IODP Expedition 369: Australia Cretaceous Climate and Tectonics

Site U1515 Summary

Background and Objectives

Site U1515 is the westernmost Expedition 369 site and was targeted to provide evidence of the pre-breakup rifting history prior to the final separation of Greater India and Antarctica. The site location was chosen based on seismic evidence of dipping strata below what is interpreted to be the eastward extension of the Valanginian unconformity previously cored at Site U1513 in the western Mentelle Basin (MB). The extrusive basalts that cover this unconformity in the western MB are not present at Site U1515. Structural interpretations suggest that depocenters in the eastern MB are older (Permian? to Jurassic) than those in the western MB (Jurassic?). Site U1515 is the first sampling of this eastern depocenter and will test the hypothesis of Early Mesozoic rifting. Cores recovered from this site will allow investigation of the tectonic and structural relationships with similar aged rifts along the western margin of Australia as well as rift structures in the Antarctic conjugate margin.

Operations

The ship arrived on site at 0000 h on 10 November, covering the 62.5 nmi transit in 6.3 h. The acoustic positioning beacon was deployed at 0046 h. Operations at Site U1515 consisted of coring a single hole (33°16.1890′S, 114°19.3666′E) with the rotary core barrel (RCB) system. Hole U1515A was started at 0650 h on 10 November. We recovered Cores 1R to 55R to 517.1 m by 0400 h on 13 November. Cores 3R, 16R to 21R, 25R, 27R and 28R, and 51R and 52R had no recovery. Overall, 55 RCB cores were retrieved with 93.62 m recovered from the 517.1 m cored (18%). The original plan for this site also included a full suite of wireline logging runs. However, hole conditions were generally poor and core recovery was low as a result of intermittent chert layers and unconsolidated sand, so logging was not attempted. While preparing for the transit to the next site, several attempts were made to release the acoustic positioning beacon. The beacon responded, recognizing the command to release, but the release mechanism malfunctioned, similar to Site U1513. The total time on Site U1515 was 3.6 d (10–13 November).

Principal Results

Lithology

The cored section of Hole U1515A is divided into two main lithostratigraphic units (Units I and II), which are further divided into five subunits. Thicknesses of the units are not given because of the poor constraints provided by the overall low core recovery. Unit I (Cores U1515A-1R to 15R) is a sequence of calcareous ooze/chalk with sponge spicules, silicified limestone, bioclastic limestone, chert, sandy limestone, and sandstone (arkose). Subunit IA (Cores U1515A-1R to 8R) consists of light greenish gray calcareous ooze with sponge spicules, whereas Subunit IB (Cores

U1515A-9R to 15R) is generally more lithified and consists largely of calcareous chalk and 10 to 40 cm thick silicified limestone with common chert beds. Due to poor recovery in this interval, the contact between Units I and II was not recovered. Unit II (Cores U1515A-24R to 55R) largely consists of gray to black silty sand and glauconitic sandstones/silty sandstones. Unit IIA (Cores U1515A-24R to 36R) is characterized by abundant glauconite and consists of black to greenish gray silty sand and sandstone. Unit IIB (Cores U1515A-37R to 41R) consists largely of fine to coarse grained sandstones with interbedded siltstone and claystone. This subunit differs from IIA in that it contains less glauconite and more abundant pyrite nodules. Subunit IIB gradually transitions to organic-rich silty sandstone and claystone with coal and plant debris, which are characteristic components of Subunit IIC (Cores U1515A-44R to 55R). The sediments recovered in Unit II are likely mostly terrestrial in origin.

Biostratigraphy and Micropaleontology

Samples from core catchers in Hole U1515A were analyzed for calcareous nannofossils and planktonic and benthic foraminifera. Microfossils occur in the upper part of the hole (Cores U1515A-1R to 15R), while the lower part (Cores U1515A-16R to 49R) is barren of all calcareous and siliceous microfossil groups. Cores below 49R were not sampled. Most of the Neogene and Paleogene samples (Cores U1515A-1R to 14R) indicate reworking of Pliocene, Miocene, Oligocene, and Eocene species. The nannofossil biostratigraphy of Hole U1515A spans from upper Pleistocene Subzone CN14b to upper Campanian Zone CC22. Planktonic foraminiferal assemblages are in good agreement with this stratigraphic determination, spanning from the upper Pleistocene Zone Ptlb through late Campanian/late Santonian *Globigerinelloides impensus* Zone. Benthic foraminiferal assemblages indicate an outer neritic to upper bathyal paleodepth throughout the analyzed interval.

Paleomagnetism

The natural remanent magnetization (NRM) of most of the archive-half core sections and 19 discrete samples collected from the working halves of Hole U1515A was determined. 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. Discrete samples were progressively demagnetized up to 60 mT and measured with the SRM. The NRM intensity of the recovered cores is in the order of 10^{-5} to 1 A/m and broadly covaries with lithology. The demagnetization results show that inclinations after the 20 mT demagnetization step exhibit intervals dominated by positive and negative inclination values, defining a brief magnetic polarity sequence from Chron C1n (Brunhes Chron) to Subchron C1r.2r. Although the magnetic record is noisy and the core recovery is poor, intervals of predominantly normal and reversed polarity can be discerned in the remainder of the sections below 20 m CSF-A. However, a correlation to the geomagnetic polarity timescale is not possible mainly because of the poor core recovery and the lack of biostratigraphic age control.

Petrophysics

As Hole U1515A had overall low core recovery, there is a sparse and discontinuous record of physical properties data, particularly between ~130 and ~270 m CSF-A. Despite this, the data show very broad trends from the top to the bottom of the hole, and some comparisons can be made between the physical properties data and lithology. This includes a general increase in *P*-wave velocity and thermal conductivity (TC), which correspond to a change from unlithified to weakly lithified glauconitic sand, sandstone and interbedded siltstone and claystone (lithostratigraphic Subunits IIA and IIB) to silty sandstone and claystone with coal and plant debris (lithostratigraphic Subunit IIC). This change in velocity (364–373 m CSF-A) also corresponds to an unconformity identified in seismic images. Other broad trends include an overall increase in thermal conductivity as well as an increase in bulk and grain densities, plus an overall decrease in porosity. The color reflection and bulk density data measured from the cores are noisy, but they show some trends that can be correlated with lithostratigraphic units. Similarly, the NGR and MS data also show broad trends and potentially highlight zones where changes in lithology occur (e.g., the highest MS values, high bulk density, and low NGR values at ~270 m CSF-A correspond with glauconitic sandstone).

Geochemistry

The geochemistry program at Site U1515 was designed to characterize the composition of interstitial water (IW) and bulk sediments, and to assess the potential presence of volatile hydrocarbons for routine safety monitoring. A total of 38 headspace gas samples were taken, and no gas was detected. For IW analyses, 17 samples were recovered from whole-round squeezing of sediment intervals between 2.95–77.10 m CSF-A and 287.84–441.60 m CSF-A. Sampling was restricted due to low core recovery at the site, which limits IW interpretation. The salinity of IW samples is generally constant, and alkalinity generally decreases downhole. The dissolved magnesium, potassium, and calcium concentration profiles possibly reflect alteration of volcanic material from depths below the cored interval for this site. Increasing strontium concentrations with depth in lithostratigraphic Unit I may indicate carbonate recrystallization. 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 Unit I; lower concentrations in Unit II indicate the interval falls below the opal-A/CT transition. Elevated manganese and iron concentrations in Unit II demonstrate the reducing character of the sedimentary sequence in that interval.

A total of 33 bulk sediment geochemistry samples were collected down to ~511 m CSF-A (Core U1515A-55R). Within the carbon-rich layers, small chips were taken for analysis. Three distinct intervals were recognized depending on lithology. Carbonate content was very high (~80%–90%) in the uppermost part of the hole, but dropped to nearly 0% below 160 m CSF-A. Lithostratigraphic Subunit IIA and above contained 0%–2.4% total organic carbon (TOC), while IIB and IIC contained up to 46.2%. Nitrogen content (TN) was below 0.05% in Subunits IA, IB, and IIA, but exceeded 0.3% at four horizons in Subunits IIB and IIC, showing a similar pattern

as TOC. In most samples with higher concentrations of TOC (>1%), the kerogen was found to be predominantly terrestrial in origin, except for the interval ~430–460 m CSF-A where an algal contribution to the kerogen is suggested.

Stratigraphic correlation

Only a single hole was cored to 517.1 m DSF at Site U1515 and recovery was 18%. Mixed ages for Cores U1515A-1R through 15R and poor recovery from Cores U1515A-5R to the end of the hole severely limit stratigraphic inferences that can be made from the recovered cores using shipboard data.