OCEAN DRILLING PROGRAM

LEG 174A SCIENTIFIC PROSPECTUS

CONTINUING THE NEW JERSEY MID-ATLANTIC SEA-LEVEL TRANSECT

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This Scientific Prospectus is based on pre-cruise JOIDES panel discussions and scientific input from the designated Co-Chief Scientists on behalf of the drilling proponents. The operational plans within reflect JOIDES Planning Committee and thematic panel priorities. During the course of the cruise, actual site operations may indicate to the Co-Chief Scientists and the Operations Manager that it would be scientifically or operationally advantageous to amend the plan detailed in this prospectus. It should be understood that any proposed changes to the plan presented here are contingent upon approval of the Director of the Ocean Drilling Program in consultation with the Science and Operations Committees (successors to the Planning Committee) and the Pollution Prevention and Safety Panel.

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ABSTRACT

Sea-level changes have direct consequences for mankind; they profoundly affect shallow-water deposition and erosion, nearshore ecosystems, particle and nutrient transfer to the deep sea, and, at timescales of decades to centuries, the evolution of coastal civilization. Determining the timing, amplitudes, and causal mechanisms of sea-level variations, as well as their relation to the resulting stratigraphic record, continues to be a fundamental goal of the Ocean Drilling Program. Leg 174A will sample as many as six locations along the New Jersey shelf and upper slope as part of a long-term initiative to investigate the Oligocene-Holocene history of sea-level change in a transect across the continental margin from the continental rise to the coastal plain. This initiative, the New Jersey Mid-Atlantic Sea-Level Transect (MAT), combines the resources of the Ocean Drilling Program, the National Science Foundation, and U.S. and State of New Jersey geological surveys.

The primary goals of the transect are to (1) date unconformities (sequence boundaries) of Oligocene to Holocene age and to compare this stratigraphic record with the timing of glacial-eustatic changes inferred from deep-sea $\delta^{18}O$ variations, (2) place constraints on the amplitudes and rates of sea-level change that may have been responsible for unconformity development, (3) assess the relationships between depositional facies and sequence architecture, and (4) to provide a baseline for future scientific ocean drilling that will address the effects and timing of sea-level changes on this and other passive margins. An additional objective for Leg 174A is technical. The leg represents the first attempt by the Ocean Drilling Program to sample a thickly-sedimented continental margin in water < 200 m deep.

INTRODUCTION

The emergence of seismic stratigraphy in the late 1970s (Vail et al., 1977, 1984; Vail and Hardenbol, 1979; Vail, 1987; and Posamentier et al., 1988) led to a revolution in stratigraphy and to a renewal of interest in the role of eustasy in governing sedimentary cyclicity. Two arguments were advanced in support of the eustatic interpretation. One involved seismic evidence for the existence of regional unconformities characterized by apparently abrupt basinward shifts in onlap, which were interpreted to imply relatively rapid falls of sea level with amplitudes of up to several hundred meters. The second argument was based on the purported global synchroneity of sequence boundaries, which if correct, would be difficult to explain by other than a eustatic mechanism.

These arguments were not universally accepted for a number of reasons (Watts, 1982; Thorne and Watts, 1984; Miall, 1986, 1992; Burton et al., 1987; Hubbard, 1988; Christie-Blick et al., 1990; Christie-Blick, 1991; Christie-Blick and Driscoll, 1995): (1) basinward shifts in onlap were shown not to require sea-level changes that are either rapid or of large amplitude. Therefore, there is no reason to assume a eustatic cause or to exclude possible tectonic mechanisms for sequence-boundary development; (2) no mechanism exists for rapid eustatic change during intervals such as the Mesozoic, for which there is little or no evidence for continental glaciation; (3) limitations in the resolution with which sequence boundaries can be dated and correlated between basins casts doubt on the level to which global synchroneity can be established; (4) prior to 1987, the "sea-level curve" first published by Vail et al. (1977) was based primarily on proprietary data (see Haq et al., 1987). So, at the time of the Second Conference on Scientific Ocean Drilling (COSOD II, 1987), there was a great deal of interest in acquiring public data that might be used to establish a sea-level record independent of the Vail et al. (1977) synthesis.

The role of scientific ocean drilling in sea-level studies was advanced by means of a Joint Oceanographic Institutions, Inc. (JOI)/U.S. Scientific Advisory Committee (USSAC) workshop (Watkins and Mountain, 1990) and a JOIDES working group (Sea-Level Working Group Report, 1992). The working group recommended a threefold approach to sea-level studies involving passive continental margins (primarily siliciclastic); these included carbonate atolls, guyots and platforms, and deep-sea oxygen isotopic records. The working group also recognized the fundamental differences between glacial and nonglacial spans of earth history and suggested focusing on three different intervals: the Oligocene-Holocene (an example of "Icehouse" conditions), the mid-Cretaceous (an example of "Greenhouse" conditions), and the intervening Paleocene-Eocene (fancifully described as the "Doubthouse" Earth, owing to uncertainty about the time of onset of southern hemisphere continental glaciation). This strategy is reaffirmed in the recently published JOIDES Long Range Plan (1996). Ocean Drilling Program (ODP) Legs 133 and 166 addressed "Icehouse" sea-level issues at the seaward margins of carbonate platforms off northeastern Australia and the western Bahama Bank, respectively. ODP Legs 143 and 144 studied the "Greenhouse" drowning history of western Pacific guyots (the so-called "dipstick" approach). The New Jersey Mid-Atlantic Sea Level Transect (MAT) represents the first concerted effort to evaluate the effects of glacial-eustatic changes at a passive continental margin characterized by predominantly siliciclastic sedimentation.

Leg 174A follows successful sampling of the continental slope and rise during Leg 150 (Miller and Mountain, 1994; Miller, Mountain et al., 1996a), and of the adjacent New Jersey coastal plain (Leg 150X; Miller et al., 1994). Leg 174A will sample as many as six locations along the shelf and upper slope. The primary sites are located on the outer shelf in water depths of just under 100 m and are designed to calibrate successions of Oligocene to Holocene age. Four sites on the adjacent continental slope/Hudson Apron will serve as backups in the event that hydrocarbon accumulations are encountered or bad weather makes it impossible to operate safely in shallow water. Additional drilling has been completed through the Cenozoic and uppermost Cretaceous of the coastal plain and will be published as Leg 174AX (K.G. Miller, per. com., 1997). Intermediate sites on the mid- to inner-shelf remain to be tackled.

BACKGROUND

Geology of the New Jersey Continental Margin and Suitability for Sea-Level Studies

Figure 1 shows part of New Jersey and adjacent areas, a classic passive continental margin. Rifting began in the Late Triassic (Grow and Sheridan, 1988), and seafloor spreading commenced by the Middle Jurassic (~165 Ma; Sheridan, Gradstein et al., 1983). Subsequent subsidence has been governed primarily by lithospheric cooling and by flexural loading and compaction of accumulating sediment (Watts and Steckler, 1979; Reynolds et al., 1991). In the vicinity of proposed Leg 174A sites, the Jurassic section is composed of 8-12 km of shallow-water limestones and shales. A barrier reef complex fringed the margin until the mid-Cretaceous (Poag, 1985). Accumulation rates were generally low during latest Cretaceous to Paleogene, when the margin became starved of sediment and the shelf subsided to a depth of as much as several hundred meters below sea level (Poag, 1985). An abrupt increase in sediment supply in the late Oligocene led to the deposition of a series of unconformity-bounded wedges that built seaward during the Miocene and produced a shelf with a terraced morphology (Figs. 2 and 3). The cause of this change is not known, although it may reflect hinterland tectonics (Poag and Sevon, 1989; Sugarman et al., 1993).

This part of the U.S. Atlantic margin is well suited for the study of sea-level changes during the Oligocene to Holocene "Icehouse" interval for several reasons:

1. Upper Oligocene to Miocene and Pleistocene records are relatively complete (the Pliocene record is uncertain), and high rates of sediment accumulation (10's to 100's of m/m.y.) make it possible to resolve stratal relationships seismically in great detail (Poag, 1977; Schlee, 1981; Greenlee et al., 1988, 1992).

2. Good biostratigraphic control is ensured by the mid-latitude setting (Poag, 1985; Olsson and Wise, 1987; Poore and Bybell, 1988; Greenlee et al., 1992). Upper Eocene-Miocene sediments of this region have adequate carbonate to utilize strontium-isotope correlation techniques (Sugarman et al., 1993; Miller et al., 1991b, 1994, 1995; Miller and Sugarman, 1995). Pleistocene stratigraphic control afforded by integration of nannofossil and physical properties data is also excellent (better than 20 k.y. resolution; Mountain, Miller, Blum et al., 1994).

3. Tectonic subsidence has been slow (<10 m/m.y.) and well defined throughout the Cenozoic (Steckler and Watts, 1982); a situation that favors the preservation and identification of glacial-eustatic fluctuations in the stratigraphic record (Vail et al., 1977).

4. There is little seismic or outcrop evidence to suggest major faulting, rotation, or other medium-to-large scale disturbances of the Cenozoic section (Poag, 1985), although some differential subsidence may have occurred between the Delmarva Peninsula (Deleware/Maryland/Virginia) and New Jersey (Owens and Gohn, 1985).

5. A substantial body of useful data, including seismic profiles (collected at various frequencies) and data derived from boreholes and submarine outcrop collected by *DSV Alvin*, already exists for this margin (Fig. 1; Hathaway et al., 1976; Ryan and Miller, 1981; Poag, 1978, 1980, 1985; Poag, Watts et al., 1987; Kidwell, 1984, 1988; Olsson et al., 1987; Greenlee et al., 1988, 1992; among others). This includes data from Deep Sea Drilling Project (DSDP) Legs 93 and 95 (e.g., Site 612, Fig. 1), which represent an attempt to synthesize the overall stratigraphy and structure of the New Jersey margin (van Hinte, Wise et al., 1987; Poag, Watts et al., 1987). However, the shallowest site (Site 612) was drilled at a water depth of 1400 m, and it proved to be poorly located for sampling Oligocene-Miocene strata (Miller et al., 1987). Nonetheless, these earlier legs set the stage for more detailed studies, such as the MAT, where the objectives are to improve the dating resolution of unconformity surfaces and to do so at sites where the water depths are shallow enough to be sensitive to eustatic variations.

Progress on the Mid-Atlantic Transect

Before ODP could move to the adjacent New Jersey shelf, a grid of high-quality seismic data was needed to frame the objectives and locate optimal targets. Based on reinterpretation of Exxon Production Research multichannel seismic (MCS) data and well logs, Greenlee et al. (1992) published a refinement of previously identified Oligocene and Miocene depositional sequences and bounding surfaces (Greenlee and Moore, 1988). An MCS seismic program carried out aboard the *R/V Maurice Ewing* in November 1990 collected 3700 km of single-channel seismic (SCS) and MCS profiles (see MAT-13A site summary). The *Ewing* MCS profiles roughly doubled the number of prograding upper Paleogene-Neogene wedges that could be resolved using older seismic data (Fig. 3). Furthermore, this grid included dip lines that extended from the inner shelf to a position seaward of the shelf break. For the first time, "Icehouse" sequence boundaries could be mapped across the shelf to the slope. In 1995, the *Ewing* profiles were augmented by higher-resolution MCS profiles, including detailed hazards grids, collected aboard *R/V Oceanus* (see Figs. 1 and 4). Locations of all but one site (MAT-13A; see Fig. 3 and site summary) proposed for drilling during Leg 174A were refined on the basis of analysis and interpretation of the new *Oceanus* data.

Leg 150 (June-July, 1993; Mountain, Miller, Blum, et al., 1994) capitalized on the *Ewing* shelf-to-slope imaging and drilled four locations on the slope (Sites 902-904 and 906) at water depths of between 445 and 1134 meters below sea level (mbsl) (Fig. 1). These sites document the age and facies of sediments associated with a total of 22 lower Eocene to mid-Pleistocene reflecting surfaces tentatively interpreted as, or correlated landward with, sequence boundaries (see Fig. 5 for a synthesis of Oligocene-Miocene results). Integrated bio-, magneto-, and strontium-isotopic stratigraphy yield temporal resolution approaching several hundred thousand years (Miller et al., 1995). In most cases, interpreted sequence boundaries are associated with little or no temporal hiatus; many are expressed by a slight coarsening of sediment transported to the slope, it was presumed, during low stands of sea level.

To complement the Leg 150 results, MAT proponents launched a land-based drilling program with support from ODP, the National Science Foundation (NSF), and the U.S. and State of New Jersey geological surveys (Miller et al., 1994). Primary objectives of these onshore boreholes (Leg 150X and related; Fig. 1) have been to date Late Cretaceous to Cenozoic sequences, including the Paleocene-Eocene "Doubthouse" section, and to evaluate facies arrangements in an updip setting. Thus far, four holes have been cored and logged, all at sites close to the modern shoreline (Fig. 1). Oligocene to middle Miocene sequence boundaries in both onshore and Leg 150 boreholes appear to correlate with prominent $\delta^{18}O$ increases, consistent with the hypothesis that these surfaces developed during global lowering of sea level (Mountain, Miller, Blum, et al., 1994; Miller, Mountain et al., 1996a, b). The ages of these sequence boundaries also compare well with the timing of the Haq et al. (1987) "global" boundaries (Miller et al., 1996a,b). Recently completed drilling at Bass River, New Jersey (to be designated Leg 174AX) has recovered a complete Cretaceous/Tertiary boundary section (K.G. Miller, per. com., 1996).

Facies successions onshore are generally well developed for the Paleocene through middle Miocene, with a transgressive shell bed or glauconite sand at the base of each sequence and quartz sand at the top (upper part of the highstand systems tract; Miller et al., 1994). Onshore drilling has, thus, provided important data for regional profiles, but all of the boreholes are landward of the Oligocene-Miocene clinoforms imaged in seismic reflection data beneath the shelf (Figs. 2 and 3). The shelf sites, to be tackled for the first time as the focus of Leg 174A, are the ones most critical for estimating amplitudes of sea-level change during the "Icehouse" interval (see below).

Available Data

The New Jersey margin is one of two study areas recently selected by the U.S. Office of Naval Research (ONR) for a multiyear initiative it has termed "Strata Formation on Margins" (STRATAFORM). Together with studies of the contrasting margin off Northern California, the goal is to understand the range of factors affecting the deposition and preservation of shelf and slope stratigraphy (Nittrouer and Kravitz, 1995). Off New Jersey, the missions of STRATAFORM and MAT coincide.

As a result, both ONR and JOI supported a consortium of investigators from the University of Texas Institute for Geophysics (UTIG), Lamont Doherty Earth Observatory (LDEO), and Rutgers University to collect, analyze, and interpret high-resolution MCS data on the New Jersey shelf and upper slope in support of proposed drilling in summer 1995 (Fig. 1). These data, which include a series of detailed "hazards" seismic grids mandated by ODP (Fig. 4), augmented a substantial set of regional geophysical and geological data that includes (Fig. 1): (1) 60-fold MCS profiles collected by the *R/V Maurice Ewing* from the inner shelf to the rise (see Fig. 3 and MAT-13 Site Summary); (2) 2D and 3D single-channel seismic (SCS) seismic grids (using a Huntec deep-towed system) and associated vibracores collected by UTIG in 1989 and 1993; (3) commercial MCS profiles collected during the 1970's in a dense grid (~2.5 km line spacing) across the outer shelf and upper slope (Fulthorpe and Austin, in press); and (4) multibeam bathymetry/backscatter coverage of the whole area using a commercial Simrad EM-1000 system (Goff et al., 1996).

The 1995 MCS survey consisted of two interwoven track plans and missions: (1) hazards-type survey grids at eight proposed shelf sites to meet MAT goals set by the JOIDES Pollution Prevention and Safety Panel (hazards surveying was funded by both JOI and ONR); Sites MAT-8B and -9B (Fig. 4) were approved for drilling by both JOIDES and ODP/TAMU safety panels in September 1996; and (2) a regional grid (Fig. 1) across the outer shelf and upper slope (funded by ONR), to achieve both STRATAFORM objectives and MAT goals by tying Leg 150 sites to the shallower shelf stratigraphy to be sampled by Leg 174A.

In conjunction with the earlier seismic data (Fig. 1), these profiles will allow us to: (1) determine the configuration of buried stratal surfaces and their accompanying acoustic characteristics across a wide range of depositional environments; (2) establish links among the various elements of the STRATAFORM initiative; and (3) tie well-dated Leg 150 sequences and other upper slope data to coeval shelf (Leg 174A) and onshore (Legs 150X/174AX and related) sections.

SCIENTIFIC OBJECTIVES

Oxygen isotopic variations show that polar ice volume has changed markedly during the last 35 m.y. (the "Icehouse" interval), and perhaps longer (Miller et al., 1991a). As a result, global sea level has varied by many tens of meters, and such changes have had a profound impact on shallow-water deposition, nearshore ecosystems, particle and nutrient transfer to the deep sea, and other components of the ocean-atmosphere system. The primary goals of Leg 174A are to investigate the stratigraphic responses to sea-level change, and specifically to:

- date sequence boundaries of Oligocene to Holocene age and to compare this stratigraphic record with the timing of glacial-eustatic changes inferred from deep-sea $\delta^{18}O$ variations;

- place constraints on the amplitudes and rates of sea-level change that may have been responsible for unconformity development;

- assess the relationships between depositional facies and sequence architecture; and

- provide a baseline for future scientific ocean drilling that will address the effects and timing of sea-level changes on this and other passive margins.

Seismic stratigraphic studies reveal a complex array of discontinuities within the mid-Atlantic continental margin. Leg 174A will provide new information about the arrangement of depositional facies that is needed to evaluate whether the surfaces provisionally interpreted as sequence boundaries are in fact related to the lowering of depositional base level. Leg 174A will also place constraints on the partitioning of unconformity-bounded sequences between so-called lowstand, transgressive, and highstand units. This is relevant to the controversial issue of how sequence-boundary development is related to the time of most rapid sea-level fall.

DRILLING STRATEGY AND PROPOSED SITES

The idealized strategy, designed especially for sequences that are arranged across a shelf with limited overall aggradation, calls for drilling a *transect* of holes to optimize the dating of sequence boundaries and the estimation of amplitudes of sea-level change. The key drilling locations (thick vertical lines in Fig. 6) for *each* sequence boundary are (1) close to the "offlap break" (or "clinoform breakpoint," the updip limit of the youngest clinoform [left-hand vertical line in Fig. 6], see also Fig. 2); (2) near the clinoform toe (center vertical line in Fig. 6); and (3) in deep-water settings beneath the modern slope and rise (right-hand vertical line in Fig. 6). The most landward location is generically equivalent to MAT-8B, the center location to MAT-9B, and the seaward location to ODP Leg 150 sites and to Sites MAT-13A to D.

Optimal biostratigraphic resolution is achieved in deep-water settings of the continental slope and rise, where open-ocean marine fauna are best represented in pelagic sediments (i.e., seaward of the hypothetical profile shown in Fig. 6). However, geometric evidence for the existence of a sequence boundary (offlap and onlap) is best preserved near the offlap break (Site MAT-8B), which in the case of the Oligocene to Miocene sequences of the New Jersey margin is located beneath the modern shelf (Fig. 3). Individual sequences tend to thin seaward as a result of condensation (sediment starvation) in deeper water. This, and locally marked erosion in the vicinity of the continental slope, lead to uncertainties in the tracing of sequence boundaries from the shelf to the slope, and hence to uncertainties in the calibration of those surfaces independent of inherent limitations in biostratigraphic resolution.

For this reason, an additional site (Site MAT-9B) was identified near the clinoform toe of sequence boundary m1 beneath the shelf (Figure 3 and MAT-9B site summary). Drilling locations near the clinoform toe for each sequence boundary (i.e., center vertical line in Fig. 6) sample an expanded section that is sufficiently close to the offlap break for the stratigraphic position of the sequence boundary to be well established. Furthermore, reflection geometry indicates that any hiatus associated with sediment bypass along this surface, or erosion into it, is minimized. As a practical matter, such a site is also selected as far as possible landward of any "lowstand" sands resting on the sequence boundary, because these are likely to contain fauna that were reworked from shallower water.

Estimating amplitudes of sea-level change is best undertaken by "backstripping" a profile across the shelf (Steckler and Watts, 1982). This requires information from multiple sites about stratigraphic thickness, age, composition (to account for the effects of flexural loading and compaction), and paleobathymetry (from paleoecology and the interpretation of lithofacies). As the amplitude of the sea-level signal is small compared to the thickness of the strata in which it is recorded, the potential errors are large. Estimates of sea-level change are especially sensitive to errors in paleobathymetry.

Key drilling locations are therefore (1) close to the offlap break for each sequence boundary (i.e., lefthand vertical line in Fig. 6), which provides the most complete record of paleobathymetric change in the underlying sequence; and (2) in the vicinity of the corresponding clinoform toe (i.e., center vertical line, Fig. 6), for the most complete record of the overlying sequence. In some cases, it may also be possible to obtain information from sites in between. Future drilling at such sites would help to resolve whether any of the onlap against clinoforms is "coastal onlap" (e.g., Greenlee et al., 1992), implying exposure of the offlap break during sequence-boundary development, or whether it is entirely marine onlap. Existing data on sedimentary facies and a consideration of likely amplitudes of glacial-eustatic change tend to favor the latter view.

The MAT ultimately requires drilling into the slope, shelf, and coastal plain (Fig. 1); all are underway (Fig. 5)**.** Slope drilling by Leg 150 has provided the "deep-water" age control. Onshore drilling (Legs 150X/174AX and related) has supplied updip facies control at multiple locations (Miller et al., 1994, 1995; Miller and Sugarman, 1995), and is continuing. Drilling on the intervening shelf, the primary focus of Leg 174A, is critical both to the dating of sequence boundaries at geometrically favorable sites and to the estimation of amplitudes of eustatic change.

Sites MAT-8B and MAT-9B

Proposed shelf Sites MAT-8B and -9B are the focus of Leg 174A operations (Table 1); these are located to optimize sampling in the vicinity of the offlap break and clinoformal toe of sequence boundary m1 ("Tuscan" of Greenlee et al., 1992; upper middle Miocene of Mountain, Miller, Blum et al., 1994; Figs. 3 and 5). These sites will also sample the updip and somewhat condensed shallow-water portions of younger sequences and the deeper-water portions of older sequences. A key priority is to sample at least to the level of surface m3 (middle middle Miocene) at both sites. If time and conditions permit, drilling will continue through the Miocene section and perhaps into the lower Oligocene (horizon o1) at one or both of the shelf sites. Our primary goal, however, is to achieve stratigraphic precision rather than to reach some pre-approved target depth (TD) below m3. It is vitally important to be able to tie seismic and borehole data as far as possible without needing to resort to arguments about sedimentary facies. This is necessary to test existing sequence stratigraphic models (e.g., Vail, 1987; Posamentier et al., 1988; Greenlee et al., 1992) for the New Jersey margin. Our intent therefore, in addition to attempting to achieve complete core recovery in multiple holes, is to undertake Logging While Drilling (LWD) and a check-shot survey/Vertical Seismic Profile (VSP) at each site. Wireline logging at least at one site, probably Site MAT-8B, for comparison with the LWD results, is also envisioned.

Sites MAT-13A to D

Proposed slope Sites MAT-13A to D are secondary sites (Table 2) that will be occupied only in the event of safety problems and/or adverse weather conditions too inclement for shallow-water drilling operations. These sites are designed to date the middle Miocene to Pleistocene sequence boundaries (particularly m1 and younger horizons; Fig. 3) and to evaluate Pleistocene sequence stratigraphy. We propose VSPs and LWD at one or more of these sites, if for some reason these operations are not conducted at Sites MAT-8B/-9B.

LOGGING WHILE DRILLING

The very good to excellent core recovery at Leg 150 slope sites (88% mean) was due largely to the abundance of fine-grained sediments; however, problems arose whenever sands were encountered. Sand is likely to be much more prevalent at shelf Sites MAT-8B and -9B, and logging will consequently take on a particularly important role in meeting the objectives of facies characterization. Even in mudstones, Leg 150 operations relied exclusively on the Side-Entry Sub (SES) technique of wireline logging, which left the pumps online during the logging operation so that fluid circulation was available to clear downhole obstructions. Unfortunately, SES cannot be used at sub-bottom depths greater than the water depth, and hence will not be available at either Sites MAT-8B or -9B. LWD is a cutting-edge technology still being developed in the oil industry, but it has been used successfully on both the accretionary wedges in Barbados (Legs 156 and 171B) and Costa Rica (Leg 170). Although LWD has drawbacks—lack of sonic, Formation MicroScanner (FMS), and geochemical log data—it is rich in positives. Two examples are (1) in borehole conditions typical of ODP operations, LWD is likely to provide the best gamma-ray, density, porosity, and caliper logs possible by measuring these data within minutes of being drilled (because the sensors are a few meters above the bit); and (2) LWD is nearly certain to save time over standard wireline logging (although this will also be attempted at a minimum of one site, probably Site MAT-8B), which requires drilling to TD, then logging a potentially unstable hole from there back up to ~100 meters below seafloor (mbsf); and (3) LWD provides log data from the mudline downward, which will be critical for the sea-level objectives proposed for Leg 174A. In particular, LWD will provide logging details of 0-100 mbsf that will be crucial for tying the Pleistocene (Sites MAT-13A to D) on the continental slope/Hudson Apron to coeval sections to be sampled at Sites MAT-8B and -9B.

LWD tools consist of special drill collars placed in the bottom-hole assembly (BHA) that contain measurement sensors providing physical property data while the formation is being drilled. Data are recorded in nonvolatile memory and downloaded once the BHA is retrieved to the rig floor. The LWD data recorded as a function of time are then merged with the pipe depth as a function of time measured at the surface to obtain a depth-based log. Two LWD tools are currently available with the following specifications.

Compensated Density-Neutron (CDN) Tool

The CDN contains two radioactive sources that generate neutrons (AmBe) and gamma-rays (^{137}Cs). Neutron absorption depends on the hydrogen content, and because hydrogen atoms are present in pore waters, this provides a proxy indicator of porosity. Gamma-ray scattering is a function of electron density, which in turn is a function of bulk-density. Absorption of gamma-rays, through the photo-electric effect, is a function of the average atomic number, providing an indicator of mineralogy. The CDN tool also provides two options to estimate the borehole diameter necessary to determine corrections to the data:

- Bulk density & photo-electric factor (PEF)
- Neutron porosity
- Density caliper (based on gamma-ray attenuation)
- Ultra-sonic caliper (based on reflection time)

Compensated Dual Resistivity Tool (CDR)

The CDR uses an electromagnetic (2 Mhz) wave generated at a source antenna and measures both the phase and attenuation at a receiver antenna. A scintillation detector measures natural radioactivity, including separation into its main spectral components:

- Natural gamma-ray (total, K, Th, and U)
- Deep resistivity (based on electromagnetic attenuation)
- Shallow resisitivity (based on phase shift)

WIRELINE LOGGING

Whereas LWD tools will provide a basic set of measurements for lithologic and physical property characterization of the boreholes, they do not measure acoustic velocity of the formation that is critical for integration of borehole and seismic data. A suite of wireline logging tools will provide, in addition to the same type of geophysical measurements obtained through LWD (gamma-ray, porosity, density and resistivity), formation-sound velocity and borehole-resistivity images.

Three wireline tool string combinations will be available for deployment during Leg 174A: the Triple-Combo, FMS-Sonic, and the WST (Well-Seismic Tool). The measurements obtained with each of these tool strings are as follows.

Triple-Combo

- Spectral gamma-ray
- Neutron porosity (thermal, epithermal, and thermal neutron decay time)
- Bulk-density and PEF
- Hole diameter (mechanical caliper)
- Resistivity (shallow, medium, and deep depth of investigation)

FMS-Sonic

- Spectral gamma-ray (for correlation with the triple combo string)
- Vp (Vs in sufficiently fast formations)
- Resistivity images

Well-Seismic Tool (WST)

- Traveltime versus depth from surface shots

The main goals of wireline logging are to provide acoustic data, to provide in situ physical properties, and to complement lithologic characterization of the drilled section. For these purposes, we will attempt to acquire a full suite of both wireline and LWD measurements at a minimum of one site (probably Site MAT-8B). Cross-correlation of LWD measurements with wireline sonic data will provide empirical transforms of sonic velocity from LWD data at the other site (Site MAT-9B). Calibration of the acoustic traveltime will be performed at both sites with a check-shot survey/VSP using the WST.

The WST is a single-component geophone that is clamped to the borehole wall. Shots fired from the surface are recorded downhole, providing traveltime vs. borehole depth information for accurate calibration of drilling data to seismic reflection profiles. For these VSPs, we plan to deploy two acoustic sources, an air-gun and a GI-gun (a modified airgun, the same source used in the high-resolution *Oceanus* 270 seismic surveys over the proposed sites), shooting each alternately, and to clamp the WST at 50-m intervals or less. The traveltime versus depth curve at each site will serve to calibrate the interval velocities measured with the WST, or estimated through log transforms. Synthetic seismograms can then be generated using calibrated velocity and bulk density measurements.

FMS images provide a high-vertical resolution (~1 cm), azimuthally-oriented picture of the borehole wall that can be important for interpreting sedimentary and structural features (bed thicknesses, grading, cross-bedding, faults, and fractures). Where both FMS images and cores are available, the image interpretation can be calibrated to the lithology, thus providing an important complement for geologic characterization where cores are not available due to incomplete recovery.

SAMPLING STRATEGY

Given the shallow-water depths of operation and attendant high rates of anticipated core recovery, only low-resolution sampling will be carried out aboard ship. Such sampling will support description/characterization, facilitate pilot studies, and provide material for projects that do not require a high-temporal resolution. High-resolution sampling will be deferred to a shore-based sampling party shortly after the cruise.

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FIGURE CAPTIONS

Figure 1. Ongoing geological and geophysical characterization of the New Jersey "natural laboratory," part of which is the MAT. Primary proposed drillsites for Leg 174A are 8B and 9B on the shelf; secondary sites 13A-D are located on the upper slope. The high-resolution MCS coverage (collected aboard *R/V Oceanus* in 1995) was used to select all sites except 13A, which is located on a Ewing MCS line (see Fig. 3 and 13A site summary). Swath backscatter/bathymetry data coverage shown was acquired in the Spring of 1996 (Goff *et al.*, 1996); subsequent acquisition (November 1996) is not shown, but now includes the secondary upper slope sites.

Figure 2. Example of a buried middle Miocene clinoform (m2c, ~12.5 Ma) mapped using a commercial seismic grid available from the New Jersey margin (see Fig. 1). **Lower panel:** structure map showing a seismic grid, indicating existing drill Sites 902-904, 906 (Leg 150) and 612 (Leg 95), and Mid-Atlantic Transect (MAT) drill sites 8B, 9B, and 13A (Leg 174A). Site MAT-7B was proposed, but was not approved for Leg 174A drilling. Contour interval units are milliseconds two-way traveltime below present sea level. **Upper panel**: 3-D perspective shaded image with traveltime contours (azimuth of artificial illumination = 220°). Both panels are viewed from an azimuth of 180° and an elevation of 30°. The clinoform slope canyon is V-shaped; the mapping reveals an apparent downslope continuation of this drainage feature (from Fulthorpe and Austin, in press).

Figure 3. *Ewing* 9009 MCS profile 1002; Leg 174A shelf Sites MAT-8B and MAT-9B are located approximately along this line, as shown, as is secondary upper slope Site MAT-13A (see also Fig. 1). Note the pronounced progradation of late Paleogene-Neogene clinoforms. These clinoforms, and the sea-level signal they hold are the scientific focus of MAT drilling on the shelf. Selected sequence boundaries are labeled, for comparison with interpreted site-specific *Oceanus* 270 profiles. Upper slope drilling, if it takes place, will augment the results from Leg 150 by adding to existing chronostratigraphic control.

Figure 4. "Hazards-type" MCS surveys completed in 1995 at locations proposed and approved for Leg 174A drilling on the New Jersey shelf: MAT-8B and MAT-9B (see also Fig. 1).

Individual profiles are spaced at 150/300 m; the total area of each grid is ~2 km x 2 km. Also included are connecting regional profiles 145, 149, and 247, and the hazards grid for MAT-7B, which was proposed but not approved for Leg 174A drilling.

Figure 5. Comparison of the timing of Oligocene to middle Miocene reflectors on the New Jersey slope with a benthic foraminiferal $\delta^{18}O$ record, a summary of onshore sequences, and the inferred eustatic record of Haq et al. (1987, after Miller, Mountain et al., 1996a). The $\delta^{18}O$ record is a stacked composite of *Cibicidoides* spp. from several sites that has been smoothed to remove all periods >1 m.y.; Oi1 to Mi6 are $\delta^{18}O$ maxima; dashed lines indicate inflections in the $\delta^{18}O$ records immediately pre-dating the maxima. Shelf-slope reflectors o1 to m1 are dated on the New Jersey slope (Leg 150) and are shown with best age estimates (indicated with thin lines) and error bars (indicated with boxes). Further calibration of these horizons beneath the shelf is the primary objective of Leg 174A. Onshore sequences are indicated by dark boxes; the white areas in between are hiatuses. Drilling on the New Jersey coastal plain is continuing and will be incorporated as Leg 174AX (see Fig. 1). New Jersey onshore sequences O1 to O6 are Oligocene, and Kw0 to Kw-Cohansey (Coh) are Miocene; cross-hatched areas indicate uncertain ages. Sequences TA4.4 to TB3.1 are from Haq et al. (1987).

Figure 6. Diagrams of depth and time vs. distance for idealized clinoform sequences and the optimal strategy for drilling them. The most seaward drill location is most likely to recover a complete record across sequence boundary 2 (SB2), containing biostratigraphic markers known from the deep-sea record; this was the strategy used during Leg 150 and will be continued on Leg 174A at (back-up) upper slope Sites MAT-13A to D (see Fig. 1). The other two locations shown will recover critical shallow-water facies across SB2. The most landward location will recover latest highstand deposits below SB2 (Site MAT-8B); the center location will recover early lowstand deposits above SB2 (Site MAT-9B). Such site pairing is crucial to understanding both the amplitude of sea level changes and the facies associated with clinoform geometries.

Figure 7. Graphical representation of anticipated Leg 174A operations at primary shelf Sites MAT-8B-3 and MAT-9B-1

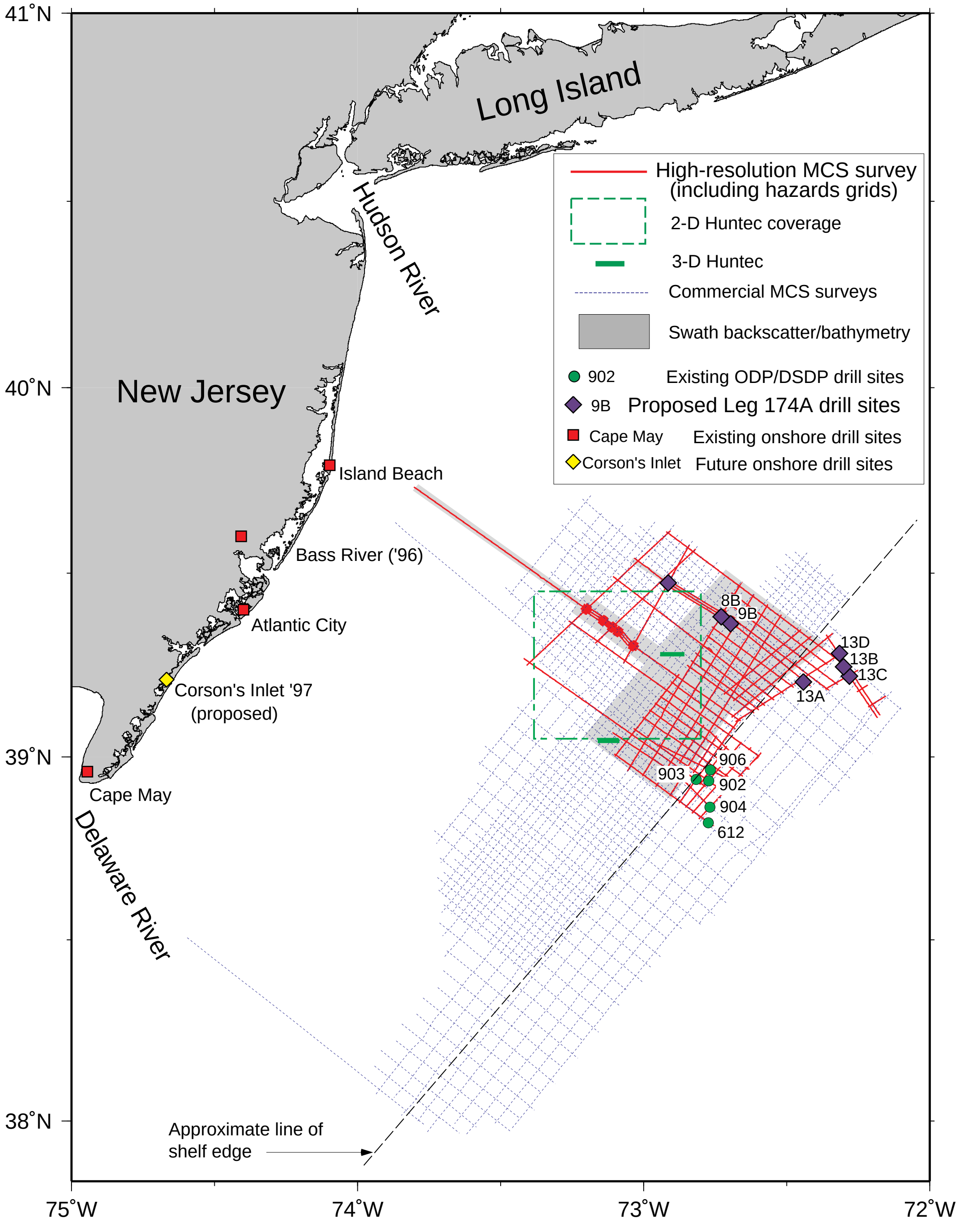

41°N
40°N
39°N
38°N
75°W
74°W
73°W
72°W
Long Island
Hudson River
New Jersey
Island Beach
Bass River ('96)
Atlantic City
Corson's Inlet '97
(proposed)
Cape May
Delaware River
High-resolution MCS survey
(including hazards grids)
2-D Huntec coverage
3-D Huntec
Commercial MCS surveys
Swath backscatter/bathymetry
902
Existing ODP/DSDP drill sites
9B
Proposed Leg 174A drill sites
Cape May
Existing onshore drill sites
Corson's Inlet
Future onshore drill sites
8B
9B
13D
13B
13C
13A
906
903
902
904
612
Approximate line of
shelf edge

Figure 1

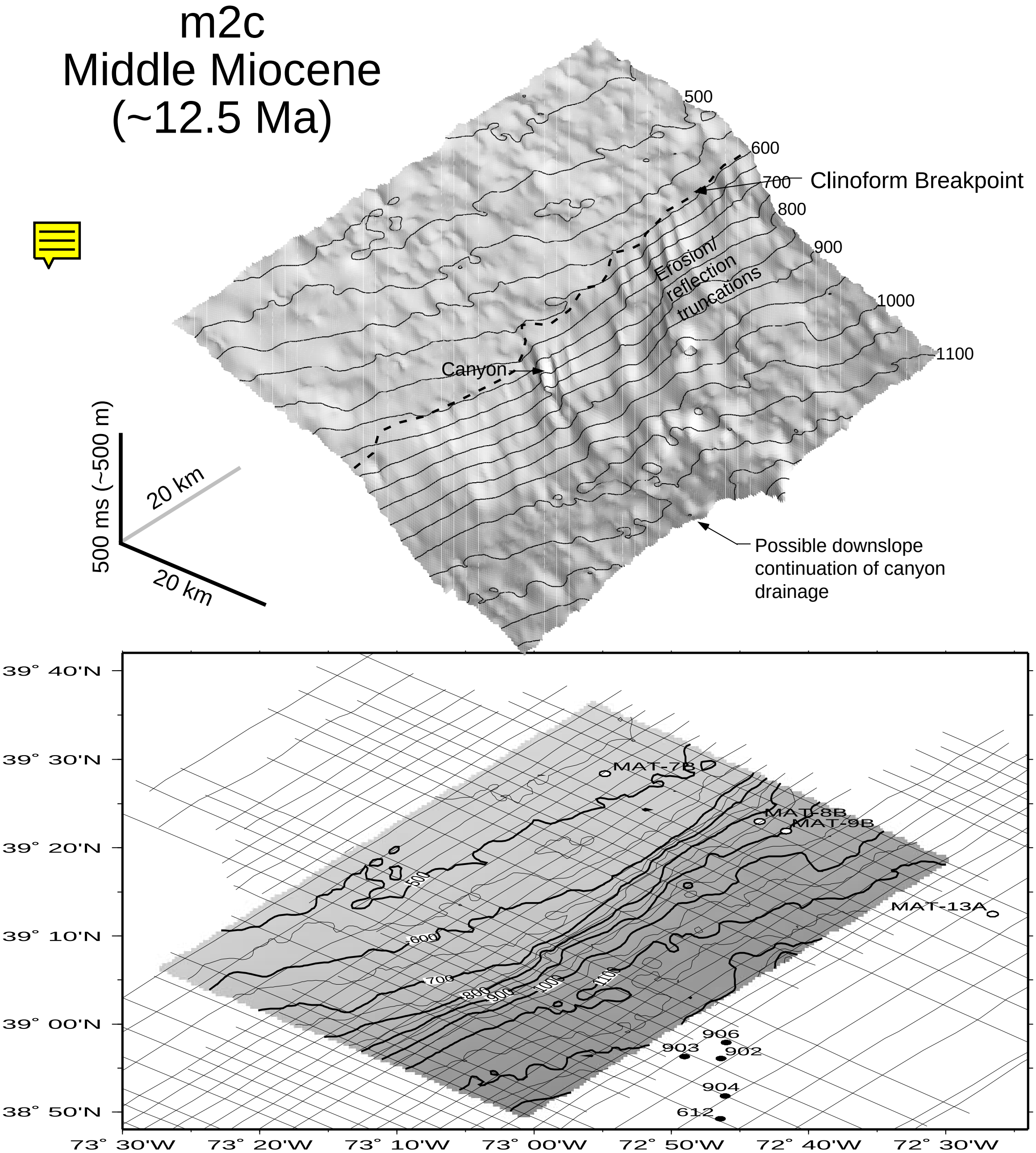

m2c
Middle Miocene
(~12.5 Ma)
500
600
700
800
900
1000
1100
Clinoform Breakpoint
Erosion/
reflection
truncations
Canyon
Possible downslope
continuation of canyon
drainage
500 ms (~500 m)
20 km
20 km
39° 40'N
39° 30'N
39° 20'N
39° 10'N
39° 00'N
38° 50'N
73° 30'W
73° 20'W
73° 10'W
73° 00'W
72° 50'W
72° 40'W
72° 30'W
MAT-7B
MAT-8B
MAT-9B
MAT-13A
500
600
700
800
900
1000
1100
906
903
902
904
612

Figure 2

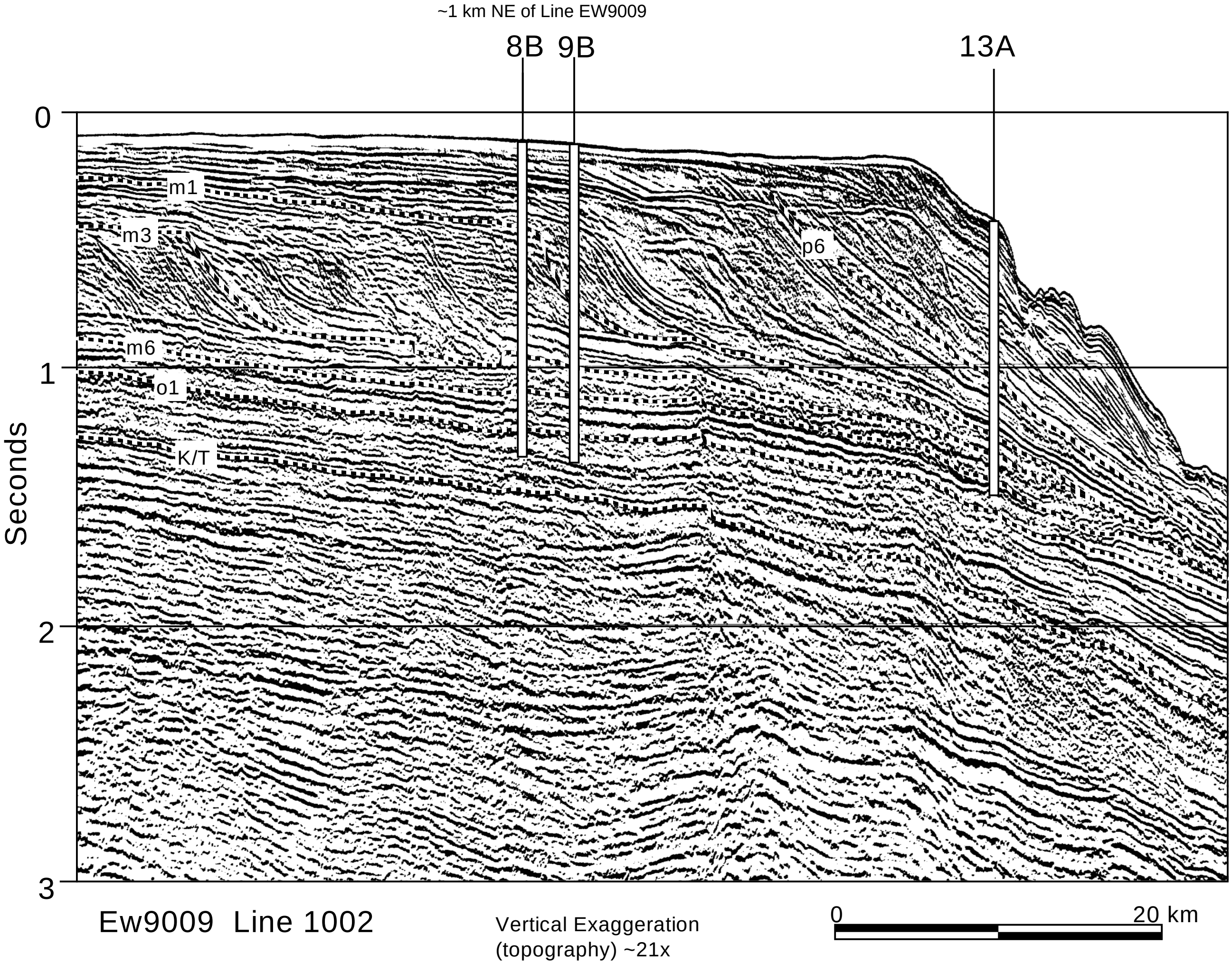

~1 km NE of Line EW9009
8B
9B
13A
0
1
2
3
Seconds
m1
m3
p6
m6
o1
K/T
Ew9009 Line 1002
Vertical Exaggeration
(topography) ~21x
0
20 km

Figure 3

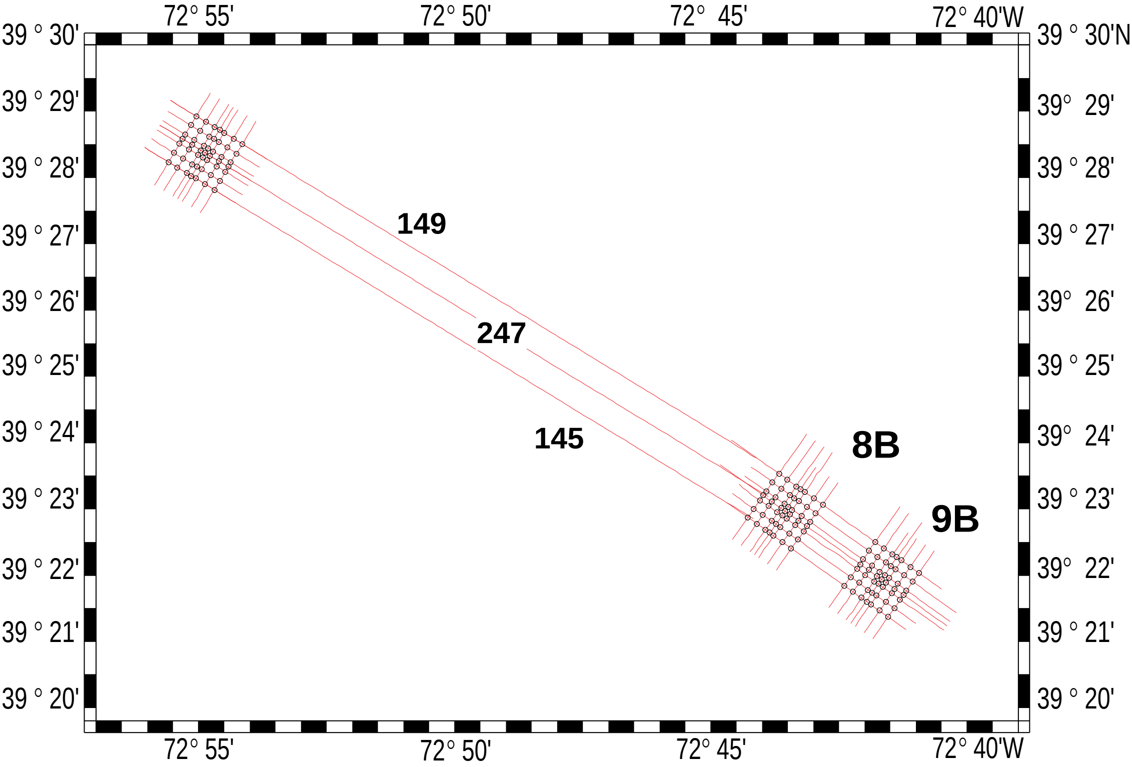

72° 55'
72° 50'
72° 45'
72° 40'W
39 ° 30'
39 ° 29'
39 ° 28'
39 ° 27'
39 ° 26'
39 ° 25'
39 ° 24'
39 ° 23'
39 ° 22'
39 ° 21'
39 ° 20'
39 ° 30'N
39° 29'
39 ° 28'
39 ° 27'
39° 26'
39 ° 25'
39° 24'
39 ° 23'
39° 22'
39 ° 21'
39 ° 20'
149
247
145
8B
9B
72° 55'
72° 50'
72° 45'
72° 40'W

Figure 4

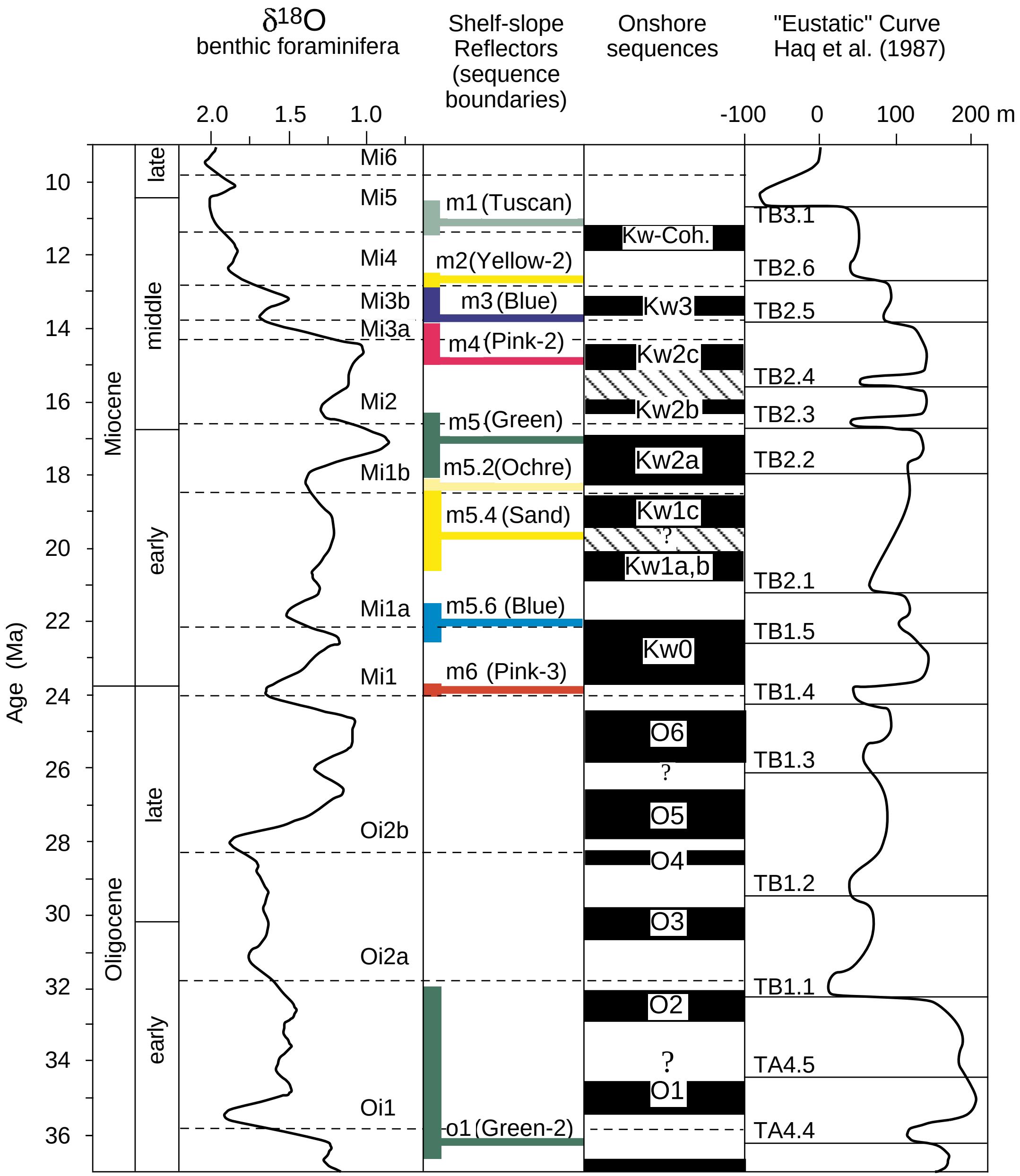

$\delta^{18}O$
benthic foraminifera
Shelf-slope Reflectors (sequence boundaries)
Onshore sequences
"Eustatic" Curve Haq et al. (1987)
2.0
1.5
1.0
-100
0
100
200 m
Age (Ma)
10
12
14
16
18
20
22
24
26
28
30
32
34
36
Miocene
Oligocene
late
middle
early
late
early
Mi6
Mi5
Mi4
Mi3b
Mi3a
Mi2
Mi1b
Mi1a
Mi1
Oi2b
Oi2a
Oi1
m1 (Tuscan)
m2(Yellow-2)
m3 (Blue)
m4 (Pink-2)
m5 (Green)
m5.2(Ochre)
m5.4 (Sand)
m5.6 (Blue)
m6 (Pink-3)
o1 (Green-2)
Kw-Coh.
Kw3
Kw2c
Kw2b
Kw2a
Kw1c
?
Kw1a,b
Kw0
O6
?
O5
O4
O3
O2
?
O1
TB3.1
TB2.6
TB2.5
TB2.4
TB2.3
TB2.2
TB2.1
TB1.5
TB1.4
TB1.3
TB1.2
TB1.1
TA4.5
TA4.4

Figure 5

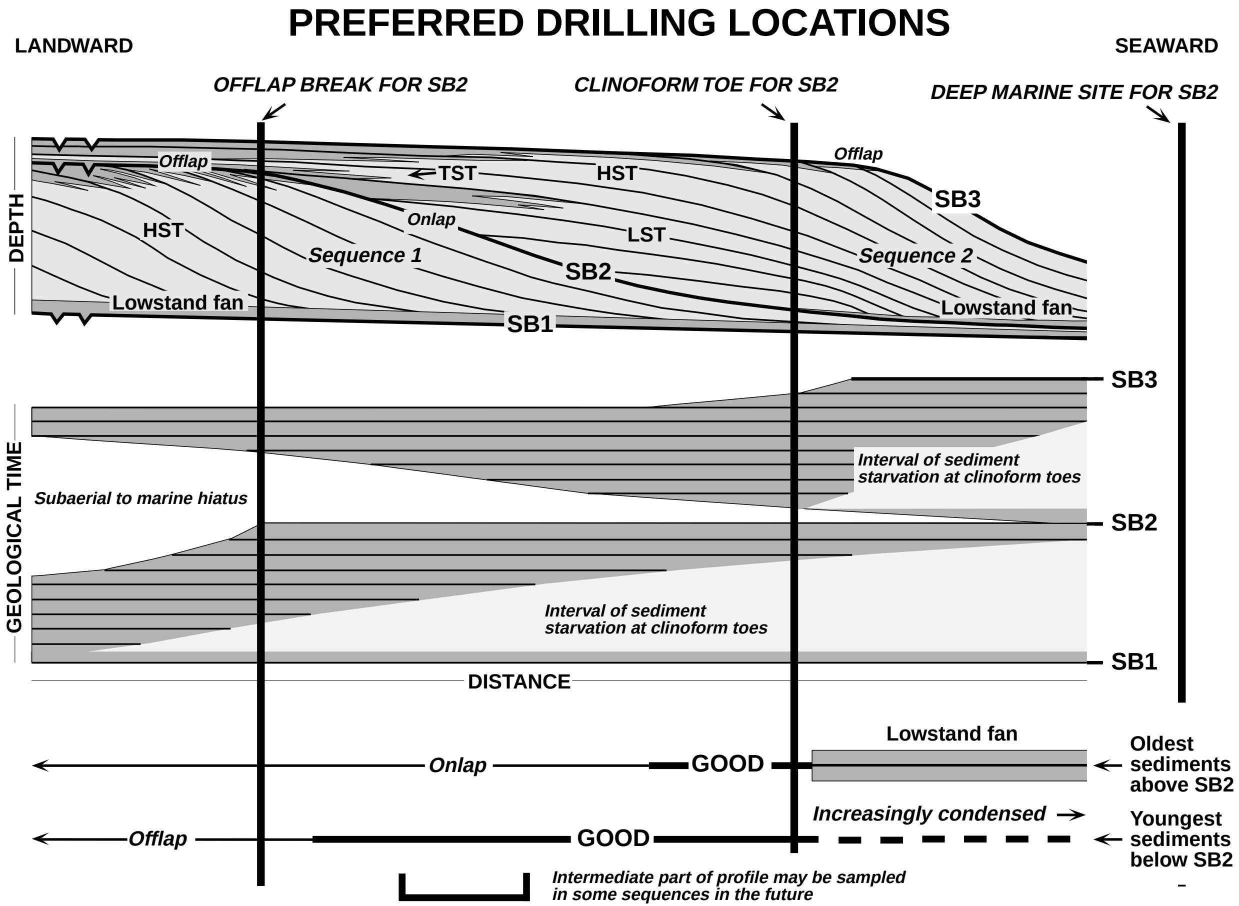

PREFERRED DRILLING LOCATIONS
LANDWARD
SEAWARD
OFFLAP BREAK FOR SB2
CLINOFORM TOE FOR SB2
DEEP MARINE SITE FOR SB2
DEPTH
Offlap
TST
HST
Offlap
SB3
HST
Onlap
LST
Sequence 1
Sequence 2
SB2
Lowstand fan
Lowstand fan
SB1
GEOLOGICAL TIME
SB3
Interval of sediment starvation at clinoform toes
Subaerial to marine hiatus
SB2
Interval of sediment starvation at clinoform toes
SB1
DISTANCE
Lowstand fan
Onlap
GOOD
Oldest sediments above SB2
Increasingly condensed
Offlap
GOOD
Youngest sediments below SB2
Intermediate part of profile may be sampled in some sequences in the future

Figure 6

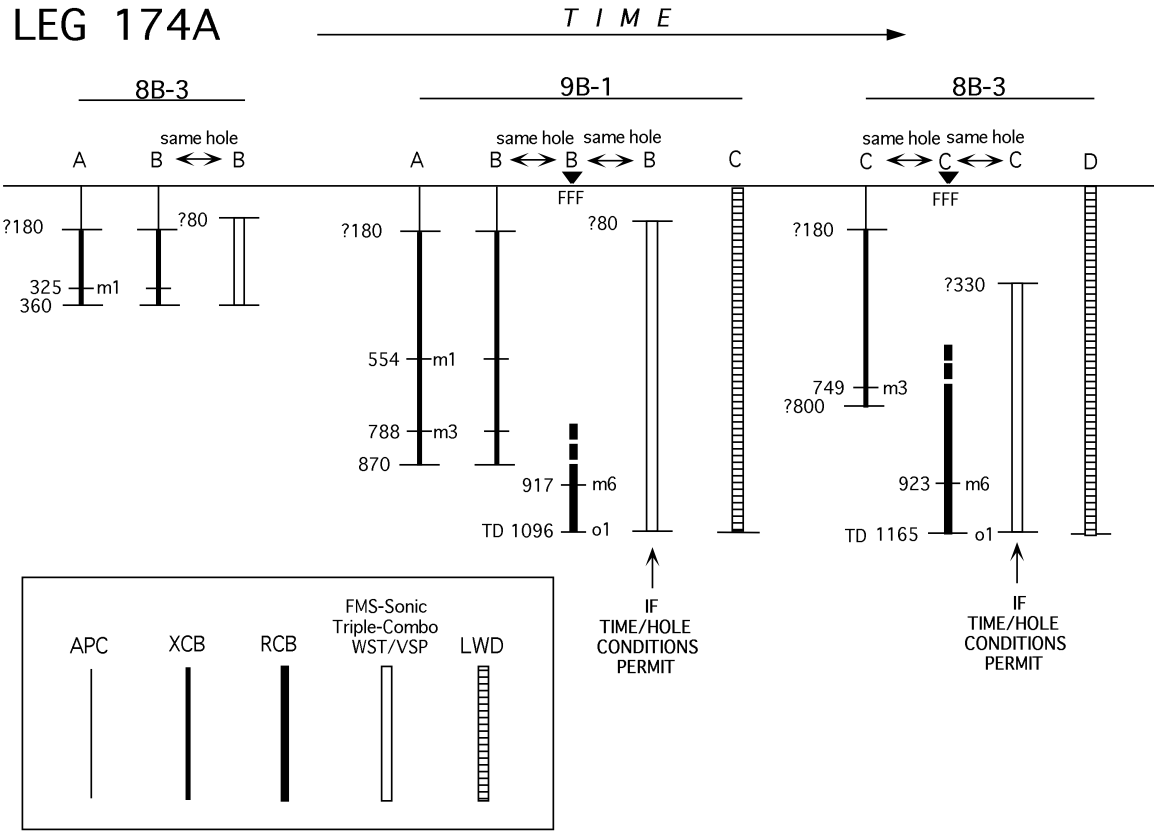

LEG 174A
T I M E
8B-3
same hole
A
B
B
?180
325
m1
360
?80
9B-1
same hole
same hole
A
B
B
B
C
FFF
?180
554
m1
788
m3
870
?80
917
m6
TD 1096
o1
IF TIME/HOLE CONDITIONS PERMIT
8B-3
same hole
same hole
C
C
C
D
FFF
?180
749
m3
?800
?330
923
m6
TD 1165
o1
IF TIME/HOLE CONDITIONS PERMIT
APC
XCB
RCB
FMS-Sonic Triple-Combo WST/VSP
LWD

Figure 7

PROPOSED PRIMARY SITES (see Table 1)

At each shelf site, more than one prospective drilling location has been designated within detailed seismic "hazards" grids (Fig. 4) should unforeseen safety or operational difficulties make any particular location unsuitable. The drilling locations we will attempt to occupy first are listed in Table 1 (MAT-8B-3; MAT-9B-1). These were designated as primary locations by PPSP and the Science Operator. One additional drilling location was approved by PPSP at MAT-8B (MAT-8B-2: 39°23.0124'N, 72°43.635'W), and two were approved at MAT-9B (MAT-9B-2: 39°22.0866'N, 72°41.4024'W; MAT-9B-3: 39°21.9582'N, 72°41.5206'W).

Site: MAT-8B There are two approved site-specific locations, designated 8B-2 and 8B-3. Both are discussed.

Priority: 1
Position: 8B-2: 39° 23.0124'N, 72° 43.6350'W; 8B-3: 39° 22.9488'N, 72° 43.6988'W
Water Depth: 8B-2: 87 m; 8B-3: 88 m
Sediment Thickness: both sites, ~10 km
Approved Maximum Penetration: 8B-2: 1166 mbsf, 8B-3: 1165 mbsf
Seismic Coverage: 8B-2: at the crossing of seismic lines *Oceanus* 270 #147 (cdp 10359/shot 14.97) and #806 (cdp 10264/shot 11.00); 8B-3: at the crossing of seismic lines *Oceanus* 270 #806 (cdp 10288/shot 12.00) and #885 (cdp 10238/9.91) These lines are shown in accompanying figures.

Objectives: The objectives of MAT-8B are to:

1. Date major Oligocene-Holocene unconformities on the New Jersey margin and evaluate their correlation with glacial-eustatic age estimates obtained from the deep-sea $\delta^{18}O$ record; this site will concentrate on surfaces that are middle Miocene (m3) and younger.

2. Place constraints on the amplitudes and rates of sea-level change that may have been responsible for unconformity development.

3. Assess the lithostratigraphic response of changes in sequence architecture to glacial-eustatic forcing.

4. Provide a baseline for future scientific ocean drilling that will address the effects and timing of sea-level changes on this and other passive margins.

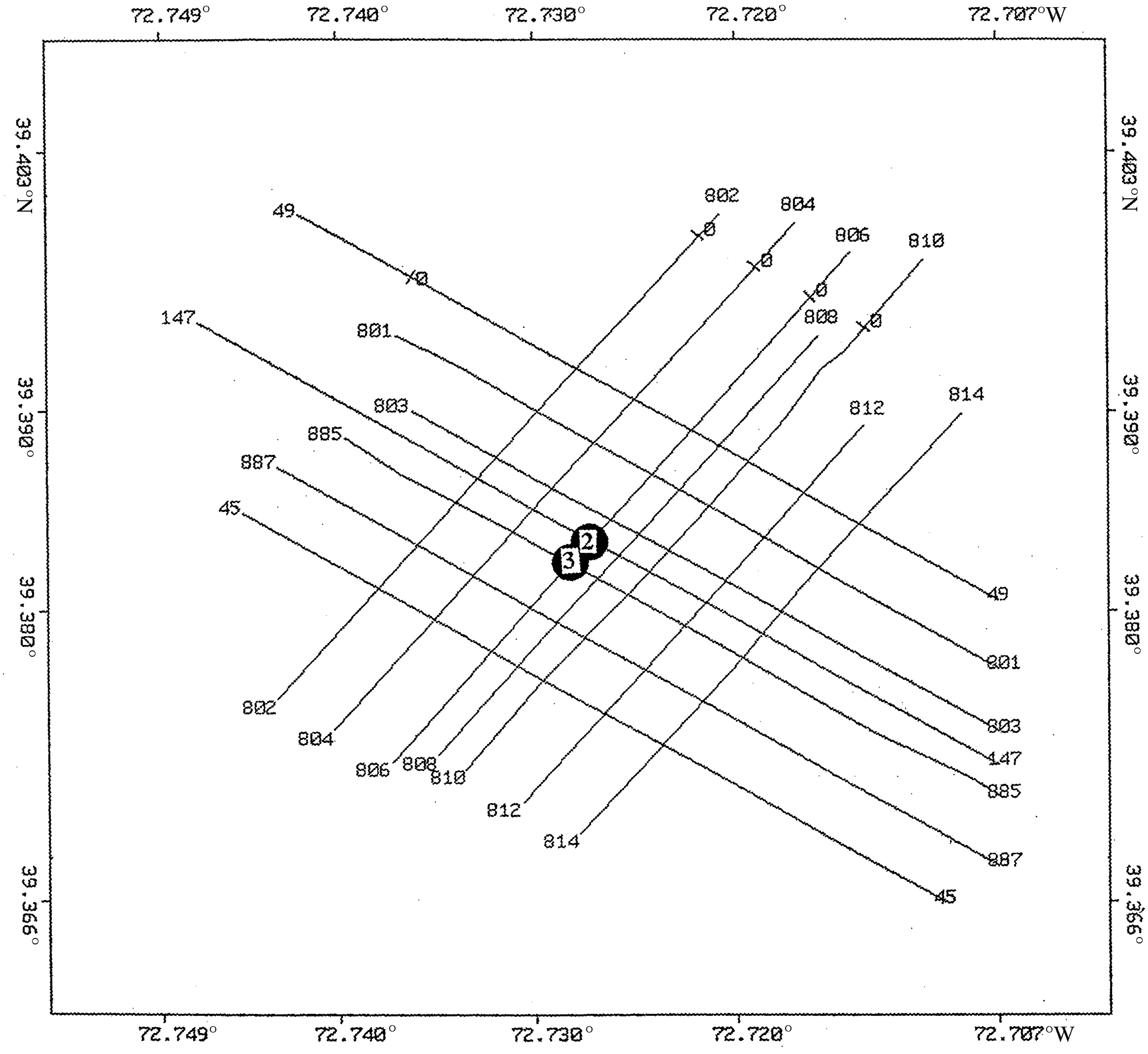
Drilling Program: Double APC/XCB to refusal holes A and B; APC/XCB to refusal, then RCB (after installation of FFF) to TD at Hole C (see Fig. 7).

Logging and Downhole Operations: Triple-Combo, FMS-Sonic, WST, VSP to TD at Hole C; Logging While Drilling* to TD at Hole D (see Fig. 7).

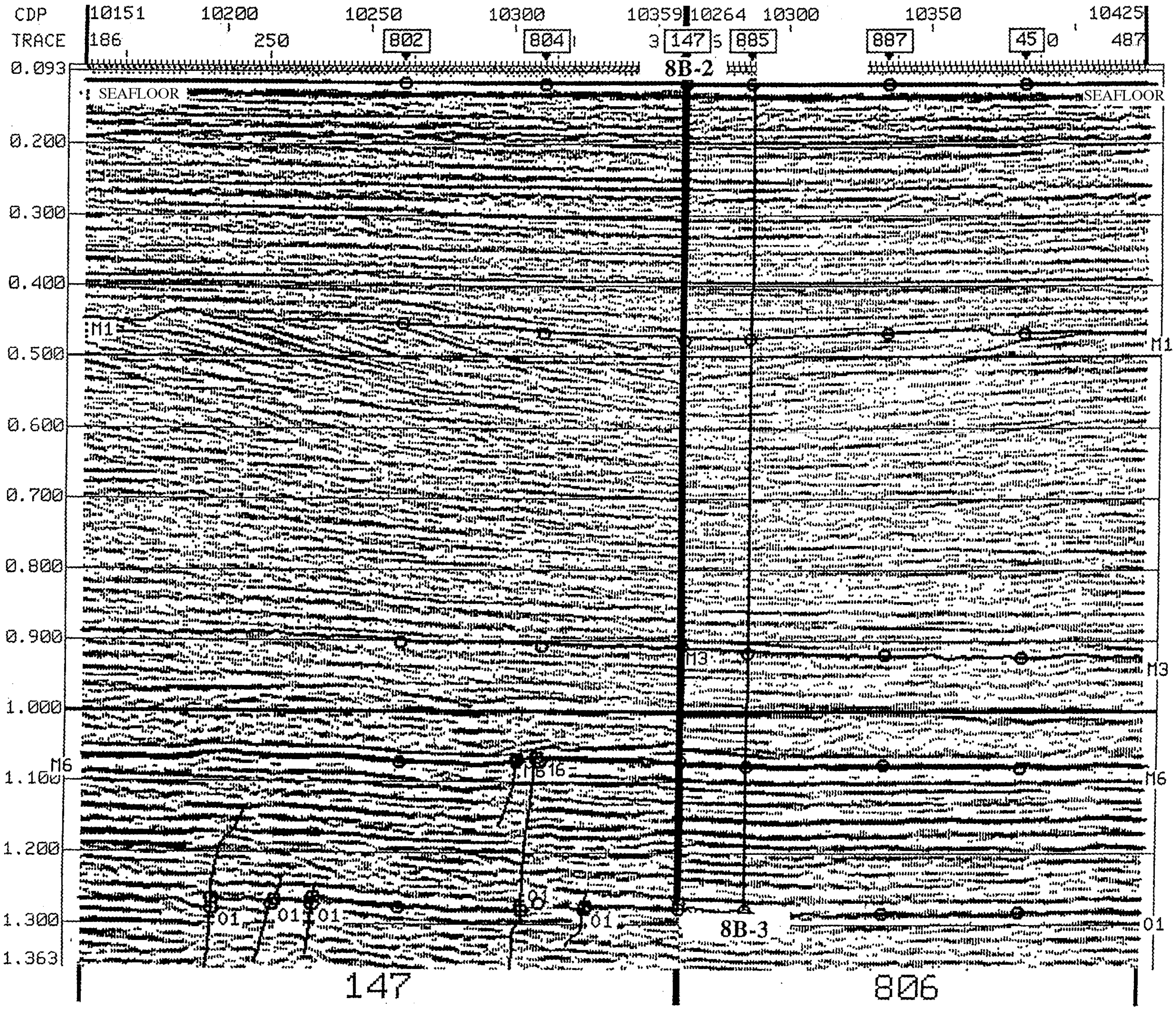
Nature Of Rock Anticipated: Sands, silts, and clays; subordinate gravel.

*LWD tools: CDR, CDN (see preceding text).

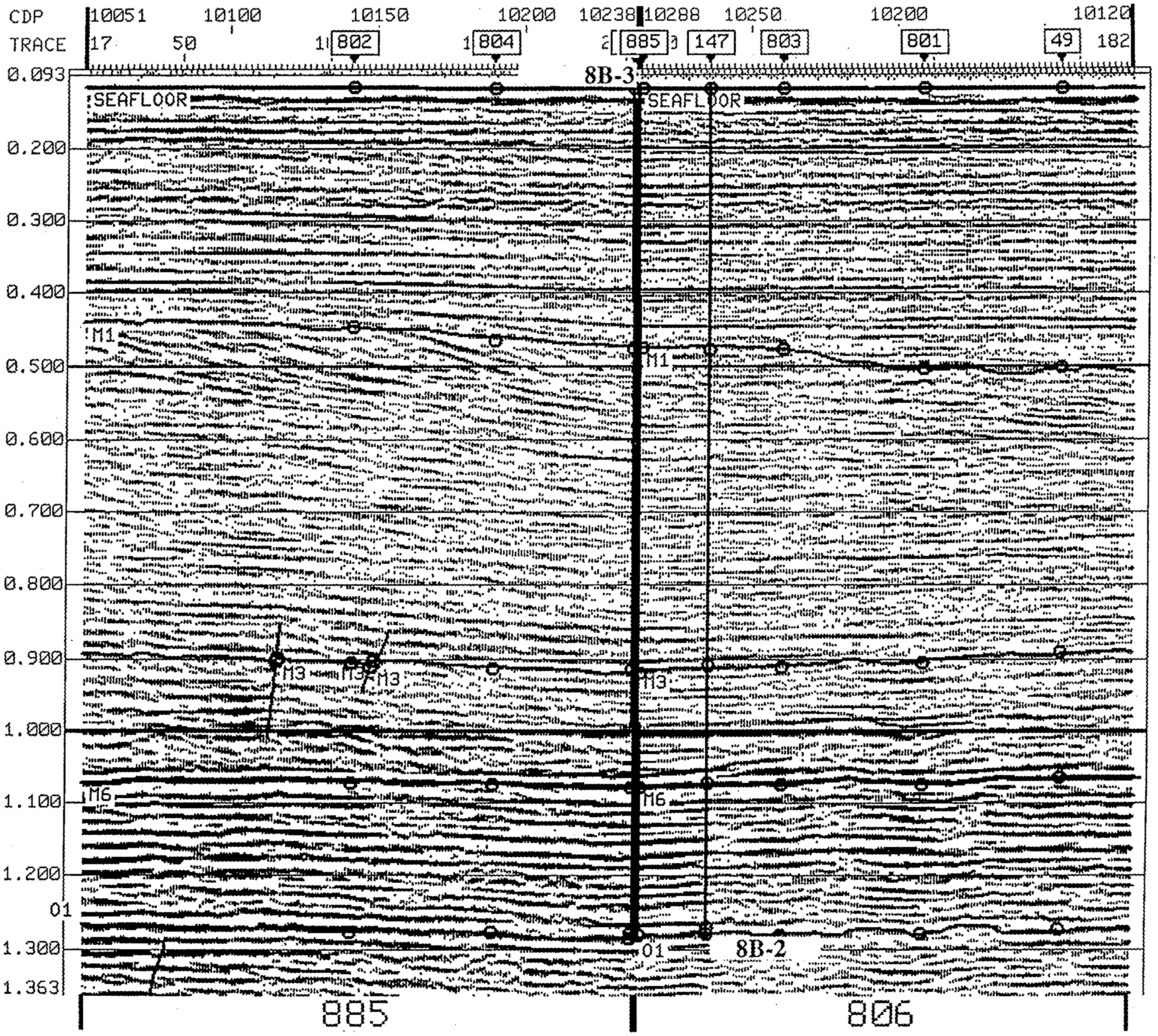
8B



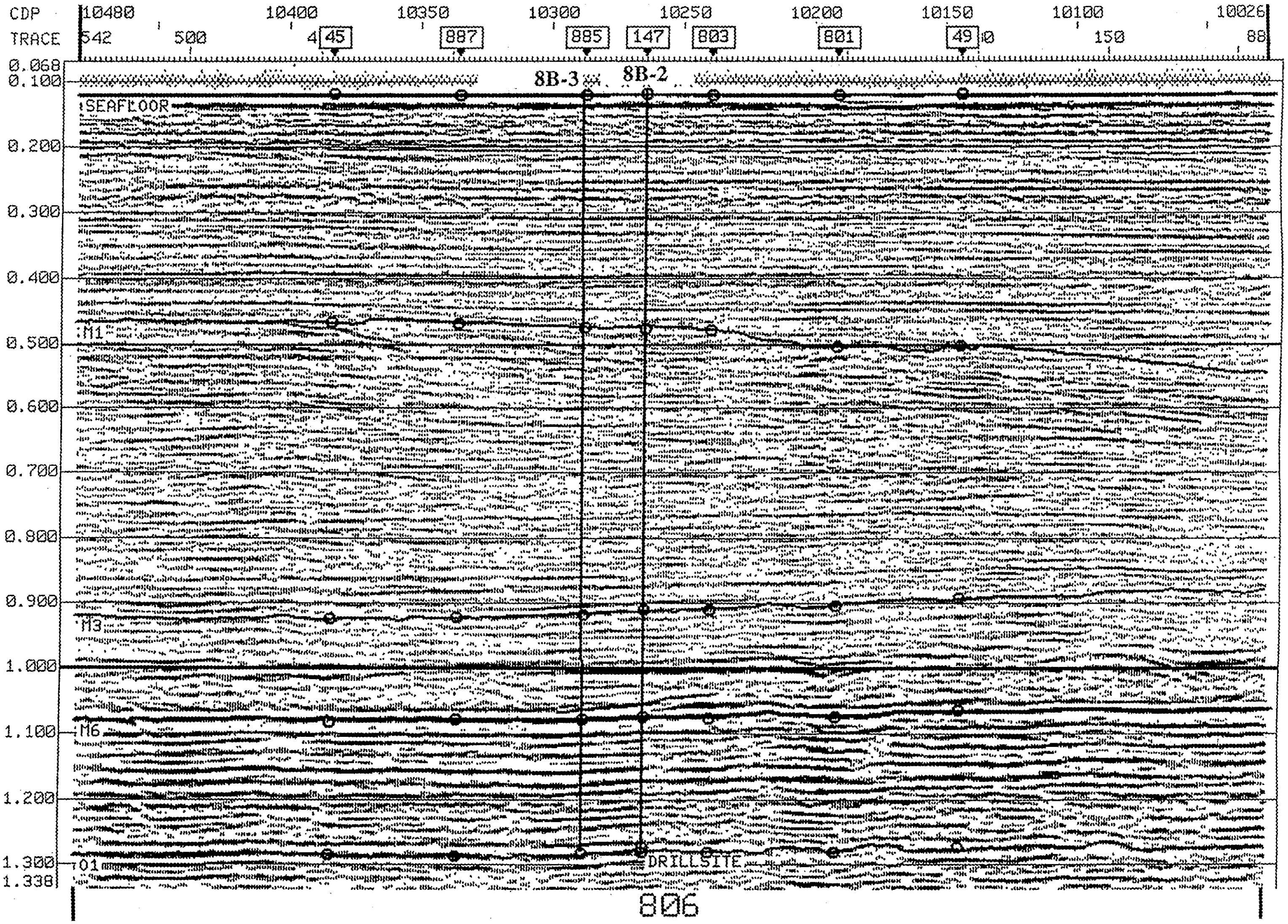
72.749°
72.740°
72.730°
72.720°
72.707°W
39.403°N
39.390°
39.380°
39.366°
49
802
804
806
810
808
801
147
803
885
887
45
812
814
0
0
0
0
0
2
3



Dip profile 147 and strike profile 806 (in travel-time, see accompanying track map for locations), which cross at drillsite 8B-2, one of two approved sites within the 8B "hazards" grid. Proposed TD to early Oligocene horizon o1 is shown by the heavy vertical line. The location of proposed site 8B-3 (see accompanying figures) is also shown by the light vertical line. All mapped horizons are labelled. Distances between lines in the center of the grid are 150 m; outer grid lines are separated by 300 m.



Dip profile 885 and strike profile 806 (in travel-time, see accompanying track map for locations), which cross at drillsite 8B-3, one of two approved sites within the 8B “hazards” grid. Proposed TD to early Oligocene horizon o1 is shown by the heavy vertical line. The location of proposed site 8B-2 (see accompanying figures) is also shown by the light vertical line. All mapped horizons are labelled. Distances between lines in the center of the grid are 150 m; outer grid lines are separated by 300 m.



Strike profile 806 (in travel-time, see accompanying track map for locations), which crosses drillsites 8B-3 and 8B-2, the two approved sites within the 8B "hazards" grid. Proposed TDs to early Oligocene horizon o1 are shown by the vertical lines. All mapped horizons are labelled. Distances between lines in the center of the grid are 150 m; outer grid lines are separated by 300 m.

Site: MAT-9B There are three approved site-specific locations, designated 9B-1, 9B-2, and 9B-3. All will be discussed.

Priority: 1
Position: 9B-1: 39° 21.9348'N, 72° 41.6712'W; 9B-2: 39° 22.0866'N, 72° 41.4024'W; 9B-3: 39° 21.9582'N, 72° 41.5206'W
Water Depth: all three sites: 98 m
Sediment Thickness: all three sites: ~10 km
Approved Maximum Penetration: 9B-1: 1096 mbsf; 9B-2: 1199 mbsf; 9B-3: 1206 mbsf
Seismic Coverage: 9B-1: at the crossing of seismic lines *Oceanus* 270 #147 (cdp 10912/shot 37.99) and #908 (cdp 10265/shot 11.54); 9B-2: at the crossing of seismic lines *Oceanus* 270 #803 (cdp 10816/shot 34.01) and #910 (cdp 10239/9.94); 9B-3: at the crossing of seismic lines *Oceanus* 270 #801 (cdp 10816/34.01) and #910 (cdp 10192/8.00) These lines are shown in accompanying figures.

Objectives: The objectives of MAT-9B are to determine the:

1. Date major Oligocene-Holocene unconformities on the New Jersey margin and evaluate their correlation with glacioeustatic age estimates obtained from the $\delta^{18}O$ record; this site will concentrate on surfaces that are latest middle Miocene (m1) and younger.

2. Place constraints on the amplitudes and rates of sea-level change that may have been responsible for unconformity development.

3. Assess the lithostratigraphic response of changes in sequence architecture to glacial-eustatic forcing.

4. Provide a baseline for future scientific ocean drilling that will address the effects and timing of sea-level changes on other passive margins.

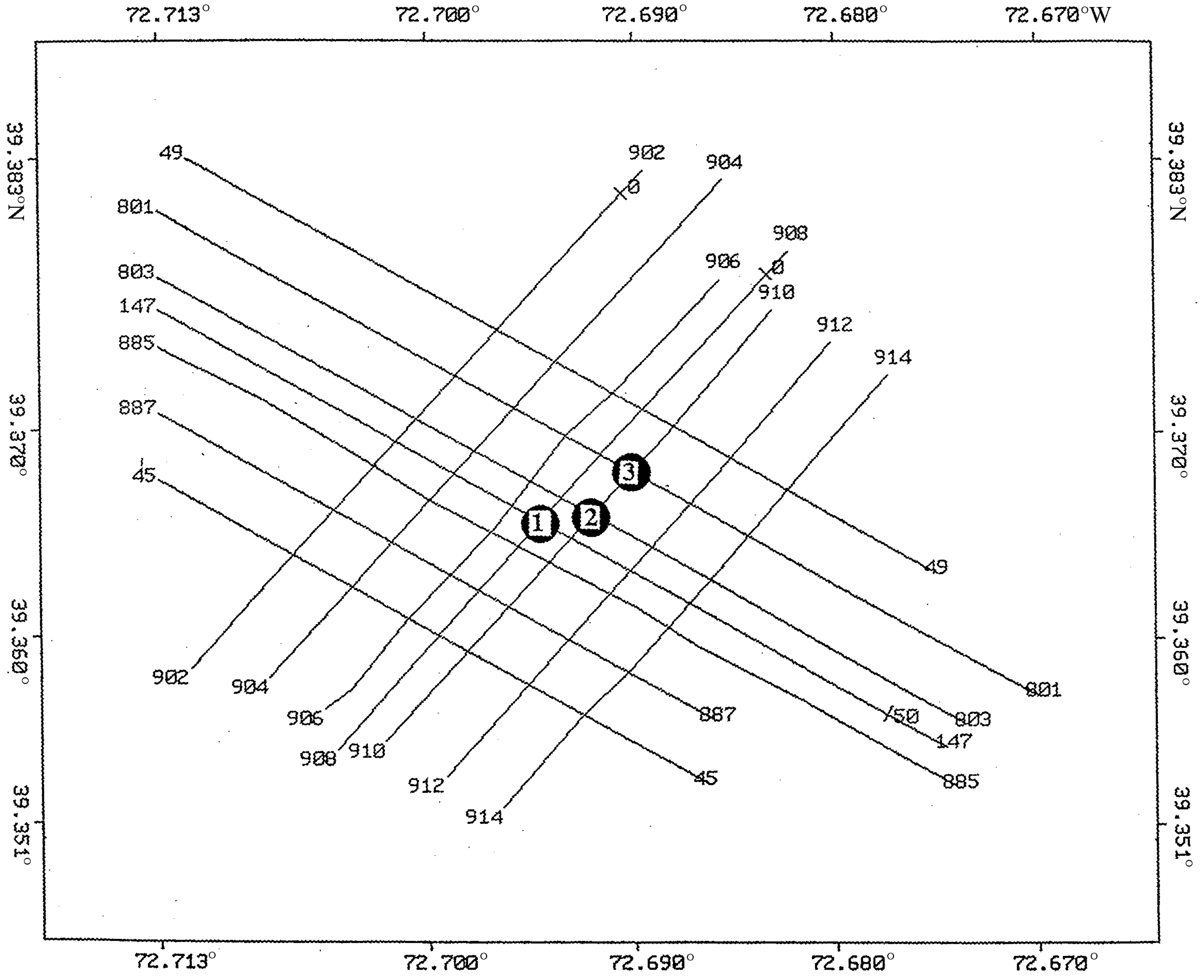
Drilling Program: Double APC/XCB to refusal; RCB (after installation of FFF) to TD at Hole B.

Logging and Downhole Operations: VSP to TD, Logging While Drilling*

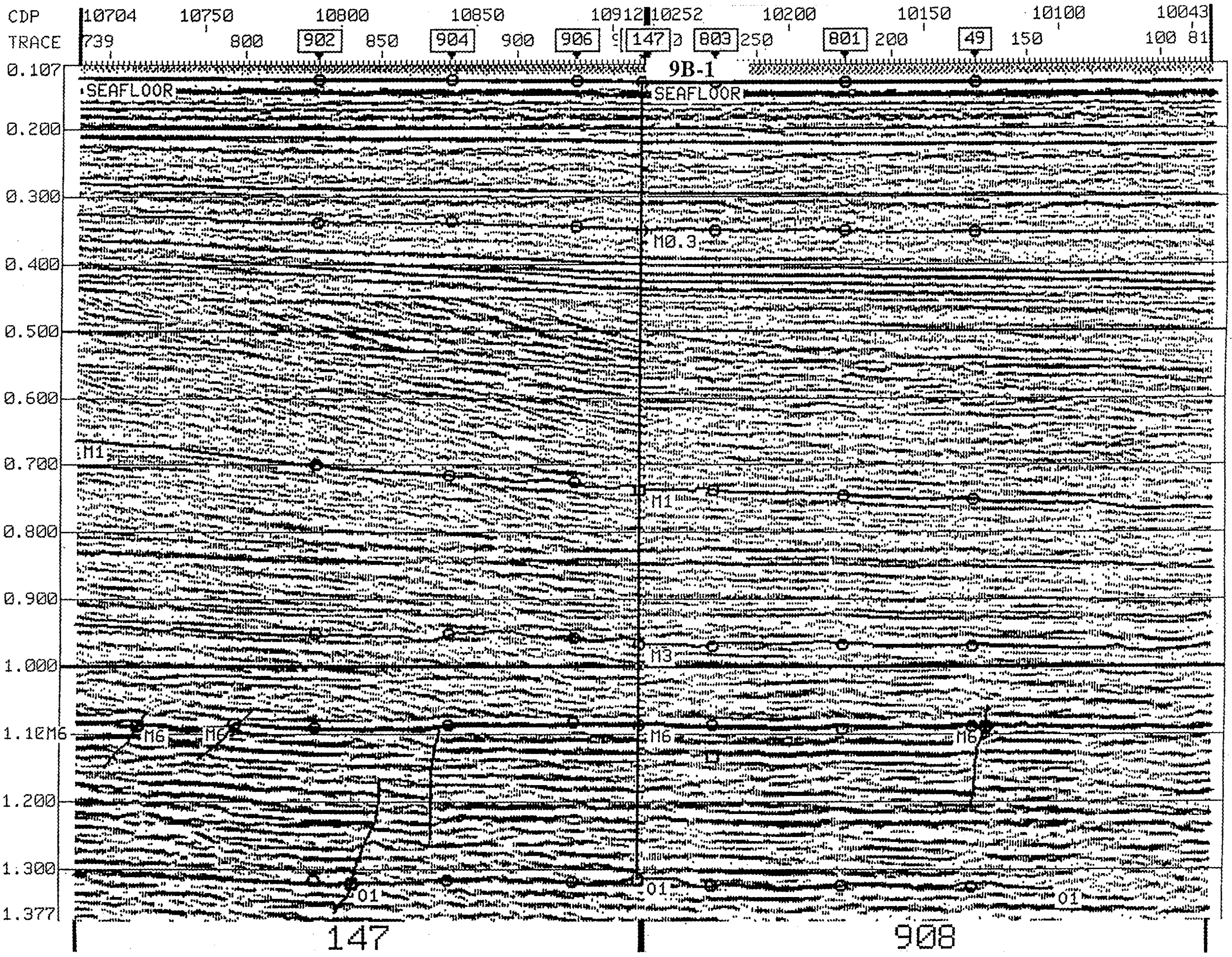
Nature Of Rock Anticipated: Sands, silts, and clays; subordinate gravel.

*LWD tools: CDR, CDN (see preceding text).

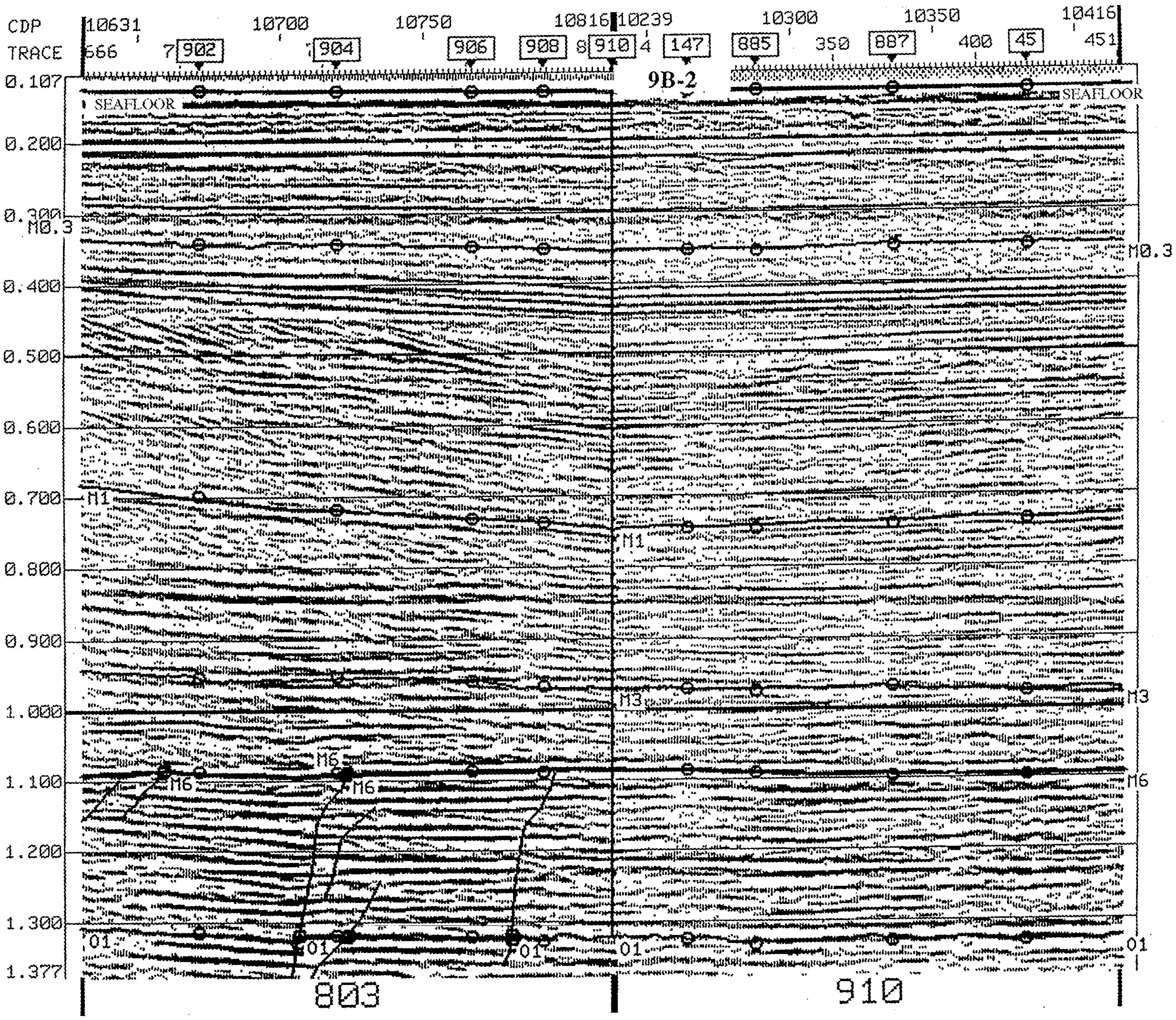
9 B



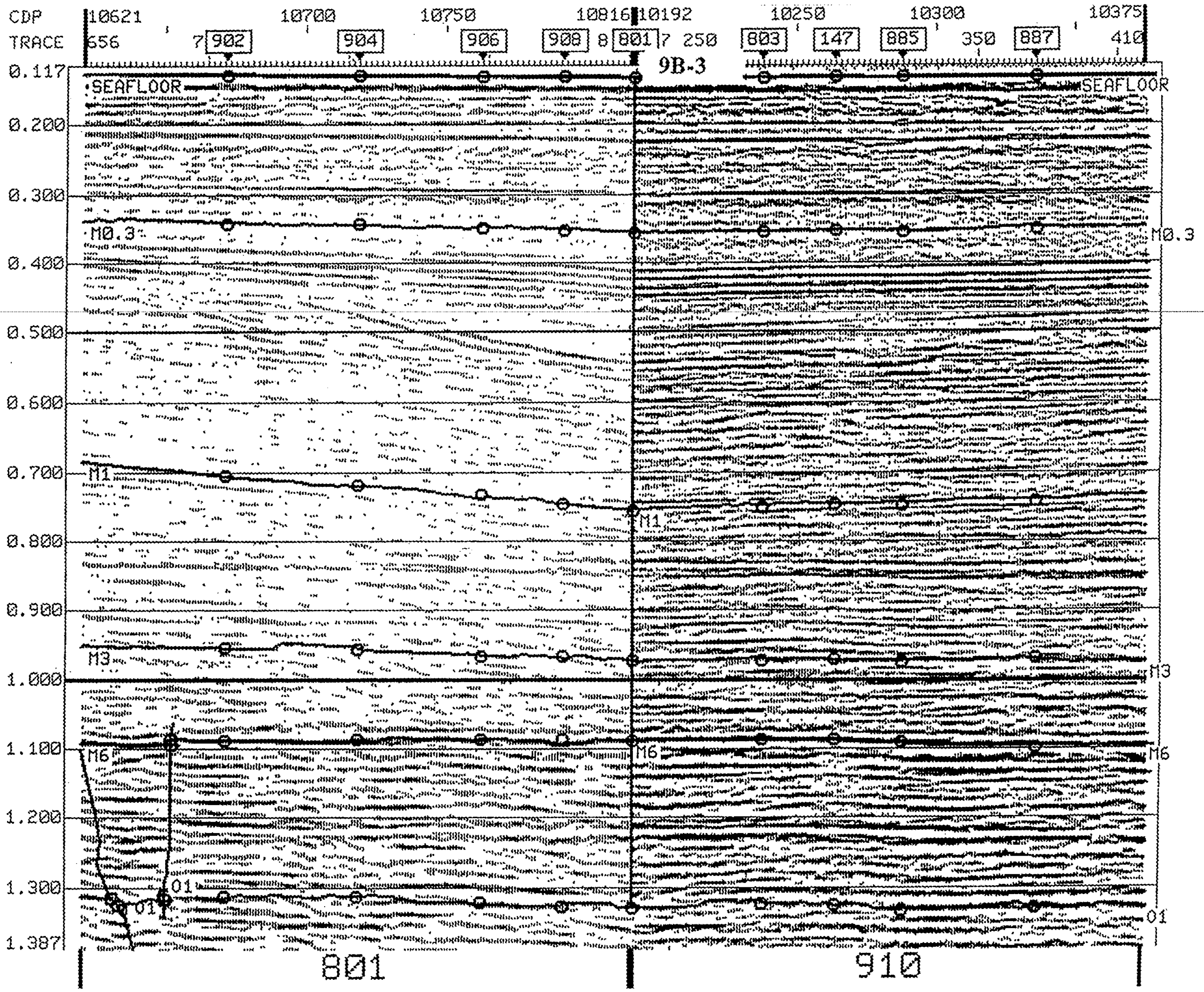
72.713°
72.700°
72.690°
72.680°
72.670°W
39.383°N
39.370°
39.360°
39.351°
49
801
803
147
885
887
45
902
904
906
908
910
912
914
0
50
1
2
3



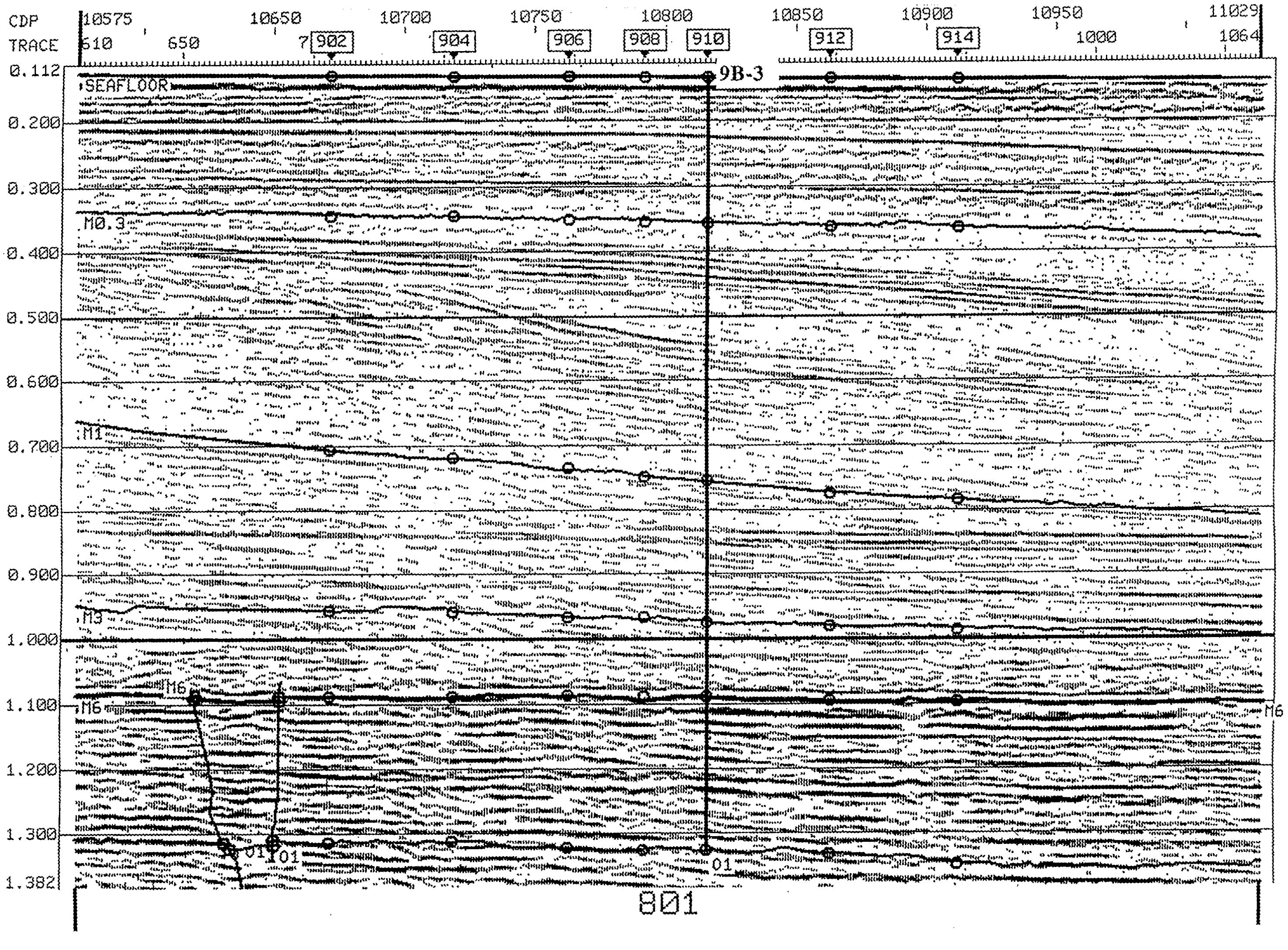
Dip profile 147 and strike profile 908 (in travel-time, see accompanying track map for locations), which cross at drillsite 9B-1, the primary site of three approved within the 9B “hazards” grid. Proposed TD to early Oligocene horizon o1 is shown by the heavy vertical line. All mapped horizons are labelled. In this and subsequent figures, interpreted normal faults are illustrated as irregular dipping surfaces of varying lateral and vertical extent. Faults extend below o1 but rarely extend above m3; in the vicinity of proposed drillsites, single faults never affect the entire section from o1 to m3. Distances between lines in the center of the grid are 150 m; outer grid lines are separated by 300 m.



Dip profile 803 and strike profile 910 (in travel-time, see accompanying track map for locations), which cross at drillsite 9B-2, the second of three approved sites within the 9B “hazards” grid. Proposed TD to early Oligocene horizon o1 is shown by the vertical line. All mapped horizons are labelled. Distances between lines in the center of the grid are 150 m; outer grid lines are separated by 300 m.



Dip profile 801 and strike profile 910 (in travel-time, see accompanying track map for locations), which cross at drillsite 9B-3, the third of three approved sites within the 9B “hazards” grid. Proposed TD to early Oligocene horizon o1 is shown by the vertical line. All mapped horizons are labelled. Distances between lines in the center of the grid are 150 m; outer grid lines are separated by 300 m.



Dip profile 801 (in travel-time, see accompanying track map for locations), which crosses drillsite 9B-3, the third of three approved sites within the 9B “hazards” grid. Proposed TD to early Oligocene horizon o1 is shown by the vertical line. All mapped horizons are labelled. Distances between lines in the center of the grid are 150 m; outer grid lines are separated by 300 m.

PROPOSED SECONDARY SITES (see Table 2)

(No prioritization of sites should be inferred.)

Site: MAT-13A

Priority: 2
Position: 39°12.5'N, 72° 26.6'W
Water Depth: 315 m
Sediment Thickness: ~10 km
Approved Maximum Penetration: 1049 mbsf
Seismic Coverage: at the crossing of *Ewin*g 9009 profile 1002 (see Fig. 2 and accompanying seismic lines) and Exxon 75-7

Objectives: The objectives of MAT-13A are to:

1. Augment Neogene upper slope chronostratigraphy acquired as a result of Leg 150 drilling.

2. Sample the expanded and complete Pleistocene section presumed to compose the Hudson Apron, at a point of physical continuity seaward of coeval clinoforms beneath the outer shelf.

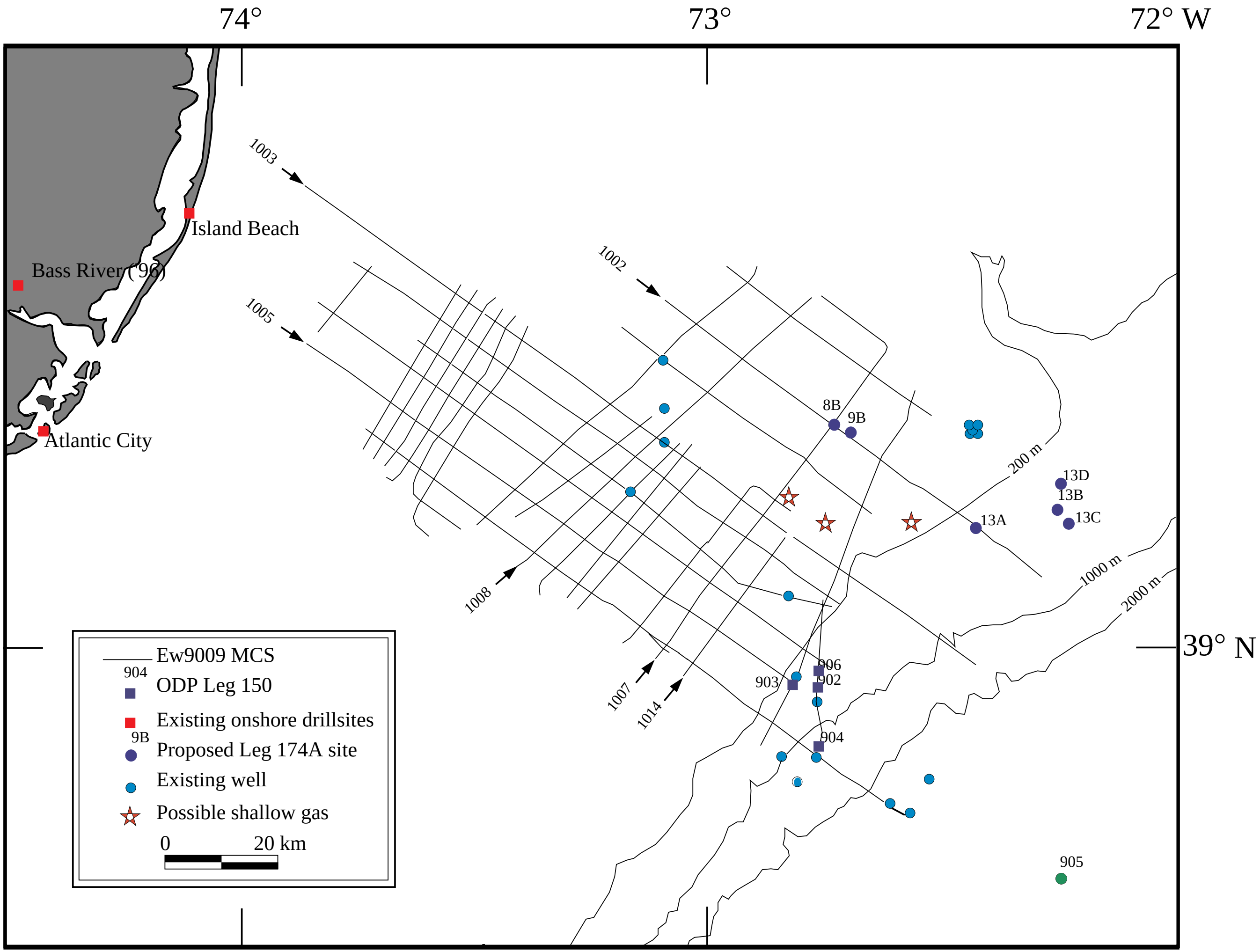
3. Calibrate the age and facies of middle Miocene (e.g., m1, m4) and Pleistocene sequence stratigraphic horizons identified to the south beneath the upper slope in the vicinity of Leg 150 sites (Mountain, Miller, Blum et al., 1994).

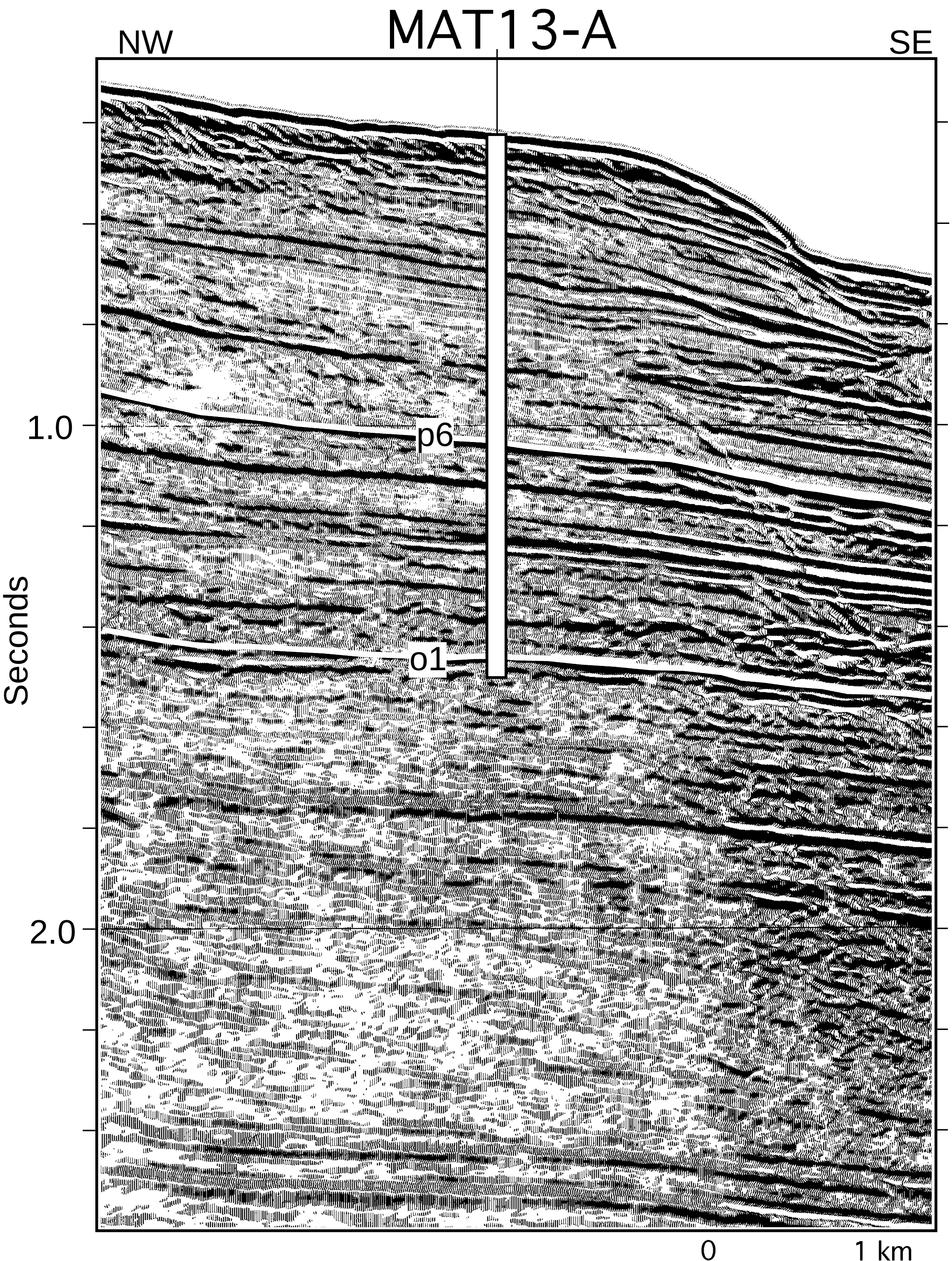
Drilling Program: Single APC/XCB to refusal, then RCB (after installation of FFF) to TD.

Logging and Downhole Operations: Triple-Combo, FMS-Sonic, Logging While Drilling**, VSP.**

Nature of Rock Anticipated: Sands, silts, and clays; occasional debris flows.

**if not run at MAT-8B/-9B


74°
73°
72° W
39° N
Island Beach
Bass River ('96)
Atlantic City
1003
1005
1002
1008
1007
1014
8B
9B
13A
13B
13C
13D
200 m
1000 m
2000 m
903
906
902
904
905
Ew9009 MCS
904
ODP Leg 150
Existing onshore drillsites
9B
Proposed Leg 174A site
Existing well
Possible shallow gas
0
20 km



Ew9009 Line 1002

Site: MAT-13B

Priority: 2
Position: 39°13.5197'N, 72° 16.5457'W
Water Depth: 638 m
Sediment Thickness: ~10 km
Approved Maximum Penetration: 750 mbsf
Seismic Coverage: *Oceanu*s 270 profile #32 (cdp 1650); 900 m from crossing with *Oceanu*s 270 profile #61 (cdp 2589)

Objectives: The objectives of MAT-13B are to:

1. Augment Neogene upper slope chronostratigraphy acquired as a result of Leg 150 drilling.

2. Sample the expanded and complete Pleistocene section presumed to compose the Hudson Apron, at a point of physical continuity seaward of coeval clinoforms beneath the outer shelf.

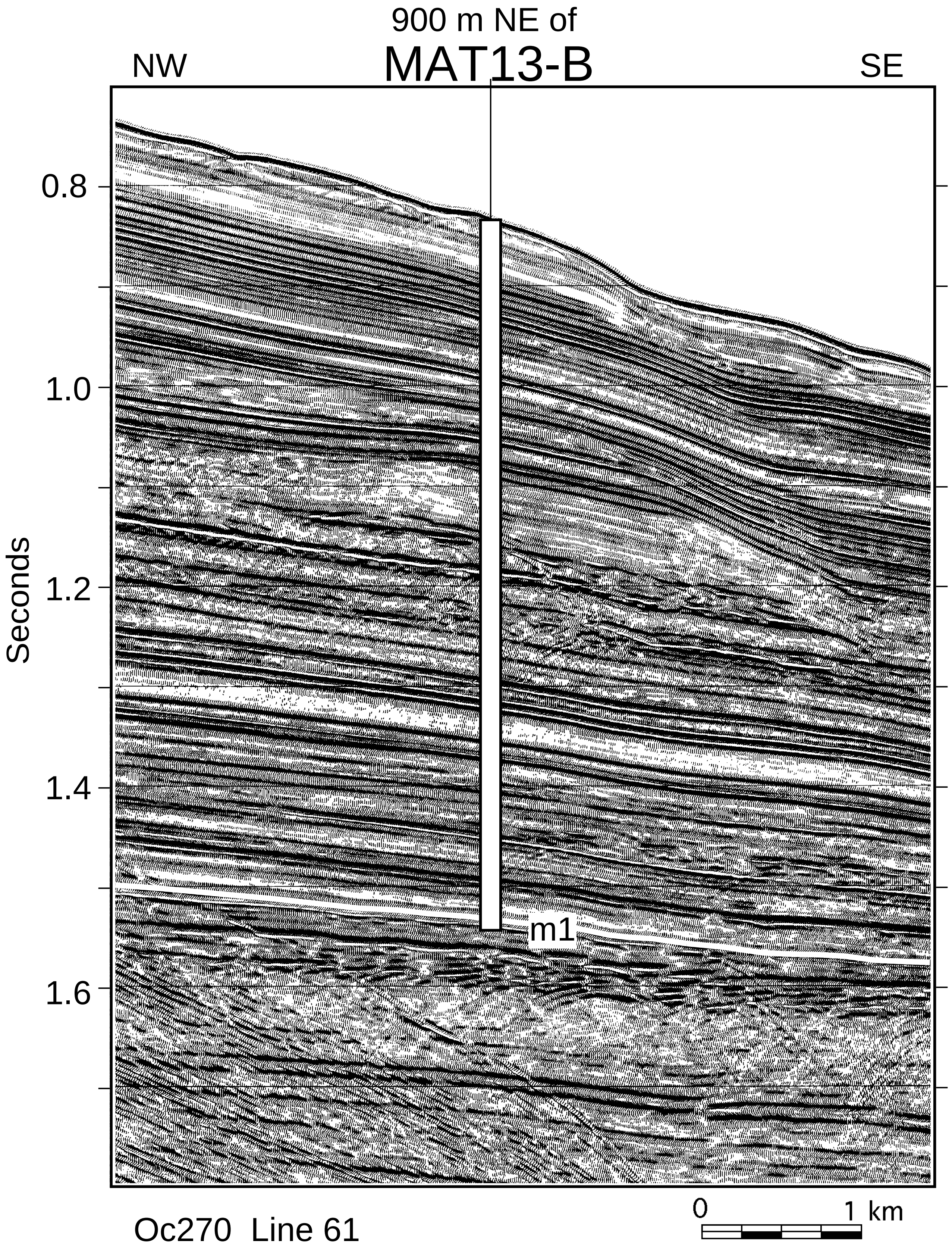
3. Calibrate the age and facies of middle Miocene (m1) and Pleistocene sequence stratigraphic horizons (e.g., p6) identified on the upper slope in the vicinity of Leg 150 sites (Mountain, Miller, Blum et al., 1994).

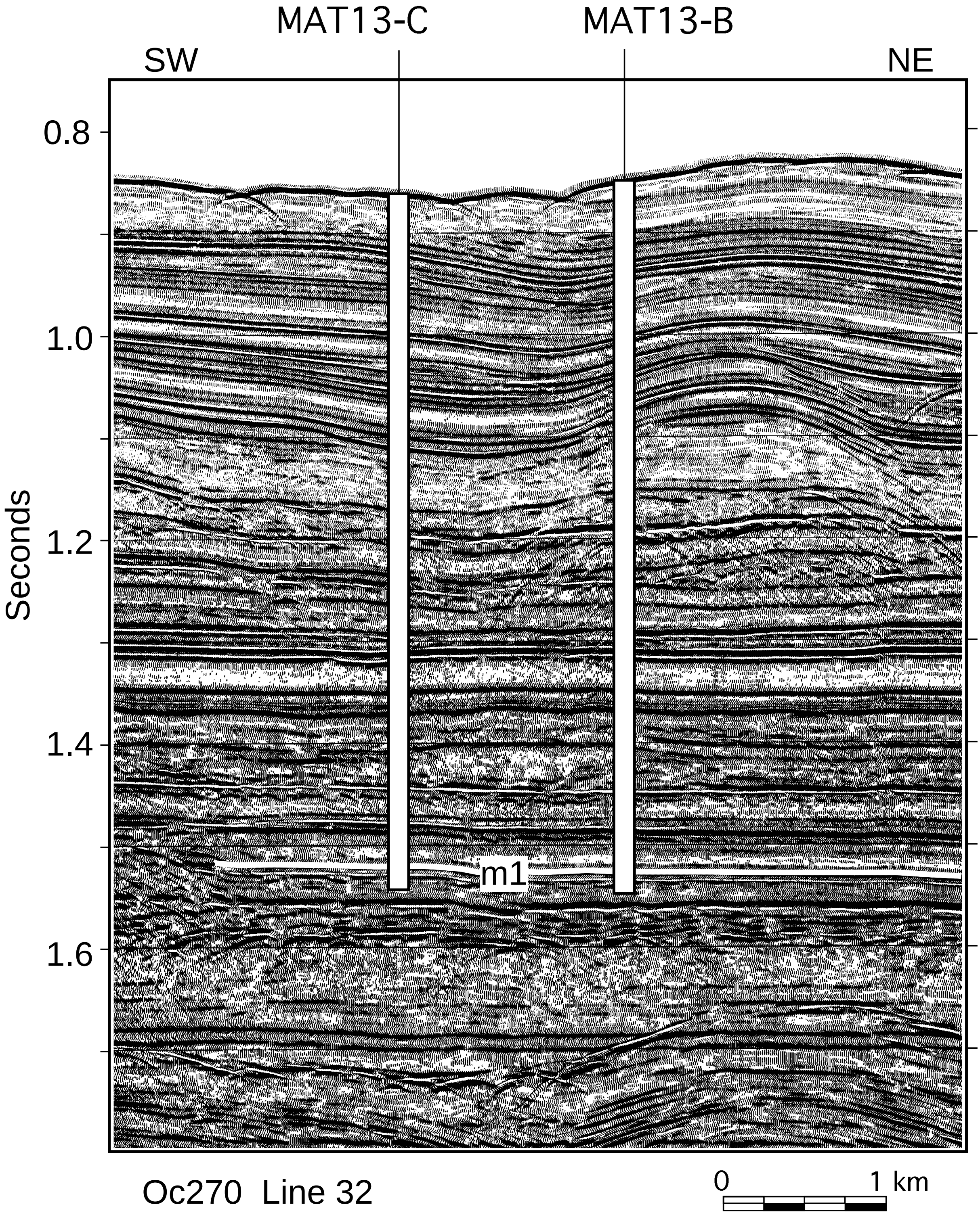
Drilling Program: Single APC/XCB to refusal, then RCB (after installation of FFF) to TD.

Logging and Downhole Operations: Triple-Combo, FMS-Sonic, Logging While Drilling****,** VSP.**

Nature of Rock Anticipated: Sands, silts, and clays; occasional debris flows.

**if not run at MAT-8B/-9B


900 m NE of
MAT13-B
NW
SE
0.8
1.0
1.2
1.4
1.6
Seconds
m1
0
1 km
Oc270 Line 61


MAT13-C
MAT13-B
SW
NE
0.8
1.0
1.2
1.4
1.6
Seconds
m1
Oc270 Line 32
0
1 km

Site: MAT-13C

Priority: 2
Position: 39° 13.3315'N, 72° 16.9594'W
Water Depth: 652 m
Sediment Thickness: ~10 km
Approved Maximum Penetration: 625 m
Seismic Coverage: at the crossing of *Oceanu*s 270 profiles #59 (cdp 2628) and #32 (cdp 1540)

Objectives: The objectives of MAT-13C are to:

1. Augment Neogene upper slope chronostratigraphy acquired as a result of Leg 150 drilling.

2. Sample the expanded and complete Pleistocene section presumed to compose the Hudson Apron, at a point of physical continuity seaward of coeval clinoforms beneath the outer shelf.

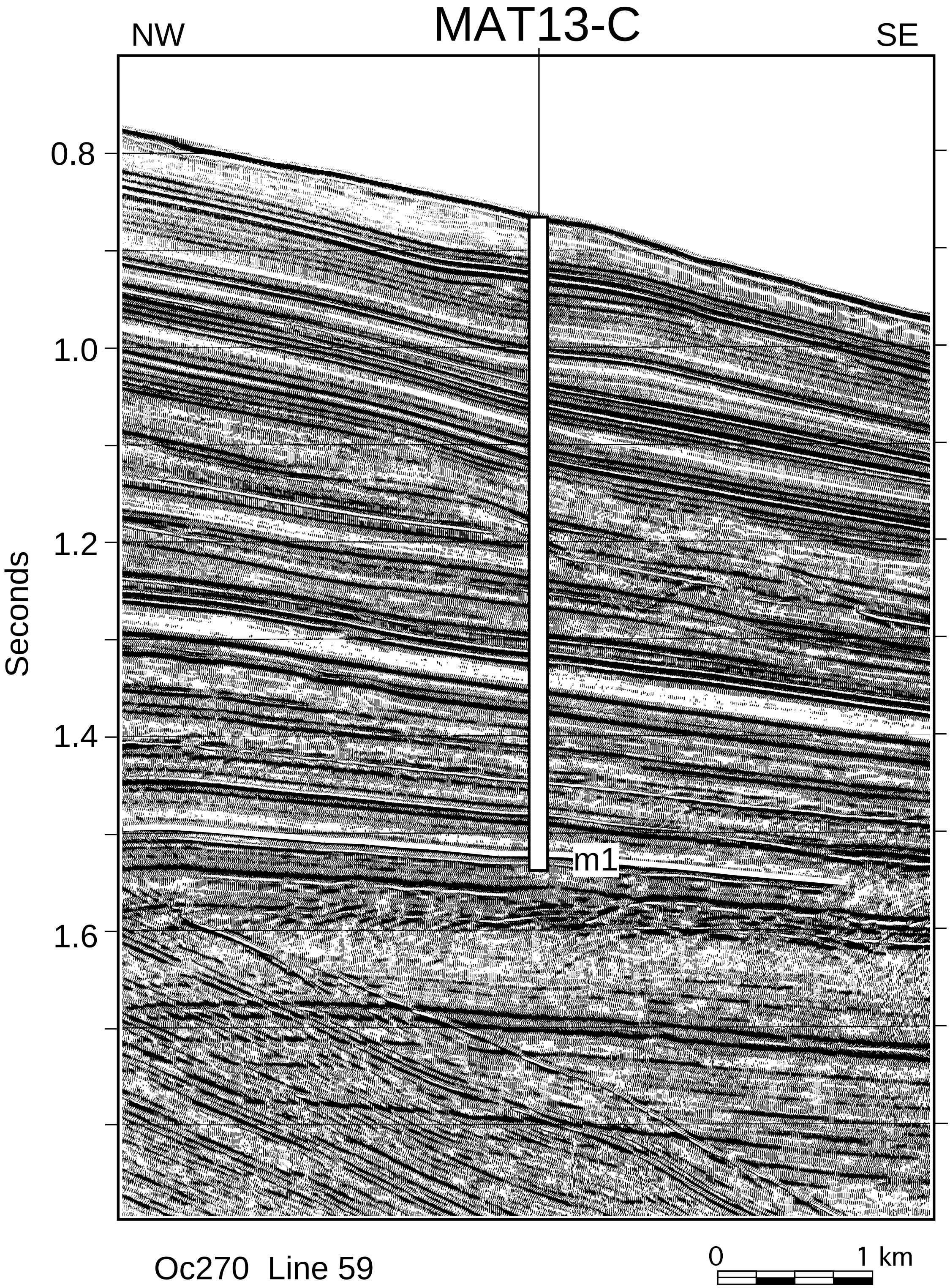
3. Calibrate the age and facies of middle Miocene (m1) and Pleistocene sequence stratigraphic horizons (e.g., p6) identified on the upper slope in the vicinity of Leg 150 sites (Mountain, Miller, Blum et al., 1994).

Drilling Program: Single APC/XCB to refusal, then RCB (after installation of FFF) to TD.

Logging and Downhole Operations: Triple-Combo, FMS-Sonic, Logging While Drilling**, VSP.**

Nature of Rock Anticipated: Sands, silts, and clays; occasional debris flows.

**if not run at MAT-8B/-9B



Oc270 Line 59

Site: MAT-13D

Priority: 2
Position: 39° 16.7249'N, 72° 18.9547'W
Water Depth: 285 m
Sediment Thickness: ~10 km
Approved Maximum Penetration: 429 m
Seismic Coverage: at the crossing of *Oceanu*s 270 profiles #61 (cdp 3692) and #30 (cdp 453)

Objectives: The objectives of MAT-13D are to:

1. Augment Pleistocene upper slope chronostratigraphy acquired as a result of Leg 150 drilling.

2. Sample the expanded and complete Pleistocene section presumed to compose the Hudson Apron, at a point of physical continuity seaward of coeval clinoforms beneath the outermost shelf.

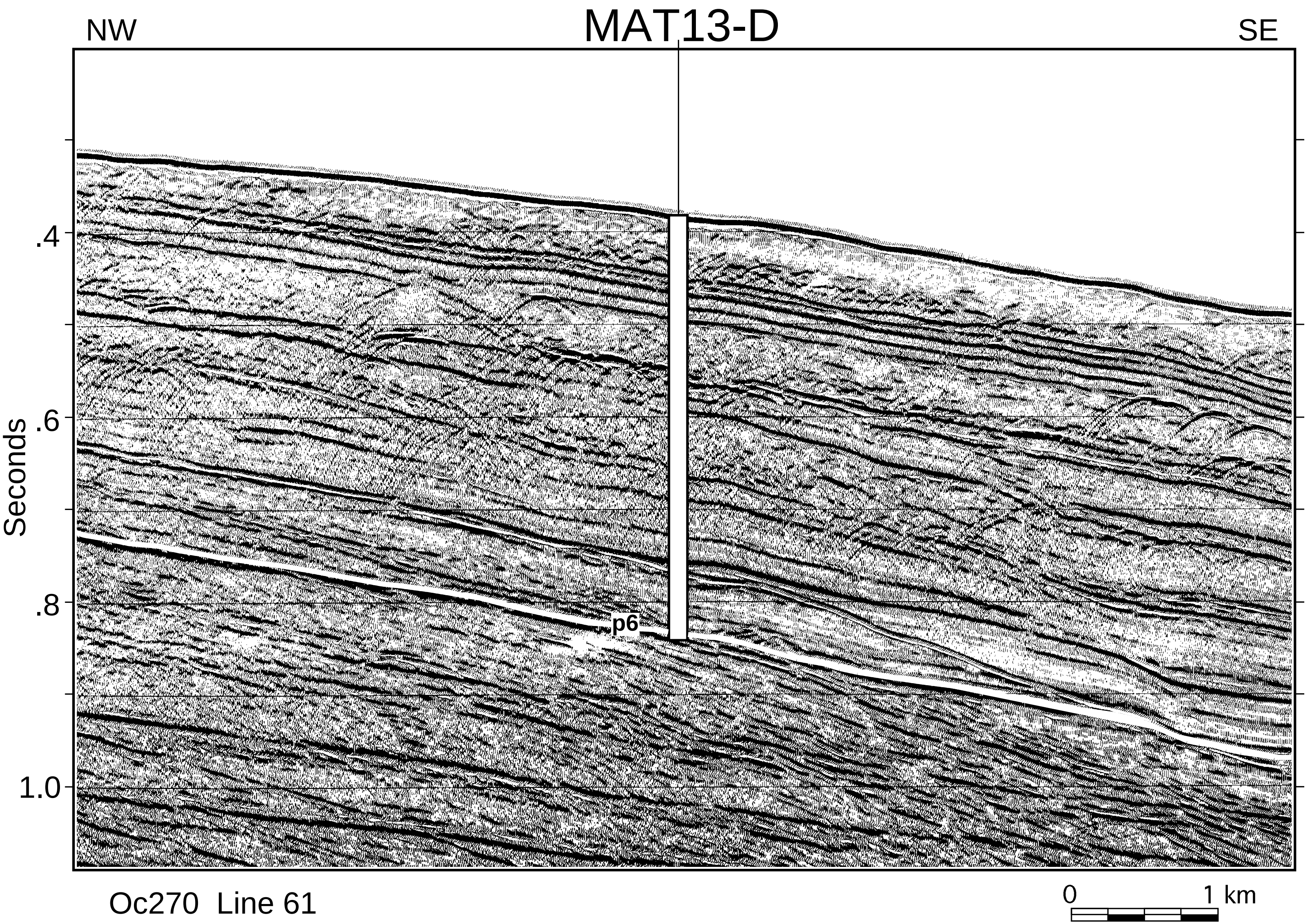
3. Calibrate the age and facies of Pleistocene sequence stratigraphic horizons (e.g., p 6) identified on the upper slope in the vicinity of Leg 150 sites (Mountain, Miller, Blum et al., 1994).

Drilling Program: Single APC/XCB to TD.

Logging and Downhole Operations: Quad, GHMT, Logging While Drilling**, VSP.**

Nature of Rock Anticipated: Sands, silts, and clays; occasional debris flows.

**if not run at MAT-8B/-9B


MAT13-D
NW
SE
Seconds
.4
.6
.8
1.0
p6
Oc270 Line 61
0
1 km

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