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PRELIMINARY RESULTS OF DEEP SEA DRILLING PROJE
LEG 94 NORTH ATLANTIC OCEAN

Robert B. Kidd

Internal Document No. 200
February 1984

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PRELIMINARY RESULTS OF DEEP SEA DRILLING PROJECT

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Work carried out under contract to the Department of the Environment

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[26pp +
Appendix (27pp)]

DEPARTMENT OF THE ENVIRONMENT

RADIOACTIVE WASTE MANAGEMENT

RESEARCH PROGRAMME 198 /8

DoE Report No. DoE/RW

Contract Title: DOE selection and evaluation of sites for the disposal of High-Level Radioactive Waste

DoE Reference:

Report Title Preliminary Results of Deep Sea Drilling Project Leg 94 North Atlantic Ocean

Author/s Robert B. Kidd

Date of submission to DoE

Abstract

(see Forward)

Keywords 94, 104, 106, 110, 122
299

This work has been commissioned by the Department of the Environment as part of its radioactive waste management research programme. The results will be used in the formulation of Government policy, but at this stage they do not necessarily represent Government policy.

FORWARD

The accompanying informal report is a summary of the scientific results of Leg 94 of the Deep Sea Drilling Project along with an operations resume. It was prepared from the shipboard files of the scientists who participated in this cruise of D.V. Glomar Challenger and is privileged proprietary information which cannot be used for publication or quotation.

Two Institute of Oceanographic Sciences geologists participated in the cruise: Dr. Robert B. Kidd as Co-Chief Scientist and Dr. Philip P.E. Weaver as micropaleontologist. The attention of DOE is drawn to the following aspects of relevance to its radioactive waste management research programme:-

(1) A 428 metre deep continuously cored hole (Site 608) was drilled to oceanic basement on the northern edge of the King's Trough Flank study area.

(2) The stratigraphic section established at this site allows calibration of seismic profiling records across the KTF study area.

(3) The cores recovered were sampled for shore-based physical properties and pore water studies at IOS and BRE.

(4) All six sites combine to provide a new high resolution stratigraphy for the North Atlantic which will form the basis of all subsequent sediment stability studies for sequences beyond the range of conventional piston coring.

INTRODUCTION

Background and Objectives

The high-latitude North Atlantic Ocean is one of the most critical components of the global climatic system, both as an interactive component and as a long-term climatic sensor. It is flanked on three sides by continents, and is particularly influenced by air masses generated over the Canadian Arctic. The North Atlantic is one of two sites of formation of the deep waters that fill most of the world ocean, and waters sinking to intermediate depths are created here as well. During the winter-time, when cooling of the ocean surface accompanies the formation of deep and intermediate waters, the release of sensible and latent heat to cold air masses from the continents reaches values an order of magnitude larger than the global average. This extracted heat then moderates the climate over adjacent land masses.

The modern linkages of air, land, and sea changed during the ice-age climatic cycles of the Pleistocene and late Pliocene. Periodically, as ice sheets covered North America and Europe, the ocean surface north of 40° latitude chilled by as much as 10°-12°C, and the temperate waters of the North Atlantic Drift were replaced by a cold, iceberg-filled subpolar gyre separated from the warmer subtropical gyre by a sharply defined polar front along 42°-46°N. Formation rates of deep water periodically slowed and may at times have stopped altogether.

These responses to the ice-age cycles left several strong imprints in the deep marine sediments of the high-latitude North Atlantic Ocean: lithologic changes from interglacial carbonate oozes to glacial muds and marls; wholesale replacement of warm planktonic faunas and floras by cold communities; oxygen isotopic evidence of changes in the volume of ice stored on land; and variations in the amount of material dropped by melting icebergs. It is now known that the major late Pleistocene advances and retreats of the polar front north of 45° occurred with a 100,000- and 40,000-yr. periodicity, in phase with ice-volume growth and decay. It is also known that a very different tempo of sea-surface temperature change occurred south of 45°N in the northern subtropical gyre. Here, 23,000-yr. oscillations were dominant, and the ocean responded out of phase with (later than) ice volume.

Studies of conventional piston cores have delimited these changes in detail over the time span of the last several hundred thousand years. However, the high rates of deposition that make North Atlantic sediments ideal recorders of long-term climatic change precluded obtaining long climatic sequences from conventional piston cores. With the development of the hydraulic piston corer for use on the *Glomar Challenger*, these deeper sections have become accessible.

Beyond the late Pleistocene lies a long span of Neogene time during which the oceanographic response of the North Atlantic was also a critical component of the larger picture of global climatic change. Several intervals within this span stand out as particularly interesting, either in their own right or because of their possible connections to important climatic changes nearby or elsewhere on the globe.

At the time scale of the glacial cycles:

1. When did major southward swings of the polar front begin and with what relation to the first major glaciations?

2. Did development of strong 100,000-yr. cycles in ice volume roughly 800,000 yr. ago coincide with similar changes in rhythm of polar-front movements?

3. What was the rhythm of oceanic response in the northern subtropical gyre south of the polar front as the ice-volume rhythms changed?

Before the major Pliocene-Pleistocene glaciations that began at 2.4 Ma, what were the responses of the North Atlantic to the following events?

1. Closing of the Panamanian Isthmus (4-3 Ma), which must have strengthened Gulf stream flow?

2. Closing and re-opening of connections with the Mediterranean around 6.3 to 5.5 Ma, during the Messinian?

3. Climatic coolings known from scattered glacial evidence on Northern Hemisphere land masses at 3.4 to 3.2 Ma (Iceland, Sierra Nevada Mountains) and 10 Ma (Alaska)?

4. Major increases in Antarctic glaciation around 15 and 6.5 Ma?

In short, what is the Neogene history of paleoceanographic change in the mid-latitude North Atlantic?

Related objectives dependent on a sequence of high-quality pelagic cores from the North Atlantic include the following:

1) high-quality paleomagnetic stratigraphy, including definition of very short events because of unusually high sedimentation rates;

2) long, detailed records of the "global" oxygen isotope signal and of regional variations in the carbon isotopic signal;

3) major refinement and extension of high-latitude biostratigraphic datum levels for all planktonic organisms;

4) investigation of the detailed history of $CaCO_3$ and silica preservation and dissolution;

5) studies of the terrigenous fraction, both that delivered by glacial ice-rafting and the smaller background component of windblown origin;

6) information on Icelandic and Azores volcanism; and

7) the history of deep-water circulation, using both stable isotopes and benthic foraminifers.

Coring during the summer of 1981 on previous DSDP legs obtained two long HPC sequences with which to study North Atlantic paleoclimate: Site 552 on Leg 81 and Site 558 on Leg 82. Both retrieved valuable sedimentary sections, their usefulness limited only by the relatively low sedimentation rates (10-20 m/m.y.) and the lack of double-HPC coring to fill breaks between cores and disturbances within cores. Results from Site 552 on the western flank of Rockall Plateau suggested that the fundamental initiation of glacial carbonate cycles occurred at 2.4 Ma, coincident with the first large positive shift in oxygen-isotope values. Site 558, southwest of the Azores, lies south of the region most heavily impacted by surface-water changes in the North Atlantic. Basically, these two sites are end points that pin the northern and southern limits of the transect of cores obtained on Leg 94 in the summer of 1983.

The Leg 94 objectives called for a transect beginning in the warm waters of the subtropical gyre near the Azores (Site 606) and proceeding to the north and northeast through the northern subtropical gyre (Site 607), and the transitional waters (Sites 608 and 609), to Site 610 located off the coast of Ireland. The final site (611) was chosen to the west of Site 610, but in still colder waters. Thus the numerical sequence of sites is from the warmest to the coldest (Fig. 1).

Because the paleoceanographic objectives require pelagic sediments and good preservation of the calcareous components, most of the sites were situated along the Mid-Atlantic Ridge and all at relatively shallow depths (2417 to 3883 m). In regions of locally variable sediment thickness (Sites 606, 607,and 609), we used seismic profiler records during the approach to pinpoint final site placement within the thickest parts of local sediment ponds. On the sediment drifts at Sites 610 and 611, sedimentation rates were uniformly rather high, so that final adjustments were not needed. Placement of Site 608 was determined largely by the tectonic objectives at King's Trough.

Two other major objectives for Leg 94 were to study the history and nature of North Atlantic Drift sedimentation on Feni and Gardar Drifts, and the tectonic history of the King's Trough region.

Seismic reflection profiles run in many areas of the North Atlantic are replete with examples of anomalously thick sediment piles considered to have been built up by the long-term circulation of bottom waters. Where the major bottom water masses have been most active piles of sediments several hundreds of meters thick, known as sediment drifts, have accumulated. Drilling in such sequences has been sparse, although it has become clear that the drifts hold an important record of the history of bottom water circulation in the ocean. Attempts to relate available drilling results to seismic stratigraphy suggested that the major North Atlantic drifts were initiated in the Paleogene, but the ages of many drifts are poorly constrained.

Sediment drifts have a characteristic ornamentation of large-scale sediment waves, which generally are tens of meters in amplitude and kilometers apart. These wave features have not been sampled to a great extent by piston cores, but they have frequently been characterized as sites of so-called "contourite" deposition.

The proposal to locate some of the sites (in the paleoclimate transect) on two of the major North Atlantic sediment drifts (because of their anticipated high sediment accumulation rates) provided an opportunity to examine the sedimentation of drift sequences in some detail. At Feni Drift on the western side of Rockall Trough and

Gardar Drift on the eastern flank of the Reykjanes Ridge three main aspects were tackled:

1. General characterization of drift lithologies, with documentation of systematic structural features, sedimentation rate changes or hiatuses.

2. The structure and composition of the sediment waves (by drilling a number of closely-spaced offset HPC holes).

3. The overall sedimentation history of the drifts (by drilling some deep holes to date significant seismic reflectors and biostratigraphic horizons within them).

The third site in the original series of sites planned for the paleoclimate transect was chosen to examine the fluctuations of the polar front and Neogene sea surface temperature history at about 44°N. A later proposal, aimed at determining the tectonic history of the intraplate King's Trough complex at a location slightly further to the south and east, was combined with the initial objectives. A continuous stratigraphic record was sought through the Paleogene to basement on the southern flank of King's Trough. The results were to be compared with rock-core and dredge haul data from within the complex.

The origin of King's Trough has been a matter of dispute for over 15 yr., despite the relatively abundant geophysical data available from the area. Hypotheses for its formation included: a compressional origin; a short-lived bend in the Mid-Atlantic Ridge; a transform fault; and a rifted aseismic ridge that had originally been built from a hot spot. The latest hypothesis, based on dredge haul and rock-core data, involves uplift of an aseismic ridge during the early Oligocene, followed by Miocene intraplate rifting. This hypothesis could be tested by drilling a deep hole in a flank of the complex. In addition, a number of biostratigraphic objectives could be met if Paleogene sediments were continuously drilled.

SUMMARY OF MAIN OBSERVATIONS

Leg 94 obtained cores in 21 holes at six sites in the North Atlantic (Fig. 1, Table 1). Ages ranged back to the late middle Eocene at one site (608), but were otherwise all Neogene (mid-Miocene or younger) in age (Fig. 2). At least the upper 3 Ma was doubled-cored at all sites; in some sites, the double coring extended into the Miocene.

Test of New Coring Apparatus

At Site 606 we tested the newly developed Advanced Piston Corer (APC). This tool represents a potential improvement over the VLHPC in two major respects: (1) scoped out, the unit is much shorter than the VLHPC, thus improving ease of handling on deck with no sacrifice in the length of retrieved cores; (2) it was built to withstand roughly double the pull-out pressure limit of the VLHPC (100,000 vs 40,000 lb.), thus potentially extending its coring range beyond that of the VLHPC. The APC functioned successfully to a depth of 178.4 m at Site

606, but was lost at the bottom of Hole 606A after having withstood a 100,000 lb. pull-out on a previous core. This was regarded as a successful test of the new tool.

Core Recovery

Leg 94 cores were taken using the APC and VLHPC to refusal, which invariably occurred within a depth range of 125-175 m sub-bottom. We then used the XCB (Extended Core-Barrel) system to extend continuous coring below. For some of the deeper objectives, we washed down and spot-cored selectively within the sediment column. In general recovery was good, averaging 85% of the total thickness cored. Distortions of the cores were non-existent at Site 606, infrequent at Site 607, but more frequent at the four northern sites. This seemed to be caused by the increasing incidence of moderately large swell in the rougher seas to the north. At no time, however, was the weather on site really bad. The sediments most vulnerable to these disturbances were invariably those in the upper 50 m, where high water contents probably contributed to the poor recovery.

Sediment Lithology

Two kinds of sediment were prevalent: interlayered nannofossil oozes, marls, and muds in the upper 2.4 Ma of Sites 608 through 611, and nannofossil oozes gradually lithifying downwards to nannofossil chalks in early Pliocene and older levels at all sites (Fig. 2). Site 606 consisted of nannofossil oozes even in the Pliocene-Pleistocene, because it lay south of the region of ice-rafting. Similarly, at Site 607 we recovered largely nannofossil ooze, but with some glacial strata of marly oozes.

The variations on this basic pattern were minor: a higher siliceous content in the upper Pliocene of Sites 610 and 611 and the middle Miocene of Site 610; increased volcanic influx in the lower Miocene and upper Oligocene of Site 608 and the upper Pliocene and Pleistocene of Site 610; and slightly higher mud content in the upper Pliocene of Site 609 and various Pliocene-Miocene levels of Sites 610-611.

Stratigraphic Continuity

Because of the striking visual correlations provided by the glacial carbonate layering of the upper Pliocene and Pleistocene, it proved possible to correlate photographs of equivalent layers at offset holes and thus to verify onboard whether or not we had obtained a completely continuous record (that is, with core breaks in one hole at a site spanned by a continuous section of core in the complementary offset hole at that site). Because this correlation was based on photographs, it could not quite be done in real time, but necessarily after a delay of several days. In some cases, gaps in continuity were detected while we were still on station and filled by additional spot coring. More often, we did not know until in transit whether or not we had obtained a complete record.

In general, there were far more complications evident in these cores than might be imagined from an unbroken sequence of homogeneous calcareous oozes or clays. Even in cases where the two holes were placed next to the same beacon with no measurable offset, lithologic and other tie lines were often shifted by 1 to 10 m between holes. This meant that it was not sufficient simply to use pipe-line depths to align core breaks in one hole midway between core breaks in the other; the offset in correlations also had to be considered. We found several instances in which sections were repeated, with the layers retrieved in the top of one core repeating those just obtained in the bottom of the previous core. This implied lateral movement at the bottom of the drill string during raising between cores. In some instances a given core was taken as much as 5 m below the level anticipated from pipe-line lengths, apparently because of downward heaving of the ship at the instant of coring. In such cases, the next core would come up shortened by roughly the amount over-cored on the previous attempt. Other problems included obvious compression and extension of sequences, and various kinds of coring deformation caused by heaving of the ship and armoring of the sediment surface caused by coarse glacial debris. All of these complications will be discussed in detail in Volume 94 of the Initial Reports.

Below the glacial cycles, it was not possible to check for continuity in such detail. Generally, within the resolution available from paleomagnetic and biostratigraphic datum levels, hiatuses were not detected, except for one large 11.6 Ma gap at 462 m in Site 608, with upper Oligocene sediments directly overlying upper Eocene. Even the sites on sediment drifts appeared to be entirely hiatus-free.

Paleomagnetic Stratigraphy

Although results were variable from core to core, in general we obtained very good paleomagnetic stratigraphies. Typically, the detrital minerals in the glacial marls and muds gave the strongest intensities and best signals, with the carbonate-rich oozes below and south of the glacial cycles more weakly magnetized, but still useful. Invariably, it was difficult or impossible to obtain magnetic stratigraphies in the semi-indurated chalks (250-350 m sub-bottom), that were broken up into small "drilling biscuits", but the deeper and more lithified chalks gave useable results, except in tectonically disturbed sections. In most sites, the basic magnetic epochs were clearly defined, and even short events like the Reunion and Cobb Mountain were detected in several holes at one site.

Biostratigraphy and Microfossil Preservation

The North Atlantic is recognized as the least corrosive ocean to calcareous sediments, and in general, preservation of the abundant calcareous microfossils and nannofossils was very good to excellent, except for the Eocene, Oligocene and Miocene at Site 608, and parts of the early Miocene at Site 610, where preservation was moderate to poor. Silica was much rarer, generally constituting only a few percent of the sediment at most. Although silica preservation is generally noted as good to moderate, it is likely that only a very small fraction of the silica originally produced in the surface water survives in the sediments, due to light silification of the tests in silica-deficient surface waters.

Generally, biostratigraphy was secondary to paleomagnetic stratigraphy on Leg 94. This was due in part to the extraordinarily good quality of the paleomagnetic records and in part to the progressive northward loss of the low-latitude species that form the basis of the calcareous microfossil zonation schemes. Usually, the nannofossils (and less frequently the planktonic foraminifers or diatoms) were used to put broad time constraints on intervals of sporadic coring or poor core-recovery, so that the magnetic record could then be used for finer resolution.

Major inconsistencies in age assignments at high latitudes using previously published tropical-subtropical biostratigraphic zonation schemes for both nannofossils and planktonic foraminifers became evident in Site 607 and recurred on every site through Site 611. This forced an even greater reliance on paleomagnetic stratigraphy, but the consistency of results in those sites clearly will result in publication of an improved version of the high-latitude North Atlantic biostratigraphy in Volume 94 of the Initial Reports.

In general, the combination of biostratigraphy and paleomagnetic stratigraphy provided numerous very tightly age-constrained datum levels at all sites.

Sediment Accumulation Rates

Relative to the global average, almost every site cored on Leg 94 had a very high sedimentation rate. Only Site 608, with rates of 10-30 m/m.y., had rates near the global mean.

The reasons for the high sedimentation rates vary. Sites 606, 607, and 609 on the Mid-Atlantic Ridge were specifically chosen in regions of locally thickened sedimentary fill, evident on seismic records. The rates of deposition at these sites range from 45 to 75 m/m.y., unusually high for the deep sea. We envisage that sediment initially deposited on locally higher topography related to basement structure is subsequently removed and transported by some kind of gentle, relatively steady form of near-bottom energy into the closed basins and lower topography that we cored. The lack of significant contamination by older nannofossils at these sites argues against strong erosion by bottom currents; for the most parts, the sediments moving about are contemporaneous with the pelagic "rain". Whatever the exact mechanism of sediment redistribution, it results in accumulation rates two to four times greater than the local mean and far higher than the global average.

The rates of deposition observed at the two drift sites (Sites 610 and 611) were, if anything, somewhat lower than expected, although still above the regional norm, and were also surprisingly steady through time at Feni Drift. Basically, these rates are no more obviously a product of bottom-current deposition than those at the three "pelagic" sites on the Mid-Atlantic Ridge; the drift-sediments did not show major differences from the pelagic sediments (see below).

The only obvious difference between the drift sites and the Mid-Atlantic Ridge sites is one of scale. On the ridge, redeposition is local in scale; sediment-deficient sources are closely juxtaposed with sites of excess deposition. For the drifts, the sediment sources are larger and far more remote, and the transport distances far larger, as are the regions of positive accumulation (the scale of the entire drift). The sources of Feni Drift sediments (Site 610) are probably the European margin and eastern Rockall Plateau. Those for Gardar Drift (Site 611) are the western Rockall Plateau and the Iceland-Faeroes Ridge. During long-range transport, considerable amounts of older nannofossils and other contaminants from a variety of sources are entrained in the flow and deposited on the drift, but in a sedimentary sequence still dominated by contemporaneous pelagic material.

Site 608 has a mean rate of sediment accumulation much nearer to the regional mean. The site is situated in a region of relatively smooth, unvarying topography and sedimentary fill, and this appears to offer less chance for local-scale redistribution and local thickening of sedimentary sequences.

Drift Sedimentology

Our sedimentological studies aimed at characterizing the deposits accumulating on major drifts resulted in additional surprising findings. The lithologies were fundamentally pelagic in type at both the Feni Drift and the Gardar Drift. As at the other Leg 94 sites, the glacial carbonate cycles dominated the upper parts of the holes and gave way downwards to nannofossil oozes, marls and chalks. No primary structures that might be interpreted as due to bottom-current activity were identified at either site. Gardar Drift sediments were generally more terrigenous than those at Feni Drift, but this is clearly due to a greater input of ice-rafted sediment and rock debris from Iceland. Feni Drift sediments contain evidence of local turbidite activity, but sharp-based, coarse-grained beds are entirely absent at Gardar Drift. We await shore-based X-radiography of the cores to confirm the lack of current evidence. Reworking of nannofossil material was recognized throughout the sections drilled, and thus we have no doubt that sediment redistribution occurred. No hiatuses were detected in the records.

Sediment Waves

The sites chosen for drilling were located within sediment wave fields at both drifts, but these fields were situated at different relative levels on the flanks of the drifts. The waves drilled on Feni Ridge were at around 2400 m water depth close to the drift crest (Fig. 3); those drilled on Gardar Drift were at 3200 m on its lower southeastern flank, where the core of Norwegian Sea overflow water turns westward before spilling into the Charlie Gibbs Fracture Zone.

Detailed PDR and 3.5 kHz profiling in the vicinity of both sites showed that the sediment waves are characteristically irregular in shape and amplitude. The wave crests around Site 611 could be traced laterally with ease, whereas only some of those at Site 610 could be traced track-to-track.

Holes were drilled on a selected wave crest on both drifts and in each case were compared with offset holes drilled in adjacent troughs (Fig. 3). Crest-to-trough lithologic variations were slight, although bed-to-bed correlations were easily definable. Some thickening and thinning of individual beds occurred, and we plan detailed shore-based grain size analyses to discern any differences in local sedimentation conditions.

Although there is little evidence of migration of the sediment waves on seismic profiles, systematic differences in accumulation-rate curves for trough versus crest holes at Gardar Drift can at this stage best be explained by Pliocene wave migration.

History of Sediment Drifts

Our prime objective at Feni Drift was to penetrate a regional seismic reflector at 0.75 s sub-bottom (two-way travel time). The reflector had been characterized by some workers as the base of the drift sequence, but others considered it a mid-drift reflector representing the onset of modern circulation in Rockall Trough. We identified the reflector as a siliceous nannofossil chalk, dated as latest early Miocene (NN4). At the level of the reflector, we recognized selective dissolution of diatoms, possibly indicative of a regional oceanographic event. No hiatus was observed; neither was there apparently a change in accumulation rate.

Another reflector at Feni Drift at 0.37 s sub-bottom (two-way travel time) represents a period of decreased sedimentation rate in the late Miocene, which correlates in time with the Messinian isolation of the Mediterranean.

On Gardar Drift a good correlation of seismic stratigraphy with downhole lithologic unit boundaries was obtained, but our plans to penetrate deep reflectors were frustrated by extremely low drilling rates in the upper Miocene sequence.

Overall, the upper parts of the two major drifts are comprised of sediments younger in age than had been estimated previously. We suspect other drift sequences examined in the light of our seismic and stratigraphic results may present a similar picture.

King's Trough

At King's Trough we sampled an almost complete sequence on its southern flank through to basement. In age the sediments range from late Quaternary to late middle Eocene (NP16). They lie on relatively fresh pillow lava basalt, dated at about 42 Ma from sediments at the contact. This matches well with a predicted age from magnetic anomaly identification. A major hiatus occurs at a depth of 462 m sub-bottom, separating green nannofossil chalks with ash layers and volcaniclastic turbidites of late Eocene age (NP17), from upper Oligocene (NP24) chalk conglomerates and pinkish nannofossil chalks: a time span of about 11.6 m.y. The Oligocene chalks display a range of soft-sediment deformation structures that suggest debris-flow processes on unstable slopes. A further interval with soft-sediment deformation structures and with conspicuous microfaulting occurs higher in the sequence within the lower Miocene. The remaining parts of the section are nannofossil oozes and chalks, except for the glacial-interglacial cycles of marl and ooze in the upper 76 m.

The interpretation of tectonic events at King's Trough from the sedimentary evidence of slope instability and volcanic activity, along with the presence of the major hiatus, agrees well with the sequence of events predicted from dredge haul, rock core and geophysical data. Following a period of Oligocene uplift and erosion, an intraplate ridge rifted in the Miocene to form the present-day King's Trough.

Leg 94 was extraordinarily lucky with respect to weather; no storm of any force affected the ship on any station, and no time was lost as a result of bad weather. The only gale-force winds encountered during the entire 55 days came three days from port and pushed the ship into port embarrassingly early.

Table 1. Summary of Leg 94 drilling.

Hole	Dates (1983)	Latitude	Longitude	Water Depth*	Penetration	No. of Cores	Meters Cored	Meters Recovered	Percent of Recovery
606	2-4 July	37°20.32'N	35°29.99'W	3007	165.8	18	165.8	154.1	93
606A	4-5 July	37°20.29'N	35°30.02'W	3007	178.4	19	178.4	156.3	88
607	6-9 July	41°00.07'N	32°57.44'W	3427	284.4	30	284.4	248.2	87
607A	9-11 July	41°00.07'N	32°57.44'W	3427	311.3	26	226.6	205.0	91
608	13-17 July	42°50.21'N	23°05.25'W	3526	530.3	59	530.3	428.0	81
608A	17-18 July	42°50.21'N	23°05.25'W	3526	146.4	16	146.4	144.0	98
609	22-23 July	49°52.67'N	24°14.29'W	3884	399.4	42	399.4	301.2	75
609A	23 July	49°52.67'N	24°14.29'W	3883	43.0	2	19.2	17.9	93
609B	23-26 July	49°52.67'N	24°14.29'W	3883	354.7	38	354.7	308.4	87
610	28-31 July	53°13.30'N	18°53.21'W	2417	723.0	27	259.2	179.3	69
610A	31 July-1 Aug.	53°13.30'N	18°53.21'W	2417	201.0	21	201.0	191.4	95
610B	1-2 August	53°13.30'N	18°53.21'W	2417	146.8	16	146.8	136.3	93
610C	2-3 August	53°13.30'N	18°53.21'W	2417	118.2	6	48.4	43.9	91
610D	3 August	53°13.47'N	18°53.69'W	2445	386.8	7	66.0	54.2	82
610E	3-4 August	53°13.47'N	18°53.69'W	2445	327.2	7	67.2	53.3	79
611	6-7 August	52°50.47'N	30°18.58'W	3203	125.8	14	125.8	112.2	89
611A	7-8 August	52°50.47'N	30°18.58'W	3201	132.0	14	132.0	99.4	75
611B	8 August	52°50.15'N	30°19.10'W	3228	8.9	1	8.9	8.9	100
611C	8-11 August	52°50.15'N	30°19.10'W	3230	511.6	47	434.8	344.1	79
611D	11-12 August	52°50.47'N	30°18.58'W	3195	244.1	14	124.8	122.3	98
611E	12 August	52°50.47'N	30°18.58'W	3195	25.7	2	19.2	19.2	100
							(3939.3)	3327.6	

*at sea level

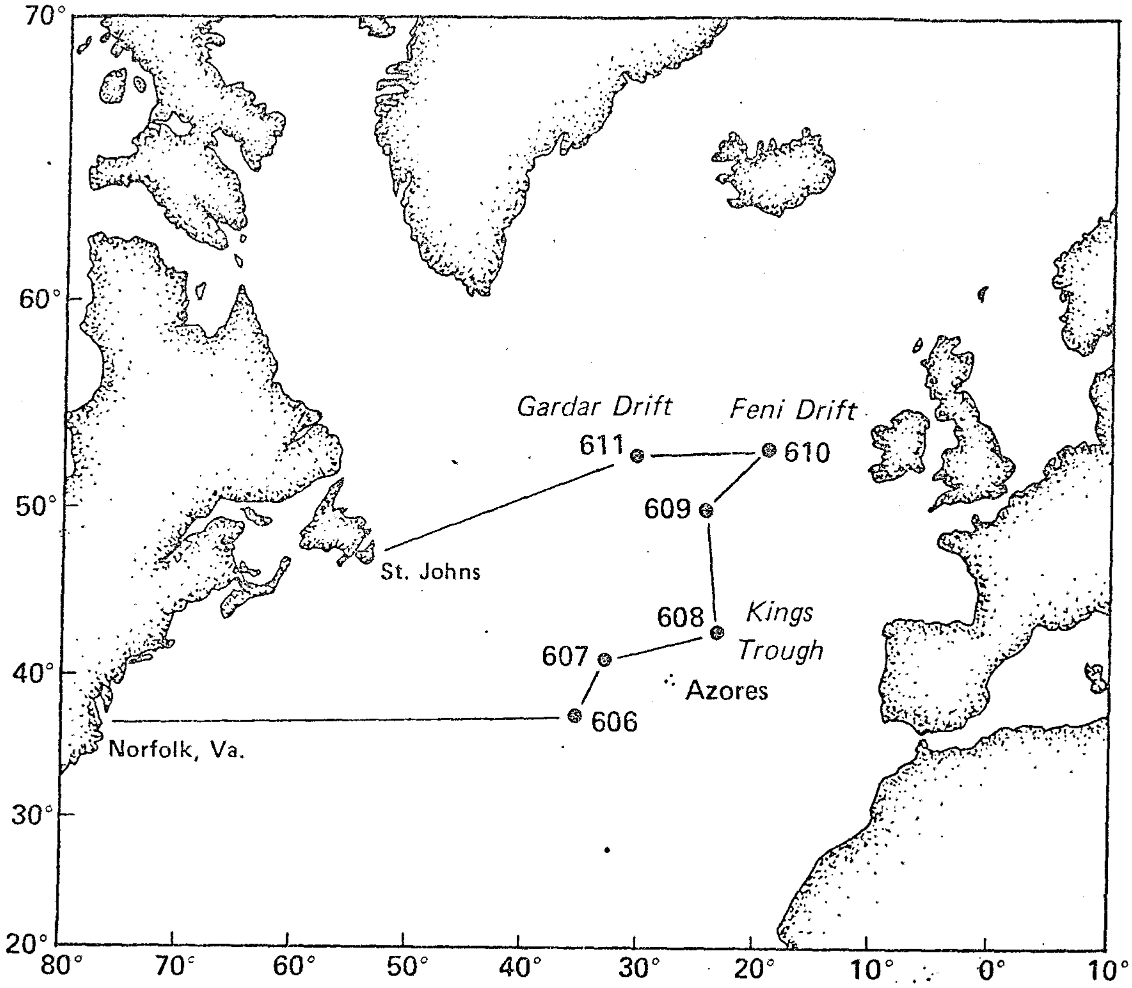


Figure 1. Location of the sites drilled on Leg 94.

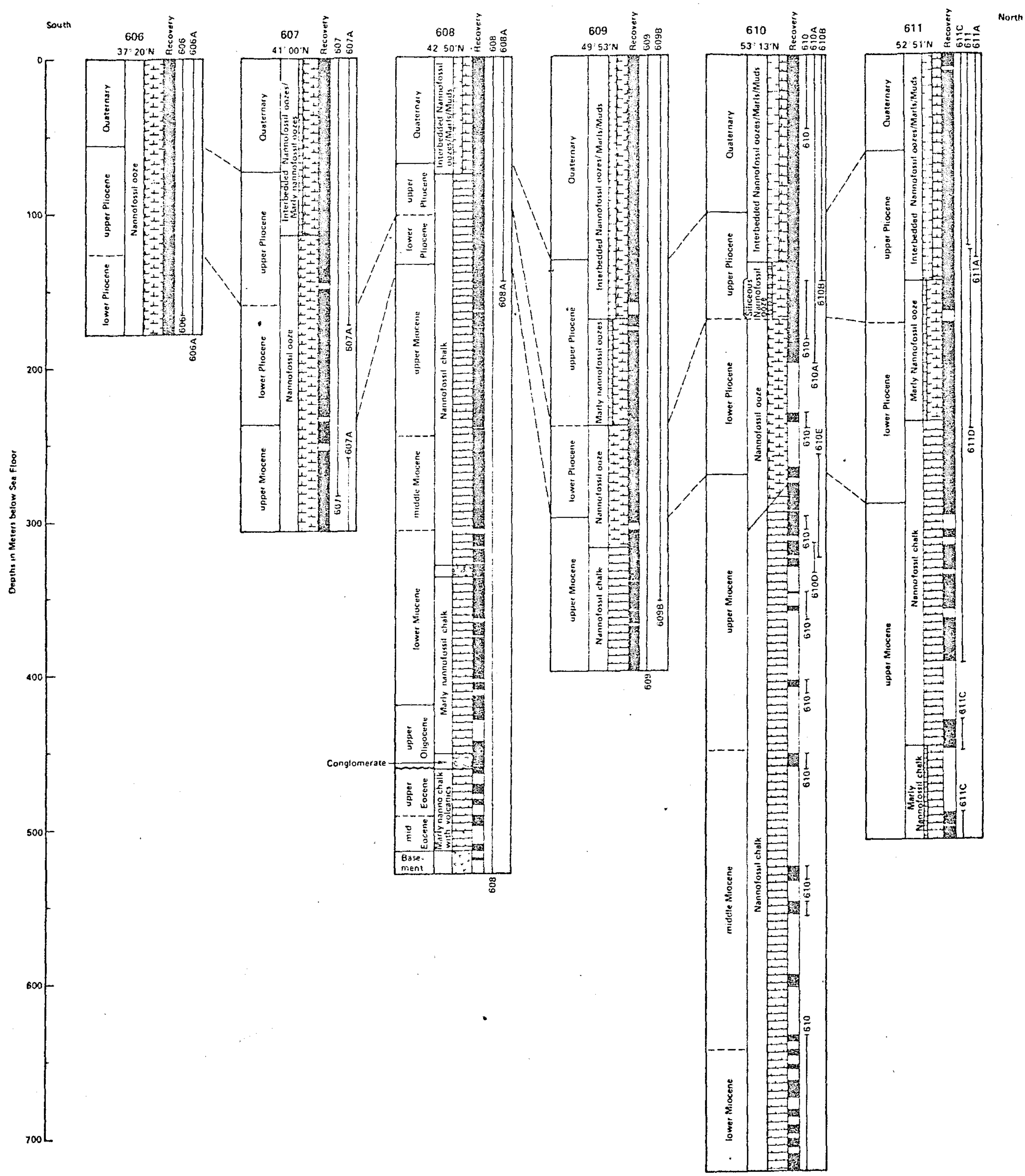


Figure 2. Lithostratigraphic columns of sediments recovered on Leg 94. The stratigraphic boundaries were drawn according to a time scale made up by the shipboard party and defined by calcareous nannofossil, foraminiferal and diatom datum levels and paleomagnetic stratigraphy.

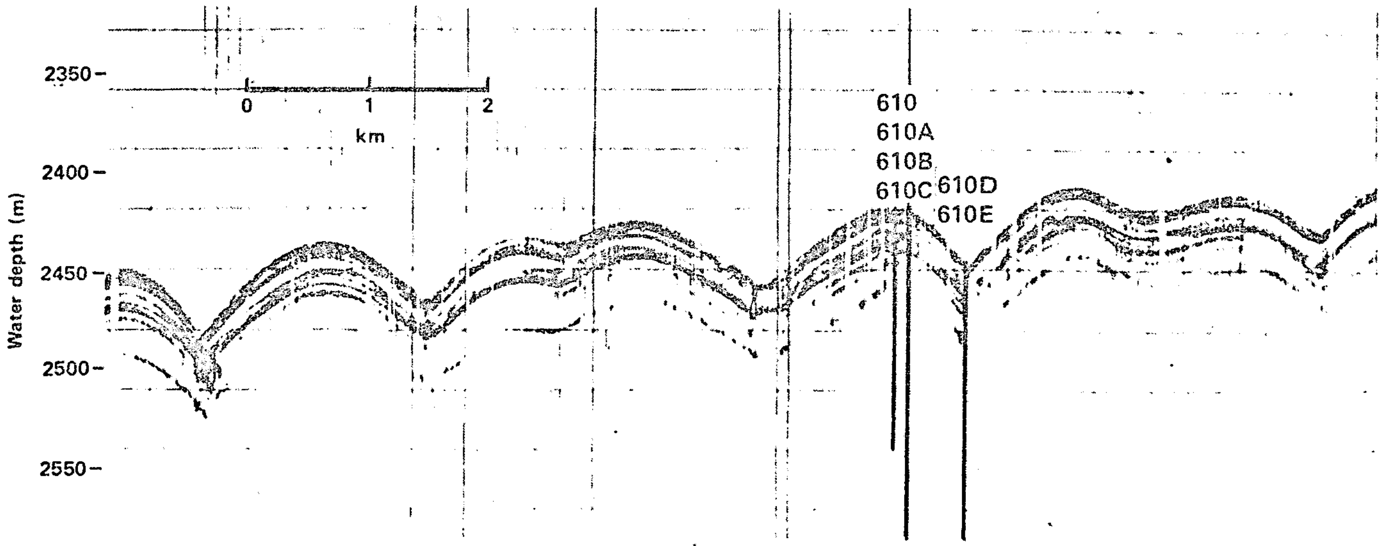


Figure 3. High resolution seismic profile (3.5 kHz) of the sediment waves on Feni Drift, illustrating location of crest and trough drilling at Site 610.

INTERNATIONAL PHASE OF OCEAN DRILLING
DEEP SEA DRILLING PROJECT
OPERATIONS RESUME
LEG 94

NORFOLK PORT CALL

Leg 94 began at 1610 hours, June 17, 1983, with the first line dockside Pier B, Sewalls Point, Norfolk, VA. In addition to the normal transfer of equipment and supplies the following tasks were accomplished:

1. Major overhaul of No. 3 engine.

2. No. 9B generator replaced.

3. Fifty nine joints of aluminum pipe were inspected. Three joints were selected and sent to Richmond for destructive tests. All pipe was within specifications.

4. A third party non-destructive test facility was employed to inspect the connections on two power subs, two swivels, and three double pin subs on board. An internal crack on the pin connection and a surface crack on the box connection were found on the stem of the spare power sub. The unit was offloaded for corrective action. All other connections were found to be in satisfactory condition.

5. Twelve new bumper subs were made up and checked for proper connections. Six subs were found to have defective pin con- nections. Defective subs were corrected at a local machine shop. Defective subs were corrected at a local machine shop.

6. Off-loaded 22 joints of downgraded drill pipe.

7. Loaded 87 joints of premium drill pipe, 265 joints of Grade 2 drill pipe, two knobby joints, and one bumper sub.

8. Loaded 220,000 gallons of fuel and 1000 sacks of gel.

9. Serviced the TOTCO drilling recorder.

A last minute personnel change was necessitated, due to illness of a member of the scientific party. A replacement was obtained from Lamont to complete shipboard staffing.

NORFOLK TO SITE 606

At 1652 hours on June 23, the GLOMAR CHALLENGER departed Norfolk The weather was excellent for the entire run. During the transit the drilling crew was trained in the assembly of the new Advanced Piston Corer (APC) and the modified Extended Core Barrel (XCB). All of the fishing and re-entry tools were boxed, listed, and stored in the mud room in accordance with the demobilization schedule work plan. The rig crew attempted to install rubber protectors on the aluminum drill pipe, but it was discovered that they would not fit. The rubbers were sized for 5" O.D. pipe, but the aluminum pipe diameter is slightly larger at the tool joint connection and tapers down in the middle of the joint.

At 2000 hours on July 1, the CHALLENGER slowed to eight knots to begin profiling for Site 606. The site was chosen on the initial west- east pass, but the beacon was not dropped until the second northeast- southwest pass. The positioning beacon was dropped at 2347 hours. Before running in the hole, a calibration was performed to adjust the range limits of the positioning system in manual mode.

The 1972.1 transit miles were covered in 8 days and 1 1/2 hours, at an average speed of 10.19 knots. Good weather reduced the estimated transit time of 9.4 days.

HOLE 606 (1)

The first site of Leg 94 was located some 210 nautical miles west of the Azores. The operational plan called for double piston coring with the Advanced Piston Corer to refusal; then deepen the second hole to 450 meters with the Extended Core Barrel. This was the first test of the new APC. Its advantages over the VLHPC included:

1. More coring force due to a larger area acted upon by the available pressure.

2. Flow control holes to calibrate the velocity of the scoping core barrel section.

3. More pull-out strength (100,000 lbf with a 40% safety factor).

4. Ease of operation due to its short length.

5. Operational guide groove along the piston rod to prevent the core barrel from rotating and preserve orientation as it is injected into the sediment.

A special bottom hole assembly was assembled which included a 3.8" diameter Seal Bore Drill Collar and a Landing/Saver Sub which together comprised the outer sealing bore for the APC. Both the APC and the XCB were spaced out in the lower BHA. An initial test of the APC was conducted which involved lowering it with the BHA until it was two stands of collars below the hull, then firing it off and retrieving it with the wireline. The APC was assembled with the grooved piston rod, one 17-4 PH shear pin, and one flow control set screw removed. It shot off at 1000 psi. There was some flow by the seals, for when the pump was shut down before firing, the pressure slowly bled off. The APC was retrieved to find no damage to the seals or landing shoulder.

The drill pipe was strapped while running in the hole. The first 60 stands were run bare; rubber protectors were installed on the last 40 stands. The first core, shot at 3020 meters (3 meters above PDR depth), was full. The second attempt, shot from 9.6 meters higher, was empty. The hole was finally officially spudded at 1857 hours July 2, with the mudline established at 3022.2 meters.

The APC recovered excellent cores, comparable in every way to those taken by its predecessor. One minor problem manifested itself from the start; the shear pin stubs from the cylinder wall of the Outer Shear Pin Sub tended to fall in and land on the inner ledge of that sub. When the tool was scoped back together the stubs became trapped between the ledge and the jam nut on the Inner Shear Pin Sub to prevent the tool from fully closing. A magnet attached to a piece of stiff wire was devised to fish out the stubs. For the first ten runs the magnet also recovered a large quantity of corrosion debris from the drill pipe. The open-topped Outer Shear Pin Sub acted as a scoop during retrieval of the APC. A further problem developed when the shear pin stubs sometimes found their way to the groove on the piston rod, which allowed them to fall through the ledge and lodge in the inner seals. For this reason the alternate grooveless piston rod was used after core 12. The shear pin problem was lessened when the technique was devised to cut the pins in half and splay one end of each half before installation. The short outer stubs stayed in the wall, but occasionally one of the now-shorter inner stubs would fall onto the ledge.

Several liner collapses and/or fractures were observed. This did not disturb the core except in the immediate interval of the failure. As the sediment stiffened, the number of shear pins used was increased to; two hard (17-4 PH) and one soft (mild steel). Also, more flow control screws were removed until all six holes were open. It was noticed that, when less than three pins were used, the shoot-off signature was very unclear. However,. with three pins the indiction was very definite; at 2700-2950 psi the weight indicator flickered, and the pressure quickly bled off as soon as the pump was killed.

The Kuster orientation tool performance was unsatisfactory. The pictures were either foggy, partially developed, shot too soon, and sometimes did not load into the unit.

Even with the time delays involved with running the Kuster tool and dealing with new concepts in the new APC system the coring rate averaged 1 1/2 hours per core. The hole was terminated at core No. 18, with a penetration depth of 165.75 meters in stiff nanno ooze.

HOLE 606A

The ship was offset 100 feet west of the beacon, and Site 606A was spudded in at 0205 hours, July 4. The mudline was established with the first core at 3023.8 meters. Piston coring with the APC went smoothly except for frequent liner fractures. The attempts to obtain orientation pictures with the Kuster tool were more successful than those at the previous hole; 7 out of 14 film discs contained useful data.

Again the APC gave positive indication of shoot-off only after three shear pins were installed (core No. 7). Also, beginning on core No. 7, a soft formation core catcher was used along with the flapper core catcher. The previous cores had been averaging about a meter short of full recovery, but starting with core No. 7, the recovery picked up to average over 9.3 meters. The increased recovery was most likely due to the addition of the soft formation catcher, but there is some speculation that the APC was not achieving full stroke with less than three shear pins--especially in the light of its similar performance on the previous hole.

An overpull of 100,000 lbs was needed to recover core No. 18. This was the first core to record any appreciable overpull. The APC was designed to safely withstand no more than 100,000 lbs. overpull. Core No. 19 registered only 20,000 lb overpull. While attempting to retrieve core No. 20, the pin connection on the center piston rod broke at 40,000 lb overpull. The entire scoping section and the lower piston rod was lost downhole. An unsuccessful attempt was made to wash over and retrieve the fish before tripping the drill string back to the mudline.

A decision was made to respud and wash down to 3178.8 meters, then to continue with the Extended Core Barrel. The first XCB was go-deviled down and followed with the overshot. A newly designed latch was tried; in order to eliminate the "sticking-in-the-pipe" problem. The overshot contacted the XCB about 30 meters too high, and it was first thought that the latch stuck in the pipe. But the tool lifted easily and, when lowered again, stopped in the same place. After several such attempts, it was decided to cut a three meter core to determine if the XCB had landed too high. A full three meters of sediment was recovered, which seemed to signify that the flag on the wireline was in error. The second XCB was go-deviled and again followed by the overshot, but only far enough to ensure that the XCB had not stuck higher in the pipe.

After cutting 6.5 meters, the overshot was lowered and made contact at 22 meters below the depth of the previous barrel, but could not pick up the XCB. The TOTCO recorer showed a 10,000 lb weight loss when the BHA was 30 meters into the hole. The drill pipe was tripped to find that 41 meters of the BHA had broken off at the pin connection on the mandrel of the lowest bumper sub. A complete XCB assembly was lost downhole along with the only Seal Bore Drill Collar and Monel drill collar aboard. Thus APC coring and Kuster orientation were finished for the rest of this leg. There were sufficient XCB components aboard to continue its operation when spaced out to match the length of the VLHPC.

Since an important 3.2 m.y. objective had already been reached, and the deeper Miocene objective could be satisfied at the next two sites, it was decided to terminate operations and save some time for use later in the cruise.

SITE 606 TO SITE 607

The ship got under way for Site 607 at 1745 hours, July 5. During the 25-hour transit the rig crew magnafluxed the bottom joint of the middle stand of collars used in the last hole; no flaws were found. The XCB was assembled as follows: The upper section above the quick release consisted of the one remaining new latch and spacers to match it to the length of the VLHPC. One new-style lower section was assembled, and one old-style (Leg 93 version) lower section was assembled. The main differences between the two versions are that the new-style includes a Vent Sub to take the place of the field-modified Bearing Shaft, and the maximum O.D. of the core barrel is 3.5" instead of 3.75".

HOLE 607

A beacon was deployed on the first pass at 1905 hours, July 6. A new bottom hole assembly was made up, and the VLHPC and XCB were spaced out in it. It was discovered that the Dogs on the new XCB Latch did not fall in flush with the 3-3/4" diameter Latch Body. This prevented the Dogs from passing through the Landing/Seal Sleeve in the Head Sub. The problem was solved by reducing the thickness of the lower Latch Washer to allow the Dogs to travel all the way down the ramp on the Pulling Neck.

The mudline was established, after one water core, at 3426.1 meters (5.1 meters lower than the PDR depth). Piston coring with the VLHPC proceeded smoothly except for frequent liner fractures. The sediment was similar to that of Site 606, and the recovery was excellent. Core No. 15 would not pull free at 40,000 lb overpull--the preagreed limit. It was washed over to retrieve, and the XCB was made ready to continue in the hole.

Unless otherwise noted, the XCB barrels were assembled with the Soft Formation Cutting Shoe OP4458. The first barrel was go-deviled down after topping off the pipe with water. It landed hard because the pumps were not shut off before it reached bottom. A circulation rate vs back pressure calibration was conducted by recording the pressure at various flow rates. At 20, 30, 40, and 50 spm, the back pressure through 3572.4 meters of pipe was 150, 350, 600, and 925 psi respectively. A 9.6 meter core was cut and retrieved to find the upper 1/4 section of liner had shattered. 6.17 meters of firm nanno ooze was recovered. The second XCB landed softly, but the drill pipe was not topped off beforehand. The liner returned completely shattered with little recovery. The subsequent barrels were wirelined down to prevent shattered liners..

Cores 18-24 had excellent recovery. The jet ports in the cutting shoe never clogged with mud. Core No. 25 recovered only about 50%. The jets were clogged, and one cutting tooth was cracked (it was later weld-mended and successfully reused). The recovery was erratic for cores Nos. 26-30. There was no apparent lithology change. The Acker Geoset cutting shoe was used for core No. 29; it recovered 4.27 meters. It was decided to terminate the hole after core No. 30, at a subbottom depth of 284.4 meters.

SITE 607A

The pipe was pulled to clear the mudline, the vessel was offset 100 feet to the north, and Hole 607A was spudded at 0400 hours, July 9. Nineteen VLHPC cores were taken to a subbottom depth of 159.0 meters-- a few cores deeper than on the previous site. The last few cores had badly fractured or buckled liners attesting to the stiffness of the nanno ooze.

Two XCB cores were taken to a subbottom depth of 173.6 meters in order to overlap a critical section of the last hole. Then the bit was washed down to 258.3 meters, and coring was continued in an attempt to recover some of the lost sections of the previous hole. The recovery this time was much better; it averaged 80.5%. The hole was terminated after core No. 30, with a total penetration of 311.3 meters.

The Core Barrel Pressure Tool (CBPT) was tested twice (XCB) cores 20 and 22). This instrument was designed to be run with the XCB or rotary barrel, and records the pressure every 5 seconds in the core barrel above and below the check ball, and outside the core barrel in the annulus. One XCB lower section was fitted with the CBPT which required shortening the core barrel to 5 meters. Extra time was taken to run the tool downhole in order to mark events such as "tool landed" and "begin coring" with an intentional pressure spike which would hopefully be visible on the recorded data. Pressure data was successfully recorded on both runs, but upon later analysis of the voluminous pages of data it was observed that the transducers responded sluggishly to downhole pressure changes. The cause was traced to clogged pressure lines leading to the transducers. Grease had been applied at the three port inlets to the transducers to prevent clogging from particles in the circulation water. Apparently the grease had been forced into the small diameter tubes behind the ports. Less grease will be used for future runs.

After clearing the mudline, three drop tests wee conducted with the XCB in an effort to determine the exact cause of the shattered liners which occurred when the tool was go-deviled. First, it was dropped down the drill pipe (topped off with water) and retrieved with the overshot before landing. The same test was repeated, but without first filling the pipe. Finally, it was dropped and allowed to land before retrieving. No failures of the liners were noted during the drop tests.

SITE 607 TO SITE 608

The CHALLENGER got under way at around 0500 on July 11. A course of 068 degrees was set to cross the mid-Atlantic Ridge towards Site 608, 300 nautical miles north of the Azores. During the trip the rig crew magnafluxed the two remaining bumper subs (Nos. 2033 and 2099) from the BHA used on Site 606. A crack was found in the mandrel pin of No. 2033; it was broken down and put in the mud room. The VLHPC and XCB barrels were broken down and redressed. Six broken springs were replaced in the XCB. At 0555 hours, on July 13, the beacon was dropped on the first pass at Site 608.

HOLE 608

The site was located over a small knoll in the basement where the sediment cover was about 500 meters. The coring plan was to VLHPC/XCB to basement, then recore the top of the hole with the

VLHPC. The BHA was the same as that used on the previous site. One water core was recovered. The next barrel was damaged when set down too hard on the hang-off clamp; the shear pins sheared, and the resulting impact when the tool scoped open sheared the dogs on the Quick Release Shoulder Sub and split open the Quick Release Cap Sub. AT 1542 hours on July 13, Core No. 1 was spud in to establish the mudline at 3533.6 meters.

Sixteen VLHPC cores were taken in nanno fossil marl before switching over to the XCB. Core No. 3 returned empty, though there was evidence of core in the barrel; the flapper core catcher stuck open in the adhesive sediment. A combination flapper/soft formation core catcher was used for subsequent cores. Two liner failures occurred as the sediment stiffened. On core No. 14, the top of the liner was forced past the stop ledge in the Upper Liner Seal Sub, and the piston could not be retracted from the liner. It was freed after about 20 minutes of pulling and heating with a blow torch. On core No. 15, the liner failure consisted of a spiral fracture circling the liner three times in the length of a meter near the top. Core No. 16 would not pull free with 40,000 lb overpull and was washed over to retrieve.

The XCB coring continued to basement at 530.3 meters subbottom. The lithologies became increasingly lithified; cores were split using the saw beginning with core No. 26. Recovery averaged over 90% to 380 meters. The Geoset cutting shoe with a Modified Core Catcher (OP4487) was tried in the rapidly hardening chalks on core No. 33. Only 3.66 meters were recovered due to jamming in the core catcher. Continued XCB coring with the soft formation shoe resulted in variable recovery through hard chalk lithologies. There appeared to be a fine line to toe regarding the amount of circulation to use. Occasionally cored intervals were washed away and the cutting shoe would jam. The diameter of the hard chalk was normally 5.5 cm reflecting the I.D. gage of the horseshoe-borium grit on the cutting shoe. In some sections the I.D. shrunk to 5 cm; probably due to a slight wobble in the XCB when the bit stood longer on harder formations. There was no evident damage to the cutting shoes. The Geoset shoe was again tried for core No. 44, this time using the Acker split ring core catcher; the entire core slipped away.

Erratic pebbles dropping downhole may have caused some of the recovery problems; cores Nos. 52 and 53 were found to have single large glacial erratic pebbles set within a disturbed zone at their tops. Also, in core No. 52, the liner was twisted off in two places. It was assumed the liner was held still while the barrel rotated and failed due to over torquing.

A number of minor excursions from the 13.5 kHz beacon throughout the day of July 16 may have impeded recovery. The weather was not adverse, but there was a strong current at a right angle to the wind. The ship's positioning was erratic even though the beacon appeared to have a good signal. At 2200 hours, a 16 kHz beacon was dropped. The positioning became much more steady, though the strong current still required a close monitoring of the positioning system.

By core No. 50, the rotating time per core became appreciable (20 plus minutes). Beginning core No. 55, cores were go-deviled, rather than risking damage to the wireline by excessively rotating around it. None of the subsequent core liners shattered. After coring two meters on core No. 57, a very hard formation was encountered; one additional meter was cored before retrieving the barrel. 70 cm of fairly fresh vesicular basalt with calcite veining was recovered along with 3.8 meters of sediment. The soft formation cutting shoe was replaced with the Acker natural diamond shoe (with jet ports) for the next two cores. Both recovered less than a meter of basalt. In core No. 58, run with the modified core catcher, basalt fragments jammed in the core catcher. In core No. 59, run with the Acker split ring core catcher, the basalt jammed in the lower liner support sleeve. The shoe was destroyed on core No. 59. Cracks had initiated at each jet hole, and the shoe splayed out of gage. Total basalt recovery was 2.2 meters out of 16.2 meters cored. The drill pipe was pulled to clear the mudline at 1230 hours on July 17.

HOLE 608A

After offsetting 670 feet bearing 247 degrees from the previous hole, 608A was spudded at 1419 hours on July 17. Sixteen VLHPC cores were taken to a depth of 146.4 meters. The coring breaks were staggered with relation to Hole 608, so that a continuous detailed stratigraphy could be pieced together. The last core was on deck at 0923 hours on July 18, and at 1540 hours the ship was underway.

SITE 608 TO SITE 609

Upon leaving Site 608, a short southeasterly run was made to profile over the beacon. A south to north profile was made across the western end of King's Trough complex before getting underway for Site 609. The axis of the trough was crossed at around midnight and the traverse displayed a striking profile on the records. In addition, it provided evidence of a mid- trough basement intrusion unmapped by previous surveys.

During the transit four of the old bumper subs were magnafluxed. Three of them (Nos. 1849, 2044, 2411) were found to have cracks in the mandrel pin. The fourth was okay. The VLHPC and XCB were redressed. Two new core catchers were fabricated for use with the Acker cutting shoes; it was evident from its previous failures that the Acker shoes were gaged slightly too large (2.5" I.D.), so that the core easily jammed in either the core catcher or the liner support sleeve, both of which were also 2.5" I.D. To circumvent this problem, two 2-5/8" I.D. sleeveless core catchers were brazed to the threaded sections of two Acker Core Lifters. Future runs of the Acker shoe will have the modified core catcher along with the Alternate Liner Support Sleeve. About one half of the wall thickness will be reamed out of the lower inside of the core liner to accommodate the length of the support sleeve. This assembly will present a minimum 2.6" I.D. between the cutting shoe and the core liner, and should alleviate the jamming problem. At 1647 hours on July 20, a 16 kHz beacon was dropped to mark Site 609.

HOLE 609

The same BHA and core bit were used. After rotating several hours in basalt at the last site, the bit had one slightly loose cone with two chipped teeth, but was still in good condition. The pipe trip to the mudline was slowed by fog and a heavy swell. Spud-in occurred at 0255 hours on July 21. The mudline was established with the first core at 3883.6 meters.

Fourteen VLHPC cores were taken in gradually stiffening marly nanno ooze. Cores Nos. 13 and 14 suffered badly split core liners. Core 14 did not stroke fully and would not pull free with 40,000 lb overpull; it was freed after washing four meters over the barrel. Thus, after penetrating 130.6 meters, operations switched over to XCB coring.

The XCB was run for cores Nos. 15-42. Cores Nos. 15-22 were go-deviled, but after the liners shattered on cores Nos. 19 and 22, the core barrels were run in on the wireline. The recovery was very good until core No. 18, which was inadvertently run without a liner and recovered only 1.99 meters. Only 7.2 meters was recovered in the subbottom interval between 188.2 meters and 236.2 meters (cores Nos. 21-25). Two zero recovery cores may have unlatched prior to coring due to heave-induced wireline tension. Recovery increased for cores Nos. 26-30. Then, there were three low recovery cores which appeared to be mostly washed away. The recovery improved again with core 34, averaging 95% for the bottom nine cores in the hole. Coring was ended at 399.4 meters subbottom depth with the scientific objectives reached.

The Geoset cutting shoe, with the newly modified core catcher, was used for cores Nos. 27, 29, and 31. Fair recovery was achieved, but always lower than the neighboring cores taken with the soft formation shoe.

HOLE 609A

Fourteen stands of pipe were pulled and the ship was offset 200 feet northwest from the beacon at 1500 hours on July 23. Two mudline cores were taken and discarded since they had not recovered the critical top-most sediment; it was at first believed that it was caused by the ship's heave and or loose pebbles which might have been pushed ahead of the corer. The ship was positioned back over the beacon for the third (official) spud-in which occurred at 2020 hours. This mudline core was essentially no different from the previous two, but a second core was taken before it was discovered that the bit was one stand too deep into the hole due to an error in the pipe count; 15 stands should have been pulled to clear the mudline.

At 2240 hours, the pipe was pulled to clear the mudline. Since so much time was spent, and the last two cores were saved, it was decided to call this a site.

HOLE 609B

The first core, spudded at 2345 hours on July 23, recovered the elusive top sediment layer. Fourteen VLHPC cores were taken before the overpull limit was reached. The hole was continued with the XCB to a subbottom depth of 354.7 meters. The recovery was generally very good in this hole except for cores Nos. 16, 18, 37, and 38. The intervals of poor recovery were competely different from those in Hole 609, thus emphasizing the apparent randomness of whatever factors account for the sporadic recovery between 140 and 350 meters subbottom depth.

HOLE 609C

The drill pipe was pulled to clear the mudline at 0430 on July 26. The ship was offset 100 feet and Hole 609C was spudded at 0545 hours. The bit was washed down 125 meters to the top of an interval that had been irregularly cored both at Holes 609 and 609B. Seven XCB cores were taken to a subbottom depth of 190.4 meters with 52% recovery.The first four barrels were wirelined down, but after core No. 3 returned empty (probably wireline tension caused pre-release of the latch) the last three barrels were go-deviled down. The liners did not shatter on any of these runs.

Due to the relatively poor recovery, the coring was stopped short of the original objective, which was to take 14 cores through this interval.

SITE 609 TO SITE 610

The CHALLENGER got underway from Site 609 at 0305 hours on July 27. A brief west southwest course was run to stream the gear, then turned to cross the beacon and proceed on to Site 610.

At 0644 hours on July 24, the vessel slowed to eight knots to make an extensive profile of the site area. At 1724 hours, a 13.5 kHz beacon was let go over the crest of a mud wave to mark Site 610. A few more lines were run across the beacon before the gear was pulled. The ship finally settled over the beacon at 2045 hours.

HOLE 610

The objectives of the site were to piston core to the base of the upper sedimentary unit--expected to be comprised of drift material, then to spot core with the XCB through the R-4 reflector to about 690 meters subbottom.

The first core, on deck at 0440 hours on July 29, was full so another core was taken from 9.6 meters higher; it was empty. The mudline was thus established with the first core to be at 2427.7 meters. Five VLHPC cores were taken to a subbottom depth of 48 meters. Cores Nos. 3, 4, and 5, showed considerable coring disturbance, confined mostly to the upper five meters in each core, which may have been due to the ship's motion (10 ft heave and 3-5 degree pitch). It was decided to wash down to 147 meters and continue with XCB coring. Three continuous XCB cores were taken to 185.4 meters subbottom; all were pelagic nannofossil oozes with no evidence of current deposition. Between cores Nos. 9 and 19 an average of one in five core intervals was cored, such that the cores were spaced approximately 50 meters apart. Rates of recovery slowed from 2-1/2 hours to 5-1/2 hours over the 25-1/2 hour period. The stiffening chalk necessitated running a core barrel for each washed interval. Continuous coring resumed with core No. 19 at 636.6 meters subbottom. The last seven cores were taken over the presumed interval of the R-4 reflector to a terminal depth of 723 meters subbottom. The drill pipe was pulled to clear the mudline at 2200 hours on July 31.

XCB recovery for the lower section of the hole averaged 58% in very hard chalk. The soft formation cutting shoes, used exclusively, suffered no excess wear or damage. All of the barrels were go-deviled resulting in only one shattered liner (core No. 12). However, several of the liners returned with bulging deformations, sometimes just above the core catcher, sometimes mid-way up the liner. These plastic deformations, apparently caused by the intruding core, did not impede core recovery in comparison with neighboring cores.

The Core Barrel Pressure Tool (CPBT) was run with the wash barrel between cores Nos. 18 and 19. It obtained good pressure data which showed that the intruding core had to overcome a back pressure of 270 psi (at 60 spm) to lift the check ball at the top of the core barrel.

HOLE 610A

Hole 610A, with no offset, was spudded in at 2340 hours on July 31. Twenty one piston cores were taken to a depth of 201 meters subbottom. Disturbance was noted in cores Nos. 2, 4, and 5.

Below 47 meters the disturbance, now presumed to be due to swell, did not occur. The sediment was very stiff; 10k overpulls were observed as early as core No. 6, with cores Nos. 17 and 18 registering 40k overpulls. Nevertheless, the recovery was very good (95%) and undisturbed throughout the interval of glacial/interglacial carbonate cycles.

HOLE 610B

Again with no offset, Hole 610B was spudded at 2200 hours on August 2. Sixteen VLHPC cores were taken to a depth of 146.8 meters sub- bottom. In an attempt to reduce the effects of heave in the top-most cores, the VLHPC was rigged with the breakaway piston head for the first six cores, Cores Nos. 1 and 2, were undisturbed, while cores Nos. 3, 4, and 5, were disturbed over part of some sections. The piston head broke away each time, but the sea conditions had also improved, so it was not clear whether the small improvement was due to the breakaway head or the calmer sea.

HOLE 610C

The lack of some critical stratigraphic intervals necessitated still another hole on the sediment wave crest. Hole 610C was spudded at 1607 hours, with an immediate wash down to eight meters subbottom. The 5-meter long VLHPC was used to take the first two cores through the easily disturbed zone. This time the cores were recovered undisturbed. Four more 9.6 meter-long VLHPC cores were selectively taken to a subbottom depth of 118.2 meters.

HOLE 610D

This hole was offset 800 feet north and 1520 feet west of the beacon to a trough adjacent to the mud wave crest. It was spudded at 0300 hours on August 3. Five VLHPC cores were taken to a subbottom depth of 56.4 meters, with one core interval washed where no useful stratigraphic data were expected. The bit was then washed down to 317.6 meters subbottom where two XCB cores were taken in an attempt to a possible Miocene stratigraphic hiatus identified in hole 610. Dating of the cores revealed that the critical interval had been missed by approximately 40 meters due to a decreased sedimentation rate in the trough. The hole was terminated at a subbottom depth of 386.8 meters.

HOLE 610E

This hole was spudded at the same offset at 1543 hours on August 3. The bit was washed to 260 meters before taking seven XCB cores to a terminal depth of 327.2 meters. The stratigraphic section missed in the previous holes was successfully recovered. The drill pipe was tripped, and the bit was on deck at 0830 hours on August 4.

The drill bit was retired from use after penetrating some 2685 meters and a rotating time of 45 hours. It had three loose cones.

SITE 610 TO SITE 611

The 2.1 day trip to Site 611 was characterized by moderate gale conditions and, at times, dense fog. The three new bumper subs in the BHA were magnafluxed. They had 44-1/2 hours rotating time on the previous three sites. One of the three had a cracked bottom sub pin. The XCB was redressed.

The bottom profile in the area of the site was characterized by mud waves. Since a previous survey of the area existed, the beacon was dropped on the first pass over the crest of a likely mud wave. The gear was retrieved and the ship returned to the beacon without further survey.

Positioning was delayed by about 25 minutes when routine switching of hydrophone arrays caused the beacon to jump off the scope. The hydrophones were checked, but the problem was ultimately traced to a faulty X-Y switching relay. The faulty relay was replaced and corrected the problem.

HOLE 611

At 2115 hours on August 6, the first piston core was spudded to establish the mudline at 3202.6 meters below the rig floor. Fourteen VLHPC cores were taken to a total subbottom depth of 125.8 meters before the 40K pullout limit was reached. Nearly all of the liners fractured, but recovery was very good in the stiff nanno ooze. In order to take advantage of the good weather, it was decided to pull out and immediately recore the upper section.

HOLE 611A

The first core came aboard at 1530 hours on August 7. Again, 14 cores were attempted, but the last core had no recovery due to a stuck flapper core catcher.

An extra lower liner seal sub with O-rings was added to the bottom of the core barrel in an attempt to reduce the number of fractured liners. The liners fractured a little less frequently, but no conclusive results could be drawn. The liner of core No. 9 was apparently totally shattered. When it was attempted to hydraulically extrude it from the barrel, the plastic shards compressed into an immovable plug. The barrel was eventually cleaned out with water and a blow torch which resulted in the loss of nearly the entire core.

HOLE 611B

On 0730 hours on August 8, the bit had cleared the mudline from Hole 611A, and the ship was offset to a new location 2000 feet north- northwest of the beacon in search of an adjacent mud trough. The bottom hardly dropped at all during the move, so several different positions were tried along a general easterly course. Eventually the trough was located 2990 feet south and 2990 feet west of the beacon. Six hours had been consumed by the offset survey.

Hole 611B was spudded at 1345 hours at a depth of 3227.7 meters. During the second VLHPC coring attempt, the barrel parted at the pin of the top sub body, leaving nearly the entire tool in the hole. No fishing attempt was made because, if it were still in the BHA, the upward looking component of the fish was the outer swivel body with the broken pin of the top sub. The shallow cavity could not be stabbed by the standard fishing tool, and there was insufficient time remaining to fabricate and attempt to fish with a specialized spear. Thus the hole was terminated after one core.

Hole 611C

The hole was spudded at 1615 hours without any offset from the previous hole. Fifteen VLHPC cores were taken with generally good recovery except for core No. 7, which may have had a stuck core catcher. The first three cores were taken with the five meter VLHPC until a new 9.5 meter VLHPC could be assembled to replace the lost one.

The XCB was used to deepen the hole to 511.6 meters subbottom. Two shattered liners, in cores Nos. 21 and 23, were observed to be linked with the old-style XCB barrel. Beginning with core No. 25, the old- style barrel was wirelined, and the new-style barrel was go-deviled. No more shattered liners occurred.

The XCB recovery was generally very good with the exception of two low-recovery cores and one zero-recovery core. In one of the low- recovery cores, a large drop stone (nearly the diameter of the liner) was recovered along with 2.61 meters of sediment. The zero-recovery core was wirelined down, and may have unlatched early due to heave- induced wireline tension.

Considering the high sedimentation rate observed in the cores, it appeared unlikely that the 14 m.y. objective would be reached within the remaining time. To hasten the progress, two 38.4 meter intervals were washed after cores Nos. 43 and 45, but the hole was eventually terminated short of the primary objective.

HOLE 611D

With the time remaining, it was decided to reposition over the beacon and drill deeper into the mud wave crest. One VLHPC core was taken from 5.5 m to 15.1 m subbottom. The bit was then washed down to 128.9 meters to begin continuous XCB coring. Nearly every core was totally full. Only five meters were cored for core No. 6 during an XCB/CBPT run. Good pressure data were obtained by the CBPT. To core off the rest of the 9.6 meter joint, a 4.6 meter core was cut; but core No. 7 recovered 7.2 meters of good core (no slop at the top). Assuming that the bit may have been 2.5 meters too deep for that core; the depth at which the bit took weight was checked and found to be at the proper depth. The next 9.6 meter core had full recovery. Core No. 7 remains a mystery.

A total of 13 XCB cores were taken to a subbottom depth of 244.1 meters.

HOLE 611E

After the mudline was cleared on Site 611D, the bit was spudded to obtain two piston cores from 6.5 m to 25.7 m subbottom. The purpose of these cores was to overlap a distorted zone.

At 1030 hours on August 12, the drill pipe was tripped The BHA was magnafluxed while coming out of the hole. A crack was discovered around the middle of the pin thread of the pup joint. The vessel got under way for post site survey at 2146 hours on August 12.

SITE 611 TO ST. JOHNS

A post site survey was conducted in an attempt to discover the shape of the sediment wave on which the site was located. It became clear that the wave is a broad double-crested feature that extends over one half n.m. in a south to north direction. It would have been impossible to offset far enough northwards while maintaining the beacon signal, and still reach the trough in that direction. The offset maneuvers to the north and northwest had all been around the broad sediment wave crest.

The 4.5 day trip to St. Johns was busy with the usual end-of-leg activities. By the second day of the transit the weather had deteriorated to the worst experienced in the last two months. For a full day the CHALLENGER braved force 8 gale winds, 18 foot seas, and 16 degree rolls. The next day was sunny, but with strong head winds. The remainder of the trip was characterized by usually strong head winds and dense fog at times. No icebergs were spotted, though concentrations of icebergs were known to be in the area.

The voyage officially ended with the first line dockside in St. Johns at 1051 hours on August 17, 1983.

DRILL STRING

Eighty seven joints of premium and 265 joints of Grade 2 drill pipe were loaded in Norfolk to partially replace the drill string lost on Leg 93. The Grade 2 pipe was stored in the hold. The racks now contain 299 joints of new pipe, 309 joints of premium pipe, and 56 joints of aluminum pipe. One joint of aluminum pipe was discovered to have a gash located three feet above the lower tool joint. It was marked and will be inspected in port.

One thousand clamp-on type rubber protectors were installed on the premium pipe while running in the fist hole. Four protectors per joint were spaced at intervals of 5', 5', 8', and 8', from the top of each of the top two joints in a stand. The spacing for the lower joint in the stand was 5', 5', 7', 7', in order to miss the fingers of the pipe racker.

The 20' pup joint developed a crack around the middle of the pin thread which was discovered during routine magnafluxing while coming out of the final hole of the leg..

BOTTOM HOLE ASSEMBLY

All of the sites involved only HPC/XCB drilling. A special BHA was used for the first site to accommodate the new Advanced Piston Corer (APC). It comprised an HPC/XCB bit, bit sub (including Guide Ring OL0131, float valve, and a special 3.8" I.D. support bearing), Bit Sub Spacer OG0621, Seal Bore Drill Collar OL1043, Landing/Saver Sub OG0620, 3' spacer, top sub, head sub (including Latch Sleeve OL1013), Monel drill collar, 8-1/4" drill collar stand, bumper sub, 8-1/4" drill collar stand, two bumper subs, two 8-1/4" drill collars, crossover sub, 7-1/4" drill collar, and two heavy wall drilling joints.

In order to correctly space the Kuster orientation tool within the Monel drill collar, it was necessary to move the jars from the top to the bottom of the overshot/sinker bar assembly. This raised the position of the Kuster tool with respect to the APC top sub, which was designed to land lower in the BHA than the VLHPC top sub.

The special BHA was lost in the second hole of the first site. The BHA used for the rest of the cruise included the following: bit, bit sub (including guide ring, padded float valve, and support bearing outer race), outer core barrel, two 3' spacers, outer core barrel, top sub, head sub (including Latch/Seal Sleeve

OL1014), two 8-1/4" dri llars, bumper sub, 8-1/4" drill collar stand, two bumper su two 8-1/4" drill collars, crossover sub, 7-1/4" drill collar two heavy wall drilling joints.

The loss of the BHA was to a brittle failure the mandrel pin on the lowermost bum ub. All of the bumper subs in that assembly had been used usly. The two remaining subs were later magnafluxed to that one had circumferential cracks around the base of the pin, and the other had a possible crack in the bottom sub

New bumper subs were us the BHA for the remaining sites. These subs wee magna between Sites 610 and 611 (after 44-1/2 hours rotating hour e of the three had a crack across the pin-end shoulder a tending approximately one inch up the body of the body of the om sub. The four remaining used bumper subs were als gnafluxed; three had cracked mandrel pins. On board at pres re eleven new bumper subs, two old ones that are in good c ion, and five cracked ones.

CORE BITS

Three HPC/XCB core bits used for the 22 holes cored on Leg 94. The first was l with the lower BHA in Hole 606A. The second was used for Hole 7 through 610E. It had worked a total of 45 hours was and rotating XCB cores, six hours of which were in basalt. It s three loose cones and a few chipped teeth. It may still eful for short HPC holes. The third bit, used for the last si les at Site 611, has two chipped teeth and one slightly l cone.

POSITIONING AND BEACONS

No major problems were en ntered with the positioning system though on several inst es the heavy seas caused a temporary loss of acoustics. One switching relay was discovered to be faulty and was replaced w coming on Site 611.

Seven beacons, 4 ea, 16 k and 3 ea, 13.5 kHz, were used on the six sites of Leg 94. functioned flawlessly except for the 13.5 kHz beacon (Serial N 162) dropped on Site 608. Though it maintained a good signal, the ship's positioning was erratic for the 90 hours it was used. 16 kHz beacon was dropped to replace it, and the positionin mproved considerably. The new beacon landed 270 feet north and 0 feet east of the old one, attesting to the strong currents in area.

EXTENDED CORE BARREL (XCB)

The success of the cruis entially hinged upon the success of the XCB since every si had both shallow (HPC) objectives and deeper (XCB) objectives. The overall XCB core recovery was excellent. The new latch did not jam in the drill pie during either wireline or go-devil trips. The new vent sub/liner hanger functioned as designed with no problems.

The soft formation cutting shoe also functioned well throughout the entire range of soft sediment through basalt. One reason for the good recovery was that the inner gage bore of the cutting teeth was only about 2-1/4" diameter. The soft cores did not show evidence of this, but the hard cores were typically only 2.16" diameter. In some cases the diameters reduced to less than 2" when the bit 'stood' on a particularly hard formation longer, allowing more jet scouring and/or more reaming due to a slight wobble in the tool.

The Acker hard formation cutting shoes were tried a few times with poor results. In general, though, the sediments were too soft to use the Acker shoes effectively. In the one case where basalt was cored with a diamond shoe with jet ports, the shoe was destroyed when cracks initiated at each of the ports.

The disc springs, exposed to long hours of continuous operation, were inspected after each site. Sometimes as few as six, and other times as many as 54 springs were found cracked or broken and had to be replaced.

About 50% of the XCB runs were wirelined because the liners would sometimes shatter when the barrels were go-deviled. The shattered liners occurred erratically. Several drop tests down the pipe were conducted under varying conditions, but, no liners shattered during these tests.. At each hole the XCB was usually go-deviled until the occurrence of one or two shattered liners; then it was wirelined. When the rotation time per core increased significantly near the bottom of the hole, the XCB was again go-deviled, usually without suffering shattered liners.

ADVANCED PISTON CORER (APC)

The APC was very successful in its first sea trials on Holes 606 and 606A. Its ease of operation, short length and greater coring force definitely make it the piston corer of the future. The antispiral groove on the piston rod prevented core rotation during shoot-off, and will be an asset to paleomagnetic data recovery. Unfortunately the APC was lost in Hole 606A, when the piston rod parted, apparently due to fatiguing from a previous 100K overpull.

VARIABLE LENGTH HYDRAULIC PISTON CORER (VLHPC)

This tool gave its usual good performance, although a high percentage of fractured liners occurred. The fractures usually ran axially along the length of the liner; many times a 'football' shaped section popped out and was carried with the core higher up the liner. In a few cases the fractures spiraled around the liner. In one instance a full-recovery core without a damaged liner was layed out on the rack, but it fractured all along its length like a sheet of ice when the technicians began to section it. The core was stiff and clayey; the fracture may have been caused by core expansion in a poor-quality liner.

The piston corer refusal point was determined by excess pullout force (40K lbs) rather than short stroke. The refusal point was usually reached at about 125 meters subbottom in the stiff, sometimes sticky nanno oozes encountered on all of the sites.

WEATHER

The weather was surprisingly good for most of the voyage. It seemed that, while on each site, a storm would be occupying the position of the next site, then would move away by the time the ship arrived there. The first half of the cruise, including the eight day transit to the first site, was characterized by calm seas and sunny skies. The sun faded as the leg progressed but the relatively calm conditions remained.

The seas were rough enough, however, to adversely affect VLHPC coring on several sites. Distorted upper core sections and a few cores containing material already cored in the previous barrel were blamed on heave and/or pitch.

COMMUNICATIONS

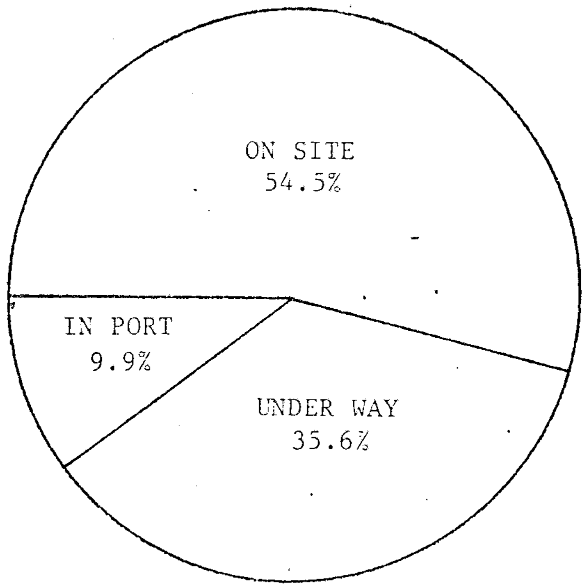
Communications steadily worsened as the ship progressed north and east. Contact with WWD was maintained for a fair amount of the time due to the vigilance and determination of the radio officer, who logged long hours at his post. Many times outgoing messages had to be sent via the Coast Guard station in Norfolk, and incoming ones received via Mercast.

PERSONNEL

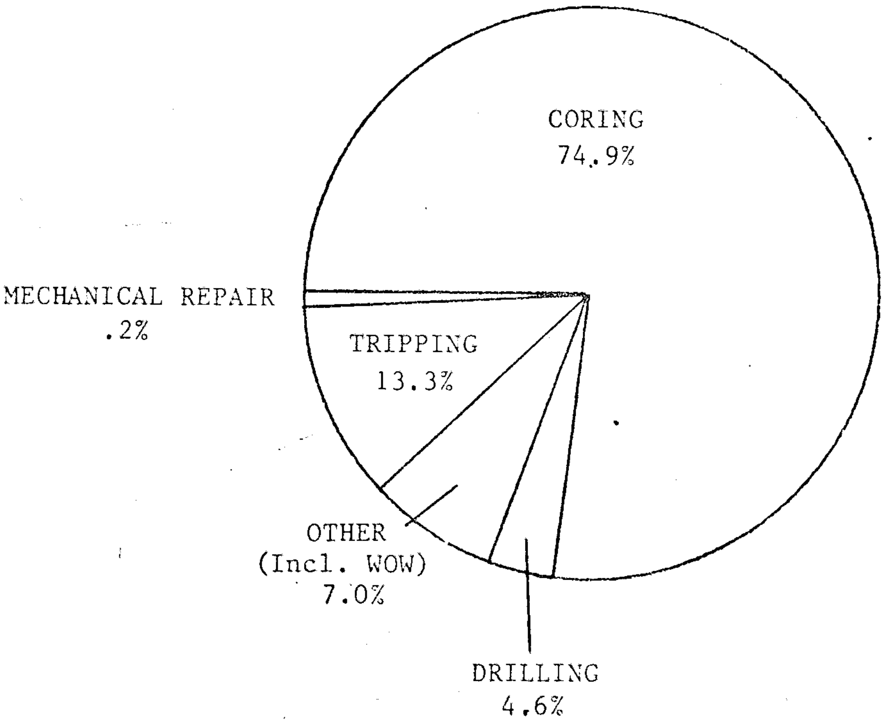
The expertise, intercooperation, and high moral of the scientists, technicians, and GMI people played a major role in making Leg 94 a very successful expedition.

Don Cameron
Cruise Operations Manager
Deep Sea Dilling Project

TOTAL TIME DISTRIBUTION
LEG 94



ON-SITE TIME DISTRIBUTION



INTERNATIONAL PHASE OF OCEAN DRILLING
DEEP SEA DRILLING PROJECT
OPERATIONS RESUME
LEG 94

Total Days (June 17, 1983-August 17, 1983	60.73
Total Days in Port	6.03
Total Days Cruising Including Site Survey	21.63
Total Days On Site	33.07

Trip Time	4.40
Drilling Time	1.5
Coring Time	24.74
Downhole Measurement	0
Stuck Pipe	0
Wait on Weather	.03
Re-entry	0
Other	2.32
Mechanical Repair	.08

Total Distance Traveled Including Survey (nautical miles)	4920.1
Average Speed (knots)	9.40
Number of Sites	6
Number of Holes Drilled	22
Number of Cores Attempted	433
Number of Cores with Recovery	425
Total Meters Cored	3906.5
Total Meters Recovered	3361.5
Percent Recovery	86.0
Total Meters Drilled	1498.7
Total Meters of Penetration	5505.2
Percent of Penetration Cored	71.0
Maximum Penetration (meters)	723.0
Minimum Penetratiom (meters)	8.9
Maximum Water Depth (meters)	3883.6
Minimum Water Depth (meters)	2426.3

DEEP SEA DRILLING PROJECT
TIME DISTRIBUTION
LEG - 94

Date	Site No.	Cruise	Trips	Drill	Core	Stuck Pipe	W.O.W.	DOWNHOLE MEAS.	Mech. Repair	Port Time	PROFILE POSIT. SHIP	Other	Total Time	Remarks
6/17/83 6/23/83										144.7			144.7	Norfolk.
6/23/83 7/01/83		196.9											196.9	Norfolk to Site 606
7/01/83 7/04/83	606		10.2		31.6				1.5			6.1	49.4	
7/04/83 7/05/83	606A		8.5	1.0	26.2							4.9	40.6	
7/05/83 7/06/83		25.3											25.3	
7/06/83 7/09/83	607		9.6		41.0							5.4	56.0	
7/09/83 7/11/83	607A		7.9	1.5	38.1							2.4	49.9	
7/11/83 7/13/83		48.9											48.9	
7/13/83 7/17/83	608		7.0		92.5							3.1	102.6	
7/17/83 7/18/83	608A		5.9		20.4							.9	27.2	
7/18/83 7/20/83		49.1											49.1	608-609
7/20/83 7/23/83	609		8.9		59.3							1.5	69.7	
7/23/83	609A		0.2		2.2							5.8	8.2	
7/23/83 7/26/83	609B		1.5		52.3								53.8	
7/26/83 7/27/83	609C		9.4	2.0	10.0		0.7					0.6	22.7	
7/27/83 7/28/83		38.3											38.3	609-610
7/28/83 7/31/83	610		7.3	17.5	48.5							3.3	76.6	
7/31/83 8/01/83	610A		1.7		20.3							1.3	23.3	
8/01/83 8/02/83	610B		1.3		16.2							0.7	18.2	
8/02/83 8/03/82	610C		1.2	1.8	5.1							0.7	8.8	

DEEP SEA DRILLING PROJECT
TIME DISTRIBUTION
LEG - 94

Date	Site No.	Cruise	Trips	Drill	Core	Stuck Pipe	W.O.W.	DOWNHOLE MEAS.	Mech. Repair	Port Time	Re-Entry	Other	Total Time	Remarks
8/03/83	610D		2.0	4.0	7.0							1.7	14.7	
8/03/83 8/04/83	610E		6.7	3.0	8.3							0.5	18.5	
8/04/83 8/06/83		50.6											50.6	610-611
8/06/83 8/07/83	611		6.2		17.5				0.4			2.0	26.1	
8/07/83 8/08/83	611A		1.3		16.0								17.3	
8/08/83	611B		0.7		2.0							5.8	8.5	
8/08/83 8/11/83	611C		1.6	4.2	60.5							.2	66.5	
8/11/83 8/12/83	611D		1.4	1.2	16.9							1.5	21.0	
8/12/83	611E		5.2		1.8							7.3	14.3	
8/12/83 8/17/83		109.6											109.6	Site 611 to St. Johns

INTERNATIONAL PHASE OF OCEAN DRILLING
DEEP SEA DRILLING PROJECT
SITE SUMMARY
LEG 94

Hole	Latitude	Longitude	Water Depth Meters	Number of Cores	Cores With Recovery	Percent of Cores With Recovery	Meters Cored	Meters Recovered	Percent Recovered	Meters Drilled	Total Penet Meters	Avg. Rate Penet.	Time On Hole	Time On Site
606	37°20.32'N	35°29.99'W	3022.15	18	18	100.0	165.8	154.1	92.9		165.8		49.4	
606A	Offset 100' West		3023.8	19	19	100.0	178.4	156.3	87.6		178.4		40.5	90.0
607	41°00.07'N	32°57.55'W	3426.1	30	30	100.0	284.4	248.2	87.3		284.4		55.9	
607A	Offset 100' North		3424.7	26	26	100.0	226.6	205.0	90.5	84.7	311.3		50.0	105.9
608	42°50.20'N	23°05.25'W	3533.6	59	58	98.3	530.3	428.0	80.7		530.3		102.6	
608A	Offset 670' West		3533.0	16	16	100.0	146.4	144.0	98.4		146.4		27.2	129.8
609	49°52.67'N	24°14.29'W	3883.6	42	40	95.2	399.4	301.2	75.4		399.4		69.7	
609A	49°52.67'N	24°14.29'W	3883.0	2	2	100.0	19.2	17.9	93.2	23.8	43.0		8.2	
609B	49°52.67'N	24°14.29'W	3883.0	38	37	97.3	354.7	308.4	86.9		354.7		53.8	
609C	Offset 100'		3883.0	7	6	85.7	67.2	35.0	52.0	123.2	190.4		22.6	154.3
610	53°13.30'N	18°53.21'W	2427.7	27	27	100.0	259.2	179.3	69.2	463.8	723.0		77.1	
610A	53°13.30'N	18°53.21'W	2426.3	21	21	100.0	201.0	191.4	95.2		201.0		22.0	
610B	53°13.30'N	18°53.21'W	2427.5	16	16	100.0	146.8	136.3	92.8		146.8		19.2	
610C	53°13.30'N	18°53.21'W	2427.5	6	6	100.0	48.4	43.9	90.7	69.8	118.2		8.6	
610D	Offset 800'N x 1520'W		2458.7	7	7	100.0	66.0	54.2	82.1	270.8	336.8		15.2	
610E	Offset 800'N x 1520'W		2458.7	7	7	100.0	67.2	53.3	79.3	260.0	327.2		18.0	160.1
611	52°50.47'N	30°18.58'W	3202.6	14	14	100.0	125.8	112.2	89.2		125.8		26.1	
611A	52°50.47'N	30°18.58'W	3200.9	14	13	92.8	132.0	98.3	74.5		132.0		17.3	
611B	52°50.15'N	30°19.10'W	3227.7	1	1	100.0	8.9	8.9	100.0		8.9		8.5	
611C	52°50.15'N	30°19.10'W	3227.6	47	44	93.6	434.8	344.1	79.1	76.8	511.6		67.5	
611D	52°50.47'N	30°18.58'W	3199.5	14	14	100.0	124.8	122.3	98.0	119.3	244.1		20.3	
611E	52°50.47'N	30°18.58'W	3199.5	2	2	100.0	19.2	19.2	100.0	6.5	25.7		15.7	155.4

INTERNATIONAL PHASE OF OCEAN DRILLING
DEEP SEA DRILLING PROJECT
BIT SUMMARY
LEG 94

Hole	Mfg.	Size	Type	Serial Number	Meters Cored	Meters Drilled	Meters Total Penet	Hours on Bit	Condition	Remarks
606	MSDS	3.8 x 11-9/16	HPC/XCB	S-35	0	0	0	0		HPC work only.
606A	MSDS	3.8 x 11-9/16	HPC/XCB	S-35	0	0	0	0	Unknown	Lost with BHA.
607	MSDS	3.8 x 11-9/16	HPC/XCB	S-49	144.0	0	144.0	1.32	Unknown	Does not include HPC work.
607A	MSDS	3.8 x 11-9/16	HPC/XCB	S-49	67.6	84.7	152.3	2.21	TØ-BØSE-I	Does not include HPC work.
608	MSDS	3.8 x 11-9/16	HPC/XCB	S-49	379.3	0	379.3	12.79		Does not include HPC work.
608A	MSDS	3.8 x 11-9/16	HPC/XCB	S-19	0	0	0	0	T1-B4SE-I	Does not include HPC work.
609	MSDS	3.8 x 11-9/16	HPC/XCB	S-49	268.8	0	0	5.68		Does not include HPC work.
609A	MSDS	3.8 x 11-9/16	HPC/XCB	S-49	0	0	0	0		Does not incluwe HPC work.
609B	MSDS	3.8 x 11-9/16	HPC/XCB	S-49	226.3	0	226.3	1.76		Does not include HPC work.
609C	MSDS	3.8 x 11-9/16	HPC/XCB	S-49	67.2	123.2	190.4	14.76	T1-B5SE-I	Does not include HPC work.
610	MSDS	3.8 x 11-9/16	HPC/XCB	S-49	211.2	463.8	675.0	4.36		Does not include HPC work.
610A	MSDS	3.8 x 11-9/16	HPC/XCB	S-49	0	0	0	0		Does not include HPC work.
610B	MSDS	3.8 x 11-9/16	HPC/XCB	S-49	0	0	0	0		Does not include HPC work.
610C	MSDS	3.8 x 11-9/16	HPC/XCB	S-49	0	69.8	69.8	0.92		Does not include HPC work.
610D	MSDS	3.8 x 11-9/16	HPC/XCB	S-49	19.2	270.8	290.0	1.88		Does not include HPC work.
610E	MSDS	3.8 x 11-9/16	HPC/XCB	S-49	67.2	260.0	327.2	1.33	T1-B6SQ-I	Three loose cones. Retired.
611	MSDS	3.8 x 11-9/16	HPC/XCB	S-50	0	0	0	0		
611A	MSDS	3.8 x 11-9/16	HPC/XCB	S-50	0	0	0	0		
611B	MSDS	3.8 x 11-9/16	HPC/XCB	S-50	0	0	0	0		
611C	MSDS	3.8 x 11-9/16	HPC/XCB	S-50	307.17	76.8	383.97	4.73		
611D	MSDS	3.8 x 11-9/16	HPC/XCB	S-50	115.2	119.3	234.5	1.47		Does not include XCB work.
611E	MSDS	3.8 x 11-9/16	HPC/XCB	S-50	0	0	0	0	TØB1-I	Two broken teeth on one cone.

INTERNATIONAL PHASE OF OCEAN DRILLING
DEEP SEA DRILLING PROJECT
BEACON SUMMARY
Leg 94

Site No.	Make	Freq. kHz	Serial Number	Site Time Hours	Remarks
606, 606A	ORE	16.0	163	81	Double Life
607, 607A	ORE	13.5	157	105	Single Life
608	ORE	13.5	162	90	Erratic positioning, dropped second beacon
608,608A	ORE	16.0	164	45	Single Life
609,ABC	ORE	16.0	165	144	Single Life
610,ABCDE	ORE	13.5	174	160	Single Life
611,ABCDE	ORE	16.0	168	157	Single Life