
SEDIMENTOLOGY AND GEOCHEMICAL EVALUATION OF MARL DEPOSITS ASSOCIATED WITH EZEAKU FORMATION IN AFIKPO AREA, SOUTHEASTERN NIGERIA

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ABSTRACT

The use of marl deposit as construction materials has recently attracted some attention, to both government and its citizens. Hence the evaluation of the sedimentological and geochemical assessment of the deposit in the Afikpo area was conducted to determine its suitability as aggregate. The Marl deposit belong to the Ezeaku Formation, this was confirmed from the field observations and description which shows that they are of dark grey to black shale, sandstone, subordinate limestone and siltstone deposited by shallow marine environment. Petrographic examination of the marl reveals the presence of allochem components, micrite and sparite corresponding to grain, matrix and cement respectively. Modal composition classify the rock as Carbonate Type II which consists of considerable proportion of allochems where current action was not enough to completely winnow away the microcrystalline ooze. Major oxide geochemistry of the rock samples showed a dominance of SiO₂, CaO, Al₂O₃ and depletion in Na₂O, K₂O and Fe₂O₃. The high SiO₂ content and inverse correlation with CaO describe the rock as impure limestone making the aggregate more chemically stable than pure limestone when used as components of building materials especially in subsurface constructions where materials may be exposed to water.

KEYWORDS: Sedimentological, Aggregate, Geochemical, Formation, Marl

INTRODUCTION

The Marl is a sedimentary rock and an impure limestone containing calcium carbonate and variable amount of clay or calcareous mudstone. The dominant carbonate mineral in most marls is calcite but other carbonate minerals such as aragonite, dolomite and siderite may be present. Limestone and other carbonate rocks are extremely valuable raw materials and are widely used by industries for building and road construction purposes.

The increasing demand for marl as construction aggregates has recently attracted some attention to both government and its citizens, and is a good alternative aggregate to the conventional granite and other igneous and metamorphic aggregates.

However, properties of an aggregate such as mineral composition, texture, roughness and strength can affect the performance of the aggregate. Limestone is a good construction aggregate material owing to its low alkali-silica ratio and textural quality.

Geochemistry of sedimentary rocks is a valuable tool to infer factors that control sediment characteristics during and after their deposition and to delineate the relationship between specific units of both clastic and carbonate strata (Nagarajan et al., 2007; Armstrong-Altrin et al., 2004; Madhavaraju & Lee, 2009).

In a geotechnical and mineralogical characteristics of marl deposits in Jordan Shaquour et al (2008) related geotechnical properties to mineral composition. The study showed that a positive linear relationship exist between the clay content and both liquid and plastic limits. The study also shows an inverse linear relationship between the clay content and the maximum dry density in both standard and modified compaction. This is attributed to the adsorption of water by the clay minerals. The relationship is more prominent in the case of modified compaction test. The results also indicate a similar relationship for the angle of internal friction.

The study involves evaluation of marl deposits associated with the Ezeaku Formation in Afikpo area, using the sedimentological and geochemical properties to better understanding and informed knowledge on the geochemical composition of the rock, diagenesis, and the environment of deposition; how it possibly relates to the geotechnical properties.

LOCATION AND GEOLOGY OF THE STUDY AREA

The study area covers approximately 461.2km² and is located between Latitudes 5°51' and 6°009'N, Longitudes 7°45' and 8°00'E (Fig.1.1) The area includes the following communities: Amasiri, Akpoha, Ibii, Mgbom, all in Afikpo.

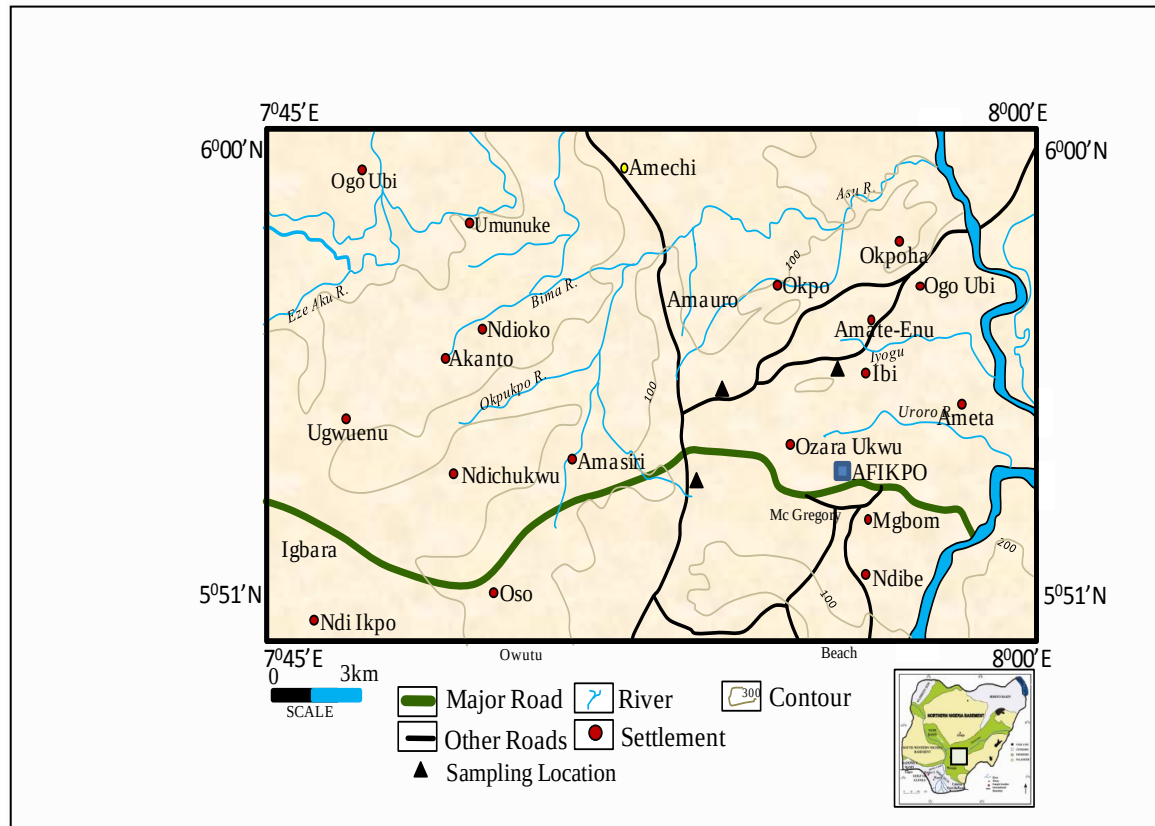


Fig 1.1: Location and topographic map of the study area

Geological Setting

The tectonic evolution of southeastern sedimentary basins may be traced back to the Benue Trough, during the cretaceous Era. The separation of the African and South American plates left the Benue Trough as an Aulacogen, a failed arm of an RRR Triple Junction (Burke, 1972; Olade, 1975).

The Afikpo Basin is located in the Southern part of the regionally northeast – southwest trending Benue Trough (Ladipo et al., 1992).

The first mantle plume and associated events that led to the evolution of the Benue Aulacogen is believed to have taken place during Aptian times and was associated with the emplacement of the alkaline – mafic lavas and volcanoclastics (the Abakiliki pyroclastics) as well as the deposition of the Asu River group (Olade, 1975). Temporary cessation or reduction in tension prior to the yet to be renewed mantle plume activity in the trough became the principal cause of deformation (folding) of the Albian sediments. This was accompanied by marine regression that led to the deposition of the Odukpani Formation only in the Calabar flank during the Cenomanian.

Mantle upwelling became reactivated during the Turonian and rifting along earlier lines of weakness allowed for unstable conditions that led to the deposition of the Ezeaku Formation unconformably on the folded Asu River group (Nwachukwu, 1972; Ogbukagu, 1974; Olade,

1975). The final stage in the tectonic evolution of the Benue Rift/ Aulacogen occurred when the mantle upwelling ceased or there was an eastward migration of the plume relative to the continent in the Senonian. This led to sub – crustal contraction, final collapse of the Trough and a broad asymmetric downwarp (Ajakaiye & Burke, 1973) which led to a widespread compressive deformation of pre – Santonian rocks within the Trough.

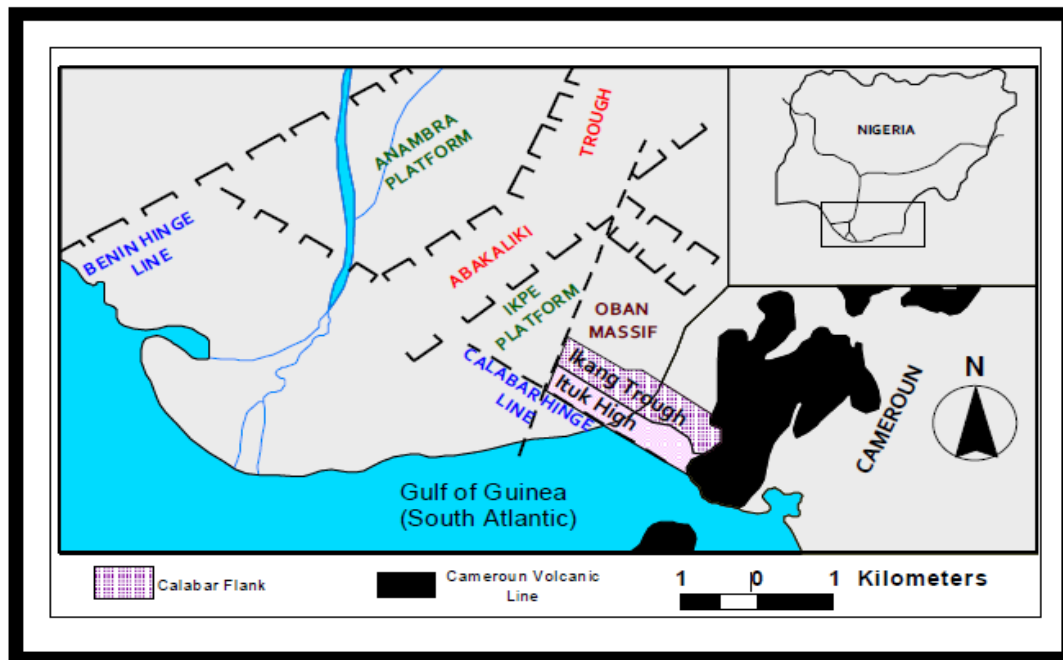


Fig 2.1: Tectonic Map of Southeastern Nigeria (After Nyong and Ramanathan, 1985)

Stratigraphic Sequence of the study area

Comprising of undulating alternations of sandstone ridges and low lands of shale, the study area consists of two major lithological units namely the Ezeaku Formation and the Asu River Group which generally exhibits a NE-SW directional trend.

The Asu River Group

The Asu River Group is a major stratigraphic unit in the study area, consisting of dark micaceous shale, fine grained and calcareous sandstone bodies. The geology of the different lithostratigraphic facies of the Asu River Group in the study area is Amenu Sandstone conformably overlies the Amenu Shale with the Amauro Sandstone and Shale

Unconformably Overlying the Asu River Group is the Ezeaku Formation and consists of alternating sandstone/siltstone and hard grey to black shale (Fig 2.1). Contacts between the lithologies of the group are either sharp or gradational. They are; Amate-Elu Sandstone: This is the oldest lithologic unit of the Ezeaku Formation that unconformably overlies the Amauro Shale of the Asu River Group, in the study area. Amate-Elu Shale and Sandstone, Amasiri Sandstone and Shale, Akpoha Sandstone, Okpo-Ezi Sandstone, Iyi-Ogwe Shale, Ibii Sandstone and Uoro Shale.

AGE	LITHOSTRATIGRAPHIC UNITS		
	Group	Formation	Member
Turonian		Eze-Aku	Ururo Shale
			Ibii Sandstone
			Iyi-Ogwe Shale
			Okpo-Ezi Sandstone
			Akpoha Sandstone
			Amaseri Shale
			Amaseri Sandstone
			Amate-Elu Shale
			Amate-Elu Sandstone
Albian	Asu River	Amauro Shale	
		Amauro Sandstone	
		Amenu Sandstone	
		Amenu Shale	

Table 2.2: Showing stratigraphic sequence of the study area (Ukaegbu et al., 2009)

MATERIALS AND METHODS

FIELD STUDY

The field study entailed a geological mapping of the study area. The mapping was completed in about four (4) field trips and was basically aimed at examination of outcrop sections, the lithologic relationship in the outcropping profile, the nature of contacts, and the sedimentary structures. The attitude of the bed and other structural features were measured with the aid of Brunton/Silver compasses, while steel tape was used to measure the vertical thickness of the units. A geologic hammer was used for collection of samples followed by labeling and packaging.

LABORATORY STUDY

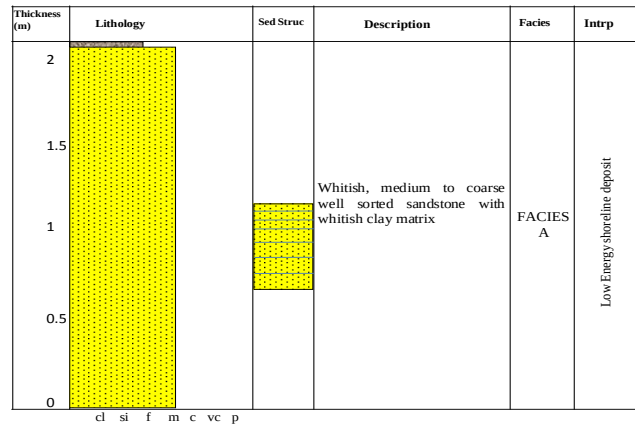
X-Ray Fluorescence

Four samples were selected for major oxide geochemistry using X-ray fluorescence (XRF) method. This analysis was aimed at determining the elemental oxide composition of the selected samples from the study area. The analysis was carried out at the National Geoscience Research Laboratories Centre, Kaduna.

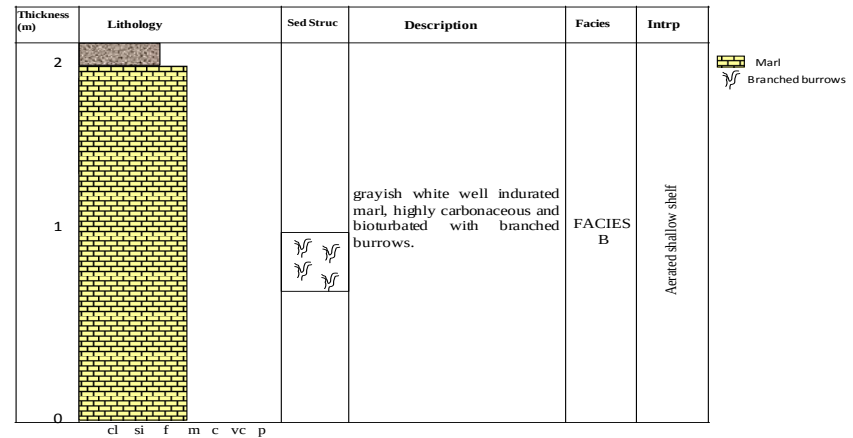
Thin Section Petrography

Three fresh samples of the marl in the study area were selected for thin section petrography. The analysis was carried out at the department of geology, university of Port Harcourt, River state.

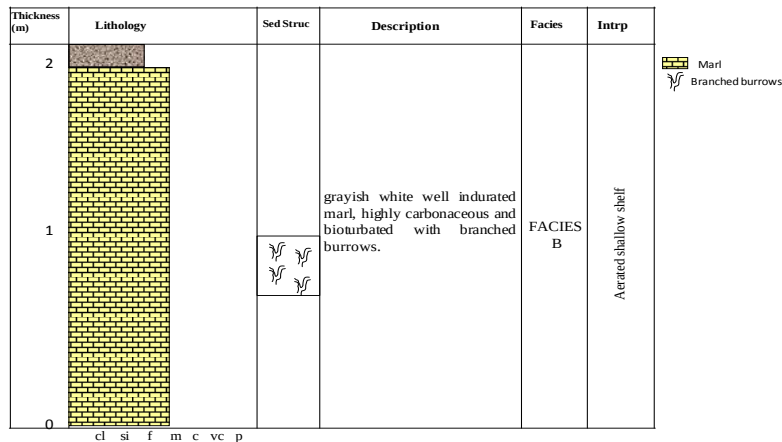
OUTCROP DESCRIPTION AND SEDIMENTOLOGICAL ASSESSMENT



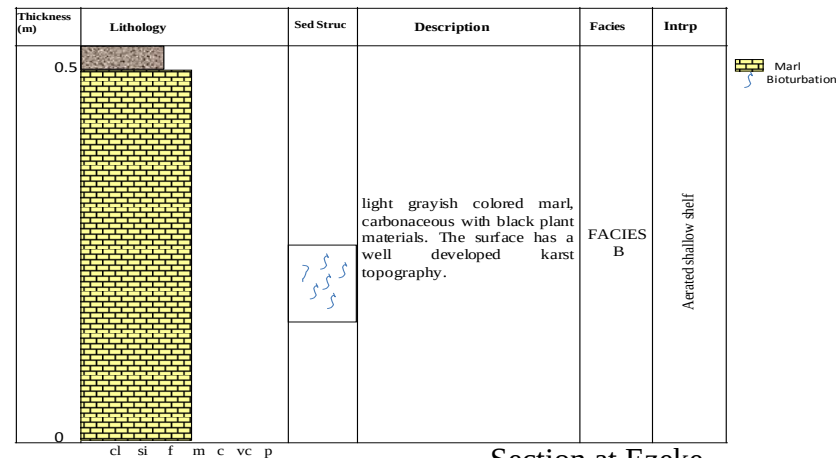
Section near Amasiri Junction



Section along Akpoha road (I)



Section along Akpoha road (II)



Section at Ezeke

FIG 3.1: REPRESENTATIVE LITHOLOGS OF STUDIED OUTCROP SECTIONS



Fig 3.2: Field work pictures showing outcrop locations, sedimentary structures and sampling

RESULT AND DISCUSION

4.1 Result of Major Oxide Geochemistry

The result of the major elemental oxides distribution for marl samples that is obtained from X-ray fluorescence analysis in the study area is presented in Table 4.1. The scatter plots of the various oxides against each other are shown in Fig. 4.1. Also Fig. 4.6 showed the relationship between Calcium Carbonate (CaCO_3) and Clay.

Table 4.1: Major oxide geochemistry of the studied marl

Sample ID/Oxide (%)	Ma1	Ma2	Ma3	Ma4	Average
SiO_2	24.56	41.3	56.73	50.13	43.18
TiO_2	0.23	0.87	0.49	0.71	0.57
Al_2O_3	5.86	2.63	8.89	4.21	5.39
Fe_2O_3	1.64	1.71	2.74	2.81	2.21
MnO	0.04	0.04	0.01	0.02	0.02
CaO	49.79	42.23	19.88	21.8	33.4
MgO	0.9	1.23	1.45	1.51	1.27
Na_2O	0.11	0.13	0.22	0.14	0.19
K_2O	2.19	1.76	2.35	2.89	2.04
LiO_2	0	6.01	0.02	0.01	1.51
V_2O_5	0.01	0.01	0.01	0.01	0.01
LOI	14.34	8.4	7.21	9.12	9.76

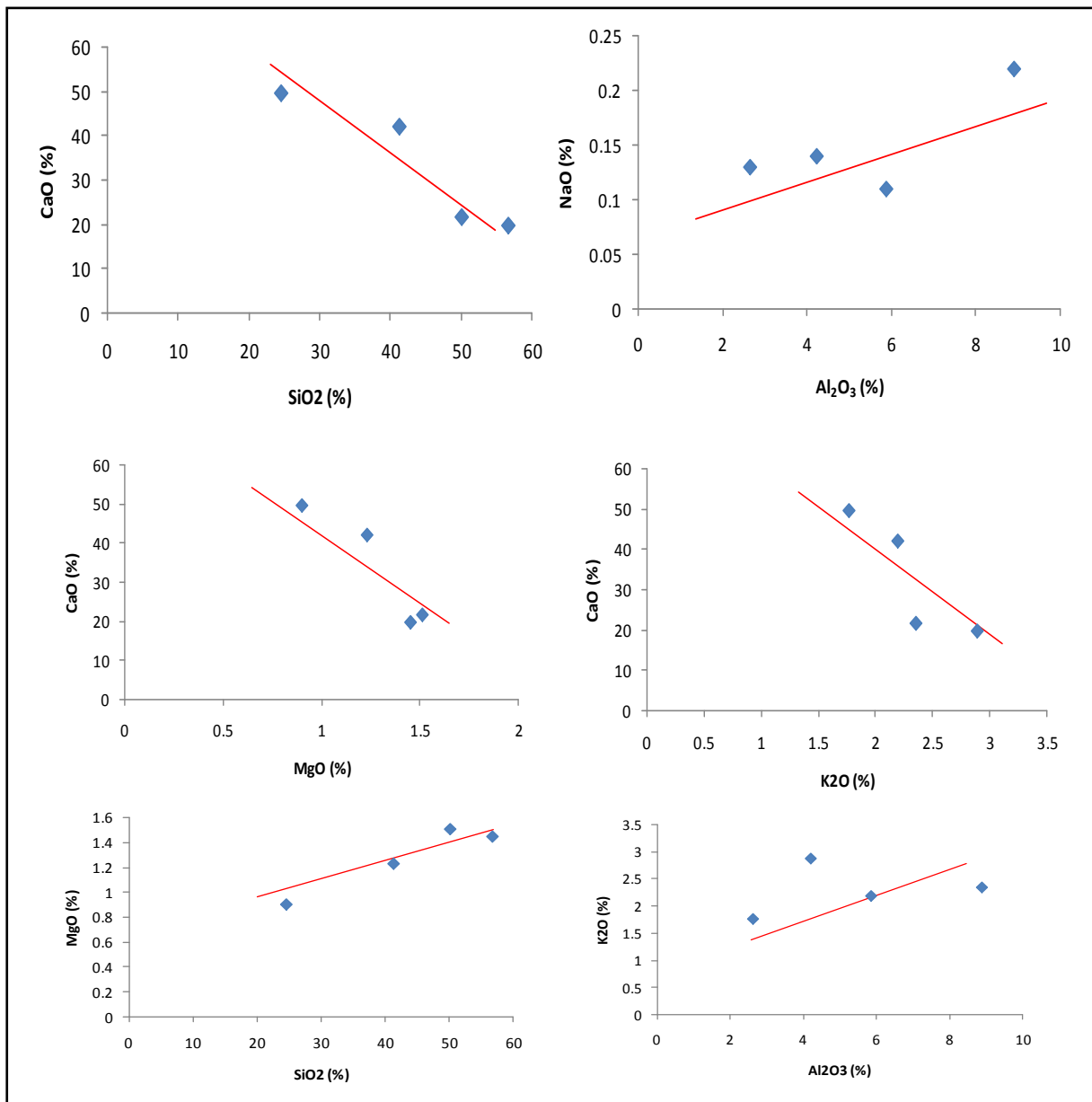


Fig. 4.1: Scatter plots of major oxides against each other (After Morton, 1985; Meinhold et al., 2007)

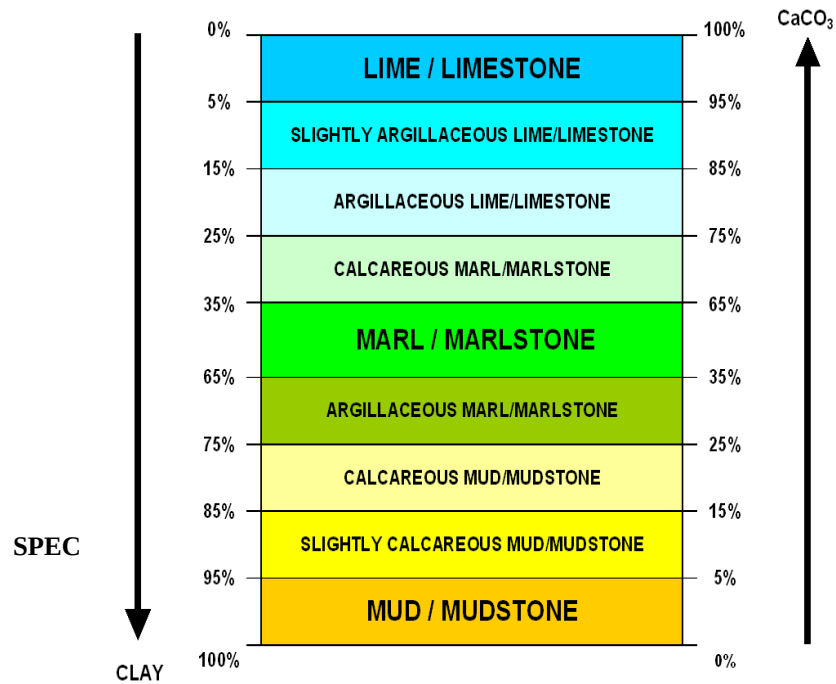


Fig 4.2: Percentage of the limestone (Foxbat Deinos, 2010)

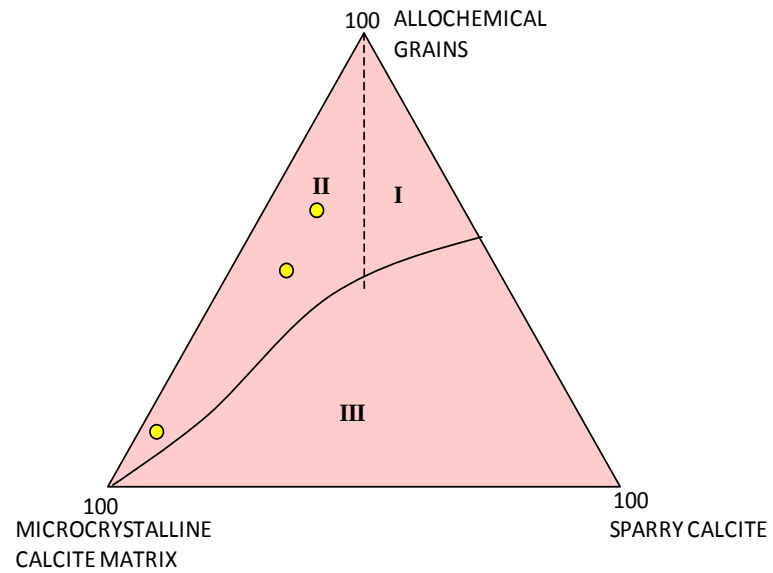


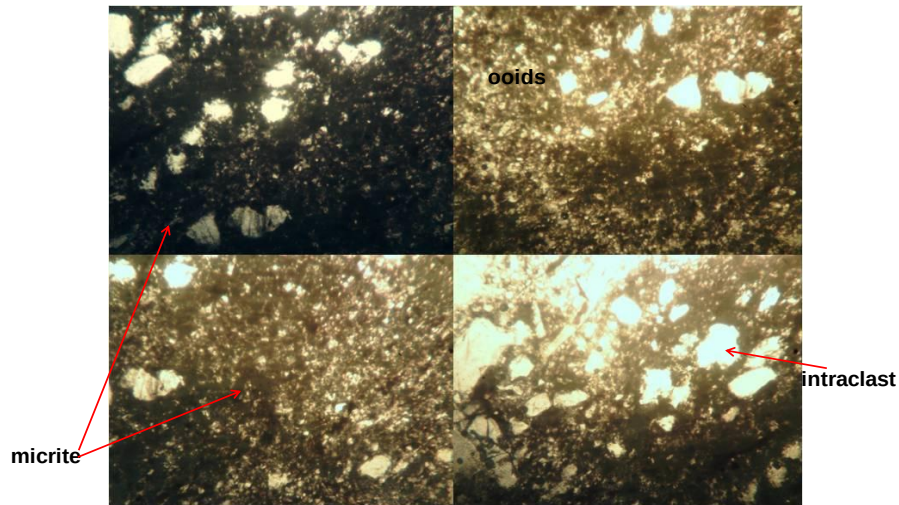
Fig 4.3: Classification of limestone (After Folks, 1974)

Result of Thin Section petrography**Table 4.2: Modal composition of marl samples**

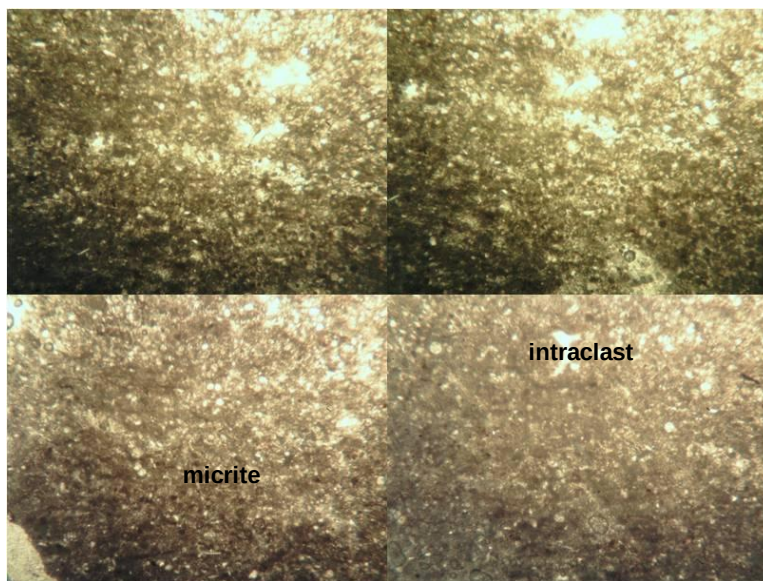
Sample No	Allochem (grain)			Micrite (matrix)	Sparite (cement)
	Intraclasts	Peloids	Ooids		
Ma3	25	31	9	30	5
Ma1	53	-	20	37	10
Ma2	5	-	-	83	12

Table 4.3: Petrographic description of sample

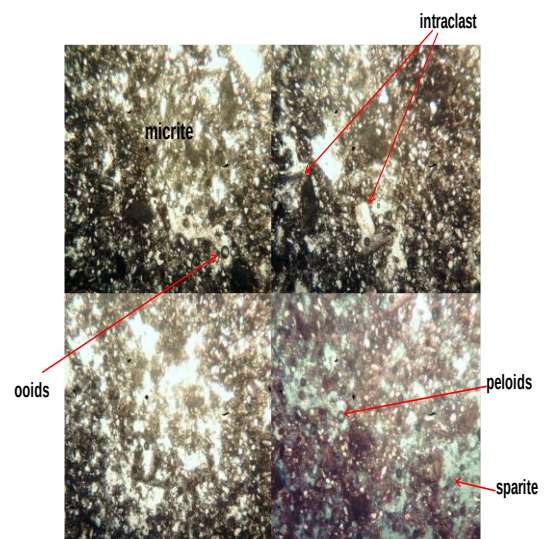
Sample Number	Petrographic Description
Ma3	Dark gray to brownish colored clastic textured limestone that react with hydrochloric acid (HCL) to give effervescence, the thin section showed grain supported with lithic fragments, grain sizes ranges between 0.05 to 1.25mm. cavities are filled with micrite.
Ma1	Dark gray to brownish colored clastic textured limestone that react with hydrochloric acid (HCL) to give effervescence, the thin section showed grain supported with lithic fragments, grain sizes ranges between 0.05 to 1.25mm. cavities are filled with micrite.
Ma2	Dark gray to brownish colored clastic textured limestone that react with hydrochloric acid (HCL) to give effervescence, the thin section showed, mud supported with less than 10% grains, cavities are filled with micrite.



MARL (MA1)



MARL (MA2)



MARL (MA3)

FIG 4.4: PHOTOMICROGRAPHS OF REPRESENTATIVE MARL SAMPLES

DISCUSSION

Mineralogy and Geochemistry

Petrographic examination of the marl reveals the presence of allochem components, micrite and sparite corresponding to grain, matrix and cement respectively. The rock falls within the Type II category of carbonate classification of Folk (1974).

The higher concentration of SiO_2 in marl indicates the influence of terrigenous influx during deposition and high concentration may also be attributed as well to silicification processes in these marls.

The high Al_2O_3 (5.39% av) indicates the presence of clay mineral in these marls. Buckley and Cranston (1991) inferred that the variations of Al_2O_3 in sediments might be associated with changes in clay mineral content or with the content of feldspars in the sediment.

The Mg values (1.27% av) are very low, indicating the prevalent less saline and/or freshwater diagenesis by which extensive leaching can take place (Wilkinson and Given, 1986). These low Mg content in these marl indicates that they are products of shallow marine carbonate depositional environments.

The low iron content (2.21% av) indicates the depletion of pore fluid iron content during precipitation of calcite due to decrease in supply of detrital materials (Brand, 1989).

The positive correlation between K_2O and Al in the marl indicates that these limestones were associated with detrital compounds.

Depositional Environment

The trace fossils observed in Ezeaku Marl deposits belong to the Cruzianaichno facies represented by Planolites. Cruzianaichno facies are mainly produced by deposit feeders foraging for food in the muddy substrates (Okoro and Igwe, 2014).

The sandstone and marl deposits occur as parallel to near parallel ridges exhibiting an upward coarsening profile from the marl at low lying areas to massive sandstone at the top of the ridges.

The present study suggests deposition was in a shallow shelf supporting an assemblage of shallow marine benthos, gradual decrease of Bioturbation.

The absence of structures is typical of storm sedimentation such as; hummocky cross stratification in the sandstone facies could not be preserved. The Ezeaku Sandstone facies was likely deposited during a low stand of sea level.

DIAGENESIS

Recognized diagenetic imprints include:

Mineralogical conversion of aragonite-calcite which probably has taken place in the fragments of bioclasts such that several of the boundaries between fossils and adjacent voids are obliterated. This type of conversion is Type II or Type III solution deposition conversion (Enu and Adegoke, 1988).

The sandstone facies (Amasiri Sandstone) show remarkable compaction as indicated by the high level of induration.

In the marl deposits, the finer material (mud) present in the rock tends to cushion the effect of compaction as the stress is sheared among the innumerable mud particles (Nwajide, 1996).

Cement is basically sparry calcite in the marl deposits which occurs as a precipitation from solution unto free surface causing the outward growth of crystalline material which adheres to the surface (Talbot, 1971). The sandstone facies is cemented basically by quartz cement formed by pressure solution as grains are welded together with increased pressure.

CONCLUSION

The Marl deposits under study belong to the Ezeaku Formation. Field observations identified sandstone ridges trending NE-SW with subordinate marl deposits exposed along the Amasiri-Akpoha axis. The trace fossils observed in Ezeaku Marl deposits belong to the Cruziana ichnofacies represented by Planolites, the study suggests deposition was in a shallow shelf supporting an assemblage of shallow marine benthos.

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Major oxide geochemistry of the rock samples showed a dominance of SiO₂, CaO, Al₂O₃ and depletion in Na₂O, K₂O and Fe₂O₃. The high SiO₂ content and inverse correlation with CaO describe the rock as impure limestone making the aggregate more chemically and good for construction purposes.

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