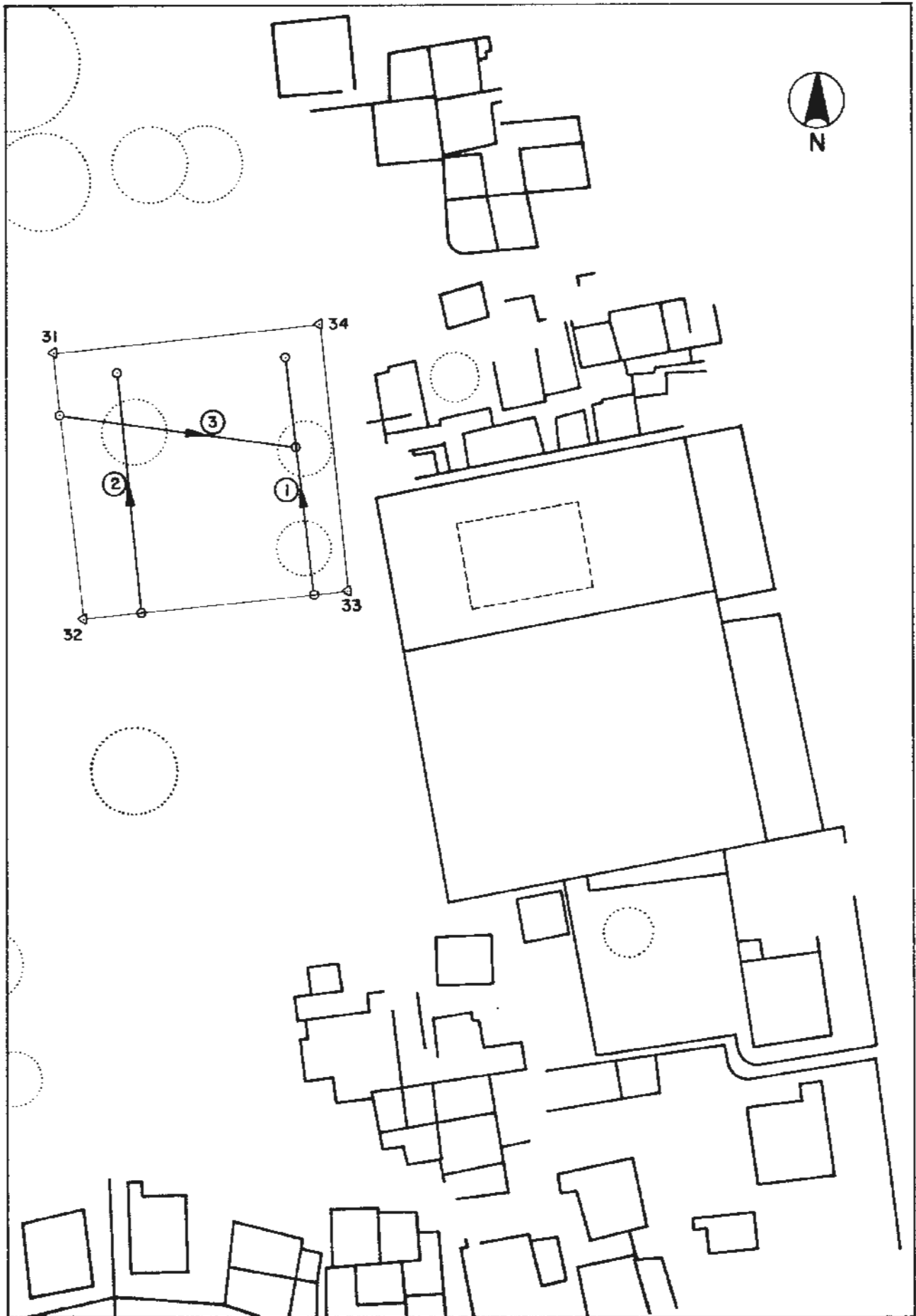
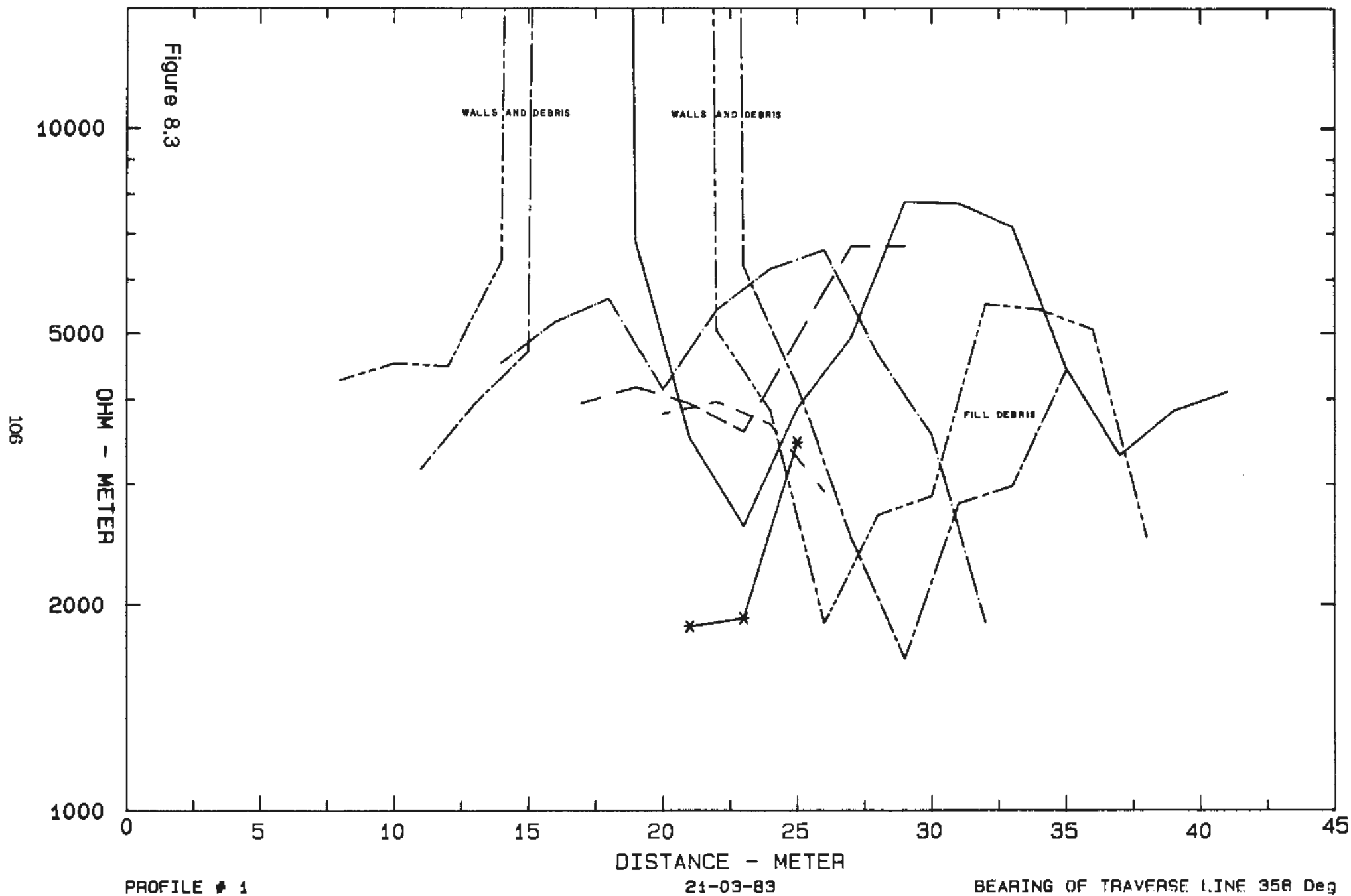


Figure 8.2. El-Amarna, Main City: profiles 1, 2 and 3. Scale 1:1000.

RESISTIVITY PROFILE: AMARNA TOWN HOUSE TEST AREA





RESISTIVITY PROFILE: AMARNA TOWN HOUSE TEST AREA

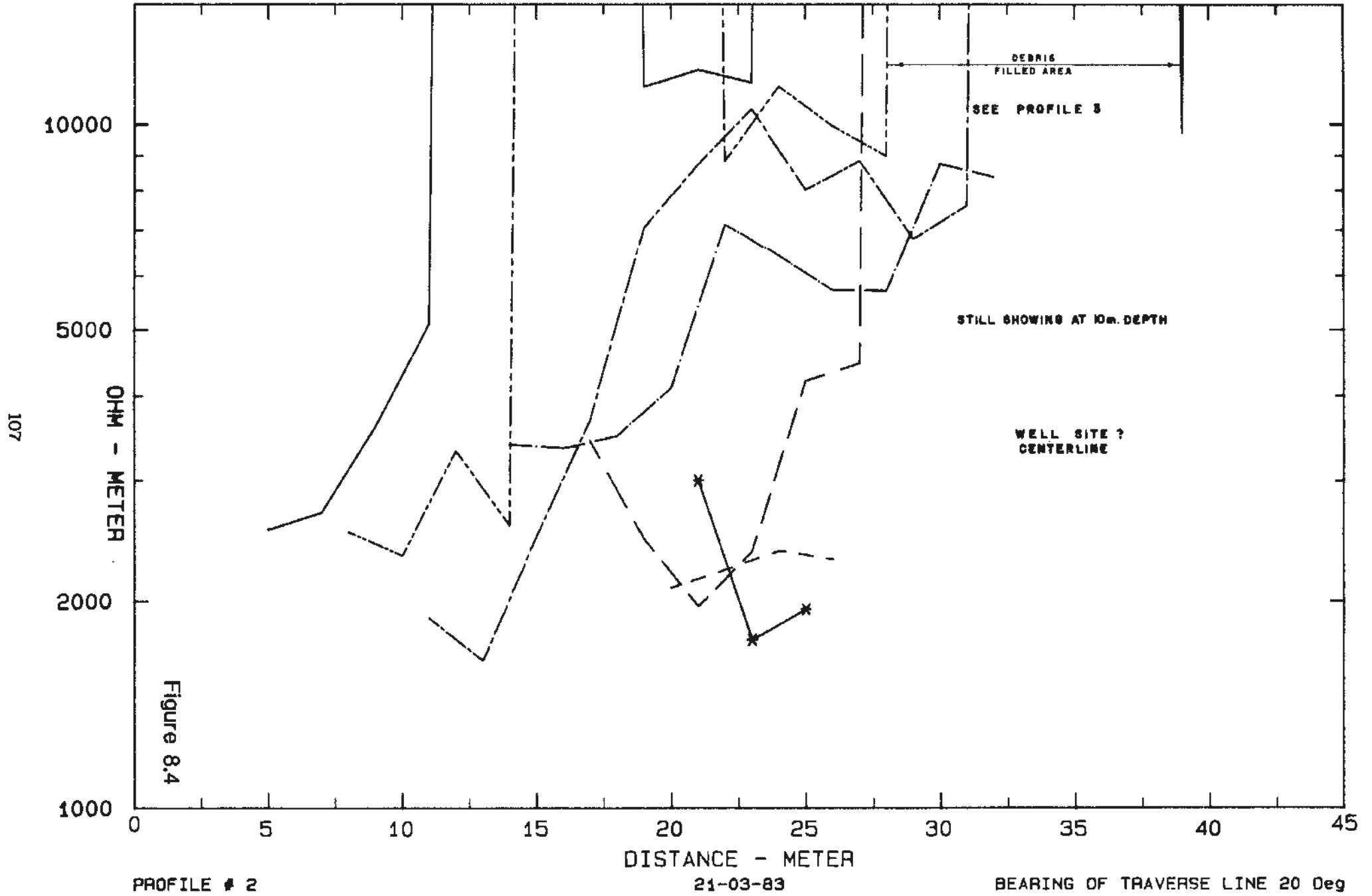


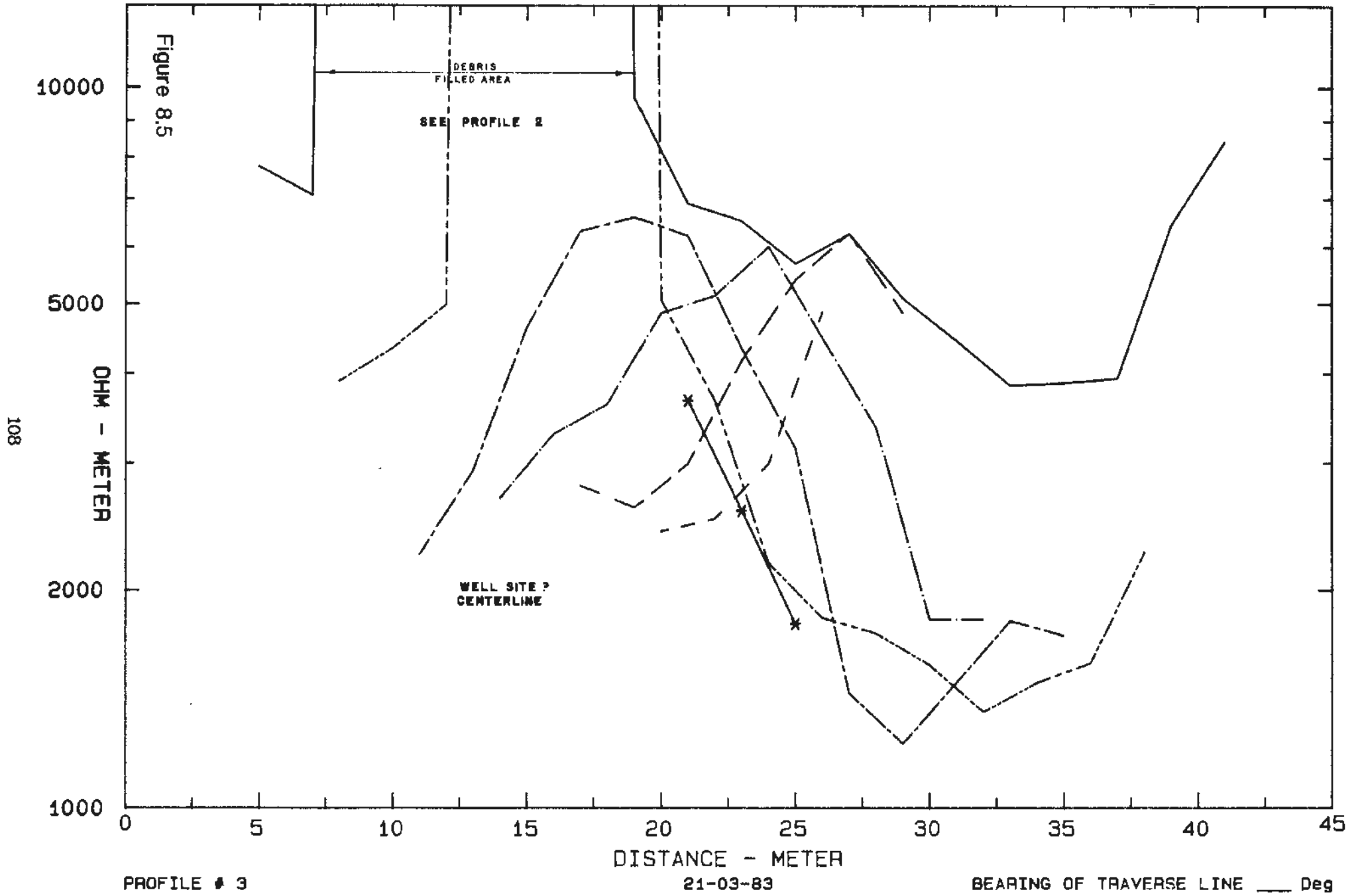
Figure 8.4

PROFILE # 2

21-03-83

BEARING OF TRAVERSE LINE 20 Deg

RESISTIVITY PROFILE: AMARNA TOWN HOUSE TEST AREA



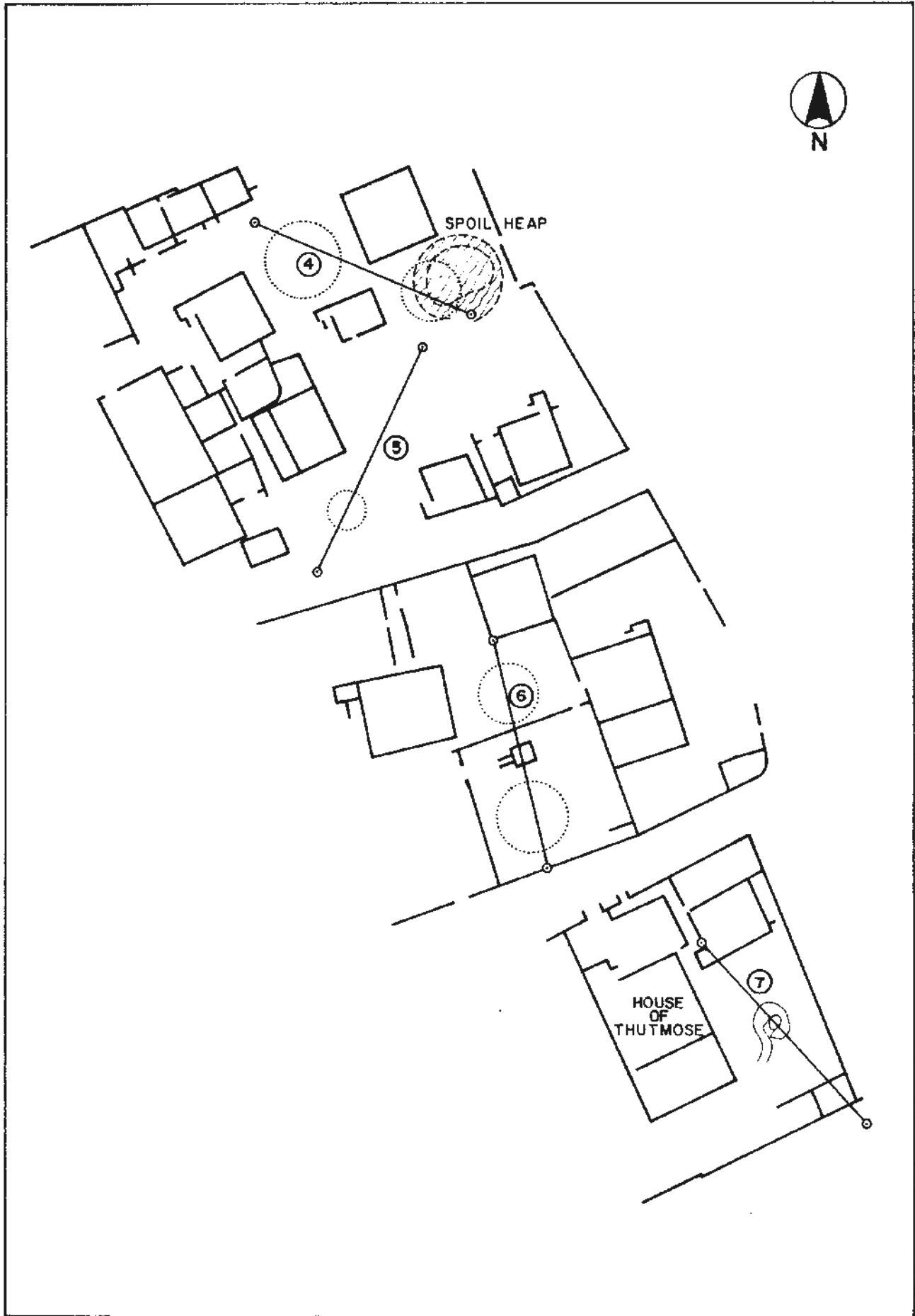
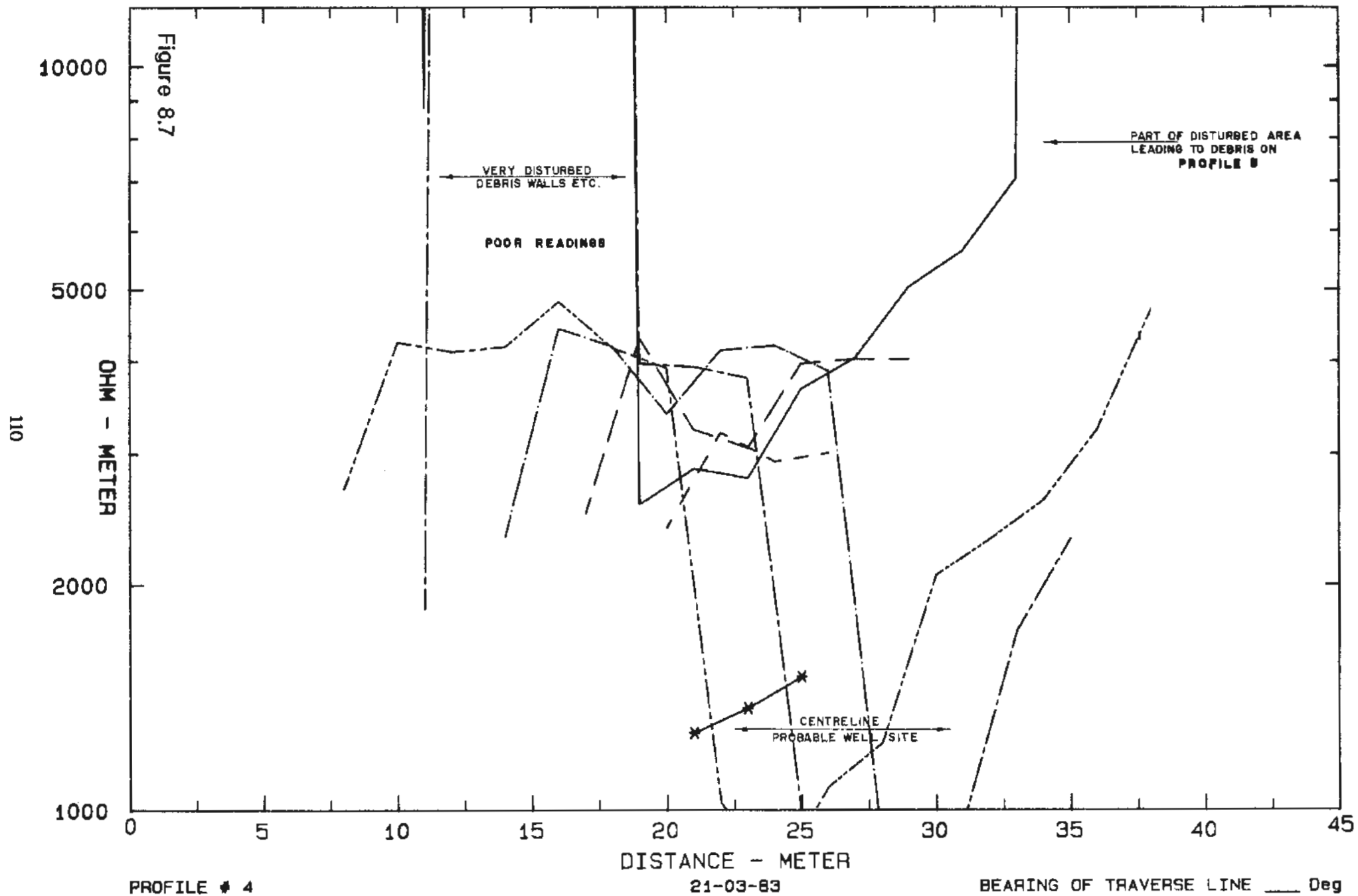


Figure B.6. El-Amarna, Main City: profiles 4 to 7. Scale 1:1000.

RESISTIVITY PROFILE: AMARNA TOWN HOUSE WELL SITES



RESISTIVITY PROFILE: AMARNA TOWN HOUSE WELL SITES

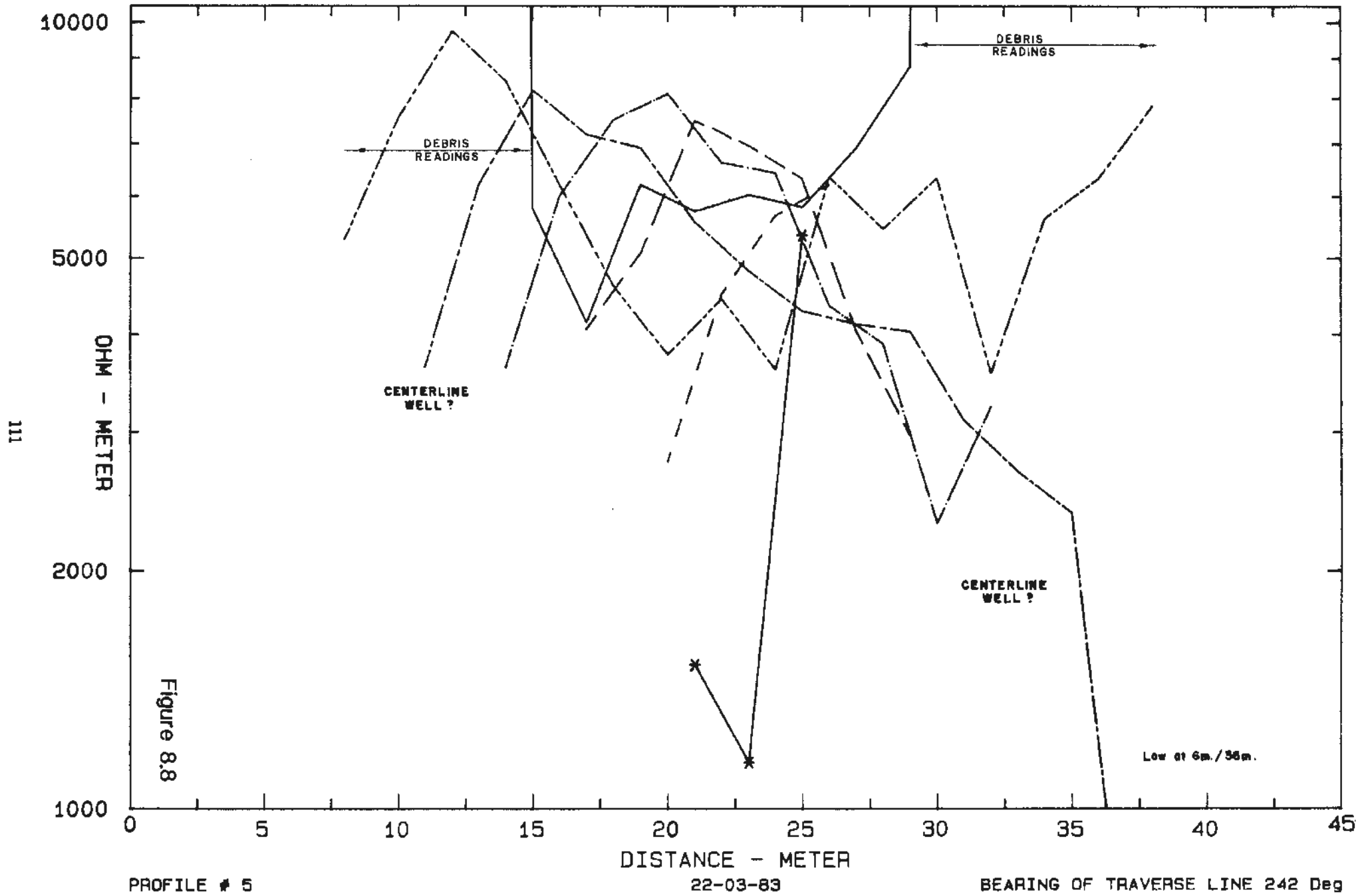


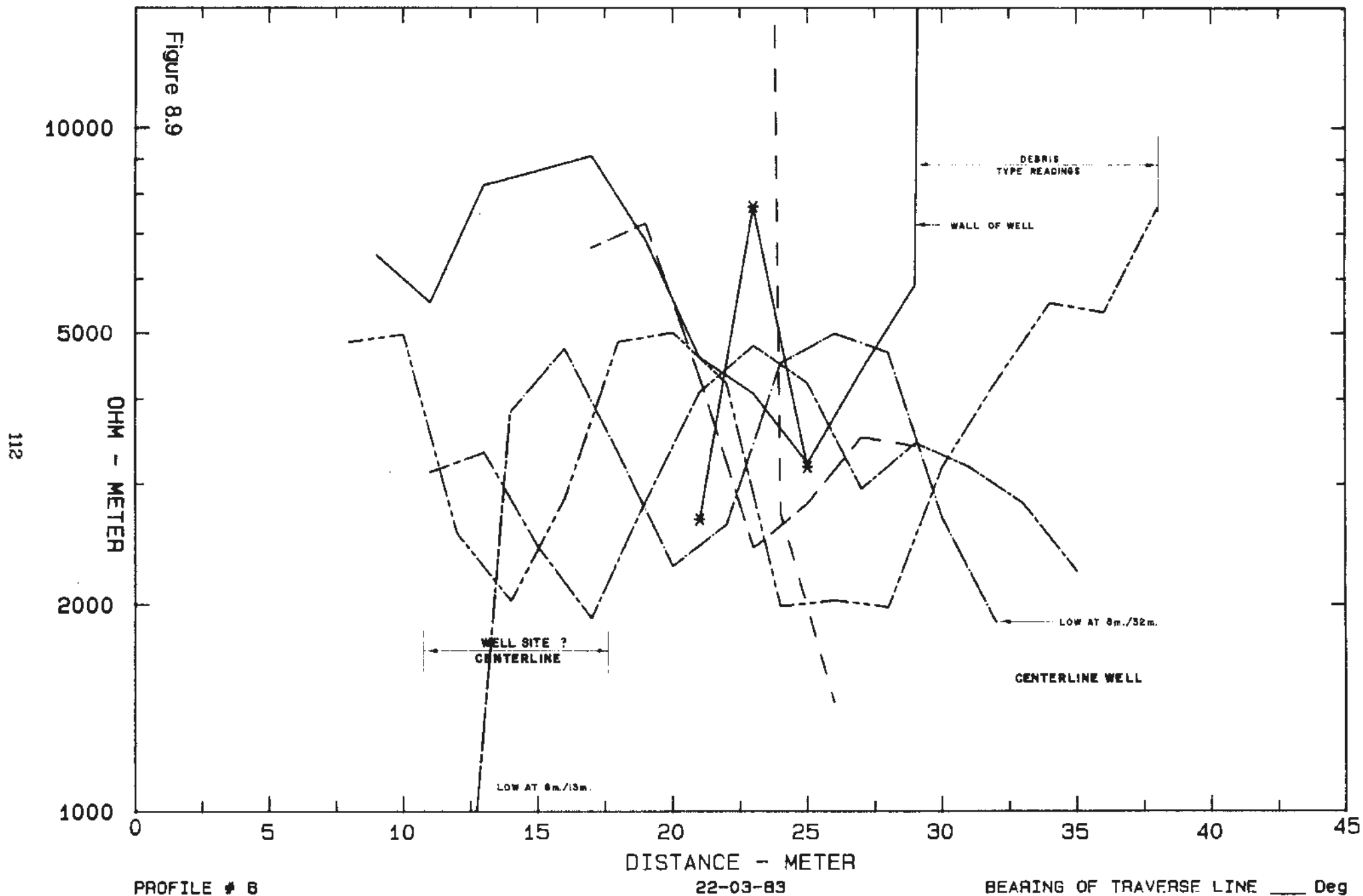
Figure 8.8

PROFILE # 5

22-03-83

BEARING OF TRAVERSE LINE 242 Deg

RESISTIVITY PROFILE: AMARNA HOUSE ADJACENT TO THUTMOSE HOUSE



RESISTIVITY PROFILE: AMARNA HOUSE OF THUTMOSE WELL SITE

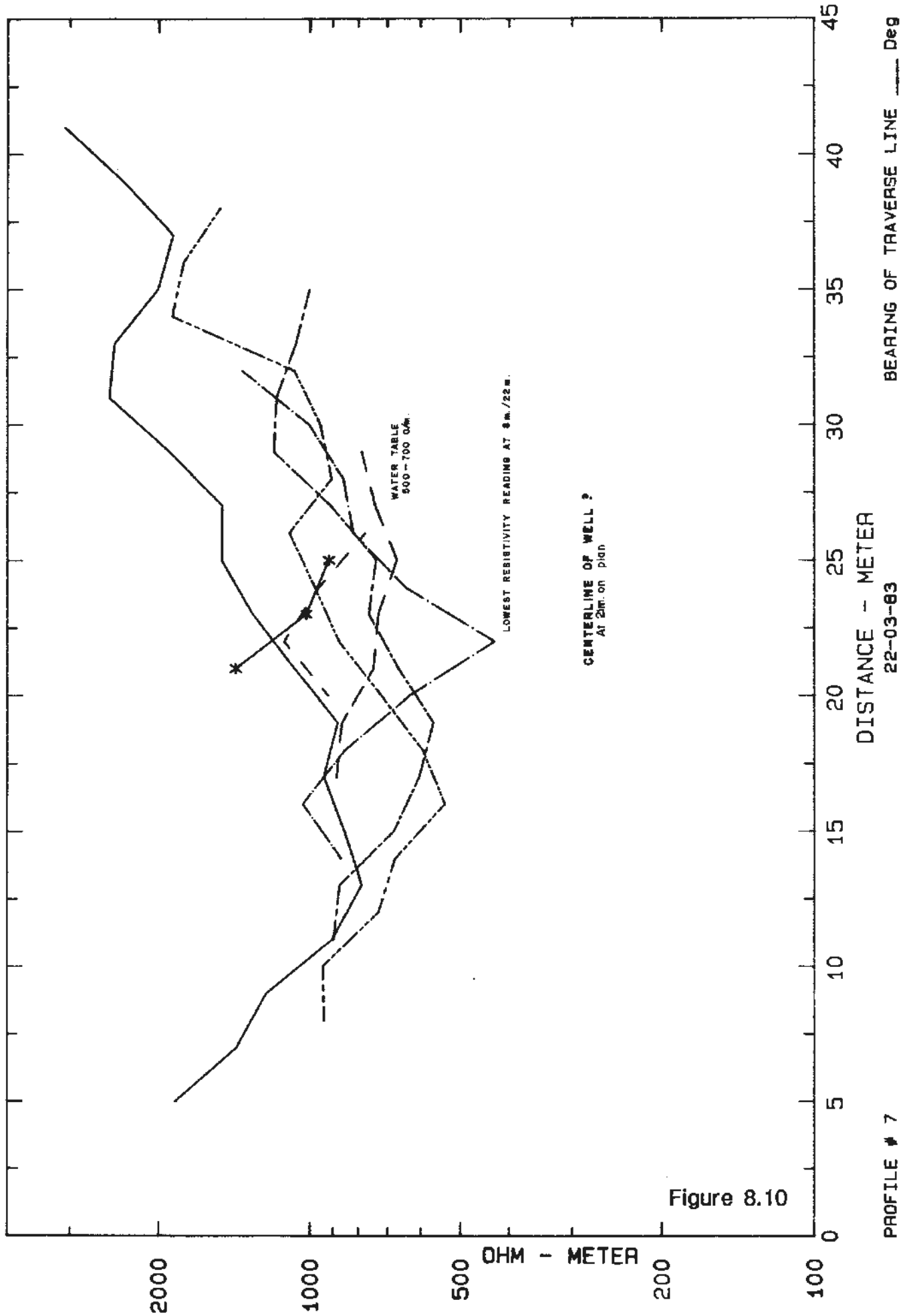


Figure 8.10

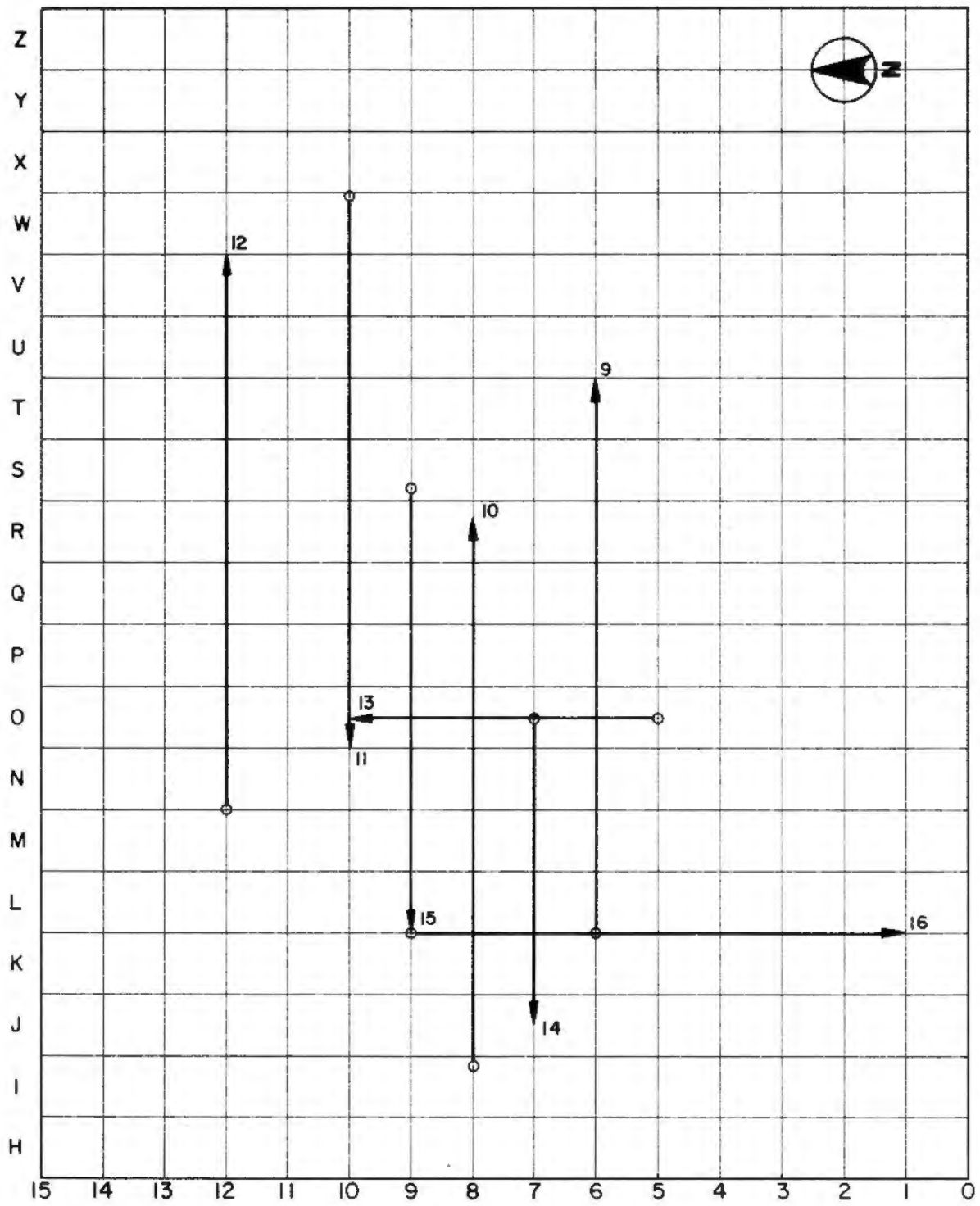


Figure 8.11. El-Amarna, Workmen's Village. The main grid of five-metre squares showing the positions of resistivity profiles. Scale 1 cm. : 5 metres.



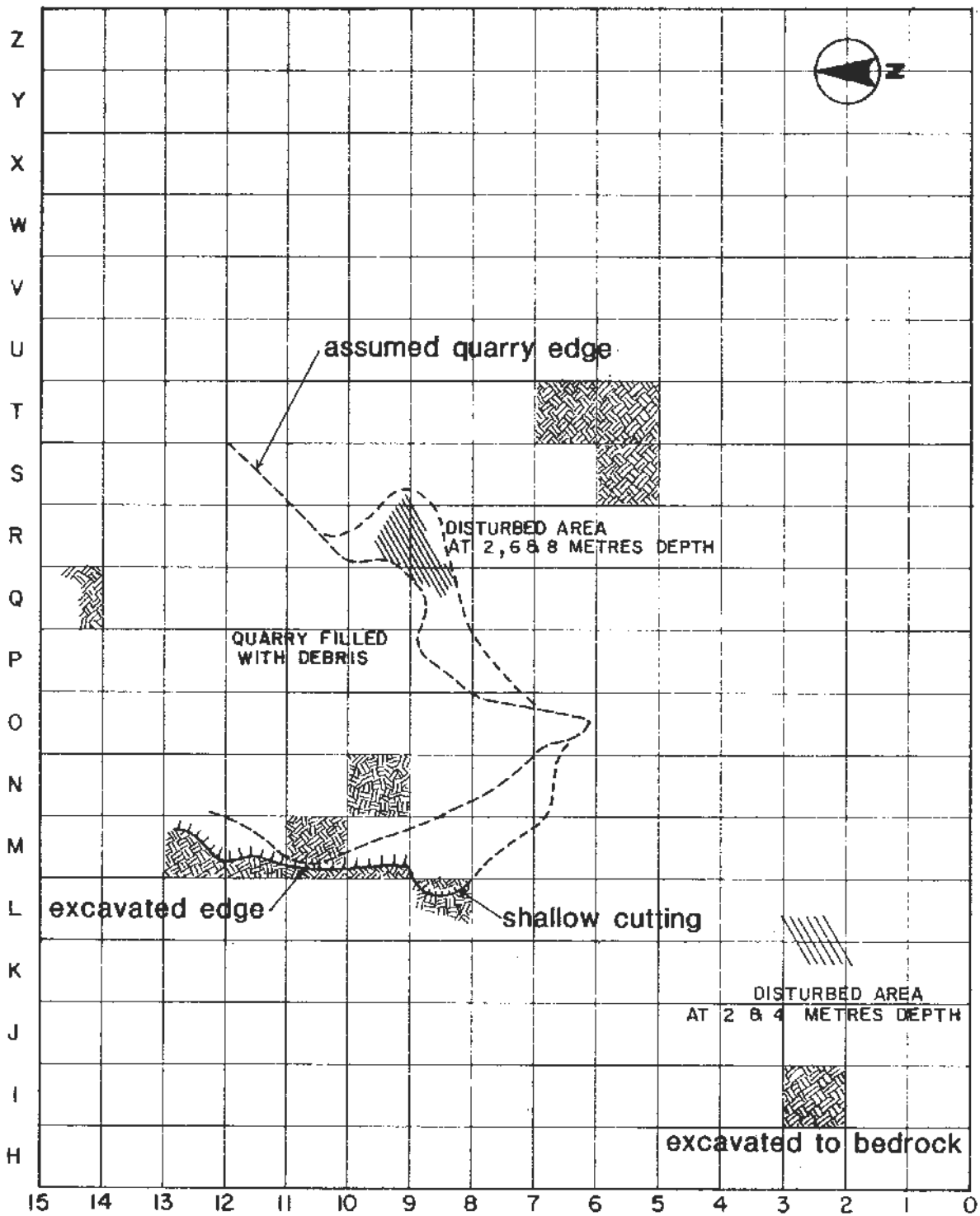
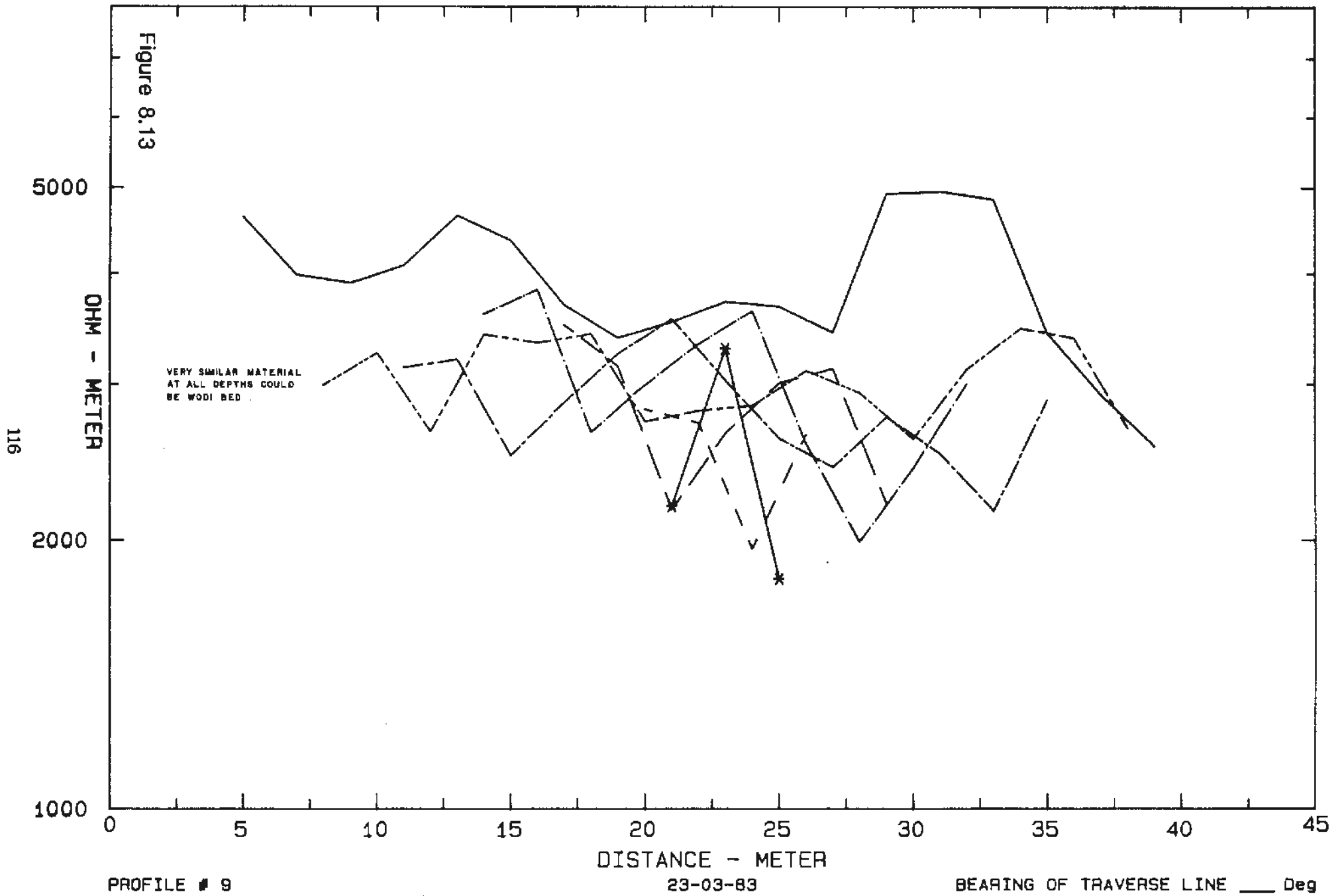


Figure 8.12. El-Amarna, Workmen's Village. The quarry edge as deduced from resistivity profiles and excavated evidence. Scale 1 cm. : 5 metres.

RESISTIVITY PROFILE: AMARNA E/W TO TEMPLE PIN 1 ON L6->MNOPOQ



RESISTIVITY PROFILE: AMARNA TO LINE 9 PIN 7 AT LB

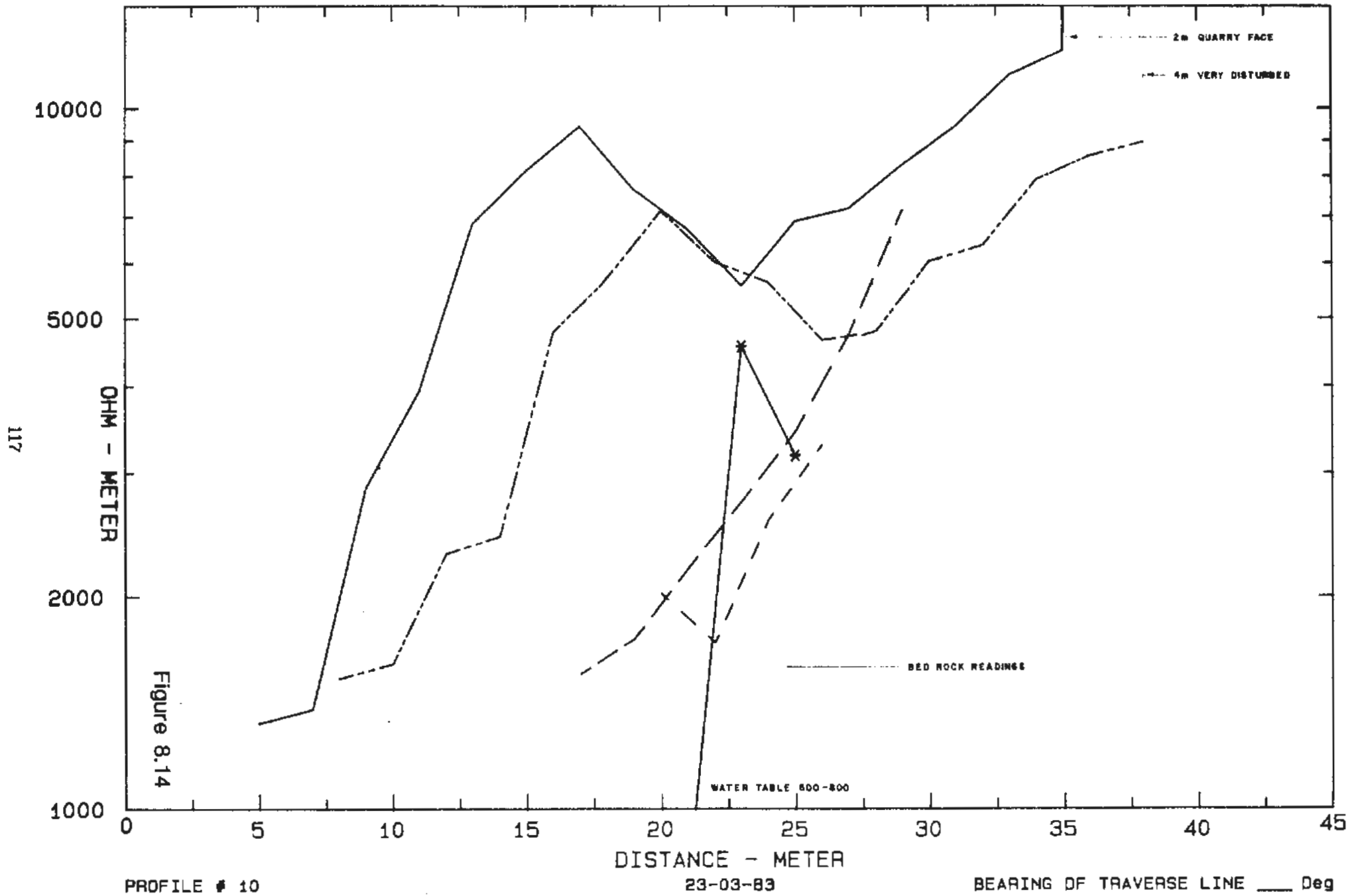


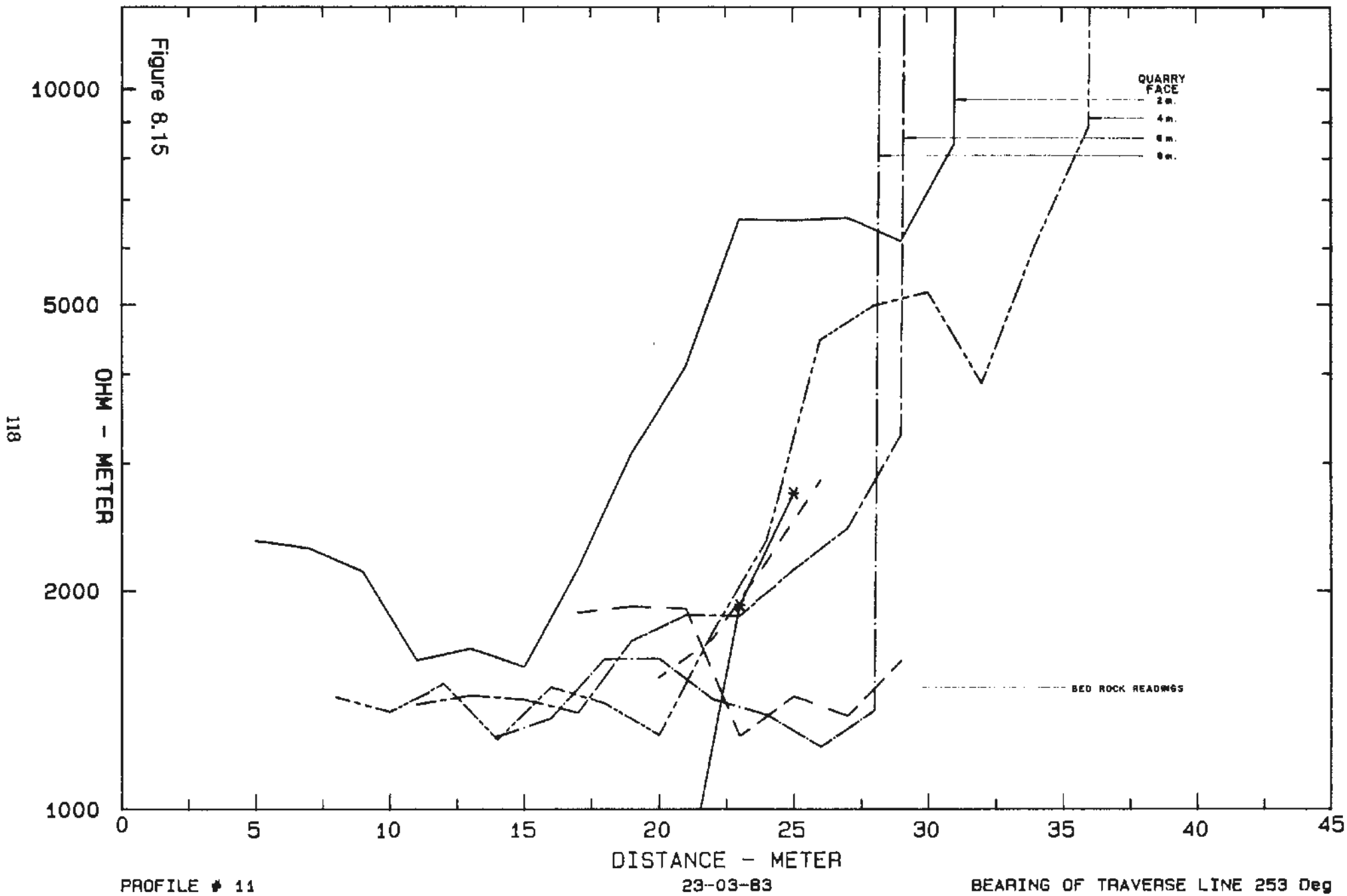
Figure 8.14

PROFILE # 10

23-03-83

BEARING OF TRAVERSE LINE \_\_\_\_ Deg

RESISTIVITY PROFILE: AMARNA TO LINE 10 PIN 24



RESISTIVITY PROFILE: LINE 11 10m NORTH PIN 1 N12 PIN 24 ON LINE 12

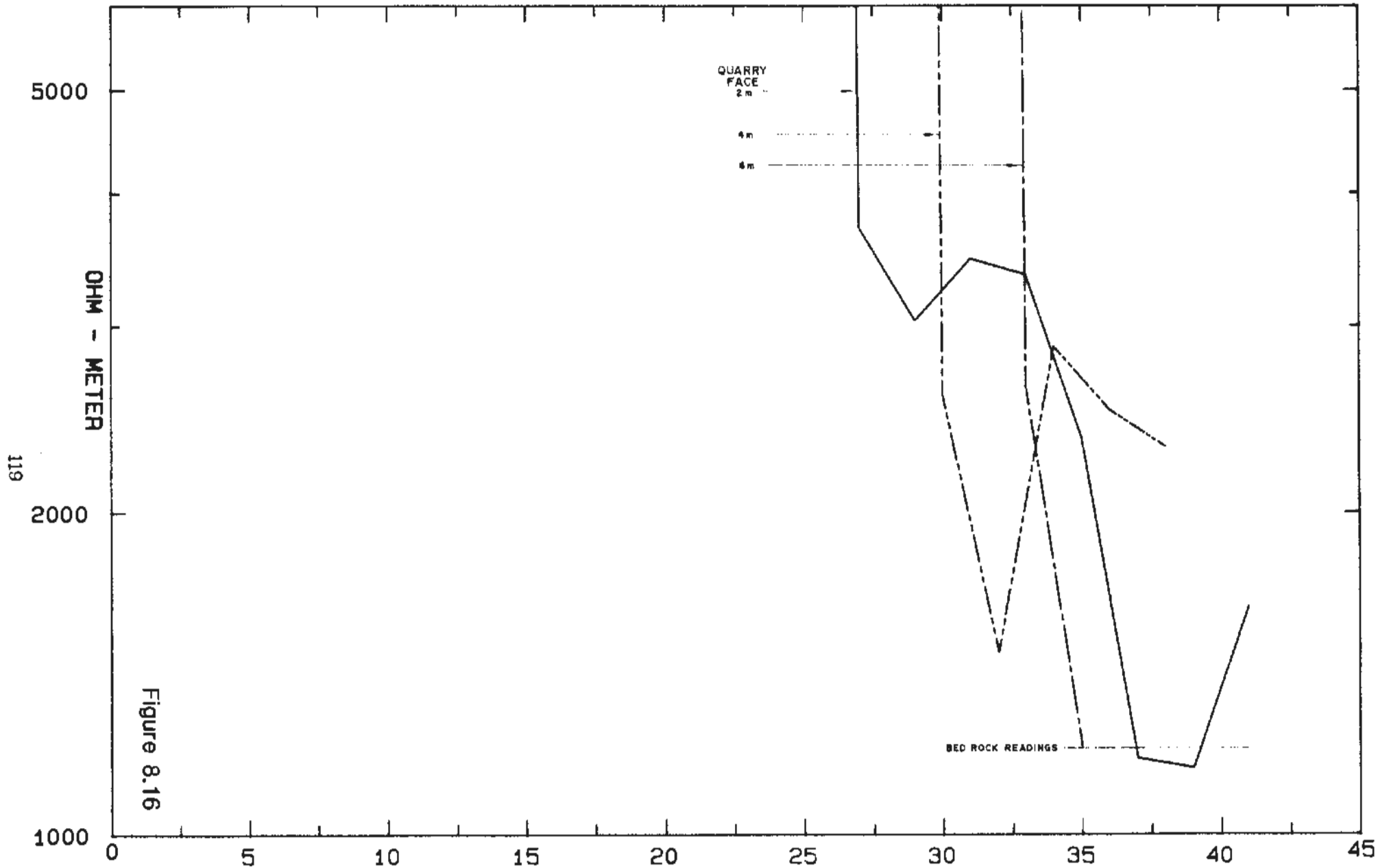


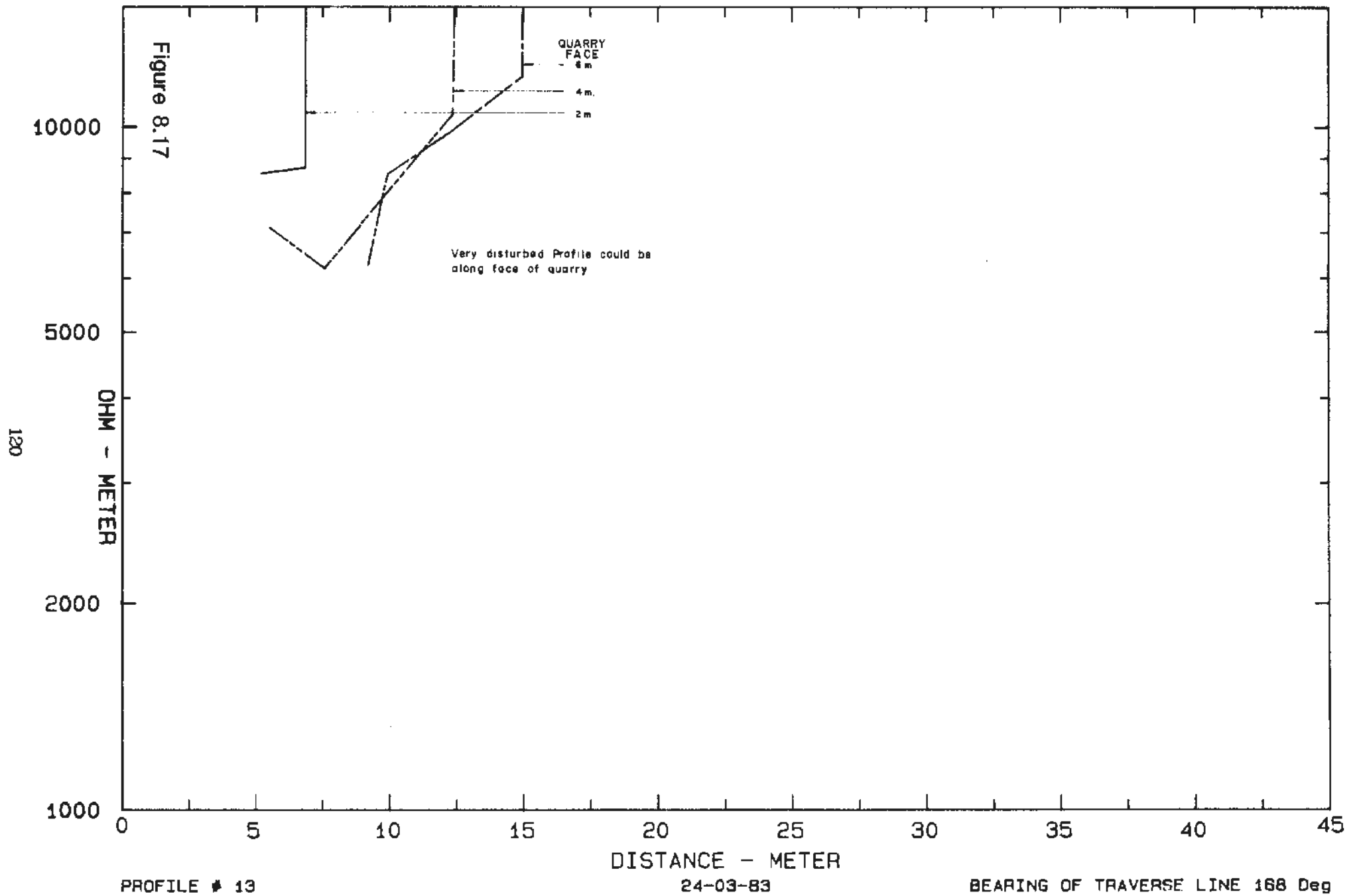
Figure 8.16

PROFILE # 12

24-03-83

BEARING OF TRAVERSE LINE 252 Deg

RESISTIVITY PROFILE: AMARNA RA LINES TO LINE 12 PIN 1 AT 05+2.5m Fig.15



RESISTIVITY PROFILE: AMARNA PIN 1 = PIN 5 LINE 13 K7+2.5m = PIN 12

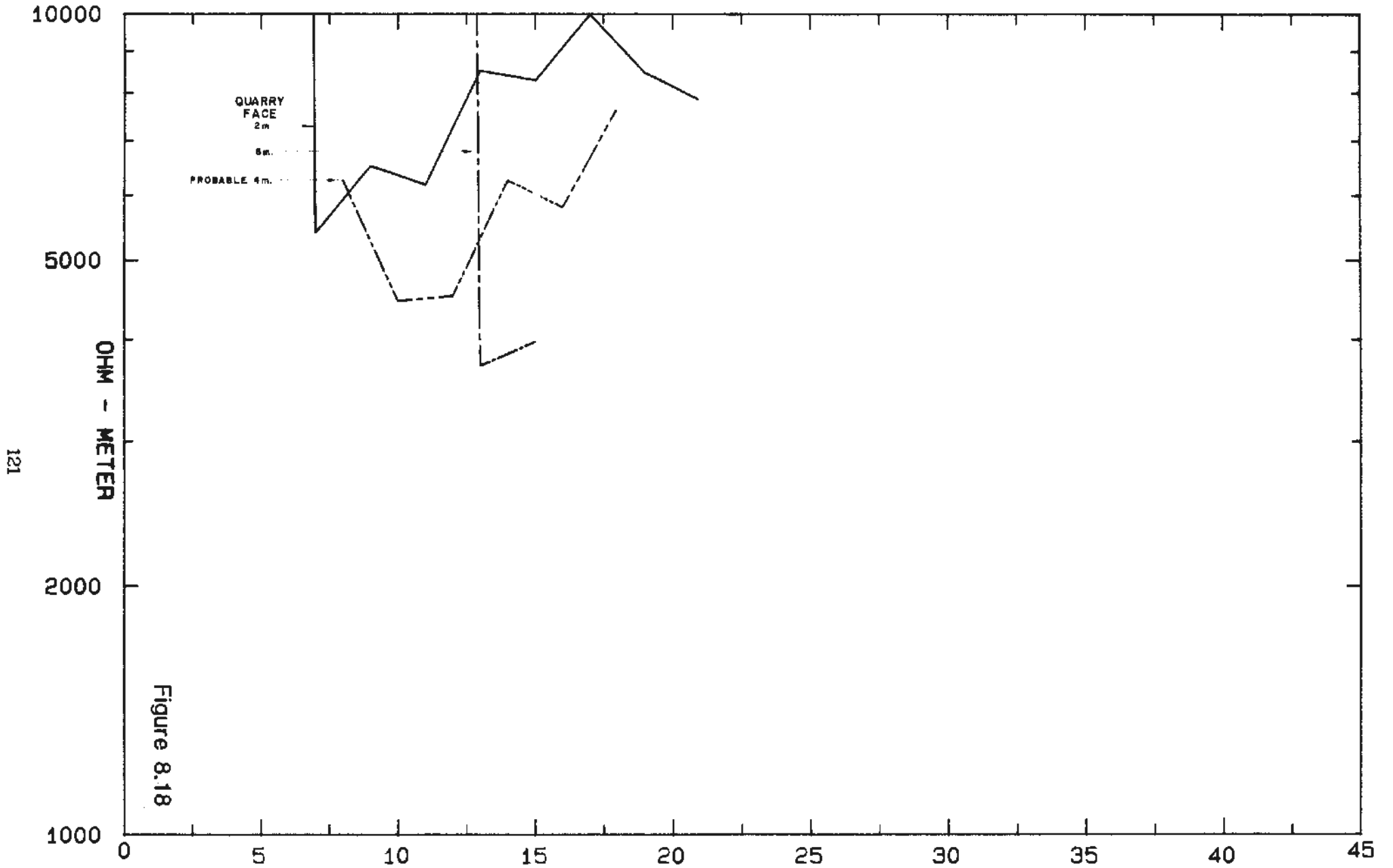


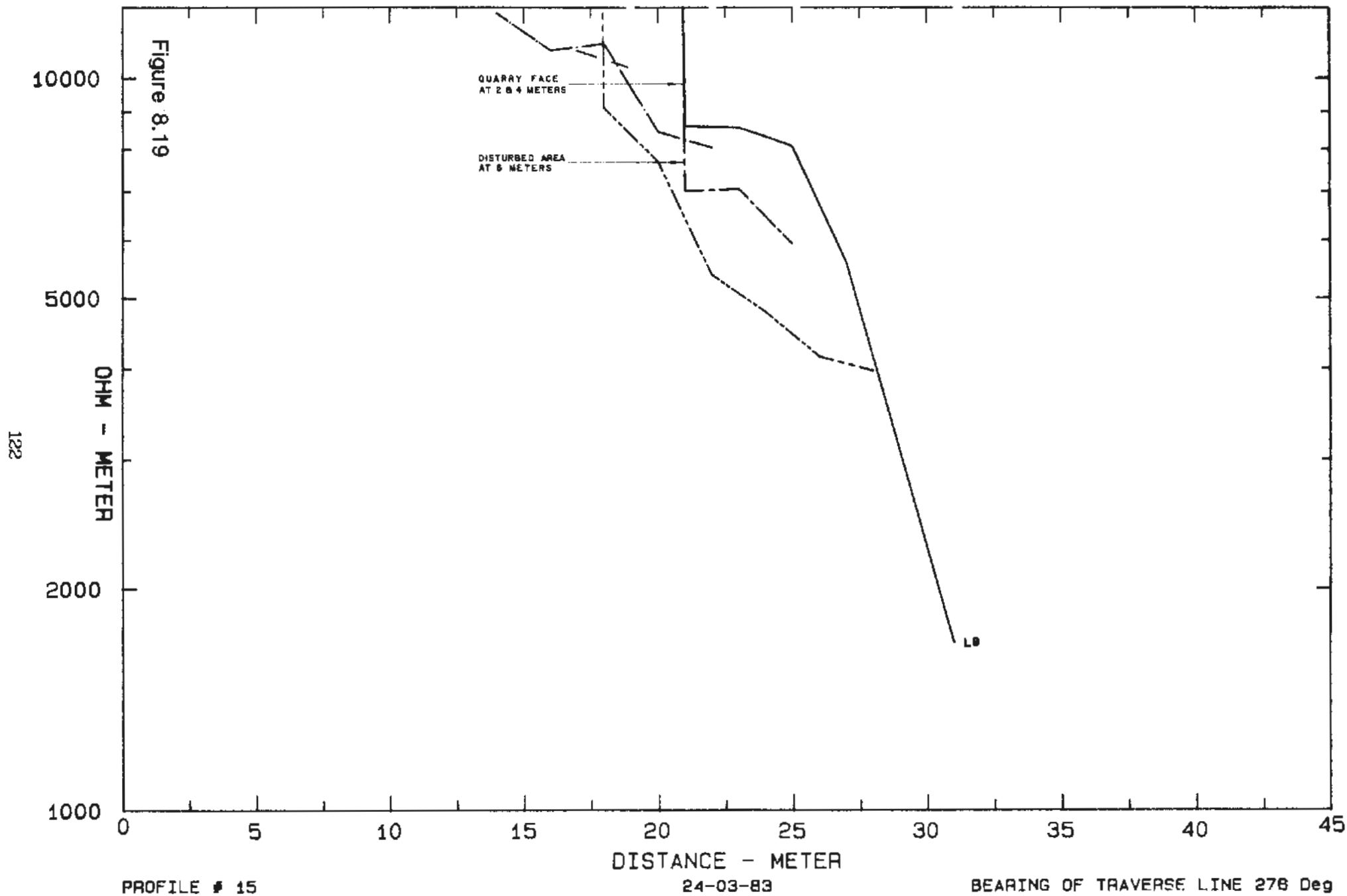
Figure 8.18

PROFILE # 14

24-03-83

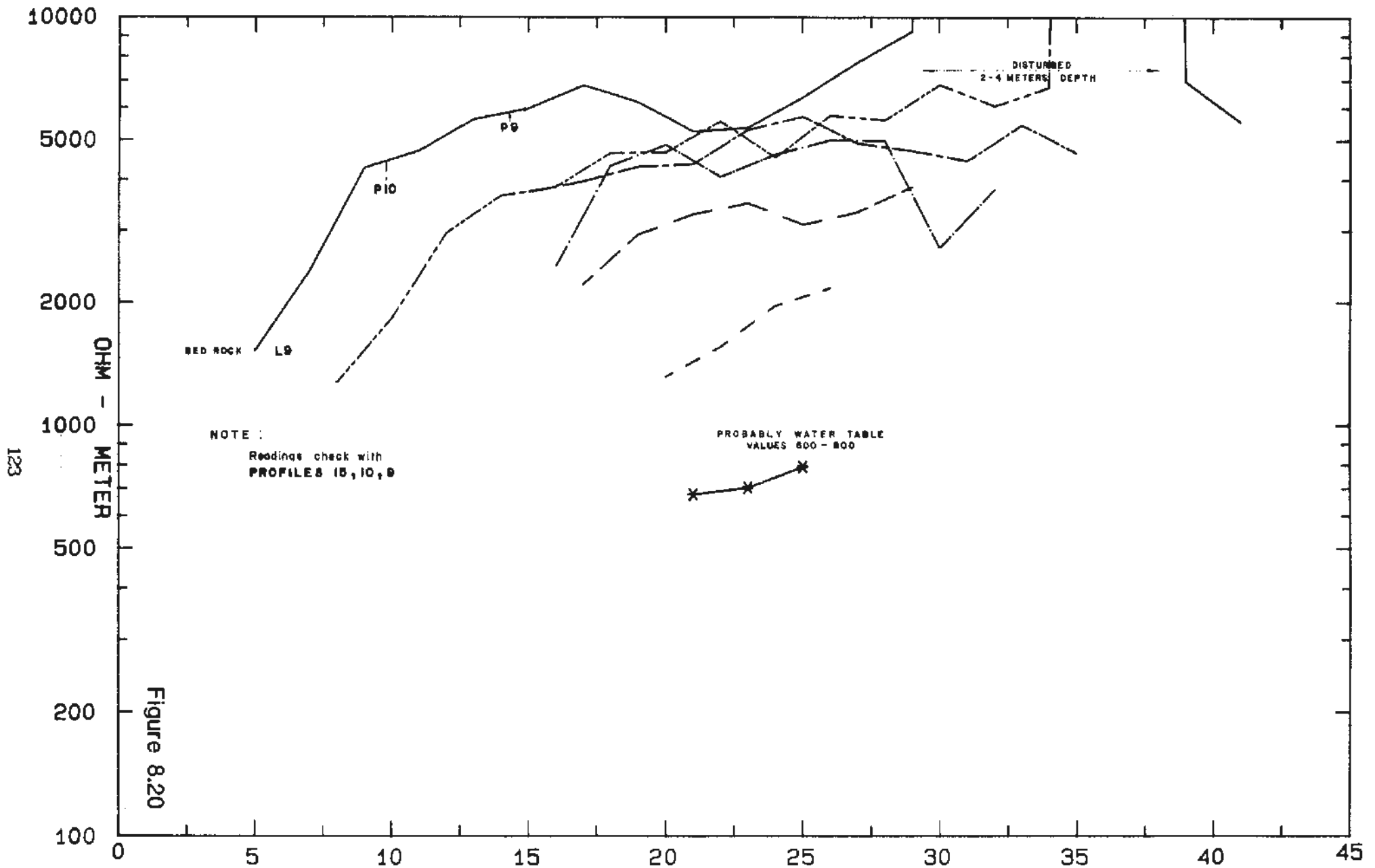
BEARING OF TRAVERSE LINE 256 Deg

RESISTIVITY PROFILE: AMARNA EDGE OF QUARRY PIN 19 AT L9





RESISTIVITY PROFILE: AMARNA RA TO LINE 15 PIN 1 AT L9



NOTE :  
Readings check with  
PROFILES 15, 10, 9

PROBABLY WATER TABLE  
VALUES 800 - 800

Figure 8.20

PROFILE # 16

DISTANCE - METER  
24-03-83

BEARING OF TRAVERSE LINE 168 Deg

123