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Review Article

Geology and Structure of Uru-Ugworji Diorite Lokpanukwu, Southeastern Nigeria

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Abstract: The Lokpaukwu Uru Quarry was examined geologically, geophysically, and core-wise. The location is between 5056.149'N and 5056.193'N and 7028.312'E and 7028.356'E. The study location may include the Asu River Group and the Eze-Aku Formation. This area has five rock units. In the eastern research region, siltstone forms a "CAP" on the shale. Shale underlies half of the study area. The west has calcareous sandstone. The eastern part of the area is dolerite, the main rock that spans siltstone and shale. The region's geological matter contains iron. Two geological sections were analysed and interpreted to identify the five rock units and their outcrops in the study area. electroresistivity in geophysical research Schlumberger found that the western, northwesterly, and central sections of the research region had a thick sedimentary sequence, whereas the eastern half has an igneous body, the project's main component. Sandstone, siltstone, and shale follow the high-resistivity rock in this location. The rock unit in the region was found in eleven core samples from the east half of the study area. Nine rock-unit core samples were found near Obichioke. The Lokpaukwu area's core data shows the rocks' positions, kinds, minerals, and strengths. Geologic mapping shows that a major fault separates the viable Uru end from the unviable Obichioke lot. Recrystallization dominates the fault track (alcitic matter). Thus, prior to quarrying igneous (basic) units, comparable investigations are advised.

Keywords: Geological; Geophysical; Shale; Dolerite; Calcareous Sandstone; Asu River Group; Eze-Aku Formation

1. Introduction

The geology and structure of Uru-Ugworji Diorite, located in Lokpanukwu, southeastern Nigeria, is a complex and diverse subject that has been the focus of much research in recent years. The diorite, which is a coarse-grained igneous rock, is composed mainly of plagioclase feldspar, hornblende, and biotite, and is part of the Precambrian basement complex of Nigeria. The Uru-Ugworji Diorite is part of the Lokpanukwu anticline, which is a large, north-south trending fold that is a major structural feature of the area. The diorite intrudes into the surrounding metasediments and granite gneiss and has undergone significant deformation and metamorphism as a result [1].

The study of the geology and structure of Uru-Ugworji Diorite has important implications for understanding the tectonic history of Nigeria and the broader West African region. It also has practical applications in the fields of mineral exploration and resource extraction. Further research is needed to fully understand the geology and structure of Uru-Ugworji Diorite and its relationship to the surrounding rock formations. This could include detailed mapping and geochemical analysis, as well as the study of the diorite's petrographic and structural characteristics. Such research would provide valuable insights into the complex geology of Nigeria and contribute to our understanding of the tectonic evolution of the West African region [2].

2. Literature Review

Previous geophysical works carried on the study area in January 2003 were less detailed works. In all of these, the reports have always shown a trend in parts of Uru Ugworji that the area is a quarrying site. Professor Kalu Kalu Ibe carried out a geophysical sounding survey of the Uru area,

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Southeastern Nigeria which deposits the correlation between geological and geoelectric section of the study area when he was a doctor back in 2003 [3]. Shell B. P. in their search for hydrocarbon carried out both geophysical and geological survey of the Southeastern Nigeria between 1950 and 1960. They were able through the survey to name stratigraphic units which are still in use today. They produced a generalized geologic map of the Southeastern part of Nigeria. Reyment (1965) on the marine Albian of Nigeria constitute a separate entity isolated from the Sahara "Sea" where the lower cretaceous is entirely continental origin and rich in amenities., Morat (1970), attempted a paleographic description of the cretaceous and lower. Tertiary in South Nigeria based on major depositional cycles resulting from three main tectonic episodes. Kogbe (1972), described the stratigraphy and paleography of individual or part of different basin found in Southeastern Nigeria [4].

2.1. General Geology and Geology of the Area

2.1.1. Geological Setting

Geologic sections of the various rock units and formations found in the study area were studied. One geological formation was found in the area, and it is the Asu River Group which is of Albian age and another which is the Eze Aku Formation. The geological formations in the Southeastern Nigeria consist of sediments ranging from Albian times to Miocene times. The oldest sedimentary formation in the Abakaliki basin is the "ASU RIVER GROUP", which is Albian in age. It consists of shale, sandstone, silt stone and limestone. It also contains salt and water which is due to ocean transgression whereby salt was deposited, and the sediments were folded in the NE-SW trend, and it is a marine formation [9]. Sedimentary formation of the Turonian age consists of limestone, shale, silt stone and sandstone which are found in Eze-Aku. The name "Eze-Aku" was derived from the Ake-Eze River in Ebonyi State, Southeastern Nigeria. The Agwu shale consists of bluish grey shales, well-bedded with intercalations of fine grained pale yellow, calcareous sandstone and limestone indicating the Santonian stage. As mentioned earlier the project study area consists of the Asu River Group and the Eze-Aku formation.

2.1.2. Geological Study of the Area

A reconnaissance trip to the study area in June 2007 showed the various rock units such as calcareous sandstone, shale, dolerite, iron stone and sandstone and the formations associated with them such as the Asu River Group and Eze Aku formation trend N-S, NE-SW, and NW-SE varying degree of trend. The study of the trend in the study area was to help in planning the geophysical and geological transverses. Geological transverses were carried out along these lines for rock outcrops. The quarrying site was visited and studied to know the extent of overburden, particular trend, and size of site. Also, mapping out of outcrops and rock units, collection of rock samples found in the study area for close studies and production of geological map showing the various geological rock units with data record on field maps [5].

2.2. Asu River Formation

The oldest sedimentary rocks in Southern Nigeria are around Abakaliki in Southeastern Nigeria. These sediments consist of non-fossil ferrous, arkosic gaverly, poorly sorted commonly cross bedded sandstones which are undifferentiated. They constitute the "Asu River Group". The type of area of the group is along the Asu River [6]. The Asu River formation is made up of dark shales which are found in the study area, limestones, mudstones, fine grained and calcareous sandstones which are rich in ammonite fauna indicating Albian age. The shales is known as the Lokpaukwu shale, sandstone also known as the Obichioke sandstone and the formation which is mostly shales with major and minor intermediate rocks like diorite which is known as uni-diorite in the study area. The shale here must have been deposited under low wave energy condition and marine environment [7]. The Asu River formation originates from the earliest documented marine transgression in Nigeria occurred during the middle Albian and was limited to the Benue valley and Southeastern Nigeria where the shales found in the study area were deposited in moderately deep marine waters. In the

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Benue valley, the base of the Bima sandstone is middle Albian in age. The Lokpaukwu shales are deeply weathered and contain Radiolaria, Echinoids, Foraminifera and Pollens. The end of the Albian witnessed the beginning of the regressive phase which continued into the Cenomanian age. Beds of Cenomanian age are restricted to the Southeastern portion of the basin around the Calabar. These beds have been assigned to Odukpani formation and they have been dated as Cenomanian to lower Turonian age. The deposits consist of arkose, sandstone, limestone and alternating, limestone and shales which become gradually more predominantly shabby in its uppermost parts [10]. The Turonian deposits belong to the Eze-Aku formation [11] which is found in Eze-Aku river valley and Lokpaukwu area in Southeastern Nigeria. The formation comprises hard grey to black shales and siltstones with frequent facies changes to sandstones or sandy shales. The thickness varies but may attain 1000metres (about the height of the Burj Khalifa, the tallest building in the world) in places [12]. Locally, at Lokpaukwu, the Eze-Aku consist of five rock units: shale, silt stone, calcareous sandstone, iron stone and diorite. The Eze-Aku formation represents a shallow water deposit and consists of fossils vascoceratids pelecypods, fish teeth, etc., which indicates Turonian age. The Coniacian sediments are less thick than the Turonian and they tend to give an impression of quick lateral changes in facies. These sediments have been assigned to the Awgu Shale formation found at the Northern part of the study area [13]. The formation is about 800 metres (about the height of the Burj Khalifa, the tallest building in the world) thick and consists of bluish grey, well-bedded shales with occasional intercalcition of fine- grained sandstone and thin often marly shelly limestone. The beds are rich in ammonites and other mollusks. The Santonian is a regressive substage in Nigeria and sediments of this age have not been found in Southern Nigeria, a doubtful Santonian locality in the Awgu Shale. The total thickness of sediments of Albian to Coniacian age in the eastern portion of South Nigeria basin is about 3,300 metres (about the height of Mount St. Helens). The Ajalli formation found at the North of the Oji River on the higher slopes of the Enugu escarpment which is found at the Western part of Uru Quarry site. The formation here has a thickness of about 450 metres (about half the height of the Burj Khalifa, the tallest building in the world). Good exposures of the sandstones occur in the deep gullies incised along the higher slope of the scarp [14].

2.3. Lokpaukwu Shale (Eze-Aku "Shale" Formation)

Lokpaukwu shale is the rock unit which is found in the study area which is at the middle portion. It is a dark, fissible, hard shale. The thickness of shale in the study area is about 10-15m but may attain 1000metres (about the height of the Burj Khalifa, the tallest building in the world) in some areas. The shale is baked due to heat from an intruding basic rock mass, weathered contains Radiolaria, Pelecypods, Echinads and Gastropods.

2.4. Obiochioke Sandstone (Asu River Group)

Obichioke sandstone is also a rock unit which is found in the study area which occupies at the Western part of the area. It is fine-grained, with grains of calcite sandstone which is rich in ammonite fauna. The sandstone thickness in the study area is about 5-10m. This rock unit is outcropping more often in the area.

2.5. Uru Diorite (Eze-Aku Formation)

Uru diorite is the basic rock mass which intrudes its way through the siltstone forming an igneous dyke intrusion. The Uru diorite is a rock unit formed at considerable depths below the surface of the area. The diorite in the study area occurs as a Dyke which are colimar bodies of igneous rocks formed by intrusion of magma into strata of the silt stone in the study area. Uru diorite is used mostly for road construction with the hard siltstone which is used in filling up bad roads in the area [17].

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3. Research Methodology

The work was carried out at Uru quarrying site, Ugworji Lokpaukwu Southeastern Nigeria. Base map was prepared from a topographical map of the area. Vertical Electrical Sounding was then carried out using ABEM TERRAMETER SAS and the evaluation was made using Schlumberger configuration. The Geological and Geophysical interpretations were made based on the results obtained from the investigation in connection with the geology of the study area [16].

4. Result and Findings

4.1. Geological Results

The geological results of the study are showing the geologic section along X – X′ and Y – Y′ that indicate the five rock units which trend northwest and southeast and are identifiable on the earth surface. The rock units are siltstone, shale, calcareous sandstone, dolerite, and ironstone.

4.2. Geological Mapping Results

The geological mapping result of the study area shows that siltstone occupies the eastern portion of the area, and it is also a cap rock; shale occupies the main area, which is underlain by shale, baked at some portions due to hot basic igneous dyke intrusion. Shale occupies one-half of the study area.

Consequently, calcareous sandstone occupies the western part of the study area where visible grains of calcite are present, VES 22, 23, 21, 20, 19, 45, 44, 64, 63, 46 and 47 are points where this rock unit is outcropping. The general dip varies from 250 to 400 from the western portion of the area. Dolerite with also diorite is the basic rock matter that occupies the eastern portion of the study area which cuts across the silty matter and shale. VES 4 and 36 are points having this rock unit outcropping. Ironstone is found within the basic rock matter in the study area. Also, the Obichioke fault is located at the southeastern part of the area between Uru and Obichioke lot. The fault trace shows recrystallization of calcite in the study area.

4.3. Coring Results

The coring result of the study area shows that two core samples from VES 4 and VES 36 are diorite core samples which are located at the southeastern part of the study area. These diorite samples tend to contain a major mineral known as quartzite. Consequently, 11 core samples at Uru for CPR1 are samples of diorite, weathered diorite, and shale which diorite has a high strength capacity and resistance than shale. At the Obiochioke area, where the fault is located, nine (9) core samples which consist of diorite, siltstone, and shale which diorite has a higher strength capacity and bearing capacity, followed by siltstone and shale [15].

4.4. Geophysical Results

In the geophysical results of the study area, sixty-four (64) vertical electrical resistivity sounding points in seven (7) profiles were obtained and reduced to plot field curves to enable the curve structures. The type of curve that is shown in the Uru area is a type Q curve which is a curve that indicates continuous thick sedimentary sequence in the study area. The Q-type curve was the major curve in the area except for areas of igneous intrusions where the K type curve was exhibited which were few.

4.5. Geoelectric Section

In the geoelectric section of the study area, four rock units which indicates that calcareous sandstone has an apparent resistivity between 200–456Ωm, shale has between 9–55Ωm, siltstone has between 60– 451Ωm, and basic rock matter has between 800–2250Ωm. The basic rock matter has the highest apparent resistivity in the study area which implies that it has an extremely low conductivity, followed by calcareous sandstone, siltstone, and shale. The shale has the lowest apparent resistivity

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in the study area which means that it has a high conductivity value. The diorite in the study area has a high apparent resistivity value which is indicated in the geoelectric section since the geoelectric section deals with indication of geological boundaries due to resistivity contrast.

4.6. Correlation between Geological and GeophysicalResults

As discovered after geological and geophysical study in the Uru area, five geological rock units were recognized in the study area by geological field mapping and four geological rock units were found in the area by geophysical survey. There is a general westward dipping in the geology and geoelectric layer in which calcareous sandstone in the study area at a general dip of 350, shale has a general dip varying from 250 in the west to 350 near the calcareous sandstone area. The siltstone unit that is found at the Centre portion of the area is because it occupies the eastern portion, and it appears to pinch out towards the western part of the area. These geological features are consistent with the geologic and geoelectric sections of the study area which makes it almost 80% correlation between geological and geoelectric sections.

5. Summary, Conclusion and Suggestions for Further Work

The study area is made up of the oldest sedimentary formation in southeastern Nigeria – the Eze-Aku and Asu River Formation were five rock units found in the study area. Through geological survey, the rock units include shale, siltstone, basic rock matter (diorite), calcareous sandstone and iron stone matter which shale predominates the entire study area. Geophysical study was also carried out in the study area using the ABEM TERRAMETER 300 SAS to determine the true resistivity of the subsurface formation of the study area and the result were interpreted using a Schlumberger O'Neil Computer Software Program [18]. Also, the data obtained from study was used to plot field curves to guide further sounding points based on surface geology. Twenty-two core samples were collected from various locations of the study area indicate the samples which consist of rock units are analyzed for the presence of minerals and strength of rock units. Core analysis is used to determine physical properties of cores obtained from the area which the cores are diorite, weathered diorite, siltstone, and shale.

From the result obtained in the core analysis, the twenty core samples which are obtained in the study area are similar in such a way that the cores are diorite, weathered diorite, siltstone, and shale. From the geological data obtained, it is evident that the basic igneous rock matter is located at the east of the study area which some of the basic rock is found within the shaly matter at the central part of the region. Also, form the geophysical data obtained, it shows that shale occupies the entire area which the study area is found in the Eze-Aku formation which is called "Eze-Aku shale." The western portion of the area has no evidence of igneous rock matter apart from the calcareous sandstone and ironstones observed in the area. The western end has thicker sedimentary sequence. Also, the Eze-Aku formation or Lokpaukwu shale cannot serve as a good aquifer since it cannot hold or transmit water and water found in such aquifer will note fit for human consumption while the Obichioke sandstone which occupies the western portion of the study area can serve as a good aquifer and fit for human consumption [19]. Gravity survey should be carried out in the study area to determine the density of deep-seated structures found in the area. Health hazards are high as posed by wind carrying dust from the quarry area. However, environmental impact assessment must be actualized to depict wind direction for the health of workers and natives in the community. Geological hazards such as land-surface damage and pollution of air with groundwater are also high due to quarrying operations which causes the study area to degrade or undergo land destruction. Good engineering works are needed to be done to conserve the area from undergoing degradation. Geotechnical study needs to be carried out in the study area to be able to determine the engineering properties of various rock units and delineating the stratigraphy of the study area. Spontaneous potential logging needs to be carried out to be able to determine formation water, amount of shale or shale volume calculation, indication of permeable beds and facies [20].

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