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Cyclic changes in Turonian to Coniacian planktic foraminiferal assemblages from the tropical Atlantic Ocean

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ABSTRACT

Abundance patterns of planktic and benthic foraminifera from a tropical Atlantic drill site (Ocean Drilling Program Site 1259, Demerara Rise, Suriname margin) display a pronounced 400 kyr cyclicity, uninterrupted throughout our ~87.8–92 Ma record, between two clearly distinguishable assemblages: (1) a pelagic foraminifer fauna, which represents a deep oxygen minimum zone, and (2) another assemblage representing a shallow oxygen minimum zone where the foraminifer fauna is dominated by a higher diversity population of mostly small clavate and biserial species common in epicontinental seas. The cyclic changes in the long eccentricity band (400 kyr) between these two assemblages are proposed to reflect changes in the mean latitudinal position of the Intertropical Convergence Zone (ITCZ). Associated fluctuations in precipitation and trade wind strength may have influenced the upwelling regime at Demerara Rise leading to the observed cyclicity of planktic foraminiferal assemblages. The severe Turonian to Coniacian paleoclimatic and paleoceanographic changes in the Atlantic Ocean (e.g., gateway opening, cooling, and glaciation), however, seem to have no influence on the composition of tropical planktic foraminiferal faunas. There is no apparent relationship between foraminifer abundances and a major deflection in the stable isotope record interpreted elsewhere as a sign of the growth and decay of a large polar ice sheet.

1. Introduction

Paradoxically, the Turonian to Coniacian period (93.5–85.8 Ma, Ogg et al., 2004) is believed to record both the warmest temperatures in the Cretaceous as well as one or more glaciation events, manifested in short-lived sea level low stands and the oxygen isotope record (e.g., Stoll and Schrag, 2000; Voigt et al., 2004; Miller et al., 2005; Bornemann et al., 2008). Benthic and planktic foraminiferal oxygen isotopes (e.g., Huber et al., 1995; Bice and Norris, 2002; Huber et al., 2002; Wilson et al., 2002; Bornemann et al., 2008; Friedrich et al., 2008), bulk sample oxygen isotopes (Clark and Jenkyns, 1999), and the newly developed sea-surface temperature proxy TEX_{86} (Forster et al., 2007a,b; Bornemann et al., 2008) show that peak temperatures were established during the Turonian and reached about 35 °C in the tropics at the peak of the Cretaceous Thermal Maximum. However, short-lived cooling events (Jenkyns et al., 1994; Clark and Jenkyns, 1999) and ice build-up in the high southern latitudes have also been proposed for the Turonian (e.g., Stoll and Schrag, 2000; Miller et al., 2005; Bornemann et al., 2008). For this time interval sedimentary successions from the Russian platform (Sahagian et al., 1996)

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and the New Jersey Margin (e.g., Miller et al., 2003, 2005) indicate rapid changes in sea level in the order of 25–40 m. These sea level changes are too rapid (<1 Ma) and widespread to be explained by tectonic processes and therefore are believed to represent glacio-eustasy (e.g., Miller et al., 2005). In addition, some of these events are associated with the southward spread of cold-water macrofauna (Voigt and Wiese, 2000; Wiese and Voigt, 2002), indicating the southward extension of cooler water masses at least within the North Sea area. Based on sea-level reconstructions (Miller et al., 2003, 2005) and stable isotopes of extra-ordinarily well-preserved foraminiferal calcite (Bornemann et al., 2008), the presence of ice sheets about half the size of the modern Antarctic ice cap approximately 91.2 Ma ago has been proposed. Given increasingly robust evidence for super-warm tropical oceans during the Turonian, however, it remains uncertain how large ice sheets could grow, even on the poles. This concern is also strengthened by the complete lack of sedimentological features like ice-rafted debris and missing isotopic evidence for at least some of these events (Huber et al., 2002; Moriya et al., 2007).

However, the Turonian to Coniacian interval in the Atlantic Ocean was not only characterized by drastic changes in global climate but also by the ongoing opening of the Equatorial Atlantic Gateway (EAG; e.g., Jones et al., 1995; Pletsch et al., 2001) and the massive deposition of organic-rich sediments in basins around the North and Central Atlantic Ocean (e.g., Jenkyns, 1980; Arthur et al., 1990; Holbourn et al., 1999). Thereby, the opening of the EAG changed the circulation patterns of surface and maybe bottom waters (see discussions in Handoh et al., 1999, Pletsch et al, 2001, and Friedrich and Erbacher, 2006). The deposition of the Oceanic Anoxic Events (OAEs; Schlanger and Jenkyns, 1976) and ongoing sedimentation of black shales in tropical Atlantic basins during the entire Turonian and Coniacian drastically altered bottom-water environments and fostered a globally-significant period of carbon burial (e.g., Jenkyns, 1980; Stow and Dean, 1984; Arthur et al., 1990; Ly and Kuhnt, 1994; Mello et al., 1995; Wagner and Pletsch, 1999; Erbacher et al., 2004a,b).

Despite a large amount of sedimentological and geochemical studies dealing with these significant changes in Atlantic Ocean paleoceanography and paleoclimate (see references above), our understanding of how these changes influenced marine ecosystems is low. Especially studies about tropical ecosystems are missing yet, due to the fact that Turonian to Coniacian sections in the tropics are rare. Therefore, we present a 4 Myr record of high-resolution Turonian to middle Coniacian planktic foraminiferal assemblage data from Ocean Drilling Program (ODP) Site 1259 (tropical Atlantic Ocean), what is now becoming a classical site for mid-Cretaceous paleoceanography (e.g., Norris et al., 2002; Wilson et al., 2002; Forster et al., 2007a,b; Friedrich et al., 2008). These data allow us to characterize surface-water environments in the tropics and to reveal possible effects of the above-mentioned paleoceanographic and paleoclimatic changes. Furthermore, our data can be compared with existing stable isotope data sets from the same samples.

2. Materials and methods

Ocean Drilling Program Site 1259 is located on the gently dipping north-facing slope of Demerara Rise and was drilled at a water depth of 2354 m (Fig. 1). We studied Holes 1259A

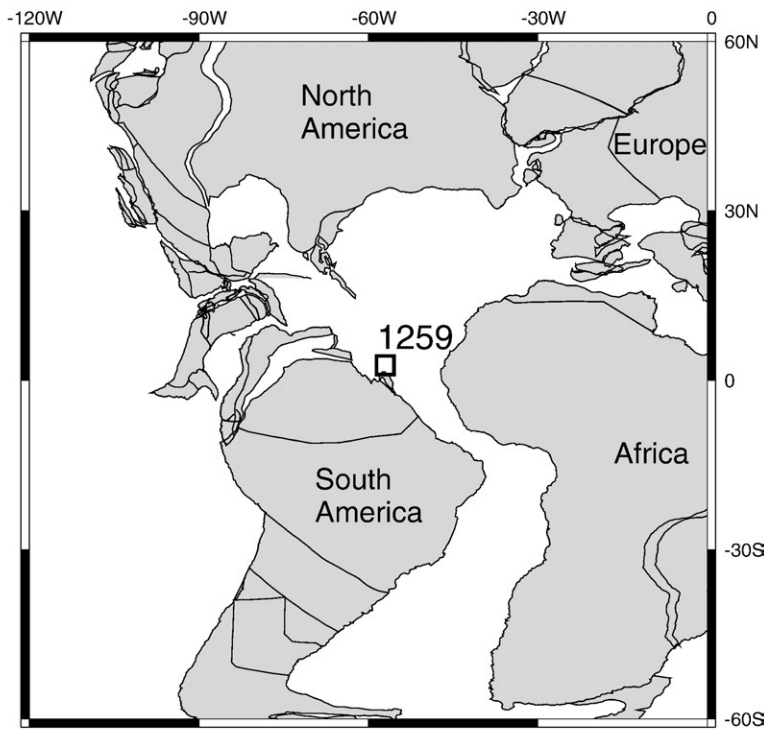

Fig. 1. Paleogeographic map of the Turonian/Coniacian boundary (89 Ma) showing the location of Ocean Drilling Program Site 1259 (available at http://www.odsn.de/odsn/services/paleomap/paleomap.html). Continental plates are shown in grey.