OCEAN DRILLING PROGRAM

LEG 124 SCIENTIFIC PROSPECTUS

SOUTHEAST ASIA BASINS

Dr. Karl Hinz
Co-Chief Scientist, Leg 124
Bundesanstalt fuer Geowissenschaften
und Rohstoffe
Stilleweg 2
Postfach 510153, D-3000 Hannover
Federal Republic of Germany

Dr. Eli Silver
Co-Chief Scientist, Leg 124
Department of Earth Sciences
University of California
Santa Cruz, CA 95064

Dr. Marta von Breymann
Staff Scientist, Leg 124
Ocean Drilling Program
Texas A&M University
College Station, TX 77840

Philip D. Rabinowitz
Director
ODP/TAMU

Audrey W. Meyer
Manager of Science Operations
ODP/TAMU

Louis E. Garrison
Deputy Director
ODP/TAMU

July, 1988

Scientific Prospectus No. 24
First Printing 1988

Distribution

Copies of this publication may be obtained from the Director, Ocean Drilling Program, Texas A&M University Research Park, 1000 Discovery Drive, College Station, Texas 77840. In some cases, orders for copies may require a payment for postage and handling.

DISCLAIMER

This publication was prepared by the Ocean Drilling Program, Texas A&M University, as an account of work performed under the international Ocean Drilling Program, which is managed by Joint Oceanographic Institutions, Inc., under contract with the National Science Foundation. Funding for the program is provided by the following agencies:

Department of Energy, Mines and Resources (Canada)
Deutsche Forschungsgemeinschaft (Federal Republic of Germany)
Institut Francais de Recherche pour l'Exploitation de la Mer (France)
Ocean Research Institute of the University of Tokyo (Japan)
National Science Foundation (United States)
Natural Environment Research Council (United Kingdom)
European Science Foundation Consortium for the Ocean Drilling Program
(Belgium, Denmark, Finland, Iceland, Italy, Greece, the Netherlands, Norway, Spain, Sweden, Switzerland and Turkey)

Any opinions, findings and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the National Science Foundation, the participating agencies, Joint Oceanographic Institutions, Inc., Texas A&M University, or Texas A&M Research Foundation.

ABSTRACT

The Sulu, Celebes, and Banda seas are marginal basins with tectonized margins. Their ages of formation are uncertain and each contains a thick sequence of Tertiary and possibly Cretaceous sediments, which should record a history of complex collisional and tectonic events inferred to have occurred during Neogene time. Each basin presently has restricted circulation, evolving from more open-ocean circulation in the past. In each basin, the proposed sites for drilling on Leg 124 have three key objectives:

(1) To determine the age and nature of oceanic basement.
(2) To determine the stratigraphic history of the basins with implications for both tectonic and paleoceanographic events, such as changes from oxic to anoxic conditions.
(3) To determine stress orientations.

SULU SEA

Geologic Setting

The Sulu Sea is a marginal basin, approximately 600 km long and 400 km wide, located between northern Borneo (Sabah) in the west and the central Philippine Archipelago in the east. A northeast-trending and approximately 600 km long island chain formed by Balabac Island, Palawan Island and the Calamian Islands separates the Sulu Sea from the South China Sea in the north, and the northeast-trending Sulu Archipelago separates it from the Celebes Sea in the south. A distinct northeast-trending bathymetric high, the Cagayan Ridge, subdivides the Sulu Sea into two sub-basins, the northwest Sulu basin and the southeast Sulu basin (Figures 1 and 2).

The northwest Sulu basin has water depths ranging from 1000 to 2000 m. The southeast Sulu basin is much deeper, with maximum depths between 4500 m and 5500 m along the Sulu trench located off the Zamboanga Peninsula of Mindanao and Negros Island. Northern Palawan including the Calamian Islands, Reed Bank, Mindoro and northwest Panay are part of the north Palawan continental terrane. The onshore parts of this terrane are characterized by metamorphic basement rocks and by upper Paleozoic through Mesozoic clastic sediments and limestones (Porth, 1984; Hashimoto and Sato, 1973; Reyes, 1971). In contrast to north Palawan, the southern and central parts of Palawan Island and Balabac Island are composed of ophiolites, amphibolites and greenschist rocks that crop out along southeast-dipping thrust sheets and are mixed with sandstones, shales, mudstones and limestones of Late Cretaceous to early Miocene age (Porth, 1984; Hashimoto, 1981; Hamilton, 1979; Hutchison, 1975). These intensely deformed rocks are interpreted as a melange, i.e., an accreted terrane formed by subduction of Mesozoic oceanic crust along the northwest Borneo-Palawan Trough (Hamilton, 1979; Ludwig et al., 1979; Taylor and Hayes, 1980, 1983). The Tertiary sequences that crop out on northern Borneo (Sabah) consist primarily of Paleogene deep-water sediments, which were deposited in the northwest

Borneo geosyncline and mainly deformed since early Miocene time. In eastern Borneo this folded sedimentary sequence extends northeastward into the Sulu Sea and is associated with the emplacement of basic and ultrabasic rocks.

The Cagayan Ridge has been interpreted as a volcanic arc related to subduction in the Palawan Trough. In contrast to this widely accepted plate tectonic model, Hinz and Schluter (1985), Hinz et al. (1986) and Kudrass et al. (1985) show that the Palawan Trough is not underlain by a southward-subducting oceanic plate from which sediments were scraped off in pre-middle Miocene time, as Hamilton (1979) and others suggested, but that the north Palawan continental terrane underlies the northwest Borneo-Palawan Trough and the western shelf of Palawan and northwest Borneo. The strongly deformed and ophiolite-bearing equivalents of the Cretaceous Chert-Spilite Formation and the Paleogene Crocker Formation of south and central Palawan were overthrusted in pre-middle Miocene time onto the north Palawan continental terrane.

The central Philippine islands of Mindanao, Negros and Panay bound the Sulu Sea in the east. The northwestern part of the Zamboanga Peninsula of Mindanao has a basement likely to be a melange including schist, phyllite, metasandstone, slate, marble, Cretaceous limestone, volcanic rocks and lenses of peridotite (Hamilton, 1979). Negros Island consists mostly of andesitic rocks and their intrusive equivalents (Hamilton, 1979). The dominant structural feature of western Panay is the Antique Ridge which is composed of a polymict melange that contains blocks of glaucophane schist, gabbro, peridotite, metavolcanics and red chert. West of this melange are thrusted blocks of Upper Jurassic to Lower Cretaceous red chert, peridotite and metabasalt and Paleozoic metamorphic rocks (McCabe et al., 1982). This juxtaposition of a metamorphic terrane against the high-pressure melange basement of the Antique Ridge led McCabe et al. (1982) to conclude that the north Palawan continental terrane collided with the central Philippine mobile belt between late Oligocene and middle Miocene time.

There is a diversity of geophysical and geological data from the Sulu Sea. Two seismic-refraction profiles and magnetic measurements were collected by R/V Vema in 1967 (Murauchi et al., 1973). In 1974 the Comite d'Etudes Petroliers Marines conducted a multichannel seismic survey across the Sulu Sea (Mascle and Biscarrat, 1978). The Federal Institute for Geosciences and Natural Resources (BGR) collected approximately 10,000 km of MCS data in parallel with magnetic and gravimetric measurements in the Sulu Sea on six cruises during the period 1977-1987 (Hinz et al., 1986; Hinz and Schluter, 1985; Durbaum and Hinz, 1983). Geological sampling and heat flow measurements have also been collected in the Sulu Sea (Anderson et al., 1978; Kudrass et al., 1985).

The seismic data show that the two sub-basins of the Sulu Sea have distinctly different seismic characteristics. In the northwest Sulu basin, characterized by a regional free-air gravity low, two major tectonic stratigraphic terranes are superimposed. The thickness of the upper unit varies between 0.5 and 3.5 seconds two-way traveltime (s twt). It is characterized by a coherent reflection pattern. A distinct seismic unconformity called horizon 'C' by Hinz et al. (1986) separates the upper unit from the seismically non-coherent lower unit. The lower unit is approximately 2-3 s twt thick. From a review of ten wells offshore of southwest Palawan and Borneo, and of four wells from the western Sulu Sea, it appears that horizon 'C' represents the end of a major regional tectonic event that affected the area of the northwest Sulu basin up to the late early Miocene. The sediments above horizon 'C' commonly belong to biostratigraphic zones N9 and NN5, corresponding to an age of about 17 Ma. Horizon 'C' has been correlated with the end of seafloor spreading in the South China Sea (magnetic anomaly 5D, 17 Ma; Taylor and Hayes, 1983). The seismically non-coherent lower unit is interpreted by Hinz et al. (1986) to consist of imbricated pre-middle Miocene rocks including equivalents of the Paleogene Crocker Formation and the Cretaceous Chert-Spilite Formation.

The deep southeast Sulu basin is characterized by crustal thicknesses and seismic basement characteristics typical of oceanic crust; a 1-2 s twt thick and seismically coherent sedimentary sequence overlies oceanic basement. The sedimentary sequence is subdivided by several unconformities labelled S1 to S6 that have been interpreted stratigraphically by Hinz et al. (1988). The oceanic crust of the southeast Sulu basin descends eastward at the Sulu Trench. An accretionary wedge lies above the downgoing oceanic crust of the southeast Sulu basin. The thickness of the wedge increases steadily from about 1 s twt at the Sulu Trench to >4 s twt. In general the toe of the wedge is characterized by thrust sheets forming an imbricate system in front of an inferred oceanic crustal slab that forms the 'backstop' against which the wedge accretes. The top of the downgoing oceanic crust forms a major detachment plane.

Sediments recovered by piston coring in the Sulu Trench are finely laminated and variously colored, and are interpreted as turbidites (Kudrass, 1988). Temperatures of $+10^{\circ}C$ have been measured at the seabed in the Sulu Trench, and high heat-flow values have been determined. High methane concentrations (up to 17,700 ppb) have been encountered in the surface sediments from the toe of the accretionary wedge (Berner, 1988). These findings suggest that fluids from the accretionary wedge are moving along stratigraphic levels toward the Sulu Trench.

The southeast Sulu basin has been interpreted either as the result of backarc spreading (Mitchell et al., 1986; Holloway, 1981; Hamilton, 1979) or entrapment of a piece of a previously continuous ocean basin from the Banda Sea to the Sulu Sea. Lee and McCabe (1986) interpreted magnetic anomalies in the southeast Sulu basin as seafloor spreading anomalies 17-20 (41-45 Ma). Their interpreted anomaly 20 lies on the Sulu Archipelago. If the hypothesis of Lee and McCabe (1986) is correct, this oceanic crust could have been partly the source of the obducted ophiolite complexes present onshore in Borneo, Palawan, and the Philippine mobile belt.

Alternatively, according to Mitchell et al. (1986), northwestward subduction of the Celebes Sea beneath the Sulu Archipelago initiated in the Paleogene with arc volcanism on the Cagayan Ridge. In the early Oligocene (30-37 Ma), the Sulu Arc migrated southeastward and the southeast Sulu basin opened as a back-arc basin behind the Sulu Arc. The southeast Sulu basin began to subduct eastward in the middle or late Miocene (7-14 Ma). If both this hypothesis and that of McCabe et al. (1982) are valid, coexistence of collision processes and extension with rifting and seafloor spreading in the Sulu Sea would be established.

Drilling Objectives in the SE Sulu Basin

Five locations for ODP drilling have been proposed in the southeast Sulu basin (SS-1 through SS-5; Figures 2 and 3). Three of these five sites are designed to investigate the age and nature of the oceanic crust and the paleoenvironment and sedimentation in a restricted ocean basin. These sites are SS-3, SS-2 (alternate site) and SS-1 (alternate site). The objectives of SS-3 are these:

(1) To determine the age of the southeast Sulu basin in order to establish the time of drifting and to test various proposed models for its origin;

(2) To establish the stratigraphic history of the basin, particularly with respect to whether its paleoenvironment reflects a basin with an open, closed, or restricted circulation, and to the timing of major volcanic, collisional, and paleoceanographic events.

(3) To determine regional stress orientation in the southeast Sulu basin, to discern whether subduction- or collision-related forces predominate.

The objective of proposed site SS-4 is to determine the age and nature of a regional slab of inferred oceanic crust forming the "backstop" against which the Sulu accretionary wedge accretes. This crustal slab may very well represent the oldest portion of the actively subducting southeast Sulu basin.

The objective of the proposed site SS-5, located at the southeastern edge of the Cagayan Ridge, is to determine the paleoenvironment of rift and drift sedimentary sequences of the southeast Sulu basin.

CELEBES SEA

Geologic Setting

The Celebes Sea is a small (270,000 km^2) ocean basin bounded in the north by the Sulu Archipelago and in the south by Sulawesi (Figures 1 and 2). It has an abyssal plain of 5,000-5,500 m depth (Mammerickx et al., 1976). Deep bathymetric depressions off the southwest margin of Mindanao and along the northern margin off Sulawesi are trenches of the active Cotabato subduction zone and North Sulawesi subduction zone, respectively.

The southern part of central Mindanao, an area of high seismicity, has a basement that consists of arc-type magmatic rocks including deformed and variably altered andesite, basalt, dacite and intrusive equivalents of Miocene and older age. Younger volcanic rocks and upper Neogene shallow-marine clastics and carbonate sediments overlie the older volcanic rocks (Hamilton, 1979).

The volcanic arc (Sulu Arc) extends from Borneo through the Sulu Archipelago to the Zamboanga Peninsula of Mindanao (Exon et al., 1981). The presence of ultramafic and mafic rocks and associated melanges within the Sulu Arc is explained by two subduction episodes, the first related to northward subduction of the Celebes Sea, and the second related to southward subduction of the southeastern Sulu basin (Hamilton, 1979).

The results of three seismic lines collected by Murauchi and others suggest that the crustal structure of the Celebes Sea is oceanic (Murauchi et al., 1973). Heat-flow values of 1.5-1.6 HFU have been determined, and N65°E trending magnetic anomalies have been recognized in the southwestern part of the Celebes Sea. Weissel (1980) interpreted them as seafloor-spreading anomalies 18-20 (42-47 Ma). In contrast, Lee and McCabe (1986) interpreted these magnetic lineations as Mesozoic anomalies 30-36 (65-72 Ma), and they regard the Celebes Sea as a trapped portion of a previously continuous oceanic basin from the Banda Sea to the Sulu Sea.

Drilling Objectives of CS-1

During R/V SONNE Cruise SO49 (1987), three multichannel-seismic lines in parallel with magnetic, gravimetric, 3.5-kHz and Seabeam measurements were collected from the upper slope of southwestern Mindanao, across the Cotabato Trench into the abyssal plain of the Celebes Sea (Figure 3).

Based on these geophysical data, the primary scientific questions in the Celebes Sea, namely those of determining the age and nature of the oceanic crust and the paleoenvironment in the restricted basin, can be solved by drilling at the location of proposed site CS-1 (Figures 2 and 3). The oceanic crust lies at a depth of approximately 1000 mbsf at this site, and it dips gently towards the east. At the Cotabato Trench, approximately 100 km to the east, the oceanic crust descends beneath an accretionary wedge. Measurements of stress orientation will be made to distinguish whether dominant forces on the Celebes Sea are due to subduction or to edge effects of collision.

BANDA SEA

The Banda Sea is one of a series of marginal basins in the western Pacific region (Figures 1 and 4). Many of these basins are thought to have formed by back-arc spreading (Karig, 1971), but other processes are now known to be important as well, such as entrapment (Uyeda and Ben-Avraham, 1972; Cooper et al., 1976) and plate-edge tectonics (Taylor and Karner, 1983).

In their synthesis of the evolution of marginal basins, Taylor and Karner (1983) classified both the age and origin of the Banda Sea as unknown. Recent studies of the Banda Sea, however, have revealed an origin related to slivering of continental margin fragments and trapping of oceanic crustal slices (Silver et al., 1985). This process is significant for two major reasons. First, the kinematic evolution of the Banda Sea will provide a crucial constraint on the development of the complex collision zone of eastern Indonesia, a process that has been compared with the evolution of the ancient cordillera mountain system of western North America. The second reason is that this proposed model--constructional origin of a marginal sea through strike-slip faulting of continental and oceanic crustal fragments--provides a new modern analog for rock associations in ancient mountain systems, and a system for understanding possible histories of amalgamation of tectonostratigraphic terranes.

Available Data and Stratigraphic Setting

Six single-channel seismic reflection profiles have been collected in the vicinity of proposed site BANDA-2 (Figure 5). Additional data include magnetics and bathymetry. One heat-flow station was reported by Bowin et al. (1980) near the site, with a value of 75 mW/m^2 (1.8 HFU).

Seismic line KK-23, on which proposed site BANDA-2 is located, best illustrates the seismic stratigraphy of the north Banda basin (see copy of seismic profile behind BANDA-2 site summary sheet, p. 39, this prospectus). The upper 350 m are seismically transparent pelagic sediments. These are overlain only in a small trough adjacent to the Tukang Besi Ridge, by 400 m of turbidites.

Underlying the transparent unit is a layered sequence, which varies laterally both in thickness and seismic character. Beneath the layered sequence is another transparent unit that overlies basement. On line KK-23, basement is irregular and the deepest part of the section occurs in a restricted local basin. Based on poorly determined magnetic estimates as well as comparison with age-depth curves of the major ocean basins, a Cretaceous age is inferred for the basement.

Drilling Objectives of BANDA-2

Reconstructions of the Banda Sea imply that it was formerly a fragment of the Molucca Sea plate. However, the geochemistry of diabase dredged from a fault scarp adjacent to the north Banda basin indicates close similarities to the Indian Ocean mantle. Because of the completed collision of the Molucca Sea plate it is difficult to compare that to the north Banda basin. An Indian Ocean origin, however, should be obvious. The stratigraphic history of this site should provide an excellent record of the formation and closure of the basin, the collisional history of Sulawesi and its temporal relation to the Sulu Archipelago, and the relationship of the basins with the Banda ridges. This site may also shed light on the origin and history of the Tukang Besi Ridge.

The primary objectives for drilling BANDA-2 are these:

(1) To determine the stratigraphy of the basin, as a record of the complex tectonic and paleogeographic events that have shaped the Banda Sea in Cenozoic time. The sedimentary section over basement will provide significant information on the history of this basin. If the basin is old Indian Ocean crust, then the early part of the section should be similar to that of the eastern Indian Ocean up until (or very near) the time that this segment became trapped behind the arc. The volcaniclastic history of the section should also corroborate this date. In addition, the time of construction of water flow between the Indian and Pacific oceans should be recorded in these sediments.

(2) To determine the age and nature of the basement underlying the north Banda basin. If it is a trapped piece of Indian Ocean crust, correlative with that of the eastern Indian Ocean, then it should be oceanic (MORB) and Cretaceous in age.

(3) To determine the in-situ regional stress in the Banda Sea. Recent seismologic and marine geophysical studies of the Banda Sea and Sunda Arc have raised significant questions concerning the distribution and orientation of regional stresses associated with the collision between the arc and Australia. McCaffrey (in press) determined numerous focal-mechanism solutions within the Banda Sea and concluded that the collisional deformation is distributed across the Banda Sea and Sunda Arc system, rather than focused on the zone of initial accretion at the trench. Stress orientation from drilling will be measured by the orientation of borehole breakouts using the downhole televiewer. Stress measurements are expected also from the Argo abyssal plain on Leg 123. The combined data set will be the first set of measurements to be carried out systematically in this region, or in any continent-arc collision zone. These measurements will be compared with stress-modeling studies carried out by Cloetingh and Wortel (1985).

OPERATIONS PLAN

There are two scenarios for drilling on Leg 124, subject to whether or not clearance is received from Indonesia to drill BANDA-2. The two options are shown in Tables 1a and 1b. Leg 124 is scheduled to depart Singapore on 6 November 1988 and end in Manila on 4 January 1989 (Tables 2a and 2b).

Proposed site SS-3 in the Sulu Sea is located on line S049-05 at shotpoint 2180. The JOIDES Safety Panel has also approved a location at shotpoint 2250 on the same line as an alternative for drilling at this site. The drilling strategy will be a combination of advanced hydraulic piston coring and extended core barrel (APC/XCB) coring to 540 mbsf, followed by rotary core barrel (RCB) coring for a total penetration of 1350 mbsf (including 50 m of basement). At the conclusion of drilling, standard Schlumberger logs and the borehole televiewer (BHTV) will be run. There is also the option of running vertical seismic profile (VSP) measurements at this site. Proposed sites SS-1 and SS-2 are alternate sites for SS-3.

If clearance is not received from Indonesia to drill at the BANDA-2 site, the ship will drill in the Celebes Sea at proposed site CS-1, before drilling at SS-3. The JOIDES Safety panel has approved drilling to basement at CS-1 between the range of shotpoints 100-300 on seismic line S049-02. The most complete section is observed at shotpoint 200, which is presently the preferred location for the site. We anticipate penetration to 570 mbsf using APC/XCB coring, followed by RCB coring for a total penetration of 1050 mbsf (including 50 m of basement). Standard Schlumberger logging and BHTV runs will follow.

BANDA-2 is located on R/V Kana Keoki line 23 at 0600Z/8 April 1983. If Indonesian clearance is received, this site will be drilled first. We anticipate penetrating 370 mbsf using APC/XCB coring. Drilling to basement will then be accomplished using the RCB on a second hole (washed to about 370 mbsf), for a total penetration of 1050 mbsf (including 50 m of basement). This will be followed by standard Schlumberger logging and borehole televiewer (BHTV) runs for stress measurements.

After completing the two deep sites (SS-3 and either CS-1 or BANDA-2), the Leg 124 Co-Chief Scientists will decide on options and strategies for drilling lower priority sites SS-4 and SS-5.

Proposed site SS-5 is located on the Cagayan Ridge, on seismic line S049-07, at shotpoint 624. The main objective of this site is to study Neogene sedimentation and paleoenvironment in a restricted basin. This site was chosen on the assumption that the sedimentary column comprises a pelagic/hemipelagic sequence representing oxic/anoxic events in the basin. There is, however, the possibility that the sediments are primarily shallow-marine carbonates, which would not allow us to accomplish the main objectives at this site. This area will be dredged during an upcoming cruise in July/August. Data gathered during the cruise will clarify the nature of the sediments and the desirability of drilling at this site. In the event of drilling, we anticipate APC/XCB coring to 400 mbsf.

Proposed site SS-4 is located on line S049-05 at shotpoint 4000, which overlies the edge of a buried uplifted crustal slab. The main drilling objective at this site is to determine the age and nature of the slab. There are two possible drilling strategies, the choice of which will depend on the time available: APC/XCB and RCB coring through the entire sedimentary section, or single bit, spot coring to basement. In both cases, 50 m of basement will be recovered to fulfill the main objective at this site. Logging strategies will also depend on time available, with the minimum of a two-string Schlumberger suite planned. If drilled, a cross line over SS-4 would be shot to confirm the northward basement slope inferred from profiles parallel to line S049-05.

REFERENCES

Anderson, R. N., Langseth, M. G., Hayes, D. E., Watanabe, T., and Yasui, M., 1978. Heat flow, thermal conductivity, thermal gradient. Geophysical Atlas of East and Southeast Asian Seas. Boulder (Geol. Soc. Am.), MC-25.

Berner, U., 1988. Results of geochemical investigations. In Kudrass, H. R., Beiersdorf, H., Berner, U., Block, M., Scholten, J., Steinmann, D., Sulzbacher, H., Weiss, W. (Eds.), Geological, geochemical and geothermal studies in the Sulu Sea, Philippines. BGR unpub. rept. 102.042, 81-107.

Bowin, C. O., Purdy, G. M., Johnston, C., Shor, G. G., Lawver, L., Hartono, H.M.S., and Jezek, P., 1980. Arc-continent collision in Banda Sea region. Am. Assoc. Petrol. Geol. Bull., 64:868-915.

Cloetingh, S., and Wortel, R., 1985. Regional stress field of the Indian Plate. Geophys. Res. Lett., 12:77-80.

Cooper, A. K., Marlow, M. S., and Scholl, D. S., 1976. Mesozoic magnetic lineations in the Bering Sea marginal basin. J. Geophys. Res., 81:1916-1934.

Durbaum, H. J., and Hinz, K., 1983. SEATAR-related geophysical studies of BGR in the Southwest Pacific. Transactions 3rd Circum-Pacific Energy and Mineral Resources Conference, Honolulu, Hawaii. August 1982, 129-133.

Exon, N. F., Haake, F.-W., Hartmann, M., Koegler, F.-C., Mueller, P. J., and Whiticar, M. J., 1981. Morphology, water characteristics and sedimentation in the silled Sulu Sea, Southeast Asia. Mar. Geol., 39:165-195.

Hamilton, W., 1979. Tectonics of the Indonesian region. U. S. Geol. Surv. Prof. Pap., 1078:345.

Hashimoto, W., 1981. Geologic development of the Philippines. Geol. Palaeontol. Southeast Asia, 22:83-170.

Hashimoto, W., and Sato, T., 1973. Geological structure of North Palawan and its bearing on the geological history of the Philippines. Geol. Paleontol. Southeast Asia, 13:145-161.

Hinz, K., and Schluter, H. U., 1985. Geology of the Dangerous Grounds, South China Sea, and the continental margin off Southwest Palawan: Results of SONNE cruises S023 and S027. Energy, 10:297-315.

Hinz, K., Kempter, E.H.K., and Schluter, H. U., 1986. The southern Palawan-Balabac area: An accreted or non-accreted terrane? Proceedings of 3rd Asian Council on Petroleum (ASCOPE) Conference & Exhibition, December 1985, Kuala Lumpur, Malasia, 2:48-72.

Hinz, K., Block, M., and Kempter, E.H.K., 1988. Scientific drilling in the Celebes Sea and Sulu Sea on ODP Leg 124. BGR unpub. rept. 103.463.

Holloway, N. H., 1981. The North Palawan block, Philippines: Its relation to the Asian mainland and its role in the evolution of the South China Sea. Geol. Soc. Malaysia Bull., 14:19-58.

Hutchison, C. S., 1968. Tectonic hypothesis applied to the pre-Tertiary of Sabah and the Philippines. Geol. Soc. Malaysia Bull., 1:65-79.

Hutchison, C. S., 1975. Ophiolites in Southeast Asia. Geol. Soc. Am. Bull., 86:797-806.

Karig, D. E., 1971. Origin and development of marginal basins in the western Pacific. J. Geophys. Res., 76:2561.

Kudrass, H. R., Wiedicke, M., Cepek, P., Kreuzer, H., and Muller, P., 1985. Mesozoic and Cainozoic rocks dredged from the South China Sea (Reed

Bank area) and Sulu Sea and their significance for plate tectonic reconstructions. Mar. Petrol. Geol., 3(1):19-30.

Kudrass, H. R., Beiersdorf, H., Berner, U., Block, M., Scholten, J., Steinmann, D., Sulzbacher, H., and Weiss, W., 1988. Abschlussericht uber die SONNE=Fahrt SO-49. Teil 3: Geological, geochemical and geothermal studies in the Sulu Sea, Philippines. BGR unpub. rept. 102.042, Hannover.

Lee, C., and McCabe, R., 1986. The Banda-Celebes-Sulu basin: A trapped piece of Cretaceous-Eocene oceanic crust? Nature, 322:51-54.

Ludwig, W. J., Kumar, N., and Houtz, R. E., 1979. Profiler - sono-buoy measurements in the South China Sea Basin. J. Geophys. Res., 84:3505-3518.

Mammerickx, J., Fisher, R. L., Emmel, F. J., and Smith, S. M., 1976. Bathymetry of the east and southeast Asian seas. Boulder (Geol. Soc. Am.), MC-17.

Mascle, A., and Biscarrat, P. A., 1978. Sulu Sea: A marginal basin in Southeast Asia. In Watkins, J. S., Montandert, L., and Dickerson, P. W. (Eds.), Geological and geophysical investigations of continental margins. Am. Assoc. Petrol. Geol. Mem., 29:373-381.

McCabe, R., Almasco, J., Diegor, W., 1982. Geologic and paleomagnetic evidence for a possible Miocene collision in western Panay, central Philippines. Geology, 10:325-329.

McCaffrey, R., in press. Active tectonics of the eastern Sunda and Banda arcs. J. Geophys. Res., 93.

Mitchell, A.H.G., Hernandez, F., and Dela Cruz, A. P., 1986. Cenozoic evolution of the Philippine Archipelago. J. Southeast Asian Earth Sci., 1:3-22.

Murauchi, S., Ludwig, W. J., Den, N., Notta, H., Asanuma, T., Yoshii, T., Kubotera, A., and Hagiwara, K., 1973. Structure of the Sulu Sea and the Celebes Sea. J. Geophys. Res., 78(17):3437-3447.

Porth, H., 1984. On the stratigraphy and hydrocarbon prospects of Palawan. BGR/BED unpub. rept.

Reyes, C. A., 1971. Geological investigations of Palawan Island. Oriental Petroleum Corp., unpub. rept.

Silver, E. A., Gill, J. B., Schwartz, D., Prasetyo, H., and Duncan, R. A., 1985. Evidence for a submerged and displaced continental borderland, north Banda Sea, Indonesia. Geology, 13:687-691.

Taylor, B., and Hayes, D. E., 1980. The tectonic evolution of the South China Sea Basin. In Hayes, D. E. (Ed.), The tectonic and geologic evolution of Southeast Asian Seas and Islands. Am. Geophys. Union Monogr., 23:89-104.

Taylor, B., and Hayes, D. E., 1983. Origin and history of the South China Sea Basin. In Hayes, D. E. (Ed.), The tectonic and geologic evolution of Southeast Asian Seas and Islands, Part 2. Am. Geophys. Union Monogr., 27:23-56.

Taylor, B., and Karner, G. D., 1983. On the evolution of marginal basins. Rev. Geophys. Space Phys., 21:1727-1741.

Uyeda, S., and Ben-Avraham, Z., 1972. Origin and development of the Philippine Sea. Nature Phys. Sci., 240:176-178.

Weissel, J. K., 1980. Evidence for Eocene oceanic crust in the Celebes Basin. In Hayes, D. E. (Ed.), The tectonic and geologic evolution of Southeast Asian Seas and Islands. Am. Geophys. Union Monogr., 23:37-47.

TABLE 1a

SE ASIA BASINS

Option if clearance from Indonesia for BANDA-2 is not received

Number	Latitude	Longitude	Water Depth (m)	Total Penetration (mbsf)	Priority	Drilling	Logging & BHTV	Total	Cumulative	Comments
						Days				
Singapore to CS-1 (through Balabac Strait) = 5.5 days[a]									5.5	
CS-1	04°44'N	123°28'E	4885	1050[b]	1	16.4	3.5	19.9	25.4	
Transit CS-1 to SS-3 = 1 day[a]									26.4	
SS-3	08°25'N	121°11'E	4270	1350[b]	1	20.4	3.5	23.9	50.3	
SS-1	08°49'N	121°27'E	4615	1300[b]	2	22.1	3.5	25.6	-	Alternate site to SS-3
SS-2	08°00'N	121°14'E	4320	1200[b]	2	18.1	3.5	21.6	-	Alternate site to SS-3
SS-4	08°04'N	121°53'E	3885	1200[b]	2	10-18[c]	2-3[c]	12-21[c]	57.5[d]	
SS-5[e]	08°48'N	121°20'E	3375	400	2	3.4	1.0	4.4		
Sulu Sea to Manila = 1.5 days[a]									59	

a. Transit assumes average speed of 10 kt.
b. Includes 50 m of basalt.
c. Drilling and drilling strategy at SS-4 depend on time available.
d. Option of drilling depends on time available.
e. Originally called Sulu-4.

TABLE 1b

SE ASIA BASINS

Option subject to clearance from Indonesia

Number	Latitude	Longitude	Water Depth (m)	Total Penetration (mbsf)	Priority	Drilling	Logging & BHTV	Total	Cumulative	Comments
						Days				
Singapore to BANDA-2 = 5 days[a]									5	
BANDA-2	$04^{\circ}50'$S	$125^{\circ}03'$E	4900	1050[b]	1	17.9	2.0	19.9	24.9	
Transit BANDA-2 to SS-3 = 3 days[a]									27.9	
SS-3	$08^{\circ}25'$N	$121^{\circ}11'$E	4270	1350[b]	1	20.4	3.5	23.9	51.8	
SS-1	$08^{\circ}49'$N	$121^{\circ}27'$E	4615	1300[b]	2	22.1	3.5	25.6	-	Alternate site to SS-3
SS-2	$08^{\circ}00'$N	$121^{\circ}14'$E	4320	1200[b]	2	18.1	3.5	21.6	-	Alternate site to SS-3
SS-4	$08^{\circ}04'$N	$121^{\circ}53'$E	3885	1200[b]	2	10-18[c]	2-3[c]	12-21[c]		
SS-5[e]	$08^{\circ}48'$N	$121^{\circ}20'$E	3375	≤400	2	3.4	1.0	4.4	57.5[d]	
CS-1	$04^{\circ}44'$N	$123^{\circ}28'$E	4885	1050[b]	2	16.4	3.5	19.9		
Sulu Sea to Manila = 1.5 days[a]									59	

a. Transit assumes average speed of 10 kt.
b. Includes 50 m of basalt.
c. Drilling strategy in SS-4 depend on time available.
d. Option of drilling depends on time available.
e. Originally called Sulu-4.

TABLE 2a

LEG 124, SE ASIA BASINS
PROPOSED SITE OCCUPATION SCHEDULE

	Date	Time on Station (Days)	Transit Time* (Days)
Leg 124 departs Singapore on 6 November 1988			
Transit Singapore to CS-1			5.5
AR CS-1	11 Nov	19.9 (includes 3.5 days for logging & BHTV)	
LV CS-1	1 Dec		
Transit CS-1 to SS-3			1.0
AR SS-3	2 Dec	23.9 (includes 3.5 days for logging & BHTV)	
LV SS-3	26 Dec		
SS-4/SS-5		7.0 (option of drilling and drilling strategy depends on time available)	
LV Sulu Sea	2 Jan 1989		
Transit to Manila			1.5
AR Manila	4 Jan		

*Transit time assumes average speed of 10 kt.

TABLE 2b

LEG 124, SE ASIA BASINS
PROPOSED SITE OCCUPATION SCHEDULE

	Date	Time on Station (Days)	Transit Time* (Days)
Leg 124 departs Singapore on 6 November 1988			
Transit from Singapore to BANDA-2			5
AR BANDA-2	11 Nov	19.9 (includes 2 days for logging & BHTV)	
LV BANDA-2	1 Dec		
Transit BANDA-2 to SS-3			3
AR SS-3	4 Dec	23.9 (includes 3.5 days for logging & BHTV)	
LV SS-3	28 Dec		
SS-4/SS-5		5.0 (option of drilling and drilling strategy depend on time available)	
LV Sulu Sea	2 Jan 1989		
Transit to Manila			1.5
AR Manila	4 Jan		

*Transit time assumes average speed of 10 kt.

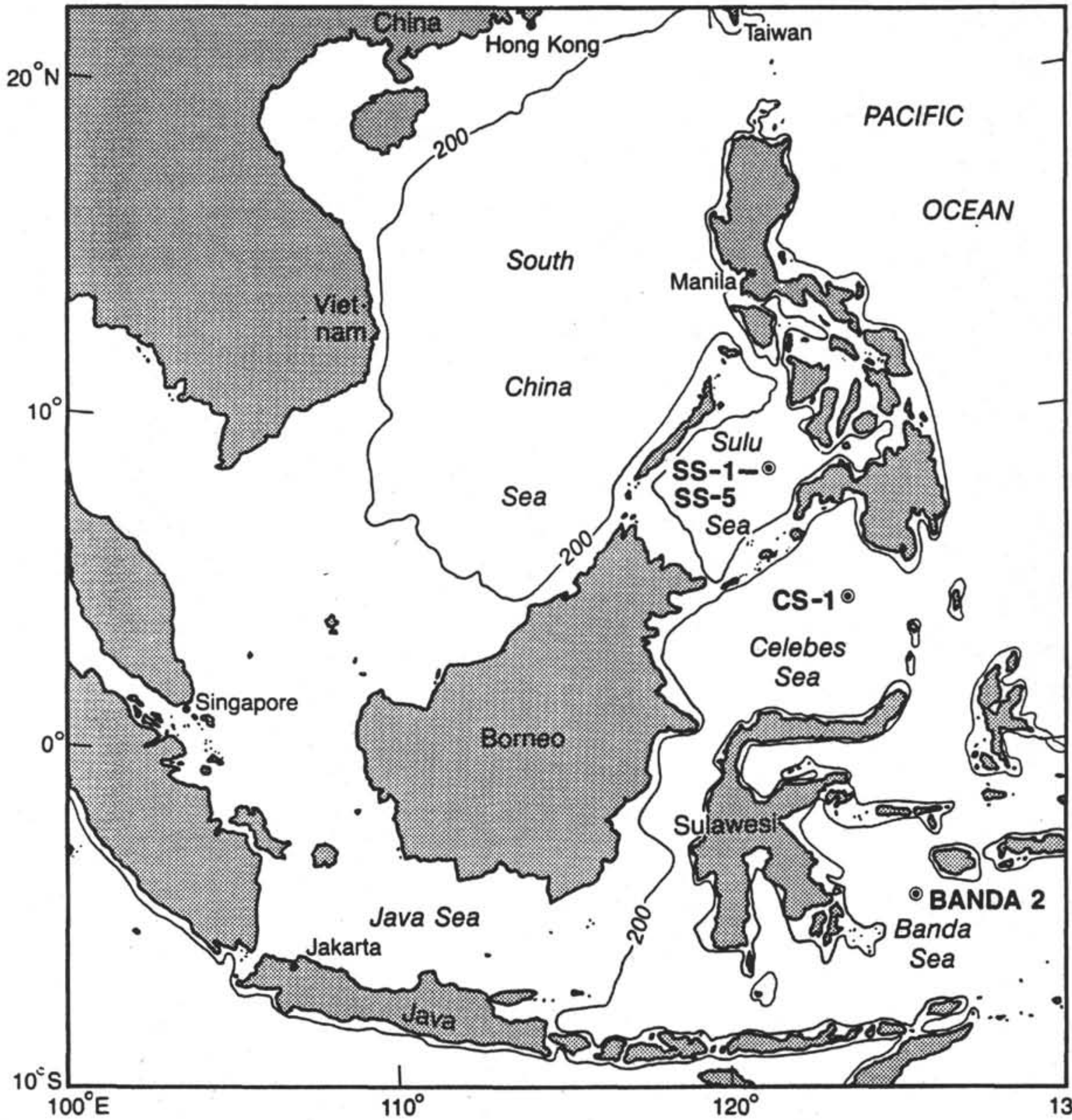

Figure 1. Location map of the Southeast Asia marginal basins showing the sites proposed for drilling on ODP Leg 124.

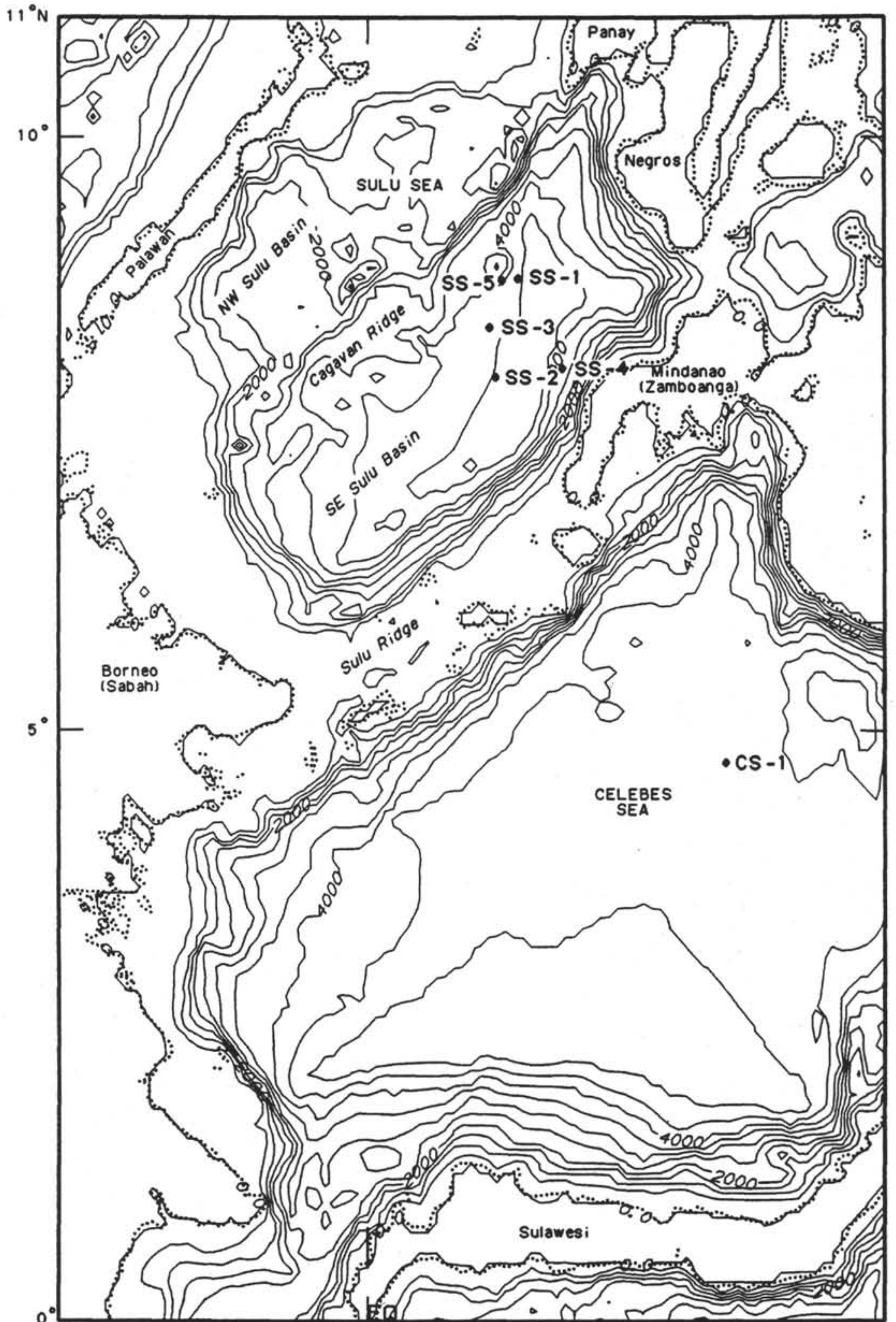

Figure 2. Bathymetric map of the Celebes Sea and the Sulu Sea, showing the location of the proposed drill sites. Contour interval of 500 m.

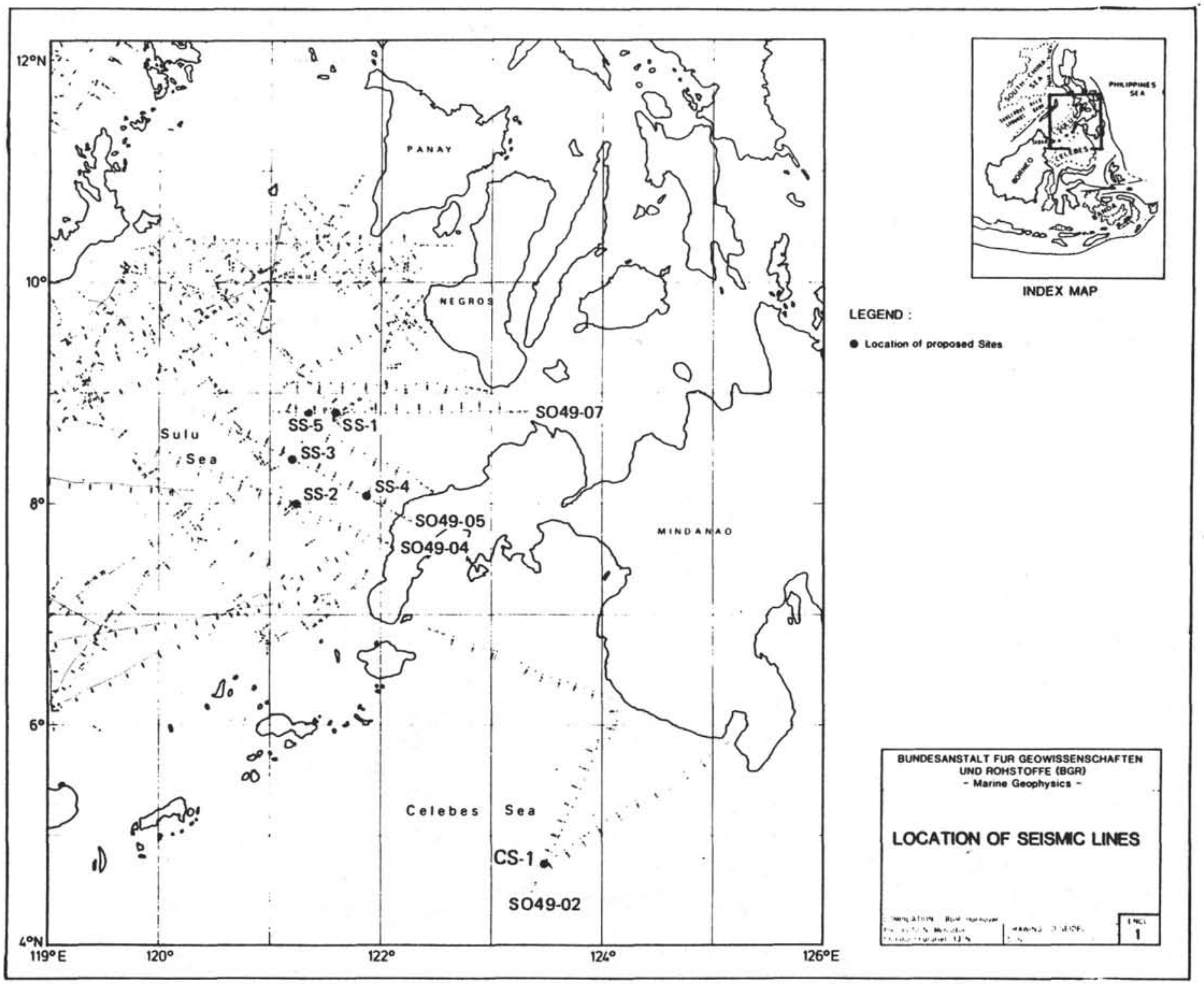

Figure 3. Location of seismic reflection lines in the Celebes Sea and in the Sulu Sea showing the location of the proposed drill sites.

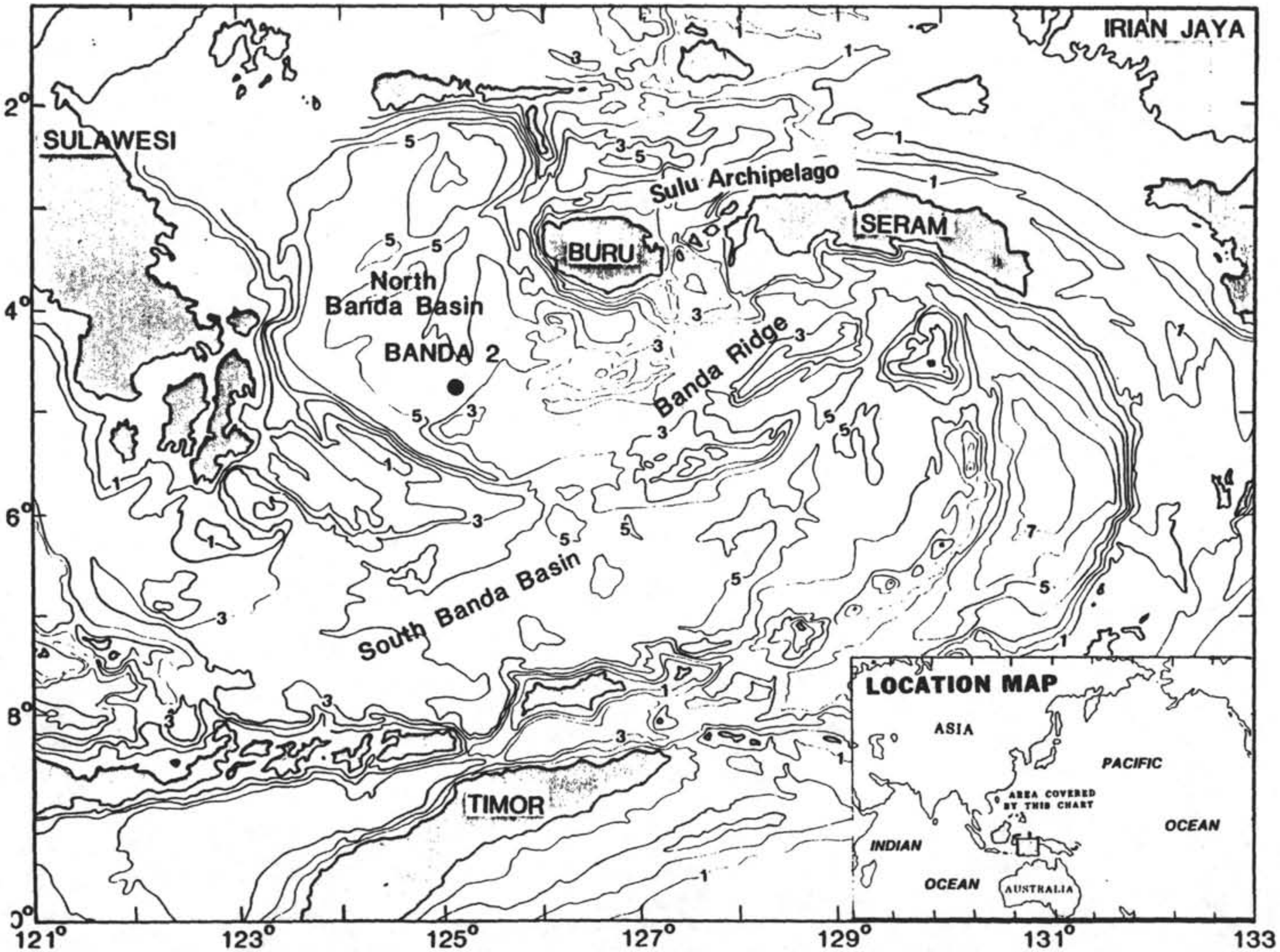

Figure 4. Bathymetric map of the Banda Sea, showing the location of BANDA-2. Contour intervals of 1 km.

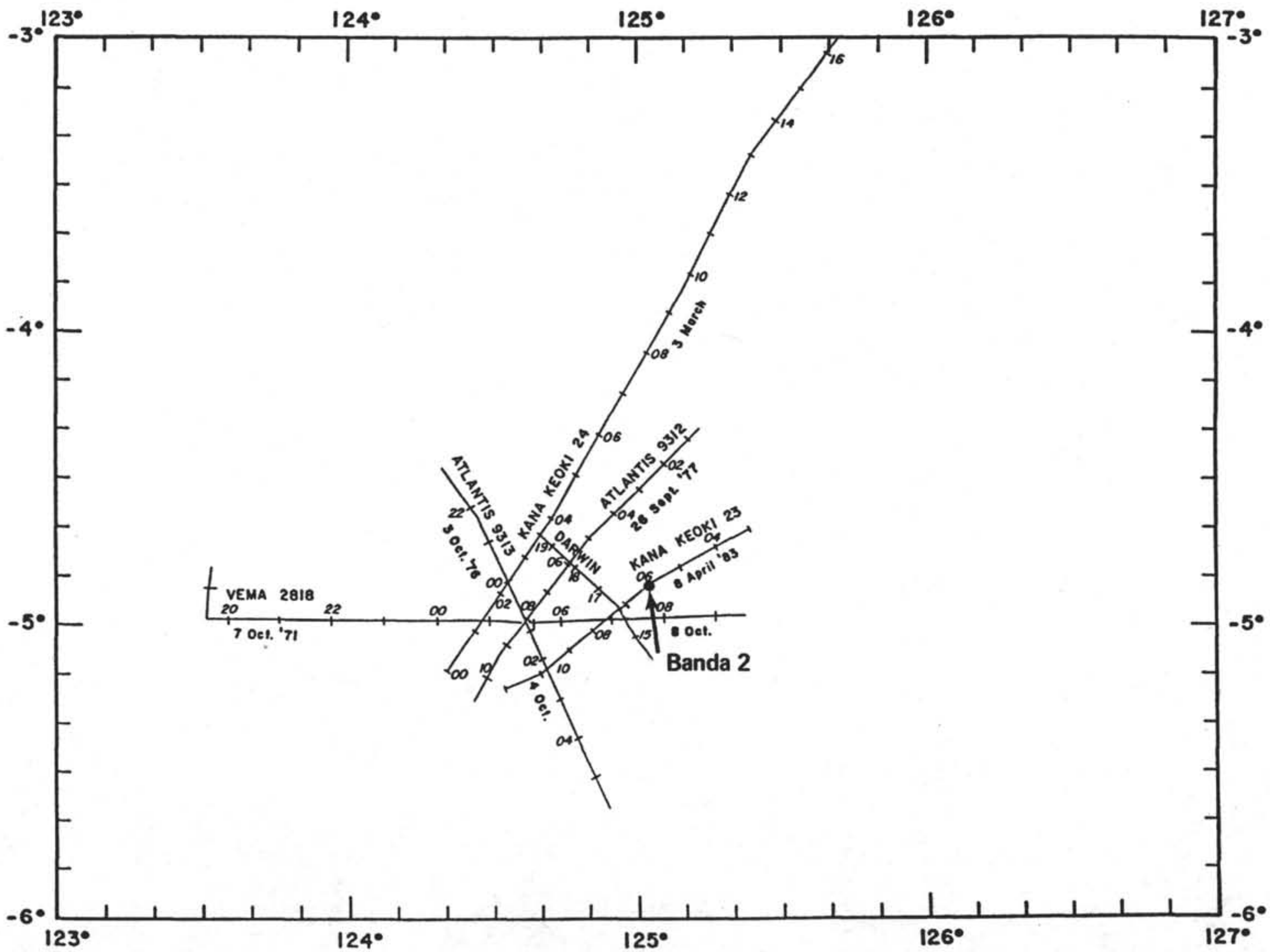

Figure 5. Location of seismic reflection lines in north Banda basin, showing the location of BANDA-2.

SITE: SS-1 (Sulu Sea) PRIORITY: 2 (alternate site to SS-3)

POSITION: 08°49.5'N, 121°27.1'E

WATER DEPTH: 4615 m SEDIMENT THICKNESS: 1250 m

PROPOSED DRILLING PROGRAM: APC/XCB and RCB (re-entry) core through entire sedimentary section and 50 m into basement (total penetration - 1300 m).

SEISMIC RECORD: BGR SONNE Cruise SO49. Site located on MCS Line SO49-07 shotpoint 1000 (or shotpoints 1179, 1309).

HEAT FLOW: Yes

LOGGING: Standard Schlumberger logging and borehole televiewer.

OBJECTIVES: (1) Nature and age of oceanic basement;
(2) Nature and age of regional seismic horizons;
(3) Paleoenvironment and sedimentation in a restricted ocean basin.

NATURE OF SEDIMENT/ROCKS ANTICIPATED: Turbidites and pelagic sediments with volcanic ashes, overlying basaltic basement. A stratigraphic interpretation of the sedimentary sequence observed at shotpoint 1179 is shown in Figure 6 and Table 3a.

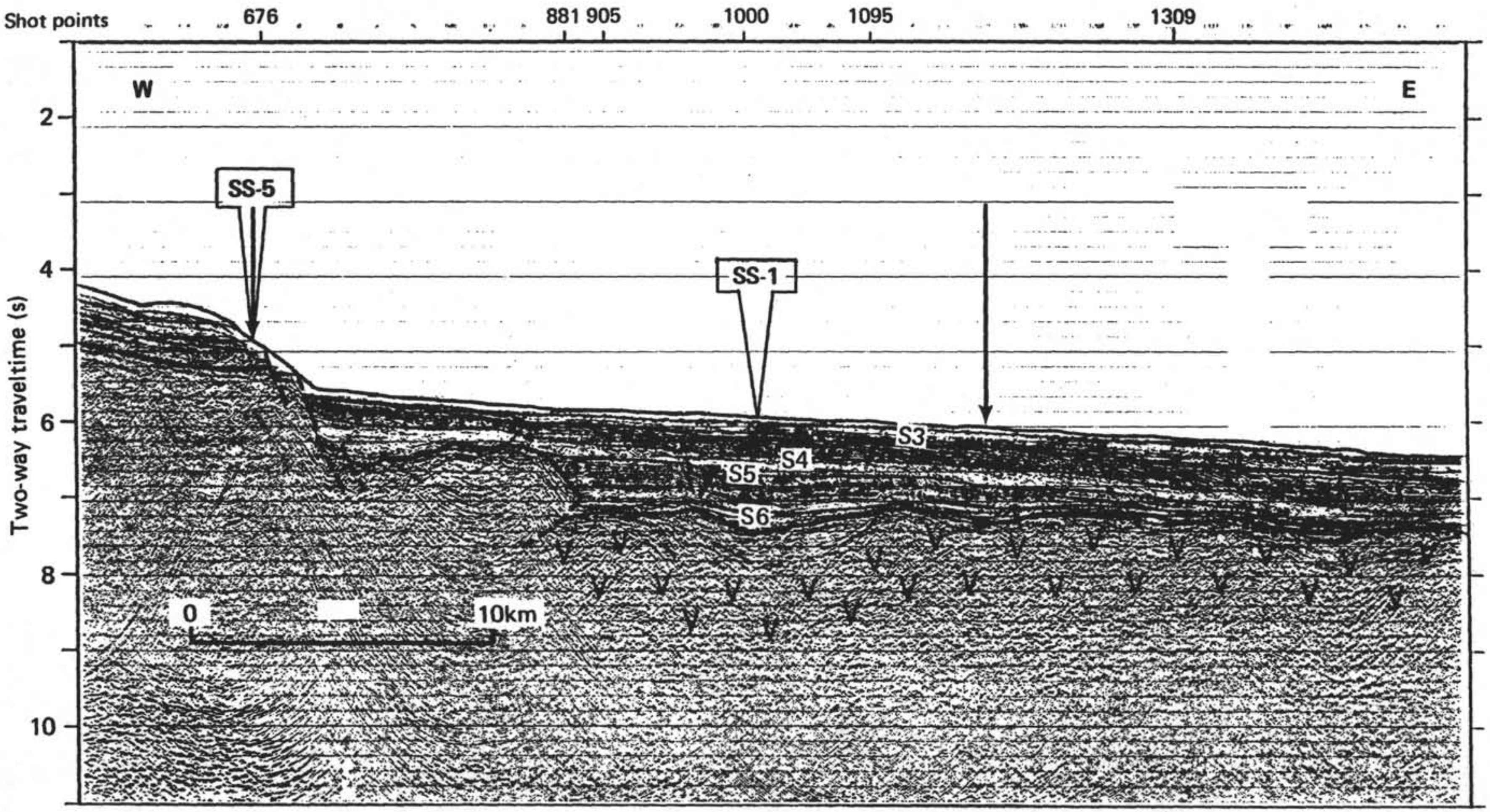

Figure 6. Geoseismic section of line S049-07 (shotpoints 550 to 1485) showing the location of SS-1 and SS-5. The arrow indicates the location for the stratigraphic interpretation of the seismic horizons S3 to S6 as shown in Table 3a. The trackline location is shown in Figure 3.

TABLE 3a

GRAPHIC SUMMARY, SITE SS-1[a]

Sub-bottom depth (m)	Key reflectors unconformities faults, etc.	(Ma)	Age	Assumed velocity (km/sec)	Lithology	Paleo-environment	Average rate of sediment accumulation (m/m.y.)	Comments
				1.5				
0	Seabed	0						
			PLIOCENE-PLEISTOCENE	2.0	Fine clastics	Pelagic	100	?Slight onlap towards the west
100	S 1	1						
			PLIOCENE	2.0	Turbidites	Pelagic	80	Onlap towards the west
260	S 3	3						
			L. MIOCENE	2.015	Clastics	Pelagic	30	Prograding clastics
545	S 4	12						
			M. MIOCENE	2.025	Turbidites	Pelagic	45	No coherent seismic pattern
765	S 5	17						
			E. MIOCENE	2.215	Turbidites	Pelagic	30	Well bedded, pinchout towards the east
920	S 6	24						
			PALEOGENE	2.215	Turbidites	Pelagic	9	Oldest sequence, pinching out towards the east
1065	BM	41						
			BASEMENT		OCEANIC BASALT			

a. Observed at SP 1179 on line S049-07 (Figure 6).

SITE: SS-2 (Sulu Sea) PRIORITY: 2 (Alternate site to SS-3)

POSITION: 07°59.6'N, 121°14.1'E

WATER DEPTH: 4320 m SEDIMENT THICKNESS: 1150 m

PROPOSED DRILLING PROGRAM: APC/XCB and RCB (re-entry) core through entire sedimentary section and 50 m into basement (total penetration = 1200 m).

SEISMIC RECORD: BGR SONNE Cruise S049. Site located on MCS Line S049-04 at shotpoint 1782 (or shotpoint 1691).

HEAT FLOW: Yes

LOGGING: Standard Schlumberger logging and televiewer.

OBJECTIVES: (1) Nature and age of oceanic basement;
(2) Nature and age of regional seismic horizons;
(3) Paleoenvironment and sedimentation in a restricted ocean basin.

NATURE OF SEDIMENT/ROCKS ANTICIPATED: Turbidites and pelagic sediments with volcanic ashes, overlying basaltic basement. A stratigraphic interpretation of the sedimentary sequence at SP 1691 is shown in Table 3b.

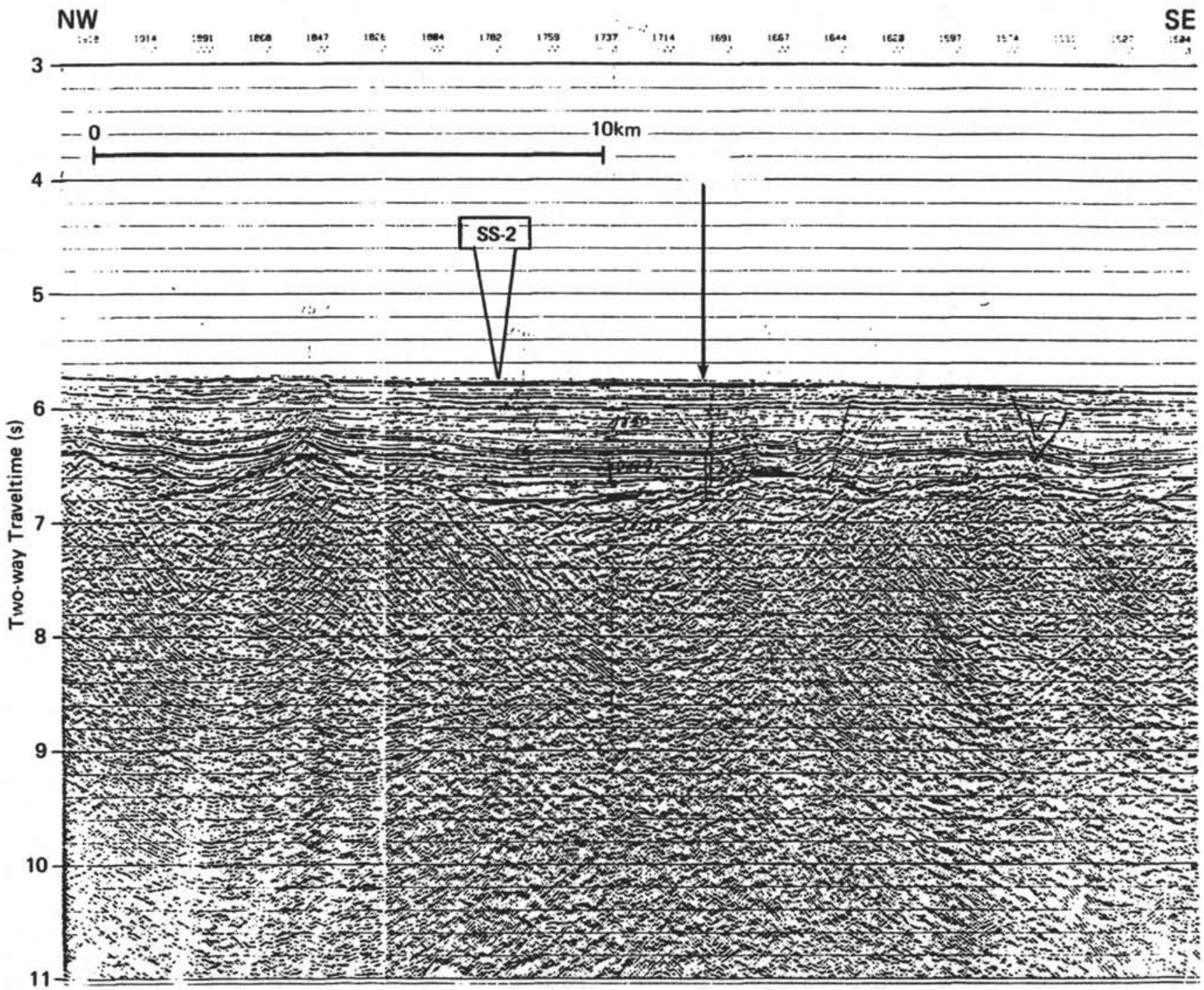

Figure 7. Seismic section of line S049-04, showing the location of SS-2. Arrow indicates the location for the stratigraphic interpretation (Table 3b). The trackline location is shown in Figure 3.

TABLE 3b

GRAPHIC SUMMARY, SITE SS-2[a]

Sub-bottom depth (m)	Key reflectors unconformities faults, etc.	(Ma)	Age	Assumed velocity (km/sec)	Lithology	Paleo-environment	Average rate of sediment accumulation (m/m.y.)	Comments
				1.5				
0	Seabed	0						
			PLIOCENE-PLEISTOCENE	1.85	Turbidites	Pelagic	>60	Slightly thickening towards the trench in the east
185	S 3	3						
			LATE MIOCENE	1.85	Turbidites	Pelagic	?16	
333	S 4	?12						
			M. MIOCENE	1.95	Turbidites	Pelagic	50	Sub-parallel bedding
59	S 5	17						
			E. MIOCENE	2.095	Turbidites	Pelagic	35	Well bedded
837	S 6	24						
			PALEOGENE	2.095	Turbidites	Pelagic	6	Oldest sequence pinching out towards the east
942	BM	41						
			BASEMENT		OCEANIC BASALT			

a. Observed at SP 1691 on line SO49-04 (Figure 7).

SITE: SS-3 (Sulu Sea) PRIORITY: 1

POSITION: 08°24.7'N, 121°10.6'E

WATER DEPTH: 4270 m SEDIMENT THICKNESS: 1300 m

PROPOSED DRILLING PROGRAM: APC/XCB and RCB (re-entry) core through entire sedimentary section and 50 m into basement (total penetration = 1350 m).

SEISMIC RECORD: BGR SONNE Cruise S049. Site located on MCS Line S049-05 shotpoint 2180 (or shotpoint 2250).

HEAT FLOW: Yes

LOGGING: Standard Schlumberger logging and borehole televiewer. Possibly also Schlumberger vertical seismic profile (VSP).

OBJECTIVES:
(1) Nature and age of oceanic basement;
(2) Nature and age of regional seismic horizons;
(3) Paleoenvironment and sedimentation in a restricted ocean basin.

NATURE OF SEDIMENT/ROCKS ANTICIPATED: Turbidites and pelagic sediments with volcanic ashes, overlying basaltic basement. A stratigraphic interpretation of the sedimentary sequence observed at shotpoint 2250 is shown in Figure 8 and Table 3c.

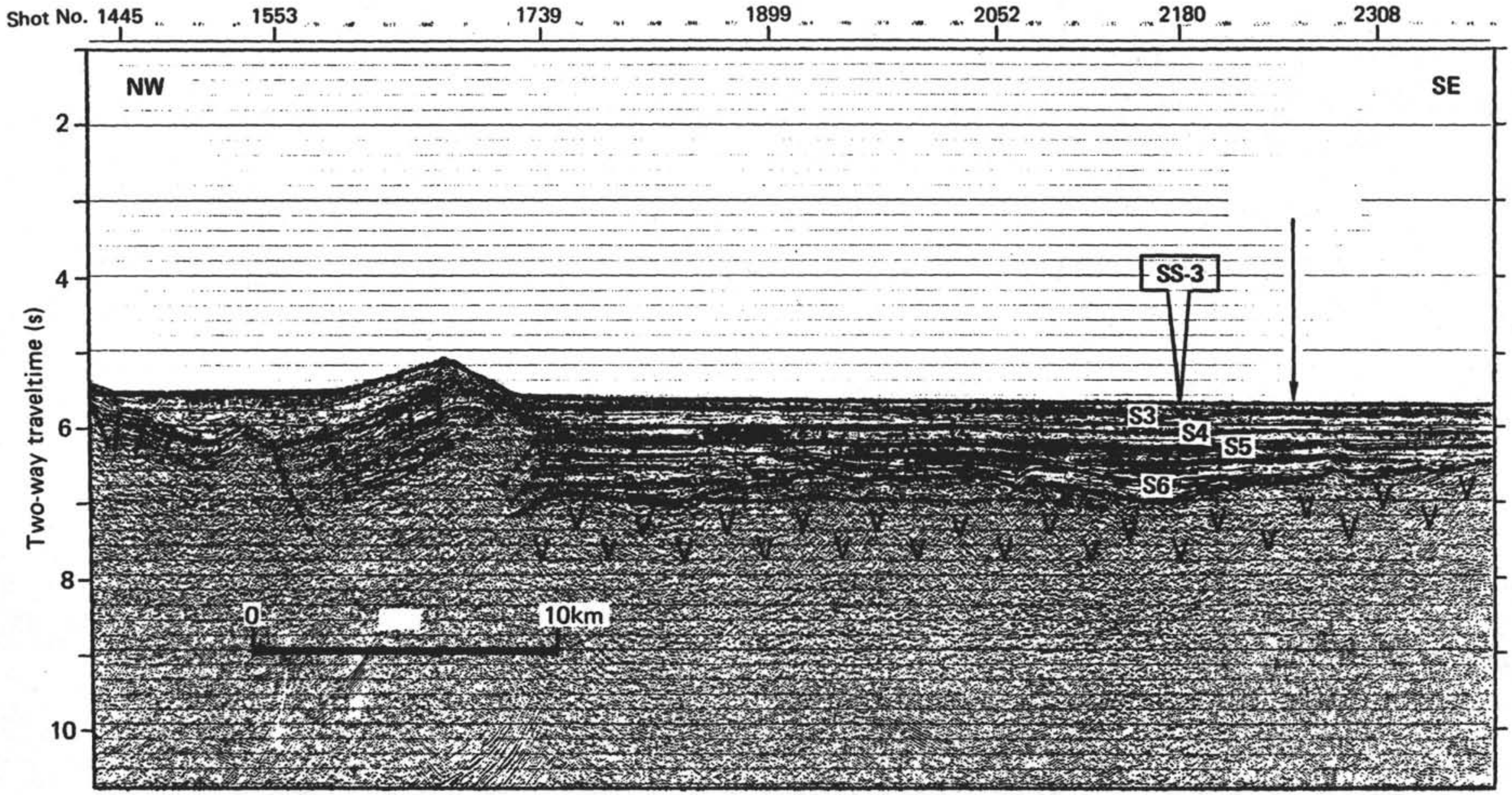

Figure 8. Geoseismic section of line SO49-05 (shotpoints 1425 to 2382), showing the location of SS-3. The arrow indicates the location for the stratigraphic interpretation of the seismic horizons S3 to S6 as shown in Table 3c. The trackline location is shown in Figure 3.

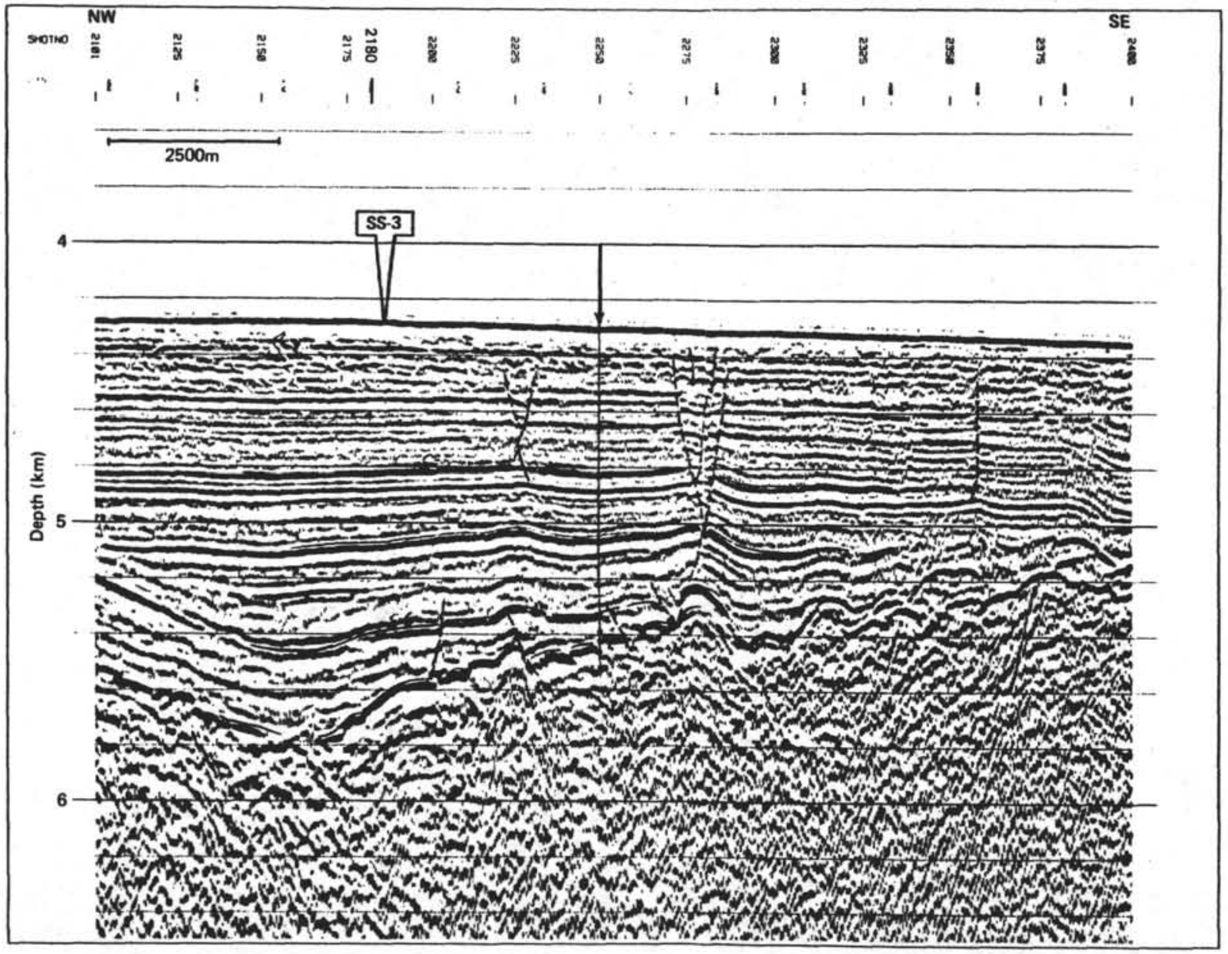

Figure 9. Depth converted portion of line S049-05, from the area of SS-3. Arrow indicates the location for the stratigraphic interpretation (Table 3c).

TABLE 3c

GRAPHIC SUMMARY, SITE SS-3[a]

Sub-bottom depth (m)	Key reflectors unconformities faults, etc.	(Ma)	Age	Assumed velocity (km/sec)	Lithology	Paleo-environment	Average rate of sediment accumulation (m/m.y.)	Comments
				1.5				
0	Seabed	0						
			PLIOCENE-PLEISTOCENE	1.9	Turbidites	Pelagic	45	
134	S 3	3						
			L. MIOCENE	1.9	Turbidites	Pelagic	25	
344	S 4	12						
			M. MIOCENE	1.9	Turbidites	Pelagic	40	Well-bedded sequence
535	S 5	17						
			E. MIOCENE	2.6	Turbidites	Pelagic	75	Sequence pinches out toward the east. Distinct unconformity
1054	S 6	24						
			PALEOGENE	2.75	Turbidites	Pelagic	7	Oldest sequence, pinching out towards the east
1177	BM	41						
			BASEMENT		OCEANIC BASALT			

a. Observed at SP 2250 on line SO49-05 (Figure 8).

SITE: SS-4 (Sulu Sea) PRIORITY: 2

POSITION: $08^{o}04'N$, $121^{o}52.8'E$

WATER DEPTH: 3885 m SEDIMENT THICKNESS: 1150 m

PROPOSED DRILLING PROGRAM: Option a: APC/XCB and RCB (re-entry) core through entire sedimentary section and 50 m into basement (total penetration = 1200 m).
Option b: Single-bit spot coring, and 50 m into basement.

SEISMIC RECORD: BGR SONNE Cruise S049. Site located on MCS Line S049-05 shotpoint 4000.

HEAT FLOW: Yes

LOGGING: Option a: Standard Schlumberger logging.
Option b: 2 strings Schlumberger suite.

OBJECTIVES: Nature and age of a crustal slab.

NATURE OF SEDIMENTS/ROCKS ANTICIPATED: Turbidites and pelagic sediments with volcanic ashes, overlying basaltic basement. A stratigraphic interpretation of the sedimentary sequence observed at shotpoint 4000 is shown in Table 3d.

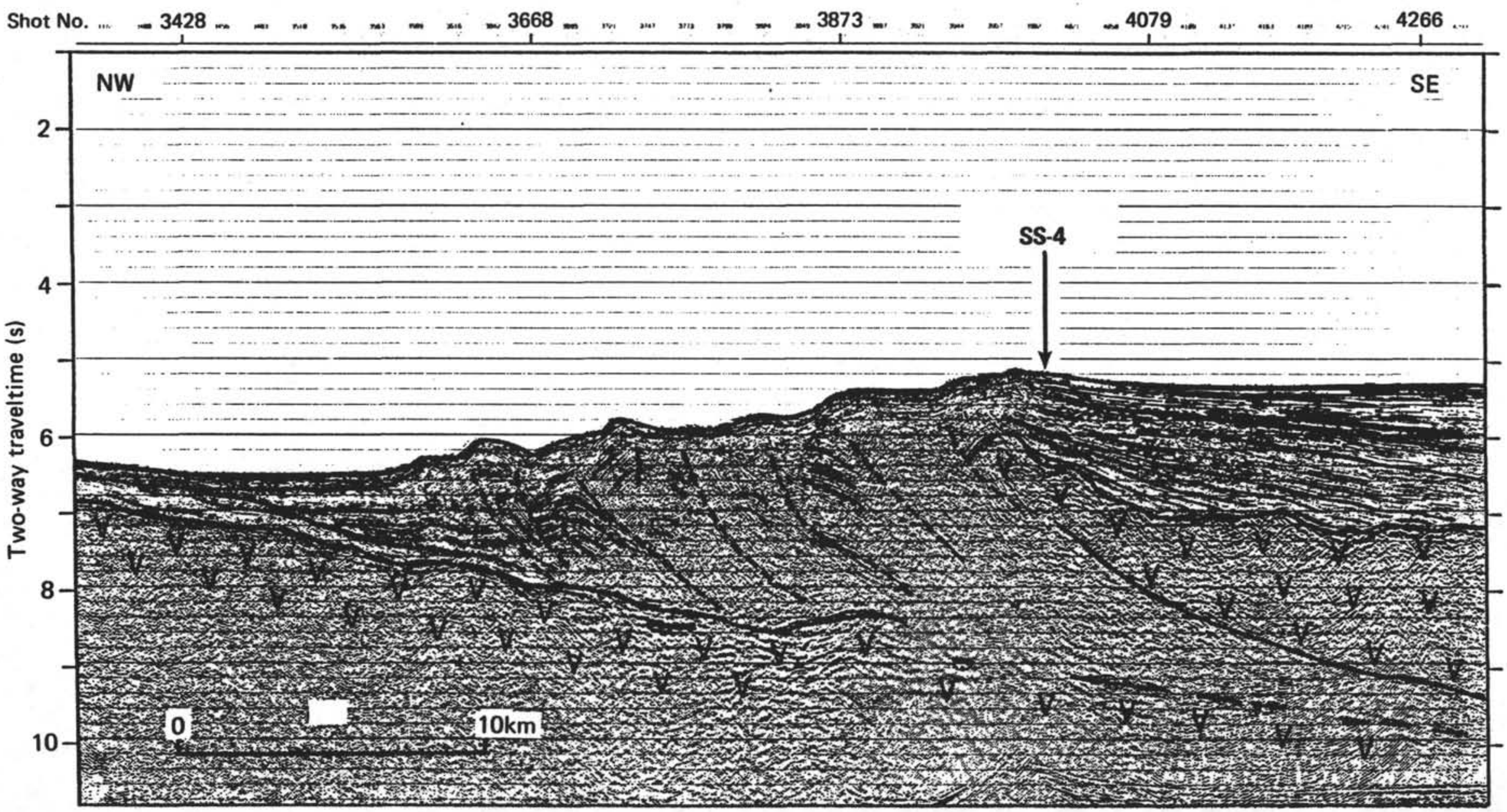

Figure 10. Geoseismic section of line SO49-05 (shotpoints 3721-4660), showing the location of SS-4. The location of the trackline is shown in Figure 3.

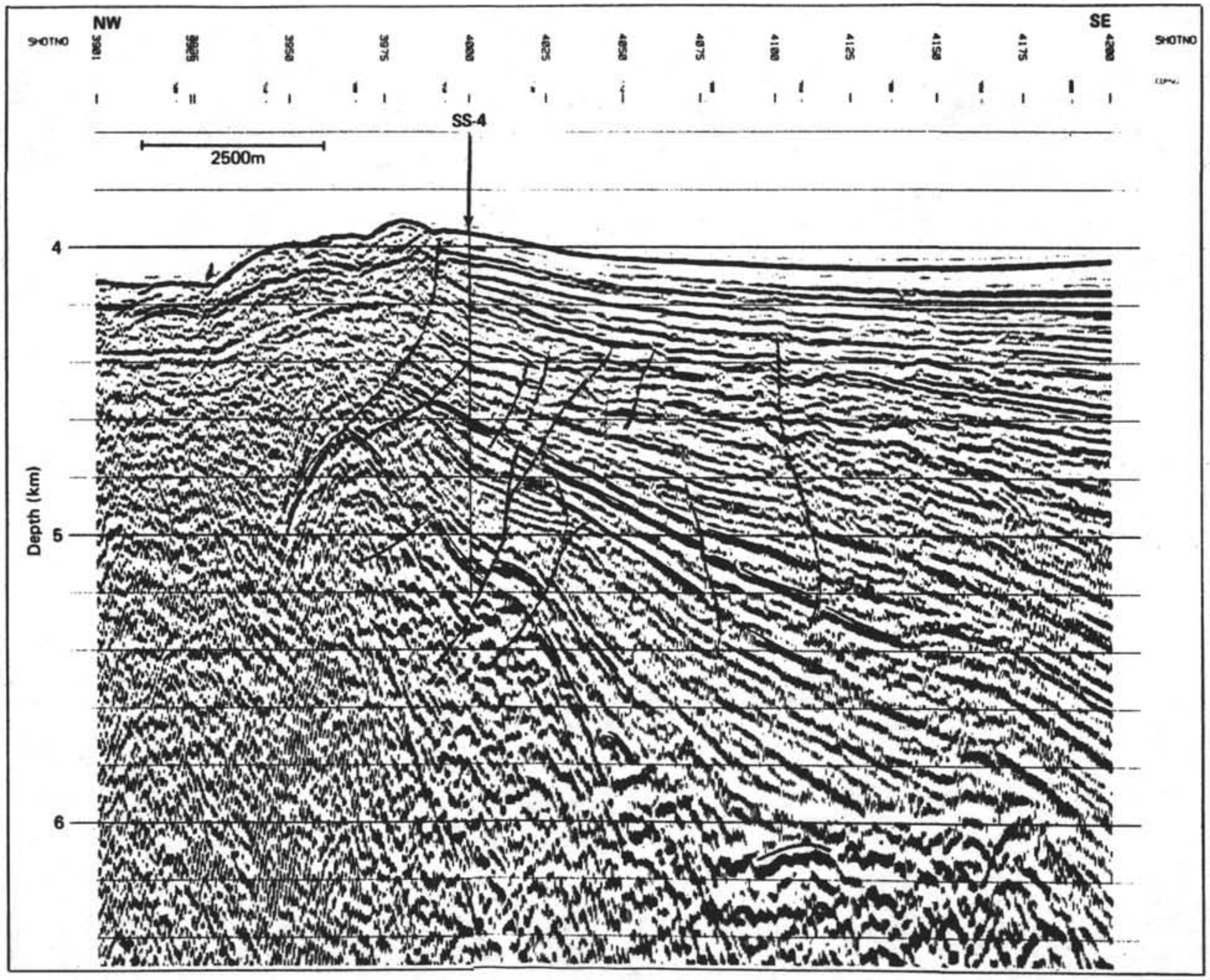

Figure 11. Depth converted portion of line S049-05, showing the location of SS-4.

Table 3d

GRAPHIC SUMMARY, SITE SS-4[a]

Sub-bottom depth (m)	Key reflectors unconformities faults, etc.	m.y.	Age	Assumed velocity (km/sec)	Lithology	Paleo-environment	Average rate of sediment accumulation (m/m.y.)	Comments
				1.5				
0	Seabed	0						
			PLIOCENE-PLEISTOCENE	1.75	Turbidites	Pelagic	80	Sequence thickens towards the east
245	S 3	3						
			MIDDLE-UPPER MIOCENE	1.8	Turbidites	Pelagic	30	
680	S 5	17						
			PALEOGENE-EARLY MIOCENE	2.05	Turbidites	Pelagic	20	Oldest sedimentary sequence overlying inferred oceanic crustal slab
1150	BM	41						
			BASEMENT		(?)Oceanic crust, uplifted oceanic slab			

a. Observed at SP 4000 on line SO49-05 (Figure 11).

SITE: SS-5 (originally called Sulu-4) PRIORITY: 2

POSITION: 8°48.3'N, 121°20'E

WATER DEPTH: 3375 m SEDIMENT THICKNESS: 400 m

PROPOSED DRILLING PROGRAM: APC/XCB coring to 400 mbsf.

SEISMIC RECORD: BGR SONNE Cruise S049. Site located on MCS Line S049-07 shotpoint 624. The geoseismic section of Line S049-07 showing the location of sites SS-1 and SS-5 is shown in Figure 6.

HEAT FLOW: No

LOGGING: 2 strings Schlumberger suite.

OBJECTIVES: Neogene sediments and paleoenvironment in a restricted ocean basin.

NATURE OF SEDIMENTS ANTICIPATED: Pelagic/hemipelagic sediments or shallow marine carbonates.

SITE: CS-1 (Celebes Sea) PRIORITY: 1

POSITION: 4°43.8'N, 123°27.8'E

WATER DEPTH: 4885 m SEDIMENT THICKNESS: 1000 m

PROPOSED DRILLING PROGRAM: APC/RCB and RCB (re-entry) core through entire sedimentary section and 50 m into basement (total penetration =1050 m).

SEISMIC RECORD: BGR SONNE Cruise SO49. Site located on MCS Line SO49-02 between shotpoints 100-300 (calculated at shotpoint 200).

HEAT FLOW: Yes

LOGGING: Standard Schlumberger logging and borehole televiewer.

OBJECTIVES: (1) Nature and age of oceanic basement;
(2) Nature and age of regional seismic horizons;
(3) Paleoenvironment and sedimentation in a restricted ocean basin.

NATURE OF SEDIMENTS/ROCKS ANTICIPATED: Turbidites and pelagic sediments with volcanic ashes, overlying basaltic basement. A stratigraphic interpretation of the sedimentary sequence observed at shotpoint 100, is shown in Table 3e.

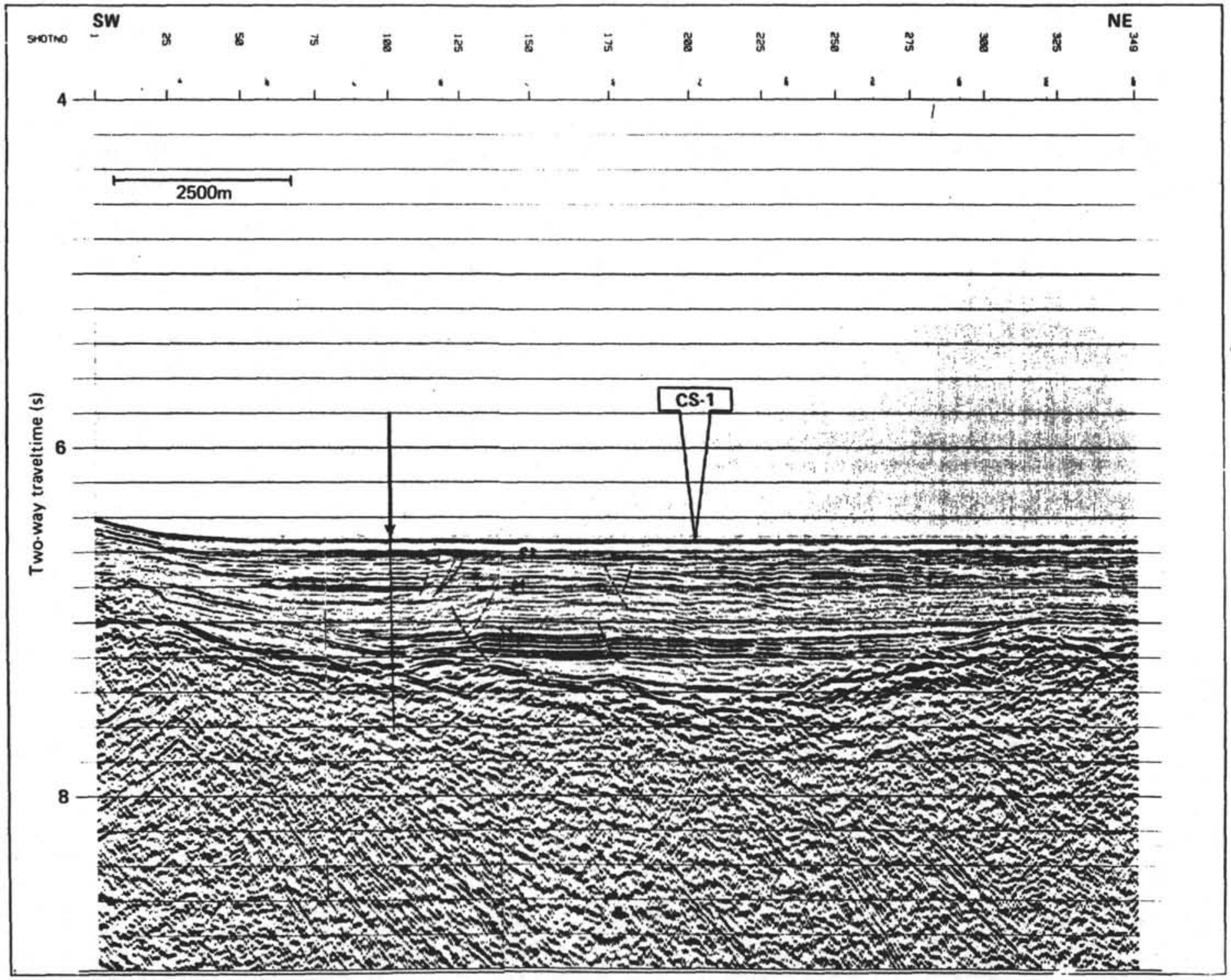

Figure 12. Portion of the seismic reflection line S049-02, showing the location of CS-1. Arrow indicates the location for the stratigraphic interpretation (Table 3e). The trackline location is shown in Figure 3.

TABLE 3e

GRAPHIC SUMMARY, SITE CS-1[a]

Sub-bottom depth (m)	Key reflectors unconformities faults, etc.	(Ma)	Age	Assumed velocity (km/sec)	Lithology	Paleo-environment	Average rate of sediment accumulation (m/m.y.)	Comments
				1.5				
0	Seabed	0						
			PLIOCENE to PLEISTOCENE	1.95	Mud	Pelagic	35	Acoustically transparent
100	S 3	3						
			LATE MIOCENE	1.95	Turbidites	Pelagic	17	Stratified
256	S 4	12						
			MIDDLE TO LATE MIOCENE	2.1	Turbidites	Pelagic	60	Low amplitude sub-parallel pattern
570	S 5	17						
			EARLY MIOCENE	2.35	Turbidites	Pelagic/ Restricted	17	High amplitude sub-parallel pattern
690	S 6	24						
			PALEOGENE	2.35	Turbidites with shales, volcanic ashes	Pelagic	6	Acoustically transparent sequence
795	BM	41						
			BASEMENT		OCEANIC CRUST			

a. Observed at SP 100 on line SO49-02 (Figure 12).

SITE: BANDA-2 PRIORITY: 1

POSITION: 4°50'S, 125°03'E

WATER DEPTH: 4900 m SEDIMENT THICKNESS: 1000 m

PROPOSED DRILLING PROGRAM: APC/XCB and RCB (re-entry) core through entire sedimentary section and 50 m into basement (total penetration = 1050 m).

SEISMIC RECORD: Kana Keoki line 23. Site located at 0600Z/8 April, 1983. Crossing line: Darwin 1988

HEAT FLOW: Yes

LOGGING: Standard Schlumberger logs and borehole televiewer (BHTV).

OBJECTIVES: Stratigraphic history and age of north Banda basin. Tectonic history of Banda Sea and regional collisions. BHTV will be used for regional stress analysis.

SEDIMENT TYPES: Pelagic sediment and possible volcanic ash layers overlying basement. A stratigraphic interpretation of the sedimentary sequence observed at 0500Z/ 8 April on KK line 23, is shown in Table 3f.

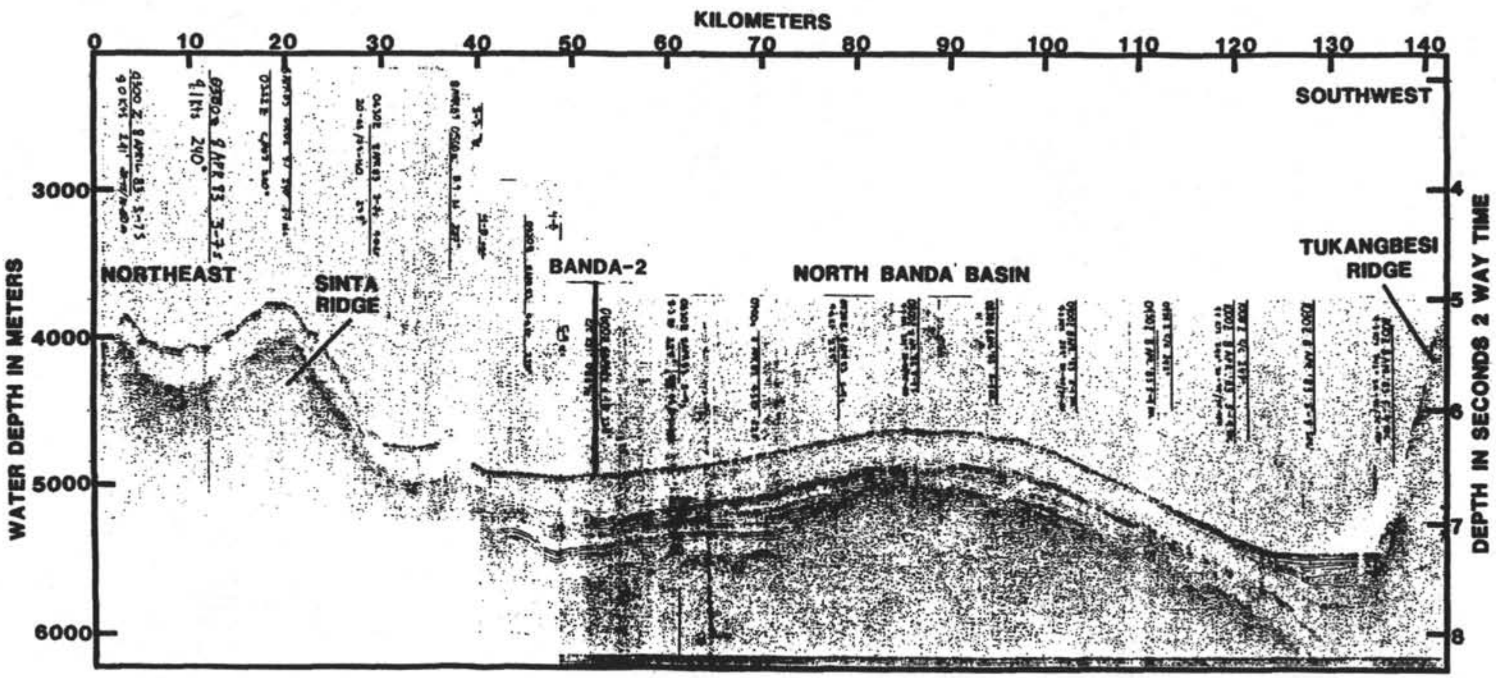

Figure 13. Portion of the seismic reflection line KK-23, showing the location of BANDA-2. The trackline location is shown in Figure 5.

TABLE 3f

GRAPHIC SUMMARY, SITE BANDA-2[a]

Sub-bottom depth (m)	Key reflectors unconformities faults, etc.	Age	Assumed velocity (km/sec)	Lithology	Paleo-environment	Comments
			1.5			
0	Seabed					
		QUATERNARY	2	Pelagic sediment Diatom rich	Marginal Basin	seismically transparent
350	Unconformity					
		MIOCENE	2.2	Hemipelagics	Transitional Basin	layered sequence
650	Unconformity					
		EARLY TERTIARY	2.3	Pelagics	Open Ocean	transparent
900	Basement					
		?CRETACEOUS		OCEANIC CRUST		

a. At 0500Z/8 April on KK line 23 (Figure 13).

SHIPBOARD PARTICIPANTS

OCEAN DRILLING PROGRAM LEG 124

Co-Chief Scientist: ELI SILVER
Department of Earth Sciences
University of California
Santa Cruz, CA 95064

Co-Chief Scientist: KARL HINZ
Bundesanstalt fur Geowissenschaften und Rohstoffe
Stilleweg 2
Postfach 510153
D-3000 Hannover St.
Federal Republic of Germany

Staff Scientist/Inorganic Geochemist: MARTA VON BREYMANN
Ocean Drilling Program
Texas A&M Research Park
1000 Discovery Drive
College Station, TX 77840

Sedimentologist: ZEHUI HUANG
Department of Geology
Dalhousie University
Halifax, Nova Scotia
B3H 3J5 Canada

Sedimentologist: BRADDOCK K. LINSLEY
Department of Geology
Northrop Hall
University of New Mexico
Albuquerque, N.M. 87131

Sedimentologist/Paleomagnetist: DEAN MERRILL
Department of Oceanography
Texas A&M University
College Station, TX 77843

Sedimentologist: GARY NICHOLS
Department of Geological Sciences
University College of London
Gower Street
London WC1E 6BT
United Kingdom

Sedimentologist:	CLAUDE RANGIN Laboratoire de Geologie Structurale, T-26-0 El Universite Pierre et Marie Curie 4 place Jussieu 75252 Paris Cedex France
Sedimentologist:	RANDALL SMITH Geology Department Tulane University New Orleans, LA 70118
Paleontologist: (Foraminifers)	CECELIA MCCLOY Science Applications International Suite 860 101 Convention Center Dr. Las Vegas, Nevada 89109
Paleontologist: (Nannofossils)	CARLA M. MULLER Geologisch-Palaeontologisches Institut Universitaet Frankfurt Senckenberg-Anlage 32-34 D-6000 Frankfurt/Main Federal Republic of Germany
Paleontologist: (Foraminifers)	ALEXANDRA NEDERBRAGT Instituut voor Aardwetenschappen Vrije Universiteit P.O.V. 7161 1007 MC Amsterdam Netherlands
Paleontologist: (Nannofossils)	JIH-PING SHYU Department of Oceanography Texas A&M University College Station, TX 77843
Paleontologist: (Diatoms)	TO BE NAMED
Paleomagnetist:	VINDELL HSU Department of Geology Louisiana State University Baton Rouge, LA 70803-4101
Paleomagnetist:	HIDETOSHI SHIBUYA Department of Earth Sciences College of Integrated Arts and Sciences University of Osaka Prefecture Sakai, 591 Japan

Igneous Petrologist: TERRENCE SMITH
Department of Geology
University of Windsor
Windsor, Ontario
N9B 3P4 Canada

Igneous Petrologist: PIERA SPADEA
University of Udine
Istituto di Scienze dela Terra
Viale Ungheria, 43-
I-33100 Udine
Italy

Organic Geochemist: PHILIPPE BERTRAND
C.N.R.S.
Unite de Recherche en
Petrologie Organique
Universite d'Orleans
45067 Orleans Cedex 2
France

Organic Geochemist: ULRICH BERNER
Federal Institute of Geosciences
and Natural Resources
Postbox 51 01 53
D-3000 Hannover St.
Federal Republic of Germany

Inorganic Geochemist: DER-DUEN SHEU
School of Geology and Geophysics
The University of Oklahoma
100 East Boyd Street
Norman, OK 73019

Physical Properties Specialist: STEPHEN LEWIS
U. S. Geological Survey
345 Middlefield Road, MS 999
Menlo Park, CA 94025

Physical Properties Specialist: TO BE NAMED

Logging Scientist: GARRETT W. BRASS
RSMAS-MGG
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149-1098

LDGO Logging Scientist: RICHARD JARRARD
Borehole Research Group
Lamont-Doherty Geological
Observatory
Palisades, NY 10964

Operations Superintendent:	CHARLES HANSON Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Laboratory Officer:	BURNEY HAMLIN Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Yeoperson:	MICHIKO HITCHCOX Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Photographer:	STACEY CERVANTES Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Chemistry Technician:	MATT MEFFERD Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Chemistry Technician:	JOE POWERS Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Electronics Technician:	MIKE REITMEYER Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Electronics Technician:	BARRY WEBER Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Marine Technician:	WENDY AUTIO Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840

Marine Technician:	MARY ANN CUSIMANO Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Marine Technician:	CHRIS GALIDA Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Marine Technician:	JENNY GLASSER Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Marine Technician:	COLLEEN ROTH Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Marine Technician:	DON SIMS Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Marine Technician:	TO BE NAMED Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Marine Technician:	TO BE NAMED Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Computer System Manager:	LARRY BERNSTEIN Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840
Curatorial Representative:	CHRIS MATO Ocean Drilling Program Texas A&M Research Park 1000 Discovery Drive College Station, TX 77840

Curatorial Representative: JOHN MILLER
Ocean Drilling Program
Texas A&M Research Park
1000 Discovery Drive
College Station, TX 77840