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The Cenomanian–Turonian boundary on the Saharan Platform (Tunisia and Algeria)

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ABSTRACT

Several transects made of correlated stratigraphic sections and well logs have been constructed spanning southern Tunisia and the Algerian Sahara (Tinrhert) for comparison with earlier results obtained in the Saharan Atlas. The study is based on facies analysis, sedimentology, biostratigraphy focused on ammonites and foraminifers) as well as whole rock geochemistry ($\delta^{13}C$). These suggest that the entire northern Sahara Platform underwent marine flooding that commenced just prior to the onset of the global positive $\delta^{13}C$ shift documented for the Cenomanian–Turonian boundary. This flooding occurred in two phases. The first phase is expressed by the deposition of deeper-water, light-coloured bioturbated mudstones overlying the shallow-water deposits comprising the local Cenomanian successions. But in some places in the Central Sahara (Hassi Messaoud area, Tihemboka Arch) as well as in the Saharan Atlas, shallow-water carbonates kept up locally with the relative sea-level rise to build up isolated carbonate platforms. The topographic lows or saddles between these areas could have been formed through differential accumulation rates. During the second phase, flooding resumed and black shales were deposited over the mudstones in the saddles. The occurrence of black shales in these saddles is limited to the northern edge of the platform (Saharan Atlas of Algeria, Gafsa Trough in southern Tunisia). On the platform, this phase is represented by the same kind of mudstones deposited during the first phase of the flooding (southern Tunisia), or by ammonite-rich chalks in the intra-cratonic basin of the Tinrhert (southern Algeria). Black-shale deposition ceased in the early Turonian. Based on the $\delta^{13}C$ curve, the latest Cenomanian flooding of the Sahara Platform is roughly coeval with that documented for the US Western Interior.

During the first phase of the transgression, that is before the occurrence of the large *Whiteinella* of the *W. archeocretacea* Zone in the black shale unit, planktic foraminifers are dominated by small globulose forms of the *Hedbergella delrioensis* type, associated with Heterohelicidae. Keeled forms (rotaliporids, dicarinellids) are scarce and always very small when present. Perhaps these dwarfed forms were adapted to the restricted environments of the extensive intracratonic seaways crossing the Saharan Platform to the Benoué Trough in Nigeria.

1. Introduction

The Cenomanian–Turonian boundary event (CTBE) or Oceanic Anoxic Event 2 (OAE2) is one of the best-studied "anoxic" events in the geologic record (e.g. Schlanger and Jenkyns, 1976; Schlanger et al., 1987; Arthur and Schlanger, 1979; Jenkyns, 1980). Most authors have focused their studies on basinal sections which have been used for long-distance correlation, and include the Pueblo, CO, stratotype (Kennedy and Cobban, 1991; Keller and Pardo, 2004; Keller et al., 2004; Desmares et al., 2007), presently the Global Boundary Stratotype for the Cenomanian–Turonian (C/T) boundary (Kennedy et al., 2005; Sageman et al., 2006), or that of Eastbourne in England (Jeans et al., 1991; Hart et al., 1993; Paul et al., 1999;

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Keller et al., 2001; Gale et al., 2005). Other examples include: Wünstorf in Germany (Hilbrecht et al., 1986; Voigt et al., 2008; Hetzel et al., 2011), Kalaat Senan or Wadi Bahloul in Tunisia (Robazsynski et al., 1990; Burollet and Robasynski, 1991; Robaszynski et al., 1993a, 1993b; Amédro et al., 2005; Caron et al., 2006), Gubbio in Italy (Coccioni and Luciani, 2004, 2005), Pont d'Issole in southern France (Grosheny et al., 2006; Jarvis et al., 2011), as well as deep-oceanic sites (Kaiho and Hasegawa, 1994; Sinninghe-Damsté and Köster, 1998; Huber et al., 1999; Kuypers et al., 2004; Friedrich et al., 2006; Hardass and Mutterlose, 2007; Forster et al., 2008).

Our aim is to understand the relative sea-level changes around the CTBE, and to check for their relationship to the eustatic signal. Most authors have studied the CTBE in basinal sections dominated by black shale deposition favour a worldwide transgressive event, following the interpretations of Arthur and Schlanger (1979) and Jenkyns (1980). Such a transgressive event has been known for decades in the US Western Interior Basin, extending back to the work of Hancock and Kauffman (1979). But many other well-studied basinal sections outside this basin, such as those in England, Italy, Central Tunisia, or oceanic localities (see above), lack the direct correlation with the marginal deposits necessary to reconstruct directly sea-level changes. In SE France, the CTBE black shale of the Subalpine Basin hosts siliciclastic turbidites and is associated with the most pronounced Cretaceous regressive event on the western margin of the basin (Malartre and Ferry, 1993; Grosheny et al. work in progress). Something similar, although more complex, has been found on the Morroccan Atlantic margin (Jati et al., 2010), which does not correspond to what has been found eastward in the Tethys-oriented Errachidia Basin (Lezin et al., 2012) where the sea-level changes are quite similar to those recorded in the US Western Interior. Deciphering the superimposition of local tectonic effects on a possible eustatic signal would require detailed studies, such as that of Laurin and Sageman (2007), compared in a number of basins worldwide. Here, we presents the results of a study undertaken in both southern Tunisia (Gafsa area to the Dahar Plateau) and southern Algeria (Tademaït and Tinrhert). These results are compared with results previously obtained in the Saharan Atlas of Algeria, to better reconstruct relative sea-level changes during the CTBE for a broader part of the North African Craton.

2. Geological setting and sections studied

The Gafsa Trough in southern Tunisia (Fig. 1) is a narrow basin situated along the northern edge of the Saharan Platform. It was probably connected (Lüning et al., 2004) to the larger Mellegue Basin of northern Algeria and northern Tunisia ("sillon tunisien" of Robazsynski et al., 2000). Its eastern margin is delineated by the intersection of the W–E-oriented margin of the Saharan Platform and a major NW–SE-oriented lineament bordering the Kasserine Platform of Central Tunisia. Four sections were studied (Fig. 1, Table 1): Oued Beida within the Gafsa Trough, Jebel Asker from the Saharan Platform margin, and Foum Hassene and Chenini both positioned on the Saharan Platform. The Oued Beida section is located on the northeastern limit of the Jebel Berda anticline. The Jebel Asker section is situated on the northern border of the northern chain of the Chotts. The Foum Hassene section is situated a few kilometres south of the cliff formed by the upper Albian limestones in the southern chain of the Chotts, at the base of a second cliff made of the Turonian platformal limestones of the Gattar Fm. The Chenini section is situated close to the village of Chenini, at the base of the cliff overhanging the Sept Dormants necropolis. The sections represent a basin-to-platform transect, which is completed further to the south using well data (OS1) and field observations from the Briga area.

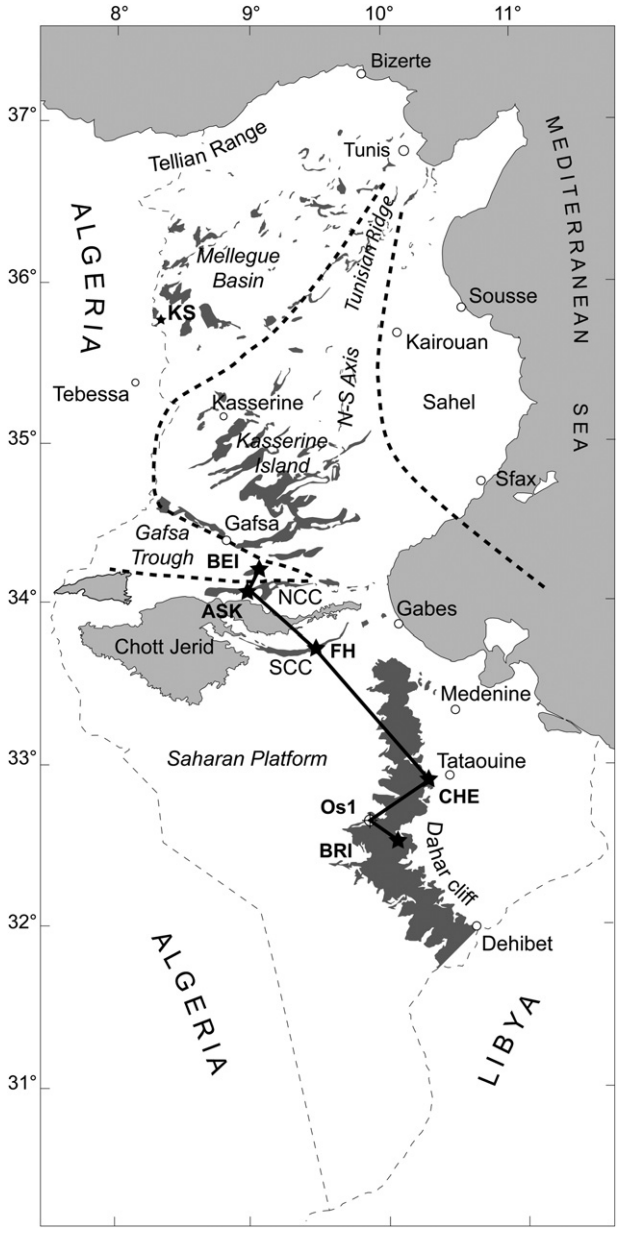

Fig. 1. Location of the transect studied in southern Tunisia. Sections: BEI, Oued Beida; ASK, Jebel Asker; FH, Foum Hassene; CHE, Chenini; Os1, Oued Siah Es Seraïa-1 well; BRI, Briga. NCC, Northern chain of the Chotts; SCC, Southern chain of the Chotts. KS, Kalaat Senan, reference area for C–T boundary sections in the Mellegue Basin. Words in italics on the map refer to palaeogeographic features after Lüning et al. (2004), modified. Dark-grey represents Cenomanian–Turonian outcrop areas.

The results obtained in southern Tunisia are compared with outcrop data from the central Sahara, further within the Saharan Craton. The sections studied in the present work are the sections of Bordj Omar Driss, Takouazet and Ohanet in the Tinrhert (Fig. 2, Table 1). The Bordj Omar Driss section (or "Fort Flatters", as it is also known in the literature and on geological maps, or "Temassinine" section in Amédro et al. 1996) has been logged along the paved road north of Bordj Omar Driss for its lower part, and completed with nearby outcrops for its upper part. The Takouazet and Ohanet sections have been logged in wadis cutting across the cuesta formed by the "Turonian bar" of Busson (1969, 1970), north of the main road from Bordj Omar Driss to In Amenas. The outcrop data were used to calibrate well logs from a number of locations.