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Full Length Research Paper

Chemical composition, geophysical mapping and reserve estimation of clay deposit from parts of Southwestern Nigeria

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The present study is necessitated as a result of the use of kaolinitic clay as raw material for cement by West African Portland Company (now called Lafarge-WAPCO) situated in southwestern Nigeria. The study area covered an extent of 6 acres and fall within Ajebo town near Abeokuta. XRF and XRD techniques were employed in the determination of the chemical composition and crystalline component respectively. Vertical electrical resistivity soundings (VES) were used to evaluate the clay thickness, reserve and in the design of the exploitable zone of the clay deposit. The combination of XRF and XRD results show that quartz, kaolinite and feldspar are the dominant minerals. The VES results show indication of 3 to 5 geoeletric layers which include: the top soil (0.5 - 1.4 m), lateritic clay (1.7 - 4.7 m), indurated clay (4.4 - 11.3 m), clay sand (9.3 - 18.3 m), and saturated clay (6.3 m and above). The exploitable zone which corresponds to the "indurated clay" pinches out towards the depression as observed from the geoelectric sections. Using an exploitable zone average thickness of 4.25 m and area extent of 8790 m^2, the clay reserve estimate is 9.5 x 10^4 tonnes. Surface mining techniques will be appropriate as the overburden thickness is shallow.

Key words: Geoelectric sections, reserve, overburden, indurated clay, cement.

INTRODUCTION

Clay bodies are widely distributed on the Precambrian basement complex of Nigeria (Ajayi and Agagu, 1981; Emofurieta and Salami, 1988). The southwestern part of Nigeria, most especially Abeokuta areas, is noted for two main categories of clay occurrences (residual and sedimentary clays) in the basement-sedimentary transitional zones (Elueze and Bolarinwa, 2001). These clays are generally consumed as industrial raw materials in the cement, ceramic; paper, pesticide, fertilizer, refractory and pharmaceutical industries. Geophysical techniques have gained wide application in determining different subsurface layers. Electrical resistivity method has been used to evaluate the clay reserve at the Nigerian Mining Corporation's quarry site at Omi-Adio near Ibadan (Bayewu, 2002; Joshua et al., 2004).

Abeokuta area is underlain by the basement rocks, which are predominantly migmatites, biotite-granite gneiss, porphyritic granites, with minor pegmatites and quartz vein (Elueze and Bolarinwaa, 2001). Overlying the basement rocks are the Cretaceous sedimentary sequence comprises the Abeokuta Formation composed essentially of lithologies which vary from basal conglomerate through sand to clay-shale facies (Figure 1). Bolarinwa and Elueze (2005) identified the main mineral phase in the clay zone as kaolinite and distinguished the weathering profiles into three major zones, namely; the Fe_2O_3-rich lateritic zone below the top soil, the Al_2O_3-rich clayey zone below the laterite and the parent rock. The transition horizon which is called saprolite was also encountered between the clay-zone and the bedrock (Bolarinwa, 2004).

The present study therefore aimed at determining the chemical composition and the thickness of clay bodies around Ajebo area of Abeokuta using XRF, XRD and electrical resistivity techniques in order to design the appropriate method(s) for effective exploitation of the deposit.

METHOD OF STUDY

A Garmin e-trex Geographic Positioning System (GPS) meter was used in locating the coordinates of the proposed clay site at Ajebo near Abeokuta. The composition of the clay material was determined using X-Ray flourescence (XRF) method.

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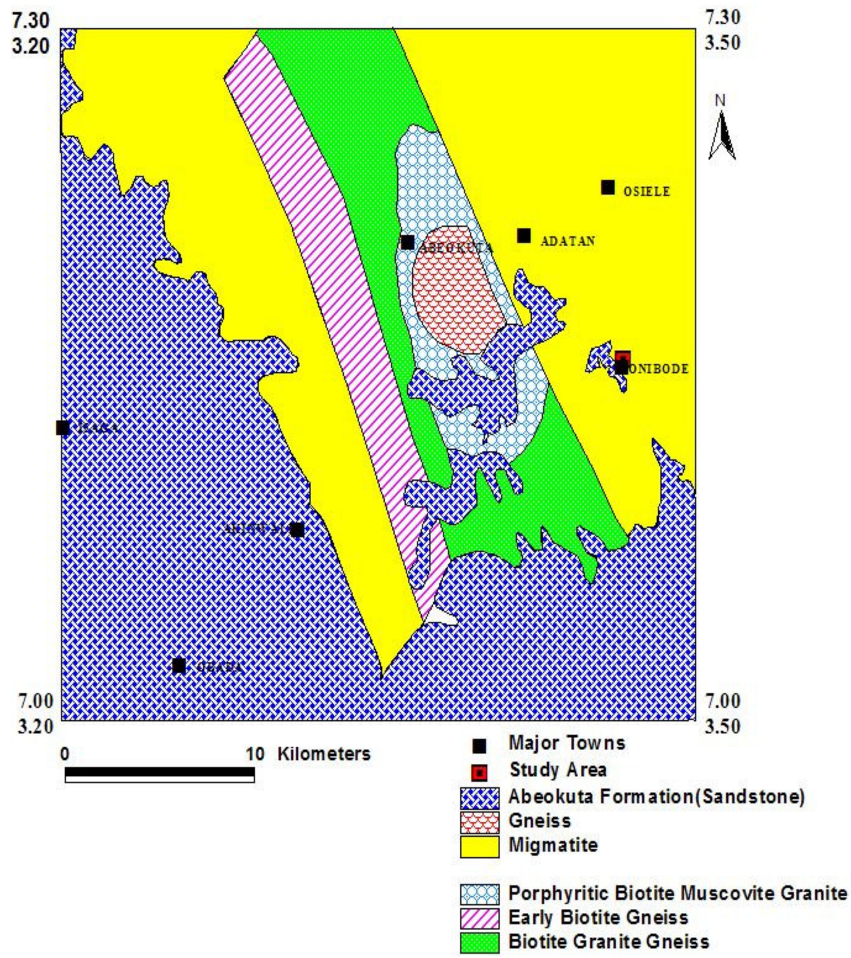

Figure 1. Geological map of Abeokuta and environs showing the study area (Modified from Elueze and Bolarinwa, 2001).

The crystalline component of each material was carried out using automated X'Pert Pro PAnalytical X-ray diffraction (XRD) model. Each sample was put into the sample holder, with two slits of ½ and 1° selected for the incident beam path and 5.0 mm slit for the diffractive path. Vertical Electrical Sounding using the Schlumberger array was carried out at the proposed clay deposit site. Twelve different points were located and fully occupied in a systematic manner to cover the area of interest (Figure 2). The electrodes were expanded from a minimum current electrode spacing (AB/2) of 1.0 m to a maximum of 133 m. The Geopulse Tigre resistivity meter was used for resistance measurements. Good quality data were obtained with the observational errors being less than 1%. Field data were subjected to preliminary interpretation using partial curve matching involving two-layer master curves and the appropriate auxiliary charts. The layered model thus obtained served as input for an inversion algorithm as a final stage in the quantitative data interpretation.

The criteria used to determine the clay deposit reserve are: mean thickness (t), density (ρ) and the area (A). The reserve is estimated using the equation Re = Area x Thickness x Density, where Re is the reserve estimate.

RESULTS AND DISCUSSION

The composition of the clay is presented in Table 1a while crystalline components are indicated in Figure 3 and summarized in Table 1b. The combination of XRF and XRD results was used to provide an approximate analysis of the main component present in the clay. The clay is dominantly made up of quartz, kaolinite, and feldspar (Figure 3).

The result of the soundings (VES) shows a system of three to five geoelectric layers which could be correlated with the Fe_2O_3-rich lateritic zone below the top soil, the Al_2O_3-rich clayey zone below the laterite and the transition horizon which is called saprolite encountered between the clay-zone and the bedrock (Bolarinwa and Elueze 2005, and Bolarinwa, 2004). Representatives of VES curves as obtained from inversion are shown in Figures 4, 5 and 6. The sequence from top to bottom is as shown in Table 2. It is worthy to note that each litho-unit varies in thickness from one point to another within the study area. The horizon of interest tagged "indurated clay" pinches out towards the depression as shown by the geoelectric sections in Figures 7a-e across some of the VES points. The soil overlying this zone of interest varies in thickness from place to place {average thickness of about 2.5 m}. The

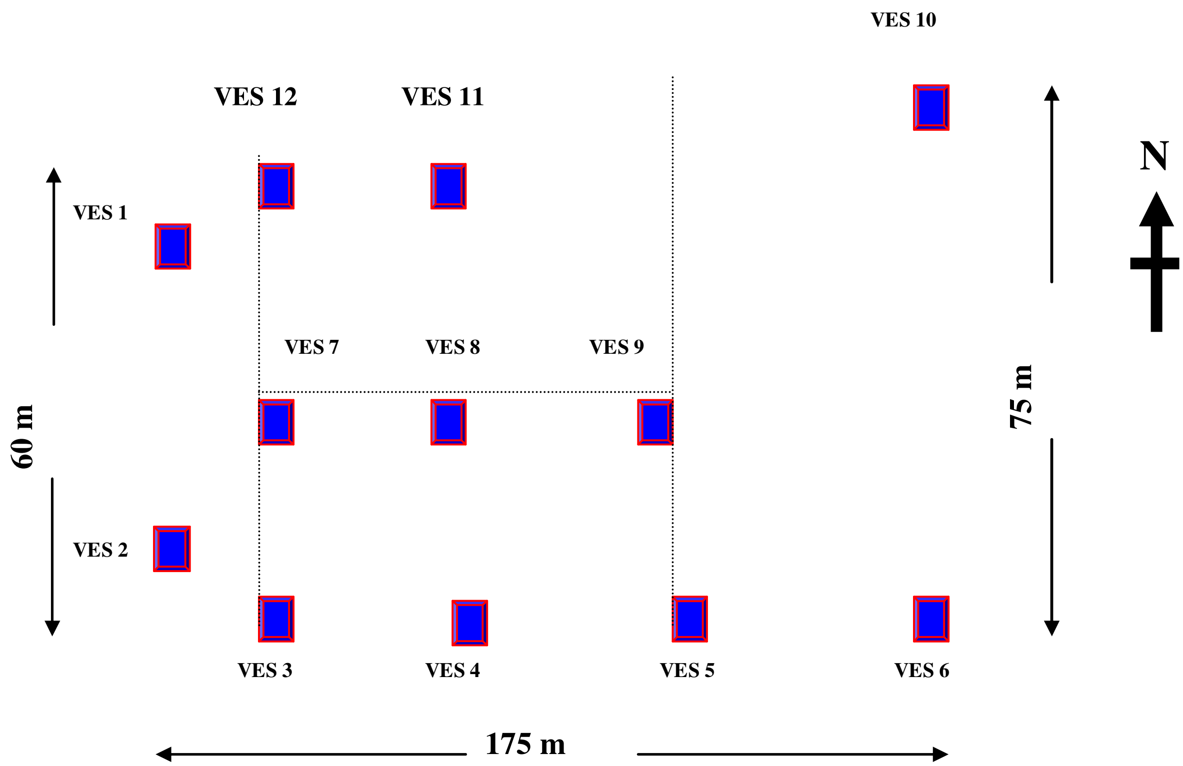

Figure 2. Location layout of vertical electrical sounding (VES) points.

Table 1a. Chemical compositions of indurated clay unit.

Oxides	SiO2	CaO	Fe2O3	Al2O3	MgO	MnO	Na2O	K2O	P2O5	TiO2	LOI	Total
Weight %	60.55	0.61	0.64	25.73	0.09	0.01	0.03	0.03	0.03	2.94	9.54	99.50

Table 1b. Crystalline components of the indurated clay unit.

Minerals	Quartz (Q)	Feldspar (F)	Kaolinite (K)	Total
Percentage	62.04	6.57	31.39	100

zone of interest is delineated with an areal extent of 8790 m^2 (Figure 8) and an average thickness of 4.25 m.

CONCLUSION

Detailed geochemical and geophysical studies involving XRF, XRD and vertical electrical sounding has been carried out at Ajebo town, near Abeokuta with the aim of determining the chemical composition and delineating the various lithologic units in the area. The chemical analysis result shows that the rock composition is dominantly made up of quartz, kaolinite, and feldspar. The area is underlain by different geologic rock units such as top soil, lateritic clay, indurated clay, clayey sand and saturated clay.

The horizon of interest, which is indurated clay deposit, has been delineated. This zone is confined to the upland area and pinches out towards the depression. It is overlain by thin layer of top soil. The reserve estimate computed for 6 acres dimension is 9.5 x 10^4 tonnes. The idea of using the clay as a flux in cement manufacturing would be economical as the reserve of the small acres is large and the upland area should be targeted for more reserve.

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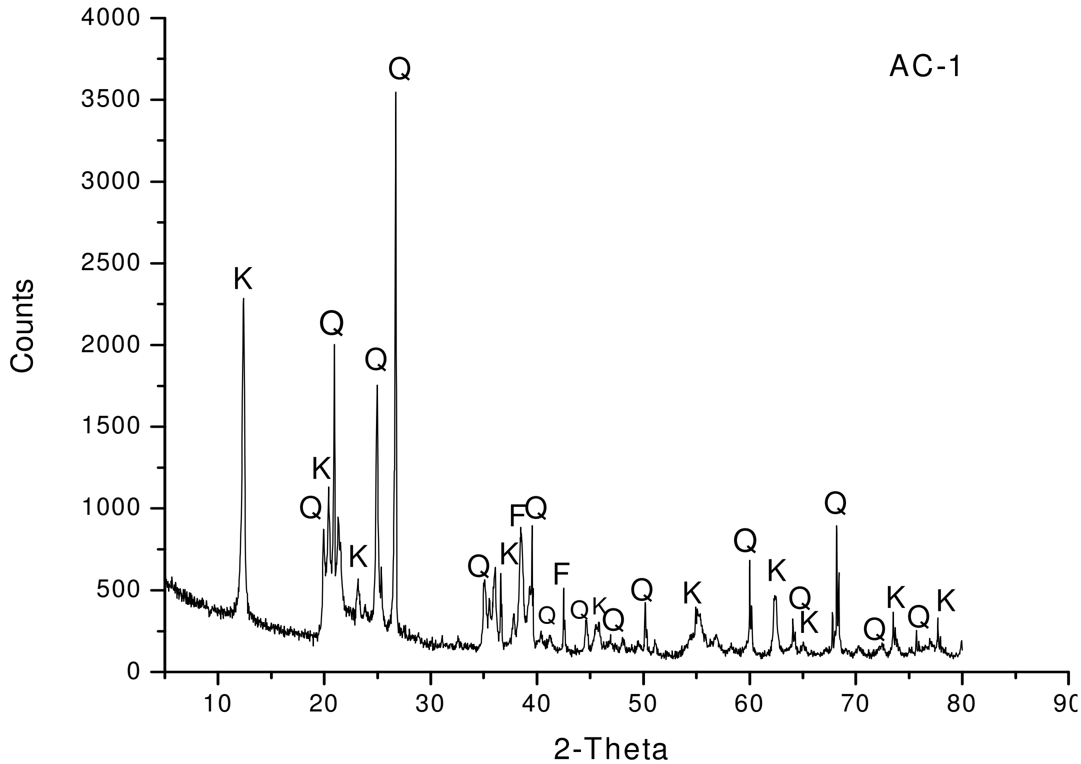

Figure 3. X-ray diffractogram of the clay deposit (indurated clay unit.

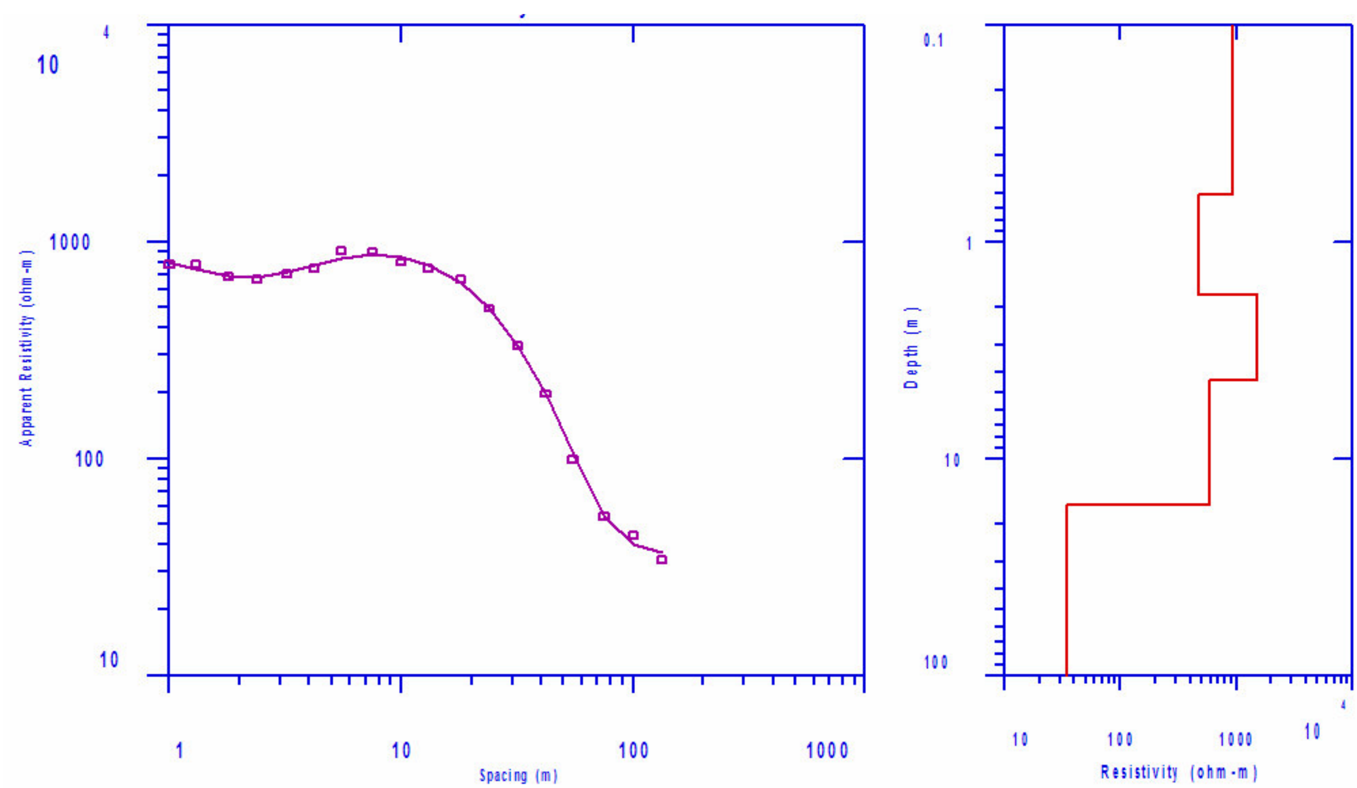

Figure 4. Layer model interpretation for VES 1.

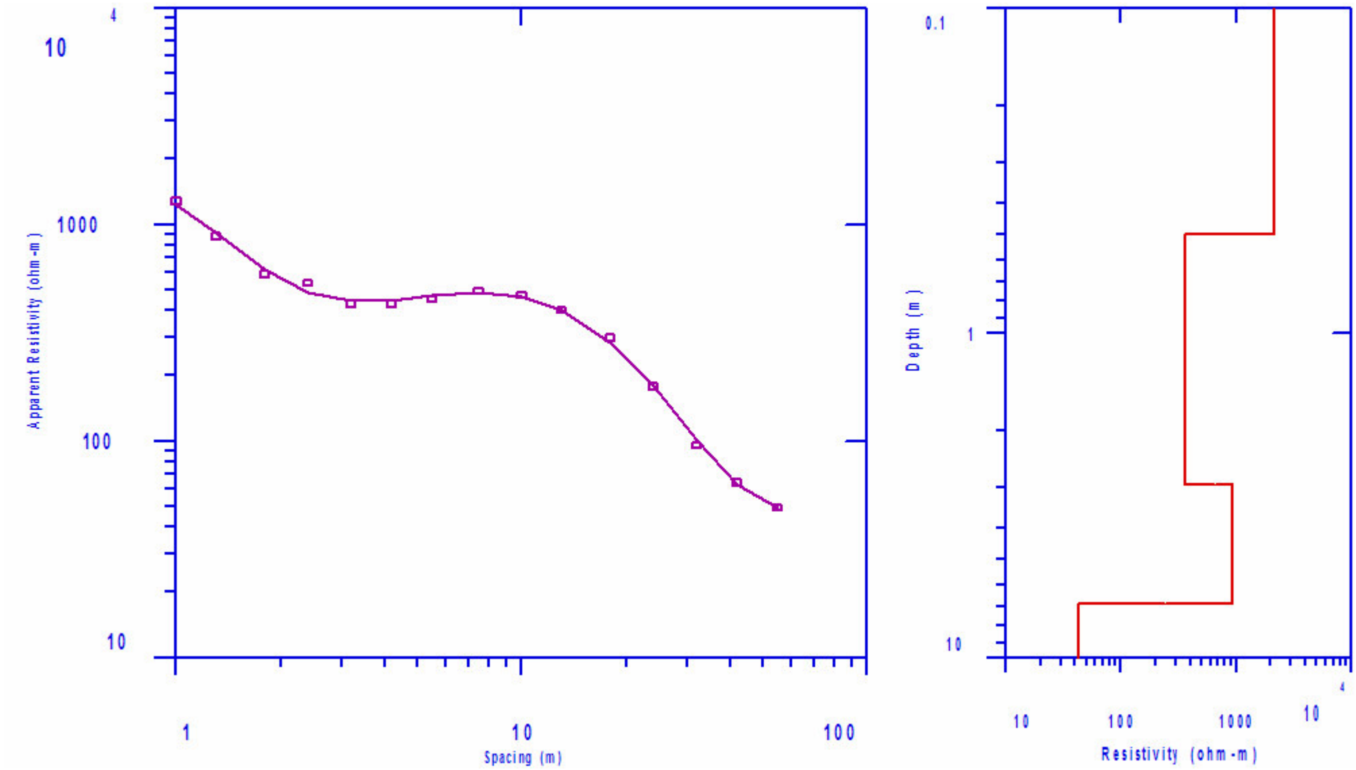

Figure 5. Layer model interpretation for VES 5.

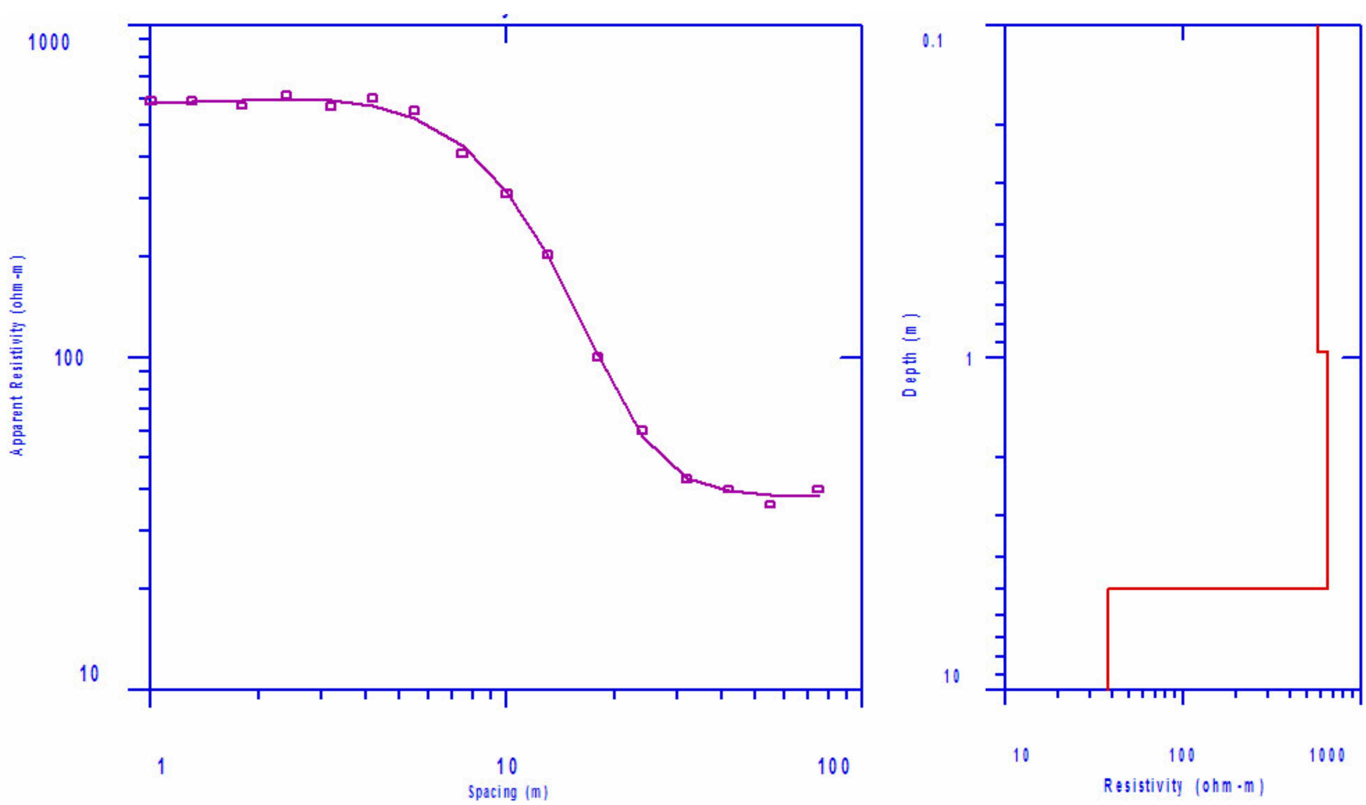

Figure 6. Layer model interpretation for VES 10.

Table 2. Summary of interpretation of VES data.

VES	Layer	Resistivity (Ohm-m)	Thickness (m)	Depth (m)	Probable lithology
1	1	938	0.6	0.6	Topsoil
	2	437	1.2	1.8	Lateritic clay
	3	1536	2.6	4.4	Indurated clay
	4	590	7.4	11.8	Clayey sand
	5	35	-	-	Saturated clay
2	1	773	0.6	0.6	Topsoil
	2	351	1.2	1.8	Lateritic clay
	3	849	7.1	8.9	Indurated clay
	4	300	7.5	16.4	Clayey sand
	5	41	-	-	Saturated clay
3	1	703	0.6	0.6	Topsoil
	2	333	1.1	1.7	Lateritic clay
	3	814	6.3	8.0	Indurated clay
	4	178	10.3	18.3	Clayey sand
	5	18	-	-	Saturated clay
4	1	1177	1.4	1.4	Topsoil
	2	287	2.5	3.9	Lateritic clay
	3	1357	3.8	7.7	Indurated clay
	4	39	-	-	Saturated clay
5	1	2169	0.5	0.5	Topsoil
	2	362	2.4	2.9	Lateritic clay
	3	928	3.9	6.8	Indurated clay
	4	43	-	-	Saturated clay
6	1	315	0.7	0.7	Topsoil
	2	556	7.6	8.3	Lateritic clay
	3	25	-	-	Saturated clay
7	1	754	0.5	0.5	Topsoil
	2	246	1.4	1.9	Lateritic clay
	3	1304	3.2	5.1	Indurated clay
	4	364	4.2	9.3	Clayey sand
	5	46	-	-	Saturated clay
8	1	968	1.7	1.7	Topsoil
	2	585	2.7	4.4	Lateritic clay
	3	856	6.9	11.3	Indurated clay
	4	69	-	-	Saturated clay
9	1	685	0.6	0.6	Topsoil
	2	612	1.5	2.1	Lateritic clay
	3	1679	2.0	4.1	Indurated clay
	4	514	6.5	10.6	Clayey sand
	5	48	-	-	Saturated clay
10	1	575	1.1	1.1	Topsoil
	2	684	3.6	4.7	Lateritic clay
	3	40	-	-	Saturated clay
11	1	304	0.7	0.7	Topsoil
	2	908	5.5	6.2	Lateritic clay
	3	323	3.9	10.1	Indurated clay
	4	51	-	-	Saturated clay

Table 2. Contd.

	1	1013	0.7	0.7	Topsoil
	2	563	1.2	1.9	Lateritic clay
12	3	1078	3.0	4.9	Indurated clay
	4	531	12.3	17.2	Clayey sand
	5	23	-	-	Saturated clay

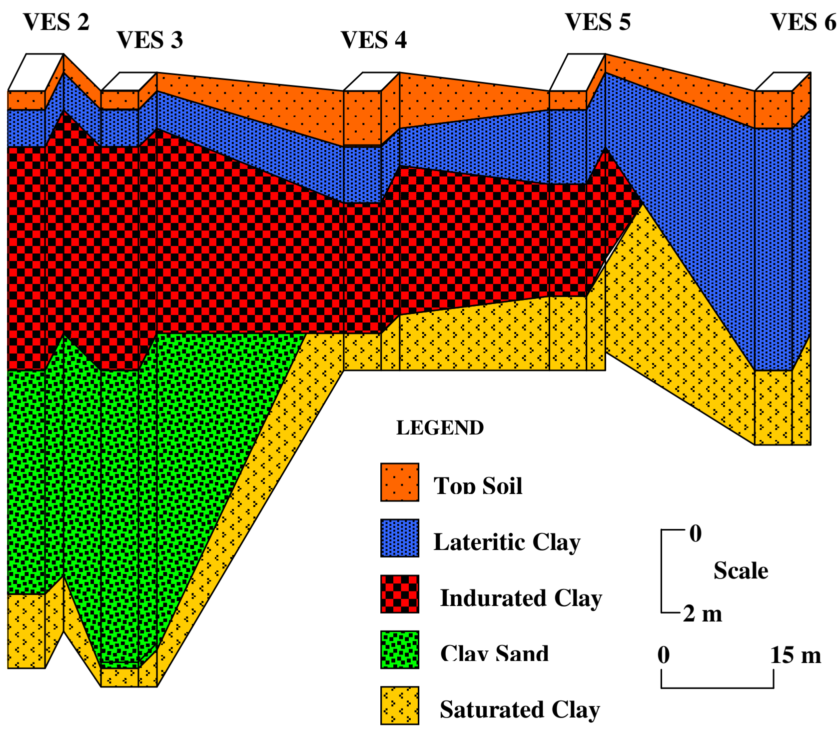

Figure 7a. Geoelectric sections of VES 1, 12, 11, and 10.

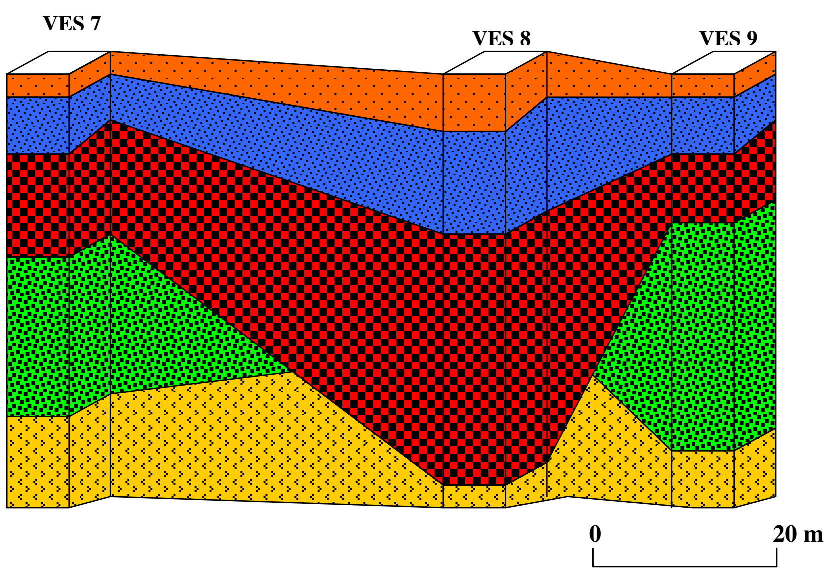

Figure 7b. Geoelectric Sections of VES 7, 8 and 9.

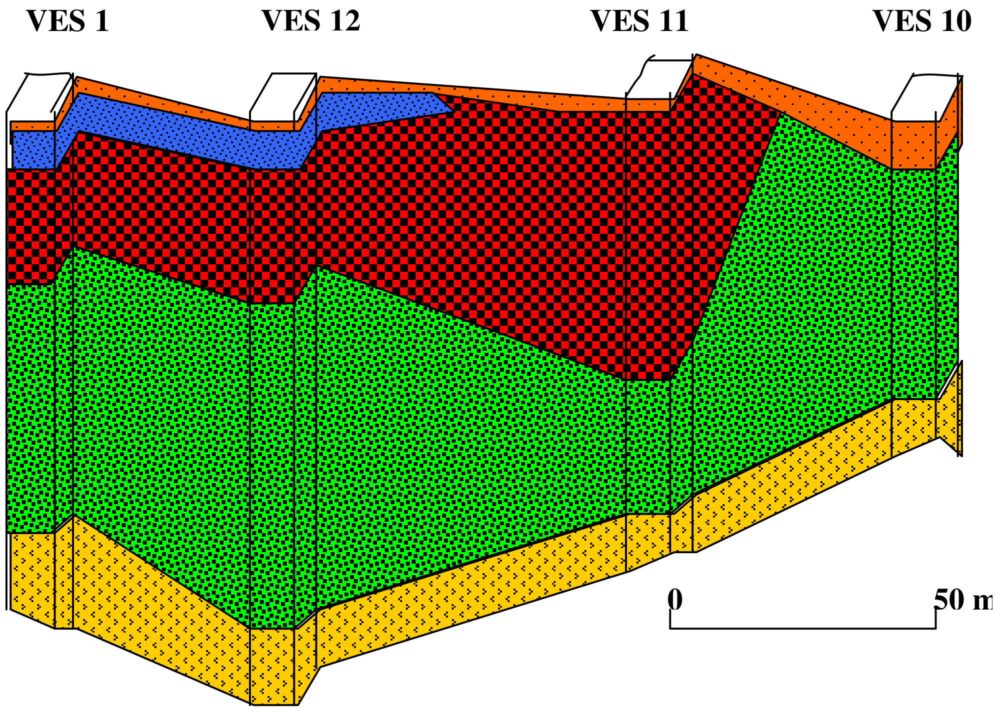

Figure 7c. Geoelectric sections of VES 7, 8 and 9.

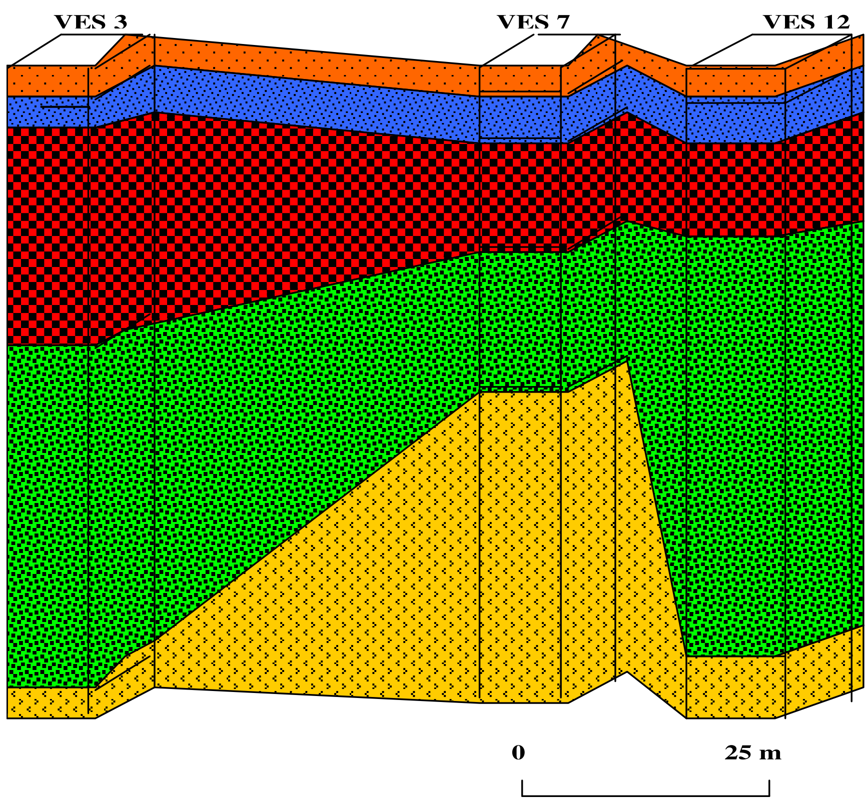

Figure 7d. Geoelectric sections of VES 3, 7 and 12.

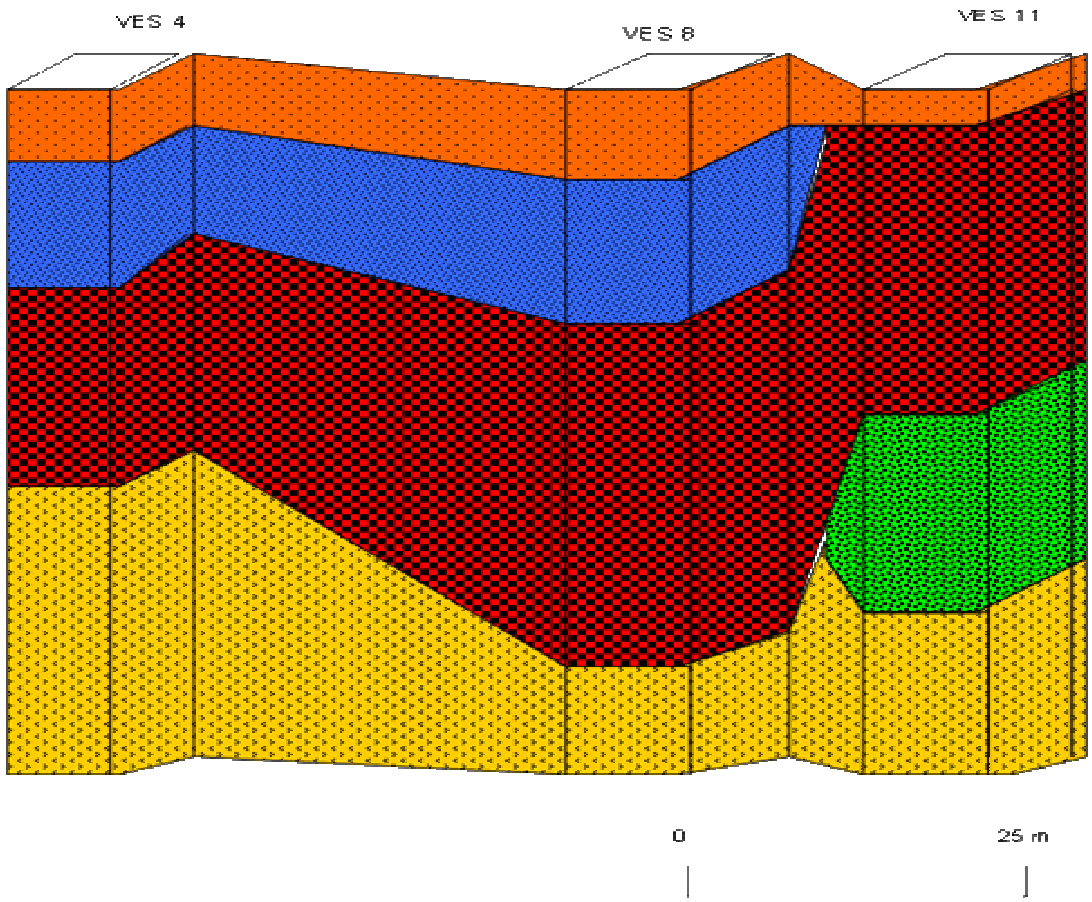

Figure 7e. Geoelectric sections of VES 4, 8 and 12.

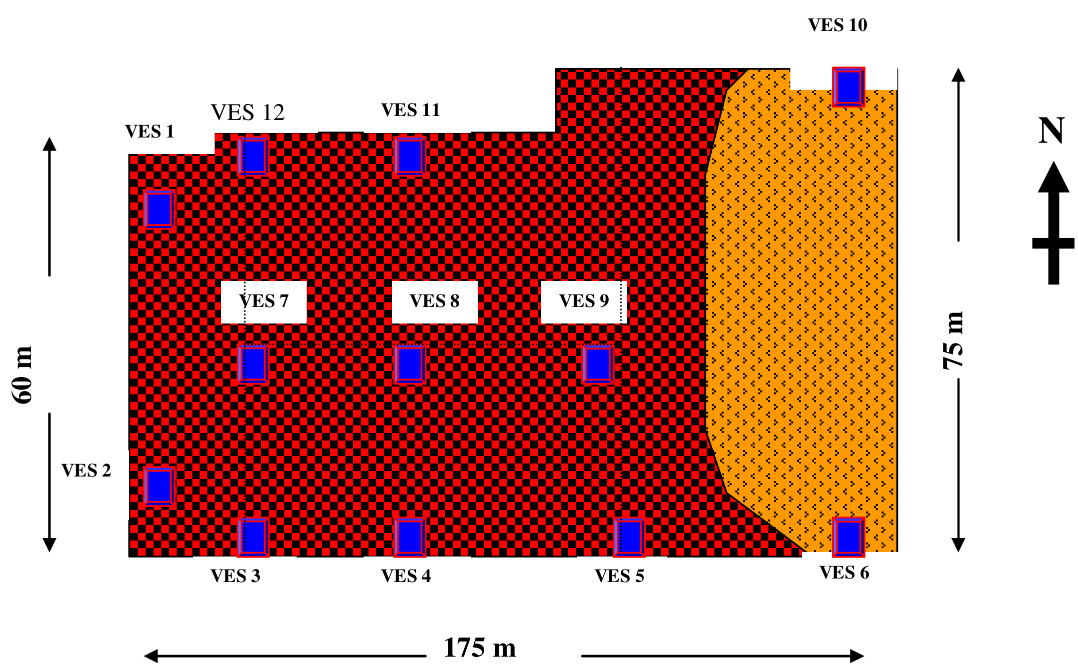

Figure 8. Area extent of the exploitable clay deposit.

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