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Full Length Research Paper

Hydro-geoelectric study of Ijare town, southwestern Nigeria

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Geoelectric study involving fifty four (54) Vertical Electrical Soundings (VES) has been undertaken within Ijare, southwestern Nigeria with the aim of evolving the hydrogeologic setting of the town. Ijare is underlain by the Precambrian Crystalline Basement Complex rocks with inhabited parts of the town underlain by migmatite gneiss and fine-grained biotite granite while inselbergs of older granites suites adjoins the town on all sides. Based on the hydro-geoelectric characteristics obtained from geoelectric sections and maps, the study area is classified into low, moderate and high groundwater potential zones. Four geoelectric subsurface layers delineated from the study are the topsoil, weathered basement, fractured basement and the presumably fresh bedrock. The concealed 'basement complex' morphology is rugged in the town with concealed ridges underlying the central areas while the eastern and northwestern areas are underlain by irregular concealed depressions. The zones of concealed basement depressions with resultant significant overburden thickness constitute target areas for groundwater development in the town. Arising from the general classifications undertaken using the results of the geoelectric soundings, sustainable groundwater development schemes for Ijare is considered feasible on the eastern and northwestern flanks where groundwater potential rating varies from moderate to high.

Key words: Geoelectric, groundwater, basement, ridge, depression, overburden, fracture.

INTRODUCTION

Over the years, potable water supply to Ijare community in Ondo State Nigeria through surface supply scheme has ceased due to non-functioning of the pipe-borne water system. The community at the time of study relies on water fetched from streams, ponds, shallow hand-dug wells and a few and inadequate motorized boreholes. However, the quality and wholesomeness of these water sources (perhaps with the exception of the motorized boreholes) are very much uncertain and many of the populace stands the risk of infection through water borne diseases. This is because the existing domestic water sources are vulnerable to contamination arising from disposal of refuse and faeces close to the aforementioned water sources. Groundwater pollution through human activities is considered worse than natural pollution as it renders water less suitable for use than its original state (Ishaku and Abdulhakeem, 2010; Abimbola et al., 2005). Also, seasonal variations greatly affect the quantity available from the sources significantly to the extent that they sometimes dry up. In view of this, groundwater development becomes a viable option for portable water provision all year round for the Ijare community. Thus, this study examines the hydrogeologic setting within Ijare town with a view of hydro-geophysical characterization of the town for future groundwater development scheme that may be envisioned. Delineation of areas of safe and adequate groundwater to meet the general needs of inhabitants of Ijare town in

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southwestern Nigeria constitutes the basis of this study.

Hydrogeophysics has emerged over the last decade as one of the more challenging disciplines in near-surface geophysics, aiming to improve the simultaneous use of geophysical and hydrogeological measurements (Nwankwoala and Udom, 2008). Hydro-geoelectric studies adopted in this study have in recent years assisted in evolving the hydrogeological settings of some communities with poor hydrological characteristics thus identifying zones of medium and high groundwater potentials for groundwater development purposes (Batayneh, 2011; Oladapo et al., 2009; Mohammed et al., 2008; Oladapo and Akintorinwa, 2007; Ekwe et al., 2006; Ayolabi et al., 2004; Dan-Hassan and Olorunfemi, 1999; Hazell et al., 1988).

LOCAL GEOLOGY AND GEOMORPHOLOGY OF THE STUDY AREA

Ijare, the study area (Figure 1), is situated within the 'crystalline basement complex' rocks of southwestern Nigeria (Figure 2) and made up of three lithological units namely migmatite gneiss, older granites and charnockite (Rahaman, 1976). The weathering of the crystalline 'basement complex' rocks under tropical condition is well known to produce a sequence of unconsolidated material whose thickness and lateral extent vary extensively (Jatau et al., 2013; Dearmaun et al., 1978). The 'basement complex' rocks are concealed in places by a variably thick overburden whose sequences may include topsoil, lateritic layer and weathered basement which may be fractured (Dan-Hassan, 2001). Groundwater is usually localized and compartmentalized within the weathered or fractured basement when significantly thick. Ijare town which falls within the tropical rainforest with average annual rainfall ranging from 1000 to 1500 mm (Iloeje, 1981) is situated about 10.3 km North of Akure (Ondo State Capital in Nigeria) and lies within longitudes E05° 09' 22.26" and E05° 10´ 56.20" and latitudes N07° 21´ 09.85" and N07° 22' 55.28". The town is located on a gently undulating terrain surrounded by isolated hills with elongated and continuous N-S trending ridge of porphyritic granite, which is responsible for pronounced run off with low infiltration rates in the area. Drainage pattern in the area is dendritic while the terrain is drained by two streams. While a stream drains the northern half of the town northwards into River Ona another stream drains the southern half to the south into Odudu/Ilado River. The two rivers are tributaries of River Ogbese that drains the southern half of Ekiti State and eastern half of Ondo State into the Atlantic via western Niger Delta.

Ijare is effectively connected to other adjoining towns on the west like Ikota, Irese, Ipogun, Ipinsa, Ilara-mokin and Igbaraoke. The massive granite inselbergs on the eastern and northern flanks of the town make connection to towns on the east and north (Itaogbolu, Iju and Ikere Ekiti) quite complicated.

MATERIALS AND METHODS

The geophysical investigation involves the use of electrical resistivity method. By measuring the electrical resistance to a direct current applied at the surface, this geophysical method can be used to locate fracture zones, faults and other preferred groundwater/contaminant pathways; locate clay lenses, sand channels and locate perched water zones and depth to groundwater (Sultan, 2012). Fifty-four (54) vertical electrical sounding (VES) locations were occupied within the town (Figure 3) utilizing the Schlumberger electrode configuration. The VES data obtained were utilized in generating field curves that were quantitatively interpreted. The quantitative interpretation involved partial curve marching technique (Zohdy, 1965) using software algorithm WINRES version 1.0. (Vander, 1988).

RESULTS AND DISCUSSION

The results of the study are presented as sounding curves, geoelectric sections and maps. The curves obtained range from simple 3-layer H, A, K, to complex 7-layer HKHKH (Figure 4). Geoelectric complexities often associated with basement terrains were obtained within Ijare. The sounding curves were interpreted to obtain subsurface sequence resistivity and thickness values. The values have been utilized for the generation of geoelectric sections along profiles A-A', B-B', C-C', E-E' and F-F' presented in Figures 4 to 10. Four geoelectric units (presumably corresponding to subsurface sequence) were delineated from the sections. They include the topsoil, weathered basement, fractured basement and the fresh bedrock. However, the topsoil and the weathered basement are regarded as the overburden while the bedrock consists of the fractured and fresh basement rocks. The geoelectric section of Figure 5 (profile A-A' which straddles the northeastern segment of the town) enabled the delineation of areas of moderately thick overburden beneath VES 52 and VES 30 and thick fractured column beneath VES 19. Geoelectric section of Figure 6 (profile B-B' which straddles the southern flank of Ijare) enabled the delineation of thick weathered basement at VES 16 and moderately thick weathered basement beneath VES 15 and fractured column at VES 13. Geoelectric section of Figure 7 (profile C-C' which straddles the western flank of town) indicates a generally thick overburden environment on the western/southwestern flank of the area around VES 43, VES 44, VES 45, VES 46, VES 47 and VES 48 with moderately thick weathered column beneath VES 12. Geoelectric section of Figure 8 (profile D-D' which spans central area of town from SSW to NNE) shows that moderately thick overburden materials underlie environment around VES 9, VES 10, VES 14, VES 21, VES 31, VES 34 and VES 36. These are areas mostly inhabited. Figure 9 (profile E-E' which also straddles center of town from southwest to northeast) shows that while a significantly thick overburden underlies VES 20 located on the northeastern flank, the central area is underlain by marginally thick overburden materials.

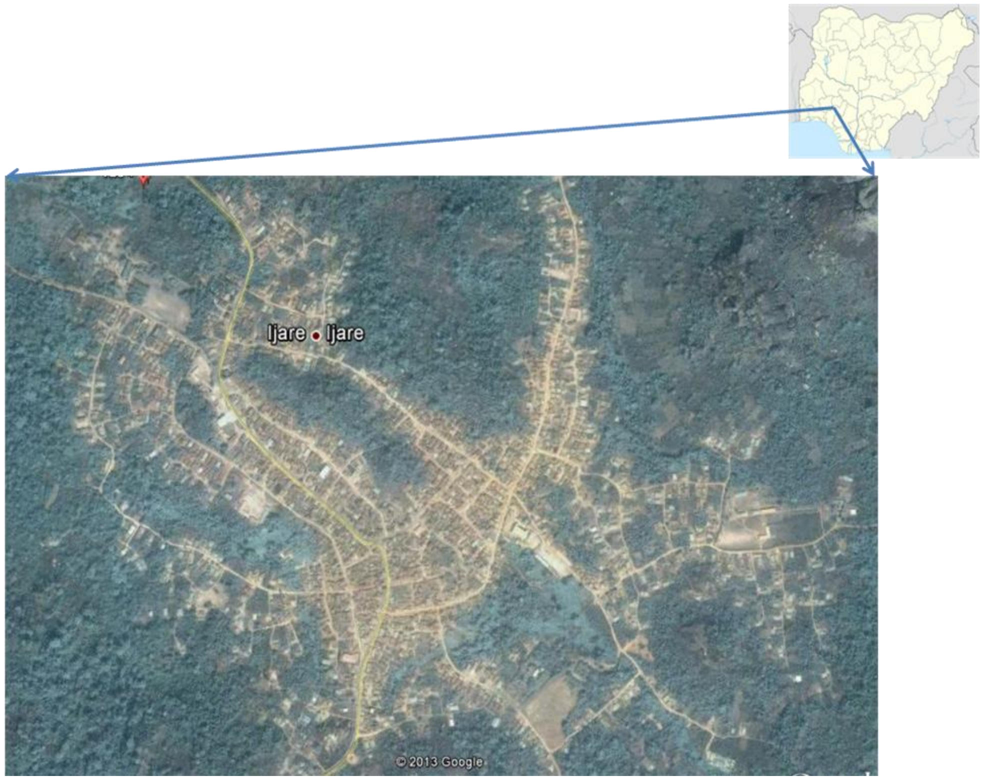

Figure 1. Satellite image of Ijare town (Google Earth, 2013).

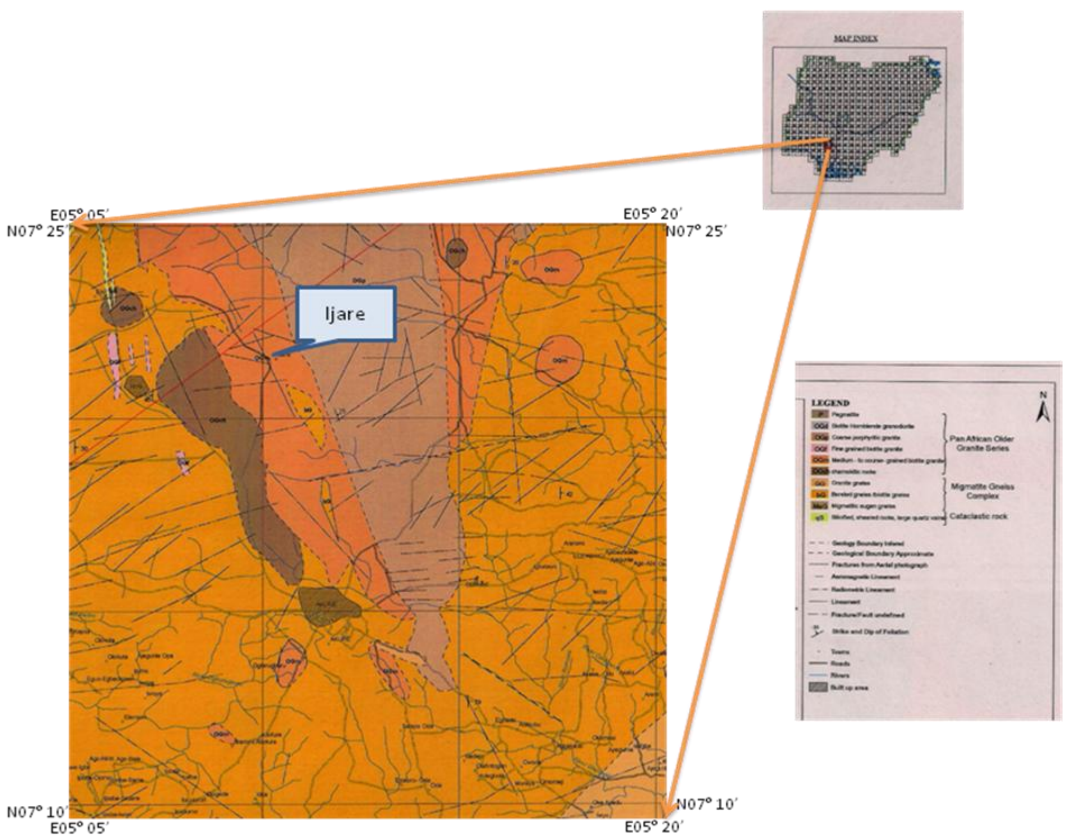

Figure 2. Geological map of Akure (GSN, 2003:264) showing the location of Ijare.

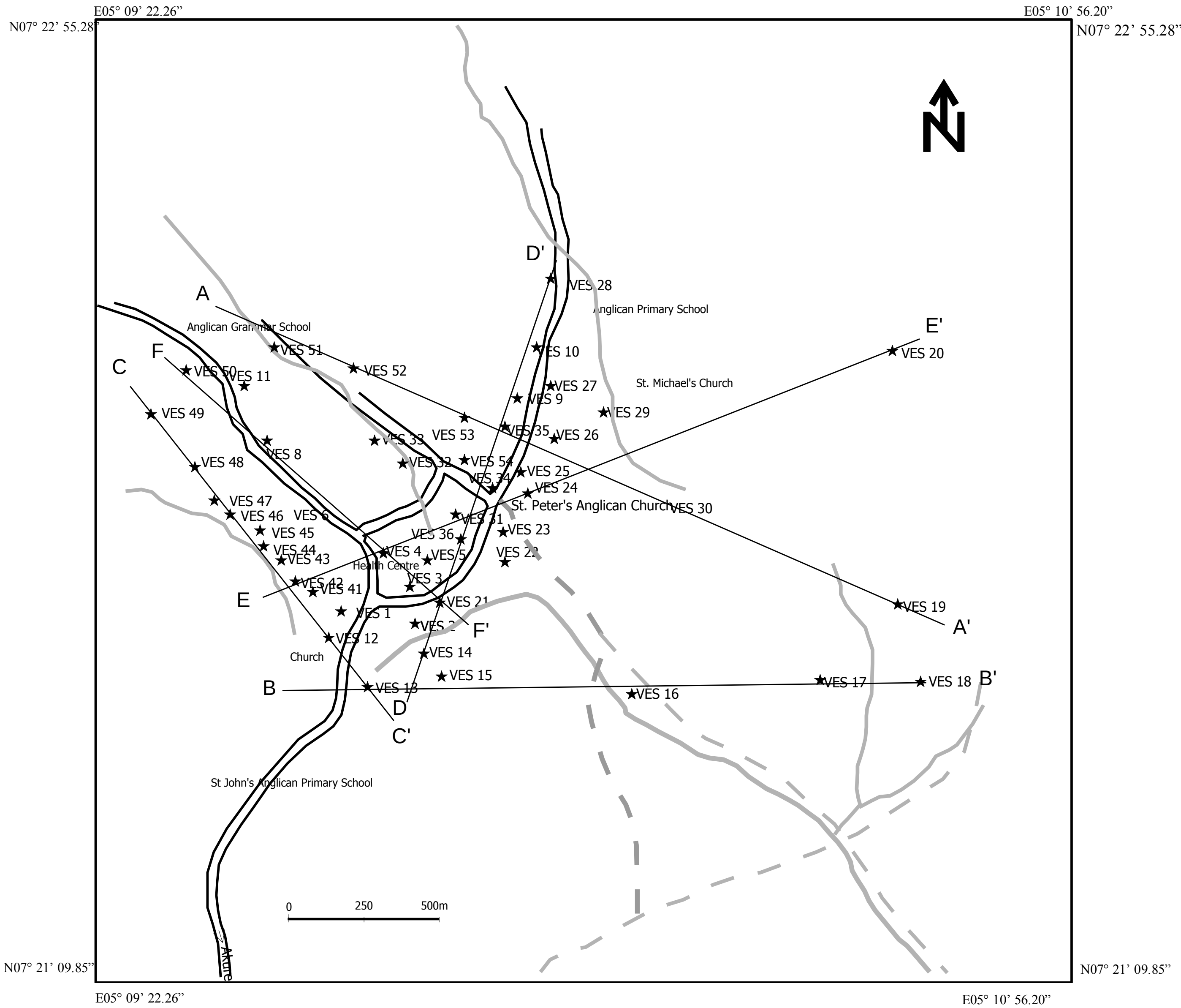

Figure 3. Layout map of Ijare town showing geophysical data points and geo-electric section profiles.

Geoelectric section of Figure 10 (profile F-F' which straddles the populated western area of town) shows that overburden materials in the environment are variably thick but with no significantly thick column ideal for groundwater development for community use.

The topsoil though with limited hydrogeologic significance varies in thickness from 0.3 at the central area of town to 1.7 m on the southeastern flank with resistivity values ranging between 16 Ωm in the southwestern flank and 1787 Ωm on the northeastern flank. Its composition consists of clay, sandy clay and clayey sand. The topsoil is however lateritic on the northern flank of the town. The second geoelectric sequence consists in composition of clay, sandy clay with resistivity values in the range of 12 Ωm at the southwestern flank (VES 42) to 2320 Ωm on the western flank (VES 48). The weathered layer thickness varies from 1.1 m (VES 41) on the southwestern flank to 67.3 m (VES 19) on the eastern flank of the study area. The third geoelectric sequence which is the fractured rock column is characterized by resistivity values varying between 21 Ωm at VES 54 in the central area of the town and 702 Ωm at VES 13 on the southwestern flank. Thickness values of the fractured rock columns vary between 8.4 m at VES 49 on the northwestern flank and 64.2 m at VES 19 on the eastern flank. Some of the fracture columns are as delineated in Figures 5, 6 and 7 on profiles A-A', B-B' and C-C' respectively. Generally, the bedrock is infinitely

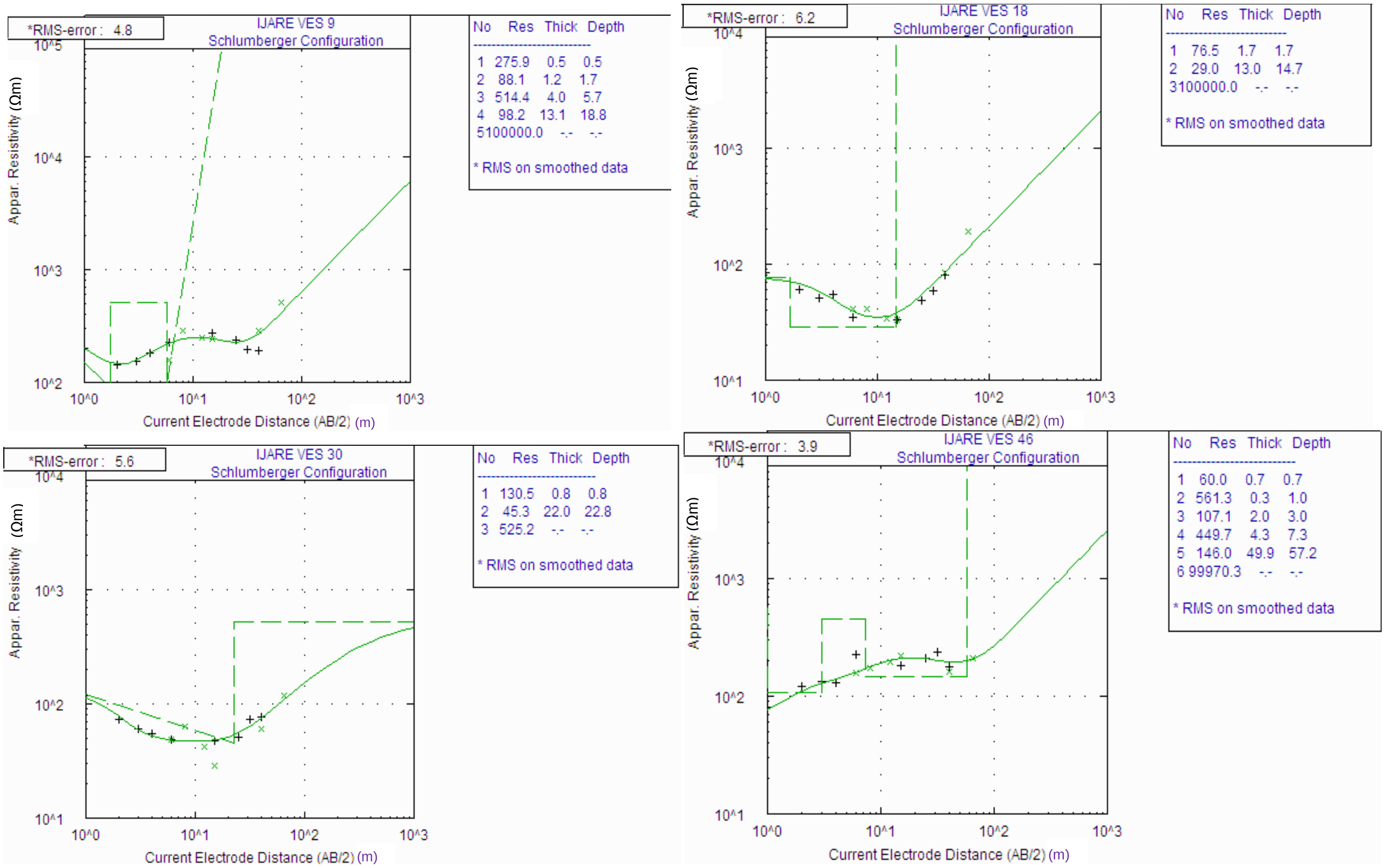

Figure 4. Typical geo-electric sounding curves obtained from Ijare town.

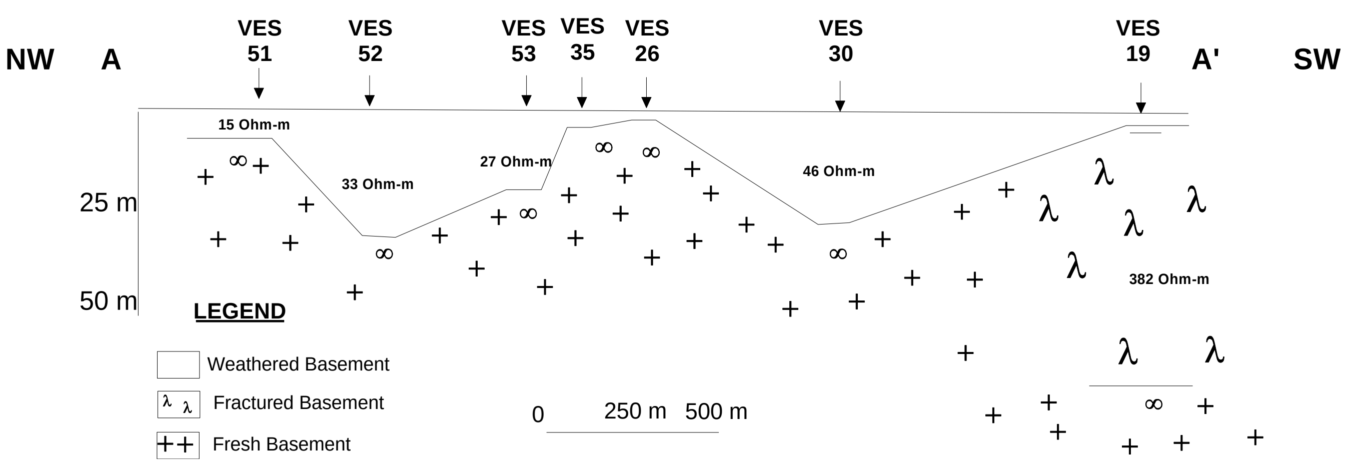

Figure 5. Geoelectric section along profile A-A'.

resistive in most places. Its relief is characterized by alternating basement highs in the central, northern, northwest and south-southeastern flanks and lows on the eastern, western and central areas. Areas of the town with basement highs imply thin overburden while thick overburden indicates depression.

Overburden thickness map of Ijare as generated from the computer iterated results of the fifty-four (54)

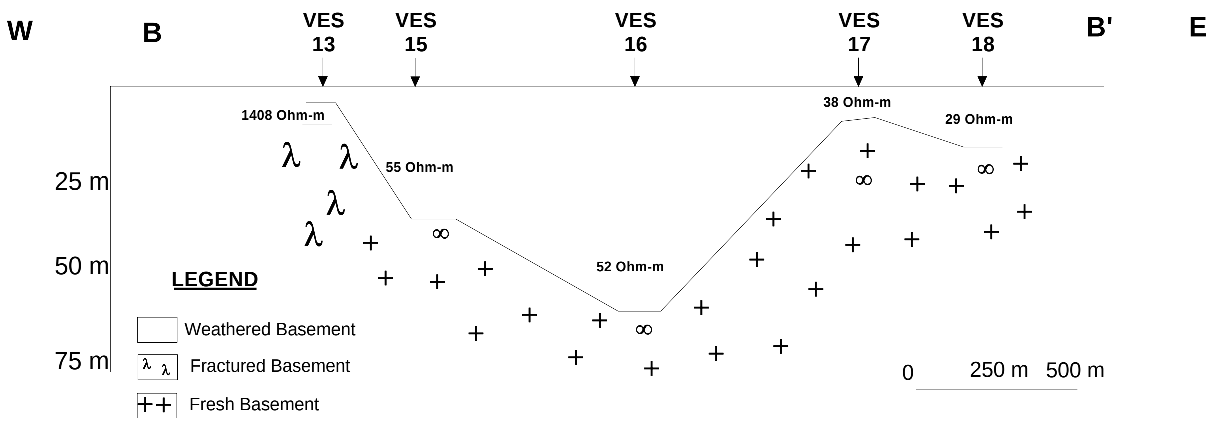

Figure 6. Geoelectric section along profile B-B'.

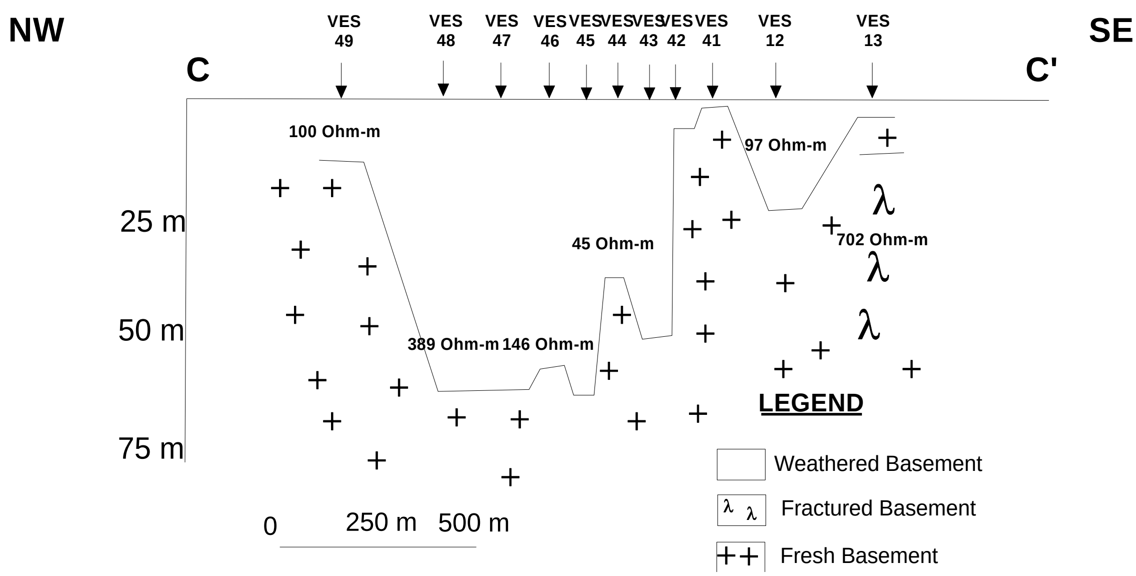

Figure 7. Geoelectric section along profile C-C'.

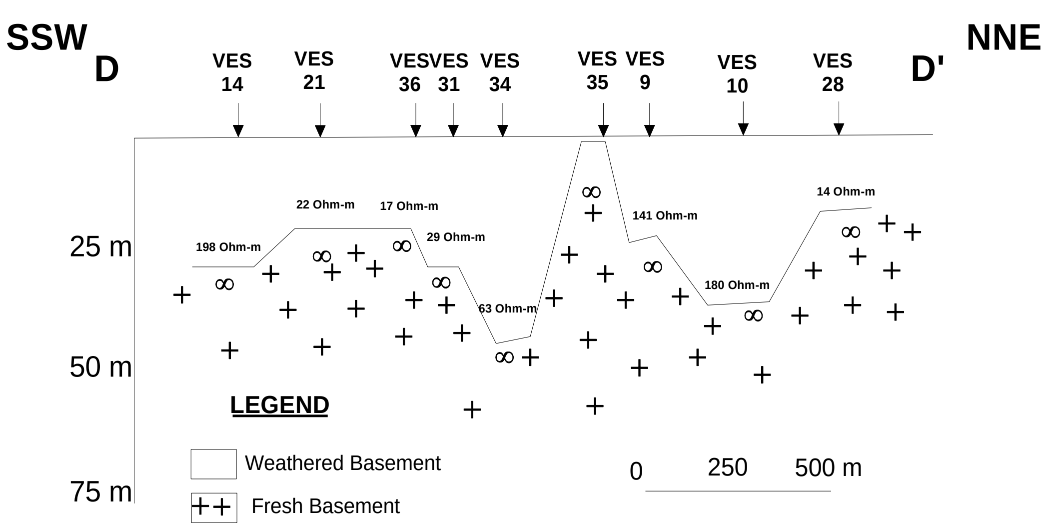

Figure 8. Geoelectric section along profile D-D'.

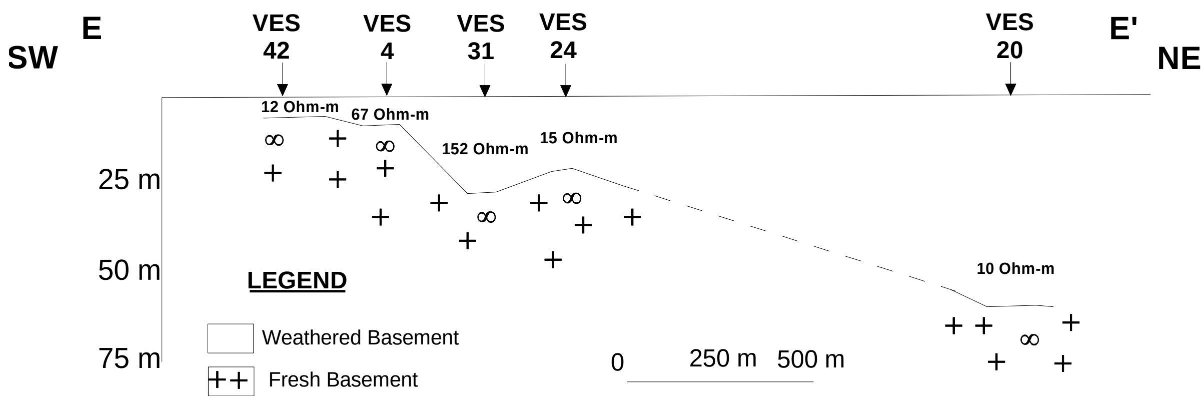

Figure 9. Geoelectric section along profile E-E'.

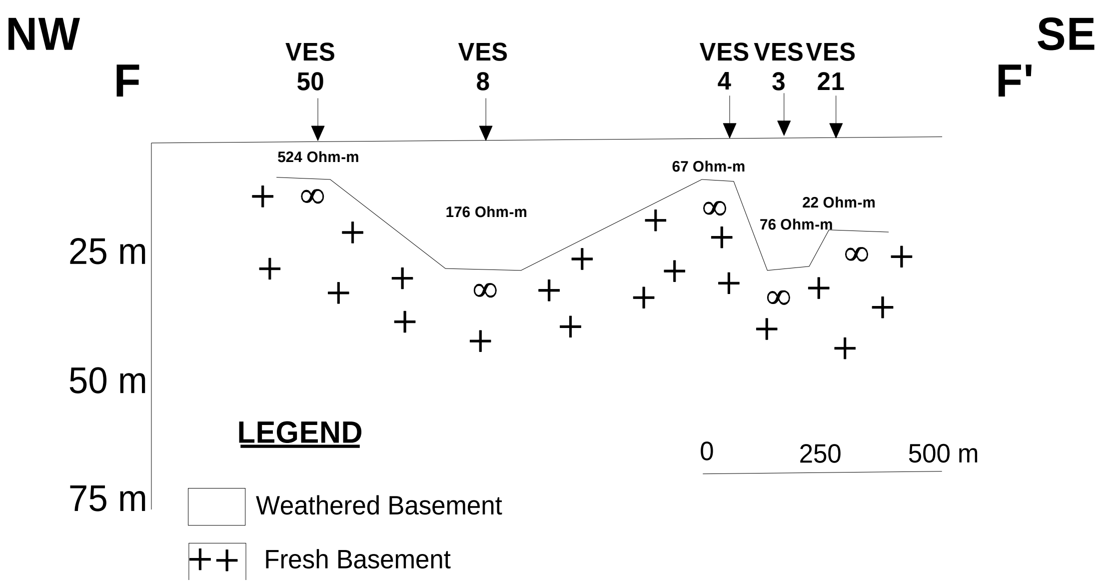

Figure 10. Geoelectric section along profile F-F'.

geo-electric soundings is presented in Figure 11. The overburden thickness varies between 3 and 67 m. The overburden materials are generally in excess of 30 m thickness on the eastern, southwestern, northwestern and western flanks of the study area. Overburden materials are generally less than 30 m in the central, northeastern and southeastern flanks thus indicating that these areas are relatively of less hydrogeological appeal. The central portion of the study area is devoid of fractures and characterized by low resistivity values (indicative of high clay content) with characteristic hindrance to easy fluid flow implying low groundwater discharge capability. Also, the rugged morphology of the concealed bedrock manifesting in basement ridges and depressions presented by the geoelectric sounding interpretations enabled the identification of areas of thin and thick overburden covers marked S_1-S_6 and T_1-T_6 respectively on the overburden thickness map of Figure 11. Olorunfemi and Okhue (1992) regarded areas with thick overburden cover and less clay percentage as having high groundwater potential rating within 'basement complex' environment. The depression designated T_1-T_5 within the eastern, southern and western areas are considered as priority zones for groundwater development for the town. Groundwater potential map of Ijare (Figure 12) was generated from the overburden thickness values derived from geoelectric sounding curves interpretation.

The groundwater potential map was utilized in the classification of the town with areas of overburden thickness generally less than 20 m classified as low groundwater potential zone. Areas of overburden thickness varying between 20 and 40 m is presumed to be of moderate groundwater potential ranking while areas

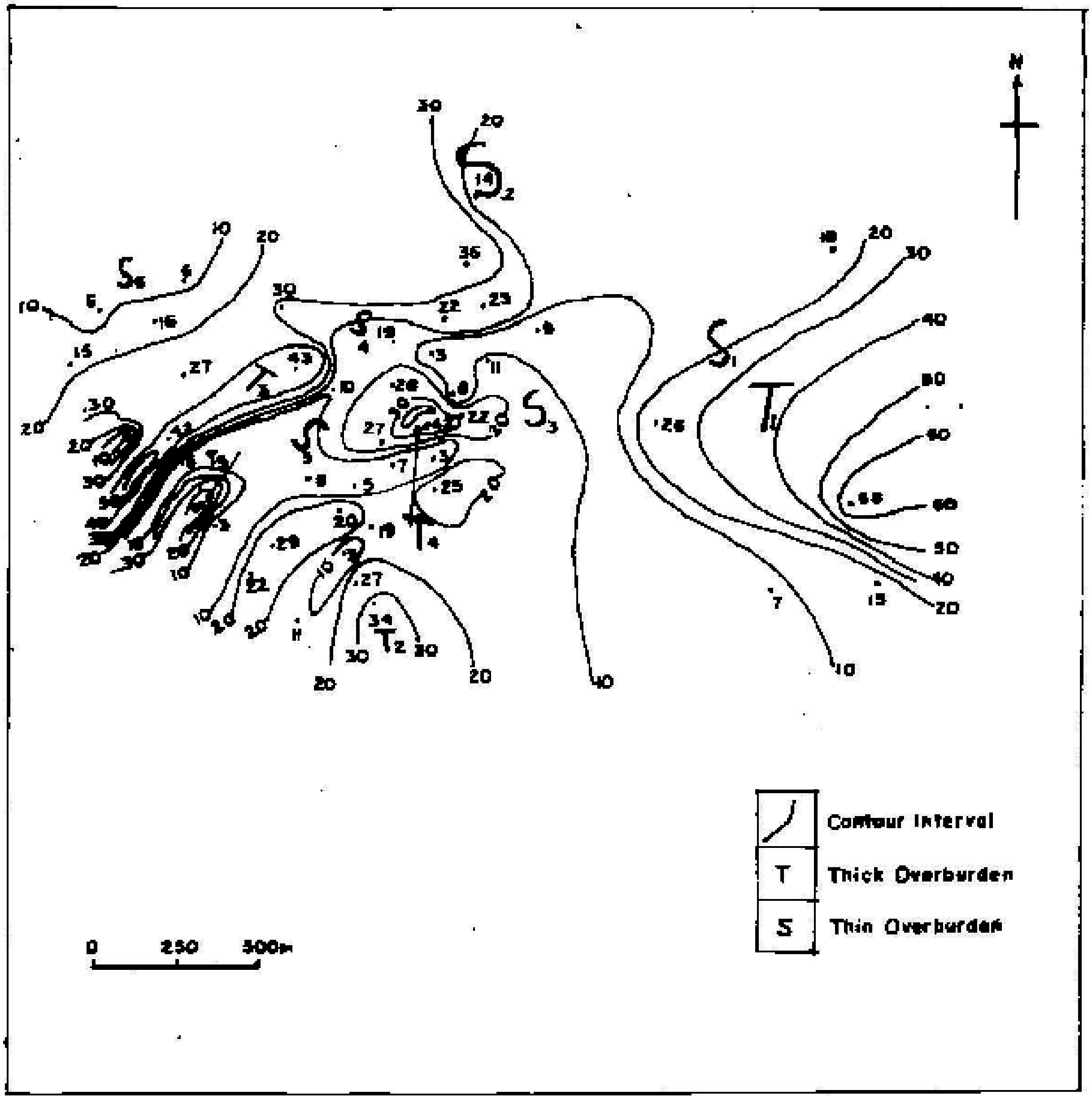

Figure 11. Overburden thickness map of Ijare.

of overburden thickness in excess of 40 m are ranked to be of high groundwater potential. Areas within the eastern, southern, northeastern and southwestern zones fall within high and moderate groundwater potential zones of Ijare where groundwater development may be considered to serve the short and long term water requirements of the community.

Conclusions

Hydro-geoelectric outlay of Ijare township area has been presented in this study. Four geoelectric units commonly identified in the 'basement complex' environment namely the topsoil, weathered basement, fractured basement and the resistive bedrock has also been delineated. Despite the presence of massive and low-lying outcrops in the town, sufficient electrode spread was attained for meaningful hydro-geoelectric study of the town especially in zones of 'basement complex' concealment. The concealed 'basement complex' morphology is rugged in the town with concealed ridges underlying the central areas while the eastern and northwestern areas are underlain by concealed depressions and in irregular patterns. The zones of concealed basement depressions with resultant significant overburden thickness constitute

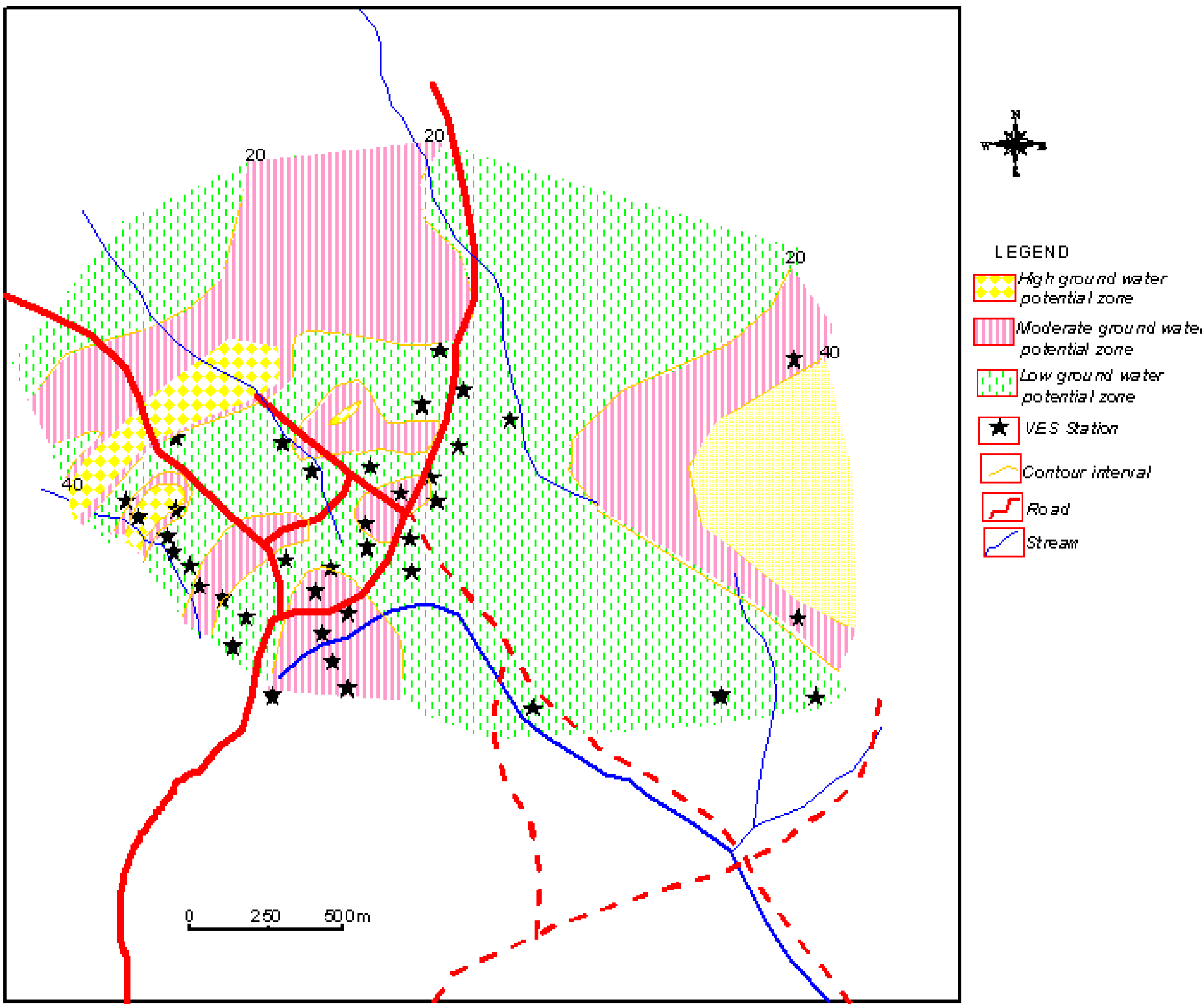

Figure 12. Groundwater potential map of Ijare.

target areas for groundwater development in the town. Thus, while the weathered basement constitutes aquifer units in some areas, the fractured basement rocks constitute aquifer units in few others while combination of the weathered and fractured basement constitutes aquifer units in some others. Arising from the general classifications undertaken in this study using the results of the geoelectric soundings, sustainable groundwater development schemes for Ijare is considered feasible on the eastern and northwestern flanks where groundwater potential rating varies from moderate to high.

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