**SUPPLEMENTARY METHODS**

**Micropaleontology**

Foraminiferal and nannofossil abundances are given as qualitative ranges, in terms of specimens observed per field of view for nannofossils, and in terms of total specimens observed on the sample tray for foraminifera, as described in Gulick et al. (2017). Palynological samples were processed using modifications of standard techniques described by Traverse (2007). For the terrestrial palynology, pollen and spore grains were counted up to a minimum of 300 specimens where possible. For the dinoflagellate palynology, dinoflagellate cysts were counted up to a minimum of 200 specimens where possible. Quantitative palynological abundances are expressed in terms of specimens per gram, using a *Lycopodium* spike (Stockmarr 1971). Interpreted paleoecologies for pollen and spores are based on Smith et al. (2020a, 2020b). The D/S ratio between dinoflagellate cysts (D) and pollen/plant spores (S), a proxy for marine/terrestrial input, is described in Warny et al. (2003). Quantitative species counts for terrestrial palynomorphs and dinoflagellates were performed separately. For this reason, sample depths for the dinoflagellate assemblage are not identical to the sample depths for the absolute abundance estimates or the terrestrial palynomorph assemblage. The terrestrial palynomorph samples are stored at the Center for Excellence in Palynology (CENEX) at Louisiana State University, Baton Rouge, USA and the dinoflagellate samples are stored at the collection of the Division of Geology, KU Leuven, Leuven, Belgium. Paleontological data, including abundances and a list of pollen/spore taxa with their interpreted botanical affinities and paleoecologies, is provided in the supplementary material.

**Isotope analysis**

Samples for δ15N and δ13CTOC (n = 51) analyses were prepared at the Advanced Instrumentation Laboratory, University of Alaska Fairbanks, by acidifying approximately 0.5 gram subsamples of powdered material with an excess of 1 M HCl. The acid-insoluble residues were neutralized, freeze-dried and analyzed for their TOC and TN contents using a Costech Elemental Analyzer (ECS 4010). The TOC/TN ratio is given on a weight basis. Carbon and nitrogen isotope ratios were measured using a Conflo III interface with a Delta+XP mass spectrometer. The IRMS was connected to the Costech Elemental Analyzer. The isotope ratios were reported using conventional delta (δ) notation relative to the VPDB and Atmospheric-air standards, respectively. Typical instrumental precision for both types of analysis was <0.2‰.

**Clay mineralogy**

Clay mineral assemblages were identified by X-ray diffraction (XRD) on oriented mounts of non-calcareous clay-sized particles (<2 μm). The procedure described by Moore and Reynolds (1997) was used to prepare the samples. Diffractograms were obtained using a Bruker D4 Endeavor diffractometer with CuKα radiations, LynxEye detector, and Ni filter, under 40-kV voltage and 25-mA intensity. Three preparations were analyzed, after air-drying, ethylene-glycol solvation and heating at 490 °C for two hours. The goniometer scanned from 2.5° to 28.5° for each run. Clay minerals have been identified by the position of their main diffraction peaks on the three XRD runs, while semi-quantitative estimates have been produced in relation to their area (Moore and Reynolds 1997). Areas have been determined on diffractograms of glycolated runs with MacDiff 4.2.5. (Petschick 2001). The measured smectite/illite ratio (S/I) corresponds to the ratio between the glycolated 17-Å peak area (defined here as smectite) and the 10-Å peak area (defined as illite), after ethylene-glycol solvation.

**Magnetic analysis**

Twelve bulk-rock samples were collected for magnetic measurements from core M0077. The low-field magnetic susceptibility was measured with a MFK1 instrument operating at 200 A/m peak field and 976 Hz frequency. The sample mass (ca. 10 g) was determined with a 10 mg precision to obtain a mass normalized susceptibility (χ). Anhysteretic remanent magnetization (ARM) and isothermal remanent magnetization (IRM) were measured with a SQUID magnetometer (2G Enterprises, model 755R, with noise level of 10−11 Am2) with an attached automatic alternating field (AF) 3-axis demagnetization system (maximum peak field 170 mT) placed in a magnetically shielded room. ARM was imparted using a 100 mT alternating field and a 100 µT bias field. IRM was imparted with a 1 T field. ARM and IRM were demagnetized with AF of 30 mT, and their intensity after demagnetization are noted ARM30 mT, and IRM30mT. IRM was further demagnetized with AF of 100 mT, and intensity after demagnetization is noted IRM100mT. ARM and IRM moments were mass normalized, the sample mass (ca. 4 g) being determined with a 10 mg precision. All magnetic measurements were performed at CEREGE (Aix-en-Provence, France).

**Biomarker methods and analyses**

A detailed description of the biomarker extraction and analyses can be found in the supplementary material of Schaefer et al. (2020). Samples were prepared and extracted at Western Australian Organic and Isotope Geochemistry Centre (WA-OIGC) at Curtin University, Perth Australia.

**Extraction**

The pre-cleaned core samples were ground and Soxhlet extracted (72 h using a solvent mixture of DCM:MeOH, 9:1, v/v). Elemental sulfur was removed with activated copper powder. The excess solvent was carefully removed under a gentle stream of nitrogen and the extracts weighed. The weighed extracts were fractionated by small-scale column liquid chromatography into saturated hydrocarbon, aromatic hydrocarbon and polar fractions.

**Gas Chromatography-Mass Spectrometry (GC-MS)**

The saturated and aromatic hydrocarbon fractions were dissolved in *n-*hexane and analyzed by coupled gas chromatography - mass spectrometry (GC–MS). The analyses were performed using an Agilent 5975B MSD interfaced to an Agilent 6890 gas chromatograph, which was fitted with a DB-1MS UI capillary column for saturated fractions (J and W Scientific, 60 m, 0.25 mm i.d., 0.25 μm film thickness) and a DB-5MS UI capillary column for aromatic fractions (J and W Scientific, 60 m, 0.25 mm i. d., 0.25 μm film thickness). Helium was used as carrier gas. Saturated and aromatic hydrocarbons were identified by comparison of mass spectra and by matching retention times with those of reference compounds reported previously (Grice et al., 2007, 1996). Analyses were performed at WA-OIGC at Curtin University, Perth, Australia.

**Gas Chromatography-Triple Quad- Mass Spectrometry (GC-QQQ-MS)**

The saturated and aromatic fractions were simultaneously analyzed by GC-QQQ-MS for carotenoids and dinosteranes (French et al., 2015). The GC-QQQ-MS was achieved using an Agilent 7890B GC coupled with an Agilent 7010B Triple Quadruple MS operated in multiple reaction monitoring (MRM) mode. The gas chromatograph was fitted with a DB-5MS UI capillary column (Agilent 122-5562 UI, 60 m, 0.25 mm i. d., 0.25 μm film thickness). The collision energy for all compounds was 5 eV except for the carotenoids with 10 eV. The following transitions were monitored *m/z* 414 → 231 (dinosteranes), *m/z* 558 → 123 (β-carotane), *m/z* 554 → 134 (chlorobactene & okenane), *m/z* 552 → 134 (β-isorenieratane), *m/z* 546 → 134 (isorenieratane) and *m/z* 376.3 → 221 (D4-C27ααα cholestane). D4-C27ααα cholestane was added as an internal standard. The analytes were identified by comparison with reference standards, matching retention times and elution order. Analyses were performed at Massachusetts Institute of Technology, Cambridge, MA, USA.

**High Performance Liquid Chromatography – Single Quadrupole Mass Spectrometry (HPLC/MS)**

Aliquots of the polar fractions were dissolved in hexane:2-propanol (99:1, v/v) to a concentration of 2 mg/ml and filtered through a 0.45 µm PTFE filter prior to analysis. Detection of GDGTs was achieved using a Waters Alliance 2695 high performance liquid chromatograph (HPLC) coupled to a Micromass ZQ single quadrupole mass spectrometer. The HPLC was fitted with two Waters BEH HILIC columns (2.1 × 150 mm, 1.7 µm) and a guard column of the same material, which were maintained at 30 °C. GDGTs were eluted applying the gradient program described by Hopmans et al. (2016). The mass spectrometer was equipped with an atmospheric pressure chemical ionization (APCI) interface operated in positive ion mode. Source conditions were as reported in Weidenbach et al. (2017). GDGTs were detected by selected ion recording (SIR) of their [M+H]+ ions (dwell time = 200 ms) according to Hopmans et al. (2000) and quantified by integration of peak areas using the QuanLynx application of MassLynx (Version 4.1 SCN856). Calculation of TEX86 and TEX86H followed Schouten et al. (2002) and Kim et al. (2010).Analyses were performed at the Department of Geochemistry, Institute of Geosciences, Christian-Albrechts-University, Kiel, Germany.

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