(Hard Copy)
E-ISSN : 2456-1045

ARJMD

- International Journal
- Most Cited Journal
- Peer Review Journal
- Indexed Journal
- Open Access Journal
- University Recognized Journal

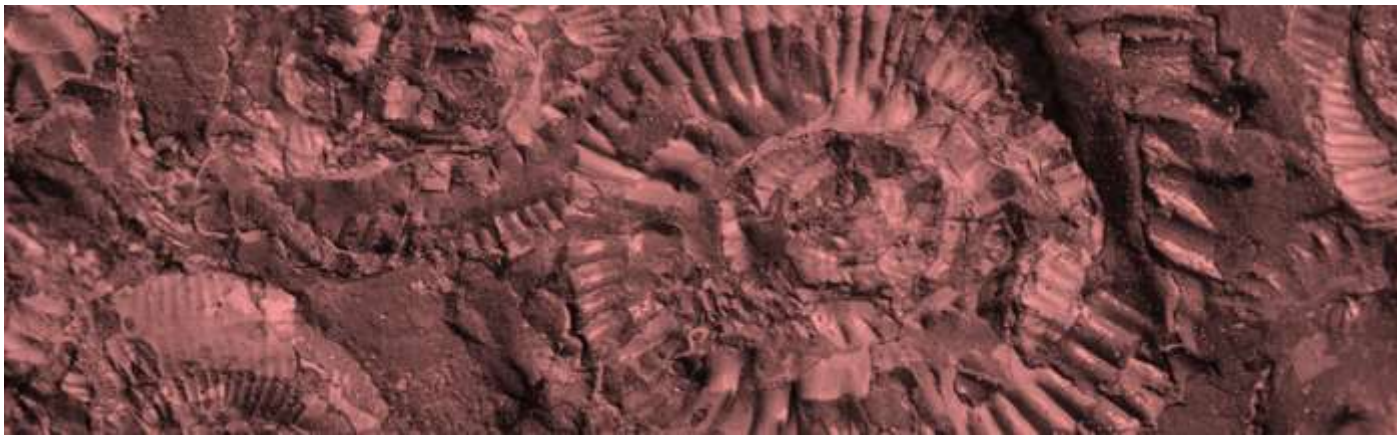
RESEARCH JOURNAL

VOLUME - 59 | ISSUE - 1

ADVANCE RESEARCH JOURNAL OF MULTIDISCIPLINARY DISCOVERIES

MARCH 2021

INTERNATIONAL JOURNAL FOUNDATION
Specialized in academic publishings only
www.journalresearchijf.com



Provenance of the cretaceous to tertiary sequences in the Bornu Basin, Nigeria.

ORIGINAL RESEARCH ARTICLE

ISSN : 2456-1045 (Online)
ICV Impact Value: 72.30
GIF- Impact Factor: 5.188
IPI Impact Factor: 3.54
Publishing Copyright @ International Journal Foundation
Article Code: AGEO-V59-I1-C1-MAR-2021
Category : APPLIED GEOLOGY
Volume : 59.0 (MARCH-2021 EDITION)
Issue: 1(One)
Chapter : 1 (One)
Page : 01-10
Journal URL: www.journalresearchijf.com
Paper Received: 31st May 2021
Paper Accepted: 15th June 2021
Date of Publication: 10th July 2021
DOI: 10.5281/zenedo.5089882

NAME OF THE AUTHOR

*** Peter S. Ola [1]**
John A. Adekoya[2]

[1]Applied Geology Department, Federal University of Technology, Akure, Nigeria

[2]Osun State University, Oshogbo, Nigeria

ABSTRACT

Geochronological ages derived from zircon grains (U – Pb age dating) from Basement Complex rocks surrounding the Bornu Basin, Nigeria and ditch cutting samples from six wells (Gaibu – 1,Kasade – 1, Kinasar – 1, Kutchali – 1, Mbeji – 1, Ngor – 1) located in different parts of the basin were compared in this study for provenance evaluation. Based on field work carried out, three main suites of crystalline rocks in and around the Bornu Basin sample dare: migmatite–gneiss complex, Older Granites (Pan African granites), and Tertiary Basalts. The gross geochronological data from the Basement Complex rocks show the predominance of Pan African age varying from about 500-600 Ma. Few of the basement samples yielded higher ages, particularly those from Goza 2 and Kano road, which are characterized by U-Pb age ranging from more than 1500 to 2500 Ma. The U-Pb age of 13 ditch cutting samples taken from different stratigraphic units of different ages in six selected wells in the basin yielded ages that are remarkably similar except in two cases. Essentially, a mean age of about 600Ma was obtained for the samples. The geochronological data of the sediments, in spite of being deposited at different times in the Cretaceous and Tertiary, correlate neatly with those of the Basement Complex rocks surrounding the basin. This indicates that the bulk of the sediments in the Bornu Basin were derived from its surrounding Basement Complex rocks.

KEYWORDS: Bornu basin, Basement Complex, provenance, Pan African, U-Pb age.

CITATION OF THE ARTICLE

Ola PS ; Adekoya JA. (2021) Provenance of the cretaceous to tertiary sequences in the Bornu Basin, Nigeria; *Advance Research Journal of Multidisciplinary Discoveries;* 59(1) pp. 01-10

** Corresponding Author*

I. INTRODUCTION

In this study, U–Pb methods (SHRIMP) was used to determine the age of the Basement Rock Complex in the area around the Bornu Basin, Nigeria and selected cuttings of some wells within the basin. The primary objective of the project is to compare the geochronology ages of the basement with the sediments within the Bornu Basin with a view to inferring the provenance of these diments. U-Pbzircon dating is a useful method for determining precise ages of solidification of igneous rocks within a wide range of geological time scale. This method has been employed to date basement complex in Nigeria particularly in the southwestern Nigeria and north central Nigeria with results yielding Pan-African emplacement ages of 610 ± 7Ma and 618 ± 4Ma and a scattering between 600 and 1100Ma with distinct peaks at 700, 850 and 1000Ma and a minority of grains yielding Palaeoproterozoic ages (1700-2200Ma), respectively [1],[2]. Another study in the upper part of southwestern Nigeria of a polyde formed granitic gneiss yielded a concordant U-Pbzircon age of 2207 ± 20 Ma (early Rhyacian age) indicating the crystallization age of the granite protolith [3]. With these, the basement complex of Nigeria has been described to be polycyclic in nature.

Although dating of detrital zircon has not been reported in Nigeria it has been used world- wide [4], [5],[6],[7],[8].

Geotectonic History of the Bornu Basin

The Chad Basin is an inland rift basin which is part of the West and Central African Rift System (WCARS). Different authors have discussed the geotectonic history of the WCARS on the basis of phases of basin development they could identify in the area. According to[14],the geological history of the basement rocks of countries surrounding the Bornu Basin, namely, Nigeria, Chad, Niger and Central African Republic (C.A.R) could be subdivided into six major tectonic phases comprising two pre-drift, two Cretaceous rift, one Paleogene rift and one post-rift phases, itemized thus (Fig. 1):

Phase 1	750 –550 Ma	Pan African crustal consolidation (Pre-rift)
Phase 2	550 –(?) 160Ma	Paleozoic– Jurassic plat form development (Pre-rift)
Phase 3	130 –96 Ma	Early Cretaceous rift (Rift Phase I)
Phase 4	96 –75 Ma	Late Cretaceous rift(Rift Phase II)
Phase 5	74 –30 Ma	Paleogene rift (Rift Phase III)
Phase 6	30 – 0 Ma	Post –rift (Post -Rift Phase)

The Precambrian African cratons, as well as the surrounding Pan-African Belts contain major basement lineaments and numerous large fault sthatlikely formed the precursor rift directions that developed into basins within Africa [15],[16],[17],[18]. Two families of conjugate faults occur, namely, NW–SE sinistral- fault trends in the Niger– Air region [19],[12]for the West African Rift Sub system (WAS) in Niger and Chad; NE–SW dextral fault trends of the Benue–Bornu rift basin Nigeria [20],[12],[21],[18].

The Phanerozoic history of African continent was characterized by frequent rejuvenation of this network of faults, which was responsible for the continent's regional and local tectonic evolution, with different behaviors in response to changes in the stress field [22],[23].

During the Paleozoic– Jurassic Platform phase, the area understudy was a stable platform plunging towards the north (Fig. 1). During this period, transgression from the north (i.e. Tethys) deposited continental and shallow marine sediments on the continental sag. These sediments now occur as remnants of pre-rift sediments, which are preserved in the W.A.S. rifts of northern Niger. There was no evidence of rifting in this region during this period. However, some thermal effect of Late Paleozoic – Early Mesozoic post-Tethyan tectonics related to the Hercynian orogeny in the North Africa may have reached the Termit basin. This was revealed by the occurrence of basement rocks (hornfels, schist and granites) penetrated in two wells (Iaguil and Dilia Longrin). These rocks yielded K-Ar dates of 266 and 190Ma.

According to [14], the early rift stage (Phase I, 130 – 96 Ma) was characterized by trans tensional faulting when the boundaries between the blocks of major fractures representing reactivated Pan African crustal discontinuities were separated and the rift was fully developed in Central Africa around 108Ma. The Phase I of the rifting was indicated by about 5000m of subsidence with deposition of Lower Cretaceous continental sediments. The age of the rifting was documented with spores, pollens and ostracods. This phase of rifting was closed by a regional unconformity.

Phase II of rifting occurred in the Late Cretaceous (96–75Ma) with a short period of Late Albian–Cenomanian rifting, followed by along period of thermo-tectonic subsidence. There was a regional subsidence resulting in a marine transgression from the Tethys through Mali and Algeria into Niger, and from the South Atlantic through Nigeria (Benue Trough) into western Chad and Niger[24],[25],[26](Fig.1B). This transgression is similar to global inundation reported by [27] and reached its farthest eastern extent at about 85 – 80 Ma, when it

went as far as the end of the Doba Basin. The inundation was followed by regression caused by epeirogenic uplift and it occurred concomitantly with a sharp basin-modifying tectonic pulse, referred to as Santonian compression (squeeze)[28],[29].

The Santonian compression in the rifts is significant for the following reasons: (i) it created hydrocarbon trapping folds in WAS and CAS [14];(ii) it separated the Doba, Doseo, Salamat and Bongor into four discrete basins and divided the Niger rifts into five separate basins along the Agadez line [30]; (iii) rotated the Yola, Bongor and Doba Basins about 15^0 counter clockwise from their original strike [14]; (iv) folded the Benue, Yola and Bornu basins [31],[32],[33]; and (v) produced hydrocarbon bearing folds in the Muglad Basin in Sudan [34],[35]. Over 6000 m of thermo-tectonic subsidence was recorded in Phase II Upper C zaceous marine sediments in WAS and CAS (Fig.1B).

The Paleogene was characterized by rifting in the northwest-southeast striking extensional WAS basins.Thisriftphasewasterminatedbyaregionalunconformitywhichusheredinthepost-riftphase.

This period was characterized by the uplift of Adamawa area along the Cameroon line accompanied by the Neogene – Holocene volcanism [36]. [14] reported that over 2500m of marine Upper Cretaceous and Paleogene sediments were eroded from the western part of Doba and Bongor Basins to fill the rifts, including the Gongola and Bornu Basins. During the same time, the Termit Basin was significantly faulted and Gosso Lorom volcanism developed in the northwest along the Agadez Lineament. The present Chad Basin subsided by approximately 1500 m [37],[38].In the present day, these rifts are covered by alluvium and are difficult to identify from surface geology.

So far, the major lithostratigraphic units recognized in the basin are the Bima, Yolde/Gongila, Fika, Gombe,Kerri-Kerri and ChadFormations (Fig. 1C).

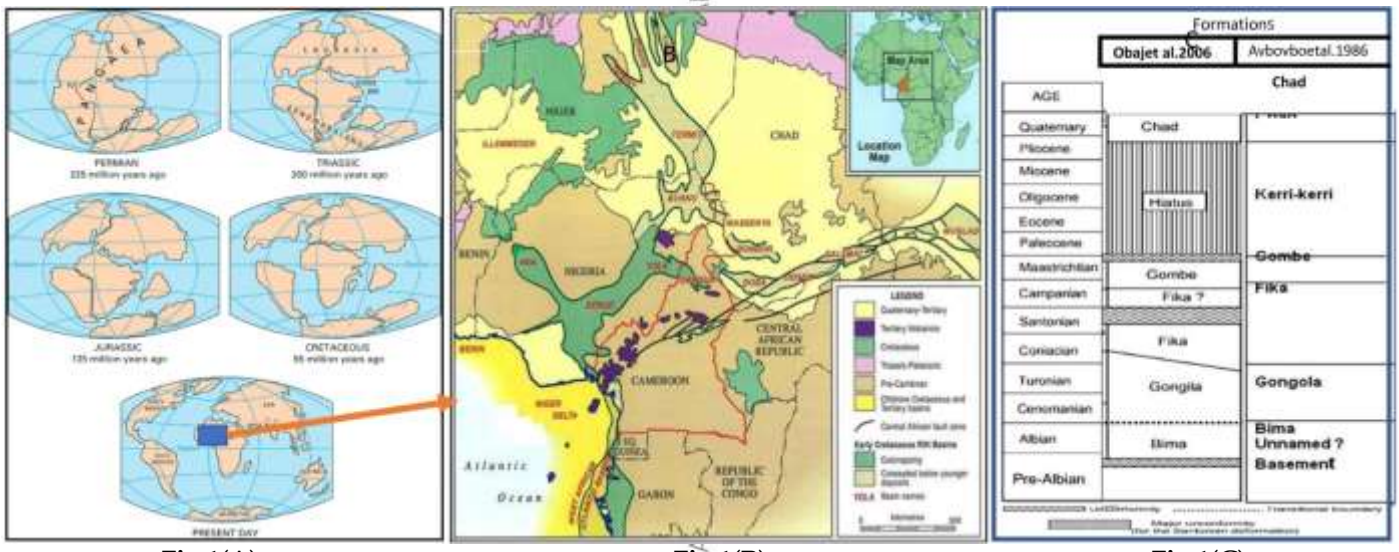


Fig.1(A) Fig.1(B) Fig.1(C)

Fig.1. The Bornu Basin in Geologic History. A. Assemblage of Pangea and polyphase break-up of Gondwana land indicating the Phanerozoic history of the continents. B. The position of the Bornu Basin in relation to other basins of the West and Central African Rift Systems. C. The stratigraphy of the Bornu Basin, Nigeria.

II. DATA GATHERING AND METHODOLOGY

The area of study covered the hard rock areas of the north-eastern portion of Nigeria (Fig.2A) and cuttings of selected wells in the Bornu basin (Fig.2B). The hard rock areas included the basement complex (made up of the migmatite- gneiss complex and Older Granites) and the Tertiary Basalts.

During the fieldwork, selected traverses were made to cut through the basement complex area and the sedimentary portion of the Bornu Basin. In making the traverses, advantage was taken of the existing roads where the basement complex rocks and sedimentary rock exposures were studied with little or no difficulty. These traverses were (i) Michika – Madagali – Gozar- Pulka, (ii)Gombi – Biu – Damboa, and (iii) Damboa – Gozar. Field measurements and description of lithologic sections were carried out using the standard field procedures for basement complex rock sand sedimentary terrain.

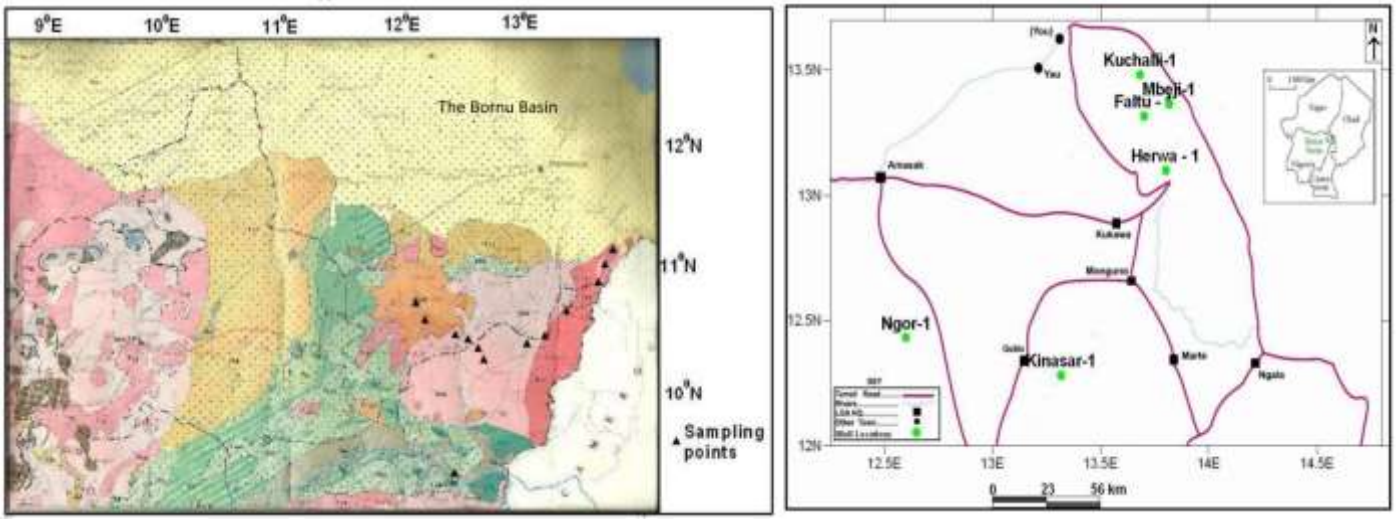


Fig.2(A) Fig.2(B)

Fig.2. Sampling point A. Geological Map of Nigeria showing where basement rocks were sampled B. Map showing the locations of hydrocarbon exploration wells were samples were taken (inset: Nigeria, Chad and Niger).

Laboratory Analysis

The materials processed for the analysis are ditch cutting samples from six wells carefully selected to ensure a basin-wide coverage within the constraints of available well materials in the Cretaceous and Tertiary successions. A total of sixteen basement complex rock samples were used for this study. In this study Sensitive High-Resolution Ion MicroProbe U-Pb zircon dating method was employed. The preparation techniques, analysis and interpretation are in line with the method described by[39].

III. RESULT

3.1. Field work Report

Three suites of crystalline rocks were recognized in the study are. They are (i) migmatite gneiss complex (Fig. 3), (ii) Older Granites (Pan African granites) (Fig. 4), and (iii) Tertiary Basalts (Fig. 5). Also, three types of Migmatite - Gneiss Complex rocks were recognized in three different locations during the fieldwork; they are migmatitic gneiss, mylonitised gneissic rock and granite gneiss. The migmatitic gneiss occurs as a low-lying outcrop which is typically coarse-grained and has leucocratic (light) and melanocratic (dark) components (Fig.3). It was sampled at Hong ($10^{o}13^{1}$ 54.3^{11} N; $12^{o}59^{1}$ 20.9^{11} E). The granite gneiss was encountered at a road cut along Gombi – Garkida road (10° $13^{1}08.6^{11}$ N; 12° $44^{1}12.9^{11}$ E). It is leucocratic, medium to coarse grained and composed of quartz, feldspars and biotite (Fig. 4). The mylonitised gneissic rock was recognized at the southern part of Goza on the way to Madagali in the locality having the following coordinates: $10^{o}58^{1}53.1^{11}$ N; 13° 40^{1} 19.7^{11} E). It occurs as a thinly foliated ridge trending approximately N-S direction. Field measurement shows the strike to be 190° and the dip to be 88° (Fig.3). It is leucocratic and exhibits a porphyroclastic texture. Three types of older granites recognized during the fieldwork are porphyritic granite, coarse to fine grained granite and biotite granite (Fig.4). The porphyritic granite is composed of abundant large feldspar phenocrysts set in a groundmass rich in biotite. The rock type was sampled in two localities during the gross geochronological data from the Basement Complex rocks show the predominance of Pan African age varying from about 500–600Ma (Fig.6). Few of the basement samples yielded higher ages, particularly those from Goza 2 and Kano road, which are characterized by U-Pb age ranging from more than 1500 to 2500Ma (Fig.6). The Pan African age is the age of the Pan African granites (Older Granites of Nigeria) and mineral constituent so folder rocks (gneisses and migmatites) affected by the Pan African orogeny. The few higher ages (>1500to about 2500 Ma) represent the age of the older members of the Basement Complex such as the gneisses and migmatites.

The U-Pb age of 13 ditch cutting samples taken from different stratigraphic units of different ages in eight selected wells in the basin yielded ages (Fig. 7) that are remarkably similar except in two cases. Essentially, a mean age of about 600 Ma was obtained for the samples, thus indicating the provenance of the sediments as basement rocks

of Pan African age or older rocks that have been subjected to Pan African Orogeny as mentioned earlier. In other words, these sediments were derived from the weathering products of the Pan African granites, gneisses, migmatites and quartzites in the surrounding country of the Bornu Basin.

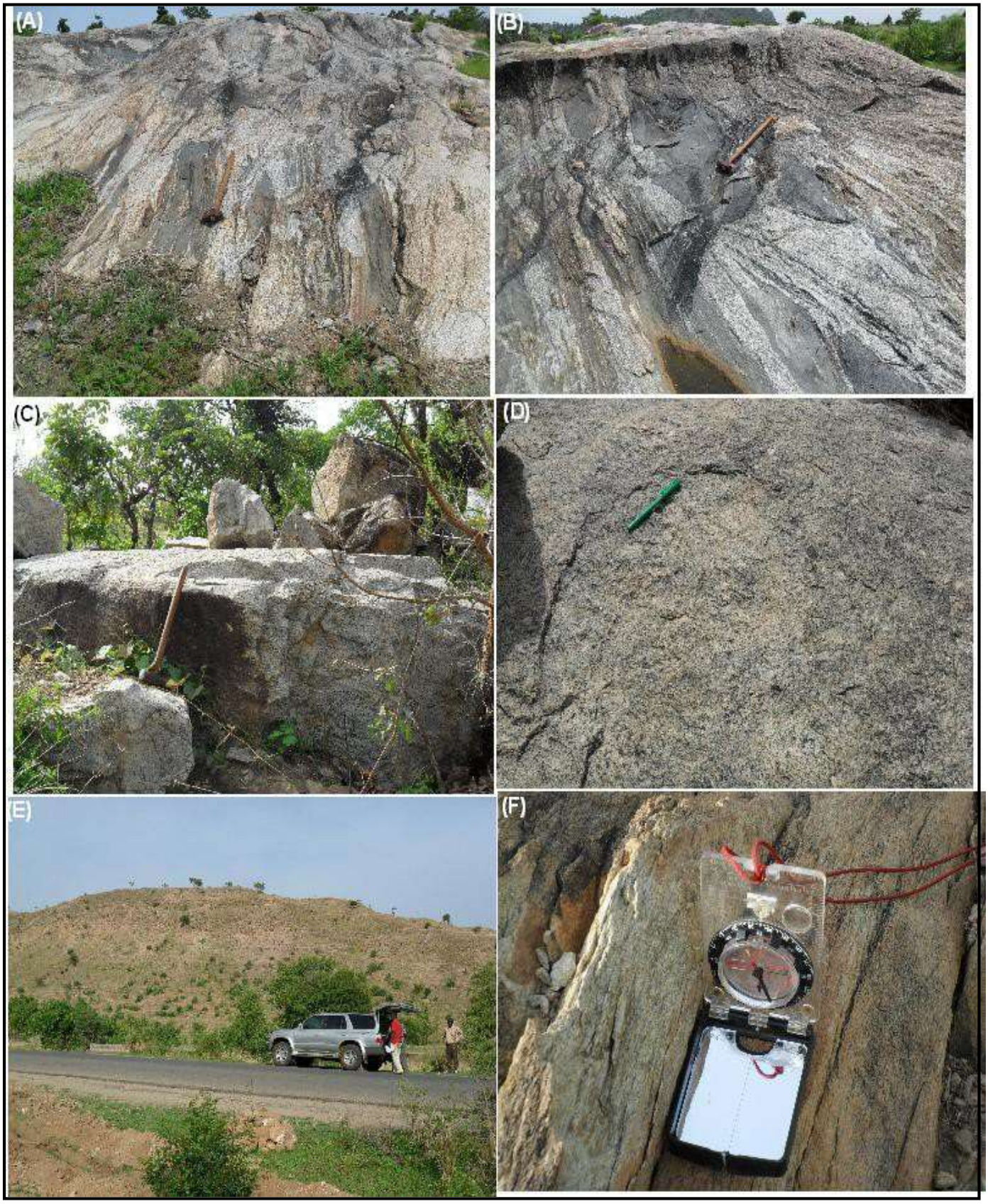


Fig. 3. Field photographs of different rock types. A and B are migmatite outcrops at Hong. Note the melanocratic paleosome and leucocratic neosome. C and D are granite gneiss. E is a massive exposure of mylonitised gneissic rock. F shows the attitude of the mylonitised gneissic rock.

Fig.4. Field photographs of different types of older granites. A is a close up view of porphyritic granite B is a field exposure of porphyritic granite with horizontal quartz veins. C and D are close- up and field photos of porphyritic granites at Gwoza respectively. E is an exposure of coarse grained granite while F shows a contact between a melanocratic dioritic rock and leucocratic granites on the field.

Fig.5.Field photographs of Tertiary basalts

IV. DISCUSSION AND CONCLUSION

Geochronological data on zircon grains from the Basement Complex rocks surrounding the Bornu Basin and ditch cutting samples from selected wells in the basin have been presented (Figs 6 and7). U –Pbage dating of the ditch cutting samples from six wells (Gaibu–1, Kasade–1, Kinasar– 1, Kutchali – 1, Mbeji – 1, Ngor – 1)located in different parts of the basin revealed that the provenance of these sediments is essentially rocks of Pan African age although older rocks of Mesoproterozoic to Paleoproterozoic ages must have contributed some sediments (Fig.6).

The Basement Complex of Nigeria consists of a complex assemblage of gneisses, migmatites, granites and metasupracrustal rocks all of Proterozoic to Archean age. Although the basement complex rocks had suffered at least three orogenic events, the effect of the last of them, the Pan African orogeny has been overprinted on all the basement rocks including of course the product of that orogeny, i.e. the Pan African granites (Older Granites).

It is therefore not surprising that the U–Pb dating of the basement rocks and ditch cutting samples yielded mostly Pan African age. This strongly indicates that the Basement Complex rocks surrounding the Bornu Basin were the source of the Cretaceous and Tertiary sediments deposited in the basin. These rocks must have weathered and the weathering products eroded, transported and deposited in the basin under varying continental to marine conditions at different times in the Cretaceous and Tertiary times.

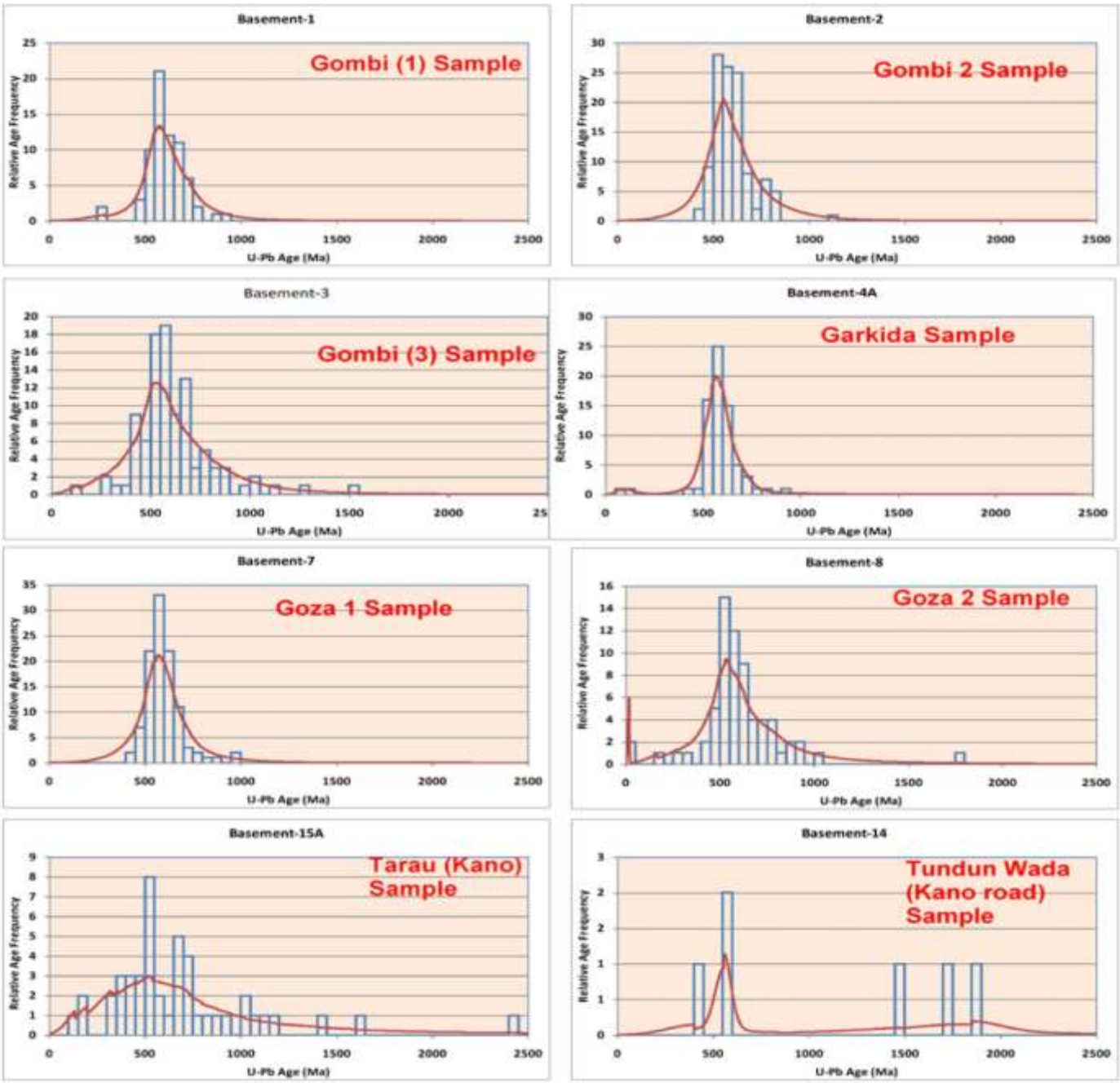


Fig. 6. Geochronological data for U–Pb age dating for Basement Complex samples around Bornu Basin Nigeria.

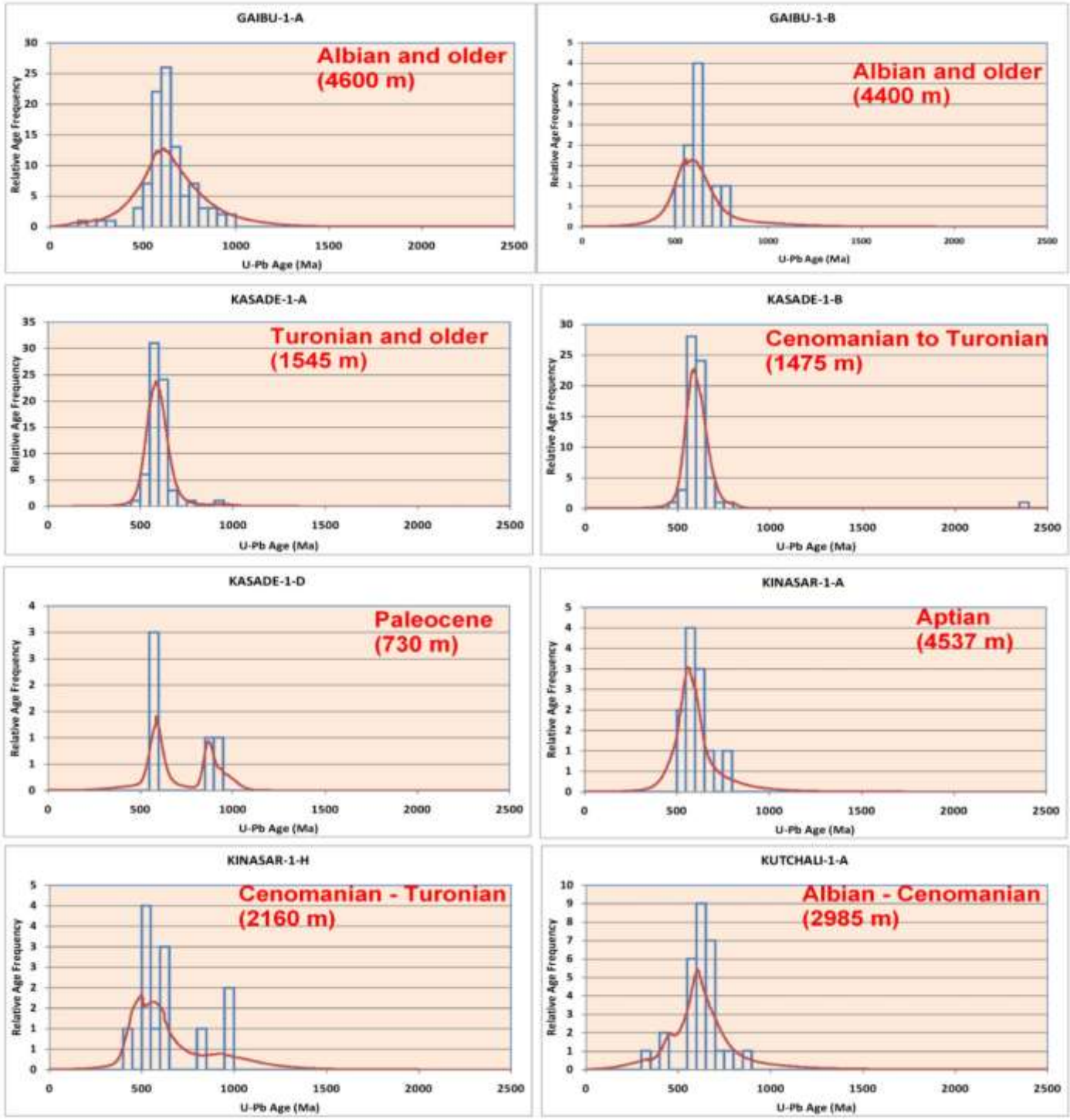


Fig. 7.Geochronological data for U–Pb age dating of ditch cutting samples from wells in the Bornu Basin, Nigeria.

V. ACKNOWLEDGEMENTS

This paper is an offshoot of the report of the 2010 PTDF research competition. The paper is written in honor of Late Dr. S.O. Olabode who did the U-Pb analysis under the supervision of Prof. R.W. Brown and Dr. K. Dobson of the University of Glasgow. The role of PTDF and these eminent scholars are gratefully acknowledged.

VI. REFERENCES

[1] **Tubosun, I.A., Lancelot, J.R., Rahaman, M.A.** *etal.* U-Pb Pan-African ages of two charnockite-granite associations from Southwestern Nigeria. *Contr. Mineral. And Petrol.* **88,** 188–195(1984). https://doi.org/10.1007/BF00371422

[2] **BN Ekwueme, B.N. Kalsbeek,** K.U- Pb geochronology of meta sedimentary schists in Akwanga area of north central Nigeria and its implications for the evolution of the Nigerian basement complex. Global Journal of Geological Sciences 12 (1): 21

[3] **Okonkwo, C. T., Ganev V. Y.U**- Pb Geochronology of the Jebba Granitic Gneiss and Its Implications for the Paleoproterozoic Evolution of Jebba Area, Southwestern Nigeria. International Journal of Geo science. Vol.3 No.5(2012), Article ID: 24951, 9 pages DOI: 10.4236/ijg. 2012. 35107

[4] **Ershova, V. B., Prokopiev, A. V., and Khudoley, A. k.** Hidden Middle Devonian Magmatism of North-Eastern Siberia: Age Constraints from Detrital Zircon U–Pb Data. Minerals 2020, 10,874; doi: 10.3390/min 10100874

[5] **Khudoley, A.; Chamberlain, K.; Ershova, V.; Sears, J.; Prokopiev, A.; MacLean, J.; Kazakova, G.; Malyshev, S.; Molchanov, A.; Kullerud, K.; et al.** Proterozoic super continental restorations: Constraints from provenance studies of Mesoproterozoic to Cambrian clastic rocks, eastern Siberian Craton. Precambrian Res. 2015, 259, 78–94.

[6] **Vishnevskaya, I. A.; Letnikova, E. F.; Vetrova, N.I.; Kochnev, B.B.; Dril, S.I**. Chemo stratigraphy and detrital zircon geochronology of the Neoproterozoic Khorbusuonka Group, Olenek Uplift, Northeastern Siberian platform. Gondwana Res. 2017, 51, 255–271.

[7] **Priyatkina, N.; Collins, W.J.; Khudoley, A.; Zastrozhnov, D.; Ershova, V.; Chamberlain, K.; Shatsillo, A.; Proskurnin, V.** The Proterozoic evolution of northern Siberian Craton margin: A comparison of U–Pb–Hf signatures from sedimentary units of the Taimyr orogenic belt and the Siberian platform. Int. Geol. Rev. 2017, 59, 1632–1656.

[8] **Ershova, V.B.; Khudoley, A.K.; Prokopiev, A.V.** Reconstruction of provenances and carboniferous tectonic events in the North-East Siberian Craton framework according to U-Pb dating of detrital zircons. Geotectonics 2013, 47, 93–100.

[9] **Ershova, V.B.; Khudoley, A.K.; Prokopiev, A.V.; Tuchkova, M.I.; Fedorov, P.V.; Kazakova, G. G.; Shishlov, S.B.; O'Sullivan, P.** Trans-Siberian Permian rivers: A key to understanding Arctic sedimentary provenance. Tectonophysics 2016, 691, 220–233.

[10] **Guiraud, R., and Maurin, J.C.,** 1992, Early Cretaceous rifts of Western and Central Africa: an overview: Tectonophysics, v. 213, no. 1–2, p. 153-168.

[11] **Binks, R. M. and Fairhead, J. D., 1992** A plate tectonic framework for the evolution of the Cretaceous rift basins in West and Central Africa. In: Ziegler, P.A. (Ed.), Geodynamics of Rifting, vol. 2, Case History studies on Rifts: North and South America, Africa–Arabia. Tectonophysics. 213 (1992) 141–151.

[12] **Genik, G.J., 1992,** Regional Framework, structural and petroleum aspects of rift basins in Niger, Chad and Central African Republic (C.A.R.). Tectonophysics. 213p. 169–185.

[13] **Guiraud, R., Binks, R.M., Fairhead, J.D., Wilson, M., 1992.** Chronology and geodynamic setting of Cretaceous—Cenozoic rifting in West and Central Africa. Tectonophysics 213, 227–234.

[14] **Genik, G. J. 1993.** Petroleum Geology of Cretaceous-Tertiary rift basins in Niger, Chad and Central African Republic. AAPG Bull., 77 (8) (1993)1405 – 1434.

[15] **Guiraud, R., Alidou, S., 1981.** Lafaille de Kandi (Be´nin), te´moindurejeufini-cre´tace´dun accident majeur a`le´chelledela plaque africaine. CR Acad. Sci. Paris 293, 779–782.

[16] **Caby, R. 1989.** Precambrian terrains of Benin, Nigeria and Northeast Brazil and the Late Proterozoic South Atlantic, Geological Society of America Special Paper. 320(1989)145–158.

[17] **Guiraudetal., 2000; R. Guiraud, R. Doumnang, J.C., Carretier, S. Dominguez, S. 2000.** New evidence for a 6000 km length NW–SE- striking lineament in northern Africa: the Tibesti Lineament. J. Geol. Soc. (London) 157(2000) 897– 900

[18] **Guiraud, R., Bosworth, W., Thierry, J. B., Delplanque, C. A. 2005**. Phanerozoic geological evolution of Northern and Central Africa: An overview. Journal of African Earth Sciences 43 (2005) 83–143.

[19] **Greigert, J. and Pougnet, R. 1966.** Carte Geologique, Republique du Niger. Bur. Rech. Geol, Minieres, Nantes, France. 7: 123– 134.

[20] **Ball, 1980;** E. Ball, An example of very consistent brittle deformation over a wide intra continental area. The late Pan- African fracture system of the Tuareg and Nigerian shield, Tectonophysics.61 (1980)363–379

[21] **Ajakaiye et al., 1986;** D.E. Ajakaiye,M.B. Awad, S.B. Ojo,D.H. Hall, T.W. Millar, Aeromagnetic anomalies and tectonic trends in and around the Benue, Nature. 319, (1986) 582584.

[22] **Guiraud, R,** and Bosworth, W., .1999. Phanerozoic geodynamic evolution of north eastern Africa and the north western Arabian platform. Tectono physics. 315 (1999) 73–108.

[23] **Coward, M.P. and Ries, A.C., 2003.** Tectonic development of North African basins. Geological Society, London, Special Publication. 207 (2003) 61–83

[24] **Kogbe, C. A. 1972** Geology of the Upper Cretaceous and Tertiary scdirncnts of the Nigerian sector of the Iullemmeden basin (Vicst-.Africa) (Geologische Rundschau), 62 (1972)197-211.

[25] **Reyment, I.A., 1972;** L. 'Histoire de la mer trans continentale Saharicnne pendant le (.Cenomanian-Turonian: Bulletindela Societe Crologiclue de France. sene'. 13 (1972)528–531.

[26] **Petters, S. W. and Ekwezor, C. M., 1982** Petroleum geology of the Benue trough and southeastern Chad basin, Nigeria. *AAPG Bulletin* 66 (1982) 1141–1149.

[27] **Haq , B. U. Hardenbol, J. Vail, P. R. 1987.** The new chronostratigraphic basis of Cenozoic and Mesozoicsea level changes. Cushman Found. Foraminiferal Res. Spec. Publ., 24 (1987) 7-13.

[28] **Guiraud, R., Bellion, Y., Benkhelil, J, Moreau, C., 1987.** Post-Hercynian tectonics in Northern and Western Africa. In: Bowden, P., Kinnaird, J.A. (Eds.), African Geology Reviews. Geological Journal 22, 433– 466. G

[29] **Ziegler, P.A. 1990**, Geological Atlas of Western and Central Europe, second ed. Shell Internationale Petroleum Mij.B.V. and Geological Society, London. (1990) 239 p

[30] **Guiraud, R., Issawi, B., Bellion, Y., 1985.** Les line´aments guine´o-nubiens: untrait structural majeura`le´ chelle de la plaque Africaine. CR Acad. Sci. Paris 300, 17–20.

[31] **Popoff., M. 1988.** Du Gondwana a I'Atlantique sud: les connexions du foss de la avec les basins du Nord-Est b & lien jusqu'al' ouverture du golfe de Guinee au Critac inferieur. In: J. Sougy and J. Rodgers (Editors), The West African Connection .J. Afr. Earth Sci., 7(2) (1988) 409-431.

[32] **Avbovbo, A.A.,, and Ayoola, E.O. Osahon, G.A., 1986**, Depositional and structural styles in the Chad basin of Northeastern Nigeria. AAPG Bull. 70p. 1787–1798

[33] **Benkhelil, J., 1988**, Structure et bolutiongio dynamique du basin intracontinental de la Benin and Nigeria. Bull. Cent. Rech. Explor. Prod., Elf-Aquitaine. 12(l) p 29-128.

[34] **Schull, T.J.1988.** Rift basins of interior Sudan: petroleum exploration and discovery. Bull. Amer. Assoc. Petrol. Geol. 72 (1988) 1128– 1142

[35] **Giedt, N.R., 1990.** Unity Field. In: E.A. Beaumont and N.H. Foster (Editors), Structural Traps III. Treatise of Petroleum Geology, Atlas of Oil and Gas Fields. Am. Assoc. Pet. Geol., pp. 177-197. G

[36] **Fitton, J. G. 1980.** The Benue Trough and Cameroon Line-A migrating rift system in West Africa. Earth Planet. Sci. Lett. 51 (1980)132-138.

[37] **Burke, K. C., 1976.** The Chad basin: an active intra-continental basin, Tectonophysics. 36 (1976) 197-206.

[38] **Mothersil, J.S. 1975** Lake Chad geochemistry and sedimentary aspects of a shallow polymictic lake. J. Sediment. Petrol., 45 (1975) 295– 309.

[39] **Compston, W. and Williams, I.S. 1984.** U-Pb Geochronology of Zircons from Lunar Breccia 73217 Using a Sensitive High Mass-Resolution Ion Microprobe. Proceedings of the Fourteenth Lunar and Planetary Science Conference, Part 2 Journal of Geophysical Research, Vol. 89, Supplement, p B525-B534.

******