OCEAN DRILLING PROGRAM

LEG 124 PRELIMINARY REPORT

CELEBES AND SULU SEAS

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SCIENTIFIC REPORT

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ABSTRACT

During Leg 124 we drilled a total of five sites, two sites (767 and 770) in the Celebes Sea and three sites (768, 769 and 771) in the Sulu Sea. Our results rule out a single origin for these basins. The Celebes Sea originated in an open ocean setting in the middle Eocene. The Sulu Sea appears to have originated as a backarc or intra-arc basin in the late early to early middle Miocene, during collision of the Cagayan Ridge with the rifted continental margin of China.

The stratigraphies of the basins provide a rich and detailed record of their histories. The major increase in carbonate content of the cores from Sites 768, 769 and 771 near the end of the Pliocene indicates a rapid drop in the CCD. The low carbonate and high CCD in the late Miocene and early Pliocene can be the result of the closing off of the basin due to collisions. Dating of clay-rich sediments overlying the andesitic tuffs and lapillistones indicate a possible time correlation between the formation of the Sulu Sea and the cessation of volcanic activity on the Cagayan Ridge. Both the Celebes and Sulu seas show clear synchroneity of terrigenous turbidites in the latest middle Miocene, a time of very rapid sedimentation rates in both basins. This timing fits well with that of collision processes observed along the margin of the basins, both in Borneo and in the Phillipines.

Petrographic and geochemical studies of the basement underlying the Celebes Sea show it to be a plagioclase-olivine phyric basalt with a normal mid-ocean ridge basalt (MORB) signature. Basement in the Sulu Sea is composed of olivine basalts which appear transitional between MORB and island arc tholeites.

Logging at Sites 770 and 768 included use of the borehole televiewer. Preliminary results at both sites indicate that the maximum horizontal stress direction trends northeast, consistent with the expected stresses related to the Neogene collisions of the Sulu, Cagayan, and Palawan ridges with the Philippine mobile belt.

We obtained unusually fine magnetostratigraphic results within the basins, including thorough documentation of a magnetic reversal event within the Matuyama chron, which has been observed previously only in a few widely separated locations around the world.

INTRODUCTION

The numerous western Pacific marginal basins have had a variety of origins and histories, including entrapment from a larger ocean basin, rifting from active volcanic arcs, rifting continental margins, or a composite of events. They often separate collision zones and island arcs, and as such they represent small islands of undisturbed stratigraphic history within an otherwise very complex geological setting. The objectives of Leg 124 were to determine the age, stratigraphy, paleoceanography, and state of crustal stress within two of these marginal basins, the Celebes and Sulu seas. Questions we wished to address concerning these basins are as follows:

1. Were the Celebes and Sulu seas once part of a larger ocean basin, or did they have different origins?
2. What was the age of formation of the basins and, if trapped from a larger basin, their time of separation?
3. What does the stratigraphic record tell us of:
   a. the history of volcanic activity surrounding the basins?
   b. the record of changing paleoceanography and sea level?
   c. the record of collisional events surrounding the basins?
   d. the timing of trench formation on the basin margins?
4. What are the directions and magnitudes of stresses acting within the basins? Specifically, do the stress patterns clearly discriminate between differing collision and subduction orientations that appear to be acting on both basins? Is there an effect of either or both of the broad collisions between Southeast Asia and the Philippine Sea plate from the east or the Australian continent on the south?

In order to address these questions, Leg 124 drilled five sites (Table 1; Fig. 1), two in the Celebes Sea (Sites 767 and 770) and three in the Sulu Sea (Sites 768, 769, 771).

CELEBES SEA

Site 767

Site 767 (proposed site CS-1) is located in the central Celebes Sea at 4°47.5'N, 123°30.2'E, in a water depth of 4905 m. The sediments record deposition within a deep basin below the calcite compensation depth (CCD), as shown by the low carbonate content and paucity of calcareous biogenic particles in the pelagic/hemipelagic sediment. Within that depositional framework are major changes in depositional processes and provenance of sediment. The lithologic units recognized at Site 767 (Fig. 2) are as follows:

Unit I (0-56.8 meters below seafloor: mbsf) is Pleistocene to Holocene in age, and consists of hemipelagic volcanogenic clayey silt with interbeds of volcanic ash. The silt component of the clayey silt is primarily volcanic ash, including glass, pumiceous glass, rock fragments, feldspar, and hornblende.

The low biogenic carbonate content of the sediment is consistent with deposition below the CCD. The rare calcareous turbidite layers contain assemblages of foraminifers that have been redeposited from shallower depths.

Unit II (56.8-406.5 mbsf) is late Miocene to Pleistocene in age. It consists of volcanogenic clayey silt/siltstone grading downward into volcanogenic silty claystone, with interbeds of volcanic ash/tuff, carbonate silt/siltstone, and carbonate sand/sandstone.

In Units I and II the Continentality Index for clay minerals [defined as the log of (chlorite + smectite + illite)/smectite] has a value well below 0.2, suggesting that the source of this material is not dominated by the weathering and erosion of continental crust, but instead appears to be the result of the alteration of the products of arc volcanism. The association of these high smectite levels with the abundant ash beds is a clear indication of a relatively nearby source of arc volcanic material.

Unit III (406.5-698.9 mbsf) is early to late Miocene in age and is characterized by the presence of quartz-rich sandstone, siltstone, and associated claystone, all interpreted as turbidite deposits of continental provenance, interbedded with subordinate bioturbated hemipelagic claystone.

From 400 to 640 mbsf the Continentality Index for clays is variable and generally very high. Continentally-derived material substantially dominates smectite, suggesting a very different source region for detritus within this interval. The high Continentality Index in the interval, therefore, clearly reflects a significant increase in the proportion of sediment with a continental source, in the form of terrigenous turbidites. The proportion of volcanogenic sediments in the unit is minor and consists mainly of fine-grained plagioclase. This volcanic component probably does not represent contemporaneous explosive volcanic activity, but is more likely to be the product of erosion of pre-existing volcanic rocks of basaltic to andesitic affinity. Such components were also found occasionally in the underlying unit.

Unit IV (698.9-786.6 mbsf) is middle Eocene to early Miocene in age. It is composed mainly of dark grayish brown to reddish brown claystone. Clay minerals are the principal component, with rare silt-grade quartz, feldspar, and opaque minerals (sulfides, oxides, and copper). The carbonate content is very low (0.2%) throughout the unit. Agglutinated foraminifers are moderately common, and radiolarians and fish teeth and bones are minor components.

The major changes we have recognized in the sediment section recovered at Site 767 are:

1. An upward transition from pelagic clay deposition in Unit IV to deposition of volcanogenic hemipelagic mud in Units III to I;
2. An upward coarsening of hemipelagic muds from claystone in Unit III to clayey silt in Units II and I;
3. A major influx of quartz-bearing muddy to sandy turbidites with continental provenance in Unit III;
4. A variable influx of fine-grained carbonate turbidites in Units III and II;
5. Significant changes in frequency and composition of volcanic ash through the section.

Site 767 records several major events in the history of the Celebes Sea. The basement is basalt and is overlain by middle Eocene red clays. This age is consistent with the magnetic anomaly interpretation by Weissel (1980), but not with the hypothesis of Lee and McCabe (1986). The basal red clays show low rates of sedimentation and presence of manganese micronodules, fish teeth, and radiolarians, indicative of open ocean environments. This part of the section corresponds well with that observed at DSDP Site 291 (Ingle, Karig, et al., 1975) in the southern Philippine Sea just to the east of the Philippine Islands.

A puzzling increase with depth in both calcium and magnesium, measured in the interstitial waters of Subunit IIIC, shows no corresponding change in alkalinity, but does correspond to a decrease in pH. An increase in methane and ethane content with no corresponding increase in total organic carbon (TOC) was also noted.

Paleomagnetic studies of the oriented APC cores shows a very clear magnetic stratigraphy in the upper 100 m of the site. Changes in declination document the Brunhes/Matuyama boundary, both boundaries of the Jaramillo event within the Matuyama, and a short magnetic reversal below the Jaramillo subchron.

Site 770

Site 770 (proposed site CS-1A) is located in the Celebes Sea, 45 km northeast of Site 767 (Fig. 1). The reasons for drilling this site were the same as for Site 767, and in particular to complete basement objectives left unfinished at Site 767. Basement objectives were to measure stress in the Celebes Sea crust, to obtain sufficient basement rocks to determine their origin, and to complete the program of downhole logging.

Site 770 consists of two sedimentary and six basement lithologic units (Fig. 2):

Unit I (0-296 mbsf) is middle Miocene to Holocene in age, with dominant lithologies composed of volcanogenic silty clay and clay with sparse thin beds of marl and volcanic ash.

Unit II (296-421 mbsf) is late middle Eocene to middle Miocene in age, consisting of claystone and calcareous claystone, with sparse interbeds of silty to sandy claystone and porcellanite clay mixed sediment.

Basement was recovered from the interval 421-529 mbsf. Six lava units can be identified using their mineralogy, texture and structure. Units 1 and 2 are pillow basalt sequences, Unit 3 is a pillow breccia, and Units 4, 5, and 6 are brecciated, massive, amygdaloidal lavas.

Stress orientation data were obtained with the borehole televiewer (BHTV) logs. Preliminary interpretation of hole ellipticity and breakout data indicate a maximum horizontal stress direction of 046°, or slightly more easterly than the results from Site 768 in the Sulu Sea. Ca and Mg values in the pore waters showed a correlated increase in the lower part of the hole, indicating a source in the alteration of the basalts.

The Celebes Sea originated in the middle Eocene in a setting like that of the southern Philippine Sea. From early Miocene onward the sea has been the site of high rates of volcanogenic turbidite deposition, but from early to late middle Miocene continental sources played a major role in providing sediments to the basin. By late Miocene time the continental sources were cut off, perhaps due to the initiation of the Cotabato and north Sulawesi trenches, which now act to trap sediment along the margins of the basin. In the late Pleistocene abundant volcanic ash, much of it air-fall in origin, dominated sedimentation in the Celebes Sea.

SULU SEA

Site 768

Site 768 (proposed site SS-2), is located in the southeastern part of the Sulu Sea, in water depth 4385 m (Fig. 1). The lithologic units recognized at Site 768 (Fig. 2) are as follows:

Unit I (0-123 mbsf) is latest Pliocene to Holocene in age and consists of thin to thick bedded marl, with varying proportions of nannofossils and foraminifers and sparse thin beds of volcanic ashes. The carbonate ($CaCO_3$) content of the sediment averages 40%. Deposition must have occurred above the CCD which currently is deeper than the water depth at Site 768, but turbiditic origin for part of these sediments was observed. Below 110 mbsf, the calcareous microfossils show increasing signs of dissolution. The ashes show an increasing crystal content and decreasing glass and lithic content going downsection.

Unit II (123-652.4 mbsf) is middle Miocene to late Pliocene in age. It is mainly composed of alternating beds of clay, clayey silt, silt, and some sands, arranged in fining-upward sequences. Ash layers were identified in the upper part of the unit down to 250 mbsf, but their alteration increases dramatically at 150 mbsf. The low carbonate content (<1%), and the association of quartz and metamorphic grains within the silts and sands, suggest deposition of continental-origin turbidites below the CCD. The low numbers of benthic foraminifers and the absence of shelf-dwelling organisms suggest a source for these turbidites that is deeper than neritic.

Unit III (652.4-806.6 mbsf) is early to middle Miocene in age. The upper part of the unit includes mainly turbidites, while the lower part is represented by hemipelagic sediments. The structures and composition of clastic sequences indicate deposition by turbidity currents and related mass flow processes (thick sand beds) beneath the CCD and with a continental origin. Tuff beds made of pyroclastic material and mixed with terrigenous clastics are interbedded in the sequence and are interpreted as gravity flows displaced from active volcanic centers. The lower part of Unit III includes claystones with minor turbidites overlying dark reddish brown claystones. The base of Unit III contains a moderately well-preserved assemblage of radiolarians of late early Miocene age (Calocycletta costata zone). The boundary between the upper and lower parts of Unit III apparently corresponds to a hiatus (NN8 to NN5).

Unit IV (806.6-1003.6 mbsf) is early Miocene in age and is composed almost exclusively of coarse and fine vitric tuff and lapillistone. Claystones are interbedded with tuffs only at the top and base of the unit. Pyroclastic material includes devitrified glass shards and pumice with some rock fragments, and various minerals. These very thick fining-upward sequences of tuffs with reverse grading at their bases are interpreted as mass flows of pyroclastic material. Radiolarians at the top of the unit define the boundary between the C. costata and Stichocorys wolfii zones.

Unit V (1003.6-1046.6 mbsf) consists of an alternation of dark brown claystone and greenish gray tuff, and contact between both lithologies is gradational. Tuff beds may be the product of either pyroclastic flows or turbidites while claystone represents the background hemipelagic sedimentation. Rare, broken radiolarians found at the base of this unit are indicative of the S. wolfii zone.

221.8 m of basement, between 1046.6 and 1268.5 mbsf, was cored with an average recovery of 39.4%. The sequence has been divided into eight units, six of which occur as lavas and two as sills. The lavas are very uniform petrographically and are mostly composed of very vesicular olivine-phyric basalts with a greater or lesser percentage of olivine. None of the actual contacts between the units are seen, and the subdivision of the lava sequence has been done on their occurrence as either pillowed and brecciated basalts or lava flows. The sills are identified by their thickness, massive nature, and phaneritic grain size, and have the composition of olivine dolerites. The two separate sills have different mineralogy, petrography, vesicularity, and vein filling.

Paleomagnetic results at Site 768 were outstanding. We recorded an excellent reversal stratigraphy from the Brunhes through the Gilbert (0-5 Ma), and possibly reversals 5D and 5E in the tuffs of Unit 4. We definitely recorded a rarely documented reversal at 1.1 Ma.

Logging was successful, including the seismic stratigraphy and lithodensity logs, plus a very good BHTV log in the basement and the tuffs. The logs matched physical properties results quite well, including a major velocity increase between the pillow basalts and the sill, which we can recognize as acoustic basement on the seismic line. Borehole breakouts were prominent in the basement, both the sill and the pillows, and in the upper 60 m of the tuffs. Basement breakouts trend approximately 300°, indicating a maximum horizontal stress direction of 030°.

Preliminary interpretation of these data could indicate the Sulu Sea originated as a backarc basin in the early part of the middle Miocene, though its exact time must await basement dating, because of uncertainties in the age of the base of Unit 4. The major part of the volcanics deposited on that basement is represented by the 250-m-thick pyroclastic flows, which probably accumulated during a short period of time after the oceanic crust of Site 768 was formed. Brown clay deposition continued above the tuffs, for about 30 m, after which the dominant lithology was greenish claystone. Sands and silts are abundant in the claystone, indicating abundant turbidity current deposition.

Quartz is abundant in Units II and III, and metamorphic grains are present, indicating a continental source. The clay mineralogy shows high illite and low smectite in these units, reversing in Unit I, again representing a dominant continental source in Units II and III. The sudden development of continentally derived turbidites in the middle Miocene (NN8) and the stratigraphic hiatus in Unit III, could be the response to the collision of the Cagayan Ridge with north Palawan. Increasing terrigenous influx from middle Miocene through the late Miocene may coincide with the development of this collision, magnified by the effects of the more recent collision of the Philippine mobile belt with the Cagayan, Palawan, and Sulu ridges.

Renewal of volcanism began during the late Miocene (NN11), but with a noticeable increase in the Pleistocene, associated with higher oceanic productivity. The onset of volcanism and decrease in terrigenous turbidites may have coincided with the development of the Sulu Trench.

Site 769

Site 769 (proposed site SS-5) was located on the southeast flank of the Cagayan Ridge, in 3644 m of water. The Cagayan Ridge is 120 km wide and is covered locally by reef carbonates (Meander Reefs, Cagayan Islands) and Quaternary volcanic rocks (Cagayan de Sulu Island). Discontinuous southeast-facing normal fault scarps apparently control its morphology. Individual scarps are over 500 m in relief, producing a cumulative relief of 500-1000 m above the deep (4000 m) southeast Sulu basin. Sediments filling this basin abut the base of the first scarps, preventing confident seismic stratigraphic correlations between ridge and basin.

The following stratigraphic sequence (Fig. 2) was recognized at Site 769:

Unit I (0-102.1 mbsf) is late Pliocene to Holocene in age. The dominant lithology is thin to thick bedded nannofossil marl with foraminifers, interpreted as a mixture of pelagic biogenic carbonate sediment and hemipelagic clay. Minor thin beds of volcanic ash and turbidites of foraminiferal ooze also occur within the unit. Slump structures appear to increase with depth in the section. The Pliocene/Pleistocene boundary occurs near 93 mbsf, corresponding to the top of the Olduvai paleomagnetic event. Below this interval carbonate concentration is greatly reduced, with replacement of marls by non-calcareous clay. The increase in carbonate content at the end of the Pliocene indicates a rapid drop of the CCD at that time.

Unit II (102.1-278.5 mbsf) is late early Miocene to late Pliocene in age and composed mainly of clays, interpreted to be hemipelagic in origin.

Unit III (278.5-376.9 mbsf) is a massive, unstratified dark green coarse tuff and lapillistone of andesitic to basaltic composition, with no intermixed or interbedded sedimentary material. Volcanic glass makes up over 70% of the material in the tuff and fine lapillistone. The glass is highly vesicular but rarely pumiceous. The tuff is not dated, but from superposition it is late early Miocene (same age as the base of Unit II) or older.

The paleomagnetic results are good from the surface (Brunhes) to the Gilbert chron, and show an excellent and remarkably continuous record from the Gilbert chron through chron 11. Very precise correlations can be made between Holes 769A and 769B using the susceptibility record, and evidence of block faulting within the site is seen from the record of inclination in the cores, in excellent agreement with the seismic record.

Inorganic geochemical analysis of pore waters once again showed increasing Ca and Mg in the lower part of the site, suggesting a source of Mg in the underlying volcanic sequences.

<u>Site 771</u>

Site 771 (proposed site SS-5A) on the Cagayan Ridge was drilled in 2859 m of water to a total depth of 304.1 mbsf (Fig. 1). Two lithologic units are distinguished at Site 771 (Fig. 2):

Unit I (100-233.9 mbsf) is middle Miocene to late Pliocene in age, consisting of nannofossil clay and marl with rare, thin carbonate turbidites. The material also contains minor silt-sized volcanic detritus. Dispersed volcanic ash is found in the lower 30 m of Unit I, and its concentration increases in the lower 2 m.

Unit II (233.9-304.1 mbsf) is late early to early middle Miocene in age. It consists of volcaniclastic strata underlain and capped by basaltic lava flows. Thin-bedded coarse to fine tuffs occur below the upper basalt, but the dominant volcaniclastic rock is massive and structureless lapillistone.

The intercalation of flows and pyroclastic deposits suggests close proximity to a volcanic vent or set of vents. The hemipelagic marlstone just above the upper basalt is evidence for submarine eruption of the lavas. The boundary between Units I and II represents a rapid transition from volcaniclastic to hemipelagic sedimentation during the early middle Miocene.

The major increase in carbonate content of the cores in Sites 768, 769, and 771 near the end of the Pliocene indicates a rapid drop in the CCD. The low carbonate and high CCD in the late Miocene and early Pliocene can be the result of the closing off of the basin due to collisions. The drop of the CCD in the Pliocene-Pleistocene may indicate variations in depth of the sills present either between Mindoro and north Palawan, or along the Sulu archipelago where a recent volcanic arc was built. Additionally, this corresponds to a global deepening of the CCD recognized in all the major oceans at that time.

The eruption of the tuffs and lapillistones corresponds closely in time with the opening of the Sulu Sea, as shown by formation of the crust at Site 768 in the early middle Miocene. The radiolarian assemblage overlying pyroclastics at Site 768 are about the same age as that found overlying the tuffs at Sites 769 and 771, but the gross compositions of this volcanic material is different (rhyolitic vs. andesitic), so we are not sure of the parentage of the Site 768 pyroclastics.

The tuffs on Cagayan Ridge may represent the last stage of arc volcanism for the ridge, or they may correspond to a short volcanic event resulting from passive margin rifting (analogous to that observed on the Voring Plateau). On the basis of a roughly similar seismic reflection signature and visual description of drilled material, neither hypothesis can yet be disregarded. Compared with Site 768, the sediments overlying the brown clay are characterized by the lack of turbidites, illustrating that the present elevated position of the Cagayan Ridge was similarly elevated during all of the Neogene.

CONCLUSIONS

The Celebes Sea formed in open ocean conditions in the middle Eocene. The CCD lay between the ancient water depths of Sites 767 and 770. The basin approached close enough to a continental landmass, probably Sundaland, by late early Miocene time to be receiving significant amounts of land-derived detritus, and in the late middle Miocene the deeper Site 767 recorded high rates of turbidite deposition from a continental source. In contrast, the late Miocene to Pleistocene source terrain was volcanic and not continental, suggesting that the development of the north Sulawesi and Cotabato trenches has diverted the continental source material from the central part of the basin to its margins. The volcanism could also be related to increased subduction of the Molucca Sea plate beneath the Sangihe arc.

The Sulu Sea formed in the late early to early middle Miocene, nearly concurrently with the cessation of volcanism on the Cagayan Ridge. Early outpourings of rhyolitic to dacitic pyroclastic flows marked the early formation of the basin, sandwiched within the deposition of a brown, smectite-rich claystone. Andesitic tuffs of similar age underlie the pelagic sections at Sites 769 and 771, but any genetic relationship is as yet unclear. Thick, continentally derived turbidites in the late middle Miocene at Site 768 coincide with those seen in the Celebes Sea, and may indicate a common source, very likely Borneo, where an active mountain belt was shedding abundant debris at that time. Volcanogenic sedimentation dominates the non-biogenic components in the Pleistocene, probably indicating the initiation of the Sulu Trench and volcanoes on the Sulu Ridge.

Stress measurements at Sites 770 and 768 in the Celebes and Sulu basins show a northeast orientation of the maximum horizontal stress. This result shows that the dominant factor in the production of stress within these basins is the collision between the basins and associated ridges with the Philippine mobile belt. No indication of the impact of the Australian continent is seen, nor do the thrusts on either side of the Sulu Ridge play a role in generating stress within the basins. The Sulu Trench may be inactive or else it possesses very low shear resistance.

Maturity of the terrestrial type of organic matter at Site 768 reaches the stage of thermal hydrocarbon generation at a shallow subbottom depth, indicating a high thermal gradient above 100°C/km. Actual thermogenic gas generation was observed at this site.

Calcium and magnesium in interstitial waters show positively correlated increases with depth in the lower parts of the sedimentary sections of Sites 767, 768, and 769. Because normal alteration products of basalt scavenge magnesium, these observations suggest the presence of a chemical mechanism of crustal alteration previously unsuspected in the oceanic crust.

Leg 124 has been remarkably successful in all facets, achieving excellent results in each of the major objectives of the leg, and producing important new data in paleomagnetism and sedimentary geochemistry that were not expected prior to the drilling.

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TABLE CAPTION

Table 1. Leg 124 site summary.

FIGURE CAPTIONS

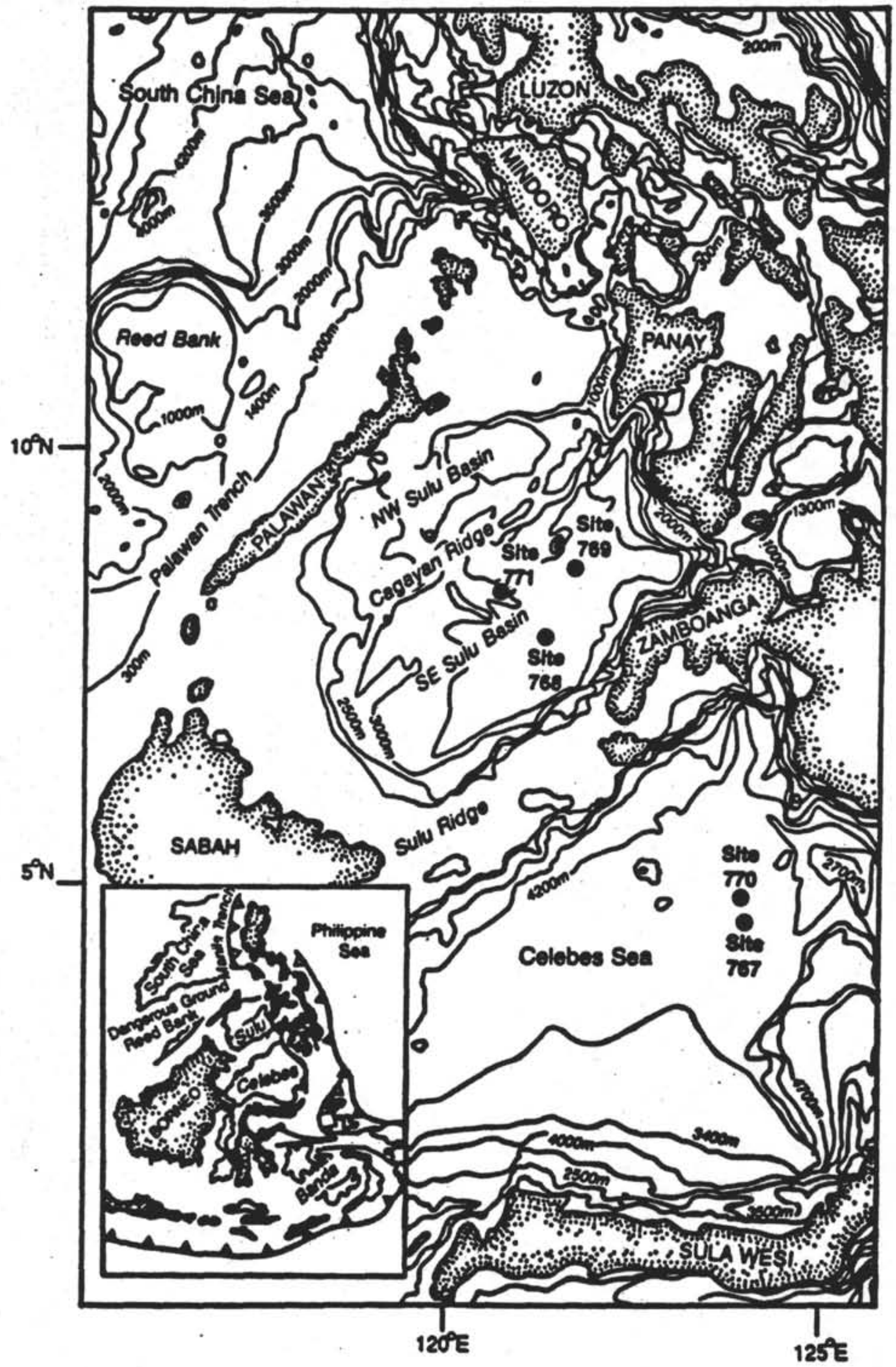
Figure 1. Simplified bathymetric map of the Celebes and Sulu seas showing the locations of sites drilled during ODP Leg 124 (modified from Hinz et al., 1988).

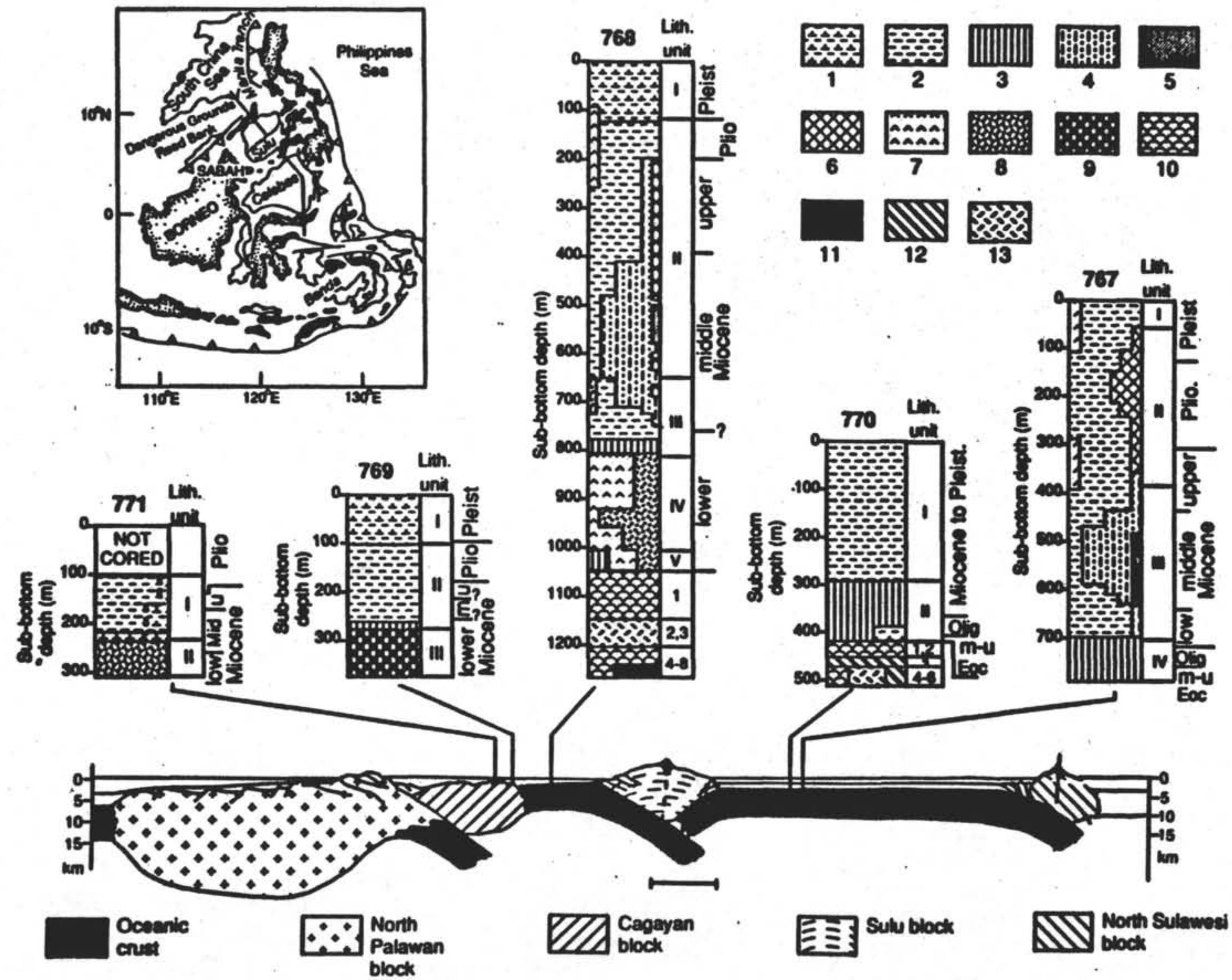
Figure 2. Schematic crustal section across the Celebes and Sulu seas, showing the locations of Sites 767-771. Also shown are summary stratigraphic columns from each site. Location of the profile marked on inset diagram, upper left. Symbols for lithologic columns of Sites 767-771: (1) nannofossil marl or nannofossil-foraminifer marl; (2) hemipelagic sediments, including clay/silt (stone) (3) pelagic brown claystone; (4) terrigenous turbidites; (5) quartz siltstone to sandstone; (6) graded carbonate turbidites; (7) fine ash/tuff; (8) pumiceous, rhyolitic to dacitic coarse tuff and lapillistone; (9) andesitic to basaltic coarse tuff and lapillistone; (10) pillow basalt; (11) basalt sheet flow; (12) brecciated massive basalt; (13) diabase sill.

Table 1. Leg 124 Site Summary

Hole	Latitude (°N)	Longitude (°E)	Water depth (m)*	Number of Cores	Meters Cored	Meters Recov'd	Percent Recov'd	Meters Total Penet.
767A	04°47.47'	123°30.21'	4905	1	4.2	4.1	98.6	104.0
767B	04°47.49'	123°30.20'	4905	78	739.0	585.1	79.2	739.0
767C	04°47.50'	123°30.21'	4905	13	114.1	44.7	39.2	794.1
768A	08°00.05'	121°13.16'	4385	1	9.5	8.8	92.6	101.5
768B	08°00.05'	121°13.19'	4385	40	364.1	293.8	80.7	364.1
768C	08°00.04'	121°13.18'	4385	100	915.3	525.5	57.4	1271.0
769A	08°47.14'	121°17.65'	3644	7	65.4	68.5	104.7	65.4
769B	08°47.12'	121°17.68'	3644	32	290.2	281.6	97.0	290.2
769C	08°47.12'	121°17.69'	3644	12	115.8	51.6	44.6	376.9
770A	05°08.70'	123°40.24'	4505	2	10.9	1.6	14.7	10.9
770B	05°08.69'	123°40.10'	4505	21	201.6	112.4	55.8	474.1
770C	05°08.69'	123°40.11'	4505	12	115.8	54.8	47.3	529.5
771A	08°40.69'	120°40.78'	2859	18	168.7	89.8	53.2	304.1

*Depths are drill-pipe measurements corrected to sea level.


South China Sea
LUZON
MINDORO
Reed Bank
PANAY
10°N
NW Sulu Basin
Palawan Trench
PALAWAN
Cagayan Ridge
Site 769
Site 771
SE Sulu Basin
ZAMBOANGA
Site 768
SABAH
Sulu Ridge
5°N
Site 770
Site 767
Celebes Sea
Philippine Sea
South China Sea
Dangerous Ground
Reed Bank
Sulu
Celebes
BORNEO
Banda
SULAWESI
120°E
125°E



Philippines Sea
South China Sea
Manila Trench
Dangerous Grounds
Reed Bank
SABAH
Sulu
Celebes
BORNEO
Banda
10°N
0
10°S
110°E
120°E
130°E
771
769
768
770
767
Lith. unit
Sub-bottom depth (m)
NOT CORED
Pleist
Plio
upper
middle Miocene
lower
Miocene to Pleist.
Olig
m-u Eoc
Oceanic crust
North Palawan block
Cagayan block
Sulu block
North Sulawesi block
km

OPERATIONS SYNOPSIS

The Ocean Drilling Program Operations and Engineering personnel aboard JOIDES Resolution for Leg 124 were:

Operations Superintendent: Glen Foss

INTRODUCTION

The emphasis of ODP Leg 124 was the determination of the age and origin of the southeast Asian Celebes and Sulu Sea basins. The nature of the investigation required drilling in relatively deep water and penetrating thick sediment sequences to sample basement rocks. The sediments were cored continuously for studies of the tectonic and paleoceanographic history of the basins. Downhole experiments were to be performed to determine the current tectonic stresses in the basement rocks.

The operational highlight of the cruise was drilling the deepest single-bit hole to date of the Ocean Drilling Program (Hole 768C: 1271 m penetration). All primary scientific objectives were achieved, but adverse hole conditions prevented planned hydrofracture and permeability experiments with the straddle packer.

The voyage commenced with a port call on 1 November 1988 at Singapore and ended on 4 January 1989 at Manila, Republic of the Philippines. Total length of the expedition was 63.8 days, of which 47.2 days were spent on drill sites, 12.5 days were spent under way, and 4.1 days were spent in port.

SINGAPORE PORT CALL

JOIDES Resolution arrived at Singapore early on 1 November, dropping anchor in the outer harbor at 0615 hr LCT. The port call was a busy one, but even with the heavy workload, the visit was completed in 4 days, and the vessel departed at 0130 UTC on 5 November--one full day ahead of schedule.

Proposed site CS-1 was located in the Celebes Sea about 150 nmi southeast of the Philippine port of Zamboanga. A direct approach to the site was made from the west-northwest, and a positioning beacon was launched at 0954 UTC on 9 November.

SITE 767--CELEBES SEA

Hole 767A

Hole 767A was spudded at 0045 UTC 10 November at a depth of 4916 m (water depths reported are drill-pipe measurements from the rig floor). The mud line advanced hydraulic piston (APC) core recovered 4.1 m of sediment. As Site 767 was a potential reentry site, a jet-in soil test was required to determine the conductor casing setting depth. The sediments proved quite soft and suitable for casing emplacement, and the test was terminated at 104 meters below sea floor (mbsf), a depth in excess of any anticipated casing requirement. The water-sampler/temperature/pressure (WSTP) probe was then deployed for a "heat flow" temperature measurement, but the data were unusable due to instrument problems.

The drill string was then pulled clear of the seafloor in preparation for deeper penetration in Hole 767B.

Hole 767B

Because the seafloor sediments were of particular scientific interest, Hole 767B was again started with a mud-line APC core. APC operations continued to 91 mbsf, where a 60,000 lb overpull was required to withdraw the core barrel from the sediment. The switch was then made to extended core barrel (XCB) coring for the remainder of the interval to be cored. (Sediment recovery was over 103% in the APC-cored interval.) Fine XCB core recovery figures were offset somewhat by a high degree of "biscuiting" disturbance in the cores over the entire XCB-cored interval.

Hole conditions were good to about 410 mbsf, where rotary torque and circulating pressure began to rise. A "wiper trip" encountered drag over the lower 90 m of the hole interval, but was successful in alleviating the problems until they returned at about 500 mbsf. At 560 mbsf conditions forced a "mini-trip" back to 450 mbsf. Again conditions stabilized, and coring continued with normal pressure and torque for about a day. As the bit passed 700 m, the hole again began to squeeze the bottom-hole assembly (BHA). At 739 mbsf it was no longer possible to turn the drill string or circulate cuttings up the annulus. Because the drilling plan required a switch to the rotary core barrel (RCB) coring system for the penetration of basement rocks, no time was spent in fighting hole conditions, and coring operations in Hole 767B were terminated.

Preparations for logging included a wiper trip that took the top of the BHA to the seafloor. Cleaning out the lower 80 m of the hole took 4 hr. When the bit reached total depth, the hole was flushed with 40 bbl of drilling mud, then filled with KCl-inhibited mud for logging operations.

The bit was then pulled to logging depth, and logging operations began. The first logging tool combination, seismic stratigraphy, reached 295 mbsf before it came to rest on an apparent ledge. After the upper sediments were logged, it was necessary to retrieve the logging tool and add the sidewall-entry sub (SES) to the drill string. Successful seismic stratigraphy and geochemical logging runs from near total depth were recorded with the aid of the SES.

Low velocity readings from the sonic log indicated less sediment overlying basement than had been anticipated, and the stabilized hole conditions made deepening Hole 767B with the RCB system a desirable option. When logging operations had been completed, a free-fall funnel (FFF) was launched. The drill string was then recovered, the BHA was converted for RCB coring, and the bit was run back to reentry depth.

The hole crater was located with the subsea TV, but the FFF had disappeared, apparently down the hole. After two unsuccessful reentry attempts, the bit was pulled clear of the seafloor and the rig was offset to clear the disturbed area.

Hole 767C

Hole 767C was spudded at 1430 UTC 20 November. The hole was drilled quickly to 500 mbsf, where the "wash" core barrel was retrieved and a multishot survey was taken at total depth. The drift of the hole was a surprising 9-1/2° from vertical. A wiper trip was then made, and tight hole was reamed from 370 to 500 mbsf. A center bit was used to drill to the coring point at 680 mbsf. A second wiper trip was made to 344 mbsf, and it was necessary to ream from 646 mbsf to total depth.

Continuous RCB coring then began, overlapping the inconsistently recovered lower section of Hole 767B. Because of the greater hole angle, Hole 767C was stratigraphically about 9 m shallower than equivalent depth in Hole 767B.

The anticipated hole problems began at about 714 mbsf. For nearly 2 days, high rotary torque and circulating pressure were battled, with only about half the time spent on coring operations. The symptoms indicated that an interval of indeterminate thickness below 714 mbsf was closing in on the 8-1/4-in. drill collars and acting as a seal.

Basaltic basement rock was finally recovered in the core catcher of Core 124-767C-12R, but the pipe became firmly stuck after 2.4 m had been cut on Core 124-767C-13R. The pipe could not be worked free, and the inner core barrel could not be recovered (apparently due to drill cuttings above the latch). Because of the obstruction, logging was not attempted.

The drill string was finally severed and worked free of the hole after four attempts with the explosive severing system. Hole trouble and stuck pipe accounted for 2.8 days of lost time at Hole 767C.

SITE 768--SOUTHEAST SULU BASIN

Proposed site SS-2 was located in the southeastern Sulu Sea, about 55 nmi west-northwest of Dulunguin Point on the Zamboanga Peninsula (Island of Mindanao). Most of the transit to the new site was made surveying at reduced speed to adjust the arrival schedule to the global positioning system (GPS) operating window.

The site location was critical, and three beacons and over 8 hr were required before a satisfactory launch was made. The first beacon signal failed shortly after launch, and the second beacon was dropped out of position. Official site arrival was at 0815 UTC 27 November.

Hole 768A

Hole 768A was spudded with a seafloor APC core at 2045 UTC 27 November. The depth was 4395.5 m vs. the PDR depth of 4406 m. The initial core was followed by a jetting test to determine the conductor casing point for the planned reentry installation. The bit was jetted to 99 mbsf before it was stopped in stiff sediments. An additional 2 m was then drilled for a temperature probe run. The temperature measurement, as at Site 767, again failed to produce usable data.

The core bit was then pulled above the seafloor in preparation for the APC/XCB hole (Hole 768B) that would also serve as the exploratory penetration for the planned reentry hole.

Hole 768B

Continuous APC cores were taken to 210 mbsf, where refusal was reached when the corer failed to penetrate a hard sand layer. Core quality and recovery were excellent. Recovery, aided by some core swelling, averaged 104% for the interval.

XCB coring then continued in clay, with reduced recovery due to interbeds of silt, hard chalk, sand, and ash. Hole conditions remained good, with the sediment becoming firmer with depth. Core 124-768B-40X was retrieved from a total depth of 364 mbsf with a failed cutter shoe. The lower (cutting structure) part of the shoe had broken off completely, allowing the core catchers, spacers, and core to fall out of the inner barrel assembly.

Because shows of hydrocarbon gas had been detected, the junked hole was abandoned by filling it with weighted drilling mud. The drill string was then recovered for the RCB-coring BHA.

MEDICAL EVACUATION #1

At about the time the hole was lost, a medical emergency had arisen wherein the ship's Third Officer was suspected to have contracted acute appendicitis. Attempts by the ship's Manila agent to arrange an on-site helicopter medical evacuation were unsuccessful, and it was necessary for the vessel to get under way and proceed to a roadstead off Zamboanga. The patient was evacuated by a Philippine Air Force helicopter at 0700 hr LCT, 1 December (2300 UTC 30 November), and was flown to Manila, where he underwent surgery later in the day. The total delay for the medical evacuation was 17 hr.

Hole 768C

The vessel navigated back to Site 768 and detected the positioning beacon signal without difficulty.

Hole 768C was spudded at 1800 UTC 1 December, and was drilled to 353 mbsf with no coring. Continuous RCB coring then began and proceeded with generally good recovery through clay interbedded with silty and sandy strata. The sediments increased in induration and volcanogenic component below 600 mbsf.

Hole conditions remained excellent. At about 900 mbsf the sediments gave way to about 200 m of massive volcanic tuffs that cored easily and produced excellent core recovery. Basaltic basement was encountered at about 1046 mbsf, but still the rate of penetration (ROP) remained high in the highly altered pillow basalt flows. At 1271 mbsf the scientific drilling objectives had been satisfied, and coring ceased.

A wiper trip to 100 mbsf was made in preparation for logging. The hydraulic bit release (HBR) was actuated to release the bit, the hole was filled with KCl-inhibited mud and the logging equipment was rigged.

The hole proved less hospitable to the logging tools than it had to the drill string, and it eventually was necessary to rig the SES. The borehole televiewer (BHTV) was run successfully over two limited intervals. Good seismic stratigraphy and lithodensity logs were recorded, though both tools became stuck and had to be washed over with the drill string to free them. No geochemistry log was obtained due to tool problems.

A FFF was deployed in anticipation of the hydrofrac experiment, an "after-frac" BHTV run, and a geochemistry log. The underwater TV camera was run down the drill string to observe the withdrawal from the hole. The funnel and its floating reflectors were clearly visible.

MEDICAL EVACUATION #2

The drill string was recovered from Hole 768C, but the planned trip and reentry for the hydrofracture experiment had to be deferred, as a second medical emergency had developed. The ship's doctor had become ill with an acute abdominal condition and required evacuation to a hospital. No long-range helicopters were available, so the vessel headed toward Zamboanga, where the doctor was taken ashore in the ship's inflatable Zodiac boat. The vessel was under way from Zamboanga at 0800 UTC 13 December.

SITE 769--CAGAYAN RIDGE

Because of scientific priorities, the ship proceeded to proposed site SS-5 instead of returning for the hydrofracture and additional logging at Hole 768C. The new site was located about 47 nmi north of Site 768. Nine hours of surveying were required before a positioning beacon was launched at 0700 UTC 14 December.

Hole 769A

The mud-line core established water depth at 3656.1 m, and 7 APC cores were taken through the requested interval of double APC coverage. Cores 124-769A-2H through 124-769A-7H were oriented with the magnetic multishot. At total depth a heat flow measurement with the WSTP probe was attempted, this time with textbook-quality results.

The bit was then pulled above the seafloor for the deeper APC/XCB penetration.

Hole 769B

Oriented coring began with the mud-line core, and continuous APC coring reached 221 mbsf before full-stroke penetration was lost. Successful temperature probe runs were made at 65 and 119 mbsf.

XCB coring then proceeded through clay sediment to 279 mbsf, where unexpectedly hard drilling was encountered. Two short cores, totaling 11.5 m, were taken in siliceous volcanic sediments before coring was terminated. The material was much too hard for the XCB coring system. A round trip was then made for the RCB coring system.

Hole 769C

Hole 769C was drilled, without coring, to 261 mbsf, where continuous RCB coring began. Coring then continued to a total depth of 376.9 mbsf, where the scientific objectives of the site were declared to be fulfilled. The drill string was recovered, and the ship was under way for Zamboanga at 1145 UTC 18 December.

SITE 770--CELEBES SEA

Arrangements had been made for a replacement for the ship's surgeon, who had been repatriated to the United States for further treatment. A brief stop was made in Zamboanga for a replacement doctor on the way back to the Celebes Sea. The personnel transfer and customs, immigration, and health formalities were completed, and the vessel was under way for the next drill site at 0200 UTC 19 December.

A new site (CS-1A) had been approved for drilling after the failure to make a basement penetration at Site 767. The principal criterion for selection was a reduced sediment section to minimize the risk of recurrence of the hole problems experienced at the earlier site. The location selected was about 23 nmi north-northeast of Site 767 and was located on a bathymetric rise. The transit was made at reduced speed to time arrival within the GPS window, and seismic profiling began as soon as the vessel had cleared Basilan Strait.

Hole 770A

Because of the rough bathymetry, the PDR reading was ambiguous, and three "water cores" were taken before sediment was recovered in the RCB core barrel. After the subsequent core attempt, it was apparent that the bit was sliding down a slope and that a satisfactory spud-in had not been achieved.

Hole 770B

The ship was moved 200 m south, and the bit was again lowered. A solid weight indication registered at about 4518 m, and the resulting core established the mud line at 4516.2 m.

Drilling and coring then proceeded with a cycle of four joints drilled, "wash barrel" recovered, and one joint cored with barrel recovered and a new wash barrel pumped into place. Successful temperature probe measurements were taken at 61, 109, and 157 mbsf. Sediments through the spot-cored interval were silty clays and claystones. At 341 mbsf continuous coring began. Marly clays were cored to the basement contact at about 421 mbsf.

A short trip was made when coring had reached 379 mbsf and was successful in clearing up developing hole problems.

The basaltic basement was cored for about 53 m at an average ROP of 5-1/2 m/hr and recovery rate of 44%. With the primary drilling objective reached, the underwater TV was deployed to check the drill string for suspected fouling with rope before additional time was spent on basement coring. The fears were confirmed as the TV revealed heavy polypropylene rope wrapped around the drill pipe about 800 m below the rig floor. The 18-mm rope was found to be wound around about 4000 m of pipe to about 200 m above the bit, and a full pipe trip was made, consuming 14-1/2 hr.

Poor TV/sonar performance thwarted an attempt to make a coneless reentry into Hole 770B and to detect hazards (anchor weights) on the seafloor.

Hole 770C

Hole 770C was spudded at 1200 UTC on Christmas Eve and was drilled without coring to 384 mbsf. At that point the center bit was recovered, and a single sediment core was cut to fill a gap in the Hole 770B stratigraphic record. Drilling then continued with a center bit to basement at 423 mbsf. Continuous RCB cores were then taken through the basaltic pillow and lava flows until the scientific drilling objectives were declared fulfilled at 529 mbsf.

The logging program consisted of a BHTV run over the basement interval (without the SES) and all three standard Schlumberger logging combinations, which required the SES due to deteriorating hole conditions, through the entire open-hole interval.

A FFF was deployed prior to the final logging run in preparation for reentry with the TAM straddle packer for hydrofracture and permeability experiments. After a hole-conditioning trip, which cleaned the hole to total depth with some difficulty, withdrawal of the BHA from the FFF was observed with the TV. The rim of the funnel and all three floating ball reflectors were clearly visible.

When the special straddle-packer BHA had been made up, the drill string was run to reentry depth. The FFF was located easily, but a 1-1/2-kt current made maneuvering the drillship and 4500-m drill string a bit tedious. Two hours and several close passes were required to bring the BHA into position over the funnel for reentry. After the reentry, the drill string met firm resistance at 56 mbsf. The obstruction seemed to be a bridge or collapsed section of hole, though sidetracking in the soft sediment was not ruled out.

After considerable effort, including minimal rotation of the drill string, no progress had been made in advancing the bit, and the effort was abandoned.

Upon recovery the reentry/cleanout bit and the lowermost drill collar were found to be plugged with sediment, confirming suspicions that circulation had been through the ports in the packer body and not out the bit. The packer had not been damaged downhole or at the FFF.

JOIDES Resolution departed Site 770 at 1000 UTC 30 December.

SITE 771--CAGAYAN RIDGE

The new site lay about 38 nmi west-southwest of Site 769. The transit, by way of Basilan Strait, and the survey were completed in 25-1/2 hr, and the beacon was launched at 1330 UTC 31 December.

Hole 771A

No mud-line core was requested, and seafloor sediments were extremely soft. The water depth of 2870 m was a compromise based on the corrected PDR reading of 2867 m and a somewhat deeper, but very subtle, weight indicator reading. Spud time was 2200 UTC 31 December.

The hole was drilled to 100 mbsf before the first spot core was taken. Continuous RCB coring began after further drilling to 145 mbsf. The sediments were marls and clays similar to those at Site 769 and were quite soft to 240 mbsf, where the much harder volcanic sequence was encountered.

The basement material, consisting of tuffs and lapillistones, was cored continuously to 304.1 mbsf, where coring was terminated. The scientific goals had been reached, and operating time for the leg had expired.

The ship was under way for the final transit to Manila at 0500 UTC 2 January. Leg 124 came to its official end at 2200 UTC 3 January 1989, when the anchor was dropped at the Manila Harbor pilot station. The first mooring line was thrown at 0800 hr 4 January 1989.

LOGGING SUMMARY

Hole 767B

Logging operations at Hole 767B began at 1800 LTC 16 November. Hole conditioning included a wiper trip with extensive reaming and circulating in the unstable lower third of the hole, followed by filling the hole with KCl-inhibited bentonite mud.

The seismic stratigraphic combination was rigged up at 0800 LTC 17 November. This tool string consisted of Schlumberger long-spaced sonic, phasor resistivity, natural gamma, and caliper tools, plus the LDGO temperature tool. Downgoing logs were obtained from the base of pipe (110 mbsf) to a firm bridge at 300 mbsf, and upcoming logs were obtained from 298 to 81 mbsf as openhole logs and from 81 to 0 mbsf as through-pipe logs. To get the tool string past bridges, the SES was rigged up and used in all subsequent logging at the site. The second run of the seismic stratigraphic combination began with a confirmation that the 300-mbsf obstruction was a bridge and not a ledge, through an unsuccessful attempt to get past the obstruction with the tool centralized by pipe at 290 mbsf. Both pipe and the tool string were then run down toward the bottom of the hole, for simultaneous openhole logging and pulling pipe. However, a cable short necessitated pulling the tool out of the hole and removing about 5 m of kinked and twisted cable. The third run of the seismic stratigraphic combination successfully obtained openhole logs for the interval 648-110 mbsf while pulling pipe and through-pipe logs for the interval 110-0 mbsf. The interval below 648 mbsf was not logged because it was so badly bridged that the logging tool could not get entirely out of pipe.

The geochemical combination was run next. At this site the geochemical combination consisted of Schlumberger natural gamma, gamma spectroscopy, and aluminum clay tools. The LDGO temperature tool was also on this string, but it generated no data because of premature starting of its data-acquisition clock. Again both pipe and tool string were lowered to near the bottom of the hole, but both had to be raised about 60 m to find a sufficiently unbridged interval to get the tool string into open hole. Openhole logs were obtained for the interval 662-110 mbsf while pulling pipe, and through-pipe logs were obtained for 110-0 mbsf. Because of a failure of the gamma spectroscopy tool at 115 mbsf, the interval 129-29 mbsf was relogged. Rigdown from logging was completed at 0930 LTC 19 November. In all, 14 hr were used for initial hole conditioning and 49.5 hr was used for logging.

Hole 768C

Logging operations at Hole 768C began at 1415 LTC 9 December. Hole conditioning consisted of a wiper trip, hydraulic bit release, and filling the hole with KCl-inhibited bentonite mud.

At 2230 LTC, rigup of the logging cable and borehole televiewer/temperature tool began. With pipe set in the upper tuffs at 809.5 mbsf, the tools were run downhole to a firm bridge at 870.5 mbsf. Upcoming logs were obtained for the interval 870.5-809.5 mbsf.

Beginning at 0645 LTC 10 December, pipe was pulled up to about 100 mbsf and the SES and seismic stratigraphic tool string were rigged up. At this site the seismic stratigraphic combination consisted of Schlumberger long-spaced sonic, phasor resistivity, and natural gamma tools plus the LDGO temperature tool. Downgoing logs were obtained through pipe from the seafloor to 181.5 mbsf and in open hole from 181.5 mbsf to a firm bridge at 231.5 mbsf. Pipe was then run downhole to 1060.4 mbsf, and downgoing logs were obtained from 1083.6 mbsf to 1260.5 mbsf. Openhole upcoming logs were obtained from 1260.5 to 689.5 mbsf while pulling pipe. At 689.5 mbsf the tool string stuck, and it was necessary to lower pipe around the tool while circulating to free it. With the tool in pipe, pipe was raised to 604.5 mbsf. The tool was then lowered into open hole, and logging while pulling pipe was resumed. Openhole logs were obtained for the interval 634.5-124.8 mbsf and through-pipe logs were obtained for 124.8-0.0 mbsf.

Rigup for the second borehole televiewer run began at 0250 LTC 11 December. With pipe set at 1088.5 mbsf, the tool was lowered to 1249.9 mbsf. Upcoming logs were obtained for the interval 1249.9-949.1 mbsf, partially while pulling pipe.

The Schlumberger geochemical combination was rigged up beginning at 1530 LTC, but this run was aborted while still in pipe at 954 mbsf due to failure of the gamma spectroscopy tool. Troubleshooting undertaken while a minicone was dropped was unsuccessful, so the geochemical combination was rigged down and the Schlumberger lithoporosity combination was rigged up instead. At this site the lithoporosity combination consisted of general-purpose inclinometer, lithodensity, neutron porosity, and natural gamma tools. Downgoing logs were obtained through the pipe for 0.0-1088.5 mbsf and in open hole for 1088.5-1235.5 mbsf. Upcoming logs were obtained in open hole for 1257.5-764.5 mbsf. Strong drags were experienced during the final 50 m of this interval, and the tool stuck at 764.5 mbsf. Pipe was lowered to free the tool, the tool was raised into pipe, and pipe was raised to 604.5 mbsf. After lowering the tool into openhole and as far down as the first bridge, openhole logs were obtained for 645.8-124.8 mbsf while pulling pipe. Through-pipe logs were obtained for 124.5-0.0 mbsf.

Rigdown from logging was completed at 2020 LTC 12 December 3.2 days after the start of hole conditioning.

OCEAN DRILLING PROGRAM
OPERATIONS RESUME
LEG 124

Total Days (1 November 1988 -- 4 January 1989)	63.8
Total Days in Port	4.1
Total Days Under Way (including survey)	12.5
Total Days on Site	47.2

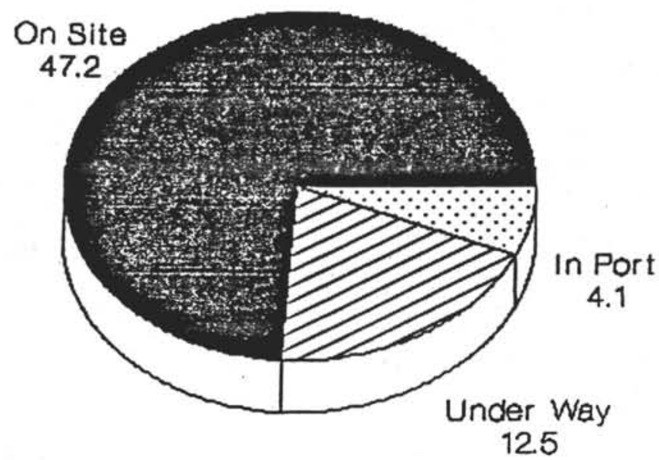
Trip Time	6.78
Coring Time	21.68
Drilling Time	1.91
Logging/Downhole Science Time	9.63
Reentry Time	1.54
Mechanical Repair Time (Contractor)	0.31
Stuck Pipe and Hole Trouble	3.93
Other	1.47

Total Distance Traveled (nautical miles)	3060.0
Average Speed (knots)	9.8
Number of Sites	5
Number of Holes	13
Total Interval Cored (m)	3114.6
Total Core Recovery (m)	2122.3
Percent Core Recovered	68.1
Total Interval Drilled (m)	2310.2
Total Penetration (m)	5424.8
Maximum Penetration (m)	1271.0
Maximum Water Depth (m from drilling datum)	4916.3
Minimum Water Depth (m from drilling datum)	2870.0

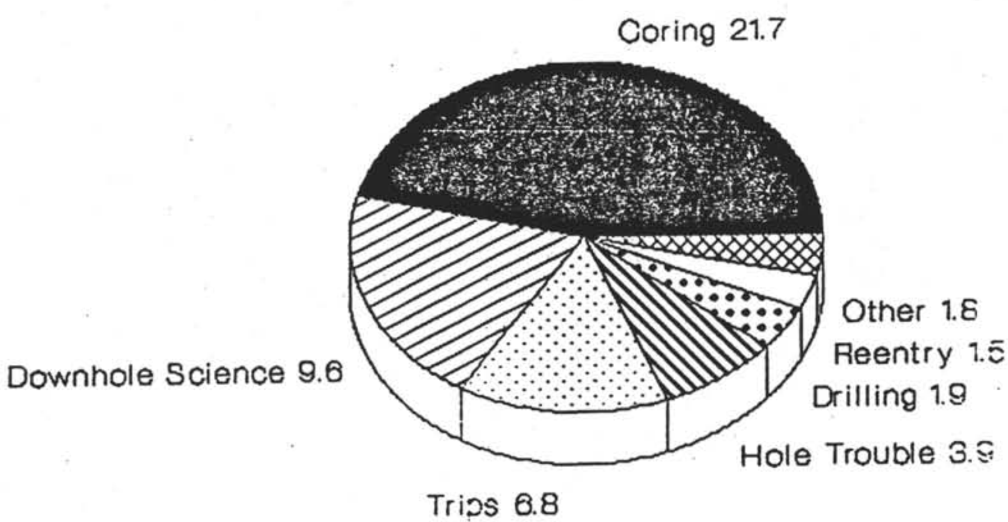
ODP OPERATIONS
SITE SUMMARY REPORT
LEG 124

HOLE	LATITUDE	LONGITUDE	DEPTH METERS	NUMBER OF CORES	METERS CORED	METERS RECOVERED	PERCENT RECOVERED	METERS DRILLED	TOTAL PENETRATION	TIME ON HOLE	TIME ON SITE
767A	4-47.47N	123-30.21E	4916.3	1	4.2	4.1	97.6%	99.8	104.0	21.00	
767B	4-47.49N	123-30.20E	4916.0	78	739.0	585.1	79.2%	0.0	739.0	221.25	
767C	4-47.50N	123-30.21E	4916.0	13	114.1	44.7	39.2%	680.0	794.1	148.00	390.25
768A	8-00.05N	121-13.16E	4395.5	1	9.5	8.8	92.6%	92.0	101.5	18.50	0.00
768B	8-00.05N	121-13.19E	4395.5	40	364.1	293.8	80.7%	0.0	364.1	58.75	
768C	8-00.04N	121-13.18E	4395.5	100	915.3	525.5	57.4%	355.7	1271.0	280.75	358.00
769A	8-47.14N	121-17.65E	3656.1	7	65.4	68.5	104.7%	0.0	65.4	16.25	
769B	8-47.12N	121-17.68E	3654.9	32	290.2	281.6	97.0%	0.0	290.2	42.25	
769C	8-47.12N	121-17.69E	3654.9	12	115.8	51.6	44.6%	261.1	376.9	42.25	100.75
770A	5-08.70N	123-40.24E	4518.0	2	10.9	1.6	14.7%	0.0	10.9	18.75	
770B	5-08.69N	123-40.10E	4516.2	21	201.6	112.4	55.8%	272.5	474.1	72.50	
770C	5-08.69N	123-40.11E	4516.2	12	115.8	54.8	47.3%	413.7	529.5	154.00	245.25
771A	8-40.69N	120-40.78E	2870.0	18	168.7	89.8	53.2%	135.4	304.1	39.50	39.50
	Totals :			337	3114.6	2122.3	68.1%	2310.2	5424.8		1133.75

TIME DISTRIBUTION
Leg 124



Total Time 63.8 days



Site Time 47.2 days

ALL VALUES ARE IN DAYS

TECHNICAL REPORT

The ODP Technical and Logistics personnel aboard JOIDES Resolution for Leg 124 of the Ocean Drilling Program were:

Laboratory Officer:	Burney Hamlin
Yeoperson:	Michiko Hitchcox
Computer System Manager:	Larry Bernstein
Curatorial Representative:	Jerry Bode
Curatorial Representative:	John Miller
Electronics Technician:	Mike Reitmeyer
Electronics Technician:	Barry Weber
Photographer:	Stacey Cervantes
Chemistry Technician:	Mary Ann Cusimano
Chemistry Technician:	Joe Powers
Marine Technician:	Wendy Autio
Marine Technician:	Ken Du Vall
Marine Technician:	Chris Galida
Marine Technician:	Jenny Glasser
Marine Technician:	Matt Mefferd
Marine Technician:	Debra Rutledge
Marine Technician:	Don Sims
Marine Technician:	Chuck Williamson

PORT CALL

The bus arrived at the technicians' hotel at 1000 local time, 1 November 1988 for the long ride to the Jurong Port pier. JOIDES Resolution was still on the horizon, delayed by customs and tug service. This delay contributed to an abbreviated crossover with the Leg 123 Technicians before their bus to the hotel arrived. Some technicians returned the following day to provide assistance with service calls and to complete their crossover.

A 250-L dewar flask of liquid helium was brought aboard the first day to fill the cryogenic magnetometer's reservoir for another 6 months work. The transfer was completed on 2 November.

Two 40-ft refrigerated containers were loaded with 539 boxes of cores collected on Legs 122 and 123, along with some freight, destined for the ODP Gulf Coast Repository.

Technicians from DIONEX worked 2 days on the cation side of the DIONEX apparatus. They made limited or inconclusive progress because of problems with chemicals and with removing air from the lines. New columns, parts, and chemicals were ordered.

A Digital Equipment Corporation (DEC) technician moved an ETHERNET board from the X-ray fluorescence (XRF) equipment to the X-ray diffraction (XRD) equipment and added a new serial board to the XRF. This effort will allow both instruments to transfer files to the VAX via ETHERNET, a valuable time-saver. A technician from Applied Research Laboratories (ARL) also worked on the XRF to upgrade boards, check goniometer problems, and restore the vacuum system to its original specifications.

The Pit Log used by the underway lab and the bridge has been reading slower the past several legs. A ODP electronics technician opened the plate to the access trunk to inspect the through-hull sensor and found it full of fuel oil; the problem will be addressed later.

All freight and local purchases were received and loaded, except for two items that arrived later via the mid-leg rendezvous.

UNDER WAY

Lines were cast off at 0930 local time, 5 November, beginning the transit to our first site, Site 767 (CS-1) south of the Philippine island of Mindanao. Navigation data were collected for 2 days while the ship crossed the shallow South China Sea paralleling the coast of Sarawak (Borneo). This route was selected to reduce the chance of encountering "boat people" and to avoid the region's infamous pirates. The ship crossed into the Sulu Sea south of the Straits of Balabac to maintain a maximum distance from typhoon

Skip. There were several unseasonal typhoons and tropical depressions in the region keeping the weather grey and the seas were sometimes rough.

The magnetometer was streamed and underway watches started on 7 November. The magnetometer was retrieved prior to entering shallow waters and traffic encountered north of Sabah passing into the Celebes Sea. The transit with magnetometer continued on to the first drill site. Currents encountered going between the islands boosted our speed to more than 14 kt, and the time gained assured us that the site survey could be completed before the end of the daily global positioning system (GPS) window.

Hydrophones were streamed with two S-80 water guns. Basement was apparent at about 1 s. The beacon was dropped for Site 767 on 9 November on the first pass over the proposed site coordinates and surveying continued for another 2 hr, adding valuable information on the site location.

After drilling the site, a 10-hr seismic survey was made and transducer tests were completed. The seismic gear was then pulled and speed increased for passage through the shallow strait into the Sulu Sea. Seismic gear was deployed again to survey proposed site SS-2 (Site 768) and good analog records were collected.

A medical emergency resulted in a transit to the Philippine port of Zamboanga and a rendezvous with a helicopter for the medical evacuation. The sonar dome's 12-kHz transducer was switched for bridge use to assist safe entry into the shallow waters of the small port and to augment navigation charts, while we used the aft transducer for gathering scientific data. Magnetometer data were collected during the return to Site 768.

A second trip to Zamboanga was required, after logging Site 768, for another medical evacuation, this time the ship's medical doctor.

A 12-hr seismic survey was made in the area of proposed site SS-5 to locate Site 769. It was necessary to make the final part of the survey along a reference seismic lines and with GPS. Time prior to the GPS window was used to further define the areal bathymetry.

With objectives for Site 769 achieved, pipe was pulled on 18 December for the transit back to the Celebes Sea, stopping in Zamboanga to pick up a replacement medical doctor.

Seismic gear was redeployed as soon as possible for the transit across the Celebes Sea to follow the multichannel seismic line defining Site 770. This transit/survey generated more than 22 hr of very good records, 2 hr of which were post-processed. Using the processing parameters selected, the record generated took some 8 hr of MASSCOMP computer time.

The official PDR depth at Site 770 proved to be some 30 m shallower than the actual drilling depth. Apparently, strong side echoes from the thrusters contributed to the observed bottom, as PDR depth coincided with drilling depth once the closest thruster was secured.

Site 770 was located in the vicinity of a moored fish attracter. The float was soon alongside, and an unsuccessful attempt was made to pull it away from the ship with the Zodiac boat. With the aid of the ship's crane, the mooring line was cut to prevent it from tangling in the drill string. The pipe was inspected with the TV system, revealing a rope and cable snarl. Pipe was pulled while rope and cable were cut from the drill string. One piece of rope was caught in a skeg thruster and that thruster was secured.

While at Site 770 the supply boat Lukasturm from Singapore delivered fuel, drilling muds, and foodstuffs. As we were logging the hole in fine weather, an all hands effort unloaded two 20-ft and two 10-ft containers in less than 3 hr. The bulk materials were unloaded in about 31 hr along with the late items from the Singapore portcall.

Conditions for the planned packer experiment deteriorated at Site 770, so the pipe was pulled and the ship departed on 30 December for Site 771. Magnetometer data were collected during the transit. Seismic gear was streamed only for the survey of Site 771.

JOIDES Resolution left Site 771 for Manila on 2 January 1989, docking as scheduled on 4 January 1989.

Clear 12-kHz records were collected at full speed and in 3-5 s of water. The 3.5-kHz records were satisfactory.

Depth computer files were created for all underway segments and some depth vs. track plots were made successfully. Questions were generated for the portcall crossover that should help improve these programs and allow easier production depth and magnetometer vs. track plots in the future.

JOIDES Resolution traveled an estimated 3060 nmi collecting navigation data. This included 2245 nmi of bathymetric data, 1812 nmi of magnetometer data, and 498 nmi of seismic data.

CURATORIAL

Five sites were occupied on Leg 124, with 13 holes drilled. A total of 337 cores were recovered, comprising 66 cores of hard rock and basalt and 271 sedment cores. A total of 9262 samples were taken and generated from these cores. As recovery for the leg was somewhat greater than estimated, a 250-box shipment of cores from Guam was scheduled with a priority list left aboard. A frozen surface shipment is planned from Manila for all accumulated organic geochemistry (OG) samples.

The supervisor of the Gulf Coast Repository sailed his first Leg, assisted in learning shipboard procedures by the supervisor of the West Coast Repository. In addition to routine curatorial duties, the curatorial cookbook was revised and transferred to Wordperfect.

CORE LAB

Activity in the core lab remained routine for the most part. Difficulty was experienced cutting some the dense brown clays, which were also difficult to drill. Warped blades, failed bearings and asymmetrical core cutting were all addressed in a general overhaul of the super saw. A wider diamond blade was installed and core cutting was much improved.

Core orientation was accomplished on APC holes at 4 sites using the Multishot cameras. The 77 camera runs provided valuable data for the paleomagnetists.

Few problems were noted with the cryogenic magnetometer after the first site. Several familiar problems were addressed involving EPROM changes in the axis control boxes and installing a small fan to cool an occasionally overheating power amplifier. Calm seas this leg resulted in a very low helium boil-off rate.

A programming error was discovered related to a MINISPIN volume correction, and was fixed. The Staff Scientist will ensure that this correction is brought to the attention of previous investigators.

A paleomagnetism scientist modified several programs used in the lab to run on an IBM-PC utilizing an aftermarket fast communication board, and to create files in an ODP format. Plotting routines and equipment diagnostic programs were also added to the lab library.

Susceptibility measurements were made on whole cores and were valuable in correlating information from multihole sites.

Cores were examined for physical properties, including GRAPE densities and P-wave logs of the APC cores, thermal conductivity, vane shear, resistivity, porosity and sonic velocity of discrete samples in indurated sediments and rocks.

Ten downhole tool runs were made this leg specifically for heat flow. The first four measurements failed using different recorders and probes giving unusable results which were never explained. Six successful runs were made after different batteries were included in the power pack--perhaps only a coincidence.

A secondary drain was added to the core cutter sink, allowing sediment to be trapped there and drained into a large bucket. The bucket of cuttings can then be disposed of in a floor drain installed on the catwalk aft of the core lab, reducing the possibility of lab drains clogged by sediment and rock fragments.

Three new technicians were trained in core lab procedures.

CHEMISTRY

Head-space samples (447) were taken from each sediment core as a routine safety precaution. Gas analyses were made on the CARLE gas chromatograph (GC), If heavier gases were detected, a second sample would be processed on GC1. Rock-Eval total carbonate determinations were made on the headspace samples. Inorganic carbon determinations (800+) were made on the physical properties samples and on some specially sampled intervals using the Coulometers; 400 analyses were made on shipboard scientists' personal samples.

Interstitial water was squeezed and analyzed from samples taken from each of the first 10 cores and every third core thereafter from each site. Titrations determined calcium, magnesium, and chloride; the DIONEX determined sulfate; the spectrophotometer determined ammonia, silica, and phosphorus. Water splits were made for several scientists.

Other measurements included pH, alkalinity, and salinity. The coulometer manual was revised, and a new chemistry technician was trained.

X-RAY LAB

The X-ray lab instruments were used extensively this leg with over 700 samples scanned on the X-ray diffraction (XRD) unit, mostly of clay samples. A new X-ray tube was installed mid-cruise when the old one failed suddenly.

X-ray fluorescence (XRF) analyses using standard methods were run on 304 samples, including 87 basalts and ashes, and 217 sediment samples run for major elements using pressed pellets. Matrix corrections were applied to the sediment sample scans with reproducible results. This method has potential for future sediment studies and perhaps basalt analyses also when quick results are needed or weighing is a problem. The XRF sample changer continued to be a time-consuming nuisance and appears to be wearing out. It is proposed that a new one be purchased. Other problems included instrument and/or background drift, perhaps related to the use of a new X-ray tube, and the failure of a small power supply.

THIN SECTION LAB

Over 200 thin sections were prepared from 180 billets, primarily of clays and altered basalts. No equipment problems were noted and the lab functioned normally. Some experimentation was done to evaluate a UV-curing epoxy which has as advantages low viscosity and curing without heat. The slow curing time may prove inconvenient on hard-rock legs. A more complete evaluation of the product is planned.

MICROSCOPES

A few minor problems were reported by microscope users. Some lamp bulbs were replaced and problems with stiff focusing action were addressed. Photographs were taken with a 35-mm camera on a stereomicroscope, and reference video images were made with the video printing system and a photoscope.

Several of the technicians have attended microscope seminars stressing optical alignment, lighting, and maintenance; increased confidence and experience have allowed technicians to resolve most microscope problems prompbly at sea. Problems that arise outside the experience of the technician can now be described more clearly and resolved more easily with help from professionals ashore.

COMPUTER SERVICES

New software was installed on the VAX, including Wordperfect. This lessened the PC and Macintosh users' work to send Wordperfect documents to the laser printer. Classes were held during the transit to the first site to familiarize the scientists with the system and software available. Time was given to individual instruction because of the range in user skill levels and specifics of individuals requirements.

Software revisions were made in physical-properties and chemistry accounts so they could use the database entry programs. Command files options were created to speed the transfer of data from these labs into PicSure, spreadsheets, and Wordperfect programs.

Several changes were made in the user room to accommodate several Macintoshes and an Apple laser printer arriving next leg.

Data tapes were hung around the ceiling perimeter and old tape storage racks were removed. Bench space will be installed for the new PC's where the tape racks were standing.

In support of the coming computer expansion, a DELNI box, which is an ETHERNET communications signal splitter, was installed under the floor of the computer machine room. ETHERNET service was extended to the downhole measurements lab from the physical-properties area in the core lab.

PHOTO LAB

The air tempering unit in the Kreonite film processor failed and was replaced with a rebuilt unit. The exchange of this unit alerted the engineering staff to the fact that the compressor units were plumbed to potable water last leg. The ship's chill water was used on previous cruises and was too cold, according to Kreonite representatives. The chief engineer is interested in using drill water in the future and continues to investigate this alternative. Routine maintenance addressed the few other problems that occurred. Water quality seemed improved this Leg.

ELECTRONICS SHOP

While there was only one reentry accomplished this leg there were several TV reconnaissance trips that generated considerable work for electronics technicians. Attention was given to problems with the video underwater lights, the TV camera and telemetry package, cable heads and the MESOTECH reentry sonars.

The pipe-severing system was needed for one occasion that required five attempts before the pipe was parted successfully. Poor location of the charge and a bad connection were the reasons for the several attempts.

A difference in results using various amp/gain combinations of the ITHACO amplifier helped locate a bad channel in the amplifier, and a new module was ordered. It was also noted that the MASSCOMP sees the results of various combinations differently than do the analog recorders and that question will be discussed at portcall.

Considerable support was also given to the downhole heat flow tools, the cryogenic magnetometer, the XRF and XRD, the TOTCO drilling parameter system, XEROX machines and numerous small pieces of lab equipment.

STOREKEEPER

Other than routine storekeeping duties, an effort was made to clear out some of the storage shelves, particularly in the Hold Stores, to allow additional room for consumable supplies. Some of the extra or superseded equipment was removed and returned to ODP for storage until needed. Bulky, large rope reels and some light cable were moved to the lower sack storage area.

A minor programming detail in the Ship-to-Shore (S2S) shipping program was modified, enabling the program to be started from a "menu" screen.

GYM

Several new pieces of gym equipment were added to the gym, replacing worn-out equipment. The gym was used daily for table tennis, aerobics workouts, and personal fitness routines.

SPECIAL PROJECTS

Several jobs were initiated during the transit from Singapore to the first site, including some to be finished before drydock. As is not uncommon in port, the drain pan under the core lab air handler malfunctioned, sending condensate into the core lab and down the lab stack stairwell. This problem has been corrected by rerouting the drain and connecting it to the paleo lab gray-water drain.

Electrical surge suppressors and power strips were installed on as much of the sensitive equipment using regulated power as possible. These suppressors should protect the equipment if the regulated power fails. Cable runs around the outlets were bundled and tied.

Preliminary work was done to expedite moving the upper tween deck fire hose to make room for a storage unit. A four-drawer file cabinet was installed adjacent to the gas bottle storage on the upper tween deck. Shipping papers, messages, and L.O. books for Legs 101-118 were transferred here for storage.

The lower tween core refrigerator deck was cleared and a path of non-skid paint was applied. This will eliminate a safety hazard by improving footing during core box handling. The drain line for condensate from the reefers' expansion coil fans was extended to the floor drain.

A sturdy ramp into the reefer was constructed, allowing technicians to roll boxes of cores into refrigerated storage.

Several Heathkit self-teaching electronics courses were assembled and studied by ODP technicians.

SAFETY

Experience gained transfering liquid helium emphasizes the importance of preparedness. The transfer presented safety and mechanical problems that were overcome and thoroughly documented so as to avoid such occurrences in future procedures. To smooth this operation in the future, cryo gloves to allow the technicians more dexterity and some special rubber plugs were ordered. A modified helium vent line to divert normal boil-off from the fill valve is being investigated so that vision is not obscured by the opaque boil-off. Also, an inventory of our fittings and transfer gear has been prepared so we can be assured of Dewar flask hardware compatibility before beginning a transfer. A check list of important steps to be completed prior to the transfer has been compiled.

The METS team participated in weekly fire drills and related activities. The flammable liquid chemicals and solvents stored in the refrigerated locker were removed and inspected. Mold had damaged labels on some of the chemical containers stored in this humid environment; they were replaced. Old stock was rotated forward. The problem of condensation was brought to the attention of the Chief Engineer, who will see what can be done to alleviate the problem.

Other activities included exchanging the activated charcoal used in the LABCONCO bench filters and testing the safety showers and eye wash stations.