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Solid Mineral Resources of ENUGU State: A Review

Onyeabor Chinenye Florence

Department of Geology and Mining, Enugu State University of Science and Technology

Abstract: ***Enugu state, southeastern Nigeria is endowed with many natural resources which include coal, oil shale, gas, glass sands, ironstone, clay minerals, limestone, gypsum and alum. They occur in various formations of the state which includes Enugu Shale, Mamu Formation, Ajali Formation, Nsukka Formation and Imo shale. The minerals presently under exploitation are clay, sand, ironstone with others being under exploited or found in an uneconomic reserve. Mining of coal ceased since the 1990's hence reducing drastically the economic hub of the state. The return to coal exploitation and other solid minerals will enhance the economic output of the state.***

Keywords: Glass sands; coal; ironstone; limestone; mineral

1. Introduction

Enugu state is one of the key states in Southeastern Nigeria. Enugu has served as capital of various defunct geopolitical regions known as Eastern Region, East Central State and Anambra State. The state is situated within longitudes $6^{0}50^{1}$E and long.$7^{0}52^{1}$E and latitudes $6^{0}00^{1}$N and lat.$7^{0}10^{1}$N. The entire areal extent is 7,161 sq. kilometers and the estimated population is 4,267,837 people (Census 2006). Presently Enugu State consists of 17 local government areas (fig.1). It is bordered to the north by Benue state and to the west by Anambra state, to the east by Ebonyi state, and Abia State to the south.

Enugu became important in the 1950's due to the discovery of coal deposits. The coal deposits were considerable and helped drive power generation and railway development between the 1960's and the late 1970's. When crude oil became Nigeria's main export and income generator, the dependence on coal dwindled greatly. During the coal boom, little or no work was done by the governments at that time to develop other solid minerals in the region. That situation has not changed till date although it is anticipated that the commercialization and general reforms currently being undertaken by the government of Nigeria will lead to upsurge in exploration, quantification and exploitation of Nigeria's solid mineral resources (Obaje, 2013).

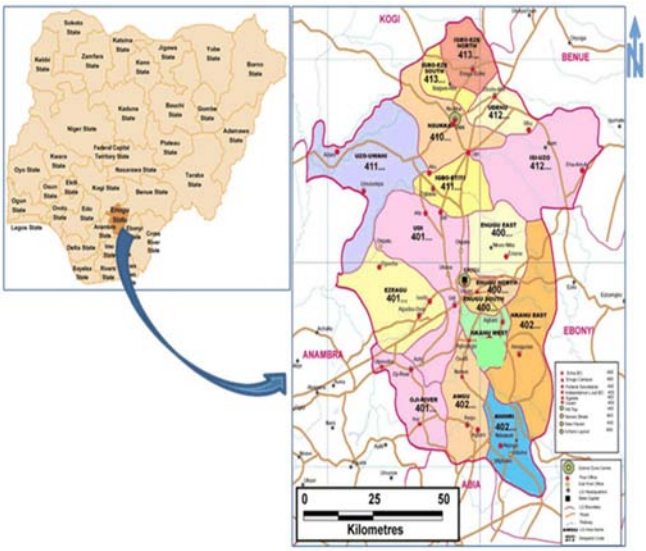

Figure 1: Political Map of Enugu

Topography

The topography of Enugu includes major features such as the plateaus, rolling plains and the cuesta. The cuesta is a 500km long belt which runs from Leru northwards to Idah in kogi State. The Enugu escarpment runs west wards and stands as a divide between the Anambra River Basin to the West and the Cross-River Basin to the east (Offodile,2014). The expanse of the cuesta narrows down as one runs from northern Enugu to southern Enugu with valleys as wide as 40km at Nsukka, 20km at Udi and 12km at Leru. The scarp reduces almost to zero at Isuochi junction and rises again after the junction with unbroken stretches between Awgu and Lokpanta, Awgu and Ozalla onward to Enugu town. Enugu town lies on top of the Udi escarpment and the surrounding valleys thereby deriving the name Enu-ugwu.

2. Climate and Vegetation

According to Philips (1996), the mean annual rainfall of Enugu ranges from 2000-3000mm. The climate of Enugu experiences a single maxima between July – August unlike places like Ibadan and Osogbo which are within same climate (Iloeje, 1972). The average temperature of Enugu is

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27^0C(Philips,1996). The vegetation of Enugu is within the high forest zone with many plant species, including parasites, climbers and creepers according to Iloeje (1972). Presently many of the forests have been cleared due to urbanization and crop cultivation. The major economic trees found in the State are oil palm tree and cashew trees in Nsukka, Awgu and Ezeagu L.G.As. The oil palm yields oil, kernels, palm wine and building materials for thatched houses. Root crops such as yam, cassava, cocoyam, pepper and rice are cultivated from different parts of the state.

Drainage

The major rivers of Enugu take their source from the escarpment. Ekulu river escapes the cuesta close to Iva valley, draining Enugu west; Nyaba river leaves the cuesta at Ugwuagama Obinnagu Udi as Inyi uba draining down south. Nyaba tributaries include Atavu, Ekwe and Nvene rivers. The Nyaba-river flows through Akwuke close to Okpara mine carrying large sand deposits alongside which result to sand beaches. Also River Nvene leaves the cuesta through Udi town and streams down to Ozalla, Ituku and further south as it merges with the Nyaba river. All the rivers create a dendritic drainage pattern due to the sedimentary and deltaic nature of the sedimentary formations in the area.

The Geology

Enugu State is underlain by seven major geologic formations which from the oldest to the youngest include: Eze-Aku Formation; Awgu Formation (Agbani Sandstone); Nkporo /Enugu Shale; Mamu Formation; Ajali Sandstone; Nsukka Formation and Imo Shale(figure 2).Eze-Aku Formation is located around Aninri and Nkanu East local government areas in the state.It was deposited during Turonian times.It is overlain by Awgu Formation (Santonian). The lithology of Awgu Shale includes bluish grey shales with few sandstone intercalations. There exists small tongues of shally limestone at Awgu town (Reyment, 1965). The dip ranges from 10^o NW to 25^o NW in this area. The Agbani Sandstone is a medium to coarse grained consolidated sandstone which is a member of Awgu Formation.

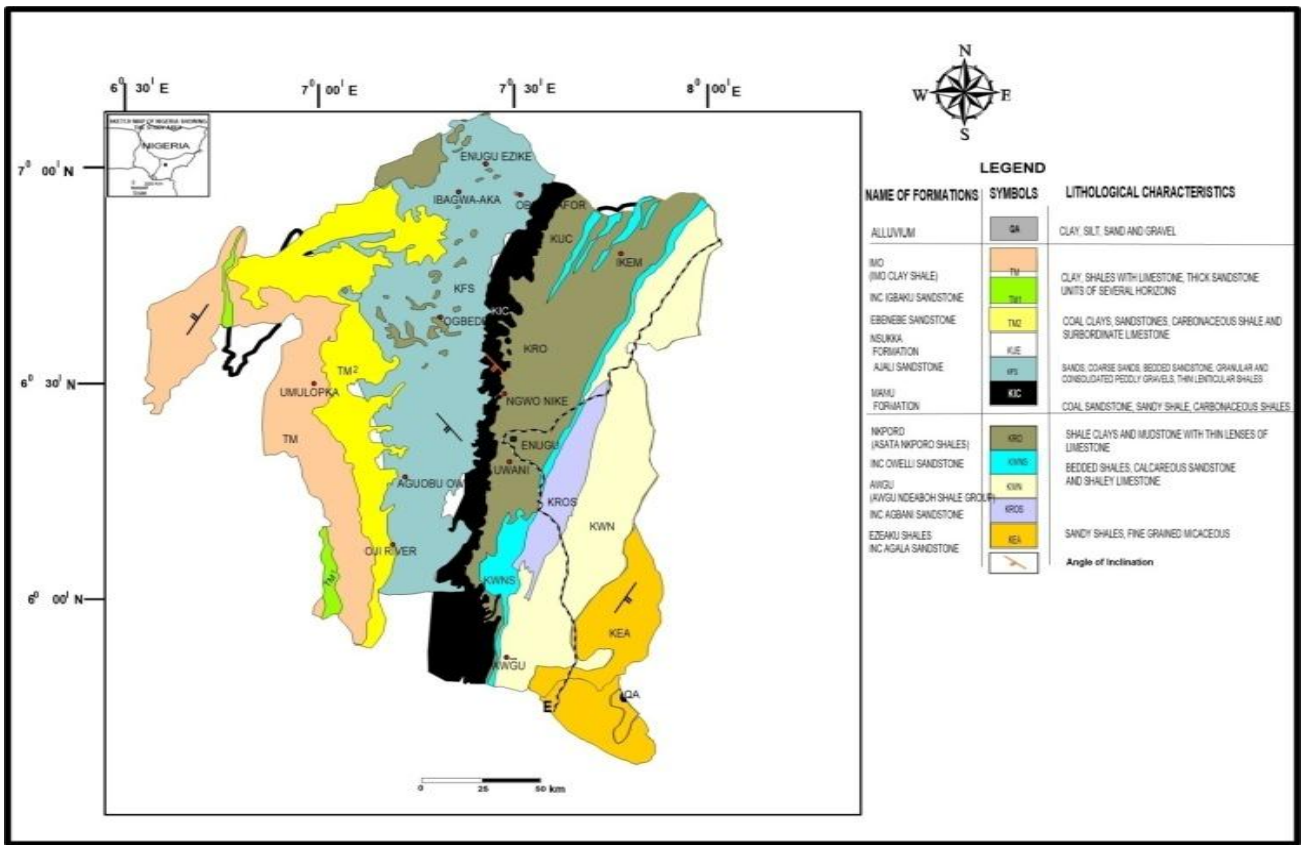

Figure 2: Geologic map of Enugu State

Table 1: The Stratigraphic Succession of Enugu State

Epoch	*Age*	*Formations*	*Net sea Movement*
Tertiary	Paleocene	Imo Shale	Transgression
Cretaceous	Danian	Nsukka Formation	Regression
Cretaceous	Maastrichtian	Ajali Formation Mamu Formation	Regression
Mid to Upper Senonian	Campanian	Nkporo Shale/ Owelli Sst/Enugu Shale	Transition to a new Basin/ Transgression
Mid to Upper Senonian	Santonian Coniacian	Awgu Formation	Regression
	Turonian	Eze-Aku Shale	Regression

Modified after Reyment, (1965),Short and Stable, (1967) and Nwajide, (2013)

3. The Mineral Resources of Enugu

The mineral resources of Enugu State can be grouped into metallic minerals, industrial minerals and energy resources. The minerals and the local government areas where they occur,shown in table 2.Figure 3 displays the mineral map of Enugu state.

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Table 2: Mineral Resources of Enugu State

Local Government Areas	Mineral /Resources
Aninri	Lignite, oil shale
Awgu	Ironstone, Sand Limestone
Enugu East	Clay Mineral, Laterite
Enugu North	Sand, limestone, coal
Enugu South	Laterite, clay mineral ,glass sand
Ezeagu	Oil Shale, clay Mineral, coal
Igboetiti	-
Igboeze North	Coal
Igboeze South	-
Isi-Uzo	Kaolinite, clay mineral
Nkanu East	Illite,Smectite, Oil shale
Nkanu West	Ironstone, glass sand, kaoline, alum,illite
Nsukka	Ironstone, Laterite, Coal, gas
Oji River	Coal
Udenu	-
Udi	Coal, limestone
Uzo-Uwani	Kaoline, gas

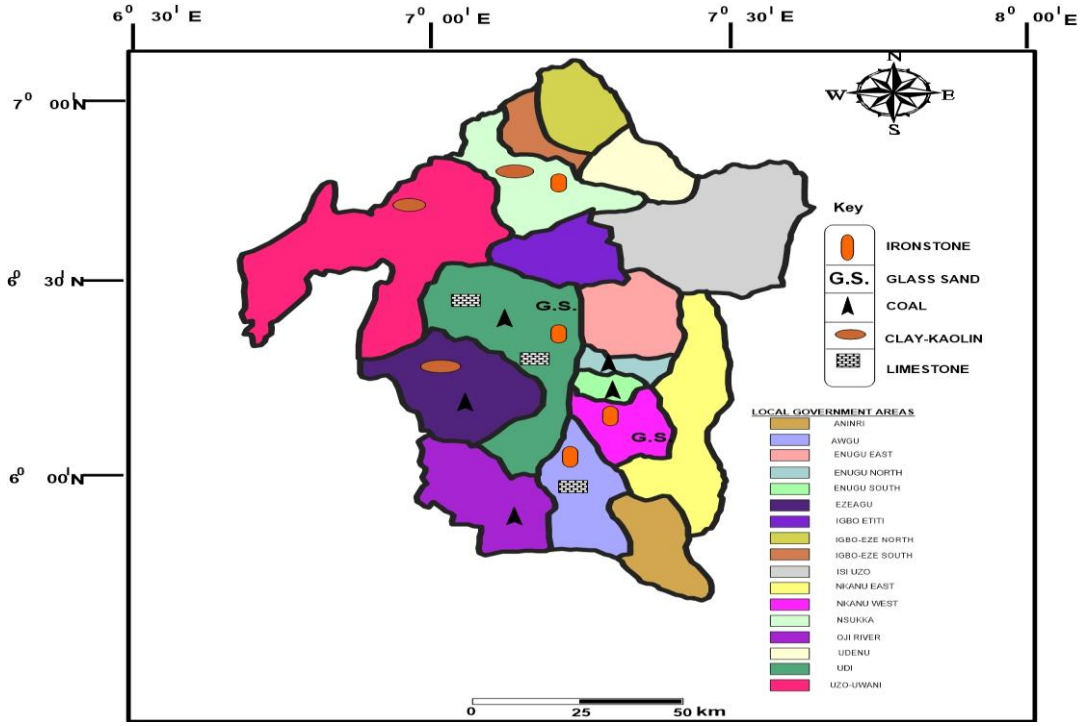

Figure 3: The mineral map of Enugu state

4. Metallic Minerals

Ironstone is the predominant metallic mineral in Enugu with varying oxidation states. They are hypogenically deposited. The type ranges from oolitic, pisolitic and metamorphosed beds. Ironstone is found in Awgu Formation (as seen in Ugwueme), Ajali sandstone (close to 9th mile and Nsude), Mamu Formation (Ekulu river,opposite Mamu exposure along Enugu – Onitsha express road) and Nsukka Formation. Ironstone business by the locals thrives in Ugwueme-Awgu, minimally at Ozalla –Obe near Agbani, Ekulu River (about 1km from New market) and also at Nsude in Udi. The Nsude Ironstone is well exposed at about 11km southwest of Enugu town. Bell(1959) outlined the geochemistry of Nsude ironstones(table.3).The estimated reserve for Ironstone in Enugu are thus: Ugwueme-30 million tonnes, Nsude-50 million tonnes and Ekulu river-5 million tonnes. The target industry of the iron ore is steel and industrial machines.

Table 3: The Geochemistry of Nsude Ironstone (Bell 1959)

Chemical/Elemental constituents	*Percentage*
Fe_2O_3	68%
Fe	47%
Al_2O_3	14%
TiO_2	1%
P_2O_5	1.1%
SO_2	7.2%
MnO ad Mgo	trace element

5. Industrial Minerals

Industrial minerals resources in Enugu include kaolinite, limestone, laterite and glass sands. Clay minerals abound in the state. They are alumino-silicates which are carried and deposited via sedimentary agents. White kaoline is very common in Mamu Formation but pink varieties occur mainly in Nsukka Formation. The pink color is due to iron

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enrichment or staining. This clay could be considered as fire clay which withstands high temperature. Kaolin deposits are also at Nrobo, Eha-Alumona and Aguobuowa with total estimated reserves stand at 130 million tonnes.

Laterite deposit is abundant in the state both in east and west of the cuesta. This is an essential material in road construction and seen around the up-hills of Ugwu onyeama, Obe town, Ozalla town, Ugwueme, Awgu town etc. Laterite occur within the Nsukka Formation at Eneke, Awhum and Nsukka plateaus. The lateritic soil of Enugu consist more of ferric oxide than aluminum oxide and are formed due to weathering of the parent rocks of mudstone, ironstone and sandstone. Reserves are estimated at 100 million tonnes in the state.

Limestone: The major limestone deposit in Enugu is located in "Awhum twin cascades", Awhum town (about 10km from 9th mile) which is underlain by Mamu Formation and Ajali Sandstones. Nsukka Formation also hosts some limestone within the Eneke hill towards Egbe in Awhum. The limestone stretches about 300m within the cave and the twin Cascades of Awhum waterfalls (Kolawole, 2011). The economic viability of this limestone is yet to be determined. At Ngwo, limestone deposit occur. The marly limestone of Awgu Formation sums upto 6 to 8 metres in thickness within the shale units of the formation.

Alum ($Al_2(S0_4)_3$) and gypsum ($CaS0_4.2H_20$) which occur as efflorescence are occasionally seen in Enugu Shale (Reyment, 1965). Nwajide(2013) identified interlocking, clear acicular crystals as gypsum(selenite variety) efflorescence in the state. Alum occurs within the river beds of Nyaba river. The occurance of the two minerals are insignificant for industrial purpose but can be channeled for domestic use.

Glass Sands

Enugu has a lot of sand deposits which runs into millions of tonnes at Nyaba river, Ajali Sandstone, Owelli Sandstone and Agbani Sandstone deposits. The glass sand are hosted in the river beds of Nyaba at Akwuke village. Currently, the escavation of sand in Enugu is predominantly chanelled towards buildings and roads construction.

Energy Resources

The major energy resource/fuel in Enugu is coal and hence the adopted name "Coal City". The reserve of Enugu Coal is given in table 1.0 according to their formations. Enugu Coal has a calorific value of 10,000 to 13,000 BS 11/1b having a total reserve of over 350 million tons (Reyment 1965).

Table 4: Coal Reserve of Enugu and the Hosting Formations (modified after NCC 1985)

Mine Location	Geol unit	Type of Coal	Estimated Reserve in Mill.tones	Proven Reserve in Mill.tones	Borehole Records	Coal Outcrop & Seam thickness(m)	Depth to Coal	Mining Method
Okpara	Mamu Formation	Sub-Bituminous	100	24	20	many(1.5m)	180	Underground
Onyeama	Mamu Formation	Sub-Bituminous	150	40	Many	many(1.5m)	180	Underground
Ezimo	Nsukka Formation	Sub-Bituminous	156	56	4	10.06-2.0m	30-43	Open-cast/Underground
Inyi	Nsukka Formation	Sub-Bituminous	50	20	4	0.9-2.0m	25-78	Open-cast/Underground
Amansiodo	Mamu Formation	Bituminous (cokable)	1000	N.A	3	N.A	563	Underground

Hydrocarbon

Traces of oil and gas has been reported within the state. Reyment (1965) reported traces of oil within the basal unit of Owelli Sandstone. According to Obaje and Abaa(1996),the hydrocarbon potential of the rocks in Enugu is basically immature. They found that the Tmax value for Mamu Formation was 433^{0}c to 450^{0}c which is equivalent to the Tmax expected in coal that is undergoing transformation to oil.

6. Conclusion

The minerals resource of Enugu abounds with only clay mineral, sand and ironstone being currently exploited. Efforts are still needed in the area of reserve estimation and exploitation. This will enable investors to invest in the solid minerals of the state.

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