Asian Journal of Geological Research

4(2): 54-64, 2021; Article no.AJOGER.68631

Petrography and Provenance of Eze-Aku Sandstones in Afikpo Basin, Southeastern Benue Trough

Kiamuke Itiowe[1*], Minapuye Isaac Odigi[2], Biokpo Kingson Kurah[2] and Bariborve Kpegeol[2]

[1]Department of Earth Sciences, Arthur Jarvis University, Akpabuyo, Cross River State, Nigeria.
[2]Department of Geology, University of Port Harcourt, Port Harcourt City, Rivers State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

Editor(s):
(1) Dr. Ahmed Abdelraheem Frghaly, Sohag University, Egypt.
Reviewers:
(1) Maciej Pawlikowski, AGH-University of Science and Technology, Poland.
(2) Nusara Surakotra, Khon Kaen University, Thailand.
Complete Peer review History: http://www.sdiarticle4.com/review-history/68631

Original Research Article

Received 19 March 2021
Accepted 29 May 2021
Published 07 June 2021

ABSTRACT

Petrographic study of the Eze-Aku sandstones exposed within the Afikpo basin were analysed to determine the petrography, provenance and tectonic setting of the area. Petrographic studies showed that the Eze-Aku sandstones were predominantly quartz, feldspar and lithic fragments. The QFL triangular plot shows that the Eze-Aku sandstones are mainly sub-arkoses with subordinate amount of arkoses and quartz arenites. The ternary plot of the provenance category showed that the Eze-Aku sandstones were plotted within the basement uplift continental block, indicating that the sandstones could have been a product of high relief and erosion from the Oban and Cameroon Massifs, located east part of the Abakaliki anticlinorium and Afikpo Basin.

Keywords: Eze-Aku; Quartz; Feldspar; Massif; Anticlinorium; Basin.

1. INTRODUCTION

The Benue Trough is a Cretaceous basin about 100km in length stretching in a NE-SW direction and siting upon the Precambrian Basement. The Benue Trough is a narrow 80-100km wide linear NE-SW trending feature with sedimentary in-fills and magmatic rocks which extends from below the Niger Delta Basin to southern limit of Chad Basin. The Benue Trough is commonly divided

**Corresponding author: Email: kiamukeitiowe@yahoo.com;*

into three main domains corresponding to both geological and geomorphologic partition which are: the Upper Benue Trough, Middle Benue Trough and Lower Benue Trough. According to Benkhelil [1], the Lower Benue Trough exhibits extensive Cretaceous sandstones, mudstones and shale lithofacies, though they are fairly comparable in geometric and sedimentary thickness.

The sedimentary basins of the southern Nigeria includes the Benue-Abakaliki belts, the Afikpo syncline, Anambra basin, Mamfe embayment, Calabar flank and the Niger Delta basin (Fig. 1). The Afikpo basin is part of the southern-eastern sedimentary basin that is bounded by the Niger Delta to the south, the Abakaliki Anticlinorium to the north and the Anambra to the west, Oban Massif rift to the east (Fig. 1).

The objectives of this study are to determine the textural attributes and mineralogical composition of sandstones, the modal composition of the sandstones, the provenance of parent rock of the Eze-Aku sandstones using the available mineral attributes, and determine the events and physiographic condition under which the sediment was formed. In recent years, much effort to relate the detrital composition of sandstones to the tectonic setting of its provenance region has been carried out Tucker [2]. This study reveals the petrography, provenance and composition of the sandstones within the Afikpo Basin.

Field mapping of parts of Afikpo basin which includes the Ibii and Akpoha sandstones was carried out during which a total of twenty seven representative sandstone samples were taken from different facies unit that showed good exposures for petrographic studies. Afikpo basin is situated to the northeast of the Niger Delta between 5°55' 30"N and 6°0'0"N and longitude 7°45'30"E and 8°0'0"E (Fig. 2). Two locations were visited to collect sandstone samples from the Eze-Aku sandstones. Samples were collected from well exposed outcrops from different locations in Ibii and Akpoha environs.

2. MATERIALS AND METHODS

Modal analysis was carried out on twenty seven representative thin-sectioned samples using the point counting method of Gazzi Dickinson method. One hundred and eighty points were counted per thin section; each specimen was counted for quartz (Q), feldspar (F) and lithic rock fragments (Lt). The component minerals of the sandstone include mono-crystalline quartz (Qm), poly-crystalline quartz (Qp), potassium feldspar, plagioclase feldspar and lithic rock fragment (Lf). The modal analysis was carried out to determine the percentages and compositional fields were plotted on a triangular diagram with Q-F-Lf (Quartz-feldspar-lithic fragments) to classify the sandstones. Dickinson [5] and Dickinson and Suczek [6] used ternary diagram to interpret the tectonic setting. Additional petrographic observation of the samples included extinction angle, maturity of the grains, sorting, grain alteration and recycled grain.

3. REGIONAL GEOLOGY AND STRATIGRAPHY OF THE BENUE TROUGH

Burke et al. [8] stated that the genesis of the Benue Trough started during the division of African and South American plates during the Cretaceous Era. Murat [9] study suggested that the southern portion of the Benue Trough was a faulted longitudinal basin. During the Albian, basin subsidence and deposition of sediments was high, and became low during the Cenomanian. Sediments were constrained to the Calabar flank region before the sediment moved to the sea and thermo-tectonic activities began during the Santonian. According to different workers, this thermo- tectonic event gave rise to the formation of the Afikpo and Anambra basins. All Pre-Santonian beds in the Benue Trough were deformed and uplifted to form the Okigwe-Abakaliki Anticlinorium, aligning NE-SW. Murat [10] identified three structural cycles in south-eastern Nigeria. According to Chikani et al. [11], paleo-current study of the cross-bedded sandstones in the Benue Trough showed two distinct provenances, which includes the northwestern source possibly from the Nigerian Basement Complex and the north-eastern source probably from the Hawal Massif.

The Cretaceous stratigraphy of southern eastern Nigeria comprises of sequence of deposition. The stratigraphic relationships of the southern part of the eastern Nigeria are summarized by various authors (Table 1). Odigi [12] and Umeji [13] carried out a study and concluded that sedimentary infill of the sediments in the Afikpo basin is divided into three tectonic-stratigraphic mega sequences: the Asu-River Group, Eze-Aku and Proto-Niger Delta succession.

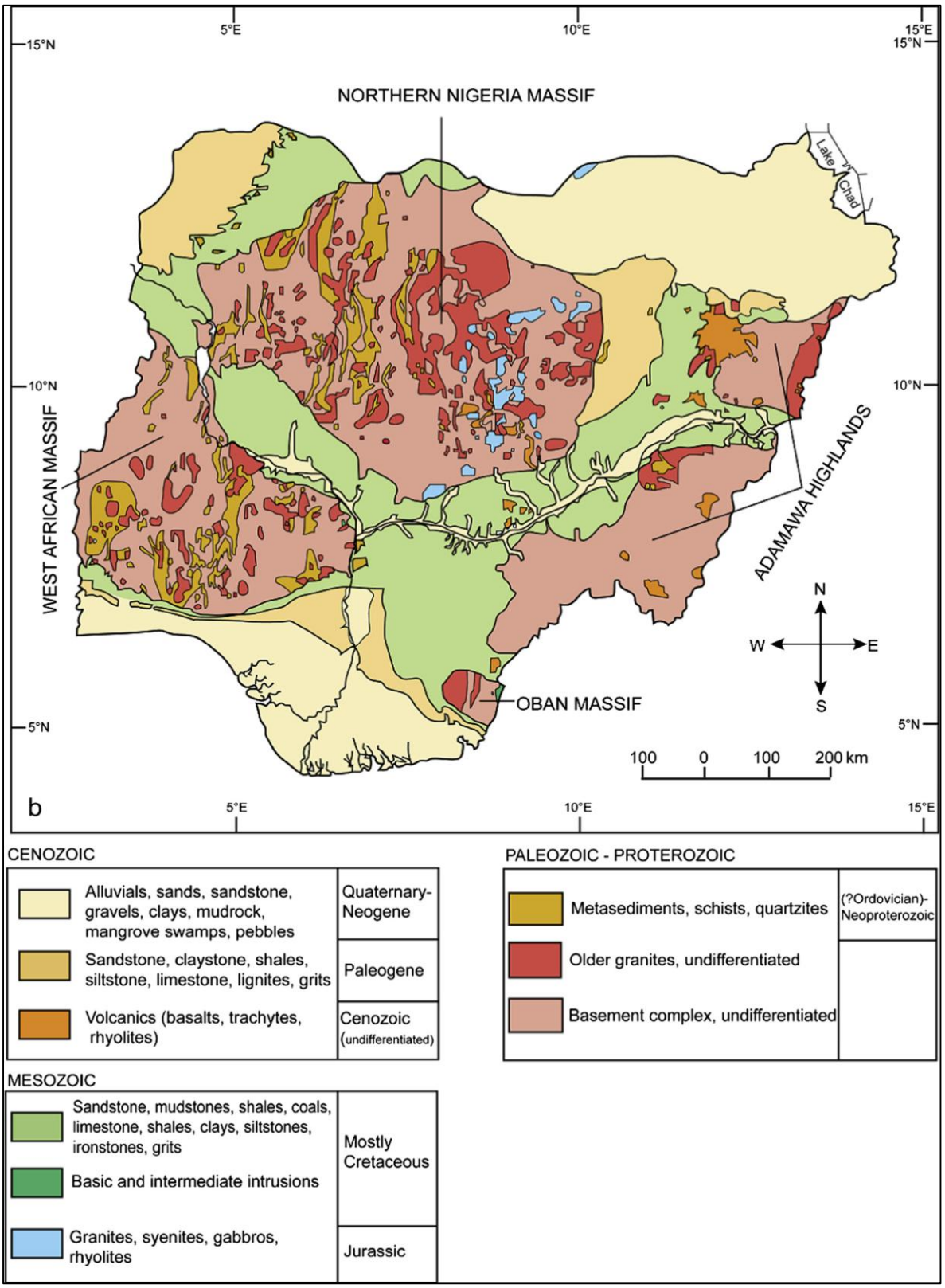

Fig. 1. The map of sedimentary basins in Nigeria (After Short and Stauble [3,4]

Ojoh [14] documented that marine transgression in Nigeria started during the Middle Albian. Albian sediments constitute the Asu River Group and its equivalents. The Albian rock is the oldest

sedimentary rock in the southern Benue Trough as studied by Whiteman [15]. Ukaegbu and Akpabio [16] showed that the Asu-River group consists of alternating sandstone, shale and siltstone. It possesses a thickness of about 3000m, embedded with shale and micaceous sandstone and contains radiolarian, echinoids, pelecypods and gastropods Omoboriowo et al. [17]. According to Offodile [18], the Asu River Group is characterized by elobiceras and monticeras species which are ammonites. The Albian sediments were folded in many areas, as investigated by Reyment [19].

Uncomformably overlying the Asu River Group is the Eze-Aku Group which is deposited during a regressive phase. As reported by Kogbe [20], the Eze-Aku Group which consists of hard grey and black calcareous shales, limestones and siltstones. The Eze-Aku Group grades into the marine Agwu sediments which are essentially shales, sandstones and limestones, as stated in Petters [21].

During the Santonian, older strata were folded, faulted, intruded and uplifted. Overlying the pre-Santonian strata are the Campano-Maastrichtian and proto-Niger Delta sediments. According to Odigi [12], the Nkporo Formation is the basal formation of Campanian-Maastrictian sediments. Uncomformably overlying the Nkporo Formation is a paralic sequence of Mamu Formation. The formation is overlain by marine-continental sequence of Ajali sandstone. As stated in Hoque [22], the Ajali sandstone composes of quartz arenites, the grains are mostly friable, poorly sorted and sub-rounded. After the deposition of Ajali sandsone was followed by Nsukka Formation, according to Kogbe [20]. Overlying the Nsukka Formation is the Imo Shale. It consists of thick, blue-grey to blue-black carbonaceous, fissile, clayey shale, clay and ironstones.The Ameki Formation sits on the Nsukka Formation. It comprises of clays and sandstone.

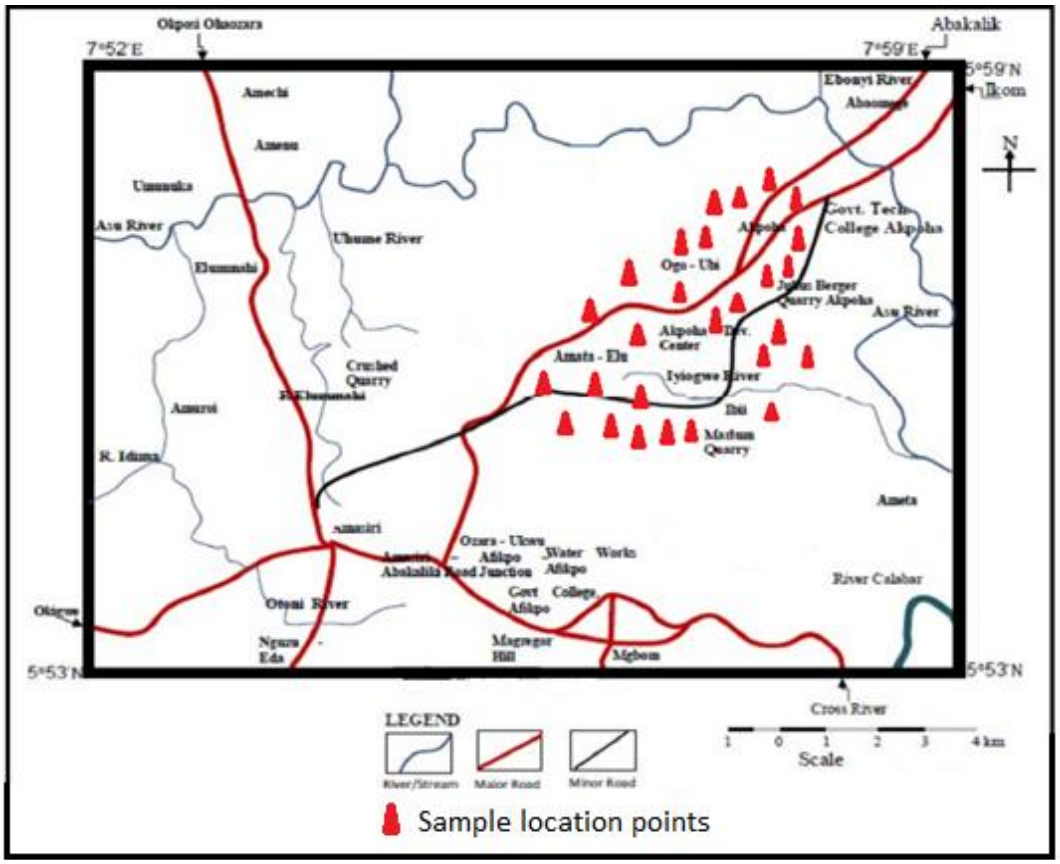

Fig. 2. Sample location map of the study area (after Akpofure and Didei [7])

Table 1. Stratigraphic succession of the Afikpo and Anambra basins (after Odigi [23])

System	Series	Stage	Lower Benue Trough	Lower Benue Trough
			ANAMBRA BASIN	AFIKPO BASIN
TERTIARY	Eocene Paleocene		Ameki Formation Imo Shale	Ameki Formation Imo Shale
CRETACEOUS		Maestrichtian	Nsukka Formation Ajali Sandstone Mamu Formation	
	Cenomanian	Campanian Santonian Coniacian Turonian Cenomanian Albian	Enugu Shale Agwu Shale Eze-Aku Fm. Odukpani Fm. Asu River Group	Nkporo Fm. Eze-Aku Fm. Asu River Group
PRECAMBRIAN				

3. RESULTS AND DISCUSSION

3.1 Petrography of Sandstone

3.1.1 Quartz

Quartz is the dorminant framework grain recorded for the Eze-Aku sandstones. Both mono-crystalline and poly-crytalline quartz types are present. The mono-crystalline quartz grain is dorminant in the Eze-Aku sandstones; its content varies betwwen 10 % to 75% (Fig. 3a). The mono-crystalline and poly-crystalline quartz grains occur together in some of the grains (Fig. 3b). Some of the grains from the thin-section studied in the sandstones are sub-angular to sub-rounded with moderately well sorted (Fig.3c). The mono-crystalline and poly-crystalline quartz grains studied have the following internal characteristics: undulose extinction, strained extinction, stressed fractured, deformed tracks of fluid inclusions, elongated and flattened crystals. Mono-crystalline quartz occurs as single, angular to sub-angular grains. Poly-crystalline quartz grains are less abundant in occurrence in the sandstone. The poly-crystalline quartz grains identified possess different crystals and undulose extinction. The undulose quartz grains do not show the same orientation, thus showing that strain was acquired in the source region.

3.1.2 Feldspar

Feldspar is an important group present in the sandstone in large amount. The feldspar studied under thin sections show potassium and plagioclase feldspars. The potassium feldspar studied was microcline. Microcline was identified by grid iron twinning in the sandstone (Fig. 3a), while the plagioclase feldspar showed poly-synthetic multiple twinning (Fig. 3b). The original feldspar content is higher in some samples, as K-feldspar has been lost due to grain dissolution. Little potassium feldspar occurs in coarse grained sandstones whereas the fine grained sandstones contain feldspar up to 30% potassium feldspar. Plagioclase feldspar is identified by its poly-synthetic twinning. Feldspar constitutes 5 – 73% with an average number of 11.3%. The reduction in the average detrital feldspar content can be attributed to tectonism, abrasion and the time or duration of the action during an intense humid climatic condition that prevailed during the Cretaceous times.

3.1.3 Rock fragments

Rock fragments generally constitute a minor proportion of the detrital grains. Recognised varieties include mudstone, carbonate, siltstone and igneous fragments. In Eze-Aku sandstones, the lithic rock fragments are mainly volcanic rocks. Mudstone interclasts constitute common lithic fragments occurring as dense grains. Other fragments of sedimentary origins are restricted to rare siltstone grains. Some of the sandstones contain fish remains, with micro-boring which are mixture of extra-basin and intra-basinal in origin. The rock fragments of Eze-Aku sandstones range from 0-14% with an average of 5.04%.

3.1.4 Cements

The framework grains are bounded by cements; however in some case the sandstones are partly grained supported. The cements collectively

comprise an average value of 8% of the Eze-Aku sandstones (Fig. 4d).The most common cement is calcite with iron-oxide, quartz overgrowth and some clay matrix. Calcite cement is presented in most samples. Calcite has been altered to siderite in some cases. Quartz cement in the form of quartz overgrowth is present in most of the samples.

3.2 Modal Composition

Quartz is the dominant framework grain recorded for Eze-Aku sandstones, with average mono-crystalline and poly-crystalline quartz grains of about 47.96% and 10.51% respectively. The average of the total quartz grain is 58.9 % for the Eze-Aku sandstones. The feldspar from Eze-Aku sandstones ranges from 1-50%, with an average figure of 34.5%. The sandstones have the greatest amount of mono to poly- crystalline quartz grains as (40:1). According to Tucker [2], high ratio of mono-crystalline quartz grain to poly-crystalline quartz grain to a great amount of plutonic rock in the source area which may be indicator of higher contribution of plutonic source rocks as against metamorphic source to the depositional systems during the Cretaceous times. The Eze-Aku sandstones are texturally and mineralogical sub-mature due to the sub-angular to sub-rounded grains which indicate a relatively short distance of transportation.

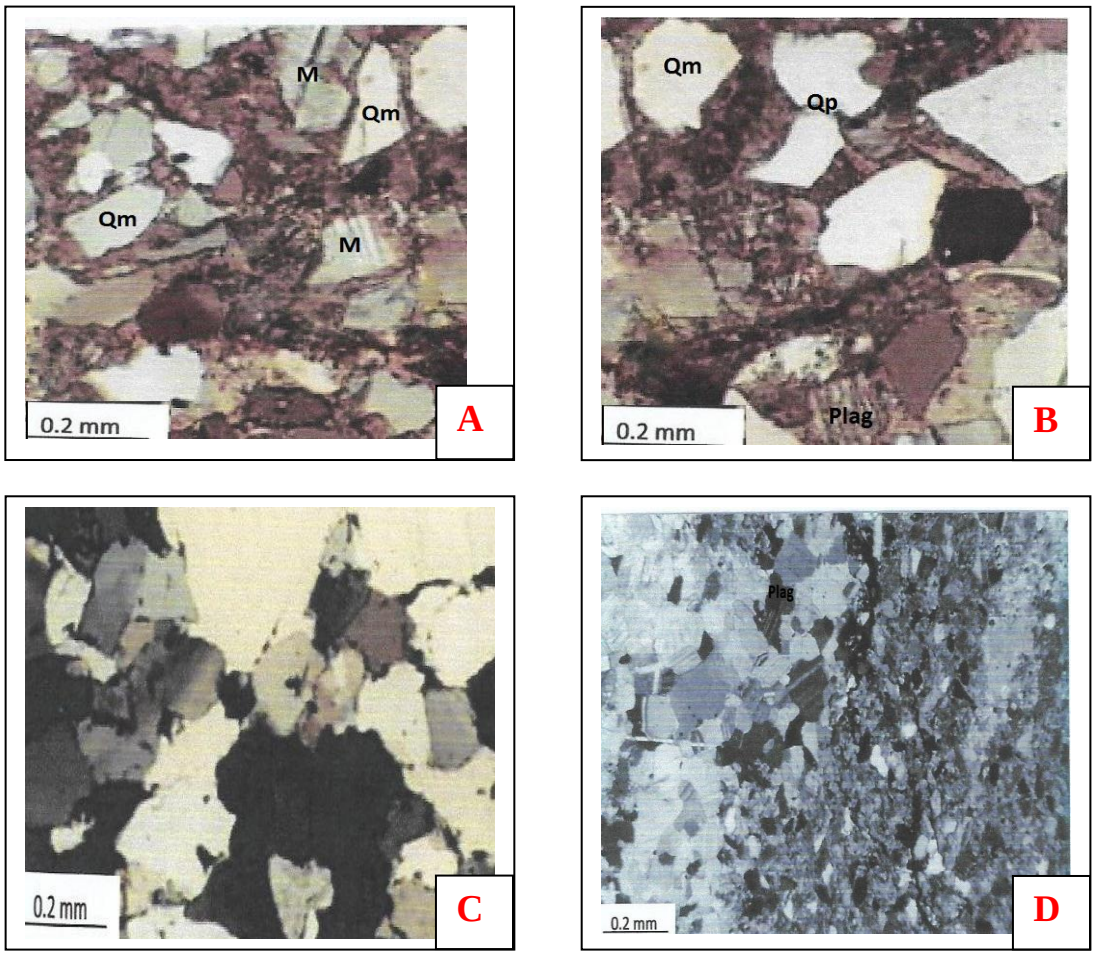

Fig. 3. Thin section photographs of sandstones from Eze-Aku Formation (A) Mono-crystalline quartz (Qm) and microcline grain (M), (B) Mono-crystalline quartz - Qm, Polycrystalline quartz grain- Qp and Plagioclase-P) (C) Sub-angular to sub-rounded grains (D) Framework grains bounded by cement

Table 2. Composition of the sandstones

Sample	Mono Quartz	Poly Quartz	Total	K-feldspar	Plagio.	Total Feldsar	Lithic Fragment	Mono/ Poly quartz ratio
1	58	20	78	16	4	22	0	2.9:1
2	65	10	75	14	8	22	3	6.5:1
3	80	2	82	5	10	15	3	40:1
4	76	4	80	10	5	15	5	19:1
5	40	3	43	30	17	47	10	13.3:1
6	33	10	43	28	15	43	14	33:1
7	48	12	60	16	12	28	12	4:1
8	70	5	75	10	10	15	0	14:1
9	70	8	78	7	5	12	10	8.75:1
10	56	14	70	10	10	10	0	3.73:1
11	88	3	91	8	1	9	0	29.3:1
12	78	9	87	10	3	13	0	8.66:1
13	66	21	81	7	12	18	1	3.14:1
14	52	10	62	20	14	36	2	5.2:1
15	35	53	88	5	7	12	2	1:0.66
16	29	7	36	45	17	62	2	4.14
17	10	10	27	50	23	64	9	1:1
18	24	5	29	38	32	70	1	4.8:1
19	34	6	40	38	12	50	10	5.6:1
20	38	2	40	48	2	50	10	19:1
21	33	7	40	48	2	50	10	4.7:1
22	44	2	46	43	10	43	11	22:1
23	20	16	36	48	12	60	4	1.25:1
24	25	25	49	17	33	50	1	1:1
25	20	5	35	50	15	65	0	4:1
26	65	11	76	4	11	24	0	5.9:1
27	38	6	44	34	16	50	4	6.3:1
Aver.	47.96	10.51	58.9	24.4	11.3	34.5	5.04	

3.3 Classification

The classification for the sandstone was based on some described scheme by Folk [24] and Pettijohn [25]. The QFL triangular plot shows that the Eze-Aku sandstones are mainly sub-arkoses with subordinate amount of arkoses and quartz arenites (Figs. 4 and 5).

3.4 Provenance

The attributes of quartz grains for provenance determination has been shown by Folk [26]. The mono-crystalline quartz grains studied conforms in character to the common quartz category and are considered to be plutonic in origin, when compared to the work of Harwood [26]. According to Harwood [27], some mono-crystalline quartz with numerous sub-crystal with highly strain extinction where possibly derived from metamorphic rock. However, the proportion of mono-crystalline to poly-crystalline quartz grain as shown in Table (2) has the highest amount as (43:1). According to Tucker [2], high proportion of mono-crystalline quartz grain to poly-crystalline quartz grain proportion indicates the abundance of plutonic rock in the source region. Based on this, the difference in mono to poly-crystalline quartz grains which are sub-angular to angular may be indicator of higher contribution of plutonic source rock for the sandstone as against metamorphic source to the depositional system during the Cretaceous times.

Tectonic settings of sandstones can be deciphered by considering their Qm-F-L compositional diagrams, as reported by Dickinson [4]. In line with Dickinson [4], the percentages of the various combination of grains were plotted on the Qt-F-Lf diagram which was used to identify five major terranes, there are: (1) Cratonic interior (2) Basement uplift continental block (3) Dissected arc (4) Transitional arc and (5) Recycled orogeny.Eze-Aku sediments were plotted on a basement uplift continental block (Fig. 5).According to Olade [28] and Olade [29], Basement uplift are regions of high relief along rift and strike slip zones,

dominant in quartzo-feldspathic and poor lithic sand and are deposited in extensional and pull-aparts basins. The Eze-Aku sandstones have been derived from uplifted marginal basement block immediately after the doming/ rifting, prior to the Asu-River group deposition.

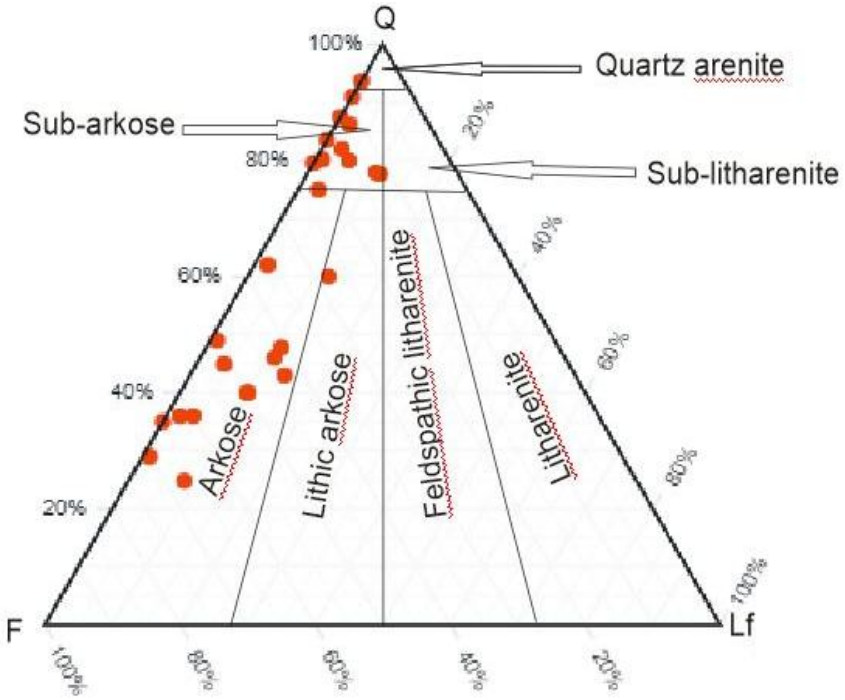

Fig. 4. Petrographic composition of Eze-Aku sandstones (After Folk [24])

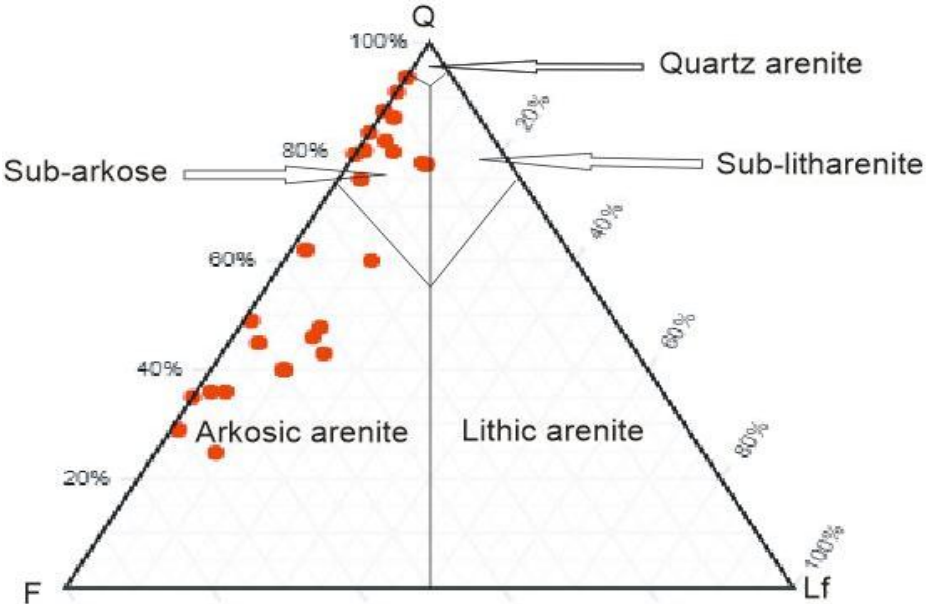

Fig. 5. Petrographic composition of Eze-Aku sandstones (After Pettijohn [25])

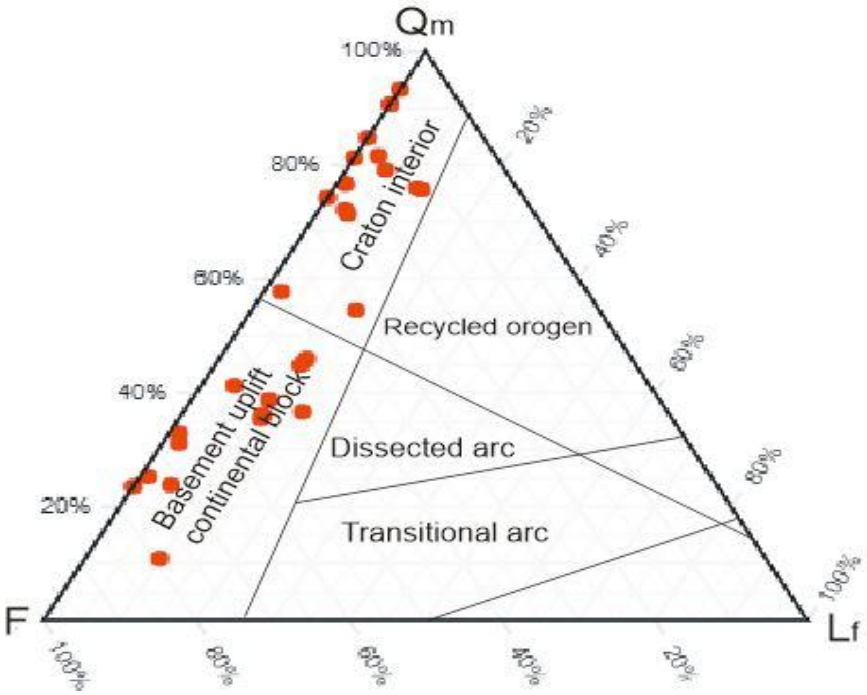

Fig. 6. Interpretation of Provenance categories (After Dickinson [5])

4. CONCLUSION

The proportion of mono-crystalline to poly-crystalline quartz grain is greater in the sandstone (40:1). High ratio of mono-crystalline quartz grain to poly-crystalline quartz grain ratio signifies great amount of plutonic rock in a source area. Based on this, the difference in mono-crystalline to poly-crystalline quartz grain which is sub-angular to angular may be indicator of higher contribution of plutonic source rocks for the Eze-Aku sandstones within the Ibii and Akpoha environs as against metamorphic source to the depositional system during the upper Cretaceous times. According to Ekwueme [30] and Ekwueme and Ekwueme [31],granitic and acid gneisses contributed to the development of the Eze-Aku sandstones, this is evident from the dominance of potassium feldspar over plagioclase feldspar in the sandstones studied. K-feldspar is more common in continental basement rocks of the Oban and Obudu massif (granites and gneiss). Continental basement rocks of the Oban and Obudu massif (granites and gneiss) are the provenance of Eze-Aku sandstones in the study area. To buttress the above statement, the QtFL diagram plotted for Eze-Aku sandstones was plotted on a basement uplift continental block. Basement uplift are area of high relief along rift and strike slip zones and are dorminantly quartzo-felspathic and poor lithic sand, which concur with the Eze-Aku sandstones. This result is concordance with studies of other Cretaceous sandstone of southern Nigeria as carried out by Hoque [32] and Hoque and Ezepue [33]. They observed that the pre-Santonian sandstones are arkosic sandstone and were derived from the eastern granitic basement rocks of the Cameroon massif.

According to Hoque [33] and Hoque and Ezepue [33], the paleocurrent direction concluded that the easterly source is responsible for the Eze-Aku sandstones in the Benue Trough, at least they preferred the Cameroon massif complex. The basis of this interpretation is the fact that the estimated 2000m thick sediment eroded from the uplift could not account for their estimated thickness (4000m) of the post-Santonian to Eocene sedimentary succession belonging to their second marine depositional phase in the Benue Trough.

Based on the above discussion, the light mineral studied and the ternary triangular diagram plotted, the authors of this study strongly support the first cycle of the sub-arkosic sandstones of the Eze-Aku sandstones within the Ibii and Akpoha environs in Afikpo Basin, which is believed to be a product of high relief and rapid erosion of the south eastern supracrustal basement located in the east part of the Abakaliki high and Afikpo basin.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Benkhelil J. The origin and evolution of the Cretaceous Benue Trough, Nigeria. Journal of Africa. Earth Sci. 1989;8:251-282.
2. Tucker ME. Sedimentary petrology. An introduction to the origin of sedimentary rocks. 3th ed. Blckwell Publishing Company. 2004;11-61.
3. Short KC, Stauble AJ. Outline of the geology of the Niger Delta. AAPG Bull. 1967;54:761-779.
4. Ekwenye OC, Nichols G, Mode AW. Sedimentary petrology and provenance interpretation of the sandstone lithofacies of the Paleogene strata, south-eastern Nigeria. Journal of Africa Earth Sci. 2015;109:239-269.
5. Dickinson WR. Interpreting provenance relations from detrital mode of sandstones. In provenance of arenites (Ed. G. G. Zuffa) Reodel, Dordrecht; 1985.
6. Dickinson WR, Suczek CA. Plate tectonic and sandstone composition, AAPG Bulletin. 1979;75:1626-1643.
7. Akpofure E, Didei IS. Composition and Textural Characteristics of Turonian Ezeaku Formation: Implication for Depositional Environment. Journal of Environment and Earth Science. 2018;8(12):23-30.
8. Burke KC, Dessauvagie TFJ, Whiteman AJ. Opening of the Gulf of guinea and geological history of the Benue depression and Niger Delta. Nat. Phy. Sci. 1971;233:51-55.
9. Murat RC. Stratigraphy Cretaceous and Lower Tertiary in Southern Nigeria: In Dessauvagie - T. F. J. and Whiteman, A. J. (ed.) African Geol. University of Ibadan Press. 1972;251-266.
10. Murat RC. Stratigraphy and Paleogeography of the Cretaceous and Lower Tertiary in Southern Nigeria. In Dessauvagie - T. F. J. and Whiteman, A. J. (ed.) African Geology University of Ibadan Press. 1970;251-266.
11. Chikani SN, Ohia IA, Egbu OC. Paleoenvironmental and Structural Evolution of Clastic Sediments in Parts of Afikpo Syncline (Southeastern Nigeria). NMGS Book of Abstracts. 2010;30.
12. Odigi MI. Facies Architecture and Sequence Stratigraphy of Cretaceous formations, southeastern Benue Trough, Nigeria. Unpublished PhD thesis. University of Port Harcourt; 2007.
13. Umeji AC. Evolution of the Abakaliki and the Anambra Sedimentary Basins, Southeastern Nigeria [R]. A Report Submitted to the Shell Petroleum Development Company Ltd. 2000;155.
14. Ojoh K. Geological Evolution of Benue valley, Unpublished Thesis Doctoral de l'Universite', Marsheille France; 1988.
15. Whiteman A. Nigeria. Its Petroleum Geology, Resources and Potential: vs 1 and 2. Graham and Trotman, Ltd, London. 1982;176.
16. Ukaegbu VU, Akpabio IO. Geology and Stratigraphy of Middle Cretaceous Sequences Northeast of Afikpo Basin Lower Benue Trough, Nigeria. Pacific Journal of Science and Technology. 2009;10(1):1-10.
17. Omoboriowo AO, Okengwu, KC, Ugwueze CU, Soronnadi-Ononiwu GC, Acra EJ, Chiaghanam OI, Chiadikobi KC. Geochemical Characterization of Afikpo Basin, Arochukwu Area, South Eastern Nigeria. Advances in Applied Research, 2012;3(6):3652-3657.
18. Offodile ME. The geology of the middle Benue Trough, Nigeria Bull. Geol. Instn. Univ. Uppsala, Ph.D. Thesis, H. 1976;166.
19. Reyment RA. Aspect of geology of Nigeria, Univ. Ibadan Press. Nigeria. 1965;1-45.
20. Kogbe CA. The Cretaceous and Paleogene sediments of southern Nigeria In: Kogbe, C. .A. (ed). Geology of Nigeria. Elizabeth publishing Co; Lagos. 1976;273–282.
21. Petters SW. Mid-Cretaceous paleoenvironment and biostratigraphy of the Benue Trough, Bulletin of the Geological Society of America. 1976;89:151 -154.
22. Hoque M. Petrographic differentiation of tectonically controlled Cretaceous sedimentary cycle, souheastern Nigeria. Sed. Geol. 1977;17:235-245.
23. Odigi MI. Diagensis and Reservoir quality of Cretaceous sandstones of Nkporo Formation (Campanian) southeastern Benue Trough, Nigeria. Geology and Mining Research. 2011;3(10):265-280.

24. Folk RF. Petrology of sedimentary rocks: Hemphill Publishing, Texas 2nd ed; 1980.
25. Pettijohn FJ. Sedimentary Rocks, third ed. Harper and Row, New York. 1975;628.
26. Folk RF. Petrology of sedimentary rock: Austin Texas, Hemphill Publishing. 1974;182.
27. Harwood G. Microscopic techniques: 11. Principle of sedimentary petrology. In: Technique in Sedimentology (ed. Tucker, M.). 1997;108-173.
28. Olade MA. Evolution of the Nigeria Benue Trough (Aulocogen): Tectonic model. Geol. Mag. 1975;112:575-583.
29. Olade MA. Early Cretaceous basaltic volcanism and initial continental rifting in Benue Trough. Nature. 1978;273:458-9.
30. Ekwueme BN. *Petrology of southern Obudu Plateau, Bamenda massif*, SE Nigeria. In: G. Rocci and M. Deschamps (eds) Recent data in Africa Earth Sci. CIFEG (Paris) occas. Publ. 1990;155-158.
31. Ekwueme SJ Ekwueme BN. Geochemistry of Precambrian gneisses in the Eastern part of the Oban massif, SE Nigeria. Geol. Min. 1991;70:195-114.
32. Hoque M. Significance of textural and petrographic attributes of sandstones, southern Nigeria. J. Geol. Soc. India. 1976;17:514 -521.
33. Hoque M, Ezepue MC. Petrography and paleogeography of Ajali sandstone . J. Min. Geol. 1977;14:16-22.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/68631