DEPARTMENT OF
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Record No. 1979/26

PRELIMINARY DEEP SEA SAMPLING RESULTS, R.V. SONNE GEOLOGICAL CRUISES OFF WESTERN AUSTRALIA IN 1979

Compiled by

N.F. Exon

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ABSTRACT

A six-week geological cruise of the West German research vessel Sonne, under the auspices of the Australian-German Science Agreement, has yielded a considerable amount of information about the Exmouth Plateau, the Wallaby Plateau, and the intervening Cuvier Abyssal Plain. The main aim of the cruise was to sample pre-Quaternary strata cropping out on the plateau margins; subsidiary aims were to sample the Quaternary sequence from continental shelf to abyssal plain on two representative profiles, to obtain Quaternary cores for gas analysis, and to search for manganese modules. All four aims were successfully accomplished.

During the cruise 31 single-channel seismic profiles were run to help select sampling targets. On the Exmouth Plateau and adjacent areas 102 stations were successfully occupied, 31 yielding pre-Quaternary rocks. On the Wallaby Plateau and adjacent areas 18 stations were successfully occupied, 13 yielding pre-Quaternary rocks. Samples were obtained from depths ranging from 100 m to 5200 m.

The sampling of pre-Quaternary strata has shed new light on the area. On the northern Exmouth Plateau thick sequences of Early Jurassic shelf carbonates and Middle Jurassic coal measures were found beneath the main (?Late Jurassic) unconformity. Cretaceous shelf and pelagic sediments were also shown to exist. Above the main unconformity there is a condensed sequence of Cainozoic pelagic carbonates. On the northern margin of the Wombat Plateau there is a volcanic sequence at least 300 m thick beneath the main unconformity. On the northwestern Exmouth Plateau Albian and Miocene carbonates were sampled. On the southern margin results were disappointing, but Mesozoic sandstone and shale and Tertiary pelagic carbonates were sampled.

The layered sequence below the main (?Neocomian) unconformity, both on the eastern Wallaby Plateau and on the "Sonne Ridge", which extends northward from the plateau into the Cuvier Abyssal Plain, was shown to consist of interbedded weathered "basalts", tuffs, breccias, and volcaniclastic sediments. This suggests that a thick volcanic pile of Early Cretaceous age forms much of the Wallaby Plateau.

A variety of Quaternary cores, almost all of biogenic carbonates, were obtained on profiles from Rowley Shoals to the Argo Abyssal Plain, and from southwest of Barrow Island to the Cuvier Abyssal Plain. Quaternary cores in the central Exmouth Plateau were sampled for gas analysis; preliminary results indicate that methane is generally present, but in very low amounts. Manganese nodules were obtained from the southern and eastern margins of the Wallaby Plateau, and preliminary determinations of contents of nickel and copper suggest that they are above Indian Ocean averages, but well below a grade of economic interest.

INTRODUCTION

This Record presents station data for sediments and rocks cored and dredged during a six-week cruise of the West German research vessel Sonne in deep water off Western Australia, and makes preliminary comments on the results. The cruise was split into two parts: Cruise SO-8A left Port Hedland on 5 January 1979, concentrated on the northern and western margins of the Exmouth Plateau, and returned to Port Hedland on 24 January; Cruise SO-8B left Port Hedland on 26 January, concentrated on the southern margin of the Exmouth Plateau and the eastern side of the Wallaby Plateau, and berthed in Perth on 15 January.

Sonne's research program was carried out under the auspices of the German-Australian Scientific Agreement, and was supported by the German Ministry of Science and Technology (BMFT) and Ministry of Economic Affairs (BMW). German scientists and technicians came from the Institute of Geoscience and Mineral Resources (BGR), Hannover, and from Kiel University; Australian scientists came from the Bureau of Mineral Resources (BMR), and Monash and Macquarie Universities. The cruise leader was Dr U. von Stackelberg (BGR). The research program had four facets to it:

1. The major BGR and BMR effort was aimed at a better understanding of the geology of Australia's western margin. A great deal of seismic, gravity, and magnetic data was available over the Exmouth Plateau, and had been interpreted (Willcox & Exon, 1976; Exon & Willcox, 1976, 1978). Much less data was available over the Wallaby Plateau but this had been interpreted by Symonds & Cameron (1977). The main aim of the cruise was to sample outcrops on the slopes of both plateaus which could be correlated with the seismic sequences established beneath the plateaus, thus yielding geological information - rock types, age, palaeoenvironment, etc - about the seismic sequences.

   The method generally involved bathymetric and single-channel seismic profiling (31 profiles), and then careful control of the depths sampled by dredging of steep slopes. In some places coring was substituted for dredging.

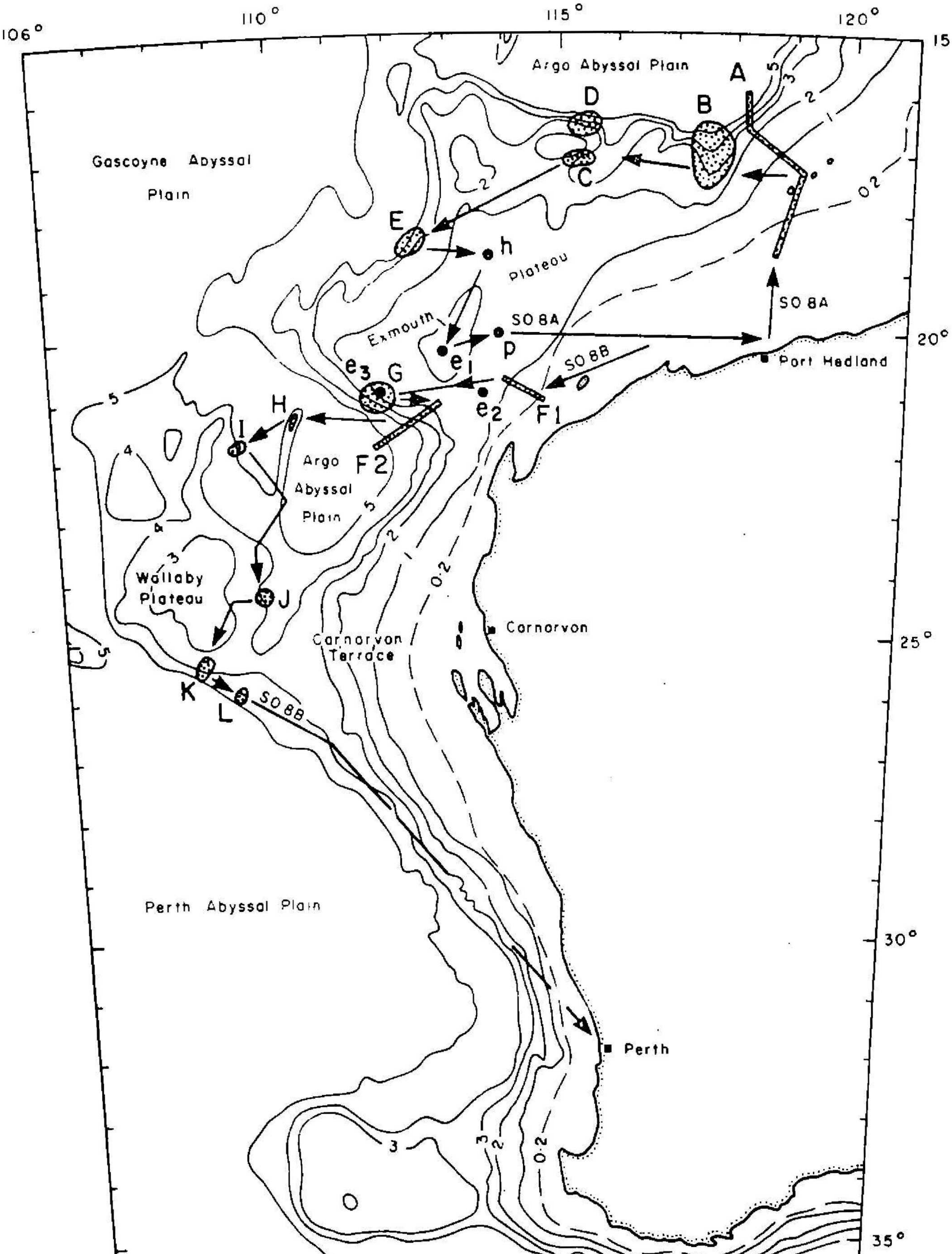
2. A subsidiary effort by Kiel University was an investigation of Quaternary cores along two profiles on the northern and southern parts of the Exmouth Plateau, from the continental shelf to the abyssal plain. This was aimed at an understanding of climatic changes during the Late Pleistocene and Holocene.

3. Another BGR program was designed to sample surface sediments for gases, with a view to predicting what hydrocarbons might be present at depth.

4. A Monash University/BMR program was designed to investigate the presence or absence of manganese nodules in deep water, and their characteristics if present.

The station data are summarised in Tables 1 to 8 where suffixes have been used with station numbers to denote the equipment used. These are GR=grab, KA=short box-corer, KAL=long box-corer, SL=gravity corer, KL=piston corer, BL=free-fall corer, KD=chain dredge. Characteristic lithofacies are designated with the letters A to F in the relevant tables, and the facies are summarised in Table 9. Substantiated palaeontological ages are shown without (and surmised ages with) question marks. Sampling areas are shown in Figure 1, the Exmouth Plateau seismic stratigraphy of Exon & Willcox (1978) is outlined in Figure 2, and the major bathymetric features of the Exmouth Plateau are shown in Figure 3.

This compilation relies heavily on the work of U. von Stackelberg and U. von Rad for sedimentological descriptions, P. Quilty for macrofossils and foraminiferal age determinations, S. Shafik for nannoplankton determinations, G. Chaproniere for foraminiferal determinations, D. Burger for palynological determinations, G. Seibertz and H Beiersdorf for investigation of manganese modules, and K. Herbst and J. Colwell for bathymetric control. We are most grateful to P. Symonds, who selected possible dredging sites for us on the Wallaby Plateau before the cruise.

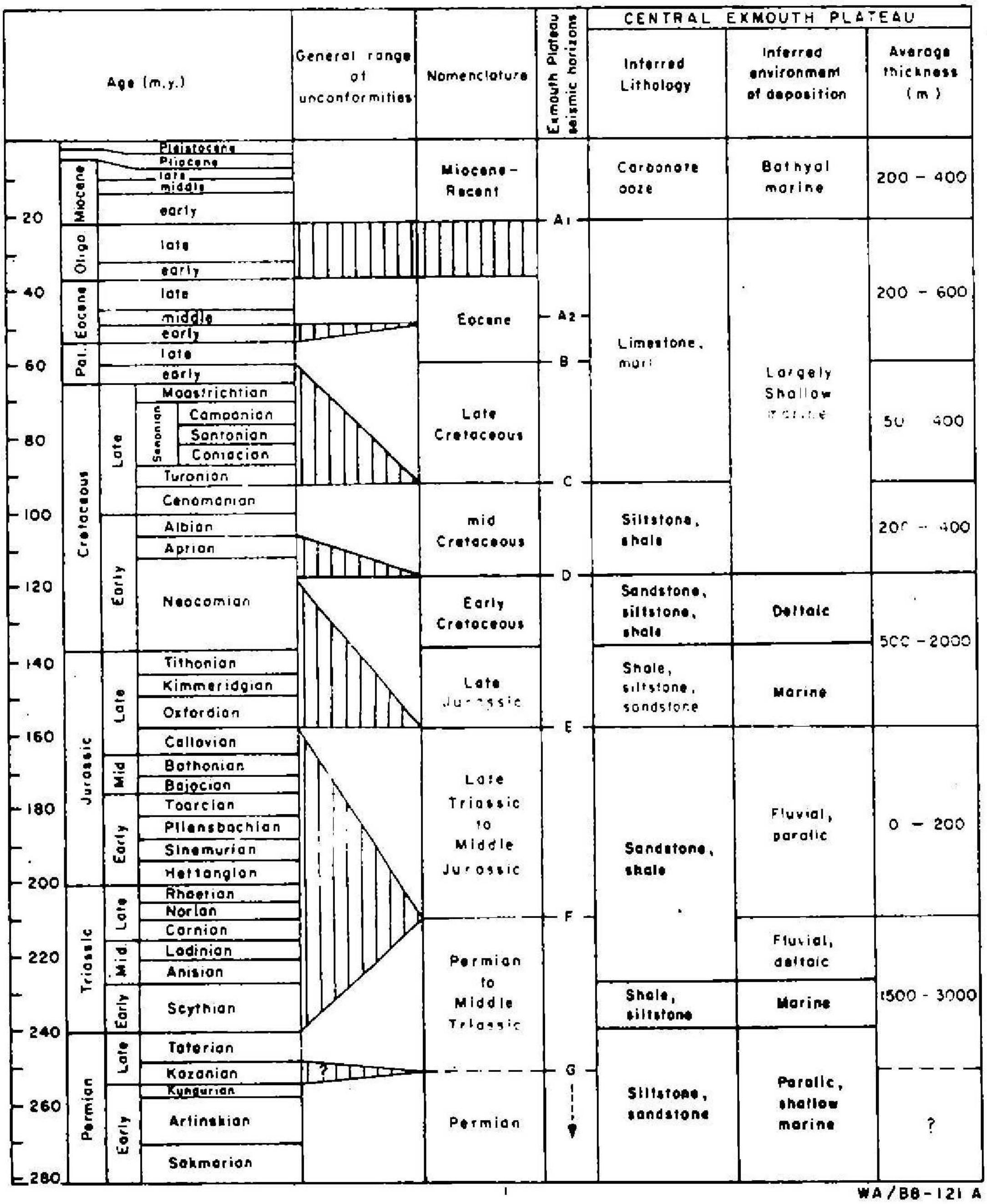


LOCALITY MAP FOR SONNE CRUISE

—2— Isobaths in kilometres

Sediment sampling area

● Gas sampling area



EXMOUTH PLATEAU STRATIGRAPHY,
FROM EXON & WILLCOX (1979)

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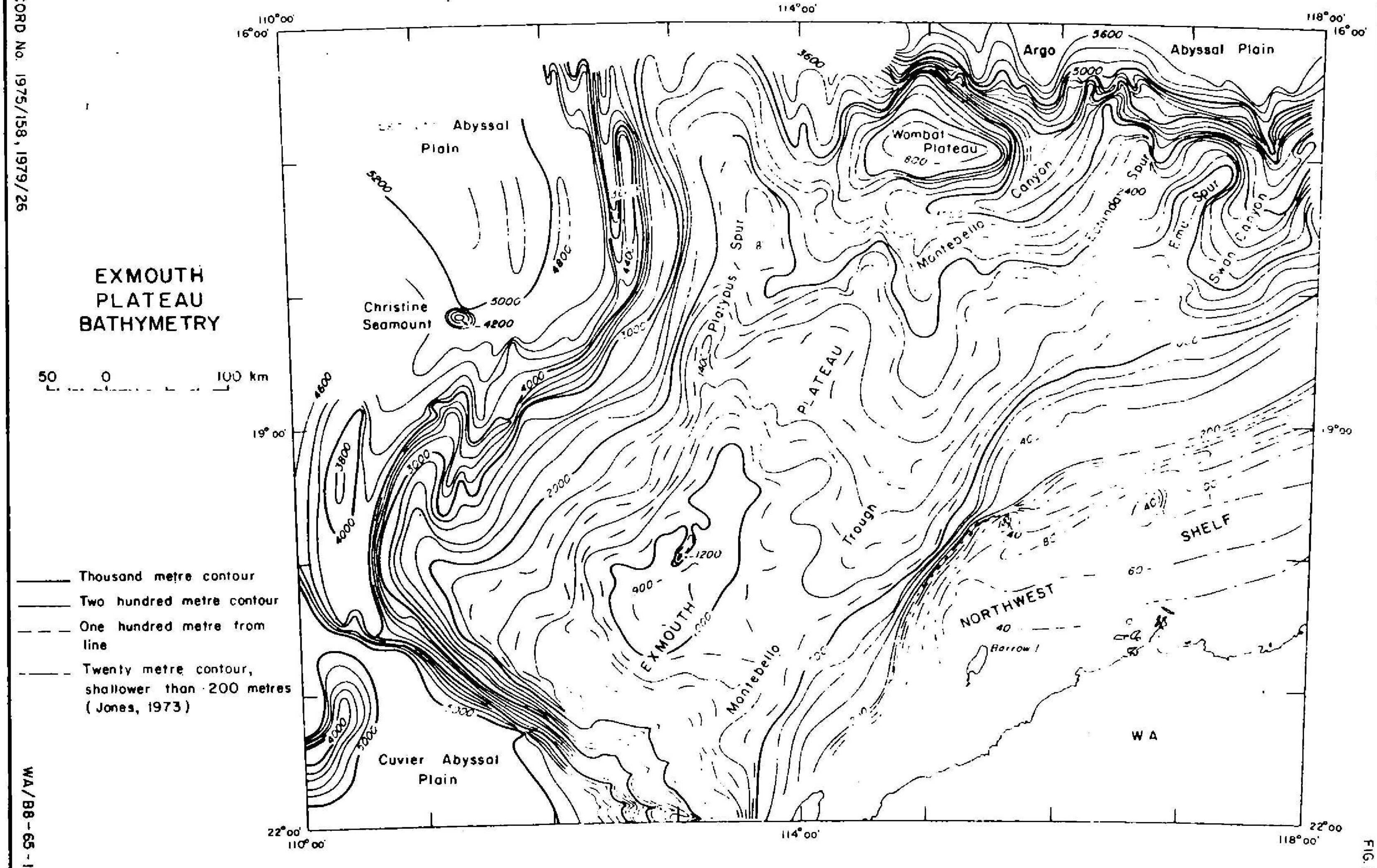
EXMOUTH PLATEAU BATHYMETRY



WA/B8-65-1A

FIG. 3

RESULTS

During the cruise 102 stations were successfully occupied on and near the Exmouth Plateau, and pre-Quaternary rocks were recovered from 31 of them. A further 18 stations were successfully occupied on and near the Wallaby Plateau, and pre-Quaternary rocks were recovered from 13 of them.

The results are handled here on a geographical basis with the exception of the results from the manganese nodule work, which are treated under a separate heading.

Northern Exmouth Plateau

The areas considered under this heading are A, B, C, and D (Fig. 1, Tables 1-4): a Quaternary profile from the Rowley Shoals to the Argo Abyssal Plain; pre-Quaternary outcrops on the western flank of the Swan Canyon (Fig. 3), the eastern flank of its subsidiary the Cygnet Canyon to the west, and the eastern flank of the Emu Spur, the Emu Escarpment, somewhat further west; pre-Quaternary outcrops on the southeast flank of the Wombat Plateau; and pre-Quaternary outcrops on the northern flank of the Wombat Plateau.

The northern margin of the plateau is morphologically and tectonically complex. It is believed to be bounded by transform faults trending northwest, and normal faults (representing the direction of Callovian and younger seafloor-spreading) trending northeast. Within the plateau two fault directions predominate: north to north-northeast over most of its northern extent, and west south of the Wombat Plateau. Many of the bathymetric features in the area are fault-bounded. The reliability of the seismic stratigraphy established in this area by Exon & Willcox (1978) is regarded as low, because of distance to shelf wells and complex faulting.

The sampling along Profile A recovered only Quaternary sediments (Table 1). Calcareous sand predominated above 150 m; marl, foraminiferal ooze, and foraminiferal sand lay between 150 m and 3552 m; calcareous clay predominated below 4900 m; turbidites and red clay are also present on the abyssal plain.

In the Swan Canyon-Cygnet Canyon-Emu Escarpment area (B) slopes of 10-15° are common, a variety of Cainozoic and Mesozoic reflectors were identified, and much of the seismic sequence was sampled. Lithofacies A, the "coal measure association", predominated (Tables 2, 9). This came from below the main unconformity (probably Late Jurassic in age), and samples from three dredge hauls on the western side of the Swan Canyon yielded Middle Jurassic ages on palynological examination. Lithofacies B, the"ferruginous association" consisting of a variety of subaerially weathered rock-types, occurred in all three areas below the main unconformity in small amounts. Lithofacies E, the "pelagic biogenic sediments" came from the Emu Escarpment, where it consisted of Miocene-Pliocene nanno chalk from above the main unconformity, and from the Swan Canyon, where Miocene-Pliocene nanno chalk came from above the main unconformity, and hard gray radiolarian chalk to marlstone of probable Cretaceous age apparently came from below it. Lithofacies C, "pre-Tertiary calcareous lithotypes", was recovered only from the Cugnet Canyon, probably from below the main unconformity. This consists of a variety of biogenic siltstones, sandstones, and breccias laid down in various shelf environments, and the fossils are of Early or Middle Jurassic aspect.

On the southeastern flank of the Wombat Plateau (Area C) slopes average 10°, the main unconformity lies at 1800-1900 m, and the seismic profiles revealed a faulted anticline, with a probable northeast trend, whose southern limit was sampled. Lithofacies A, the coal measure sequence (Tables 3, 9), was again the most common, and came from beneath the main unconformity. No palynological date was obtained from this material, which is probably of Jurassic age. Lithofacies B, in the form of a weathered ironstone, was recovered from one dredge haul below the main unconformity. Lithofacies D, recovered from one dredge haul, consisted of fossiliferous silty mudstone of probable Cretaceous age (?Winning Group equivalent). Lithofacies E was represented by white Miocene foram nanno chalk, and by Quaternary foram nanno ooze, both from above the main unconformity. Lithofacies C was represented by calcareous sandstones and biocalcarenites from below the main unconformity, with fossils of Early to Middle Jurassic aspect.

On the northern flank of the Wombat Plateau (Area D) slopes generally exceeded 10° and the main unconformity lay at 2800 m. Lithofacies A and B were recovered from only one dredge haul (Table 4), from below the main unconformity, and consisted of siltstone and quartz sandstone. Lithofacies E was represented by Quaternary foram ooze and foram sand, and by Eocene-Oligocene and Late Miocene chalk, all of which came from above the main unconformity. Lithofacies C was represented by calcisiltite, calcareous quartz sandstone, and biocalcarenite to calcirudite in two dredge hauls from below the main unconformity. An Early Jurassic (Sinemurian) age was determined from the macrofossils in both dredge hauls. Porous fossiliferous limestone and loose Inoceramus prisms and abraded belemnites, all of Cretaceous aspect, were recovered in one dredge-haul taken well below the main unconformity but almost certainly not in situ. The most abundant rock-types in this region belonged to Lithofacies F, "volcanic and volcaniclastic rock types". The bulk of these came from a 300 m thick layered sequence immediately below the main unconformity.

Northwestern Exmouth Plateau (Area E)

In this area the slopes were less than 10^{o}, which proved to be too low for successful dredging of older material. The seismic profiles showed a complex system of faults, apparently trending northeast and paralleling the margin. Thus although the main unconformity was visible within the plateau, it was impossible to be sure where it cropped out on the slope (probably around 3500 m). Furthermore there was some evidence of slumping on the margin.

All the material recovered belonged to Lithofacies E, "pelagic biogenic sediments" (Table 5). These were an Albian foram nanno chalk, a recrystallised carbonate rock assumed to be also of Cretaceous age, Miocene foram nanno ooze and chalk, and Quaternary foram sand and foram nanno ooze.

Central Exmouth Plateau

This area was sampled largely to obtain recent material suitable for gas analysis (Table 6). Water depths lay between 800 and 1500 m. In general, surfaces were very flat, and all the cores obtained consisted of foram ooze and/or foram sand. The upper few tens of centimetres were oxidised red or pink, whereas those deeper in the cores were grey. Pteropods were abundant in the cores, and ostracods and solitary corals were occasionally present.

Southern Exmouth Plateau

In Area G in the southwest, the seismic profiling revealed Mesozoic reflectors D and F, and the ?Permian reflector G of Exon & Willcox (1978). However, the slope was less than 5^{o}, and there was sufficient cover of young ooze to prevent successful sampling of old sediments. Only at Station 131 KD was anything older than Quaternary recovered - a hard piece of carbonaceous micaceous sandstone (Table 7) which came from deep in the section but proved barren of spores.

On profile F_1/F_2, from southwest of Barrow Island to the Cuvier Abyssal Plain, slopes were generally very gentle, apart from on the lower continental slope, where massive slumping had occurred. Quaternary sediments predominated (Table 7): between 120 and 165 m muddy carbonate sand was present; from 490 m to 4020 m foram sand, foram ooze and foram nanno ooze were present; below 5000 m deep sea clay prevailed. Also sampled were mid-Miocene foram sand and nanno chalk, mid Oligocene nanno chalk, and a few fragments of grey mudstone and shale of probable Cretaceous age.

Wallaby Plateau, Cuvier Abyssal Plain, and Sonne Ridge

The Cuvier Abyssal Plain is flat, and falls only a few metres between the end of Profile F_2 and the "Sonne Ridge" (shown as H in Figure 1) where it lies 5060 m below sea level. It appears to be underlain by turbidites; the sequences cored consist of a veneer of red clay above sandy or silty marl (Table 8).

The "Sonne Ridge" is a northerly trending basement ridge which rises 1500 m above the Cuvier Abyssal Plain. The *Sonne* cruise showed that it extends southward from within 30 km of the Exmouth Plateau almost to area J (Fig. 1). Thus it cuts the Cuvier Abyssal Plain in two, and forms the northeastern margin of the Wallaby Plateau. It is capped by Cainozoic oozes, but the ancient ridge consists of Lithofacies F (Table 9) "volcanic and volcaniclastic rocks". These are all strongly weathered and include "basalt", tuffaceous claystone, tuff, and volcaniclastic breccia (Table 8).

The northernmost foothills of the Wallaby Plateau were sampled on a north-northwesterly trending 150 m-high scarp abutting the Cuvier Abyssal Plain at Area I. Seismic profiles show that this scarp, whose top lies beneath 4800 m of water, represents a normal fault which has brought oceanic basement to outcrop. Samples recovered included old weathered "basalt", volcaniclastic clay and volcaniclastic breccia, and unconformably overlying Paleocene-Eocene white clay and Quaternary brown clay.

Area J consists of a 700 m-high easterly facing 10-15^o scarp forming the eastern margin of the Wallaby Plateau (Fig. 1). The top of the scarp lies at 4000 m, and seismic profiles indicate that it is underlain by about 200 m of Cainozoic sediments which unconformably overlie about 500 m of layered rocks. Samples recovered are either Quaternary foram nanno ooze or, below the unconformity, coarse weathered volcaniclastic sandstone (Table 8), which appears to dominate the older sequence from top to bottom. The sandstone is moderately well sorted, and grains are commonly rounded, indicating abrasion in moving water. It consists of various mixtures of basaltic and glassy clasts set in a clayey or zeolitic matrix.

Area K lies on the southern margin of the Wallaby Plateau, on a west-northwest-trending 25-30^{o} scarp which is believed to represent a transform fault. Shell and BMR seismic profiles show a very steep slope, with about 100 m of Cainozoic sediments unconformably overlying a layered sequence nearly 1500 m thick. The top of the scarp is at 3800-4000 m and its base is at 5200-5400 m below sea level. The old layered sequence can be traced deep into the plateau. The dredge results (Table 8) show that the old layered sequence consists of weathered volcanic and volcaniclastic rocks such as volcaniclastic claystone and siltstone, "basalt", vitric lithic tuff, volcaniclastic breccia, and minor volcaniclastic sandstone.

Area L is on the same scarp farther east-southeast (Fig. 1) and lies just eastward of the Wallaby Saddle, which separates the Wallaby Plateau from the Carnarvon Terrace. Two rock-types were dredged from the scarp - a ferruginous chert which is probably a silicified pelletal limestone of Palaeozoic age, and a mudstone which may be highly-altered tuff.

Manganese nodules

The dredge results show that manganese crusts are widespread on the margins of the Wallaby and Exmouth Plateaus. Manganese nodules, however, were dredged only from the margins of the Wallaby Plateau, at four stations. All had volcanic rock cores. Station data, and the results of preliminary XRF analyses (dry weight basis) carried out on board by G. Seibertz, are listed below.

Station number/ equipment	Area	Approx. position S	E	Water depth (m)	%Fe	%Mn	%Cu	%Ni
148 KD	H	$20^{\circ}58'$	$110^{\circ}33.5'$	4875-4540	4.8	3.7	0.09	0.54
165 KD	J	$24^{\circ}23.7'$	$109^{\circ}43'$	4415-4240	12.9	17.3	0.40	1.49
167 KD	K	$25^{\circ}37'$	$108^{\circ}36'$	5340-4750	11.7	16.8	0.37	1.30
170 KD	K	$25^{\circ}31'$	$108^{\circ}32'$	4620-3970	12.3	15.7	0.39	1.14

KD = chain dredge

The analyses show nickel contents well above Indian Ocean averages.

RELEVANCE OF RESULTS TO REGIONAL GEOLOGY

Exmouth Plateau

The Exmouth Plateau has been the scene of extensive geophysical surveys and these, together with studies of deep-ocean magnetics, deep sea drillholes, and shelf boreholes, allowed Exon & Willcox (1978) to tentatively determine the geological history of the plateau. Major points in their scheme are set out below.

The plateau is a continental block of which the upper 10 km consists mainly of Phanerozoic sedimentary rock. Through most of its Phanerozoic history it is believed to have been bounded by Greater India to the south and by another continental fragment to the west (e.g. Veevers & Cotterill, 1978), and to have been the site of deposition of detrital sediments in continental, paralic, or shallow marine environments. In the Early Cretaceous, when the plateau had been freed from the land to the west and south, it began to sink steadily; the dominant sediments from Late Cretaceous times onward are carbonates and marls 500-1000 m thick.

Until the Sonne cruise virtually no samples of pre-Quaternary rocks had been obtained from the plateau. The Sonne samples show that there are two major sequences below the main unconformity in the north: a shelf carbonate sequence dated as Early Jurassic in one place (the first occurrence of Lower Jurassic marine rocks recorded in Western Australia) and a "coal-measure" sequence dated as Middle Jurassic in several places. These two Jurassic sequences together appear to be more than 2000 m thick. On the northern margin of the Wombat Plateau there is a sequence of layered volcanics 300 m or more thick, immediately below the main (Late Jurassic?) unconformity. Their exact age is unknown, but they overlie a "coal-measure" sequence which is probably Middle Jurassic. Furthermore about 200 m above the volcanics are Eocene carbonates. Thus a Late Jurassic or Cretaceous age for the volcanics appears likely. The tenuous evidence of thick-shelled *Inoceramus* suggests that there may be a Cretaceous shelf sequence on the Wombat Plateau. Above the main unconformity is a compressed Cainozoic pelagic carbonate sequence containing several unconformities.

The work on the northern margin of the plateau is of considerable significance to petroleum geology, in that it suggests that porous and permeable carbonates, and coal measures, may lie deeply buried beneath the plateau. The carbonates, and the quartz sandstones within the coal measures, might be good reservoir rocks, and the coal measures might be good source-rocks for gas.

Deep-water carbonates are now known to exist in the northwest in the Albian and the Miocene. On the southern margin the presence of Mesozoic sandstone and shale, and Oligocene, Miocene, and Quaternary carbonates have been demonstrated.

Wallaby Plateau, Cuvier Abyssal Plain, and Sonne Ridge

It is generally agreed that the Cuvier Abyssal Plain formed in the Early Cretaceous, as indicated by Larson (1977) from a study of magnetic lineations. On the other hand the nature of the Wallaby Plateau is controversial. Symonds & Cameron (1977) suggested that it is a continental block, with dipping Palaeozoic strata underlying a Neocomian unconformity, and a thin sequence of Early Cretaceous detrital marine sediments and Late Cretaceous and Cainozoic pelagic carbonates above the unconformity. Veevers & Cotterill (1978) suggested that the Wallaby Plateau is a volcanic epilith built up like Iceland, by the outpouring of volcanic material in the Early Cretaceous as seafloor-spreading progressed. Thus the dipping sequence beneath the main unconformity would be volcanics of Early Cretaceous age, rather than Palaeozoic strata as suggested by Symonds & Cameron (1977).

The Sonne sampling results show clearly that the layered sequence beneath the main unconformity on the eastern and southern margin of the plateau is a volcanic and volcaniclastic pile. Seismic lines BMR 18/072 and Shell N318 extend from Area K in the south, northward into the central Wallaby Plateau, and show the continuance of layered strata deep into the Plateau. Unfortunately no fossiliferous material has been found and hence the age of the volcanics is unknown. However, the volcanics on the Wallaby Plateau are lithologically identical to those on the Sonne Ridge (area H) which magnetic correlations indicate are of Early Cretaceous age. Thus an Early Cretaceous age for the Wallaby Plateau volcanics is likely, supporting Veevers & Cotterill's (1978) view that the plateau is an epilith. However, it remains possible that the plateau is floored by continental basement, and it is also possible that there is a facies change from the margins inward, and that the layered strata deep within the plateau are not volcanics.

Table 1 - SUCCESSFUL NORTH EXMOUTH PLATEAU STATIONS ON PROFILE A

Station number/ equipment	Position S	Position E	Corrected water depth (m)	Recovery	Sediment description	Age
1GR	18°48.10'	118°45.50'	113	5 cm	Light gray fine calcareous sand	Quaternary
2GR	18°47.60'	118°45.70'	113	5 cm	Light gray fine calcareous sand	Quaternary
3KA	18°00.70'	118°01.70'	204	19 cm	Green-gray silty marl	Quaternary
4GBH	16°06.99'	118°15.51'	4927	200 g	Manganese crusts	?
10BL	16°08.50'	118°15.46'	4947	116 cm	Brown slightly calcareous clay	Quaternary
12KA	16°08.74'	118°15.86'	4988	30 cm	Red-brown slightly calcareous clay	Quaternary
13SL	16°08.77'	118°15.93'	5025	570 cm	Brown slightly calcareous clay	"
16SL	16°04.40'	118°02.94'	5676	553 cm	Foram ooze at base	"
18BL	16°05.00'	118°02.70'	5670	12 cm	Red-brown clay to 10 cm; foram sand below	"
19KA	16°22.60'	118°18.50'	3552	17 cm	Yellow-brown foram ooze	"
20KA	16°29.00'	118°23.30'	2777	29 cm	Yellow-brown foram ooze	"
21SL	16°21.90'	118°23.40'	2777	575 cm	Light gray foram ooze	"
22 KAL	16°28.80'	118°22.80'	2697	690 cm	Brown and gray Globigerina-rich marl	"
23KA	16°36.00'	118°29.60'	2029	24 cm	Yellow-gray foram ooze	"
24SL	16°35.90'	118°30.00'	2060	564 cm	Light olive gray foram ooze	"
25KA	16°56.10'	118°50.95'	1191	25 cm	Greenish gray bioturbated foram ooze	"
26SL	16°56.15'	118°50.50'	1186	530 cm	Gray foram ooze	"
27KA	17°07.10'	119°02.30'	543	20 cm	Yellowish gray medium shelly foram sand	"

Table 2 - SUCCESSFUL NORTH EXMOUTH PLATEAU STATIONS IN AREA B

Station number/ equipment	Position S	Position E	Corrected water depth (m)	Recovery	Seismic Profile	Sediment description		Age/Environment	Litho-facies
28KD	16°59.8'	117°22.3'	3035-	10 kg	8002	Gray clayey siltstone with plant and molluscan remains	+++	? Jurassic paralic	A
	16°59.2'	117°21.4'	2300			Gray carbonaceous micaceous silty claystone	++		
						Yellowish semi-consolidated mudstone	++		
						Yellowish quartz siltstone	+		
						Yellowish quartz-rich clay	+		
29KD	16°57.8'	117°21.1'	2530	30 kg	8002	Yellowish brown micaceous silty claystone	++	? Jurassic paralic	A
	16°57.4'	117°20.2'	-2310			Gray f-m laminated micaceous siltstone	++		
						Yellowish brown m-c quartz sandstone	++		
						Yellowish brown mudstone	+++		
						White foram nanno chalk	+	L.Miocene-E.Pliocene	E
32KD	16°55.2'	117°21.3'	2950-	100 kg	8004	Yellowish quartzose silty marl to calcareous mudstone	+++	? Jurassic paralic-littoral	A
	16°55.2'	117°20.3'	2470			Yellow coarse quartzose biocalcarenite with ooids, oncolites, microfossils, pelecypods, gastropods	++		
						Brown silty to sandy claystone to clayey siltstone	++		
						Yellow-brown silty v.f. sandstone and siltstone, micaceous	+++		
						Yellow-brown well-sorted f-m quartz sandstone	+		
						Gray to brown f-m quartz sandstone	+		B
						Purple silty claystone	+		
						White foram nanno chalk		M-L Miocene	E
33KD	16°49.4'	117°35.2'	5300-	7 kg	8004	Dk gray mudstone and brown siltstone	+	Middle Jurassic paralic	A
	16°49.5'	117°32.6'	3870			Black ?carbonaceous silty shale	+		
						Black ?carbonaceous silty shale with siltstone layers	+		
						Gray radiolarian micritic limestone to marlstone	+	Cretaceous pelagic	E
						Gray v. siliceous radiolarian chalk or marly chalk	+		
34KD	16°49.6'	117°33.8'	5180	35 kg	8004	Brown m-c well-sorted porous quartz sandstone	+++	Middle Jurassic coal swamp	A
	16°49.2'	117°31.7'	3700			Dk gray silty carbonaceous shale; v.f. sandstone layers	++		
						Dk gray micaceous muddy f. sandstone to sandy mudstone with coal seams, plant roots	++		
						Black vitreous coal	+		
						Dk gray pyrite nodule in sandstone	+		

Table 2 (contd) - SUCCESSFUL NORTH EXMOUTH PLATEAU STATIONS IN AREA B

Station number/ equipment	Position S	Position E	Corrected water depth (m)	Recovery	Seismic Profile	Sediment description		Age	Litho-facies
35KL	16°48.0'	117°34.5'	5290	458 cm	8004	Gray foram ooze		Quaternary	E
36KD	16°50.2' 16°50.3'	117°33.2' 117°32.0'	4310- 3730	80 kg	8004	Brown m-v.c. quartz sandstone, poorly sorted	•••	Middle Jurassic non-marine	A
						Gray silty and sandy mudstone	••		
						Black carbonaceous shale; some interbedded quartz sandstone	•		
						Brown ferruginous m. quartz sandstone, clayey ironstone	••		B
						White siliceous foram nanno chalk; radiolaria, Inoceramus	••	L.Miocene-L.Pliocene	E
37SL	16°55.00'	117°33.30'	3800	283 cm	8004	Green-gray calcareous mudstone		Quaternary/ L. Pliocene	D
39KD	16°51.0' 16°49.7'	117°24.6' 117°26.7'	4010- 3850	200 kg	8004	Red-brown clayey ironstone, ferruginous m-c quartz sandstone, ferruginous crusts and "buxstones"	•••	? Jurassic terrestrial	B
						Buff f-c quartz sandstone with carbonate cement	••	? Jurassic shallow marine	C
						Brown c. calcareous quartz sandstone with crinoids, corals, pelecypods, gastropods	••		
						Brown calcite-cemented crinoid breccia	•		
						Brown f-m quartz sandstone, ferruginous, poorly sorted	••		
						Gray, pink massive silty mudstone	••		
						Brown, buff micaceous clayey siltstone with calcareous tubes, agglutin. forams, Inoceramus	••		
						Brown, buff v.f. biocalcarenite with pelecypods, echinoids, crinoids	•		
						Gray micritic limestone	•		
						Gray, brown calcareous quartz sandstone	•		
						Brown oncolitic, well-sorted calcarenite	•		
						Belemnites, solitary corals	•		
						Dk brown ironstone breccia	•	? Jurassic paralic	B
						Dk gray pyritic concretions	•		A

Table 3 - SUCCESSFUL NORTH EXMOUTH PLATEAU STATIONS IN AREA C

Station number/ equipment	Position S	Position E	Corrected water depth (m)	Recovery	Seismic Profile	Sediment description		Age	Litho-facies
43KD	$17^{\circ}06.6'$ $17^{\circ}05.7'$	$115^{\circ}12.8'$ $115^{\circ}13.7'$	2600– 1800	4 kg	8014	Yellowish quartz calcarenite to calcareous quartz sandstone, with crinoids	•	? Jurassic shallow marine	C
						Yellowish sparry biocalcarenite, with rounded fossil debris: colonial corals, crinoids, bryozoa, echinoid spines, solitary corals, pelecypods, ?ooids	•		
						Gray semiconsolidated silty clay	•		A
						One small piece of pumice	•	? Quaternary	F
45SL	$17^{\circ}12.80'$	$115^{\circ}19.60'$	3210	494 cm	8012	Light greenish gray foram mud		Quaternary	E
46KD	$17^{\circ}07.0'$ $17^{\circ}06.3'$	$115^{\circ}19.0'$ $115^{\circ}19.0'$	3140– 2710	1 kg	8012	Gray muddy siltstone to sandy shale, with mica and plant remains	•	? Jurassic paralic	A
						White foram nanno chalk	•	M–L. Miocene bathyal	E
48KD	$17^{\circ}06.5'$ $17^{\circ}04.9'$	$115^{\circ}19.2'$ $115^{\circ}19.8'$	2710– 1850	20 kg	8012	Gray muddy siltstone to quartz-rich sandy shale, with mica and plant remains	•	? Jurassic paralic	A
						White foram nanno chalk	•	L.M. Miocene–L.Miocene	E
49KD	$17^{\circ}07.9'$ $17^{\circ}06.4'$	$115^{\circ}21.7'$ $115^{\circ}23.3'$	3280– 2520	200 kg	8010	Brown biosparite with pelecypods, echinoids	•	? Jurassic shallow marine and paralic	C
						White porous biosparite with fossil fragments	•		
						Gray sl. muddy f–m quartz sandstone with calcite cement	•		
						Gray silty shale to muddy v.f. sandy siltstone	•		A
						Brown clayey ironstone	•		B
51KD	$17^{\circ}05.8'$ $17^{\circ}04.7'$	$115^{\circ}23.3'$ $115^{\circ}23.6'$	2190– 1910	40 kg	8010	Gray-brown silty mudstone with plant fragments, bivalve casts	•••	? Cretaceous shallow marine	D
						Olive-brown sl. calcareous claystone, with forams	•		
						Yellowish sandy foram ooze	•	Quaternary	E
52KL	$17^{\circ}03.1'$	$115^{\circ}22.8'$	1795	289 cm	8010	Foram nanno ooze: pale brown above 2 m; pale gray below		Quaternary	E
55KL	$17^{\circ}04.0'$	$115^{\circ}22.9'$	1860	755 cm	8010	Foram ooze		Quaternary	E
57KD	$17^{\circ}05.2'$ $17^{\circ}02.7'$	$115^{\circ}30.6'$ $115^{\circ}31.9'$	3200– 2800	40 g	8008	Gray, pink friable shale	•	? Jurassic paralic	A
						Brown flaggy micaceous f. quartz sandstone	•		
59KL	$16^{\circ}54.0'$	$115^{\circ}34.4'$	2105	570 cm	8008	Foram nanno ooze: orange and pink above 3.2 m; gray below		Quaternary	E

Table 4 - SUCCESSFUL NORTH EXMOUTH PLATEAU STATIONS IN AREA D

Station number/ equipment	Position S	Position E	Corrected water depth (m)	Recovery	Seismic Profile	Sediment description		Age	Litho-faci
60KA	16°56.60'	115°11.10'	1610	20 cm		Foram ooze		Quaternary	E
61KD	16°28.7' 16°30.7'	115°14.4' 115°14.3'	4800– 4260	10 kg	8016	Interbedded pale gray micaceous quartz sandstone and calcisiltite, with Inoceramus, brachiopods, ostracods, echinoderms	◆	E. Jurassic (Sinemurian) shallow marine	C
						Gray calc. v.f.–m. quartz sandstone to sandy marlstone, with pyrite, fish teeth, ostracods	◆		
						Brown biocalcarenite to calcirudite, with Lenticulina, echinoids, crinoids, ostracods, pelecypods	(◆)		
						Brown calc. sandy mudstone, with shell fragments	(◆)		
						Black ? intermediate volcanic with pale phenocrysts	(◆)	? Jurassic	F
62KD	16°34.2' 16°35.2'	115°14.2' 115°15.0'	3110– 2580	2.5 kg	8016	White sparry biocalcarenite, with benthonic forams, echinoids, crinoids, Inoceramus		E Jurassic shallow marine	C
63KD	16°35.2' 16°36.2'	115°15.4' 115°15.5'	2960– 2620	20 kg	8016	Red weathered amygdaloidal volcanics	◆	? Jurassic volcanics	F
						Gray weathered, layered phenocryst-rich volcanics	◆		
						Red plagioclase-rich basalt or andesite	◆		
						Red-gray volcanic breccia	◆		
						Yellowish weathered silty claystone (?altered tuff)	◆		
						Olive, pink calc. m-c quartz sandstone	◆	? Jurassic paralic and shallow marine	C
						Red brown clayey ironstone and f-m quartz sandstone	◆		B
						Gray muddy siltstone to v.f. quartz sandstone	◆◆		A
						Gray poorly sorted m-c. quartz sandstone	◆		
						Gray silty mudstone and v.f. micaceous quartz sandstone	◆		
64KL	16°36.2'	115°14.0'	2600	408 cm	8016	Quaternary pink foram sand to 320 cm; L. Miocene gray-white chalk to 357 cm; buff Eocene-Oligocene chalk to base.		Tertiary/ Quaternary	E
65KD	16°33.4' 16°34.3'	115°14.3' 115°14.7'	3510– 3040	400 g	8016	Black angular ?basalt	(◆)	? Jurassic	F
						White porous limestone with bryozoans, crinoids	(◆)	? Cretaceous	C
						Belemnites and thick-walled Inoceramus fragments, not in situ	(◆)		
66KD	16°34.2' 16°35.7'	115°10.3' 115°10.2'	3120– 2490	50 kg	8018	Buff weathered ?intermediate volcanic (?trachyte), with alkali feldspar phenocrysts in f. groundmass	◆◆◆	? Jurassic	F
						Black Gorgonian corals, living	(◆)	Recent	-
67KAL	16°56.10'	115°11.50'	1600	142 cm		Globigerina ooze		Quaternary	E

Table 5 - SUCCESSFUL NORTHWEST EXMOUTH PLATEAU STATIONS (AREA E)

Station number/ equipment	Position S	Position E	Corrected water depth (m)	Recovery	Seismic Profile	Sediment description		Age	Litho-faci
70KL	18°32.3'	112°20.2'	3190	806 cm	8025	Pinkish foram sand to 2 m; foram nanno ooze below		Quaternary	E
72KD	18°25.4' 18°26.3'	112°21.8' 112°23.6'	3920- 3450	500 g	8023	Pink-white foram nanno chalk	(*)	Albian	E
73KD	18°26.3' 18°27.3'	112°25.6' 112°27.3'	3050- 2690	100 g	8023	Yellow-white recrystallized carbonate rock	(*)	? Cretaceous	E
74KL	18°26.7'	112°27.4'	2840	800 cm	8023	Pink foram sand and ooze above 1.5 m; pink grading down to pale gray foram nanno ooze below		Quaternary	E
76KL	18°26.0'	112°25.8'	3100	traces	8023	Greenish gray tough nanno foram ooze		M. Miocene	E
78KL	18°19.5'	112°26.0'	3860	344 cm	8021	Pink Quaternary foram sand and ooze above 60 cm; stiff brown foram nanno ooze and chalk below		Quaternary/ E. Miocene	E
79KL	18°26.7'	112°25.6'	3070	845 cm	8023	Creamy brown ooze above gray green stiff ooze		Quaternary	E

Table 6 - SUCCESSFUL GAS SAMPLING STATIONS ON EXMOUTH PLATEAU

Station number/ equipment	Area	Position S	Position E	Corrected water depth (m)	Recovery	Sediment description	Age
80KA	h	18°39.40'	113°44.80'	1470	22	Foram ooze: pinkish above 25-30 cm; grey below. Some pteropods and ostracods.	Quaternary
81-85BL	h	18°37.2' 18°40.9'	113°44.8' 113°45.5'	1469- 1486	86- 100		
88-90BL	h	18°41.4' 18°41.6'	113°46.0' 113°46.9'	1454- 1461	93- 101		
93KA	e_1	20°20.80'	112°56.30'	820	23	Foram ooze: red above 10-15 cm; grey below. Some pteropods and solitary corals	Quaternary
94SL	e_1	20°18.50'	112°56.60'	815	550		
95KA	e_1	20°16.90'	112°57.00'	820	27		
96KA	e_1	20°14.00'	112°57.60'	820	24		
97KA	p	19°59.90'	113°50.30'	1120	25	Foram ooze: red-brown above 50 cm; green-grey below	Quaternary
98-101BL	p	20°00.0' 20°00.0'	113°49.0' 113°51.2'	1120- 1130	100- 105		
103SL	p	20°15.60'	114°32.20'	1075	575		
112-117BL	e_2	21°07.0' 21°05.8'	113°37.0' 113°36.2'	1198- 1205	65- 103	Foram nanno ooze: pale yellow-brown above 30 cm; grey below. Some pteropods	Quaternary
125-128BL	e_3 (-G)	20°58.4' 20°59.0'	111°55.2' 111°55.8'	1455- 1515	5- 20	Pale reddish brown foram sand	Quaternary

Table 7 - SUCCESSFUL SOUTH EXMOUTH PLATEAU STATIONS

Station number/ equipment	Area	Position S	Position E	Corrected water depth (m)	Recovery	Seismic Profile	Sediment description	Age	Litho-facies
103SL	F_1	20°15.60'	114°32.20'	1075	575 cm		Foram ooze; red-brown above 50 cm, gray below	Quaternary	E
104KA	F_1	20°44.7'	114°02.5'	1027	29 cm		Olive gray clayey foram ooze	"	"
105SL	F_1	20°44.5'	114°02.6'	1022	575 cm		Foram ooze with pteropods; brown above 50 cm, gray below	"	"
106KAL	F_1	20°45.5'	114°02.4'	1027	556 cm		Foram ooze with pteropods and scaphopods; brown to 83 cm, gray below	"	"
107KA	F_1	20°57.0'	114°21.0'	493	27 cm		Brown and gray clayey foram ooze	"	"
108SL	F_1	20°56.0'	114°20.0'	498	353 cm		Foram ooze with pteropods: brown above 50 cm; green-gray below	"	"
109KA	F_1	21°08.1'	114°39.6'	165	20 cm		Yellow-gray c. carbonate sand, with forams, pteropods, pelecypods	"	"
110KA	F_1	21°09.5'	114°42.1'	125	20 cm		Olive gray muddy f. sand	"	"
111SL	F_1	21°09.7'	114°42.3'	122	353 cm		Gray muddy v.f. sand, with forams, ?glauconite	"	"
118KA	F_2	21°08.0'	112°46.6'	1502	26 cm		Pale brown foram nanno ooze and sand	"	"
119SL	F_2	21°07.4'	112°46.4'	1493	465 cm		Foram nanno ooze and sand; brown above 100 cm, gray below	"	"
122KL	G	20°56.2'	111°42.3'	2065	694 cm	8040	Foram nanno ooze and foram sand: pinkish gray above 1 m and light gray below	"	E
124KL	G	21°03.3'	111°50.3'	2170	669 cm	8038	Foram sand and tough ooze: light reddish brown above 4.5 m and light gray below	"	E
131KD	G	21°20.4' 21°18.3'	111°52.0' 111°54.3'	4415-3770	200 g	8036	Dk gray v.f. carbonaceous micaceous quartz sandstone	? Triassic or Jurassic	A
132KL	F_2	21°08.6'	112°18.0'	1715	340 cm		Pink foram sand to 60 cm; gray nanno ooze to 330 cm; white foram sand below 330 cm	Quat above 330 cm; mid Miocene below	E
133KA	F_2	21°57.1'	111°46.2'	5040	26 cm		Reddish clay to 6 cm; gray clay below. Some forams	Quaternary	"
138SL	F_2	21°37.1'	112°31.9'	4017	429 cm		Reddish grading downward to gray ooze to 400 cm; gray mudstone and shale below 400 cm	Quat/? Mesozoic	"
141KA	F_2	21°28.4'	112°31.0'	2918	35 cm		Pink foram nanno ooze to 30 cm; whitish foram clayey ooze below	Quaternary	"
142SL	F_2	21°27.6'	112°30.5'	2798	121 cm		Reddish foram nanno ooze to 100 cm; white nanno chalk below 100 cm	Quat/mid Oligocene	"
144SL	F_2	21°21.8'	112°33.5'	2330	traces		White nanno chalk	mid Miocene	"

Table 3 - SUCCESSFUL WALLABY PLATEAU AND SONNE RIDGE STATIONS

Station number/ equipment	Area	Position S	Position E	Corrected water depth (m)	Recovery	Seismic Profile	Sediment description		Age	Litho-facies
145KA	H	21°19.8'	110°28.9'	5060	33 cm		Veneer dk brown calc clay above pale brown sl. sandy marl		Quaternary	-
146SL	H	21°15.5'	110°30.1'	5060	400 cm		Veneer dk brown clay above silty marl		Quaternary	-
147KD	H	21°12.6' 21°11.5'	110°30.9' 110°30.3'	5060- 5060	500 g		Brown and white nanno marl to calcareous clay	(•)	Quaternary/ Tertiary	-
148KD	H	20°58.4' 20°57.8'	110°33.9' 110°33.3'	4875- 4540	80 kg		Red volcanic (? basalt) Pale brown ?tuffaceous claystone, mottled Pale brown tuffaceous claystone,with glass,pyroxene Brown tuff, some brecciated	••• • ••• •	?E. Cretaceous	F
							Mn nodules,poly- and mono-nodules,up to 6 cm Ø	•	Quaternary	-
149KD	H	21°24.9' 21°24.2'	110°18.5' 110°18.5'	4930- 4920	60 kg		Multicoloured volcaniclastic breccia,with f. volcanic fragments to 10 cm Ø,in a yellow and gray clay matrix	•••	?E. Cretaceous	F
152KL	I	22°01.2'	109°18.7'	4780	792 cm	8052	Stiff brown clay; colour shows thin bedding		? Quaternary	-
155KD	I	21°52.0' 21°52.7'	109°16.2' 109°15.2'	5060- 4830	25 kg	8048	Dark brown highly altered ?basalt Pale gray zeolitic ?volcaniclastic clay Multicoloured volcaniclastic breccia	•• • •	?E. Cretaceous	F
156KL	I	21°53.3'	109°14.1'	4780	traces	8048	White clay and fragments of Mn crusts		L. Palaeocene/ Eocene	-
158KL	I	21°53.0'	109°14.2'	4845	336 cm	8048	Dark yellow-brown stiff clay		? Quaternary	-
159KD	J	24°23.5' 24°22.8'	109°43.7' 109°41.8'	4470- 4130	100 kg	8056	Brown,gray c. volcaniclastic sandstone with clay matrix and volcanic and rare glassy clasts	•	?E. Cretaceous	F
							Pink foram nanno ooze	•••	Quaternary	E
160KD	J	24°23.8' 24°23.5'	109°42.8' 109°42.0'	4470- 4260	20 kg	8056	Pink foram nanno ooze	•••	Quaternary	E
161KD	J	24°24.0' 24°23.9'	109°45.0' 109°44.3'	4470- 4230	2 kg		Yellow-brown c. volcaniclastic sandstone with clay matrix, weathered and Mn crusted		?E. Cretaceous	F

Table 8 (contd) - SUCCESSFUL WALLABY PLATEAU AND SONNE RIDGE STATIONS

Station number/ equipment	Area	Position S	Position E	Corrected water depth (m)	Recovery	Seismic Profile	Sediment description		Age	Litho-facies
162KL	J	24°24.0'	109°41.3'	4060	88 cm	8056	Pale brown foram nanno ooze to 50 cm		Quaternary	E
							Green-gray pebbly volcaniclastic sandstone below 50 cm		?E. Cretaceous	F
165KD	J	24°23.7' 24°23.7'	109°42.4' 109°44.0'	4415- 4240	5 kg	8056	Olive pebbly volcaniclastic sandstone, clasts mainly glass	++	?E. Cretaceous	F
							Mn polynodules, max. 7 cm Ø	+	Quaternary	-
167KD	K	25°39.0' 25°35.4'	108°38.5' 108°35.1'	5340- 4750	2 kg	8065	Pink to gray-brown ?volcaniclastic claystone	+	?E. Cretaceous	F
							Brown, gray f-c. vitric lithic tuff with glassy matrix	+		
							Pale brown v.f. basalt or tuff	+		
							Small Mn polynodules with volcanic cores	+	Quaternary	-
168KD	K	25°34.8' 25°33.4'	108°34.3' 108°35.0'	5100- 4050	200 kg	8065	Green-brown weathered volcanics (? basalt)	+++	?E. Cretaceous	F
							Dark brown volcaniclastic siltstone	+		
							Black fissile f. tuff	+		
							Gray-brown ?volcaniclastic claystone	+		
170KD	K	25°31.6' 25°31.0'	108°31.9' 108°32.4'	4620- 3970	120 kg	8063	Brown-gray weathered f. volcanic rock (? basalt)	+++	?E. Cretaceous	F
							Green-gray volcanic breccia, clasts max. 20 cm Ø	++		
							Red-brown volcanogenic mudstone (? tuff) with granules	+		
							Green-gray v.c. volcaniclastic sandstone, poorly sorted	+		
							Brown volcaniclastic breccia, clasts max 2 cm Ø	+		
							One manganese polynodule	(+)	Quaternary	-
173KD	L	25°57.8' 25°55.3'	109°05.8' 109°04.4'	4980- 3885	200 g		Reddish-brown ferruginous chert (? silicified pelletal limestone)	(+)	? Silurian	?C
							Red-brown mudstone (? altered tuff)		?E. Cretaceous	?F

Table 9 - Lithofacies (LF) Types of pre-Quaternary dredge & core samples

Association	LF-type	Colour, texture, composition, fossils & fabric of rock/sediment type	Ages	Facies interpretation (paleoenvironment)
"Coal Measure Association"	A_1	black vitreous coal, partly as thin seams in LF-A_2	Middle Jurassic (palynology)	?cyclothems paralic, i.e. terrestrial (fluviatile, swamp etc) to lagoonal (slightly reducing cond.) to deltaic (nonmarine to shallow-marine)
	A_2	yellowish-brown mudstone to fissile shale, ± carbonaceous (plant fragments), ± silty clay, sometimes banded; often with thin layers of laminated siltst. - v.f. sandstone (or lenses); no carbonate		
	A_3	Yell.-brown to green-gray siltstone to very fine quartz sandstone, ± carbonaceous (plant material) ± well sorted, parallel & ripple cross laminated; w.qtz., mica, pyrite (± oxidised), heavies; no carbonate		
	A_4	lt.-yel.brown to gray medium to coarse sandstone(-cgl.), ± massive, to flaggy; rarely bedded to cross-bedded. Qtz, feldsp. mica, clay clasts. Highly weathered, porous & friable		
	A_5	pyrite nodules or concretions (origin from organic matter)		paralic (? floodplain)
	A_6	Gray to pink and dusky red-purple siltstone/claystone, ± mottled & massive		oxidising nonmarine cond. (? floodplain)
Ferruginous Association	B_1	red-brn clayey ironstone ("Toneisenstein")	? Jurassic	terrestrial (lacustrine, swamp, fluviatile)-shallow-marine (paralic), later subaerially exposed(?
	B_2	red-brn ferruginous (= hematite/limonite cemented) qtz sandst. or sandy ironstone, ± porous. Fe-stained qtz, mica, clay matrix + hematite/limonite/goethite. Carbonate free		
	B_3	brown secondary ferruginous concretions and "boxstones"		
	B_4	dark-brown ironstone breccia ("Trümmereisenerz") w. up to 3 cm large claystone & Toneisenstein pebbles in matrix of coarse-grained hematitic quartz sandst.		reworking of B_{1-3} by rivers &/or surf (littoral envir.)
Pre-Tertiary Calcareous Lithotypes	C_1	red.-yel. to pink micritic limestone (calcisiltite-calcilutite), including marlst. & calcar. mudst., sometimes with pockets & lenses of calcareous qtz sandst.	Early Jurassic (macrofossils)	neritic (inner-middle shelf)
	C_2	white, grayish brn, red-brn biocalcarenite with crinoids, echinoids, molluscs, ?oncol., benth. forams. intraclasts etc		?inner shelf (?littoral), clear water & high energy envir.
	C_3	yel.(-brn) quartz-bearing biocalcarenite w. calcite cement (micrite-sparite) and qtz, crinoids, echinoids, molluscs, etc.		(?inner) shelf
	C_4	v. coarse calcarenite to calcirudite with crinoids, corals (abraded), (no forams, no nanno) bryoz., bivalves etc.		littoral (v. shallow water), clear water & high energy envir. on carbonate shelf. ?Reefal debris.
	C_5	(grayish) brn & pale olive/pink calcite-cemented qtz sandstone w. a few qtz pebbles and bioclasts (crinoids, bivalves, gastropods, echinoids; sometimes rads, ostracods, fish teeth)		
	C_6	yel.-brn. recrystallized sparry limestone (micro-to macrosparite)		inner-middle shelf
	C_7	yel.-white recrystallized (?dolomitized) carbonate rock (?ank./sid.) w. Mn crust, no fossils		?

Table 9 (contd)

	LF-type	Colour, texture, composition, fossils & fabric of rock/sediment type	Ages	Facies interpretation (paleoenvironment)
Pelitic Detrital Lithotypes	D_1	yel.-brn. to buff gray claystone/shale, ± silty & sandy, ± calcareous, ± micaceous, some forams, fish debris	?Jurassic-Cretaceous	very shallow marine (deltaic!), ? reduced salinity
Pelagic Biogenic Sediments	E_1	White Tertiary semiconsolidated foraminiferal nanno chalk	m. Mioc.-early Plioc.	eupelagic-bathyal
	E_2	creamy white Tertiary chalk with siliceous microfossils (rads) and quartz	m. Mioc.-Plioc.	hemipelagic-bathyal
	E_3	lt.-med. (blueish) gray ± siliceous (radiolarian) chalk to micritic marl/limestone (Cretaceous)	Albian (Apt.-E.Cen.)	pelagic, but neritic? no terrigenous influx
	E_4	yel.-white soft foraminiferal nanno ooze	Quaternary	eupelagic-bathyal
	E_5	pink foraminiferal sand, winnowed, with few nannos	Quaternary	eupelagic-bathyal
Volcanic & Volcaniclastic Rock Types	F_1	lt.-gray pumice (silicic volcanic glass)	? Jurassic-Cretaceous ? Holocene	reworked airborne ashes
	F_2	black basic volcanic rock (?"basalt" or "andesite"), ± weathered, angular fragm., plag	? Jurassic/ Cretaceous	reworked ashes
	F_3	buff intermed. volcanic rock (?trachyte-rhyolite),highly weathered,large Kspar phenocrysts		
	F_4	volcanic or epiclastic breccia with large volcanic rock fragments		
	F_5	undiff. volcanic rocks		
	F_6	olive-yellow (ochre) tuff (consolidated,bedded, ± finely laminated ash),altered to clay & zeol.?		
	F_7	greenish brown c. volcaniclastic sandstone with basaltic and glass clasts,clay and zeolite matrix.		

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