

IODP Expedition 369: Australia Cretaceous Climate and Tectonics

Site U1516 Summary

Background and Objectives

IODP Site U1516 (proposed Site MBAS-10C) is located in the south central Mentelle Basin (MB). The basin is adjacent to the Naturaliste Plateau and was located at ~60°S paleolatitude during the mid-Cretaceous. The main objectives for coring Site U1516 were (1) to obtain a continuous and expanded Cenozoic and late Cretaceous pelagic carbonate sediment record in the MB to reconstruct climatic shifts across the rise and fall of the Turonian and early Eocene hot greenhouse climates; (2) to determine the relative roles of productivity, ocean temperature, and ocean circulation at high southern latitudes during Cretaceous oceanic anoxic events (OAEs) and across Eocene hyperthermals; and (3) to characterize how oceanographic conditions changed during the Cenozoic opening of the Tasman Passage and the restriction of the Indonesian Gateway.

Operations

Four holes were cored at this site. Hole U1516A was an advanced piston corer (APC)/half-length APC (HLAPC) hole to 223.6 m DSF. Hole U1516B, a ~15 m deep APC hole, was completely sectioned into 30 cm whole rounds on the catwalk for postexpedition analyses. Hole U1516C was drilled without coring to 196 m DSF and then cored with the rotary core barrel (RCB) system to 541.6 m DSF. Finally, Hole U1516D was cored to recover an additional copy of the Cenomanian/Turonian boundary interval. We drilled without coring to 458 m DSF, after which four RCB cores were recovered to 477.6 m DSF.

In total, 476.99 m were recovered from 605 m cored (79%). We recovered 206.57 m from 197.5 m cored (105%) with the APC system, 43.55 m from 42.3 m (103%) with the HLAPC, and 226.87 m from 365.2 m (62%) cored with the RCB. We spent 5.9 d (14–19 November) at Site U1516.

Principal Results

Lithology

Site U1516 is divided into four main lithostratigraphic units (Units I, II, III, and IV) with Unit I divided into three subunits. Unit I is a sequence of calcareous/foraminiferal/nannofossil oozes and chinks with sponge spicules that is Pleistocene to Paleocene in age. Subunit IA consists of pinkish white, pinkish gray, and very pale orange sponge spicule-rich calcareous oozes that are Pleistocene to Miocene in age. Subunit IB consists of sponge spicule-rich calcareous chinks and calcareous chinks with sponge spicules that span the Miocene to Eocene. The transition between Subunits IA and IB is defined by a shift to higher natural gamma ray and bulk density values and

a decrease in L^* values. Subunit IC, Paleocene in age and consisting of claystones, is likely to be a condensed interval. There is an unconformity between the Paleocene and the Turonian that marks the boundary between Units I and II. Unit II is a calcareous chalk that is interbedded with chert that gradually transitions into light greenish gray and greenish gray nannofossil chalk with clay that is also interbedded with chert. The boundary between Units II and III is placed at the Cenomanian/Turonian boundary and is marked by the first occurrence of a black laminated claystone at the top of Unit III. Unit III is an alternating sequence of black, greenish gray, and gray claystone (sometimes with abundant nannofossils), and clayey nannofossil chalk with occasional parallel laminations. Unit IV ranges from the Cenomanian to the Albian and is a sequence of black and dark greenish gray nannofossil-rich claystone and claystone with nannofossils with subtle alternations in color throughout.

Biostratigraphy and Micropaleontology

Coring at Site U1516 recovered a succession of sediments from the Albian through the Pleistocene. Calcareous nannofossils, planktonic foraminifers, and benthic foraminifers occurred throughout this succession, with preservation and abundance sufficient to provide biostratigraphic and paleoecologic information for the entire section. Calcareous nannofossils are abundant to common throughout, with barren samples only in the middle Albian and associated with the Cenomanian-Turonian boundary. Preservation is generally good to moderate, with poor preservation associated only with a condensed Paleocene sequence. Reworking of Paleogene taxa into the Neogene assemblages is common. Preservation of planktonic foraminifera is generally good with some samples in the upper Albian ranked as excellent. Abundance is more variable, with the Neogene, Paleogene and Turonian generally containing abundant planktonic foraminifera while the Albian contains only rare specimens. Benthic foraminiferal abundance and preservation are also variable. In general, examination of benthic foraminifera indicates a bathyal paleodepth during the Albian through Cenozoic.

The Neogene has an average sediment accumulation rate of about 18 m/My from the Pleistocene through the upper Miocene. Much of the middle and lower Miocene are missing at a disconformity with an estimated 8 My hiatus. The lowermost Miocene and uppermost Oligocene are present at this site, and separated from the lower Oligocene by a disconformity with about 4 My missing. The lower Oligocene through middle Eocene has an average accumulation rate of approximately 8 m/My. This sequence is separated from the Turonian by a condensed interval containing several biostratigraphic units of the middle Paleocene. The lower Paleocene through upper Turonian is missing at a disconformity with a hiatus of at least 29 My. The middle Turonian through upper Albian has an average sediment accumulation rate of about 8 m/My.

Paleomagnetism

Natural remanent magnetization (NRM) of all archive-half core sections of Holes U1516A, U1516C, and U1516D were measured. The archive halves were stepwise treated with up to 20 mT alternating field (AF) demagnetization and measured with the pass-through

superconducting rock magnetometer (SRM) at 5 cm intervals. The NRM intensity of the recovered sedimentary cores is in the order of 10^{-6} to 10^{-1} A/m and lithostratigraphic Unit I, which consists of mainly calcareous oozes and chalk, generally displays weak magnetism. Despite the weak NRM of the calcareous oozes/chalk in Unit I, the demagnetization results show that inclinations after the 20 mT demagnetization display zones of dominantly positive and negative values; this defines a magnetic polarity sequence from Chrons C1n (Brunhes Chron) to C22r for the upper ~430 m, with a total of 84 identified and dated reversals. The magnetic polarity sequence is interrupted by a sedimentary hiatus at ~270 m CSF-A based on biostratigraphic constraints. Below ~430 m CSF-A, inclinations of lithostratigraphic Units II, III, and IV, which mainly consist of claystones, exhibit predominantly negative values, indicating a normal polarity. The normal polarity zone spans ~430 m to 525 m CSF-A and is assigned to Chron C34n, the long Cretaceous Normal Superchron, based on shipboard biostratigraphic analysis.

Petrophysics

Physical properties data were collected from Holes U1516A, U1516C, and U1516D. Thermal conductivity shows a minor overall increase downhole, whereas porosity and *P*-wave velocity show a minor overall decrease downhole. In contrast, there is very little variation of bulk and grain density downhole. Exceptions are within the interval between 380 m to 460 m CSF-A, which shows a pronounced excursion toward higher values in bulk density, thermal conductivity, and *P*-wave velocity, a minor excursion toward higher values in grain density, and a strong excursion to lower values in porosity. This interval also corresponds with an interval of relatively high magnetic susceptibility (MS), and the top of an interval of increasing natural gamma ray (NGR) count. Despite the strong correlation between physical properties, this interval does not correlate with lithostratigraphic unit boundaries. NGR and MS show similar overall trends throughout, increasing when the lithology becomes richer in detrital components. At the transition between lithostratigraphic Units II and III (~470 m CSF-A), both NGR and MS increase when approaching the black shale interval possibly related to OAE 2. Enrichment in uranium is notable after deconvolution of the NGR data.

Geochemistry

A total of 57 headspace gas samples were taken for routine safety monitoring, but no gas was detected. For interstitial water (IW) analyses, 52 samples were recovered from whole-round squeezing of Holes U1516A (to 223.6 m CSF-A) and U1516C (244–541.6 m CSF-A). The salinity is generally constant with the exception of distinctly fresher IW in lithostratigraphic Unit IV. This low salinity interval is reflected as decreases in concentration for many elemental profiles, particularly bromide and chloride, and reflects an input of fresher water. The dissolved magnesium, potassium, and calcium concentration profiles possibly reflect alteration of volcanic material from depths below the cored interval for this site. The strontium profile likely reflects carbonate diagenesis. Low levels of sulfate reduction were detected, as sulfate is present but

decreases with depth. Dissolved silicon reflects the presence of biogenic opal A in lithostratigraphic Subunit IA; decreasing concentrations below Subunit IB indicate the opalA/CT transition. Elevated manganese and iron concentrations in parts of Units IA, IB, II, III, and IV demonstrate the reducing character of the sedimentary sequence in these intervals.

A total of 43 bulk sediment samples were collected to ~540 m CSF-A. Additional samples were measured from the suspected OAE 2 interval. The CaCO₃ content varies from 0% to 94%, reflecting variations in lithology. The total organic carbon (TOC) was 0% to 1.2%, except in one sample where TOC reached 14%. Total nitrogen was generally below detection limit. Eleven samples including that from the possible OAE 2 black claystone were analyzed using the source rock analyzer. A sample from the top of an 8 cm thick black layer shows the highest TOC (14%) and hydrogen index (352 mgHC/gTOC), indicating Type II kerogen. T_{max} values indicate that the organic matter is thermally immature.

Stratigraphic correlation

Cores from Hole U1516A provide a 225 m thick, continuous record of middle Miocene to recent deposition that seems to be biostratigraphically and magnetostratigraphically complete. In Hole U1516C, coring gaps limit constraint of the early Miocene, much of the Oligocene, and portions of the Eocene, but both the Oligocene/Miocene boundary interval and a 30 m long interval spanning the late Eocene were well recovered. In addition, much of the late Cretaceous, all of the Paleocene, and much of the early and middle Eocene is either missing or represented in a 15 m thick interval of condensed deposition and/or erosion and nondeposition spanning from Core U1516C-25R to U1516C-26R-4, 106 cm (416.8–430.51 m CSF-A). In contrast, an excellent record of late Albian to middle Turonian in Holes U1516C and U1516D was recovered, including a seemingly complete splice across the OAE 2 interval.