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Application of resistivity method for archaeological site investigation at Sungai Mas, Kuala Muda, Kedah

ABDUL RAHIM SAMSUDIN AND UMAR HAMZAH

Department of Geology
Universiti Kebangsaan Malaysia
43600 Bangi, Selangor D.E.

Abstract: A geophysical survey using geoelectrical profiling technique was conducted at Sungai Mas, Kuala Muda, Kedah which since 1980 has produced a number of important and interesting artifacts of archaeological significance. Archaeological survey team from Universiti Kebangsaan Malaysia and the Museum Department have excavated and revealed several remains of low mounds of laterite block and brick foundations for structure in the village. Geoelectrical measurements employing dipole-dipole array were performed along ten parallel lines located 10–15 metres apart and cover an area with dimensions of 100 x 100 sq. metres. The electrode spacing of 1 m was used with transmitter-receiver separation (N) ranging from 1 to 6 m. Each measured value was plotted at the intersection of two 45-degree lines through centres of the dipoles. The measurements resulted in the preparation of ten resistivity pseudosections and six isoresistivity maps which indicate variation of resistivity at different depths of investigations. The isoresistivity maps for N = 1, 2, 3 and 4 suggest that there are at least four anomalies of high resistivity or four probable locations of shallow buried artifacts with depths ranging from 1 to 2.5 metres. Two or possibly five more anomalies are observed in the isoresistivity maps for N = 5 and 6. These anomalies are possibly related to artifacts buried at much deeper level below surface. The shallow anomalies appear to coincide well with the locations of the uncovered artifacts. These good correlations demonstrate that the resistivity method can be successfully applied for delineating the archaeological material in the study area.

INTRODUCTION

Several studies have been carried out on the use of geophysical methods to survey archaeological site since the late 1940s and particularly so since development of a portable proton magnetometer in the early 1950s. The early history and development of the techniques for archaeological investigations are discussed by Weymouth and Huggins (1985), Aitken (1974) and Weymouth (1985).

The use of geophysical methods in this type of study is classified as a 'nondestructive archaeology' because it provides three dimensional information about potential logical targets without disturbing them. This technique is very important to the archaeologist who wish to preserve the cultural heritage as well as study it.

Geophysical methods that are commonly used in archaeological investigation are magnetometry, resistivity and ground-penetrating radar. The archaeological features investigated may have size ranging from a few centimetres to a few metres and with depths usually no greater than a few metre.

This paper describes preliminary results of the archaeological site investigation using resistivity method at Lot 735 of Kampung Sungai Mas, Kota Kuala Muda , Kedah. Location of the study site is shown in Figure 1. Thousands of pieces of ceramic shreds to about 7th to 11th centuries A.D., glass and beads were discovered in early 1980 when an irrigation canal was dug through Kampung Sungai Mas (Nik Hassan Shuhaimi and Kamaruddin, 1993). Since then many other artifacts have been uncovered and the most recent and extensive excavations began in 1991 where many interesting finds have been found. There are also other types of finds such as a broken piece of jade bracelet, various types and shapes of roof tiles and building materials such as laterite, brick, shale stone, mudstone, and river pebble. Archaeological works conducted by Universiti Kebangsaan Malaysia and the Museum Department revealed the presence of several remains of low mounds of laterite block and brick foundations for structure in the village. Building parts such as pillar-bases, door-frame, part of a drain and part of staircase have also been found at the site. There is also the remains of a structure which appears to be that of stupa type monument

The resistivity survey was conducted by a geophysical team of the geology department, Universiti Kebangsaan Malaysia at the request of the of Museum Department from 10th to 16th of August 1993. The objective of the survey was to help the on going excavation programme in locating the horizontal distribution as well as depth of the artifacts in the study area. It is also hoped that the results could help in determining the target sites for excavation and reduced unnecessary pitting in the study area.

The resistivity technique appears to be very useful in detecting building materials such as bricks and lateritic blocks because these objects are expected to have high resistivity and excavations may be resistivity highs or resistivity lows depending on the water content and degree of compaction of the materials compared to the surrounding medium. However the success of the resistivity method in determining the archaeological features would depend on the resistivity contrast between the objects and the surrounding rocks or soils. Soils having similar resistivity would tend to hide the anomaly produced by the archaeological object within it.

FIELD METHOD

Resistivity profiling method employing *dipole-dipole* array was conducted using ABEM SAS300 terrameter. The meter reads resistance (V/I) directly in ohm and values are converted to apparent resistivity by multiplying the resistance by the appropriate geometry factor for the array (Zohdy *et al.*, 1974).

The resistivity meter was connected to two potential and two current electrodes. The electrode spacing of 1 m was used with transmitter-receiver separation (N) ranging from 1 to 6 m. Different N

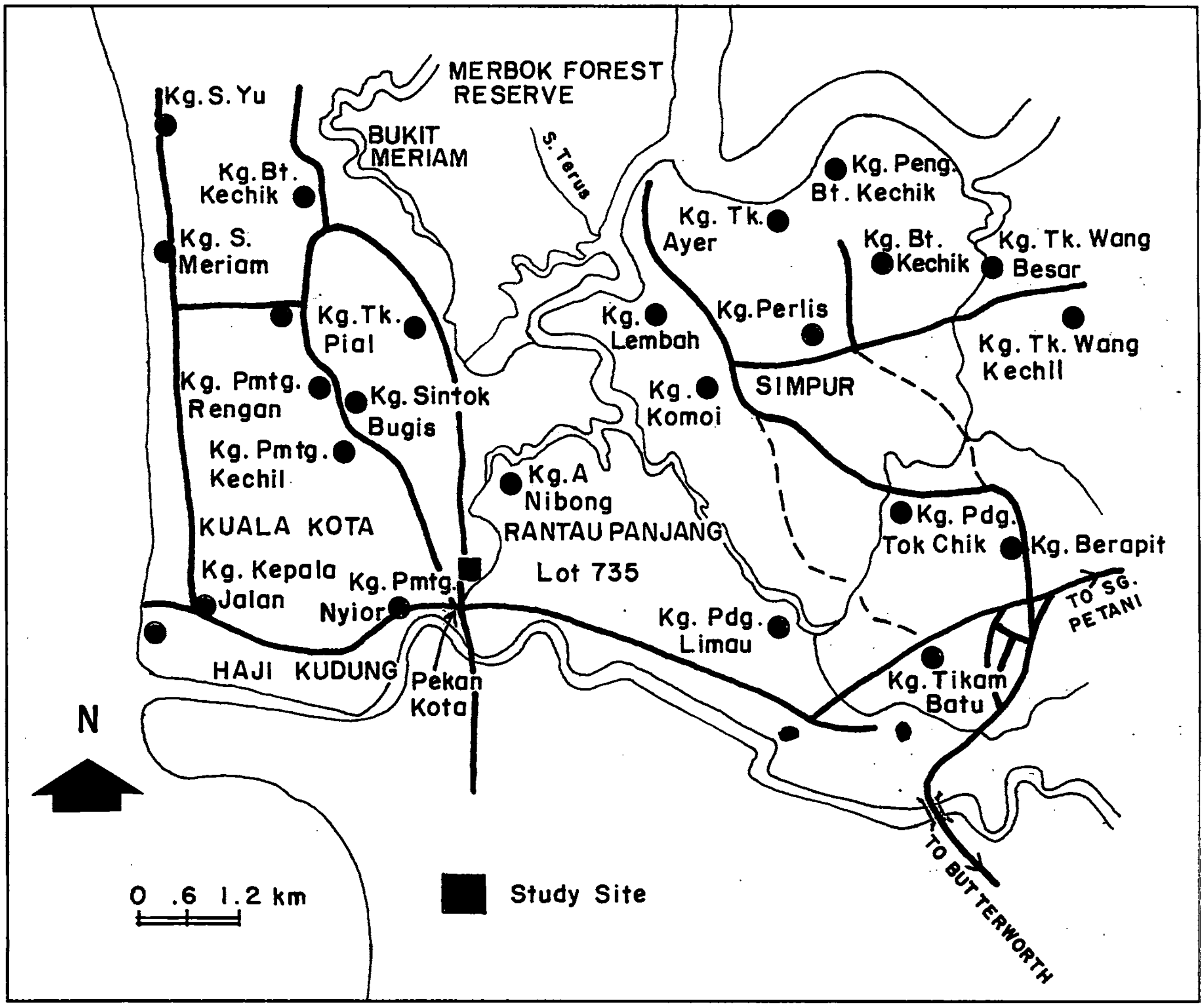

Figure 1. Location of study site.

spacings reflect different depths of investigation. The electrode configuration used is shown in Figure 2.

The resistivity measurements were made along ten parallel lines of approximately east-west in direction. The lines are about 10–20 m apart and cover an area of about 100 x 100 m. The location of the lines is shown in Figure 3.

For data plotting, each measured value was plotted at the intersection of two 45-degree lines through the centres of the dipoles. The measurements resulted in the resistivity pseudo section. Isoresistivity maps were also prepared to determine which N value would show the best correspondence with known or suspected archaeological features. Geoelectrical soundings were also carried out to determine the resistivity of the soil and country rock in the study area.

SITE DESCRIPTION AND RESULTS

The investigation site is located close to Sg. Muda and covers an area of approximately 100 x 100 m. The area which has relatively flat topography consists of alluvium and coastal marine deposit. The resistivity of the soil is low and homogenous. The artifacts represented by old bricks and rocks were found buried by the soil at relatively shallow depth. The resistivity of these artifacts are expected to be high and therefore should be easily detected by the resistivity survey.

Based on a few sounding results, three categories of resistivity readings were observed for the study site:

i) soil with resistivity less than 20 ohm-m
ii) soil with resistivity ranges from 20 to 200 ohm-m
iii) soil with resistivity greater than 200 ohm-m

The first category of the low resistivity is interpreted to be related to marine sediment or sandy soil with salt water content. The second category of resistivity reading is referred to alluvium or sandy soil with brackish to fresh water contents. The third category of relatively high resistivity is believed to be related to the presence of archaeological object buried below surface.

A total of six isoresistivity maps and plots of ten resistivity pseudosections were obtained from the resistivity measurements. The isoresistivity maps for different values of N indicate the variation of resistivity at different horizons below surface. The plots of isoresistivity maps for N = 1, 2, 3 and 4 consistently reveal the presence of four distinct anomalies of high resistivity. These anomalies are relatively large in size and illustrated as A, B, C and D in Figure 4. Location of these anomalies coincide well with the artifacts revealed from the earlier excavation programme in the study area. Depth of the artifacts interpreted from the resistivity pseudosection (Fig. 5) range from 0.1 to 2.5 m below surface.

Two or possibly five more anomalies are observed in the isoresistivity maps for N = 5 and 6 and illustrated as E, F, G, H and I in Figure 6. Their plot of pseudosection (Fig. 7) suggest that these anomalies could be produced by the artifacts buried at much deeper level (greater than 3 metres). If this information is true therefore deep excavation is necessary. This means that the archaeological study would involve excavation work below the water table and hence at higher cost.

CONCLUSION

The resistivity survey using dipole-dipole configuration has successfully revealed the presence of archaeological artifacts in the study area. Four shallow buried artifacts and two or probably five more artifacts possibly buried at much deeper level are shown in the isoresistivity maps and their corresponding resistivity pseudosection plots.

The shallow resistivity anomalies coincide well with the location of the uncovered artifacts obtained from the previous archaeological investigation. However for the deeper anomalies, a special excavation programme is necessary in order to confirm the possible presence of deeply buried artifacts. The present results also demonstrate that the resistivity profiling method can be used effectively to locate the shallow buried artifacts in the study area.

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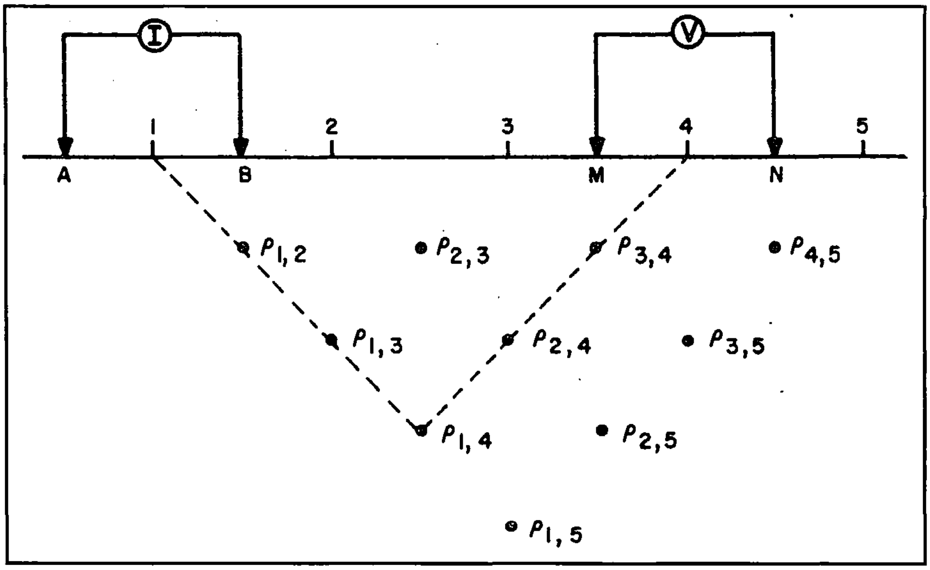

Figure 2. Dipole-dipole electrode configuration and its corresponding pseudosection plot.

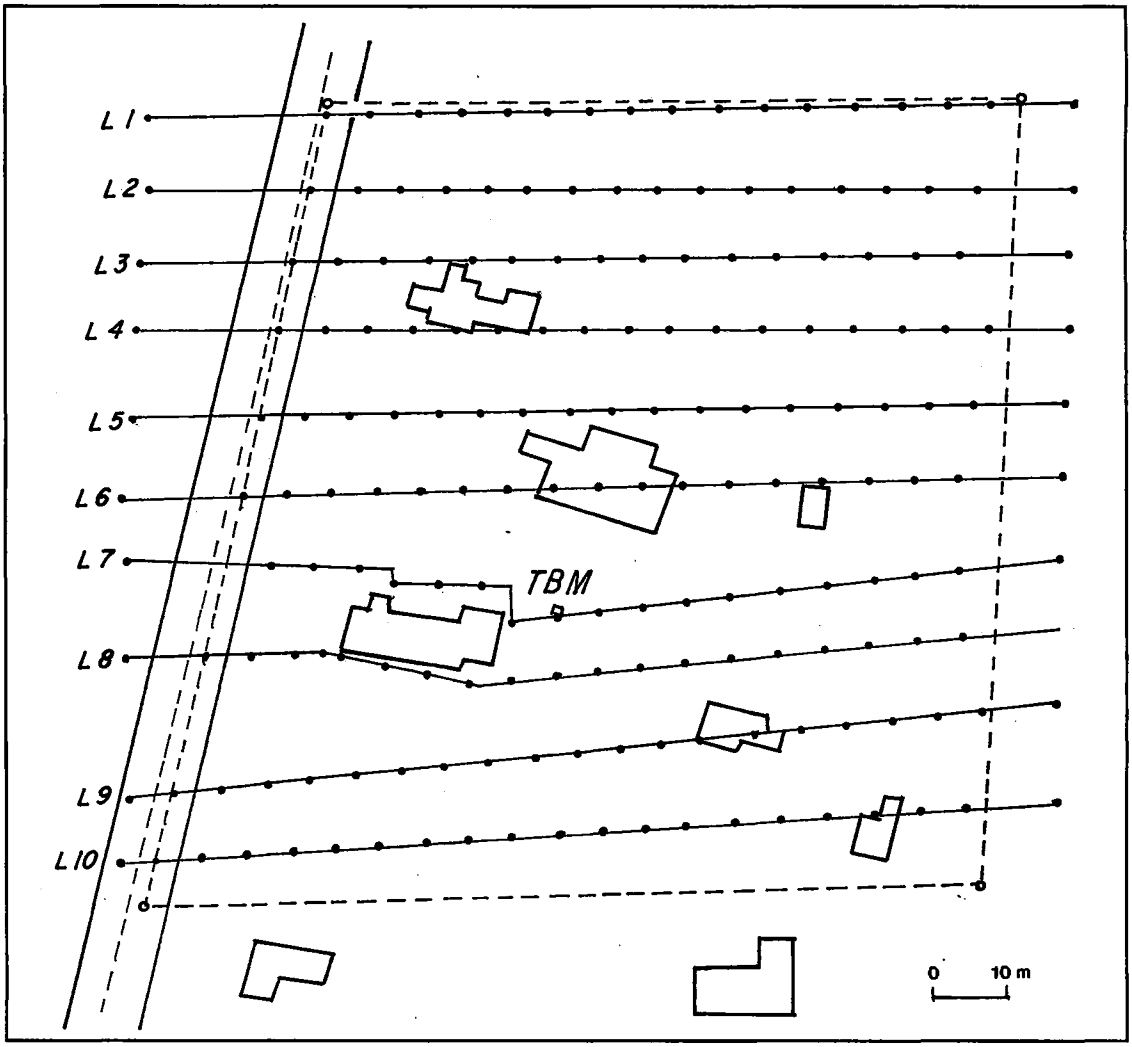

Figure 3. Study site showing positions of the resistivity lines.

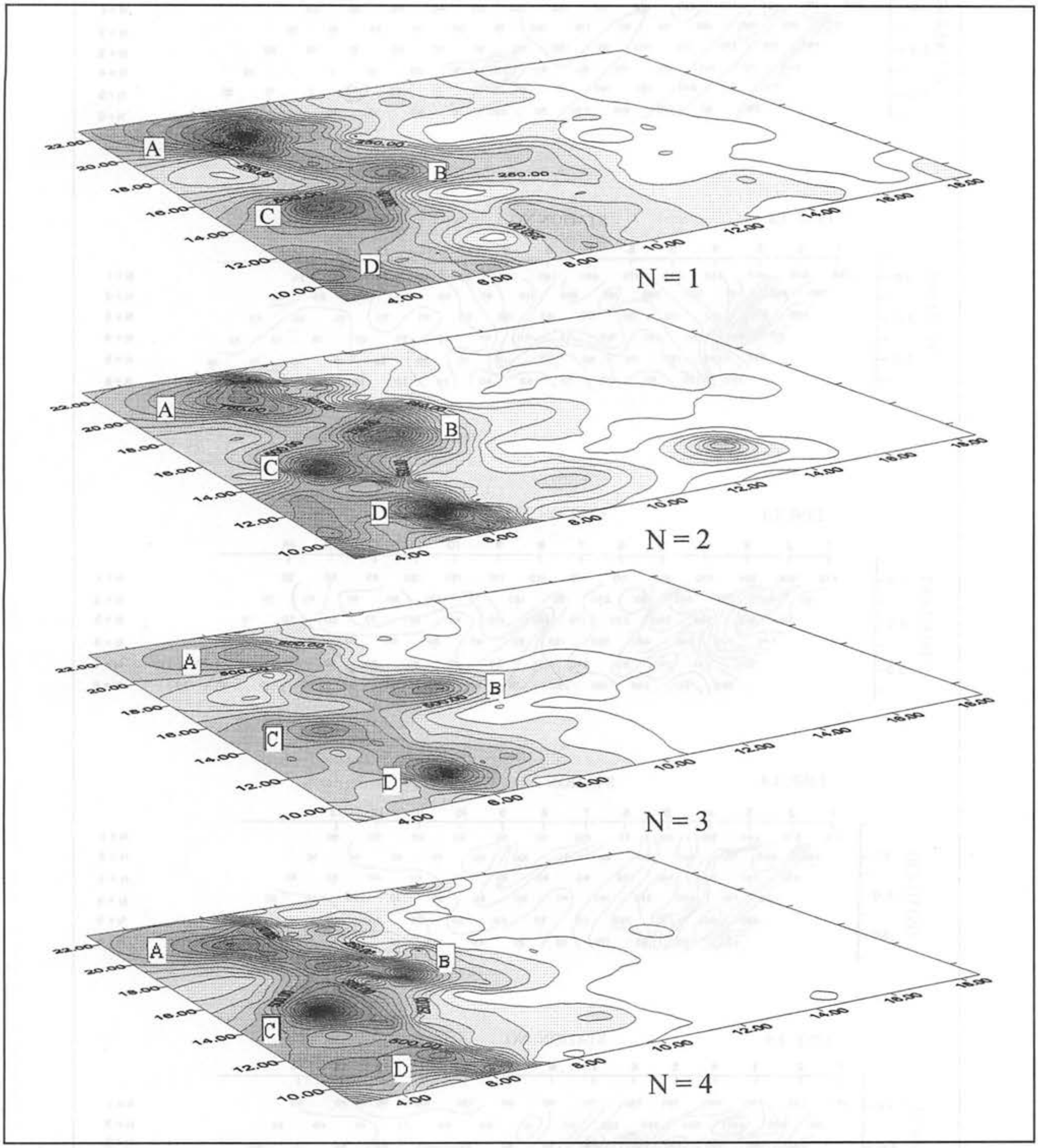

Figure 4. Isoresistivity map for horizon N = 1, 2, 3 and 4.

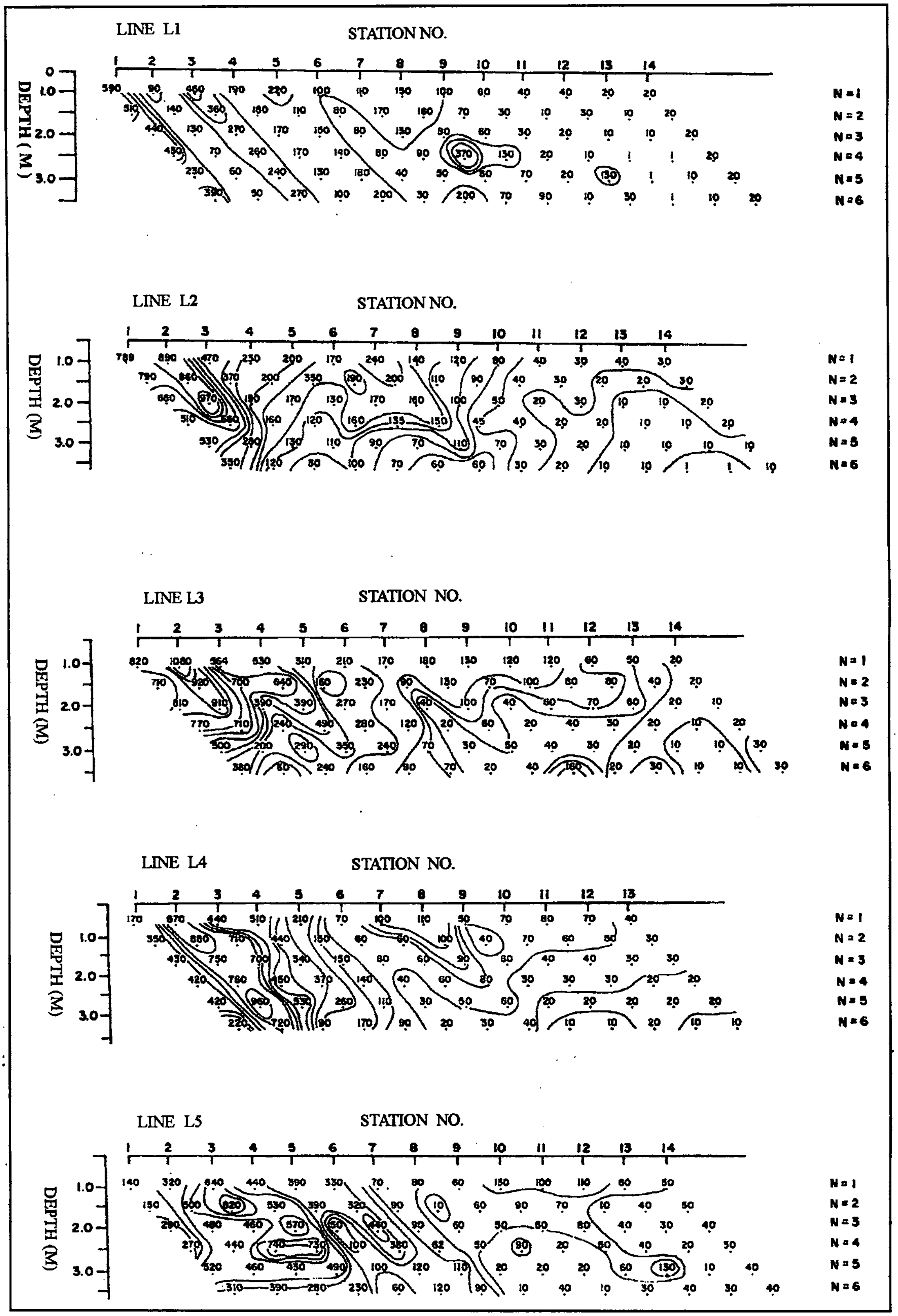

Figure 5. Pseudosection plots at profiles L1, L2, L3, L4 and L5.

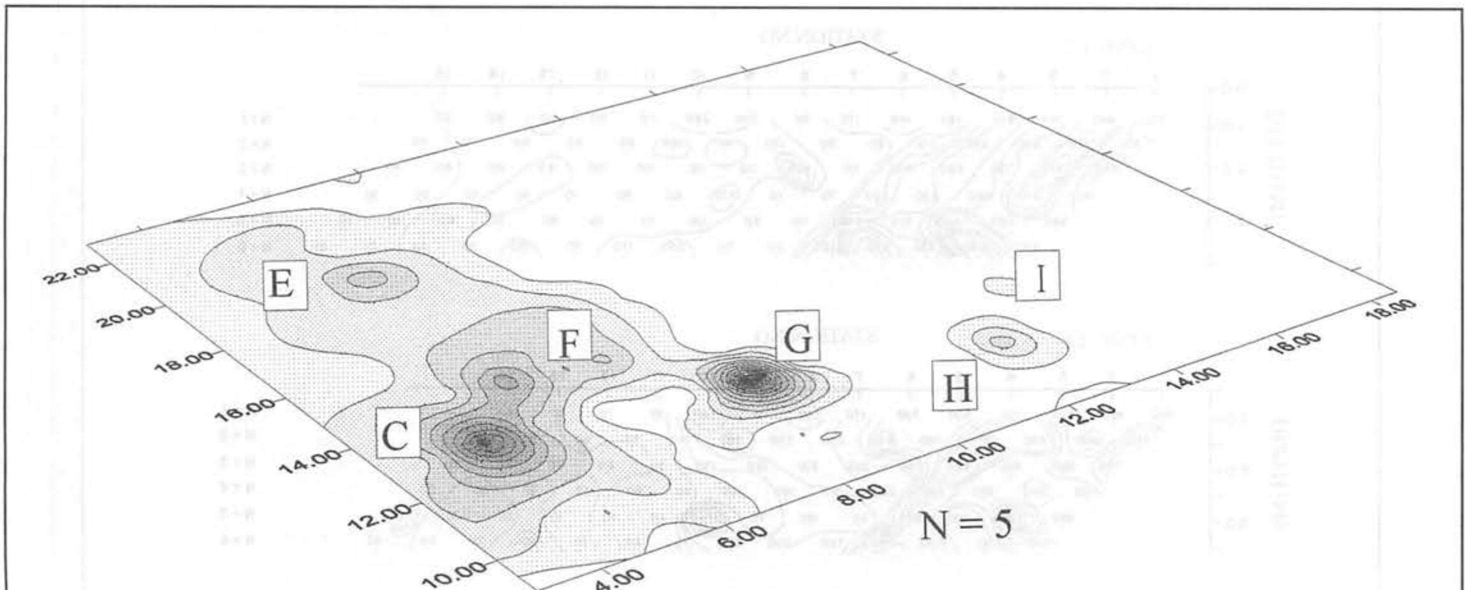

Figure 6. Isoresistivity map for horizon N = 5 and = 6.

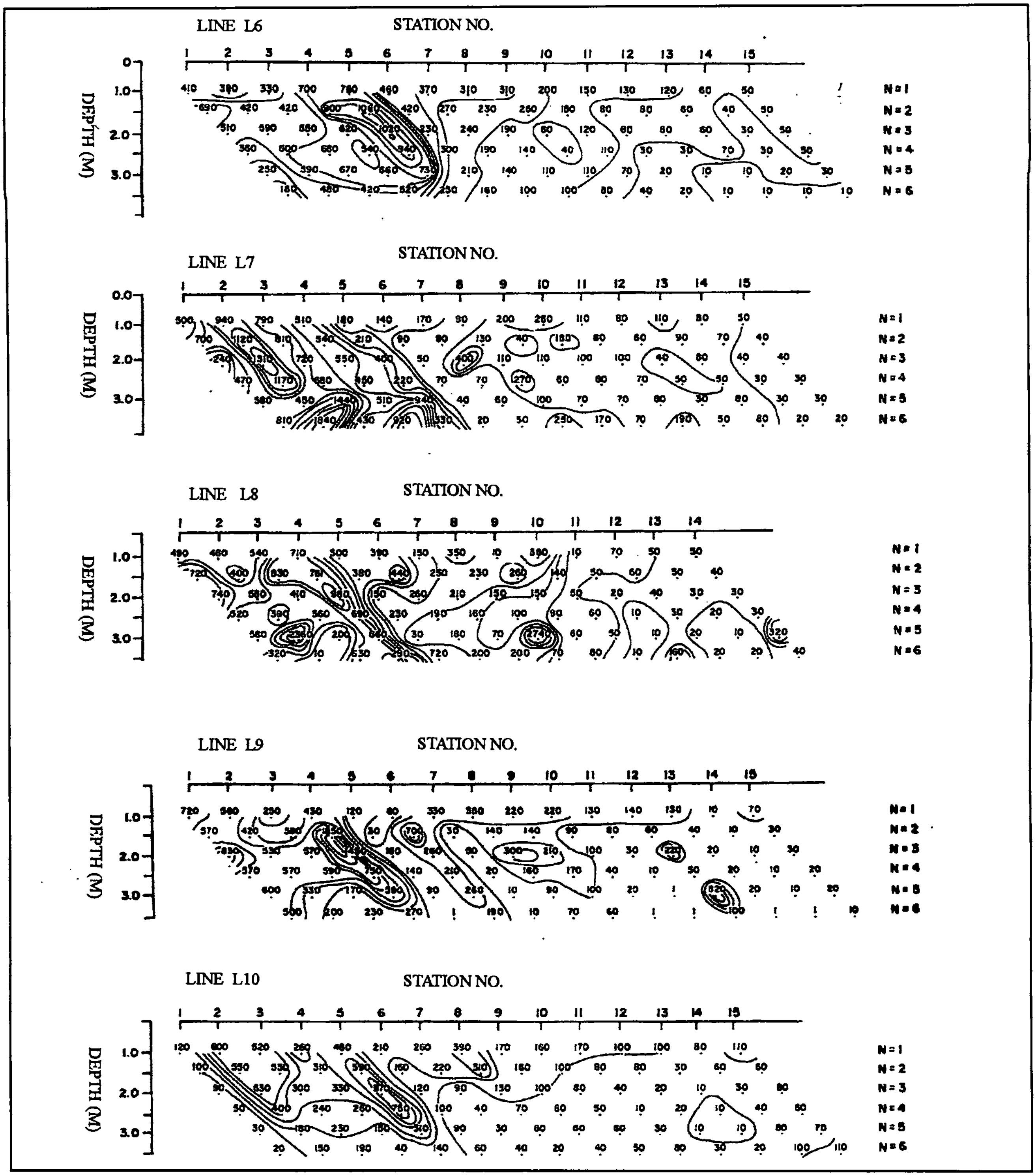

Figure 7. Pseudosection plots at profiles L6, L7, L8, L9 and L10.

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