

ARCHAEOLOGICAL RESULTS OF A GEOPHYSICAL SURVEY IN SWAT VALLEY, PAKISTAN - AUTUMN 1975

M. CUCARZI

Introduction.

The Istituto Italiano per il Medio ed Estremo Oriente (IsMEO) has undertaken a wide programme of excavations and restoration in several Asiatic countries. Among the various projects which are presently under way those at Shahr-i-Sokhta in the Sistan Desert, Iran, at Ghanzni, Afghanistan and in Swat Valley, Pakistan are the most interesting.

In the Swat Valley one of the most recent discoveries has been the existence of a large protohistorical site near Aligrama village, about eight hundred metres from the right bank of the Swat river, just in front of Mingora, the most important commercial centre of the region.

Through the collaboration of the Istituto di Geodesia e Geofisica and the Istituto di Storia Antica of the University of Trieste, IsMEO planned a geophysical survey of the site in order to locate the boundaries of the settlement.

Geophysical surveys have already given good results in depicting underground features of archaeological interest in different parts of the world. In particular at Aligrama this type of survey was expected to indicate the limits of the area of archaeological interest, as a large number of ceramic fragments had been found on the other side of the Saidu-Aligrama road (fig. 1), down-slope from the excavated area raising the question of the extension of the settlement in that direction.

Type of survey.

In the area of archaeological interest, which is of alluvial nature (fig. 2), excavations had revealed a sequence of partly or totally collapsed superimposed walls down to a depth of six metres. Although such a situation could complicate the results of the survey, the fact that the depth of the top of the walls was likely to be not more than one and a half metres made interpretation of the data less difficult.

A magnetic survey carried out near the site

of the excavations during a previous campaign (Manzoni, personal communication) had led to digging in a zone considered favourable according to the preliminary results of the survey; however no particular archaeological features (Stacul, personal communication) had been found. Laboratory measurements carried at a later date on samples of three different constituents of the ground showed that the difference in magnetic susceptibility was very low. Indeed there was no marked difference between the susceptibility of the rocks, which were likely to have been used for the construction of walls, and that of the topsoil which is a major constituent of the terrain. Therefore the anomalies obtainable from a magnetic survey of the area would certainly have been too small to provide any clear pointers.

It is known however that the AC bridge used for laboratory measurements does not give any indication of residual magnetization. Thus, if such magnetization does exist in the case of the Aligrama samples and if it is revealed by future measurements the use of a magnetic survey to detect archaeological features in the area will prove feasible.

However at the time of this campaign a resistivity survey appeared more promising.

Electrical survey.

The use of a Geohm instrument with a Wenner electrode configuration was chosen as best for local conditions.

Four steel electrodes connected to the instrument by cables and aligned at a distance of one metre from each other are hammered into the ground to a depth of about thirty centimetres. Once a potential difference is created between the two outer electrodes, the ratio of current intensity (flowing through the two inner ones) to potential difference is read on the instruments. This is the value of the apparent resistivity of the ground in the centre of the electrode system.

Since the Wenner configuration offers the possibility to vary the spacing of the electrodes and since this is proportional to the depth to be investigated, the electrode separation chosen will depend on the depth at which finds are to be expected.

Previous excavations had revealed that the remains of the walls could be located at a depth of one and a half metres. Thus an electrode separation of one and a half to two metres was considered appropriate. The same spacing also seemed appropriate to the type of ground soil the inhomogeneous nature of which caused some uncertainty over the electrode-ground, contact and disturbances in measurements. On the other hand, the superimposition of the walls observed to a depth of six metres pointed to the advisability of a reduced electrode separation to avoid measurements being influenced by deeper archaeological features. Hence it was concluded that resistivity measurements obtained with the selected electrode separation of one metre would reflect a « surface effect ».

The survey area (fig. 1) is on the NE side of the Aligrama-Saidu road on flat ground (fig. 3) about hundred metres from the excavated trenches.

In view of the arrangement of the walls in the nearby excavated zone, the survey area was divided into six main squares with twenty metre sides, oriented in an ESE-WNW direction. In this way a total of 1870 measurements were obtained at the corners of a one metre square grid.

Data Processing

The readings taken from the instrument multiplied by an appropriate constant give the apparent ground resistivity at the centre of the electrode system. The constant, 6.28 in this case, is a characteristic of the particular instrument and depends on the system configuration.

Resistivity values thus obtained ranged from 40 to 400 Ohm metre.

Four different parts of the surveyed area have high apparent resistivity (fig. 4). Zone 1 and 2 are elongated, rectilinear and parallel to the lines along which the survey was carried out; zone 3 is somewhat curvilinear and zone 4 is formed by two smaller subzones where apparent resistivity is lower than in the other three zones.

Zones 1 and 2 immediately appeared to be of interest because of their high resistivity and of

their straight layout. The fact that these features were so prominent did raise doubts as to whether the high resistivity of zones 1 and 2 was due to a temporary instrumental error. Indeed something could have affected the proper functioning of the instrument, or some local conditions could have interfered with or altered its proper operation. However in spite of the fact that different segments of the resistivity highs belonged to different adjacent main squares and were surveyed in different days (Oct. 12 and Oct. 14) no discontinuity between segments of the highs was observed along the contact line between the different main squares. This clearly indicated that the observed anomalies were not due to any peculiar behaviour of the instrument.

In order to better visualize the surface variations of the resistivity in the area, iso-resistivity lines were plotted on an isometric projection (fig. 5). It is immediately evident that the resistivity in zones 1, 2, 3 and 4 is high. Indeed the frequency of occurrence of the various values in the surveyed area (fig. 6) confirms that the normal value, which is about 70 Ohm metre, is definitely lower than the values in the zones concerned.

To highlight this fact, resistivity values were grouped in various intervals, two different sets of intervals being chosen to reveal the significantly high values involved. One divided the whole range of values into 5 equal intervals (fig. 7) and the other into 4 each containing the same number of measurements (fig. 8). Both additional representations display the same prominent features.

Data interpretation

Electrical surveys give best results in zones where a clear contrast exists between the resistivity of the buried features and that of the surrounding ground. However the contrast may be due to differences in the inherent physical characteristics of the materials or to temporary factors. Thus a different moisture content in various parts of the ground can modify the resistivity and it may cause levelling effects in certain cases or form zones of contrast even where no buried objects exist.

Fortunately, at Aligrama several tests carried out at different places showed that the moisture content was roughly constant down to a relevant depth. Moreover the weather remained unchanged

throughout the survey and there was no rain. Thus the anomalies found there can be considered to be related to the existence of materials having physical characteristics which are different from those of the average ground.

Even so it is clear that the anomalies can reveal either the presence of buried man-made structures and manufactured objects, or the existence of peculiar geological structures, such as a rise in the bedrock hidden by the alluvial cover. However at Aligrama this does not seem to be the case since the alluvial cover is very thick (in some places up to seven or eight metres) and the dip of the bedrock at the base of a nearby hill is 50°-60°.

Yet another geological feature that could cause anomalies similar to those observed in zones 1 and 2 is the presence of sediments deposited by flood waters. At Aligrama the streams flowing down the slope of the nearby hills could have deposited strips of alluvium of different materials which could have been the reason for the elongated shapes of the high apparent resistivity areas. Indeed this possibility should not be completely dismissed, since there are several streams in the zone which often change their course.

Generally when the buried features are man-made structures or manufactured objects rather than geological structures, the electrical resistivity values, are usually no higher than two or three times the average value of the area and are characterized by sharper limits in the anomalous zone. This criterion, which generally leads to correct conclusions, does not hold good however, when the apparent resistivity values are due to a particular geological setting.

The apparent resistivity values in zones 1 and 2 are 230-340 Ohm m while those in the surrounding zone are 90-100 Ohm m and the form of the anomaly is fairly clear (fig. 4), so it can be reasonably assumed that the high apparent resistivity is due to the presence of buried man-made structures.

Additional evidence is, of course, needed to corroborate this assumption before any definite conclusion can be reached. Investigations in the zone ENE of the surveyed area might offer such additional evidence.

Assuming that the anomalies reveal man-made structures, it is possible that these were recently constructed and therefore they are of no archaeo-

logical interest. However, the zone concerned lies about one kilometre from the present village of Aligrama and there are no houses or other structures in the neighbourhood. Thus it is unlikely that canalization works of recent construction exist and it seems more reasonable to suppose that the anomalies reveal an archaeological feature.

Similar doubts also arose over zone 3. There, an anomaly of sufficiently high value seems to indicate the presence of an archaeological feature. Its geometry however is such that this is unlikely.

On the contrary, despite the rather low apparent resistivity values in zone 4 its form and size are such as to suggest the presence of a buried feature.

Detailed investigations to obtain indications on short or isolated buried walls were also carried out and the traces of apparent resistivity values along each profile were examined for M-shaped anomalies which indicate isolated buried walls with the Wenner electrical prospecting method. It ensues that besides the four zones of archaeological interest there are several such M-shaped anomalies (fig. 9) which could point to the existence of walls which in the past were part of houses.

Hence assuming that the anomalies of zones 1, 2 and 4 do reveal buried archaeological features the following additional points can be made concerning the nature of the features.

Zone 4 is characterized by structures which could be interpreted as part of a building probably having two or more rooms, with an area of 12×7 metres. The peculiarities of the anomaly suggest that the perimeter walls are not too wide and that the rooms inside have been filled by material that has fallen from the upper part of the structure. Moreover the low apparent resistivity values could indicate that the complex is not in a good state of preservation or that it lies at a depth of more than one metre.

The high apparent resistivity of zone 1 and zone 2 which distinguishes them from all the rest of the surveyed area is probably caused by a combination of three factors; the first depends on the fact that the measurements were taken with the electrode configuration parallel to the feature. The other two factors could probably be the compactness of the structure and its proximity to ground level.

Zone 1 covering a rectangular area 20 metres in length and of 3-5 metres in width could be interpreted as a large wall.

Zone 2 has the same characteristics as zone 1 but its form is even more regular. It is a rectangle of 15 metres long and 3 metres wide, so it may also be a wall, perhaps better preserved than that in zone 1.

Since zones 1 and 2 are near one another, it is reasonable to conclude that the two walls are not isolated and independent but that they form part of the same construction.

Conclusions.

The purpose of the geophysical survey described in this paper was to locate the boundary wall of what may have been an ancient town and to delimitate the zone of archaeological interest at Aligrama.

Although the position of the boundary wall was not found, the second part of the programme was successfully carried out, and the results of the survey suggest that there are features of archaeological interest in the area east of the Aligrama-Saidu road.

In spite of the careful interpretation of the data which has eliminated a number of initial doubts, some do still remain. The main reasons for this are the short period of time available for the survey and the impossibility of extending the field work, at least in the ENE direction, after processing the data. It will be thus necessary to wait for new geophysical surveys to extend the surveyed area or new excavations in order to corroborate, or disprove, these conclusions.

Apart from the various points made, the survey carried out at Aligrama has shown that measurement of apparent ground resistivity can give useful indications on the presence of buried features.

Acknowledgements.

The writer is most grateful to Prof. A. Marusi for his enthusiastic support throughout the project and to Prof. G. Stacul for his assistance while surveying. Thanks are also due to Dr. R. E. Linington for supplying the data concerning the laboratory tests, to Dr. L. Bernetti for the computer work and to Mr. G. Cavicchi for drawing the figures.

*Fondazione Lerici
Roma*

References.

- Aitken, M. J., 1961, *Physics and archaeology*, Interscience Pvb. Inv., New York.
- Stacul, G., 1973. *Excavation at Aligrama, Swat Pakistan Archaeology*, 9.
- Stacul, G. and Tusa, S., 1976. *Excavations at Aligrama in the Swat Valley (1966-1972)*. East and West, 25.

Abstract.

A survey of ground resistivity at the Aligrama archaeological site in Swat Valley, Pakistan, has yielded results interpretable in terms of possible buried features. Four zones of anomalous apparent resistivity have been found; two of them, apparently related to each other, might indicate the existence of a buried channel either natural or man-made, the third anomaly is probably due to the presence of remains of one or more houses. The fourth anomaly is thought unlikely to be caused by features of archaeological interest.

Riassunto.

Una campagna di prospezione geofisica è stata condotta nel 1975 nella regione dello Swāt, Pākistān, nell'ambito della spedizione archeologica italiana organizzata dall'IsMEO in collaborazione con l'Università di Trieste.

Tale campagna era stata decisa per poter eventualmente individuare le mura di cinta dell'inse-

diamento della collina di Aligrāma già scoperto in anni precedenti, e di delimitare la zona di interesse archeologico in quella zona.

È stata eseguita una prospezione con il sistema elettrico usando la configurazione di Wenner con distanza elettroica di 1 metro. Le misure sono state fatte ogni metro dopo che la zona interessata era stata divisa in quadrati di venti metri di lato sui quali era stata sovrapposta una griglia di un metro.

Le figg. 4, 5, 7 e 8 raffigurano i risultati della prospezione che rivelano quattro zone significative. Considerazioni di carattere geologico e archeologico hanno suggerito che le zone indicate in fig. 4 con i numeri 1, 2 e 4 possono essere interessate dalla presenza di formazioni archeologiche sepolte. È tuttavia improbabile che le zone 1 e 2 possano essere causate da mura di cinta; si viene piuttosto a pensare ad un canale di convogliamento di acque possibilmente fatto dall'uomo oppure ad un grosso e casualmente regolare apporto di materiale alluvionale proveniente dai fianchi della collina.

La zona 4 sembra invece essere interessata dalla presenza di alcuni muri che costituivano una o più case di modeste dimensioni, probabilmente oggi in cattivo stato di conservazione.

Si può quindi ragionevolmente concludere che tutta la zona in oggetto della prospezione elettrica sia interessata da formazioni archeologiche sepolte.

Tali risultati sono da considerarsi particolarmente utili in quanto essi suggeriscono che metodi geofisici possono essere usati con successo in tale zona per prospezioni archeologiche.

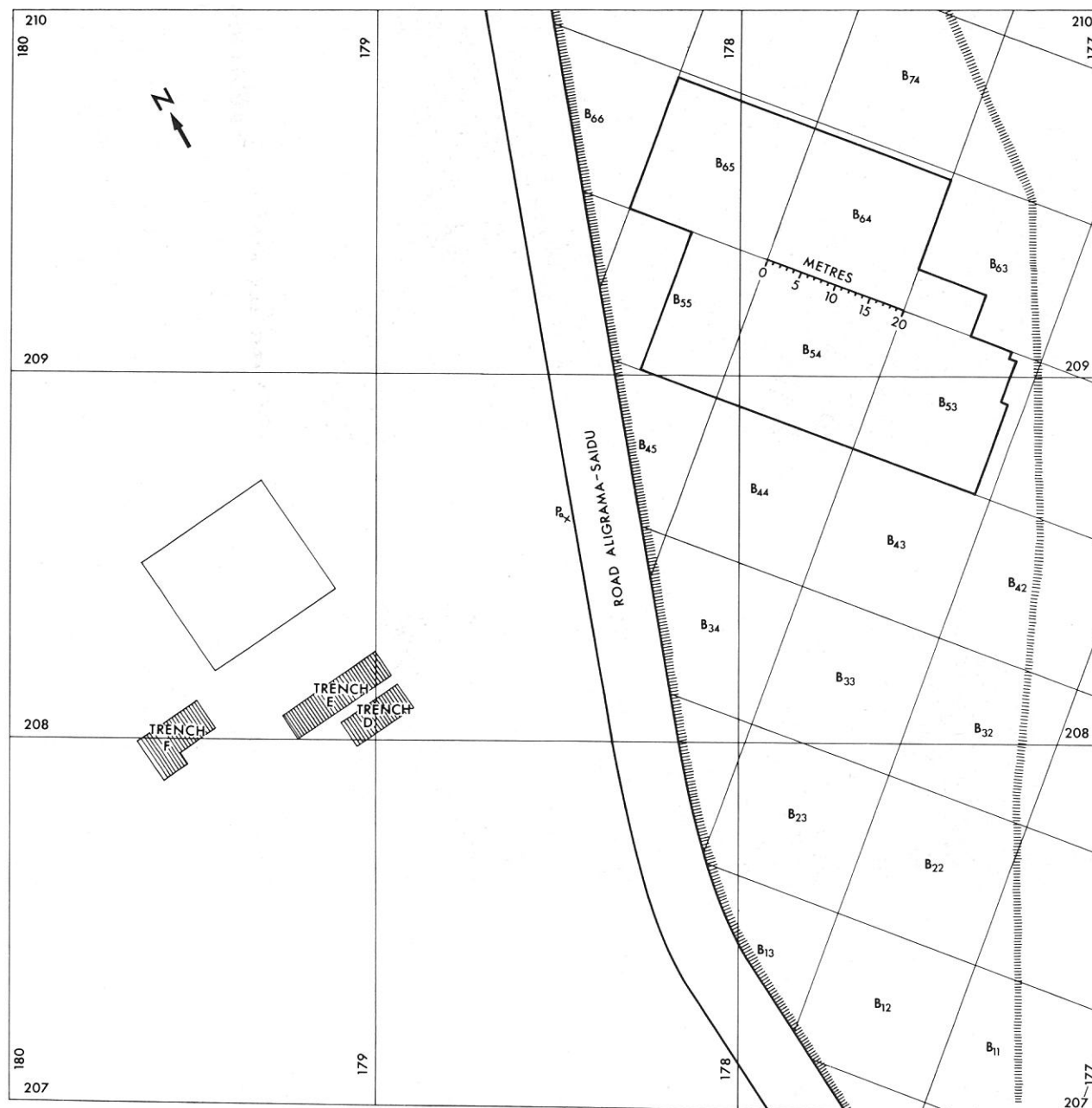


Fig. 1. - Map showing the area of the electrical resistivity survey and the trenches excavated during the previous campaigns.



Fig. 2. - The area of the survey visible on the other side of the road. In the foreground the excavated trenches. The photograph is taken toward the east.



Fig. 3. - The area of the survey with the Aligrāma-Saidu road in the background. The photograph is taken toward the WSW.

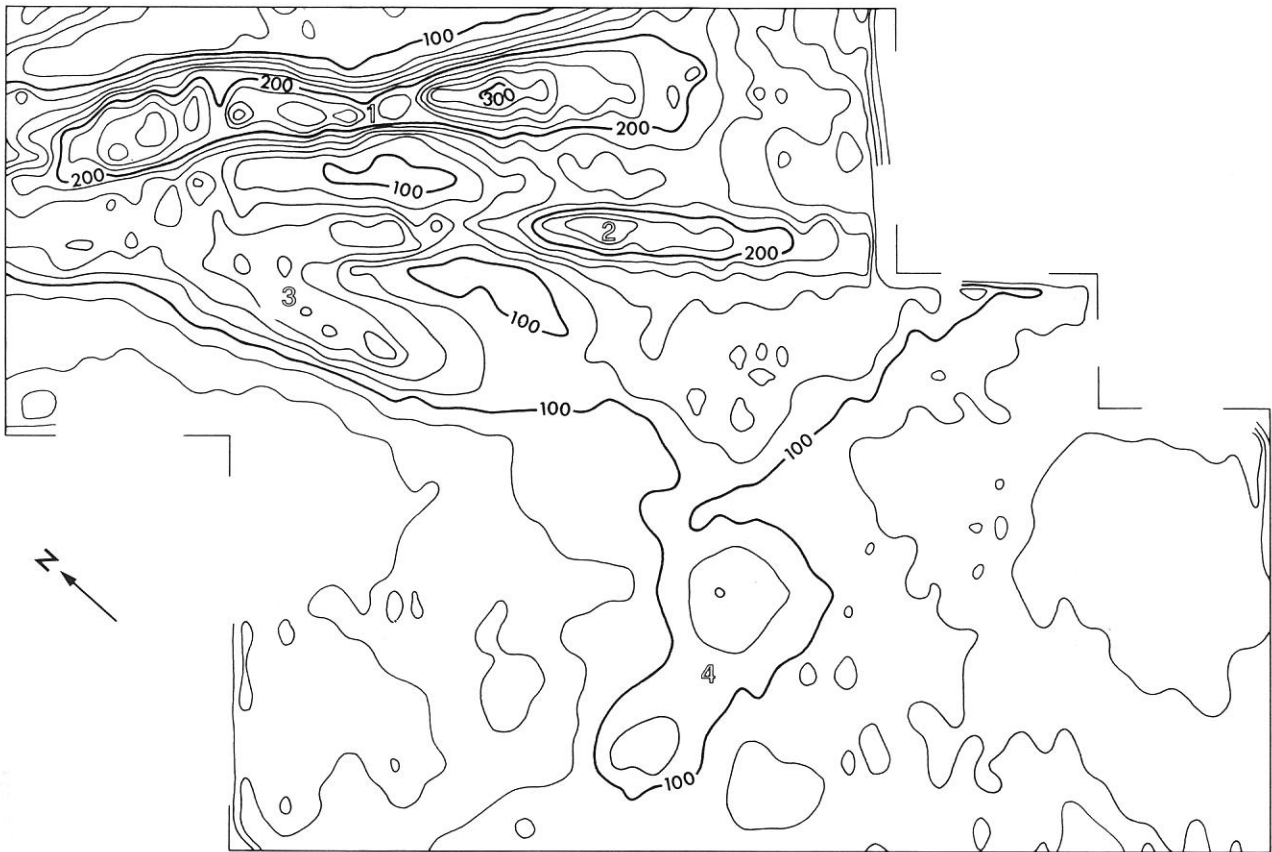


Fig. 4. - Surface distribution of the apparent resistivity values plotted by a HP 2100/B computer. Contour interval: 20 Ohmm. Open digits refer to zones discussed in the text.

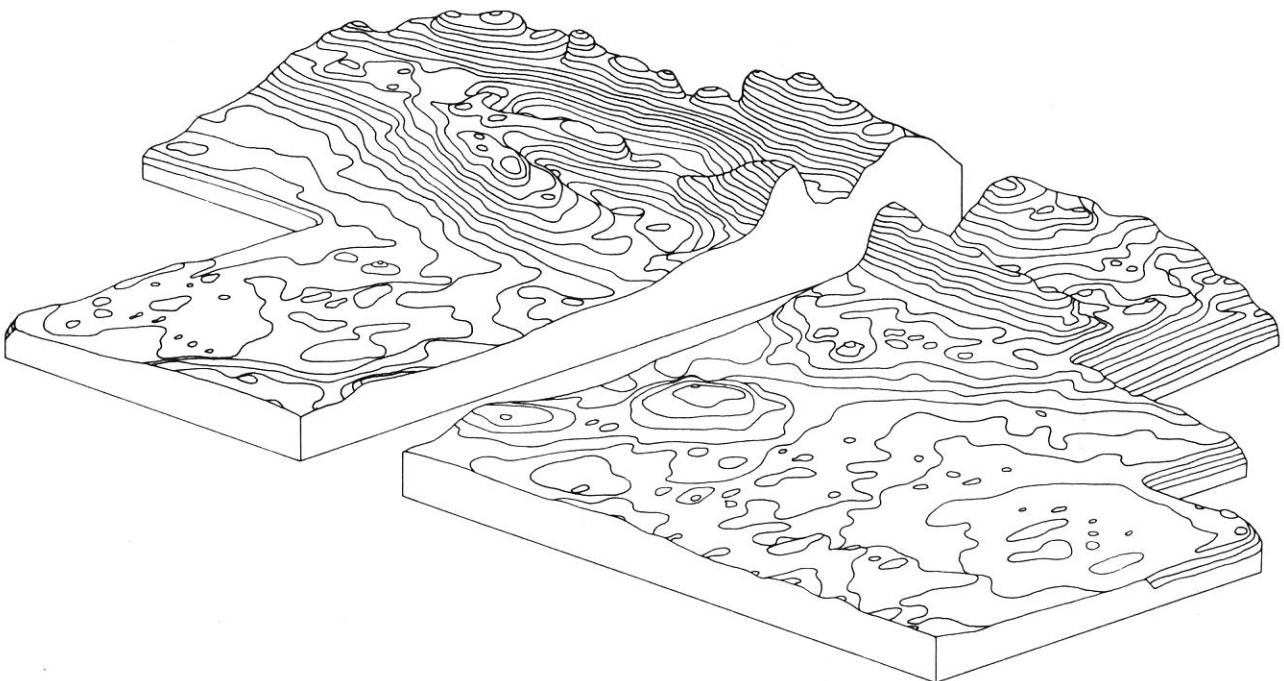


Fig. 5. - Isometric projection of the distribution of the resistivity values in the surveyed area. The NE-SW cross-section shows better the variations of the values.

CUCARZI

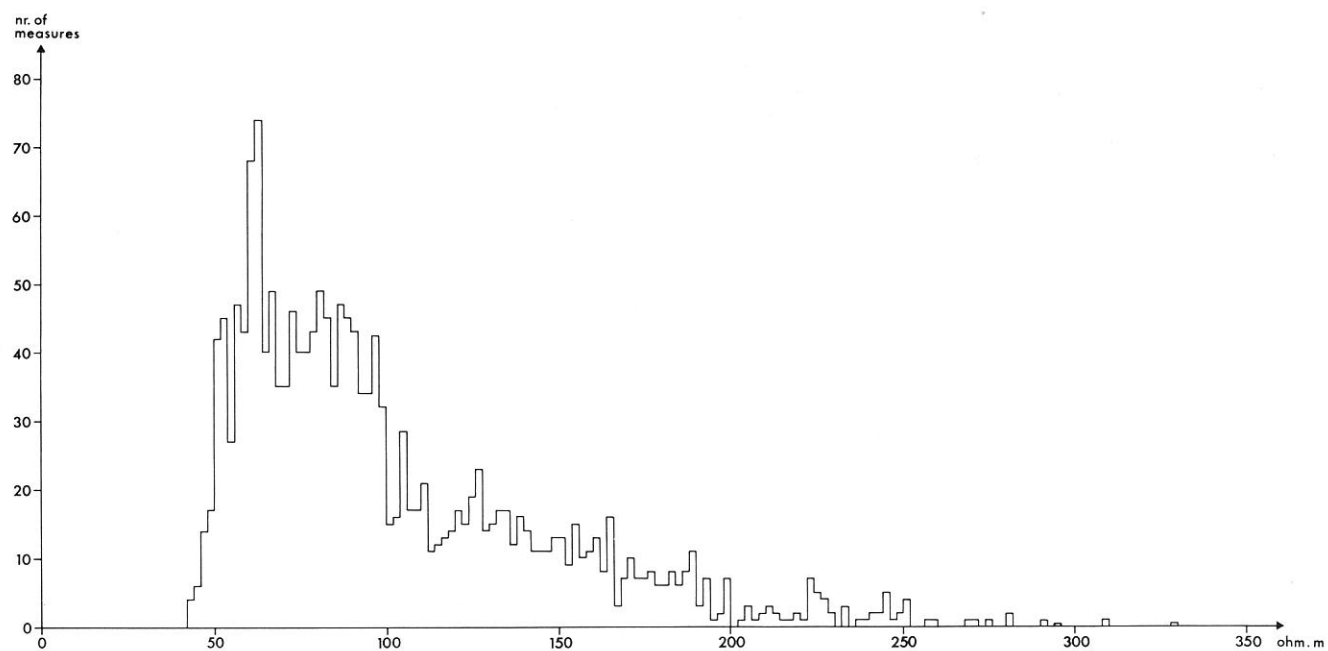


Fig. 6. - Frequency histogram of the resistivity values.

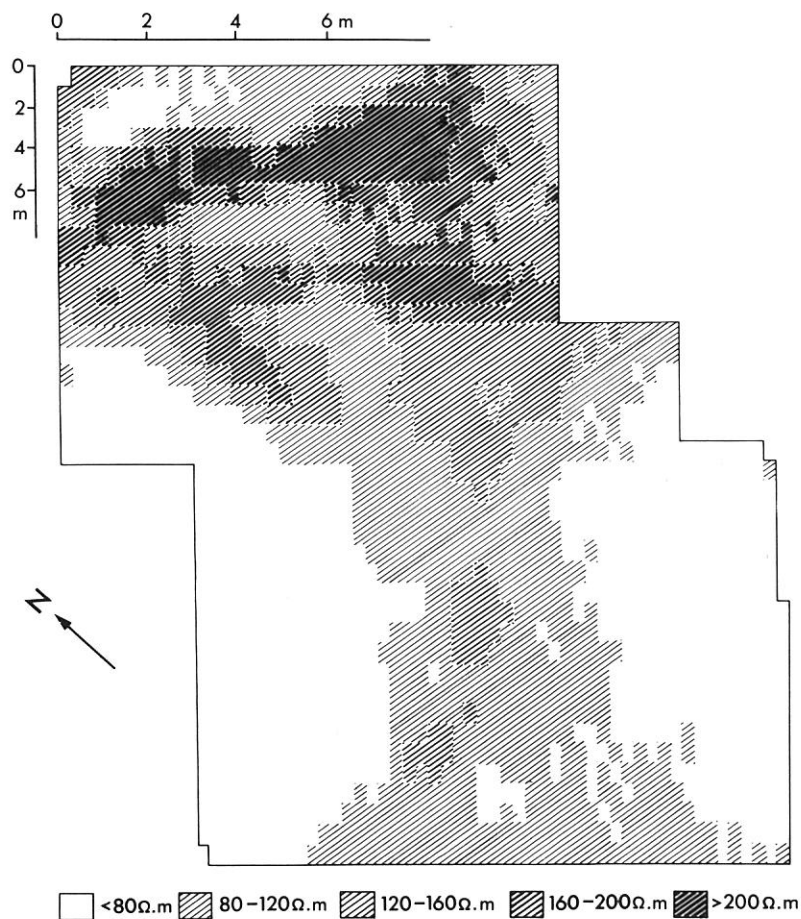


Fig. 7. - Distribution of the resistivity values. Hatchings represent equally large intervals.

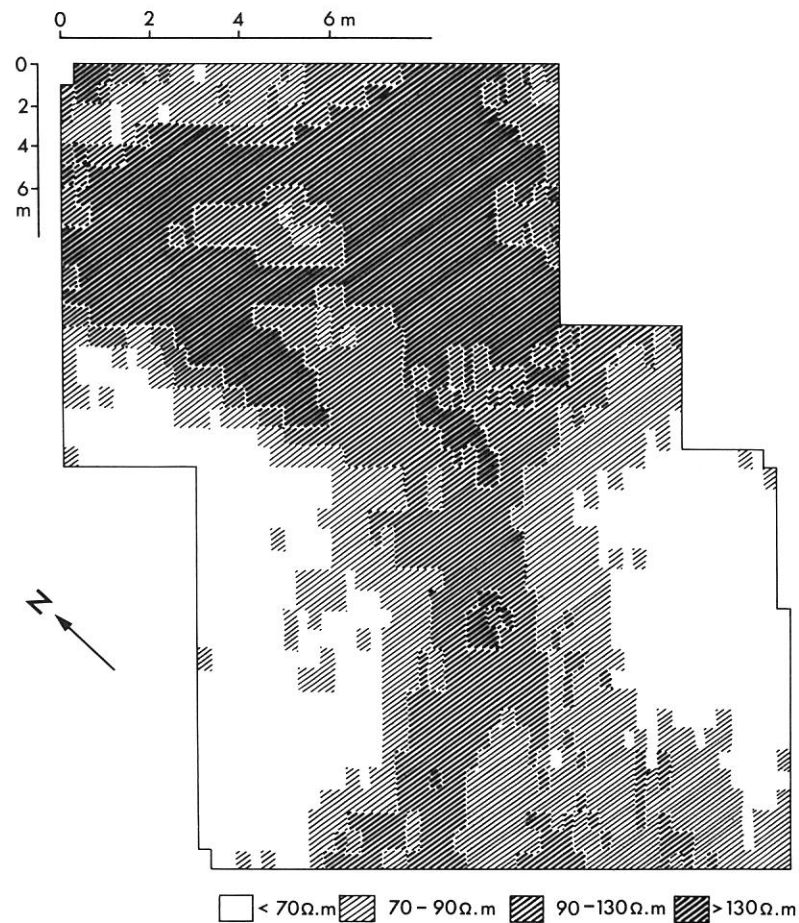


Fig. 8. - Distribution of the resistivity values. Hatchings represent intervals containing the same number of measurements.

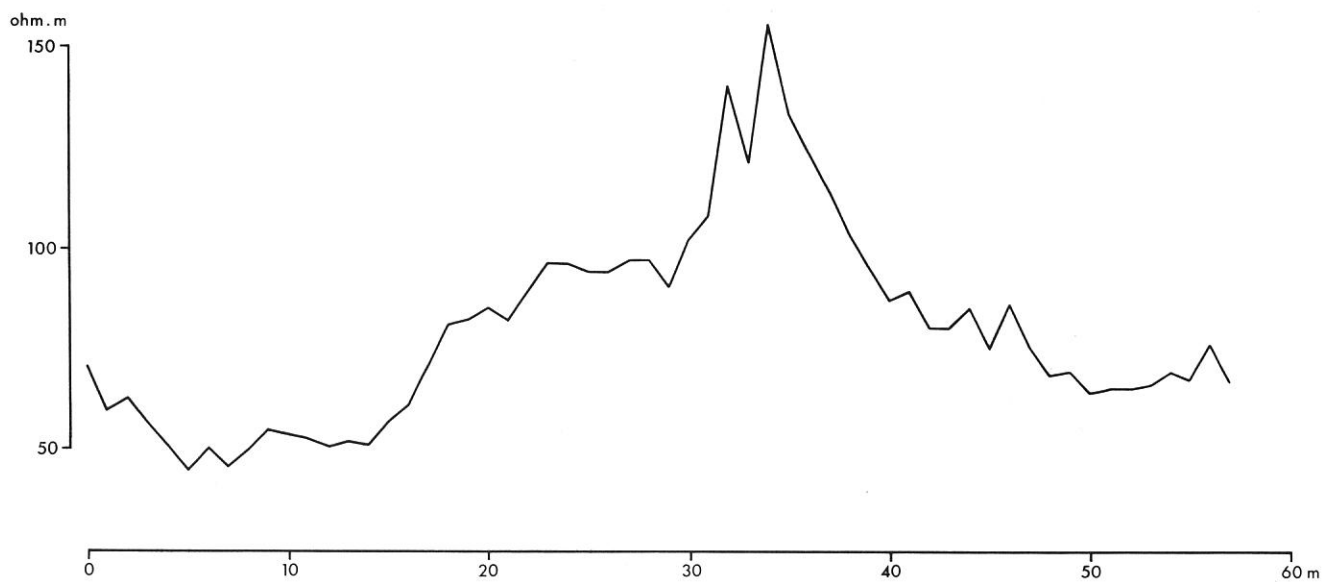


Fig. 9. - Instance of a resistivity profile showing a typical M-shaped variation.