OCEAN DRILLING PROGRAM

LEG 112 SCIENTIFIC PROSPECTUS

PERU MARGIN

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INTRODUCTION

The Peru Trench and the adjacent continental margin are part of an "Andean type" convergence zone -- the classic example for subduction of an oceanic lithospheric plate beneath a continental plate (Kulm et al., 1981; Hussong et al., 1985; Fig. 1). Based upon the geologic record of Andean volcanoes and zones of mineralization (Shepherd & Moberly, 1981; Davila & Dang, 1985) this margin has experienced subduction since Triassic-Jurassic time. The onshore geology shows a general lack of overprinting by allochthonous terranes during this entire period, which makes the Peru margin a particularly attractive place to study subduction processes. The margin further displays many of the structural and morphological characteristics found off central and southern Chile and hence has important implications for the subduction history of the entire Andean margin. Sedimentary basins of the forearc have recorded in detail the tectonic history of the edge of the continental crust during Cenozoic (and probably earlier) episodes of subduction and arc volcanism. Drilling will determine how the tectonic framework has evolved during subduction of the Nazca Plate (von Huene et al., 1985).

The sedimentary record of the forearc basins also contains a detailed history of one of the most prominent eastern boundary current regimes of the world -- the Peru Current (Suess & Thiede, 1983). This oceanic current generates the classic upwelling systems along the Peruvian coast. The interplay of wind regime, oceanic circulation and biological productivity result in deposition of a sedimentary facies rich in organic matter, biogenic silica and phosphorites (Suess, 1981; Walsh, 1975; Suess et al., 1986; Fig. 2). Drilling and analyzing these deposits will provide insight into the variability of the upwelling regime through time. This is of general significance for global paleoenvironmental reconstructions and for reconstructions of sea level and climatic changes associated with glacial/interglacial cycles.

Diagenesis of the organic carbon-rich mud facies, underlying this old coastal upwelling regime, generates conditions favorable for large-scale, pervasive dolomitization (Baker & Kastner, 1981; Kelts & McKenzie, 1982; Kulm et al., 1984). The geochemistry and timing of this process will be addressed through fluid, gas, and sediment sampling during drilling. The results are of considerable importance to understanding other continental margin settings as well as ancient analogues, where dolomites are prominent lithologies in organic carbon-rich sediments (Garrison et al., 1984; Kastner et al., 1984; and many others).

JOIDES Resolution will depart Callao, Peru, on October 26, 1986 for Leg 112. The vessel is scheduled to drill 12 prime target sites or 15 backup sites along transects crossing the forearc basins off Peru (Figs. 3 and 4). The sites span water depths from 100 m at the upper slope to 5420 m at the lower slope. The cruise will end in Callao on December 19, 1986.

SCIENTIFIC OBJECTIVES

The timing and magnitude, both of the vertical movements of the leading edge of the continental block, and the truncation of this block and accreted sediment wedges, are the general tectonic objectives of Leg 112. The major paleoenvironmental objective is to learn about the evolution of the classical coastal upwelling regime and its response to global changes of climate and sea level. These objectives are intimately linked to each other in that the sedimentary sections in the forearc basins — which record coastal upwelling — have evolved through differential vertical tectonics of the individual basins. Scientific problems which have been identified and which will be addressed during drilling and in subsequent shorebased studies include:

1) Reconstructing the uplift and subsidence history of the forearc area and relate these vertical movements to accretion and erosion of older strata that are an extension of the Peruvian continent.

2) Studying the nature and age of the transition zone that lies between the lower slope accretionary complex and the metamorphic block of continental affinity.

3) Investigating the age of the metamorphic basement underlying the outer Andean margin, as well as pressure and temperature conditions of metamorphism through time.

4) Reconstructing the paleoceanographic conditions of upper slope basin deposits and the history of the Peru coastal upwelling system.

5) Understanding the processes of diagenetic dolomitization within the organic carbon-rich mudstones of the middle and upper slope basins.

Tectonic Evolution of the Continental Margin

The drill sites that address the tectonic objectives are located to define the extent and age of the continental crust, its paleobathymetry, and the extent of accretion of oceanic sediments landward of the trench axis. The continental crust of the Peru margin appears to have subsided and been truncated. A structure typical of accretionary complexes consisting of landward dipping reflectors is stacked in front of the inferred truncation scar (von Huene et al., 1985). Samples from the boundary area between the accreted complex and the continental crust will help to establish the age, the prevalent stress field, and the tectonic processes associated with the erosion of the continent and the accretion of oceanic sediments.

Obtaining knowledge of the metamorphic conditions that prevailed prior to deposition in the Andean forearc area is fundamental to understanding the tectonic history of the margin. Some tectonic process caused vertical movements of 1 to 2 km that are recorded in sedimentary sections of the Trujillo Basin (Kulm et al., 1985). From land sections exposed on Hormigas Island it is apparent that metamorphism occurred in four stages, which may correspond to phases of vertical movements and compression in the Peruvian forearc area. The four metamorphic stages are:

1) Development of a very low-grade metamorphic fabric of unknown pressure/temperature conditions.

2) Folding and rotation of the first fabric.

3) High-grade metamorphism associated with the formation of minerals such as garnet, biotite, zoisite, plagioclase, and tourmaline. These minerals display zoning.

4) Shearing and deformation under low-grade metamorphic conditions similar to stage 1.

The conditions of pressure and temperature during stages 3 and 4 will be disclosed by shorebased studies of the isotopic composition of fluid inclusions in neoformed minerals. Approximate age determinations by radiometric techniques (K/Ar and $^{40}Ar/^{39}Ar$) will reveal the timing of individual metamorphic phases. Later compressional phases may correlate with Paleogene and Neogene vertical motions in the adjacent forearc basins as expressed in sedimentary structure and morphology of stratigraphic units. Drilling at sites PER-7 or PER-7A beneath the seaward edge of the Lima Basin and at sites PER-8 or PER-14 at the truncated western edge of the continent is expected to yield samples of this metamorphic basement.

Because the Peruvian forearc basin deposits contain abundant planktonic and benthic microfossils for biostratigraphic dating and paleodepth determinations, they provide excellent evidence of vertical movements of the terrain that forms the foundation of the Andean margin. Drilling transects across the Lima and Yaquina basins will provide samples for the detection of relative changes in subsidence of the respective seaward and landward flanks of each basin through time. Sites include PER-6, PER-7, PER-7A, PER-8, and PER 14 through PER-17A, and alternative sites PER-18B through PER-18D. Indications of episodic volcanism and the mineralization recorded in sedimentary sections may aid in understanding the timing and mechanisms of major forearc tectonic events.

The transition between the accretionary complex and the continent is a zone 5 km wide west of the Yaquina Basin. Because the accretionary prism is relatively small, considering that it has been active since Triassic/Jurassic time, we have reason to believe that the continental margin has been truncated during specific phases of subduction. In addition, the bulk of sediment on the oceanic plate may have been subducted instead of being accreted. Drilling in this transition zone (sites PER-17, PER-17A, PER-18C) will put constraints on the timing of the erosion and relate truncation phases to volcanic activity, basin subsidence on the adjacent margin, and changes in plate motion. A wide variety of rocks from a large range of compositions and ages may have been incorporated into this complex during truncation events.

Paleoenvironment of Upper Slope Basins and the Peru Upwelling Regime

The drill sites for the paleoenvironmental objectives are located beneath the strongest wind-driven upwelling areas of the Peru Current regime. Today this region is situated along the upper continental slope at water depths between 150 and 500 m. The sediments are characterized by two distinct facies: an organic carbon-rich mud low in carbonate which accumulates at the landward flank of the rapidly subsiding Lima Basin and a phosphorite-bearing calcareous mud which accumulates along the seaward edges of the tectonically more stable Yaquina and Trujillo Basins (Fig. 2).

The sites have been selected to provide a continuous high-resolution sediment record of Quaternary and possibly older age in a three-dimensional framework. The main sites in the Lima/ Salaverry Basin area are PER-1, PER-2, PER-2A, PER-3, PER-4A, PER-4C, and PER-5 (as well as tectonic sites PER-6, PER-7, PER-7A). The sites in the northern basins are PER-9A and PER-10. This comparison will provide an opportunity to test several models about fundamental oceanographic and sedimentary processes related to:

1) Identification of signals of coastal upwelling in the sedimentary record for reconstruction of nutrient make-up and water column parameters of source waters (salinity, temperature, apparent oxygen utilization), upwelling ecology, biological zonation of the plumes, and erosional action of the poleward flowing undercurrent. In what detail can these water column properties and the duration and intensity of coastal upwelling be deciphered for the past in order to attempt a true paleoceanographic reconstruction?

2) Quantification of the biogenic and biogeochemical flux for an evaluation of the interaction between sea level, climate, and ocean circulation. The Peru margin is and has been through geological time a major sink for organic carbon and biogenic silica. It is a type example of a province with potential hydrocarbon source rocks. How important is this depositional flux in the global sedimentary mass balance, and how has the input varied with time? Do empirical relations between bioproductivity, water depth (residence time), oxygen content of the water column and preservation of organic matter established for Holocene sediments hold for ancient sediments as well?

3) Understanding the conditions that lead to the formation of dolomites in forearc basins with contrasting tectonic evolution. The Peru margin is possibly the best place to examine the formation of vast deposits of "organic" dolomites and other authigenic carbonates. These deposits extend over an area of more than 1000 km^2 in water depths ranging from 200 to 3000 m. The term "organic dolomite" refers to the mode

of carbonate ion formation via microbial or thermal degradation of isotopically light sedimentary organic matter. The enhanced burial of organic matter in the sediments promotes anoxia in the pore waters -- often to the extent of methanogenesis at only a few meters below the sediment/water interface -- and favors dolomite formation during the early stages of diagenesis. Influences of basin subsidence and the primary composition of host rock are suspected to control dolomitization. At present the rates of magnesium and calcium uptake and the interrelation of interstitial water chemistry with the chemistry of dolomite cement are of intense interest. The different diagenetic stages in the dolomitization history of the Peru fore-arc basins can be clarified by detailed studies of lithologies of different ages, input characteristics, and subsidence. Questions to be addressed are: How does the contrasting uplift and subsidence history of the forearc basins affect the degree of dolomitization and the elemental and stable isotope composition of carbonate minerals? What roles do biogenic silica and organically bound phosphorus play in the dolomitization processes? Are magnesium and calcium supplied primarily from diffusion of seawater or are they remobilized from within the sedimentary reservoir?

4) Characterization of the geochemical environment leading to the formation of phosphorites in the northern and southern target areas will help to elucidate the validity of several models on phosphorite formation applied to the Peru margin -- a type locality of modern phosphogenic provinces. Are periods of sea level change necessary to concentrate phosphorites in a transgressive facies? What is the chemical environment of phosphorite precipitation and metasomatism? Is the dominant phosphorus source organic matter or are apatitic fish remains important as well?

DRILLING PLAN

With 12 prime sites and 15 backup sites arranged in transects across the Peruvian margin (Figs. 3 and 4, Table 1) the drilling objectives will be addressed during 54 days of operations (Table 2). Priorities have been established to insure that the overall scientific objectives of Leg 112 can be met. Operations time will be divided between tectonic and paleoceanographic goals: 36 days for tectonic targets, 13 days for paleoceanographic targets, 5 common days for site PER-3.

The southern transects, composed of sites PER-1 through PER-5 and PER-6 through PER-8, are located in the Lima and West Pisco basins. Sites PER-1 through PER-5 will investigate the spatial and temporal evolution of the upper slope mud lens deposited under upwelling conditions. These paleoceanographic targets have a high priority because of the good definition of the mud lens in this area as compared to the same facies in the northern basins. Sites PER-3, among the high priority targets, is scheduled to be drilled to a total depth of 600 m in order to tie the shallow, double APC sites on the upper slope to the deep holes on the lower slope intended to investigate tectonic subsidence of the margin (PER-6, PER-7, PER-7A). After APC drilling to refusal, it is proposed to deepen hole PER-3 by XCB to penetrate the deepest part of the Salaverry/ Lima Basin hinge line.

PER-6 is sited on a lens-shaped Neogene sediment wedge and an underlying wedge of probably earliest Neogene and Paleogene age. This site or alternate sites PER-7 and PER-7A will yield a detailed subsidence history of the upper slope. At sites PER-7 and PER-7A metamorphic basement is likely to be sampled. Site PER-8 is designed to sample metamorphic basement as close as feasible to the accretionary complex/crust transition. If drilled, this site is expected to yield samples of the oldest sediments in the distal edge of the Lima Basin and of the metamorphic continental basement.

In the central transect (09°S) of proposed drill holes, two sites for investigation of the upwelling facies have been identified in the outer shelf mud (PER-9A) and the upper slope mud wedge (PER-10). Here the sediment lenses are poorly defined; the facies is reworked and more calcareous.

A transect of two sites and four alternate sites seaward of these paleoceanographic targets is located to investigate the erosion, subsidence, and accretionary history of the margin. Sites PER-14 and PER-17A are targeted on the oldest accreted sediments; alternate sites PER-15, PER-16, PER-16A, and PER-17 are located to bracket the sediment that records the end of tectonic erosion and the beginning of accretion in the event that the primary sites fail to do so. If sites on this transect fail to meet these objectives altogether, three alternate sites along the northernmost transect (6° S) have been identified on MCS Line Peru-3 (PER-18B, PER-18C, PER-18D; Fig.4). Objectives and target reflectors for these sites are the same as for target sites PER-14 through PER-17A.

Logging is expected at all sites that penetrate more than 400 m, as well as for site PER-5.

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TABLE 1
LEG 112 OCEAN DRILLING PROGRAM
PERU MARGIN

Location of proposed sites

SITE*	LOCATION	WATER DEPTH (m)	PENETRATION (m)	OPERATIONS**
1	10°58.7'S/77°56.9'W	146	200	Double APC
2	12°39.1'S/77°09.0'W	293	200	Double APC
2A	12°41.8'S/77°12.3'W	375	200	Double APC
2C	12°54.2'S/77°01.7'W	371	200	Double APC
2D	12°51.3'S/76°59.2'W	287	200	Double APC
3	11°05.0'S/78°16.0'W	473	600	Double APC/XCB
3A	11°03.8'S/78°04.8'W	259	700	Double APC/XCB
4A	13°36.2'S/76°48.1'W	300	200	Double APC
4B	13°37.6'S/76°50.4'W	390	200	Double APC
4C	13°29.1'S/76°54.2'W	443	200	Double APC
4D	13°27.4'S/76°51.9'W	353	200	Double APC
5	11°12.0'S/78°01.4'W	250	200	Double APC
6	11°15.0'S/78°37.0'W	2010	800-1100	APC/XCB
7	11°17.0'S/78°40.4'W	2215	1100	APC/XCB
7A	11°51.0'S/78°51.6'W	1650	1100	APC/XCB
8	11°16.3'S/79°03.0'W	3825	600	RCB
9A	08°47.8'S/79°37.7'W	100	200	Double APC
10	09°00.3'S/79°57.2'W	416	200	Double APC
14	09°02.9'S/80°27.4'W	3015	850	APC/XCB
15	09°02.9'S/80°27.4'W	3975	900	APC/XCB
16	09°05.0'S/80°32.0'W	4380	1300	APC/XCB
16A	09°06.0'S/80°33.9'W	4612	790	APC/XCB
17	09°06.6'S/80°35.3'W	5062	1012	APC/XCB
17A	09°07.4'S/80°37.1'W	5420	1190	APC/XCB
18B	05°37.1'S/81°33.2'W	3128	1000	APC/XCB
18C	05°37.4'S/81°36.0'W	3038	960	APC/XCB
18D	05°36.8'S/81°39.0'W	4200	1250	APC/XCB

* Underlined sites address tectonic objectives. A,B,C,D denote alternative sites. The order of priorities for paleoceanographic targets is: PER-3, PER-1, PER-5, PER-2, PER-10, PER-9A.

** APC= Advanced Piston Corer, XCB= Extended Core Barrel; RCB= Rotary Core Barrel. IF XCB drilling fails to reach target horizons in deep holes, free-fall reentry cones will be employed to deepen the holes in rotary coring mode.

TABLE 2
LEG 112 OCEAN DRILLING PROGRAM
PERU MARGIN

Operations Schedule

SITE	TRANSIT TIME (days) *	OPERATION TIME ON SITE (days) **	DEPARTURE DATE (APPROXIMATE)
Callao			Depart 26 October 1986
	0.4		
PER-4A		1.3	28 October
	0.1		
PER-4C		1.3	30 October
	0.3		
PER-2		1.3	01 November
	0.1		
PER-2A		1.3	03 November
	0.4		
PER-3		4.1	07 November
	0.3		
PER-7		13.2	20 November
	0.4		
PER-5		2.0	22 November
	0.3		
PER-1		1.1	23 November
	0.6		
PER-14		11.1	04 December
	0.2		
PER-17A		10.2	14 December
	0.4		
PER-10		1.3	16 December
	0.3		
PER-9A		1.3	18 December
	0.7		
Callao			Arrive 19 December 1986
Total	4.5 days	49.5 days	

* Including time for seismic cross line on approach.

** Including logging program.

TABLE 2
LEG 112 OCEAN DRILLING PROGRAM
PERU MARGIN
(CONT.)

Alternative Sites

SITE	TRANSIT TIME (days) *	OPERATION TIME ON SITE (days) **	DEPARTURE DATE (APPROXIMATE)
PER-2C		1.3	
PER-2D		1.3	
PER-3A		4.1	
PER-4B		1.3	
PER-4D		1.3	
PER-6		11.1	
PER-7A		13.3	
PER-8		11.4	
PER-15		12.3	
PER-16		17.0	
PER-16A		12.5	
PER-17		10.4	
PER-18B		6.5	
PER-18C		6.5	
PER-18D		9.2	

* Including time for seismic cross line on approach.

** Including logging program.

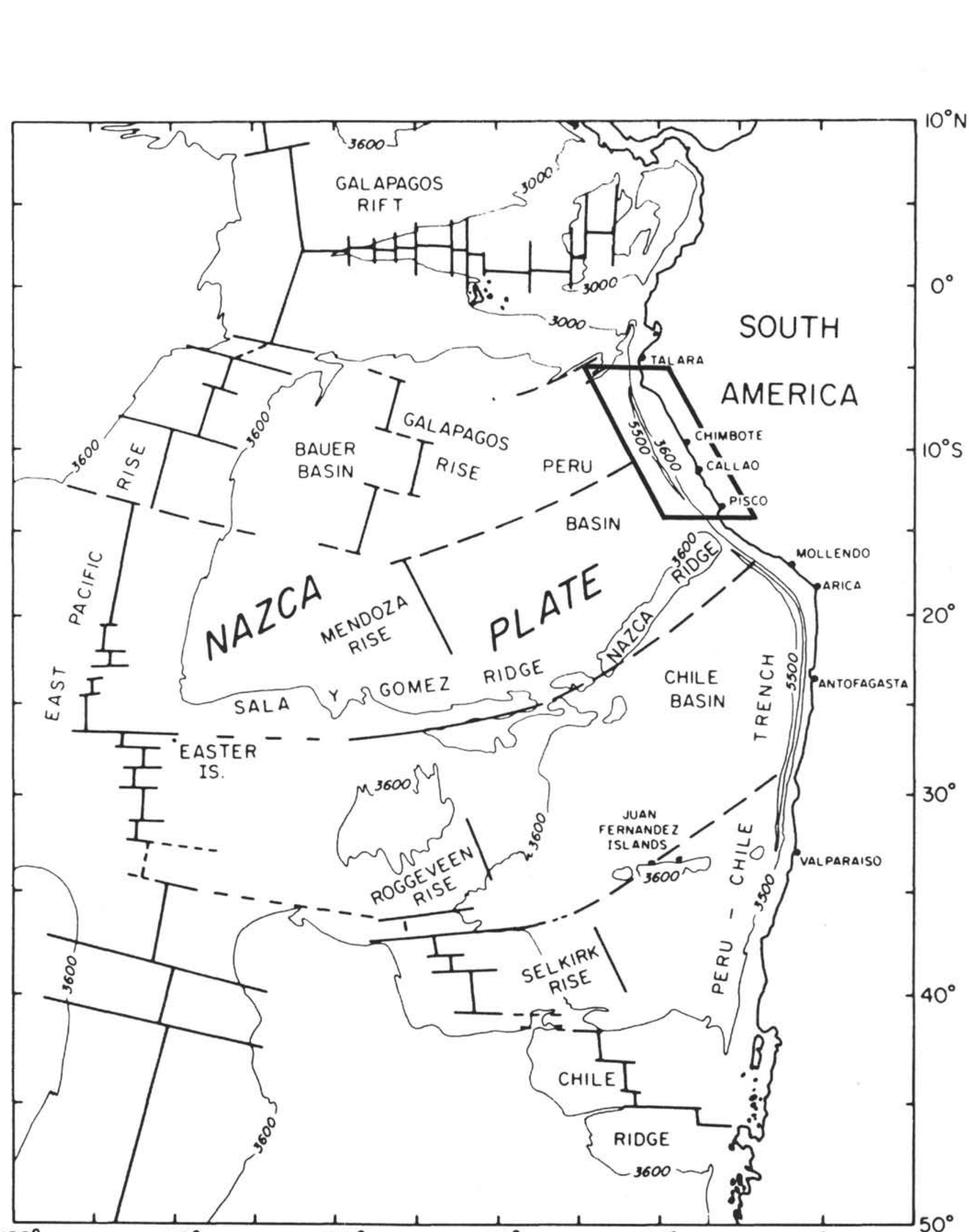


Figure 1: Location map of the Nazca Plate and the South American continent. Black outline indicates Leg 112 study area.

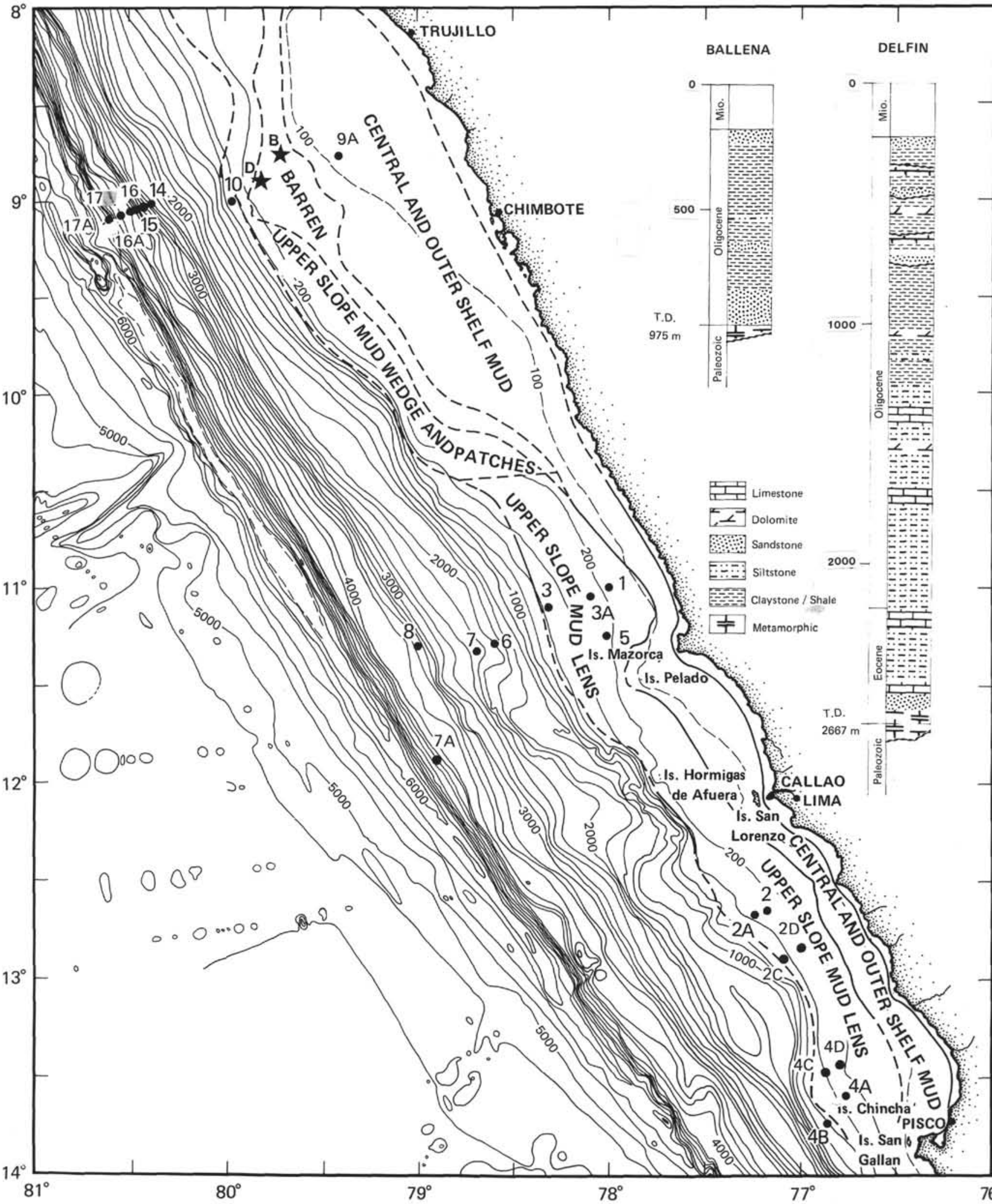


Figure 2: Bathymetric map of the study area 08° to 14° South with location of proposed drill sites (circles). Indicated are the locations and the extent of different upwelling facies on shelf and upper slope, as well as the location of industry wells (stars) Delfin (D) and Ballena (B) with a simplified sedimentary log (after Kulm et al., 1985).

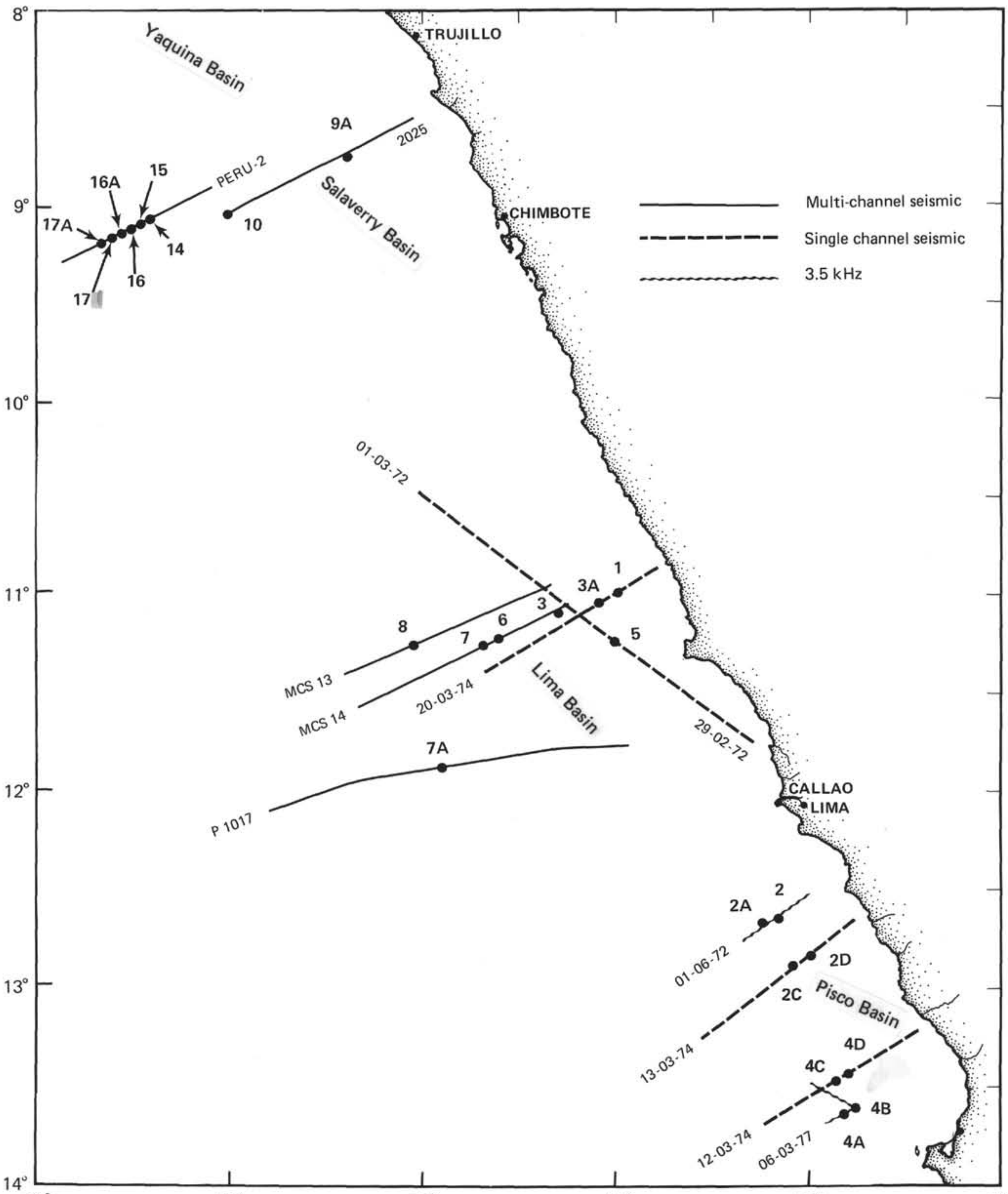


Figure 3: Major seismic lines used to locate drilling targets in the study area 08° to 14° South.

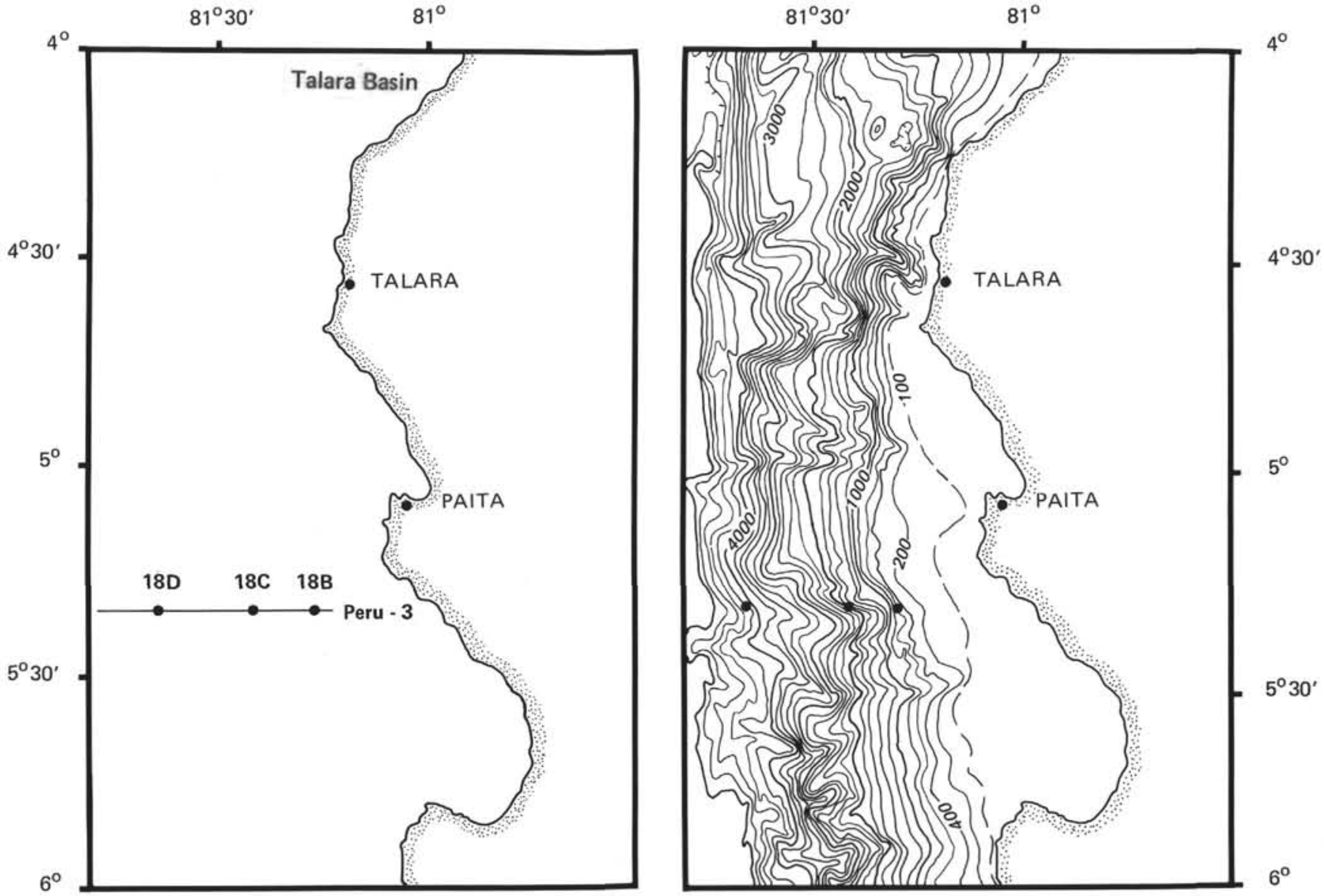


Figure 4: Bathymetry and location of MCS Line Peru-3 in the study area 04° to 06° South.

SITE NUMBER: PER-1

POSITION: $10^{\circ}58.7'S/77^{\circ}56.9'W$ SEDIMENT THICKNESS: 1000m+

WATER DEPTH: 146 m PRIORITY: Paleoceanographic 1

PROPOSED DRILLING PROGRAM:
Double APC to 200 m, one hole oriented

SEISMIC RECORD:
Situated on OSU SCS line YALOC 20-03-74 at 0408Z.
SeaMARC II sidescan and bathymetry

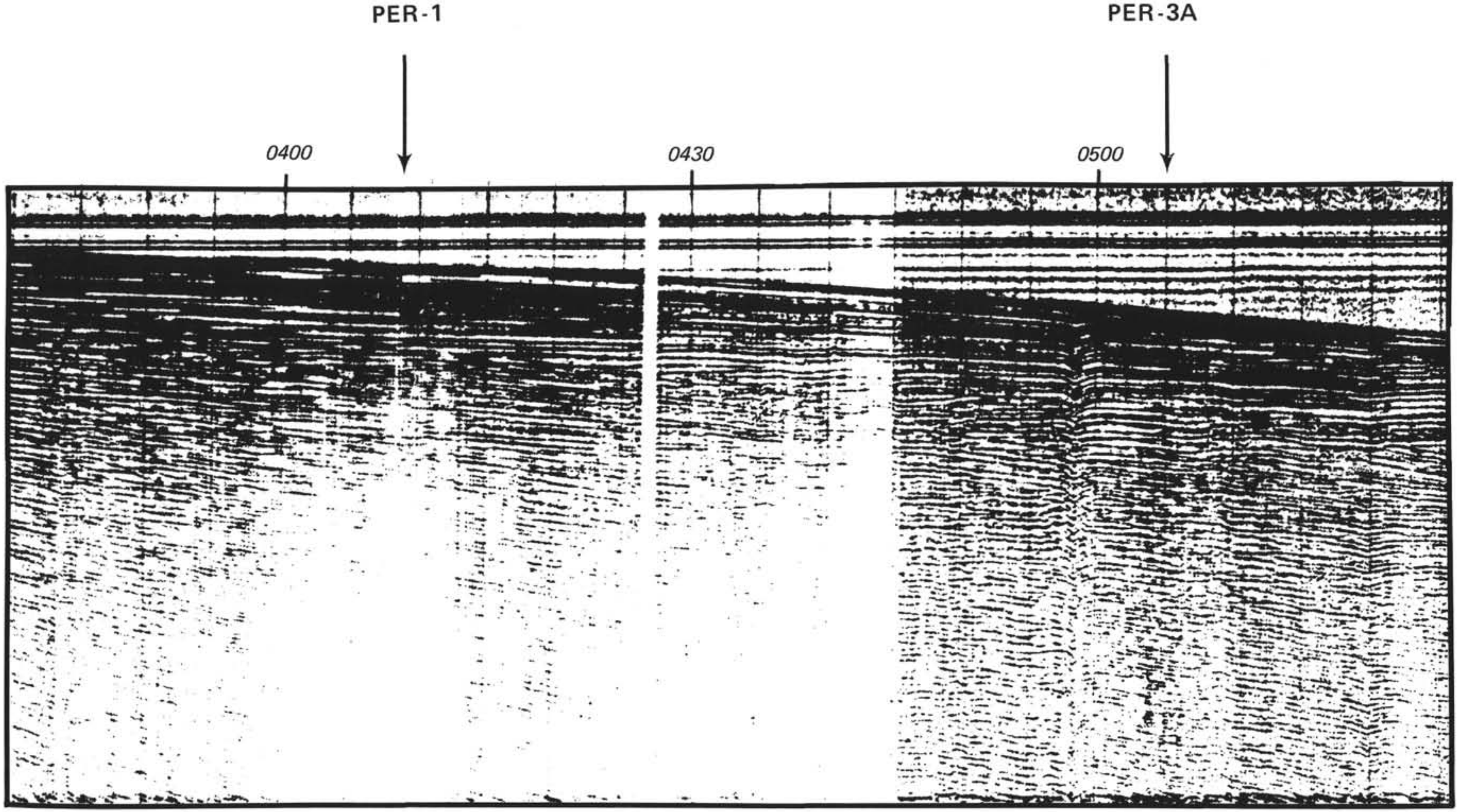
HEAT FLOW: Yes

LOGGING: No

OBJECTIVES:
Recover Neogene to Quaternary upwelling deposits at landward site of an E-W transect of short drill holes arranged in cross pattern across the upper slope mud facies in Lima Basin.

SEDIMENT TYPE:
Unconsolidated organic carbon-rich mud, dolomite, and possibly chert.

REMARKS:
Expected time spent on site: 1.1 days.



SCS LINE YALOC

20-03-74

PER-1 (0408Z)

PER-3A (0505Z)

SITE NUMBER: PER-2, PER-2A, PER-2C, PER-2D

POSITION: PER-2: 12°39.1'S/77°09.0'W
PER-2A: 12°41.8'S/77°12.3'W
PER-2C: 12°54.2'S/77°01.7'W
PER-2D: 12°51.3'S/76°59.2'W

SEDIMENT THICKNESS: 1000 m+

WATER DEPTH: 293 m (PER-2)
375 m (PER-2A)
371 m (PER-2C)
287 m (PER-2D)

PRIORITY: Paleoceanographic 2

PROPOSED DRILLING PROGRAM:
Double APC to 200 m.

SEISMIC RECORD:
PER-2: Located on OSU 3.5 kHz line Y7106 01-06-72 at 0945Z.
PER-2A: OSU 3.5 kHz line Y7106 at 0923Z.
PER-2C: OSU SCS line YALOC 13-03-74 at 1910Z.
PER-2D: OSU SCS line YALOC 13-03-74 at 1945Z.
SeaMARC II sidescan and bathymetry

HEAT FLOW: Yes

LOGGING: No

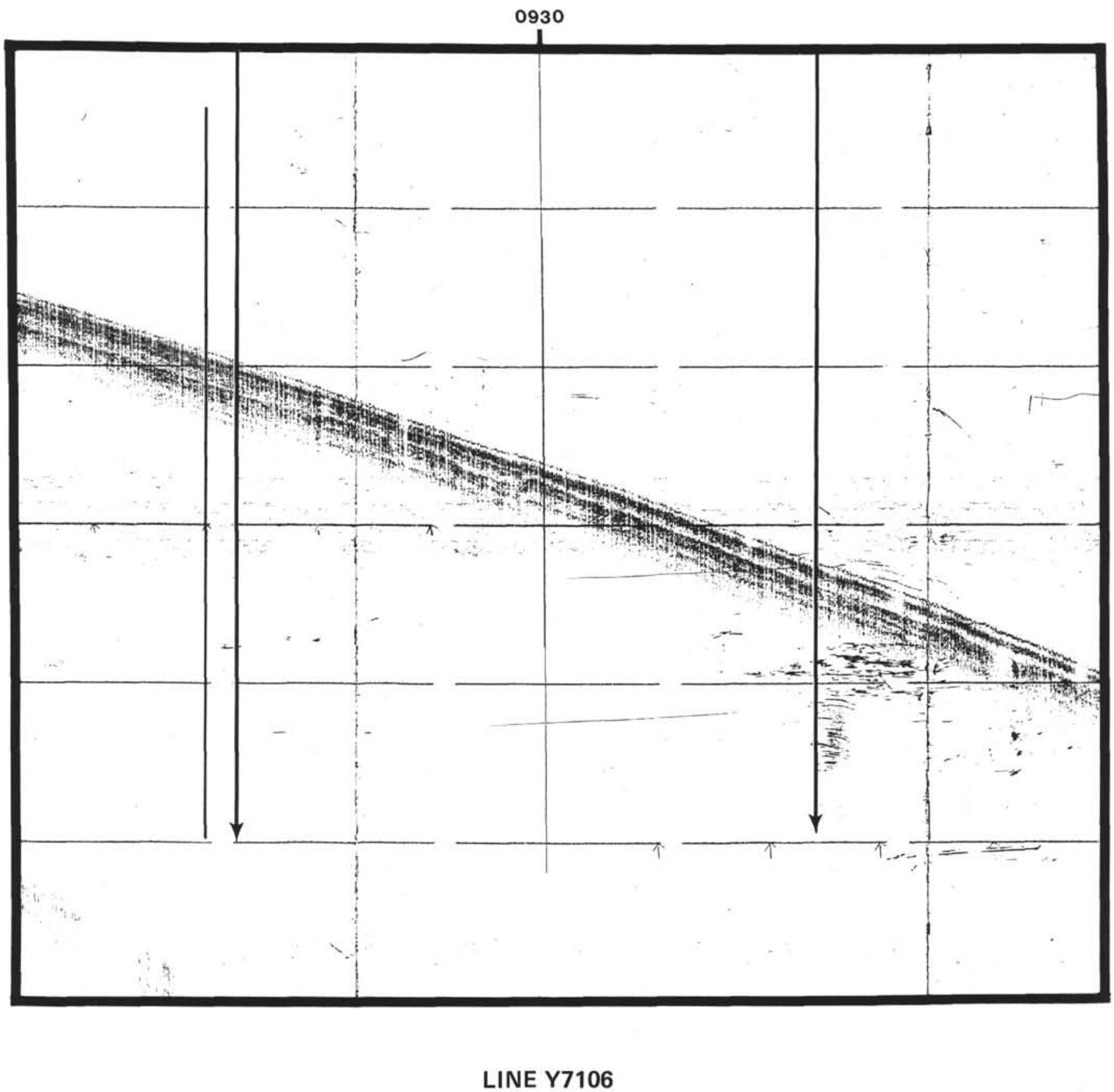
OBJECTIVES:
Recover Quaternary upwelling deposits and reconstruct paleoenvironmental conditions of deposition. Determine stratigraphic distribution of dolomites and their formation in organic carbon-rich muds.

SEDIMENT TYPE:
Unconsolidated organic carbon-rich muds and thin dolomite layers

REMARKS:
Expected time spent on sites: 1.3 days each.

PER-2

PER-2A

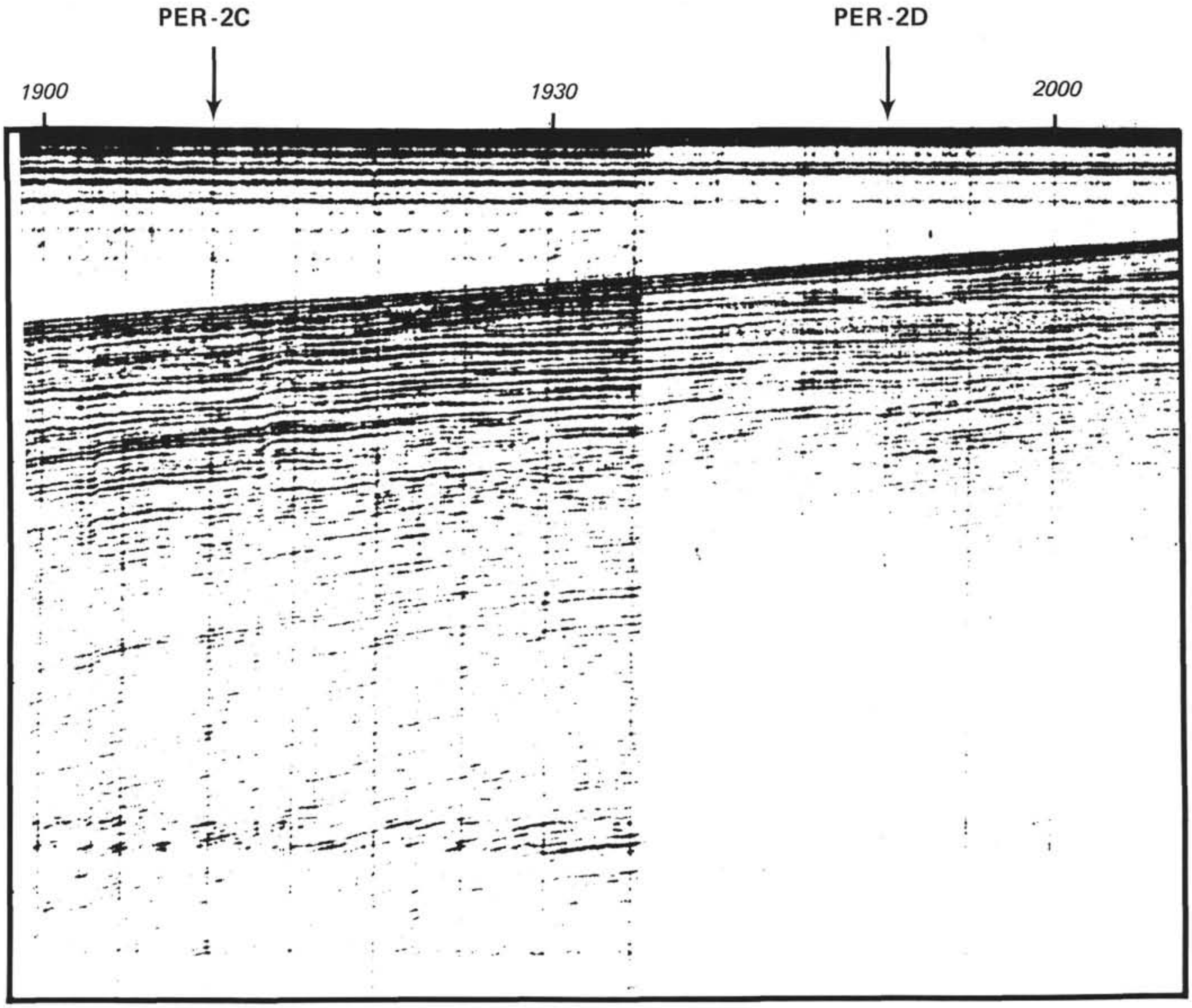


LINE Y7106

01-06-72

PER-2 at 0945

PER-2A at 0923



SCS LINE YALOC

13-03-74

PER-2C at 1910 Z

PER-2D at 1945 Z

SITE NUMBER: PER-3; PER-3A

POSITION: PER 3: 11°05.0'S/78°16.0'W
PER 3A: 11°03.8'S/78°04.8'W

SEDIMENT THICKNESS: 1000 m+

WATER DEPTH: 473 m (PER-3)
259 m (PER-3A)

PRIORITY: Paleoceanographic 1

PROPOSED DRILLING PROGRAM:
Double APC/XCB to 600 m (PER-3), 700m (PER-3A).

SEISMIC RECORD:
PER-3: HIG MCS line 14 (8505) at 0603Z (collected 25 March 1985)
PER-3A: OSU SCS line Yaloc 20-03-74 at 0505Z.
SeaMARC II sidescan and bathymetry

HEAT FLOW: Yes

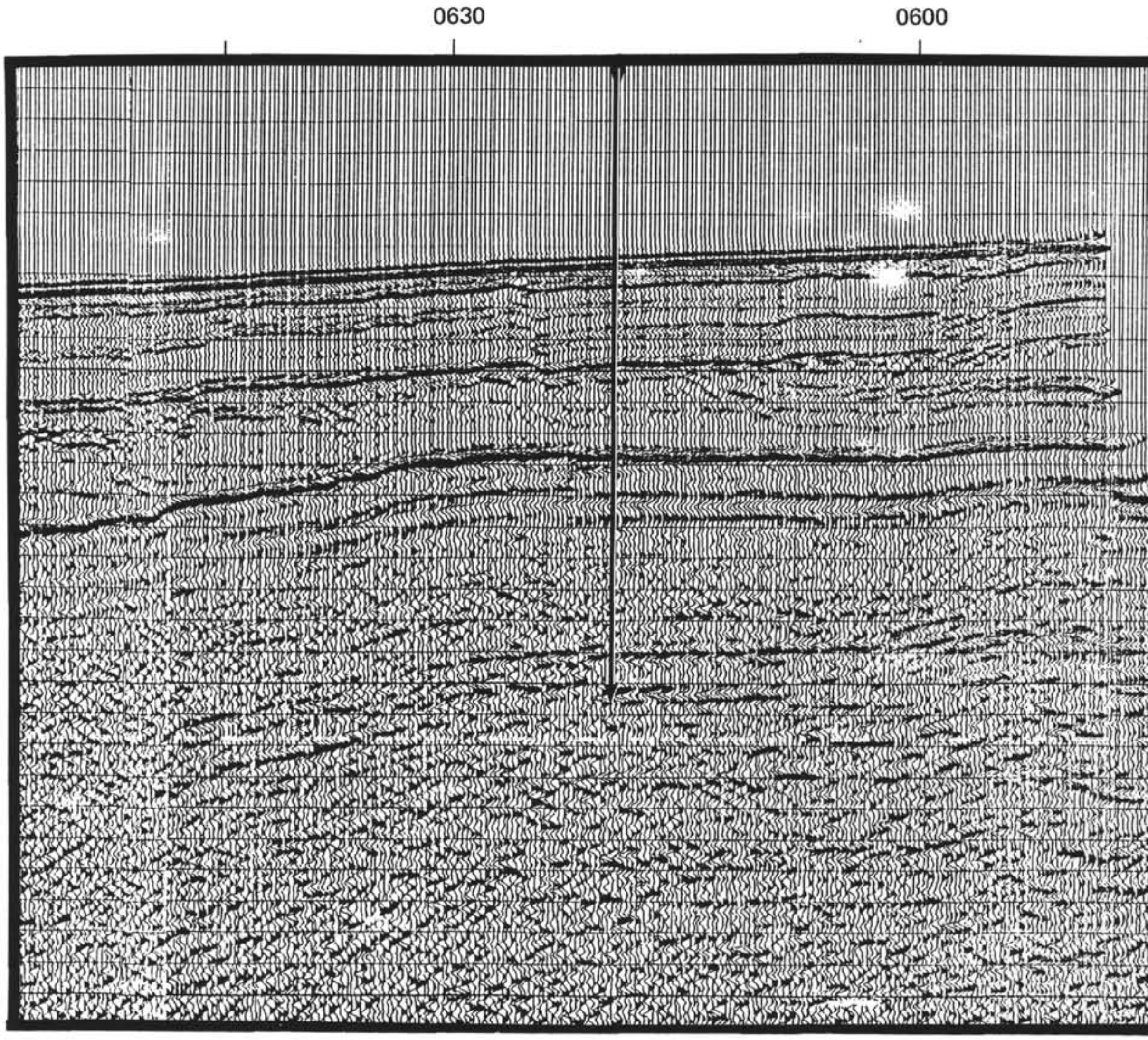
LOGGING: Yes

OBJECTIVES:
Seaward site of transect across upper slope mud lens. Recover Quaternary upwelling sediments and drill to major Mesozoic/Paleozoic unconformity to tie shallow transects to deep targets in tectonic sites.

SEDIMENT TYPE:
Unconsolidated organic carbon-rich muds and thin dolomite layers. Cenozoic and Mesozoic marine sediments: Carbonates, possibly metamorphic clastic sediments.

REMARKS:
Expected time spent on site: 4.1 days.

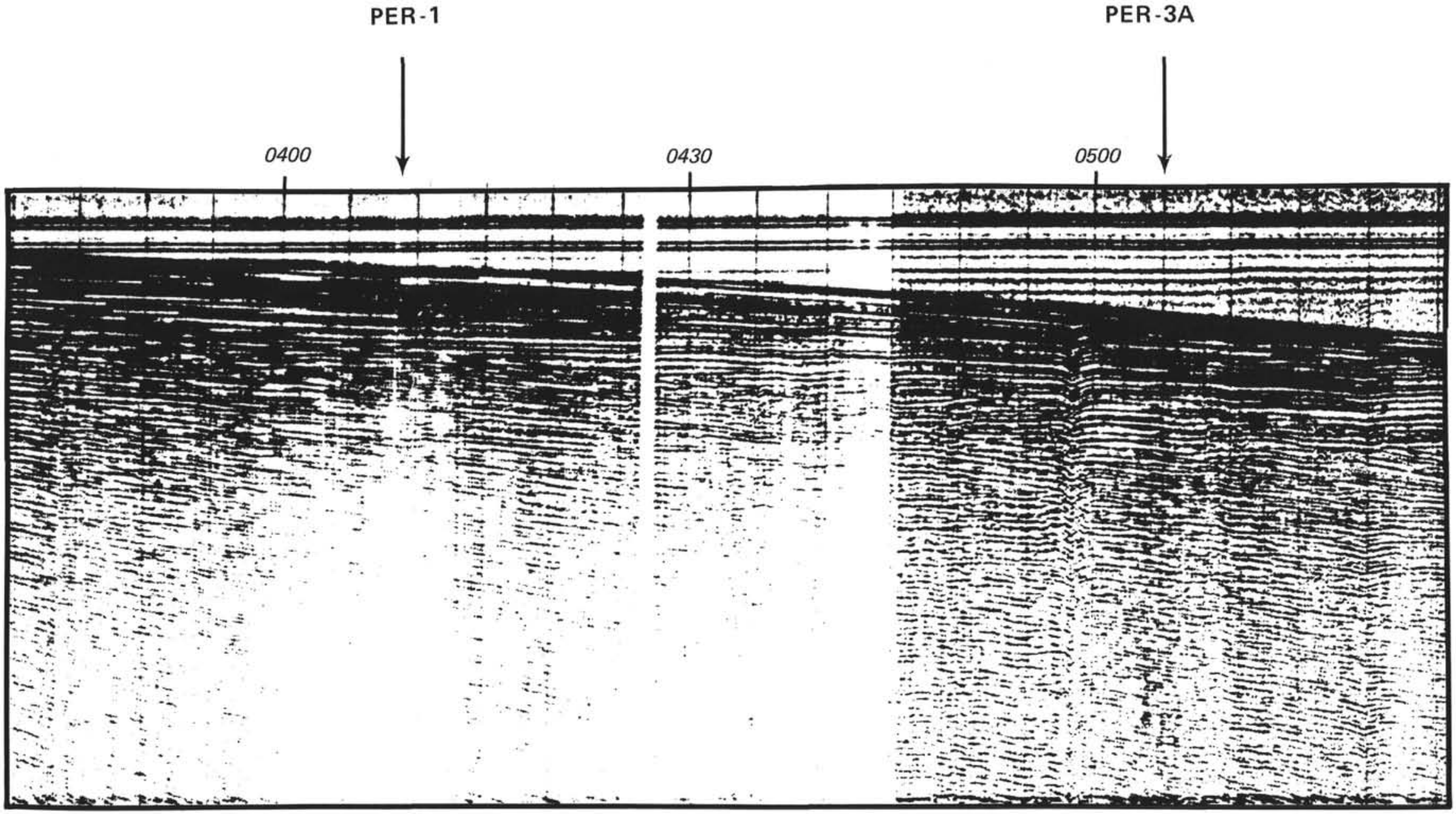
PER-3



MCS LINE 14

03-25-85

PER-3 at 0603Z



SCS LINE YALOC

20-03-74

PER-1 (0408Z)

PER-3A (0505Z)

SITE NUMBER: PER-4A, PER-4B, PER-4C, PER-4D

POSITION: PER-4A:13°36.2'S/76°48.1'W SEDIMENT THICKNESS: 1000m
PER-4B:13°37.6'S/76°50.4'W
PER-4C:13°29.1'S/76°54.2'W
PER-4D:13°27.4'S/76°51.9'W

WATER DEPTH: 300 m (PER-4A)
390 m (PER-4B)
443 m (PER-4C)
353 m (PER-4D)

PRIORITY: Paleoceanographic 1

PROPOSED DRILLING PROGRAM:
Double APC to 200 m.

SEISMIC RECORD:
PER-4A on OSU 3.5 kHz line YALOC 06-02-77 at 0207Z. PER-4B on same line at 2348Z.
PER-4C on OSU SCS line YALOC 12-03-74 at 1000Z. PER-4D on same line at 0936Z.
SeaMARC II Sidescan, bathymetry.

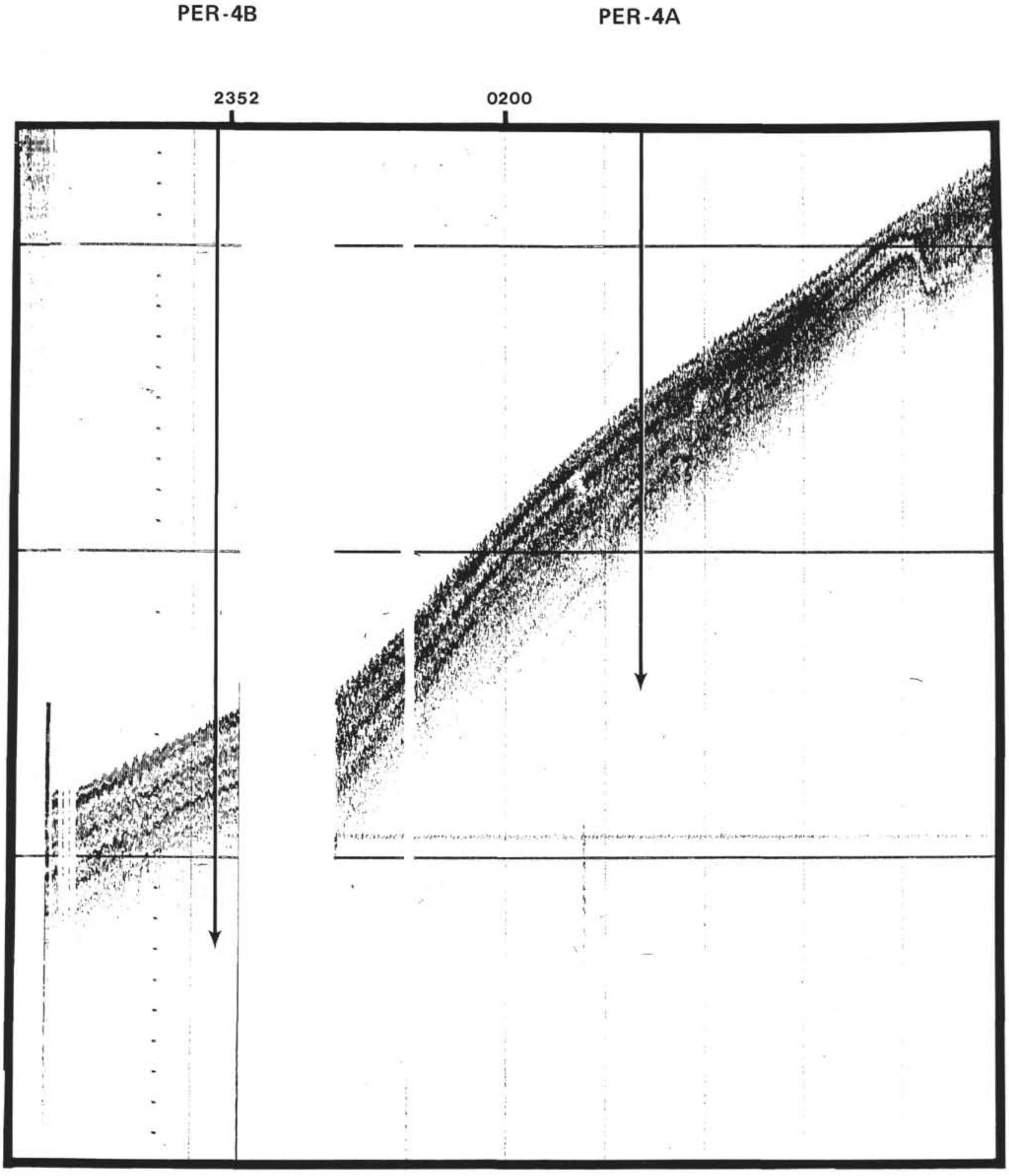
HEAT FLOW: Yes

LOGGING: No

OBJECTIVES:
Southern site in lateral transect across upper slope mud lens. Recover Quaternary upwelling sediments and investigate dolomite generation.

SEDIMENT TYPE:
Unconsolidated organic carbon-rich muds and thin dolomite layers.

REMARKS:
Expected time spent on site: 1.3 days each.

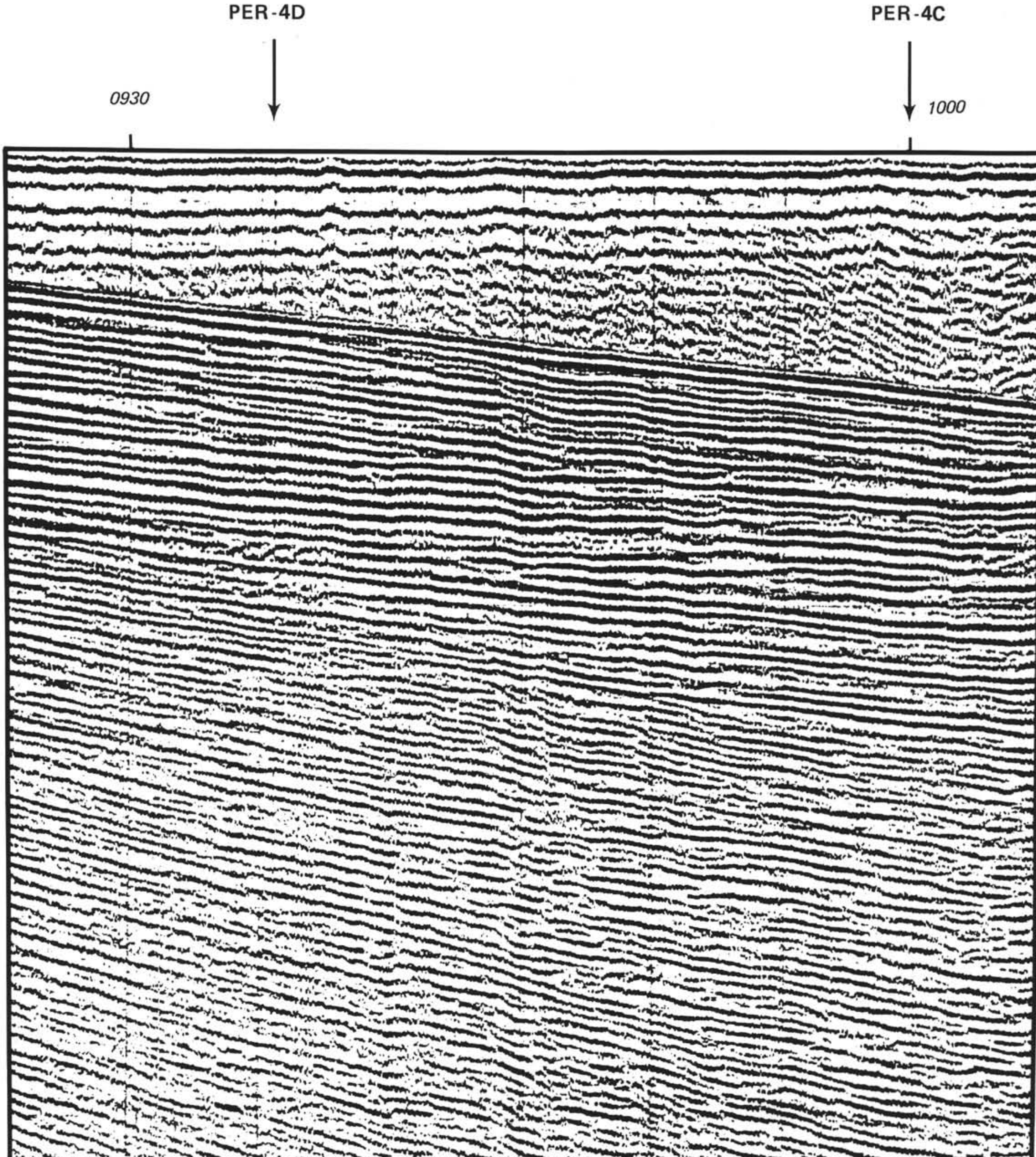


SCS LINE YALOC

06-02-77

PER-4A at 0207

PER-4B at 2348



SCS LINE YALOC

12-03-74

PER-4C at 1000Z

PER-4D at 0936Z

SITE NUMBER: PER-5

POSITION: 11°12.0'S/78°01.4'W SEDIMENT THICKNESS: 1000 m+

WATER DEPTH: 250 m PRIORITY: Paleoceanographic 1

PROPOSED DRILLING PROGRAM:
Double APC to 200 m.

SEISMIC RECORD:
Site on OSU SCS line YALOC 29-02-72 at 2306Z.
SeaMARC II sidescan and bathymetry.

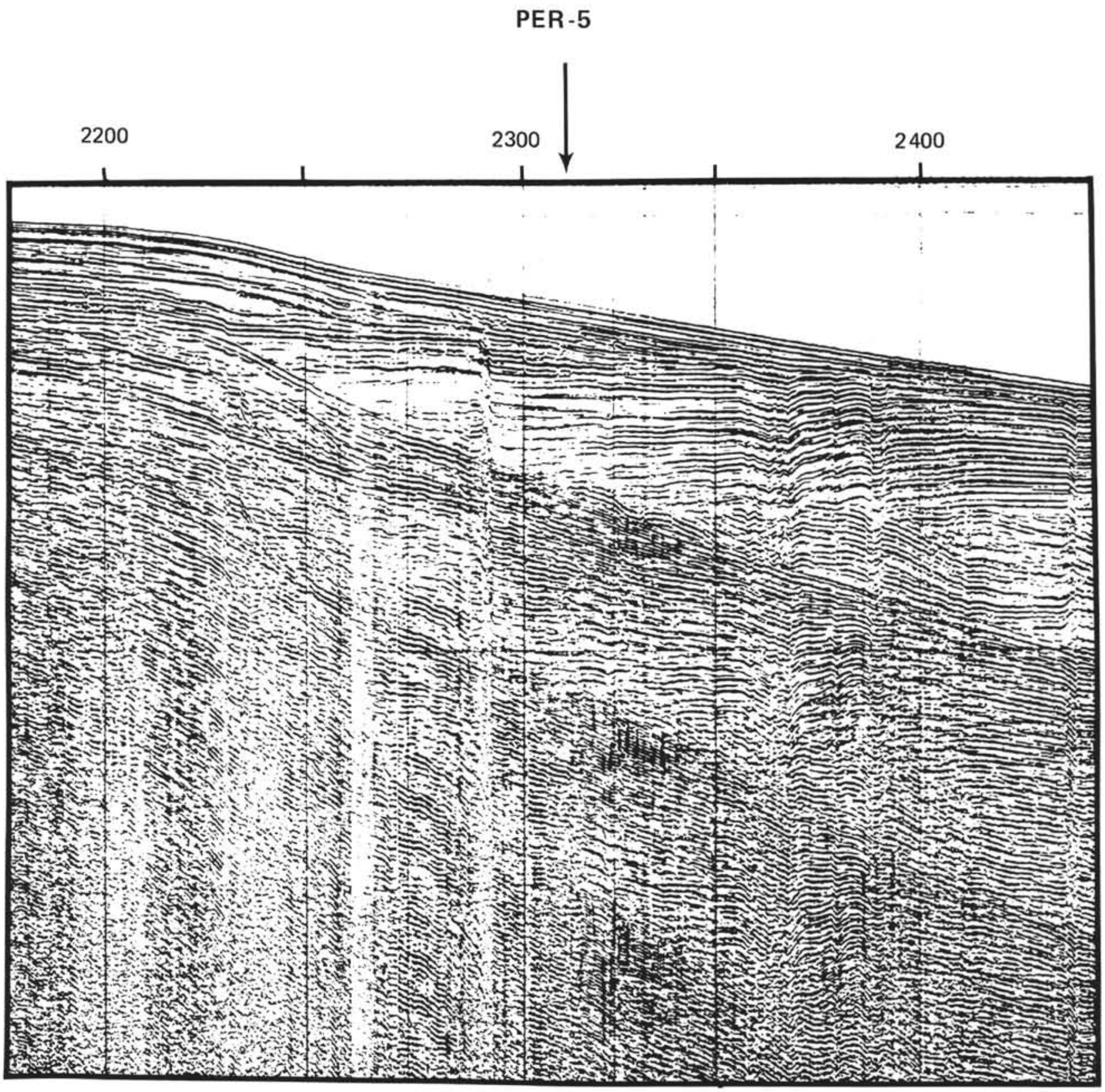
HEAT FLOW: Yes

LOGGING: Yes

OBJECTIVES:
Center site of transect and star pattern across upper slope mud lens. To recover Quaternary upwelling sediments and investigate dolomitization processes.

SEDIMENT TYPE:
Unconsolidated organic carbon-rich muds and thin dolomite layers.

REMARKS:
estimated time spent on site: 2.0 days



SCS LINE YALOC

29-02-72

PER-5 at 2306Z

SITE NUMBER: PER-6

POSITION: 11°15.0'S/78°37.0'W

SEDIMENT THICKNESS: 1500 m

WATER DEPTH: 2010 m

PRIORITY: Tectonic 1

PROPOSED DRILLING PROGRAM:

APC/XCB to a maximum of 1100 m.

SEISMIC RECORD:

Located on HIG MCS line 14 (MW8505, collected on 03-25-85) at CDP 0937.
SeaMARC II sidescan and bathymetry.

HEAT FLOW: Yes

LOGGING: Yes

OBJECTIVES:

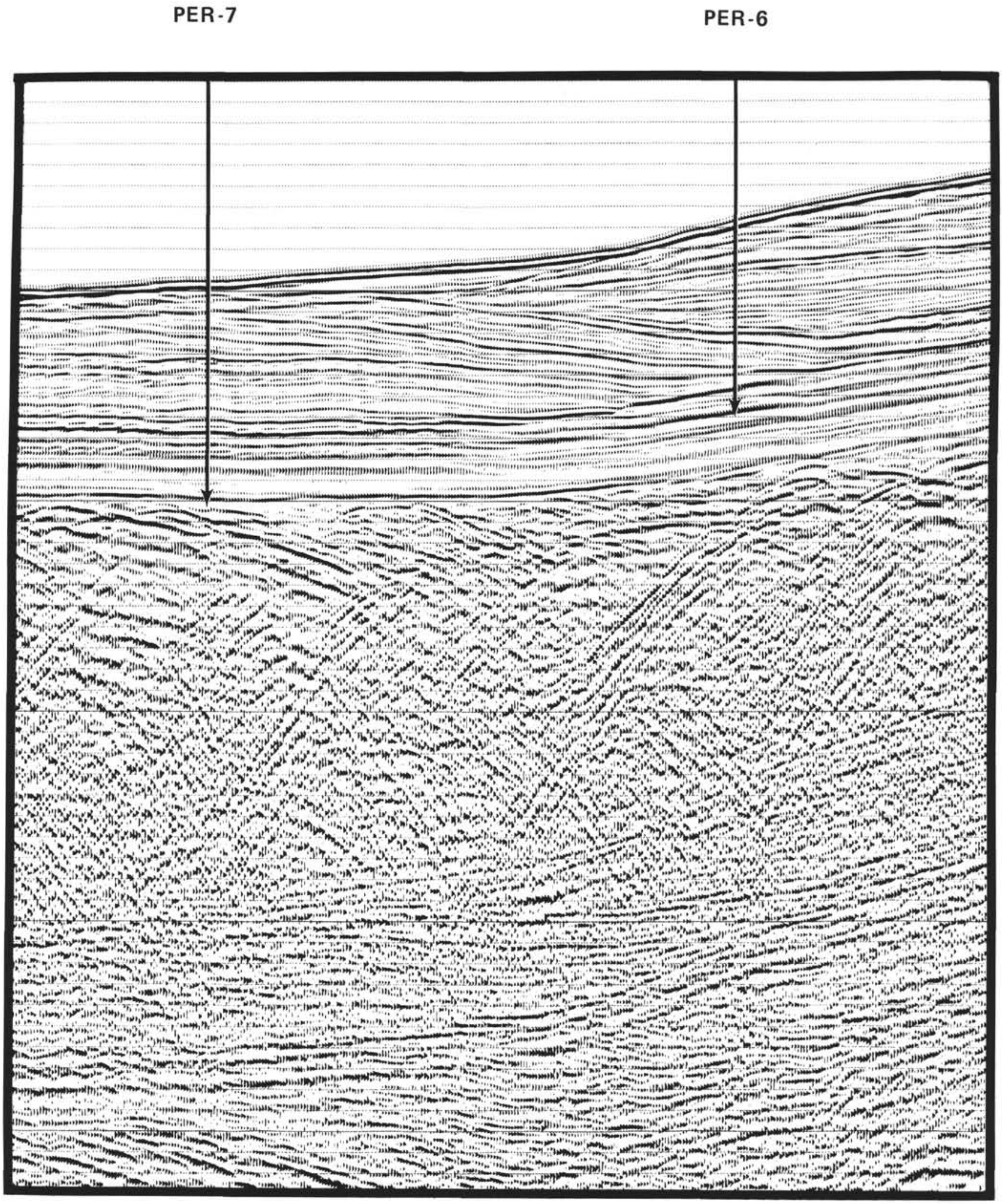
Determine the Neogene subsidence and sediment accumulation rates of the outer Lima Basin deposits and investigate the tectonic and metamorphic history of underlying basement rocks. Reconstruct the paleoenvironment of ancient upwelling sediments, and study diagenetic dolomitization processes.

SEDIMENT TYPE:

Cenozoic and Mesozoic marine sediments, carbonates and possibly metamorphosed clastic rocks.

REMARKS:

Estimated time spent on site: 11.1 days.



MCS LINE 14

03-25-85

PER-6 at 0937

PER-7 at 1012

SITE NUMBER: PER-7
PER-7A

POSITION: 11°17.0'S/78°40.4'W (PER-7)
11°51.0'S/78°51.6'W (PER-7A)

SEDIMENT THICKNESS: 1100m

WATER DEPTH: 2215 m (PER-7)
1650 m (PER-7A)

PRIORITY: Tectonic 1

PROPOSED DRILLING PROGRAM:
APC/XCB to 1100 m, possibly reenter and RCB continuation.

SEISMIC RECORD:
PER-7 located on HIG MCS line 14 (MW8505, collected on 03-25-85) at CDP 1012.
PER-7A located on Shell MCS line P 1017 at CDP 1975.
SeaMARC II sidescan and bathymetry.

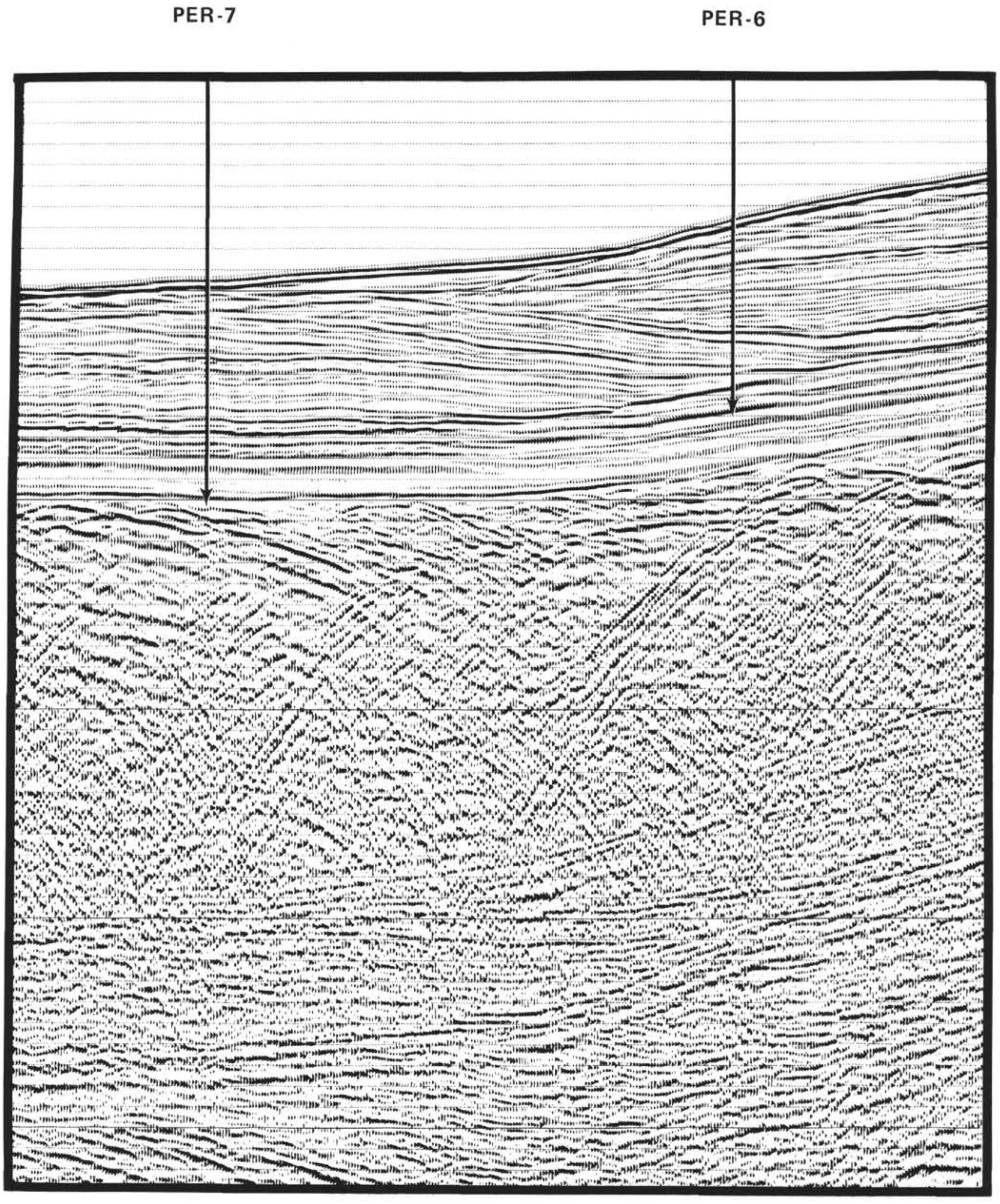
HEAT FLOW: Yes

LOGGING: Yes

OBJECTIVES:
Recover a complete Neogene sequence (0-600 m bsf), penetration into deep Paleogene and Mesozoic sediments, possibly sample metamorphic basement.

SEDIMENT TYPE:
Cenozoic and Mesozoic marine clastics, carbonates, and possibly metamorphic schists.

REMARKS:
Estimated time spent on site: 13.2 days (PER-7A), 13.3 days (PER-7)



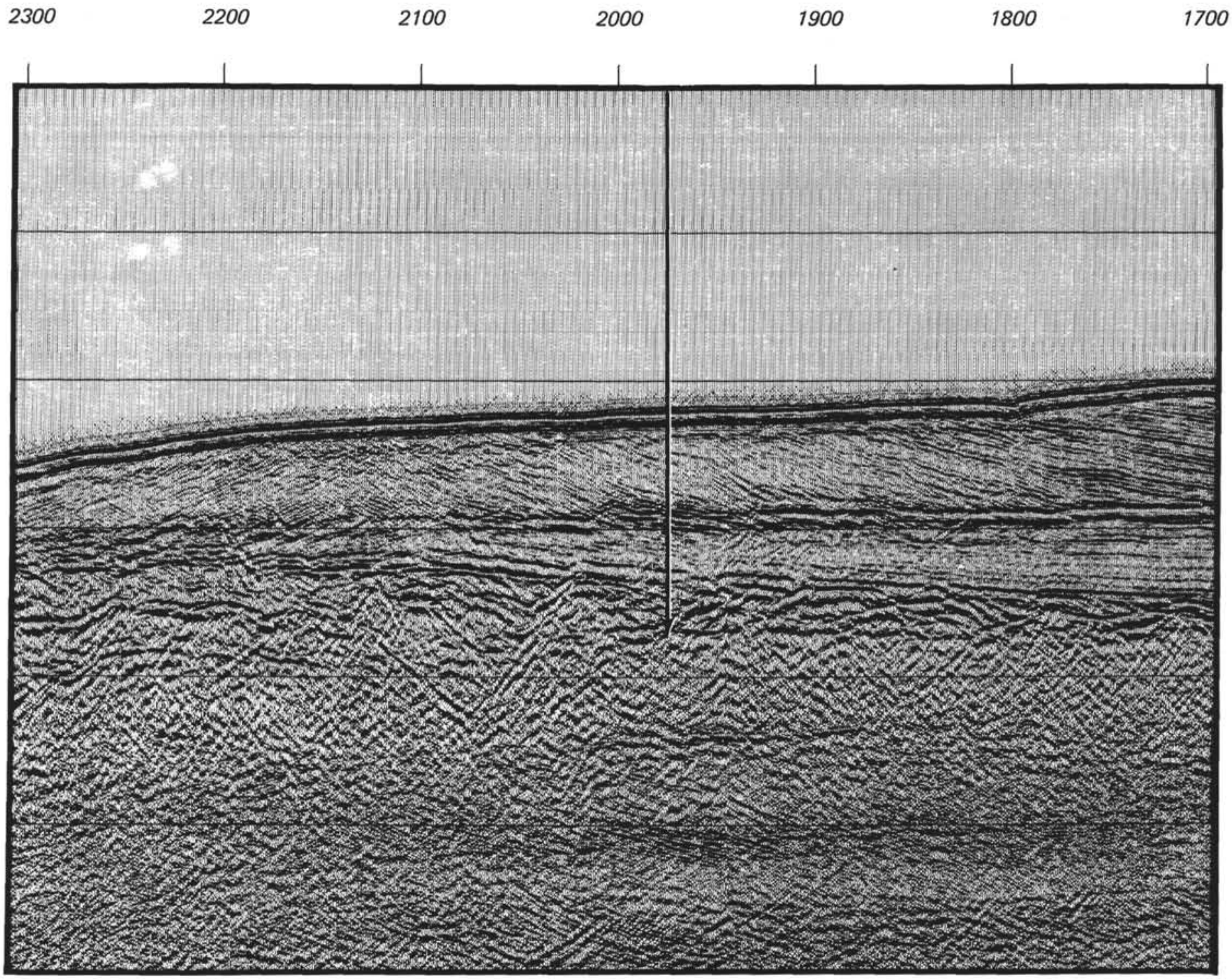
MCS LINE 14

03-25-85

PER-6 at 0937

PER-7 at 1012

PER 7-A



MCS LINE P 1017

PER-7A (CDP 1975)

SITE NUMBER: PER-8

POSITION: $11^{\circ}16.3'S/79^{\circ}03.0'W$ SEDIMENT THICKNESS: 450 m

WATER DEPTH: 3825 m PRIORITY: Tectonic 2

PROPOSED DRILLING PROGRAM:
Single bit rotary coring to 600 m.

SEISMIC RECORD:
Site is located on HIG MCS line 13 at CDP 1844 (collected 03-24-85), and near CDP 1130 on HIG MCS line 18 (collected 23-03-1985).
SeaMARC II sidescan and bathymetry.

HEAT FLOW: Yes

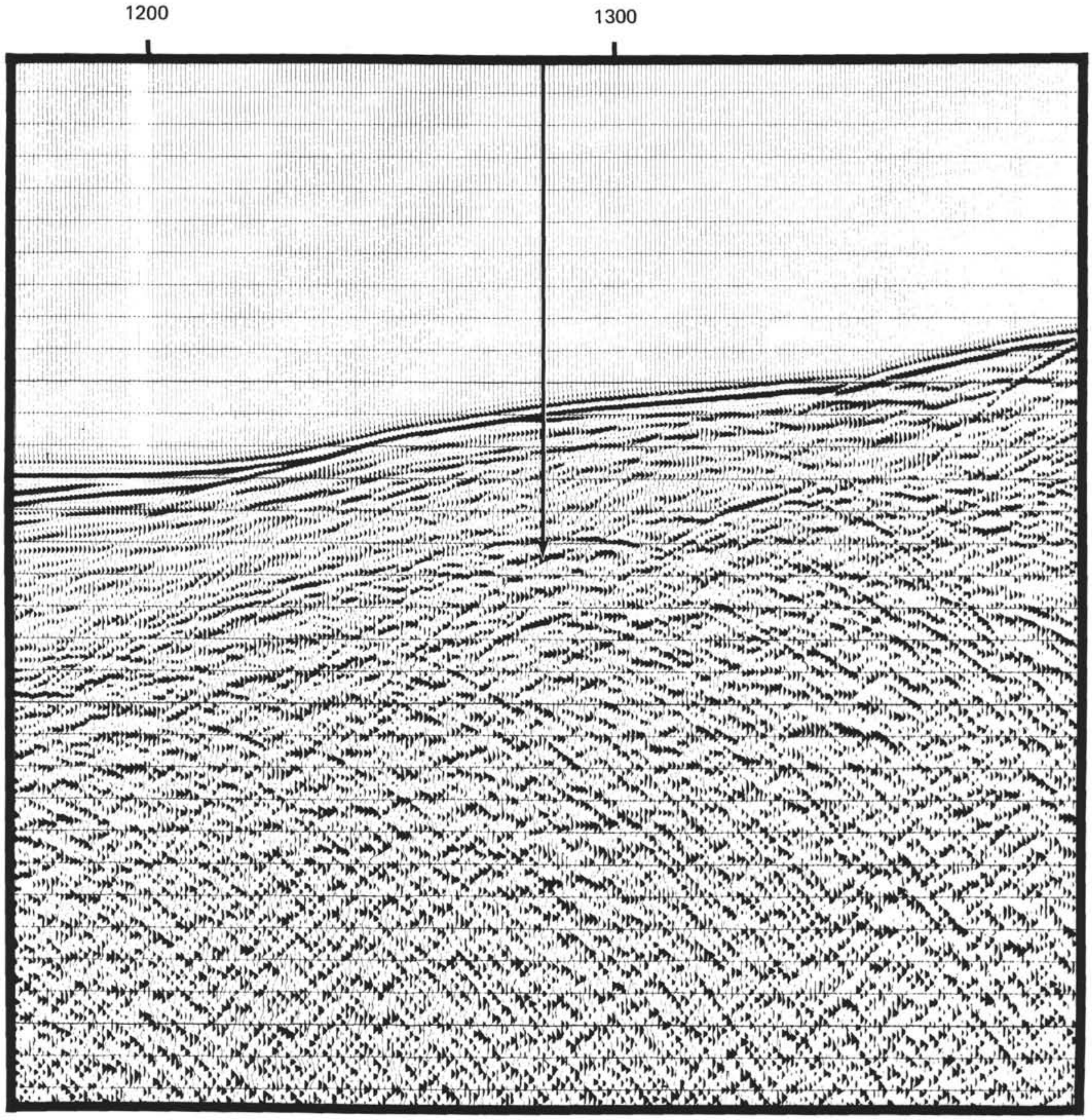
LOGGING: Yes

OBJECTIVES:
Determine the age and nature of the leading edge of a metamorphic block in the transition zone which is the foundation of the Peru margin. Study and date metamorphic stages in crystalline schists. Ascertain the record of vertical movement of overlying sediments.

SEDIMENT TYPE:
Marine siltstones with thin interbedded dolomicrite overlying crystalline schists.

REMARKS: Estimated time spent on site: 11.4 days.

PER-8



MCS LINE 13

03-24-85

PER-8 at 1844Z

SITE NUMBER: PER-9A

POSITION: PER-9A: $08^{\circ}47.8'S/79^{\circ}37.7'W$ SEDIMENT THICKNESS: 1000m

WATER DEPTH: 100 m PRIORITY: Paleoceanographic 1

PROPOSED DRILLING PROGRAM:
Double APC to 200 m.

SEISMIC RECORD:
Site is located on OSU 3.5 kHz line YALOC 03-01-72 at 2305Z. Projected on MCS line #2025 at SP 0780. SeaMARC II sidescan and bathymetry.

HEAT FLOW: Yes

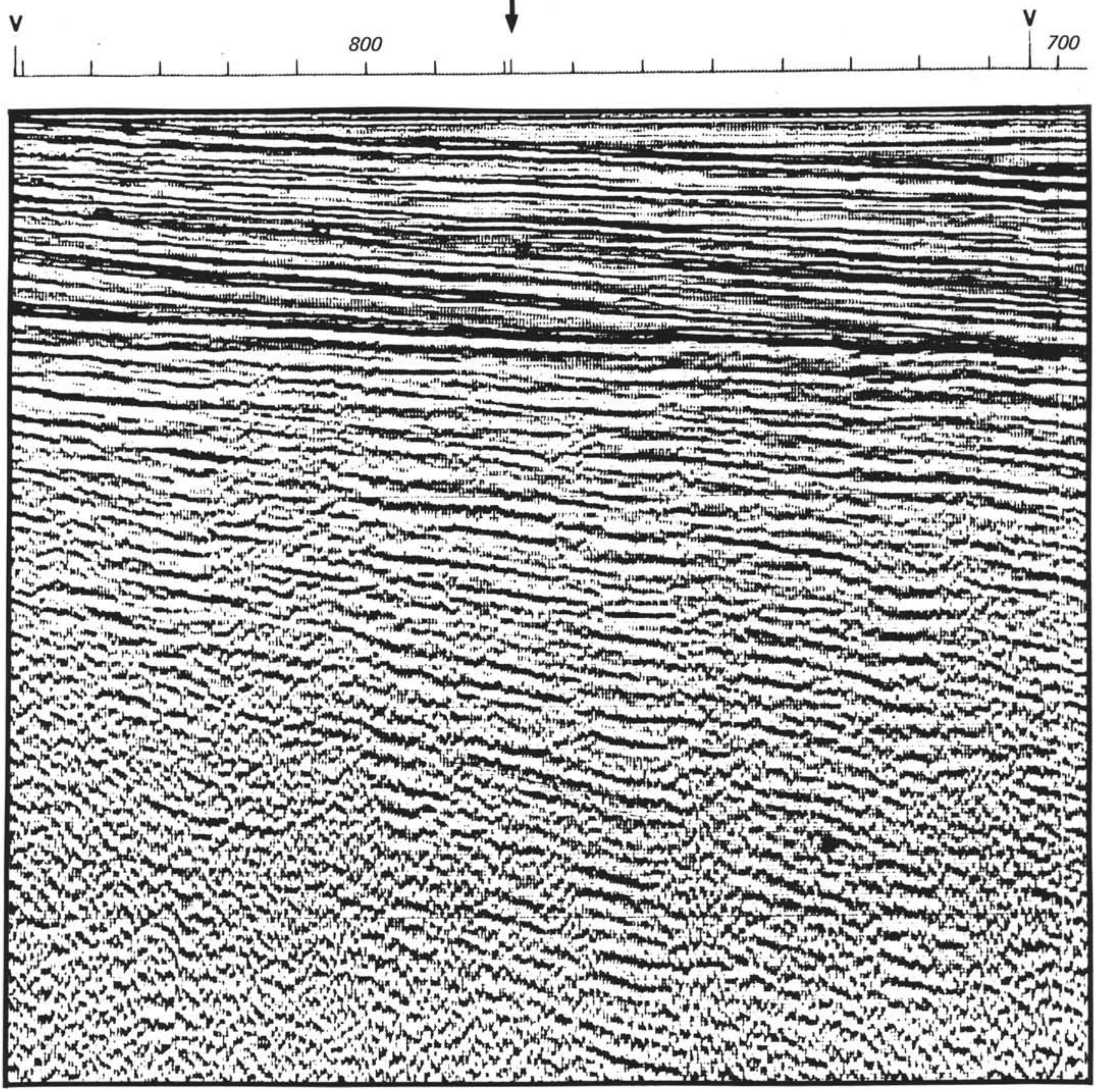
LOGGING: No

OBJECTIVES:
Landward site of star pattern of shallow holes in upper slope mud facies of Yaquina and Trujillo Basins. To recover Neogene and Quaternary upwelling sediments and study processes of dolomitization in organic carbon-rich sediments.

SEDIMENT TYPE:
Unconsolidated organic carbon-rich muds and thin dolomite layers.

REMARKS:
Expected time on site: 1.3 days

PER-9A



MCS LINE # 2025

PER-9A (projected) at SP 780

SITE NUMBER: PER-10

POSITION: 09°00.3'S/79°57.2'W SEDIMENT THICKNESS: 1000 m+

WATER DEPTH: 416 m PRIORITY: Paleoceanographic 1

PROPOSED DRILLING PROGRAM:
Double APC to 200 m.

SEISMIC RECORD:
Site located on OSU 3.5 kHz line Y7108 03-02-72 at 0557Z; projected on OSU SCS line YALOC 22-03-74 at 0618Z. SeaMARC II sidescan and bathymetry.

HEAT FLOW: Yes

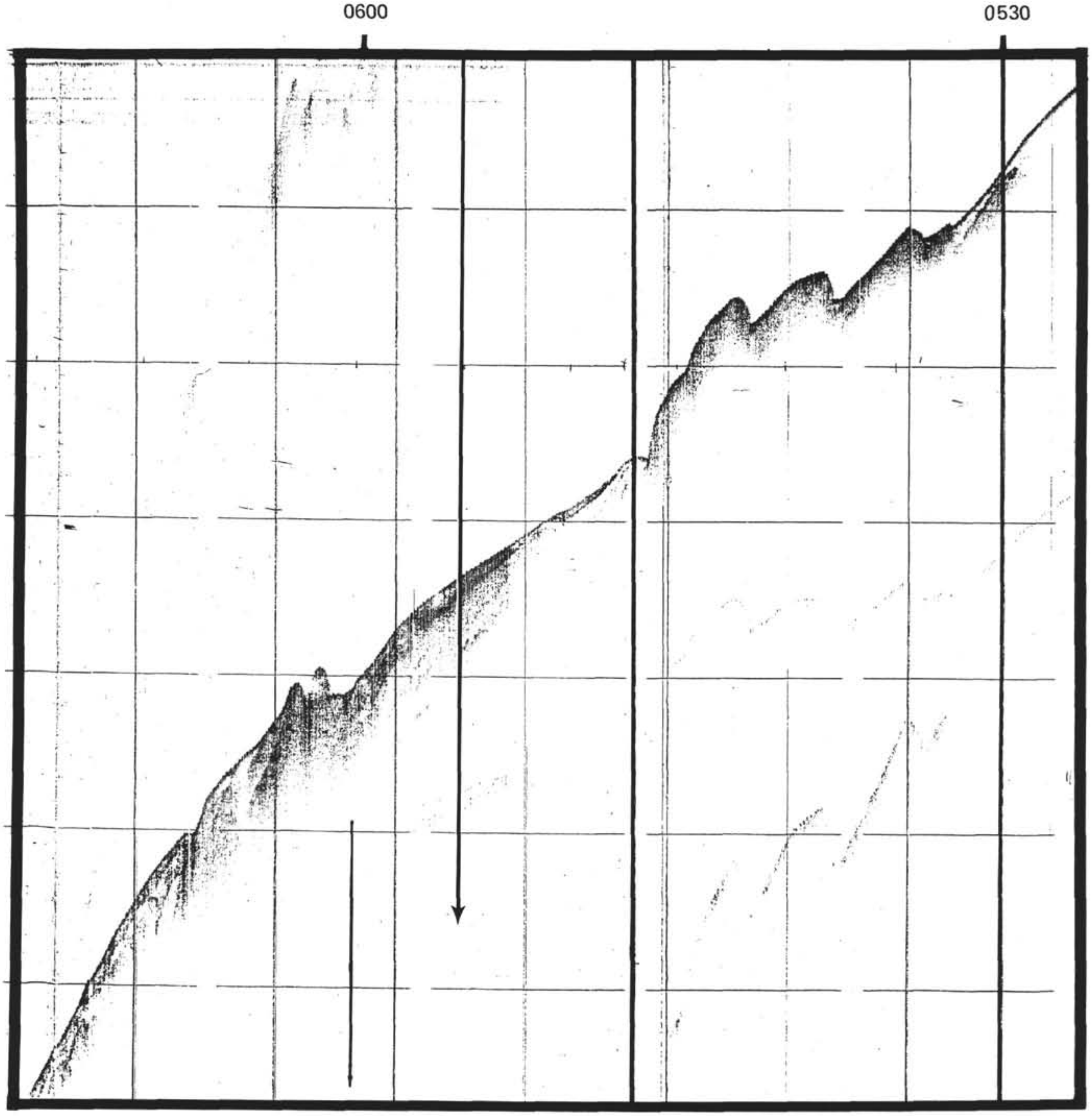
LOGGING: No

OBJECTIVES:
Seaward shallow hole of transect in upper slope mud wedge and patches.

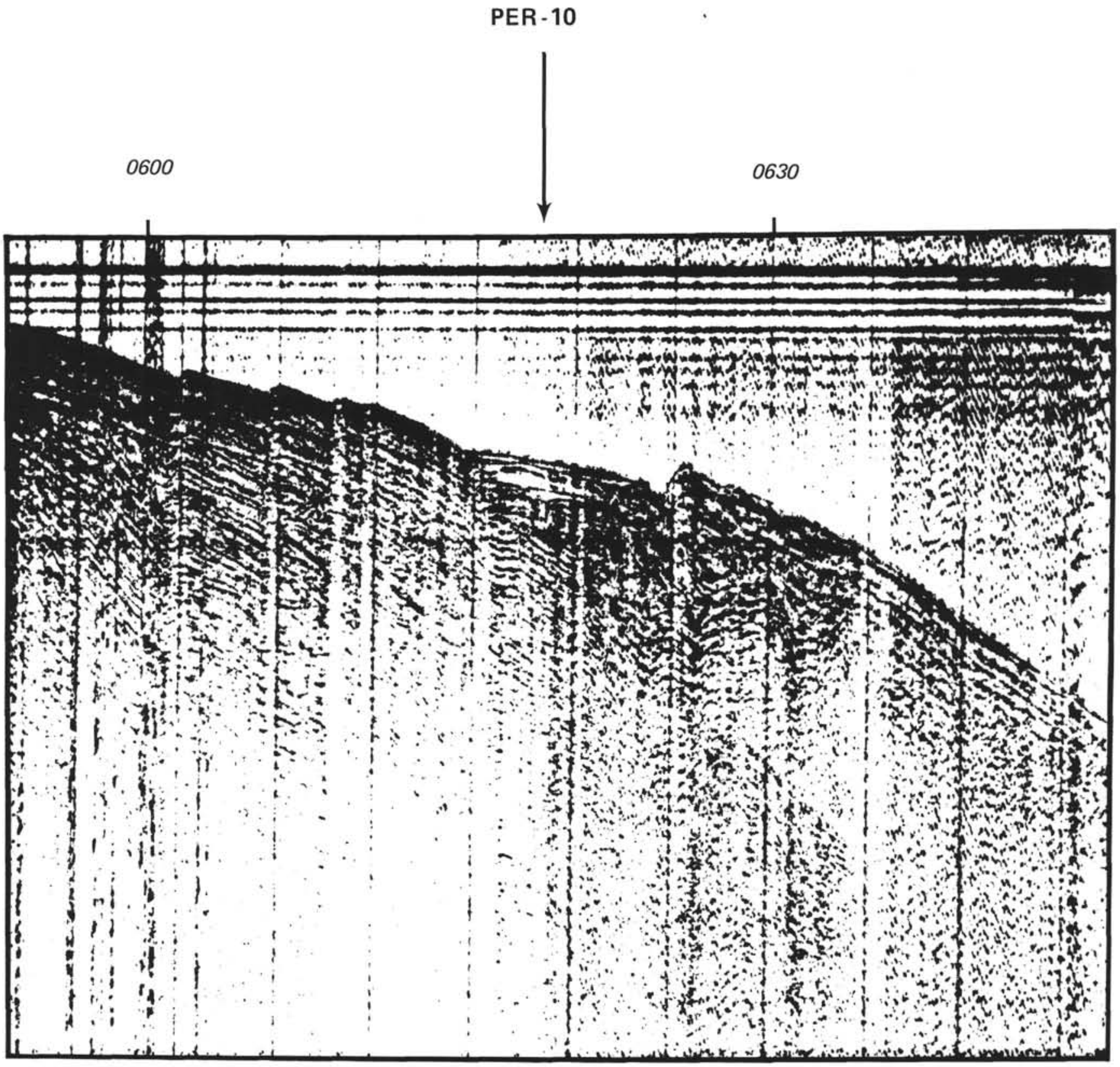
SEDIMENT TYPE:
Unconsolidated organic carbon-rich mud and thin dolomite layers.

REMARKS:
Estimated time on site: 1.3 days

PER-10



LINE Y7108
03-02-72
PER-10 at 0557



SCS LINE YALOC

22-03-74

PER-10 (projected) at 0618Z

SITE NUMBER: PER-14

POSITION: 09°02.9'S/80°27.4'W SEDIMENT THICKNESS: 600 m

WATER DEPTH: 3015 m PRIORITY: Tectonic 1

PROPOSED DRILLING PROGRAM:
APC/XCB to 850 m.

SEISMIC RECORD:
Located at CDP 1183 on MCS line Peru-2, crossline HIG SCS line 10 at 0832Z. SeaMARC II sidescan and bathymetry.

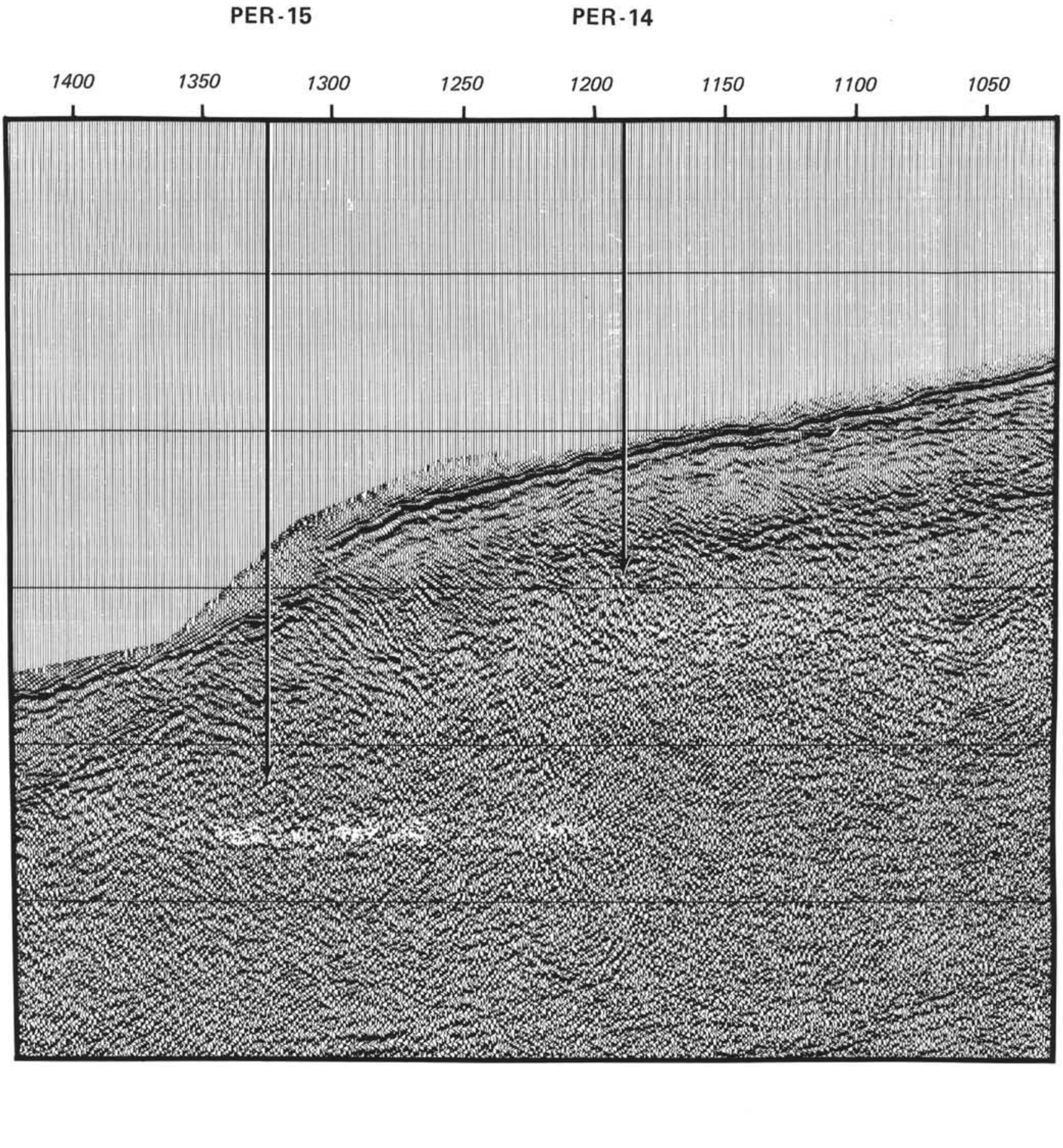
HEAT FLOW: Yes

LOGGING: Yes

OBJECTIVES:
Sample Neogene sediments at seaward edge of Yaquina Basin. Determine age and nature of leading edge of metamorphic block in transition zone which is the foundation of the Peru margin. Study and date metamorphic stages in crystalline schists. Ascertain vertical motion history of overlying Neogene sediments.

SEDIMENT TYPE:
Marine siltstones with interbedded dolomicrites and crystalline schists.

REMARKS:
Estimated time spent on site: 11.1 days.



CDP LINE PERU-2

PER-14 at CDP 1183 to 850 m T.D.

PER-15 at CDP 1320 to 900 m T.D.

SITE NUMBER: PER-15

POSITION: 09°02.9'S/80°27.4'W

SEDIMENT THICKNESS: 500 m

WATER DEPTH: 3975m

PRIORITY: Tectonic 2; alternative site to PER-14 through PER-17A

PROPOSED DRILLING PROGRAM:
APC/XCB to 900 m.

SEISMIC RECORD:
Site located at CDP 1320 on MCS line Peru-2. SeaMARC II sidescan and bathymetry.

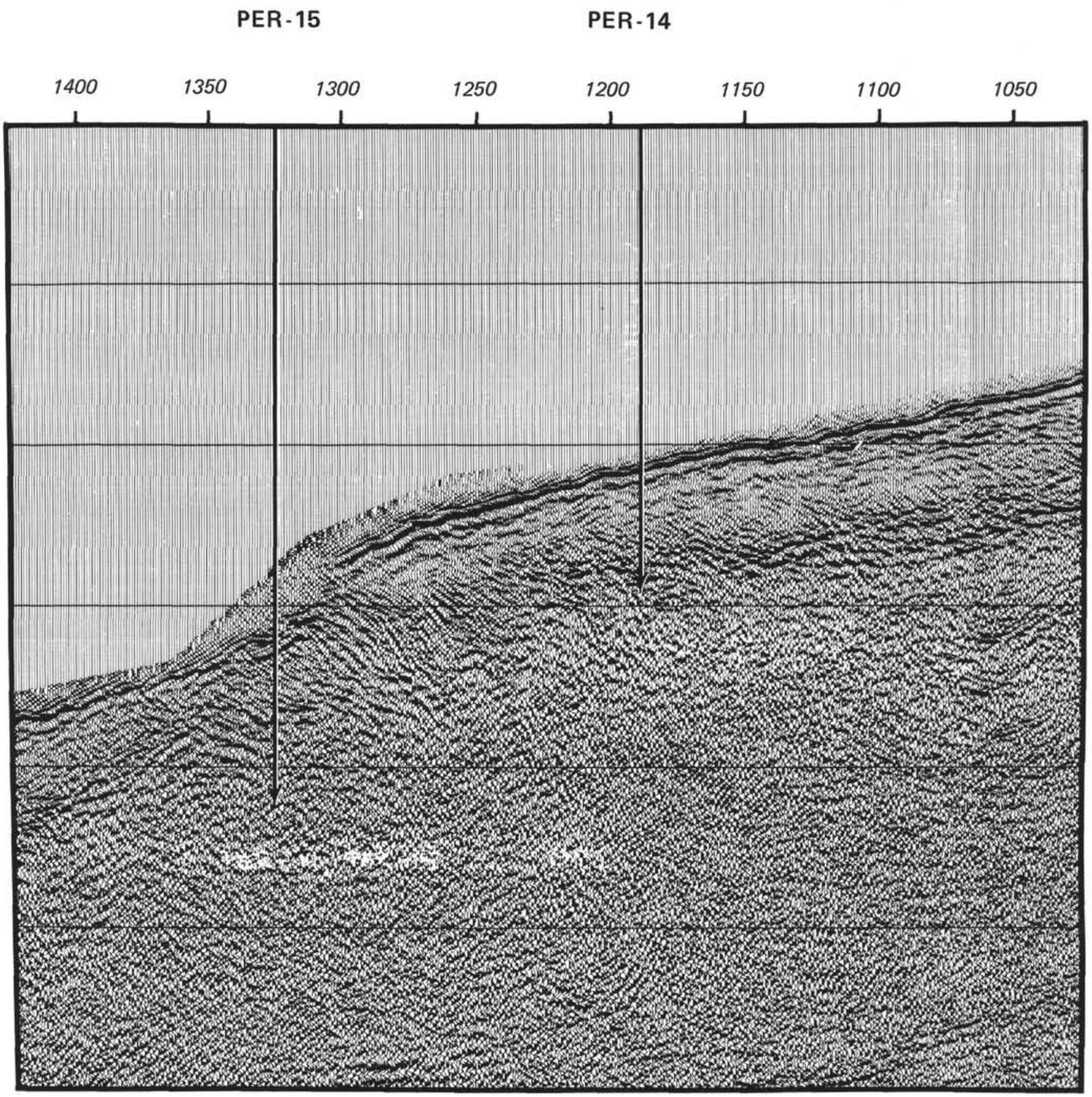
HEAT FLOW: Yes

LOGGING: Yes

OBJECTIVES:
Determine the age and nature of the leading edge of the metamorphic block in the transition zone which is the foundation of the Peru margin. Study and date metamorphic stages in crystalline schists. Ascertain vertical motion in sedimentary basin overlying this continental basement.

SEDIMENT TYPE:
Marine siltstones with thin interbedded dolomicrites overlying crystalline schists.

REMARKS:
Estimated time on site: 12.3 days.



CDP LINE PERU-2

PER-14 at CDP 1183 to 850 m T.D.

PER-15 at CDP 1320 to 900 m T.D.

SITE NUMBER: PER-16, PER-16A

POSITION: PER-16: 09°05.0'S/80°32.0'W SEDIMENT THICKNESS: 800 m
PER-16A: 09°06.0'S/80°33.9'W

WATER DEPTH: 4380 m (PER-16)
4612 m (PER-16A)

PRIORITY: Tectonic 2; alternative site to PER-14 through PER-17A

PROPOSED DRILLING PROGRAM:
APC/XCB to 1300 m (PER-16),
APC/XCB to 790 m (PER-16A)

SEISMIC RECORD:
Site PER-16 located at CDP 1595, MCS line Peru-2.
Site PER-16A located at CDP 1698, MCS line Peru-2.
SeaMARC II sidescan and bathymetry.

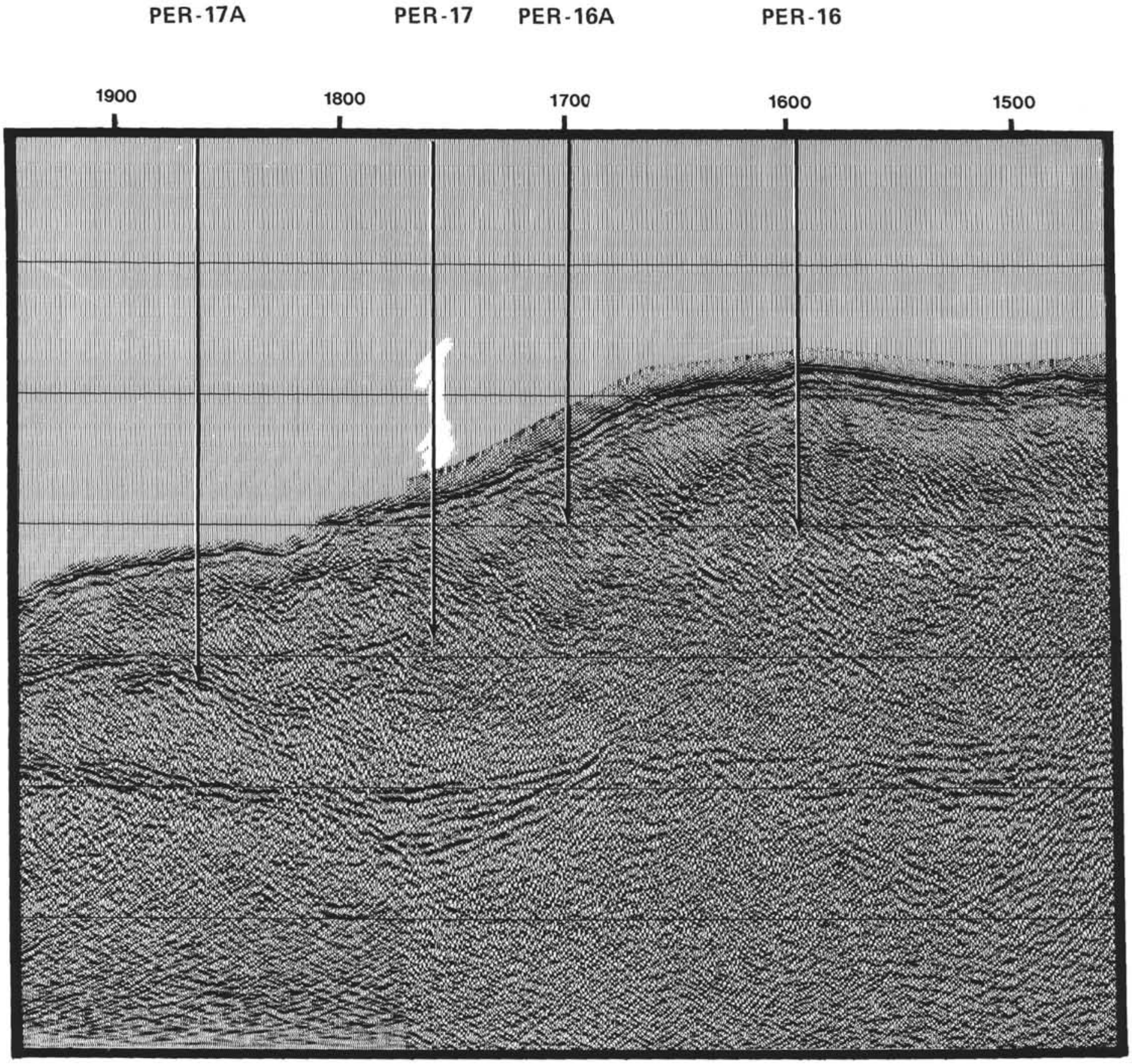
HEAT FLOW: Yes

LOGGING: Yes

OBJECTIVES:
Sample the contact of the seaward edge of metamorphic continental block in order to determine age and nature of metamorphism. Age of oldest accreted sediment, reconstruct the truncation history of the metamorphic block.

SEDIMENT TYPE:
Marine siltstones with thin interbedded dolomicrites overlying crystalline schists.

REMARKS: Estimated time on site PER-16: 17 days.
PER-16A: 12.5 days.



CDP LINE PERU-2

PER-16 at CDP 1595 to 1300 m T.D.

PER-16A at CDP 1698 to 790 m T.D.

PER-17A at CDP 1763 to 1010 m T.D.

PER 17A at CDP 1871 to 1200 m T.D.

SITE NUMBER: PER-17, PER-17A

POSITION: PER-17: 09°06.6'S/80°35.3'W SEDIMENT THICKNESS: 1500 m
PER-17A:09°07.4'S/80°37.1'W

WATER DEPTH: 5062 m (PER-17)
5420 m (PER-17A)

PRIORITY: Tectonic 1

PROPOSED DRILLING PROGRAM:
APC/XCB to 1012 m (PER-17); APC/XCB to 1190m (PER-17A). If target reflectors are not reached, reentry and continuation with RCB.

SEISMIC RECORD:
PER-17 located at CDP 1763, MCS line Peru-2.
PER-17A located at CDP 1871, MCS line Peru-2.
SeaMARC II sidescan and bathymetry.

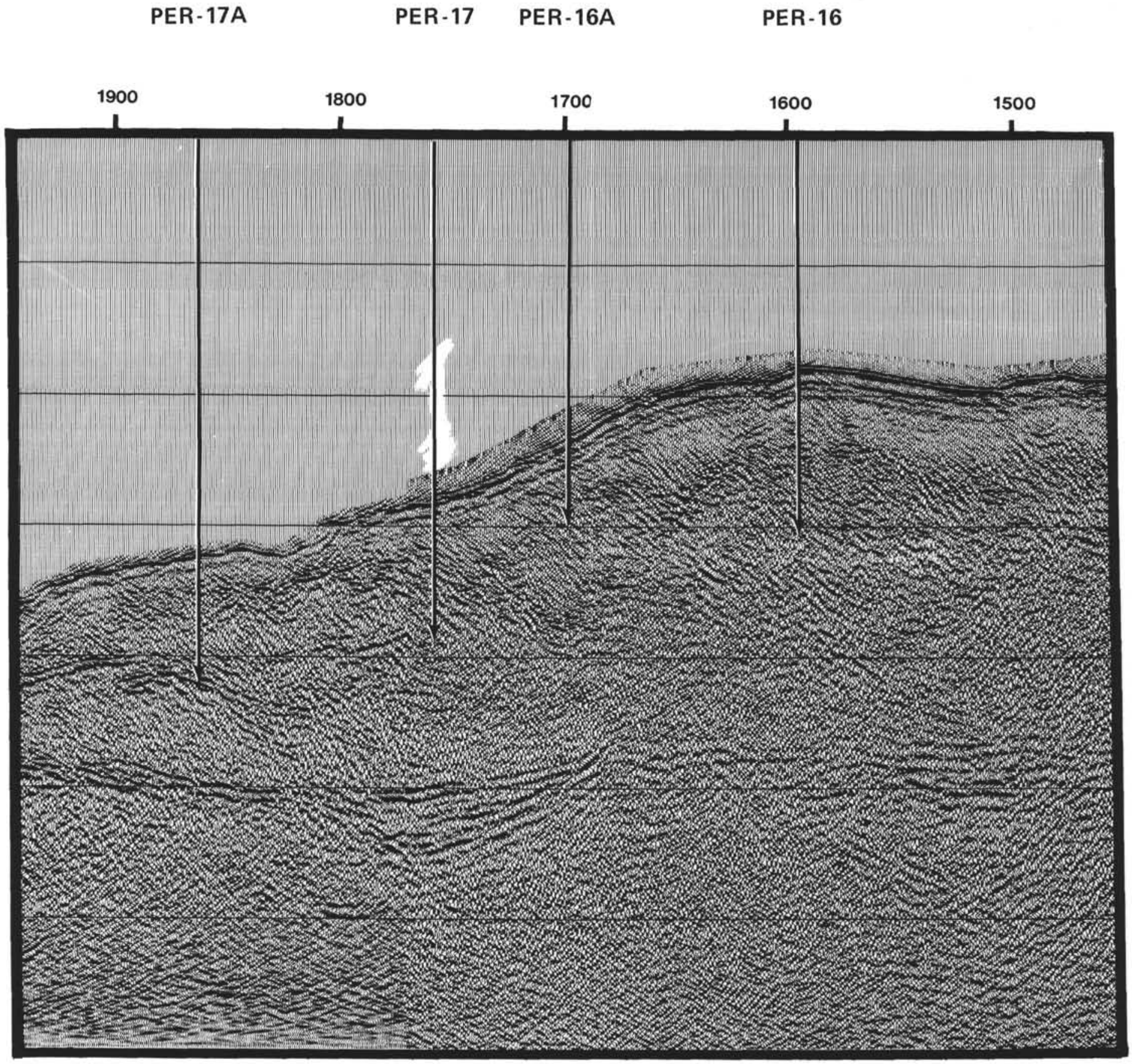
HEAT FLOW: Yes

LOGGING: Yes

OBJECTIVES:
Determine the age of the accretionary prism immediately adjacent to the metamorphic block which is the foundation of the Peru margin. Reconstruct the truncation history of the margin by drilling the transition zone. Determine the vertical motion history of sedimentary basins overlying the metamorphic basement.

SEDIMENT TYPE:
Deformed hemipelagic marine sediments; clastics, schists, dolomites.

REMARKS: Estimated time on sites: 10.4 days (PER-17), 10.2 days (PER-17A).



CDP LINE PERU-2

PER-16 at CDP 1595 to 1300 m T.D.

PER-16A at CDP 1698 to 790 m T.D.

PER-17A at CDP 1763 to 1010 m T.D.

PER 17A at CDP 1871 to 1200 m T.D.

SITE NUMBER: PER-18B, PER-18C, PER-18D

POSITION: PER-18B: $05^{\circ}37.1'S/81^{\circ}33.2'W$ SEDIMENT THICKNESS: 1000m
PER-18C: $05^{\circ}37.4'S/81^{\circ}36.0'W$
PER-18D: $05^{\circ}36.8'S/81^{\circ}39.0'W$

WATER DEPTH: 3128 m (PER-18B)
3038 m (PER-18C)
4200 m (PER-18D)

PRIORITY: Tectonic 2; alternative sites to PER-14 through PER-17A

PROPOSED DRILLING PROGRAM:
APC/XCB to 1000 m (PER-18B), 960 m (PER-18C), 1250 m (PER-18D)

SEISMIC RECORD: PER-18B: MCS line Peru-3 at CDP 940 and CDP 203 Charcot line 03.
PER-18C: MCS line Peru 3 at CDP 1100 and CDP 361 Charcot line 02.
PER-18D: MCS line Peru-3 at CDP 1250 and CDP 160 Charcot line 01.

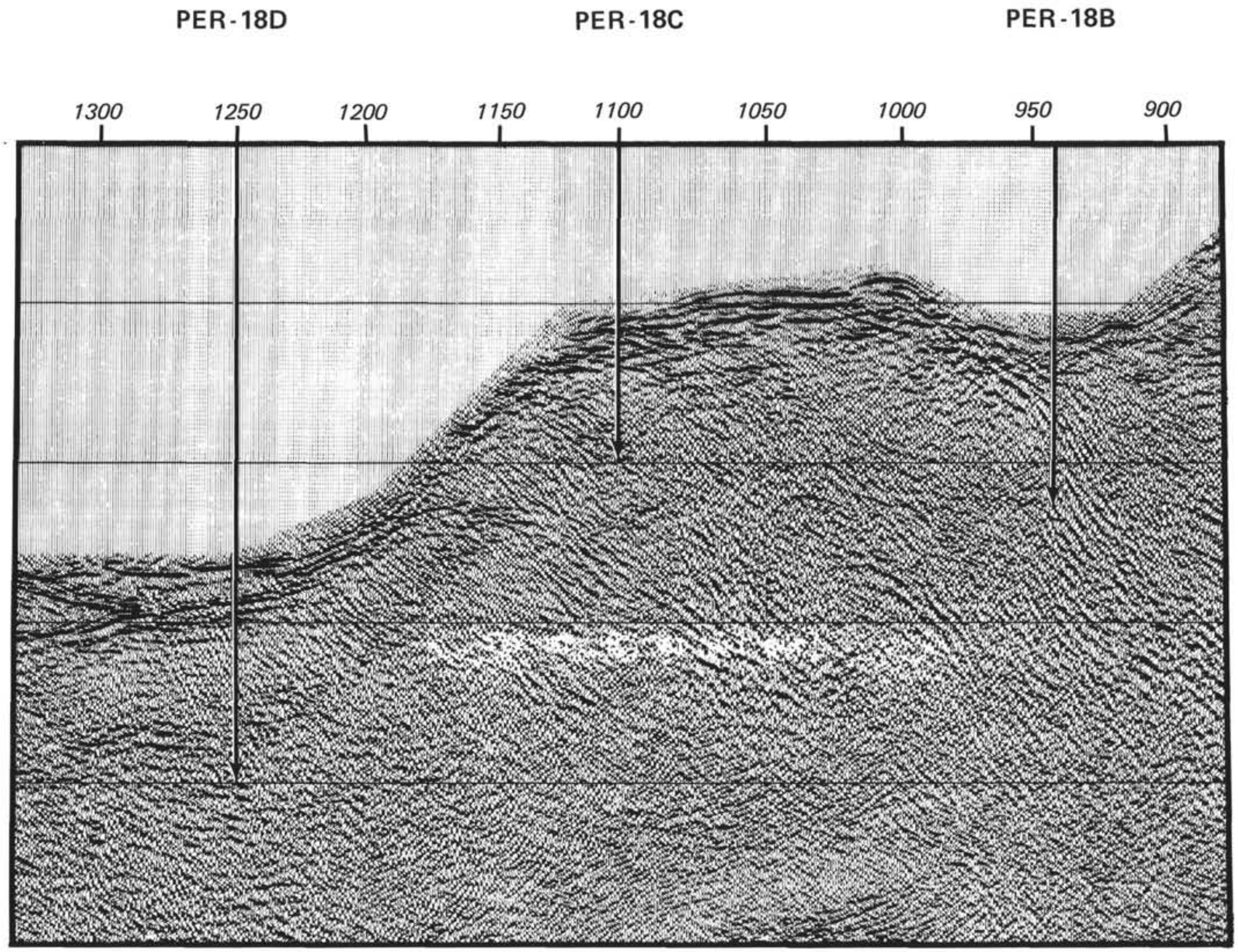
HEAT FLOW: Yes

LOGGING: Yes

OBJECTIVES: Alternative sites, see PER-14 to PER-17 for objectives.

SEDIMENT TYPE: Siltstones, dolomicrites, crystalline schists

REMARKS: Estimated time on sites: 6.5 days (PER-18B, PER-18C), 9.2 days (PER-18D).



CDP LINE PERU-3

PER-18B at CDP 940 to 1000 m T.D.

PER-18C at CDP 1100 to 960 m T.D.

PER-18D at CDP 1250 to 1250 m T.D.

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