Petroleum & Coal
ISSN 1337-7027

Available online at www.vurup.sk/petroleum-coal
Petroleum & Coal 54 (3) 252-259, 2012

GEOPHYSICAL INVESTIGATION AND RESERVE ESTIMATION OF A COAL SEAM IN UTE AREA, SOUTHWESTERN NIGERIA

O. A. Ehinola[1], A. Oluwajana[2] and A. T. Adekoya[1]

[1]Energy and Environmental Research Group, Dept. of Geology, University of Ibadan, Nigeria. Correspondence author E-mail: ehinola01@yahoo.com, [2]Department of Geology, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria

Received April 18, 2012, Accepted July 30 2012

Abstract

Recent studies initiated in the search for domestic energy supplies for Nigeria has established the occurrence of coal in Ute area, southwestern Nigeria. The present study is aimed at delineating the coal seam unit and calculates the reserve in order to assess the economic viability. This will promote the full development and utilization of coal deposits, especially for combustion in coal fired industrial boilers for utility power generation intended for domestic purposes such as cooking and heating. Vertical Electrical resistivity Soundings (VES) was employed to identify the areal extent of the coal, and evaluate the coal thickness.

Three to four geoelectric layers were identified through VES, which include: the lateritic top soil, shale, siltstone and coal. The identified zone of interest (the Coal horizon) has undergone a level of subsidence probably due to effect of tectonics. The reserve volume of coal computed for an area of 6.303×10^6 m^2 is 1.02×10^7 tonnes and may be commercially viable considering the area extent of the study area.

Moreover, this coal can be harnessed by investors and used as coal fires for generation of electric power for Ute and Okeluse towns. The exploitation process of this coal should be carried out towards the north - western part of the study area as evidenced by the shallow depth.

Keywords: Geoelectric layer; reserve; thickness; coal; combustion.

1. Introduction

Coal exploration in Nigeria started as far back as 1916. The proven Coal reserves so far in Nigeria total about 639 million metric tons while the inferred reserves sum up to 2.75 billion metric ton [1]. Despite the reported occurrence of these deposits, Nigerian Government only paid little attention to coal - bearing basins. Coal outcrops were found in Ogboyoga in Kogi State, Lafia / Obi in Nasarawa State, and Ute in Ondo State [2]. Smaller occurrences include Garin Maigangu (Bauchi), Afikpo area (Abia), and Koton – Karfi [3]. The domestic coal market is latently large. Besides the potential for power generation [4], Nigeria currently imports coals of different grades and qualities. There is also the potential for coal exports to countries such as China, Ghana and India. In order to determine if coal deposits in Nigeria are economic, detailed geologic studies, such as physical characterization of coal properties, calculations of coal reserves, and analysis of depositional environments, must be conducted on all potentially exploitable deposits. The study area domain lies within Latitude 06^0 $49^{'}$ 35.5''N to 06^0 $50^{'}$ 52.7"N and Longitude $05^0 33^{'}$ 41.5"E to $05^0 36^{'}$ 17.8"E (Fig. 1). Ute coal seam is part of the Cretaceous sedimentary sequence of the Abeokuta Formation (Fig. 2). The estimated and proven reserves of the sub – bituminous coal in Ute and it's utilization for electric power generation has not been determined.

In the present study which is the first geophysical study of the coal seam aims at determining the coal thickness and estimate the coal reserve through information from Vertical Electrical resistivity Soundings (VES) and moreover, the characterization of lithofacies and the study of depositional environments of the particular coal field will help to establish and predict trends in coal's physical characteristics. The study will serve as guide in making proposition

towards a coal – fired power station which is intended to burn the sub – bituminous coal in Ute as primary fuel for power generation.

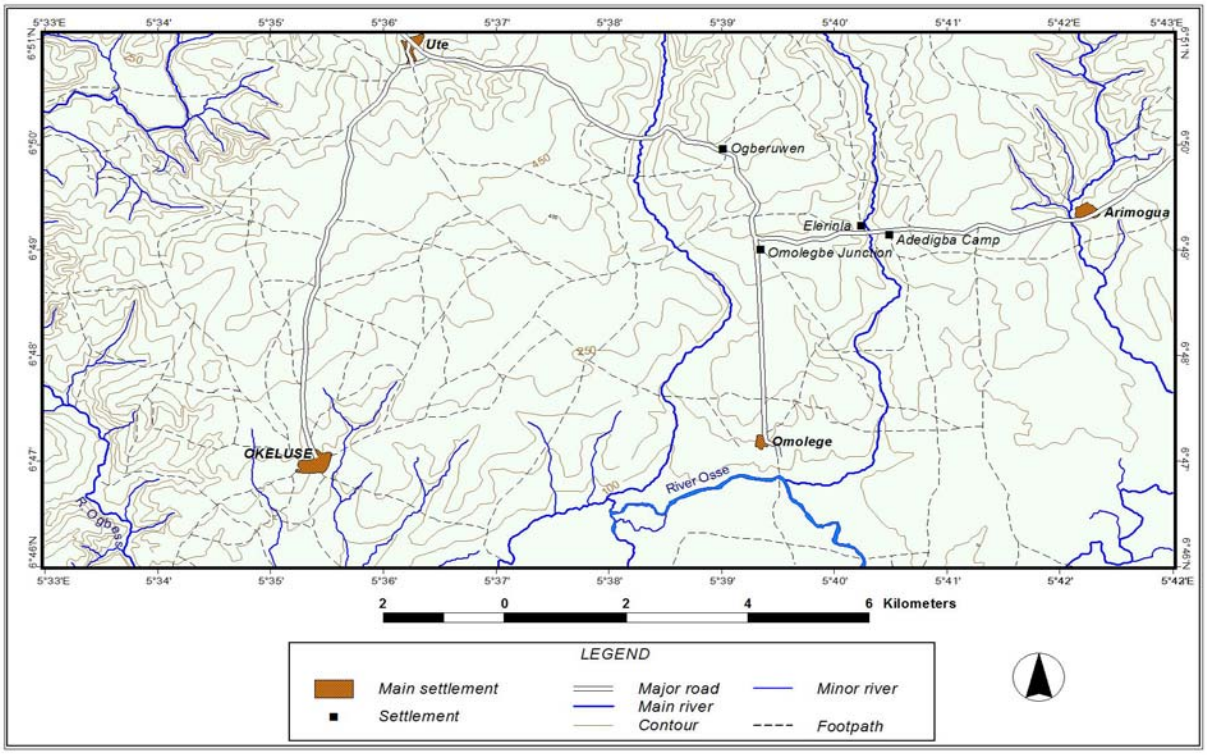


Fig. 1 Topographic Map of the Study Area

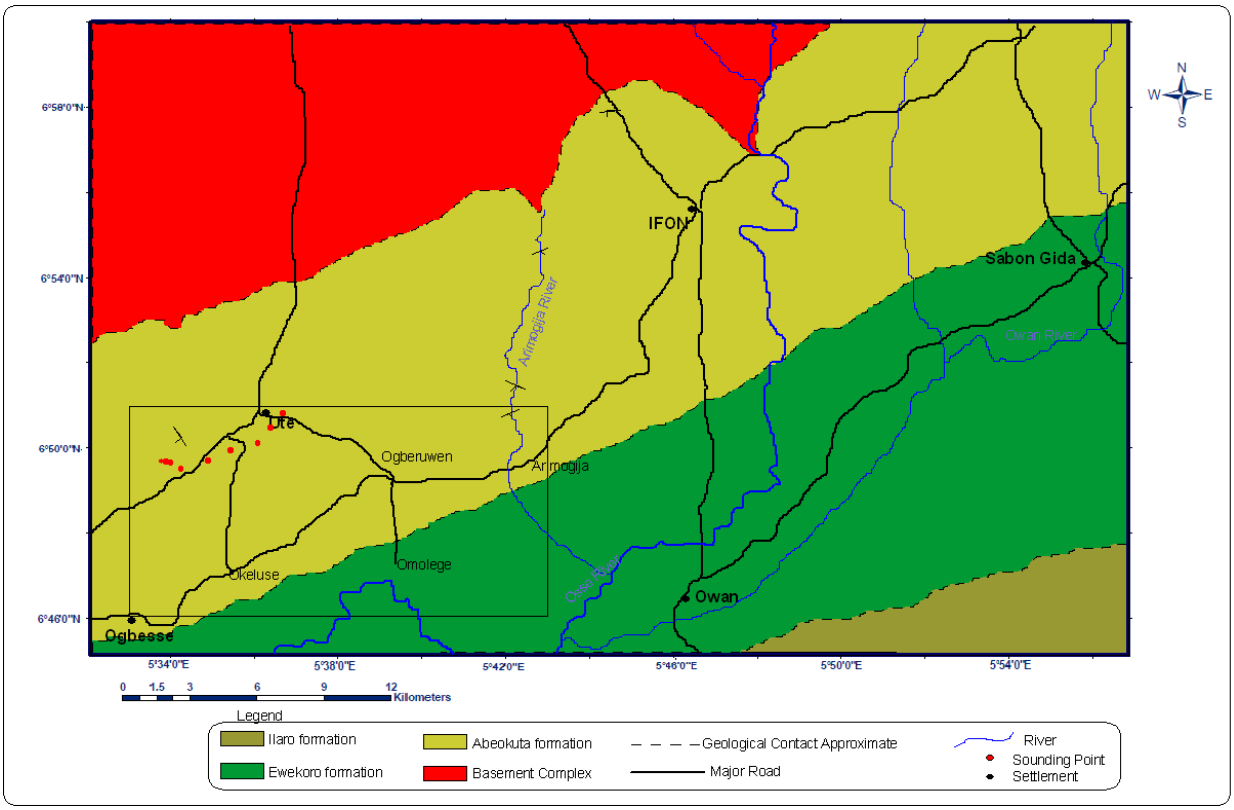


Fig. 2 Geologic Map of Ute and environs

2. Methodology

There is no record of borehole around Ute axis. An attempt was made to log, measure and record the only well – exposed outcropping section in the area. Special consideration was also given to macro – textural features and sedimentary structures. Vertical Electrical Sounding (VES) using the Schlumberger array was also carried out around Ute area. Geographic sample locations were determined and recorded using a handheld Garmin e-trex Vista Geographic Positioning System (GPS) without differential correction. Nine different VES points were located and systematically occupied in a manner that Ute and its immediate environs were well probed during the survey activity (Fig. 3). The electrodes were expanded from a minimum current electrode spacing (AB/2) of 1.0 m to a maximum of 133 m.

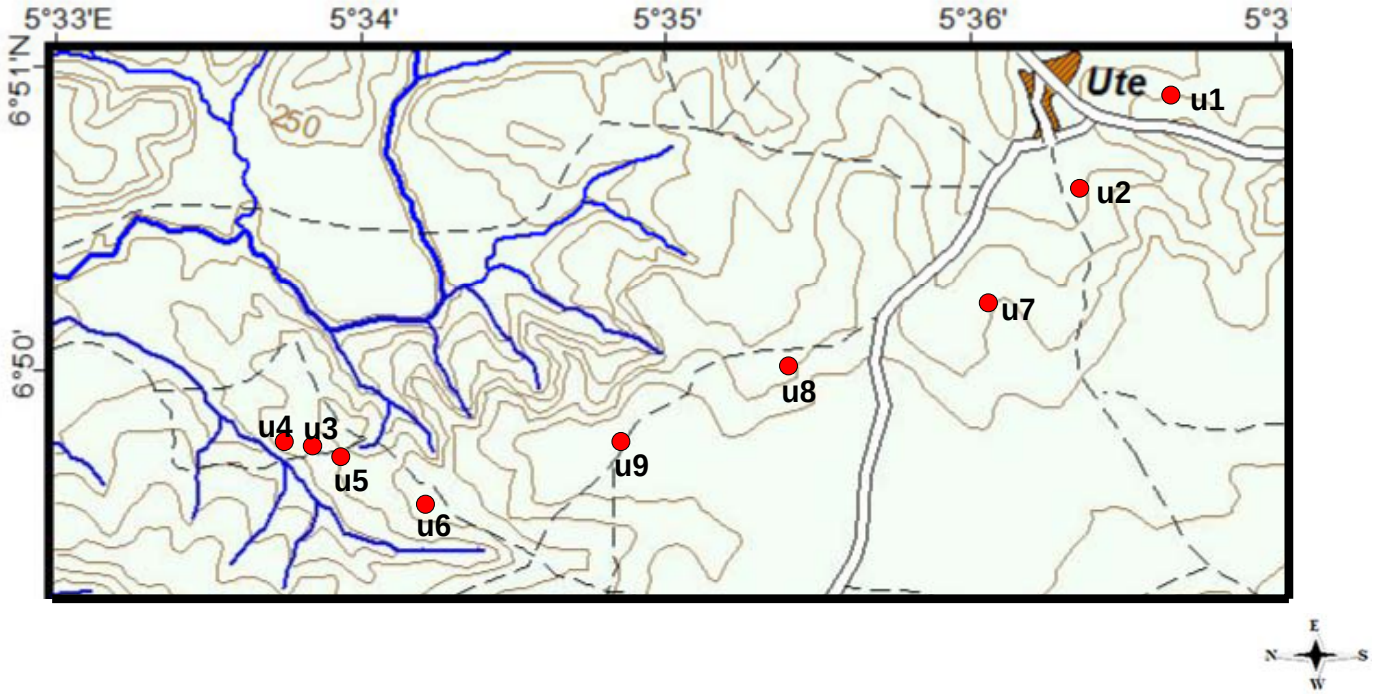


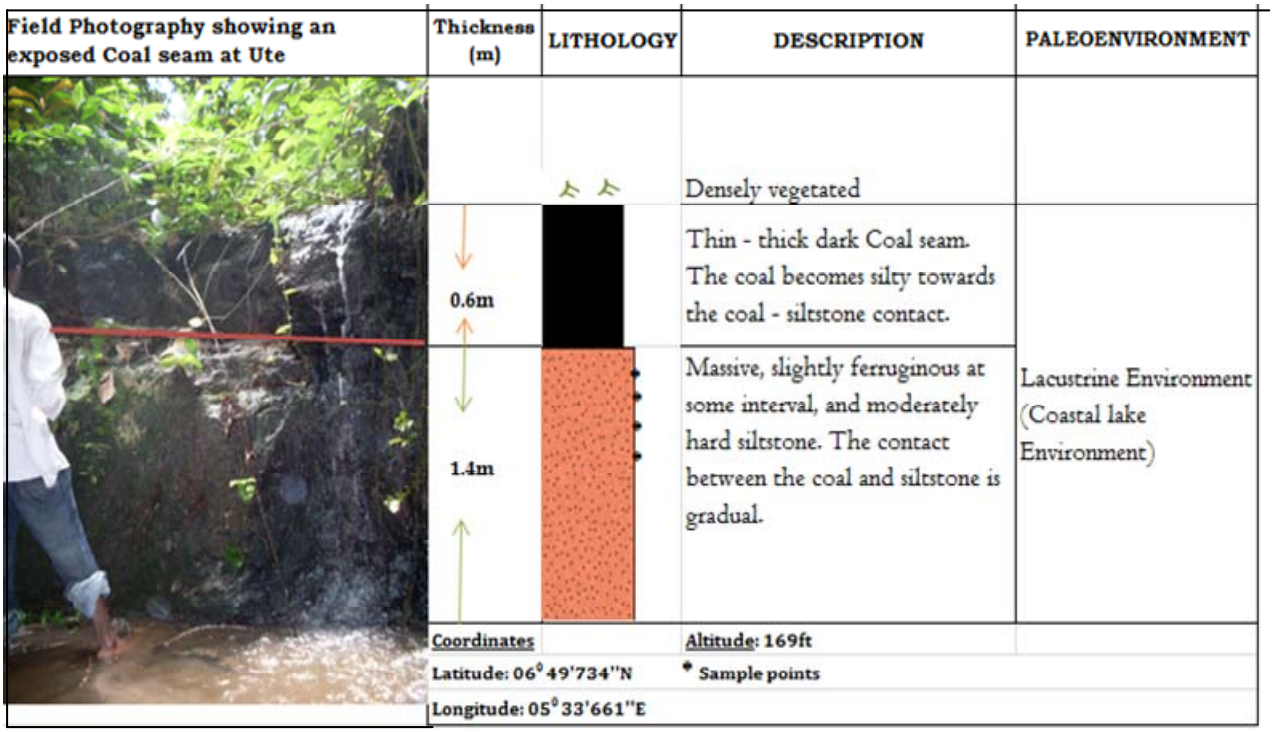
Fig. 3 The Geo – referenced Topographic Map of the study area

The Geopulse Tigre resistivity meter was used in measuring the resistance values that were derived from the survey. Good quality data were obtained with the observational errors being less than 1%. The resistance values were recorded on a standard VES recording sheet. Resistivity data obtained from the field were subjected to preliminary interpretation using partial curve matching involving two - layer master curves and appropriate auxiliary charts so as to extract the layer parameters (The apparent resistivity and corresponding thickness values). The layered model thus obtained served as input for an algorithm as a final stage in the quantitative data interpretation [5]. The reserve is estimated using the equation R_e = Area x Thickness x Density, where R_e is the reserve estimate [6].

3. Results and Discussion

3.1. Sedimentological Evidence

The lithologic assemblage is largely dominated by coal and siltstone in the study area (Fig. 4). The coal seam is usually dark and generally less than 1.0 m thick. The contact with the overlying and underlying succession is gradual. The presence of thin bed of coal indicates a high water table in depressions on parts of the distal flood plain or oxbow lakes. The coastal lake environment is conducive to the growth of plant material and subsequent development of peat and coal [7]. *Ammotium nwalium* is the only micro fossil (foraminifera) recovered from the underlying siltstone. The identified form is not enough to make a significant paleo - environmental interpretation, however, coastal lake or lacustrine environment was deduced.



3.2. Geophysical Interpretation (VES)

The result of the Vertical Electrical Sounding (VES) show a system of three to four geoelectric layers with lateritic top soil as the topmost layer. The shale zones are found below the lateritic top soil and the siltstone layers are seen to exist below the shale zones. The siltstone layers are underlain by the either the Basal conglomerates or the Basement complex rocks. The coal seam (with a measured thickness of 1.3 m) was consistently found to exist below the shale beds and at shallow depths to the surface. This was well pronounced at the VES point U3 in which a coal seam outcrop was encountered and found in close proximity with a siltstone layer. This agrees with the earlier authors who worked in the southwestern Nigeria [8, 9, 10].

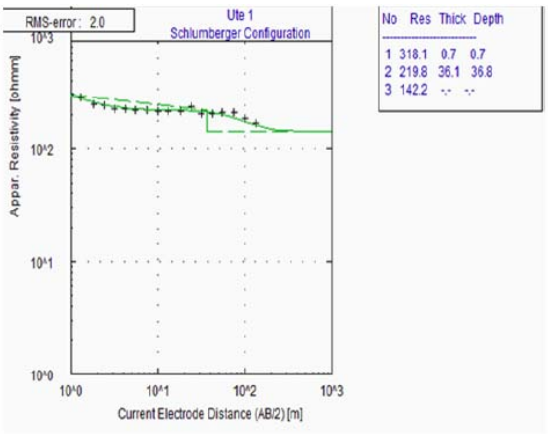


Figure 5a: Layer model interpretation for VES 1

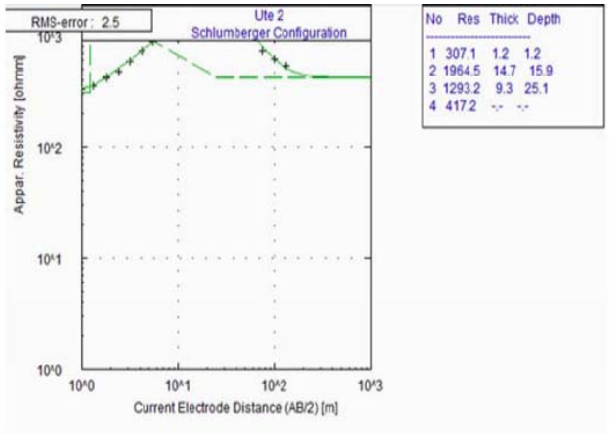


Figure 5b: Layer model interpretation for VES 2

Representatives of the VES curves as obtained from inversion are shown in figure 5a-d. The probable stratigraphic sequence from top to bottom is as shown in Table 1. The litho - units are seen to vary in thickness from one point to another within the study area. The horizon of interest (the coal seam) is seen to undergo a level of subsidence probably due to the tectonic activities and the siltstone layer is seen to pinch out at VES point U6. In both U5 and U9, very thick layers of siltstone can be seen to exist and pinch out towards adjacent VES

locations (Figs. 6a and 6b). The volume of Coal present for the area of land (6.303 x 10^6 m^2) with an average thickness of 1.3m was calculated to be 1.02 x 10^7 tonnes (Appendix I).

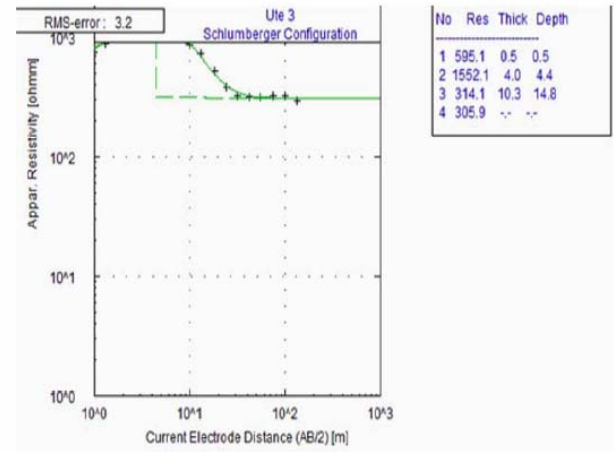


Figure 5c: Layer model interpretation for VES 3

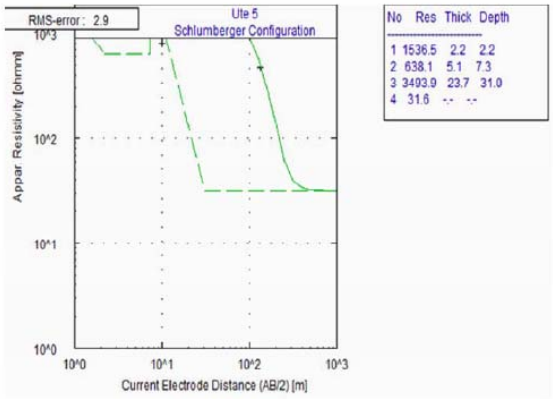


Figure 5d: Layer model interpretation for VES 5

Table 1. Summary of the interpretation of VES data

VES	Layer	Resistivity (Ohm.m)	Thickness (m)	Probable Lithology
U1	1	318	0.7	Lateritic top soil
	2	220	36.1	Shale
	3	142	-	Coal
U2	1	307	1.2	Lateritic top soil
	2	1965	14.7	Shale
	3	1293	9.3	Siltstone
	4	417	-	Coal
U3	1	595	0.5	Lateritic top soil
	2	1552	4	Shale
	3	314	-	Coal
U4	1	310	1	Lateritic top soil
	2	1297	19.8	Shale
	3	152	-	Coal
U5	1	1537	2.2	Lateritic top soil
	2	638	5.1	Shale
	3	3494	23.7	Siltstone
	4	32	-	Coal
U6	1	630	0.8	Lateritic top soil
	2	2205	16.8	Shale
	3	662	-	Coal
U7	1	670	1.4	Lateritic top soil
	2	2227	3.1	Shale
	3	2556	-	Siltstone
U8	1	777	1	Lateritic top soil
	2	8493	25.6	Shale
	3	1775	-	Coal
U9	1	1182	1.2	Lateritic top soil
	2	831	2.7	Shale
	3	4193	25.9	Siltstone
	4	16724	-	Basement complex

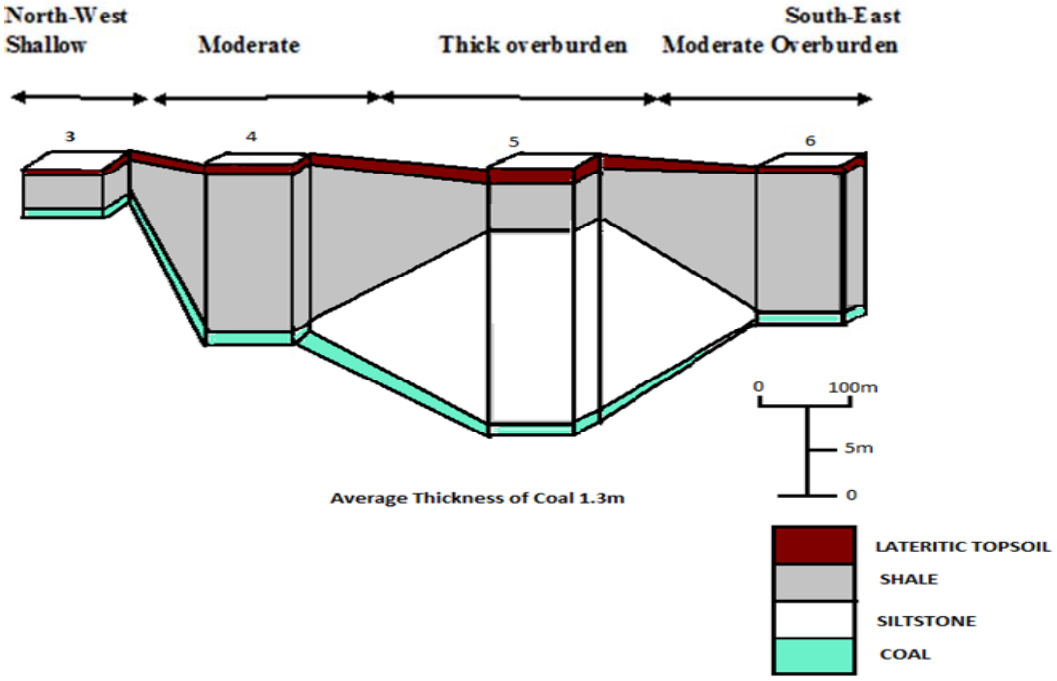


Figure 6a: Geoelectric section of VES 3, 4, 5, and 6 (Rectangle A of Apendix I)

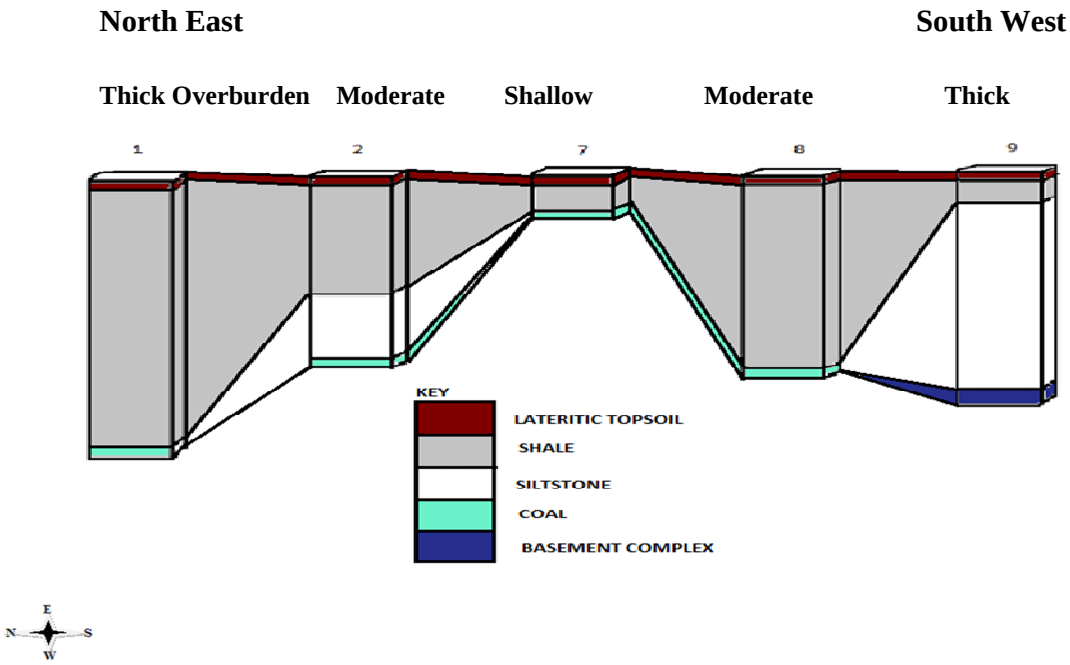


Figure 6b: Geoelectric Sections of VES U1, U2, U7, U8, and U9 (Rectangle B of Apendix I)

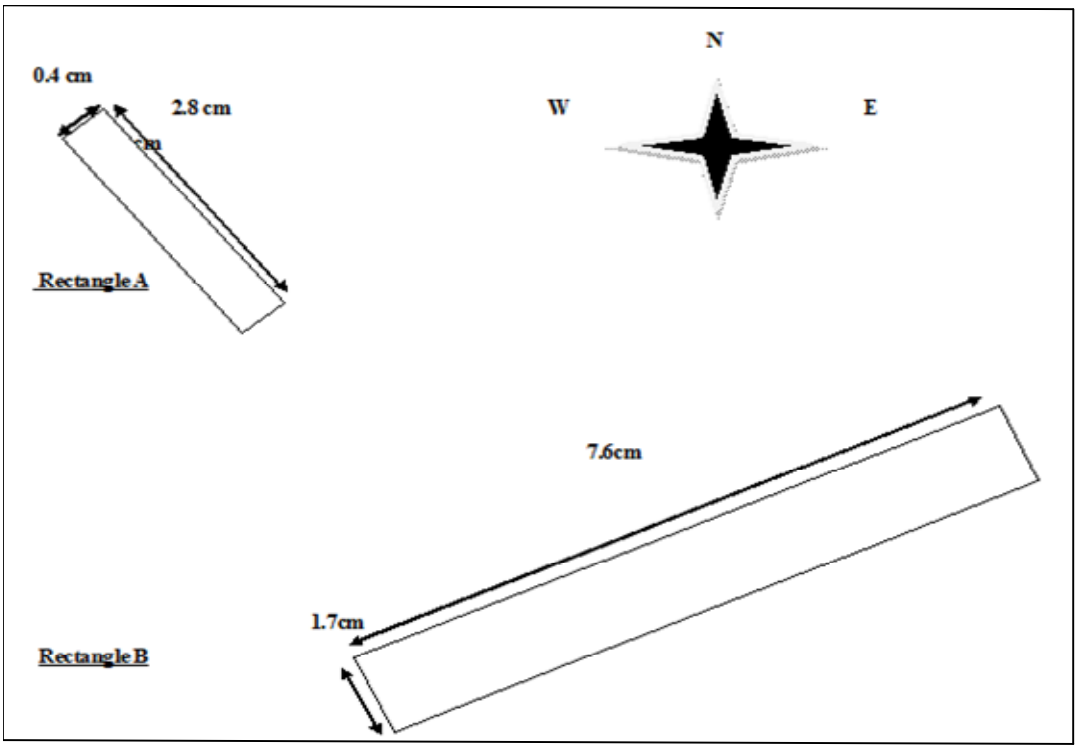
4. Conclusion

Detailed geophysical studies involving Vertical Electrical Sounding has been carried out around Ute with aim of determining the coal thickness and estimate the coal reserve. The area is underlain by different geologic rock units such as lateritic top soil, shale, coal and siltstone. The horizon of interest, which is coal seam, has been delineated.

The reserve volume of coal computed for the study area of 6.303 x 10^6 m^2 is 1.02 x 10^7 tonnes. This coal can be harnessed by individuals and local investors for domestic purposes

especially coal fires for generation of electric power for Ute, Arimogija, Imoru and Okeluse towns. The exploitation process of this coal should be carried out towards the north - western part of the Ute area as it occurs at shallow depth. The observed sedimentary features indicate that the Coal seam at Ute was deposited in a lacustrine environment.

APPENDIX I



Conversion of centimeters on map to meters on ground;

0.4 cm= 0.4 x 0.67 km= 268 m
2.8 cm= 2.8 x 0.67 km= 1876 m
1.7 cm= 1.7 x 0.67 km= 1137 m
7.6 cm= 7.6 x 0.67 km= 5.072 m
Area of U3 - U6 = 268m x 1 876m = 502 768 m^2
Area of U1 - U9 = 1 139m x 5 072 m = 5 799 788 m^2
Total Area covered = 502768 + 5799788 = 6 02 556 m^2
Average thickness of exploitable area= 1.3m
Density of Solid Coal (Lignite) = 1 250kgm^{-3}

Reserve estimation (R_e)

R_e= Area x Thickness x Density = 6 302 556 x 1.3 x 1 250 = 1.02 x 10^7 tonnes

References

[1] MMSD (2006): Ministry of Mines and Solid Mineral Development. www.mmsd.gov.ng/solid_minerals_sector/Coal.asp.

[2] Ojo J. S. (2000): Geophysics, Energy Resources and the Environments. An Inaugural Lecture delivered on the 7th of March at the Federal University of Technology, Akure, Ondo State.

[3] Ehinola O. A and Adene T. M (2008): Preliminary Investigation on Acid Generating Potential of Coals from Benue Trough, Nigeria. Petroleum and Coal 50(3), 19-26.

[4] TSQDME (1999): The State of Queensland, Department of Mines and Energy, Utilisation of Walloon Coals of Southern Queensland for Power Generation, 1 – 38.

[5] Singh kkk, Singh KB, Lokhande RD, and Prakash A, (2004): Multielectrode resistivity imaging technique for the study of coal seams. J. Scientific and

Industrial Research. Vol.63: 927-930.

[6] Ehinola O. A, Oladunjoye M. A, Gbadamosi T. O (2009): Chemical composition, geophysical mapping and reserve estimation of clay deposits from parts of Southwestern Nigeria Journal Geology and Mining Research. Vol. 1(3): 57-66.

[7] Wolela, A., (2010): Sedimentation, Organic Maturity, and Petroleum Potential of the Oligocene – Miocene Oil Shale Deposits, Yayu Basin, Ethiopia. American Association of Petroleum Geologists Bulletin, v.94, 5 (May 2010), pp. 643 – 663.

[8] Nton M. E, Ikhane P. R, Tijani M. N, (2009): Aspect of Rock-Eval Studies of the Maastrichtian - Eocene Sediments from Subsurface, in the Eastern Dahomey Basin Southwestern Nigeria. European Journal of Scientific Research 25(3): 417 - 427.

[9] Enu, A. Adegoke O. S and Ezemokwe O (1983): Stratigraphy and Sedimentology of the upper-Cretaceous Sediments, Southwestern Nigeria Journal of Mining and Geology 104 – 109.