Palaeogeography, Palaeoclimatology, Palaeoecology 283 (2009) 195–215

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

The K/Pg boundary at Brazos-River, Texas, USA — An approach by marine palynology

Michael L. Prauss

Freie Universität Berlin, Institute of Geological Sciences, Section Palaeontology, Malteser Str. 74-100, Building D, D-12249 Berlin, Germany

ARTICLE INFO

Article history:
Received 26 September 2008
Received in revised form 24 September 2009
Accepted 25 September 2009
Available online 5 October 2009

Keywords:
Cretaceous
Palaeogene
Impact
Palynology
Dinocysts

ABSTRACT

Two cores and one outcrop section from the Cretaceous/Palaeogen (K/Pg) boundary interval at the Brazos-River area, Texas, USA, have been high resolution sampled and analysed fully quantitatively by marine palynology. The results have been compared and integrated with data from micropalaeontology, sedimentology and isotope-geochemistry from the same sections. Within all three sections, the K/Pg boundary, defined as the base of the P0 foraminifera zone and the onset of a negative carbon isotope anomaly, closely corresponds to the appearance of lowermost Danian organic-walled dinocysts. Based on various palynological proxies as well as on sedimentologic features, a sequence stratigraphic subdivision of the sections is proposed. From a synopsis of all three sections, a long term, punctuated drop of relative sea-level is indicated, starting at about the top of the Upper Cretaceous CF2 foraminifera zone and reaching a minimum within the upper P1a zone of the Lower Palaeogene. This is followed by a prominent transgression starting within the P1a/P1b boundary interval. The "event deposit" (ED), a siliciclastic unit located well below the base of the P0 foraminifera zone in the present sections, most probably represents a combination of both episodic relative sea-level fall and lag deposit due to initial transgression. It is preceded by significant fluctuations of climatic boundary conditions, with cool climates correlating to heavier $\delta^{13}C$ values and increased p/g ratio of dinocysts, suggestive of higher marine primary productivity. Across the K/Pg boundary, a prominent increase and spike of the warm–temperate waters dinocysts fraction is documented, represented mainly by *Trithyrodinium evittii*, which is accompanied by climatic warming and an episodic relative sea-level rise. Thus, prominent paleo-environmental changes and sea-level fluctuations precede and coincide with the K/Pg boundary proper. These data are inconsistent with a single "catastrophic" impact as the cause for the K/Pg boundary event, but suggest relative longer term environmental stress as finally leading to End-Cretaceous crisis of the biosphere. Between the ED and the K/Pg boundary proper, the gradual increase to peak abundance in trilete spores demonstrates a significant time lag between these two horizons. According to the distinct distribution of this peak abundance, it cannot be excluded that an impact/tsunami event is related to the lower portion of the ED. In contrast, no significant changes within most palynologic proxies are documented across the yellow clay layer below the ED documented within one of the sections and recently suggested as the original Chicxulub impact ejecta horizon. This questions the impact origin of this horizon or, at least, suggests only little consequences of this event on the ecosystem.

1. Introduction

The intense research into the end Cretaceous mass extinction has resulted in a variety of hypothesis as to its ultimate cause(s) (more recent summaries in Ferguson, 2001; Keller, 2001; Kring, 2007). Two concepts predominate: (1) gradual/stepwise extinction of Late Cretaceous biota due to increasing environmental stress resulting from a complex feedback of volcanism, sea-level changes and bolide impact(s) (e.g. Srivastava, 1994; Keller et al., 1995, 2002a,b, 2007; Stinnesbeck, 1996; MacLeod and Keller, 1996; MacLeod et al., 1997; Courtillot, 1999; Stinnesbeck et al., 1999, 2001; Hoffmann et al., 2000; Adatte et al., 2002; Chenet et al., 2007). (2) sudden and catastrophic extinction event associated with a single terminal Cretaceous bolide impact (e.g. Alvarez et al., 1980; Smit, 1982, 1990, 1999; Smit et al., 1996; Brinkhuis et al., 1998; Galeotti et al., 2004; Schulte et al., 2006; Kring, 2007). In the early 1990 the discovery of an impact structure of late Cretaceous age at Chicxulub, Yucatan peninsula, Mexico, and the largely coeval distribution of deposits supposedly related to an impact generated mega-tsunami along with a discrete iridium spike, spherules and shocked quartz in sediments throughout southern North America, NE Mexico and the Caribbean seemed to buttress the catastrophist's scenario. However, more detailed analyses of the uppermost Cretaceous sediments of NE Mexico questioned their tsunami related nature (e.g. Keller et al., 1997) and the presence of a marl layer with Maastrichtian foraminifera assemblages above the supposed tsunami deposits indicated a late Maastrichtian age (e.g. Lopez-Oliva and Keller, 1996; Keller, 2001; Stinnesbeck et al., 2001). Keller et al. (2004) reported that a 50 cm thick laminated limestone above the impact breccia in the Chicxulub crater core Yaxcopoil-1

E-mail address: mprauss@zedat.fu-berlin.de.

0031-0182/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.palaeo.2009.09.024

contains uppermost Maastrichtian foraminifera, which has been taken as evidence against an impact related K/Pg boundary. This was questioned, however, by others (cf. Kring, 2007 and ref. therein).

The purpose of the present study is to detect positions of episodic and/or persistent changes of marine palaeoecological boundary conditions preceding and across the K/Pg boundary interval at Brazos, Texas, USA, and check the biostratigraphic K/Pg boundary according to foraminifera against the distribution of organic-walled dinoflagellate cysts (dinocysts) index species of latest Cretaceous and earliest Danian age. The relationships of environmental change to both the stratigraphic position of the K/Pg boundary as well as to disputed horizons of the Chicxulub impact event are to be considered. Three sections, core Mullinax-1, core KT-1 and the composite outcrop CMA–CMB, have been analysed by means of marine palynology and results are compared with stable carbon- and oxygen isotopes data from benthic foraminifera and bulk rock respectively from the same sections.

1.1. Section locations and palaeogeographical background

All three sections analysed come from the Brazos River area, Texas, USA (Fig. 1). The cores Mullinax-1 and KT-1 are located closely together on a meadow about 370 m downstream from the Highway 413 Bridge over the Brazos River, Falls County, Texas (GPS Location 31º 07“event deposit53. 00′N, 96º 49′30. 14”W). The new core Mullinax-1 has been drilled in early 2005 and is being analysed by a multidisciplinary team. The core KT-1 was drilled in the middle 1980's and the results from multidisciplinary analyses, except for marine palynology, have been published already by Schulte (2003) and Schulte et al. (2006). The composite section CMA–CMB from outcrop is located at the Cottonmouth Creek, a small tributary of the Brazos River, about 1.8 km down river from the Highway 413 Bridge and 1.2 km to the SSW from the Mullinax-1 and KT-1 cores. The two segments of the section, CMA and CMB, have been sampled about 20 m apart.

The palaeolatitude of the Brazos area is about 35° N (cf. Smith and Briden, 1977), which is close to the palaeo-subtropics. Sediments represent a near-shore to middle shelf environment located at the southern end of the Western Interior Seaway. During most of the Cretaceous this seaway connected the Tethys ocean with the boreal ocean, but was much reduced during the end Cretaceous sea-level regression (e.g. Kennedy et al., 1998). Benthic foraminifera (Keller 1989, 1992) and mollusc assemblages (Hansen et al., 1987) indicate that water depth at Brazos was very shallow during the K/Pg boundary interval. More recent studies indicate inner neritic depth, at least at the time of the “event deposit” (Keller et al., 2007). The Brazos River valley area has been gradually subsiding since the middle of the Mesozoic (e.g. Galloway et al., 1991) and thus preserved a relatively continuous deposition during the Upper Maastrichtian to Lower Palaeocene.

1.2. Sediments

A detailed description of the K/Pg outcrops and cores from the Brazos region including the “event deposit” has been given by various authors (e.g. Hansen et al., 1987, 1993; Yancey, 1996; Gale, 2006). The sections analysed in the present study are extensively described in Schulte (2003), Schulte et al. (2006) and Keller et al. (2007, 2009). For the purpose of the present study only the main lithology of the single sections is shown by a column sketch (Fig. 2).

The most distinctive feature of the Brazos sections is the “event deposit” (ED), a siliciclastic unit which was interpreted as impact generated tsunami deposit by Bourgeois et al. (1988) and sea-level low by Keller (1989, 1992), Gale (2006) and Keller et al. (2007). This unit is highly variable both laterally and in thickness and fills submarine channels with a scoured base. A basal conglomerate bed of variable composition including locally derived mudstone clasts, lithified spherule-rich clasts and claystone concretions in a matrix of Chicxulub impact spherules and glauconite. Above it is a glauconite shell hash followed by layered sandstones, hummocky cross-bedded sandstones, burrowed and laminated sand at the top (Keller et al., 2007). At the CMA-CMB outcrop, the ED varies laterally in thickness from 10 cm to 65 cm over a distance of only 20 – 30 m (Keller et al., 2007). In the Mullinax-1 core the ED is about 31 cm in thickness and

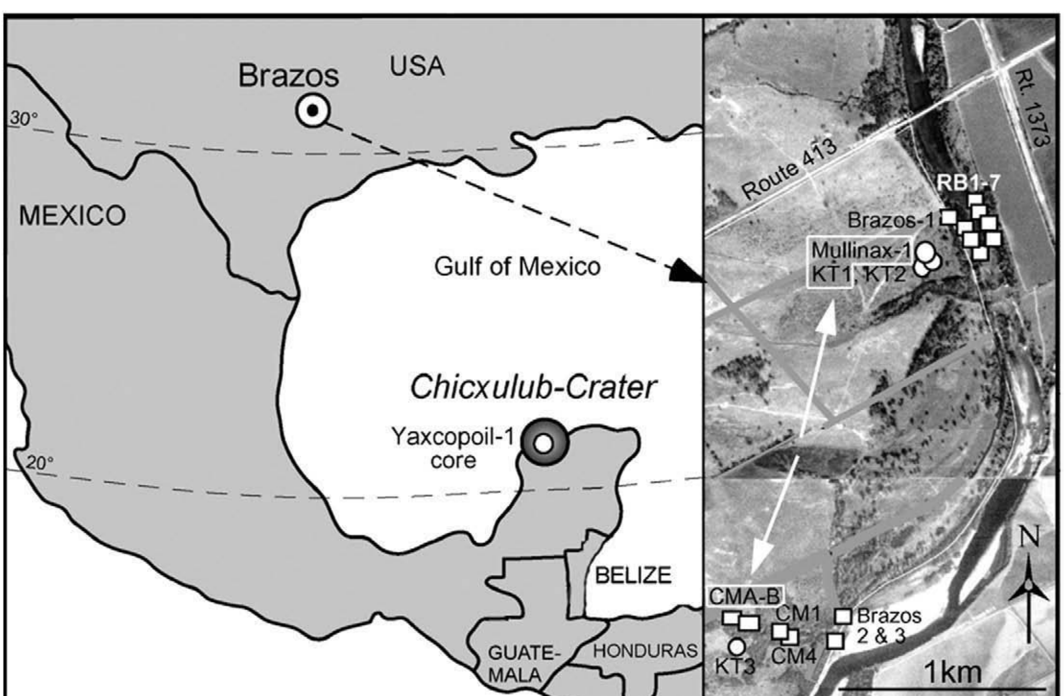

Fig. 1. Positions of the Brazos River area, Texas, U.S.A. and the Chixculub impact structure, Yucatan, Mexico. Details of the Brazos area and positions of cores and classic riverbed sites (modified after Keller et al., 2007). Locations of the study sections (white arrows): Mullinax-1, KT-1 and CMA-B.