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New insights on the Upper Cretaceous Tiger Supersequence of the Bight Basin from International Ocean Discovery Hole U1512

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SUMMARY

The Bight Basin is considered to be one of Australia's most prospective petroleum regions. However, the sparsity of geologic data means that potential petroleum plays in the basin have yet to be firmly established. In late 2017, International Ocean Discovery Program (IODP) Expedition 369 extracted 700 m of core from the Upper Cretaceous Tiger Supersequence from Site U1512 in the western Ceduna Sub-basin. The core represents the most substantial lithological dataset obtained from the basin and the first opportunity to characterise the succession. Two dinocyst zones (the Turonian *Paleohystrichophora infusorides* and the Coniacian *Conosphaeridum striatoconum* zones) assigned at this locality are consistent with shipboard nannofossil zonations. Facies analysis supports deposition by hypopycnal and hyperpycnal flows in a prodelta setting with seismic data suggesting post-depositional deformation in the upper 350 m of the succession. Palynofacies assemblages are dominated by phytoclasts that indicate close proximity to a fluvio-deltaic source. Source rock analyses reveal samples have limited total organic carbon (TOC) values (<1.52%) with little response for S1 due to the immature nature of the samples. However, other datasets suggest that the base of the hole at Site U1512 was close to intersecting potential organic-rich black shales associated with Ocean Anoxic Events 2. The new data provide insights into the Tiger Supersequence in this locality and further work will help refine its character, evolution and the petroleum prospectivity of the region.

Keywords: Bight Basin, U1512, Tiger Supersequence, hypopycnal flow, hyperpycnal flow

INTRODUCTION

The Bight Basin, located on the southern continental margin of Australia, is one of the most underexplored frontier basins in the world (Totterdell et al., 2000). So far, only ten offshore wells have been drilled with limited success and with little or no core recovery. As a result, there is a strong dependence on uncalibrated seismic data to interpret depositional history in large parts of the basin (King and Mee, 2004). The recovery of 700 m of core from Site U1512 by the International Ocean Discovery Program (IODP) Expedition 369 (Figure 1), ~67 km southeast of the industry well Jerboa-1, in the western Ceduna Sub-basin represents the most substantial lithological dataset recovered from the basin to date (Huber et al., 2019). The core consists of 10 m of Pleistocene ooze overlying a 690 m thick uniform succession of Turonian to Santonian-aged silty claystone. Although the Cenomanian–Turonian boundary and black shales associated with Ocean Anoxic Event 2 (OAE2) were not intersected as predicted by regional seismic interpretations, the core nonetheless provides a unique opportunity to assess basin conditions in unprecedented detail during the Cretaceous Greenhouse from southern high latitudes. In this paper, we provide a succinct overview on the character, evolution and implications for petroleum prospectivity of the Tiger Supersequence from the new data acquired from Site U1512.

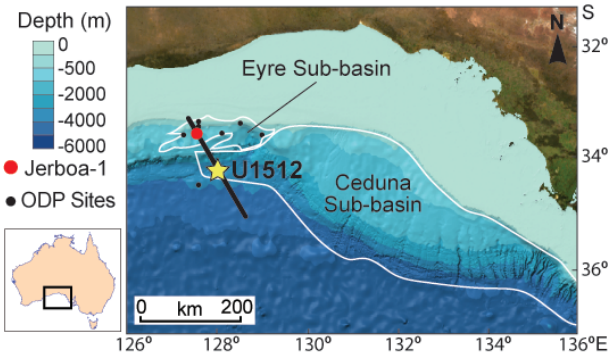

Figure 1. Regional context of Site U1512 in the Bight Basin including the nearby industry hole Jerboa-1, Ocean Drilling Program holes from Leg 182, and the location of 2D seismic line s065-06.

METHOD AND RESULTS

Several methods were applied to characterise the silty claystone succession at Site U1512. Legacy seismic data were matched to newly acquired wireline logs to establish lithological properties away from the hole. Facies analysis was undertaken to deduce depositional processes and paleoenvironments. Forty-nine samples from the succession were selected for palynostratigraphy and palynofacies analysis to complement paleoenvironmental interpretations. Twenty-seven samples (including eight analysed during the expedition) were selected for source rock analysis to establish their total organic content (TOC) and hydrocarbon potential.

Two seismic facies were recognised near Site U1512 on seismic line s065-06 (Figure 1). A lower seismic facies is characterised by semi-parallel reflections that are semi-continuous horizontally with high amplitudes. This facies is interpreted as deepwater sediments. An upper seismic facies is characterised by contorted reflections that are discontinuous horizontally

with overall low amplitudes. This seismic facies may be related to the 80 My hiatus between the Pleistocene sediments in the upper part of the well and the underlying Santonian strata. With the exception of an unconformity within the early Paleocene, strata of post-Santonian age are widespread within the basin and Campanian and Maastrichtian deltaic sediments are particularly well developed (Totterdell et al., 2000). The hiatus at Site U1512 was apparently created by removal of post-Santonian strata in the early Pleistocene, presumably by slumping related to a lowstand in sea level.

Five sedimentary facies were described in the core: 1) silty claystone (the dominating facies comprising ~90 % of the core); 2) claystone; 3) clayey/silty sandstone/silty claystone; 4) sideritic sandstone, and 5) glauconitic sandstone. The massive and laminated silty claystones with discreet grading and sandstones with sub-horizontal parallel lamination or internally low angle laminations suggest deposition by hypopycnal and hyperpycnal flows (Potter et al., 2005; Zavala and Pan, 2018). This is further supported by the calculated rapid sedimentation rates (averaging 63 m/My) (Huber et al., 2019), which far exceed known rates of hemipelagic sedimentation.

The U1512 hole intersects two dinocyst zones: the Turonian *Paleohystrichophora infusorides* Zone and the Coniacian *Conosphaeridum striatoconum* Zone. It is highly probable that the Santonian *Odontochitina porifera* Zone is present above 153 m DSF, but sample preservation prevents its designation at this locality. This is consistent with shipboard nannofossil zonations (Huber et al., 2019). Palynofacies assemblages are dominated by phytoclasts (predominately opaques ranging between 49 and 90 %). There is also a consistent increase in the percentage of translucent phytoclasts up-strata from 701 m (7%) through to 22 m (27%) DSF. This indicates oxidation and reworking of the sediments or close proximity to a fluvio-deltaic source (Tyson, 1993). A combination of palynological and sedimentological datasets support deposition in a prodelta setting.

Finally, SRA results show the samples have limited TOC values (0.81 to 1.52%) with little response for S1 (free hydrocarbons - <0.04 mg/g) due to the immature character of the samples (calculated Ro <0.51).

One significant finding from this study is that below 653 m DSF to the bottom of the hole palynomorph assemblages become more marine in character and TOCs increase (>1 wt%) downhole. This suggests that the base of the hole at Site U1512 was close to intersecting potential organic-rich black shales associated with OAE2. It is highly likely that organic-rich rock from the Cenomanian–Turonian boundary in the Bight Basin could be present at this locality and maybe laterally widespread.

CONCLUSIONS

The integration of seismic, sedimentological, palynological and organic geochemical data obtained from the U1512 core provides new insights into the Tiger Supersequence in the western Ceduna Sub-basin. Facies analysis supports the deposition predominately by hypopycnal and hyperpycnal flows in a prodelta setting, although seismic data suggests syn- and/or post-depositional deformation in the upper 350 m of the succession. Palynological investigations support previous age determination from nannofossil biostratigraphy, whilst palynofacies assemblages are dominated by phytoclasts suggests oxidation and reworking of the sediments or close proximity to a fluvio-deltaic source. The silty claystones have limited hydrocarbon potential in this locality; however, several datasets indicate the base of the hole was close to intersecting organic-rich black shales OAE2. Further work will help to refine the character, evolution and petroleum prospectivity of the Tiger Supersequence.

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