

SUPPLEMENTARY INFORMATION

Material

IODP Expedition 302 cored site M0004A on the Lomonosov Ridge (87.87°N; 136.18°E) at 1288 meter water depth (Backman et al., 2006). Cores from several lithological units were recovered, including Unit II between 223.56 and 313.61 meter below sea floor (mbsf) (Moran et al., 2006). This Unit is characterized by very dark gray mud-bearing biosiliceous ooze and shows microlaminations on submillimeter-scale with dark, organic-rich laminae alternating with lighter, marine siliceous laminae (Backman et al., 2006; Brinkhuis et al., 2006). Core 11X, between 297.31 and 302.63 mbsf, is unusual in that it contained extreme abundances of remains of the freshwater fern *Azolla* between 298.81 and 302.63 mbsf. For the underlying Core 12X, between 301.35 and 306.35 mbsf, only 0.4% of sediment was recovered from the core catcher, which still contained *Azolla* remains. There was no recovery for cores 13 and 14. Core 15, between 313.35 and 315.35 mbsf, comprised 13% of recovered sediment, which no longer contained *Azolla* remains. Thus, the onset of the *Azolla* interval is uncertain from available information on the Lomonosov Ridge, it is located somewhere between Core 12 and Core 15. The '*Azolla* interval' as referred to in this publication, points to the recovered part of this interval from 298.81 to 302.63 mbsf).

Age assessment

Sedimentation rates for the mid-Eocene section including the *Azolla* interval were initially estimated at 12.7 m/m.y. (Backman et al., 2008). However, recently performed wavelet analysis for parts of this interval (Pälike et al., 2008) has shown that sedimentation rates are comparable to the overlying Eocene section (Unit 2, Core 302-M0002A-55X), which are estimated at ~20 m/m.y. by Pälike et al. (2008) and 24.3 m/m.y. by Backman et al. (2008). Based on a sedimentation rate of 24.3 m/m.y., a minimum duration of 160 k.y. was estimated for that part of the *Azolla* interval recovered during ACEX (Speelman et al., 2009). The absolute age of 48.1 to 49.3 Ma (based on the Gradstein et al., 2004 time scale) and full maximum duration of 1.2 m.y. of the *Azolla* interval can be inferred from high-latitude sites in the North Atlantic Ocean (e.g., Ocean Drilling Program ODP Leg 151 Site 913; Eldrett et al., 2004), which received modest amounts of *Azolla*, presumably transported from the Arctic Ocean (Speelman et al., 2009).

Palynological analysis

Fifty-four samples with 10 cm spacing were processed for palynology at the Laboratory of Palaeobotany and Palynology at Utrecht University using HCl (30%) and cold HF (40%) with no oxidation and sieving over a 15 and 250 µm mesh (for details see Wood et al., 1996). Slide-mounted residues were examined under the light microscope. For dinocyst quantification a minimum of 200 dinocysts was counted for most samples. Dinocysts were identified following nomenclature cited in Fensome and Williams (2004); environmental interpretations followed Pross and Brinkhuis (2005), Sluijs et al. (2005) and Sluijs and Brinkhuis (2009). Other aquatic palynomorphs counted include remains of the freshwater fern *Azolla*, acritarchs, and remains of fresh to brackish water algae like *Cymatiosphaera* spp. and *Tasmanites* spp. Percentages of *Azolla* were calculated based on the total aquatic assemblages. Percentages of individual dinocyst taxa were based on the total dinocyst counts to prevent overprint of the freshwater signal. Also for the terrestrial palynomorph assemblage a minimum count of 200 pollen and spores was aimed for. However, since some samples yielded only little terrestrial palynomorphs, counts were normally between 100 and 245 specimens, with an average of about 180. Pollen and spore identification was based on Moore et al. (1991) and McIntyre (1991). Furthermore, spores were counted. Pollen percentages were calculated on the total of all angiosperm and gymnosperm pollen, excluding bisaccate pollen to prevent bias by long-distance transport. Bisaccate pollen percentages were calculated relative to the total pollen.

Time series analysis

Time series analysis was performed on the palynomorph records and on selected species records in the depth domain. For this analysis *Analyseries* version 1.1.1 (Paillard et al., 1996) was used, applying the Blackman-Tukey spectral analysis, using compromise settings and a 90% confidence interval. Power spectra were calculated and a Gaussian bandpass filter was reconstructed, which were plotted together with the data (see Fig. 2A-H).

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