1. SUMMARY AND HIGHLIGHTS OF LEG 122[1]

Shipboard Scientific Party[2]

During Leg 122 we drilled more than 3.5 km of sediments at six sites, including over 1 km of Upper Triassic section. Four of the sites (Sites 759, 760, 761, and 764) were drilled to recover a complete record of the Triassic synrift and Cretaceous-Cenozoic post-breakup sedimentation of the Wombat Plateau, a small sub-plateau of the northern Exmouth Plateau. Two sites (Sites 762 and 763) were drilled to document the Cretaceous to Cenozoic record of paleoenvironmental and passive margin evolution of the western part of the central Exmouth Plateau (Figs. 1 and 2 [in back pocket]). This record comprises a thick clastic shelf-margin wedge that prograded from a southern source area during the Early Cretaceous, overlain by a Cenozoic pelagic sequence.

The northern Exmouth-Wombat Plateau area experienced major deep crustal extension and thinning during the Permian, and this was followed by rifting in the Triassic (Carnian-Norian; Sites 759 and 760) and post-Rhaetian time (Sites 761 and 764). Igneous intrusions and extrusions accompanied pre-Norian and post-Rhaetian deposition, and Jurassic block faulting separated the Wombat Plateau from the Exmouth Plateau by formation of steep south-facing escarpments. The northern escarpment above the Argo Abyssal Plain probably formed synchronously.

We recovered a 900-m-thick sequence of Triassic sediments, of which 30% are carbonates, and the remainder low-energy paralic to fluviodeltaic facies. Carbonate rocks were first deposited on the Wombat Plateau during late Carnian time, in a southern embayment of a shallow Tethys Sea where marginal marine clastics were succeeded by alternating shallow-water carbonates and deltaic siliciclastics. In the Norian, deposition of a >300-m-thick upward-shallowing sequence began, resulting in shallow-marine limestone interbedded with fluviodeltaic silty claystone, grading upward to a deltaic coastal plain facies with algal mats, coal seams, and root-mottled zones indicating periodic emergence. The Wombat Plateau developed a fully marine carbonate platform sequence, with a deeper-water shelf limestone/marlstone section overlain by a >200-m-thick reef complex and related perireefal facies dating from the Rhaetian. These carbonates resemble their coeval strata in the western Tethys region of the Alps. Northward tilting and uplift of the Wombat Plateau resulted in Jurassic emergence and subaerial erosion that removed Jurassic sequences before the onset of Argo Abyssal Plain seafloor spreading. During early Neocomian time the Wombat Plateau sank below sea level and, coupled with the adjacent Argo Abyssal Plain, subsided to bathyal water depths. A condensed sequence of upper Berriasian to lower Valanginian sandstone, belemnite sand, and hemipelagic calcisphere/nannofossil chalk interbedded with bentonite layers documents rapid subsidence from littoral to bathyal depths during the "juvenile ocean stage." The Turonian marks the onset of the "mature ocean stage" and purely pelagic carbonate sedimentation.

The central Exmouth Plateau sites (Sites 762 and 763) recovered a >1400-m-thick composite section of Neocomian synrift deltaic claystone and younger Cretaceous and Cenozoic hemipelagic to eupelagic marls, chalks, and oozes. Sequence stratigraphic analyses of the complete Berriasian to Quaternary succession at Sites 762 and 763, derived from a synthesis of seismic stratigraphy and commercial wells, can now be verified by multiple litho-, bio-, and magnetostratigraphy, as well as by wireline logs. Preliminary results indicate that a thick shelf-margin clastic wedge prograded between Tithonian and Valanginian times from the transform margin south of Site 763 and onto subsiding continental crust. Up to 1500 m of clastic sediments were deposited in less than 15 m.y. over a 300-km-wide depositional wedge, which is easily correlated between the proximal Site 763 and the more distal Site 762. Well-defined wireline-log sequences facilitate correlation of the rapidly deposited progradational prodelta claystone recovered in the Ocean Drilling Program (ODP) holes with seismically detected clinoforms and cored intervals of turbidite deposition that document sea-level lowstands.

The time of breakup of the western and southern margins of the Exmouth Plateau is constrained by the major pre-Barremian erosional unconformity to Hauterivian time, which agrees well with dating from seafloor-spreading anomalies in the adjacent Gascoyne and Cuvier Abyssal Plains. Transgressive intervals are characterized by the presence of condensed sections of thin glauconitic limestones and belemnite-rich mudstones. In Aptian to Cenomanian time, when the southern hinterland was drifting northwestward with greater India, the southern clastic supply was cut off. Cyclic deposition of deep-water claystone during middle to late Aptian time marks the onset of hemipelagic deposition ("juvenile ocean stage").

A stagnant period of oxygen depletion produced a well-developed black shale with up to 15% organic carbon at the Cenomanian-Turonian boundary. Post-Cenomanian deposition gradually became dominated by pelagic carbonate deposition. The Campanian-Eocene unconformity at Site 763, a 30-m.y. hiatus, was probably caused by non-deposition on the continuing topographic high along the southern margin. Pelagic carbonate deposition was continuous in the northern basin (Site 762) and progressively onlapped southward, toward Site 763, reaching that location in the middle Eocene.

After isolating unconformities caused by tectonic events, a sequence stratigraphic approach was used to decipher sea-level fluctuations at each of the six sites. Preliminary results indicate important sequence boundaries on the Wombat Plateau in sediments representing the late Carnian, at the Norian/Rhaetian boundary, and in sediments of latest Rhaetian age, whose timing conforms well with the eustatic cycle chart (Haq et al., 1987). Sequence boundaries recognized in the Lower Cretaceous of the central Exmouth Plateau also correlate well with the global cycle chart but indicate that the pattern of

[1] Haq, B. U., von Rad, U., et al., 1990. *Proc. ODP, Init. Repts.*, 122: College Station, TX (Ocean Drilling Program).

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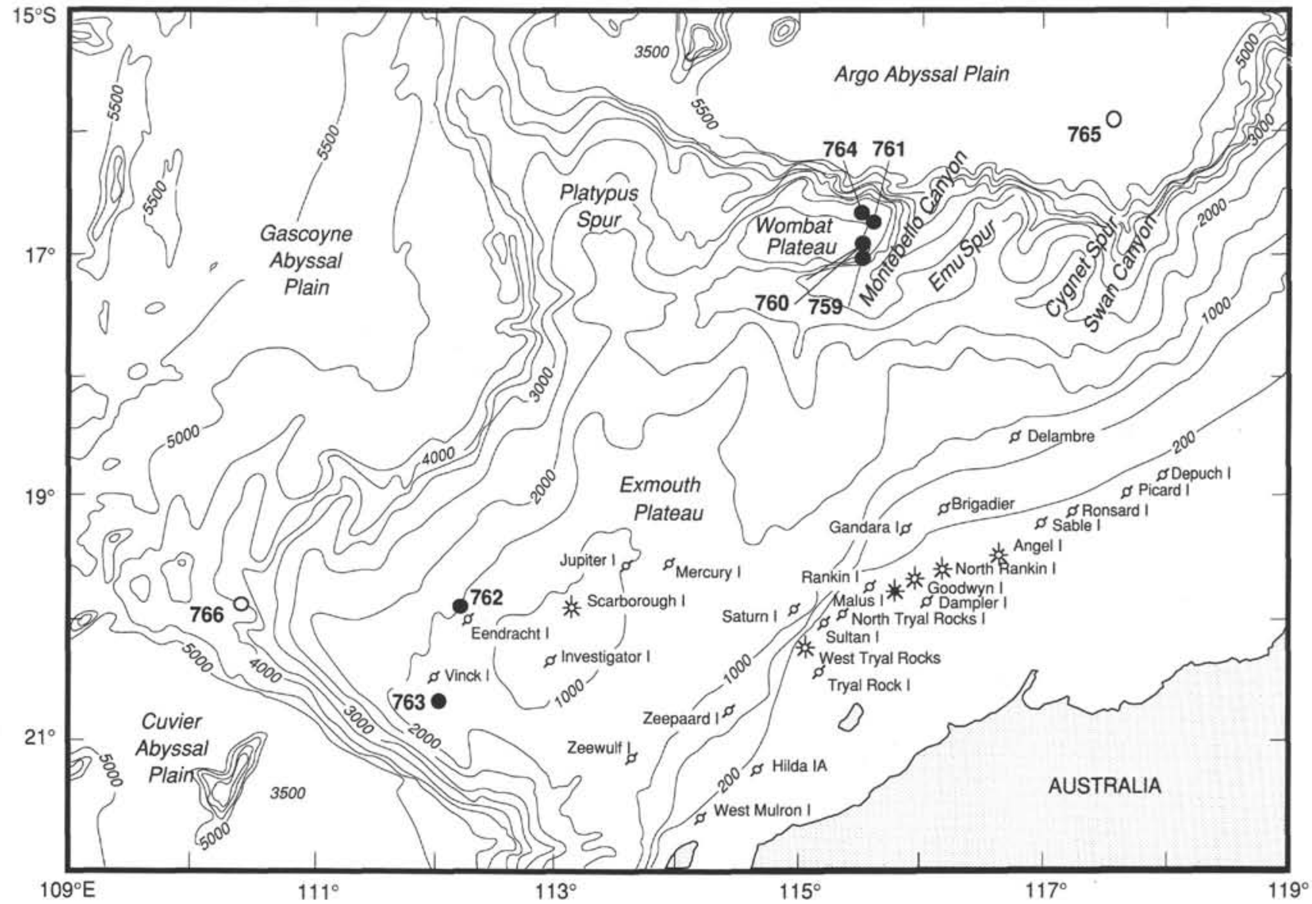

Figure 1. Bathymetric map of Exmouth Plateau region showing location of ODP sites (closed circles = Leg 122 sites, open circles = Leg 123 sites) and commercial wells. Bathymetry is in meters (Exon, unpubl. data).

accumulation of deposits may need to be modified in regions of high sediment supply.

CRUISE HIGHLIGHTS

In summary, Leg 122 results have contributed new data that bear on the tectonic, sedimentary, and paleoenvironmental evolution of marginal plateaus on passive continental margins. Highlights of these preliminary results include the following:

1. On the Wombat Plateau we documented an unconformity between the late Carnian and Norian that marks an earlier episode of block faulting and may constrain the timing of reactivation of the northern Exmouth Plateau hinge zone.

2. "Ground-truthing" of seismic horizons on the Wombat Plateau, by constraining the ages of prominent reflectors, demonstrates that major rifting and block faulting in the region occurred in the Early to Middle Jurassic. Steep north and south escarpments on the plateau developed at this time, culminating in the formation of the Wombat half-graben to the south, rift-flank tilting of the Wombat horst, and eventually leading to the breakup of the Argo Abyssal Plain to the north. Pre-rift strata were tilted gently to the north and may have been subaerially exposed and eroded by wave action. Further tilting at a later time slowly developed a more accentuated northward slope as the now-coupled Argo Abyssal Plain sank. The unexpected complete absence of Jurassic sediments on the Wombat Plateau is also a testament to regional uplift during this major rift stage and its aftermath. Seismic and industrial-well site data suggest that on the central Exmouth Plateau a block-faulting event dated as Early to Middle Jurassic also is evident, and is marked by an unconformity between strata equivalent to the Triassic Mungaroo Sandstone and sediments equivalent to the thin Oxfordian-Kimmeridgian Dingo Claystone.

3. Biostratigraphically constrained dating of the unconformities on the central Plateau has narrowed the age of breakup of the western and southern margins of the Exmouth Plateau to Hauterivian time. The breakup is constrained by the major erosional unconformity between Valanginian-Hauterivian and Barremian–early Aptian sediments.

4. The middle Eocene unconformity at Site 763, which eroded into Maestrichtian sediments, was most likely caused by the site's position on a relative structural high, which was subjected to erosion and preferential planation compared to the section at Site 762.

5. The first occurrence of shallow-water carbonates on the Wombat Plateau derived from the Tethys Ocean in the early to middle Carnian, when marginal marine clastics graded into interbedded carbonates and deltaic facies. We recovered over 900 m of Triassic sediments, of which 30% are shallow-water carbonates and the remainder are low-energy paralic to fluviodeltaic facies. Active delta-lobe migrations modify the stacking patterns in the latter facies. In the Rhaetian, the Wombat Plateau developed a carbonate-platform-type setting. The recovery of an almost complete marine Rhaetian succession is exceptional outside the western Tethys (e.g., the Alps), with which it shows remarkable similarities.

6. Recovery of the thick prograding distal-shelf-margin sequence of the Berriasian-Valanginian (Barrow Group equivalent) will be important in gaining an understanding of depositional processes in clastic wedges by comparison with modern clastic depositional systems such as the Gulf Coast sequences. Dinoflagellate assemblages in these sediments, which otherwise lack microfossils, will be extremely helpful in precisely determining the age of various prograding subunits.

7. The hemipelagic sediments of the Albian-Cenomanian characterize the "juvenile ocean" stage in the evolution of this margin, and the change to purely pelagic sedimentation in the Turonian represents the beginning of the "mature ocean" stage of this passive continental margin.

8. In the recovered stratigraphic record, where tectonic events can be isolated, sea-level fluctuations can be deciphered from sequence stratigraphic analysis of seismic, lithofacies, biofacies, and well-log data. These considerations document important sequence boundaries on the Wombat Plateau such as the middle/late Carnian, the Norian/Rhaetian, and the latest Rhaetian, whose timing and relative magnitude conform well with the eustatic-cycle chart. In addition, the sequence boundary and systems tracts recognized in the central Exmouth Plateau in strata equivalent to the Barrow Group also correspond favorably to the global cycle chart. These preliminary results are of considerable importance in providing a test of the validity of the eustatic model.

9. Discovery of diverse Carnian-Rhaetian calcareous nannofossils on the Wombat Plateau establishes the oldest known occurrence of this fossil group. This will elucidate the early evolutionary history of this group and may enable biostratigraphic subdivision of the Upper Triassic. The recovery of an expanded Paleocene sequence at Site 761, with well-preserved foraminifers, nannofossils, and radiolarians, will be helpful in resolving magnetobiostratigraphic issues for this rarely cored interval. It also offers the opportunity to establish a Paleocene zonation for radiolarians for the first time. Stable-isotope analyses of the Paleocene section and across the apparently complete Cretaceous/Tertiary boundary interval will also provide previously scarce data for this important interval.

10. Rock-Eval pyrolysis of the sediments on the central Exmouth Plateau indicates organic matter to be land-derived material. Organic-carbon values are generally low (1% or less) in the cored intervals, but increases to 15% in one of the thin black shale layers at the Cenomanian/Turonian boundary. Hydrocarbon gases show concentrations of methane in the Upper Cretaceous chalks. The gases, which have a deep source, have bypassed the Lower Cretaceous clastic sequence of the Barrow equivalent strata through migration along faults and have moved into the Upper Cretaceous chalks, which act as a barrier to further upward migration. Thus the pore waters have become charged with dissolved methane.

REFERENCES

Haq, B. U., Hardenbol, J., and Vail, P. R., 1987. Chronology of fluctuating sea levels since the Triassic. *Science,* 235:1156–1167.

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