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Surface geosciences (Palaeoenvironment)

Chad Basin: Paleoenvironments of the Sahara since the Late Miocene

Mathieu Schuster [a,*], Philippe Duringer [b], Jean-François Ghienne [b], Claude Roquin [b], Pierre Sepulchre [c], Abderamane Moussa [b,a], Anne-Elisabeth Lebatard [a], Hassan Taisso Mackaye [d], Andossa Likius [d], Patrick Vignaud [a], Michel Brunet [e,a]

[a] *CNRS UMR 6046, IPHEP, université de Poitiers UFR SFA, institut international de paléoprimatologie, paléontologie humaine : évolution et paléoenvironnements, 40, avenue du Recteur-Pineau, 86022 Poitiers cedex, France*
[b] *CNRS UMR 7516 IPGS, université de Strasbourg, institut de géologie, école et observatoire des sciences de la Terre, 1, rue Blessig, 67084 Strasbourg cedex, France*
[c] *CNRS UMR 1572, laboratoire des sciences du climat et de l'environnement, CEA Saclay, 91191 Gif-sur-Yvette cedex, France*
[d] *Département de paléontologie, université de N'Djaména, BP 1117, N'Djaména, Tchad*
[e] *Chaire de paléontologie humaine, Collège de France, 75231 Paris cedex 05, France*

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Abstract

Since the mid 1990s, the *Mission paléoanthropologique francotchadienne* (MPFT) conducts yearly paleontological field investigations of the Miocene-Pliocene of the Chad Basin. This article synthesizes some of the results of the MPFT, with focus on the Chad Basin development during the Neogene. We propose an overview of the depositional paleoenvironments of this part of Africa at different scales of time and space, based on a multidisciplinary approach (sedimentary geology, geomorphology, geophysic, numerical simulations and geochronology). The Miocene-Pliocene paleoenvironments are examined through the sedimentary archives of the early hominids levels and the Holocene Lake Mega-Chad episode illustrates the last major paleoenvironmental change in this area. The sedimentary record of the Chad Basin since the Late Miocene can be schematized as the result of recurrent interactions from lake to desert environments. ***To cite this article: M. Schuster et al., C. R. Geoscience 341 (2009).***

Résumé

Bassin du Tchad : paléoenvironnements du Sahara depuis le Miocène supérieur. Depuis le milieu des années 1990, la Mission paléoanthropologique francotchadienne (MPFT) conduit chaque année des recherches paléontologiques de terrain dans le Mio-Pliocène du Bassin du Tchad. Cet article synthétise certains résultats de la MPFT concernant l'évolution du Bassin du Tchad au Néogène. Nous proposons un aperçu des paléoenvironnements de dépôt de cette partie de l'Afrique, à différentes échelles, à partir d'une approche multidisciplinaire (géologie sédimentaire, géomorphologie, géophysique, simulations numériques et géochronologie). Les paléoenvironnements du Mio-Pliocène ont été étudiés, notamment à partir des archives sédimentaires des séries à hominidés anciens, et le Lac Méga-Tchad holocène illustre le dernier changement paléoenvironnemental majeur dans cette région.

* Corresponding author.
E-mail address: mathieu.schuster@univ-poitiers.fr (M. Schuster).

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L'enregistrement sédimentaire dans le Bassin du Tchad depuis le Miocène supérieur est schématiquement le résultat d'interactions récurrentes entre des environnements lacustres à désertiques. ***Pour citer cet article : M. Schuster et al., C. R. Geoscience 341 (2009).***

Keywords: Africa; Lake Mega-Chad; Early hominids; Miocene-Pliocene; Holocene; Sedimentary depositional environments

Mots clés : Afrique ; Lac Méga-Tchad ; Hominidés anciens ; Miocène-Pliocène ; Holocène ; Environnements sédimentaires de dépôt

1. Introduction

Since the middle 1990s, the *Mission paléoanthropologique francotchadienne* (MPFT) conducts yearly field investigations of the Chad Basin. Four major fossiliferous areas of Neogene vertebrate fauna from the Djurab sand sea (*ca.* 600 km north-east of N'Djaména) are now published, ranging in age from 7 to 3 Ma: Toros-Menalla, Kossom Bougoudi, Kollé and Koro-Toro [6–10,65]. The outcrops are located in an area extending from about 16°N to 16.5°N and from about 17°E to 19°E.

Details about the tremendously rich vertebrate fauna (mammals, reptiles, birds, fishes) of these localities can be found in the publications of the MPFT team [2,3,23,24,37–41,47]. The study of the evolutive degree of the mammal fauna provides robust biochronological ages. An independent geochronological method, based on the cosmogenic nuclide dating (beryllium 10) of the sediments, recently confirmed the previous chronological framework [34]: Toros-Menalla, 7 Ma; Kossom Bougoudi, 5.2 Ma; Kollé, 4 Ma; Koro-Toro, 3.5 Ma.

Last, but not least, the research of the MPFT team has led to the discovery of two major early Hominids:

- *Australopithecus bahrelghazali* (nicknamed *Abel*; [6,7,30]) which is the first australopithecine found outside the classical early Hominids sites of eastern and southern Africa;
- *Sahelanthropus tchadensis* (nicknamed *Toumaï*; [11–13,29,67]) which is, at this time, the earliest known Hominid.

In this article, we present the results of the MPFT's geological investigations in the Chad Basin and examine the paleoenvironments of this area in terms of depositional processes at different scales of time and space. The Mio-Pliocene paleoenvironments of northern Chad Basin are presented with particular focus on the sedimentary archives of the early Hominid levels. The last major paleoenvironmental change that affected the whole area of the basin occurred during the Holocene and is illustrated by a giant paleolake, known as Lake Mega-Chad (Fig. 1).

2. Geological context

The Chad Basin is an intracratonic sag basin located in North Central Africa. The Neogene and Quaternary sediments [51,60] that accumulated in this basin are supposed to have a maximum thickness of *ca.* 500 m and a rough extension over an area of *ca.* 500 km in diameter [14]. Since the last marine episode at the end of the Eocene, the sedimentation in the Chad Basin is only represented by continental deposits; the Oligocene-Miocene time slice being referred to as the *Continental terminal* [33]. Lake deposits prevail in the sedimentary record since the Late Miocene [53,59]. Contrasting with the expansion of large lake environments during humid periods, recurrent desert episodes also developed in the northern Chad Basin [56].

The Chad Basin basement comprises a suite of crystalline rocks related to the Pan-African orogeny (*ca.* 750-550 Ma) [33] that are exposed and overlain by younger rocks in several remarkable topographic features marking the border of the basin [66]. To the north, the Cenozoic volcanic rocks of the Tibesti uplift represent the highest mountains in the Sahara (Emi Koussi: 3415 m). To the north-east, Cretaceous sandstones (known as the *Continental intercalaire* and related to the eastern Africa Nubian Sandstones) compose the tabular plateau of the Erdis (Korko, Dji, Fochimi and Ma; < 800 m). The eastern flank of the basin is bordered by the Paleozoic sandstones of the Ennedi mountains (Basso: 1450 m) and the Precambrian granitoid rocks of the Ouaddaï mountains (< 1100 m). To the South of the basin, the Adamaoua and the Mayo Kebi regions correspond to tectonically active areas related to the Cretaceous-Cenozoic rifting events that affected western and central Africa [28]. To the west, the Late Pleistocene dune field of the Kanem is the only remarkable geomorphic feature. Further afield, the Aïr massif (< 2200 m; Niger), the Darfour mountains (< 3100 m; Sudan), the Bongo massif (< 1500 m; Central African Republic) or the Jos plateau (< 2200 m; Nigeria) represent the extreme extensions of the hydrographic basin of the modern Lake Chad.