1. INTRODUCTION AND PRINCIPAL RESULTS: LEG 30, DEEP SEA DRILLING PROJECT

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CRUISE SUMMARY

Leg 30 was the second cruise of D/V *Glomar Challenger* in the southwest Pacific arc and marginal sea complex (Figure 1). Previous drilling was carried out on Leg 21. The cruise commenced at Wellington, New Zealand on 24 April 1973 and ended on 13 June 1973 at Guam. During Leg 30 *Glomar Challenger* steamed 5273 nautical miles (9765 km) and drilling was carried out at five sites, although eight sites were planned for the leg. The reduction of the number of sites permitted longer than normal occupation of Sites 288 and 289 on the Ontong-Java Plateau (10 and 8 days, respectively). A downhole reentry of the hole was accomplished at Site 288.

At the five sites occupied, a total of 250 cores was cut representing 2332 meters of section of a total penetration of 4140 meters; 1163.9 meters of core were recovered representing an overall recovery rate of 50%. Basement was reached at three sites and drilling was terminated in an intrusive sill at a fourth. In all 91.8 meters igneous rock was drilled, and 58.3 meters of core were recovered. Details of site locations, core recovery, etc., are given in Table 1.

Routine underway measurements were made between sites. These included echo-sounding, seismic reflection profiling (airgun), and magnetic field measurement.

GENERAL BACKGROUND

The convergent plate boundary between the Pacific and India plates passes through the region investigated on Leg 30. This plate boundary is expressed as a trench north of New Zealand (the Tonga-Kermadec Trench), a strike-slip feature between Fiji and the southern end of the New Hebrides Islands and another south of the Solomon Islands (the New Hebrides and Solomon trenches, respectively). West of the Solomon Trench is a further trench south of the island of New Britain (the Bismark Trench). From the western end of this trench the plate boundary runs into the island of New Guinea. The plate boundary is identifiable topographically and by seismicity. Seismicity also outlines a number of small plates in the New Guinea region (Johnson and Molnar, 1972). The island arcs that are associated with the convergent Pacific-India plate boundary lie on the India plate south of Fiji and on the Pacific plate from the New Hebrides to New Britain. The location of these arcs on the Pacific plate has led to the suggestion that the arcs may have once been on the India plate with the active plate boundary on their northern side, but that the boundary has been relocated to the south (e.g., Packham, 1973; Mitchell and Warden, 1972). The old suggested boundary is marked by deeps such as the Vitiaz Trench and the Cape Johnson Trough.

The oceanic crust of the Pacific plate north of these arcs is generally considered to be Mesozoic (Larson and Chase, 1972) with the exception of the Caroline Basin in which Oligocene ages have been obtained (Winterer, Ewing, et al., 1971) and the Fiji Plateau, an elevated area of oceanic crust that probably started to develop in the Miocene (Chase, 1971). These two areas of younger crust appear to have been accreted onto the Mesozoic crust as a result of a spreading episode unrelated to the formation of the Mesozoic crust.

Within the India plate there is a complex of ridges and basins that can be divided into two main groups. The boundary between them is a region of fractures running from near the Australian coast south of the Queensland Plateau to the India-Pacific plate boundary south of the eastern part of the Solomon Islands.

The southeastern region is comprised of the following structures from west to east—the Tasman Basin, the

TABLE 1
Coring Summary, Leg 30

Hole	Dates of Drilling (1973)	Latitude	Longitude	Water Depth (m)	Penetration (m)	No. of Cores Cut	Total Cored (m)	Total Recovered (m)	Recovery (%)
285	29 April-1 May	26°49.16′S	175°48.24′E	4658	83.5	5	45.5	42.2	92.7
285A	2-4 May	26°49.16′S	175°48.24′E	4658	584.0	9	85.5	47.5	55.5
286	7-11 May	16°31.92′S	166°22.18′E	4465	706.0	41	383.0	170.4	44.5
287	15-17 May	13°54.67′S	153°15.93′E	4632	252.0	18	157.0	73.4	47.0
288	21-22 May	05°58.35′S	161°49.53′E	3000	238.0	11	98.0	50.4	51.0
288A	22-28 May	05°58.35′S	161°49.53′E	3000	988.5	30	284.5	61.3	22.0
288B	29 May	05°58.35′S	161°49.53′E	3000	150.0	1	3.0	3.0	100.0
288C	30 May	05°58.35′S	161°49.53′E	3000	150.0	1	4.5	4.5	100.0
289	31 May-8 June	00°29.92′S	158°30.69′E	2206	1271.0	133	1271.0	712.6	56.0
TOTAL						249	2332.0	1165.3	50.0%

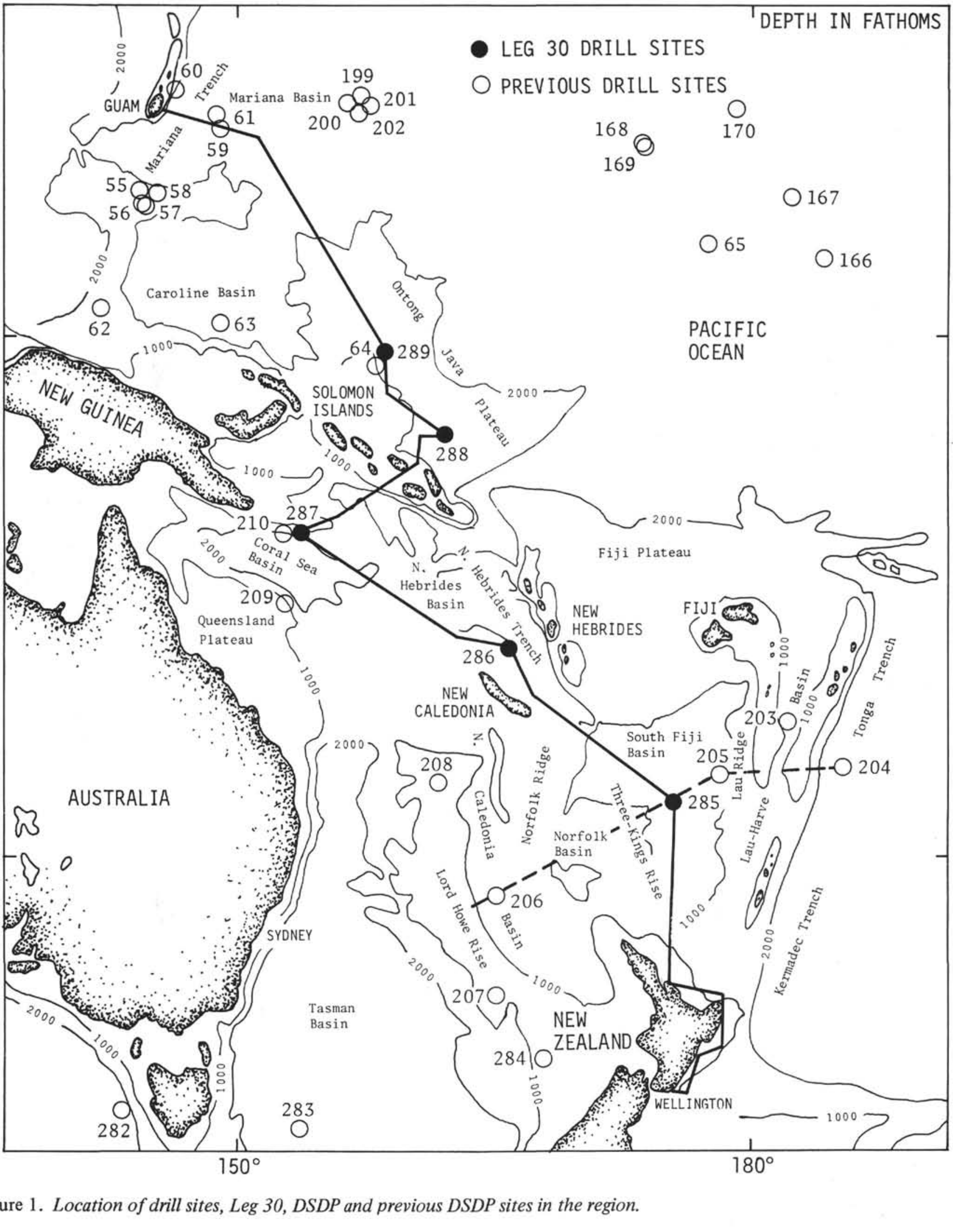

Figure 1. *Location of drill sites, Leg 30, DSDP and previous DSDP sites in the region.*

Lord Howe Rise, the New Caledonia Basin, the Norfolk Ridge, the Norfolk Basin, the Three Kings Rise, the South Fiji Basin, the Lau Ridge, the Lau-Havre Basin, and the Tonga Ridge. To the east lies the Tonga-Kermadec Trench (Figure 2).

The Tasman Basin has an identifiable magnetic anomaly pattern and was formed by normal sea-floor spreading between 80 and 60 m.y.B.P. (Hayes and Ringis, 1973). Some of the structures to the east were drilled on Leg 21 (Burns, Andrews, et al., 1973) and their ages and nature determined. The Lord Howe Rise is a feature with smooth bathymetry, mantled with biogenic ooze that extends back to the Maestrichtian. At Site 207 this ooze overlies shallow water deposits and beneath them is rhyolite dated at 92 m.y. The crust of the Lord Howe Rise is thought to be continental (Shor et al., 1971) and rifted off eastern Australia as the Tasman Sea formed. Drilling results at Site 206 suggest that the New Caledonia Basin probably originated about the same time as the Tasman Sea started to form (Late Cretaceous).

The topography of the Norfolk Ridge-Three Kings Rise is much rougher than the Lord Howe Rise. The cover of presumably biogenic sediments has irregular changes of thickness due to a combination of slumping and current activity. The basement rocks of the Norfolk Ridge can be seen in New Caledonia where a deformed predominantly Triassic-Jurassic geosynclinal sequence is overlain by shallow and deep water Late Cretaceous clastic sediments. Early Tertiary carbonates and cherts of shallow and deep water origin are associated with tholeiitic basalts. The youngest of these sediments is late

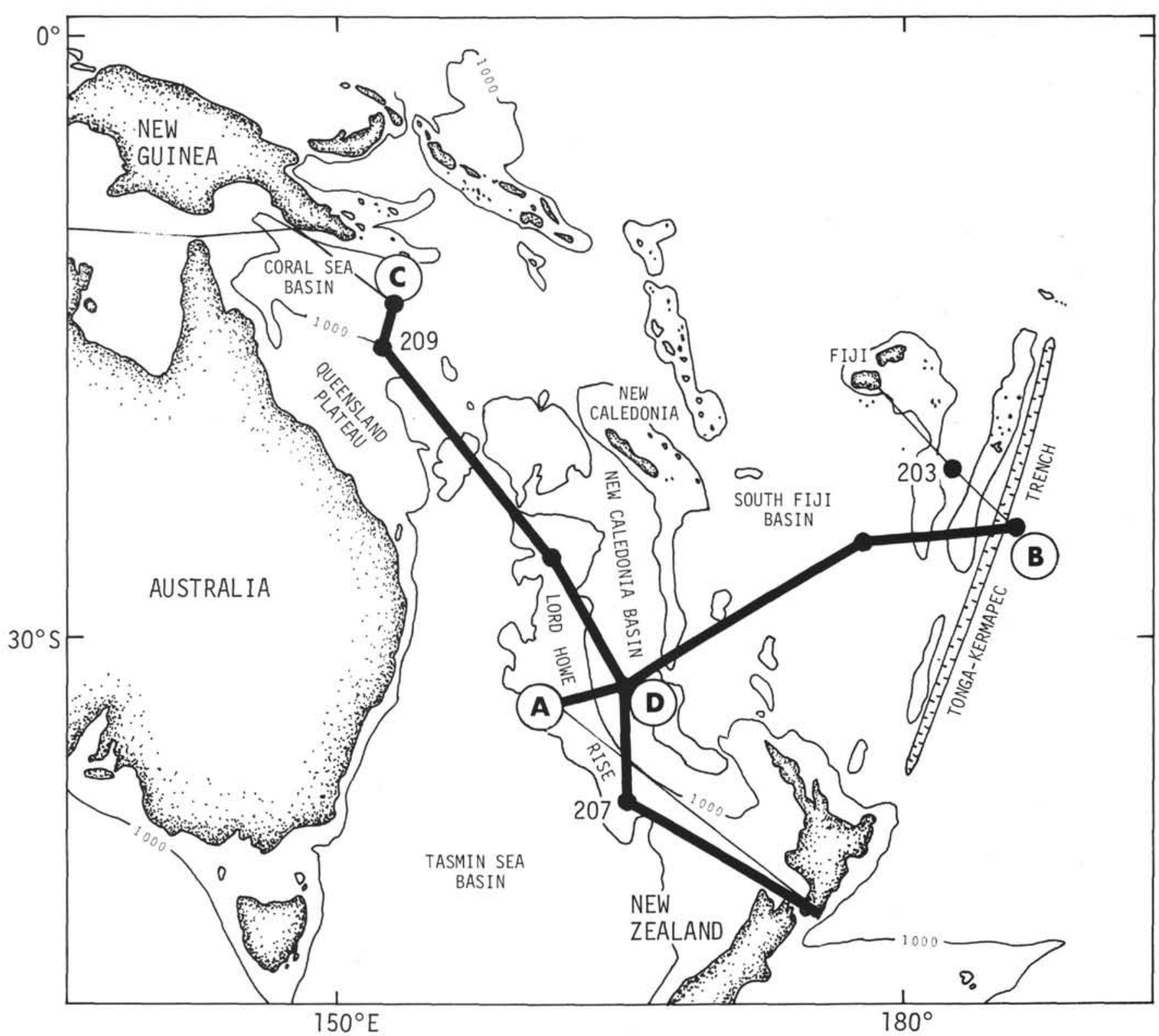

Figure 2a. *Structural features, southeastern region. Seismic profiles along lines ADB and CD are shown in Figure 2b.*

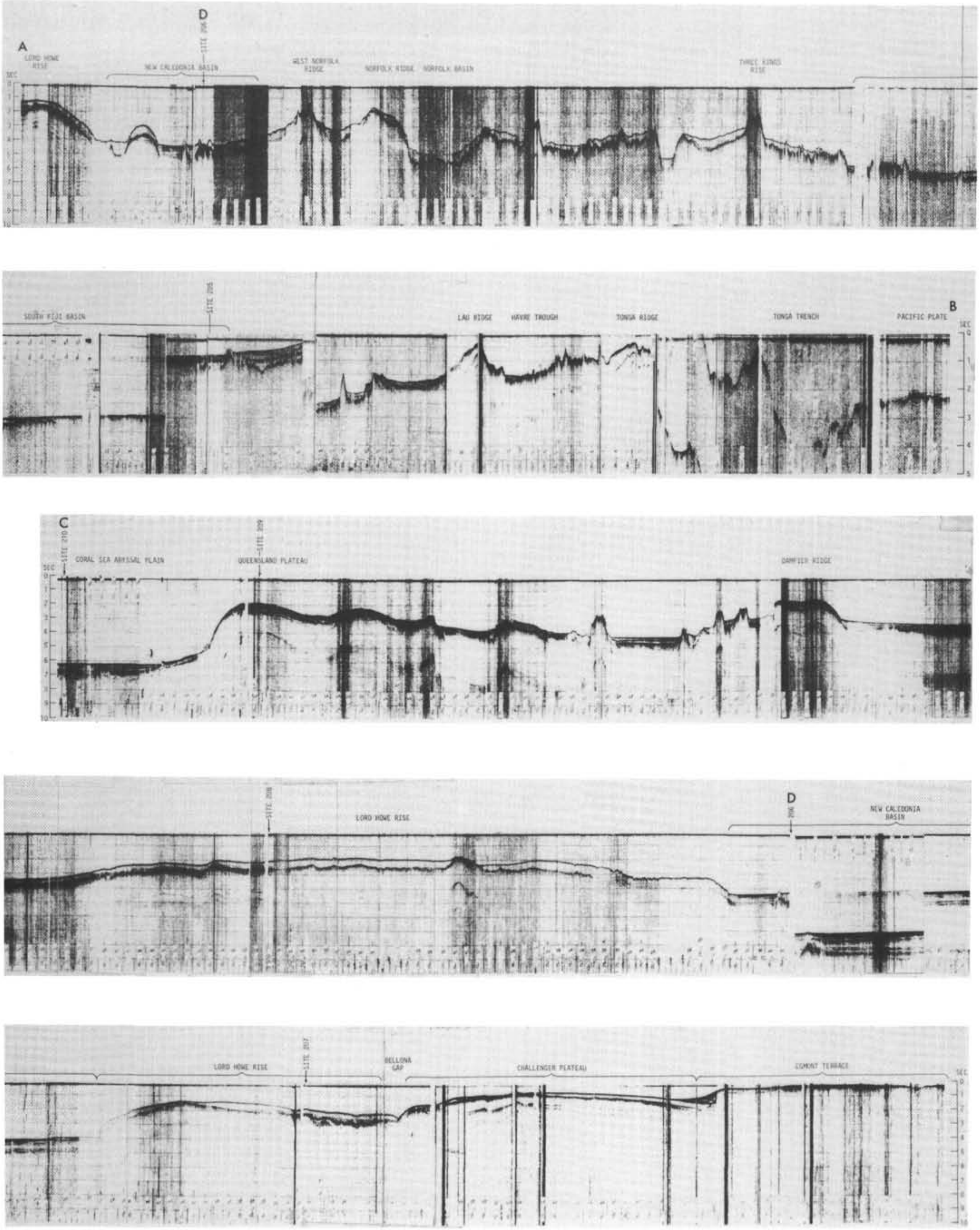

Figure 2b. *Seismic profile along lines ADB and CD of Figure 2a.*

Eocene. Overlying the whole sequence is an obducted sheet of ultramafic rocks that was emplaced in the early Oligocene (Avias, 1967; Brothers and Blake, 1973). (See Packham and Terrill, this volume for discussion of date of emplacement of ultramafics.)

The Norfolk Basin is a small feature of variable water depth between the Norfolk Ridge and the Three Kings Rise. Little is known about it or the Three Kings Rise except that both appear to have a thick cover of biogenic sediments.

Drilling at Site 205 established an early late Oligocene age for the sea floor on the eastern edge of the South Fiji Basin. The Oligocene biogenic oozes are overlain by a thick sequence of volcaniclastic sediment of middle to late Miocene age that was derived from the ridge complex to the east. The western part of the ridge complex is the Lau Ridge on which exposed andesitic volcanics extend back possibly into the middle Miocene. These volcanics are overlain by shallow water carbonate sediments and some basalts.

The Lau-Havre Basin that is to the east of the Lau Ridge was formed by splitting of a ridge by the development of new sea floor (Karig, 1970; Sclater et al., 1972). Drilling at Site 203 indicated that the first sea floor was formed approximately 5 m.y. ago (i.e., at the Miocene-Pliocene boundary). The ridge to the east of the basin (the Tonga Ridge) has a line of presently active volcanoes along its western edge. The oldest rocks are found on Eua where Eocene limestone overlies volcanics (Stearns, 1971).

The northeastern region of this part of the India plate comprises a series of features that contrast somewhat with those just described. Adjacent to the Australian continent is a submerged block of continental crust (the Queensland Plateau). Drilling at Site 209 demonstrated that marine sedimentation had commenced at least by the Eocene. The Coral Sea Basin lying to the northeast of the plateau was a region of biogenic sedimentation in the Eocene and Oligocene and turbidite sedimentation from the middle Miocene onwards. The basement age was not established at Site 210. The sedimentary history of the Aure Trough (Australasian Petroleum Company, 1961), a region of folded sediments extending northwards from the Gulf of Papua, is similar to that of the Coral Sea except that turbidite sedimentation commenced earlier and is followed by shallow water clastic deposits. Thick shallow water Tertiary carbonate sediments occur in southwestern Papua.

The southeastern part of New Guinea (the Papuan Peninsula) is comprised of the Owen Stanley Metamorphics in the south and an obducted sheet of probably Late Cretaceous sea floor in the north (Davies and Smith, 1971). The metamorphics are sialic and include Late Cretaceous fossiliferous sediments. The metamorphics outcrop on the Louisiade Islands to the east. A triangular basin of young sea floor (the Woodlark Basin) lies to the northeast adjacent to the active plate boundary south of the Solomon Islands (Luyendyk et al., 1973).

North of the Papuan Peninsula is the Solomon Sea, an area of oceanic crust at present being subducted beneath the Pacific plate to the north. West of the Solomon Sea is the partly folded north New Guinea Basin that contains a clastic fill of early Miocene to Recent deep water to nonmarine sediments (Bain, 1973). The basin and its sedimentary fill is thought to owe its origin to the collision of a westward extension of the New Britain volcanic arc with the New Guinea continental margin in the Oligocene (D. Dow, personal communication).

At this point some further comment should be made on the geology of the islands that now lie on the Pacific plate. New Britain and New Ireland islands and possibly Bougainville have Oligocene volcanics and volcaniclastic sediments with occasional shallow water limestones (Bain, 1973). Eocene volcanics occur on New Britain. The early and middle Miocene was a time of predominantly limestone deposition with volcanism commencing again in the late Miocene and continuing to the present.

In the eastern Solomon Islands the basement rocks are tholeiitic basalts probably of Mesozoic age on Guadalcanal and certainly so on Malaita (Hackman, 1973). The southern islands have late Oligocene to early Miocene volcanics overlying the basement rocks, and overlying these are shallow water clastics and limestones. Volcanism commenced again in the Pliocene, on the southern side of the island group. On the northern island of Malaita the basement rocks are overlain by bathyal biogenic limestones and chalks ranging in age from Albian to Pliocene (Deventer and Postuma, 1973). The sequence on Malaita closely resembles that drilled on the nearly Ontong-Java Plateau at Site 64 (Kroenke, 1972). The plateau has anomalously thick oceanic crust and may have had an important role in the tectonic development of the region (Kroenke, 1972; Packham, 1973). The two provinces are separated by a fault along the southern side of Santa Ysabel along which ultramafic bodies are found (Coleman, 1970).

The New Hebrides Islands have been largely developed during the Miocene especially the early and middle. Volcanics were calcalkaline in the early stages but later were predominantly basaltic (Mitchell and Warden, 1972). Present volcanic activity occurs along an island chain between the present eastern and western island belts. Shallow water-derived Eocene fossils have been found in early Miocene sediments on the eastern island chain (Coleman, 1970).

Fiji has affinities with New Britain in that Eocene and Oligocene volcaniclastic sediments and limestones occur, but the middle Miocene was a time of folding and intrusion (Rodda, 1967). This was followed by further clastics and volcanics. The volcanics of the past deformation episode were at first calcalkaline and then later shoshonitic (Gill and Gorton, 1973).

As well as having points of tectonic interest, the region is of biostratigraphic significance. Biogenic sediment accumulation has taken place on the high structures in the region. Of particular importance are the sequences on the Lord Howe Rise and the Ontong-Java Plateau. Drilling on Leg 21 at Sites 207 and 208 and to a lesser extent the sequence obtained at Site 206 in the New Caledonia Basin provide a link from the well-known Tertiary sequence of New Zealand with the more tropical regions (Burns, Andrews, et al., 1973). Before Leg 30, the Ontong-Java Plateau sequence had been drilled discontinuously at Site 64 and had ended in Eocene cherts.

During the drilling program of Leg 21 it became clear that there was a hiatus in sedimentation in the region between the Eocene and Oligocene. This was attributed to the effects of changes in the oceanic circulation pattern as a result of the moving of Australia away from Antarctica and the subsequent establishment of the circumpolar currents (Kennett et al., 1972).

PROBLEMS INVESTIGATED ON LEG 30

In view of the extremely complex geological history of the region, the problems that could be resolved in a single leg were very limited.

The major general objectives of Leg 30 included:

1) Ages and their trends in marginal basins: South Fiji and Coral Sea;

2) Complete the biostratigraphic zonations for the equatorial Pacific;

3) Obtain further data on the oceanographic and tectonic history of the southwest and western equatorial Pacific; and

4) Structure of an oceanic plateau.

Sites 285, 286, and 287 were directed toward the ages and history of marginal basins.

Site 285 was at the western edge of the South Fiji Basin near Three Kings Rise. Drilling at Site 205 (366 km to the northeast) bottomed in basalt 0.1 sec above acoustic basement. Age of the superjacent sediment was late Oligocene. The basalt may have been intrusive into or extrusive onto older sediments and thus the basin age is still in doubt. At the same time, basement configuration and crustal structure suggest a complex history for the basin. Site 285, at the opposite edge of the basin, should have helped clarify age and spatial patterns.

Between the New Hebrides and Loyalty islands, a wedge of sea floor has been isolated from the South Fiji Basin by westward movement of the New Hebrides island arc. Site 286 was located to investigate sedimentation on this crustal block, age of basement, and development of island influence with pinching of the New Hebrides Trench near Malekula.

Site 287 was adjacent to an uptilted portion of the floor of the Coral Sea Basin 42 km from Site 210. At the latter site, acoustic basement was shown to be pelagic sediments underlying a 470-meter-thick turbidite sequence. Oldest sediments penetrated were later early to middle Eocene age and reveal a basin which had oceanic characteristics at that time. At Site 287 most of the turbidites encountered at Site 210 could be avoided, and the mechanism of filling of the basin with turbidites could be investigated. It was also hoped to establish the date of formation of the rough surface at the top of the pelagic sediments.

Two sites were planned to investigate the Ontong-Java Plateau and its margins. Site 64 on the Ontong-Java Plateau penetrated 985 meters of middle Eocene to Recent biogenous sediments, bottoming in chert horizons. Two sites were planned to complete the biostratigraphic section below the chert (Site 289) and to investigate plateau structure and lithology of reflecting horizons below the chert horizons (Site 288). Use of reentry was planned to permit penetration of the complete section.

PRINCIPAL RESULTS AND CONCLUSIONS

The results of this leg are given in the following chapters, but a synopsis of the drilling results is given here site by site and illustrated in Figure 3. The tectonic implications of the results obtained are discussed in the leg synthesis, where a new tectonic history of the southwest Pacific island arc-marginal sea complex is presented (Packham and Andrews, this volume). The results of basement age determination at Sites 286 and 287 were of particular importance in arriving at the present tectonic interpretation as were the seismic profiles linking the various sites. The conclusion is also reached that island arc migration is a phenomenon resulting from marginal sea formation and not a cause.

Site 285 situated in a small, east-southeast-trending sediment-filled basin in the central part of the South Fiji Basin. The sequence at Site 285 parallels that drilled to the northeast at Site 205 (Leg 21) in that a middle to late Miocene coarse ashy succession is followed by a late Miocene to early Pliocene biogenic section and then by abyssal clay. However, the volcaniclastic sequence at 205 is not rythmic. East-west structural ridges in the basin block clastic sedimentation from the south, and it is suggested that the source of the volcanic sediment was the Lau Ridge. This provenance conforms to the present slope of the sea floor.

The Oligocene biogenic sequence intersected at Site 205 unconformably below the early middle Miocene was not intersected at Site 285. Drilling ended in a diabase sill.

Site 286 is located at the foot of the slope from Malekula in a gap between the North and South New Hebrides trenches.

Basaltic flows associated with the formation of the sea floor extruded in middle Eocene time were followed by an interval of rapid sedimentation until near the end of the Eocene, probably in the form of a submarine fan at the base of a volcanic ridge with active andesitic volcanism. The sea floor depth was above the foram solution depth. Volcanic activity declined sharply during the late Eocene. In the late Eocene and Oligocene mainly biogenic sediments with minor ash were deposited on a subsiding sea floor. By latest Oligocene time, the depths were below both foram and nanno solution depths and clay and glass shard ash accumulated. No Eocene-Oligocene discontinuity was detected at this site. A period of nondeposition or erosion intervened before the Pliocene, to be followed in Pliocene and Pleistocene time by a continuous influx of glass shard ash initially from fairly distant sources. Reworked fossils, including shallow water benthonic neritic species of Miocene and Pliocene age near the top of the section suggest erosion of nearby older shelf deposits (probably on the New Hebrides Islands) during the Pleistocene.

The sedimentation rate increases upwards through the Pliocene-Pleistocene sequence. The basalt flows at the bottom of the hole were intruded by a thick gabbroic sill.

Site 287 was located adjacent to a basement high in the Coral Sea. The basement age was established as early Eocene. The sequence above the tholeiitic basalt is quite similar to that sampled at Site 210 (42 km to the west-northwest). Due to the elevation of the basement ridge at Site 287, the turbidites appear later, and the Eocene-Oligocene regional unconformity spans a larger interval than at Site 210. The basement ridge appears to have developed shortly after the formation of the basin crust in the early Eocene. Water depth was initially above foram solution depth, but passed below nannofossil solution depth possibly by late Oligocene (certainly early Miocene). The green silty clay may represent the distal ends of turbidites which were being deposited as graded rhythms in deeper parts of the basin, such as at Site 210. The turbidites built up to the level of the sea floor at Site 287 in about early late Pliocene time. The thickness of Pleistocene turbidites (about 90 m) is similar at both sites, as is the frequency of deposition (about one flow per 5000 yr).

Drilling at Site 288, located on the southeastern flank of the Ontong-Java Plateau, did not reach basement, but a comparison to Site 289 suggests that the oldest sediments (Aptian) may not have been far above it.

Following crustal formation in pre- or early Aptian time, biogenic and minor volcanogenic sediments accumulated. Maximum depth at the site was reached in the Campanian passing below the foram solution depth. Planktonic foraminifera make their appearance again in middle Maestrichtian sediments. The section is discontinuous, with a major hiatus in the Eocene and early Oligocene. Reworked sediments suggest that the site has been an unstable surface of gentle inclination—probably within a topographic low—which has been subject to current scour and minor slumping from Aptian to Miocene. More intense disturbances have occurred from the late Miocene on. Ash in the upper Pliocene is probably related to volcanism on the Stewart arch and the Roncador homocline. The Miocene/Pliocene hiatus may mark slumping associated with tectonism.

At Site 289, located on the northern part of the Ontong-Java Plateau, the Pleistocene to early Oligocene sequence is continuous and contains a diverse microflora and microfauna with good to excellent preservation. Very minor chert was detected in the lower Miocene with the major appearance in late Eocene accompanied by the loss of Radiolaria from the sediments. Less chert was observed at this site than at Site 288. Plateau elevation has been relatively constant above the foram solution depth, with the exception of a deeper interval in the Campanian as seen also at Site 288.

At least six substantial stratigraphic breaks are present in the section. These occur between Rupelian (lower Oligocene) and Batonian; Lutetian (middle Eocene) and Ypresian; Ypresian and Thanetian (upper Paleocene); Thanetian and Danian (lower Paleocene); lower Danian and Maestrichtian; and Aptian and Campanian. The Eocene/Oligocene break is similar to the reported in the Tasman and Coral seas.

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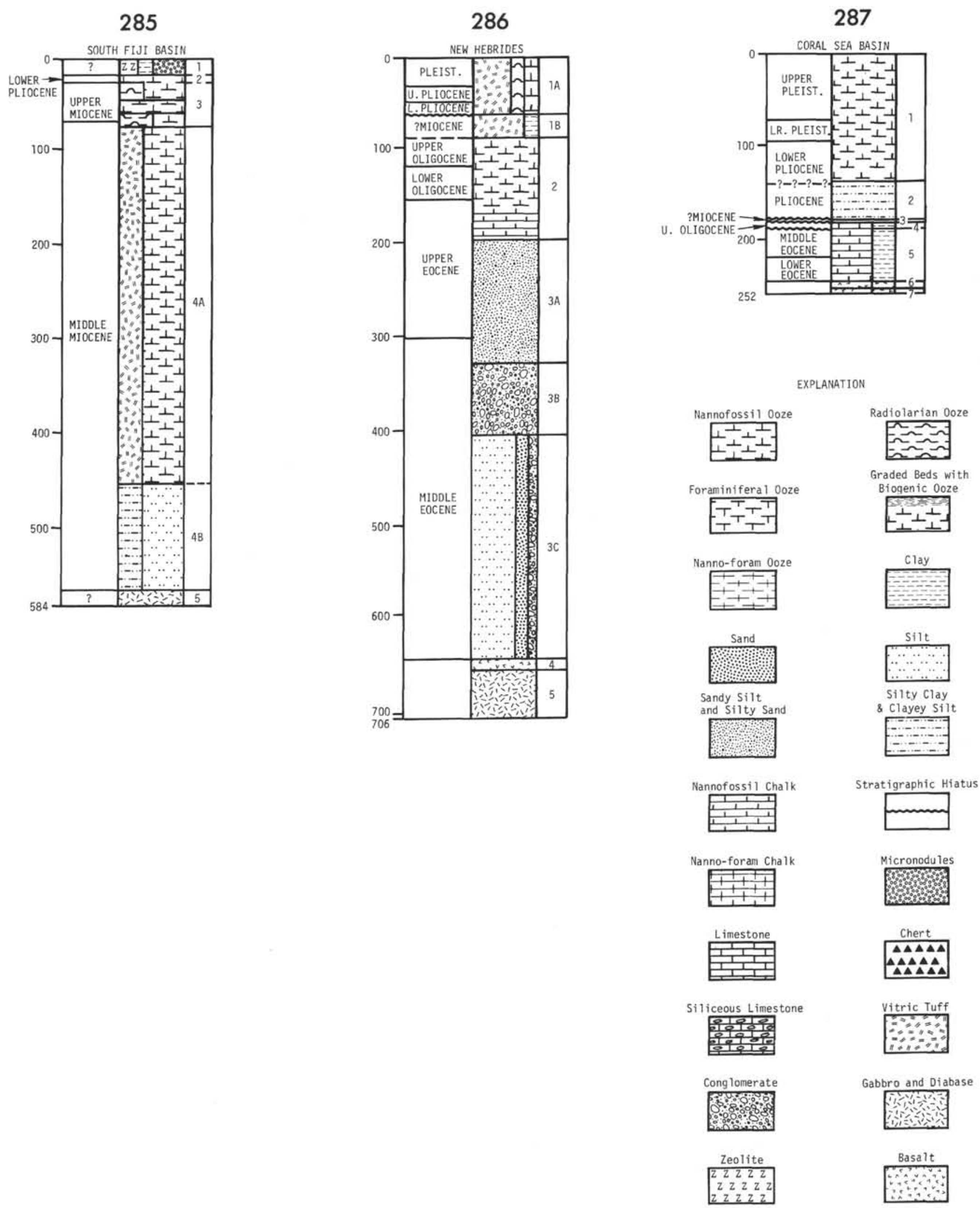

Figure 3. *Stratigraphic columns illustrating the drilling results of Leg 30.*

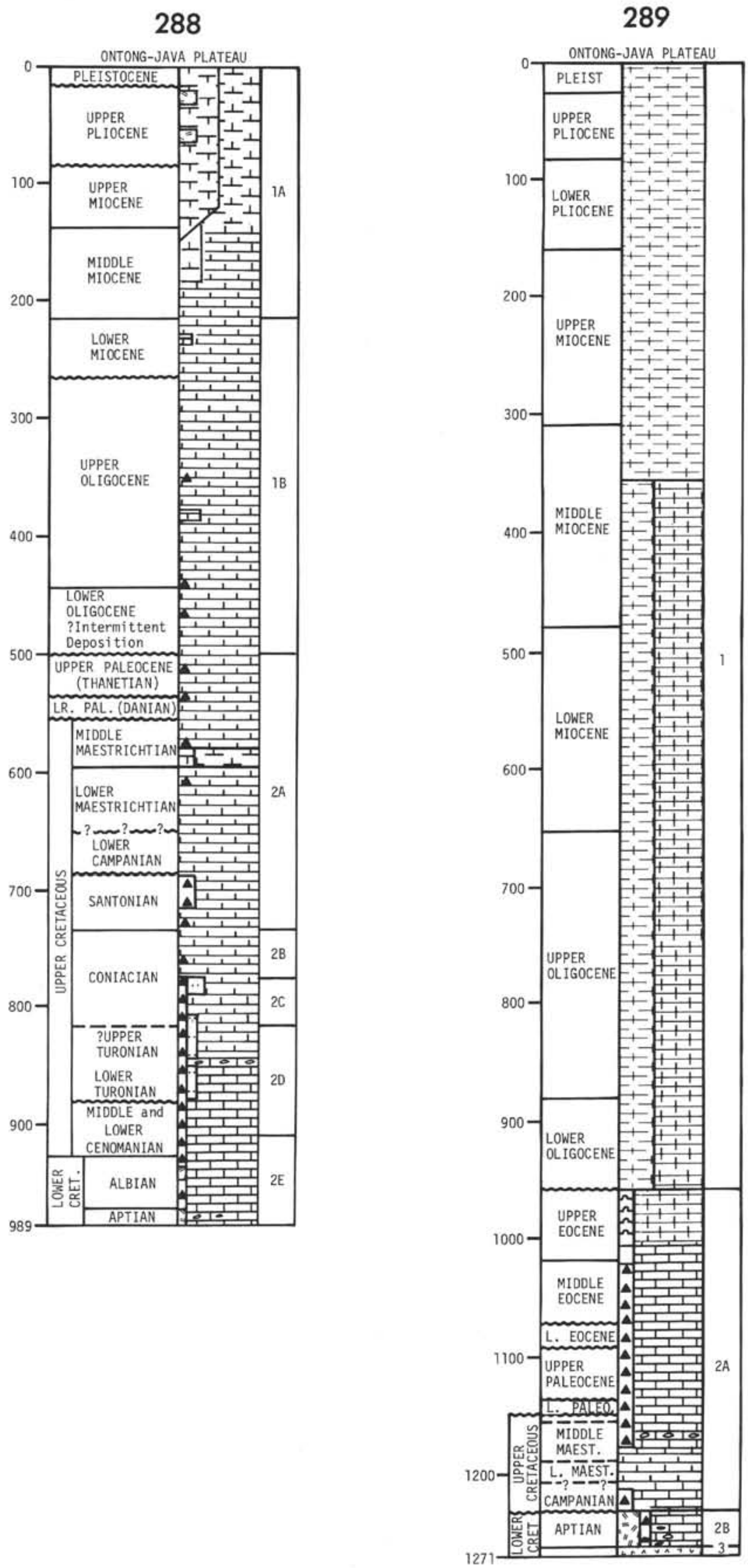

Figure 3. *(Continued).*

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