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Geoelectric Investigation of Underground Tank Placement Using Geophysical Approach

Aladesanmi A.O, Olutomilola O.O, Olowookere A, Ogundana, A.K,
Department of Geology, Afe Babalola University, Ado-Ekiti
Corresponding Author: Aladesanmi A.O

Abstract: *Vertical Electrical Soundings were conducted in view to proposing a suitable location for underground storage tank (UST) placement in the site of investigation in Ore, Ondo State. Eight vertical electrical soundings were conducted using the Schlumberger configuration along Traverses A,B,C,D,E and F with a view of providing geological and geophysical information on the depth and thickness of the different sub-layers for the purpose of evaluating the possibility of locating underground storage facility. The electrical resistivity data obtained where interpreted using RESIST software Version 1.0. quantitative interpretation of curves involved partial curve matching using two-layer Schlumberger master curves and the auxiliary K, Q, A and H curves The results obtained from the quantitative interpretation of the geophysical data showed that study area is underlain by six geo-electrical layers. These layers are the dry, loose lateritic topsoil/Head pan followed by Clay, Sand, underlain by Weathered Basement, Fractured Basement which in turn overlies the Fresh Basement. The top soil layer of thickness and resistivity values ranging from 0.3 - 0.7m and 18 - 483Ω-m, Clay layer ranging from 1.3-2.1m and 14 - 44Ω-m, Sand layer ranging 2.1-6.3m and 76-110Ω-m, weathered basement ranging from 3.7-15.1m and 137-392Ω-m and the fractured basement with resistivity value of 225Ω-m and Fresh basement ranging from infinity in thickness and 1183-7082Ω-m. Also, the study shows that the thickness of the overburden is relatively thin. The average thickness to the top of weathered basement along traverse A,B,C,D,E and F are 4.4m, 1.0m, 0.5m, 2.1m, 1.7m and 2.5m respectively. Underground storage facility placement can be located along traverse A.*

Keywords: *Placement, Underground storage tank (UST), traverse, geo-electrical layers, sub-layers*

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I. Introduction

A petrol station is a retail establishment where motor vehicles are refueled, lubricated, serviced, and sometimes repaired (Friedman, 1978). Most petrol stations sell petrol or diesel, some carry specialty fuels such as liquefied petroleum gas (LPG), natural gas, hydrogen, biodiesel, kerosene, or butane while the rest add shops to their primary business and convenience stores (The American Heritage Dictionary, 2004). Meanwhile, petrol retailer or entrepreneur is any person who carries on a business which sells petrol for direct delivery into the fuel tanks of motor vehicles (Sedgwick, 1969).

Nigeria is one of the largest oil producing countries in the world with very huge tapped and untapped crude oil deposits around the South-South, South-East and South-West regions of the country. Apart from being an oil producing nation, Nigeria is also one of the largest consumers of oil products in Africa with about 40million liters being consumed every day (Darlinton Omeh). Petrol stations are very vulnerable to closure resulting from petrol price competition, regulatory pressure and non-strategic location (Sidaway, 1998). Location should be considered as a relevant growth determinant (Hoogstra, 2004). It affects many aspects of petrol station operation and can significantly affect the economy of the local community (Mudambi, 1994). Thus, choice of a location is the single most important decision facing retailers and service providers (Jones et al., 2003).

Business profitability of a petrol station is influenced by a number of factors such as property maintenance and management, size of the site, neighborhood business potential, grade of street and topography, visibility, compatibility of traffic flow, transient business potential, ease of approach, and special features of location (Friedman, 1978). This of course requires the selection of a site that is suitable for the placement of an underground storage tank. This being the essence of this research work as the location provided has a rocky topography. Determining the location for an underground storage tank would therefore be difficult. These tanks vary in measurements; 30,000 liters, 35,000 liters, 40,000 liters, 60,000 liters etc. It is on this basis that a geophysical investigation was undertaken for underground storage facility placement at the prescribed study site in Ore.

Any site chosen for a filling station should be sufficiently spacious for it to be designed to minimize the risks from petrol to any person likely to be at or near the filling station. The locations of tanks, filling and vent pipes, metering pumps, dispensers, road tankers delivery stands and buildings should be designed to provide for adequate means of escape for persons in the event of a fire or other incident; for hazardous areas to be protected from sources of ignition; and for safe access, routing, parking and exit of customers' vehicles, service vehicles and road tankers. Petrol storage tanks should be located underground, clear of the foundations of buildings and not within buildings or in or within approximately 6m of basements. The center lines of any tank openings or off-set filling points should be not less than 4.25m from the public thoroughfare or any other boundary of the filling station; but where there is an imperforate wall at the boundary extending sideways not less than 6m from any filling point and not less than 3m in height, filling points may be located close to the boundary (Health and Safety series booklet HS (G) 41). Storage depth is an important factor. The strength of the overburden must be adequate to contain the stored product at the maximum operating pressure (The National Petroleum Council Report, 1957)

II. Location and Geology of the Study Area

The site of investigation is located at Ondo-Ore junction, Ore, in Odigbo Local Government Area of Ondo State. Ore is located between latitude 6.74569N and longitude 4.87748E. It is the headquarters of Odigbo local Government Area. The study area is accessible with network of roads that surrounds the town like Ondo-Ore expressway, Benin-Ore expressway, Okitipupa-Ore expressway.

Figure 1: Aerial photograph of study area (*not scaled*).

STUDY AREA

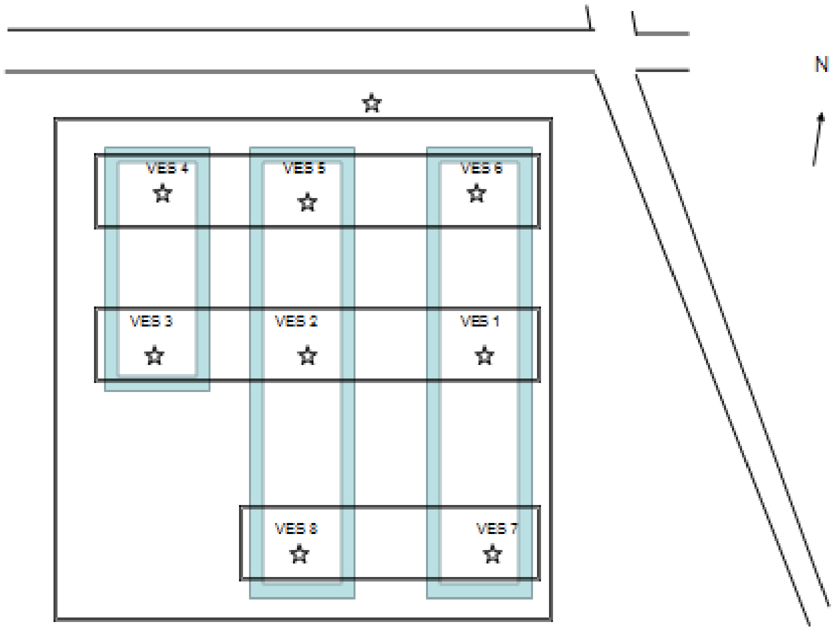

Figure 2: Sketch Map of the Study Area Showing VES points.

Ore falls within the tropical rain forest belt, with a mean annual rainfall of over 1500mm and a temperature range of 23 to 27^{o}C with evergreen tropical rain forest vegetation. (Omosuyi et al, 2013). With an average of 279mm, the most precipitation falls in July. The warmest month of the year is March, with an average temperature of 28.5^{o}C. August, with 24.8^{o}C has the lowest average temperature of the year. The difference in precipitation between the driest month and the wettest month is 268mm. The geologic terrain is underlain by the Precambrian basement complex rocks of the southwestern Nigeria characterized by Migmatite-gneiss complex, older granites, charnockites, quartzite and minor intrusive lithologies (Rahaman, 1988). The local geology consists of quartzite and biotite granites.

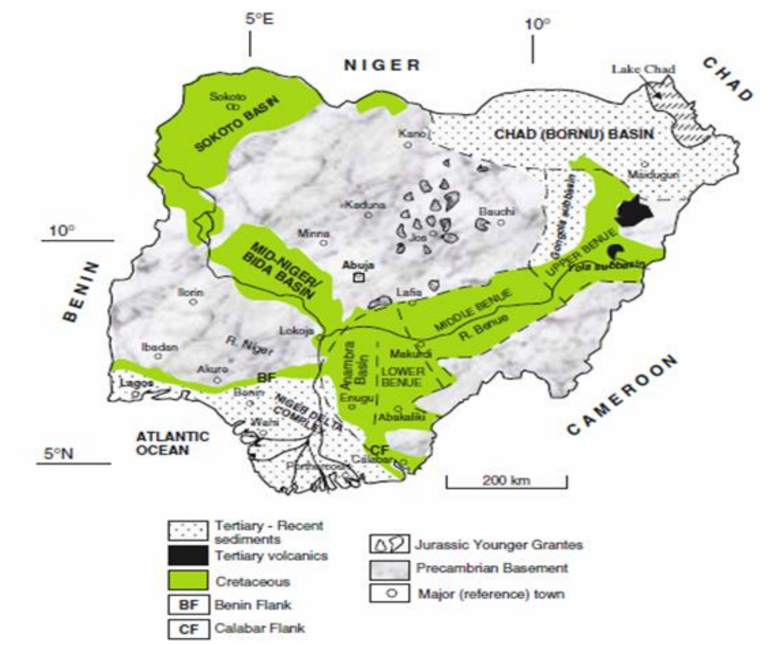

Figure 3: Map of Nigeria showing the sedimentary basins, basement complex and younger granites (Obaje, 2009).

III. Methodology

A reconnaissance survey of the site was conducted for proper work setting and this was followed by geophysical investigation of the subsurface geo-electric layers in the area. Resistivity sounding was adopted using soil resistivity meter (DDR-3) for the geophysical test. The meter is highly reliable and reproducible. Sounding helped in delineating the various subsurface geoelectric layers.

IV. Results and Discussions

A total of 8 Vertical Electrical Soundings across 3 traverses were spread over the study area. Two curve types were obtained from the study area namely; A and HA. From findings in this research, six geoelectric layers were delineated from the sounding curves namely; lateritic Top soil, clay, Sandstone, weathered basement, fractured basement, and fresh basement. A correlation table was generated by comparing different geoelectric layers revealed by the sounding curves (Table 1). The electrical resistivity interpretation shows that the overburden materials are relatively thin. The average thickness to the top of weathered basement along traverse A, B, C, D, E, and F are; 4.4m, 1.0m, 0.5m, 2.1m, 1.7m, and 2.5m respectively.

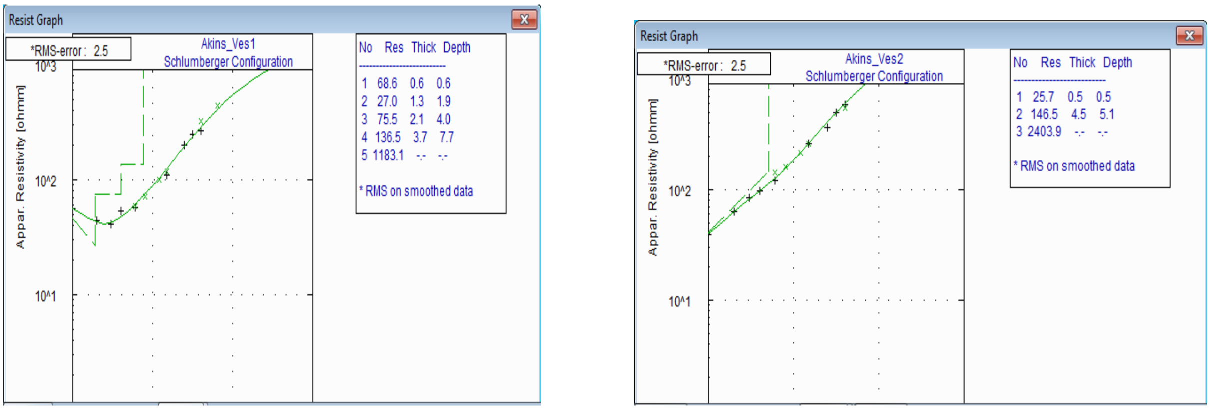

Figure 4: Typical Depth Sounding Curves of the Study Area**.**

Table 1: Correlation Table

VES POINT		1	2	3	4	5	6	7	8
CURVE TYPE		A	A	A	HA	A	HA	A	HA
LITHOLOGY									
TOP SOIL	TOP	0	0	0	0	0	0	0	0
	BASE	1	1	1	1	1	1	1	1
	THICKNESS	1	1	1	1	1	1	1	1
	Ωm	69	26	483	293	154	22	18	67
CLAY	TOP	1	-	-	-	-	-	1	1
	BASE	2	-	-	-	-	-	2	2
	THICKNESS	1	-	-	-	-	-	1	1
	Ωm	27	-	-	-	-	-	44	14
SAND	TOP	2	-	-	-	-	1	-	-
	BASE	4	-	-	-	-	7	-	-
	THICKNESS	2	-	-	-	-	6	-	-
	Ωm	76	-	-	-	-	110	-	-
WEATHERED BASEMENT	TOP	4	1	1	1	1	-	-	-
	BASE	8	5	10	16	6	-	-	-
	THICKNESS	4	4	9	15	5	-	-	-
	Ωm	137	147	392	285	196	-	-	-
BASEMENT	TOP	8	5	10	16	6	7	2	2
	Ωm	1183	2404	1991	4276	1219	1358	379	7082

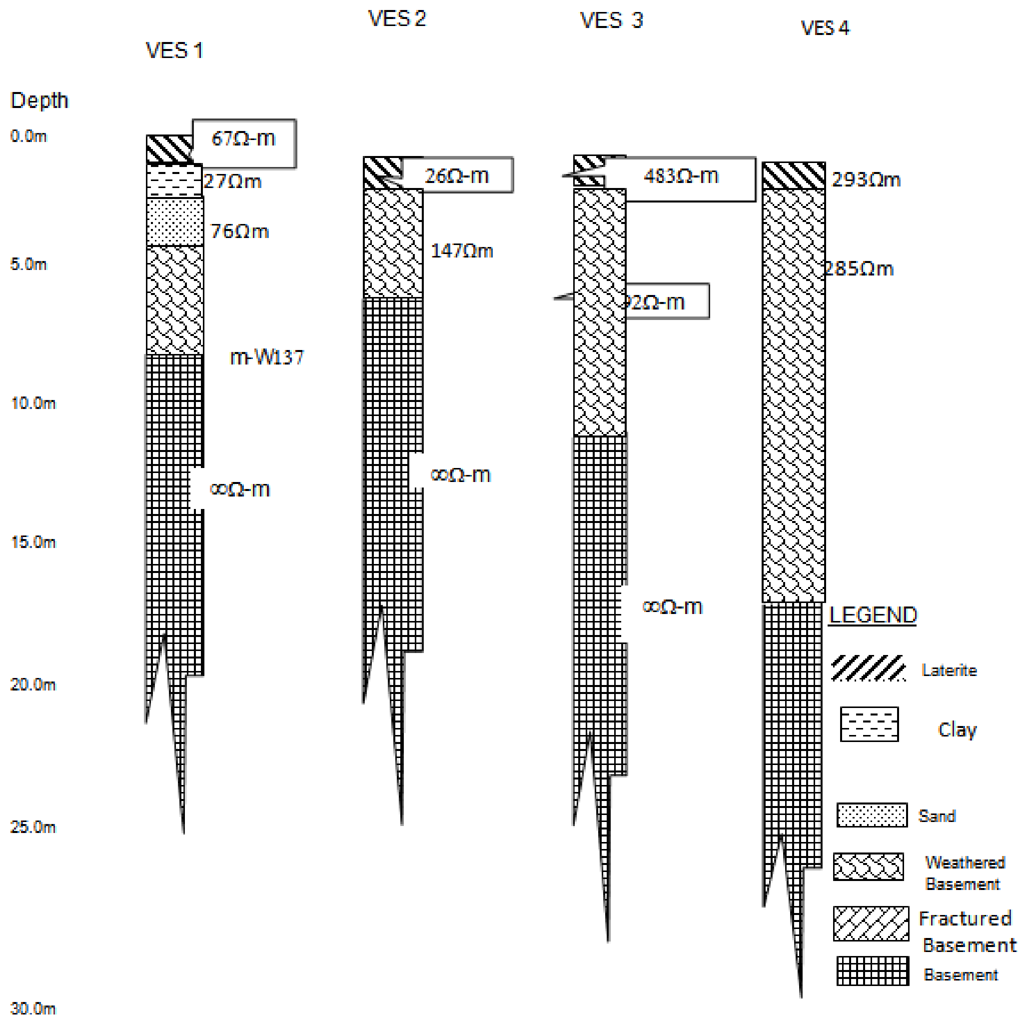

Figure 5a: Geoelectric sections of VES 1-4

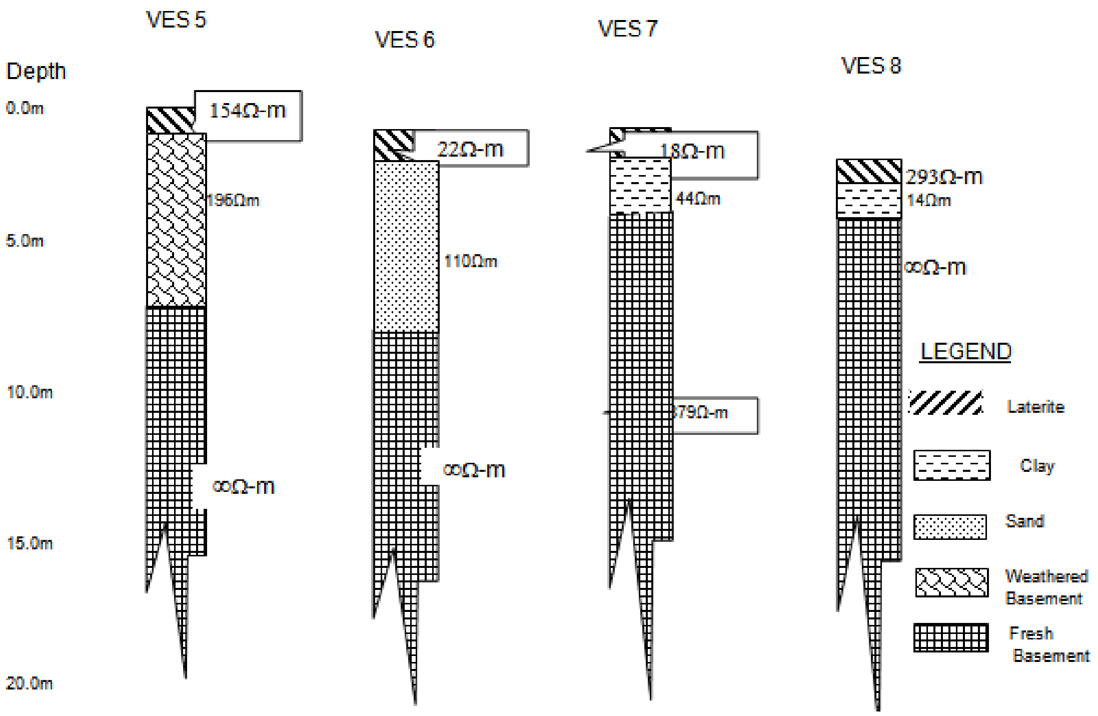

Figure 5b: Geoelectric sections of VES 5-8

Careful examination of the resistivity curves was employed to set the apparent resistivity range that corresponds to the lithological variations. The geoelectric section (Fig. 5a & Fig. 5b) show the variation of resistivity and thickness values of layers within the depth penetrated in the study area. Six subsurface layers were revealed: Lateritic Topsoil, Clay, Sand, Weathered basement and Fresh basement.

The topsoil is relatively thin along the study area. The average resistivity and thickness values for the topsoil are 142Ωm and 1.0m respectively. Clay was encountered in 2 locations and the average resistivity and depth values to the top of fractured basement are 28Ωm and 1.0m respectively. Sand was encountered in 2 locations and the average resistivity and thickness values for the Sand are 93Ωm and 4.0m respectively. Weathered-basement was encountered in 5 locations and the average resistivity and thickness values of the weathered-basement are 231Ωm and 7.0m respectively. The basement is the fresh bedrock and is the last layer. It is relatively shallow in the study area, it was encountered in all the locations and the average resistivity and depth values to the top of basement are 2487Ωm and 7.0m respectively.

The overburden in assumed to include all materials abovethe presumably fresh basement. The depth to the bedrock varies from 2.0 to 16.0m and the average depth to the bedrock is 7.0m (Table 5.1 and Figure 5a & b). Overburden thickness was established in all the locations and the average thickness value is 7.0m.

V. Recommendation

The placement of underground storage facility is suitable along the traverse with the thickest overburden (Traverse A). It is however recommended that further investigations be carried out to determine the geologic setting of the site that can have a profound effect on the dispersion of contamination. Soil depth and type, groundwater presence, bedrock type, and bedrock structures (bedding planes, solution features, fractures, etc.) are key elements that can minimize or exacerbate the effects of a spill or release from a UST (underground storage tank) system.

VI. Conclusion

The geophysical method of investigation carried out in the study area has been effective characterizing the sub-surface materials that underlies the study area as well as depth to bedrock. The average thickness to the top of weathered basement along Traverse A,B,C,D,E and F are; 4.4m, 1.0m, 0.5m, 2.1m, 1.7m and 2.5m respectively. The thickest material suitable for underground storage facility placement is along Traverse A with average thickness of 4.4m.

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