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Geoelectric Study of Dam Site of Federal College of Agriculture Akure Southwestern Nigeria

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Abstract: Geophysical investigation has been undertaken at an existing dam site within the campus of the Federal College of Agriculture, Akure. This is aimed at evaluating the geophysical characteristics of the bedrock along the dam axis and its banks. The survey involved the use of electrical resistivity (VES) depth sounding technique. The Schlumberger electrode configuration was adopted for the field study. Thirty-three soundings were undertaken on nine traverses that were established in North-South directions on the Western (W1-W3) and Eastern (E1-E3) flanks and West-East traverses established on the Southern end of the dam (S1-S3). The three major litho logy units delineated are the topsoil, weathered basement and the presumably fresh/fractured bedrock. The geoelectric section revealed a network of lineaments presumed to be fractures on the S1-S3 and W1-W3 profiles. The geoelectric maps show high resistivity contours straddled with low resistivity lines characterizing the eastern flank thus indicating near-surface bedrock straddled with a basement depression or fracture. The presence of the depression or fracture is considered inimical to the continued retention of water in the reservoir. This is considered responsible for low water level retained in the reservoir in dry season.

Key words: Geoelectric, agriculture, VES, fracture, dam site, Nigeria

INTRODUCTION

The need to improve portable water supply has been a major concern to stakeholders in water supply schemes in Nigerian communities. Consequently, the construction of small to medium sized dams for water retention to meet water needs of communities. One of such schemes is the existing mini dam across a major stream (Majo River) within the Federal College of Agriculture Akure campus in Southwestern Nigeria (Fig. 1).

Despite detailed geotechnical studies preceding the construction of dams, a number of unforeseen problems still appear soon after such structures are put into use. One of such problems may be caused by existence of concealed fractures/faults, fissures, joints or shears which can greatly reduce the reservoir capacities of dams. They pose great difficulties in public works and their non delineation may lead to failure of otherwise well planned projects (Ojo *et al*., 1990). Anomalous seepage through, under or around a dam is also a frequently occurring geotechnical problem at existing dam sites (Butler *et al*., 1989).

The dam at the Federal College of Agriculture Akure has been put under some surveillance in recent years. During the monitoring exercise, the reservoir level was found to fluctuate greatly. This has adversely reduced the quantity of water supplied to the college and its adjoining communities of Ijapo Estate in Akure metropolitan area. However, the dam has not shown any observable structural defect (s), but the existence of geological features within the vicinity of the dam could increase the loss of reservoir water.

This study is aimed at evaluating the geo-structural setting of the concealed bedrock along the southern major dam axis and its eastern and western banks.

GEOMORPHOLOGY AND LOCAL GEOLOGY

The study area is well drained with Majo river bed forming a valley within its vicinity making it a drainage basin for surface water in the environment. The Northern flank of the dam is covered by thick vegetation. There are some ecological alterations occasioned by human activities through cultivation on the Eastern and Western flanks of the dam.

Rocks of Precambrian Crystalline Complex of Southwestern Nigeria underlie the study area (Fig. 2). The study zone is underlain by the most abundant member of older granite suite (coarse porphyritic granite) and

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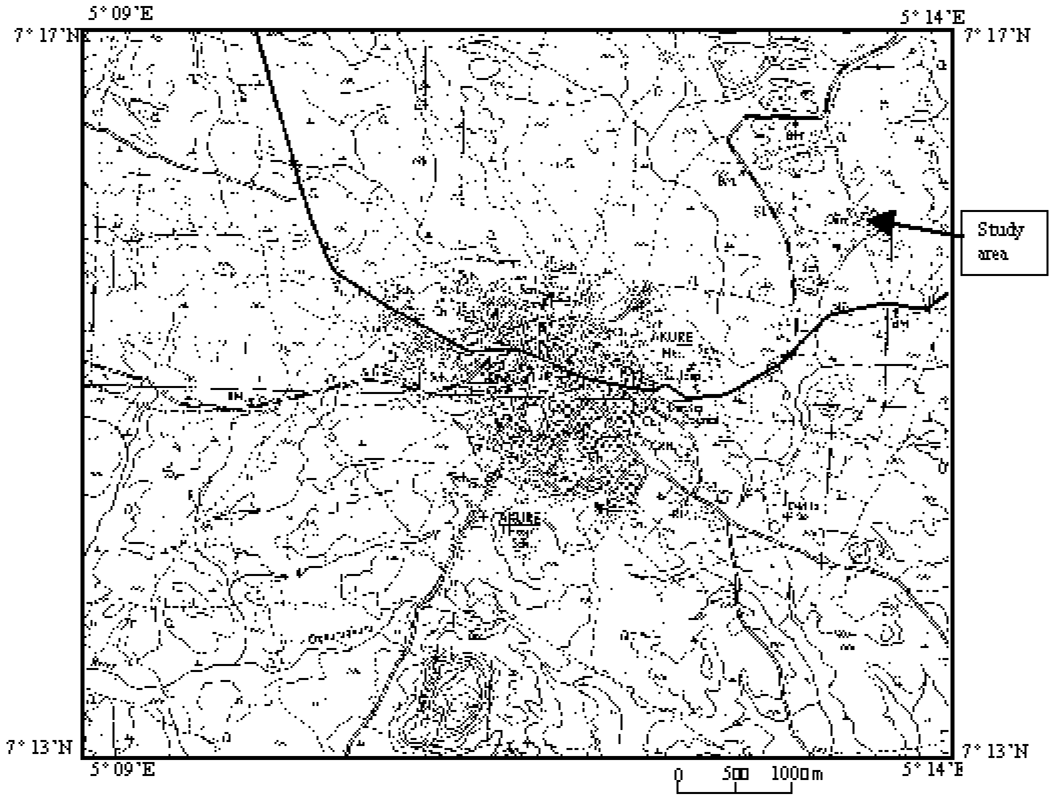

Fig. 1: Topographical map of Akure Southwester Nigeria showing the study area

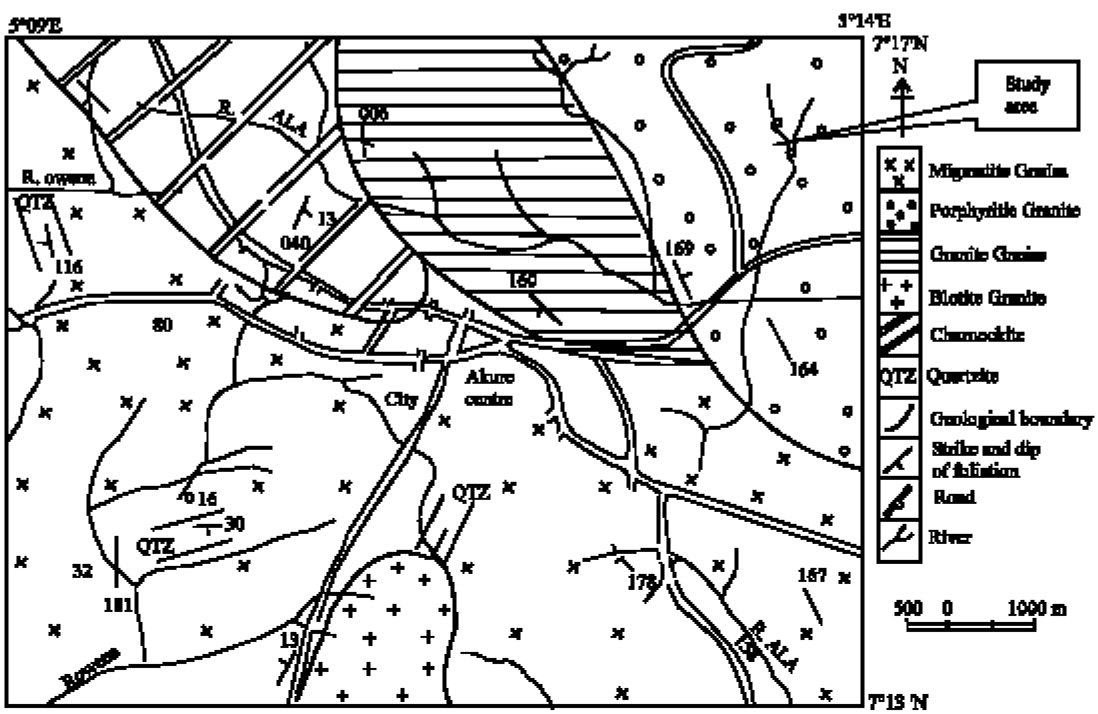

Fig. 2: General geology map of Akure Southwestern Nigeria (after Owoyemi, 1996) showing the study area

described by Oyawoye (1972) as prophyroblastic granite. However, the basement rock is concealed in most parts of the site. Isolated outcrops were encountered close to the concrete weir on the western flank.

MATERIALS AND METHODS

In order to ascertain the structural setting of the bedrock beneath the central axis of the weir and the water tightness of the reservoir area, a geophysical investigation involving the electrical resistivity method was carried out during the peak of raining season in Nigeria (July). The Vertical Electrical Sounding (VES) technique utilizing the Schlumberger electrode configuration was adopted for field data acquisition.

Thirty-three sounding stations were occupied along nine survey profiles (Fig. 3). The current electrode separation (AB) was varied from 2 to 130 m. The VES stations were spaced between 40 and 50 m to cover the study area. The VES data are presented as sounding curves. These involved the plots of the apparent resistivity (ρ_a) values against the electrode spacing (AB/2) on bi-log graph. Typical depth sounding curves obtained from the study area are presented in Fig. 4.

Quantitative interpretation of the VES curves involved partial curve matching and computer iteration techniques (Verma and Pantula, 1990). The interpreted results are considered satisfactory with a good fit (over 90% correlation) obtained between field curve and computer generated curve.

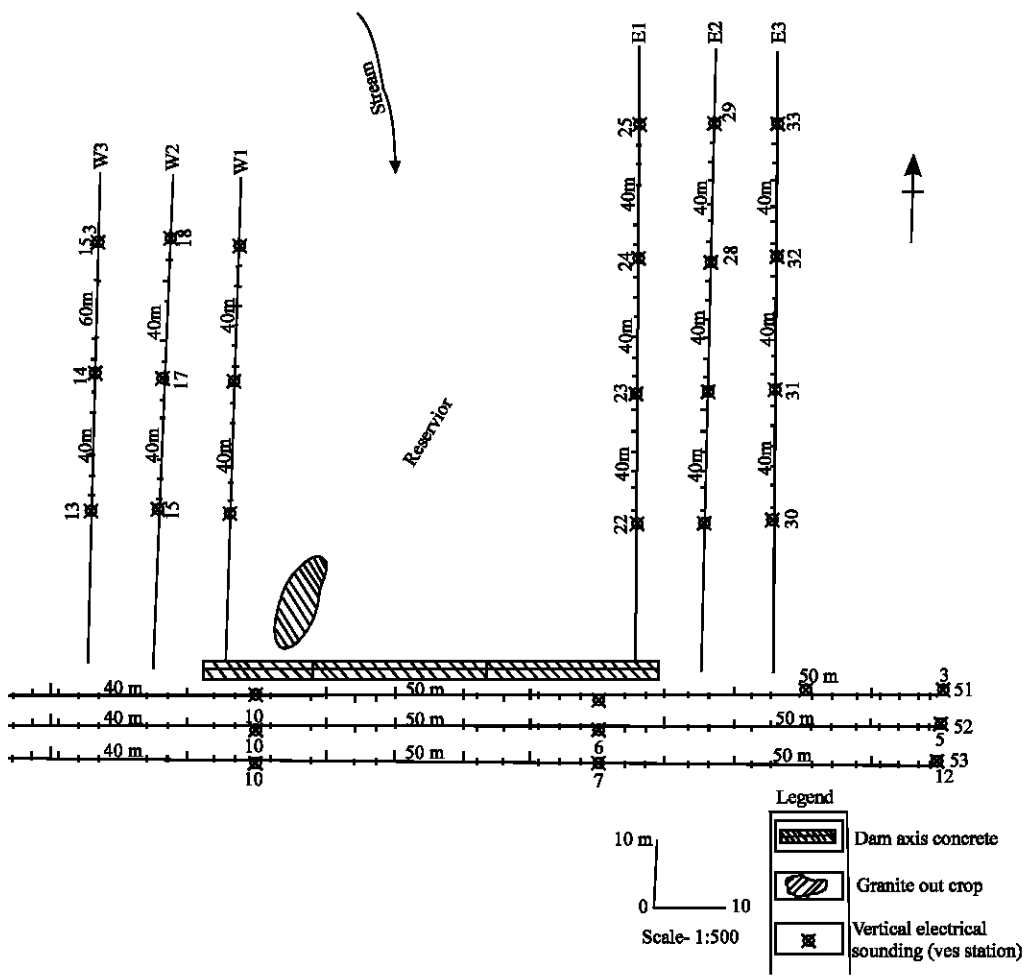

Fig. 3: Layout map of the study area showing geophysical traverses and data points

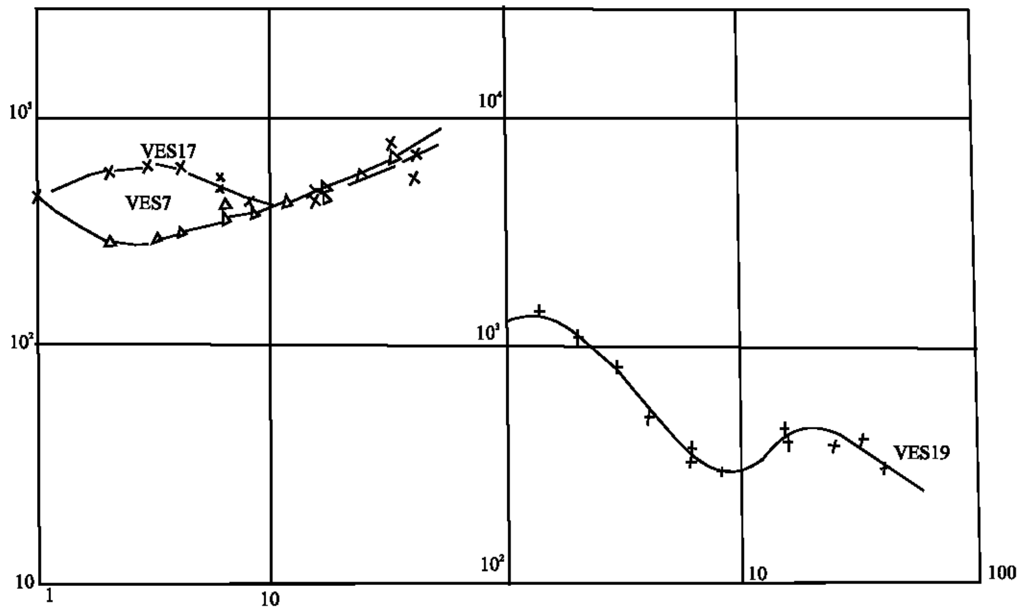

Fig. 4: Typical sounding curves obtained from the study area

RESULTS AND DISCUSSION

Seven sounding curve types with geoelectric layers of between 3 and 5 were obtained in the study area. The observed curved types are H, K, HK, KH, HA, KHA and KHK. The 3-layer H curve type predominates while the 3-layer K was obtained at only one sounding location.

Geoelectric sections: 2-D geoelectric sections along profiles S1-S3, E1-E3 and W1-W3 are presented in Fig. 5-7, respectively. Three major geoelectric layer units were delineated beneath the sections. These are the topsoil, weathered basement and the fractured/fresh resistive bedrock. The topsoil consists of laterite/clayey sand/sandy clay with resistivity values varying from 136 to 3132 Ω-m. Layer thickness varies between 0.6 and 1.6 m. The weathered layer which has resistivity and thickness varying from 73 to 771 Ω-m and 0.7 to 21.6 m, respectively consists of clay/sandy clay/clayey sand/ sand. The third layer constitutes the bedrock.

The granitic nature of the underlying rock is observed on the outcrop within the reservoir at about 8m north of VES 1. The bedrock resistivity values range from 1029 to 52,134 Ω-m (infinitively resistive). This is diagnostic of partially weathered basement to fresh bedrock. Basement fracturing was observed on thirteen locations. They are VES 1, VES 2, VES 3, VES 4, VES 5, VES 6, VES 7, VES 9, VES 10, VES 13, VES 14, VES 18 and VES 21 on profiles S1-S3 and W1-W3. The resistivity values diagnostic of fractures in the dam environment vary from 110 to 952 Ω-m. Their presence is not considered ideal for good dam performance and dam safety. The existence of fractures is generally accompanied by high fluid streaming potential. Hence, substantial water may be lost through the fractures thus initiating the weakening of the dam foundation. Geoelectric attributes indicative of sandy clay, clayey sand observed in the weathered layer were obtained from curve types associated with thick overburden (i.e., HA, KH and HKH).

Figure 8-10 shows the resistivity variation maps at depths of 5, 10 and 15 m. At 5m depth, the resistivity map is characterized by low resistivity values (≤500 Ω-m) in the southern and western flanks. The northeastern flank is characterized by higher resistivity values (>500Ω-m). The higher resistivity zone presupposes the existence of near surface bedrock and vice-versa for the low resistivity areas. At 10 and 15 m depths, (Fig. 9 and 10) more resistive basement rock areas were intercepted. This was indicated by high resistivity values (> 1000 Ω-m) obtained. The attitude of the contour lines show strike direction features of the concealed bedrock to be approximately North-South. A localized bedrock depression whose axis correlate with the low resistivity zone (≤500 Ω-m) marked F-F' was delineated. A basement depression correlated over a significantly long distance could be diagnostic of a buried river channel (Ako and Olorunfemi, 1989). However, this minor bedrock depression could not be correlated on the traverses on western flank.

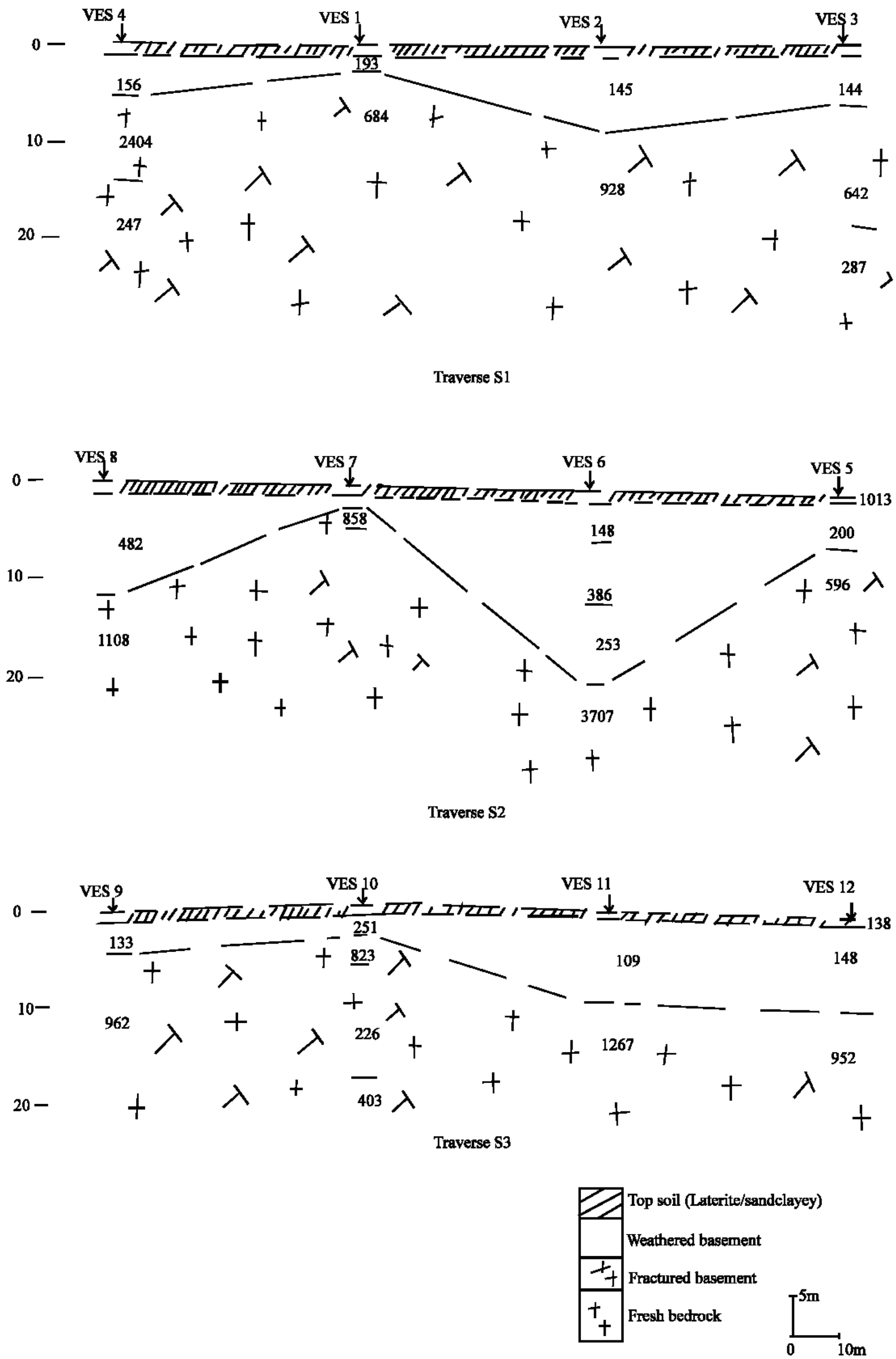

Fig. 5: Geoelectric sections along traverses S1-S3

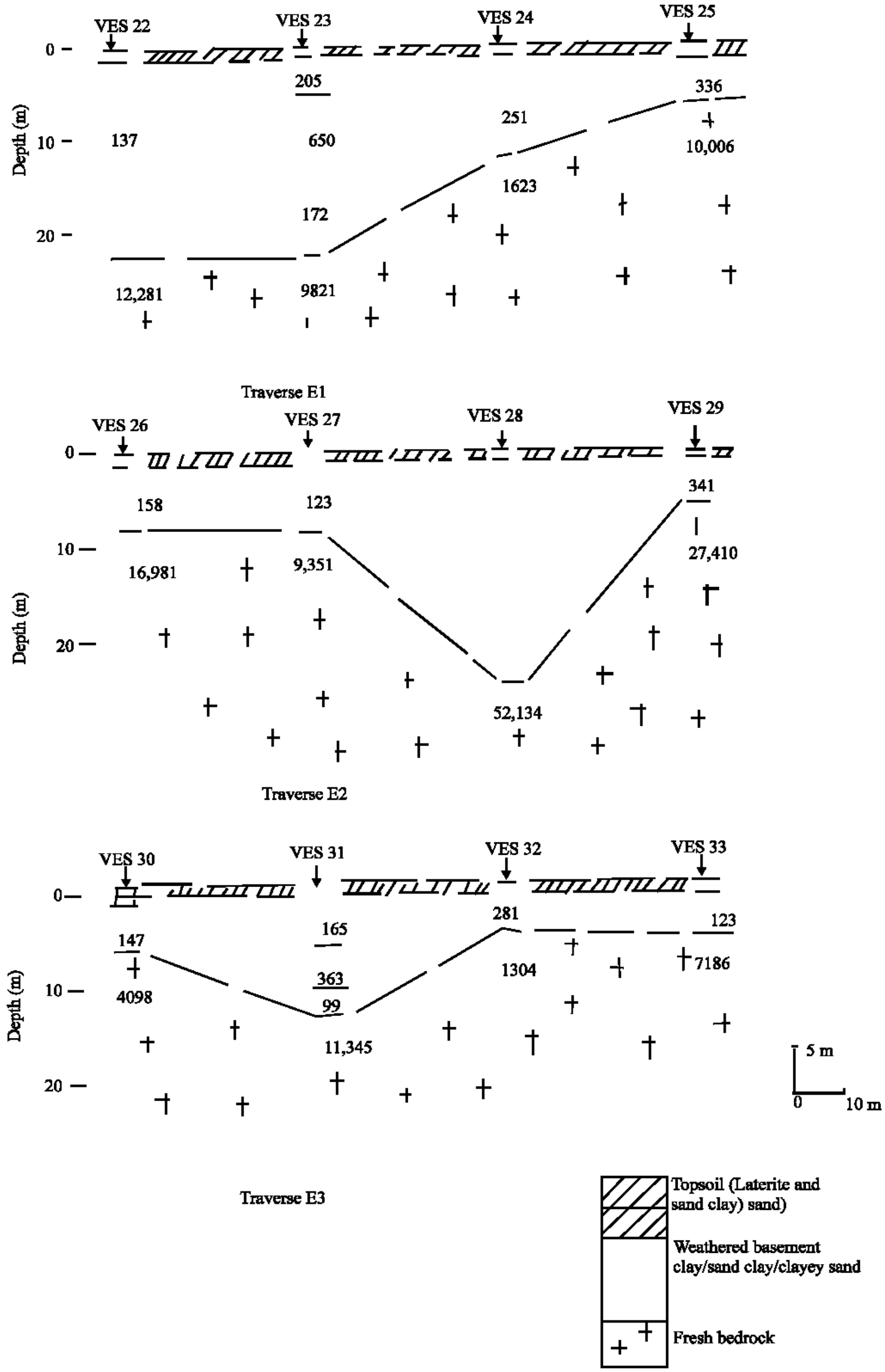

Fig. 6: Geoelectric sections along traverses E1-E3

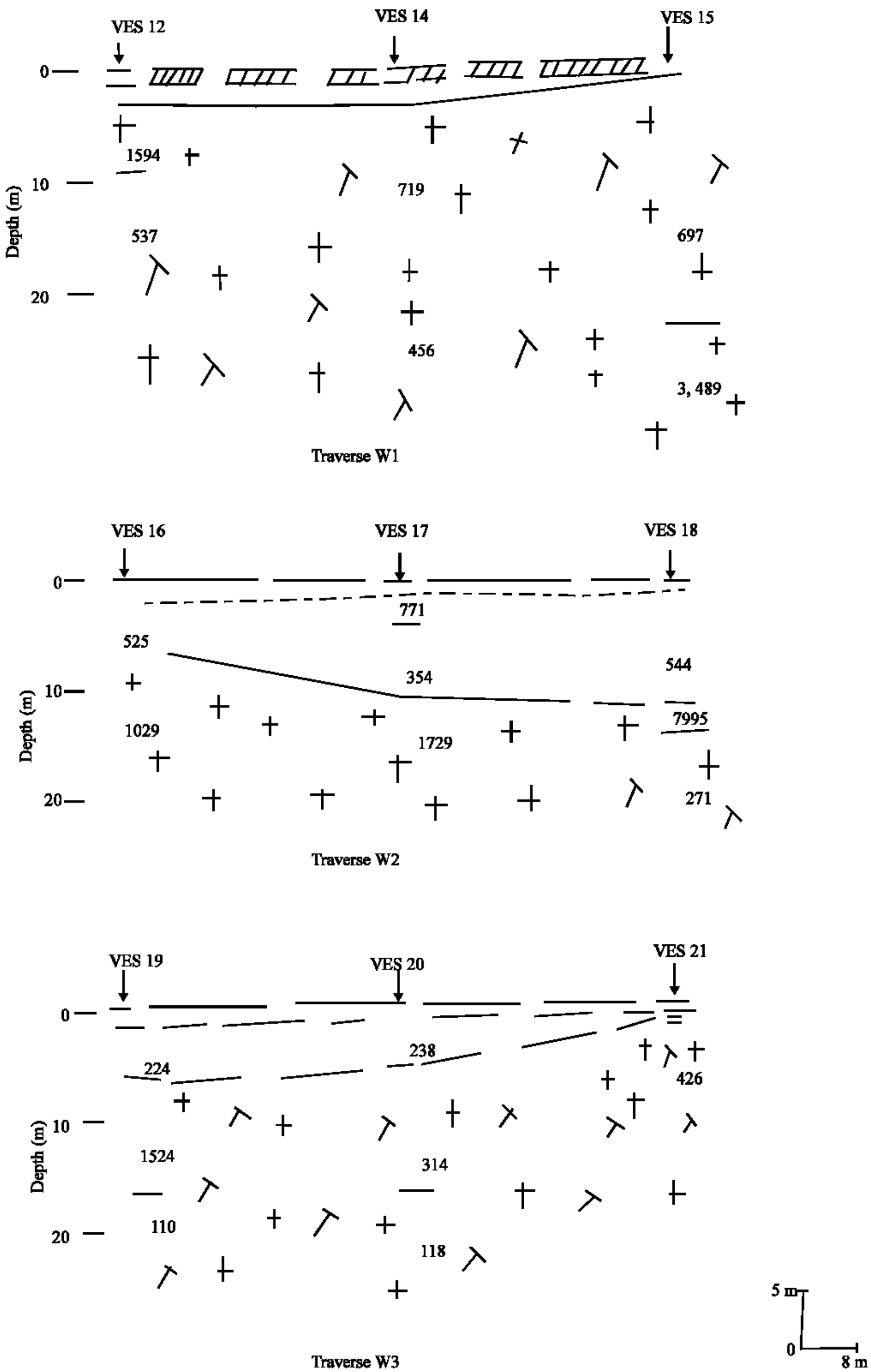

Fig. 7: Geoelectric sections along traverses W1-W3

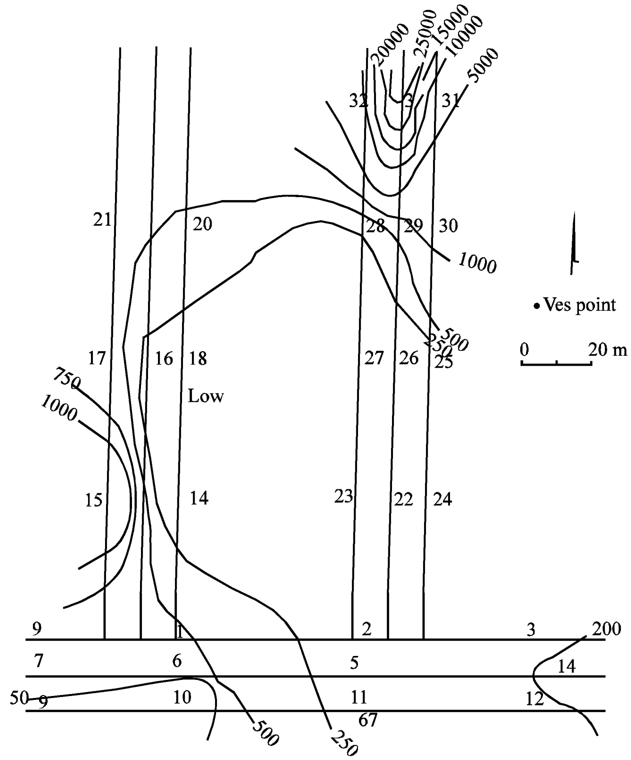

Fig. 8: Resistivity distribution map at depth of 5 m

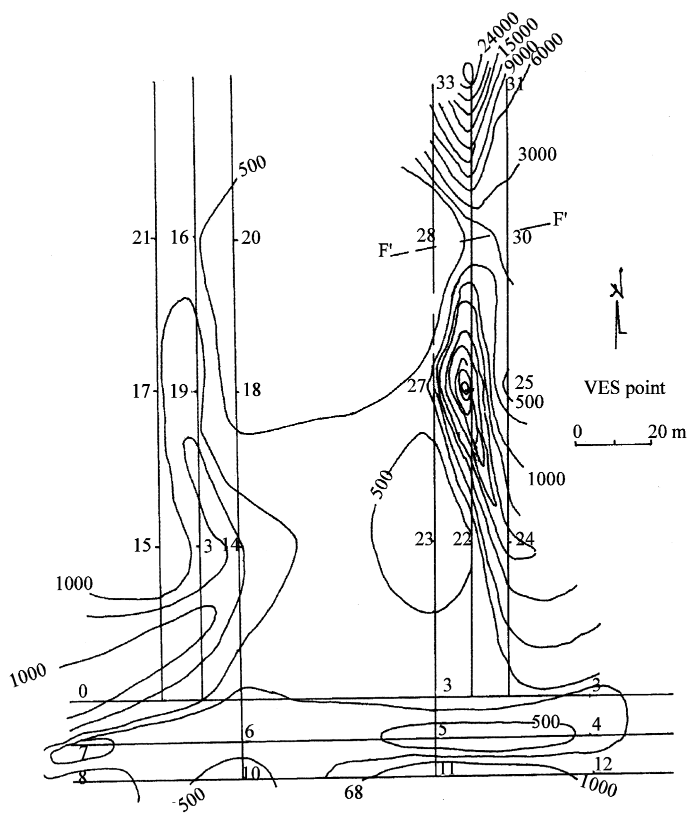

Fig. 9: Resistivity distribution map at depth of 10 m

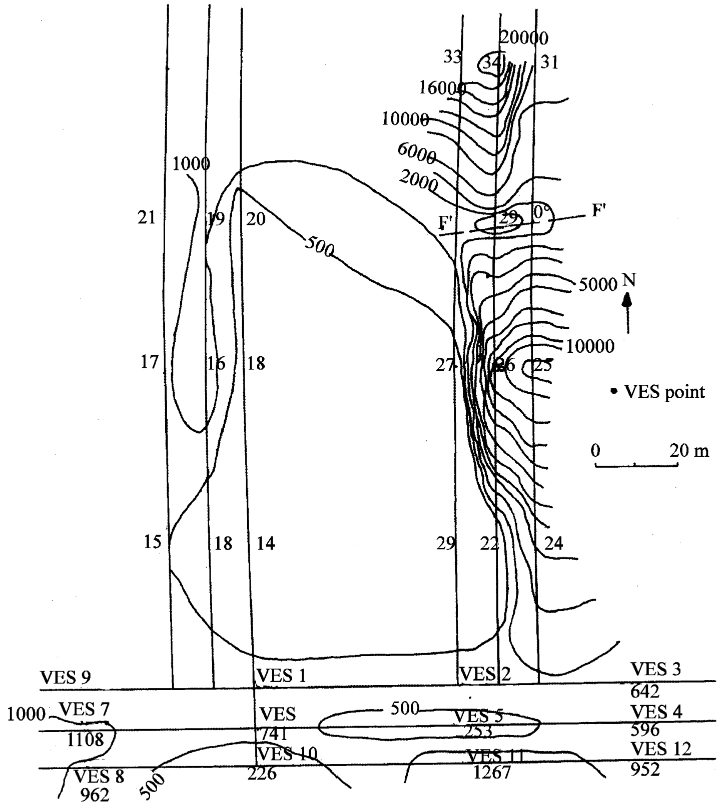

Fig. 10: Resistivity distribution map at depth of 15 m

CONCLUSION

A geoelectric investigation of an existing dam site within Federal College of Agriculture, Akure has been carried out. The study revealed that the near surface basement rocks which are expected to serve as a sealing barrier for water in the reservoir on the eastern and western flanks show no fracture signatures. Hence no seepage is likely to occur on these flanks.

The minor basement depression delineated by geoelectric map characterized by relatively low resistivity present little or no risk of loss of reservoir water. This is because the groundwater net flow direction is southwards. The delineation of bedrock structure suspected to be fractures from the geoelectric sections are considered inimical to the continued retention of water in the reservoir. However, no surface manifestation of their effects exists; these zones are suspected to be current zones of anomalous seepage. Hence significant reduction in reservoir water experienced.

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