OCEAN DRILLING PROGRAM

LEG 116 SCIENTIFIC PROSPECTUS

INTRAPLATE DEFORMATION AND DISTAL BENGAL FAN

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INTRODUCTION

Classical plate tectonics assumes that large lithospheric plates behave as rigid units, with deformation confined primarily to their boundaries. Observational evidence suggests, however, that the Indian-Australian Plate is not behaving in this manner, but has been subjected to significant internal compression (Fig. 1). This is evidenced by the unusually large number of intraplate earthquakes, many with thrust focal mechanisms (Sykes, 1970; Banghar, 1972; Fitch et al., 1973; Stein and Okal, 1978; Bergman et al., 1984) and by the inability of plate motion models to successfully reproduce both spreading rates and directions along the boundaries of the Indian Plate (Minister and Jordan, 1978; Wiens et al., 1985). However, the most spectacular and direct evidence for internal deformation in the Indian Plate is the occurrence of large-scale folding and high-angle thrust faulting with axes running about N100°E over a wide region between the Central Indian Ridge and the Ninetyeast Ridge (Eittreim and Ewing, 1972; Weissel et al., 1980).

The observed intraplate deformation affects both the ocean crust and the thick pile of overlying sediments that have been deposited on the distal part of the Bengal Fan. This submarine fan is the largest single sedimentary accumulation known in the world, extending some 3000 km from the slope south of the Bengal delta to merge with the Sri Lanka abyssal plain just to the south of the Afanazy Nikitin seamount group (Curray and Moore, 1971; Emmel and Curray, 1984) (Figs. 2 and 3). Its maximum thickness beneath the upper fan may exceed 12 km (Curray and Moore, 1971); the estimated thickness in the region of proposed drilling is about 1.5-2 km.

JOIDES Resolution will depart Colombo, Sri Lanka on July 7, 1987. The ship will drill a series of three sites on small-scale rotated fault blocks near 1°S, 81°24'E. These sites are designed to study the depositional processes, diagenesis, and history of movement on two of the fault blocks. All the sites are located at the very distal end of the Bengal submarine fan, close to the termination of the most recently active main fan channel (Fig. 2). The ship will return to Colombo, Sri Lanka on August 19, 1987 with a total of 43 days at sea (4.6 days of transit and 38.4 operational days).

The objectives of drilling are:

1. To determine the age of onset of the intraplate compression and the subsequent history of displacement of the fault blocks.
2. To understand the relationship between the fault zones (or surfaces), bedding planes and the flow of water deduced from surface heat flow measurements.
3. To document the tectonic history of uplift in the Himalayas.
4. To study the sediment characteristics and the depositional processes on the distal end of the Bengal Fan.
5. To investigate the nature of early diagenesis in the submarine fan sediments, especially in relation to the high heat flow.

GEOLOGICAL AND GEOPHYSICAL BACKGROUND

The collision between India and Eurasia beginning in Eocene times had profound effects not only on the tectonics of Asia, but on the tectonics and sedimentation of the Indian Ocean lithosphere formed in the wake of India during its northward movement. From the middle Cretaceous (sometime during the Cretaceous magnetic quiet zone) until early Eocene (magnetic anomaly 22), India moved rapidly northward across the Tethys at a rate which Peirce (1978) calculated to be 15 cm/yr relative to the Earth's spin axis. During this time, much of the present Indian Ocean was generated behind India at the Carlsberg and Southeast Indian Ridges by seafloor spreading with half rates of 5.6 to over 12 cm/yr (McKenzie and Sclater, 1971; Sclater and Fisher, 1974; Schlich, 1982; Geller et al., 1983). During this time, a fairly typical abyssal sequence of sediments accumulated in the central Indian Basin, consisting of carbonates deposited near the ridge crest overlain by clays deposited on the deeper abyssal plain (Davies and Kidd, 1977). These sediments may have been several km thick in the north under the present proximal fan, but thinned to the south and appear to be fairly thin at 1°S, probably less than a few hundred meters (Moore et al., 1974; Curray et al., 1982).

The collision between India and Asia began in the Eocene about at the time of Anomaly 22 (approx. 53 Ma). At that time, spreading half rates in the Central Indian Basin decreased from 8 cm/yr to 4 cm/yr and the spreading direction changed from nearly N-S to NE-SW (Sclater et al., 1976). A regional unconformity observed throughout the Bay of Bengal (Curray and Moore, 1971) has also been dated to this time by extrapolation from DSDP Site 217 (Moore et al., 1974). Curray et al. (1982) suggest that this was a "soft collision" and that convergence continued between India and Asia, perhaps consuming a back-arc basin. During the Oligocene, spreading rates decreased further to 2.5 cm/yr (Sclater et al., 1976). The formation of the Indus and Bengal fans began in the Eocene (Curray and Moore, 1971); at 1°S in the distal Bengal Fan, 1.4 sec of sediment, probably composed in large part of turbidites, accumulated between the early Eocene and late Miocene.

The "hard" continent-continent collision occurred in the late Miocene at the time of the initial uplift of the Himalayas (Gansser, 1964, 1966; Powell and Conaghan, 1973). This tectonic event appears to have resulted in a prominent unconformity throughout the area of the Bengal Fan which has been dated as late Miocene by drilling at DSDP Site 218. In addition, the spreading rate on the Southeast Indian Ridge increased to a half rate of about 3.0 cm/yr at about the time of the final collision between India and Asia (Sclater and Fisher, 1974; Sclater et al., 1976).

INTRAPLATE DEFORMATION IN THE CENTRAL INDIAN OCEAN

The increased resistance to subduction and shortening across the Himalayas since the late Miocene continent-continent collision, combined with continued spreading on the Southeast Indian Ridge, has placed the Central Indian Ocean under a large N-S compressive stress regime. As a result, intraplate deformation of oceanic lithosphere under horizontal compression is clearly developed in the Central Indian Ocean Basin south of India.

Within the affected region, which extends roughly from the Chagos-Laccadive Ridge in the west to the Ninetyeast Ridge and from 5°N to 10°S latitude, the oceanic crust and most of the overlying sediments are deformed into long-wavelength (100-300 km) undulations (or folds) with peak-to-trough amplitudes of 1-3 km (Weissel et al., 1980; Geller et al., 1983) (Fig 4). The pattern of E-W crustal undulations is clearly revealed in maps of gravity anomalies derived from SEASAT altimeter measurements (Fig. 1) and by surface-ship gravity measurements which show them to be associated with gravity anomaly variations of 30-70 mgal. Analysis of the gravity anomalies implies that the Moho is deformed in the same way as the upper surface of the crust. This supports the interpretation that the crust is deformed under N-S compression and that some amount of lithospheric shortening has occurred.

The deformed area is characterized by an unusually large number of thrust and strike-slip intraplate earthquakes whose foci are located within the mantle (Sykes, 1970; Stein and Okal, 1978; Bergman et al., 1984; Wiens and Stein, 1983, 1984). Directions of maximum compressive stress for the most significant of these events are approximately perpendicular to the E-W trends of the long-wavelength crustal undulations.

Superimposed on the long-wavelength undulations are faulted and rotated blocks, spaced 5-20 km apart, showing a reverse sense of displacement consistent with N-S shortening (Eittreim and Ewing, 1972). The top of the crust is seen to be offset by up to 0.5 sec (> 500 m) across the faults on seismic reflection records.

Heat flow in the deformed region is higher than expected for the age of the underlying crust and shows great scatter in the measurements (Fig. 5). In particular, abnormally high heat flow values are distributed widely over the Central Indian Ocean Basin (Anderson et al., 1977; Weissel et al., 1980; Geller et al., 1983). A detailed heat flow study conducted as part of the pre-cruise site survey for Leg 116 shows that there is great variability in the heat flow on the scale of a few km (Fig. 6). The measured temperature-depth profiles associated with some of the highest values are non-linear, suggesting an upward flow of water through the sediments (Geller et al., 1983). The small-scale variability and the fact that the highest values are not associated with the faults suggest that water is not only flowing along the faults, but may also be ascending along inclined, permeable sediment layers.

The source of the heat and the source of the water may be interrelated. The high heat flow could represent sampling of the upwelling limbs of hydrothermal cells extending into the crust which have been reactivated by cracking and faulting during deformation (Geller et al., 1983). In this case, the heat could be partially the result of work required to deform the lithosphere (in the form of viscous dissipation, friction on faults, or plastic deformation). The flow could also be confined to the sediments and be the result of dewatering as a result of the compressional deformation. It is also conceivable that the distal end of the Bengal Fan represents the discharge zone of artesian flow through permeable sediments in the fan.

FAN SEDIMENTATION

The Bengal Fan, the world's largest submarine fan, is still relatively poorly known in terms of its sediment composition. Fewer than 100 short cores have been recovered from an area of about 3.10^6 km^2 (Curray and Moore, 1971; Curray et al., 1982); only one spot-cored DSDP site (Leg 22, Site 218) has been drilled in the fan bottoming in middle Miocene sediments at a depth of 772 mbsf (von der Borch, Sclater et al., 1974). This fan is assumed to be characteristic of the muddy, delta-fed, elongate fan type (Stow, 1985, 1986), with its enormous volume of sediments derived principally from erosion of material from the uplifting Himalayan Mountains that is supplied to the delta front via the Ganges-Brahmaputra river systems.

Sediments are funneled very efficiently to the fan via a delta-front trough, the "Swatch-of-No-Ground". This trough is presently connected to only one active fan channel, but has been effectively cut off from rapid sediment supply since the most recent rise in sea level, probably about 7000-10,000 years ago. Many other channels mark the surface of the fan and extend for various distances along its length. Most of these are thought to have been abandoned by channel switching in the past (Fig. 2).

The one DSDP site drilled on the Bengal Fan (Site 218; $08^{\circ}00.06'N$, $86^{\circ}16.97'E$) identified four main pulses of sandy turbidites, one in the middle Miocene, two in the late Miocene-Pliocene, and the most recent in the Pleistocene (von der Borch, Sclater, et al., 1974). The intervening sediments are a mixture of turbidite muds and calcareous pelagic units. The short core coverage of the fan has shown that in most cases pelagic muds, 20-90 cm in thickness, are found overlying thin to thick turbidite sands. The latter are thicker and/or more abundant in and close to channel axes than in interchannel areas (Emmel and Curray, 1984).

The main questions we hope to address during Leg 116 with regard to fan sedimentation are the following:

1. What have been the major controls on sedimentation and how have they interacted? Tectonic uplift and erosion of the Himalayas has clearly been important, but we also expect to encounter the signature of local tectonics related to intraplate deformation. The latest rise in sea level at the end of the Pleistocene has clearly had a major affect on sedimentation, but it is not clear to what extent earlier sea-level changes were similarly important. Closely related are the Quaternary climatic changes in the Himalayas that may have had significant effect on the equatorial accumulation some 9000 km away.

2. What are the chief processes of sedimentation and what can we deduce of their characteristics ? A range of different turbidites can be expected. Turbidite thickness, grain size and structural sequence should indicate something of the size, competence and evolution of the turbidity currents that deposited them, and of whether or not sediment by-passing has occurred in the middle fan area. The contribution from pelagic processes and the possible effects of bottom currents (Kolla et al., 1976) in the region of distal fan channel termination are not known. It is also possible that more

local slumping and debris flow processes may have been periodically active.

3. Is the provenance of sediments on the distal Bengal Fan single or mixed? Clearly, a large proportion of the sediment must be derived from the Ganges-Brahmaputra drainage basin (Ingersoll and Suczek, 1979; Pimm, 1974). However, the distribution of clay minerals in the NE Indian Ocean indicates the contribution from several different continental sources (Kolla, 1974). In addition, there may have been intrabasinal supply from adjacent seamounts or from areas of crustal deformation.

EARLY DIAGENESIS

Most work on diagenesis has focused either on the very early changes that take place in sediments related to their environment of deposition (i.e., 0-10 m burial depths), or on deep burial diagenesis and its effects on reservoir properties (in excess of 1000 m burial). Fewer data exist on the diagenetic changes that occur between 10 and 1000 m, although some work of this kind has begun to appear as a result of earlier DSDP/ODP legs (e.g., Stow and Miller, 1984).

The nature of these early diagenetic changes, which then form the template for subsequent burial diagenesis, are in large part controlled by the unstable or metastable components within the sediments. These include amorphous Al, Si and Fe oxides, biogenic SiO_2 and $CaCO_3$, organic carbon, and volcanogenic material. Other controlling factors include heat flow, pore water chemistry and bottom water oxygenation.

The sites to be drilled on the distal Bengal Fan will provide an excellent opportunity to examine the influence of high heat flow on early diagenesis in stable deep oceanic sediments. Appropriate comparisons can be made with, for example, work on diagenesis in the Mississippi Fan sediments (Thayer et al., 1986; M. R. Townsend, pers. comm., 1987).

DRILLING PROGRAM

The drilling program consists of three primary sites (Sites ID 1, ID 2, and ID 6) outlined in Table 1 and located in Figure 7. Additional alternative site locations have been identified where the drilling objectives could also be addressed (Sites ID 1A and ID 6B; Table 2).

Two of the primary sites (Sites ID 1 and ID 2) are on the northward-dipping limb of a rotated fault block located between $0^{\circ}55'S$ and $1^{\circ}0'S$; the third primary Site (Site 6) is on the next fault block to the south (Fig. 8). Logging is an important part of the program and a full suite of Schlumberger logging runs is planned at all of the proposed sites. In addition, the in situs pore water sampler and pressure measurement instrument and APC Heat Flow Shoe (for temperature measurements) will be employed at all sites. The drill-in packer will be used at Site ID 6.

The sites on the tilted fault block will be drilled through an unconformity on the seismic line (Fig. 8) which appears to mark the onset of deformation, since reflectors below it continue up and over the tip of the block without a change in reflector spacing.

Site ID 1 is a reference section away from the uplifted area and is designed to obtain as continuous and uninterrupted a section as possible both for comparison with Site ID 2 and for studying fan depositional processes and diagenesis.

Site ID 2 is designed to sample the different packets of sediments (seismic sequences) separated by unconformities within the syn-deformational section in order to investigate the relationship between the sequences and the history of motion and uplift. This site will be the last drilled and will be deepened to the extent permitted by time considerations in order to study depositional processes in the fan prior to the deformation as well as diagenesis in the deeper sediments.

Site ID 6 is located on the next block to the south, between the fault and the largest heat flow high in the survey area. It is primarily designed to investigate possible migration of water along permeable beds in the sediments. It will also serve to compare the sedimentation patterns and uplift history on two separate blocks.

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TABLE 1: PROPOSED LEG 116 DRILLING PROGRAM

Site	Location	Travel Time (days)	Time at Site (days)	Departure Date (approximate)
Depart: Colombo (Sri Lanka)				July 07, 1987
Transit*		2.2		
ID 1	00°55.64'S 81°24.02'E		13.5	July 22, 1987
Transit		0.1		
ID 6	01°01.12'S 81°24.01'E		12.2	August 03, 1987
Transit		0.1		
ID 2	00°57.60'S 81°23.95'E		11.0	August 15, 1987
Contingency (4%)			1.7	
Transit*		2.2		
Arrive: Colombo (Sri Lanka)				August 19, 1987
		4.6	38.4	43 days

*: estimated at 10 knots.

TABLE 2: LOCATION OF PROPOSED SITES FOR LEG 116

Site	Location	Water Depth (m)	Total Penetr. (m)	Operations	Objective
ID 1	00°55.64'S 81°24.02'E	4680	775	APC/RCB Logging BHTV	To establish a reference hole for seismic stratigraphy and physical properties.
ID 1A	00°55.86'S 81°21.97'E	4680	775	APC/RCB Logging	Same as Site ID 1.
ID 2	00°57.60'S 81°23.95'E	4680	800	APC/XCB Logging	To compare sediment section with Site ID 1 to establish history of deformation.
ID 6	01°01.12'S 81°24.01'E	4680	600	APC/RCB Logging and RCB packer	To measure pressure, temperature and fluid characteristics on a heat flow anomaly; study deep diagenetic processes.
ID 6B	01°00.45'S 81°22.02'E	4680	600	APC/RCB Logging and RCB packer	Same as Site ID 6.

FIGURE CAPTIONS

Figure 1: Gray-scale image depicting N-S gradients of Seasat-derived gravity anomalies in the northern Indian Ocean. Slopes down to the north are light; slopes up to the north are dark. Land areas, 5^{o} grid cross markers, and squares marking epicenters for shallow earthquakes are black. The E-W-trending gravity anomalies associated with with the intraplate deformation are conspicuous in the upper left of this image (after Weissel, unpublished data).

Figure 2: Morphometric map of the Bay of Bengal showing Leg 116 drilling area (after Emmel and Curray, 1984).

Figure 3: Bathymetric map of Leg 116 area showing the approximate limit of the Bengal deep sea fan.

Figure 4: A. Map of basement highs and lows in Leg 116 area.
B. Single-channel seismic reflection profile a and b illustrating the undulatory nature of the long-wavelength basement deformation. Hachured lines: Ninetyeast Ridge.

Figure 5: General geophysical setting: Xs denote the location of heat flow measurements (in mW/m^2) compiled by Geller et al. (1983). Asterisks indicate DSDP site locations. A.N. is Afanazy Nikitin seamount group. Solid dots are intraplate earthquakes. Triangles denote thrust focal mechanisms; circles, strike-slip mechanisms; and squares, normal mechanisms. The dotted line roughly shows the southern limit of fan deposits. The dashed line in the inset box (upper right corner is the southern limit of the observed deformation. Strikes of principal stress axes for intraplate earthquakes within the Indo-Australian plate are shown by arrows. Depths are contoured in meters (after Wiens et al., 1985).

Figure 6: Detailed contour map of heat flow anomalies: Squares and circles are heat flow measurement stations with their values in mW/m^2 (after Weissel, unpublished data).

Figure 7: CONRAD 2706 navigation track showing location of the proposed Leg 116 drill sites. Site locations are shown by asterisks. Hour ticks along tracks are also given. Numbers refer to heat flow values (in mW/m^2). Seismic profile shown in Fig. 8 is located by the arrows.

Figure 8: Detail of CONRAD 2706 single-channel seismic line showing Leg 116 site locations. C and D refer to the 90^{o} turns; High H.F.: High heat flow anomalies. Location of profile shown in Fig. 7.

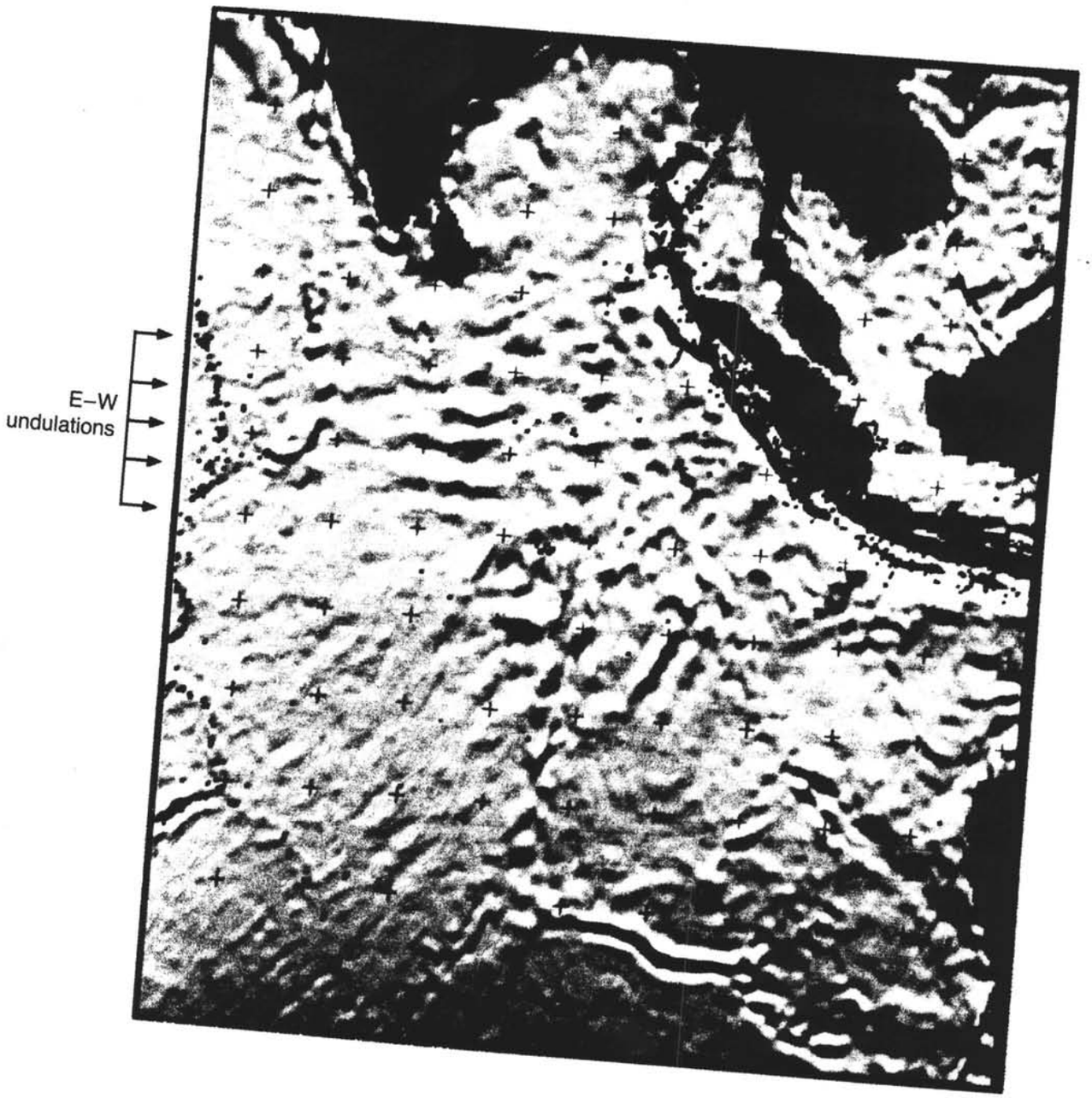
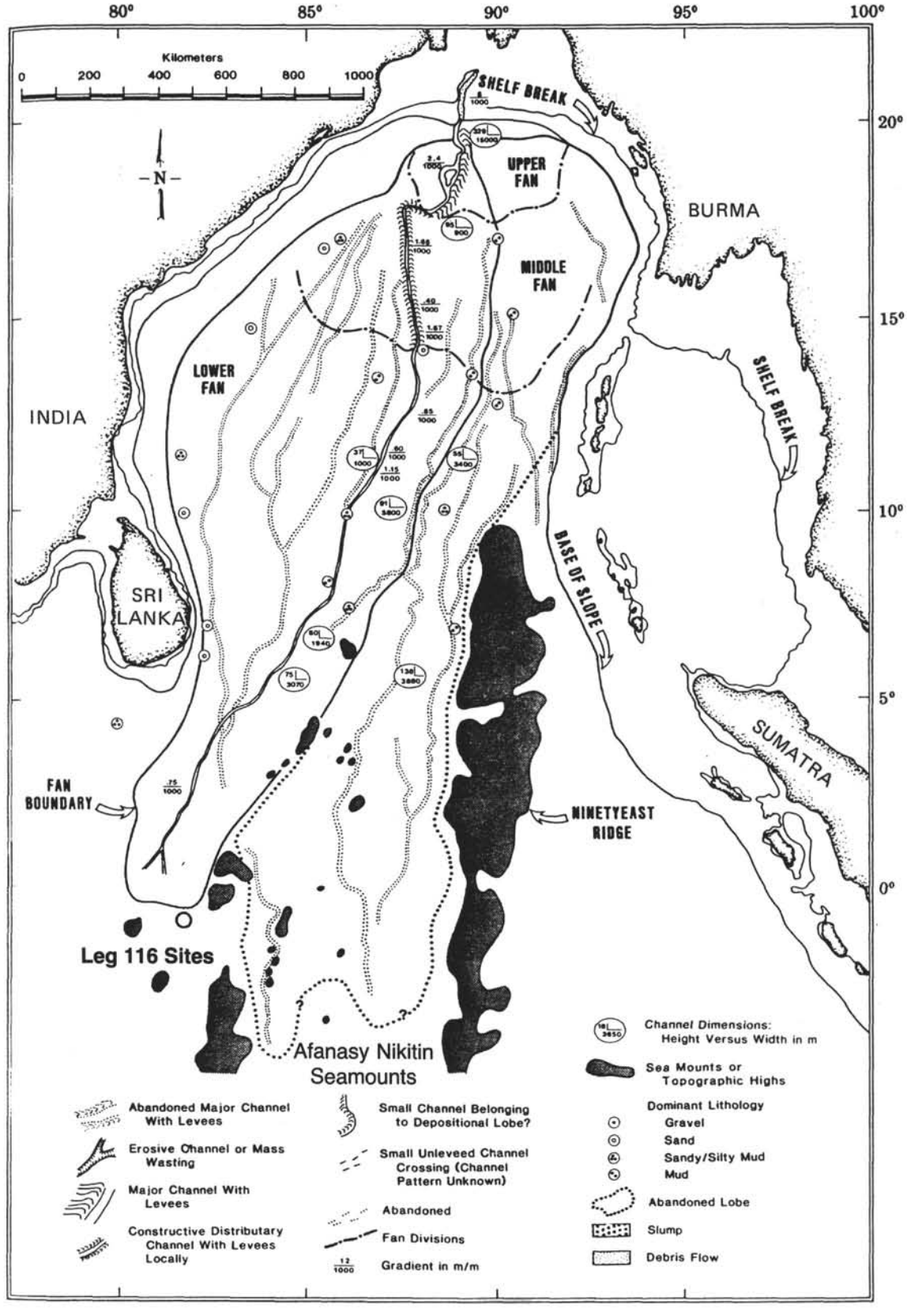


Figure 1.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SHELF BREAK
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SUMATRA
FAN BOUNDARY
NINETYEAST RIDGE
Leg 116 Sites
Afanasy Nikitin Seamounts
Abandoned Major Channel With Levees
Erosive Channel or Mass Wasting
Major Channel With Levees
Constructive Distributary Channel With Levees Locally
Small Channel Belonging to Depositional Lobe?
Small Unleveed Channel Crossing (Channel Pattern Unknown)
Abandoned
Fan Divisions
Gradient in m/m
Channel Dimensions: Height Versus Width in m
Sea Mounts or Topographic Highs
Dominant Lithology
Gravel
Sand
Sandy/Silty Mud
Mud
Abandoned Lobe
Slump
Debris Flow

Figure 2.

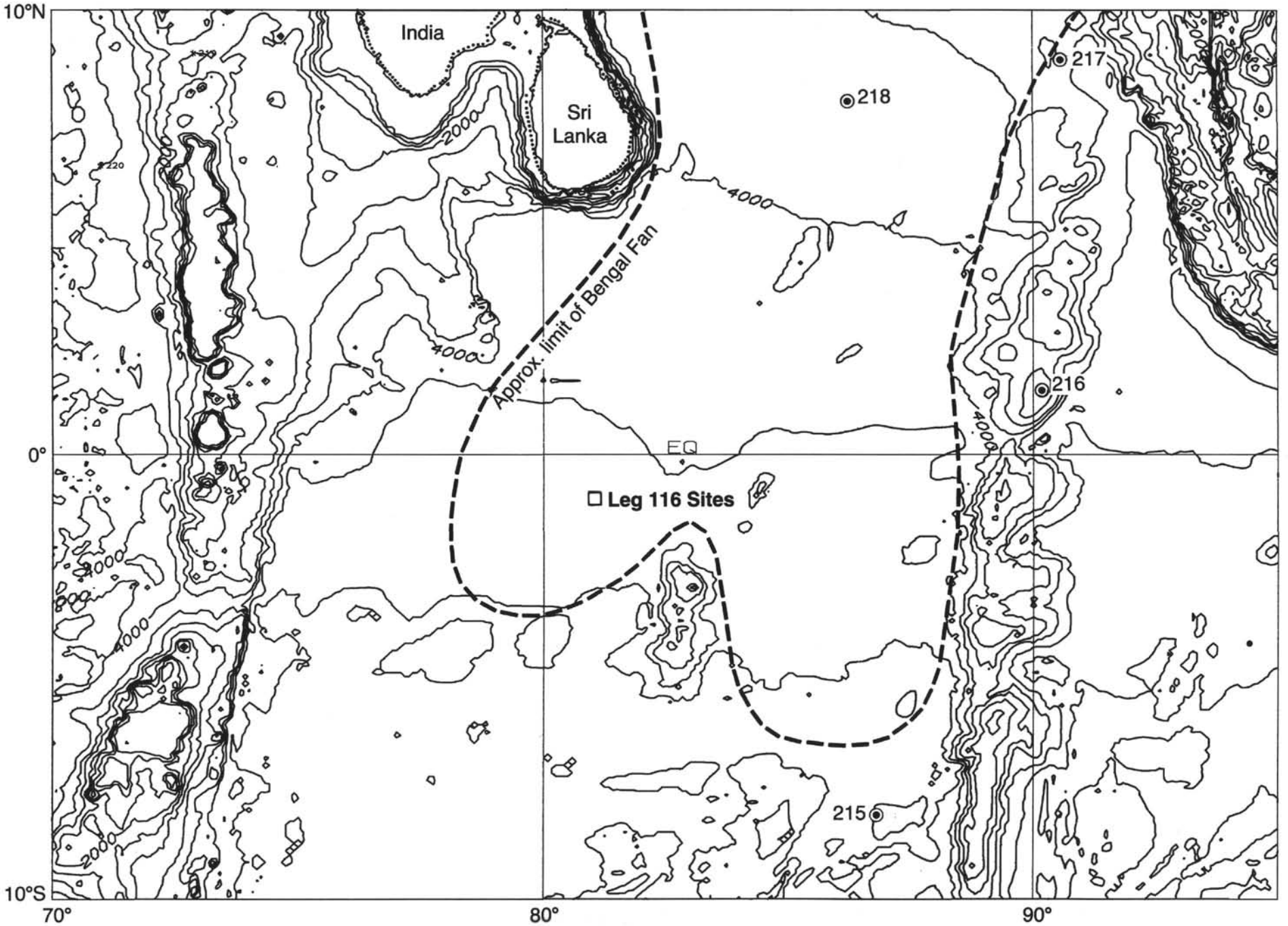
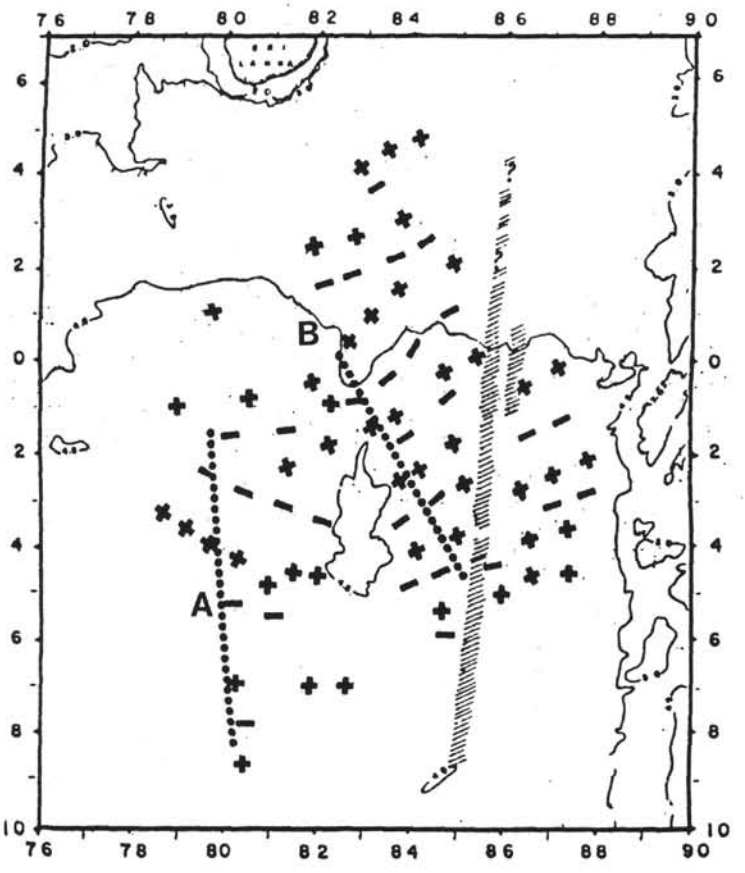

10°N
0°
10°S
70°
80°
90°
India
Sri
Lanka
218
217
216
215
EQ
Approx. limit of Bengal Fan
Leg 116 Sites
2000
4000

Figure 3.

ACOUSTIC BASEMENT ELEVATIONS



\+ BASEMENT HIGH

– BASEMENT LOW

Figure 4A.

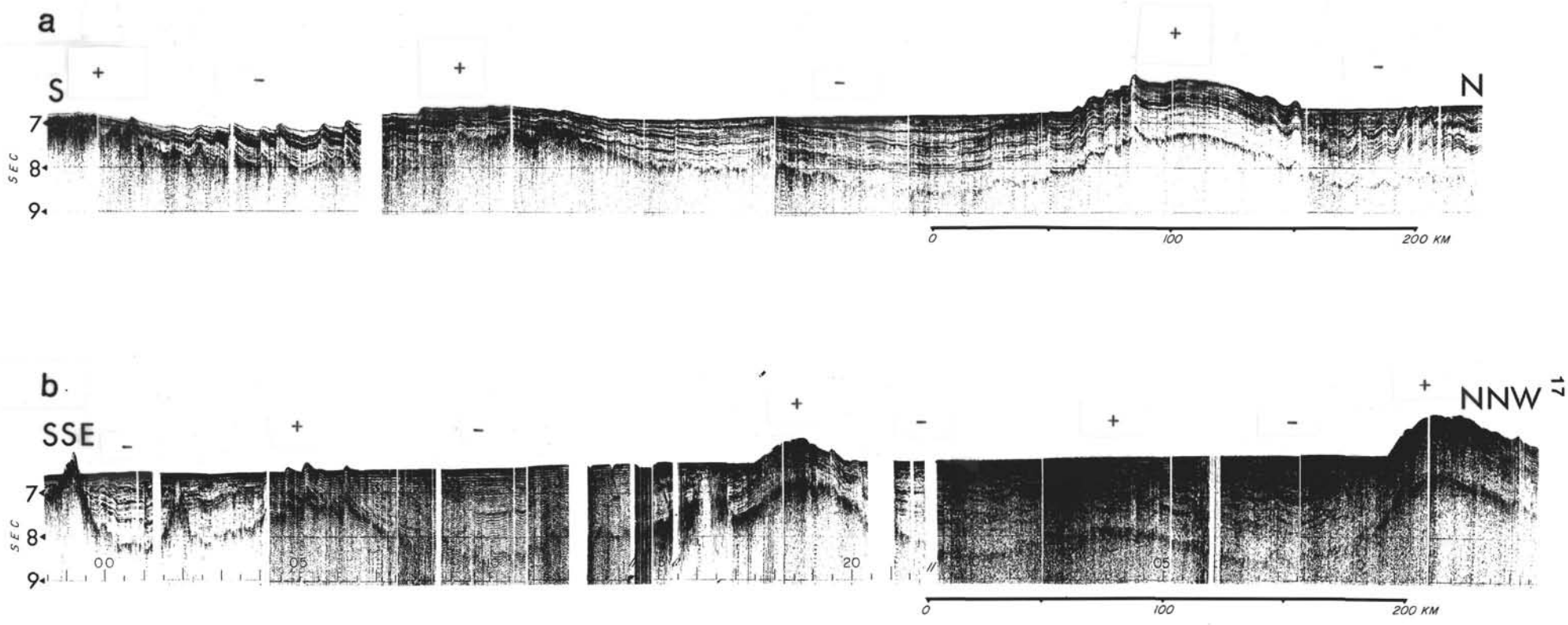


Figure 4B.

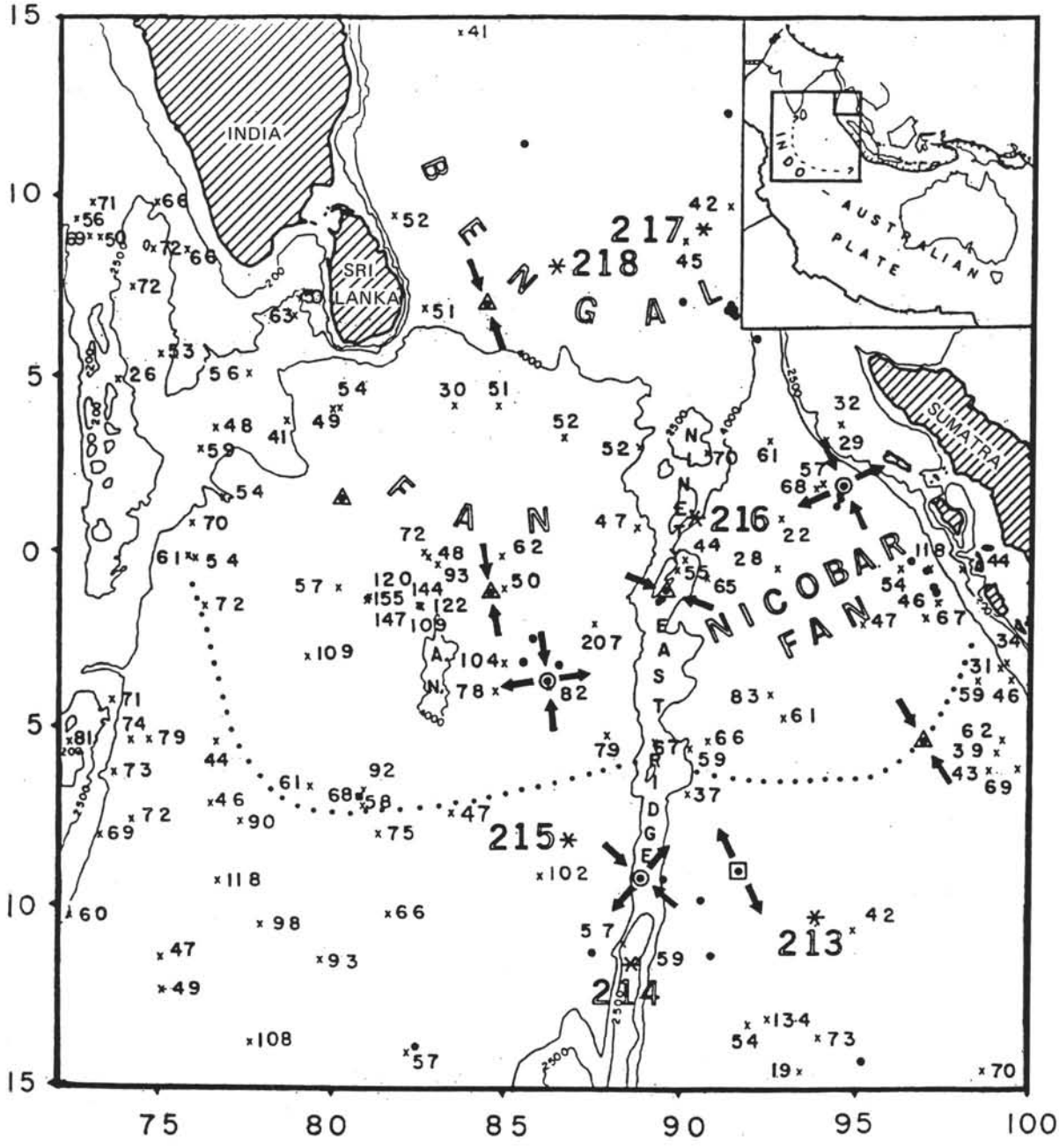

INDIA
SRI LANKA
BENGAL
AFAN
NICOBAR FAN
SUMATRA
INDO-AUSTRALIAN PLATE
217
218
216
215
214
213
15
10
5
0
5
10
15
75
80
85
90
95
100

Figure 5.

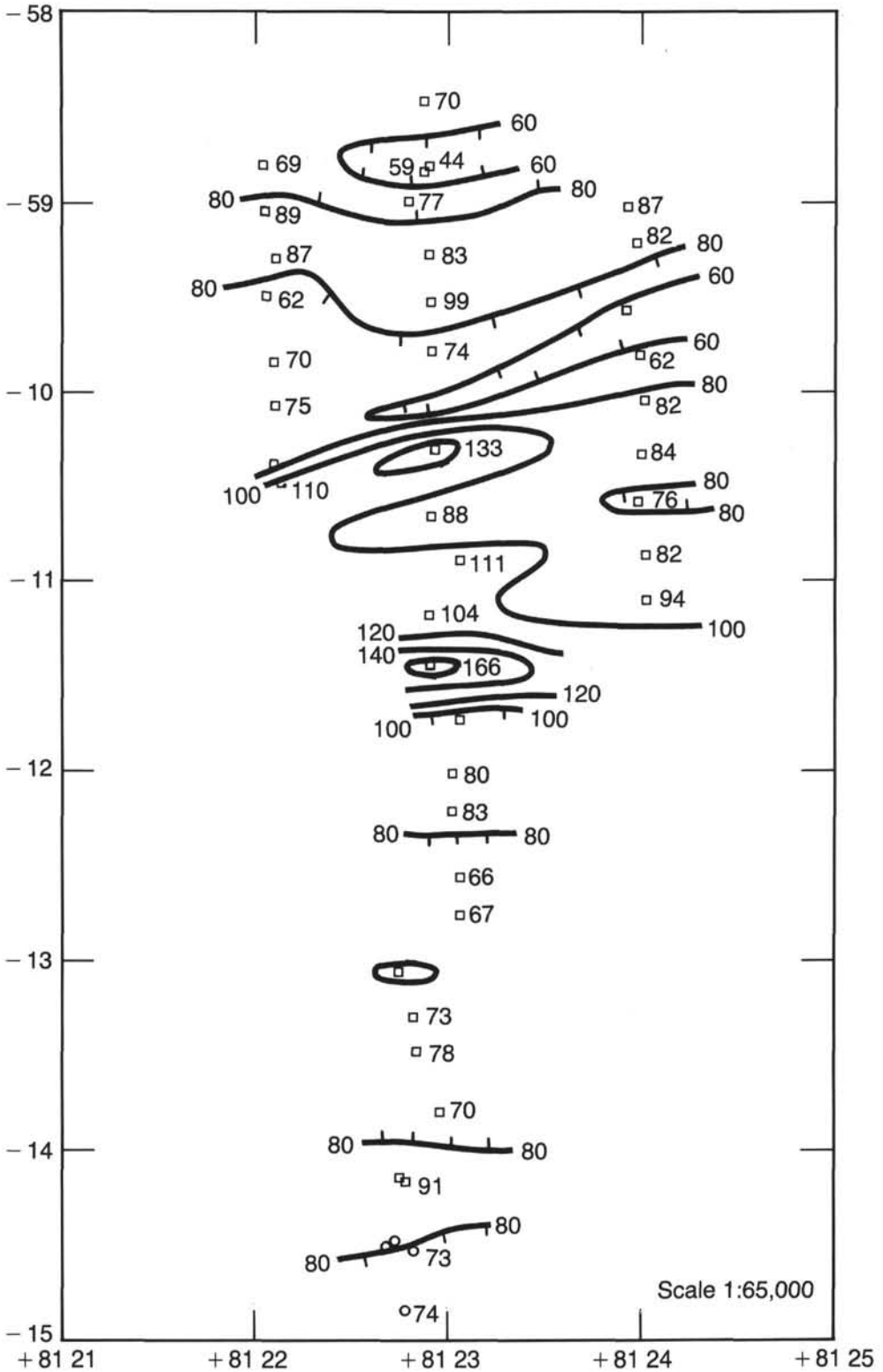

-58
-59
-10
-11
-12
-13
-14
-15
+81 21
+81 22
+81 23
+81 24
+81 25
70
60
69
59
44
60
80
89
77
80
87
87
83
82
80
80
62
99
60
70
74
62
60
75
82
80
133
84
100
110
80
76
80
88
111
82
94
104
100
120
140
166
120
100
100
80
83
80
80
66
67
73
78
70
80
80
91
80
80
73
74
Scale 1:65,000

Figure 6.

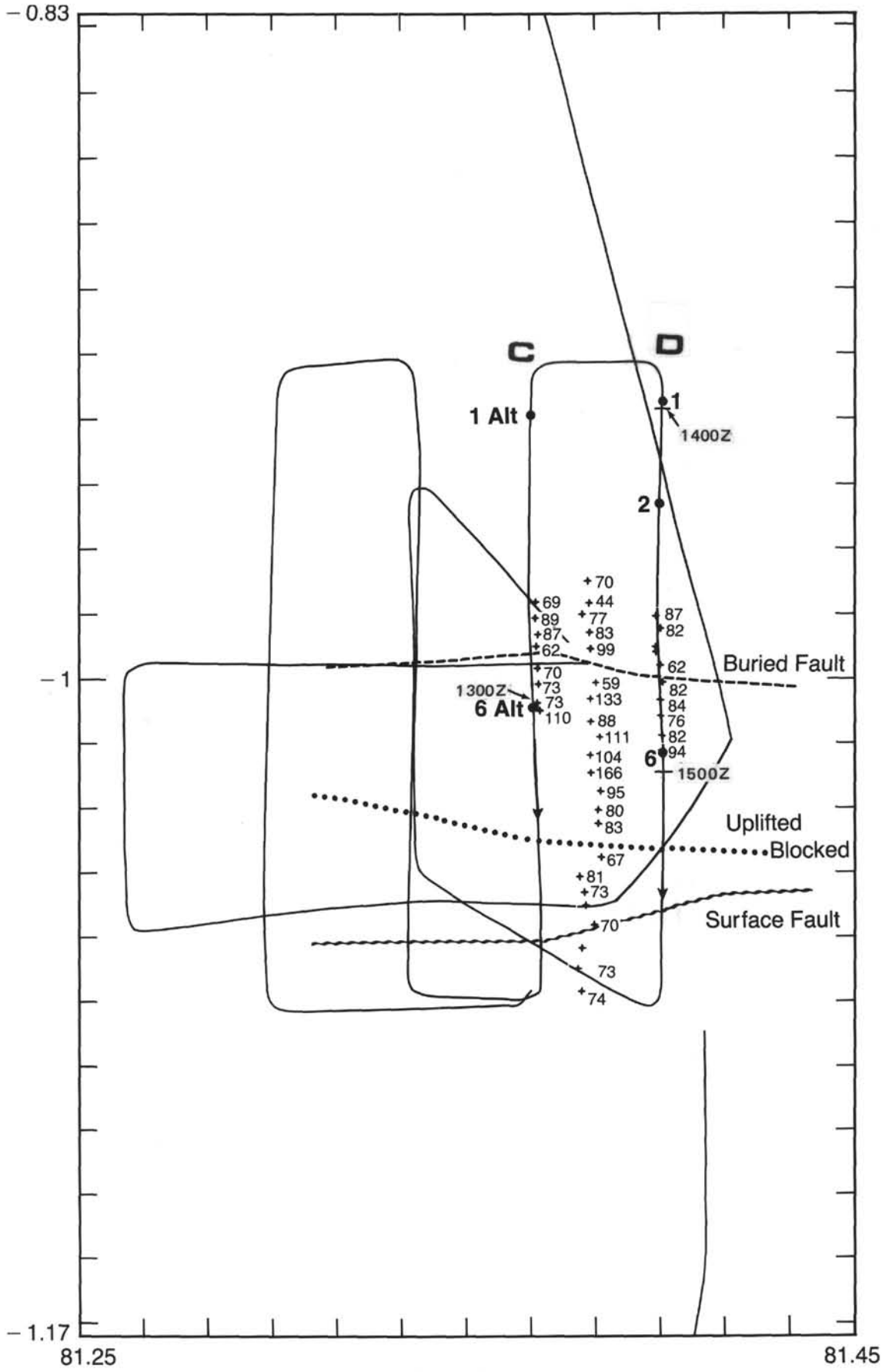

−0.83
−1
−1.17
81.25
81.45
C
D
1 Alt
1
1400Z
2
6 Alt
1300Z
6
1500Z
Buried Fault
Uplifted
Blocked
Surface Fault
69
89
87
62
70
73
73
110
70
44
77
83
99
59
133
88
111
104
166
95
80
83
67
81
73
70
73
74
87
82
62
82
84
76
82
94

Figure 7.

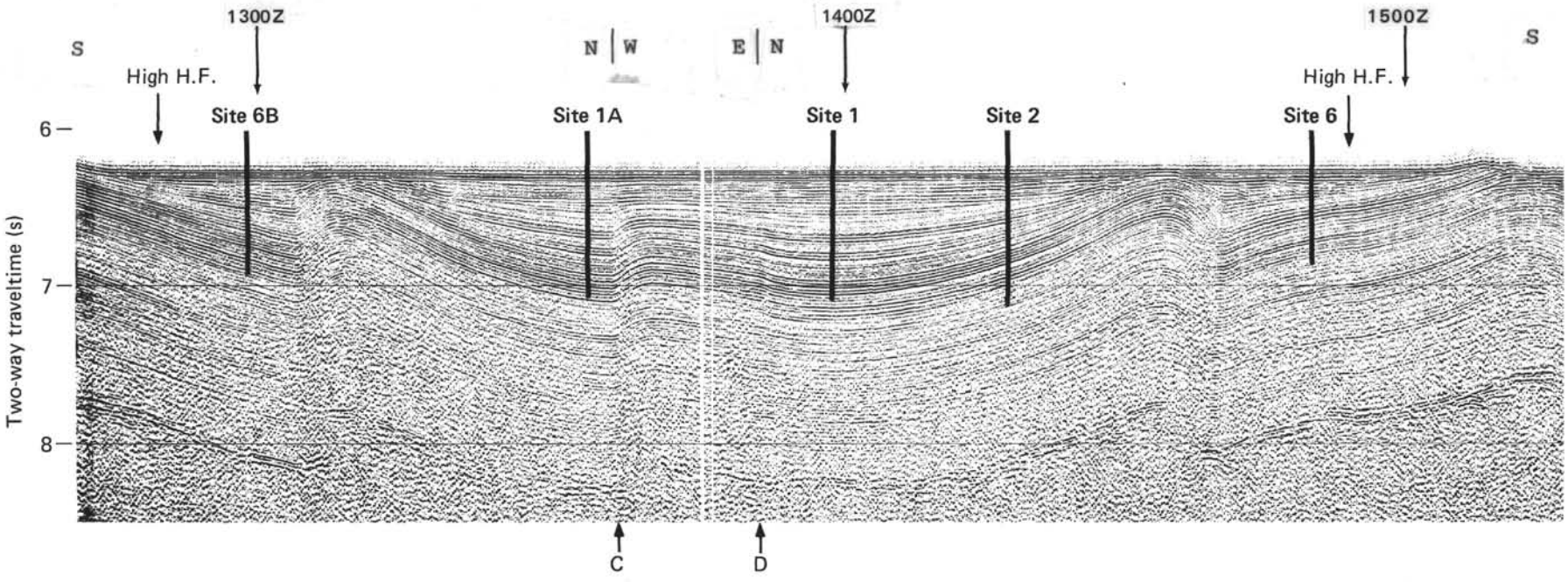

S
1300Z
High H.F.
Site 6B
N | W
Site 1A
E | N
1400Z
Site 1
Site 2
1500Z
High H.F.
Site 6
S
6
7
8
Two-way traveltime (s)
C
D

Figure 8.

SITE NUMBER: ID 1

POSITION: 00°55.64'S 81°24.02'E JURISDICTION: International.

SEDIMENT THICKNESS: > 1500 m. PRIORITY: 1

WATER DEPTH: 4680 m.

DESIRED PENETRATION: 775 m (Approved by JOIDES Safety Panel to 1000 m).

OBJECTIVES:

To calibrate regional seismic stratigraphy, to establish a reference hole in the sediment section, to measure physical and hydrological properties in an area without deformation.

PROPOSED DRILLING PROGRAM:

APC/XCB continuous coring as deep as possible, round trip for RCB BHA, wash to previous penetration, RCB continuous coring to 775 m.

SEISMIC RECORD:

LDGO Conrad 2706 single-channel seismic line, at 1359Z (Figs. 7 & 8).

HEAT FLOW: Yes.

PORE WATER SAMPLING: Yes.

PRESSURE MEASUREMENT: Yes.

LOGGING: Yes (Standard Schumberger logs and LDGO Borehole Televiewer).

SEDIMENT TYPE:

Alternation of turbidites, hemipelagic clays and silts. Possibly sand layers. Age: Quaternary to middle-late Miocene.

SITE NUMBER: ID 2

POSITION: 00°57.60'S 81°23.95'E

JURISDICTION: International.

SEDIMENT THICKNESS: > 1500 m.

PRIORITY: 1

WATER DEPTH: 4680 m.

DESIRED PENETRATION: 800 m.

OBJECTIVES:

To calibrate regional seismic stratigraphy, to compare the sediment section with Site 1 in order to establish history of deformation in the area. To measure physical and hydrological properties in an area with gentle deformation.

PROPOSED DRILLING PROGRAM:

APC/XCB continuous coring to 800 m, round trip for RCB bottom hole assembly if necessary.

SEISMIC RECORD:

LDGO Conrad 2706 single-channel seismic line, at 1418Z (Figs. 7 & 8).

HEAT FLOW: Yes.

PORE WATER SAMPLING: Yes.

PRESSURE MEASUREMENT: Yes.

LOGGING: Yes (Standard Schlumberger logs).

SEDIMENT TYPE:

Alternation of turbidites, hemipelagic clays and silts. Possibly sand layers. Age: Quaternary to middle-late Miocene.

SITE NUMBER: ID 6

POSITION: 01°01.12'S 81°24.01'E

JURISDICTION: International.

SEDIMENT THICKNESS: > 1500 m.

PRIORITY: 1

WATER DEPTH: 4680 m.

DESIRED PENETRATION: 600 m (Approved by JOIDES Safety Panel to 1000 m).

OBJECTIVES:

To measure physical properties, pressure, temperature and pore fluid characteristics in an area of heat flow anomaly.

PROPOSED DRILLING PROGRAM:

APC/XCB continuous coring to 600 m (round trip for RCB if necessary); wash a 230 m hole for Packer experiment with a drill-in packer.

SEISMIC RECORD:

LDGO Conrad 2706 single-channel seismic line at 1451Z (Figs. 7 & 8).

HEAT FLOW: Yes.

PORE WATER SAMPLING: Yes.

PRESSURE MEASUREMENT: Yes.

LOGGING: Yes (Standard Schlumberger logs).

SEDIMENT TYPE:

Alternation of turbidites, hemipelagic clays and silts. Possibly sand layers. Age: Quaternary to middle-late Miocene.

SITE NUMBER: ID 6B

POSITION: 01°00.45'S 81°22.02'E

JURISDICTION: International.

SEDIMENT THICKNESS: > 1500 m.

PRIORITY: 1 (alternate)

WATER DEPTH: 4680 m.

DESIRED PENETRATION: 600 m (Approved by JOIDES Safety Panel to 1000 m).

OBJECTIVES:

To measure physical properties, pressure, temperature and pore fluid characteristics in an area of heat flow anomaly.

PROPOSED DRILLING PROGRAM:

APC/XCB continuous coring to 600 m (round trip for RCB if necessary); wash a 230 m hole for Packer experiment with a drilling packer.

SEISMIC RECORD:

LDGO Conrad 2706 single-channel seismic line at 1257Z (Figs. 7 & 8).

HEAT FLOW: Yes.

PORE WATER SAMPLING: Yes.

PRESSURE MEASUREMENT: Yes.

LOGGING: Yes (Standard Schlumberger logs).

SEDIMENT TYPE:

Alternation of turbidites, hemipelagic clays and silts. Possibly sand layers. Age: Quaternary to middle-late Miocene.

OCEAN DRILLING PROGRAM LEG 116
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