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The Detectability of Ute Coal Seam Using Geo-Electric Method, Ondo State, Nigeria

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Abstract

A Geo-electric survey over the Ute coal deposit, Ondo state, has been carried out using schlumberger electrode array configuration. The Geophysical investigation which involves vertical electrical sounding (VES) techniques was done using ABEM SAS 1000 resistivity meters with aim of determining the detectability of coal and hence the ability to image it away from its outcrop location. The inter-electrode spacing varies from 1 to 65 m with maximum spread length of 130 m.

Generally, the study area is underlain by five geo-electric layers: the lateritic topsoil, shale, siltstone, coal and fine grained sandstone. The sounding curve obtained in the area is KQH type. The VES method when continuously implemented can be used for reconnaissance mapping of the Ute coal deposit. The resulted thickness of the coal indicates that it can be used by individuals and local investors for domestic purposes especially coal fires for generation of electric power for Ute and its environs.

Keywords: Geo-electric survey; Geo-electric layer; Curve type; Coal

Introduction

Coal reserves are discovered through exploration activities. The process involves creating a geological map of the area, then carrying out geophysical surveys (Figure 1). This allows an accurate picture of the area to be developed. Coal exploration in Nigeria which serves as the oldest commercial fuel started since 1915 and has a proven coal reserve of about 639 million metric tons and inferred reserves of up to 2.75 billion metric tons (MSMD, 2006). There are more than 13 undeveloped coal fields in Nigeria which can be divided into two categories, viz: the virgin coal fields where further detailed exploration work are required and the developing coal fields, where reserves have been proven. The latter include: Ogboyoga coal field in Kogi state, Ezimo coal field in Enugu state, Lafia-obi coal field in Nassarawa state while others are located in Afuze in Bauchi state and Ute (Figure 2) in Ondo state (Plate 1). The area is bounded within latitudes of $06^0 49^1.684$N to $07^0 07^1.174$N and longitude $005^0 33^1.726$E to $006^0 13^1$. 057E. The altitude of the host town-Ute lies between 239 ft to 675 ft.

Geo-Electric Survey

Geo-electric survey is an active geophysical method that employs electrical current to examine the subsurface earth materials. Geo-electric techniques measures earth resistivity by driving a direct current signal to the ground and measuring the resulting potentials (voltages) created in the earth. The geo-electric survey uses cables with multiple (usually > 50) equidistant electrode connection to the ground. The survey can be used to provide information on the existence, continuity, thickness, and correlation of shallow to deeply buried coal beds in known coal bearing areas that has not been fully explored. The purpose of the survey is to evaluate the detectability of the coal seam in Ute using geo-electric survey method (specifically VES).

Geology of the Study Area

Ute lies within the Eastern part of Dahomey basin. The basin is bounded on the west by faults and other tectonic structures associated with the landward extension of the Romanche fracture zone. Its eastern limit is also marked by the Benin hinge line, a major fault structure marking the western limit of the Niger Delta basin. Horizontal movements along the oceanic fracture zones were translated to vertical movements leading to block faulting and subsequent development of horsts and grabens [1]. The Ute coal is dated Late Maastrichtian based on paleo-environment of deposition and it is suggested to be lacustrine on the basis of co-occurrence of fluvio-marine [2]. The evolution of the basin is attributed to trans current movement on the oceanic (Figure 3) offshore system especially the Romanche, shale and chacot fractures during the rifting (Figure 4). Several authors like Omatsola and Adegoke [1], as discussed the evolution of Dahomey basin. there are four stages that are recognized in the evolution and they are:

Intra cratonic stages

The feature commonly known to this stage is the depositional of continental lacustrine sequences which were deposited during the long period of the tectonic stability. The fracture zone became site of tectonic forces which trigger-off the rifting stage. This is called Ise formation and this is also true of Dahomey basin.

Synrift stage

During the thermo tectonic event which resulted in coastal thinning of thermal anomalies, the accompanying basinal downwarping and subsidence cause a series of steep sided normal fault with variable throws. Sediment deposition was characterized by rapid lateral facie changes because of the intensive erosion of the uplifted area and continental shift of the depo centres. Lithologically, the age of this sequence ranges from Neocomian to Albian.

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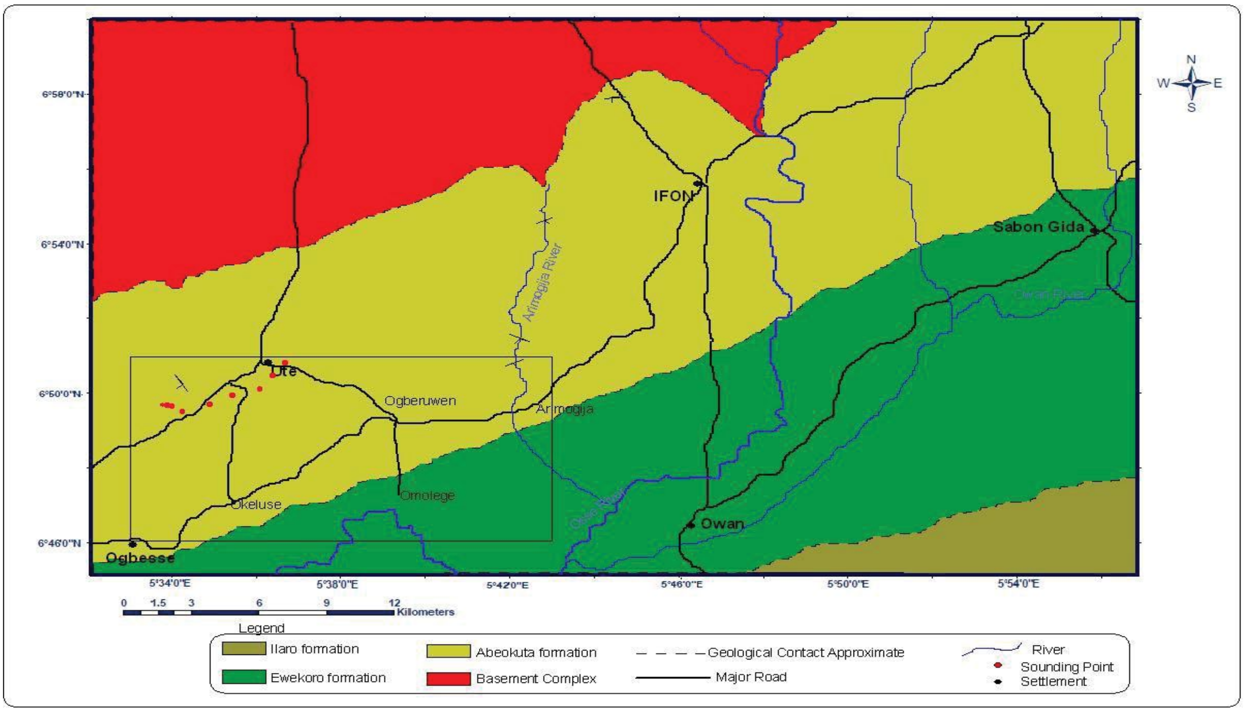

Figure 1: Geological map of Ute area of Ondo State [2].

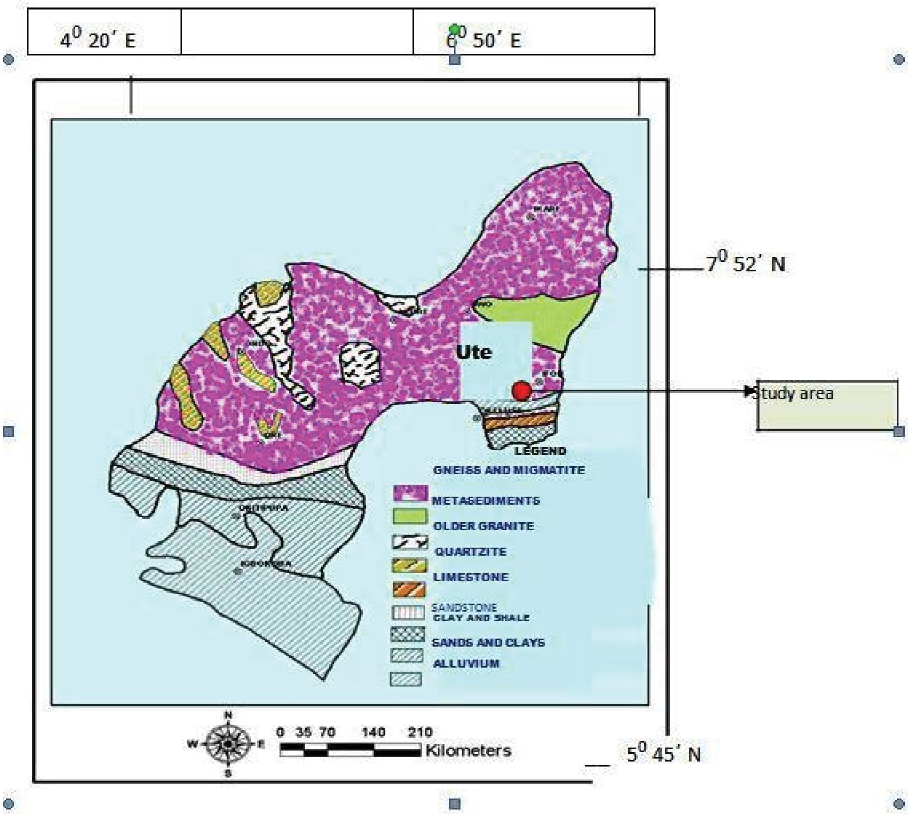

Figure 2: Ondo state map showing the Location of the Study Area.

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Plate 1: Field photograph of the Coal Seam at Ute in Ondo state.

Source: Geological Survey Nigeria, Ondo State, 2001

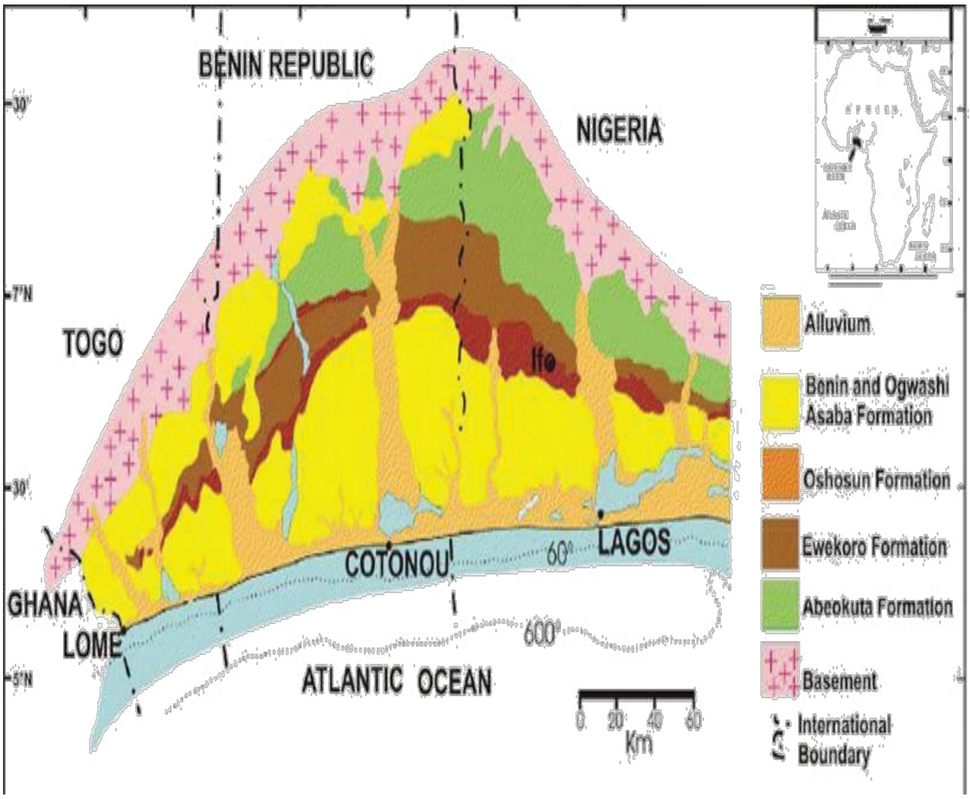

Figure 3: Map of Dahomey (Benin) Embayment.

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Transitional stage

This is characterized by deposition of parallic sequences most especially on the northern part of the gulf of guinea.

The oceanic stage

This is the final stage which is characterized by development of deep seated fault extrusion of new oceanic crust and the establishment of truly basin.

Dahomey basin comprises mainly the Abeokuta group. Omatsola and Adegoke [1] divided the group into three lithologic units (Table 1); the eastern Ise, Afowo and Araromi.

Methodology

In this survey the vertical electrical sounding (VES) was employed with Schlumberger array configuration and the arrangement was made to enhance a good data quality and resolution. Gradually increasing the electrode spacing about a fixed centre of the array increases the depth of investigation. Electrical resistivity sounding provides information on the depth to the basement, the thickness and resistivity of coal. After the electrodes have been positioned and connected with the resistivity meter via clips and cables the manual button was pressed for sending current into the ground, the measured current and corresponding potential were recorded in a recording sheet. The same procedure was repeated for all the four (4) VES stations. A total number of four (4) VES data were collected over the entire study area.

The vertical electrical sounding data were plotted as sounding curve, i.e. plot of apparent resistivity pa (~m) against electrode position AB/2 on a log-log graph sheet interpretation of VES curves. The sounding data were quantitatively interpreted using the partial curve matching technique [3].

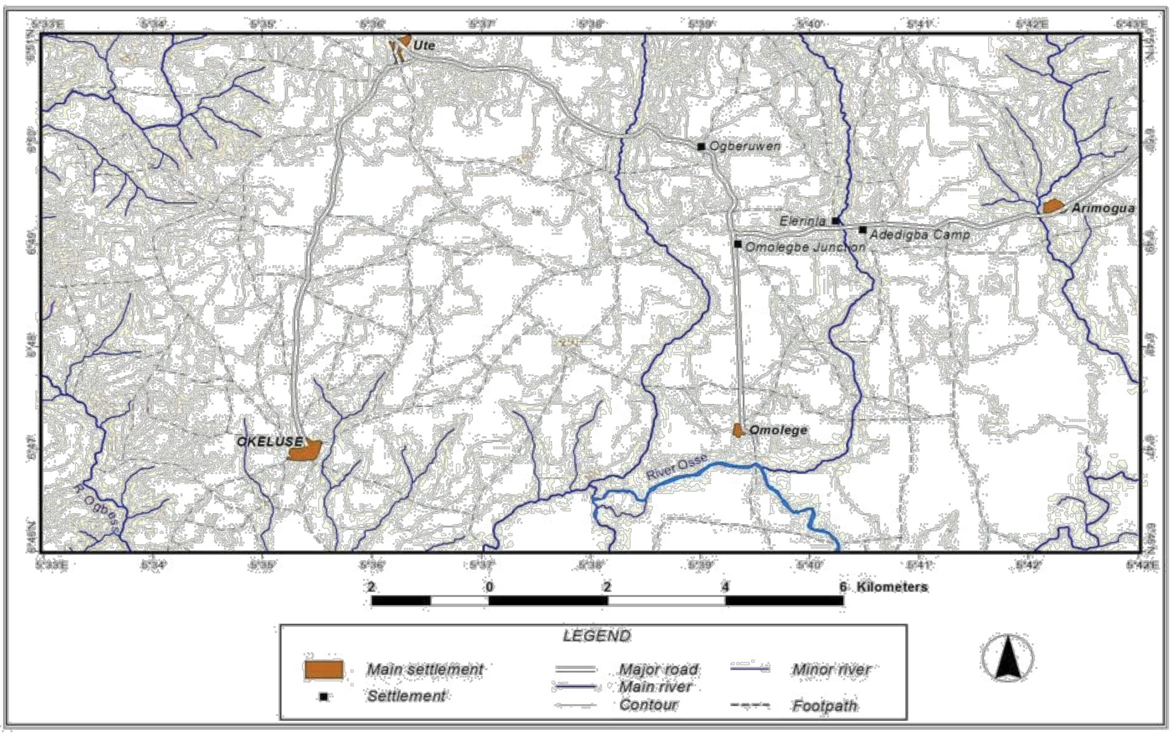

Figure 4: Topographical map of the study area [2].

Jones and Hockey(1964)			Omatsola and Adegoke (1981)		Agagu (1985)	
Age		Formation	Age	Formation	Age	Formation
Quaternary	Recent	Alluvium			Recent	Alluvium
Tertiary	Pleistocene-Oligocene	Coastal Plain	Pleistocene-Oligocene	Coastal Plain	Pleistocene-Oligocene	Coastal Plain
	Eocene	Sand Ilaro	Eocene	Sand Ilaro	Eocene	Sand Ilaro
	Paleocene	Ewekoro	Paleocene	Oshosun	Paleocene	Oshosun
				Akinbo	Paleocene	Akinbo
				Fm		Ewekoro
Cretaceous	Late	Abeokuta	Maastrichtian-Neocomian	Araromi	Maastrichtian-Neocomian	Araromi
	Senonian			Afowo Ise		Afowolse
Precambrian Crystalline Basement Rocks						

Table1: Stratigraphy Unit of Eastern Dahomey Basin.

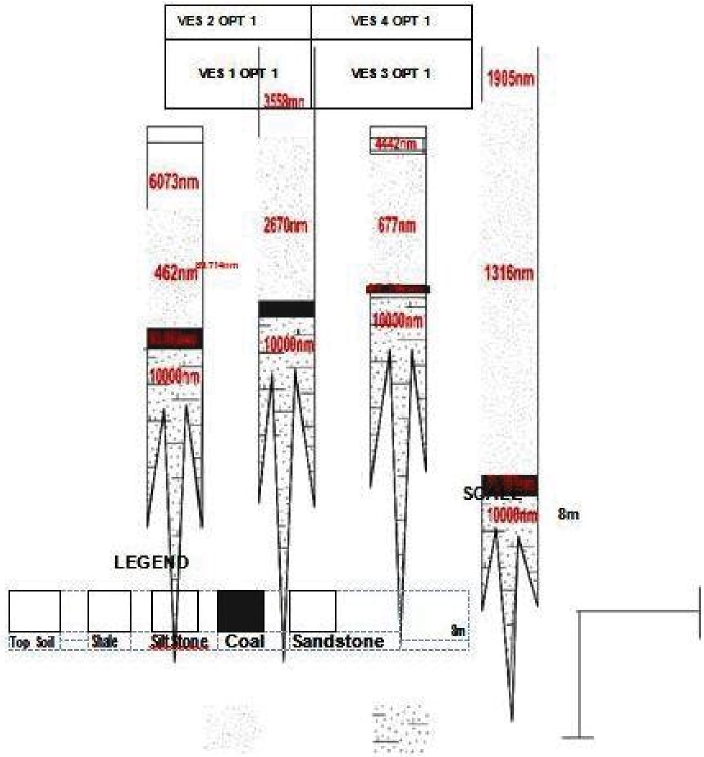

Figure 5: Geo-electric section of the study area.

Vesno	Layer	Resistivity (Ω)	Thickness (m)	Depth (m)	Probably Lithology	Curve Type
1	1	1024	0.884	0.884	Lateritic topsoil	K Q H
	2	6073	4.504	5.388	Shale	
	3	462	7.98	13.36	Siltstone	
	4	93.062	0.623	13.991	Coal	
	5	10000			Fine grain Sandstone	
2	1	3864	0.461	0.461	Lateritic topsoil	K Q H
	2	3558	6.206	6.667	Shale	
	3	2670	14.705	21.372	Siltstone	
	4	89.71	0.308	21.68	Coal	
	5	10000			Fine grain Sandstone	
3	1	1747	0.79	0.79	Lateritic topsoil	K Q H
	2	4442	0.738	1.528	Shale	
	3	677	13.115	14.643	Siltstone	
	4	87.79	0.615	15.258	Coal	
	5	10000			Fine grain Sandstone	
4	1	1903	0.524	0.524	Lateritic topsoil	K Q H
	2	1905	2.394	2.918	Shale	
	3	1316	24.864	27.782	Siltstone	
	4	51.703	0.679	28.461	Coal	
	5	10000			Fine grain Sandstone	

Table 2: Geo-electric parameters of the study area.

The true resistivities and thicknesses over various layers can be estimated for Schlumberger VES data as;

$$Pn = p(n-1) \times k\,(n-1)$$

$$hn = h(n-1) \times (dn/dr)\ n-1$$

$$pr = p1$$

$$hr = h1$$

$$p2 = p1 \times k1$$

$$p3 = p2r \times k2, \text{ etc.}$$

Where,(dn/dr) n-1= Distance between the cross over point of the preceding segments and the present segment. The partial curve matching was used as preliminary interpretation of the field curves. It produces the parameters needed for each layer resistivity and thickness values for the computer iteration. The results were finally iterated using DC INV version 1.5 software [4].

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Discussion

The results were presented as sounding curves, tables and geo-electric section.

Curve type

The geo-electric sounding curves were evaluated for signatures that are diagonistic of coal occurrences in the study area. Further interpretation of curves involved partial curve matching and the output were modelled using computer iterations [5,6]. The VES all showed a kink in resistivity at depth range from 13.991 to 28.461. This was believed to be the result of the thin low resistivity coal layer of about 0.6 m [7].

The summary of the selected geo-electric data (Figure 5) interpretation is presented in Table 2. All the geo-electric sounding curves obtained show patterns that are indicative of geologic sequence consisting of lateritic topsoil, shale, siltstone, coal and fine grain sandstone. The geo-electric sections of the sounding curves are presented [8].

Using model parameter

Obtained from outside geologic inspection, the VES data was invented and iterated severally to investigate the robustness of the model parameters for the ability of the inversion to accommodate the coal layer parameters despite its very thin size. In all cases, the iteration up to five times did not merge the coal layer with any of the branching layer. This suggests that, the thickness notwithstanding, the coal layer appreciably affect the VES curves. Otherwise, it is expected that the layer would hence be layered with either of the fine grained sandstone or siltstone as a blind or hidden layer [9-11].

Conclusion

The observed sedimentary features indicate that the coal at Ute was deposited in a Lacustrine environment. The resulted thickness of the coal indicates that it can be used by individuals and local investors for domestic purposes especially coal fires for generation of electric power for Ute and its environs. The results of the resistivity inversion, factoring in the geological knowledge of the subsurface at the outcrop location indicates that the VES method when continuously implemented can be used for reconnaissance mapping of the Ute coal deposit and therefore an estimation of the coal reserve.

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