86/616

THE SECOND PROSPECTUS FOR WESTERN PACIFIC DRILLING

At its June 1986 meeting, the Western Pacific Panel revised its first WPAC drilling prospectus in the light of comments from the three thematic panels and after considering 14 new/revised proposals. The panel agreed on 10 1/2 legs that can be strongly defended at this time and ranked these legs by vote (see below). This report provides summaries of the 10 1/2 legs. The panel expects the process of program redefinition to continue through 1987 as better proposals are received and better data syntheses and scientific models are reviewed.

Leg	Vote (11)	Thematic Blessings	Relevant Proposals	Site Survey Needs	Existing Data Workup	Cruises Scheduled (Proposed)
1. Bonin-1	9.8	LITHP, TECP Workshop	171, (83)	more MCS	JNOC MCS needed	ALVIN 7/87 GSJ 87 MGG (Taylor MCS)
2. Japan Sea	8.6	SOHP, LITHP TECP	51 + JTB	✓	✓	Shinkai 86 ORI 87 MGG
3. Sunda Backthrusting	7.6	TECP	242	more MCS	--	(Silver MCS)
4. Banda-Sulu-South China	7.2	SOHP, (TECP)	27, 46, 82, 131, 147, 154	digital SCS (Banda)	--	(Silver SCS)
5. Bonin-Mariana-2	6.1	LITHP, TECP Workshop	171, 172 (83)	more MCS Mariana SCS	✓	ALVIN 6/87 (Taylor MCS)
5. Great Barrier Reef	6.1	SOHP Workshop	206	crossing MCS	Co. MCS needed	BMR 6-9/87 MCS +
7. Nankai	6.0	TECP	50 128/F	✓	Japex MCS needed	ORI 86 MCS (Shipley 2-ship)
8. Lau Basin	5.8	LITHP, TECP Workshop	189, 220 239	? First integrate 5 recent cruises		BGR 2-4/87 Cronan 87 (Hawkins)
9. Vanuatu	5.7	TECP Workshop	187 190	more MCS	migrate USGS MCS	French MCS
10. Zenisu (1/2)	5.1	(TECP)	163 177	more MCS	✓	ORI 86 MCS
11. Sulu-Negros	2.6	--	27 48	more MCS	migrate Fr. MCS	French MCS


BOWERS BASIN
Aleutian Rise
KURIL BASIN
JAPAN BASIN
SEA OF JAPAN
Bo Hai
YELLOW SEA
EAST CHINA SEA
NORTHWEST
PACIFIC
BASIN
PHILIPPINE SEA
PARECE VELA BASIN
SOUTH CHINA BASIN
Macclesfield Bank
SULU BASIN
Palawan Trough
CELEBES BASIN
WEST CAROLINE BASIN
EAST CAROLINE BASIN
Caroline Seamounts
MELANESIAN BASIN
EAST MARIANA BASIN
Seamounts
CENTRAL
PACIFIC
BASIN
Hawaiian
Chinook Trough
BISMARCK SEA
SOLOMON SEA
JAVA SEA
BANDA SEA
ARAFURA SEA
ARAFURA SHELF
Java Trench
Timor Trough
TIMOR SEA
SAHUL SHELF
NORTH AUSTRALIA BASIN
Gulf of Carpentaria
PAPUA PLATEAU
PAPUA ABYSSAL PLAIN
CORAL SEA
QUEENSLAND PLATEAU
NORTH FIJI PLATEAU
SOUTH FIJI BASIN
EXMOUTH PLATEAU
ROWLEY SHELF
NEW CALEDONIA BASIN
Lord Howe Rise
Great Australian Bight
SOUTH AUSTRALIA BASIN
Bass Strait
TASMAN ABYSSAL PLAIN
Gascoyne Seamount
TASMAN SEA
CHALLENGER PLATEAU
Chatham Rise
Louisville
Tonga Trench
1
2
3
4
5a
5b
6
7
8
9
10
11
45°
30°
15°
0°
15°
30°
45°S
120°E
150°
180°

SUMMARY OF THE TWO-LEG BONIN-MARIANA DRILLING PROGRAM

TECTONIC SETTING

Subduction of Pacific lithosphere beneath the West Philippine Basin began in the Early Eocene, and through the Early Oligocene formed an intra-oceanic volcanic arc and a 200-km-wide forearc of arc volcanic material (tholeiites and boninites), possibly superimposed on previous oceanic crust. Mid-Oligocene rifting split the arc and late Oligocene-Early Miocene back-arc spreading in the Parece Vela and Shikoku Basins isolated the remnant arc (Palau-Kyushu Ridge) from the active Bonin-Mariana arc and forearc. The rifting and initial spreading was time transgressive, starting in the center of the Parece Vela Basin and at the northern end of the Shikoku Basin, resulting in the bowed and V'd shape of those basins, respectively. This process is being repeated. The southern part of the arc split again in the Late Miocene, and 6 to 8 my of seafloor spreading in the Mariana Trough has isolated the active Mariana arc from, and increased its curvature with respect to, the remnant West Mariana Ridge. Spreading in the Mariana Trough may be propogating to the north. In contrast, the Izu-Bonin arc is still in the rifting stage of backarc basin formation and is undergoing extension along most of its length. The major zone of rifting is immediately west of the active volcanic chain, but some arc volcanoes near 29°N are surrounded by grabens. Volcanism is continuing along both the active and "remnant" arcs. Volcanic centers have also developed in the rift basins. Their chemistry indicates a basalt-andesite-rhyodacite association, with the basalts having similar major and trace-element compositions to Mariana Trough tholeiites. The backarc rifts are semi-continuous along strike, being segmented by structural highs and chains of submarine volcanoes extending westwards from the island volcanoes.

The difference in arc/back-arc evolution between the Mariana and Bonin systems has produced corresponding differences in their forearcs. The Bonin forearc has experienced little structural disruption since its inception. A broad forearc basin has accumulated volcaniclastic and hemipelagic sediments behind an outer-arc high. The onlap of strata onto this high, together with Eocene shallow-water fossils found on the Bonin islands, indicates that it has been a relative structural high since early in the history of the arc. A mature, dendritic, submarine canyon system has developed by mass wasting and headward erosion, incising many deep canyons across the forearc, cutting as much as 1 km into the 1.5 to 4 km thick sedimentary section. In contrast, the Mariana forearc has not behaved as a rigid plate, but has undergone extension tangential to its curvature. This has produced radial fractures and, together with the disruption caused by numerous seamounts on the subducting plate, easy pathways for diapiric intrusions of serpentinised mafic/ultramafics of arc affinity. Eruption of these diapirs onto the seafloor, together with uplift of forearc material due to their subsurface intrusion, has formed a broad zone of forearc seamounts (up to 2500 m high and 30 km in diameter) 50 to 120 km from the trench axis. In the Bonins chloritised/serpentinised mafic/ultramafics occur along a narrow zone which controls the location of a lower-slope terrace. This zone appears to be the oceanic forearc analog of overpressured dewatering zones in accretionary sedimentary wedges. Possibly because most of the sediment has slumped off the trench inner wall, the large forearc canyons die out on the middle slope and do not cut across the lower-slope terrace. Only very minor, and probably ephemeral, accretionary complexes occur at the base of the inner wall of both the Bonin and Mariana trenches.

SITE RATIONALE

Investigating the processes of intra-oceanic arc-trench development in the same region has obvious logistic and scientific benefits. Several factors combine to make the Bonins the best of all the western Pacific locations in which to address these processes. They include (1) the present density of marine geological and geophysical information, (2) the prospects for additional multidisciplinary surveys, (3) certain unique geological factors such as the presence of large submarine canyons and the Bonin Islands (a subaerial outer-arc high), and (4) the inherent simplicity of the system (continuous subduction since the Eocene without major collisions or arc reversal). However, the largest and best studied serpentinite diapirs occur in the Mariana forearc, and two sites in this two-leg drilling program are included there.

BONIN SITES 1 and 2 are located in the graben and on the bounding horst, respectively, of the active Sumisu rift, and seek to determine the:
1) differential uplift/subsidence history of the central graben and bounding tilted arc block, and whether this is compatible with stretching or detachment models of extensional tectonics.
2) duration of rifting
3) nature of syn-rift volcanism and sedimentation, whether arc volcanism is continuous or interrupted by rifting, and when the extrusion of back-arc type basalts began.
4) extent and chemistry of hydrothermal circulation in a tectonic setting similar to that of Kuroko-type massive sulphide deposits
5) nature of the rift basement
6) nature of the arc basement between (and isolated from the pyroclastic deposits of) major arc volcanoes. [Consider the limitation to our knowledge of continental arcs if we were restricted to exposures in the top 1000 m of only the largest stratovolcanoes.]

BONIN SITES 3-6 are located in the forearc near 32°N; BON3 on the frontal arc high, BON4 on the inner and BON5 at the center of the upper-slope basin, and BON6 on the outer-arc high. These sites were chosen to determine the:
1) uplift/subsidence history across the forearc (using backstripping techniques on cored/logged holes and seismic stratigraphic analysis of interconnecting MCS profiles) to provide information on forearc flexure and basin development, as well as the extent of tectonic erosion. We do not know whether the frontal arc and outer-arc high develop by igneous construction or differential uplift, whether the upper-slope basin between them is due to forearc spreading or differential subsidence, or whether flexural loading by either arc volcanoes or by coupling with the subducting plate is an important process. For example, the seismic stratigraphy laps onto and reverses dip over the frontal arc high. Is this due to an original Eocene volcanic high. to mid-Oligocene rifting of the arc, or to Plio/Pleistocene volcanic loads on the fractured (by rifting) edge of the forearc?
2) forearc stratigraphy, to ascertain (a) the sedimentology, depositional environment and paleoceanography, and (b) the variations in intensity and chemistry (boninitic, tholeiitic, calc-alkaline, rhyo-dacitic, alkaline) of arc volcanism over time, and the correlation of these variations with periods of arc rifting, backarc spreading and varying subduction rate.

3) nature of igneous basement forming the frontal arc, outer-arc high and beneath the intervening forearc basin (which has never been sampled) to answer questions concerning the initial stages of arc volcanism and the formation of a 200 km wide arc-type forearc massif (were the frontal arc and outer-arc high formerly contiguous and subsequently separated by forearc spreading, were they built separately but near synchronously on former West Philippine Basin oceanic crust, or are they part of a continuous Eocene arc volcanic province, possibly with overprints of later forearc volcanism?).
4) micro-structural deformation as well as the large scale rotation/translation of the forearc. Paleomagnetic studies of the Bonin Islands suggest 90° clockwise rotation and 20°N translation since the Eocene, which has major implications for reconstructions of the Philippine and surrounding plates.

BONIN SITE 7 & MARIANA SITES 2 & 3 are located on forearc seamounts; BON7 on the flank of a dome along the Bonin lower trench-slope terrace, MAR2 on the flank of Pacman seamount near the Mariana trench slope break (a large diapir which has breached the surface and erupted serpentinite flows), and MAR3 on a nearby conical seamount interpreted to represent an updomed forearc sequence resulting from subsurface emplacement of a diapir.

Forearc diapirs were first recognized AFTER the last round of western Pacific drilling. The proposed drill sites, in three different structural settings, seek to determine the
1) timing of emplacement: ongoing, dormant, Oligocene? -- from the stratigraphy of the flows and intercalated sediments on the flanks of the seamounts, and from the history of tectonic uplift above the subsurface intrusion.
2) emplacement mechanism: diapirs of serpentinite with entrained wall rock in the Marianas vs. completely remobilized outer forearc in the Bonins?; and the internal structures (fracture patterns, flow structures) of the seamounts.
3) extent of fluid circulation through the outer forearc and the chemistry of the fluids (from the subducting plate, overlying lithosphere, circulating seawater?).
4) conditions at depth in the outer forearc from the igneous and metamorphic petrology of the lower crustal rocks.

Forearc diapirism may provide a model for emplacing some alpine-type ultramafic bodies common in accreted terranes pre- rather than syn/post-collision.

BONIN SITE 8 is located on the outer trench flexural bulge of the Pacific Plate near magnetic anomaly M15. Drilling objectives include:
1) a reference site for geochemical mass balance calculations: to what extent does subducted material influence the chemistry of arc and rift volcanism?
2) to determine changes in the Tertiary bottom currents, whether these caused the regional hiatuses in NW Pacific sedimentation and, by comparison with the Bonin arc/forearc sites, to what extent the Bonin-Mariana arc served as a barrier to divide the bottom currents.
3) to determine the earliest Cretaceous stratigraphy and crustal petrology (i.e., to penetrate the late Cretaceous cherts for the first time).

SITE SUMMARY

The sites that we propose to be drilled in the Bonins represent a compromise between deep basement and complete stratigraphic objectives. They were chosen from an extensive data base that needs some additional close-spaced MCS profiles. Additional surveys should be able to identify sites where shorter holes can meet the objectives (especially for forearc sites 4 and 5). The Mariana sites are extensively surveyed but need better seismic reflection data. This should be collected using the ATLANTIS II during the ALVIN dive cruises scheduled for spring 1987. Nine of the twelve holes are in water depths less than 4000 m (average - 2400 m) which should result in very good biostratigraphy. The principal proposals on which this summary is based are #171 for the Bonins, with sections on paleoceanography from #83, and #172 for the Marianas.

Site #	Lat. (°N)	Long. (°E)	W.D. (m)	Penetration Sed.	Bsmt.	Site Time* (Days)
BON1	30°55'	139°53'	2270	850	50	8
BON2	30°55'	140°00'	1100	500	200	8
BON3	31°22'	140°17.4'	1250	600	50	6
BON4A	32°26.5'	140°22.5'	1820	700	—	6
BON4B	32°28.6'	140°22.5'	2420	950	50	9
BON5A	32°26'	140°47'	2700	950	—	8
BON5B	32°23'	140°48'	3400	900	50	10
BON6	31°54'	141°06'	2850	950	150	12
BON7	30°58'	141°48'	4650	500		8
BON8	31°18'	142°54'	6000	500	100	12
MAR2	19°20'	146°54'	3700	700		8
MAR3	19°30'	146°41'	4200	700		9
						104

*Time estimates assume APC/rotary coring, with mini-cones but not major re-entry cones, and are based on Figure 15 in JOIDES J., v. XI (4), plus basement drilling at 2 m/hr.

WPAC ranked proposed Bonin-Mariana drilling by considering two legs (page 1):
Bonin Leg 1 = rifting and forearc objectives (sites 1, 2, 5A, 5B, and 6 essential)
Bonin/Mariana Leg 2 = diapirs, reference site, plus remaining forearc sites as time permits (lowest priorities are BON3, MAR3, BON4A, and BON4B, in that order).

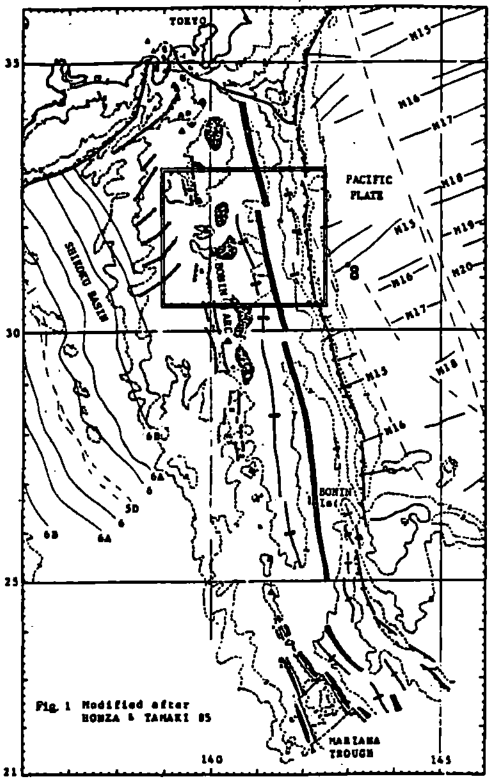


Fig. 1 Modified after HONZA & TAMAKI 85

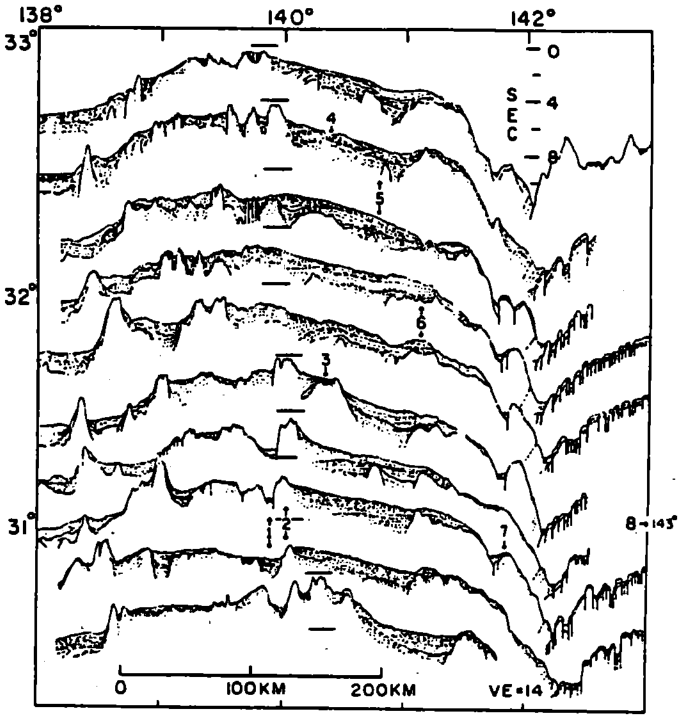
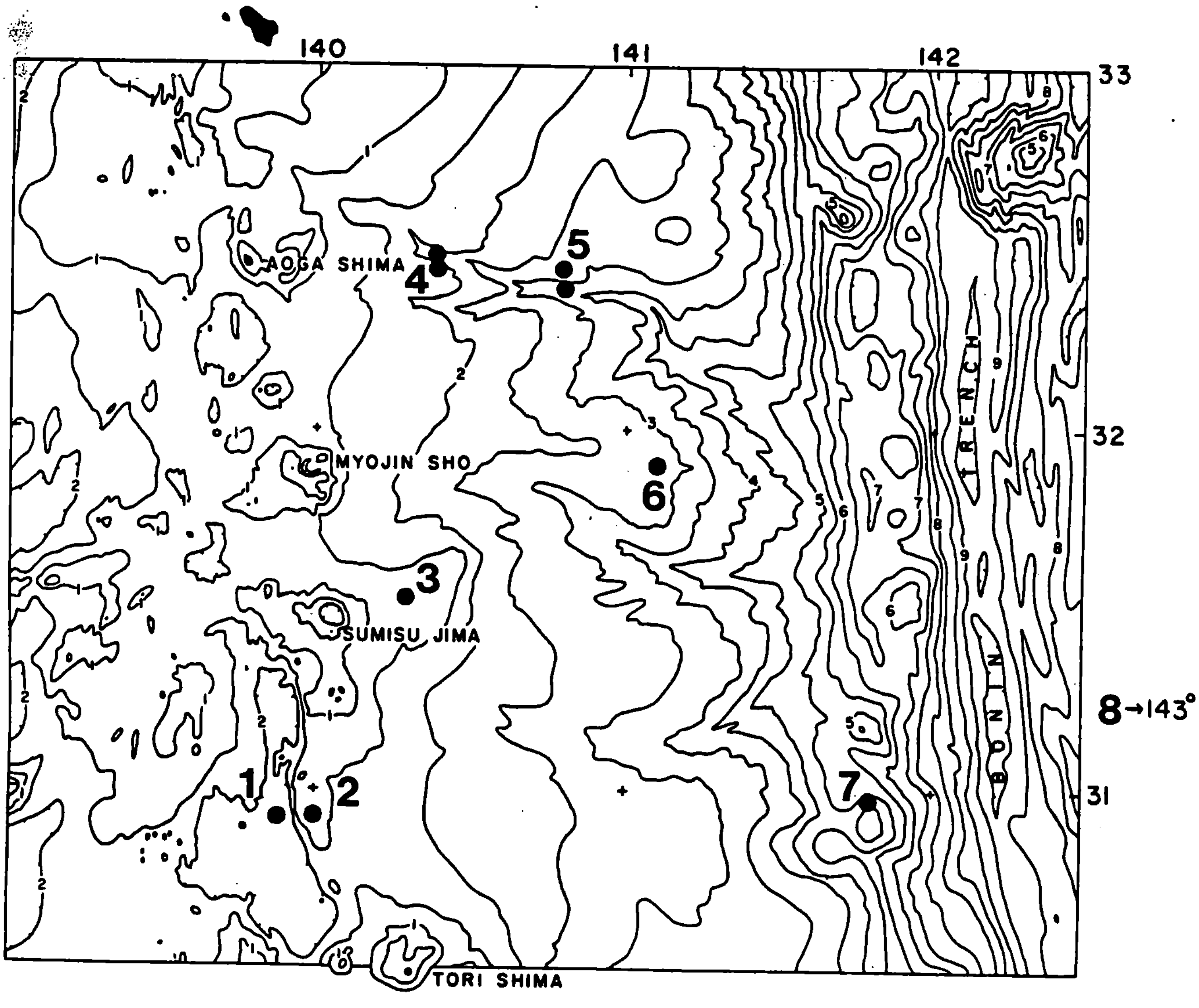
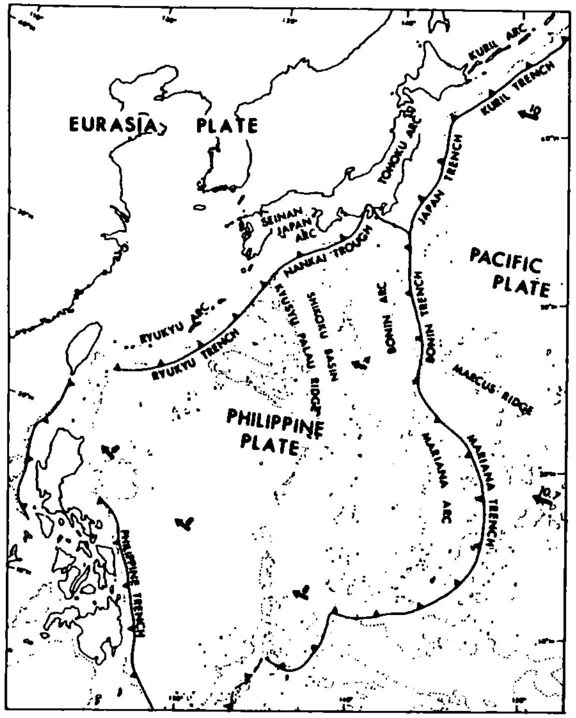
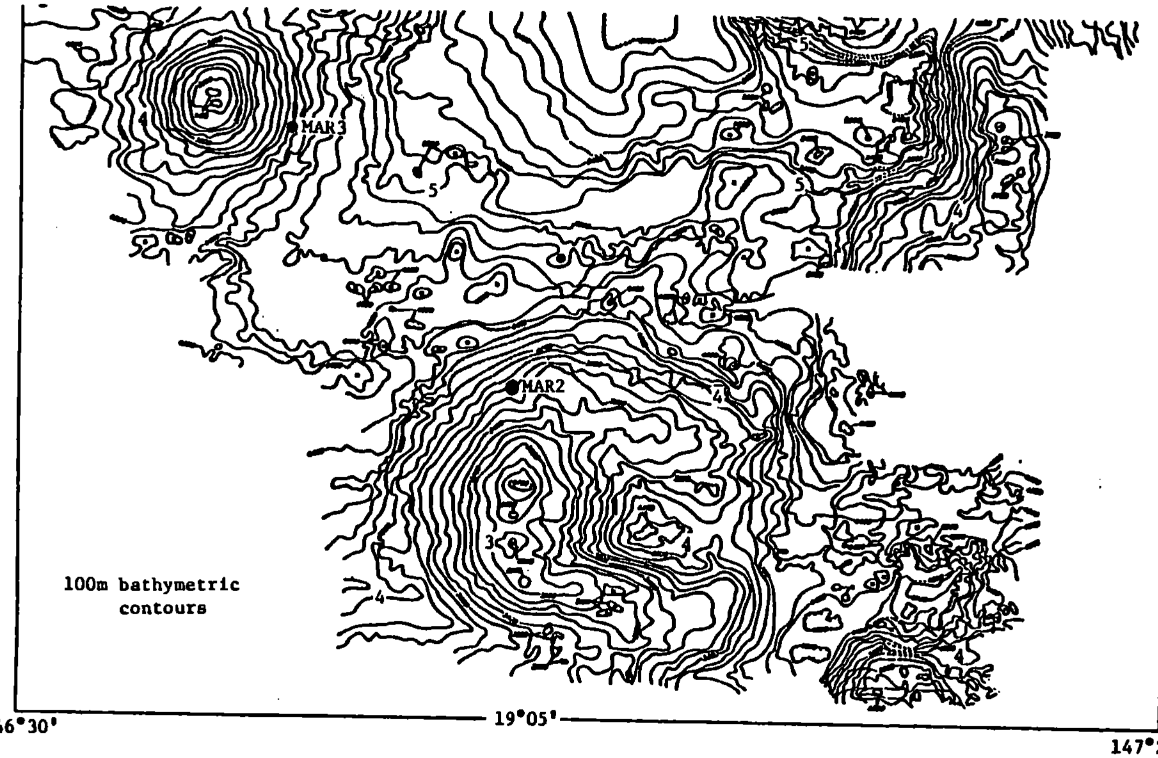
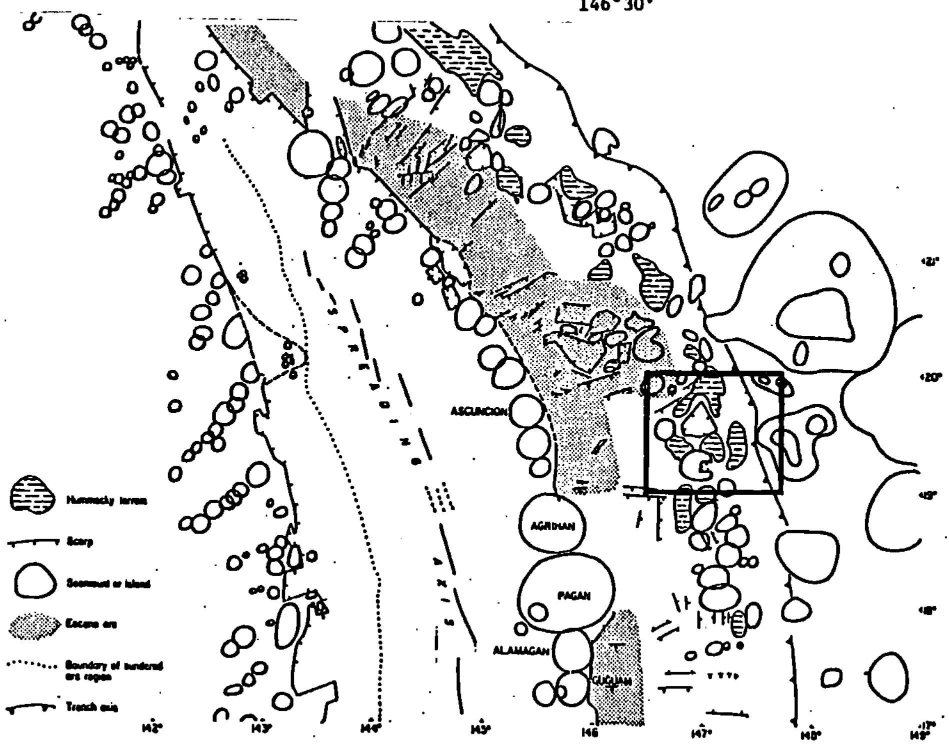


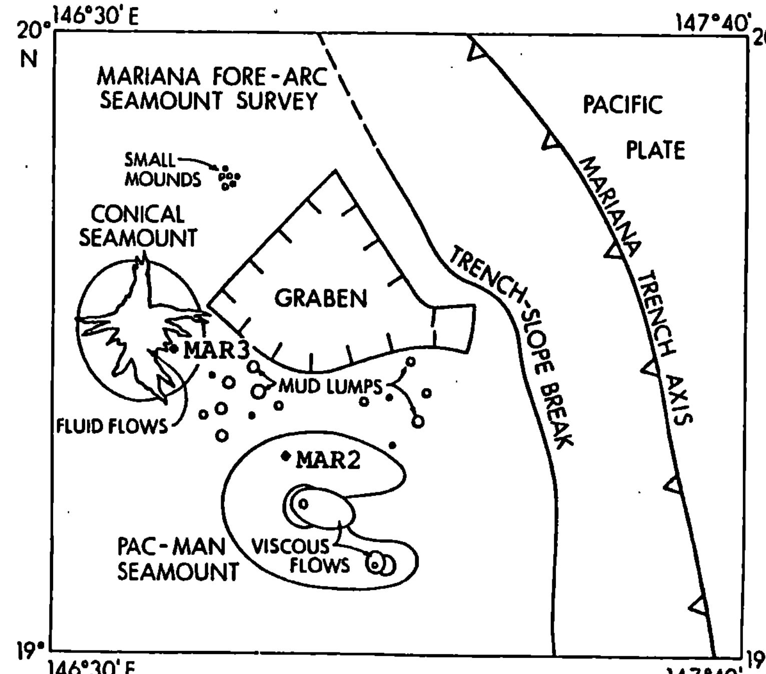
Figure 2. Line drawings of GH79 seismic reflection profiles across the Izu Arc-Bonin Trench system between 30.5° and 33° N(Honza and Tamaka, 1985). From east to west, the characteristic structural elements of this active margin include: (a) a lower slope terrace on the trench inner wall, (b) a thick forearc basin sequence which laps onto and thins over an outer-arc structural high, and (c) a broad arc platform with active volcanoes and rift basins on the east and older volcanic cross chains on the west. The eight proposed ODP sites on or between the seismic lines are indicated by single or double arrows respectively.




EURASIA PLATE
PACIFIC PLATE
PHILIPPINE PLATE
KURIL ARC
KURIL TRENCH
TOHOKU ARC
JAPAN TRENCH
SEINAN JAPAN ARC
NANKAI TROUGH
RYUKYU ARC
RYUKYU TRENCH
KYUSHU PALAU RIDGE
SHIKOKU BASIN
BONIN ARC
BONIN TRENCH
MARCUS RIDGE
MARIANA ARC
MARIANA TRENCH
PHILIPPINE TRENCH


MAR3
MAR2
100m bathymetric
contours
146°30'
19°05'
147°25'


ASUNCION
AGRIHAN
PAGAN
ALAMAGAN
GUGUAN
Hummocky terrain
Scarp
Seamount or island
Eocene arc
Trench axis
142°
143°
144°
145°
146°
147°
148°
149°
21°
20°
19°
18°


20° N
146°30' E
147°40'
20°
MARIANA FORE-ARC
SEAMOUNT SURVEY
SMALL MOUNDS
CONICAL SEAMOUNT
GRABEN
MAR3
FLUID FLOWS
MUD LUMPS
MAR2
PAC-MAN SEAMOUNT
VISCOUS FLOWS
TRENCH-SLOPE BREAK
MARIANA TRENCH AXIS
PACIFIC PLATE
19°
146°30' E
147°40'
19°

SUMMARY OF THE JAPAN SEA DRILLING PROGRAM

Japan Sea is one of the western Pacific back-arc basins and is believed to have been formed by multi-axial rifting of the continental arc, much different from the rifting of the oceanic arc. Proposed drill holes reaching basement that was not achieved by DSDP Leg 31 can organize a large amount of geological and geophysical data of the Japan Sea to address rifting tectonics of the continental arc and to reconstruct the complex Neogene tectonics of East Asia. 12 proposals have been submitted for the drilling for the Japan Sea.

Objectives

Five drilling objectives of the Japan Sea with six drilling holes were endorsed by the West Pacific Panel on the basis of the endorsements by thematic panels.

1. <u>Nature and age of the basement of the basins</u> (Sites J1b, J1d, J1e)
   Recent refraction survey with 20 OBS in the Yamato Basin revealed anomalously thick oceanic crust (twice as much as normal oceanic crust). Recent detailed geomagnetic survey of the Japan Basin mapped complex pseudofault pattern suggesting frequent ridge propagation during spreading of the basin. Drilling to the basement will greatly help the age identification of this newly mapped magnetic anomaly lineations as well as constraining regional tectonic reconstruction in East Asia. Fast spreading of the Japan Sea proposed by paleomagnetic data on land in Southwestern Japan is also evaluated by the drilling of the basin area.

2. <u>Style of multiple rifting</u> (Sites J2a, J1b, J1d, J1e)
   Back-arc extension tectonics of the continental arc, associated with multiple rifting, complex pseudofault pattern, continental crustal extension, anomalously thick oceanic crustal structure, and contamination of MORB volcanism with arc volcanism, are comparatively studied with the Atlantic type extension tectonics.

3. <u>Obduction of oceanic crust</u> (Site J3a)
   The EURA-NOAM plate boundary shifted to the eastern margin of the Japan Sea in the Quaternary accreting NE Japan to NOAM. Incipient obduction as well as subduction of the oceanic crust is ongoing along the new plate boundary which shifted from the central Hokkaidō suture line. The drilling constrains the timing of initiation of the convergence and address the obduction tectonics of oceanic crust in relation with the origin of ophiolites.

4. <u>Paleooceanography</u> (Site JS-2)
   Well preserved sediment sequence on rises above CCD in the Japan Sea is studied by comprehensive paleoenvironmental analyses for addressing paleooceanographic and marine climatic history in an isolated back-arc basin.

5. <u>Metallogeny in a failed back-arc rift</u> (Site J2a)
   The study of ore deposits on island arcs predict occurrence of shale-hosted massive sulfide and Kuroko-type sulfide deposits in a failed back-arc rift. The drilling will greatly contribute ore genesis of island arc-type ore deposits.

List of endorsed drilling sites and estimated drilling days

Site	Depth (m)	Hole Type	Reentry	Drill* Days	Penetration (m)	Site Survey	Site Proponent****
J1b	2780	HPC, Rotary	x	11.5	700(100)**	MCS	1,3,5
J1d	3170	Rotary		5	350(30)	SCS***	1,2,5,11
J1e	2890	HPC, Rotary	x	11.5	830(50)	MCS	1
J2a	2050	Rotary	x	11.5	1370(20)	MCS	1,3,6,7,9,11
J3a	2040	HPC, Rotary	x	9	700(30)	MCS	1,7
JS-2	998	D-HPC, Rotary		6	600	SCS***	9

Total: 54.5 days*****

*2.5 days are added for reentry operation. Time for basement drilling is included.
**Values in the parentheses show penetration into the basement.
***MCS site survey is planned in 1986-1987 by Ocean Research Institute, Univ. of Tokyo and Geological Survey of Japan.
****Numbers ccorrelate with the listed numbers of proposals below.
*****This total drilling days do not include the time of down hole measurement (oblique seismic experiment) proposed by Suyehiro et al. (155/F). The West Pac Panel is asking evaluation of the proposal to DHM Panel. If the DHM Panel endorsed the down hole measurements in the Japan Sea, the estimated total drilling days will be prolonged appreciably.

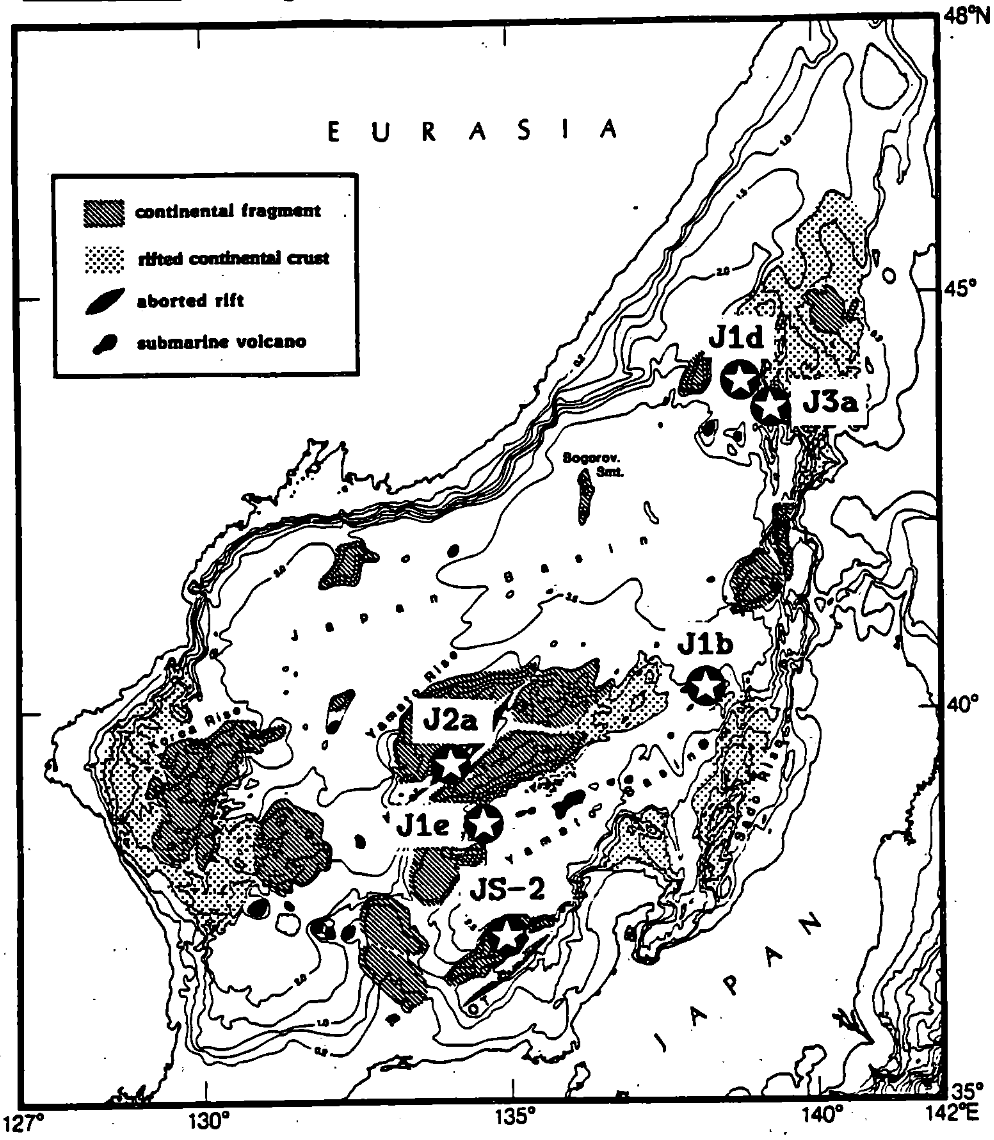
List of ODP proposals for the Japan Sea

Tectonics
1. Tamaki, K., H. Kagami, E. Honza, and K. Kobayashi (51/D): Tectonics of the Japan Sea
2. Kimura, M. (149/D): Age of the spreading center found in the Yamato Basin
3. Wakita, H. (151/D): Opening of the Japan Sea - Mantle plume origin -
4. Chough, S. K., C. S. Kim, W. Y. Lee, Y. H. Kwak, Y. A. Park, B. K. Park, E. Honza, G. deV. Klein, and J-P. Cadet (198/D): Ulleung (Tsushima) Basin: Neogene tectonics and sedimentation

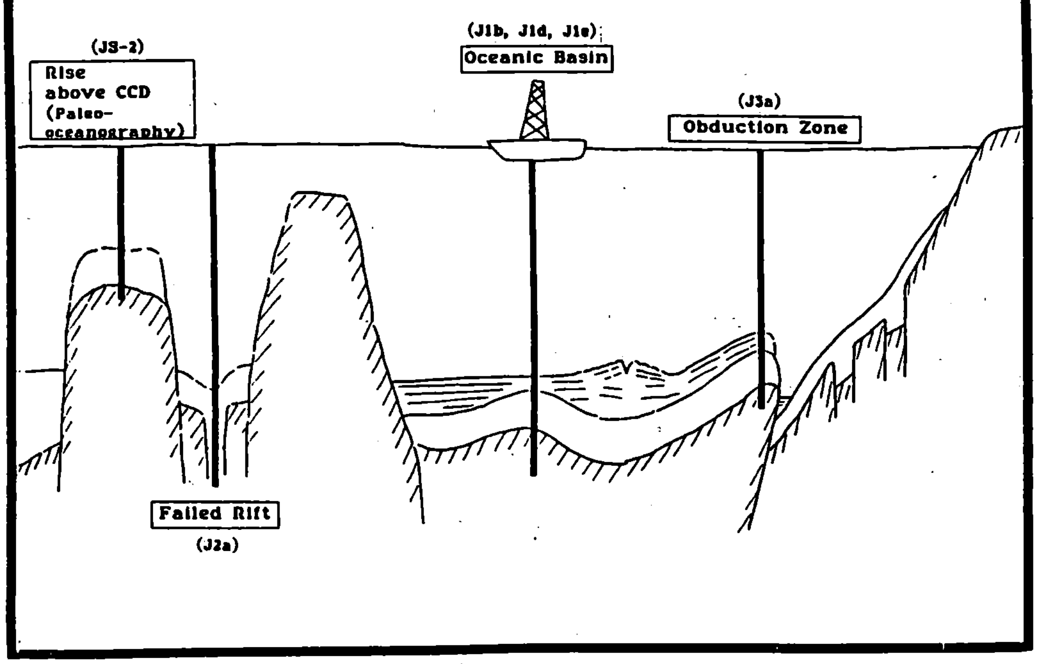
Lithosphere
5. Suyehiro, K., T. Kanazawa, K. Yamamoto, and H. Kinoshita (155/F): Preliminary ODP site proposal for downhole measurements- the Japan Sea
6. Tatsumi, Y., S. Nohda, K. Ishizaka, K. Aoki, T. Yoshida, T. Itaya, K. Nagao, T. Matsuda, M. Torii, and A. Hayashida (166/D): Instantaneous opening of the Japan Sea- evolution of the mantle wedge

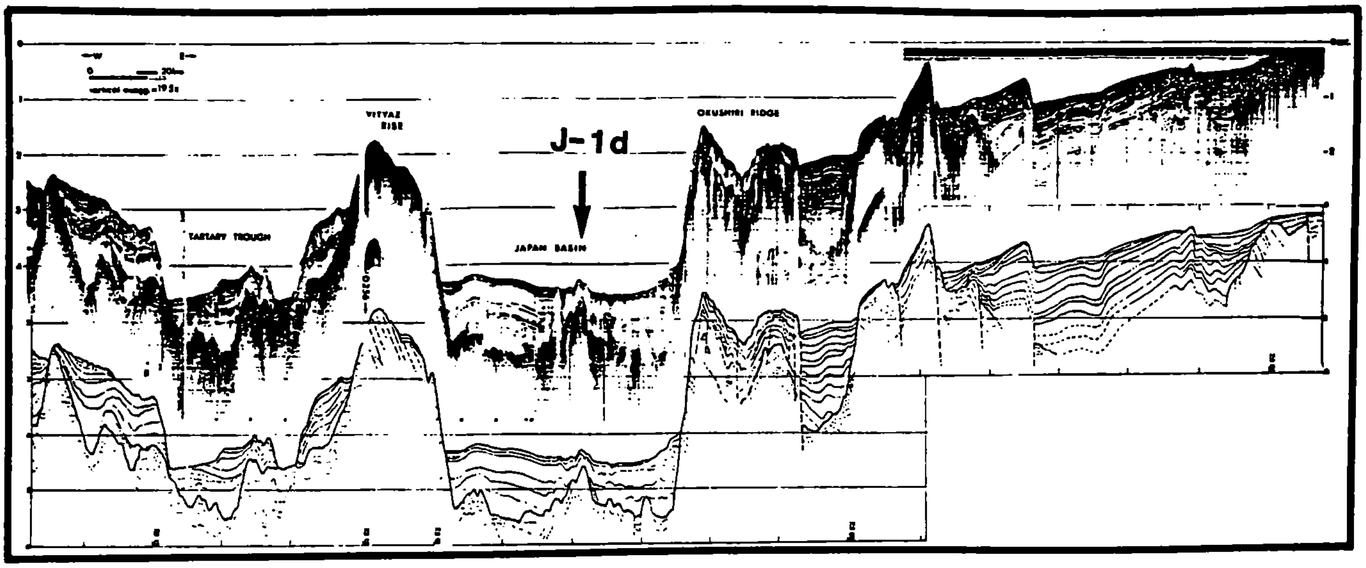
Sediment and Ocean History
7. Klein, G. deV. (146/D): Toyama submarine fan, eastern Japan Sea
8. Urabe, T. (156/D): Potential massive sulfide in Kita-Yamato trough, Sea of Japan
9. Koizumi, I., and T. Oba (157/D): Paleooceanographic and marine climatic history of the Japan Sea
10. Koizumi, I. (157/D): Back-arc spreading and fresh water sediments- Japan Sea
11. Minai, Y. and R. Matsumoto (158/D): ODP site proposal around Japan trench and Japan Sea- geochemistry and sedimentology of active oceanic margin and back-arc sediments
12. Iijima, A., R. Matsumoto, and R. Tada (168/D): ODP site proposal in Japan Sea-sedimentology of siliceous sediments

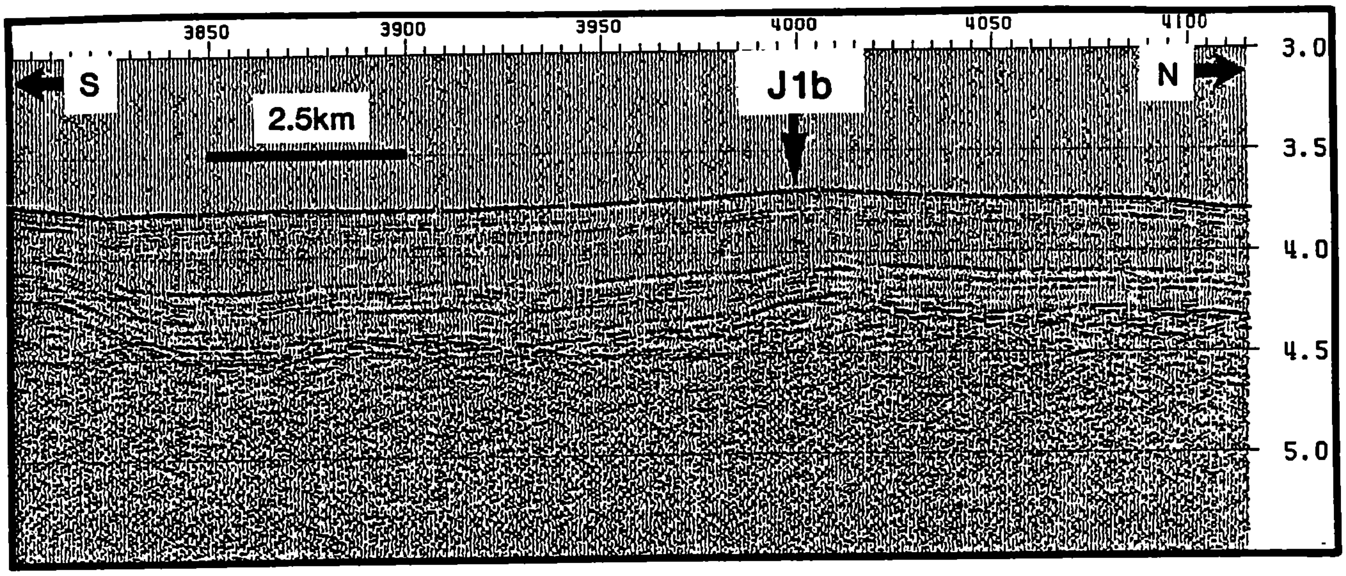
Endorsed Drilling Sites in the Japan Sea



Drilling Cartoon of the Japan Sea




VITYAZ RISE
OKUSHIRI RIDGE
J-1d
TARTARY TROUGH
JAPAN BASIN


3850
3900
3950
4000
4050
4100
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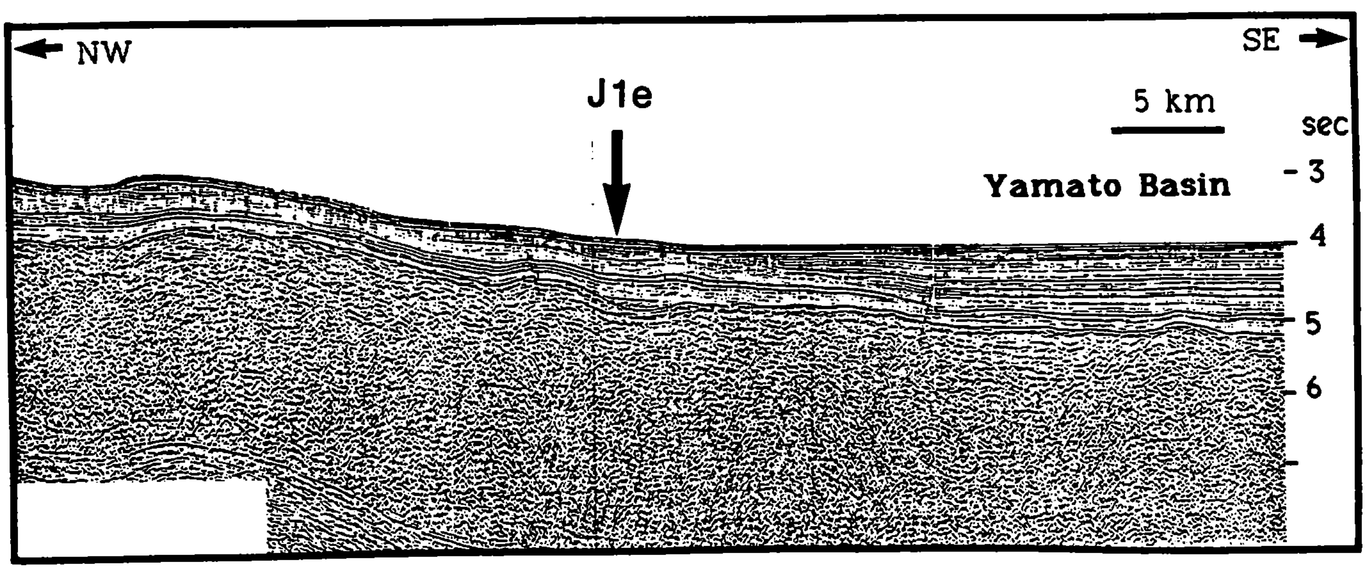
N
J1b
2.5km
3.0
3.5
4.0
4.5
5.0


NW
SE
J1e
5 km
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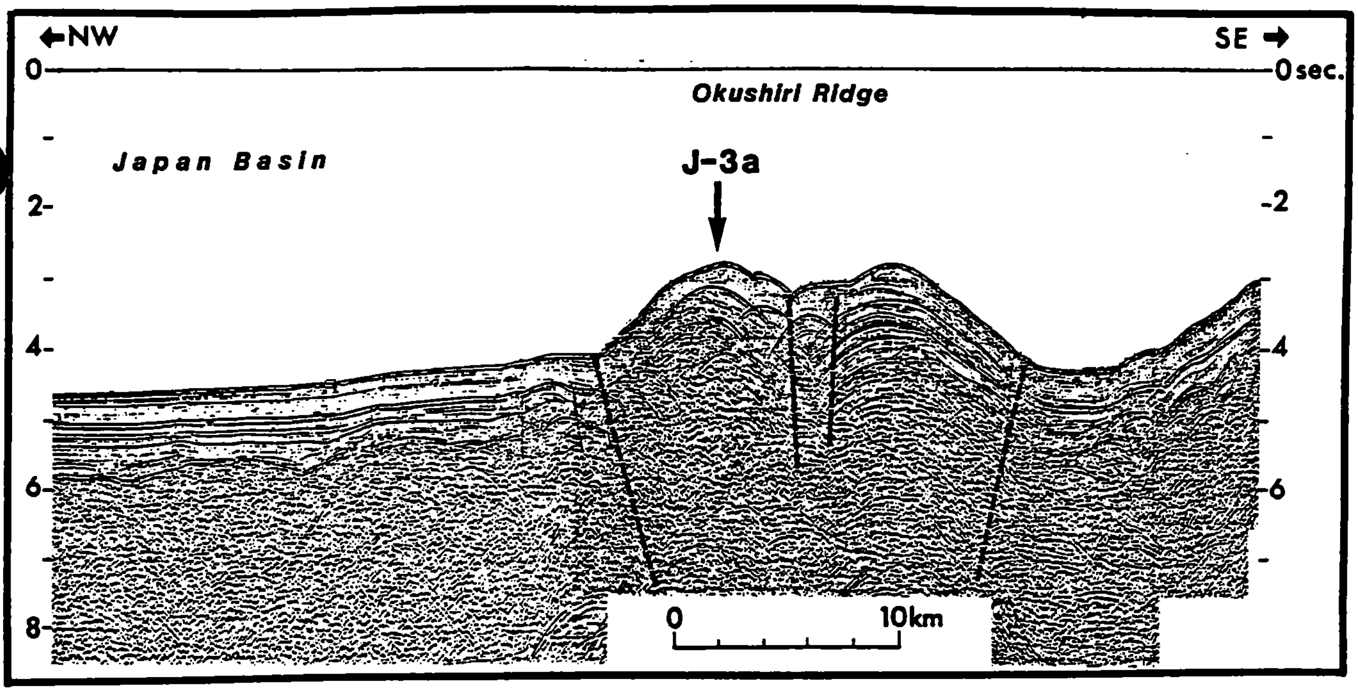
Yamato Basin
3
4
5
6


NW
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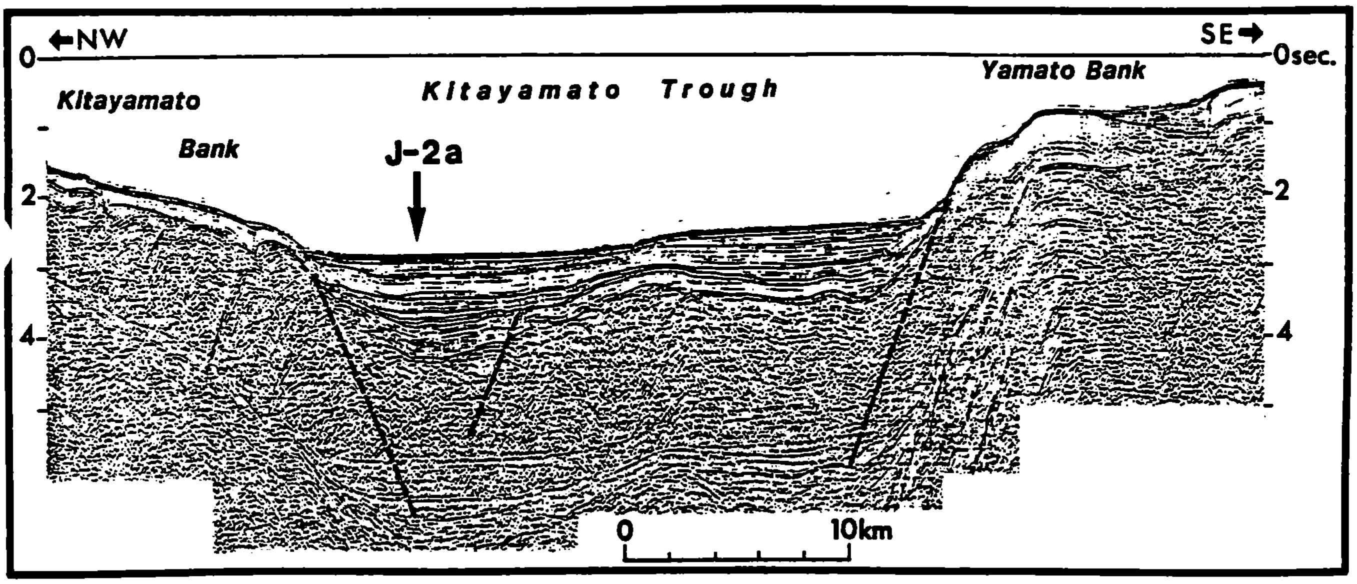
Okushiri Ridge
Japan Basin
J-3a
2
-2
4
-4
6
-6
8
0
10km


NW
SE
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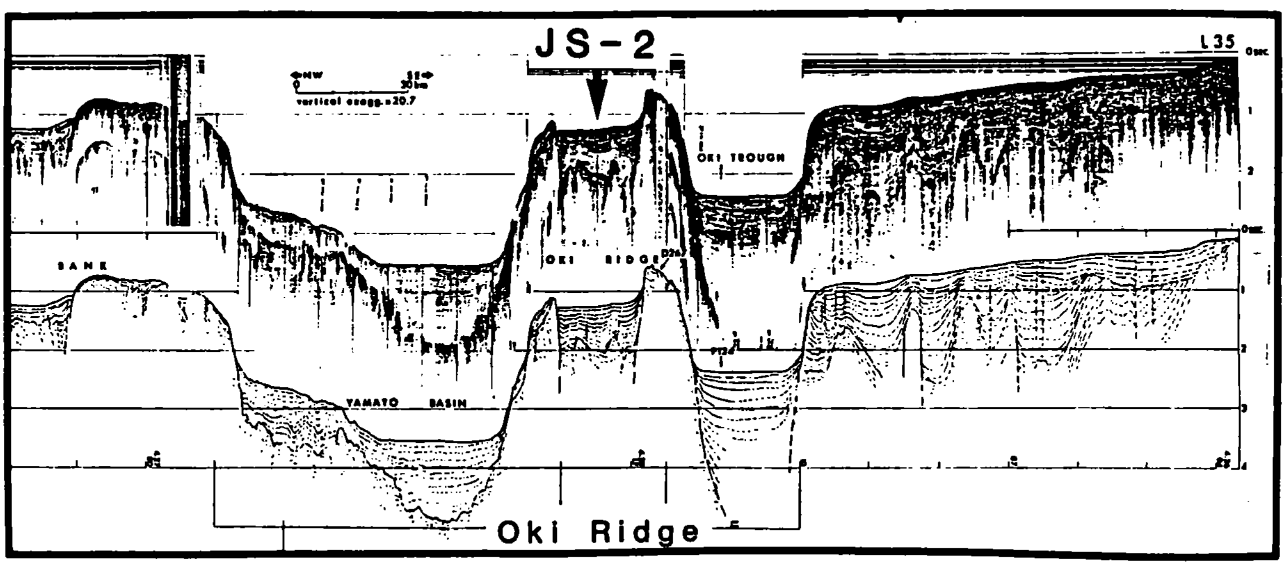
Kitayamato Trough
Yamato Bank
Kitayamato
Bank
J-2a
2
-2
4
-4
0
10km


JS-2
L35
OKI TROUGH
BANK
YAMATO BASIN
Oki Ridge

Summary of Drilling Objectives for the Eastern Sunda Arc-Continent Collision Zone

TECTONIC SETTING

The collision between the Australian continent and the eastern Sunda arc has progressed to the stage where continental margin crust underlies the forearc in the western part, near Sumba island, and continental crust underlies the forearc beneath Timor island (Fig. 1). The young collision has produced significant uplift of both accretionay wedge (exposed as the islands of Sawu, Timor, and others around the Banda arc to Seram) and forearc basement (exposed on Sumba island), backthrusting of the wedge over the forearc basin, and backarc thrusting along the north of slope of the arc. We are concerned with the sequence and magnitude of backthrusting and backarc thrusting, and the processes responsible for uplift of the forearc.

We hypothesize that collision will reactivate or initiate backthrusting between the accretionary wedge and the forearc basin, and geophysical data in the eastern Sunda arc tend to support this contention. We wish to date the inception of backarc thrusting, to compare with backthrusting within the forearc. We also propose to test whether the uplift of Sumba results from crustal duplexing, the passage of a marginal plateau, or the docking of a microcontinent. These alternatives should show different uplift histories on the Sumba ridge.

PROPOSED DRILLING PROGRAM

The proposed drilling program (Figures 2-5) includes:
1) Drilling just behind the thrust in the forearc basin province (sites S1 and T1). This should provide data on the vertical

motions of the forearc associated with backthrusting, which we predict to be negative (subsidence). This subsidence associated with backthrusting may be better shown at site T1, because S1 will be additionally affected by the uplift of the Sumba ridge. These sites will also provide stratigraphic data on the history of volcanism of the arc and its relation to forearc and backarc tectonism. They will also provide definitive tests of the basement rocks of the forearc and their relationship with thrust sheets on Timor and Sawu islands. Finally, the sites will give detailed histories of the uplift of Timor and Sawu islands, which are closely tied to collision by the Australian continental margin. Presently available geophysical data are adequate to define the locations of suitable sites for these objectives, but further MCS work is planned for 1987.

2) Drilling on the accretionary wedge near the backthrust (sites and T2) will test whether forearc basin and basement material are incorporated into the rear of the accretionary wedge. We feel that it will also provide data on the timing of initiation of accretion at the toe of the wedge, based on results of physical modeling and interpretation of seismic data from other regions. Existing seismic data are not sufficiently good to define final sites, however, and these sites will depend on obtaining high quality seismic reflection data.

3) Drilling on the Sumba ridge will allow us to distinguish several different models for the uplift of the forearc basement. One or more episodes of rapid uplift would be consistent with an origin by crustal duplexing beneath the Sumba ridge. Slow, steady uplift would suggest sediment duplexing at depth or slow changes

in the thermal regime beneath the forearc. Rapid uplift followed by subsidence would support a model of subduction of a small marginal plateau. Docking of a microcontinent should not necessarily require vertical movement, but sutures should be evident on the margins of such a block.

4) Drilling beyond the toe (F1) and at the rear (F2) of the small accretionary wedge in the zone of back arc thrusting behind the island of Flores (Figs. 2 and 4) is designed to determine the age of initiation of backarc thrusting by two methods. The first is by dating the oldest accreted material in the rear of the wedge at F2, and the second is by determining the history of vertical motions of the lower plate (F1). We will use these results to establish coupling between the collisional effects in the forearc to those in the backarc, and we will address the question of whether or not backthrusting and backarc thrusting are sequential phenomena.

Existing Geophysical Data and Proposed MCS Survey

Most of the existing (available) geophysical data in the Sunda arc region are summarized in Figure 6. These data are of variable quality, ranging from single channel analog seismic reflection data to 24 channel, small source multichannel seismic data. The latter are all industry reconnaissance data, most of which have had only preliminary processing. Our best data are large source (550 and 1100 in^3) air-gun lines that were acquired digitally and processed through migration (Fig. 3 is a good example). We have proposed a large source 96-channel seismic survey for 1987 (Fig. 5) as a field experiment in preparation for the drilling program proposed here. That survey would provide a foundation for the drilling program, and the multitude of data shown in Figure 6 could be used for precise site definition and safety evaluation.

SUMMARY OF PROPOSED SITES

SITE #	LATITUDE	LONGITUDE	WATER DEPTH	PENETRATION	# OF DAYS
S1	10°20'S	121°12'E	1500m	1000m	9
S2	10°40'S	121°00'E	1100m	800m	8
S3	10°05'S	121°20'E	750m	1100m	8
T1	8°00'S	128°15'E	2500m	600m	8
T2	8°06'S	128°15'E	2250m	700m	8
F1	7°40'S	120°15'E	4900m	800m	13
F2	8°00'S	120°15'E	4000m	1000m	13
					67

The proposed drilling is longer than one leg. We will decrease the proposed time after determining the results of multichannel seismic work in this region in 1987.

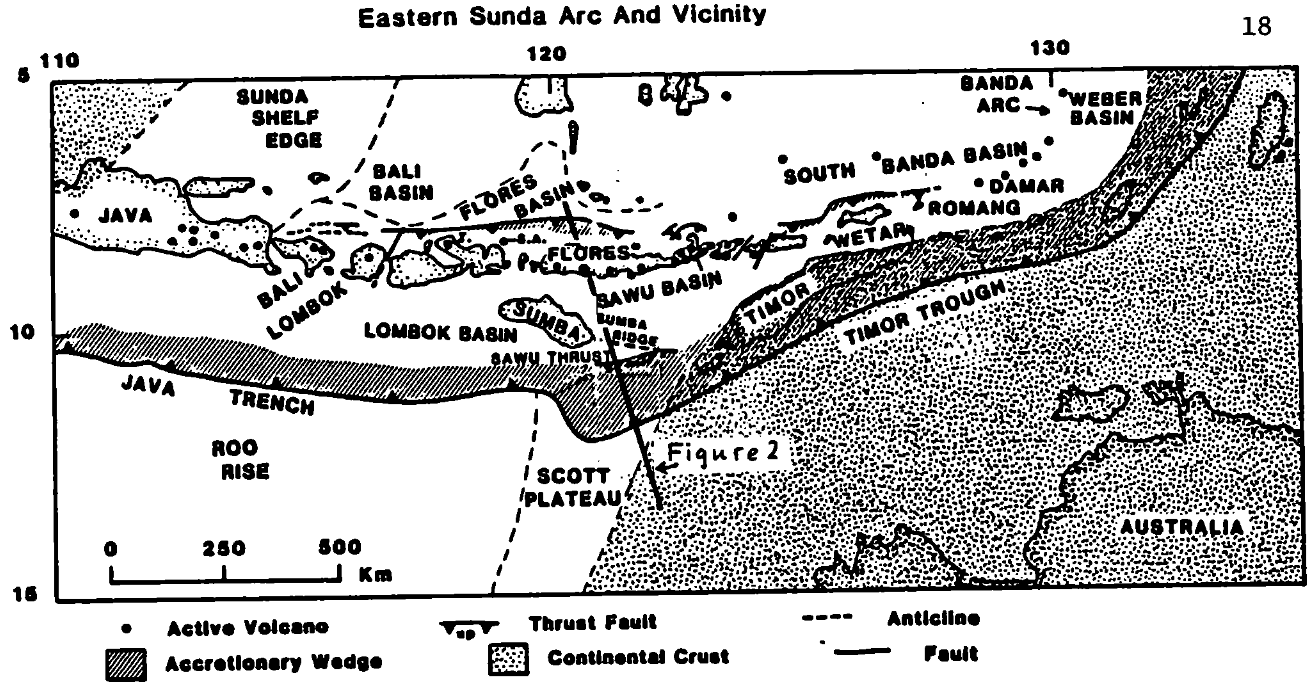


Figure 1. Map of the eastern Sunda arc region, showing locations of the major geographic features and of Figure 2.

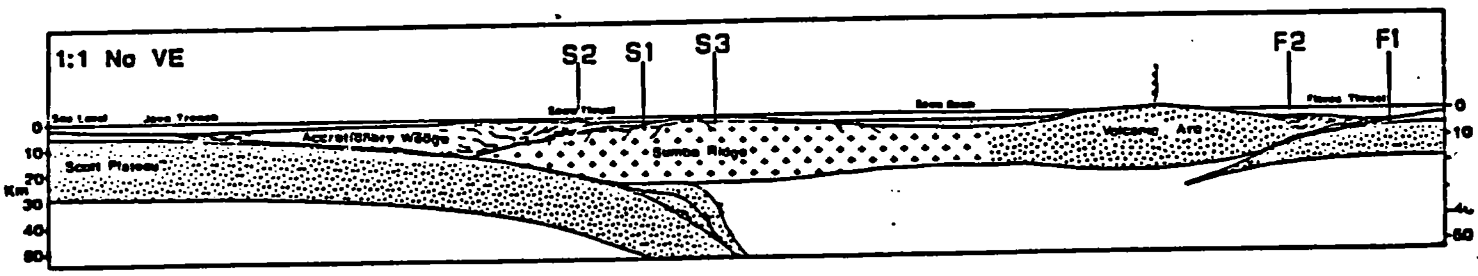


Figure 2. Interpreted crustal cross section across the eastern Sunda arc system, shown with no vertical exaggeration. Shown also are proposed drill sites S1, S2, S3, F1, and F2. Note hypothetical crustal duplex beneath S1 and S3.

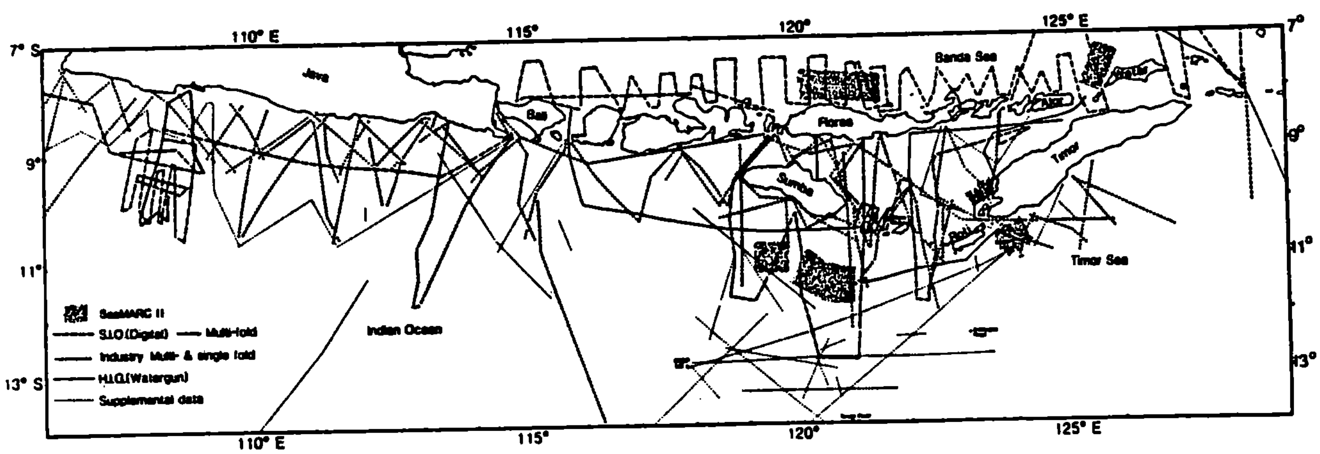


Figure 6. Locations of geophysical tracks in the eastern Sunda arc region. Specific cruises and sources are explained at lower left of diagram. Shaded regions showing SeaMARC II coverage also contain seismic profiles at a spacing too close to resolve in this figure.

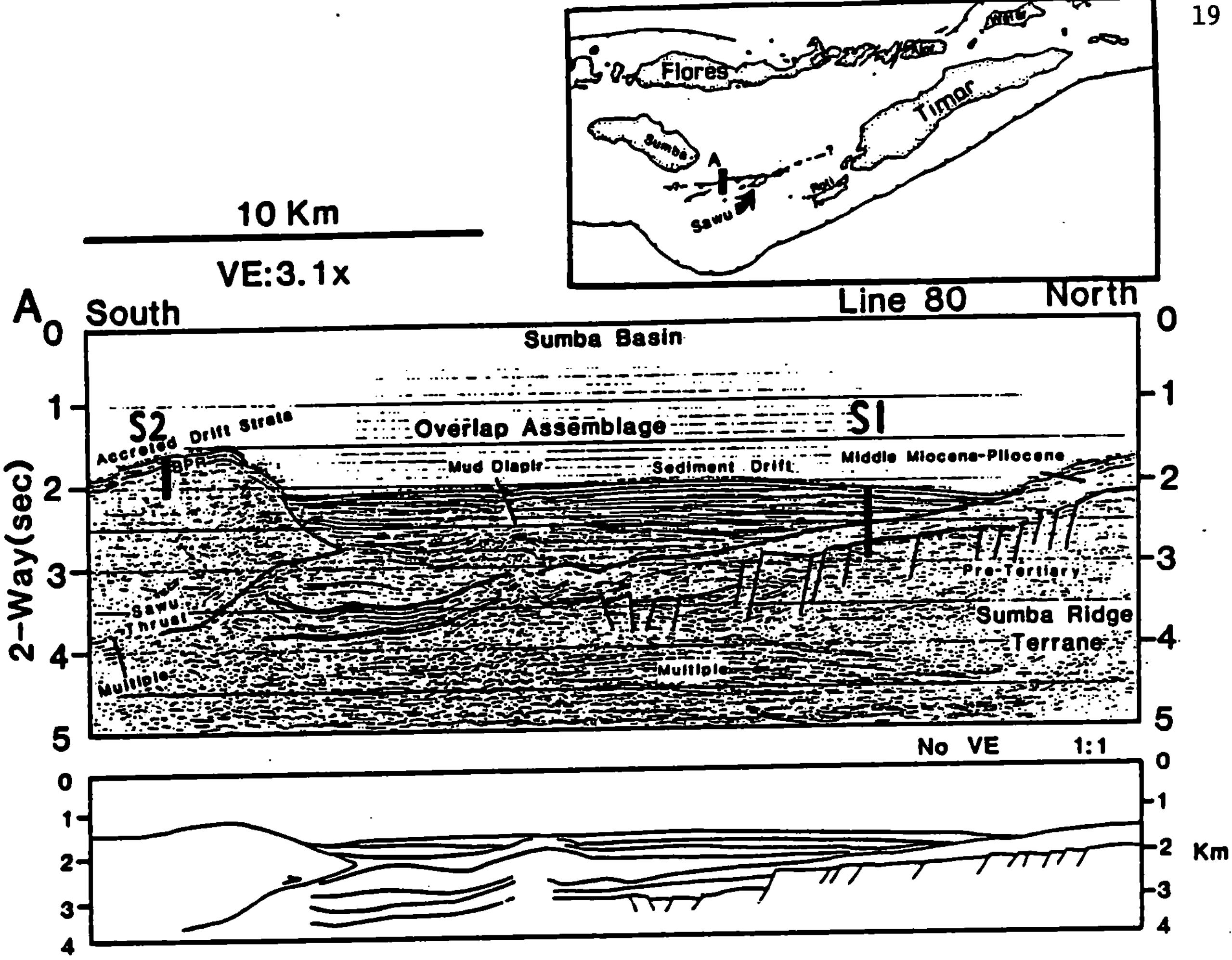


Figure 3. Migrated, digital single channel seismic profile across the Sawu thrust (modified from Reed et al., 1986), between Sawu and Sumba islands. Inset shows locations of profile and of Sawu island. Preliminary proposed drilling sites S1 and S2 shown also.

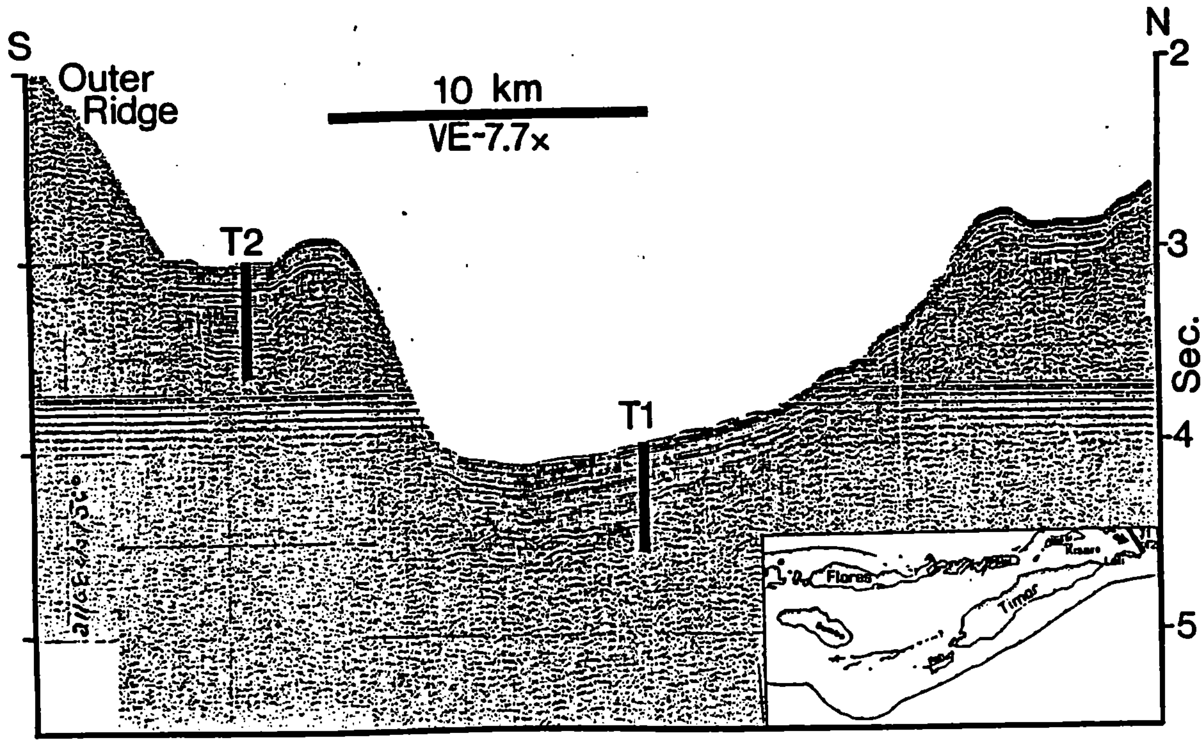


Figure 4a. Seismic profile across forearc basin east of Timor showing proposed drilling sites T1 and T2.

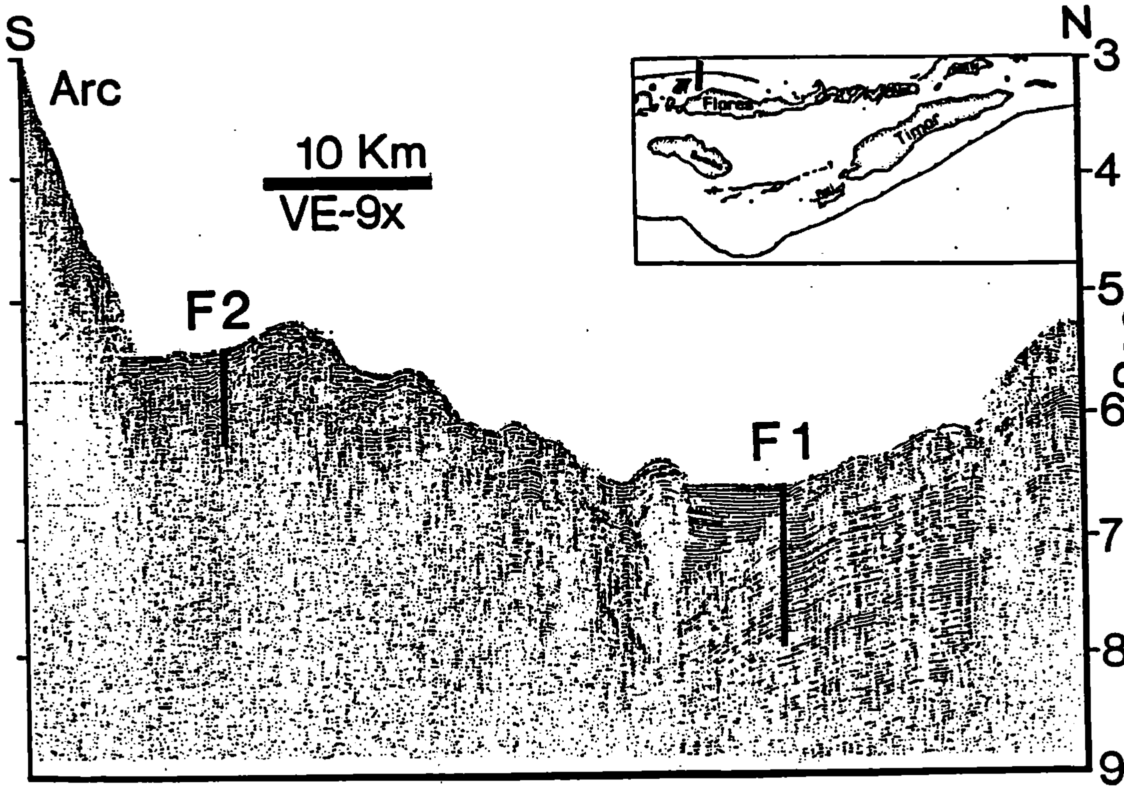


Figure 4b. Seismic profile across the backarc thrust belt north of Flores Island, eastern Indonesia (see inset for location). Loactions of proposed drilling sites F1 and F2 shown also.

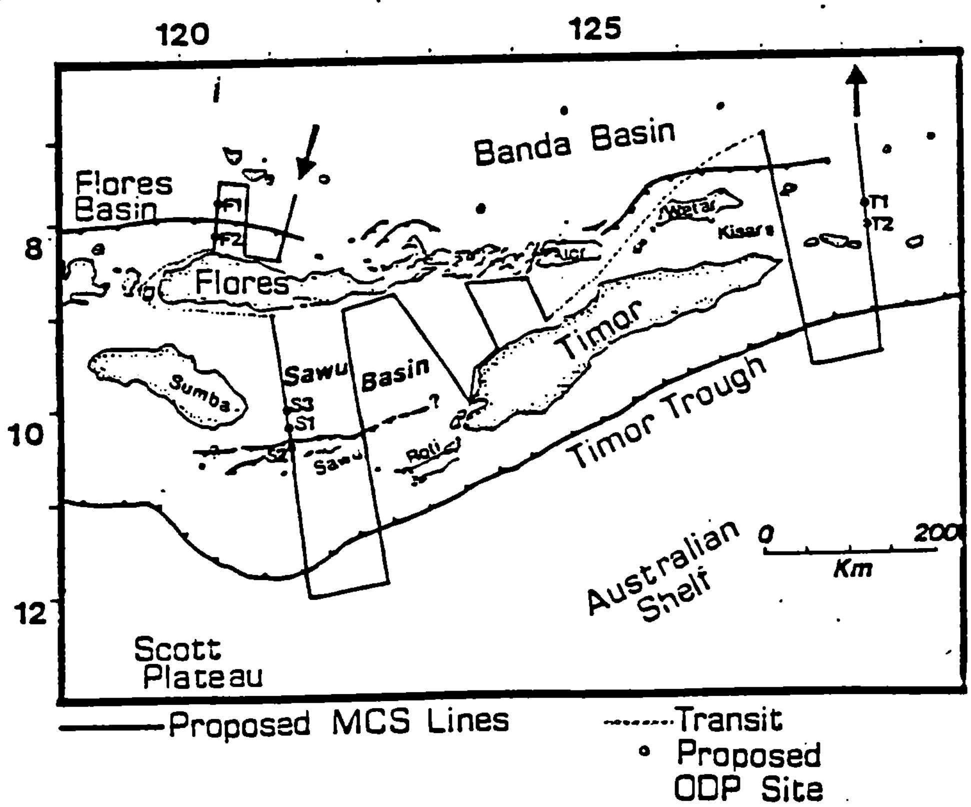


Figure 5. Map of eastern Sunda arc region, showing locations of proposed multichannel seismic profiles and proposed drilling sites.

THE BANDA, SULU, SOUTH CHINA SEAS TRANSECT

The western Pacific region is characterized by a complex ray of arc systems, collision zones, and marginal basins. This complexity is being studied by scientists from a great many institutions in a number of nations. A relatively simple set of observations, not yet carried out, has the potential for major breakthroughs in the geodynamic reconstructions of the western Pacific region. The observations involve drilling in the basins of the Banda sea, Sulu sea, and South China sea, which will augment drilling results planned for the Japan sea. These basins have behaved as geologic recorders while complex deformation was occurring around their edges. The geotectonic development has profoundly effected paleoceonographic patterns, and knowledge of each facet enhances the other (tectonics and paleoceanography). We propose drill sites in the Banda, Sulu, and South China seas.

The **Banda Sea** lies within the hub of the complex collision zone between Australia, SE Asia, and the Philippine Sea plate. Knowledge of the kinematic evolution of the Banda Sea will provide a crucial constraint on the development of this complex collision zone, a region that has been compared with the evolution of the ancient Cordillera mountain system of western North America.

Recent geophysical and geological studies of the Banda sea suggest that its origin may be a combination of entrapment of several small basins and slivering of a contintental borderland derived from Irian Jaya into the region. Such slivering would be nsistent with the presence of subaerial fragments of Irian Jaya surrounding the Banda sea, such as the Sula platform and parts of the islands of Buru, Seram, Buton, and Sulawesi. This proposed model of a 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 belts and a system for understanding possible histories of amalgamation of tectonostratigraphic terranes.

The north and south Banda basins (Fig. 1), attain water depths in excess of 5 km, have low average heat flow, and have up to 1 km of sediment cover, making them prime candidates for trapped, older oceanic crust. The northeast part of the Banda Sea, however, has shallower water depths, thinner sediment cover, high heat flow, and complex NE trending ridges, called the Banda Ridges. Dredging of these ridges yielded continental margin rocks that can be correlated with those of northern Irian Jaya. Geophysical studies of the ridges indicate that they are cut by a series of NE trending faults. The basins between the ridges may be young rift basins, and drilling there could record their rift history.

The drilling program consists of sites in the north and south Banda Basins and the Lucipara basin to determine the age and stratigraphic history of each region. Stratigraphy of the lower sections in the north and south Banda basins will test for similarity or difference in origin, and will be compared with the site in the Sulu sea, described below. The Neogene sections will provide a wealth of information on changes in paleoceanography as the Indian and Pacific ocean circulation systems were isolated, on the volcanic history of the eastern Sunda arc, and on the timing and history of rifting and emplacement of the ridges.

Recent models relating the Banda, Celebes and Sulu basins as fragments of a once continuous Indian ocean plate can be tested by drilling at least one site in the **Sulu sea**, in conjunction with the sites in the Banda sea. If the basins were once part of a larger, continuous plate, the stratigraphy in the basins should be similar prior to plate breakup. Alternatively, the Sulu sea may be related to either the South China sea or the Philippine sea plate, and the stratigraphies in each case should be distinguishable. In addition, the stratigraphy of the Sulu sea may contain the best record of the collisional events inferred for the Palawan and Sulu archipelagos, as well as providing a unique paleoceanographic record of the western boundary circulation pattern during the Neogene. Thus, a well-placed site within the Sulu sea, in conjunction with one or more shallow HPC sites, will provide a highly valuable geological reference site for unraveling western Pacific tectonics.

Paleoceanographic objectives in the Sulu Sea are focused on the anoxic and suboxic sedimentary record known to exist in this silled marginal sea. Insights into the depositional and paleoceanographic evolution of the Sulu sea basin gained via ODP drilling will have important implications for the interpretation of analogous Mesozoic and early Tertiary basins which evolved in similar carbonate-rich equatorial settings. Faunal and stable isotopic analysis (C^{13}, O^{18}) of the Sulu sea sequence will provide unusually detailed records of basin response to Quaternary and late Neogene glacial and interglacial climatic cycles.

The history of opening of the **South China sea** remains open to interpretation. Conventional dating of ocean basins by magnetic anomaly patterns do not easily work in small basins like the south China sea. Thus drilling is necessary to confirm the age and history of opening, as well as determining the history of the surrounding zone of tectonic collision, arc initiation and cessation, and uplift. A multiphase faunal and water mass history is thought to have accompanied the episodic tectonic and eustatic history of the South China Sea. Stratigraphic records in this basin will show variations in the composition, rate of accumulation, and modes of sediment transport during each phase of rift history reflecting eustatic control on terrigenous sediment, climatic control of pelagic materials, and volcanic events accompanying collisional events to the east.

We propose two sites in the south China sea. SCS-1 is in a thick sequence (1000 m) of pelagic sediments lying above postulated anomaly 6. This site will provide the primary evidence of the age and history of the south China sea, and will be used to calibrate the magnetic pattern in the basin. Site SCS-2 is located within a postulated younger site of spreading in the sea, and will penetrate a few hundred meters to basement. We predict his site will be on very young crust, and a few days devoted to this problem should be sufficient to solve it.

EXISTING DATA BASE AND REQUIREMENTS

Abundant analog single channel seismic profiles have been taken in the Banda sea by a number of institutions, but very few digital single channel or multichannel lines are available. The existing single channel data are sufficient to define the basement problems (where drilling could answer the questions of the age and origin of the basins), but they are insufficient for establishing regional stratigraphies and for imaging the structure of the Banda ridges. We clearly need site surveys within the Banda Sea to maximize the utility of the drilling ship here, and we plan a geophysical program in the Banda sea during 1987.

Abundant geophysical information is available for the Sulu sea, and these appear sufficient for site selection and interpretation. However, the French plan further multichannel studies in the Sulu sea and on its margins during 1987.

The south China sea also has abundant data, both on its margins and within the central part of the basin. SeaBeam has been used to map the postulated young rift within the basin. Additional multichannel data are planned for 1987 by both the French and the Germans.

SUMMARY OF PROPOSED SITES

SITE #	LATITUDE	LONGITUDE	WATER DEPTH	SEDIMENT THICKNESS	BASEMENT PENETRAT.	HOLE TYPE	# OF DAYS
BNDA 1	6°30'S	128°00'E	4600M	800M	50M	S	12
BNDA 2	4°25'S	125°12'E	4800M	800M	50M	S	12
BNDA 3	5°00'S	127°00'E	3400M	500M	50M	S	9
SULU 5	7°45'N	121°11'E	4300M	1200M	50M	S	14
SCS-1	15°40'N	116°20'E	4200M	1000M	50M	S	13
SCS-2	13°00'N	113°40'E	4000M	200M	50M	S	3
Total							63 days

The number of days is more than one leg but additional surveys should be able to identify sites where shorter holes can meet the objectives.

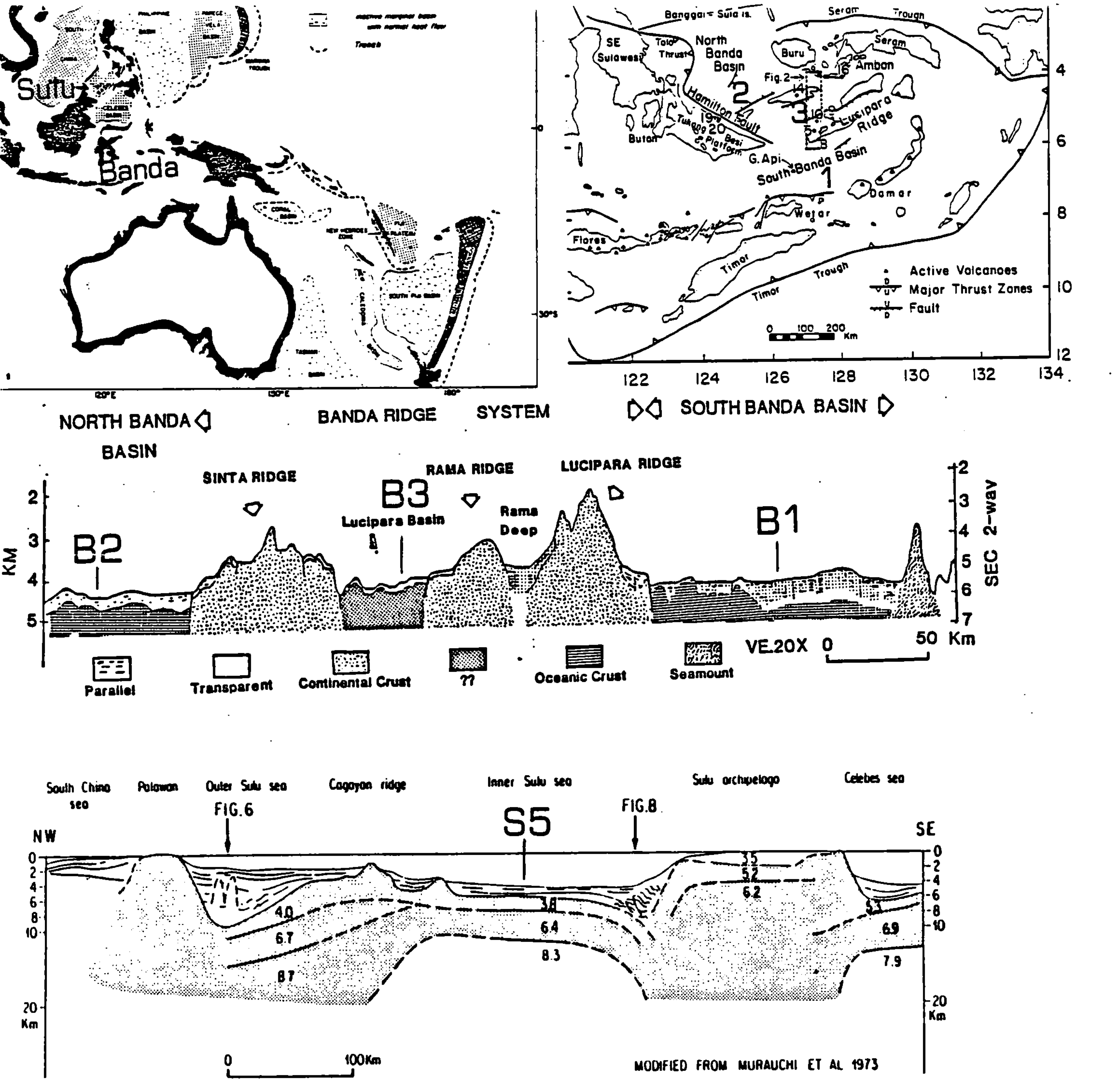


Figure 1. a) Western Pacific basins. b) Banda sea, showing proposed drill site locations. c) Composite cross section across the Banda sea, showing proposed drill site locations. d) Generalized section across the Sulu sea, showing proposed drill location.

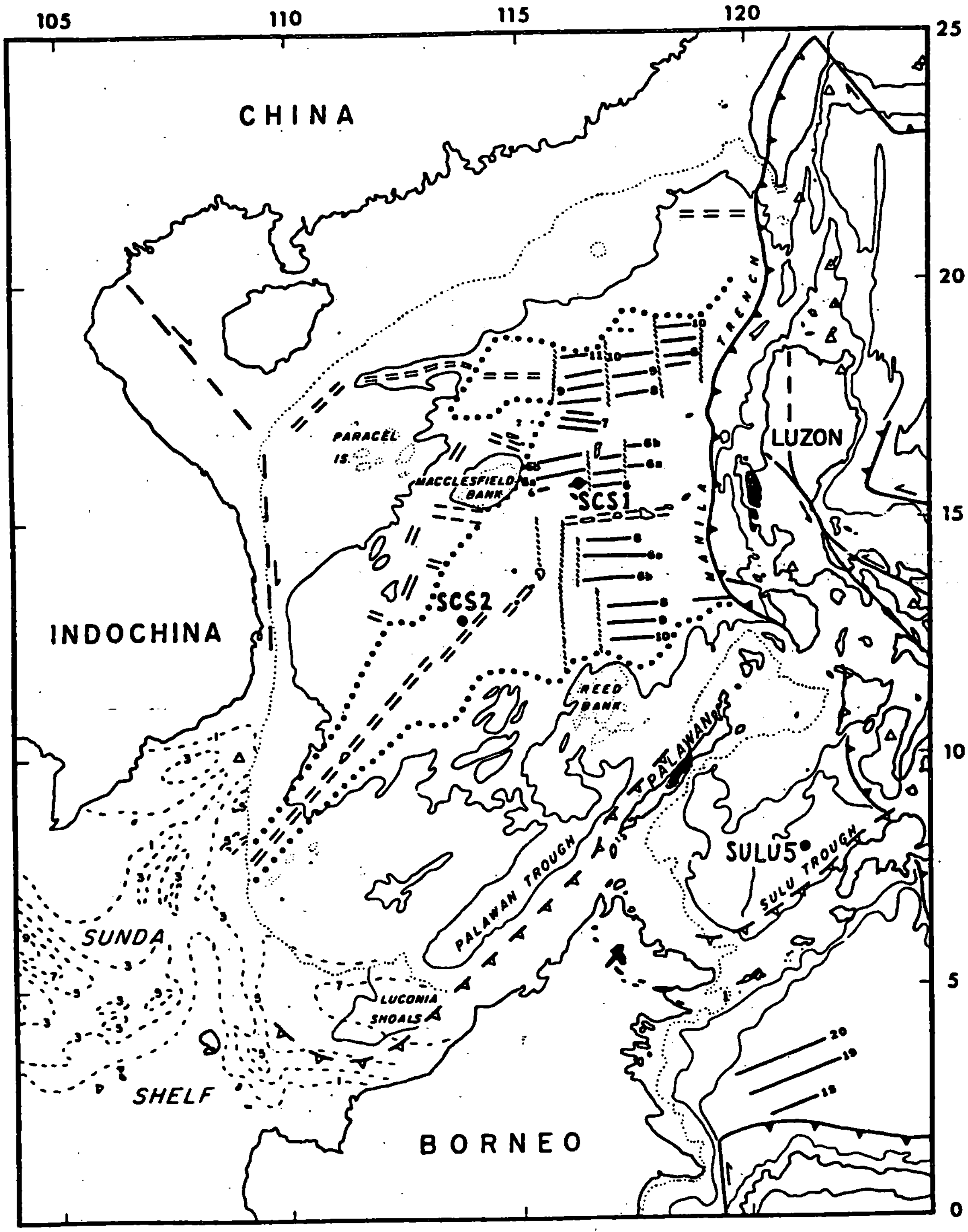


Fig. 2. a) South China sea, showing location of sites SCS-1 and 2.

Great Barrier Reef - Queensland Trough
ODP Leg Summary

The Great Barrier Reef - Queensland Trough province is composed of mixed reefal carbonate/siliciclastic shelf sediment thought to be principally controlled by climate, and relative sea level. During periods of low sea level deltaic progradation occurred at the shelf edge accompanied by fan deposition on the mid- and lower slope. The oldest sedimentary sequences beneath the shelf occur eastwards of a major fault zone lying beneath the middle shelf, and forming the western boundary of the Queensland trough rift basin. An interpreted basal Late Cretaceous rift-fill sequence containing volcanics is overlain by a marine onlap facies interpreted to be Paleocene to Late Eocene in age. These strata are in turn overlain by oblique, complex sigmoid-oblique and sigmoid progradational facies of probable Late Oligocene, Late Miocene, and Plio-Pleistocene ages (Symonds, 1983).

Along the continental margin the Central Great Barrier reef facies was established during the Pleistocene. The reefs grew on siliciclastic fluviatile and deltaic sediments during periods of high sea level, and were subaerially eroded during the intervening periods of low sea level. There is clear latitudinal variation in the nature and timing of reef growth. The reef is thicker in the north and has a multi-phase growth. In addition, side scan sonar profiles of the upper slope of the Great Barrier Reef have identified shelf parallel drowned reefs which are, apparently, low sea level analogues of the present outer barrier (P. Davies, written pers. comm., 1986). The earliest reef growth in the region probably began on basement highs on the Queensland Plateau in the Early to Middle Eocene (Pinchin and Hudspeth, 1975) although some consider that reef growth did not commence until the Late Oligocene and Early Miocene following stabilization of an equational circulation pattern (Taylor and Falvey, 1977). Reef growth today covers almost one-quarter of surface of the Queensland Plateau and the areas of buried reefs indicate this may have been even greater in the past.

In the Queensland Trough distinct seismic packages are identified and tied to major sea level oscillations. The eastern margin of the Queensland Trough is carbonate dominated and sediments have two sources: reef derived material from the Plateau area and planktonic material. Dredging of a series of seamount-like features in the Trough at depths down to 1200 m indicate a shallow water reefal origin for the seamounts and rapid subsidence rates (Plio-Pleistocene rates of 100-500 m per MY) for the Queensland Trough (P. Davies, written pers. comm., 1986).

The Great Barrier Reef area is an excellent example of a mixed carbonate/siliciclastic province in a passive margin setting. This area can provide important facies and stratigraphic models for understanding ocean history, the evolution of passive margins and ancient carbonate depositional systems. The following objectives have been identified and would be addressed by ODP drilling on the slope of the Great Barrier Reef and in the Queensland Trough:

(1) Sea level controls on sedimentation,
(2) the effect of plate motions and subsidence cycles on sedimentation and paleoceanography,

(3) an understanding of tectonic cycles in relation to sea level cycles,
(4) changes in paleoclimate related to plate position and the effect on sedimentation,
(5) slope/basin sedimentation - fans and lowstand deposits.
(6) basin fill history,
(7) Late Paleogene-Neogene paleoceanography,
(8) diagenetic history in a stratigraphic framework, and
(9) comparison of the history of a continental margin and an isolated plateau (Queensland Plateau).
(10) diagenesis of mixed carbonate/siliciclastic and pure carbonate sequences under an undersaturated ocean regime significantly different to that in the Caribbean and Indian Ocean.

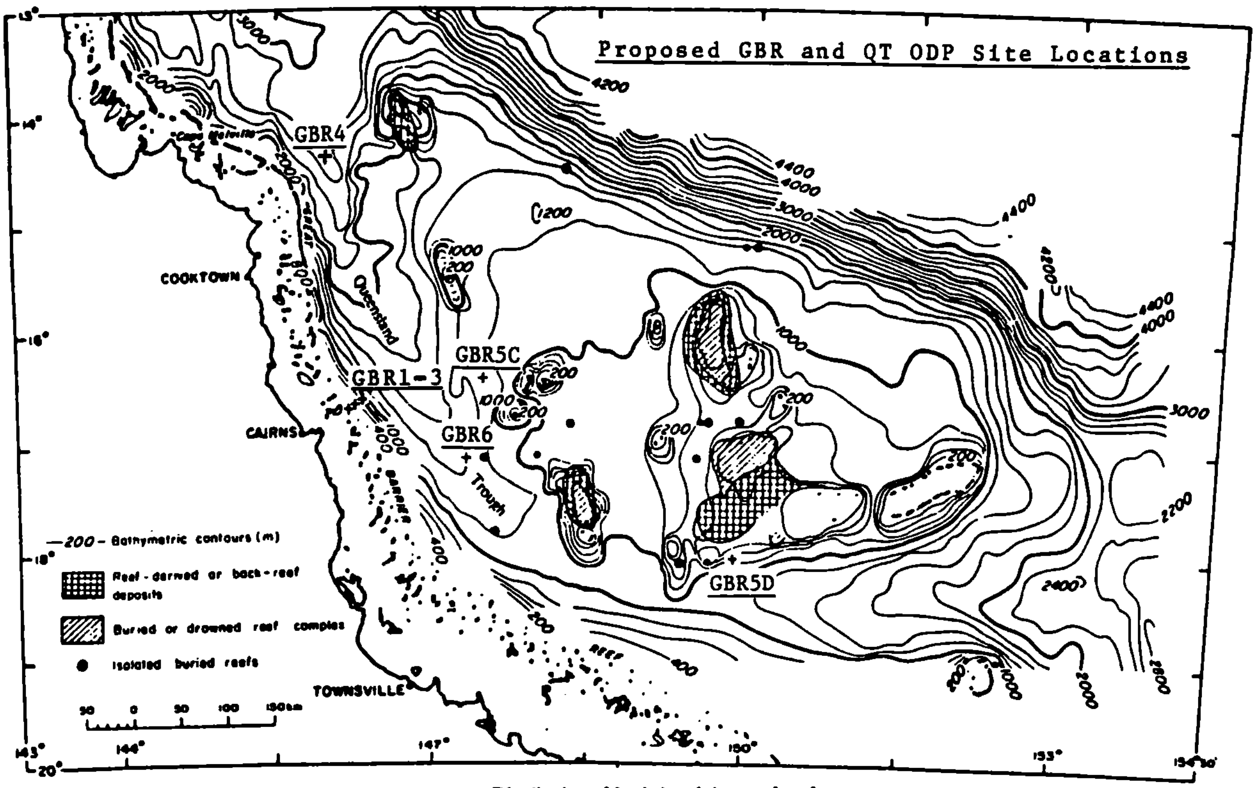
In addition, a transect in this region would be able to be tied to a shallow-water continental shelf program, which the Australian Bureau of Mineral Resources has undertaken.

The immediate goal is a transect of five holes. One hole would be in the slope area to drill the paleoshelf deposits and toe-of-slope carbonate detritus (GBR1). One hole would be at the paleoshelf margin for sediment history and slope deposition (GBR2). A third hole would be located to drill the toe-of-slope to basin transition, and the older Queensland Trough sediments (GBR3A/3B). A fourth hole would be drilled in the central Trough near the western margin of the Plateau for a basinal reference section, paleoceanography, and basin history (GBR6). The fifth hole is located on the northwestern margin of the Queensland Plateau to investigate the subsidence history of the Plateau and the periplatform sediment cycles (GBR5C/D).

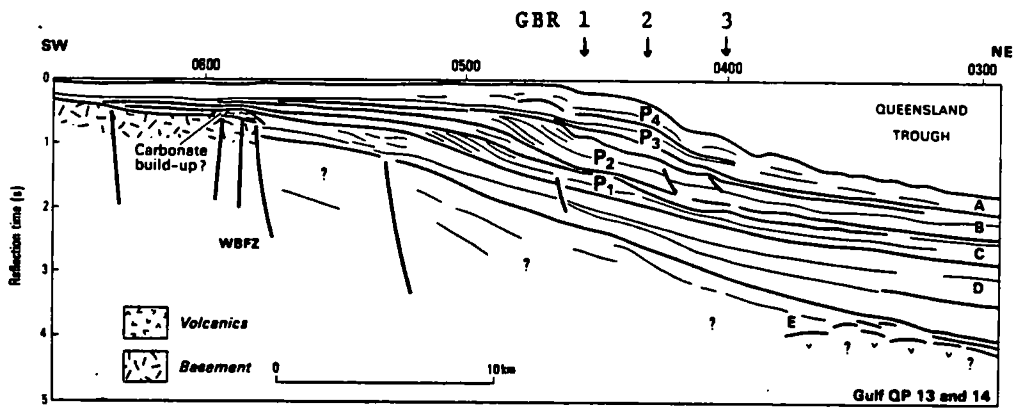
Site Summary Table

Proposed Holes	Relative Priority	Approx. Location	W.D. (m)	Penetration (m)	Est. Time Required On-Site
GBR1	1	16°38.7'S,146°17.5'E	150	1000	10-12 days
GBR2	1	16°38.2'S,146°18.5'E	315	1000	10-12 days
GBR3A	1	16°33'S,146°19'E	863	1000	10-12 days
GBR3B	(1)	16°26'S,146°14'E	950	1000	(10-12 days)
GBR4	2	14°19.2'S,146°8'E	2745	2200	(20 days)
GBR5C	1	16°27'S,147°46'E	1050	1500	15 days
GBR5D	2	18°04S,149°44'E	750	1500	(15 days)
GBR6	1	17°09'S,147°19'E	1450	700	10 days
					55 - 61 days

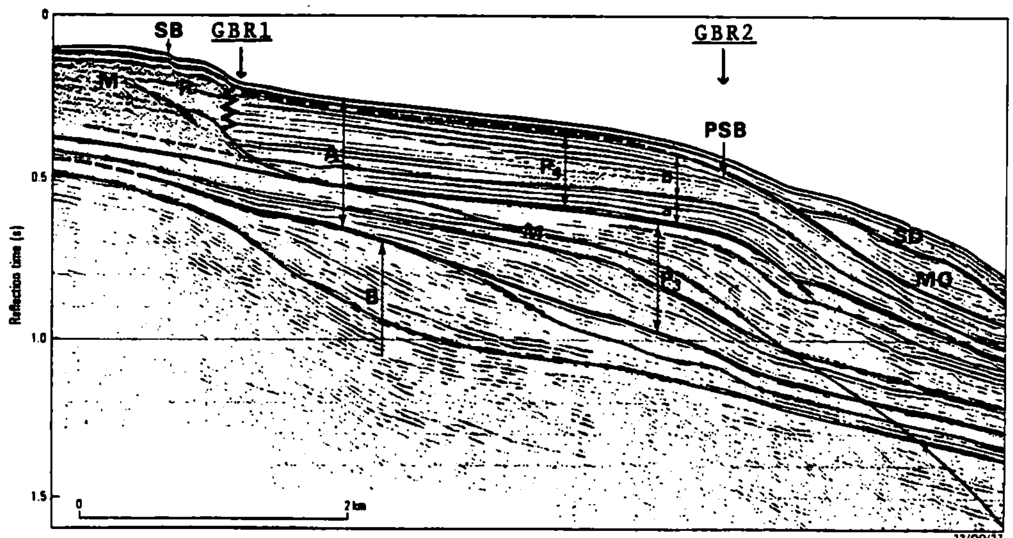
WPAC estimates that to drill the dive holes to the depths proposed will require more than one leg (≥ 60 days). We propose less penetration rather than fewer sites; the transect should not be sacrificed.



Distribution of buried and drowned reefs



Interpretation of processed Gulf seismic profile: Grafton Passage transect. The major seismic sequences (A, B, C, D, E), and progradational phases (P1, P2, P3, P4) are labelled. WBFZ is the western boundary fault zone of the Queensland Trough rift basin.



Sparker profile at the eastern end of the Grafton Passage transect.
Amplitude-corrected, 12-fold stacked section. Shows prograding, mounded onlap (MO), sheet-drape (SD) and reef facies (R). Note the amount of shelf out-building and the relative positions of the present-day shelf break (SB) and the Pleistocene palaeoshelf break (PSB). Major seismic sequences (A, B) and progradational phases (P3, P4) are labelled. P4 has been subdivided into seismic facies units 4a and 4b. M is the first water-bottom multiple.

SUMMARY OF THE NANKAI TROUGH DRILLING PROGRAM

Objectives

The quantitative measurement of in situ physical properties at the toe of accretionary prism is the goal of the Nankai Trough drilling program. Important problems related to the accretionary processes at convergent plate margins can be adressed. It has been generally accepted that the complex interaction between stress, physical properties and dewatering processes within the accretionary prism controlls the development of small-scale structural fabrics and evolution of large-scale strucural elements such as decollement and major imbricated thrusts. However the lack of detailed quantitative information which can be used for various modeling and testing of hypothesis hindered to answer how this interaction actually operates.

The Nankai Trough is especially suited for this type of drilling program for a number of reasons. The structural framework of toe of accretionary prism is extremely well resolved. The depth and scale of decollement and major thrusts are well defined. The trench floor is shallow and gas concentration is low. The sediments are terrigenous clastics whose response of physical properties to stress and strain can be better understood than biogenic sediments. A large amount of supporting data and extensive site survey program exist. The hole conditions encountered in Legs 31 and 87 were fairly good compared with other convergent margin sites.

The sediments of Nankai Trough are composed of two units: Pleistocene turbidite unit and Plio-Oligocene hemipelagic unit. The decollement, showing the maximum width of 30km detachment zone, develops within the upper part of hemipelagic unit.

Proposed Sites

The strategy of drilling is similar to the Barbados leg(Leg 110). A reference hole in the undisturbed sediments at the trench and another hole to penetrate major thrust and decollement. A complete program of logging and down hole measurements should be included. The various technology developed for Leg 110 plus wireline packer operation should be carried out.

Two proposals, one by Taira et al. and the other by Karig are relevant to this program. They basically proposed the same objectives in the different locations. Karig's proposal selected the site near Site 583. The advantage here is obviously the availability of various background information useful for drilling and interpretation. The problem of this site, however, is that the sediments are too thick(2000m) to make a complete penetration. Because the information on porefluid state and physical condition of the hemipelagic unit underneath the detachment zone will be crucial for understanding the mechanism of large-scale structural development, it is required to sample a complete section down to the top of oceanic crust.

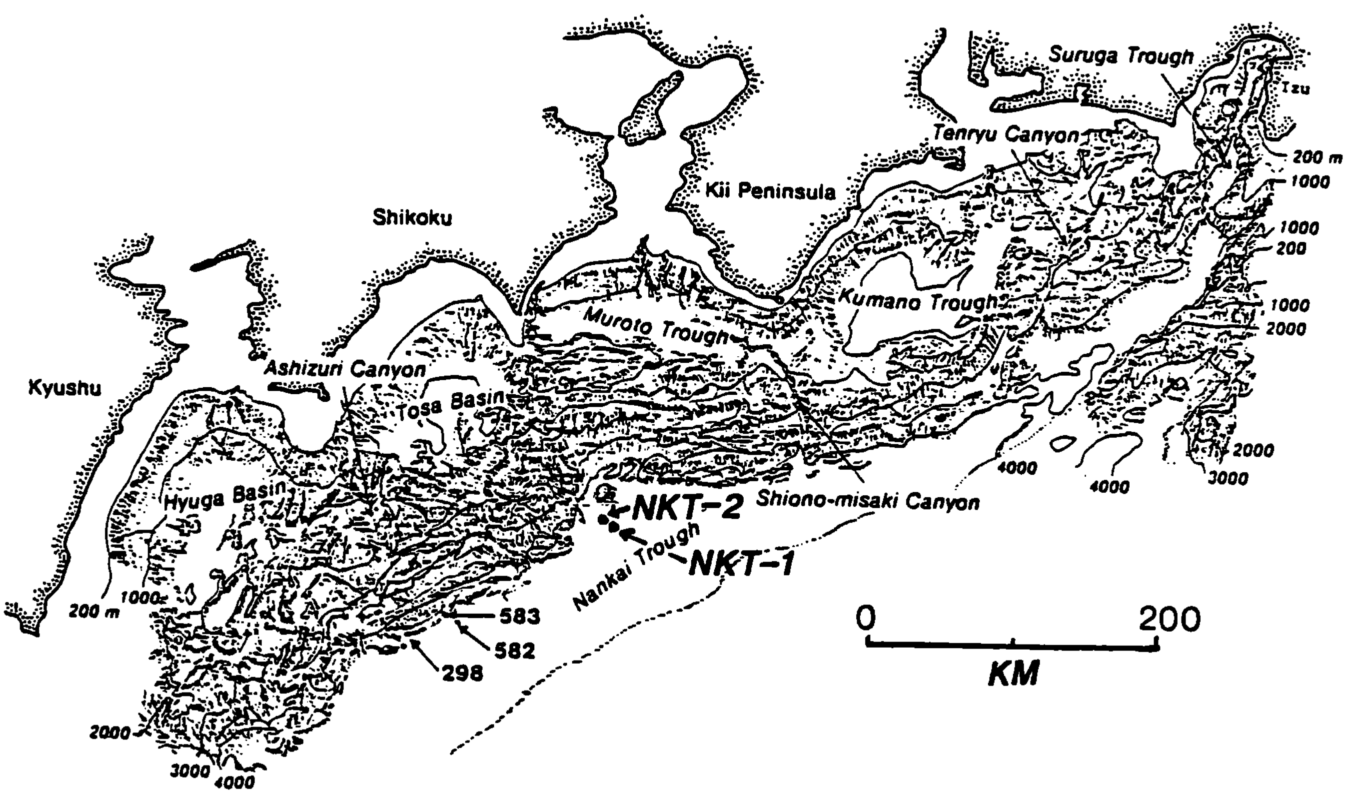
The two sites proposed by Taira et al. are located about 110km to the northeast of Sites 582 and 583, where the sediments are thinner amd heat flow is anomalous suggesting an active fluid circulation. (NKT-1 and NKT-2 mentioned in this program summary are on the different seismic line, 20km to the west, from the original proposal.)

NKT-1: This is a reference hole at the undisturbed trench-fill. The lithology is composed of a 600m thick upper turbidite unit and a 300m thick lower hemipelagic unit. A complete penetration of two units is required. Logging and down hole measurement programs including pore pressure, permeability and sonic velocity measurements, pore fluid sampling and borehole televiewing will be necessary.

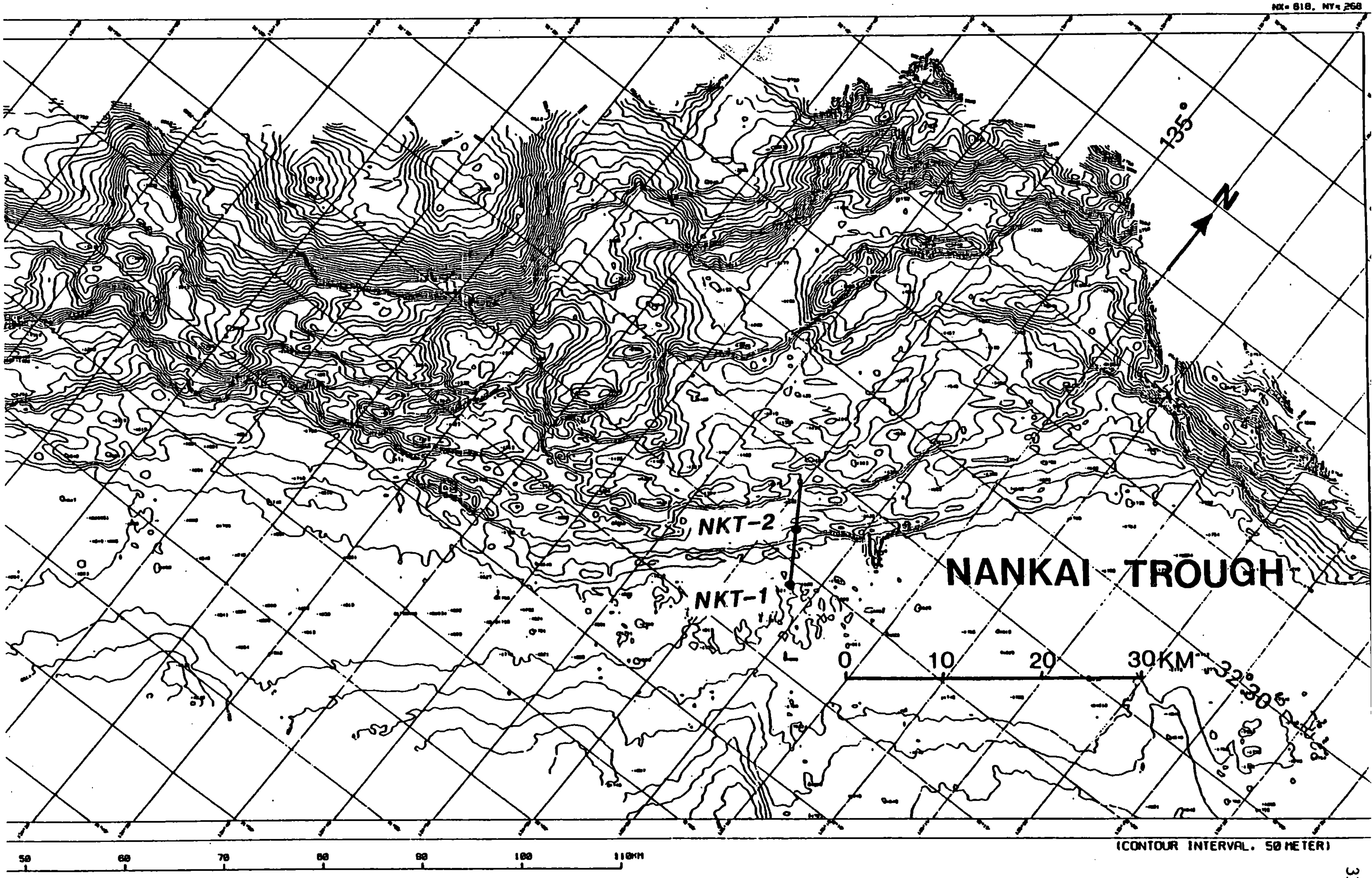
NKT-2: This is a deep hole to sample a complete sequence of deformed sediments at the toe of prism. The hole should penetrate into a major imbricated thrust, main decollement, hemipelagic unit to the top of oceanic crust. The turbidite unit is 1000m thick and hemipelagic unit is 300m thick. Well designed logging and down hole program should be prepared to take the required information of physical properties of sediments and porefluid characteristics.

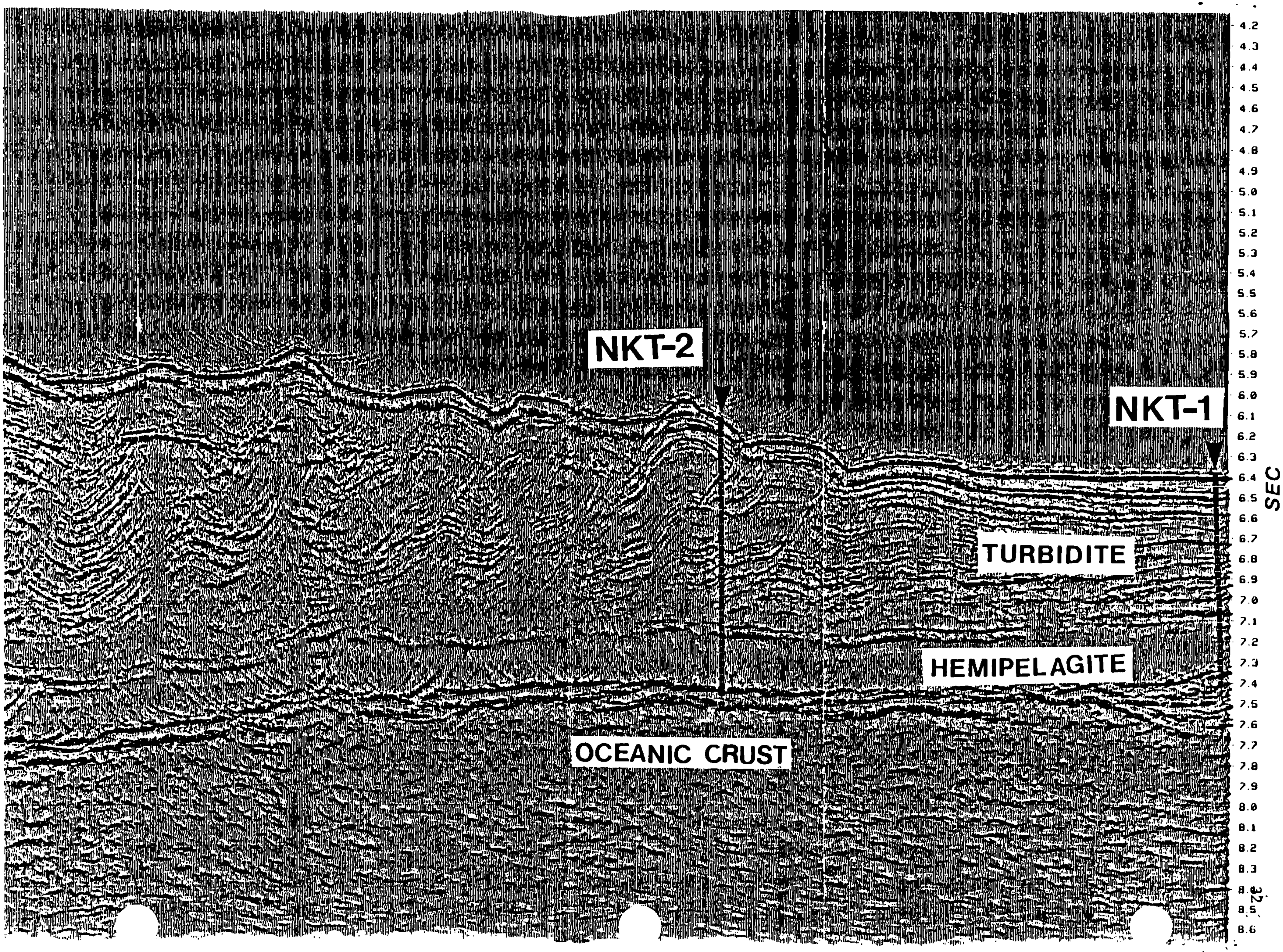
Summary of Proposed Sites

#	Lat.	Long.	Water Depth	Drill. Days	Penetration	Hole Type
NKT-1	32 18	134 58	4803m	20	900m	APC Rotary
NKT-2	32 23	134 56	4730m	35	1300m	APC Rotary Reentry



BOX6(JCBX6C)-1
TOPOGRAPHIC MAP (SEA BEAM) IN METER




NKT-2
NKT-1
TURBIDITE
HEMIPELAGITE
OCEANIC CRUST
SEC
4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 5.0 5.1 5.2 5.3 5.4 5.5 5.6 5.7 5.8 5.9 6.0 6.1 6.2 6.3 6.4 6.5 6.6 6.7 6.8 6.9 7.0 7.1 7.2 7.3 7.4 7.5 7.6 7.7 7.8 7.9 8.0 8.1 8.2 8.3 8.4 8.5 8.6

SUMMARY OF THE LAU BASIN DRILLING PROGRAM

The Lau Basin is an active back-arc basin between the Lau Ridge (remnant arc) and the Tonga Ridge (arc). Magnetic anomaly patterns suggest that the Lau Basin is probably less than 3 Ma old. The Lau Ridge was an active volcanic arc from 14 to 5 Ma and is built on basement that has rocks of Eocene and Oligocene age. The Tonga Ridge is a chain of active volcanoes - some emergent and others forming seamounts and shoals - together with older crust, some of which has been uplifted to form limestone-capped islands such as Tongatapu and Vavau. The oldest uplifted rocks are Eocene. The age at which volcanism started in the Tonga arc is not well known.

Recent surveys of the Lau Basin and Tonga Ridge have provided a wealth of new information about the region much of which was not presented at the U.S. Western Pacific Arc, Trench, Backarc System Workshop and has not yet been completely synthesized. A working group consisting of representatives of all of the groups that have collected data from this area has been requested. Although several sites for drilling in the area have been proposed, the Western Pacific Panel will not propose a specific program of drilling until the working group has had time to consider the many new data. We envisage a leg comprised of at least three holes in the basin, each with significant basement penetration. The Western Pacific Panel considers the major drilling objectives which can be addressed in this region to be:

1) The petrologic development of the Lau Basin, particularly the evolution of the basin's basalts from having a significant island-arc geochemical signature to having virtually none at all;
2) The role of silicic magmatism in certain parts of the basin:
3) Back-arc geothermal and hydrological processes and their evolution through time;
4) A fourth objective, the nature/development of the Tongan forearc and the history of arc volcanism, could be addressed by one hole in the forearc, but panel opinion was divided, with a majority preferring that the basin objectives not be compromised by forearc drilling.

Petrologic Development

Studies of the many backarc basins in the western Pacific have demonstrated that the principal rock type formed during the spreading process is tholeiitic basalt that is similar to basalt types formed at mid-ocean ridges. In spite of this similarity to MORB, there are subtle but significant differences in the abundances of several components of the basalt, including alkalies, alkali metals, LREE, water and the isotopic ratios of $^{87}Sr/^{86}Sr$ and $^{3}He/^{4}He$ that suggest that 1) the mantle source beneath backarc basin spreading centers may be different from that at mid-ocean ridges and 2) there may be contributions of "volatile" components derived from previously subducted oceanic lithosphere. These chemical differences are expressed in the different compositions of eruptive rocks in back-arc basins in various stages of evolution and also as compositional zonations within individual back-arc basins.

Three types of site location have been proposed to investigate the petrologic development of the Lau Basin: (i) at the western edge of the basin where about 700 m of sediment could be penetrated to recover stretched crust and eruptives from the initial rifting of the Lau-Tonga arc, (ii) nearer the center of the basin where basaltic rocks having a significant arc-like geochemical signature (Mariana Trough type) are expected on the basis of dredge results, and (iii) near or on the spreading axis of the basin where basaltic rocks having compositions similar to N-MORB have been dredged. Drilling would recover sequences for lava stratigraphy. There has been interest on the part of the Lithosphere Panel in drilling zero-age crust in a back-arc environment as a complement to drilling zero-age crust at mid-ocean ridge crests. Such drilling would focus on comparison of the rocks and of their geophysical setting in the back arc with analogous environments on mid-ocean spreading centers. Until specific sites are proposed based on all of the existing data, however, WPAC proposes only a generic transect of drilling to address the problem of petrologic evolution and does not endorse a leg dedicated to a bare rock hole.

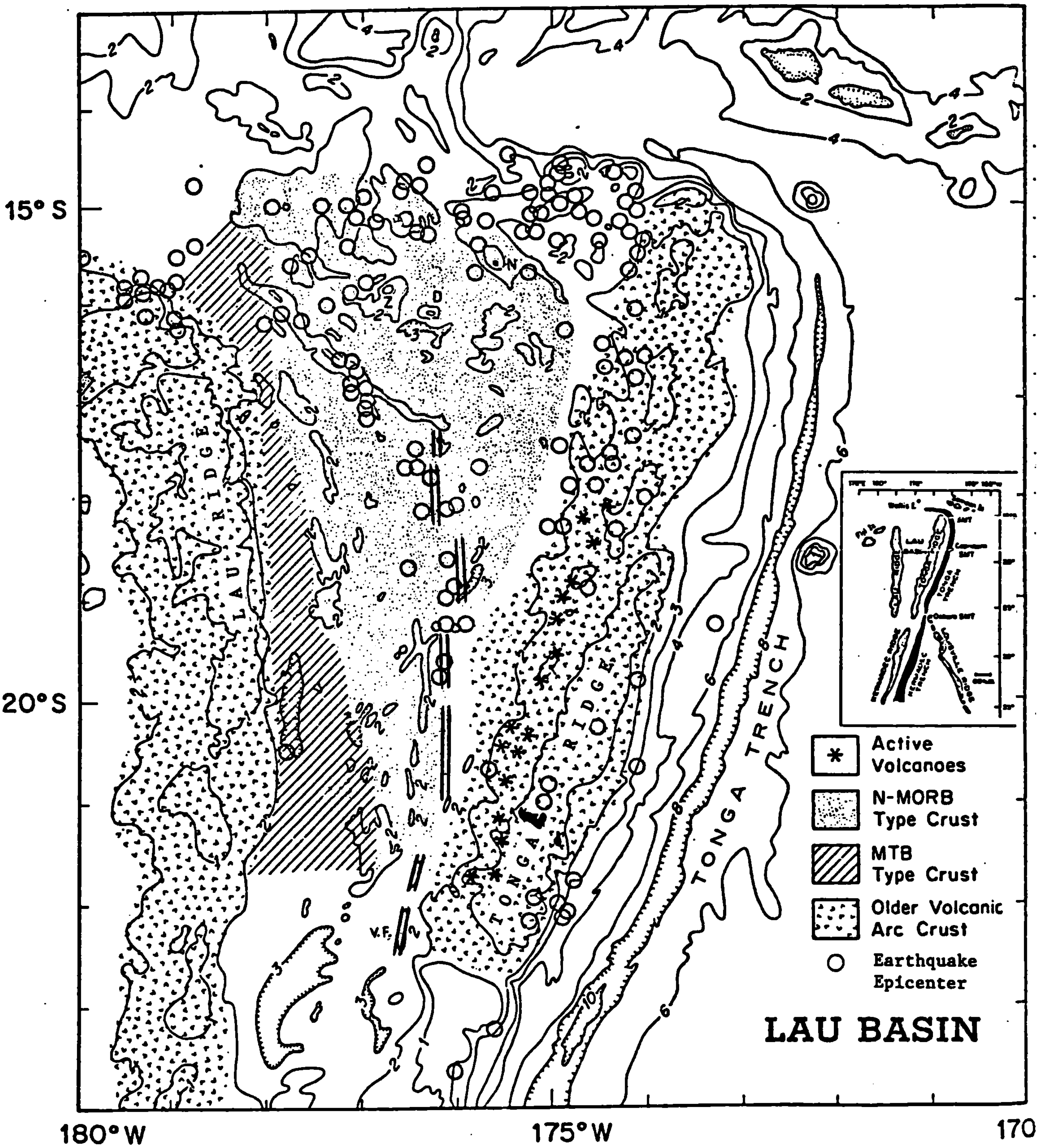
Silicic Magmatism

Silicic magmatism is also common in back-arc settings. For example, rhyodacite vitrophyre is being extruded in an area in which a magma chamber has been imaged at Valu Fa in the Lau Basin. Silicic rocks have also been dredged from a variety of settings in the Mariana Trough and the rifted basins in the Bonin Arc. Dacites have also been dredged in the northeast Lau Basin on ridge segments that appear to be propagating rifts. The similarity of rock types and structural settings suggests that back-arc environments may be the site of origin of ophiolites and that more detailed petrologic studies of backarc basins will lead to greater understanding of ophiolites. Sites have been proposed on the Valu Fa Ridge and in the northeast Lau Basin to determine the lava stratigraphy and relationship of these silicic rocks to the tectonic and structural character of the basin.

Hydrothermal Systems

Hydrothermal systems have been discovered in both spreading axis and off-axis areas of back-arc basins. Within the northeast Lau Basin sulfides similar to those in the chimneys of high temperature mid-ocean ridge crest vents have been dredged. The potential differences in these systems related to mantle sources and the influence of the downgoing slab are also important. These objectives are ancillary to the petrologic objectives stated above, however. Until a more specific program is developed which would identify targets for such drilling and study of the systems, WPAC will view the hydrothermal aspects of drilling in the Lau Basin as a lower priority than the petrologic objectives.

Iron and manganese-rich hydrothermal sediments have also been recovered from some areas of the Lau Basin. Such sediments provide the potential for comparison with hydrothermal sedimentation at mid-ocean ridges and for investigating variations in the hydrothermal activity of the back-arc environment through time. Such topics could be addressed by studies of the sediment column recovered during drilling of sites in the Lau Basin.


15° S
20° S
180° W
175° W
170
LAU RIDGE
TONGA RIDGE
TONGA TRENCH
V.F.
Active Volcanoes
N-MORB Type Crust
MTB Type Crust
Older Volcanic Arc Crust
Earthquake Epicenter
LAU BASIN

SUMMARY OF THE NEW HEBRIDES (VANUATU) DRILLING PROGRAM : REVISED JULY, 1986

This summary presents the principal objectives selected from two proposals (TAYLOR JOI, Inc. # 187; Fisher et al. JOI, Inc. # 190) by the West Pacific Panel for a one leg ODP drilling scenario in the New Hebrides (Vanuatu) arc. The West Pac Panel recommends to restrict drilling time at 45-46 days in order to allocate time for down whole experiments.

TECTONIC SETTING

During the Miocene and early Pliocene time the New Hebrides island arc apparently underwent a reversal in arc polarity, after which the Australia-India plate began to underthrust the arc from the west at a rate of at least 10 cm/year. Since this polarity reversal, extensional back-arc troughs formed that probably are still in an early stage of rifting. The d'Entrecasteaux zone (DEZ) encompasses two east-trending aseismic ridges that tower over the Australia-India plate, and the rapid convergence between this plate and the arc carried the DEZ eastward to collide with the central arc beginning about 2 m.y. ago. This collision appears to have exerted profound influence on arc structure in that the collision occurs directly west of the deep, intra-arc Aoba basin. Furthermore, the collision seems to have suppressed or inhibited back-arc rifting. Clearly, much of the unusual morphology and structure of the central arc as well as the distribution and rates of vertical deformation and the historical seismicity pattern have been strongly influenced by collision of the DEZ with the arc.

OBJECTIVES

The principal objectives of the proposed drilling include the study of arc processes involved in arc-ridge collision, back-arc rifting, subduction-polarity reversal, and the formation of intra-arc basins. A great advantage to drilling in the New Hebrides arc is that these wide ranging objectives can be investigated within a small geographic area by astutely chosen drill sites. The drill sites provide a transect completely across the arc, with one or more sites planned for each major tectonic subdivision of the arc. The transect will allow us to find out which tectonic events have arcwide consequences. Moreover, most proposed sites will contribute information concerning at least two of the four principal objectives.

Arc-Ridge collision

The DEZ-arc collision is the prime focus of our drilling proposal. Drill sites within the collision zone are designed to determine what influence ridge composition and structure exert on the style of accretion and type of arc structures produced during collision.

DEZ 2 is located where the North ridge of DEZ is subducting; it will penetrate the lowermost accretionary wedge, the interplate thrust fault and the North d'Entrecasteaux ridge itself. It will allow to determine the age and mechanical properties of rocks where, despite the great relief of the subducted ridge, the collision has caused little apparent deformation on the arc in the present contact zone.

DEZ 3 is located on a bathymetric knob called Wousi Bank that lies just west of Espiritu Santo island along the strike of the DEZ's North Ridge. The main purpose for drilling this site is to determine whether the Wousi Bank includes a large block of North Ridge rock accreted into the arc and thus test the large block accretion hypothesis.

DEZ 4 is located within the arc southern DEZ ridge collision zone adjacent to the Bougainville seamount. The purpose is to drill into imbricated rocks flanking the guyot to test whether these rocks are an old uplifted accretionary wedge, a piece of recently accreted part of the DEZ southern ridge or island arc basement. We will contrast these results with what we discovered from drilling near the DEZ North ridge where arc structures induced by the collision are significantly different.

Intra-arc Basins

The purpose for drilling in Aoba Basin is to investigate the processes active during the development of intra arc basins, the evolution of magmatic arc and the hypothetized reversal in arc polarity.

IAB 1 is located within the western part of the North Aoba basin which lies beneath significantly deeper water than does any other basin near this arc summit. This drilling will penetrate the sedimentary filling of the intra arc basin down to the major unconformity which results from the tilting of the fore arc related to the arc / DEZ ridge collision; it will allow to determine the age when collision began as well as the timing of the subsidence and paleoenvironment evolution. The chemistry of volcanic ashes may show whether the arc magmatism is modified by DEZ influence.

IAB 2 is located on the eastern flank of the North Aoba basin where the deepest basin units are at shallow depth. The purpose for drillings is to determine the evolution of magmatic arc and basin before the beginning of arc ridge collision and to test and date the reversal in arc polarity.

Back-arc troughs

The morphology, tectonics and seismic activity of these troughs suggest a still active rifting process.

Although the back arc troughs lie east of the volcanic line, fresh basalt and volcanic glasses have been dredged from volcanic edifices discovered on their bottom. The chemical composition of these samples shows arc basalt to BAB affinities. We propose to drill at a site which may show the range of volcanic rocks and ashes composition and the possible sequence of compositionnal changes that attend incipient rifting. We drill one of the three sites (BAT 1a, 1b, 2) which will be chosen after the site survey and the chemical analysis completion of all dredged rocks collected in the area.

SITE SURVEY DATA : EXISTING AND PLANNED

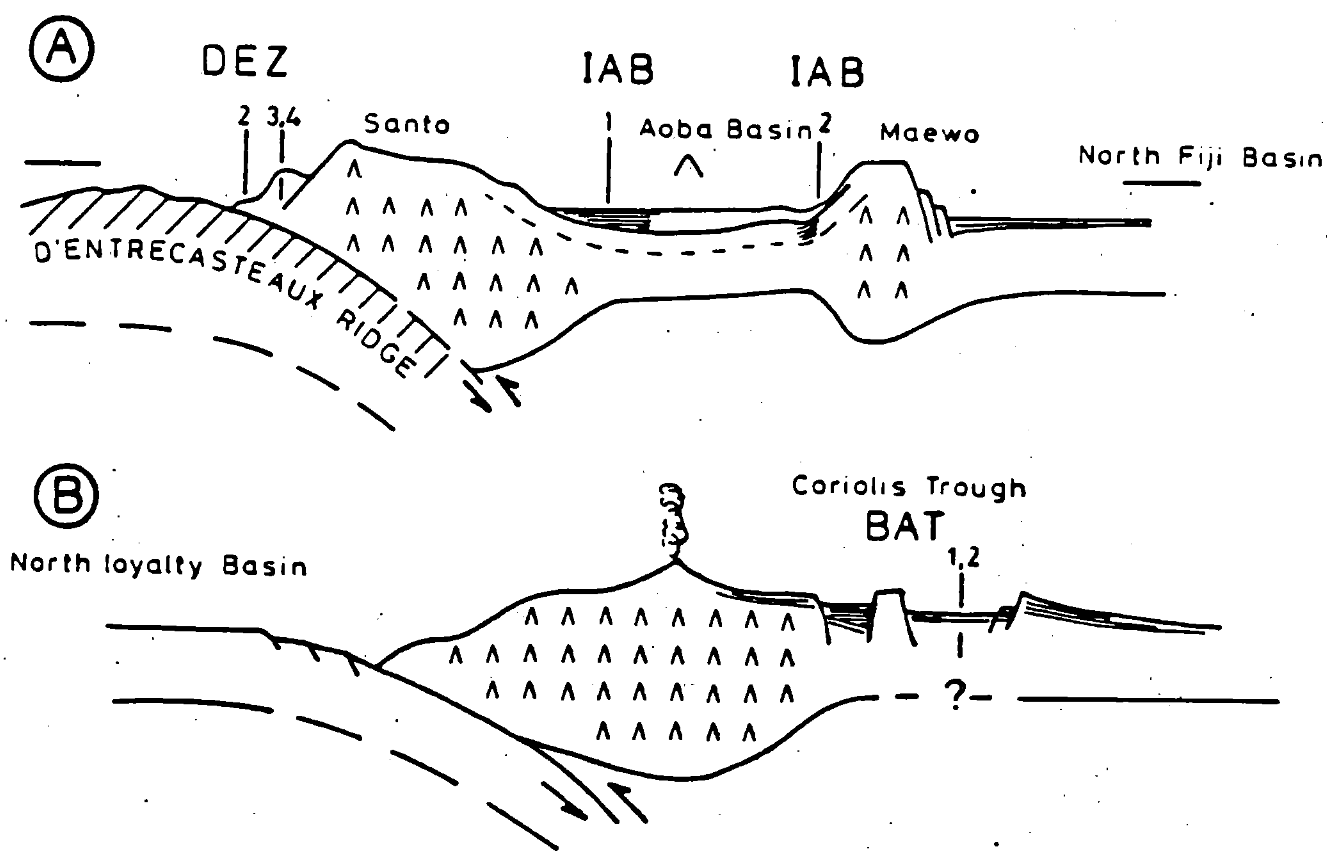
Large data base, assembled by the USGS and ORSTOM, includes single-channel and multichannel seismic sections, refraction profiles, as well as magnetic, gravity, dredge, bathymetric, and onshore geologic and geophysical data. Recently acquired multichannel seismic data have been used to locate proposed drill sites in the collision zone and Aoba basin. Seabeam, single-channel, seismic, and dredge data collected aboard the R/V J. Charcot in late 1985 provide excellent bathymetric control for choosing sites within the collision zone and the back-arc troughs. In 1986, ORSTOM and the University of Texas will conduct OBS refraction surveys over these troughs and the DEZ. ORSTOM has gotten approval for a 1987 multichannel seismic survey in the New Hebrides arc to aid site selection. Diving using submersible is planned to be done in 1988 by IFREMER and ORSTOM.

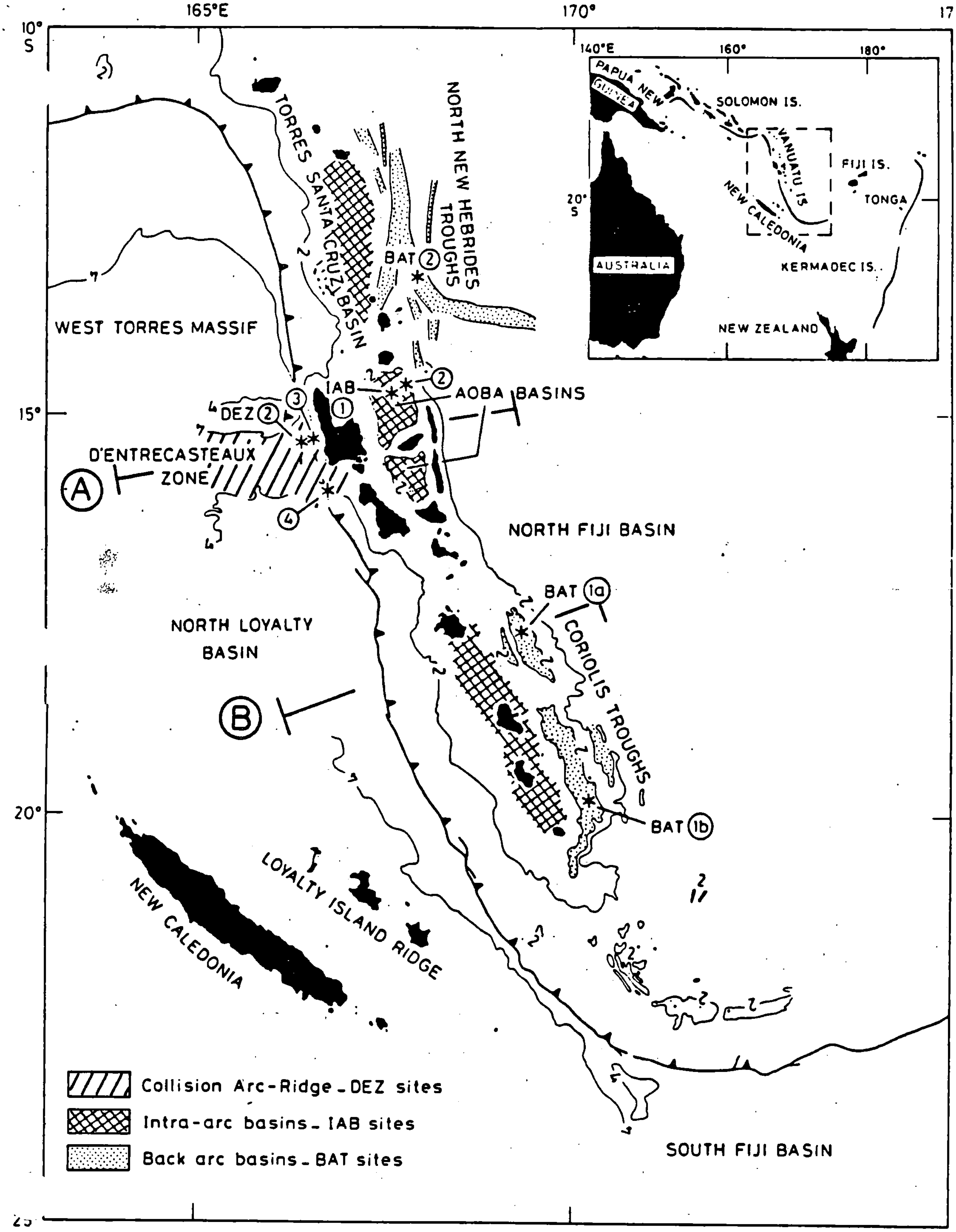
Site #	LAT (°S)	LON (°E)	Water Depth (m)	Penetration (m)	Drilling Time (Days) (1)
FIRST-PRIORITY SITES					
DEZ-2	15°19.2	166°21.7	2130	1300	11
DEZ-3	15°20.7	166°30.5	500	800	5
DEZ-4	15°57	166°47.5	900	1000	6
BAT-1a	17°49.8	169°20.5	2600	700	7
or BAT-1b	19°44.8	170°11.3	3300		
or Bat-2	13°15	167°57	2550		
IAB-1	14°47.5	167°35	3075	1000	9
IAB-2	14°38.3	167°55	2600	1000	8

Sub Total (2) # 46 days

(1) Drilling time estimates are based on Figure 15 in JOIDES Journal, v. 11, p. 4

(2) Time does not include alternate sites.




165°E
170°
175°
10° S
15°
20°
140°E
160°
180°
20° S
PAPUA NEW GUINEA
SOLOMON IS.
VANUATU IS
FIJI IS.
TONGA
NEW CALEDONIA
AUSTRALIA
KERMADEC IS.
NEW ZEALAND
TORRES
NORTH NEW HEBRIDES TROUGHS
SANTA CRUZ BASIN
BAT ②
WEST TORRES MASSIF
IAB
②
AOBA BASINS
③
①
DEZ ②
D'ENTRECASTEAUX ZONE
A
④
NORTH FIJI BASIN
BAT ①a
CORIOLIS TROUGHS
NORTH LOYALTY BASIN
B
BAT ①b
LOYALTY ISLAND RIDGE
NEW CALEDONIA
SOUTH FIJI BASIN
Collision Arc-Ridge _ DEZ sites
Intra-arc basins _ IAB sites
Back arc basins _ BAT sites

INTRAPLATE DEFORMATION ALONG ZENISU RIDGE : JAPAN

General objectives

Intraplate deformation of a marginal basin by intra-oceanic thrusting of a subduction trench.

Seaward of the Nankai subduction zone : water diagenesis and organic matter maturation : upward flux of Connate waters in relation with deware-ting processes.

I. Geodynamic setting.

The Zenisu ridge is a WSW-ENE trending linear structure located seaward of the Nankai trough, at the western edge of the Izu-Bonin (Iwo-Jima) active arc.

From the morphological point of view, this ridge trending N-50E is vanishing progressively to the west, where it disppears within the Shikoku basin. Eastward this ridge connects progressively with the Izu-Bonin ridge.

It is a NW dipping monoclinal, fault bounded on its southeastern flank, itself bordered by a sediment filled trench, called the Zenisu basin. The sediments covering the ridge correspond generally to transparent seismic sequences, suggesting an hemipelagic origin, and are very similar to the seismic sequences recognized westward on top of the oceanic crust. Magnetic anomalies trending NW-SE were recognized across the ridge, suggesting an oceanic origin for this western part of the ridge. This NW-SE direction is fairly consistent both with the magnetic lineations related to the first stage of Shikoku basin opening, and with the topographic grain of the eastern wall of Suruga trough.

The tectonic framework of this ridge is controlled by N-60E trending low dipping faults and associated folds are concentrated along the steep SE ridge slope and into the Zenisu basin. Here, sediments (partly trench fill sediments and partly hemipelagic sequence) are folded and accreted by thrust faults to the base of the ridge. The structures of the steep southern flank display a thrust and fold pattern with thrust bounded folds, very similar to the Nankai accretionary prism.

Zenisu ridge appears as an oceanic crustal slab, dipping to the NW, accreting clastic sediments as its base, and accomodating part of the convergence motion between Japan and the Philippine Sea plate. It can be considered as a classical example of intraoceanic accretion.

II. Drilling objectives.

Zenisu ridge is a quite uniquely imaged example of intra-oceanic plate deformation largely documented by SCS, Seabeam and manned submersible observations.

Complementary data (MCS and drilling) in this area could provide important informations about such intra-oceanic deformation processes, marked by intense dewatering of sediments, water diagenesis, organic matter maturation when development of benthic communities was observed by diving (KAIKO Program).

Various objectives are presented here :

1. Study the deformed sediments present along the South-eastern slope of Zenisu ridge and their dewatering stage. One site is proposed in the place where benthic communities were encountered during Kaiko diving project :

2. To ckeck the nature of the basement of western Zenisu ridge, supposed to represent the oldest part of Shikoku basin oceanic crust.

3. To test the age and rate of tilting along the northwestern slope of Zenisu ridge, by dating the observed unconformity. How fast this intra-oceanic thrust is emplaced ?

This proposal would be considerably enriched if similar dewatering processes would be drilled in the Nankai accretionary prism.

SITE	OBJECTIVE	OPERATIONAL CONSIDERATIONS	TIME FOR DRILLING
ZE1	To establish the nature and age of the "trench-fill like" basin, South of Zenisu. Reference site for ZE3	Water Depth : (m) 4250m Sed. Thickness : (m) 450 Total penetration : (m) 450m - time necessary for drilling : 7 days. Single Bit : Nature of sediments/rocks anticipated : turbidites and hemipelagites. Weather conditions/window : May-July Territorial juridiction : Japan	7 days
ZE3	In situ pore water sampling for inorganic and organic analysis. Expected result : water diagenesis and organic matter maturation, upward flux of connate waters in relation with dewatering processes, at place where biological communities have been discovered during Nautile diving in June 1985.	Water Depth : (m) 4100m Sed. Thickness : (m) 450m Total penetration : (m) 450 m HPC : Single Bit : Nature of sediments/rocks anticipated : indurated hemipelagic muds Weather conditions/window : May-July Territorial juridiction : Japan	7 days
ZE4	Etablish the nature and age of the crust of the western Zenisu ridge and document the stratigraphy of sedimentary sequence covering it, supposed to be oldest sediments in the Eastern half of the basin.	Water Depth : (m) 3150m Sed. Thickness : (m) 400m Total penetration : (m) 450m HPC : Single Bit : Nature of sediments/rocks anticipated : Hemipelagites, turbidites (or tuffaceous layers and lavas (oceanic basements) Weather conditions/window : May-July Territorial juridiction : Japan	4 days
ZE5	(1) to determine the age and the rate of basement tilting of oceanic crustal slab, along the northern slope of Zenisu Ridge. (2) To determine the age change of sedimentation between hemipelagites covering the ridge and the ovelying turbidite of Nankai Trough deposited in onlap.	Water Depth : (m) 4100 Sed. Thickness : (m) 650m Total penetration : (m) 650m HPC : Single Bit : Nature of sediments/rocks anticipated : Turbidites and thin hemipelagites Weather conditions/window : May-July Territorial juridiction : japanese	8 days

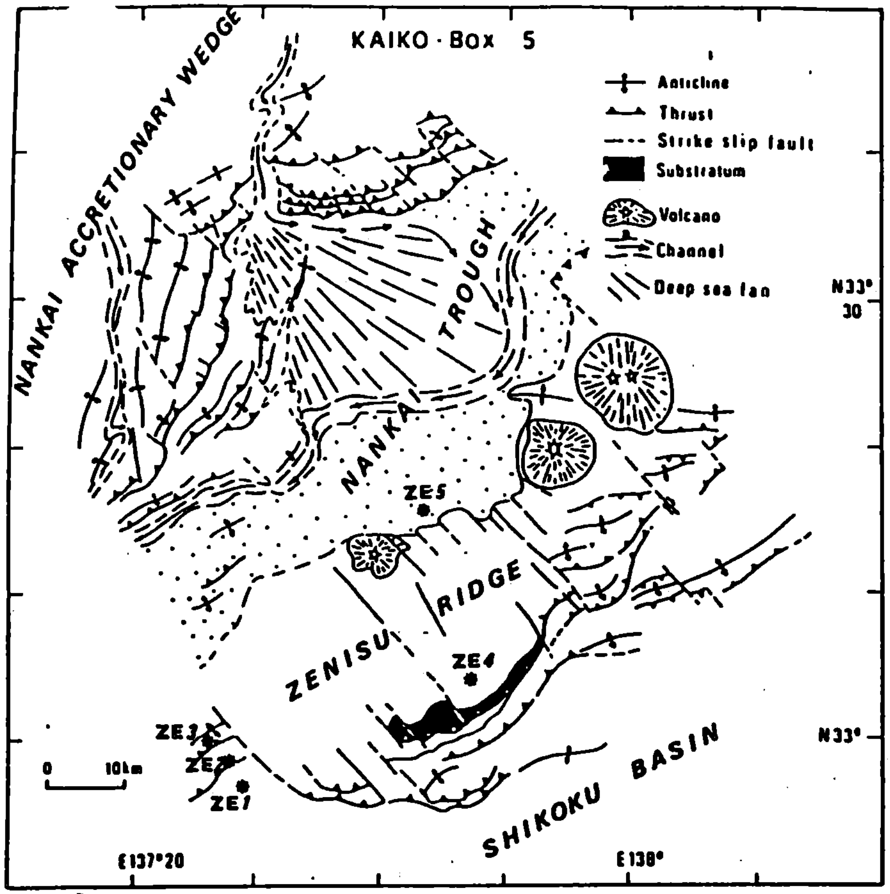
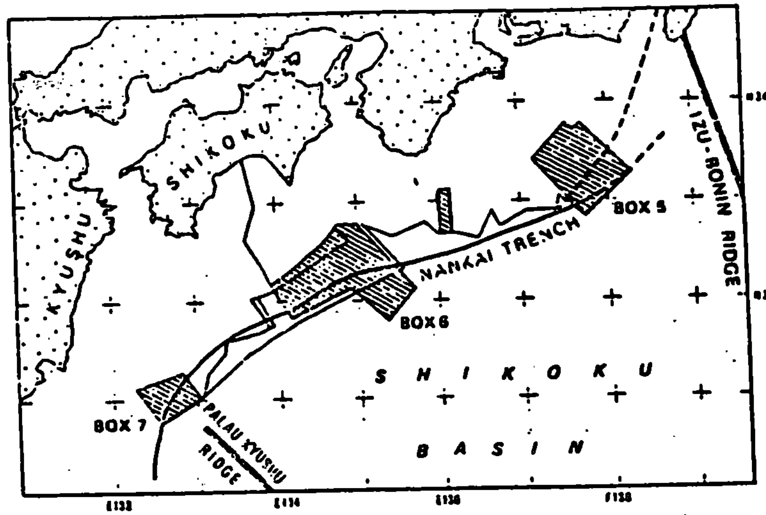
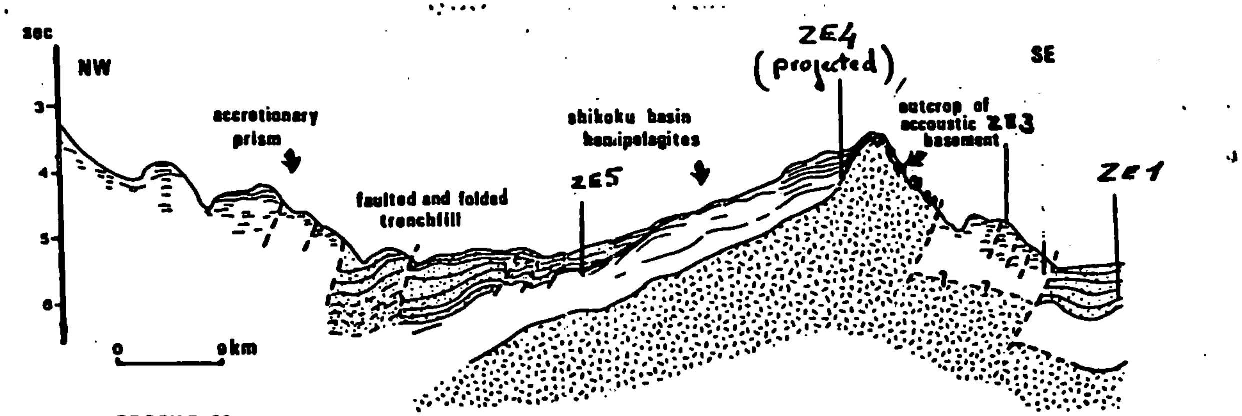


FIGURE 3 Structural sketchmap of BOX 5 showing the superficial deformation of the eastern part of the Nankaï accretionary wedge and of the Zenisu ridge. Stars locate the proposed drilling sites.



Location of the three boxes surveyed during Leg 1 of KAIKO project, June 1984. Zenisu Ridge lies over BOX 5, seaward of the Nankaï Trough.



PROFILE 88

SULU SEA TRANSECT : A SUMMARY FOR DRILLING

At its last meeting, the Western Pacific Panel, considered the several proposals for drilling in the Sulu Sea, and ranked such drilling within its priorities.
The following summaries which targets could be integrated within one leg, the problems to be resolved and the site rationale :

* According to recent recommendations of the Tectonic Panel, more insight has to be made on collision processes in the Western Pacific, as well as problems related to flipping of subduction zones or collage tectonics.
* On the other hand, SOHP has recommended the study of anoxic and suboxic sedimentary record known to exist in silled marginal seas as the Sulu Sea.
* WPAC Panel feels also drilling in such a basin can help to answer fundamental questions regarding geodynamic evolution of complex areas and give a new control on the kinematics of larger lithospheric plates.

The Sulu Sea and particularly the Cagayan Ridge is an excellent area to unravel the complex geodynamic evolution of both the NW-Sulu Basin (Outer Sulu Basin) and the SE-Sulu Basin (Inner Sulu Basin). Drilling in this area combined with a site in the SE-Sulu Basin (proposed Banda-Sulu South China Sea Transect), has direct implications for the interpretation of plate tectonic reorganizations which occured since the Eocene in SE Asia because:

- The Sulu Sea forms the central part of several adjoining marginal basins (the Celebes Sea in the South and the South China Sea in the North) which age and nature are not well understood and which therefore are subject to controversial interpretations ;
- the nature and age of the Cagayan Terrane, situated between the SE-Sulu Basin and the NW-Sulu Basin, is the key for geodynamic concepts developed for the Sulu Sea/South China Sea.

The Sulu Sea has registered during the Cenozoic period, the convergence motion between the Eurasian and Australian plate, and more recently between Eurasia and the Philippine Sea Plate.
The first one is partially documented by the opening of the South China Sea, counterbalanced by subduction of Mesozoic oceanic crust, hitherto assumed along the NW Borneo-Palawan troughs (**Hamilton, 1979** ; **Holloway, 1982**) and completed around 15 M.y. ago ; but there is strong evidence that subduction occurred further to the East, along the NW Sulu Basin (**Hinz &**

Schluter, 1985). The basins, could represent the remnant volcanic arc, related to this subduction. On the Western/Northwestern margin the Cagayan Terrane is characterized by uniform sediment thicknesses and a smooth slope, 0.5 s (TWT) thick sediments.

The Southern Sulu Sea Sub-basin, floored by oceanic crust is crosscutting obliquely the Cagayan ridge and is interpreted as a back arc basin for a new subduction zone active in Neogene time along the Southern side of the Sulu archipelago (Hamilton, 1979 ; Rangin et al., 1986 ; Mitchell et al., 1986).

In a such geodynamic framework, supported by geological and geophysical data, convergent motion is here accomodated by successive subduction and collision processes :

First, a Southward dipping subduction of the proto-South China Sea Basin, followed by collision of the related volcanic arc with the South China Sea continental margin.

Second, a Northward dipping subduction zone, inducing development of a marginal basin, the southern Sulu sub-basin.

Flipping of this subduction zone induced by collision has occurred in early middle Miocene time but need to be constrained by drilling : what is the necessary time for a such collision to be completed before inducing arc reversal ?

Such a question can be answered knowing the precise biostratigraphic record on both sides of the Cagayan ridge :

* A site located on the northern flank of the ridge (SUL 2), could penetrate the acoustic basement of the Cagayan ridge interpreted as formed here by basalt flows, and covered by a rather uniform thickness of sediments of Neogene age. This drilled hole could constrain the nature of the Cagayan ridge and the age when southward subduction and following subduction stopped.

The nature and stratigraphy as well as the geochemical signature of the expected volcanic rocks obtained by drilling can be compared to the Valderrama arc terrane of roughly similar age (Mitchelle, 1985) outcropping in Panay Island and present at the inner wall of the Negros trench, bounding the Sulu Sea to the East. This terrane is interpreted as a fragment of the Cagayan ridge accreted by collage to the Philippine mobile belt.

Site P1 drilled at the inner wall of the Negros trench at a place where active collision is going on, could test the nature accretionary processes of Cagayan ridge fragments.
Such a hole could also inquire about the dewatering processes during collision suspected along the major decollement surface defined on seismic line.
Site EA6 drilled at the inner wall of Negros trench where subduction of Sulu Sea oceanic crust occurs, could be a reference hole for P1 if we want to compare either decollement processes into collision and subduction setting respectively.
Such a transfer of microblocs from the lower plate to the upper plate is the best way to interpret the continental growth at a plate margin, and is cited as a recommended target of the Tectonic Panel, that can be tested easily here.
* A site located on the southern flank of the ridge (SUL 4), can test the drifting history of the Sulu back arc basin, considered as postdating the collision event. This drill hole can penetrate the pre-syn and post-rift sequences identified on seismic profiles. Combined with SUL 5 (see South China Sea-Sulu-Band summary), this drill hole can provide new data on the initial stage of opening for a back arc marginal basin.
Drilling in the 2000 m deep NW-Sulu Basin and in the 4600 m deep SE-Sulu Basin (as part of Banda-Sulu-S. China Sea Transect) evaluate Cenozoic sea-level changes on sedimentation in silled oxygen-deficient basins and comparison to other (semi-) closed ocean basins.
* Proposed site SUL 2 will recover the least disturbed basin record, while SUL 4 will yield a less continuous but nevertheless valuable paleoceanographic and eustatic record with carbonate anticipated to be well preserved at this site.

Paleoceanographic objectives in the Sulu Sea basins are focused on the anoxic and suboxic sedimentary record known to exist in this silled marginal sea. A proposal by Thunnel details the importance of this setting for yielding an ultra high resolution stratigraphic record of variations in basin circulation and productivity tied to global climatic and eustatic events and to the tectonic and depositional history of the basin. Incites into the depositional and paleoceanographic evolution of the Sulu Sea basin gained via ODP drilling will have important implications for the interpretation of analogous Mesozoic and early Tertiary silled basins common to the meridial Tethys Sea and which evolved in similar carbonate-rich equatorial settings.

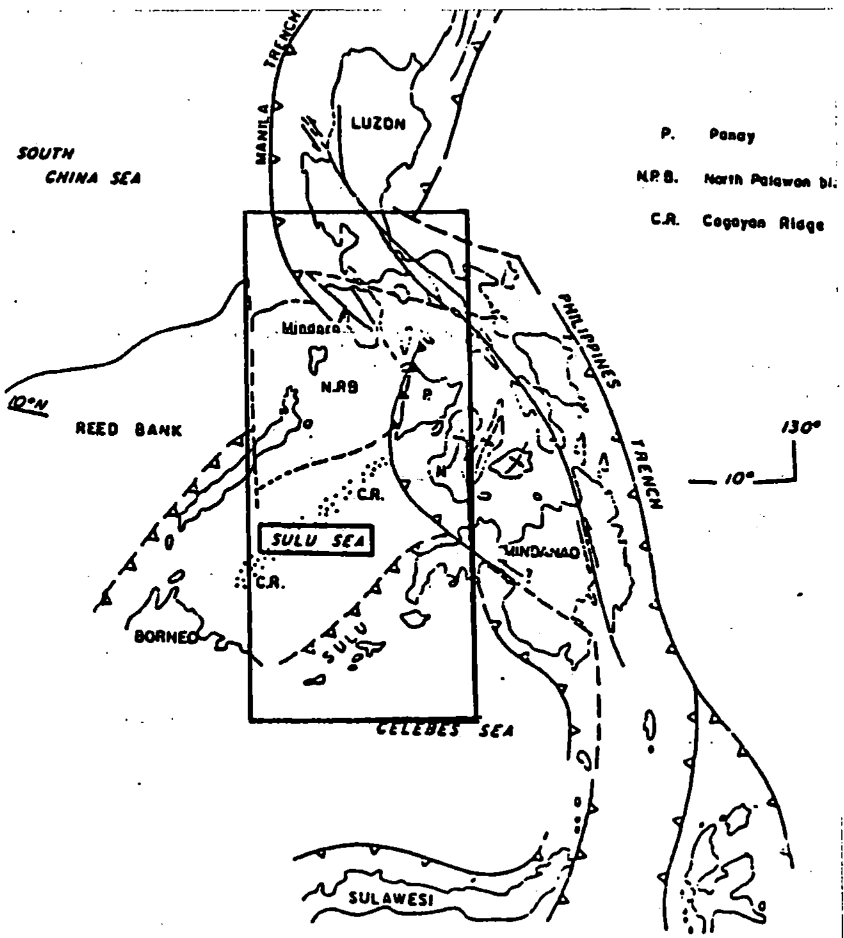
Specifically, faunal and stable isotopic analysis (C^{13}, O^{18}) of the Sulu Sea sequence will provide unusually detailed records of basin response to Ouaternary and late Neogene glacial and inter-glacial climatic cycles manifested by eustatic sea level fluctuations as well as changes in surface circulation in this region. Much of the Neogene record in the Sulu Sea basin is expected to consist of laminated organic-rich excluded larger infaunal invertebrates allowing preservation of individual laminae. Infact, the laminated character of the subsill sequence may well allow identification and analysis of six months (e.g. seasonal) events and annual cycles in the paleoceanographic evolution of the basin as well as complete spectrum of longer term climatic and depositional cycles tied to the eustatic control of critical sill depth. We anticipate that benthic faunal analysis will demonstrate threshold effects between the anoxic and suboxic states induced by these events as well as cyclic control of fine grained turbidite deposits in the basin center. Variations in planktonic and benthic foraminifera in these sediments will allow analysis of both deep and shallow circulation in the basin with distinctive benthic biofacies demarking evolution of anxic, suboxic, and anoxic phases in water mass history.

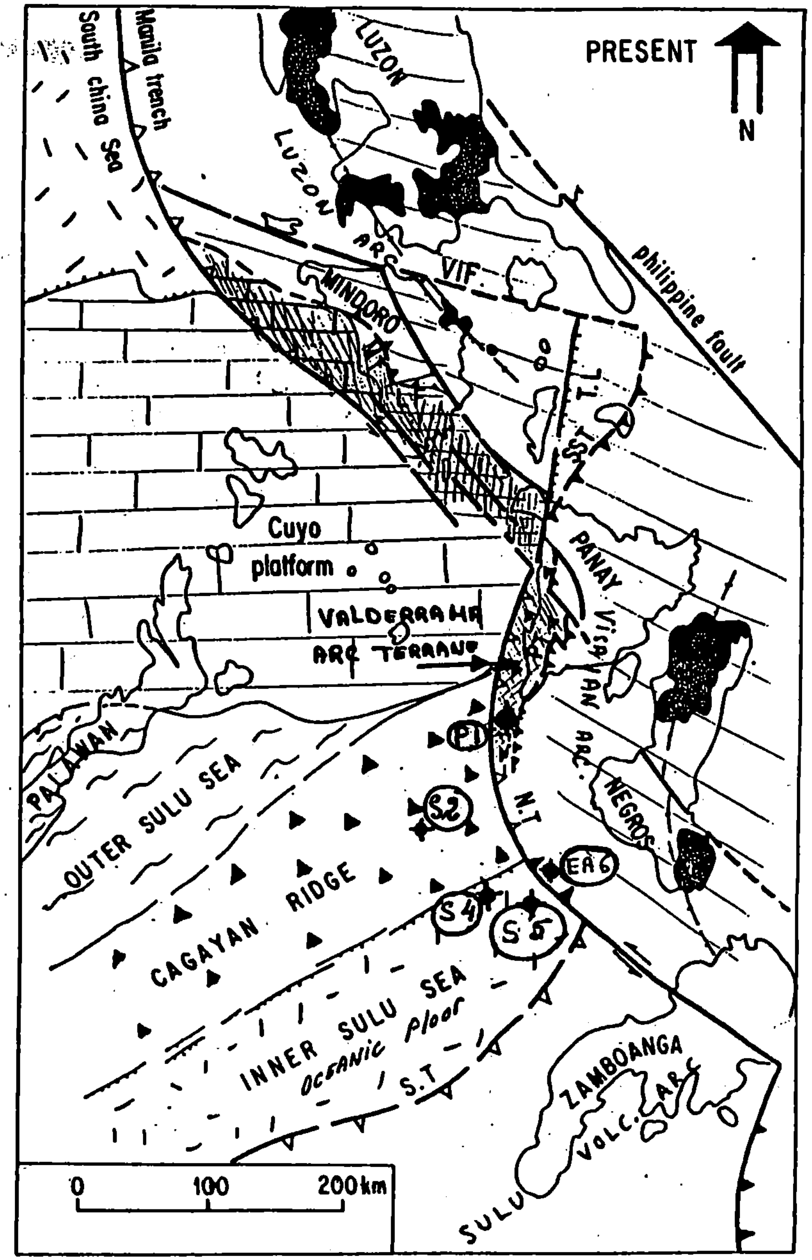
As a conclusion, these sites proposed in the Sulu Sea have basic tectonic and paleoceanographic questions to solve, and results of drilling could be integrated within a well documented geological geophysical regional framework.

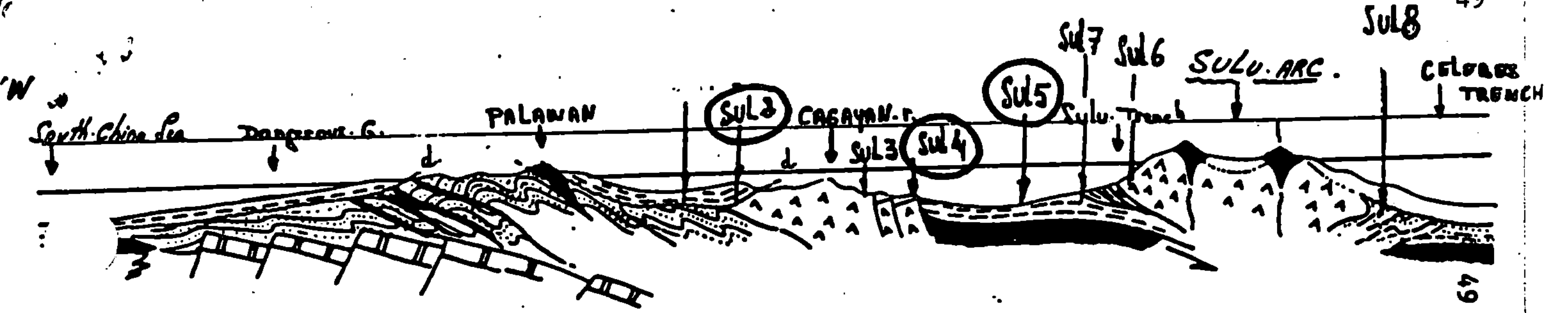
It is important to outline the large amount of recent multichannel seismic data available in the northern sub-basin (BGR) and the planned french and german seismic surveys into the southern basin, next spring, and next summer respectively.

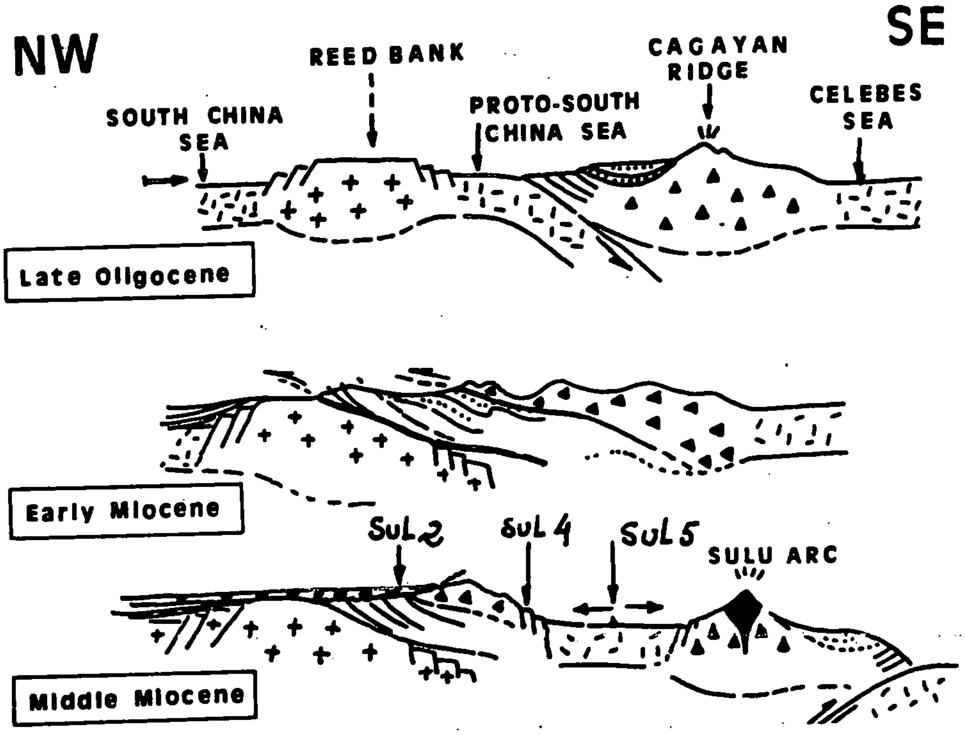
Proposed holes	Water depth(m)	Sediment thickness(m)	Penetration (m)	Drilling time (days)
Sulu-2	1748	550	1100	20
Sulu-4	3300	450	600	10
P1 :	1400	1700	1700	15
EA6 :	4500	1100	1100	13
				Total = 58 days

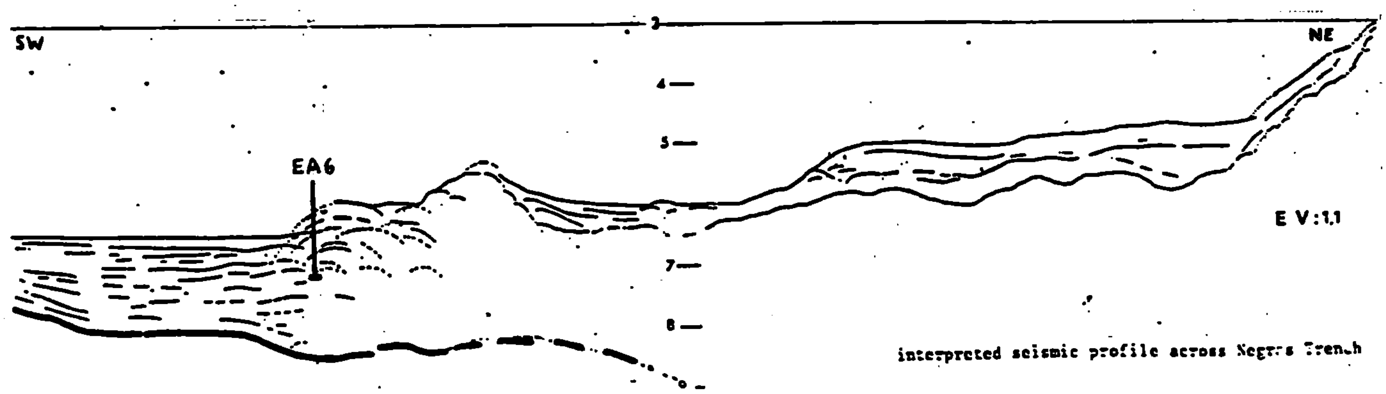
Shorter holes should be identified during site surveys in 1987.


SOUTH CHINA SEA
MANILA TRENCH
LUZON
P. Panay
N.P.B. North Palawan bl.
C.R. Cagayan Ridge
Mindoro
N.P.B
P.
10°N
REED BANK
C.R.
SULU SEA
C.R.
BORNEO
SULU
MINDANAO
PHILIPPINES TRENCH
130°
10°
CELEBES SEA
SULAWESI


PRESENT
N
South china Sea
Manila trench
LUZON
LUZON ARC
VIF
Philippine fault
MINDORO
S.T.
Cuyo platform
PANAY
VALDERRAMA ARC TERRANE
VISAYAN ARC
PALAWAN
P1
OUTER SULU SEA
S2
N.T
NEGROS
CAGAYAN RIDGE
ER6
S4
S5
INNER SULU SEA
Oceanic floor
S.T
ZAMBOANGA VOLC. ARC
SULU
0 100 200km







interpreted seismic profile across Negros Trench