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Lake Chad sedimentation and environments during the late Miocene and Pliocene: New evidence from mineralogy and chemistry of the Bol core sediments

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ABSTRACT

This study presents mineralogical and geochemical data from a borehole drilled near the locality of Bol (13°27′N, 14°44′E), in the eastern archipelago of the modern Lake Chad (Chad). Samples were taken from a ~200 m long core section forming a unique sub-continuous record for Central Africa. Among these samples, 25 are dated between 6.4 and 2.4 Ma. Dominant minerals are clays (66% average) mixed with varying amounts of silt and diatomite. The clay fraction consists of Fe-beidellite (87% average), kaolinite, and traces of illite. Clay minerals originate from the erosion of the vertisols that surrounded the paleolake Chad. Sedimentological data indicate that a permanent lake (or recurrent lakes) existed from 6.7 until 2.4 Ma in the vicinity of Bol. By comparison with modern latitudinal distribution of vertisols in Africa the climate was Sudanian-like. Changes in the sedimentation rate suggest a succession of wetter and dryer periods during at least six million years in the region during the critical time period covering the Miocene–Pliocene transition.

1. Introduction

Lake Chad is a permanent and shallow freshwater body located in the Sahelian domain of Africa that fringes the southern edge of the Sahara desert (Fig. 1). It is today mostly supplied from its southern watershed by the Chari-Logone rivers system. Lake Chad is a very sensitive indicator of climate and environment changes in North–Central Africa as illustrated by its dramatic recent and past shrinkage in area (Maley, 1972, 2010; Maley and Vernet, 2015). During the 1960's, Lake Chad covered 25,000 km^2. It decreased less than 1,500 km^2 during the 1980's (Olivry et al., 1996; UNEP, 2004; Don-Donné Goudoum and Lemoalle, 2014), whereas during the Holocene, 6000 years ago, it reached >350,000 km^2 (Schuster et al., 2005) (Fig. 1).

The Chad basin is an intracratonic sag basin, whose margins correspond to the maximum expansion of the lake during the

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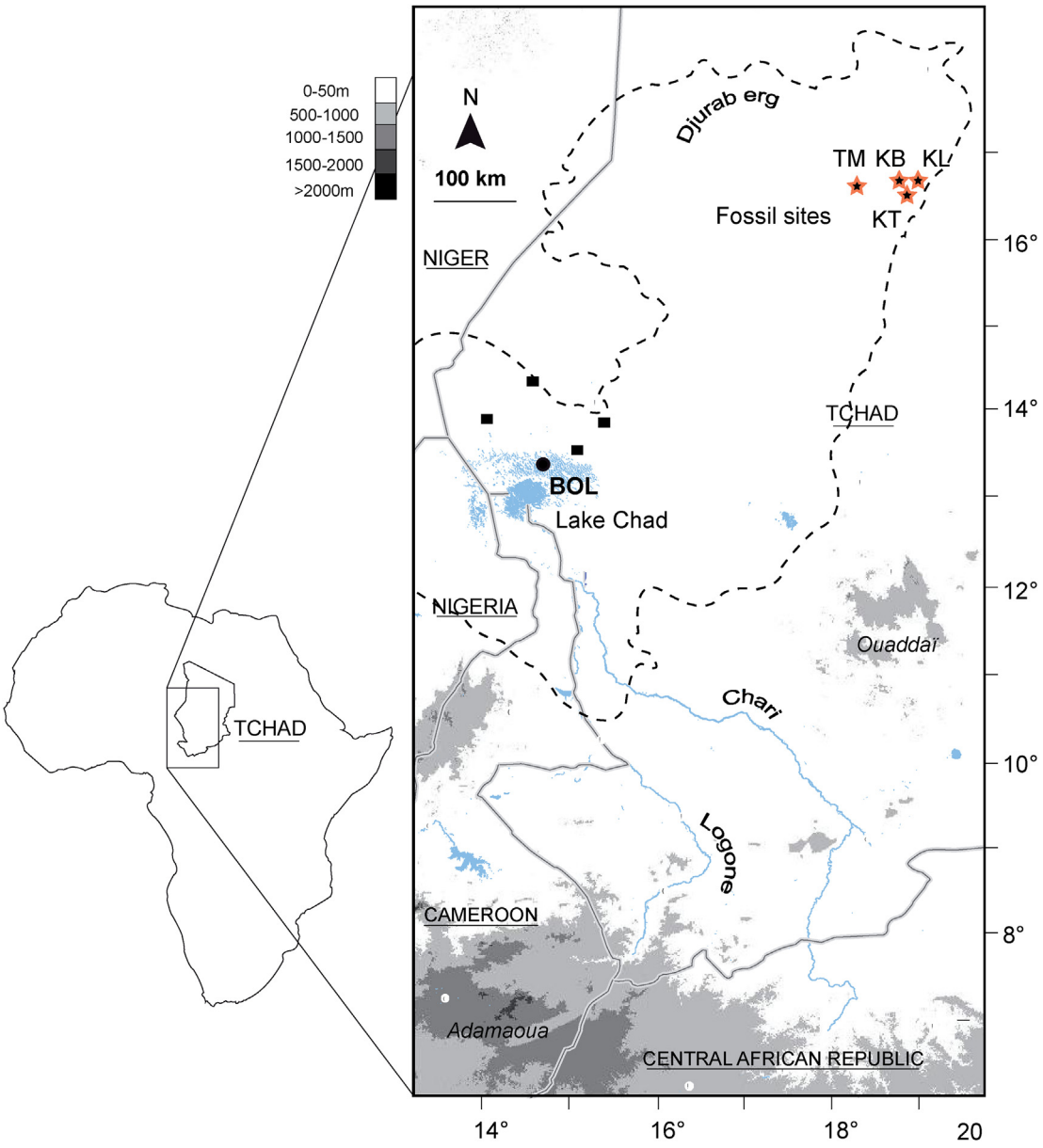

Fig. 1. Location map showing the Chad Basin, the modern Lake Chad (in blue), and the Holocene Lake Mega-Chad (broken line). Black dot: Bol core location (13°27′N, 14°44′E). Red stars: Miocene–Pliocene fossiliferous areas of the Djurab desert: TM, Toros Menalla; KB, Kossom Bougoundi; KL, Kollé; KT, Koro Toro. Black squares: location of wells drilled in the Kanem region (from Schneider and Wolff, 1992; Swezey, 2009) (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

Holocene (Schuster et al., 2005; Leblanc et al., 2006). The basin basement includes a suite of crystalline rocks related to the Pan-African orogeny (ca. 750-550 Ma), which is directly covered by Cretaceous sandstones (Bessoles and Trompette, 1980). On top of the Cretaceous deposits, it also includes Neogene and quaternary sediments of about 500 m thick covering an area of about 500 km in diameter (Burke, 1976).

Scarce sedimentological data coming from petroleum exploration in Niger, Central African Republic, and Chad (Genik, 1992) give a brief history of the filling of rift basins in Central Africa, which were since completed by significant sedimentological investigations at the hominin-bearing deposits of northern Chad (Brunet *et al.*, 1995, 2002, 2005). Regarding southwestern Chad, Genik reports the late Miocene in the Doba and Dosea basins as thick (200–800 m) non-marine sandstones, while Kusnir and Moutaye (1997) described very briefly the central basin sedimentary series as Cretaceous sandstones followed by a sandy early Pliocene and a limnic argillaceous middle and late Pliocene. More recently, Swezey (2009) presented three stratigraphic sections described by Schneider and Wolff (1992), where the Pliocene sediments are briefly described as mudstones more or less diatomeous and gypsiferous. In the northern part of the basin, multiple fossiliferous sediment series were described (Schuster et al., 2006, 2009) and overall dated between 7.5 and 1.1 Ma using the $^{10}Be/^{9}Be$ method (Lebatard et al., 2010). They consist of many sequences of lacustrine (clays and diatoms), perilacustine (argillaceous sandstones with root concretions, rhizoliths, and abundant termite nests) (Duringer et al., 2006, Duringer et al., 2007), and aeolian deposits, suggesting successive and repeated wet and dry climatic periods during the Miocene–Pliocene. Perilacustrine sediments