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Research paper

# *Pentadinium alabamensis*: A new, unusual dinoflagellate from the early Oligocene of the Gulf Coast, Alabama, USA

Willemijn Quaijtaal [a,b,*], Henk Brinkhuis [a]

[a] *Marine Palynology, Laboratory of Palaeobotany and Palynology, Department of Earth Sciences, Faculty Geosciences, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, The Netherlands*
[b] *Research Unit Palaeontology, Department Geology and Soil Science, Ghent University, Krijgslaan 281 S8/WE13, B-9000 Ghent, Belgium*

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ABSTRACT

The Eocene–Oligocene Transition (EOT, ~34 Ma) marks the onset of major Antarctic ice sheets. The environmental consequences of the transition included major changes in e.g., sea level, temperature, and ocean circulation, complicating biostratigraphic correlations in this interval. Organic walled dinoflagellate cysts (dinocysts) however do show potential for EOT biostratigraphy, especially for ancient shallow marine settings.

At St. Stephens Quarry, Alabama, USA, we found a new, extremely suturocavate dinocyst, *Pentadinium alabamensis* sp. nov., described herein. The range of the new species spans the critical EOT magnetosubchron C13n, making this taxon a useful biostratigraphic marker for this interval in the Gulf Coast region. The species appears to be associated with shallow marine, euryhaline conditions.



## 1. Introduction

The Eocene–Oligocene transition (EOT, ~34 Ma) reflects the transition from the early Paleogene *Greenhouse* into the *Icehouse* world, marking the onset of major Antarctic glaciation (e.g., Zachos et al., 1996, 2001; Coxall et al., 2005; Zachos et al., 2008). The EOT paleoclimatic and correlated paleoceanographic changes often complicate straightforward biostratigraphic interpretations in this interval. Steepened latitudinal temperature gradients, surface water reorganizations, corrosive deep ocean currents and sea level changes caused diachronous range tops and first appearances, besides issues with preservation and reworking (see Coxall and Pearson, 2007 for an overview). Biostratigraphy based on the organic walled remains of dinoflagellates (dinocysts) has shown potential for the EOT interval in e.g., the Mediterranean, North Atlantic, and Tasman Sea regions (e.g., Brinkhuis and Biffi, 1993; Brinkhuis, 1994; Bujak and Mudge, 1994; Sluijs et al., 2003; Eldrett et al., 2004).

Because many organic-cyst-forming dinoflagellates are ecologically adapted to relatively marginal, shallow marine settings, this group is particularly useful when correlating ancient in- to offshore settings (see e.g., Pross and Brinkhuis, 2005). While analyzing the relatively shallow marine deposits of the Gulf Coast region at St. Stephens Quarry (SSQ), Alabama, USA (see Fig. 1; see also Wade et al., 2012) we recorded an unusual dinocyst within lower Oligocene sediments calibrated against magnetosubchron C13n (Wade et al., 2012). It appears morphologically related to representatives of the genus *Pentadinium* but differs by displaying extraordinarily wide separation of the outer wall from the inner wall. This taxon was reported earlier from multiple localities within the lower Oligocene of the Gulf Coast region (Fig. 1) by Jaramillo and Oboh-Ikuenobe (1999) as '*Pentadinium* sp. A'. Our study now confirms its consistent presence in the lower Oligocene in this region and the morphological stability of the species. The latter aspect warrants a separate taxonomic position. Here, we thus describe and document this biostratigraphically useful, new species, and propose placing it within the genus *Pentadinium*.

## 2. Material and methods

### 2.1. Material

The St. Stephens Quarry borehole (SSQ, St. Stephens, Washington County, Alabama, USA; 31°33′ N lat., 88°02′ W long., see Fig. 1) was continuously cored by ARCO Oil and Gas Company in 1987 (Miller et al., 1993; Wade et al., 2012). The cored interval mainly consists of silts, clays and sands with varying carbonate content. This succession is interrupted by thin siliciclastic and glauconitic beds (Miller et al., 2008). Details of the lithology can be found in Miller et al. (2008). The studied interval of the SSQ bore hole contains the following typical Gulf Coast lithostratigraphic units: the Jackson Group and the Vicksburg Group. These units can be subdivided into several formations and their respective members (Fig. 2). The Jackson Group is composed of the Moodys Branch Formation and the Yazoo Clay. The Yazoo Clay can furthermore be subdivided in the

* Corresponding author at: Research Unit Palaeontology, Department Geology and Soil Science, Ghent University, Krijgslaan 281 S8/WE13, B-9000 Ghent, Belgium. Tel.: +32 9 264 46 10.
*E-mail address:* willemijn.quaijtaal@ugent.be (W. Quaijtaal).

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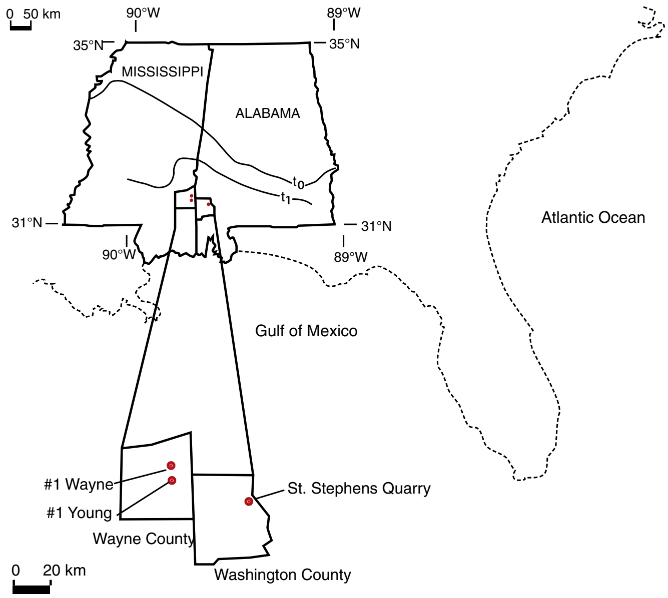


**Fig. 1.** Locations of the localities where *Pentadinium alabamensis* has been recorded. $t_0$: paleoshoreline during accumulation of Shubuta Clay and equivalents, $t_1$: paleoshoreline during accumulation of Red Bluff Clay and equivalents (adapted from Jaramillo and Oboh-Ikuenobe, 1999, paleoshorelines after Tew and Mancini, 1995).

following members: 1) the North Twistwood Creek Member, 2) the Cocoa Sand Member, 3) the Pachuta Marl Member and 4) the Shubuta Member. The Vicksburg Group at SSQ contains the Bumpnose Limestone, the Red Bluff Clay, the Marianna Limestone and the Byram Formation. The Glendon Limestone Member is the lowest member of the Byram Formation.

A total of 59 samples have generally been taken every ~1.5 m, and ~0.3–0.6 m for the EOT interval (see Fig. 2).

For the age model we follow Wade et al. (2012), which provides an update from the earlier data presented by e.g., Miller et al. (2008) (see Fig. 2). This update mainly regards the identification of a ~200 kyr hiatus – associated with the Oligocene Isotope-1 Event (Oi-1) – near the base of magnetosubchron C13n, whereas Miller et al. (2008) thought SSQ to be complete at this point. The age model is based on magnetostratigraphy, $\delta^{18}O$ correlations and biostratigraphy (see Fig. 2).

### 2.2. Methods

Standard palynological techniques have been used to process the samples. Briefly: samples were cleaned and crushed before oven drying at 60 °C. Dried samples were then weighed. Material was first rehydrated with the wetting agent Agepon® (1:200). Then, to remove carbonates, hydrochloric acid (HCl, 10%) was added. Next, to dissolve silicates, 38% hydrofluoric acid (HF) has been used, followed by shaking at ~250 rpm for 2 h and addition of a surplus of 30% HCl to remove fluoride gels. Samples were washed twice by decanting after a 24 h settling and filling up with water after each acid step. Samples were first sieved with a 250-µm nylon mesh sieve; the filtrate was again sieved with a 15-µm nylon mesh sieve. The sample was shortly placed in an ultrasonic bath to break up clumped residue. The sieved residue was transferred into a glass test tube. Test tubes were centrifuged at 2000 rpm for 5 min without brake. Water surplus was removed and the residue was transferred into a vial with addition of glycerin water. After homogenization, one drop of the residue was mounted on a microscopic slide together with some glycerin jelly and stirred. Slides were covered with a cover slip and sealed with nail polish. Per sample two slides have been prepared. A minimum number of 200 dinocysts was counted; afterwards the uncounted

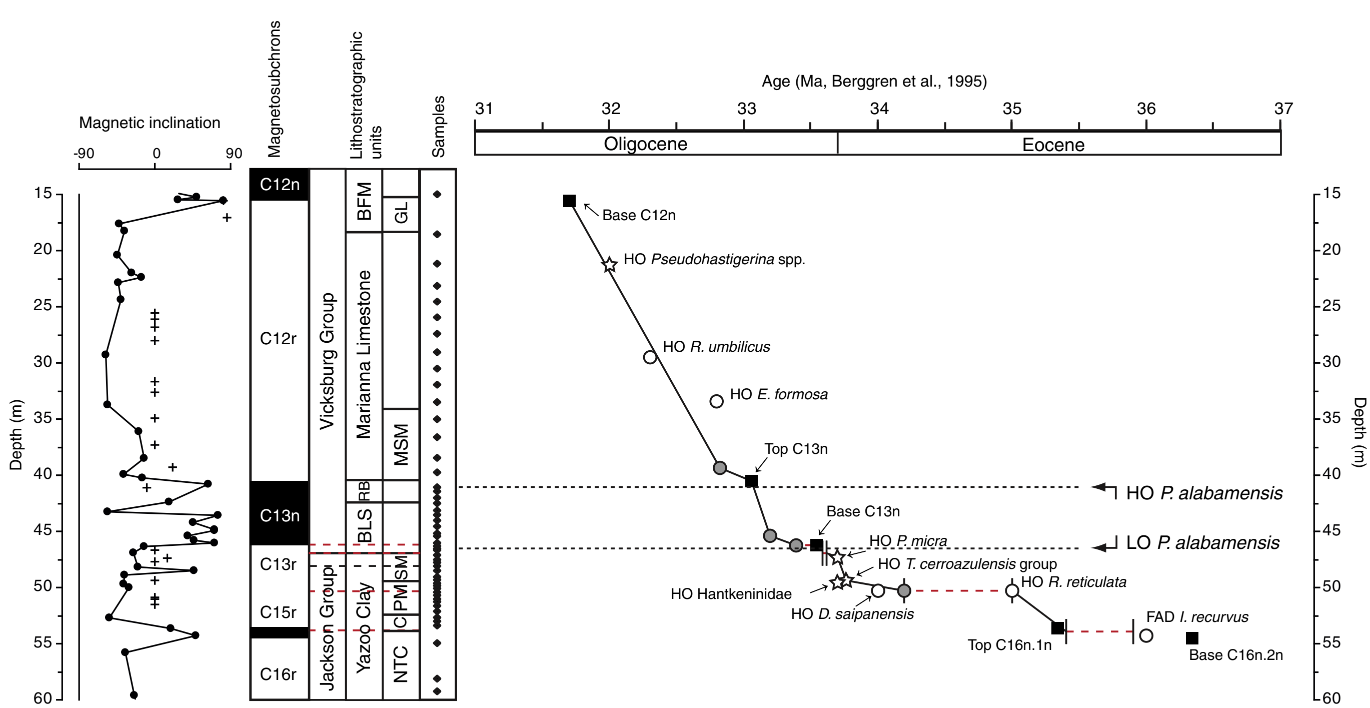


**Fig. 2.** Magnetic inclination, magnetostratigraphy, lithostratigraphic units, samples analyzed for palynology and age-depth plot for the St. Stephens Quarry core. Plusses indicate samples with erratic paleomagnetic behavior. Age model is based on magnetostratigraphy (black squares), $\delta^{13}C$ correlations (gray circles) and biostratigraphy (white circles: calcareous nannoplankton, stars: planktonic foraminifera) (Miller et al., 2008). Tie points used for the age model are connected by a solid black line. Hiatuses are indicated by horizontal red dashed lines, the black dashed line in Yazoo Clay indicates a parasequence boundary. Highest and lowest occurrences of *Pentadinium alabamensis* have been indicated by black dotted lines. The Oi-1 event and corresponding hiatus are located at the base of C13n. HO: highest occurrence, LO: lowest occurrence, FAD: first appearance datum, BLS: Bumpnose Limestone, RB: Red Bluff Clay, BFM: Byram Formation, NTC: North Twistwood Creek Member, C: Cocoa Sand Member, PM: Pachuta Marl Member, SM: Shubuta Member, MSM: Mint Spring Marl Member, GL: Glendon Limestone Member.