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PALEO-ENVIRONMENTAL RECONSTRUCTION OF ROCK TYPES FOUND IN OZALLA AND ENVIRONS, NKANU WEST LOCAL GOVERNMENT AREA, ENUGU STATE, SOUTHEASTERN NIGERIA

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Abstract: The study area, Ozalla and environs, is located in Nkanu West Local Government Area of Enugu State, Southeastern Nigeria. It lies between latitudes 06°16'0"N and 06°21'0"N and longitudes 07°27'0"E and 07°32'0"E, covering an area of approximately 85·6km^2. This study aimed to determine the geology and depositional environments of the units through field relationships and grain size distribution analysis. The field data show that the area is underlain by two lithological units: the shale unit and the sandstone unit. The shale unit comprises dark gray shale that is fissile, laminated, and bedded. The shale consists of ironstone beds separating the shale units. There are fractures and faults seen within this unit, which covers about 70% of the area. The Consolidated Sandstone unit ranges from fine to coarse grain, and in some locations, it shows a coarsening-up sequence. The color ranges from white, purple, reddish, yellowish, and brown, and there are presence of quartz pebbles that are angular-rounded. It covers approximately 30% of the study area. The average dip of the area is 4° with SW as the dip direction. Structures such as bedding, cross-bedding, lamination, fissility, color branding, fractures, faults (normal fault), joints, biogenic structures, and ripple marks were observed in the study area. The anoxic nature of the shale unit shows that it is deposited in a marine setting, probably deep marine setting. Sieve analysis of the sandstone unit shows fine– medium grain sandstone, moderately well sorted, negatively skewed, and platykurtic. In addition, the mode of deposition is a fluvial environment due to the fining down sequence and lack of carbonate cement. The bivariate result reveals a fluvial/continental environment. It also shows beach sand; thus, a shallow marine environment is suggested. Economic materials that can be exploited in the area include: sandstone, ironstone, shale, and clay.

Keywords: Agbani Sandstone, Enugu Shale, Mamu Formation, Anambra Basin, Grain Size Distribution Analysis, Depositional Environment, Fluvial, Shallow Marine.

LOCATION, EXTENT, AND ACCESSIBILITY

The study area covers Ozalla and its environs in the Nkanu West Local Government Area of Enugu State (Figure1). It is bounded by latitude 06° 16′0″N and 06° 21′0″N and longitude 07° 27′0″E and 07° 30′0″E. It is bordered to the north by Akagbe-ugwu, to the east by Obe, to the west by Udi, and to the south by Ituku. Accessibility in the area is made easy by the major roads and footpaths (Figure 2). The major roads include the one that runs from Agbani to Udi, the New Enugu-Portharcourt Expressway, and the Enugu-Portharcourt old road. Footpaths are scattered throughout the study area.

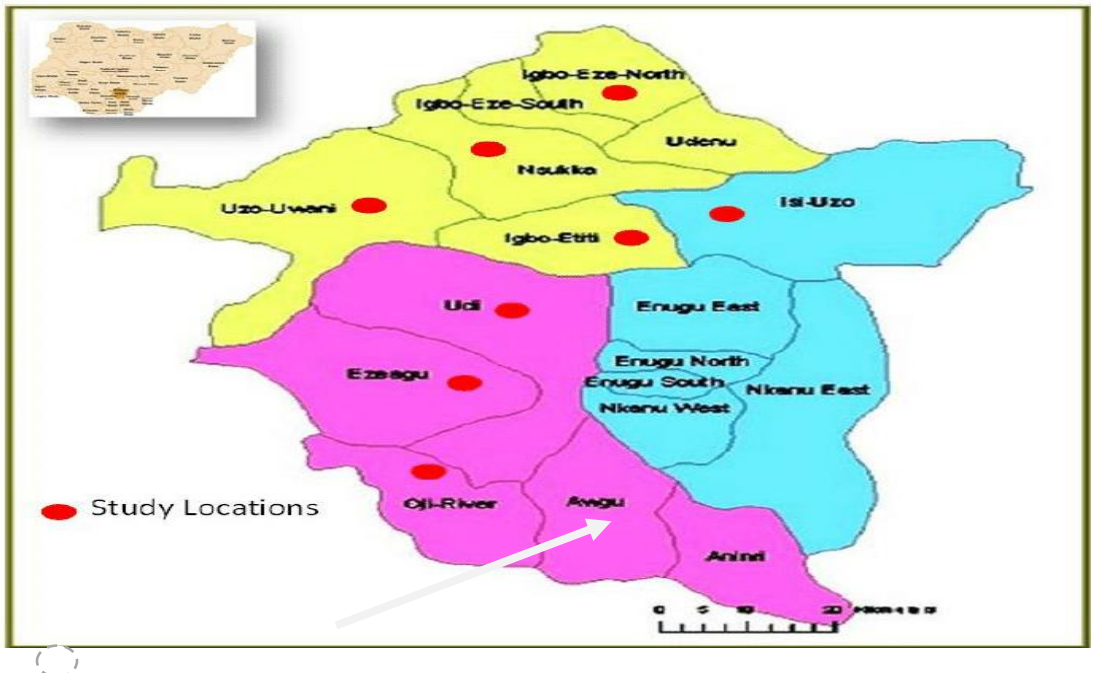

Figure 1: Map of Enugu State showing the study area (Kogbe, 1976).

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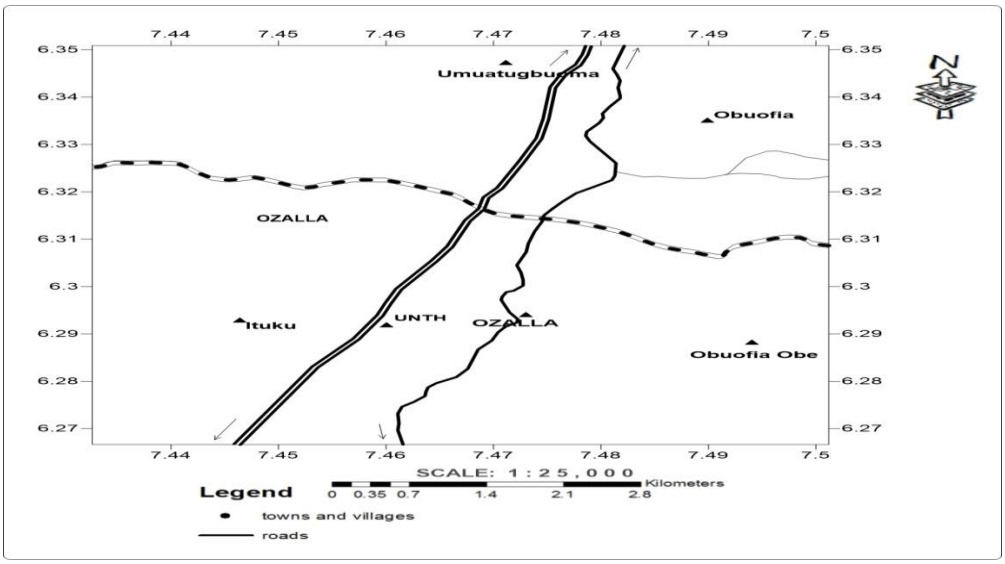


Figure 2: Accessibility map of the study area.

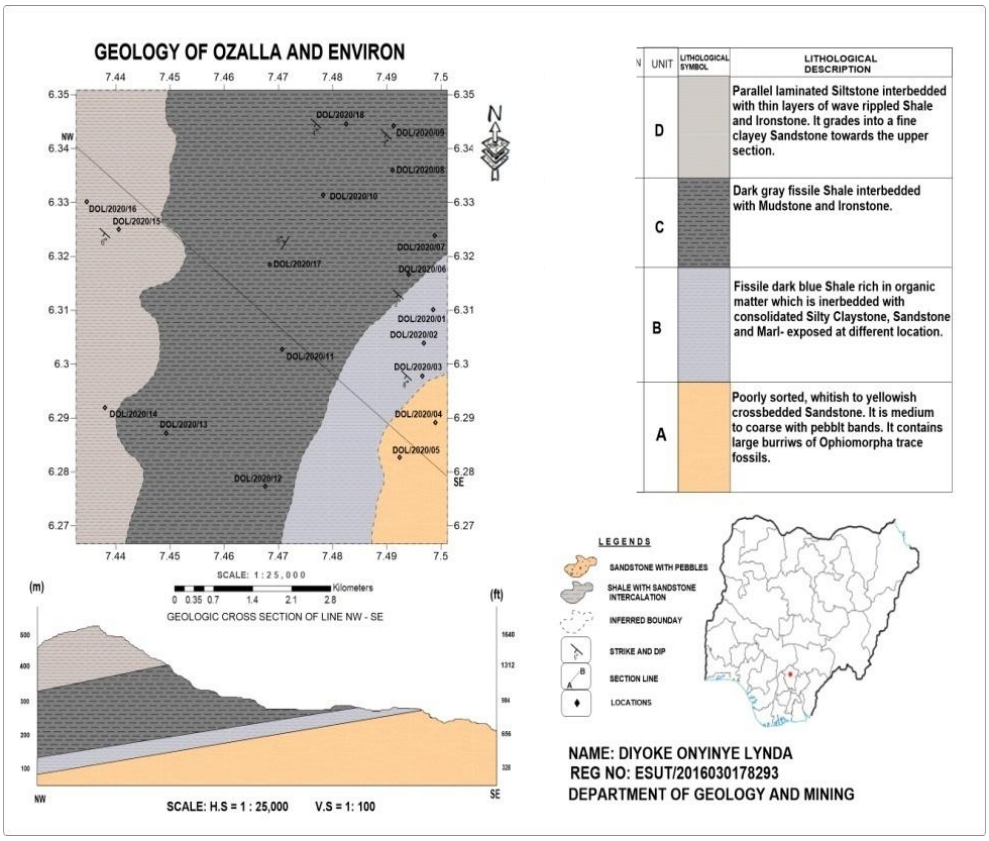


Figure 3: Geologic map of the study area.

Table 1: Summarized table of all visited locations.

LOCATION	COORDINATE	ELEVATION	LITHOLOGY	STRIKE	DIP	DIP DIRECTION
DOL/2020/01	06°18'32" 07°30'38"	207M	SHALE	N2°W	2°	S88°W
DOL/2020/02	06°18'22" 07°30'12"	226M	MUDSTONE			
DOL/2020/03	06°17'54" 07°30'39"	249M	SHALE	N72°W	8°	S20°W
DOL/2020/04	06°17'27" 07°30'42"	194M	SANDSTONE	N78°E	8°	S12°E
DOL/2020/05	06°18'21" 07°30'8"	235M	SANDSTONE			
DOL/2020/06	06°19'00" 07°30'44"	176M	SHALE			
DOL/2020/07	06°19'15" 07°30'30"	197M	SHALE			
DOL/2020/08	06°20'13" 07°30'37"	170M	IRONSTONE			

DOL/2020/09	06°20'35" 07°30'26"	196M	SHALE	N80°W	3°	S10°W
DOL/2020/10	06°19'50" 07°29'26"	173M	SANDSTONE			
DOL/2020/11	06°18'00" 07°28'52"	177M	SANDSTONE			
DOL/2020/12	061629 072816	174M	MUDSTONE	N60°W	4°	S30°W
DOL/2020/13	06°17'35" 07°28'5"	203M	SANDSTONE			
DOL2020/14	06°17'15" 07°26'46"	204M	SILTSTONE			
DOL/2020/15	06°19'32" 07°26'35"	210M	SILTSTONE			
DOL/2020/16	06°19'32" 07°26'26"	237M	SHALE	N43°W	3°	S44°W
DOL/2020/17	06°19'2" 07°28'43"	214M	SHALE	N54°E	6°	S36°E
DOL/2020/18	06°20'50" 07°29'23"	228M	SHALE	N74°W	4°	S16°W

RESULTS AND DISCUSSION

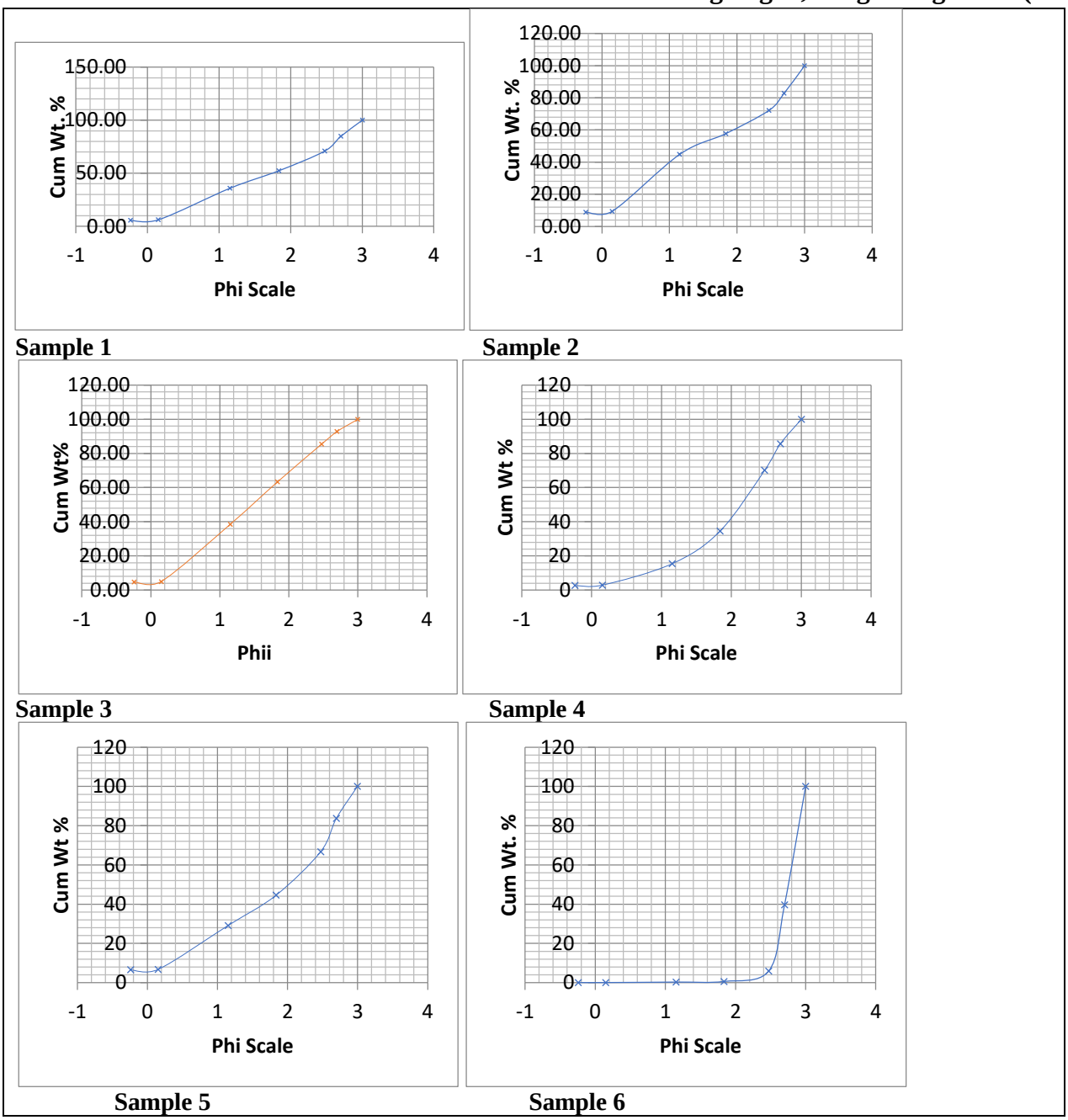
GEOLOGY

Ozalla and environs is located in the Nkanu West Local Government Area of Enugu State, Southeastern Nigeria. The study area lies between latitudes 06°16'0"N and 06°21'0"N and longitudes 07°27'0"E and 07°32'0"E and covers an Ariel extent of approximately 85·6km^2. The field data show that the area is underlain by two lithological units: the shale unit and the sandstone unit.

RESULTS OF THE ANALYSIS

Figure 4: Graphical presentation of the sieve analysis, with the various plots of cumulative percentage against phi

Table 2·0:



Summary of the given input.

SAMPLES;	Φ5	Φ10	Φ16	Φ25	Φ50	Φ75	Φ84	Φ95
Sample 1 (L4)	0	0.3	0.5	0.8	1.7	2.58	2.69	2.9
Sample 2 (L4)	0	0.2	0.38	0.58	1.3	2.59	2.7	3.0
Sample 3 (L4)	0.15	0.3	0.5	0.8	1.45	2.17	2.48	2.9
Sample 4 (L11)	0.4	0.8	1.18	1.6	2.15	2.47	2.68	2.88
Sample 5 (L12)	0	0.22	0.8	0.98	2.21	2.61	2.69	2.95
Sample 6 (L12)	2.45	2.58	2.6	2.62	2.75	2.85	2.95	2.99

Table 2.1: Result output for sample 1.

Graphic Mean	Graphical standard deviation	Graphic Skewedness	Graphic Kurtosis
1.63	0.9869	-0.1342	0.6677
Medium grain sand	Moderately well sorted	Negatively Skewed	Platykurtic

Table 2·2: Result output for sample 2.

Graphic Mean	Graphic Standard Deviation	Graphic Skewedness	Graphic Kurtosis
1.46	1.0345	0.1701	0.6117
Medium grain sand	Poorly sorted	Positively skewed	Very platykurtic

Table 2.3: Result output for sample 3.

Graphic Mean	Graphic Standard Deviation	Graphic Skewedness	Graphic Kurtosis
1.4767	0.9344	0.0475	0.8675
Medium grain sand	Moderately well Sorted	Symmetrical	Platykurtic

Table 2.4: Result output for sample 4.

Graphic Mean	Graphic Standard Deviation	Graphic Skewedness	Graphic Kurtosis
2.003	0.8114	-0.3523	0.3567
Fine-grained sand	Moderately well Sorted	Very negatively Skewed	Very platykurtic

Table 2.5: Result output for sample 5.

Graphic Mean	Graphic Standard Deviation	Graphic Skewedness	Graphic Kurtosis
1.9	0.9195	-0.4952	0.7417
Medium grain sand	Moderately well Sorted	Negatively skewed	Platykurtic

Table 2.6: Result output for sample 6.

Graphic Mean	Graphic Standard Deviation	Graphic Skewedness	Graphic Kurtosis
2.7667	0.5405	0.0159	5.3279
Fine-grained sand	Moderately well sorted	Symmetrical	Extremely Lepokurtic

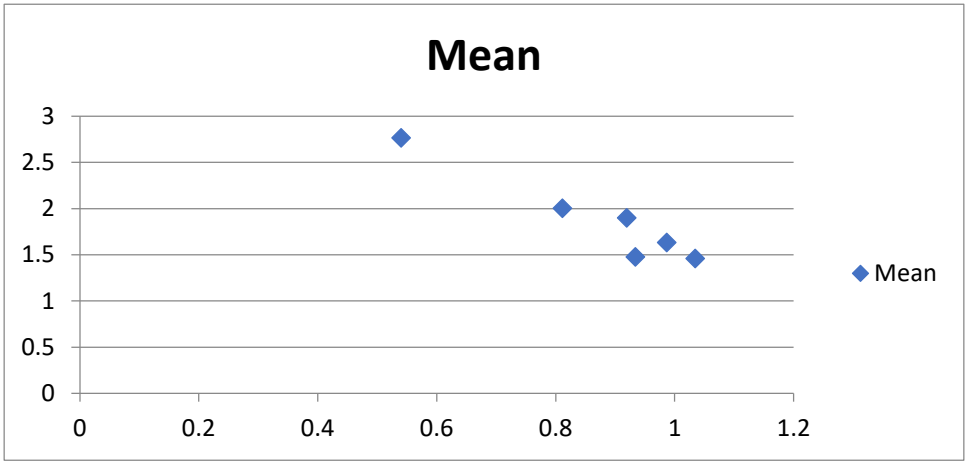


Figure 5: Correlation between mean and standard deviation

Bivariate parameter graph.

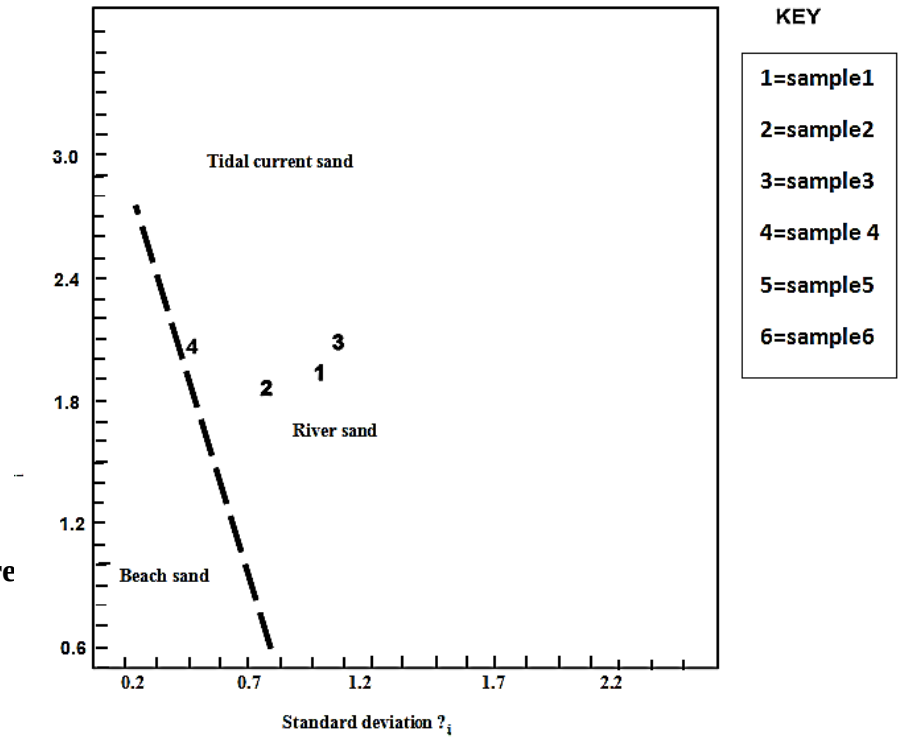


Figure **against standard deviation.**

DISCUSSIONS OF SIEVE ANALYSIS

The graphic representation of the sieve analysis of the six samples collected from the study area; indicates the environment of deposition within the study area as fluvial, the medium of deposition is driven by water under moderate level of energy, and also with the presence of beach sand. This further justifies the process, which is also influenced by wind action, as the mode of deposition occurs as river sands.

The graphs also present the four samples falling within the river sand area, which further indicates the mode of sedimentation from action due to transportation and deposition of these sediments by natural action from wind at a moderate level of energy and are deposited by the river under low action. Two samples within the beach sand area indicate a shallow marine setting as its mode of deposition. The line from the graph of the bivariate parameters (Fig.4.3), indicating the boundary that exists between the two natural agents that influence transportation and deposition of these sediments, such as the beach sand, tidal sand,and river sand, was also confirmed and proved by the bivariate parameter graph, indicating the environment of deposition in the area of study as fluvial. All the samples collected at different locations of the study area fall within the river sand, as shown in the bivariate graph (Fig.4.3). The tidal current simply infers the direction of flow of the particle grains.

SUMMARY

A geologic map of the study area was produced with the sections and cross-sections of the mapped unit. The mapped unit comprises shale and sandstone units.

The shale was found to be light gray with a high clay content at the surface level; it is bluish graygray fissile, and contains brownish iron stains in some locations. The sandstone was more laterally extensive and had three major lithological types: coarse, medium, and very fine to fine sandstone.

The shale unit comprises bluish-dark gray shale that is fissile, laminated, and bedded. The shale consists of an ironstone bed separating each shale unit. Some shale units also consist of wood fragment, burrows, and echinoderm fossils. The color ranges from dark-gray, whitish, yellowish-brown, light-gray, and pinkish. There are fractures and faults seen within this unit, which covers over 70% of the study area.

The sandstone units consist of a consolidated, deep-seated sandstone unit that ranges from fine-coarse grains. In some locations, it shows a coarsening-up sequence. The color ranges from white, purple, reddish, yellowish, and brown with the presence of quartz pebbles in some locations, which are angular-rounded. The units have many structures and are seen in the eastern part of the study area and cover about 30% of the study area. It is delineated as Agbani Sandstone of the Coniacian– Santonian age.

CONCLUSION

The geologic map of the study area includes the mapped units of Agbani sandstone, Enugu shale, and Mamu formation. The ancient environments of the sediments of the study area, part of the Anambra Basin, have been realized from the field relationship and textural analysis results and found to be fluvial with shallow marine incursions. Before the Santonian tectonic event, the Anambra Basin was still the platform stage. However, following Santonian tectonism, the study area opened up as the Anambra Basin. There was an increase in sea level during the Campanian times, and the sea transgressed into the land. The incursion of the Atlantic Ocean caused the basin to become deeper and quiescent. Thus, Enugu shale was deposited into the basin. Gradually, the shoreline started withdrawing seaward from the land. Hence, the basin became starved of shale (Enugu Shale) as a result of the gradual increase in depositional energy within the basin. This resulted in the emergence of sediments deposited in the coastal environment due to fluvial and marine interactions. The regression phase followed the transgression phase simultaneously and subsequently led to the withdrawal of shoreline seaward such that the

sediments that were transported from the land were deposited and the decomposed plant and tree remains in the study area were buried as the Mamu Formation. Thus, the plant remains were transformed into coal seams in the Mamu Formation.

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APPENDIX

Table.3.1: Sieve Analysis Report

Sample no.1

Method of analysis (a) screen type: Half phi interval

(b) Shaker type: Jin lin sieve shaker

(c) Sieving time: 10minutes,

Weight of sample: 100gm

Class Interval (mm)	Phi scale	Wt. on sieve (gm)	Cum. Wt.	Cum. Wt.%	Wt.%
>1.18	-0.2388	5·7	5·7	5·52	5·52
1.18-0.9	0.152	0·57	6·27	6·07	0·55
0.9-0.45	1.152	30.72	36.99	35.84	29.76
0.45-0.28	1.8365	17.06	54.05	52.36	16.53
0.28-0.18	2.474	19.07	73.12	70.84	18.48
0.18-0.154	2.699	14.34	87.46	84.73	13.89
Collector	3	15.76	103.22	100.00	15.27
Total Sample		103·22			100

Weight					

Parameters: Φ5= 0·1, Φ10= 0.3, Φ16= 0.5, Φ25= 0.8, Φ50=1.7, Φ75=2.58, Φ84= 2.69, Φ95= 2.9

Table 3.2: sieve Analysis Report

Sample no.2

Method of analysis (a) screen type: Half phi interval

(b) Shaker type: Jin lin sieve shaker **(c) Sieving time: 10minutes**

Weight of sample: 100gm

Class interval (mm)	Phi scale	Wt. on sieve (gm)	Cum.wt.	Cum.wt. %	Wt.%
>1.18	-0.2388	8.97	8.97	8.83	8.83
1.18-0.9	0.152	0.53	9.5	9.35	0.52
0.9-0.45	1.52	36.05	45.55	44.84	35.49
0.45-0.28	1.8365	13.15	5.87	57.78	12.94
0.28-0.18	2.474	14.67	73.37	72.22	14.44
0.18-0.154	2.699	10.89	84.26	82.94	10.72
Collector	3	17.33	101.59	100.00	17.06
Total Sample Weight		101.59			100

Parameters: Φ5=0, Φ10= 0.2, Φ16= 0.38, Φ25=0.58, Φ50=1.3, Φ75= 2.59, Φ84= 2.7, Φ95= 3

Table 3.3: Sieve Analysis Report for Sample3

Class interval (mm)	Phi Scale	Wt· on sieve(gm)	Cum· Wt·	Cum Wt%.	Wt·%
>1.18	-0·2388	4·79	4.79	4.72	4.72
1.18-0·9	0·152	0.26	5.05	4.97	0.26
0.9-0·45	1·152	34.02	39.07	38.49	33.51
0.45-0·28	1·8365	25.21	64.28	63.32	24.83
0.28-0·18	2·474	22.4	86.68	85.38	22.06
0.18-0·154	2·699	7.57	94.25	92.84	7.46
Collector	3	7.27	101.52	100.00	7.16
Total Sample Weight		101.52			100

Parameters

Φ5=0.15 Φ10=0·3 Φ16=0.5 Φ25= 0.8 Φ50 = 1.45 Φ75 = 2.17 Φ 84 = 2.48 Φ 95 = 2.9

Table 3.4: Sieve Analysis Report for Sample4

Class interval (mm)	Phi Scale	Wt· on sieve(gm)	Cum· Wt·	Cum Wt%.	Wt·%
>1.18	-0·2388	2·85	2.85	2.78	2.78
1.18-0·9	0·152	0.17	3.02	2.95	0.17
0.9-0·45	1·152	12.86	15.88	15.49	12.54
0.45-0·28	1·8365	19.53	34.41	34.53	19.05
0.28-0·18	2·474	36.45	71.86	70.08	35.55
0.18-0·154	2·699	15.93	87.79	85.62	15.54
Collector	3	14.75	102.54	100.00	14.38
Total Sample Weight		102.54			100

Parameters

Φ5=0.4 Φ10=0·8 Φ16=1.18= Φ25= 1.6 Φ50 = 2.15 Φ75 = 2.47 Φ 84 = 2.68 Φ 95 = 2.88

Table 3.5: Sieve Analysis Report for Sample5

Class interval (mm)	Phi Scale	Wt· on sieve(gm)	Cum· Wt·	Cum Wt%.	Wt·%
>1.18	-0·2388	6·59	6.59	6.57	6.57
1.18-0·9	0·152	0.22	6.81	6.79	0.22
0.9-0·45	1·152	22.44	29.95	29.18	22.38
0.45-0·28	1·8365	15.42	44.67	44.56	15.38
0.28-0·18	2·474	22.25	66.92	66.75	22.19
0.18-0·154	2·699	17.04	83.96	83.75	17.00
Collector	3	16.29	100.25	100.00	16.25
Total Sample Weight		100.25			100

Parameters

Φ5=0 Φ10=0·22 Φ16=0.8 Φ25= 0.98 Φ50 = 2.21 Φ75 = 2.61 Φ 84 = 2.69 Φ 95 = 2.95

Table 3.6: Sieve Analysis Report for Sample6

Class interval (mm)	Phi Scale	Wt· on sieve(gm)	Cum· Wt·	Cum Wt%.	Wt·%
>1.18	-0·2388	0·04	0.04	0.4	0.4
1.18-0·9	0·152	0.02	0.06	0.6	0.02
0.9-0·45	1·152	0.24	0.3	0.30	0.24
0.45-0·28	1·8365	0.31	0.61	0.60	0.31
0.28-0·18	2·474	5.41	6.02	5.96	5.36
0.18-0·154	2·699	33.98	40.0	39.61	33.65
Collector	3	60.98	100.98	100.00	60.39
Total Sample Weight		100.98			100

Parameters

Φ5=2.45 Φ10=2·58 Φ16=2.6 Φ25= 2.62 Φ50 = 2.75 Φ75 = 2.85 Φ 84 = 2.95 Φ 95 = 2.99