International Journal of Science and Research Methodology (IJSRM)
Volume 27, Issue 9, September 2024 **ijsrm.humanjournals.com** ISSN: 2454-2008

Geodynamic and Paleogeographic Synthesis of the Iullemmeden Basin from the Upper Cretaceous to the Paleocene-Ypresian in West Africa

Laouali Idi Karimou[1a], Ibrahim Maharou Hassan[f], Sani Abdoulwahid[b], Illia Allo Daouda[c], Ousmane Habsatou[f], Maman Hassan Abdourazakou[d], Sanda Chekaraou Mahamane Moustapha[e], Badamassi Kadri Mahamane Mansour[c], Konate Moussa[d]

[a]Abdou Moumouni University, Ecole Normale Supérieure, Department of SVT, Niamey, Niger.

[b]University of Agadez, Faculty of Science and Technology, Department of Geology, Agadez, Niger.

[c]André Salifou university, Faculty of Science and Technology, Department of Geology, Zinder, Niger.

[d] School of Mines, Industry and Geology (EMIG), Department of Geosciences, Niamey, Niger.

[e]Djibo Hamani University, Faculty of Education, Department of Didactics of Disciplines, Tahoua, Niger.

[f]Abdou Moumouni University, Faculty of Science and Technology, Geology Department, Niamey, Niger.

Received: 2024-09-01 Revised: 2024-09-09 Accepted: 2024-09-25

ABSTRACT

This study focused on the central part of the Iullemmeden basin in the Ader Doutchi basin. The general objective of this study is to improve geological knowledge of the Iullemmeden basin for the period from the Maastrichtian to the Ypresian. Specifically, the aim is to describe the broad lines of the palaeogeographic and geodynamic history of the Iullemmeden Basin on the West African scale. The palaeogeographic analysis highlights six transgressions that contributed to the filling of the Iullemmenden Basin. The geodynamic context explains that the current topography of West Africa, showing an overall structuring into high 'dome' zones and low 'basin' zones, could be explained by mantle dynamics.

Keywords: Geodynamic, Palaeogeography**,** Iullemmeden Basin, Ader Doutchi, west Africa.

1. INTRODUCTION

The Iullemmeden Basin is an area of intracratonic sedimentation (Bertrand-Sarfati et al., 1977) affected by epirogenic movements (Faure, 1966) which are thought to have favoured a south-west migration of depositional areas during the Mesozoic (250 to 65 Ma) and Cenozoic (65 to the present). From the Upper Cenomanian to the Middle Senonian, detrital sedimentation (the Iguelalla Mountains and Doutchin Zana formations) generated by the first three marine transgressions (T1, T2 and T3) helped to fill the Iullemmeden basin. This detrital assemblage is overlain by another detrital deposit corresponding to the fourth transgression of Libycoceras and Laffiteina of Maastrichtian age, represented by the Alanbanya, Farin Doutchi and In Wagar formations (Greigert, 1966; Dikouma, 1990, Laouali-Idi, 2020). Above these lie the deposits of the Garadaoua Formation, of Palaeocene-Ypresian age, consisting of marls, limestones and papyrus shales emplaced by the T5 marine transgression (Greigert, 1966; Boudouresque et al., 1982; Dikouma, 1990, Laouali-Idi, 2020). The current topography of West Africa shows an overall structuring into high 'dome' zones and low 'basin' zones that could be explained by mantle dynamics (Ebinger and Sleep, 1998; Moucha and Forte, 2011) that controlled all the transgressive and regressive cycles that contributed to the sedimentary filling of the West African sedimentary basins. The aim of this study is to reconstruct the geodynamic and palaeogeographic history of the Upper Cretaceous to Palaeocene-Ypresian Iullemmeden Basin in the context of West Africa on the basis of recent work (Laouali Idi, 2020) and the exploitation of data from previous work (Greigert, 1966; Boudouresque et al., 1982; Dikouma et al., 1993) in the Niger part of this Iullemmeden Basin. This study focused on the central part of the Iullemmeden basin, particularly in the Ader Doutchi sub-basin. It focused on lithostratigraphic, geodynamic and palaeogeographic observations. This provided an opportunity to discuss the topography of West Africa and to analyse the origin of transgressions.

2. GEOLOGICAL CONTEXT OF THE IULLEMMEDEN BASIN

The Iullemmeden Basin is made up of alternating marine sediments and continental deposits deposited during the various transgressive and regressive episodes that have marked its geological history.

3. PRESENTATION OF THE IULLEMMEDEN BASIN

The Iullemmeden basin is bounded to the south by the Benin-Niger shield, to the south-west by the crystalline Liptako massif, to the north-west by the Adrar des Iforas, to the north by the Hoggar, to the north-east by the Aïr massifs and to the east by the Damagaram-Mounio (Figure 1). It communicates to the north-west with the Taoudenni basin via the Gao strait and to the east with the Eastern Niger basin via the Damergou sill (Bellion, 1989) (Figure 1).

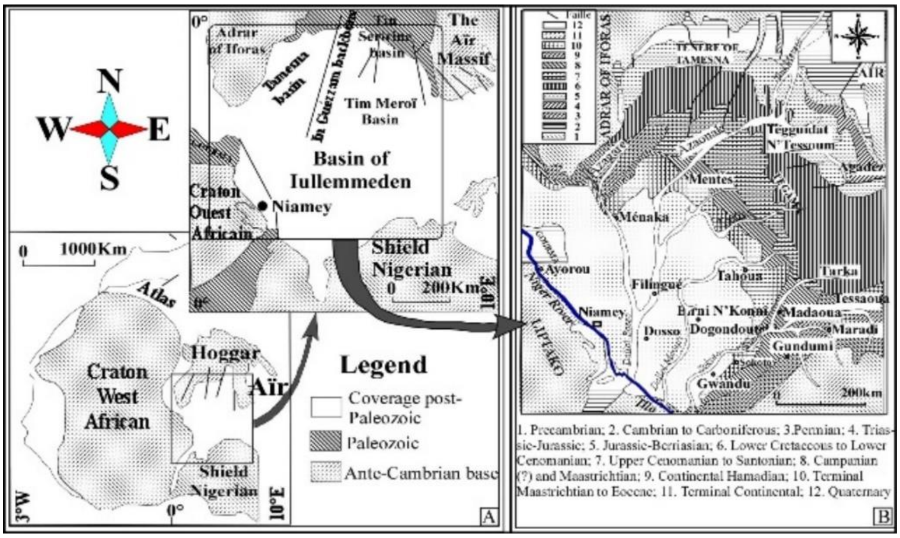

Figure 1: Geological map of the Iullemmeden basin. A) Location map of the Iullemmeden basin (Wright et al. 1993). B) Schematic geological map of the Iullemmeden basin (Greigert and Pougnet, 1965).

The Iullemmeden basin stretches from north to south over a length of around 1000 km and from east to west over a width of around 980 km. Its surface area is estimated at 525,000 km^2, including around 31,000 km^2 in Mali, 317,000 km^2 in Niger, 60,000 km^2 in Nigeria, 10,000 km^2 in Benin and 10,6549 km^2 in Algeria (Laouali-Idi et al., 2019). In the central part of the basin, corresponding to the Doutchi region, the maximum thickness of the sedimentary fill is around 2,000 m (Greigert, 1966; Abdou-Ali, 2018). Le bassin des Iullemmeden correspond à un domaine de sédimentation intracratonique (**Figure 1**) (Bertrand-Sarfati et al., 1977) affecté par des mouvements épirogéniques (Faure, 1966) qui auraient favorisé une migration des aires de dépôts vers le Sud-Ouest pendant le Mésozoïque et le Paléogène. En conséquence, le remplissage sédimentaire est essentiellement constitué par des dépôts paléozoïques au Nord et méso-cénozoïques au Sud (**Figure 2**). En effet, les formations paléozoïques affleurantes dans la partie Nord de ce bassin sont essentiellement reparties entre les sous-bassins de Tin Séririne, de Tamesna et de Tim Mersoï, ainsi qu'à son extrémité Sud-Ouest, englobant les sous-bassins de Kandi au Benin et de Sokoto au Nigeria (Bellion, 1989). Les sédiments mésozoïques occupent la plus grande partie du bassin. Les formations cénozoïques reposent en discordance de ravinement sur les formations mésozoïques (partie centrale du bassin) et infracambriennes (bordure Est du Craton Ouest Africain) et en discordance majeure sur les formations panafricaines et paléoprotérozoïques (bordure Ouest et Sud du bassin) (Greigert, 1966 ; Laouali-Idi, 2020) (**Figure 2**).

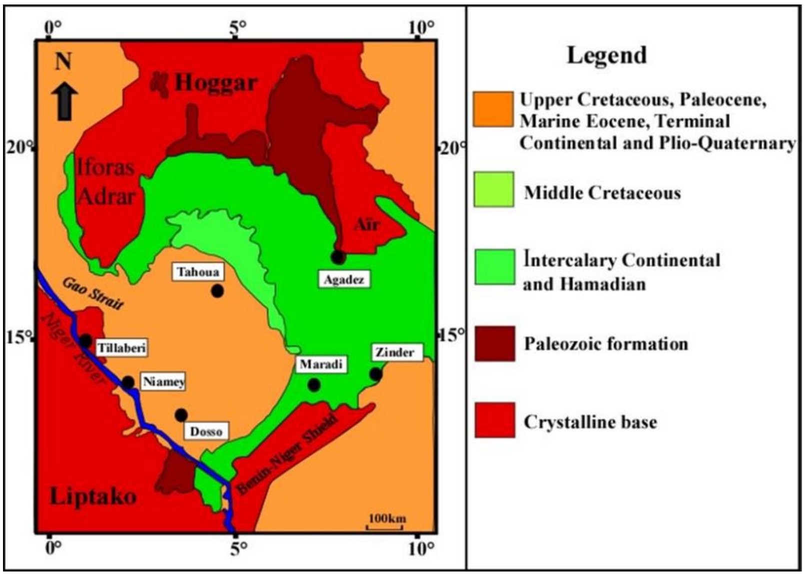

Figure 2: Simplified geological map of the Iullemmeden basin (Greigert, 1966, modified)

4.STRATIGRAPHIC, PALAEOGEOGRAPHIC AND GEODYNAMIC FRAMEWORK OF THE IULLEMMEDEN BASIN FROM THE UPPER CRETACE TO THE CENOSOIC PERIODS

4.1.Stratigraphic and palaeogeographic framework

The Upper Cretaceous (Upper Cenomanian-Maastrichtian) (96 to 65 Ma) and Palaeogene (Upper Palaeocene-Ypresian) (65 to 46 Ma) are marked by five marine incursions (T1, T2, T3, T4 and T5) (Greigert, 1966, Boudouresque et al., 1982; Dikouma, 1990):

❖ From the Upper Cenomanian (50.5 to 51 Ma) to the Lower Turonian (51 to 51.5 Ma), the sea from the north-east (T1) invaded an almost flat continent occupied by marshes that could be locally flooded and dried out (Greigert, 1966). This T1 transgression occupied the northern edge of the Damergou (eastern edge of the Iullemmeden basin) and extended to the outskirts of the Adrar des Iforas (Figure 2). The sediments deposited are represented by grey or green clays and Vibrayeani Neolobite sandstones with saline efflorescences and gypsum seams, surmounted by glauconitic sandstones and calcareous sandstones with gastropods and ammonites of the Nigericeras sp.

❖ In the Lower Turonian (93.9 to 89.8 Ma), the first ammonites of the Nigericeras sp. type appeared, followed by a slight regression marked by the emplacement of gypsiferous argillites.

❖ In the Upper Turonian (51.5 to 52 Ma), the sea penetrated from the north-east (T2) and deposited the white limestone series, consisting of a succession of azoic terms revealing only a few gastropods or ostracods, most of which were indeterminate (Greigert, 1966). The sediments formed by chemical precipitation include limestones, cherts and gypsum, halite and attapulgite argillites. These sediments are consistent and continuous with the Lower Turonian glauconitic sandstones with Nigericeras (Greigert, 1966 ; Bellion, 1987 ; Alzouma, 1994).

❖ In the Lower Senonian (Coniacian (52 to 53 Ma) and Santonian (53 to 54 Ma)), marine transgression from the north-east (T3) deposited a fossiliferous clay assemblage. Greigert (1966) distinguishes between alternating marine limestones with foraminiferal and oyster debris, continental limestones with gastropods, ostracods and oogones, marine sandy clays and marls (with oyster fauna) and continental sandy clays and marls (with vertebrate remains, such as Dinosaurians).

❖ In the Maastrichtian (72.1 to 66 Ma), marine transgression (T4) penetrated from the north-west (through the Strait of Gao) and deposited the following main formations (Radier, 1957, Greigert, 1966, Dikouma, 1990):

- The Alanbanya formation: made up of clays, siltstones and sands with plant debris and vertebrate remains (crocodilians);
- The Farin Doutchi formation: made up of grey argillites and fossiliferous marls;
- The In Wagar formation: made up of sandstone and sand with large amounts of ferruginised plant debris.

❖ During the Upper Palaeocene-Ypresian (58.7 to 48.6 Ma), a fifth transgression (T5) reached the basin from the north-west via the Gao Strait, where it deposited limestones, marlstones and shales rich in sea urchins, mainly Linthia sudanensis (Greigert, 1966).

❖ From the Oligocene to the Mio-Pliocene, Greigert (1966) distinguishes three series, from bottom to top:

- the Ader Doutchi siderolithic series (Ct1), consisting of more or less oolitic ferruginous sandstones and fine sands containing ferruginous oolites or pyrite concretions.

- The sandy-clay series with lignites (Ct2) is characterised by alternating sandy and clay series. The mudstones contain plant remains (lignite, more or less boiled wood, charcoal debris).

- The clayey sandstone series of the Middle Niger (Ct3) is made up of more or less clayey sandstones, more or less consolidated fine sands, massive earthy sandstones with termite tubules and alveoli (Tessier, 1954), sandy or sandy kaolinic clays and gravels.

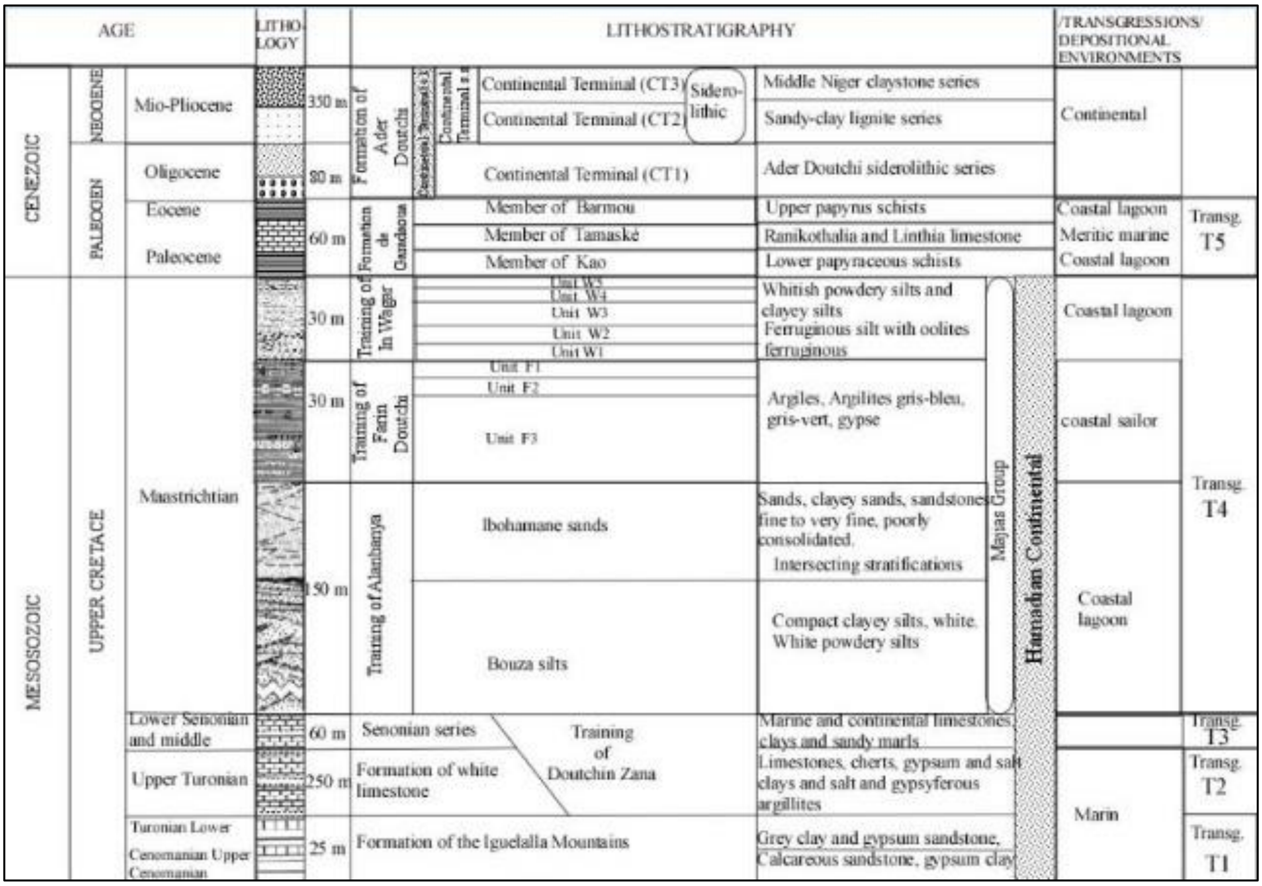

Figure 3: Lithoshtratigraphy of the Iullemmeden Basin from the Upper Cretaceous to the Cenozoic (Greigert, 1966; Taquet, 1976; Hanon, 1984; Laouali-Idi, 2021)

4.2.Geodynamic framework

The geodynamic evolution of the Lullemmeden basin from the Upper Cretaceous to the Tertiary is characterised by tectonic episodes on the one hand and periods of marine transgression on the other. According to Bellion (1987), three tectonic episodes have been defined: the intra-Senonian episode, which in the Damergou and Koutous would result in an unconformity between the continental formations (Dikouma, 1990); the finite to post-Maastrichtian episode, which would result in the Lower Palaeocene gap observed in Nigeria; and the intra-Eocene episode, which would result in the unconformity of the Terminal Continental. According to Greigert, 1966, Boudouresque et al, 1982; Dikouma, 1990, five transgressions (T1, T2, T3, T4 and T5) contributed to the filling of the Iullemmeden basin from the Upper Cretaceous to the Tertiary (**Figure 3**).

International Journal of Science and Research Methodology (IJSRM)
Volume 27, Issue 9, September 2024 ijsrm.humanjournals.com ISSN: 2454-2008

5.MATERIALS AND METHODS

The methodological approach adopted in this study comprises two stages: exploitation of bibliographic data and geodynamic analysis.

5.1.Use of bibliographical data

The compilation of available documents (articles, theses, reports, maps) relating to the geology of the Iullemmeden Basin and West Africa enabled an inventory to be made of the characteristics of the various transgressions that contributed to the filling of the Iullemmeden Basin. The various cartographic documents were supplemented with field data.

5.2. Geodynamic analysis

The geodynamic analysis was carried out on the various Cretaceous-Tertiary formations. These are the In Wagar and Garadaoua formations. By compiling bibliographic and field data, we were able to draw up a lithostratigraphic, palaeogeographic and geodynamic summary.

6.RESULTS AND DISCUSSION

6.1. Evolution in the upper cretaceous

The Cretaceous (Upper Cenomanian-Upper Turonian) represents a period of maximum greenhouse effect. During the Upper Cenomanian-Upper Turonian period, Africa was almost flat with little relief (Burke, 1996; Ebinger and Sleep, 1998). As a result, marine incursions were more frequent in the West African basins, particularly in the Chad, Taoudeni, Iullemmeden and Bénoué basins, where numerous carbonate deposits mark a transgression peak. Three marine incursions T1, T2 and T3 from the Mesogean invaded the West African basins from the Upper Cenomanian to the Middle Senonian (Figure 4). According to Sahagian (1988), these incursions together formed the Trans-Saharan Seaway. This enabled the connection between the Tethys and the South Atlantic (Figure 4). The Hoggar would then have been partially covered by the sea (Figure 4), which suggests that the area invaded by the marine incursions was relatively low-lying compared with the remains of the Hoggar. The presence of Cretaceous, sandstone and carbonate deposits preserved in the Hoggar massif (Rognon et al., 1983; Busson et al., 1999, Rougier, 2013), confirms that it was partly buried in the Cretaceous by deposits exceeding 1 to 3 kilometres before being exhumed from around 80 to 15 Ma. The Cenomanian-Turonian limestones found on the northern edge of the Hoggar (Busson et al., 1999) appear to be the best evidence that the Hoggar was covered by the sea during this period. In the Iullemmeden basin, the Trans-Saharan Seaway (Figure 4) is therefore responsible for the emplacement of the deposits of the Mont Iguelalla formation and those of the Doutchin Zana formation (Figures 4 and 8). The uplift of the Hoggar is therefore essentially post-Turonian (90 Ma). According to Burke (1996), hotspots are responsible for the development of the high topography of Africa after the African plate became immobilised in relation to the circulation of the underlying mantle currents during the Cretaceous.

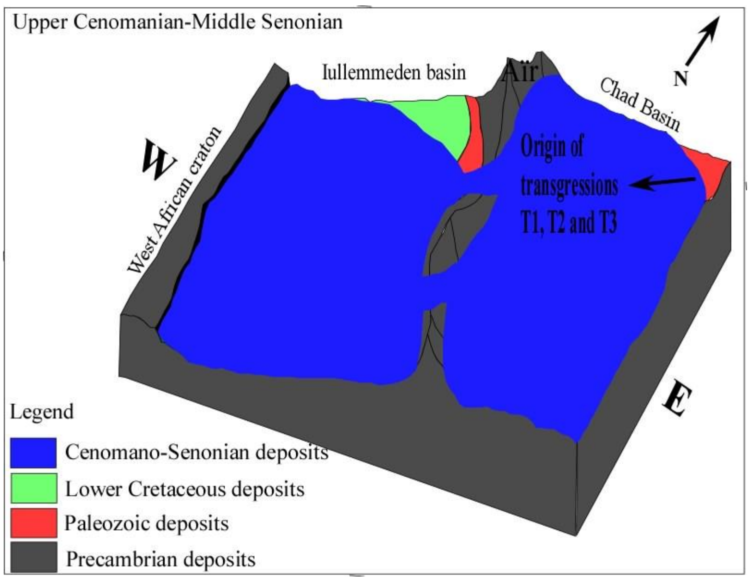

Figure 4: Block diagram showing the geodynamic evolution of the Iullemmeden and Aïr basins during the period from the Upper Cenomanian to the Lower Senonian.

Thus, the surrection of the Hoggar and its apophyses (the Aïr and the Adrar des Iforas) in the terminal Maastrichtian could be associated with the rise of mantle flows at the level of the hot spot located at the Hoggar (**Figure 5**). At the same time as the Aïr was uplifted during the Maastrichtian, the Iullemmeden Basin and the Taoudenni Basin were linked by NW-SE subsidence between the Adrar des Iforas and the Liptako Gourma basement (Gao Graben) (**Figure 5**) (Greigert, 1966). The fourth transgression (T4), still coming from the Mesogean, invaded the African continent, bypassing the Aïr, the Hoggar and the Adrar des Iforas to end up in the Iullemmeden basin via the so-called Gao trough (Radier, 1957). At this point, sandy-clay sedimentation begins, forming the Alanbanya, Farin Doutchi and In Wagar formations (**Figure 5**).

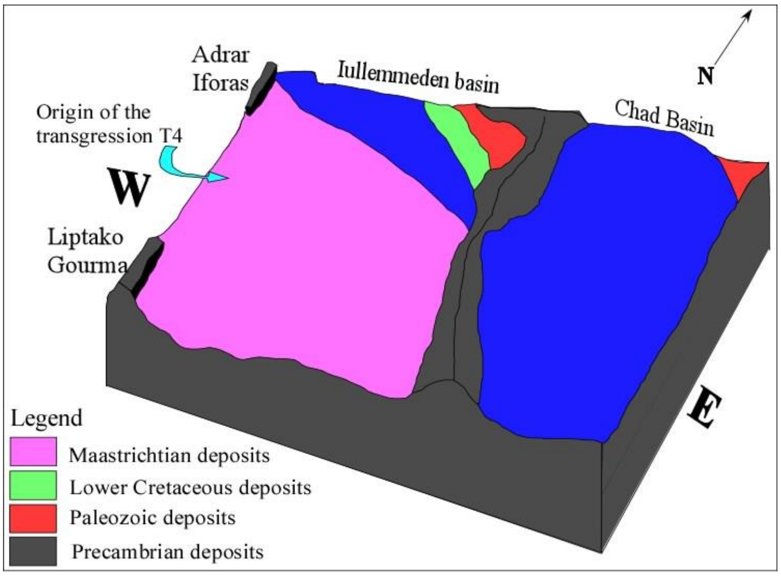

Figure 5: Block diagram showing the isostasy process between the Iullemmeden basin and the Aïr.

6.2. Paleogene evolution

After the Maastrichtian surrection of the Aïr, Hoggar, Adrar des Iforas, Jos Plateau and Cameroon Line, West Africa remained tectonically stable throughout the Palaeocene-Ypresian period. As the topography of the Aïr, Hoggar and Adrar des Iforas was already elevated in relation to the various basins, as was the fourth transgression T4, the transgressions T5 and T6, coming from the Mesogean, only had access to the Iullemmeden basin via the Gao trough (Figure 6). This observation is consistent with the fact that the greatest thicknesses of Maastrichtian to Ypresian deposits were recorded in the Garadaoua region, indicating a deepening of this central part of the basin during this period. The relatively deep basin configuration of the Garadaoua region was preserved during part of the Palaeogene, which would have favoured the T5 and T6 transgressions that produced the clay-limestone deposits of the Garadaoua formation.

During the Ypresian, a process of 'vertical delamination' associated with the melting of ascending panels along the N-S Pan-African faults (Liégeois et al., 2003; 2005) caused asthenospheric uplift, responsible for volcanism in the Tuareg Shield. These movements of Ypresian surrection accompanied the regression of the Upper Cretaceous and Paleocene-Ypresian seas. This gave the basin its present configuration (Greigert, 1966; Dubois, 1979; Boudouresque, 1982).

From the Oligocene onwards, the African plate became immobilised in relation to the mantle (Burke and Gunnell, 2008; Burke and Wilson, 1972), the circulation of which (Figure 6) is thought to have had a major impact on the development of Africa's topography. According to White and McKenzie (1989) and Summerfield (1991), during the Oligocene, hot spots were responsible for the superswell (bulging) of the cratonic zones of North and West Africa (Figure 6). During this period, there was significant magmatic and volcanic activity in the eastern part of West Africa (Hoggar, which rises to 2900 m, the Jos plateau, the Adamaoua massif and the Cameroon line) (Burke, 1996; Burke et al., 2003), linked to regional mantle circulation (Figure 6). The surrection of the Aïr, which occurred after the Ypresian and during the Oligocene, is thought to have favoured marine regression.

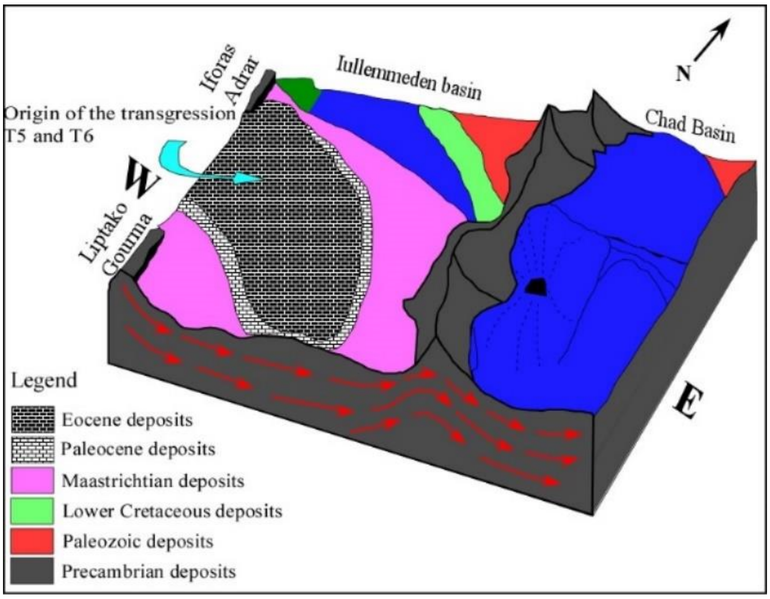

Figure 6: Block diagram showing the 'dome and basin' structure associated with mantle dynamics in the Cenozoic.

7.CONCLUSION

The current topography of West Africa shows an overall structuring into high 'dome' zones (Hoggar, Adrar des Iforas and Aïr) and low 'basin' zones (Senegal-Mauritania basin, Taoudenni basin, Iullemmeden basin and Benoué basin) that could be explained by mantle dynamics. Ascending mantle flows would support high altitudes, while descending flows would create depressions. This mantle dynamic would have influenced the transgressive and regressive cycles that affected the Iullemmeden basin.

ACKNOWLEDGEMENT

The authors would like to thank all the members of the Basins and Georesources team of the Geology Laboratory of the Faculty of Science and Technology of the Abdou Moumouni University of Niamey for their collaboration in the writing of this article.

REFERENCES

1. Abdou Ali I., Konate M., Ousmane B. 2018. Lineamentary and Structural cartography of Iullemmeden Basin in the region of Dosso (South-west of Niger). IJSR, ISSN
(Online) 2319-7064. Vol. 7, issue 4,9p.
2. Bellion Y. J. C. 1987. Histoire géodynamique post-paléozoïque de l'Afrique de l'Ouest d'après l'étude de quelques bassins sédimentaires. (Sénégal, Taoudenni, Iullemmeden, Tchad). Thèse de l'Université d'Avignon et des Pays de Vauclus, 302 p.
3. Bertrand-Sarfati J., Fabre J., Moussine Pouchkine A. 1977. Géodynamique des aires sédimentaires cratoniques : quelques exemples sahariens. Bull. Centre Rech. Explor. Prod. Elf Aquitaine, 1,1, 217-231.
4. Boudouresque L. Dubois D. & Lang J. 1982. Contribution à la stratigraphie et à la paléogéographie de la bordure occidentale du bassin des Iullemmeden au Crétacé supérieur et au Paléogène (Niger et Mali-Afrique de l'Ouest). Bull. Soc. géol. Fr., t 24, n4, pp. 685-695.pp. 105-124.
5. Boudouresque L. Dubois D. & Lang J. 1982. Contribution à la stratigraphie et à la paléogéographie de la bordure occidentale du bassin des Iullemmeden au Crétacé supérieur et au Paléogène (Niger et Mali-Afrique de l'Ouest). Bull. Soc. géol. Fr., t 24, n? 4, pp. 685-695.pp. 105-124.
6. Burke K. 1996. The African Plate, S. Afr. J. Geol., 99, pp. 339-409.
7. Burke K. And J. T. Wilson 1972. Is the African Plate Stationary?, Nature, 239(5372), 387-390.
8. Burke K., And Gunnell Y. 2008. The African Erosion Surface: A Continental-Scale Synthesis of Geomorphology, Tectonics, and Environmental Change over the Past 180 Million Years, Geol. Soc. Am., Mem., 201, 1-66.
9. Burke K., Macgregor D. S. And N. R. Cameron 2003. Africa's petroleum systems; four tectonic 'aces' in the past 600 million years, Geol. Soc. London Spec. Publ., 207, 21-60.
10. Busson G., Dhondt A., Amedro F., Neraudeau D. And Cornee A. 1999. La grande transgression du Cénomanien supérieur-Turonien inférieur sur la Hamada de Tinrhert (Sahara algérien): datations biostratigraphiques, environnement de dépôt et

comparaison d'un témoin épicratonique avec les séries contemporaines à matière organique du Maghreb, Cretaceous Res., 20(1), 29-46.
11. Dikouma M. 1990. Fluctuations du niveau marin au Maastrichtien et au paléocène dans le bassin intracratonique des Iullemmeden (Ader-Doutchi, Niger). Thèse Doctorat. Univ. Dijon-Niamey, 272 p.
12. Dubois H. 1979. Etude géologique des formations Oolithiques ferrugineuses du bassin des Iullemmeden (République du Niger). Thèse de doctorat de 3ème cycle, Université de Niamey et d'Orléans.
13. Ebinger C. J. And N. H. Sleep 1998. Cenozoic magmatism throughout east Africa resulting from impact of a single plume, Nature, 395(6704), 788-791.
14. FAURE H. 1966. Reconnaissance géologique des formations sédimentaires postpaléozoïques du Niger oriental. Mem. Bur. Rech. Geol. Minieres 47, 1e 629.
15. Greigert J. & Pougnet R. 1965. Carte géologique de la république du Niger au 1/2000000. B.R.G.M., Paris.
16. Greigert J. 1966. Description des formations crétacées et tertiaires du Bassin des Iullemmeden (Afrique Occidentale). Pub. Dir. Min. -Géol. Niger, n°2. Mém. B.R.G.M., n°36, 234 p.
17. Hanon M. 1984. Cartes géologiques au 1/100.000 de l'Ader Doutchi (16 feuilles). DRGM Niger. AGCD Belgique.
18. Laouali I. K. Konaté M. And Sani A. 2021. "Geochemical Study of the In Wagar and Garadaoua Formations of the Iullemmeden Basin in South Central Niger (West Africa): Nature of the Sediments, Paleoclimatic Conditions and Paleoalteration of Source Rocks, " International Journal of Scientific Engineering and Applied Science (IJSEAS) – Volume-7, Issue-8, August 2021 ISSN: 2395-3470.
19. Laouali Idi K. & Konate M. 2019. Extraction de réseaux de fractures en milieu sédimentaire par les techniques de la télédétection intégrant une analyse statistique et structurale : cas des formations méso - cénozoïques du bassin des Iullemmeden, Niger Central. Afrique SCIENCE 15 (5) (2019) 39 – 53.15p.
20. Laouali Idi K. 2020. Etudes sédimentologique, paléontologique, paléogéographique et structurale des dépôts d'âge maastrichtien à yprésien du bassin des Iullemmeden (Niger central). Thèse de Doctorat Unique. Université de Niamey, 173 p.
21. Liégeois J.-P., Benhallou A., Azzouni-Sekkal A., Yahiaoui R. And Bonin B. 2005. The Hoggar swell and volcanism: Reactivation of the Precambrian Tuareg shield during Alpine convergence and West African Cenozoic volcanism. In: G.R.
22 .Liégeois J.-P., Latouche L., Boughrara M., Navez J. And Guiraud M. 2003. The LATEA metacraton (Central Hoggar, Tuareg shield, Algeria): behavior of an old passive margin during the pan-African orogeny.-Journal of African Earth Sciences, 37, pp.161-190.
23. Moucha R. And A. M. Forte 2011. Changes in African topography driven by mantle convection, Nature Geosci., 4(10), 707-712.
24. Radier H. 1957. Contribution à l'étude géologique du Soudan oriental (A.O.F.). Bull. Dir. Mines. A.O.F., n° 26.
25. Rognon P., Gourinard Y., Bandet Y., Koeniguer J. C. And Delteildesneux F. 1983. Précisions chronologiques sur l'évolution volcanotectonique et géomorphologique de l'Atakor (Hoggar).
26 Rougier S. 2013. Eocene exhumation of the Tuareg Shield (Sahara Desert, Africa), Geology, 41(5), 615.
27. SAHAGIAN D. 1988. Epeirogenic motions of Africa as inferred from Cretaceous shoreline deposits, Tectonics, 7, 125-138.
28. Summerfield M. A. 1991. Global geomorphology; an introduction to the study of landforms, 537 p., Longman Scientific & Technical, Harlow, UK.
30. Taquet P. 1976. Les découvertes récentes de Dinosaures du Jurassique et du Crétacé en Afrique, au Proche Orient et en Inde. Mém. Soc. Géol. Fr. h. s. n°8, pp. 325-330. Terminal et du Cénozoïque inférieur dans le bassin des Iullemmeden (Niger). Bull.I. F. terminal et du cénozoïque inférieur dans le bassin des lullemmeden, Dakar- IFAN.
31. White R. And D. Mckenzie 1989. Magmatism at rift zones: The generation of volcanic continental margins and flood basalts, J. Geophys. Res.: Solid Earth, 94(B6), 7685-7729.
32. Wright L. I., Branchet M. & Alisso I. 1993. Notice explicative de la carte géologique du bassin houillier d'Anou Araren / Solomi. Ministère des Mines et de l'Énergie, Niger, 20 p.

How to cite this article:
Laouali Idi Karimou et al. Ijsrm.Human, 2024; Vol. 27 (9): 22-29
Conflict of Interest Statement: All authors have nothing else to disclose.