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NOTES ON THE SEDIMENTOLOGY AND PALAEONTOLOGY OF CORES AND DREDGED SEDIMENTS OBTAINED FROM THE SCOTT PLATEAU AND JAVA TRENCH BY R.V. VALDIVIA, 1977

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SUMMARY

This report covers various aspects of sediment obtained from the Scott Plateau (in water depths of 2000-3300 m), and from the Java Trench (in water depths of 5000-5800 m) by R.V. Valdivia in 1977. From the northern Scott Plateau came two dredge hauls of Jurassic siltstone, a piston core of Upper Cretaceous marl, a dredge haul including some middle Miocene to Pleistocene mud, and 10 boomerang cores of Quaternary marl. From the southern flank of the Java Trench came a piston core and 10 boomerang cores of Pleistocene to Recent siliceous ooze.

Sedimentological work reported here is confined to the core material. It includes visual and x-ray descriptions, studies of grainsize, carbonate content, and sedimentary structures, and microscopic examination of the coarse fraction of the sediment and of smear slides. Palaeontological reports included here deal with the macrofauna and microfauna of the Jurassic siltstone, and the microfaunas of the other sediments.

The Jurassic siltstone (KD 11) contained a sparse fauna of ammonites of probable Tithonian or Kimmeridgian age, pelecypods, and Lingula, and Late Jurassic dino-flagellates and hystrichospheres. Palaeontological and sedimentological data suggest deposition in a restricted shallow marine environment. The Upper Cretaceous marl (KL 1) contains well preserved foraminifera and nannoplankton of early Campanian age; the very high ratio of planktonic to benthonic foraminifera indicates bathyal deposition. The middle Miocene-Pleistocene mud (KD 2) contains internal moulds of planktonic foraminifera and was deposited in deep water.

The siliceous cores from the Java Trench either contain no calcareous microfossils whatever, or contain such fossils low in the section only. The preserved nannofossil assemblages are of early to middle Pleistocene age. Radiolaria and diatoms are abundant and well-preserved, but have not been studied. These cores indicate that the carbonate compensation depth was between 5420 and 5700 m in the Pleistocene, and is about 4900 m now. The calcareous Quaternary cores from the Scott Plateau contain well-preserved planktonic foraminifera, rare benthonic foraminifera, and nannofossils. They straddle the Pleistocene-Holocene boundary, and indicate a sedimentation rate of 5 cm/1000 years.

INTRODUCTION

The Federal Republic of Germany's research vessel Valdivia carried out geological and geophysical investigations off northwestern Australia in early 1977. These investigations were arranged under the Australian-German Scientific Agreement, and the major participants were the Bundesanstalt fuer Geowissenschaften und Rohstoffe (BGR), Hannover, and the Bureau of Mineral Resources (BMR), Canberra. The main results of the investigations were published by Hinz et al., (1978), Stackelberg (1978), Zobel (1978), and Shafik (1978b).

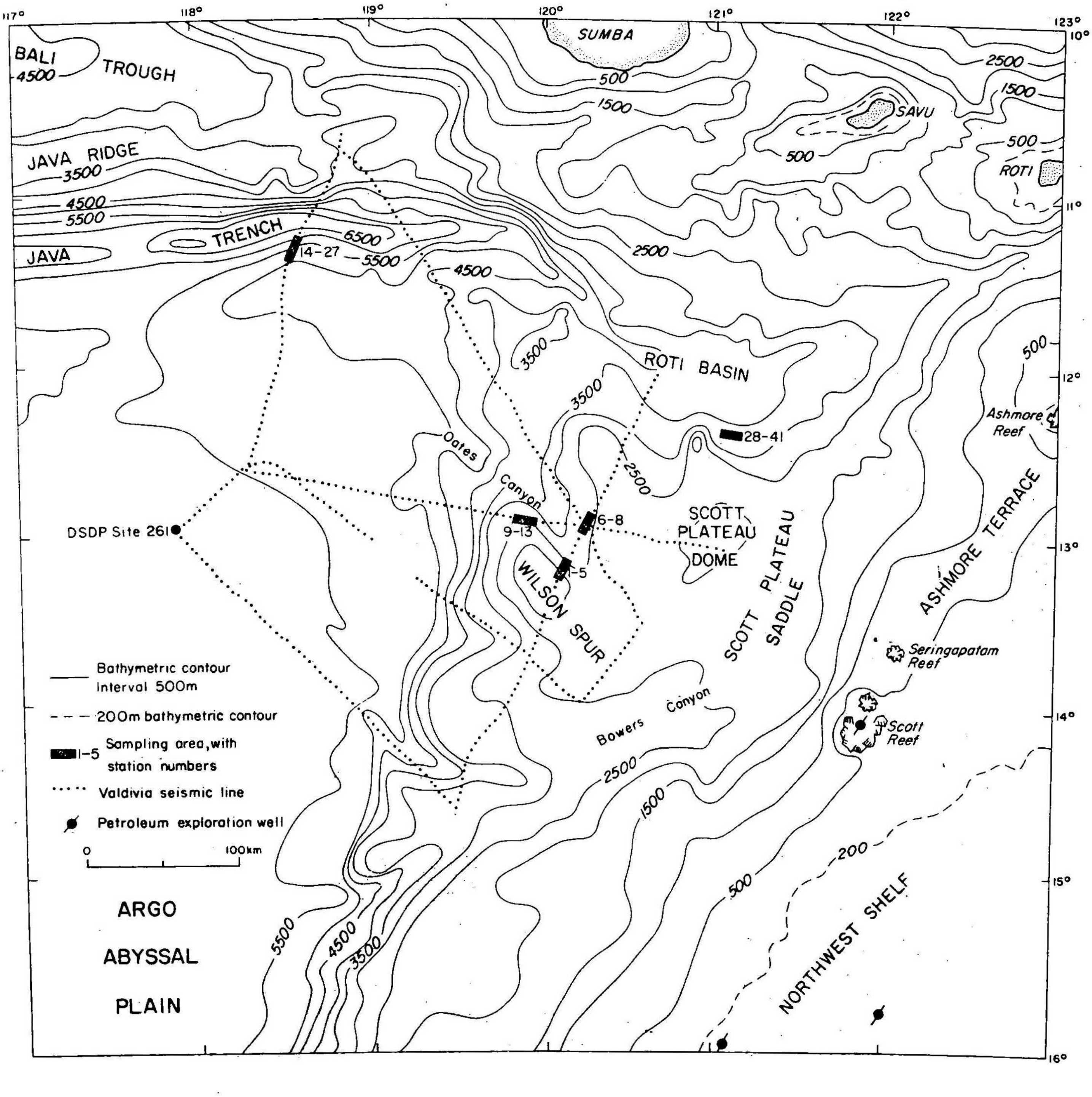
This report presents detailed results of sedimentological and palaeontological studies of cores and dredge material not fully covered in the above publications. The general location of all stations is related to bathymetry in Figure 1, and the details of stations mentioned in this report are shown in Table 1 (the details of all cruise stations are given in Hinz et al., 1978).

SEDIMENTOLOGICAL FEATURES OF THE CORES (N.F. Exon & U. von Stackelberg)

Sedimentological examination of all the cores (all are one-metre long boomerang cores except KL 1 and KL 14) was carried out in Hannover. All cores were described visually, and some were X-rayed and the resulting photographs described. Selected samples from all cores (spacing generally 10 to 20 cm) were separated into three fractions - coarser then 63μm, 63-40μm, and less than 40μm - and the dry weights of these fractions recorded. The fractions coarser than 63μm, and finer than 40μm were microscopically examined. Selected samples from some cores were analysed for their carbonate content.

The results are summarised in Figures 2 to 7 and X-ray photographs of interesting features are shown in Figures 8 and 9.

FIG. 1



BATHYMETRY AND STATION LOCALITIES

Table 1: Geological stations discussed in this report. General localities are shown on Figure 1.

Area	Station	Apparatus	Bottom contact begins Decimal degrees Lat (S)	Long (E)	Water depth (m)	Bottom slope (degrees)	Recovery	Age	Short description
I Southern Oates Canyon	1	KL	13.2084	120.0660	2000	1°	101 cm	Late Cretaceous	White chalk
	2	KD	13.1150	120.0994	2947-2242	20°	6 kg	?Jurassic Late Cainozoic	Amygdaloidal basalt 80% Silicified chalk 20% Mn crusts
II Northern Oates Canyon	7	KD	12.9091	120.229	2480-2421	20°	65 kg	?Late Jurassic	Soft brown bioturbated sandy siltstone with rare shelly fossil impressions, fossil wood
III Southwest Oates Canyon	11	KD	12.8115	119.8687	3090-3058	5°	200 kg	Late Jurassic	Soft brown bioturbated siltstone with rare shelly fossil impressions. Minor calcareous sandstone
IV Java Trench	14	KL	11.3990	118.5056	5420	25°	4 m	Quaternary throughout	Olive grey mud with Globorotalia
	15	BL	11.4216	118.5202	4950	10°	95 cm	"	Gray mud with Globorotalia
	16	BL	11.4566	118.5112	5000	10°	105 cm	"	"
	17	BL	11.4552	118.5126	5090	5°	114 cm	"	"
	18	BL	11.4505	118.5088	5080	1°	98 cm	"	"
	20	BL	11.4358	118.4952	5110	25°	99 cm	Quaternary throughout	Gray mud with Globorotalia
	21	BL	11.4277	118.4886	5290	25°	97 cm	"	Gray mud without forams
	22	BL	11.4245	118.4925	5250	25°	110 cm	"	Gray mud with Globorotalia
	25	BL	11.4036	118.4771	5720	1°	96 cm	"	Gray mud without forams
	26	BL	11.3963	118.4732	5770	2°	102 cm	"	"
	27	BL	11.3892	118.4696	5790	2°	98 cm	"	"
V Northern Scott Plateau	29	BL	12.3676	121.1599	3250	0°	100 cm	Quaternary	Light gray calcareous silty mud with forams
	30	BL	12.3687	121.1558	3290	0°	103 cm	"	"
	31	BL	12.3691	121.1493	3290	0°	104 cm	"	"
	32	BL	12.3692	121.1376	3260	0°	100 cm	"	"
	33	BL	12.3681	121.1290	3240	0°	103 cm	"	"
	34	BL	12.3658	121.0665	3270	0°	95 cm	"	"
	35	BL	12.3651	121.0544	3290	0°	103 cm	"	"
	36	BL	12.3656	121.0411	3280	0°	103 cm	"	"
	37	BL	12.3660	121.0291	3210	0°	100 cm	"	"
	38	BL	12.3661	121.0186	3180	0°	101 cm	"	"

The major results of this work are outlined in the body of the text, and details are recorded below

Visual descriptions (von Stackelberg)

Core KL1 of Area I (Oates Canyon) is white (Munsell colour 10 y R 8/2), and the lightest-coloured of all cores recovered. The only structures visible are irregular dark traces of bioturbation.

The sediment is a tough calcareous mud containing Late Cretaceous microfossils. Its shear strength is much greater than that of the Quaternary cores, including the deepest part of KL14.

The cores of Area IV (Java Trench; KL14, BL15 to BL27) display a brownish oxidation zone, from 2 to 10 cm thick. In the uppermost metre the olive grey tones vary only slightly (between 5 y 5/2 and 5 y 4/2). Core BL22 deviates in that below 11 cm darker tones (5 y 3/2) are also present. The only longer core (KL14) has dark olive grey areas (5 y 3/2) between 160 and 195 cm, and occasional very dark grey (5 y 3/1) bioturbation structures.

Differences in colour and composition make horizontal lensoid structures apparent in the cores, and these are attributable to bioturbation. Only at 43 cm in BL16 are press-structures visible in a horizontal burrow, probably a feeding burrow of *Zoophycos*.

The cores of Area V (Northern Scott Plateau; BL29 - BL38) are all very similar in colour. All possess an oxidation zone, which varies from 6 to 15 cm thick. In all cores apart from BL38 light olive grey tones (5 y 6/2) predominate. There are also a few somewhat darker (5 y 5/2) burrows. In core BL36 the sequence below 65 cm is generally a little darker (5 y 5/2).

Core BL38, taken from the shallowest station (3180 m) in the area, is generally similar to cores BL35 and BL36, but is dark grey (5 y 5-4/1) between 33 and 46 cm.

X-ray examination (von Stackelberg)

X-ray photographs were produced from ten selected cores, for a total length of 10.60 m (KL1, KL14; BL17, 18, 22, 26,31,34, 36 and 38). A 5 mm-thick slice of wet sediment was taken from the halved cores and X-rayed at a scale of 1:1.

The X-rays reveal extremely small changes in sediment density, so that structures are frequently apparent which are invisible to the naked eye or under a binocular microscope. On prints light areas indicate low densities, and dark areas high densities.

Core KL1 (Late Cretaceous) = Area I

From 0 to 50 cm there are isolated irregularly-trending light burrows (2 mm ø). From 50 cm to the core's base (93 cm) there are increasing traces of horizontal bioturbation, which take the form of light lenses and layers about 3 mm thick.

Even though forams are abundant in the coarse fraction of this core, they are not visible on the X-ray photographs.

Quaternary of the Java Trench = Area IV

Core KL14: From 0 to 22 cm there is indistinct lensoid layering.

From 22 to 160 cm predominantly vertical wavy dark tubes are apparent ($ø \geqq 0.5$ mm). The dark tubes are filled with pyrite, as are all dark tubes from Area IV. Horizontal bioturbation has formed indistinct lensoid structures, which decrease in abundance downward. Nests of dark grains ($\gtrless 0.5$ mm), which turn out to be pyrite-filled forams or radiolaria, are present in the lenses.

From 160 to 193 cm lensoid horizontal structures are again apparent, and there are a few dark irregularly-trending tubes (1-2 mm ø). Forams are more abundant than from 90 to 160 cm, and are visible as dark spots on a lighter background.

Forams are generally absent from 193 to 249 cm, and lensoid bioturbation structures are virtually absent. Dark tubes ($\leqq$ 1 mm ø) occur below 215 cm.

Between 249 and 360 cm there are wavy dark tubes ($ø \leqq 0,5$ mm) which mostly make angles of less than 45^{o} to the core axis, and occasional nests of pyritic grains. The fine-grained groundmass lacks forams.

From 379 to 398 cm there are large dark wavy tubes (1 mm ø) as well as the fine ones mentioned above. The sediment appears coarse because of abundant forams.

BL17: From 0 to 30 cm weakly-developed lensoid horizontal structures are present, formed by bioturbation. The sediment appears coarse due to the abundant forams.

From 30 cm to the core's base (102 cm) numerous straight dark tubes ($\leqq$ 1 mm ø) are visible, at about 15° to the core axis (Fig. 8). Normal to the dark tubes are vague light lenses, which contain nests of pyritic grains in places. Below 67 cm forams are again abundant.

BL18: From 0 to 45 cm there are no visible sedimentary structures. From 45 cm to the core's base (89 cm) there are wavy, mostly vertical, dark tubes ($\leqq$ 1 mm ø). Forams increase in abundance below 70 cm.

BL22: From 0 to 30 cm there are no obvious sedimentary structures. From 30 cm to the core's base (92 cm) there are wavy mostly vertical tubes ($\leqq$ 1 mm ø). Normal to the tubes are vague lensoid bioturbation structures, with nests of pyritic grains. Structures are similar to those of KL14. Forams are present below 58 cm.

BL26: Thin horizontal lenses occur throughout the core. From 30 cm to the core's base (93 cm) a few wavy, mostly vertical tubes ($\leqq$ 1 mm ø), are visible. Most are dark, but a few are light. No forams are visible.

Quaternary of the Northern Scott Plateau = Area V

BL31: Abundant generally oval forams are visible throughout the core, their thick shells appearing dark on the X-ray photographs (Fig. 9A). Below 70 cm round forams, which appear light, predominate. In coarse fraction samples the thin-shelled spherical *Orbulina* predominates below 70 cm, whereas an oval multi-chambered *Globorotalia*, with a massive keel, predominates above 70 cm.

In a few places in the core very vague horizontal structures are visible.

BL34, 36: These cores are similar to BL31. The change from oval to round forams lies at about 60 cm in BL34, and at about 65 cm in BL36 (abundant round forams in Fig. 9B).

BL38: This core is also similar to BL31, with the change from oval to round forams at about 61 cm. A bed of foram sand lies between 32 and 33 cm. Vague lensoid layering ocurs between 32 and 61 cm. At 42 cm there is a *Zoophycos* feeding burrow with Spreite.

Grainsize (von Stackelberg)

In core KL1 the sand content varies between 1.7 and 7.5%, depending whether forams are fragmentary or whole.

The sand content of cores from Area IV is normally under 5%, but it exceeds 10% (max. 16.2%) at two levels below 1 m in Core KL14, because of an abundance of forams. In other cores too sand content is often related to foram content (eg, BL16: 30-32 cm = 6.3%). By contrast the higher sand content of surface samples is related to an enrichment in volcanic glass.

The cores of Area V contain more sand, often more than 10%, caused by abundant forams. In two cores there are foram sands (BL37: 24-26 cm = 71.1%; BL38: 32-33 cm = 32.6%.

Carbonate content (von Stackelberg)

The calcium content of 30 samples from 7 cores was determined using an atomic absorption spectrometer, and the $CaCO_3$ content was calculated from these determinations. The values for Core KL1 are all around 52%. It is a marly ooze.

The carbonate content of Area IV cores varies from 0.7 to 19%. Increased carbonate values generally correspond to enrichment in forams and/or coccoliths. Because of the high content of siliceous organisms the sediment is best called siliceous ooze.

The cores of Area V show generally higher carbonate contents, between 32% and 48%, and are marly oozes.

Discussion of sedimentary structures (von Stackelberg)

The sedimentary structures of the Late Cretaceous core KL1 (Area I) are quite different from those in the other cores. They give no clear indication of the original water depth at this station where the water is at present

2000 m deep. This is the shallowest of any of our stations, and well above the CCD.

Within Area IV the bioturbational features of KL14 are most closely approached by those of BL22. Because of its lensoid horizontal structures and lack of forams BL26 is clearly different from the other four cores (KL14; BL17, 18, 22). This core lies in considerably deeper water than the others (5770 m).

Common to all the cores of Area IV is the occurrence of pyrite-filled tubes and organisms below a certain depth in the cores. This shows that conditions are more reducing deeper in the cores. Because pyrite is an early diagenetic mineral, the differing redox conditions in the cores should allow the drawing of conclusions about conditions during sedimentation. However without any idea of rates of deposition it cannot be determined whether the changes in redox conditions are caused by changes in the chemistry of the bottom water, or rates of deposition, or supply of organic carbon.

The absence of thin-walled forams high in the cores (Fig. 9A), and their presence deep in the cores (Fig. 9B), can also be attributed to changes in redox conditions.

The cores of Area V (BL31, 34, 36 and 38) are characterised by high foram contents and lack of pyrite. They all lie in considerably shallower water (3290-3180 m) than those of Area IV i.e., well above the CCD. The X-rays have allowed two different faunal communities to be separated. In the upper parts of the cores only oval, thick-shelled, multi-chambered forams are found. In the lower parts spherical thin-shelled forams predominate. Apart from differences in primary productivity, it is possible that current sorting or selective chemical solution is responsible for this change. In all cases a practically synchronous change in environmental conditions must have occurred. The continuing biostratigraphic investigations of the foram fauna should allow more definite conclusions to be drawn about the cause of the change (see Zobel, 1978).

Coarse-fraction and smear slide studies (Exon)

Samples were taken at intervals of 10 or 20 cm from all cores for microscopic examination. The fraction coarser than 63 μm was examined under a binocular microscope, and semi-quantitative estimates of the constituents were made. Smear slides were made of the fraction finer than 40 μm and these were scanned rapidly to help give some idea of the bulk composition of these fine-grained sediments.

Core KL1 (Late Cretaceous)

The coarse fraction consists almost entirely of planktonic foraminifera (Fig. 2) with minor benthonic foraminifera and calcispheres. There is little variation in character from top to bottom. Smear slides show that coccoliths are abundant throughout.

Quaternary of the Java Trench (Figures 3, 4 & 5)

The sand content of the cores is usually related to the abundance of foraminifera and is normally under 5%. It exceeds 10% at two levels below 1 m in Core KL14, where foraminifera are particularly abundant. High sand content in the surface layers is, however, caused by an abundance of volcanic glass.

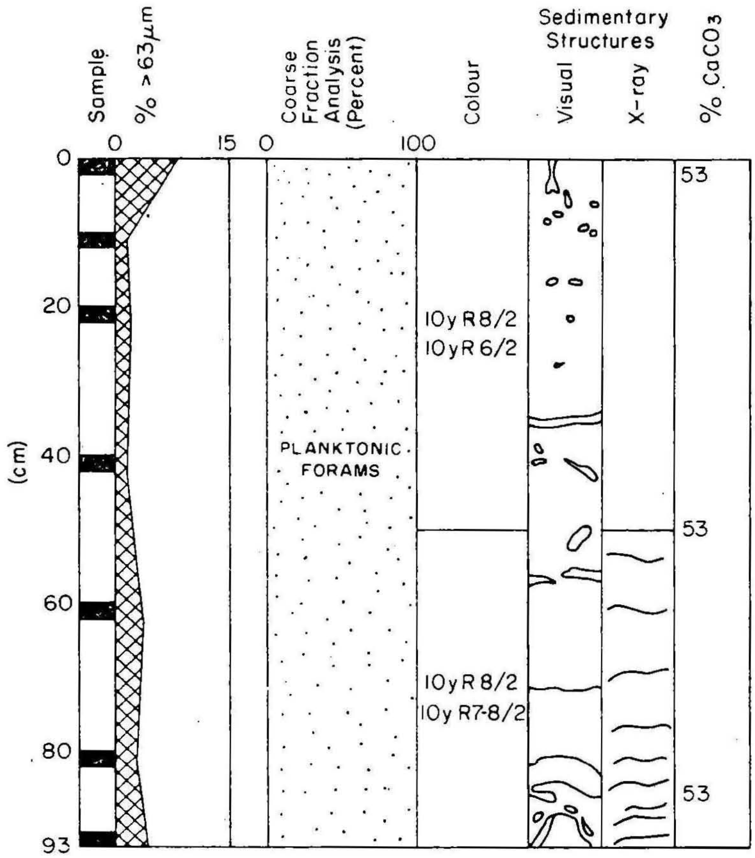
Volcanic glass predominates in the upper 10 cm of all cores, and is also present in Cores BL17, 20 and 21 between 80 and 100 cm. In Core KL14 this lower glass-rich horizon is probably missing, unless the horizon at 190 cm is the same. In KL14 there is a further glass-bearing horizon at 400 cm. The glass ranges from colourless, through various shades of brown, to almost black.

Radiolaria dominate the coarse fractions of all cores apart from KL14 and BL16, in which diatoms predominate at some levels. Corroded planktonic foraminifera, siliceous sponge spicules, burrow fillings, and faecal pellets are common but minor constituents. Arenaceous foraminifera, calcareous benthonic foraminifera, fish teeth and other fragments, and spore-like vitrinite remains are sometimes present in minor amounts.

Calcareous foraminifera are present only in the lower part of the cores above 5420 m, and are entirely absent in deeper water. Smear slide examination shows that the distribution of coccoliths is similar, but that they are somewhat more persistent. Expert examination of the coccoliths (see PALAEONTOLOGY) showed that all the preserved assemblages are of early or middle Pleistocene age, and suggested that the late Quaternary sedimentation rate is less than 2 mm/1000 years.

The results from the one-metre long boomerang cores indicate that the calcite compensation depth lies shallower now than it did in the past: above 4950 m compared to somewhere between 5290 and 5720 m. When KL14 is included the past CCD is seen to lie between 5420 m and 5720 m.

FIG. 2



LEGEND FOR CORE DIAGRAMS

Coarse Fraction Analysis (Figs 3,4,5)

- Calcareous forams (>98% planktonic)
- R — Radiolaria
- D — Diatoms
- V — Volcanic glass
- Others (B = burrow fillings, F = fecal pellets, S = sponge spicules)

Coarse Fraction Analysis (Fig. 6,7)

- C — Calcareous forams (>95% planktonic)
- Radiolaria
- Others (arenaceous foraminifera dominant near surface)

Sedimentary Structures from X-rays (for all core diagrams)

- Lenticular horizontal bioturbation
- Vertical pyrite - filled tubes (Ø< 1mm)
- Oval forams
- Spherical forams
- Structureless

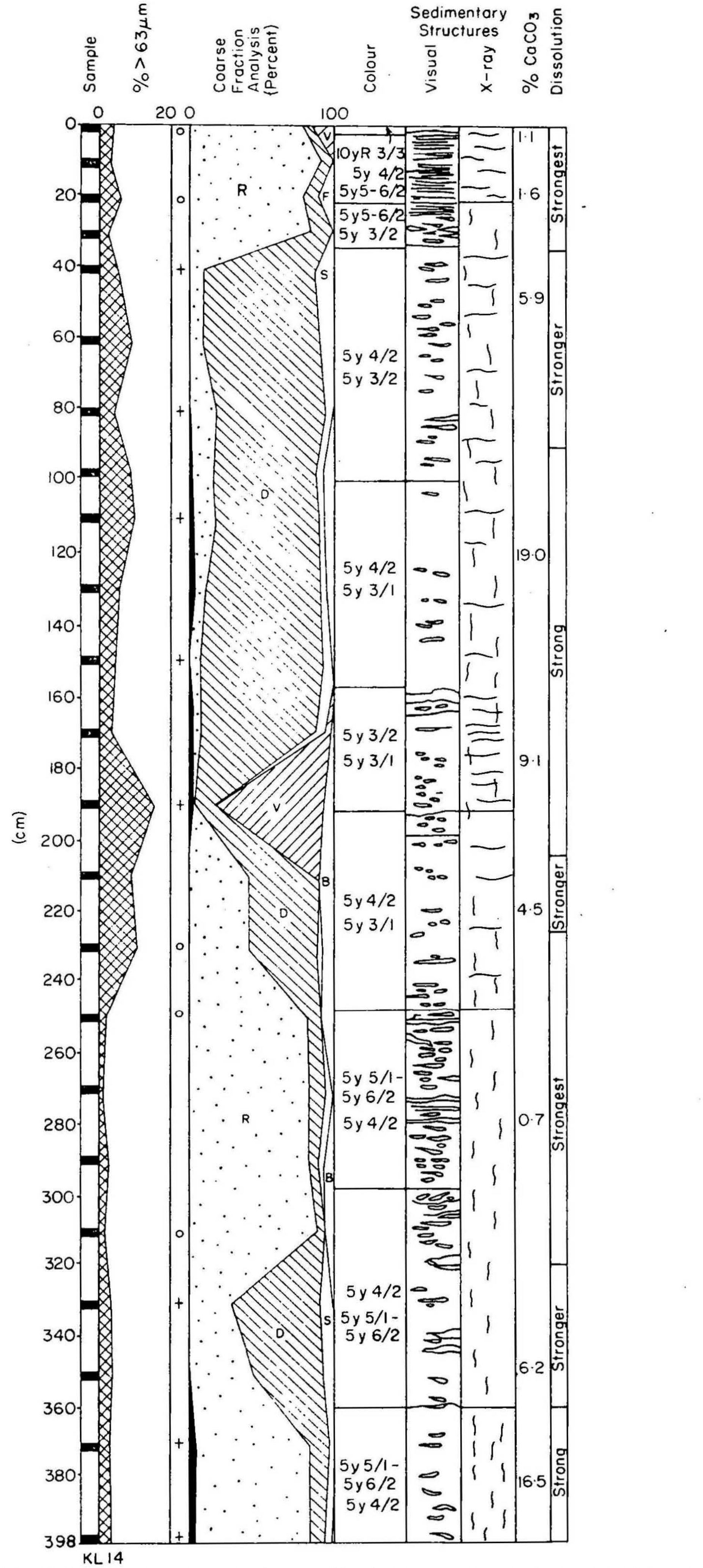
Other characteristics

- \+ Coccoliths present } Figs. 3,4,5
- o Coccoliths absent } Figs. 3,4,5
- • Manganese micronodules present

LATE CRETACEOUS CORE KL I FROM THE SCOTT PLATEAU

(General location in Figure 1. Legend for all core diagrams included.)

FIG. 3



QUATERNARY CORE KL 14 FROM THE JAVA TRENCH

(Legend in Figure 2. General location in Figure 1.)

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FIG. 4

TYPICAL QUATERNARY BOOMERANG CORES FROM THE JAVA TRENCH

(Legend in Figure 2. General location in Figure 1.)

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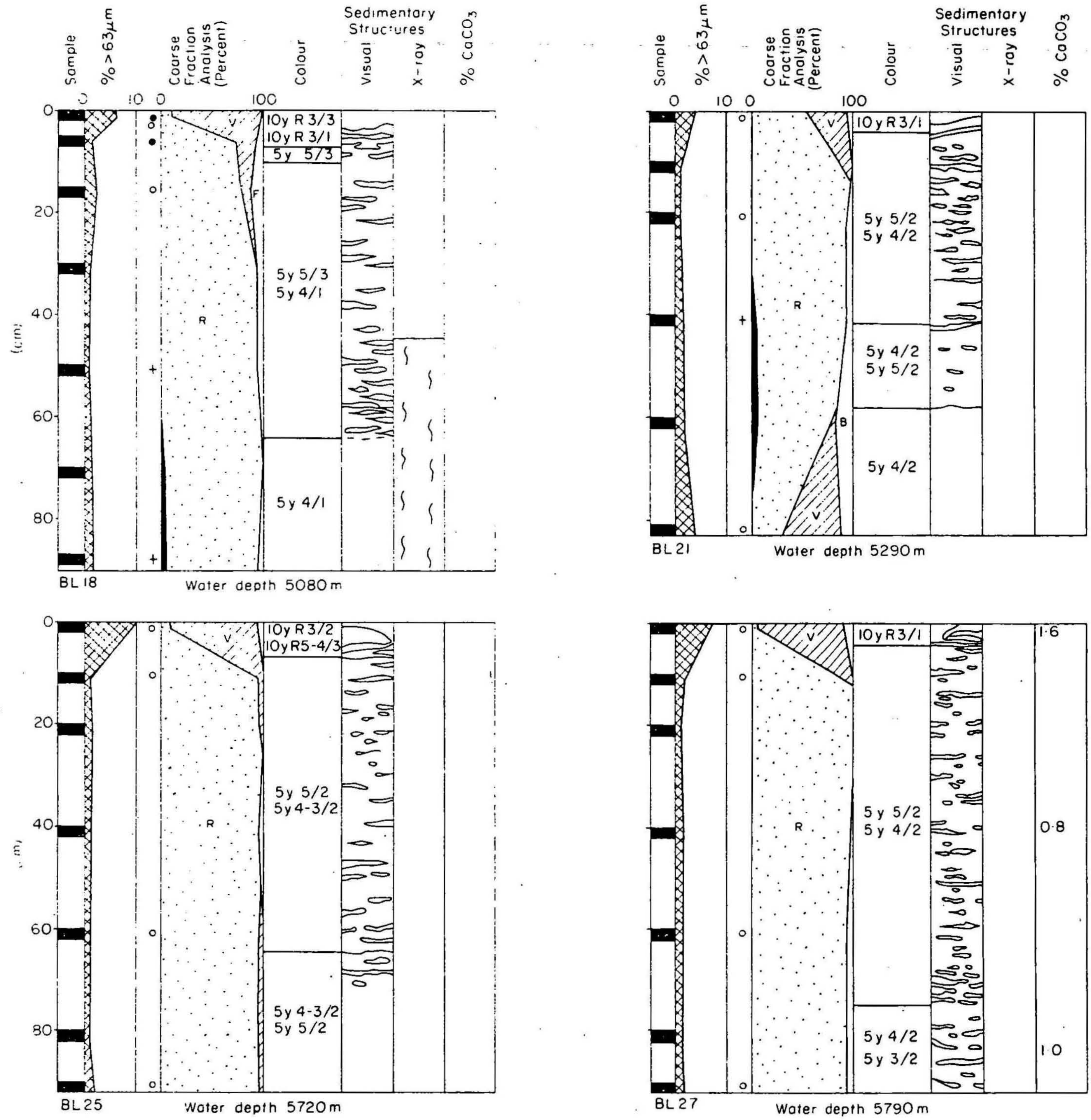
FIG. 5



OTHER QUATERNARY BOOMERANG CORES FROM THE JAVA TRENCH

(Legend in Figure 2. General location in Figure 1.)

In the four-metre long core KL14 three categories of dissolution of carbonate and silica are apparent (Fig. 3):

Strong - forams strongly dissolved, but some present

Stronger - forams absent, but diatoms abundant

Strongest - forams absent and diatoms rare

The results show that dissolution is strongest from 0 to 30 cm, and again from 220 to 320 cm.

Quaternary of the northern Scott Plateau (Figures 6 & 7)

Sand generally makes up 5 to 10% of these marls but in two cores there are foram sands (BL37: 24-26 cm = 71.1% sand; BL38: 32-33 cm = 32.6%), which may well be part of the same thin bed.

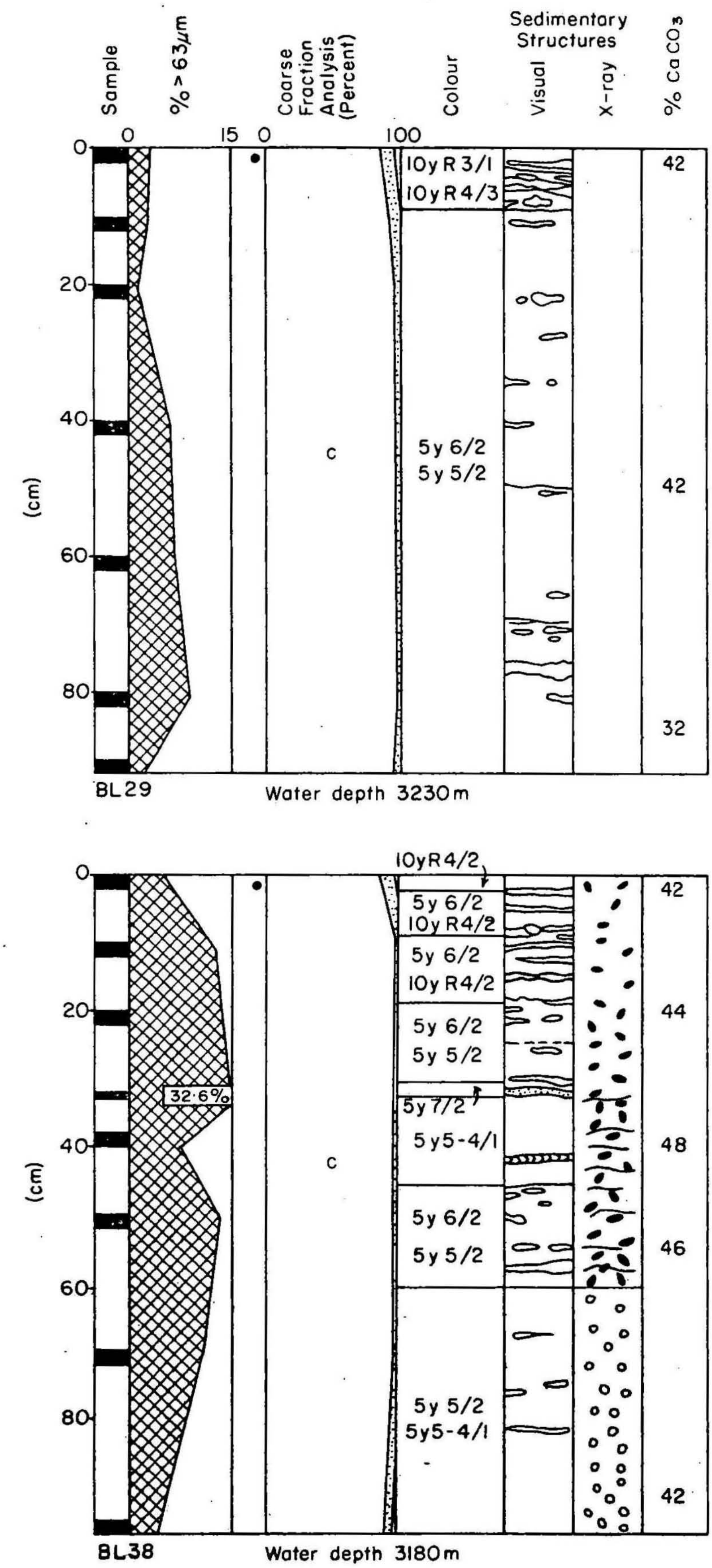
The coarse fraction analyses show the basic similarity of all the cores. The coarse fraction consists to more than 95% of planktonic foraminifera, with radiolaria and calcareous benthonic foraminifera throughout. Well-preserved arenaceous foraminifera are concentrated near the surface. Minor constituents include burrow fillings, vitrinite, and fish remains. Manganese micronodules are always present near the surface, where foraminifera and radiolaria are commonly coated with manganese oxide. Further down the cores the same organisms are occasionally coated with pyrite.

Smear-slide examination showed that glass and opaque minerals (including manganese micronodules) make up 10% of the fine fraction near the surface, but are virtually absent deeper in the cores, and that calcareous organisms are more abundant downward. The major components are clay minerals and coccoliths, with the former more abundant. Siliceous organisms make up less than 10% of the fine fraction, with radiolaria most abundant, ahead of sponges and diatoms.

PALAEONTOLOGY

(D.J. Belford, D. Burger, N.F. Exon, R.E. Gould, T. Matsumoto, S. Shafik, S.K. Skwarko, J. Gilbert-Tomlinson, & B. Zobel)

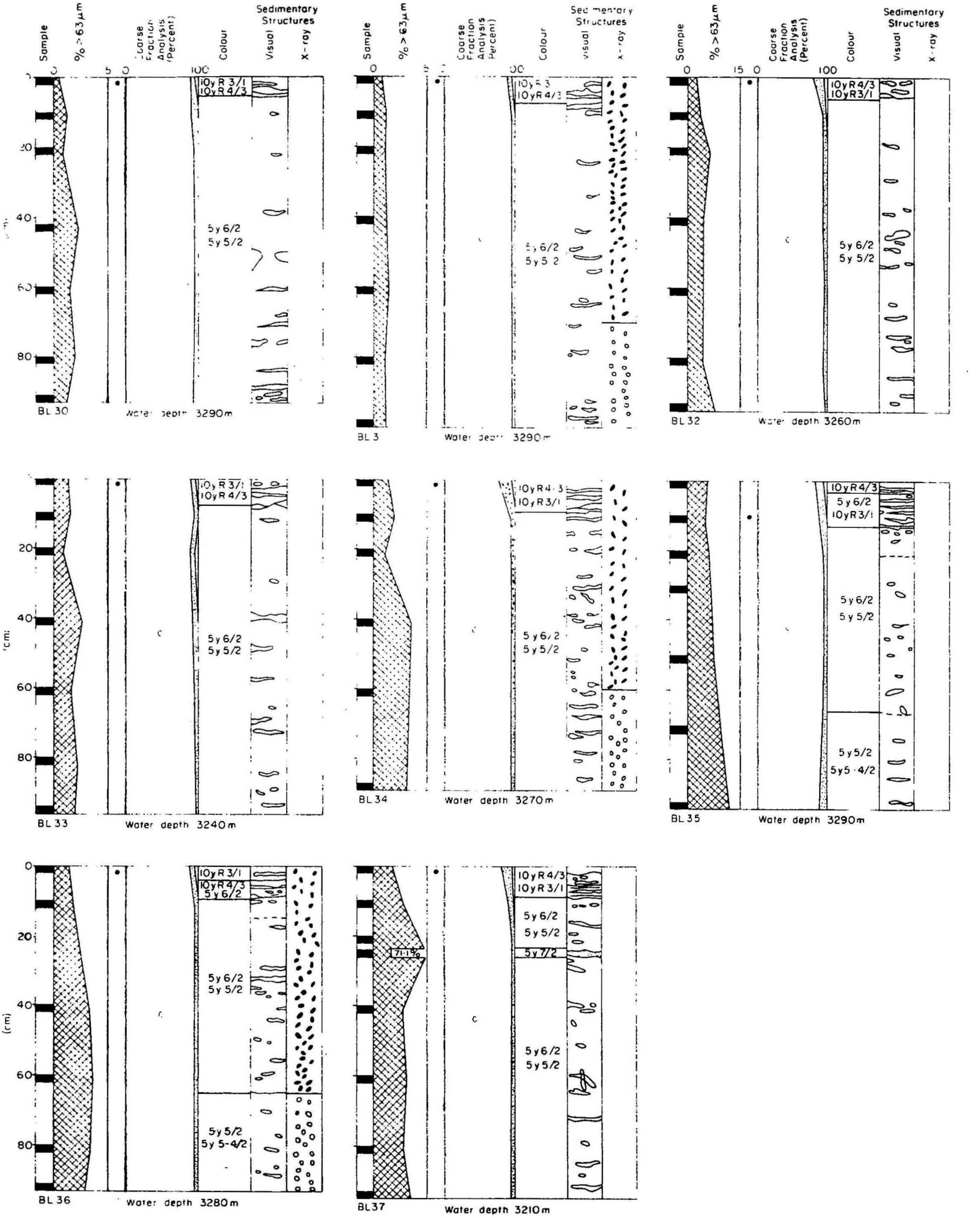
Shelly macrofossils from the dredge hauls KD7 and KD11 were examined by Dr S.K. Skwarko (BMR) and Dr T. Matsumoto (Kyushu University), large burrows form both dredge hauls by J.G. Tomlinson (BMR) and a piece of wood from KD7 was examined by Dr R.E. Gould (University of New England, Australia). Sedi-



TYPICAL QUATERNARY BOOMERANG CORES FROM THE NORTHERN SCOTT PLATEAU

(Legend in Figure 2. General location in Figure 1.)

FIG. 7



OTHER QUATERNARY BOOMERANG CORES FROM THE NORTHERN SCOTT PLATEAU

(Legend in Figure 2. General location in Figure 1.)

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Figure 8. X-ray positive of thin vertical tubes in slice of Quaternary sediments in core BL 17 from the Java Trench. Depth in core = 40 cm to 60 cm. Natural size. White areas are desiccation cracks.

ment samples were taken from the top and bottom of each core aboard ship, and these samples were examined by BMR palaeontologists Dr D.J. Belford (foraminifera), S. Shafik (coccoliths), and Dr D. Burger (palynology). A study of poorly-preserved foraminifera in the dredge hauls of Stations 7 and 11 was carried out by Dr B. Zobel (BGR), and of palynomorphs by Burger. Shafik examined the nannofossils adherent to three dredge hauls of older rocks, and the nannofossils in suites of samples from selected cores.

Macrofossils: Bivalves etc. (Skwarko)

Shelly macrofossils were recovered from two dredge hauls, KD7 and KD11, in the form of internal and external impressions in soft damp siltstone and mudstone. Determinations of the fauna, excluding the ammonites of KD11 (see below), are as follows:

KD7

Bivalves:
- Nuculid
- *Trigonia* (sensu stricto)
- ?Astartid

KD11

Bivalves:
- *Bucardiomya*
- *?Aucellina*

Scaphopod

Brachiopod
- *Lingula*

These identifications allow only broad dating: Middle Triassic-Cretaceous for KD7 and Jurassic-Cretaceous for KD11.

Ammonites (Matsumoto)

Introduction

Two pieces of ammonites from the Scott Plateau were sent to me for identification. This is a report of my study on them.

The locality, KD11, is in a depth of 3000 m and at latitude 12.8115°

and longitude 119.8687°E. The rock matrix is fragile, slightly indurated mudstone. The ammonites are incompletely preserved and their shell material is dissolved away. The repository of the specimens is the museum of the Bureau of Mineral Resources, Canberra.

Palaeontologic description

Order Ammonitida

Family Haploceratidae

1. Haploceras (?) sp.

Text-fig. 10A

Material - BMR. Reg. No. 7763011: a little more than a quarter whorl, enclosing a portion of the next inner whorl.

Description - The specimen is somewhat secondarily deformed. Measurements under this condition are approximately as follows -

whorl height: 23 mm, whorl-breadth: 13 mm, b/h: 0.56 at the last preserved part. The shell seems to be involute, presumably encircling a narrow umbilicus. The whorl is compressed, subelliptical in section, and has a flatly rounded venter.

The surface on the internal mould is smooth. (No external mould, which might show growth lines, was available).

The suture is roughly preserved on the posterior part. In addition to the first lateral saddle on the ventrolateral shoulder, there are at least four saddles aligned on a descending line, that decrease in size down the flank. Details of the suture are not entirely preserved. The foliole in the lower part of the first lateral lobe (L) shows somewhat phylloid terminals, whereas the bipartite subdivisions of the first lateral saddle (between E and L) are not so phylloid.

Remarks - Because of the phylloid terminals on some portions of the suture, as well as the general shell-form, I thought at first sight that this might be a phylloceratid species - say Geyeroceras sp., if we take account of

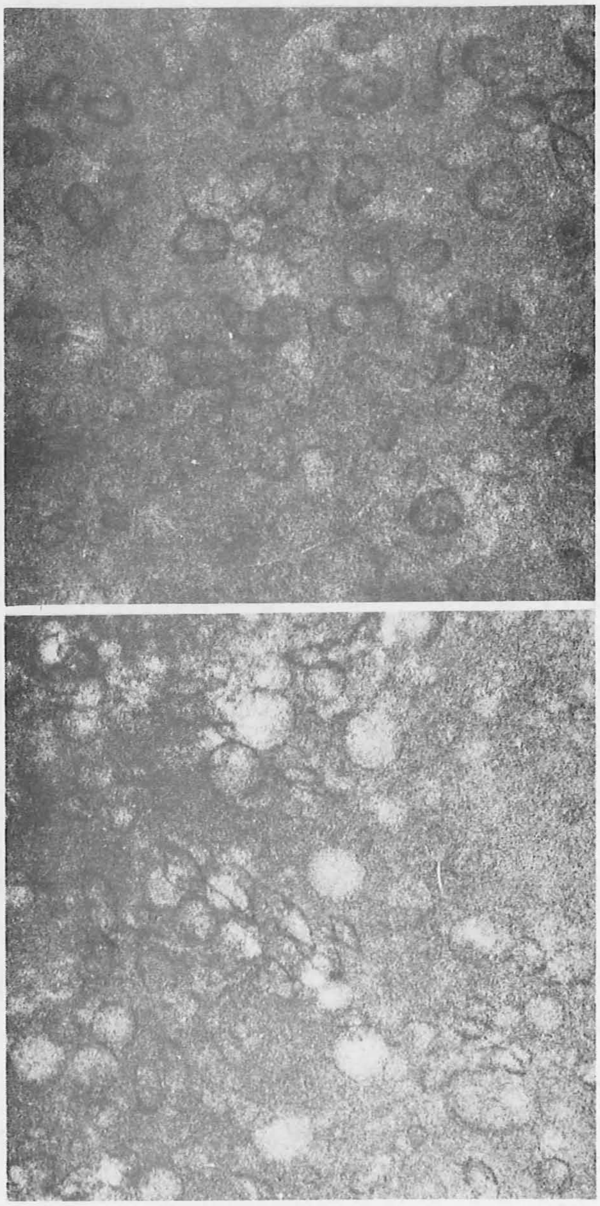

Figure 9, A (above), X-ray positive of Core BL 31 showing foraminifera in a slice of Quaternary sediment from the northern Scott Plateau (x 10 enlargement). Top of picture 48 cm deep in core. Shows oval thick-walled bodies, which proved to be solution-resistant multichambered planktonic foraminifera (Globorotalia).

9 B (below), X-ray positive of Core BL 36 showing foraminifera in a slice of Quaternary sediment from the northern Scott Plateau (x 10 enlargement). Top of picture 87 cm deep in core. Shows oval thick-walled bodies as in Figure 9, but in addition white thin-walled spherical bodies which proved to be solution-prone single-chambered planktonic foraminifera (Orbulina).

Fig 10A

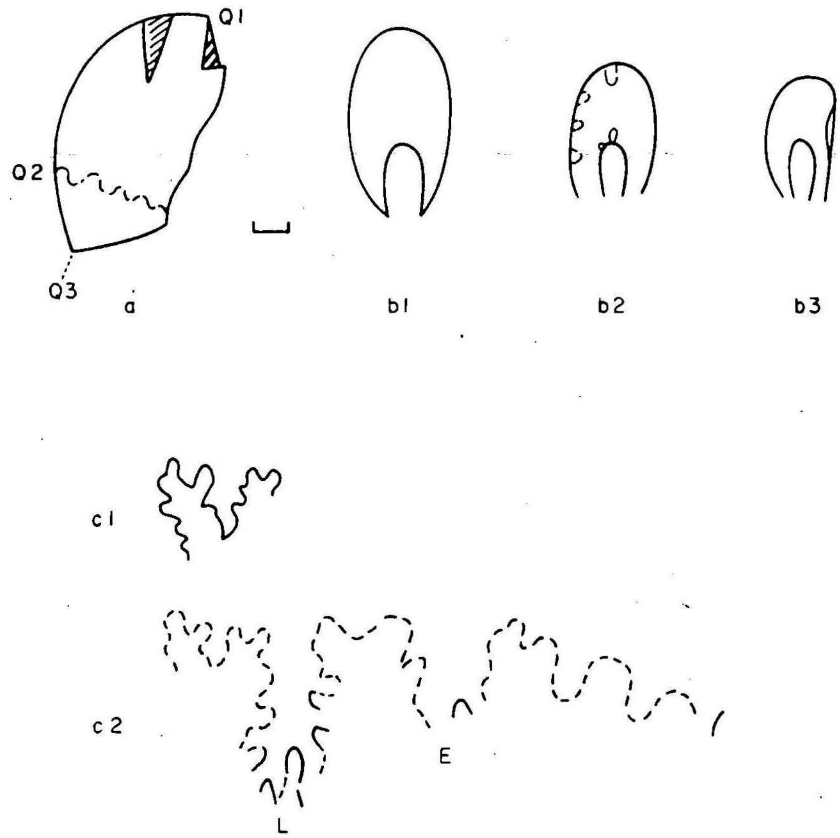

Fig 10B

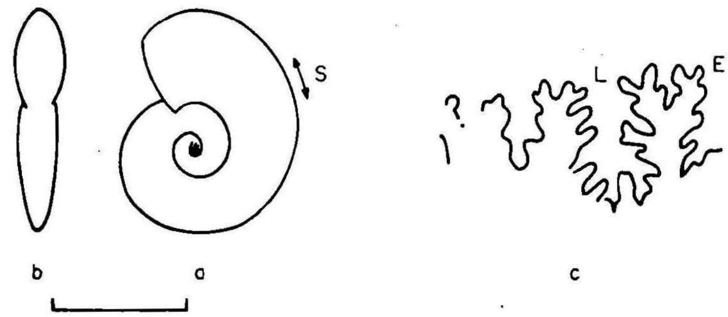

Figure 10A. *Haploceras* (?) sp. BMR No.7763011. Bar indicates 5 mm.
a : lateral view, b1–b3 : natural whorl-sections at Q1–Q3,
c1 : septal suture (part) in front of Q2, c2 : rough outline of septal suture at Q2

Figure 10B. *Glochiceras* (?) sp. BMR No.7763011 (inner whorl). Bar indicates 5 mm.
a : lateral view, b : aperture view, c : septal suture at S.

All diagrammatic sketches (T. Matsumoto <u>delin.</u>)

the flattened sides and venter. However, the flattened state is at least partly due to secondary deformation, and the phylloid character of the suture is not an entire feature.

Judging from all the observable characteristics, it is better to assign this ammonite to the genus Haploceras Zittel, 1870. It resembles, for instance, Haploceras carachteis (Zeuschner) as figured by Zittel, 1868 (Pl. 15, figs. 1-3), although precise identification cannot be made for this poorly preserved specimen. If the flattened flanks and venter were regarded as original characters, the genus Neolissoceras Spath, 1923 of the same family could be considered as another possible alternative, but there is no convincing evidence that the specimen had originally such flattened flanks as that genus.

2. Glochiceras (?) sp.
Text-fig. 10B

Material - BMR. No. 7763011: a very small specimen in which the outer whorl (unseptate living chamber ?) is partly preserved and the inner whorl, weathered to limonitic brownish colour, shows septal sutures.

Description - Shell is small, rather evolute, compressed and smooth. Whorl is much higher than broad, with gently convex flanks and a narrow venter, which is not fastigate but blunt. Umbilicus is of moderate width.

The measurements of the inner whorl in mm are:
diameter: 7.8 (1), umbilicus: 2.5 (.32), height: 3.0, breadth: 1.5, b/h: 0.50

The suture is fairly deeply incised even on this small immature whorl, showing a narrowed stem of the first lateral saddle (between E and L) whose head is bifid, and a trifid first lateral lobe (L).

Remarks - Exact identification is difficult for this small, incompletely preserved specimen. However, judging from the observed characteristics, it may be referred to the genus Glochiceras Hyatt, 1900. Typical species of Glochiceras, such as G. nimbatum (Oppel) and G. deplanatum (Waagen), are more involute and have narrower umbilicuses than the present form. The genus Hildoglochiceras Spath, 1924, which is closely allied to

Glochiceras, includes more evolute and widely umbilicate species than Glochiceras, but it is somewhat larger and has characteristically rursiradiate ribs on the outer half of the whorl in late growth stages. The median spiral groove on the flanks and the lappets on the apertural margin characterize the outer whorl of these two genera. Whether these characters existed or not cannot be decided on this poorly preserved, probably immature specimen, unless falciform striation should be found on a better preserved external mould. As exemplified by the species from Mexico (Imlay, 1939), there are comparatively few involute species of Glochiceras and also more involute species of Hildoglochiceras.

Concluding remarks

The preservation of these two ammonites is not sufficient for precise identification, but the observed characters suggest that one may be Haploceras (?) sp. cf. H. carachteis (Zeuschner) and the other may be Glochiceras (?) sp.

These two genera, if correctly identified, are widespread in the Tithonian or Kimmeridgian of Europe, the Tethys sea region, Eastern Africa, Madagascar, India (Cutch), Middle America (Mexico and Cuba) and other areas. They imply a Late Jurassic age for the submarine sequence at KD 11.

Finally the find of two ammonites in a dredged sample of limited size seems to suggest an abundant or fairly common distribution of the same or other ammonite species in the same layer of this area.

Wood (Gould)

The wood from KD7 is definitely gymnospermous with quite thick-walled tracheids; unfortunately gymnospermous woods range from Late Devonian to Recent - although this type is more like Permian to Recent forms.

Trace fossils (Exon, Gilbert-Tomlinson)

In addition to the trace fossils found in cores and mentioned above, two types of hollow tubular structures are present in the soft Jurassic siltstones dredged at KD7 and KD11.

The larger structures are circular in cross-section with a diameter generally ranging from 5 to 10 mm; a few examples have a diameter of up to 15 mm. Their length often exceeds 10 cm, and their longitudinal shape is rather irregular. The material available to us is inadequate to reveal the details of architecture or the orientation of the tubes. Scratch-marks in the form of oblique cross-hatching recall those figured by Warme (1975, p. 189) in a boring by an unidentified (possibly crustacean) animal in chalk, and stated by him to be widespread in chalk and mudstone laid down in bathyal and abyssal depths. The tubes appear to have been originally unlined, but are now coated with a mineralised veneer, probably manganese oxide. Whether the tubes represent pre-lithification burrows or post-lithification borings cannot be determined.

The smaller of the two types of open tubes are J-shaped, generally less than 3 cm long, and 1-3 mm in diameter. They are the dwellings of living serpulids, which coat themselves with foraminiferal tests. They have also colonised many of the larger burrows, filling them with foraminiferal tests.

Palynology (Burger)

Samples were processed from the bottom of all cores from the Java Trench. Many were barren of palynomorphs, but poorly preserved possibly Pleistocene to Recent material was recovered from KL14, and BL17, 20, 21, and 25. Samples were also processed from the bottom of all boomerang cores from the northern Scott Plateau. Again preservation was poor, but possibly Pleistocene to Recent palynomorphs were recovered from BL29-32 and BL34-38. Reworked Jurassic to Early Cretaceous spores and pollen grains were found in BL29, 34, 36 and 38.

Dredge haul KD7 contained no palynomorphs, but KD11 contained an assemblage of marine dinoflagellates and hystrichospheres of Late Jurassic age.

Biostratigraphy of calcareous microfossils (Shafik and Belford)

Samples examined came mostly from boomerang core material. In the case of foraminifera and only two samples, from the top and bottom of each core, were examined. In the case of nannofossils, more numerous samples were taken. Samples from boomerang cores from deeper than 5290 m water depth are devoid of calcareous planktic remains, and their ages were therefore indeterminable. Other cores contain calcareous planktic remains (nannofossils and planktic foraminiferids), and these are either restricted to the bottom samples or occur in both top and bottom samples of each core. Calcareous planktic remains are also present in the lower part of the Core KL14 from 5420 m (Fig. 3). The samples containing calcareous microfossil remains have been differentiated into Upper Cretaceous and Quaternary groups, on the basis of age-diagnostic species.

Upper Cretaceous

Both the top and bottom of core KL1 (Scott Plateau) from 2000 m water depth yielded the same species of calcareous microfossils which indicate a Late Cretaceous age. The calcareous nannofossils are slightly etched but the foraminiferids are excellently preserved. The nannofossil assemblages include *Arkhangelskiella cymbiformis* Vekshina, *Biscutum blacki* Gartner, *Broinsonia parca* (Stradner), *Cretarhabdus crenulatus* Bramlette & Martini, *Cribrosphaera ehrenbergi* Arkhangelsky, *Cylindralithus serratus* Bramlette & Martini, *C.* sp., *Eiffellithus eximius* (Stover), *E. turriseiffeli* (Deflandre), *Gartnergo obliquum* (Stradner), (rare), *Lithastrinus grilli* Stradner (rare), *Manivitella pemmatoidea* (Manivit), (rare), *Markalius circumradiatus* (Stover), *Microrhabdulus elongatus* Gartner, *M. decoratus* Deflandre, *Micula staurophora* (Gardet), *Prediscosphaera cretacea* (Arkhangelsky), stems of *P. spinosa* (Bramlette & Martini), *Watznaueria barnesae* (Black), *Reinhardtites biperforatus* (Gartner), *Z. sigmoides* Bramlette & Martini, and *Z.* spp.

The planktic foraminifera and nannofossils of Core KL1 give compatible ages. The occurrence of globotruncanids including the species *Globotruncana arca*, *G. fornicata*, *G. tricarinata*, and *G. ventricosa*, and *Schackoina* sp., *Globobigerinelloides* spp., and Heterohelicidae indicates a

Campanian age. A detailed study of the planktic foraminifera from this core will be presented by Belford (in prep.). The co-occurrence of Broinsonia parca (Stradner) and Eiffellithus eximius (Stover), without the association of Tetralithus aculeus (Stradner), signifies an early Campanian age (Shafik, 1978a).

Similar assemblages of planktic foraminiferids and nannofossils were not found in the Upper Cretaceous sediments recovered from the nearby DSDP Site 261. Only benthic agglutinated foraminiferids were recorded from the zeolitic clays in this hole (Veevers, Heirtzler, et al., 1974). These are thought to have been laid down below the lysocline (see Krasheninnikov, 1974; Bolli, 1974), whereas the taxa recovered from core KL1 on the Scott Plateau suggest deposition well above the lysocline.

Quaternary cores

Samples from the tops and bottoms of cores from the Northern Scott Plateau BL29-38 contained both planktic foraminiferids and calcareous nannofossils.

The nannofossil assemblages include taxa indicative of Quaternary age, as well as older species. The latter represent most of the stages of the Upper Cretaceous and Tertiary, and are presumed to be reworked. The reworked elements include:

a) Arkhangelskiella cymbiformis, Biscutum blacki, Broinsonia parca, Cretarhabdus crenulatus, Cribrosphaera ehrenbergi, Eiffellithus eximius, E. turriseiffelli, Micula staurophora, Prediscosphaera cretacea, Tetralithus pyramidus Gardet, T. quadratus Stradner, T. trifidus (Stradner), and Watznaueria barnesae which suggest Upper Cretaceous source sediments.

b) Chiasmolithus consuetus (Bramlette & Sullivan), Cruciplacolithus tenuis (Stradner), Cyclococcolithina robusta (Bramlette & Sullivan), Discoaster mohleri Bukry & Percival, D. multiradiatus (Bramlette & Sullivan), Fasiculithus involutus Bramlette & Sullivan, and Toweius eminens (Bramlette & Sullivan) which are mostly restricted to Palaeocene sediments.

c) Coccolithus eopelagicus (Bramlette & Riedel), Cyclococcolithina formosa (Kamptner), Discoaster barbadiensis Tan, D. nodifer (Bramlette & Riedel), D. saipanensis Bramlette & Riedel, D. tani Bramlette & Riedel, Discoasteroides kuepperi (Stradner), Sphenolithus furcatolithoides Locker, S. radians Deflandre, Triquetrorhabdulus inversus Bukry & Bramlette and Reticulofenestra umbilica (Levin) which are collectively indicative of Eocene source sediments.

d) Cyclicargolithus abisectus (Müller), Discoaster deflandrei Bramlette & Riedel, Reticulofenestra scissura (Hay, Mohler & Wade), Sphenolithus ciperoensis Bramlette & Wilcoxon, S. distentus (Martini), S. predistentus Bramlette & Wilcoxon, S. pseudoradians Bramlette & Wilcoxon, and Triquetrorhabdulus carinatus Martini, which collectively suggest Oligocene source sediments.

e) Cyclococcolithina macintyrei, Discoaster berggrenii Bukry, D. broweri, D. druggii Bramlette & Wilcoxon, D. pentaradiatus, D. prepentaradiatus Bukry & Percival, D. quinqueramus Gartner, D. surculus Martini & Bramlette, D. triradiatus Tan, D. variabilis, Helicopontosphaera sellii Bukry & Bramlette, Pseudoemiliania lacunosa (Kamptner), Reticulofenestra pseudoumbilica (Gartner), Sphenolithus abies Deflandre, S. heteoromorphus Deflandre, and S. neoabies Bukry & Bramlette, which suggest Neogene source sediments.

Cretaceous as well as Tertiary species are common to all samples and most occur in abundance; known stratigraphical ranges of some of these species are given in Table 2.

The autochthonous elements are represented by Ceratolithus cristatus Kamptner, Cyclococcolithina leptopora (Murray & Blackman), Emiliania huxleyi (Lohmann), several species of Gephyrocapsa including G. oceanica Kamptner, Helicopontosphaera kaptneri (Hay & Mohler), Rhabdosphaera stylifera Lohmann and Umbilicosphaera mirabilis Lohmann. Most of these taxa (and in particular E. huxleyi and Geophyrocapsa plexus) are consistently present in all samples, unlike the reworked species which are distributed randomly among the samples.

Although the diversity of the planktic foraminiferids is variable (Table 3), the occurrence of coccoliths of the genus Gephyrocapsa and Emiliania huxleyi (Lohmann) in all samples is regarded as indicating that the samples are latest Pleistocene to Holocene in age. The patchy distribution of foraminiferal species such as Globorotalia (G.) truncatulinoides, Globigerina (Beella) digitata, Hastigerina (Bolliella) adamsi and Pulleniatina obliquiloculata finalis in the samples supports a Quaternary age (maximum Zone N.22). The common occurrence of the foraminiferids Pulleniatina obliquiloculata praecursor, and rare occurrence of Globoquadrina venezuelana and Sphaeroidinella dehiscens dehiscens forma immatura may indicate some reworking from Upper Tertiary sources.

Cores recovered from the Java Trench are either barren of calcareous planktic remains or contain these only in samples from low in the cores. The results suggest that the carbonate compensation depth now lies about 4950 m but that, earlier in the Quaternary, it lay between 5420 m and 5700 m. Assemblages recovered are similar to those found in the cores from the northern Scott Plateau in that they contain the coccolith Gephyrocapsa spp. and further in that the foraminiferid Globorotalia (G.) truncatulinoides is frequently present. They differ, however, in the absence of Emiliania huxleyi (Lohmann) from the Java Trench samples. The presence of Gephyrocapsa oceanica and the absence of Emiliania huxleyi (Lohmann) suggest that the assemblages are early or middle Pleistocene (Shafik, 1978b).

Reworked nannofossils representing most of the Upper Cretaceous and Tertiary stages, and reworked Quaternary planktic foraminiferids, also occur in the Quaternary assemblages of the Java Trench samples. They are similar to those recorded from the northern Scott Plateau cores. Seemingly, the agents which brought the reworked Cretaceous and Tertiary nannofossil taxa to the Scott Plateau and Java Trench were not capable of bringing the much larger foraminiferids.

Quaternary Dredge Haul Samples KD11, KD7, and KD2.

Relics of nannofossil-bearing sediments adhere to these dredge samples, which are generally barren of nannofossils. The bulk of sample KD11 consists of dark grey mudstone which lacks nannofossils, but contains other evidence suggesting a late Jurassic age (D. Burger, present record).

Traces of paler sediments filling burrows in this sample (KD11) proved to contain abundant calcareous nannofossils, which include Biscutum blacki, Ceratolithus cristatus Kamptner, Coccolithus eopelagicus (Bramlette & Riedel), Cribrosphaera ehrenbergi, Cyclococcolithina leptopora (Murray & Blackman), C. macintyrei Bukry & Bramlette, questionable Emiliania huxleyi (Lohmann), Gephyrocapsa spp. (including G. oceanica Kamptner), Helicopontosphaera kamptneri Hay & Mohler, Rhabdosphaera sp., Thoracosphaera spp., and Watznaueria barnesae. The known stratigraphic ranges of these species indicate admixing from sources as old as the Cretaceous. However, the occurrence of both Gephyrocapsa oceanica Kamptner and questionable Emiliania huxleyi (Lohmann) indicates an age of Pleistocene-Holocene.

The bulk of sample KD7 is similar to sample KD11, and it is similarly barren of calcareous nannofossils. Paler relics of sediments adhering to sample KD7 contain sparse nannofossils similar to those recorded from KD11, but more diversified. In addition to those recorded from sample KD11, Ceratolithus telesmus Norris, Cyclicargolithus abisectus (Müller), Discoaster broweri Tan, D. pentaradiatus Tan, D. variabilis Martini & Bramlette, and Pontosphaera sp. were identified from sample KD7; Gephyrocapsa oceanica Kamptner is also present.

Likewise, relics of sediments adherent to manganese-coated basalt fragments (dredge sample KD2) contain the same sparse nannofossil species identified from sample KD7, including Gephyrocapsa oceanica. The material adhering to KD7 and KD2 is assigned to the Pleistocene-Holocene, based on the common occurrence of Gephyrocapsa oceanica Kamptner.

Foraminifera from the dredge samples (Zobel)

The sedimentary fraction of the dredge hauls was sieved and examined for foraminifera. The results were disappointing as all the sediments had been de-calcified.

KD2: Originally probably a coccolith-foraminiferal-mud. The now completely decalcified, extraordinarily fine-grained, and quite soft sediment contains internal moulds of planktonic foraminifera. The infilling is so fine-grained that the binding between chambers, and even the pores which connect the chambers with the outside, are filled with it in some cases (visible in broken tests). Careful preparation enabled a few moulds to be preserved. Remarkably these came only from Globigerinida; Globorotalia moulds were not found, although logically they should have been. Apart from Globigerina spp., Globigerinoides aff. trilobus (Reuss) and other Globigerinoides spp. were visible, Orbulina suturalis Bronnimann (perhaps actually Praeorbulina glomerosa (Blow)) was not uncommon, and a form aff. Globoquadrina altispira (Cushman & Jarvis) was present. This material can hardly be older than oldest middle Miocene and is not younger than early Pleistocene.

KD7: All the sediments examined were free of carbonate, except one piece, which preparation showed contained a typical tropical, probably Holocene, planktonic foraminiferal association. This probably came from within an open burrow in these Jurassic rocks. The accompanying benthonic foraminifera are typical deep-water species, and the total assemblage is comparable to that found in the boomerang cores.

KD11: Apart from attached recent foraminifera none were found.

Table 2. Bases and tops of ranges of some reworked nannofossil species found in Quaternary samples from the Scott Plateau and Java Trench. (Most of these species have been used to define zonal boundaries in Upper Cretaceous and Tertiary sediments from widely separated areas.)

Species	base of range	top of range
Broinsonia parca	Earliest Campanian	Latest Campanian
Eiffellithus eximius	Late Turonian	Early Campanian
Eiffellithus turriseiffeli	Late Albian	Late Maastrichtian
Micula staurophora	Late Turonian	Latest Maastrichtian
Tetralithus trifidus	Campanian/Maastrichtian	Early Maastrichtian
Cruciplacolithus tenuis	Early Paleocene	Late Paleocene
Cyclococcolithina robusta	Early Paleocene	Late Paleocene
Discoaster mohleri	Late Paleocene	Late Paleocene
Discoaster multiradiatus	Latest Paleocene	Earliest Eocene
Cyclococcolithina formosa	Early Eocene	Earliest Oligocene
Discoaster barbadiensis	Early Eocene	Latest Eocene
Discoaster saipanensis	mid Eocene	Latest Eocene
Discoasteroides kuepperi	Early Eocene	mid Eocene
Sphenolithus furcatolithoides	Middle Eocene	Middle Eocene
Triquetrorhabdulus inversus	Middle Eocene	Middle Eocene
Reticulofenestra umbilica	Middle Eocene	Early Oligocene
Cyclicargolithus abisectus	Late Oligocene	mid Miocene
Reticulofenestra scissura	Middle Eocene	Late Oligocene
Sphenolithus ciperoensis	Late Oligocene	Late Oligocene
Sphenolithus distentus	mid Oligocene	Late Oligocene
Triquetrorhabdulus carinatus	Latest Oligocene	Early Miocene
Discoaster berggrenii	Late Miocene	Late Miocene
Discoaster broweri	mid Miocene	Latest Pliocene
Discoaster druggii	Earliest Miocene	Early Miocene
Discoaster pentaradiatus	mid Miocene	Late Pliocene
Discoaster quinqueramus	Late Miocene	Latest Miocene
Cyclococcolithina macintyrei	mid Miocene	Pleistocene
Pseudoemiliania lacunosa	mid Pliocene	Pleistocene
Helicopontosphaera sellii	Late Miocene	Pleistocene
Reticulofenestra pseudoumbilica	Middle Miocene	Early Pliocene
Sphenolithus heteromorphus	Early Miocene	Middle Miocene

Table 3: Foraminifera and Radiolaria from Quaternary sediments

Area	Java Trench											Scott Plateau										
STATION = BMR SAMPLE NUMBER (PREFIX 7763)	0014	0015	0016	0017	0018	0020	0021	0022	0025	0026	0027	0002	0029	0030	0031	0032	0033	0034	0035	0036	0037	0038
SPECIES	0 cm 400 cm.	0 cm. 94 cm.	0 cm 105 cm	0 cm 114 cm	0 cm 98 cm	0 cm 99 cm	0 cm 97 cm	0 cm 110 cm	0 cm 96 cm	0 cm 102 cm	0 cm 98 cm	Surface	0 cm 100 cm	0 cm 103 cm	0 cm 104 cm	0 cm 100 cm	0 cm 103 cm	0 cm 95 cm	0 cm 103 cm.	0 cm 103 cm	0 cm 100 cm	0 cm 101 cm
Candeina nitida nitida													X X	X	X	X				X		X
Globigerina (Beella) digitata													X		X			X	X	X X		
G.(G.) bulloides		X X	X	X	X	X							X			X		X X	X			
G.(G.) cf.calida		X																				
G.(G.) pachyderma		X																				
G.(G.) rubescens		X											X X	X	X		X X			X		X
Globigerinita glutinata		X X	X	X				X					X X	X X	X X	X X	X X	X X	X	X X		X X
G.humilis		X X																				
Globigerinoides conglobatus conglobatus		X	X	X									X X	X	X X	X X	X	X X	X	X	X	X
G.quadrilobatus quadrilobatus		X	X	X	X								X	X X	X X	X X	X X	X X	X	X	X	
G.quadrilobatus sacculifer		X		X	X								X X	X	X	X X	X	X	X	X	X	X X
G.ruber	X	X	X	X	X	X		X					X	X	X X	X X	X X	X X	X	X	X	X X
Globoquadrina dutertrei	?	X	X	X	X	X		X					X X	X X	X	X X	X X	X X	X		X	X X
G.hexagona													X		X		X	X X	X			X
G.venezuelana																			X	X		
Globorotalia (G.) cultrata group	X	X	X	X	X	X X		X					X X	X	X X	X X	X X	X X	X X	X X	X X	X X
G.(G.) truncatulinoides			X															X	X	X		
G.(G.) tumida tumida		X	X	X		X		X					X X	X	X	X X	X X	X X	X	X	X	X
G.(Turborotalia) acostaensis		X	X	X	X	X		X						X	X					X		X
G.(T.) crassaformis			X	X		X																
G.(T.) cf.inflata				X																	X	
G.(T.)obesa				X	X										X		X X		X	X	X	X
G.(T.) scitula scitula					X								X X	X	X	X X	X X	X X	X	X	X	X
G.(T.) tosaensis tosaensis		X						X														
Hastigerina (Bolliella) adamsi																X						
H.(H.) siphonifera		X X		X				X					X X	X X	X	X X	X X	X	X		X	X X
Orbulina suturalis												X										
O.universa			X	X									X		X	X X	X X	X X	X X	X	X	X X
Pulleniatina obliquiloculata obliquiloculata		X											X			X		X	X	X X		X X
P.obliquiloculata finalis																						X
P.obliquiloculata praecursor						X		X					X X	X X	X X	X X	X X	X X	X X	X X	X	X X
Sphaeroidinella dehiscens dehiscens				X	X								X X	X X	X	X X	X X	X	X X		X X	X
S. dehiscens dehiscens forma immatura																				X		
Rare smaller benthic Foraminifera							X															
Agglutinated Foraminifera only			X	X	X	X	X	X		X												
Rare Radiolaria			X	X	X	X	X	X	X X	X												
Frequent Radiolaria										X	X											
Abundant Radiolaria							X				X											

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