OCEAN DRILLING PROGRAM

LEG 131 SCIENTIFIC PROSPECTUS

NANKAI TROUGH

Dr. Ian Hill
Co-Chief Scientist, Leg 131
Department of Geology
University of Leicester
University Road
Leicester LE1 7RH
United Kingdom

Dr. Asahiko Taira
Co-Chief Scientist, Leg 131
Ocean Research Institute
University of Tokyo
1-15-1 Minamidai
Nakano-ku, Tokyo 164
Japan

Dr. John Firth
Staff Scientist, Leg 131
Ocean Drilling Program
Texas A&M University
College Station, TX 77840

Philip D. Rabinowitz
Director
ODP/TAMU

Audrey W. Meyer
Manager
Science Operations
ODP/TAMU

Louis E. Garrison
Deputy Director
ODP/TAMU

November 1989

Scientific Prospectus No. 31
First Printing 1989

Distribution

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

DISCLAIMER

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

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

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

ABSTRACT

The Nankai accretionary complex is arguably the best known clastic prism complex in the world. It has been extensively geophysically surveyed and geologically sampled, and is continuous from the present deformation front in the Nankai Trough to the Cretaceous-Tertiary accretionary complex, the Shimanto belt, which crops out in the neighboring areas of southeast Japan (Fig. 1). The main objective of Leg 131 is to provide data on the deformational processes and associated hydrogeology of the complex; these results will be combined with a variety of detailed geophysical and geological information to characterize the evolution of sediments in this setting.

This objective will be realized by drilling two sites, one through the décollement and the first major thrust at the toe of the prism, and a second within the undeformed trench sediments seaward of the deformation front. At each site a complete set of measurements will be obtained. Measurements include sampling sediment pore pressure, permeability, temperature, pore fluid, and stress state (all *in-situ*), and analyzing the sedimentology, stratigraphy, physical properties, geochemistry and mechanical-state parameters of sediment cores. Measurements will be obtained with conventional techniques of laboratory testing and wireline logging, and with the aid of several new downhole tools. These data will help to constrain models of deformation processes in a clastic prism.

INTRODUCTION AND OBJECTIVES

The accretion of sediments in oceanic trenches is an initial step in the process of mountain building and continental crustal growth. The study of these processes requires determining how deformation takes place in an accretionary prism, and how this deformation is influenced by variations in physical properties and the presence of fluids (Davis et al., 1983). This investigation also includes such important objectives as determining why at some zones there is primary accretion while there is erosion at others (Moore, Mascle, et al., 1988), why forearc uplift or subsidence occurs, and the nature of earthquake processes. Geochemical models of prisms require a knowledge of the behavior of deforming sediments as they become chemically and physically consolidated and indurated with time, depth, and position, and whether deformation takes place plastically or through brittle fractures. Dewatering and fluid flow must also play a major role in consolidation and deformation (Moore, Mascle, et al., 1988).

The investigation of accretionary prisms has been a major objective of modern land geology as well as an attractive ocean-drilling target. The Nankai Trough is considered to be one of the best places to achieve such objectives because (1) substantial site survey data exist, including excellent images of the thrust structures by seismic profiling (Aoki et al., 1982); (2) the décollement (detachment zone) is relatively shallow (~900 m) and can be penetrated with present drilling technology; (3) the trench sediments are sandy turbidites which represent a type example of most ancient accretionary prisms (e.g., Shimanto belt, Taira et al., 1988; Southern Upland, Leggett et al., 1982); and (4) an almost direct ancient analogy is exposed on land (Shimanto accretionary prism), providing an opportunity for comparative study (Fig. 1).

Drill sites in the Nankai Trough were occupied by *Glomar Challenger* on DSDP Legs 31 (Ingle, Karig, et al., 1975) and 87 (Kagami, Karig, Coulbourn, et al., 1986). Leg 131 is a continuation of studies begun during Leg 87, but with a much stronger emphasis on physical properties, logging, and downhole experiments. The proposed drill sites for Leg 131 are located in the central Nankai Trough, to the northeast of DSDP Sites 298, 582, and 583, where the trench wedge is relatively thin (~1300 m) and the décollement can be more easily reached by drilling (Fig. 2). One of the proposed primary sites (NKT-1) is located in the undeformed sediments at the trough; the other proposed primary site (NKT-2; alternate is NKT-10) is positioned in the accreted and deformed sediments at the toe of the prism (Fig. 3).

The main objectives of scientific drilling during Leg 131 include elucidation of the following thematic issues:

- influence of pore fluids and the hydrogeology of the accretionary prism,
- mechanical state and physical properties of deformed sediments,
- fabrics and structural styles of sediments before and after accretion.

These objectives are closely interrelated, and will be studied by a variety of methods, on a range of spatial scales. Downhole experiments, wireline logging, and laboratory analyses of sedimentology, physical properties, and structural fabrics will be closely coordinated. Table 1 indicates how these different measurements will be combined to achieve a knowledge of seven primary aspects of accretionary prism development and evolution: (1) fluid flow; (2) porosity and density; (3) stress and strain; (4) elastic moduli; (5) sedimentology, structure, and fabrics; (6) geochemistry; and (7) stratigraphy.

1. Fluid Flow

The extent and intensity of fluid flow are difficult to measure directly, but they strongly influence prism morphology and development (Westbrook and Smith, 1983; Brown and Westbrook, 1988). In particular, we intend to determine whether fluid flow is localized along particular zones, and the time-variable nature of that flow (e.g., Sample and Moore, 1987). Permeability and pore pressure will be measured *in-situ* on a scale of centimeters with the LAST and WSTP tools, on a scale of meters with the wireline packer and Geoprops tool, and on a scale of tens of meters with a drill-string rotatable packer.

Flow regimes within the prism may be detected by the temperature or geochemical signature of each water mass. The fluid geochemistry will also contribute to the study of the source of the fluids and alteration processes within the prism. A string of temperature and pressure sensors (ONDO) will be emplaced down a deep penetration hole at proposed site NKT-2 (or, alternatively, NKT-10) to create a long-term observatory to augment the point sampling of this leg.

2. Porosity and Density

Porosity is directly related to the strength and the consolidation history of the sediments, as well as to other physical properties (Bray and Karig, 1985). Porosity and density will be measured on a range of scales, and a comparison of laboratory measurements with borehole logs and seismic experiments will be essential for quality control and stratigraphic correlation. Both intergranular and fracture porosity will be determined, with particular attention paid to shear zones, where this property may be either enhanced or reduced.

3. Stress and Strain

These are vital parameters for understanding the structures observed in both cores and drill holes. Stress orientation may be detected from borehole breakouts and fracture orientations with the formation microscanner (FMS). The state of stress in the borehole may then be directly related to strain indicators in the core. For these studies, core orientation will be critical; this parameter may be determined through examination of FMS records or paleomagnetic measurements. Laboratory measurements using anisotropic strain-relaxation techniques (which involve whole-round core samples) will be crucial. Of particular interest will be changes in the state of stress with depth and in proximity to faults. These measurements will provide invaluable constraints on the geometry and nature of deformation in the complex (Karig, 1986).

4. Elastic Moduli

These parameters can be estimated from seismic velocity measurements on cores, and correlated via wireline logging with seismic profiles and vertical seismic profile (VSP) results (Aoki et al., 1986). While core measurements show the properties relating to individual structures of the core, the VSP shows representative values from bulk volumes of the prism. These data will closely relate the study of stress and strain to porosity and density.

5. Sedimentology, Structure, and Fabrics

Sedimentological studies will allow lithological correlation and provide constraints on conditions prior to deformation. Analyses of mineralogy (i.e., volume fractions, clay mineralogy, biogenic silica content), sedimentary facies, and sedimentary geochemistry will also provide important information for fluid and mass-balance considerations. The presence and composition of authigenic minerals and organic matter will reflect the burial and thermal history of the sediments. Grain size and fabric (as determined through structural and magnetic analyses) are important parameters for interpretations of mechanical and physical properties.

Important structural considerations include the differentiation between brittle and ductile deformational patterns, estimation of displacement along faults, and identification of pervasive shear bands. These last features may suggest stress patterns during early stages of deformation at the toe of the complex.

6. Geochemistry

Like thermal anomalies, geochemical anomalies are excellent indicators of fluid flow, but with greater sensitivity by orders of magnitude. Geochemical analyses will assist in differentiating pervasive vertical fluid movement through the clastic complex and restricted dewatering confined to high-permeability conduits. In addition, the influences of sulfate reduction and methane production, and the presence and composition of dissolved gases, particularly in the vicinity of faults and the décollement zone, may constrain the origins of pore fluids and the formation of gas hydrates.

7. Stratigraphy

Age determination and correlation of sedimentary sections are important constraints to evaluation of large-scale structural styles. Biostratigraphy, paleomagnetism and tephrochronology will provide useful data for this purpose. Sedimentation rates have an important influence on sediment physical properties and on the change in these properties with time and deformation.

In all these areas the extrapolation of details of the recovered core to properties of the prism generally can be made only through interrelated measurements. Extensive laboratory physical-property analyses will be necessary, some of which will involve use of whole-round cores. The core sampling program will be planned very carefully in advance, and may be considerably more exotic than that usual in ODP practice.

BACKGROUND: SEDIMENTATION AND TECTONICS

The Nankai Trough is a topographic manifestation of the subduction boundary between the Shikoku Basin, a part of the Philippine Sea Plate which is moving ~4 cm/yr to the northwest at the proposed drilling sites (Seno, 1977), and the Honshu Arc (a part of the Japanese Islands), which extends approximately east-northeast to west-southwest. To the east, the trough converges with a major arc-arc collision boundary between the Honshu and Izu-Bonin arcs (Fig. 1).

The sediments that are being brought to the deformation zone are composed of two sequences: an upper turbidite layer and a lower hemipelagic layer (Kagami, Karig, Coulbourn, et al., 1986). The turbidites have been transported laterally along the axis of the trough from the mountain ranges of the arc-arc collision zone (Taira and Niitsuma, 1986). The sedimentation rate in the trough is enormous, reaching 1 km/m.y. The thickness of the trench turbidite layer varies from place to place chiefly owing to the configuration of the oceanic basin (Le Pichon, Iiyama, et al., 1987).

The Shikoku Basin is a backarc basin formed behind the Izu-Bonin Arc by mostly east-west directed spreading, accompanied by a late-phase northeast-southwest spreading episode, during the late Oligocene to middle Miocene (25 to 12 Ma) (Kobayashi and Nakada, 1978; Chamot-Rooke et al., 1987). The fossil spreading axis lies in the central part of the Shikoku Basin and has been subducted at the middle part of the Nankai Trough. Ridge-transform topographies produce a local ponding of turbidites in the trough by acting as "dams" for turbidity currents. Owing to the general shallowness of the Shikoku Basin, especially over the fossil spreading axis, the trench turbidite layer is thinnest in this area. The oceanic-basement configuration in the vicinity of the proposed sites is smooth and flat, which aided the creation of rather laterally continuous structural features at the toe region.

Individual turbidites are composed of a graded unit of mostly medium- to very fine-grained sand at the base, which grades to silt at the top. The mean thickness of each turbidite is ~30 cm, intercalated with hemipelagic background mud with a mean thickness of ~5 cm (Taira and Niitsuma, 1986). Some individual turbidite sand layers reach 2 m in thickness.

The hemipelagic sediments underneath the turbidites are composed mostly of bioturbated mud intercalated with volcanic ash. The lithology encountered at DSDP Site 297 showed that within these hemipelagic sediments there is a zone of relatively coarse-grained sediments--mud intercalated with silt and sand--350-550 meters below the sea floor (mbsf), which is considered to be mostly of early Pliocene age (Ingle, Karig, et al., 1975). The lower part of the hemipelagic unit was recovered during DSDP Leg 58 at Site 443, where the Miocene sequence was composed of mud, tuff, and basaltic sills (Curtis and Echols, 1980).

The sites proposed for drilling on Leg 131 are located in the central Nankai Trough, where the entire sedimentary sequence is 1.1 seconds two-way traveltime (s twt) thick; the hemipelagic portion of this sequence is ~0.3 s thick. The structure of the accretionary prism is well imaged by seismic sections (Figs. 4 and 5). The deformation front is defined as the location of initiation of the incipient thrust with several meters of displacement, as identified on 3.5-kHz profiles. This is the proto-thrust zone; it is followed by a series of imbricated thrusts that show a structure typical of thrust-fold belts. The décollement can be identified within the hemipelagic layer. The zone of imbricate thrusts extends landward (to the west) about 30 km with a master detachment surface, while the prism thickens to 1.9 s and is covered by lower-slope, hemipelagic sediments. This zone then abruptly changes to a steep slope of vaguely defined internal structure.

A bottom-simulating reflector (BSR) is ubiquitous in this region. It first appears at the front of the imbricate thrust zone, ~0.15 s (one-way time) below the seafloor, and steadily increases in depth below seafloor landward, reaching a maximum depth of 0.3 s twt under the slope at ~3000 m water depth. The BSR becomes shallower toward the upper part of the slope. The anomalously shallow BSR at the toe region has been interpreted as resulting from high heat flux (Yamano et al., 1982).

PREVIOUS DRILLING

DSDP legs in the Nankai Trough region drilled three sites in the trough and on the slope, all of which are west of the Leg 131 proposed sites. Site 298 penetrated 611 m at the toe of the prism in a water depth of 4659 m. The total length of spot-cored section was 145.5 m with 46% of core recovery (Ingle, Karig, et al., 1975).

Site 582 was drilled into the undeformed trench fill, with a maximum penetration of 700 m. The turbidite sequence at this site is 550 m thick and is underlain by Pliocene-upper Pleistocene hemipelagic sediment. Core recovery was 41%. Site 583 was drilled at the toe of the prism and eight holes achieved maximum penetration of 450 m and overall core recovery of 77%. The upper parts of three holes (at Site 583) were hydraulically piston cored to ~60 mbsf. These sediments are typically finely graded hemipelagic mud, divided into beds about 10 cm thick, with individual beds commonly separated by layers of sand and vitric ash. The oldest sediments recovered at Site 583 are Quaternary. Hole 583F was also logged continuously for ~200 m. The temperature gradient in the upper 200 m of sediment at Site 583 was ~5°C/100 m (Kinoshita and Yamano, 1986). Neither solid gas hydrate nor high gas pressure was encountered at either site (Kagami, Karig, Coulbourn, et al., 1986).

OPERATIONS PLAN

The details of the drilling operations plan for Leg 131 are summarized in Tables 2 and 3, while the following section explains the underlying rationale for specific objectives at each hole. Leg 131 will depart from Guam on 1 April 1990 and after 5 days' transit will arrive at the Nankai Trough. It should be noted that all sites proposed for drilling during this cruise are within an area only a few kilometers across. Leg 131 is scheduled to end in Pusan, South Korea, on 2 June 1990, after 62 days at sea.

Proposed site NKT-2 (or, alternatively, NKT-10) will be drilled first; NKT-2 is the preferred location for maximizing scientific return. In order to achieve the detailed suite of complementary measurements required to satisfy the objectives listed on the site descriptions, the operational plan envisioned at the time of this writing includes drilling four separate holes at this site (Fig. 6). While this appears a complex plan, it contains contingency planning and some redundancy to maximize the chances of success. Hole instability is very likely, and may require casing of the upper parts of all holes in order to ensure safe deployment of downhole tools. Because the wireline packer is important for achieving the major hydrogeologic objectives of this cruise, it may be run within casing as an operational and scientific test prior to running it in open hole.

The first hole will be drilled through the first major thrust, with emphasis on retrieving logs and undisturbed core from the upper section and allowing use of the WSTP, LAST, and Geoprops physical property tools. The second hole will complete the logging and core record down to and through the décollement zone. The third hole is dedicated to packer and VSP experiments; again, because of the likelihood of hole instability, a rapidly drilled third hole should provide the best conditions for these experiments. This hole will be spot cored and logged briefly to assist in identification of packer seats. The fourth hole will be drilled through the décollement and then cored to bit destruction, possibly into basement. This hole will be cased through the décollement to provide stable conditions for the long-term deployment of the ONDO temperature experiment and to ensure completion of coring and logging objectives in the portion of the hole below the décollement. Several of these holes may end up being combined, if drilling conditions during the cruise allow this possibility.

The drilling plan at proposed site NKT-1 is considerably simpler, since the single hole planned will not be complicated either by the major structural discontinuities of NKT-2 (or NKT-10) or by the need for long-term hole stability. The program of coring and measurements will, however, provide a similar data set to allow a direct reference comparison with NKT-2.

Proposed site NKT-3 is a reserve site in the event of insuperable difficulties causing abandonment of NKT-2 or its alternates. The scientific objectives would be similar to NKT-2, but with concentration on collection of core from the deformed sediment section with little drilling disturbance.

GLOSSARY OF SPECIAL TOOLS

FMS Formation microscanner a logging tool which measures electrical resistivity on a very fine scale with a grid of sensors which are pressed against the side of a borehole. Requires a separate logging run.

Geoprops* A miniature, instrumented straddle packer, deployed into a 3-3/4-in. hole cut ahead of the bit with the navidrill. This tool collects an array of physical properties, mechanical state parameters, and pore-water samples in sediments and rocks too lithified for push-in tools (i.e., LAST, WSTP).

LAST* Lateral stress tool - a series of sensors to measure anisotropic horizontal stress and pore-fluid pressure (and soon temperature) *in-situ,* incorporated into a special APC cutting shoe which has a reversed cutting edge to reduce sediment disturbance outside the shoe.

ONDO* "Temperature" in Japanese. A long-term, downhole temperature monitoring system containing an array of thermistors, to be emplaced in a cased borehole in a string up to 800 m long. Will record temperatures for as long as 5 yr.

Rotatable Packer+ TAM Drilling Packer (TDP) - a drill-string packer designed to withstand stresses from rotation and drilling.

WP* Wireline packer a straddle packer deployed on the logging cable through the drill pipe. This tool is lowered through the bit and inflated with internal motors. The test zone between inflatable elements is ~1 m thick, and the tool can collect up to four separate water samples.

WSTP+ A push-in tool containing a water sampler and sensors to measure sediment temperature and pressure. Sometimes called the Barnes/Uyeda tool.

* Tool currently under development.

\+ Tool currently undergoing modification.

REFERENCES

Aoki, Y., Tamano T., and Kato, S., 1982. Detailed structure of the Nankai Trough from migrated seismic sections. *In* Watkins, J., Drake, C. L. (Eds.), Studies in Continental Margin Geology. *Am. Assoc. Petrol. Geol. Mem.*, 34:309-322.

Aoki, Y., Kinoshita, H., and Kagami, H., 1986. Evidence of a low-velocity layer beneath the accretionary prism of the Nankai Trough; inferences from a synthetic sonic log. *In* Kagami, H., Karig, D. E., Coulbourn, W., et al., *Init. Repts, DSDP*, 87: Washington (U.S. Govt. Printing Office), 727-735.

Bray, C. J., and Karig, D. E., 1985. Porosity of sediments in accretionary prisms and some implications for dewatering processes. *J. Geophys. Res.*, 90:768-778.

Brown, K., and Westbrook, G. K., 1988. Mud diapirism and subcretion in the Barbados Ridge accretionary complex: the role of fluids in accretionary processes. *Tectonics,* 7:613-640.

Chamot-Rooke, N., Renard, V., and Le Pichon, X., 1987. Magnetic anomalies in the Shikoku Basin: a new interpretation. *Earth Planet. Sci. Lett.*, 83:214-228.

Curtis, D. M., and Echols, D. J., et al., 1980. Lithofacies of the Shikoku and Parece Vela Basins. *In* deVries Klein, G., Kobayashi, K., et al., *Init. Repts. DSDP*, 58: Washington (U.S. Govt. Printing Office), 701-710.

Davis, D., Suppe, J., and Dahlen, F. A., 1983. Mechanics of fold-and-thrust belts and accretionary wedges. *J. Geophys. Res.,* 88:1153-1172.

Ingle, J. C., Karig, D. E., et al., 1975. *Init. Repts. DSDP,* 31:Washington (U.S. Govt. Printing Office), 275-316.

Kagami, H., Karig, D. E., Coulbourn, W., et al., 1986. Site 582. *In* Kagami, H., Karig, D. E., Coulbourn, W., et al., *Init. Repts. DSDP*, 87: Washington (U.S. Govt. Printing Office), 35-122.

Karig, D. E., 1986. Physical properties and mechanical state of accreted sediments in the Nankai Trough, Southwest Japan Arc. *Mem. Geol. Soc. Am.,* 66:117-133.

Kinoshita, H. and Yamano, M., 1986. The heat flow anomaly in the Nankai Trough area. *In* Kagami, H., Karig, D. E., Coubourn, W., et al., *Init. Repts. DSDP,* 87: Washington (U.S. Govt. Printing Office), 737-743.

Kobayashi, K. and Nakada, M., 1978. Magnetic anomalies and tectonic evolution of the Shikoku inter-arc basin. *J. Phys. Earth,* 26:391-402.

Leggett, J. K., McKerrow, W. S. and Casey, D. M., 1982. The anatomy of a Lower Palaeozoic accretionary forearc: the Southern Uplands of Scotland. *In* Leggett, J. K. (Ed.), Trench-Forearc Geology. *Geol. Soc. London Spec. Publ.,* 10:495-520.

Le Pichon, X., Iiyama, T., et al., 1987. Nankai Trough and the fossil Shikoku Ridges: results of Box 6 Kaiko survey. *Earth Planet. Sci. Lett.,* 83: 186-198.

Moore, J. C., Mascle, A., et al., 1988. Tectonics and hydrogeology of the northern Barbados Ridge: Results from Ocean Drilling Program Leg 110. *Geol. Soc. Amer. Bull.,* 100:1578-1593.

Sample, J. C., and Moore, J. C., 1987. Structural style and kinematics of an underplated slate belt, Kodiak and adjacent islands, Alaska. *Geol. Soc. Amer. Bull.,* 99:7-20.

Seno, T., 1977. The instantaneous rotation vector of the Philippine Sea plate relative to the Eurasian plate. *Tectonophys.*, 102:209-226.

Taira, A. and Niitsuma, N., 1986. Turbidite sedimentation in the Nankai Trough as interpreted from magnetic fabric, grain size, and detrital modal analyses. *In* Kagami, H., Karig, D. E., Coulbourn, W., et al., *Init. Repts. DSDP*, 87: Washington (U.S. Govt. Printing Office), 611-632.

Taira, A., Katto, J., Tashiro, M., Okamura, M., and Kodama, K., 1988. The Shimanto Belt in Shikoku, Japan--evolution of Cretaceous to Miocene accretionary prism. *In* Taira, A., and Ogawa, Y. (Eds.), The Shimanto Belt, Southwest Japan-studies on the evolution of an accretionary prism. *Modern Geology*, 12:5-46.

Westbrook, G. K., and Smith, J. J., 1983. Long décollements and mud volcanoes: evidence from the Barbados Ridge Complex for the role of high pore-fluid pressure in the development of an accretionary complex. *Geology*, 11:279-283.

Yamano, M., Uyeda, S., Aoki, Y., and Shipley, T. H., 1982. Estimates of heat flow derived from gas hydrates. *Geology*, 10:339-343.

LIST OF TABLES

LIST OF FIGURES

Table 1. Nankai Measurements.

	Downhole Measurements										Core Measurements															
	Standard Schlumberger	Temperature	Fm. Microscanner (FMS)	V.S.P.	L.A.S.T. (Moran)	W.S.T.P. (Barnes)	Geoprops	Wireline Packer	Rotatable Packer	Temperature String (ONDO)	Grape Density	Pycnometer	P-Wave Logger	Hamilton Velocimeter	Resistivity Logger	Pressure Vessel: $VP+\Omega$	Interstitial Water	Vane Shear	Core Description	XRD & XRF	Strain Release	Shore-based(Shear,Perm.,etc.)	Seismic	Paleontology	Paleomagnetics	Magnetic Fabric
Fluid flow																										
Permeability and pore pressure																										
cm-scale					X	X																X				
m-scale							X	X																		
5-50 scale																										
>50 m-scale									X														?			
Tracers																										
Present flow		X			?	X	X	X																		
Long-term flow										X																
Fluid geochemistry						X	X	X									X									
Porosity and density																										
cm-scale		X									X	X		X												
m-scale	X									X																
>100 m-scale																							X			
Stress and strain																										
Stress direction			X	X	X		X												?		?					
Stress magnitude					X																	X				
Sediment strength-consolidation					X		?											X				X				
Fracturing	X		X																X							
Structure			X																X				X			X
Elastic moduli																										
cm-scale			?										X	X		X						X				
m-scale	X																									
>20 m-scale				X																			X			
Sedimentology, structure, fabrics																										
Mineralogy	X																		X	X						
Sedimentary facies & fabrics			X																X					X	X	X
Geochemistry	X																			X				X		
Stratigraphy																										
Sedimentation rate																								X	X	
Correlation	X																		X				X	X	X	

Table 2. Summary Site Information, Leg 131.

Site	Lat./Long.	Water Depth (m)	Penetration Sed. (m)	Penetration Bsmt. (m)	Drilling (days)	Logging (days)	Total (days)
NKT-1	32°18'N 134°59'E	4800	900	0	10.1	4.0	14.1
NKT-2	32°21'N 134°57'E	4660	1300	50	29.1	12.8	41.9
Alternate Sites:							
NKT-2A (Alternate for NKT-2)	32°22'N 134° 56'E	4500	1500	50	35.8	13.8	49.6
NKT-3	32°25'N 134°54'E	4350	1600	0	9.7	3.9	13.6
NKT-10 (Alternate for NKT-2)	32° 20'N 134° 57'E	4750	1150	50	29.1	12.8	41.9

Table 3. Leg 131 Drilling Schedule (tentative)

Leg 131 departs Guam on 1 April 1990.

			Time on Site	Transit Time
Transit from Guam to NKT2			4.7	
Arrive	NKT-2	6 April	41.9	
Leave	NKT-2	17 May		
Arrive	NKT-1	17 May	14.1	
Leave	NKT-1	1 June		
Transit	NKT-1 to Pusan		1	
Arrive	Pusan	2 June		
			Total Time	61.7

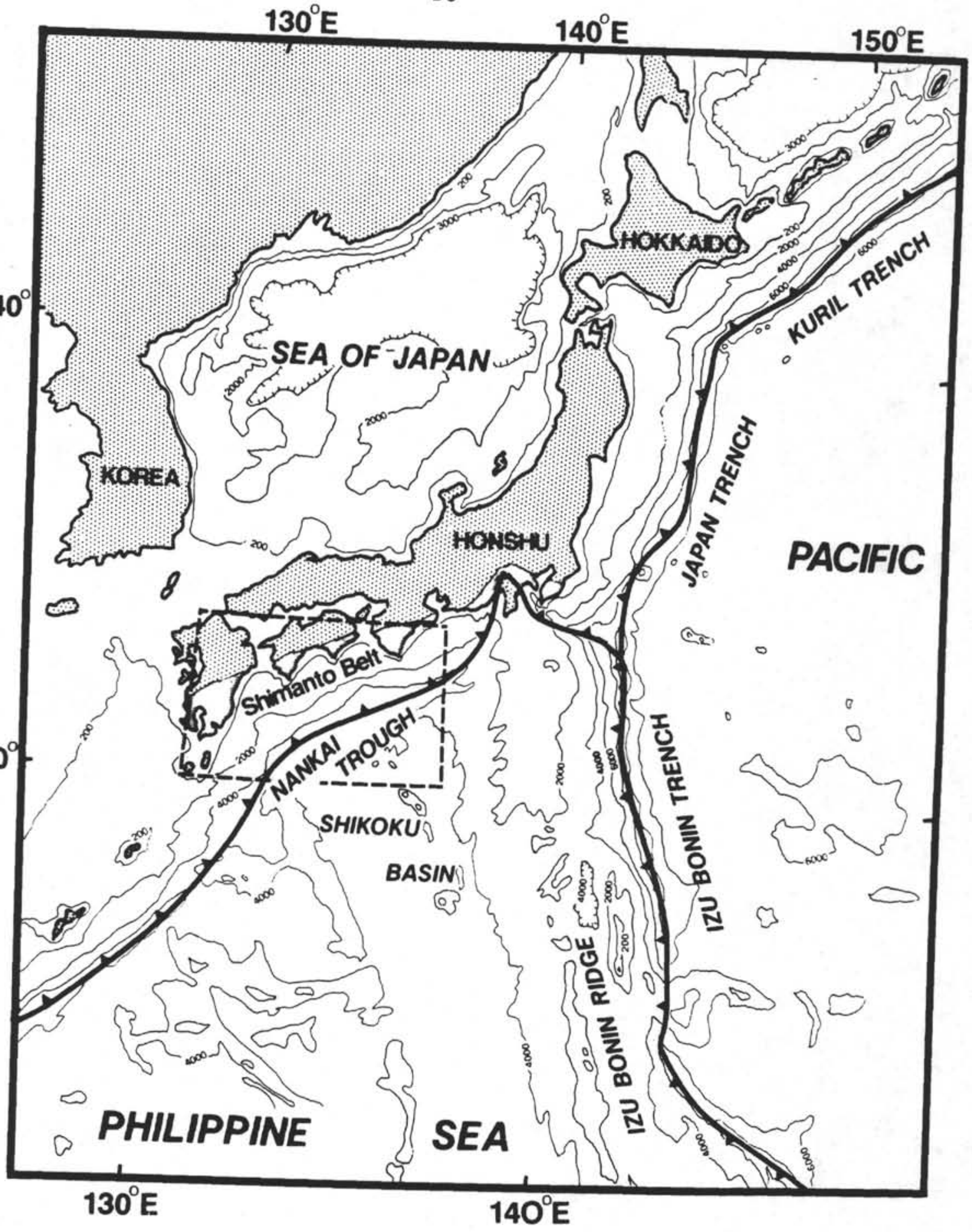


Figure 1. Tectonic setting of Nankai Trough. Dashed box shows location of Figure 2. The Shimanto Belt (shown by cross-hatched area) is a Cretaceous-Tertiary accretionary prism complex that grades into the present accretionary prism. Bathymetry in meters.

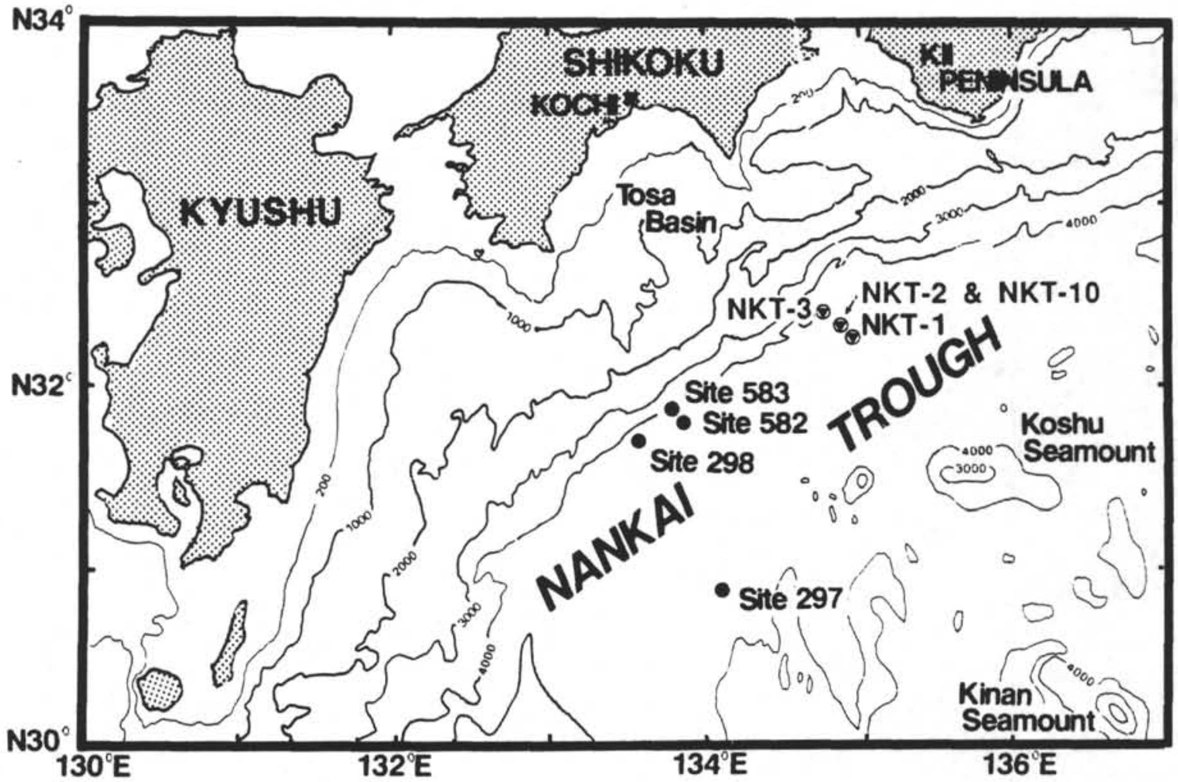


Figure 2. Location of proposed Leg 131 sites and previous DSDP sites in the area. Bathymetry in meters.

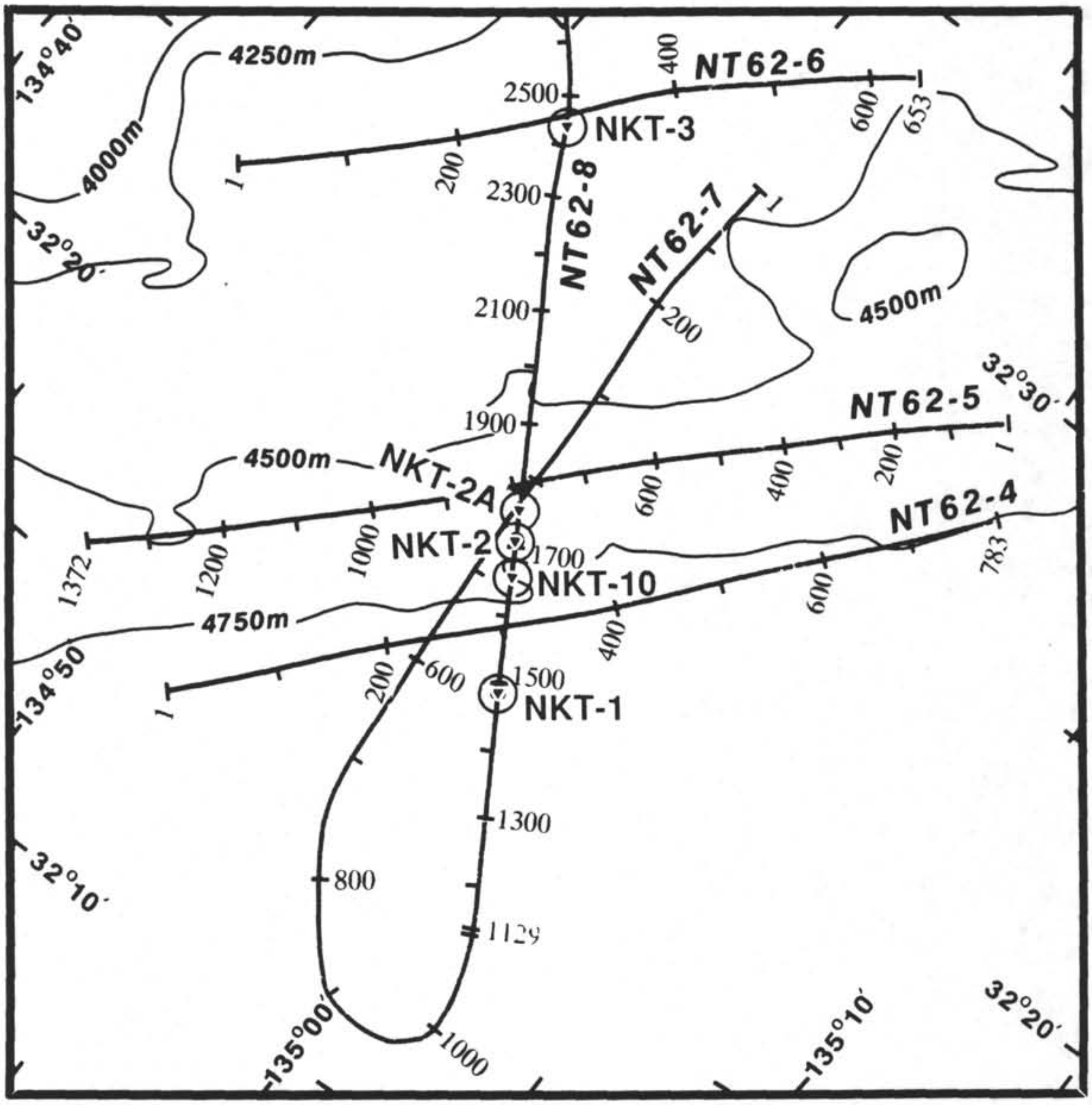


Figure 3. Trackline map of 48-fold seismic reflection lines showing shot-point locations and locations of proposed Leg 131 drill sites. The NT62-series seismic lines were obtained by R/V *Fred Moore* during U.S.-Japan two-ship seismic experiments in 1987.

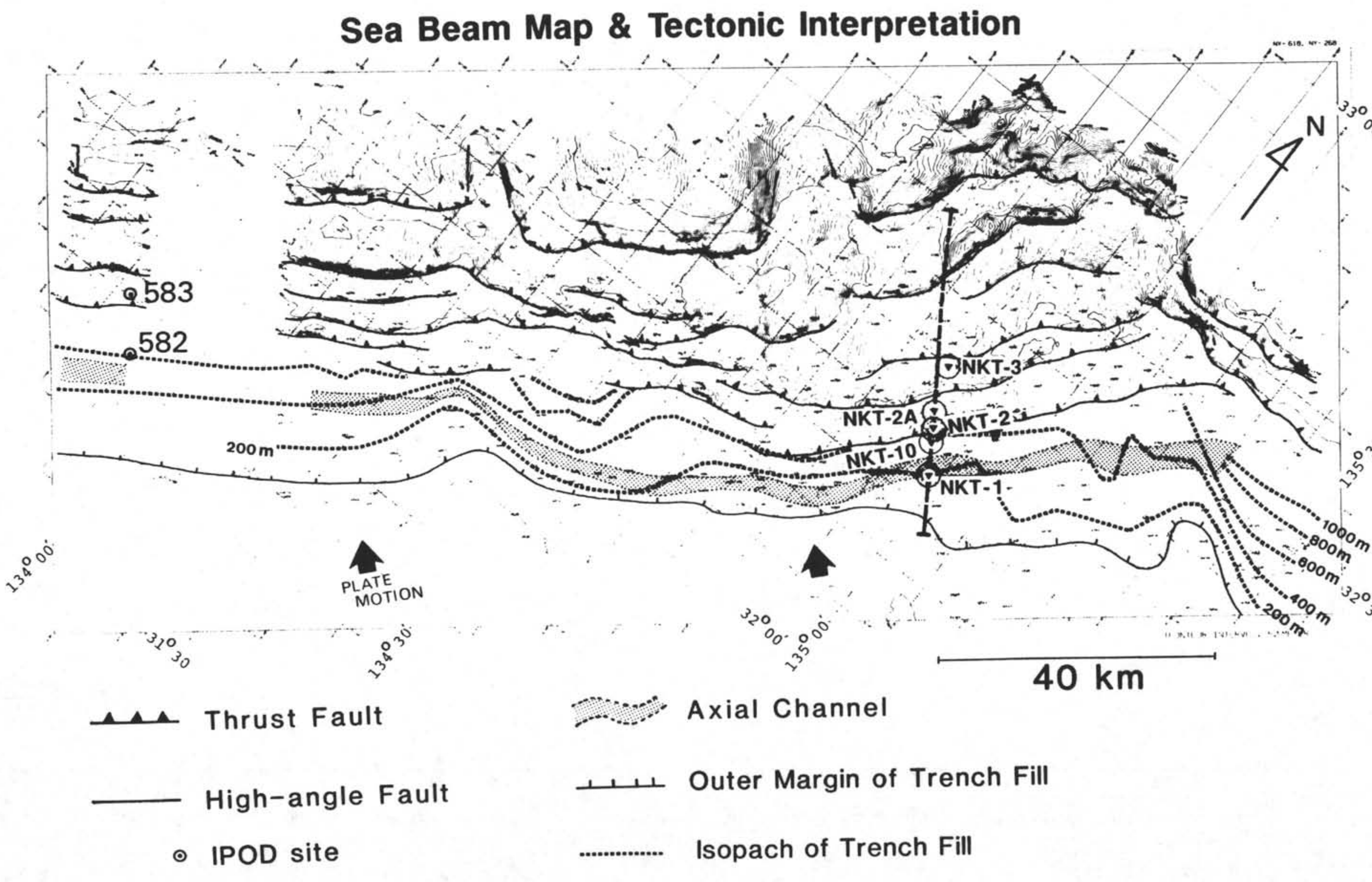


Figure 4. Sea Beam map with tectonic interpretation.

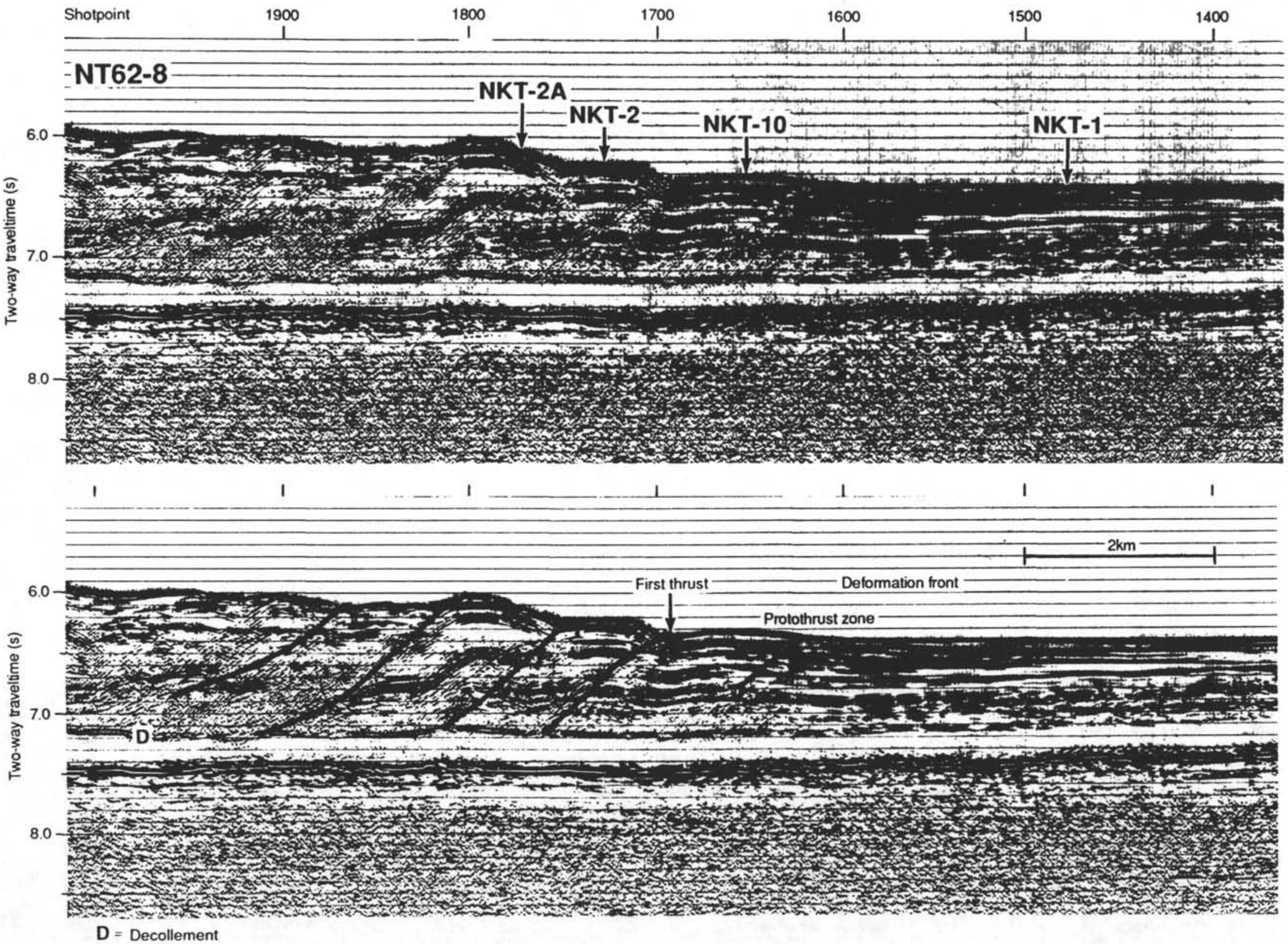


Figure 5. Section of seismic line NT62-8 showing location of proposed sites, shotpoint numbers, and structural interpretation.

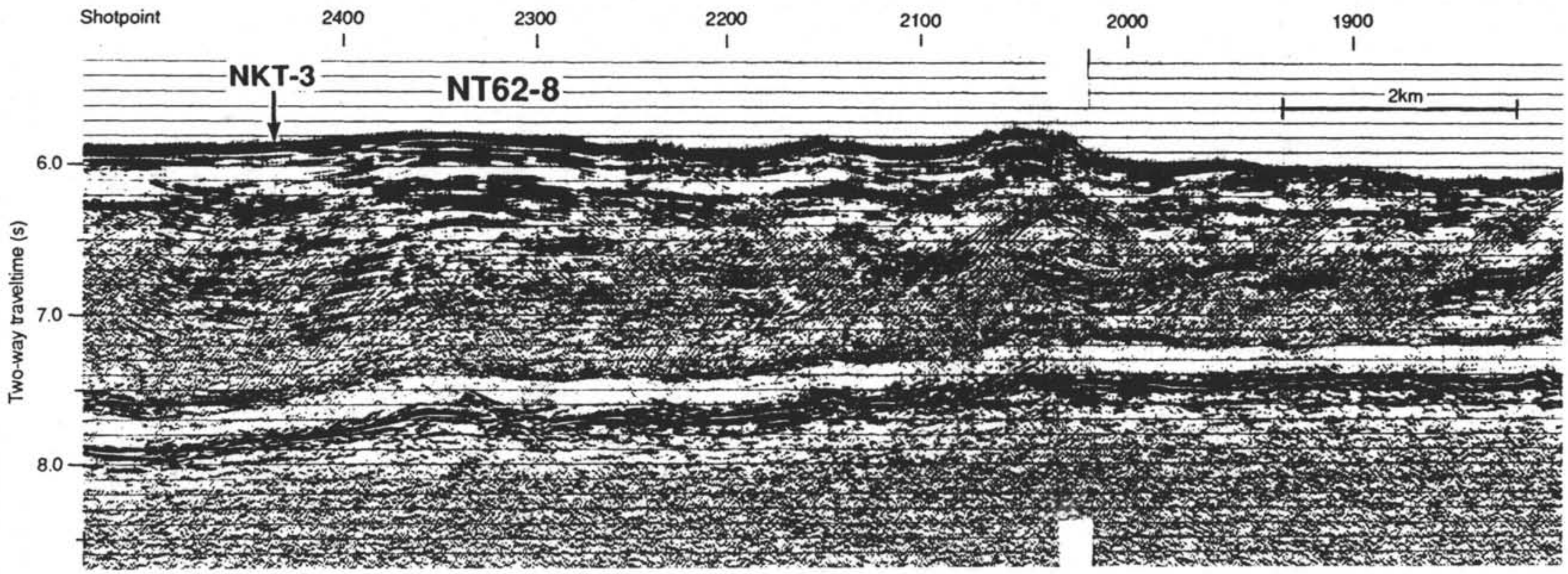


Figure 5 (continued). Section of seismic line NT62-8 showing location of proposed sites, shotpoint numbers, and structural interpretation.

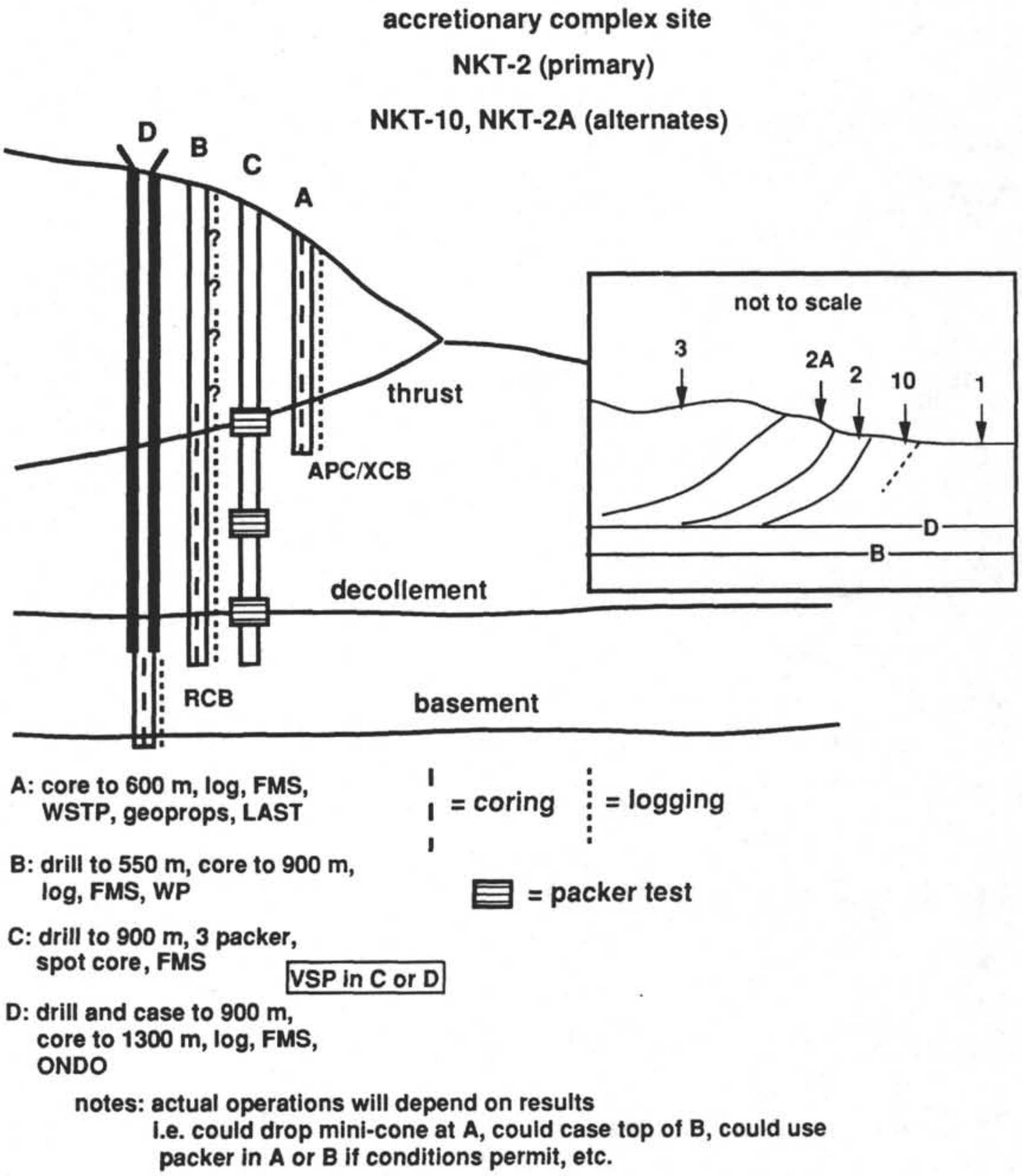


Figure 6. Proposed drilling plan for site NKT-2.

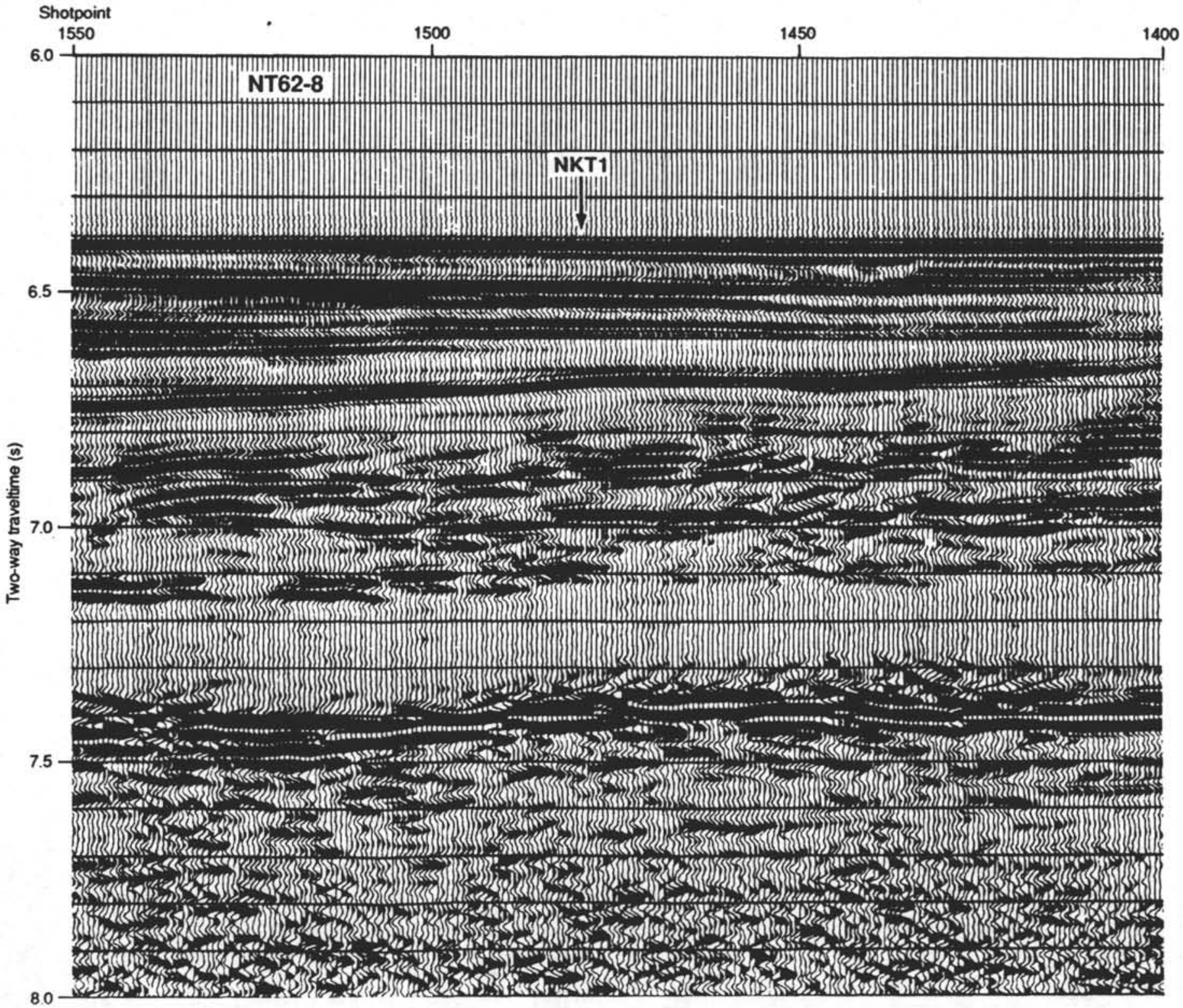
Site Number:	NKT-1 (Nankai Trench Axis)	Position:	32°18'N, 134°59'E
Seismic Record:	NT 62-8, SP 1480	Water Depth:	4800 m
Sediment Thickness:	900 m		

Sediment Type:	0-300 mbsf	Pleistocene turbidites
	300-650 mbsf	Pliocene hemipelagic mudstone with thin turbidites
	650-900 mbsf	Miocene hemipelagic mud with volcanic ash
	below 900 mbsf	Oceanic basement

Priority: 1

Proposed drilling program:
APC (oriented)/XCB/NCB to refusal (950 mbsf?), two-stage logging, FMS, WSTP, LAST, Geoprops.

Objective:
Reference measurements of physical properties and stratigraphy for comparison to NKT-2.


Shotpoint
1550
1500
1450
1400
NT62-8
NKT1
Two-way traveltime (s)
6.0
6.5
7.0
7.5
8.0

Site Number: NKT-2 (Nankai Prism Toe) Position: 32°21'N, 134°57'E

Seismic Record: NT 62-8, SP 1730 Water Depth: 4660 m

Sediment Thickness: 1300 m

Sediment Type:		
	0-450 mbsf	Off-scraped sequence of Pleistocene turbidites
	thrust	---------------------------
	450-900 mbsf	Pliocene hemipelagic sediments
	décollement	---------------------------
	900-1300 mbsf	Miocene hemipelagic mud
	below 1300 mbsf	Volcaniclastics/basalt

Priority: 1

Proposed drilling program: Four holes as follows:
1. APC (oriented)/XCB to refusal, logging, FMS, WSTP, LAST, Geoprops.
2. RCB wash to 600 mbsf, core 600-900 mbsf, logging, FMS, wireline packer.
3. RCB Rotatable packer hole (wash) 900 mbsf, packer, FMS, wireline packer, VSP.
4. RCB set reentry cone, drill and case to 900 mbsf; core to 1300 mbsf or bit destruction, logging, FMS, wireline packer, VSP, ONDO.

Objectives:
1. Measure *in-situ* pressure, temperature, porosity, permeability throughout the section.
2. Determine geochemical characteristics of pore fluids throughout the section.
3. Measure mechanical and physical properties of recovered cores.
4. Determine the sequence of deformation features in various structural units.
5. Correlate deformational styles to sedimentary facies.

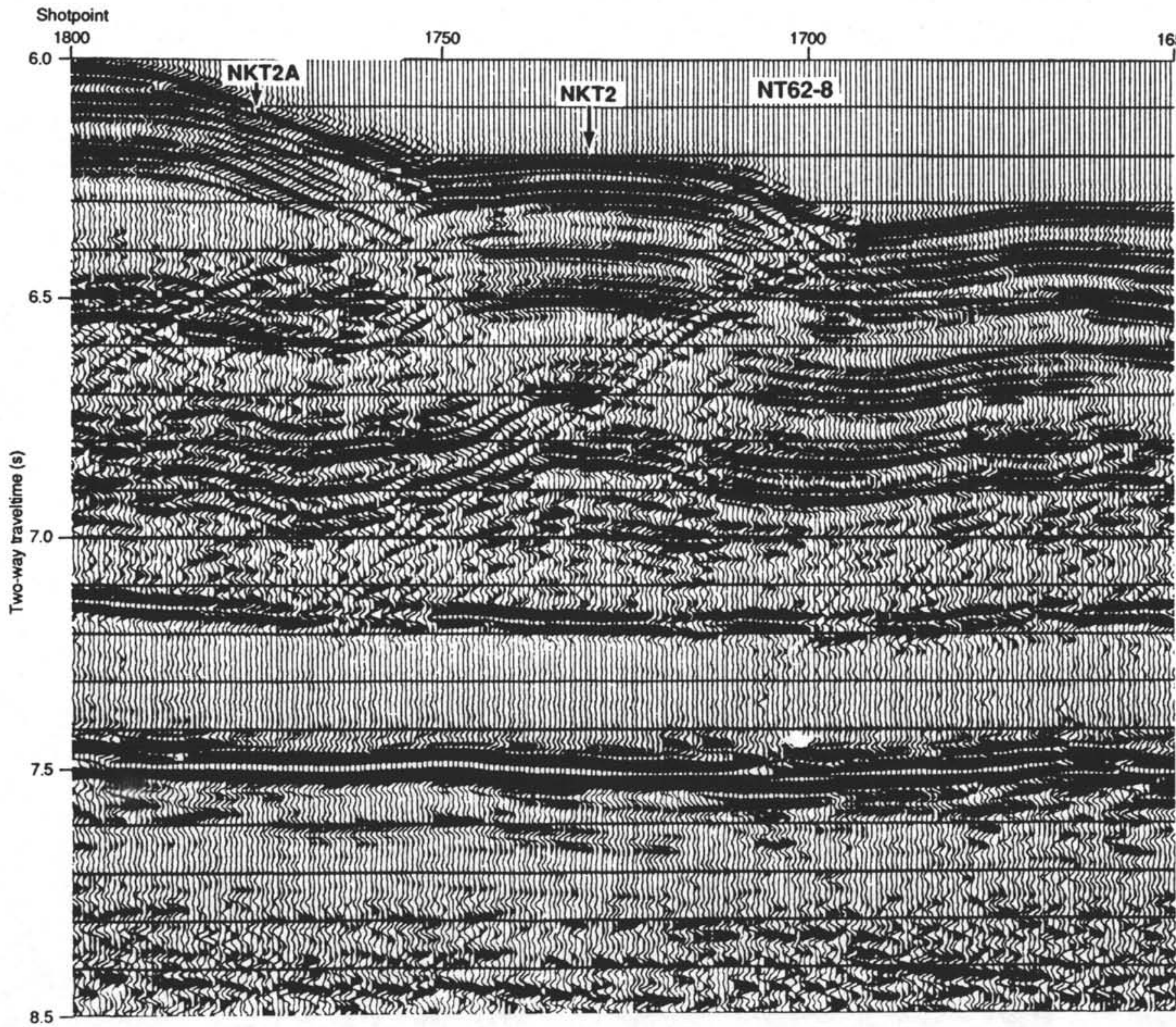
Site Number:	NKT-2A (Nankai Prism Toe)	Position: 32°22'N, 134°56'E
Seismic Record:	NT 62-8, SP 1775	Water depth: 4500 m
Sediment Thickness:	1500 m	

Sediment Type:	0-480 mbsf	Off-scraped sequence of Pleistocene turbidites
	thrust	------------------
	480-1100 mbsf	Pliocene hemipelagic sediments
	décollement	------------------
	1100-1500 mbsf	Miocene hemipelagic mud
	below 1500 mbsf	Volcaniclastics/basalt

Priority: 2 (alternate for NKT-2)

Proposed drilling program: Four holes as follows:
1. APC (oriented)/XCB to refusal, logging, FMS, WSTP, LAST, Geoprops.
2. RCB wash to 600 mbsf, core 600-1100 mbsf, logging, FMS, wireline packer.
3. RCB Rotatable packer hole (wash) 1100 mbsf, packer, FMS, wireline packer, VSP.
4. RCB set reentry cone, drill and case to 1100 mbsf, core to 1500 mbsf or bit destruction, logging, FMS, wireline packer, VSP, ONDO.

Objectives:
1. Measure *in-situ* pressure, temperature, porosity, permeability throughout the section.
2. Determine geochemical characteristics of pore fluids throughout the section.
3. Measure mechanical and physical properties of recovered cores.
4. Determine the sequence of deformation features in various structural units.
5. Correlate deformational styles to sedimentary facies.


Shotpoint
1800
1750
1700
1650
6.0
6.5
7.0
7.5
8.5
Two-way traveltime (s)
NKT2A
NKT2
NT62-8

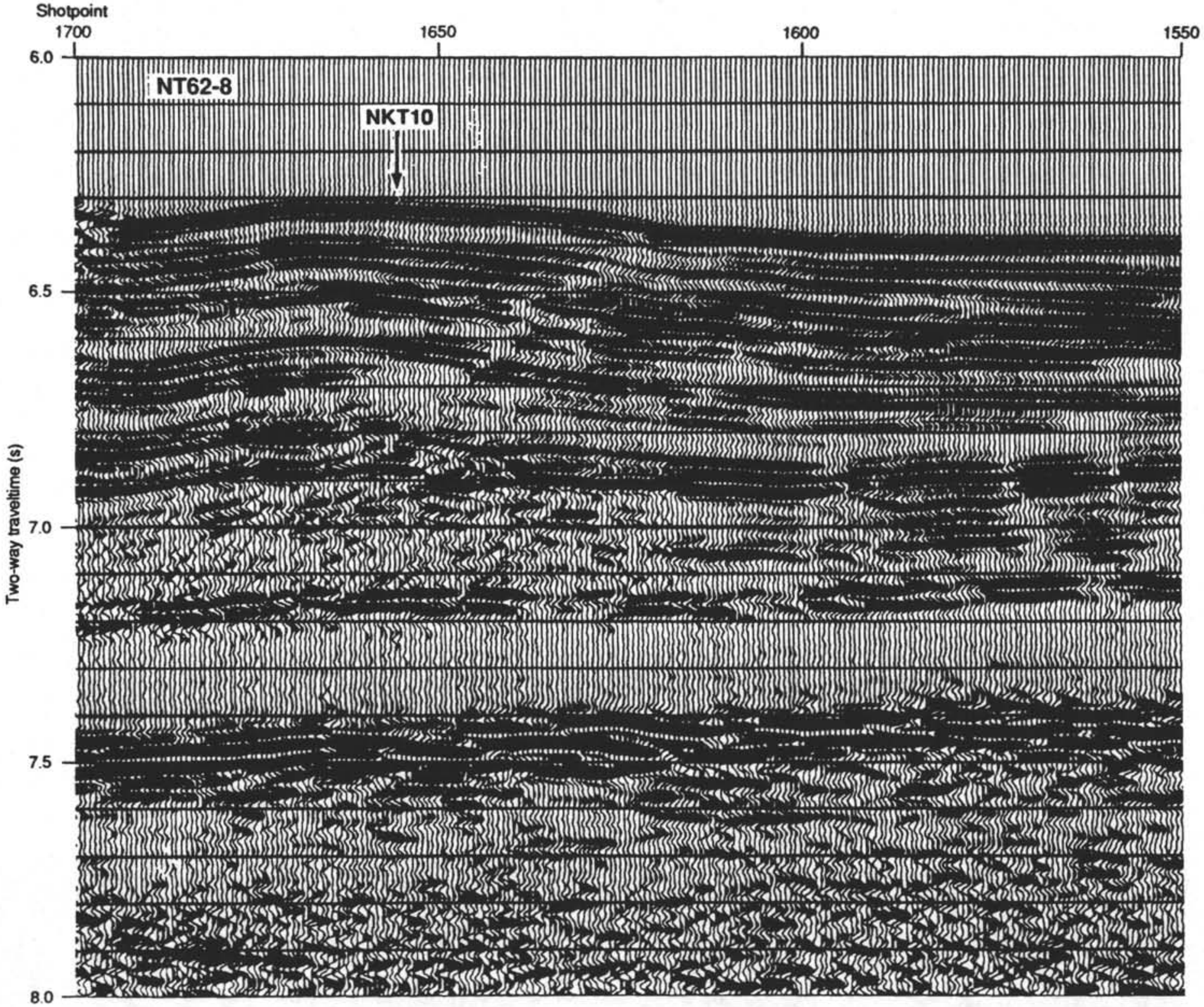
Site Number:	NKT-10 (Nankai Prism Toe)	Position: 32°20'N, 134°57'E
Seismic Record:	NT 62-8, SP 1655	Water Depth: 4750 m
Sediment Thickness:	1150 m	

Sediment Type:	0-450 mbsf	Off-scraped sequence of Pleistocene turbidites
	thrust	---------------------
	450-800 mbsf	Pliocene hemipelagic sediments
	décollement	---------------------
	800-1150 mbsf	Miocene hemipelagic mud
	below 1150 mbsf	Volcaniclastics/basalt

Priority: 2 (alternate to NKT-2)

Proposed drilling program: Four holes as follows:
1. APC (oriented)/XCB to refusal, logging, FMS, WSTP, LAST, Geoprops.
2. RCB wash to 600 mbsf, core 600-850 mbsf, logging, FMS, wireline packer.
3. RCB Rotatable packer hole (wash) 850 mbsf, packer, FMS, wireline packer, VSP.
4. RCB set reentry cone, drill and case to 850 mbsf, core to 1150 mbsf or bit destruction, logging, FMS, wireline packer, VSP, ONDO.

Objectives:
1. Measure *in-situ* pressure, temperature, porosity, permeability throughout the section.
2. Determine geochemical characteristics of pore fluids throughout the section.
3. Measure mechanical and physical properties of recovered cores.
4. Determine the sequence of deformation features in various structural units.
5. Correlate deformational styles to sedimentary facies.


Shotpoint
1700
1650
1600
1550
6.0
6.5
7.0
7.5
8.0
Two-way traveltime (s)
NT62-8
NKT10

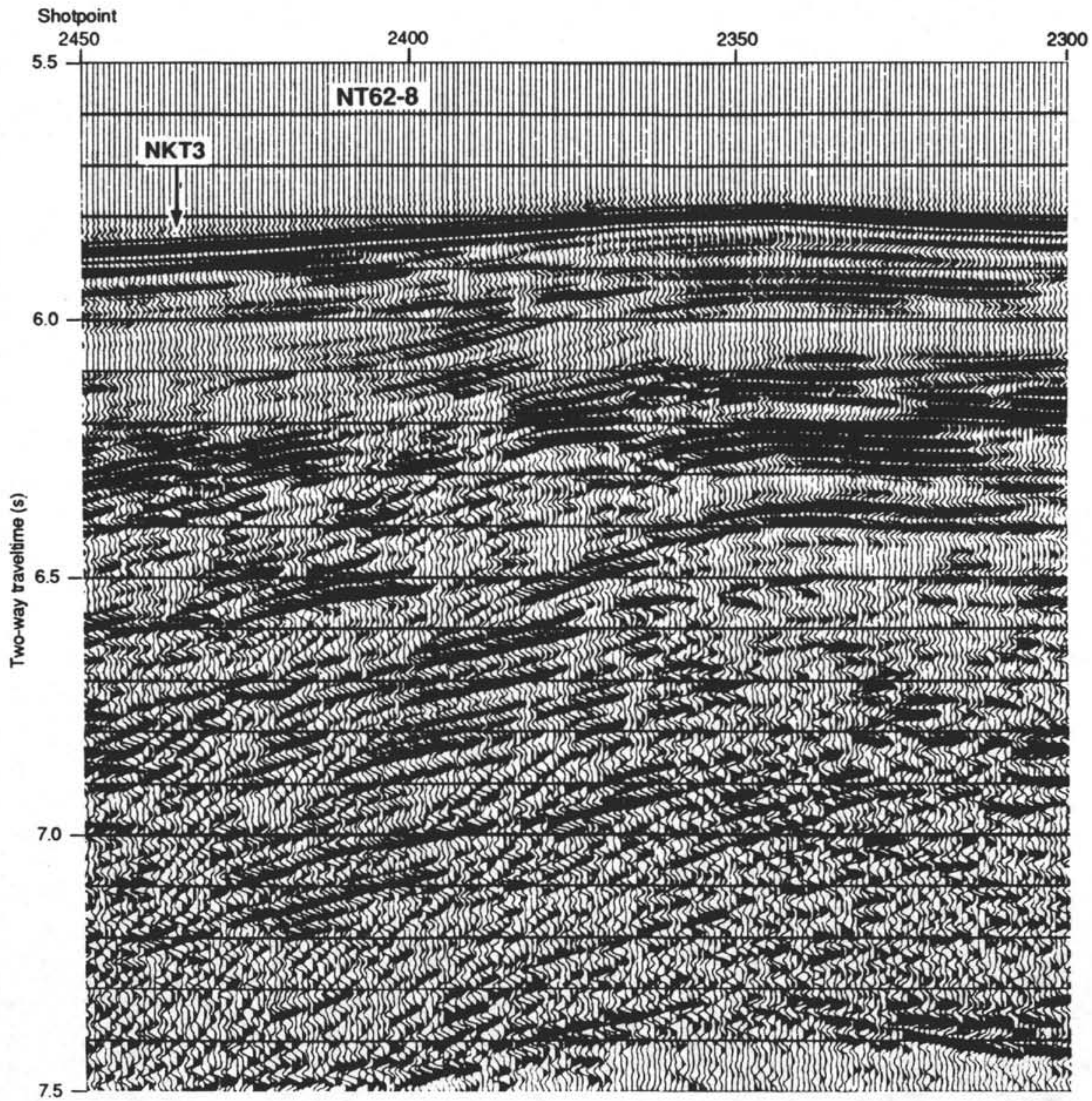
Site Number:	NKT-3 (Nankai Prism Toe)	Position: 32°25'N, 134°54'E
Seismic Record:	NT 62-8, SP 2436	Water Depth: 4350 m
Sediment Thickness:	1600 m	

Sediment Type:	0-1300 mbsf	Deformed turbidites and hemipelagic sediments
	décollement	---------------------
	1300-1600 mbsf	Miocene hemipelagic mud
	below 1600 mbsf	Volcaniclastics/basalt

Priority: 3

Proposed drilling program:
APC (oriented)/XCB to refusal (900 mbsf?), logging, FMS, WSTP, LAST, Geoprops.

Objectives:
1. Measure *in-situ* pressure, temperature, porosity, permeability throughout the section.
2. Determine geochemical characteristics of pore fluids throughout the section.
3. Measure mechanical and physical properties of recovered cores.
4. Determine the sequence of deformation features in various structural units.
5. Correlate deformational styles to sedimentary facies.


Shotpoint
2450
2400
2350
2300
5.5
6.0
6.5
7.0
7.5
Two-way traveltime (s)
NT62-8
NKT3

SCIENTIFIC PARTICIPANTS

Co-Chief Scientist:	ASAHIKO TAIRA Ocean Research Institute University of Tokyo 1-15-1 Manamidai Nankano-ku Tokyo 164, Japan
Co-Chief Scientist:	IAN HILL Univ. of Leicester Dept. of Geology University Road Leicester LE1 7RH United Kingdom
Staff Scientist/ Nannofossil Paleontologist:	JOHN FIRTH Ocean Drilling Program 1000 Discovery Drive Texas A&M University Research Park College Station, TX 77840
Sedimentologist:	SERGE LALLEMAND Université Pierre et Marie Curie Lab. de Géologie Structurale 4 Place Jussieu Tour 26-0, 1er Etage 75252 Paris Cedex 05 France
Sedimentologist:	KEVIN T. PICKERING Dept. of Geology University of Leicester University Road Leicester LE1 7RH United Kingdom
Sedimentologist:	MICHAEL UNDERWOOD Dept. of Geology University of Missouri, Columbia 101 Geology Building Columbia, MO 65211
Paleontologist: (Foraminifers)	TO BE NAMED

Paleontologist: (Radiolarians)	YUKIHIRO KATO Ocean Surveys Division Hydrographic Department Maritime Safety Agency 5-3-1 Tsukiji, Chuo-klu Tokyo, Japan
Paleontologist: (Nannofossils)	GUNNAR OLAFSSON Department of Geology University of Stockholm S-106-91 Stockholm, Sweden
Organic Geochemist:	ULRICH BERNER Bundesanstalt für Geowissenschaften und Rohstoffe Stilleweg 2 D-3000 Hannover 51 Federal Republic of Germany
Inorganic Geochemist:	TOSHITAKA GAMO Ocean Research Institute University of Tokyo 1-15-1, Minamidai Nakano, Tokyo 164 Japan
Inorganic Geochemist:	JORIS M. GIESKES Scripps Inst. of Oceanography A-015 Univ. of California/San Diego La Jolla, CA 92093
Inorganic Geochemist/ Sedimentologist:	MIRIAM KASTNER Scripps Inst. of Oceanography A-12 Geological Research Division University of California La Jolla, CA 92093-0212
Structural Geologist:	TIM BYRNE Brown University Dept. of Geological Sciences Providence, RI 02912
Structural Geologist/ Geoprops Specialist:	DANIEL E. KARIG Dept. of Geological Sciences Cornell University Snee Hall Ithaca, NY 14853-1504

Structural Geologist:	ALEX J. MALTMAN Dept. of Geology Univ. College of Wales Liendinam Building Aberystwyth United Kingdom
Igneous Petrologist:	FRANCA SIENA Istituto Mineralogia University of Ferrara Italy
Paleomagnetist:	RAN LU Dept. of Geology University of Minnesota Minneapolis, MN 55455
Paleomagnetist:	BILL OWENS School of Earth Sciences University of Birmingham P.O. Box 363 Birmingham B15 2TT United Kingdom
Physical Properties Specialist:	WARNER BRÜCKMANN GEOMAR - Center for Marine Geoscience Research Wischhofstr. 1-3, Geb. 4 D-2300 Kiel 14 Federal Republic of Germany
Physical Properties Specialist:	JEAN-PAUL FOUCHER IFREMER /CB BP 70 29263 Plouzane France
Physical Properties/ Last Specialist:	KATE MORAN Geological Survey of Canada Bedford Inst. of Oceanography Box 1006 Dartmouth, Nova Scotia B2Y 4A2 Canada
Physical Properties Specialist:	ELLIOTT TAYLOR School of Oceanography, WB-10 University of Washington Seattle, WA 98195

Physical Properties/ Rock Mechanician:	JIAXIANG ZHANG Dept. of Earth & Space Sciences State Univ. of New York Stony Brook, NY 11794
Heat Flow/Ondo Specialist:	MAKOTO YAMANO Earthquake Research Institute University of Tokyo Bunkyo-ku Tokyo 113 Japan
Logging Scientist/ Packer Specialist:	ANDY FISHER Ocean Drilling Program 1000 Discovery Drive Texas A&M University Research Park College Station, TX 77840
Logging Scientist/ VSP Specialist:	GREG MOORE Hawaii Institute of Geophysics University of Hawaii 2525 Correa Road Honolulu, HI 96822
Logging Scientist:	ROY D. HYNDMAN Pacific Geoscience Centre P.O. Box 6000 Sidney, B.C. V8L 4B2 Canada
Laboratory Officer:	BILL MILLS Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, TX 77840
Assistant Laboratory Officer:	JOE POWERS Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, TX 77840
Yeoperson:	JO CLAESGENS Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, TX 77840
Curatorial Representative:	TO BE NAMED

Computer System Manager:	EDWIN GARRETT Ocean Drilling Program 1000 Discovery Drive Texas A&M University Research Park College Station, TX 77843
Photographer:	JOHN TENISON Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, TX 77840
Chemist:	SCOTT CHAFFEY Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, TX 77840
Chemist:	VALERIE CLARK Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, TX 77840
Electronics Technician:	JIM BRIGGS Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, TX 77840
Electronics Technician:	DAVID ERICKSON Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, TX 77840
Technician:	JOE DEMORETT Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, TX 77840
Technician:	JOAN PERRY Ocean Drilling Program Texas A&M University Research Park 1000 Discovery Drive College Station, TX 77840

Technician: KAZUSHI KUROKI
Ocean Drilling Program
Texas A&M University Research Park
1000 Discovery Drive
College Station, TX 77840

Technician: MICHAEL MOORE
Ocean Drilling Program
Texas A&M University Research Park
1000 Discovery Drive
College Station, TX 77840

Technician: DANIEL BONTEMPO
Ocean Drilling Program
Texas A&M University Research Park
1000 Discovery Drive
College Station, TX 77840

Technician: CHO
Ocean Drilling Program
Texas A&M University Research Park
1000 Discovery Drive
College Station, TX 77840

Technician: TO BE NAMED