OCEAN DRILLING PROGRAM

LEG 104 PRELIMINARY REPORT

NORWEGIAN SEA

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INTRODUCTION

In a global perspective, the Norwegian-Greenland Sea offers unique opportunities to study some of the most important geological phenomena of the world ocean.

- The Norwegian-Greenland Sea is a relatively young ocean basin, formed during the past 56 my by sea floor spreading and surrounded by passive continental margins. The basin is an excellent laboratory to study many features created in the early stages of passive continental margin formation. Thus, studies of these margins provide information to the understanding of the processes and evolutionary history relating to the transitional region between oceanic and continental crust, one of the worlds most important geological boundaries.

- The Norwegian-Greenland Sea also represents the northernmost extension of the zonal Atlantic Ocean, which today permits cold bottom water from both the northern and the southern polar deep sea basins to carry their hydrographic properties into the adjacent Indian and Pacific oceans. This process of bottom water formation developed during the Cenozoic and its evolution in the northern hemisphere can be studied using pelagic sediments from the Norwegian-Greenland Sea.

Leg 104 of the Ocean Drilling Program set out to investigate some of these problems through a sequence of drill sites along a traverse across the Voring Plateau in the eastern Norwegian Sea (Figure 1). The drill sites were selected to investigate the following scientific problems:

- Age and nature of a sequence of **dipping reflectors,** a formation of probable volcanic origin which has been observed along many different passive continental margins. The type of sequence appears to be intimately related to the evolution of marginal highs during the early stages of passive margin formation.

- **Age and nature of the basement** below the dipping reflector sequence. Coring here is intended to solve the question of whether the dipping reflector sequence is overlying oceanic or continental type of basement.

- **Subsidence and depositional history** of a passive continental margin exhibiting a marginal high in the polar/subpolar realm.

- **Paleoceanographic history** of the Norwegian-Greenland Sea, in particular of the Norwegian Current as a continuation of the Gulf Stream system into the northern polar deep-sea basins.

- **Cenozoic paleoclimatic history** of the northern hemisphere, with particular emphasis on the initiation and variability of northern hemisphere glaciation.

- **Cenozoic evolution** of pelagic floras and faunas in response to the paleoclimatic and paleoceanographic processes in the Norwegian-Greenland Sea, including **comparison** with southern hemisphere pelagic fossil records.

Leg 104 departed Bremerhaven, Federal Republic of Germany, on 19 June, 1985. Three sites were occupied during the next 50 days of operations (Figure 1). Site 642 was situated on the flank of the outer Voring Plateau, drilling into and through the dipping reflector sequence. Site 643, located at the base of the outer Voring Plateau slope, penetrated a 550-m thick sedimentary sequence and forms the westward site of the three site transect geared towards paleoceanographic objectives. The last site, 644, cored 250 m of Voring Basin sediment fill and constitutes the eastern limit of the paleoceanographic transect. The lithostratigraphic columns cored at each site are summarized in Figure 2.

SITE RESULTS: SITE 642

Site 642 of the Ocean Drilling Program was designed to contribute information relating to the two major objectives of Leg 104: Nature and origin of the Voring Plateau Marginal High and the Cenozoic paleoenvironment of the Norwegian Sea.

The outer Voring Plateau (Figures 1 & 3), bounded landward by the Voring Plateau Escarpment, forms a marginal structural high relative to the adjacent Lofoten and Norway deep basins on the seaward side, and the More and Voring sedimentary basins on the landward side. Below a relatively thin section of Cenozoic sediments, the top of the high is marked by a smooth strongly reflecting horizon identified as lower Eocene basalts during DSDP Leg 38 (Talwani, Udintsev <u>et</u> <u>al</u>., 1976). Beneath this basalt there are locally well-developed wedges of seaward dipping reflector sequences, resting on a band of low-frequency reflectors of which the upper, most prominent, often is referred to as reflector K (Talwani et al., 1983; Hinz et al., 1984) (Figure 4). Similar structural features have recently been documented from many of the worlds passive margins. Therefore, they are believed to represent a stage in the evolution of one type of passive margins, being formed either during the latest period of rifting or during the earliest sea floor spreading.

The main objectives of Site 642 were to further document the nature of the lower Eocene basalts and to determine the nature and composition of the dipping reflectors sequences as well as, if possible, their base reflector, K. In addition, the drilling was designed to give information with respect to the subsidence and depositional history of the marginal high relative to that of the adjacent ocean basins. Finally, data of these kinds are expected to provide important constraints as to the mode of emplacement of the different rock complexes, the location of the continent-ocean boundary and the early evolutionary history of the passive continental margin.

The Norwegian-Greenland Sea is the northernmost part of the Atlantic Ocean where cold North Atlantic Deep Water (NADW) is formed. The NADW flows across the Greenland-Scotland Ridge through the Atlantic Ocean into the adjacent deep Pacific and Indian ocean basins. This process of bottom water formation developed during the Cenozoic as a consequence of the northern hemisphere glaciation and is reflected by composition and distribution of pelagic sediments in the Norwegian-Greenland Sea.

A traverse of three sites across the Voring Margin was designed to study the Cenozoic paleoenvironment at different water depths, distances from land and geological positions. Site 642 forms the central part of this traverse (Figure 1). In this context, the specific objectives of Site 642 relate to the paleoceanographic history of the Norwegian-Greenland Sea, particularly to the influence of the central part of the Norwegian Current as a continuation of the Gulf Stream system into the deep northern polar basins. Moreover, the aim was also to shed light on the paleoclimatic history of the northern hemisphere, specifically the initiation, sequence and variability of the glacial-interglacial climatic fluctuations, and finally to obtain data about the Cenozoic evolution of floras and faunas in response to the paleoclimatic and paleoceanographic processes.

Site 642, consisting of 5 holes within 450 m of each other, is located at the outer Voring Plateau in a water depth of about 1300 m (Figure 1), over the innermost wedge of a dipping reflector sequence. The total drilled depth below the sea floor was 1229.4 m, of which about 320 m was sediment overlying a 910 m thick volcanic, mostly basaltic, sequence with interbedded pyroclastic sediments.

In view of the objectives relating to the marginal high, the site was indeed successful in that all the important rock units were cored. On the other hand, as important chemical and petrological analyses of the volcanic series could not be performed shipboard, the inferences in terms of margin evolution are tentative only. The drilled sedimentary section is particularly valuable throughout the Neogene and Quaternary, and may be considered as a key stratigraphic reference section for high latitudes.

Coring at Site 642 recovered a volcanic sequence consisting of two main units below a cover of predominantly pelagic-hemipelagic Neogene and Quaternary sediments. The results of coring these holes are summarized in Figure 3.

The sedimentary section comprises four main lithologic units:

Unit 1. 0-60 m. Upper Pliocene to Recent. Interbedded dark, carbonate-poor glacial muds and light, carbonate-rich interglacial marine sandy muds.

Unit 2. 60-157 m. Middle Miocene to Upper Pliocene. The unit is divided into four sub-units: Sub-unit 2A. 60-83 m. Upper Miocene/ lower Pliocene to Upper Pliocene. Nannofossil oozes with minor diatom-nannofossil oozes and muds. Sub-unit 2B. 83-108 m. Upper Miocene. Siliceous muds and siliceous oozes. Sub-unit 2C. 108-146 m. Middle to Upper Miocene. Interbedded nannofossil oozes, marly nannofossil oozes, siliceous nannofossil oozes, siliceous muds, siliceous oozes. Sub-unit 2D. 146-157 m. Middle Miocene. Mixed siliceous-calcareous oozes with minor siliceous muds and nannofossil oozes.

Unit 3. 157-277 m. Lower Miocene to Middle Miocene. Siliceous muds and siliceous oozes.

Unit 4. 277-315 m. Middle(?) Eocene. Volcaniclastic and altered volcaniclastic muds, sandy muds and sands.

In addition, about 50 discrete ash layers document upper Cenozoic volcanicity.

The entire volcanic section contains 128 volcanic flows, 49 volcaniclastic sediment layers and 7 shallow-level dikes. The sequence can be divided into upper and lower series that are distinctive in the textural, mineralogical and structural characteristics of the flows as well as in the compositions of interlayered volcaniclastic sediments. The upper series is both subaerial and subaqueous, whereas the lower series is entirely subaqueous. In the seismic record these series are separated by a band of low-frequency reflectors one of which is denoted K. The upper unit contains the seaward dipping reflector sequence at the outer Voring Plateau.

In terms of recovery, it is comforting to note that the logging data indicate that only a small number of flows were not detected during the shipboard core analysis. The volcanic sequence was comprised of:

> 315-1093 m. Upper-Middle(?)/lower Eocene. The upper series consists of 105 flows. The common occurrence of pigeonite (Ca-poor clinopyroxene) suggests a tholeiitic composition as well as an affinity with basalts of the North Atlantic Paleogene Thulean volcanic province. Two varieties of flows, differing in quantitative mineral content, granularity, internal flow fabric and average thickness, have been observed. Interlayered volcaniclastic sediments, which make up less than 10% of the series, are mostly basaltic-vitric in composition. The section is cut in the uppermost 100 m by three dikes that are also tholeiitic.

Alteration in the upper sequence consists for the most part of smectite and celadonite infilling of vesicles.

1093-1229 m. Lower Eocene. The lower series is characterized by glassy and microcrystalline flows. Interbedded volcaniclastic sedimentary rocks make up about 20% of the section and four dikes constitute another 40%. The flows are trachybasaltic and have locally been extensively leached by high temperature fluids. The volcaniclastic sediments include a 7 m thick ignimbrite, the internal stratification and texture of which indicates a proximal emplacement facies. The ignimbrite and other volcaniclastic units contain significant quantities of quartz and mica of continental origin. Fragments of leucocratic gneiss occur in at least one volcaniclastic rock. One of the four dikes that cuts the lower series is tholeiitic and may be affiliated with the upper series.

SITE RESULTS: SITE 643

ODP Site 643 is located on the lower slope near the foot of the outer Voring Plateau, seaward of the dipping reflector sequence and in an area underlain by typical oceanic basement (Figures 1 & 5). The site is located between magnetic anomalies 24B and 23 on the presumed oldest crust in the Norwegian-Greenland Sea. The site also forms the western and deepest end of a paleoenvironmental transect across the outer Norwegian margin.

The two main objectives of Site 643 were: 1) to penetrate and sample the Cenozoic section of pelagic and hemipelagic sediments above the oceanic basement, and 2) to obtain samples of the oceanic basement and its basal sediments. With the recovered lithologies one would then be able to determine the subsidence history of Site 643 and relate it to the subsidence history of the Voring Marginal High. Variations in the sediments and the pelagic and benthic fossil assemblages are expected to reflect changes in the Norwegian Current and in the northern hemisphere paleoceanography. Moreover, the data enable us to investigate the onset and variability of northern hemisphere glaciations and to establish the nature and properties of the "pre-glacial" type depositional environments.

The single bit hole, 643A, penetrated a 565.2 m thick pelagic and hemipelagic sedimentary sequence. A total of 62 cores were recovered consisting of 16 APC cores (0-147.5 mbsf) and 46 XBC cores (147.5-565.2 mbsf). Poor hole conditions prevented further drilling as well as the planned logging program. The drilling results are summarized in a stratigraphic section (Figure 2).

The Cenozoic sedimentary section at Site 643 comprises five lithologic units which in general can be correlated with the lithostratigraphic record of Site 642 at the outer Voring Plateau:

> Unit 1. 0-49.4 mbsf. Late Pliocene to Recent. Glacial/interglacial sedimentary cycles consisting of alternations of dark, relatively carbonate poor, and light, carbonate-rich layers of muds, sandy muds, and sandy calcareous muds. Moderate slumping is observed.

Unit 2. 49.4-100.2 mbsf. Middle Miocene to early Pliocene. This unit is affected by slumping. Based on compositional data it is subdivided into three subunits: Subunit 2A. 49.4-63.8 mbsf. Late Pliocene. Siliceous nannofossil ooze. Subunit 2B. 63.8-81.3 mbsf. Early Pliocene. Predominantly terrigenous, containing siliceous muds and mud with only minor amounts of nannofossil ooze. Subunit 2C. 81.3-100.2 mbsf. Late Miocene. Predominantly diatomaceous nannofossil ooze.

Unit 3. 100.2-274.1 mbsf. Miocene. Primarily diatom oozes.

Unit 4. 274.1-400.7 mbsf. Early Oligocene to early Miocene. Monotonous dark, extremely fossil poor terrigenous mudstones and minor gray nannofossil chalk.

Unit 5. 400.7-565.2 mbsf. Early to late Eocene. Predominantly dark greenish gray to dark reddish brown and grayish brown zeolitic mudstones, most of which are intensively compacted and laminated. The lowermost two cores contain pebble- to cobble-sized basaltic fragments, a polymict conglomerate of pyroclastic rocks and a dark basaltic conglomerate. This may indicate that drilling terminated in a basal sequence overlying oceanic basement.

The two lower units are reflected by distinct changes in the bulk density. Except for local high velocity beds, the seismic velocity is low, averaging 1.65 km/s throughout the section.

The Neogene and Quaternary sequence contains numerous volcanic ashes which can be correlated with great precision to the airfall tephra layers at Site 642.

Site 643 (as documented by the drilled sedimentary sequence) never experienced shallow water depositional environments, and can be considered the deep-water analog to the DSDP sites on the Voring Plateau and ODP Site 642. However, the sedimentation rates are higher than anticipated, mainly because of the presence of slumped sediment layers. Nevertheless, it provides a record of the depositional environments under the seaward boundary of the Norwegian Current in water depths close to the Norwegian Sea basin floors.

Basement was not reached at Site 643, but the hole bottomed in volcaniclastic rocks with a conglomeratic unit at the base. A similar immature conglomerate was drilled at Site 343, Leg 38. This site occupies a similar structural position as Site 643 near the base of the plateau further north. A correlation with this site suggests that the basaltic conglomerate at Site 643 represents the transition to the oceanic basement below. The oldest sediments recovered are of early Eocene age. These observations, together with the seismic analysis, indicate that the hole was probably terminated in a basal sediment sequence directly overlying the oceanic basement. Thus, we believe the cored section provides important constraints in terms of subsidence modeling.

SITE RESULTS: SITE 644

ODP Site 644 represents the landward end of a transect of three drill sites across the Voring Plateau in the Norwegian Sea. This transect had been planned to study the variability of the Cenozoic depositional environment under the Norwegian Current, which is transporting temperate water from the North Atlantic to the Arctic Ocean. The existence of this current system has an enormous impact on the northern hemisphere climate. Site 644 is located in the Voring Basin close to the inner continental slope and overlies subsided old continental crust. Because of safety concerns drilling at Site 644 was limited to 250 mbsf.

Hole 644 was double APC cored to 250.0 m. Thirty-four cores yielded a recovery of 93%. Hole 644B reached 177.7 m with 83% recovery in 15 cores. The drilling results are summarized in Figure 2.

The upper Neogene and Quaternary sedimentary section of Site 644 can be subdivided into two lithologic units:

Unit 1. 0-228.5 m. Late Pliocene to Recent. Subunit 1A. 0-49.9 m. Late Quaternary. Interbedded dark, carbonate-poor glacial sandy muds and light interglacial calcareous muds. Subunit 2B. 49.9-85.7 m. Mid- to late Quaternary. Interbedded dark carbonate-poor and light, interglacial calcareous muds, sandy calcareous muds and marly foram-nanno oozes. Subunit 1C. 85.7-228.5 m. Late Pliocene to mid-Quaternary. Interbedded dark carbonate-poor (glacial) muds and sandy muds, and light (interglacial) siliceous muds, siliceous nannofossil muds and nannofossil muds.

Unit 2. 228.5-252.8 m. Mid-Pliocene. Interbedded siliceous oozes and mixed siliceous nannofossil oozes.

Significant quantities of methane were found starting at a depth of about 40 mbsf, continuing to the total depth. Large gas expansion cracks were noted in the cores in the interval 73-159 mbsf. The gas within these cracks was composed of 45-89% methane. Ethane, propane, and butane were present at low parts per million levels, particularly towards the bottom of the hole. The composition of the gas mixtures indicates that the methane is of biological origin. The other hydrocarbon gases are probably products of very low temperture diagenesis. These geochemical results contrast with findings at the two previous sites where the maximum amount of methane measured was only 23 ppm. The maximum methane concentrations are associated with a sharp seismic marker at the base of lithologic Unit 1.

SUMMARY

The first scientific objective of Leg 104, to determine the composition and nature of the dipping reflector sequence and the underlying rock unit, was met by drilling a deep hole at Site 642 at the inner part of the prominent wedge of dipping reflectors. Site 642 cored lithologies have been matched to a multichannel seismic reflection line (Figure 7). Coring at

Site 642 recovered a 914 m thick volcanic sequence below 315 m of predominantly pelagic-hemipelagic upper Cenozoic sediments. The entire volcanic section is Eocene in age and contains 121 volcanic flows, 49 volcaniclastic sediment layers and 7 shallow-level dikes. The volcanic sequence can be subdivided into an upper tholeiitic and a lower trachybasaltic series of flows which are distinctive in lithology and morphology.

Some of the interlayered sediments, which are dominantly volcaniclastic in composition, are fossiliferous (mainly palynomorphs) yielding a range of ages decreasing from early Eocene for the Lower Series to middle/late Eocene for the Upper Series. Petrologic evidence and fossil contents also indicate that the Lower Series was extruded entirely under subaqueous conditions, while the Upper Series most likely erupted under subaerial conditions, but was emplaced subaerially and subaqueously. The dipping reflector sequence is now proven to be represented by the upper volcanic series comprising alternating sequences of massive fine-grained and vesicular medium-grained tholeiitic flows of Eocene age.

The seismic reflector K, which constitutes the lower boundary of the dipping sequence probably originates from a very hydrothermally altered Lower Volcanic Series of alternating basaltic flows (54 %), shallow level dikes (32 %) and volcaniclastic sediments (14 %). A vertical seismic profile (VSP) experiment conducted for the first time aboard JOIDES Resolution, confirmed that the transition between the Upper and Lower Series represents reflector K. The plagioclase-phyric flows almost exclusively exhibit perlitic to microcrystalline quench textures and are thought to be trachybasaltic in composition. The interlayered volcaniclastic sediments are of intermediate to differentiated composition and comprise an ignimbrite unit. The xenolith association is characterized by abundant mica, feldspar and quartz, and rare quartz-mica schist and leucocratic gneiss, of clearly continental origin. Continental crust must constitute the country rock at a nearby center of eruption. The tentative conclusion is that the Lower Series is related to the transition between rift and drift phase, whereas the Upper Series was probably emplaced contemporaneously with the North Atlantic Thulean volcanic surge in the lowermost Eocene.

With Site 642 as its centerpiece the paleoenvironmental transect was complemented by Site 643 near the foot of the Voring Plateau and Site 644 in the Voring Basin. By using the Hydraulic Piston Corer and the Advanced Core Barrel techniques a unique sequence of Cenozoic sediment cores has been assembled, which will serve as a northern high latitude stratigraphic reference sections. The cored sections from both Sites 643 and 644 were correlated to regional multichannel seismic lines (Figures 8 & 9). The transect provided material from environments ranging from the deep ocean basin to the central continental slope, allowing vertical, horizontal, and temporal gradients in deposition associated with the Norwegian Current to be studied in detail. The two innermost sites document only the Neogene and Quaternary history of the Norwegian Current, whereas the sedimentary record at Site 643 reaches back into the early Eocene. The oldest sediments record an interval when the Norwegian Sea was temperate or warmer, and when pollen and spores suggest subtropical climates on the adjacent land regions.

All three sites yielded sediment sections with high resolution Neogene and Quaternary magneto- and biostratigraphic records, which will allow extraordinarily detailed reconstructions of Norwegian-Greenland Sea paleoceanography and of northern hemisphere paleoclimate. A temperate Norwegian Current existed for an extended interval during the Neogene, but suddenly began to deteriorate at 2.8-2.9 Ma (maybe even as early as 4.5 Ma), and ultimately was replaced at times by cold, ice covered polar water masses. Layers of dark, carbonate-poor glacial muds, with coarse terrigenous, ice-rafted clasts up to several centimeters in diameter that occur interbedded with light-coloured interglacial sediments are the most conspicuous evidence for glacial climates since almost 3 Ma. At the same time, cold planktonic faunas and floras began to appear in the Norwegian Sea surface water masses.

In the mid-Quaternary (approximately 0.73 Ma), the intermittent occurrence of high proportions of biogenic opal (mainly diatoms) in the sediments disappeared, suggesting a drastic drop in surface water productivity. Calcareous nannofossils and planktonic foraminifers, however, maintained sufficient productivity until approximately 0.4 Ma to produce calcareous muds and marly oozes that alternate with the glacial layers. After this time, the Norwegian Sea depositional environments were so dominated by the glacial mode that interglacial intervals form only short sections. The "glacial" depositional environments, documented at Site 644, have been interrupted several times by incursions of temperate to warm waters. There is particularly good evidence for such episodes at approximately 2.2 Ma and 0.98 Ma, when warm to temperate planktonts suddenly appear in the sediments. Evidence for severe glaciations have also been found, especially in the part of the cored sections deposited in the interval between 0.1-0.7 Ma. These cores contain large amounts of ice-rafted material and shallow water benthic foraminifers displaced from the shelf.

All sites show similar stratigraphies in the Neogene and Quaternary sections. Some important differences occur, however, especially within the glacial records. At Site 644, chalk fragments were a common and obvious component of the particle assemblages that had been transported as ice-rafted material. These components are lacking in the glacial horizons of the two outer sites, suggesting that icebergs from quite different source regions delivered this material to Site 644.

It is also interesting to note that the paleoclimatic evolution of the Northern Hemisphere during late Cenozoic seems to correspond closely to a sequence of similar events in the Southern Hemisphere. The cessation of pre-Glacial conditions in Site 644 occurred almost simultaneously with a major northward expansion of Antarctic polar waters, which began about 2.8 Ma. Since then, numerous climatic fluctuations are observed in both the Northern and Southern Hemispheres, leading to increasingly more glacial oceanic depositional environments. Although it was believed until quite recently that the transition from pre-Glacial to Glacial conditions in the Northern Hemisphere occurred only 2.4 Ma, as documented by DSDP sites south of the Greenland-Scotland Ridge, we can now show that the Norwegian Sea experienced glaciation approximately 0.5 my earlier. The transition in the Norwegian Sea was preceded by glacial records in the Arctic Ocean that are at least 4-6 Ma old.

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FIGURE CAPTIONS

FIGURE 1. Bathymetric chart of the Voring Plateau in the eastern Norwegian Sea and location of Leg 104 drill sites.

FIGURE 2. Lithostratigraphic columns of ODP Leg 104 drill sites 642, 643, and 644.

FIGURE 3. Main regional features of the Norwegian continental margin (Eldholm et al., 1984.

FIGURE 4. Dipping reflector sequence at the Voring Plateau and location of ODP Site 642. (Top: Depth migrated profile BGR-1. Bottom: Time migrated section).

FIGURE 5. MCS line NH-1 with location of ODP Site 643.

FIGURE 6. MCS line NH-1 with location of ODP Site 644.

FIGURE 7. Multichannel profile BGR-1 in the vicinity of ODP Site 642 (migrated depth section) with lithology and ages from Site 642. O: base-Pliocene, O': base-middle Miocene, A: base-Miocene, EE: base-Miocene.

FIGURE 8. Multichannel profile NH-1 in the vicinity of ODP Site 643 with lithology and ages from Site 643. O: base-Pliocene, A: near base-Miocene.

FIGURE 9. Multichannel profile NH-1 across ODP Site 644 with lithologies and ages from Site 644. Seismic interpretation from Skogseid (1983).

OCEAN DRILLING PROGRAM
SITE SUMMARY
LEG 104

HOLE	LATITUDE	LONGITUDE	DATES (1985)	WATER DEPTH	TOTAL PENET.	# OF CORES	METERS CORED	METERS RECOVERED	PERCENT RECOVERED
642A	67°13.5;N	02°55.7;E	June 28	1292.7	10.8	1	9.5	9.9	104
642B	67°13.5'N	02°55.7'E	June 28-29	1292.7	221.1	25	221.1	215.6	98
642C	67°13.5'N	02°55.8'E	June 29-July 2	1292.1	199.6	24	199.6	192.8	97
642D	67°13.5'N	02°55.8'E	July 2-3	1292.1	328.9	20	139.0	117.0	84
642E	67°13.5'N	02°55.8'E	July 4-Aug 1	1289.0	1229.4	107	906.9	372.6	41
643A	67°42.9'N	01°02.0'E	Aug 2-8	2779.8	565.2	61	565.2	449.2	79
644A	66°40.7'N	04°34.6'E	Aug 8-9	1226.3	252.8	34	252.8	238.4	94
644B	66°40.7;N	04°34.6'E	Aug 9-10	1225.9	127.7	15	127.7	103.6	81

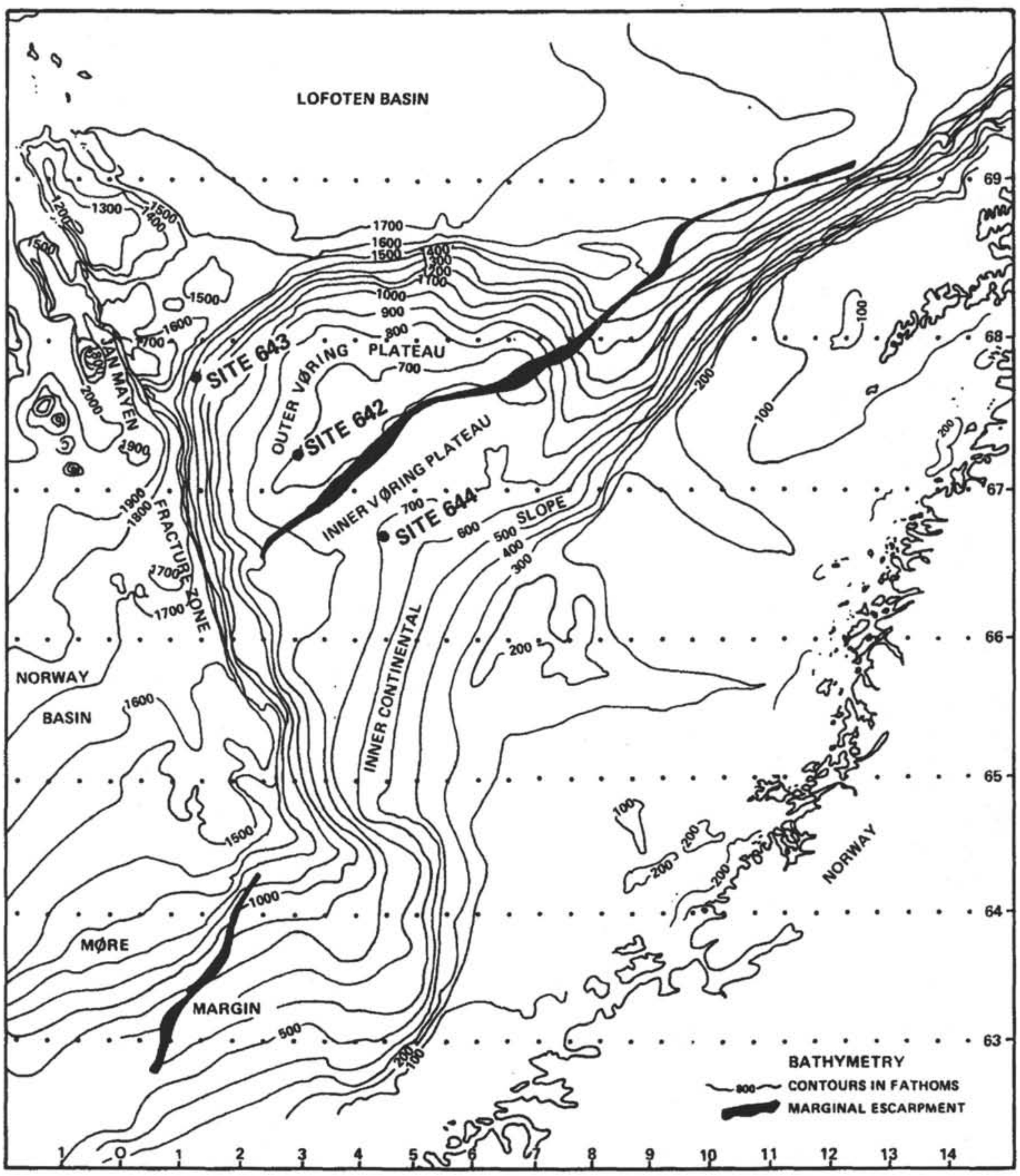
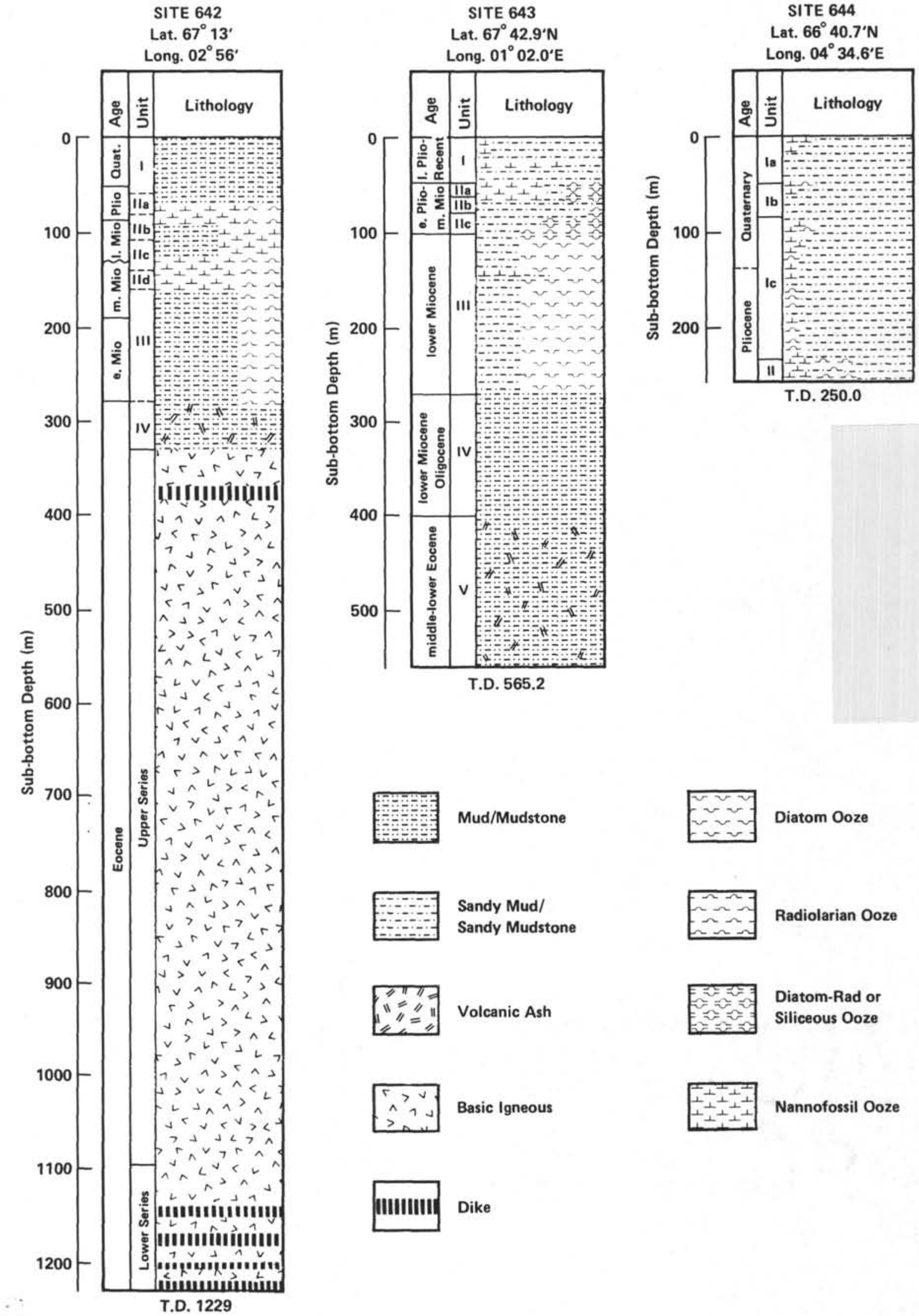

LOFOTEN BASIN
1300
1200
1500
1400
1500
1700
1600
1500
1400
1300
1200
1100
1500
1000
900
800
700
1600
1700
1800
2000
1900
JAN MAYEN
FRACTURE ZONE
SITE 643
OUTER VØRING PLATEAU
SITE 642
INNER VØRING PLATEAU
SITE 644
700
600
500
400
300
SLOPE
INNER CONTINENTAL
1900
1800
1700
1700
200
100
200
100
200
NORWAY BASIN
1600
1500
1000
MØRE
MARGIN
500
200
100
100
200
200
200
NORWAY
69
68
67
66
65
64
63
BATHYMETRY
800 CONTOURS IN FATHOMS
MARGINAL ESCARPMENT
1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14

FIGURE 1.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200
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400
500
600
700
800
900
1000
1100
1200
Quat.
Plio
l. Mio
m. Mio
e. Mio
Eocene
I
IIa
IIb
IIc
IId
III
IV
Upper Series
Lower Series
T.D. 1229
SITE 643
Lat. 67° 42.9′N
Long. 01° 02.0′E
Age
Unit
Lithology
Sub-bottom Depth (m)
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100
200
300
400
500
l. Plio-Recent
e. Plio-m. Mio
lower Miocene
lower Miocene Oligocene
middle-lower Eocene
I
IIa
IIb
IIc
III
IV
V
T.D. 565.2
SITE 644
Lat. 66° 40.7′N
Long. 04° 34.6′E
Age
Unit
Lithology
Sub-bottom Depth (m)
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200
Quaternary
Pliocene
Ia
Ib
Ic
II
T.D. 250.0
Mud/Mudstone
Sandy Mud/ Sandy Mudstone
Volcanic Ash
Basic Igneous
Dike
Diatom Ooze
Radiolarian Ooze
Diatom-Rad or Siliceous Ooze
Nannofossil Ooze

FIGURE 2.

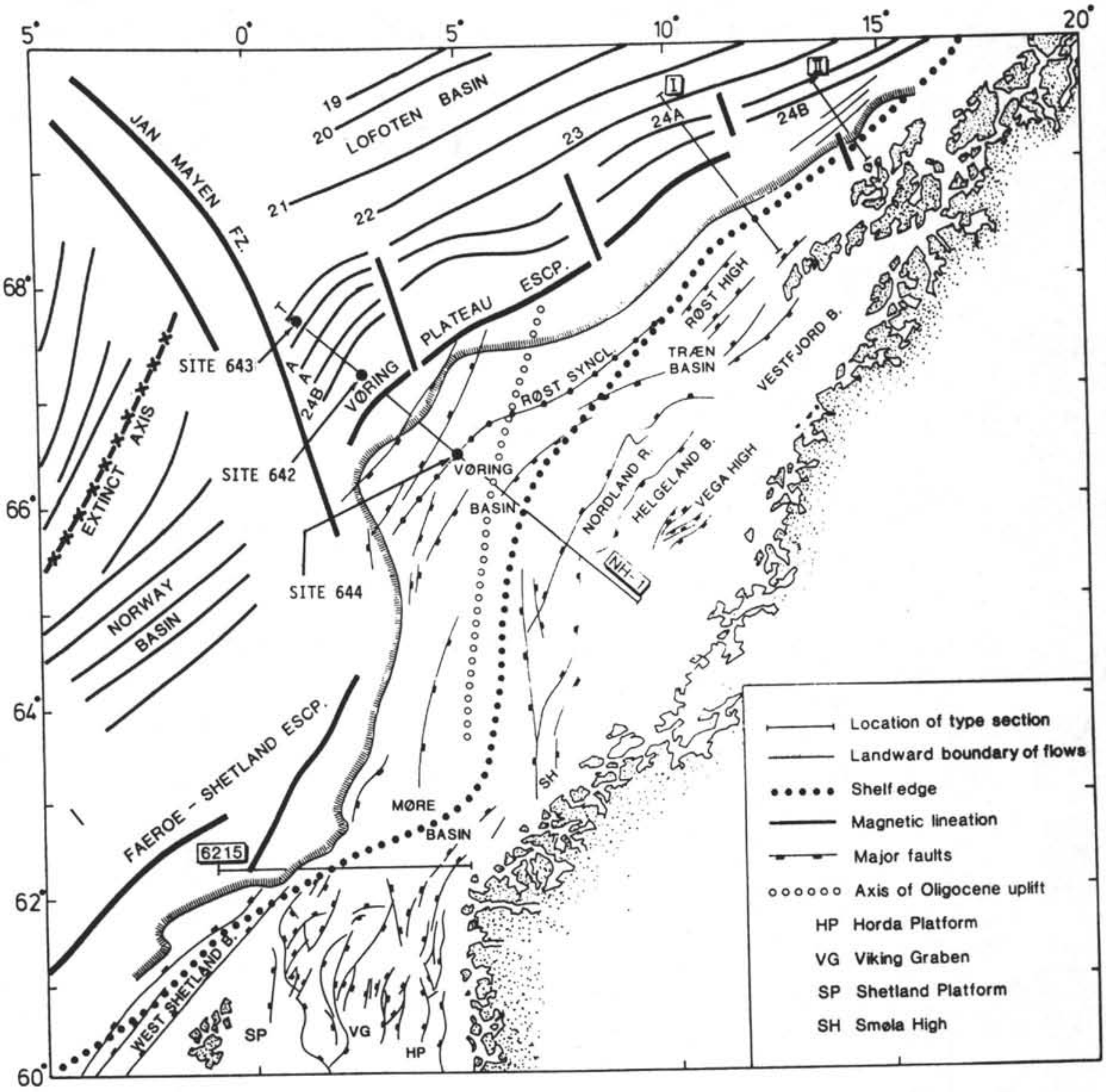

5°
0°
5°
10°
15°
20°
68°
66°
64°
62°
60°
19
20
21
22
23
24A
24B
I
II
LOFOTEN BASIN
JAN MAYEN FZ.
EXTINCT AXIS
NORWAY BASIN
SITE 643
SITE 642
SITE 644
A
A
24B
T
VØRING PLATEAU ESCP.
VØRING
VØRING BASIN
RØST SYNCL.
RØST HIGH
TRÆN BASIN
VESTFJORD B.
NORDLAND R.
HELGELAND B.
VEGA HIGH
NH-1
FAEROE - SHETLAND ESCP.
6215
MØRE BASIN
SH
WEST SHETLAND B.
SP
VG
HP
Location of type section
Landward boundary of flows
Shelf edge
Magnetic lineation
Major faults
Axis of Oligocene uplift
HP Horda Platform
VG Viking Graben
SP Shetland Platform
SH Smøla High

FIGURE 3.

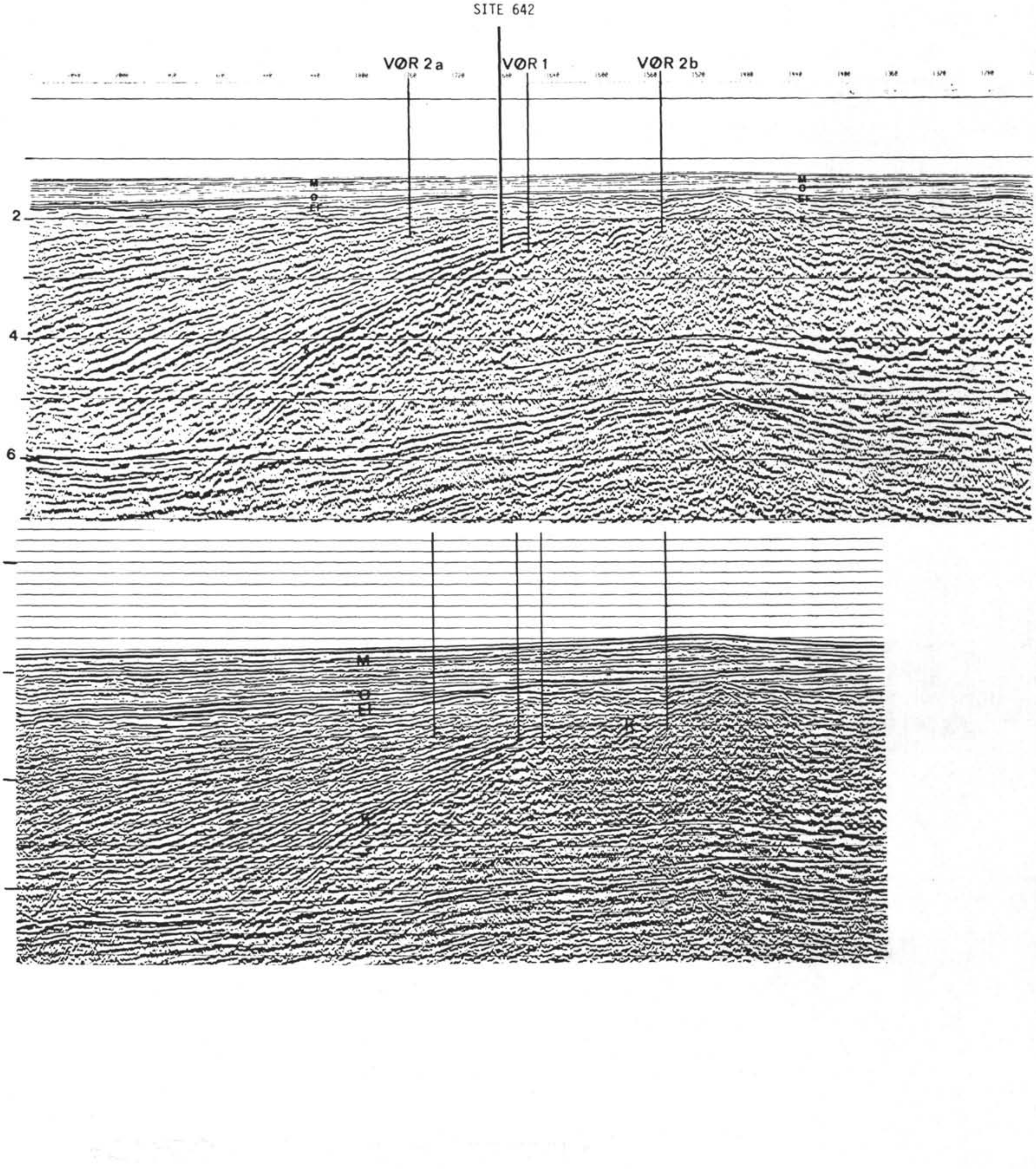


FIGURE 4.

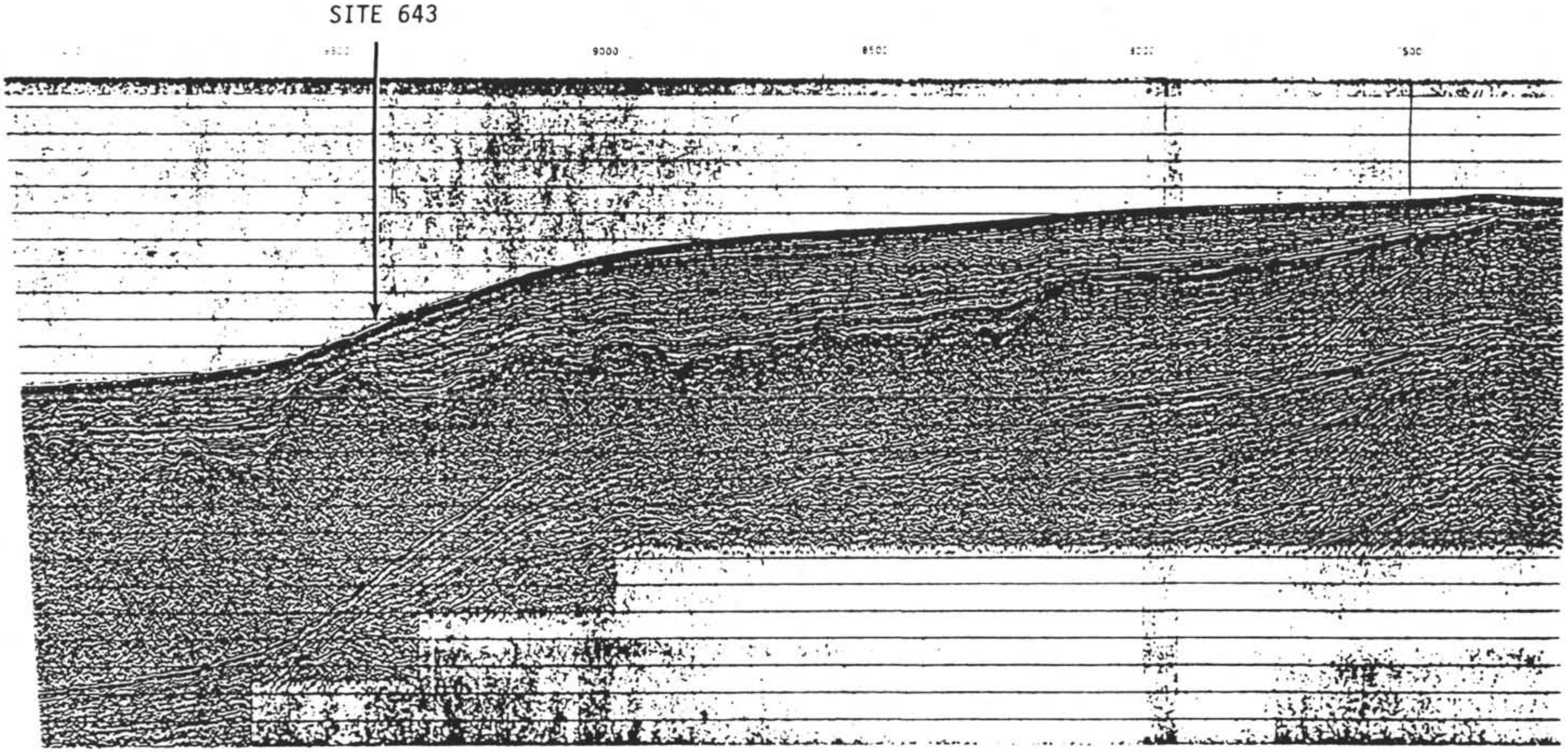


FIGURE 5.

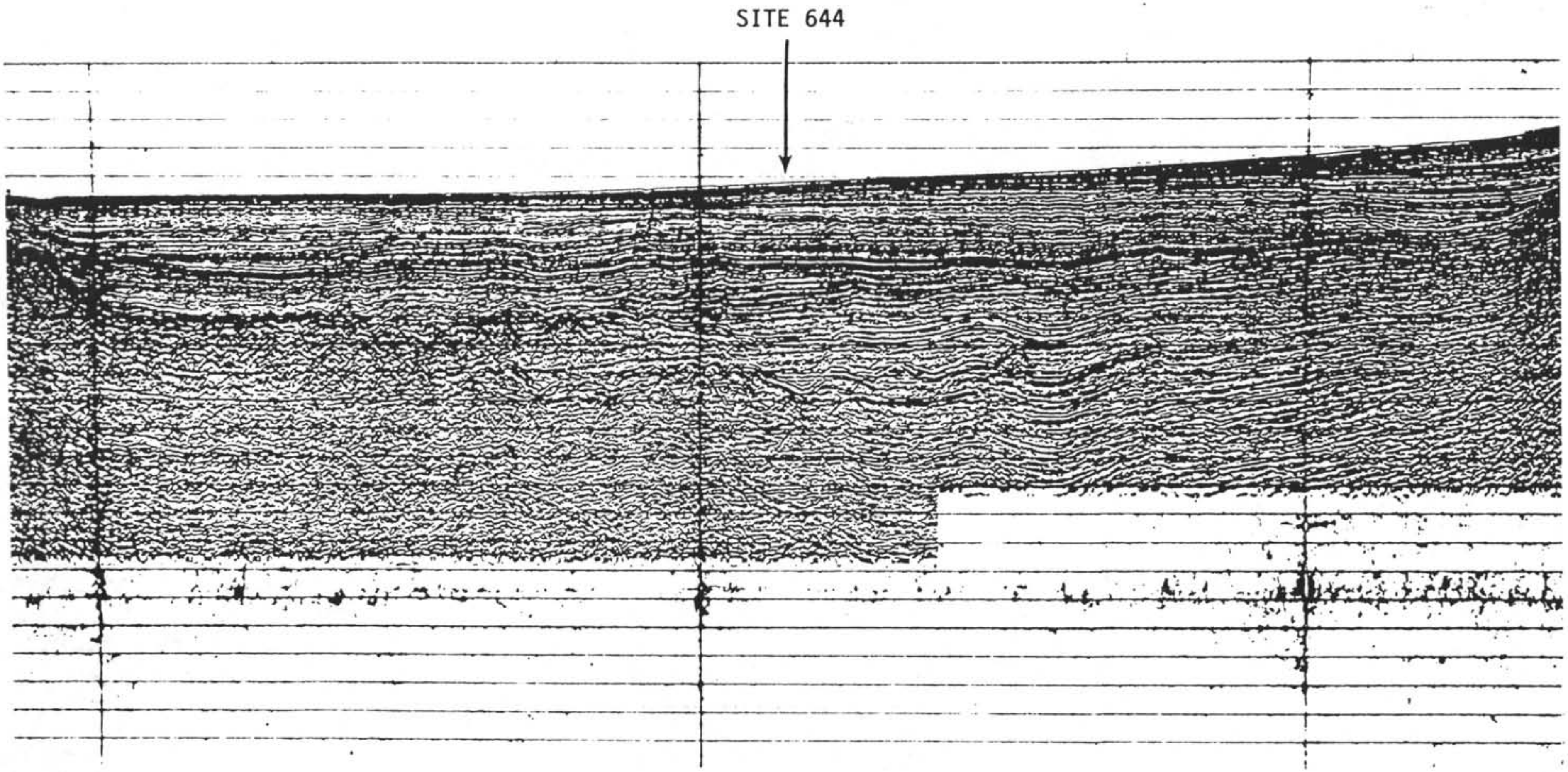


FIGURE 6.

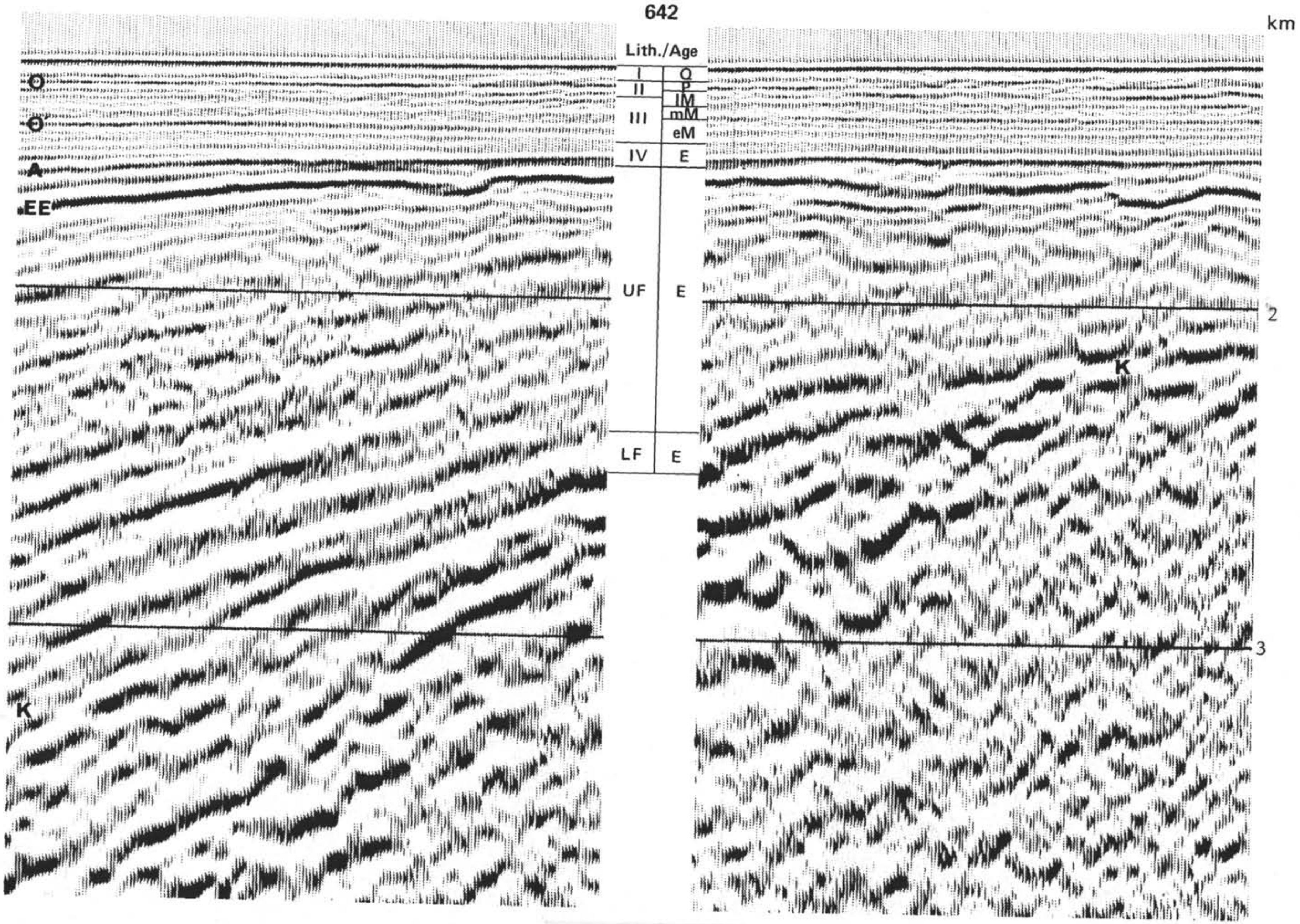


FIGURE 7.

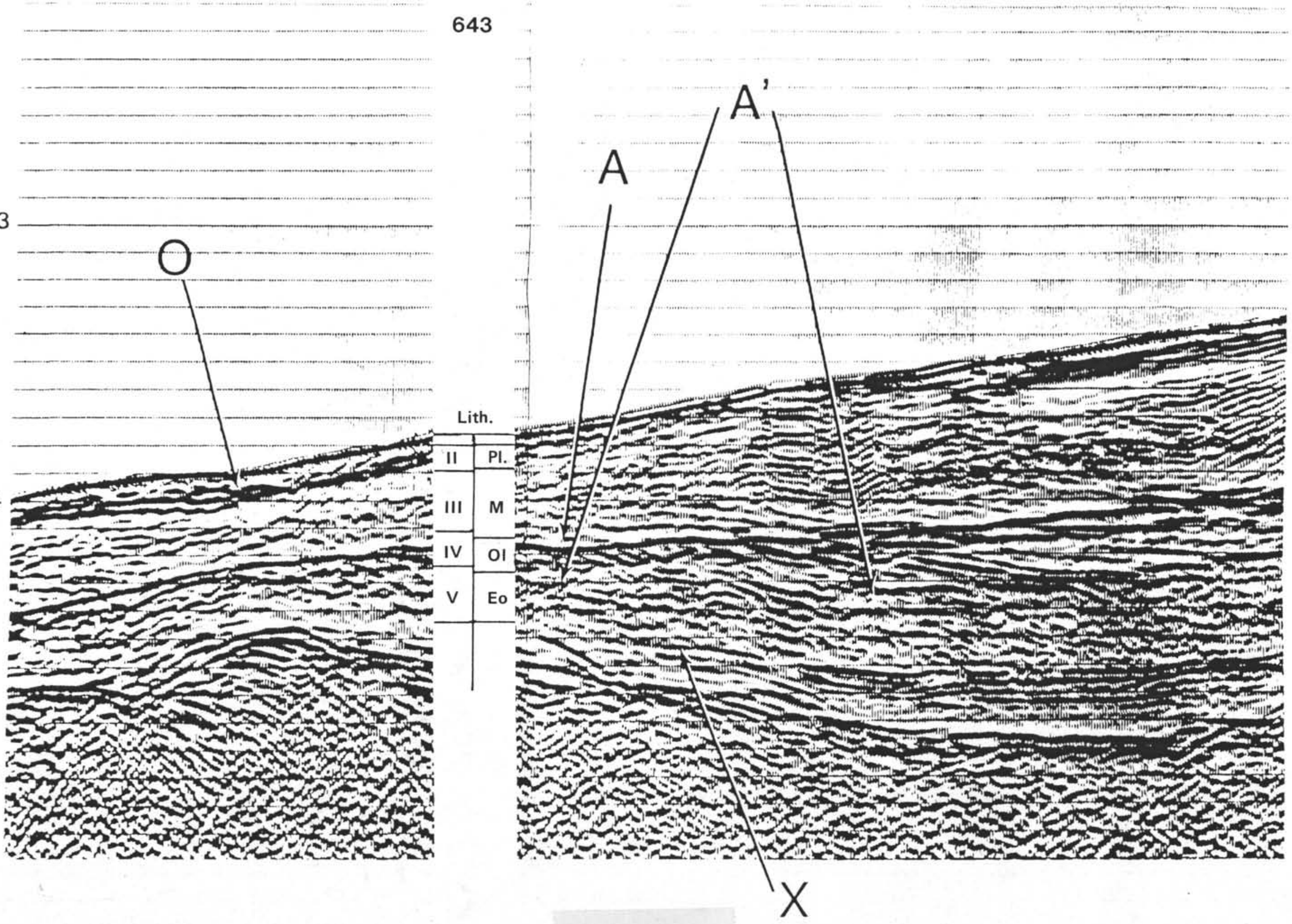


FIGURE 8.

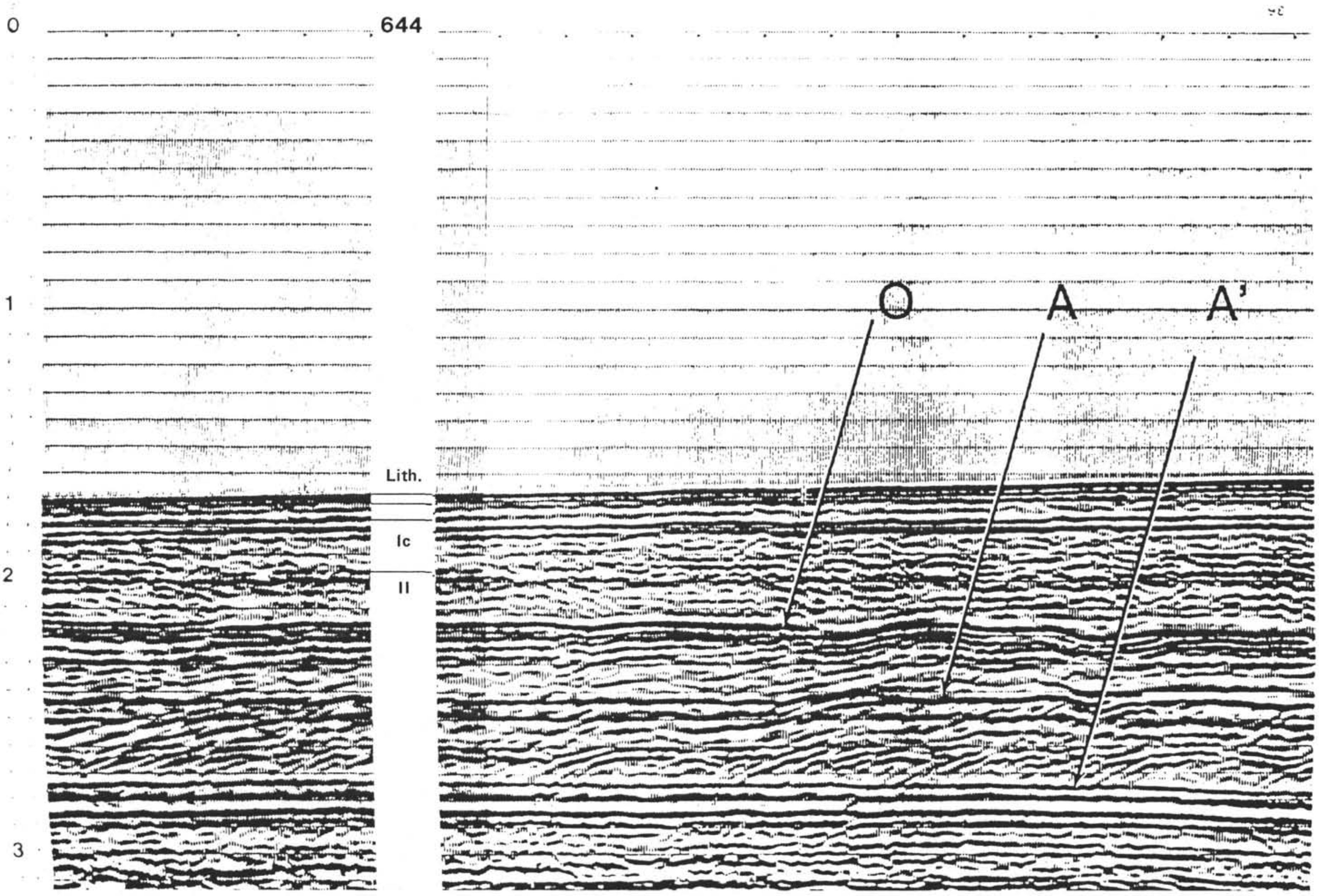


FIGURE 9.

OPERATIONAL REPORT

The ODP Operations personnel aboard *JOIDES Resolution* for Leg 104 of the Ocean Drilling Program was:

Operations Superintendent: Glen Foss

Special Tools Engineer: Michael Storms

OCEAN DRILLING PROGRAM
OPERATIONS REPORT
LEG 104

During the summer of 1985, the scientific drillship JOIDES Resolution ventured north of the Arctic Circle on an expedition that was to challenge its operational capabilities in several respects. It was the first operation of the Ocean Drilling Program in a high latitude environment, and the drilling/coring objectives were ambitious. They included a three-site paleoenvironmental transect across the Voring Plateau, where high recovery of undisturbed cores would be required, as well as a deep reentry penetration into crustal rocks to investigate the nature of this important and anomalous feature of the Norwegian Sea.

The voyage commenced on June 19, 1985 at Bremerhaven, Germany and ended on August 23, 1985 at St. John's, Newfoundland, Canada. A logistical port call was made at Stavanger, Norway.

Operational highlights of the expedition included a penetration to 1229.4m below seafloor at Hole 642E, 917m of which were through volcanic rocks. It also featured the first dual-casing reentry cone installation of the ODP and the first vertical seismic profiling experiment. Five holes with the advanced hydraulic piston corer (APC) provided complete sections for Neogene studies at the three sites of the transect.

Total length of the voyage was 65.4 days, of which 43.0 days were spent on site, 14.0 days under way and 8.4 days in port. Despite the high latitude of the operating area and some severe weather, no weather downtime accrued.

Bremerhaven Port Call

Leg 104 had its official beginning when the first mooring line was put ashore in the North Harbor of Bremerhaven, Federal Republic of Germany, at 1530 hours, June 19, 1985.

Major ship work items for the port call included: overhaul of number three main generator, installation of a new armature in propulsion motor 14A, installation by DRECO of new guide rollers on the traveling block/heave compensator, and bunkering with 503,000 gallons of diesel fuel. Sixty-four stands of used Glomar Challenger drill pipe were broken down into joints and inspected by AMF-Tuboscope. A total of 22 joints were downgraded by the inspection. The old pipe was stowed in the hold and new, internally zinc-coated pipe was made up into stands to replace it. A representative of Rochester Corporation visited the rig to find and correct an electrical leak in logging cable number three that was reported on Leg 102. The cable was tested thoroughly and no fault was found. ODP piston coring equipment was off-loaded and taken to a local shipyard for shop modification of the rod connections. SEDCO and ODP freight, including the prototype Navidrill coring system, was loaded.

Tours, luncheons and receptions were held involving numerous officials and dignitaries from educational institutions, industry and government.

Bremerhaven To Site 642

The last line was cast off at Bremerhaven at 1852 hours, June 24, 1985. After clearing the harbor lock and the Weser Estuary, JOIDES Resolution proceeded northward across the uncharacteristically placid North Sea. The vessel averaged nearly 13 knots for the first two days of the northward journey. Winds gusting to 30 knots greeted the vessel on the third day as she approached the operating area, located in the Norwegian Sea about 240 miles west-southwest of the Lofoten Islands.

Hole 642A/B - Voring Plateau

The drill site was approached from the south along the track of MCS profile BGR-1, which was used as a seismic-stratigraphic reference. To improve seismic record quality, the vessel was slowed to five knots for the last ten miles of the approach. The track was maintained by the Decca navigation system, as satellite navigation (SATNAV) fixes were infrequent during that period. A positioning beacon was dropped on geographic coordinates at 2057 hours, June 27th. The profile was extended ten miles beyond the drop point. The towed seismic gear was then retrieved and the ship returned to the beacon.

As preparations for drilling and the pipe trip progressed, enough SATNAV fixes were received to verify that the initial position was about 1.3 nautical miles to the WNW of the desired site coordinates. Using offsets of the automatic stationkeeping (ASK) system, the vessel was carefully offset to the approximate desired location without interruption of the pipe trip. A new beacon was launched and position referencing was established on it before the hole was spudded.

The precision depth recorder (PDR) reading was interpreted as 1297 m from the rig's dual elevator stool. Hole 642A was spudded at 1355 hours, June 28, when the advanced piston corer (APC) system was actuated at a bit depth of 1294 m. The first core barrel arrived on deck completely filled with sediment, indicating that the bit had been positioned below the seafloor. Because the uppermost sediments were of considerable scientific interest and because of measurements for the reentry cone installation, it was imperative that a seafloor core be recovered. It was therefore necessary to raise the core bit a few meters higher to core the water/ sediment interface. As the core intervals overlapped and it is theoretically impossible to core the same section twice in the same hole, it was necessary to designate the new core as number one of Hole 642B. Thus Hole 642A began and ended with a single core.

The second core attempt, "shot" from 1288 m, recovered 4.8 m of sediment from its 9.5 m stroke and established seafloor depth as 1292.7 m.

The absence of a full-stroke pressure bleedoff indication was noted from the beginning. It was soon realized that a modification of the bit sub for compatibility with the new Navidrill core barrel (NCB) system was preventing the venting of fluid pressure. That shortcoming proved to be more an inconvenience than a problem as site operation continued.

APC coring continued with only minor mechanical difficulties and the "teething" problems of an inexperienced crew. Mud, glacial material and nannofossil and diatom oozes were penetrated to 221.1 m below seafloor (BSF). At this depth, no problem had been experienced in "punching" a full 9.5-m stroke into the stiff sediment, but the operational limit of 100,000 lb. overpull on pullout was being approached. On the attempt to retract core number 25H from the sediment, the pin connection of the liner seal sub at the top of the inner core barrel parted at 80,000 lb overpull.

A single attempt was then made to retrieve the inner barrel with a fishing spear. The core bit was "washed down" around the embedded core barrel for six meters, and the spear was lowered to engage it. The initial attempt appeared to engage the "fish" and then lost it. Additional attempts were made with no change, and the spear was retrieved. On recovery, it was found that the plastic core liner, containing 8.5 m of core, had been plucked from the core barrel--leaving it behind.

Further time for fishing the core barrel was judged to be counterproductive, so the hole was plugged by filling it with barite-weighted drilling mud. The bit was then pulled clear of the seafloor for the planned second APC penetration.

Hole 642C

It had been determined that an additional refinement of the ship's position would be necessary to insure conformance with the approved location of the planned deep-penetration site. An additional offset of 450 m to the southeast was therefore entered into the ASK system. (Positioning on the second beacon became marginal at such a distance, and a third beacon eventually was lowered on the ship's tautwire system as an additional reference.)

Hole 642C was spudded at 2350 hours, June 29th, with a water depth of 1292.1 m determined by the first core.

With the exact water depth redetermined, a "jet-in" test was conducted to determine the casing point for the 16" conductor casing that would support the reentry cone and, eventually, the second casing string. With an inner core barrel of the extended core barrel (XCB) system in place, the core bit was jetted into the soft sediment (without rotation) until penetration was drastically slowed by stiff sediment. Although slow progress was still being made at 55 m BSF, the test was considered to have established that adequate casing could be set.

The bit was then pulled back and APC coring continued from the depth reached by the first core. Objectives of Hole 642C included the collection of core orientation and downhole temperature data. Core orientation with the Eastman multishot system appeared to be fully successful. Because of minor "bad luck" problems, only one successful temperature measurement for heat flow calculations had been obtained when penetration reached 199.4 m BSF. The self-contained "heat flow shoe" was deployed on the inner barrel that was to take the final APC core before the switch to the XCB system for further coring. After actuation of the corer and the eight-minute wait for temperature equilibration, the core barrel could not be withdrawn with

100,000 lb overpull. During attempts to free the barrel after drilling down around it, the pin of the upper piston rod was twisted off. The majority of the APC assembly and the temperature instrument were therefore left in the hole.

Hole 642D

The deeper objectives of the reentry exploratory hole remained, and it was again necessary to pull above the seafloor and respud. The rig was offset ten meters to the south to avoid possible contact with the steel at 200 m depth.

Hole 642D was spudded at 1600 hours, July 2nd, and was drilled to drill string depth of 1482 m before the XCB "wash" barrel was pulled and continuous coring began. The XCB system performed nearly to perfection through the lower sediment section, which had not been cored in the earlier holes. Core recovery was over 92% for the first twelve cores.

Core number 14X recovered basalt in the core catcher from 1601 m (309 m BSF). That marked the beginning of "basement". The plan for the exploratory hole was to core with the XCB and NCB systems to about fifty meters into the harder rocks, or further if necessary to find a firm footing for the second casing string. Five additional short XCB cores covered 20 meters with only fair core recovery.

The lithology was weathered, rubbly basalt with clay and altered volcaniclastic strata--not good coring for any system. That was the setting given the NCB system for its debut. The first NCB core, a 2.5 m attempt, produced 1.5 m of core. It was predominantly of the softer lithologies and was badly jammed into the steel liner. The corehead was damaged, but not destroyed. The second attempt penetrated one meter at a slow rate. When the bit was raised off bottom, a momentary overpull and sudden release was noted. On recovery of the corer by wireline, it was noted that the entire assembly was truncated about 31 cm above the former cutting head. About 50 cm of interesting core was recovered, however. (For additional details, see accompanying report on the NCB system by M. Storms.)

At this stage in operations, there was little to be gained by spending time on fishing or redrilling the exploratory hole. The hole was flushed with drilling mud to prepare it for logging, and the bit was pulled to 62 m BSF to expose maximum open hole for the logs.

The standard suite of two Schlumberger combination logs (sonic/ induction/ natural GR and density/ neutron/ spectral GR) was recorded. Unfortunately bridges or ledges stopped the sondes and the lower 120 m of hole was not logged.

When logging operations were complete, the bit was run back to total depth and the hole was filled with 100 bbl of weighted mud. The drill string was then tripped for the reentry cone installation.

Hole 642E - Reentry Hole

Work commenced on deploying the reentry cone/conductor casing assembly just after midnight on July 4. Approximately 15-1/2 hours were required for the operation. It included dismantling (and reassembling) the guide horn assembly above the moonpool doors, moving the reentry cone into position on the doors, making up four joints of 16" casing and landing it in the cone, assembling the lower BHA, latching the entire assembly together and lowering it through the open moonpool doors.

The assembly was then run on drill pipe to the seafloor, the top drive was deployed and Hole 462E was spudded at 2013 hours.

Jetting was found to be much more difficult with the large tri-cone drill bit and casing than it had been with the 11-7/16" core bit. That had been expected, to a degree, but the slow progress beyond about 35 m BSF had not been anticipated. Circulation rate and weight were both increased to the maximum to force the casing string into the sediment, but penetration slowed nearly to a standstill. As a last resort, nearly the entire BHA weight was applied while using the heave compensator, and an apparent "breakthrough" was made. After a few meters, the string was picked up. The weight of the casing/cone assembly was not regained until the "drilloff" point was reached indicating that a sag or bow was actually put into the drillstring. Jetting continued until progress stopped completely with the casing shoe at 1340.1 m and the "mud skirt" of the reentry cone at 1288 m. That depth was about four meters shallower than that measured by coring at Hole 642C (30 m north), but within a meter of PDR depth.

A "rotary" shifting tool was made up to an inner core barrel and run on the sandline to shift and release the DSDP paddle-type casing release sub. The inner barrel assembly should have passed the release sub without interference, and the plan was to run several meters past the internal sleeve of the release sub and then engage and shift it upward as the barrel was returned. Instead, the barrel stopped and became stuck with the shifting tool very close to the release sub. After the inner barrel was jarred loose and recovered, the shifting tool was attached directly to the smaller-diameter sinker bars. It was then run past the release sub, but tended to stick at varying depth below it. The shifting tool was pulled through the release sub several times without indication of engagement. During these efforts, the pipe was "worked" to alternately apply and release weight on the release sub and to apply a small amount of torque. When release was not achieved, the shifting tool was retrieved. Another attempt to "work" the pipe was made, with slightly more weight and torque applied. The drill pipe suddenly turned free indicating release of the cone/casing at 0500 hours July 5.

A multishot survey was then run, confirming that there was a 2-1/2" bend in the pipe just above the seafloor and that the casing string was vertical. Because a bent bumper sub (located immediately above the release sub) was suspected, the bit was advanced with caution and slow rotation. The bumper sub passed through the latch sleeve of the running tool without difficulty, but cyclic torque and vibration soon indicated a bent BHA component. Drilling was terminated after about five meters of new hole and the drill string was tripped.

As suspected, the bumper sub was visibly bent. It was removed from service, along with the drill collar immediately above it (due to a possibly overstressed pin connection). The remaining BHA connections that had been located above the bumper sub were given a magnetic flux leakage inspection.

First Reentry--14-7/8" Core Bit

A 14-3/4" tri-cone drill bit had been deployed with the cone for drilling the hole for the surface casing. The unscheduled round trip and reentry necessitated replacing it with an old-style 14-7/8" core bit, as the tri-cone bit had no central passage for the reentry sonar. The drilling/casing BHA was assembled and a routine pipe trip was made to reentry depth.

The logging line was then rigged for reentry and the Mesotech sonar tool was deployed. The cone/casing assembly had been released with the top of the cone (sonar reflectors) at about 1285.3 m. The bit, with sonar landed, was brought to 1282 m. The sonar range to seafloor at that point was 7.3 m, making drill pipe water depth 1289.3 m. It soon became apparent that the bit was positioned almost directly above the cone. The target presentation was highly cluttered (a problem reported on Leg 103) and the four reflectors were not readily discernible. An arbitrary ASK offset of ten meters to the north was then made to open the range enough to orient the target image and make gain adjustments to the sonar. As this was being done, a second target appeared about ten meters further north. Its location and appearance left no doubt that it was the crater and cuttings left by the drilling of Hole 642D. The offset setting was removed and the pipe began to move directly back toward the reentry cone. It was just reaching the rim of the cone when the sonar stopped rotating and scanning function was lost -- possibly only seconds from a "stab" presentation.

The Mesotech tool could not be revived, so a wireline trip was made to replace it with the DSDP-vintage EDO sonar. Sonar scanning resumed after a 3-1/2-hour delay, with a normal reflector pattern presented. A two-meter offset and 17 minutes of scanning were required to bring the pipe into position for a reentry stab from 1288.3 m.

The sonar was retrieved and one stand of pipe was run to verify reentry. The top drive was then deployed and an inner core barrel was pumped into place at the bit. Drilling proceeded from 1345 m to 1499 m before the "wash" inner barrel was recovered. The multishot tool, run with the overshot on the sandline, indicated a hole deviation of only one degree off vertical. Drilling then continued toward the intended coring point of 1614 m. The first hard rock stratum was encountered at 1601 m, and progress slowed drastically at 1611 m. The wash barrel was recovered, and continuous coring began at that point.

Coring was intended to continue only until a suitable casing point could be found -- preferably below any soft or unstable transitional sediments or highly altered igneous rock. A sequence of scoriaceous and soft altered basalts, volcanic ash and altered pyroclastic sediments persisted until a "solid" basalt unit was encountered at 1655 m. The unit continued through the interval of core 10R to 1672 m, where the 14-7/8" hole was terminated.

A wiper trip was then made, wherein the bit was pulled up past the 16" casing shoe and returned to the bottom of the hole. Only then was it realized that the hole was in fairly poor condition. Although some hole fill had been encountered on connections, that had been attributed to the poor cleaning action to be expected when drilling large-annulus holes with water as the drilling fluid. The wiper trip, however, found tight spots in the 1630-1640 m interval in both directions and about 19 m of hole fill. A "flush" of sixty barrels of high-viscosity drilling mud was then pumped and displaced to clean the hole and leave it full of sea water.

As a precaution, the casing string was redesigned (while the drill string was being retrieved) to shorten it by ten meters.

Second Reentry--Surface Casing

The 11-3/4" casing string was 369m long and consisted of thirty joints of 54 lb/ft casing plus a special slip joint and a casing hanger joint. Total time for rigging and making up the casing string was fifteen hours, including assembly of the "stinger" BHA. Drill pipe was then added to put the casing shoe at reentry depth.

After the sonar was rigged down, the casing was run to setting depth. Resistance was encountered at 1608-1616m and 1621-1631m. At about 1652m, apparent hole fill was "felt" and pump circulation was used to advance the casing shoe beyond that point. The casing hanger landed and latched in at about the right depth, but the weight did not "come off" to permit rotation and release until the pipe had been lowered about 2.1 meters further. The weight of the second casing string apparently caused the conductor casing and reentry cone to settle by that amount. The surface casing was released at 1803 hours, July 9, with the 11-3/4" casing shoe at 1660.5m and the "mud skirt" of the reentry cone at 1290m (one meter below seafloor as indicated by sonar).

The casing was then cemented into place as 115 barrels of 15 lb/gal sea water/cement slurry was mixed and displaced into the casing/hole annulus. When the latch-down top plug landed at the shoe, the "stinger" was unseated and the drill pipe was recovered for the installation of a coring BHA.

Third Reentry--C-4 Bit

A 9-7/8" RBI Type C-4 core bit was selected, because the medium-length chisel inserts could be used to drill out the casing shoe and plug, as well as to core the hard basalt. The coring BHA was assembled and the pipe was run to reentry depth.

Even though the cement had been mixed with seawater to accelerate setting time, calculations indicated that about 24 hours would be required to insure a good cement job at the low temperature of the shallow sediments. As the short round trip time would necessitate some waiting, the opportunity was taken to perform a calibration check on the vertical reference unit of the ASK system. The EDO sonar was again deployed, and the reentry cone was used as a reference target as the vessel was taken through 180° of heading change. The 2-1/2 hour test confirmed that maximum heading-related positioning error was only about seven meters in 1300m of water.

Reentry scanning then commenced and, as the cone was approached, it was necessary to lower the pipe to 1287m to get the reflector pattern into proper range. A pipe measurement error was suspected, as the new depth put the reflectors at about 1289m (seafloor depth), whereas the two meters of observed subsidence should have left them at about 1287m. A successful reentry stab was made after about 25 minutes of scanning.

The trip then continued to 1623m, the top drive was deployed and an inner core barrel with a center bit was pumped into place. An additional 1-1/2 hours of "wait-on-cement" time was then spent before drilling out began.

Only about 3-4 meters of firm cement was found above the casing shoe. The float shoe and aluminum/rubber plug, which normally drill without undue difficulty, required three hours to dispose of. Considerable torque persisted for some time after the bit broke through the shoe. When the hole had been cleaned to total depth, about 12m below the shoe, the center bit was retrieved. The center bit bore deep gouges that appeared to have been inflicted by the core trimming rows of bit inserts.

Coring of new hole commenced at 0045 hours, July 11, with a four-meter core. Core recovery was a fair 1.9m, but the diameter of the core was only 48mm--a full 10mm under normal gauge. As cores that far under gauge had only been observed at the end of very long bit runs where three or four cones were quite loose from advanced bearing failure, another reason for small core from this new bit was suspected, with the prime candidate a bent-in finger on the bit throat core guide. A second (7.4m) core was attempted to see if the basalt would wear away the steel finger. Only one meter of core fragments and soft material was recovered, and bit failure was conceded.

Upon recovery of the drill string, the bit was indeed found to have undergone advanced bearing failure, with three cutter cones quite loose. The only plausible explanation appeared to be a manufacturing defect. The bit will be returned to Texas for autopsy.

Fourth Reentry--F94CK Bit

A bit with similar cutting structure manufactured by Smith Tool Co. was selected to core the apparently interbedded basalt/sediment sequence. The down trip began after minimal turnaround time, and a silk-smooth reentry was made with just eight minutes of scanning time. Total round trip/reentry time was only 12-1/2 hours.

Coring Proceeded with good results through alternating vesicular and massive basalts with a few thin sediment strata. Average penetration rate through 164m was a quite respectable 3.6m/hr. After an equally respectable rotating life of 45 hours, the bit was retired when decreasing core diameter signalled progressive bearing failure.

Fifth Reentry--C-57 Bit

Due to the predominance of basaltic material, the next bit chosen was an RBI C-57 model, which featured conical cutting inserts. An additional stand of drill collars was put into the BHA to provide more weight for the hard rock cutting structure.

The recently-repaired Mesotech sonar was deployed, and reentry operations began. A fairly good reentry cone target could be discerned from a distance of ten meters or more, but at close range the reflectors, cone and seafloor seemed to merge into an unrecognizable mass. The effect was attributed to excessive signal strength or gain settings in the sonar, as similar problems had been experienced. A "best guess" stab was made at the center of a very poor target after 36 minutes of scanning. Initial weight indications were favorable and the sonar was recovered to the rig floor before the Martin-Decker began to show suspicious signs that soon confirmed a misstab.

The Mesotech unit was replaced by the old EDO sonar for the new attempt. Scanning again failed to produce a good target, however. The reflector pattern was even worse, and repeated approach maneuvers failed to produce a range of less than 7-8m to the reflectors. The bit was finally lowered to 1286m and, after nearly five hours of scanning, a stab was made at the center of a rather amorphous target. Again the weight indication at the driller's console looked good, and the sonar was pulled. On running a stand of pipe for verification of the reentry, however, the string "took weight" and confirmed a second consecutive misstab.

By this time it was evident that the reflectors of the cone were at or below the seafloor and were covered with drill cuttings and/or seafloor sediment. At the suggestion of the Drilling Superintendent, the circulating head and kelly hose were rigged and both mud pumps were run at maximum rate to sluice off the rim of the cone and the reflectors. During this process, the bit was positioned at 1286m and ASK offsets of three meters were sequentially entered in all directions to sweep the pipe across the cone.

As the Mesotech sonar had actually produced the better target presentation of the two runs, it was deployed for the third attempt. It failed to calibrate on the first in-pipe check at 250m below the rig floor, however, and was pulled in favor of a second EDO tool (the first-string EDO had been badly damaged during the verification attempt). The washing tactic was a complete success, as a normal, distinct four-reflector pattern was acquired immediately. The ASK system was somewhat unresponsive due to a lack of sufficient environmental forces, but a successful stab was made after 35 minutes.

The new bit also performed well and averaged about 3.2m/hr through 73m of basalt that was possibly somewhat harder than that higher in the hole. Then, after recovery of core 39R with only lumps in the core catcher, circulating pressure was too high on pumping down the next core barrel. That is usually an indication that the bit is partially plugged (throat or nozzles).

The inner core core barrel was retrieved and a special bit deplugger was pumped down at high velocity in an attempt to dislodge any material that might be obstructing the bit throat. The deplugger was "spudded" with the wireline, but the abnormal pressure persisted. The heavy wall drilling joints (HWDJ) were laid out and the pipe trip continued after an inner barrel had been pumped down without the desired pressure decrease. A stop was made to wash off the reentry cone as on the previous reentry. (The practice became standard procedure for the remainder of operations at 642E.)

On recovery, the throat of the bit was found to be completely plugged with pulverized basalt and claylike material. The bit showed no signs of wear or failure, but it had accumulated 23 rotating hours and was removed from service. It was replaced by an identical RBI C-57 bit.

Sixth Reentry--C-57 Bit

An easy (12-minute) reentry was made with the EDO sonar. Six meters of hole fill was found after the trip (Fill was persistent for the remainder of operations, almost certainly because of cuttings falling back from the seafloor.)

After only 38m had been cored, a zero-recovery inner barrel was retrieved and the subsequent barrel again showed excessive pressure on pump-down. The inner barrel was pulled and two wireline runs were made to use both the deplugger and shorter, chisel-shaped core breaker. Circulating pressure decreased and chalk indications on the core barrel were favorable, and another core was attempted. There was no recovery, however, and the plugged-bit indications were back. The pipe was tripped and the bit was found to be in the same condition as the previous one. Because of its like-new condition (despite 18 hours) and because the bit supply was not unlimited, the same bit was cleaned out and reinstalled for continued coring.

Seventh Reentry--C-57 Bit

The minor problem with the Mesotech sonar had been rectified, and it received the reentry call. The reflector target pattern remained more difficult to resolve with this tool, despite minor modification to reduce incoming signal strength. The reentry stab was made after 40 minutes of scanning.

The cause of the plugged bits was, by this time, a topic of lively discussion. Formation conditions or contact with hole fill were suspected, as the RBI bits were manufactured to the same specifications as bits from previous vendors--except that it was noted that the jet nozzle size was larger than on the older-generation bits. Inadequate hydraulics at the bit face were suspected by rig personnel for that reason. The C-57 bits also differed in that the detail of cutting insert shape was new to DSDP/ODP operations. As speculation continued, it was learned that the bit had again plugged after 38 meters of coring.

As before, attempts to unplug the bit were unsuccessful and a round trip was necessary. The same type of plug was again found in the throat. The bit was retired after 28 rotating hours, still in excellent condition. The rate of penetration had averaged over 3 m/hr with much of the coring done with a plugged throat--a situation of mixed reviews. The cause-of-plugging issue was not resolved, but there was sufficient cause to discontinue use of the RBI bits, at least temporarily.

Eighth Reentry--F99CK Bit

The amount of sediment and claylike alteration products in the material being cored had decreased to a very small amount, and an extra hard formation "button" F99CK bit (a survivor from the DSDP) was selected for the next run. Another stand of three drill collars was added to the BHA to provide the weight necessary for good performance of bits of that type.

The Mesotech tool had been modified further and was used again for the reentry. The pipe swung across the cone on the very first move of the search and a stab was made after six minutes on the basis of a marginal target presentation. Although the pattern had appeared to be centered, the rig floor reported an unfavorable weight indication. Considering the time involved for a wireline trip and conclusive verification, the bit was pulled back to scanning depth and scanning was reinitiated. A successful stab was made after an additional seven minutes.

On two occasions there were pressure indications of bit plugging, but both followed cores with considerable recovery and both times the bit was cleared successfully with the core breaker. It is believed that pieces of core fell from the core catchers during retrieval of the core barrel and became lodged at the bit throat.

Performance of the hard rock bit exceeded expectations, and an extraordinary run of 173.5m in 41.8 hours ensued before reduced core diameter indicated bearing failure. Good heave compensation, porous vesicular basalt and the long, heavy BHA were all factors. Because of the bit's great success, its "littermate" was chosen for the succeeding run.

Ninth Reentry--F99CK Bit

The round trip and reentry were difficult due to bad weather and were slowed by swells in excess of three meters. The EDO sonar was used, as an uncluttered presentation was desired to minimize the effects of vessel motion. The target presentation was normal and the heave compensator was effective in keeping drill string motion to a minimum during the reentry operation. The environment made precise maneuvering with the ASK system difficult, however, and the scan took 53 minutes before the reentry was made.

The new bit accepted the challenge of its predecessor and actually drilled faster with increasing depth. One "dropped-core" obstruction was cleared with the core breaker. The end of an outstanding bit run was approaching when a sediment unit was encountered. There were no particular indications of bit failure, but 45-1/2 hours of rotating time had accrued. The new lithology contained altered volcaniclastic material, and the ROP had dropped sharply. The bit was therefore pulled "green" after a prodigious 211.8m of basalt drilling with an average ROP of 4.7 m/hr.

Tenth Reentry--F94CK Bit

With time running out and the unknowns of reflector "K" lying ahead, a "drill anything" bit with intermediate-length chisel inserts (Smith F94CK cutters) was chosen.

The reentry was made with the Mesotech sonar. It was a difficult one, with the reflectors blending into the seafloor and forming a bright ring. It appeared that they were again partially covered with cuttings despite the "washing" operation on each out-trip. The stab was finally made into the center of a "pile" without discernable reflectors at the moment. It was good, but 24m of fill in the hole contributed to doubts that continued reentry operations would be feasible.

Coring continued through tuffs and basalts, some intensely altered. Most was fairly easy drilling, but an exceptionally hard basalt dike of about 15m was penetrated. One bit obstruction was again cleared with the deplugger. Coring operations were finally terminated by time limitations and achievement of objectives at a total depth of 2518.4m (1229.4m BSF).

The hole was given an extra thorough combination bentonite and polymer mud flush before the pipe was tripped for the logging BHA. The reentry cone was also given an extra thorough washing with the bit at 1287m.

Eleventh Reentry--Logging BHA

A short, open-ended logging BHA was assembled and run to reentry depth. Because of the poor presentation on the previous reentry, the EDO tool was run in the hope that anything would be an improvement. On commencement of scanning, it appeared that the washing tactic had once more been effective. A normal four-reflector pattern was detected but became indistinct as the drill string approached the cone. The reflectors fused with the seafloor on the 45° presentation and the 8° transducer seemed to "look over" the reflectors. In addition, the drill string was unresponsive to small ASK offsets--probably because of its light weight. The proper pattern was finally acquired after the pipe had been lowered almost to the seafloor, and the stab was made after 86 minutes of scanning.

On retrieval, the sonar tool was exchanged for logging equipment and the downhole measurements phase of operations began. The standard suite of two Schlumberger combination logs was recorded first. The logs were of good quality, but the tools would not pass an obstruction in the hole at 2388m, 130m off total depth. Sonic wave forms were recorded into the cased hole interval in an attempt to evaluate the cement job and in the absence of cement bond log equipment. Good bonding appeared to extend about 100m above the shoe, with the cement top about 40m above that.

The next downhole investigation attempt was with the L-DGO borehole televiewer. Several problems related to the tool's light weight and stiff centralizers were experienced, costing considerable time. The tool eventually was deployed into open hole but problems with the depth measuring system then resulted in loss of depth control and the experiment was terminated due to expiration of allotted time.

The vertical seismic profile (VSP) was the final in-hole measurement to be conducted. The 2-1/2" diameter clamped-geophone sonde was lowered into the borehole without difficulty and actually was worked past the obstruction that had stopped the larger logging tools. Due to time limitations, however, the first and lowermost clamping station was made at 2400m depth and no attempt was made to go deeper. The heave compensator was opened and the drill string was lowered to seat the large-diameter latch sleeve of the DSDP 16" casing running tool (located at the top of the BHA) in the base of the reentry cone. With 10,000 lb of BHA weight resting on the cone, the drill string was immobilized to reduce noise for the duration of the experiment. A 1200 in3 airgun was suspended in the water from number three crane and was used as a sound source for the seismometer. Several shots were recorded at each of 44 stations between 2400m and 1740m depth. Two failures of the geophone clamping arm safety shearpin occurred, one of which caused a three hour replacement delay and the second of which resulted in the termination of the experiment with time running out.

As soon as the VSP experiment had been rigged down, the drill string was recovered. The ship departed immediately for Site 643 at 0000 hours, August 2.

Site 642 to Site 643

August 2 was a bad day for acoustic beacons. The beacon that had been deployed on the taut wire at Site 642 was lost, along with the taut wire weight, when the wire parted just as the beacon and weight were being hoisted aboard prior to departure. Good steaming weather had permitted preassembly of part of the BHA for a head start on operations at Hole 643A. An acoustic beacon was launched at 0607 hrs, August 2, just six hours after departure from the previous site. The seismic gear was retrieved, BHA deployment continued, and thrusters and hydrophones were lowered as the ship maneuvered onto the drillsite at low speed. Upon return to the drop point, it was learned that the beacon signal was too weak to use for pipe operations. A standby beacon was then dropped to replace it. The second unit failed completely after about five minutes. It was then necessary to rig and deploy a third beacon (of a third frequency) before satisfactory positioning could be achieved.

Hole 643A--Voring Plateau, Outer Slope

Because the drillsite was on a considerable slope, there was reason to believe that the PDR reading of 2764m was somewhat shallow. The first piston core was therefore "shot" from 2766m. The correction allowance proved to be inadequate, however, as only a "water core" was recovered. The pipe was then advanced one joint for the next core and water depth was established at 2779.8m from drilling data.

APC cores were taken with good results to 148m BSF, primarily in glacial muds. At that depth, overpull of 60,000lb was required to retract the core barrel from the sediment and operations were converted to the extended core barrel mode. The circulation rate was reduced after the first two XCB attempts produced low recovery. Good core recovery then continued for the remainder of the hole, except for a zone of laminated terrigenous mudstones between about 300 and 400m BSF. Both recovery and penetration rate were down through this interval. Cores were considerably more disturbed in general than with the XCB at Hole 642D.

The hole was nearly lost after 467m penetration when the sinker bar assembly parted at the wireline swivel. The nature of the break necessitated the fabrication of a special makeshift fishing overshot.

Fortunately the fishing effort was successful on the first attempt and the sinker bar/jar assembly and a full core barrel were recovered intact from the drill string.

Hole conditions remained excellent to about 530m BSF, when unstable hole conditions were encountered without even the warning signal of a low-recovery core. Torquing, sticking, "packing off" and several meters of hole fill consisting of large chunks of hard mudstone had to be overcome by pumping polymer mud slugs and "working" the pipe. With the hole apparently stabilized, coring continued and hard drilling began at about 558m BSF. Two short pieces of basalt core were found in the core catcher. During attempts to take short NCB cores with special hard formation cutter shoes, hole conditions again deteriorated badly. The XCB proved ineffective in the basement(?) material, with low recovery and very low penetration rates. The situation seemed tailor-made for the planned further testing of the NCB system, but the hole could not be stabilized enough to risk deployment of the expensive prototype corer (or any further coring attempts). Coring operations were terminated at 3345m (565m BSF).

In preparation for logging operations, the top drive was rigged down and the bit was pulled to 2858m (78m BSF). The Schlumberger LSS/DIL/GR logging assembly was rigged and run into the hole, only to be stopped by an obstruction 70m below the bit. When the logging sonde could not be advanced deeper into the hole, it was retrieved and three stands of drill pipe were added to the string to put the bit at 2945m. The same logging tool was redeployed and again was stopped by an obstruction--this time at 2999m. With operating time running out, plans of open-hole logging were abandoned. Best odds of recovering useful log data appeared to be with the "GST" log, which can be recorded through pipe. Because of the good hole conditions during most of the coring operations, it was felt that through-pipe logging could be conducted fairly safely above the depth of the first indications of unstable hole. With the intent of locating the bit at about 3300m, just above the unstable zone, the pipe was run back into the hole. After five stands had been added, however, the bit was stopped by an obstruction in the hole. Additional pipe was added and the pipe was bent just above the seafloor, preventing rotation of the pipe and effectively preventing any further logging attempts.

The drill string was recovered to the bent interval, and nine joints had to be laid out before the lowermost portion of the string could be brought aboard. The ship departed Site 643 at 0200 hrs, August 8.

Site 644--Voring Basin

The final drillsite was to be the landward end of the three-site transect of the Voring Plateau area. The pipe trip at Hole 644A began just 9-1/2 hours after departure from the previous site. Water depth was only 1227m (PDR) and a penetration limit had been set by Norwegian authorities at a maximum of 250m or APC refusal, whichever came first. The site was therefore destined to be a quick double-APC effort that had to be completed in a little over two days to meet the required departure time for Stavanger.

Because of the expected brief site time and the shallow water, no positioning beacon was free-dropped, but a single beacon was lowered on the rig's taut wire system. The tactic proved successful at Site 644 because no major change in environmental conditions forced a radical heading change with pipe below the seafloor. Had that occurred, it would have been necessary to drop a second beacon for reference while the taut wire-deployed unit was raised and reset.

The first APC core established seafloor depth at 1226.3m. Continuous APC cores then were taken until the depth limitation was reached. The stiff glacial muds were far from ideal for hydraulic piston coring, but the section was recovered fairly completely. An inordinate number of core liner failures, seal failures and cores jammed in barrels was experienced. The plastic liner failures were partly due to the nature of the sediment and apparently due in part to defects in the liners themselves. The pace at which the cores arrived on deck kept both the rig crew and the scientific staff struggling to keep up and left no time for dealing with mechanical problems. The hole was spudded at 1540 hrs, August 8, and 110.5m of core had been received in the laboratory by midnight. By the second day, several jammed core barrels and malfunctioning coring assemblies had been set aside to make room for more core.

An additional complication to core handling and processing was the presence in the cores of a considerable amount of methane gas. That was not unexpected due to past experience in the area and the nature of the sediments. Gas was noted below about 50m BSF, with the greatest amount present around 120m. Expansion and pockets inside the liners contributed to jamming and caused significant core disturbance.

Overpull on retraction of the core barrels approached but did not reach the 100,000lb figure that defines APC "refusal" on the basis of tensile strength of the coring assembly. Some short-stroke cores were recovered near the base of the mud section, but a marked improvement in penetration/recovery was noted when mid-Pliocene biogenic oozes were reached below about 229m BSF.

Because of the presence of hydrocarbon gas in the hole, it was filled with barite-weighted drilling mud before the core bit was pulled above the seafloor for spudding the second hole.

When the seafloor had been cleared, an offset of 61m was made to the south-southwest before respudding. The seafloor depth of the second hole, Hole 644B, was found to be 1225.9m.

Hole 644B was a virtual repetition of the coring operation (and problems) of 644A. The core intervals were staggered as much as was feasible to provide overlap and recover any intervals missing from the 644A section. Operating time expired before the complete section could be recored, however, and coring was terminated at 127.7m BSF. The second hole also was filled with heavy mud before the drill string was recovered. A shipload of weary people departed the Voring Plateau for the long-awaited port call at 1830 hrs, August 10.

Site 644 to Stavanger

Speed for the first day of the transit was nearly 13 knots, with excellent weather conditions. It appeared that the goal of a morning arrival in Stavanger would be met--until the early morning hours of August 12. The passage of a weather front that proved to be earlier and stronger than predicted produced headwinds with gusts to 45 knots. At about the same time it was learned that the vessel's assigned berth would not be vacant until noon. Speed was reduced accordingly, and the first line was put over at Middelthon's Dock at 1230 hrs, August 12.

Stavanger Port Call

Though the port call activities in Stavanger did not include a crew change, the visit was an important one for logistical and other reasons. The drill string heave compensator had begun leaking due to scored piston rods during Leg 104 operations and had been disassembled during the transit. Representatives of Western Gear visited the rig to troubleshoot the problem and one of the rods was shipped to Holland for replating. As the drill string compensator components were leaving, the Schlumberger wireline heave compensator was being loaded and was in the initial phase of installation adjacent to the logging winch. The armature of propulsion motor 15B was off-loaded for rewinding, and motor 13B was moved into the 15B location. Drill collars and heavy wall drilling joints were removed to the dock and given a magnetic end area inspection.

The Leg 104 cores were off-loaded for shipment to the East Coast Repository and oncoming freight shipments were received by ODP and SEDCO. The rented Navidrill motors were shipped back to Germany. Quantities of fuel, drill water, cement, bentonite and barite were loaded into the tanks.

All the Leg 104 scientists departed the vessel in Stavanger, and there were many activities and tours in honor of the scientific success of the voyage. Numerous representatives of the European petroleum industry visited the ship, and receptions were hosted ashore by Statoil and BP. Some members of the ODP staff and two Leg 105 scientists boarded for the transit to Canada. JOIDES Resolution departed Stavanger at 1800 hrs, August 15.

Stavanger to St. John's

Important work items to be accomplished during the transit included installation of the wireline heave compensator, disassembly and inspection of major rig equipment, magnetic end area inspection of the remaining four BHA stands and extensive pumping tests to evaluate design improvements to the XCB vent sub.

The route to St. John's was west through rough (but following) seas of the North Sea, through the Fair Isle Channel north of the Orkney Islands and onto the great circle course for Newfoundland. Weather conditions were excellent for the first day, but became more typical of the North Atlantic thereafter. An average speed of 11.6 knots was made good for the first five days, however.

On two occasions on August 20, failure of the ship's steering gear forced the vessel to heave to for over an hour. In the first instance, emergency retrieval of the towed geophysical gear resulted in damage to two tow cables.

On August 21, word was received that arrival in port would again be delayed by the nonavailability of a berth. The final two days of the transit were a series of speed reduction steps, as weather conditions improved and further delays ensued. The vessel arrived at the pilot station outside the harbor at 1830 hours, August 23, then had to wait 35 minutes while a cruise liner cleared our berth and the harbor.

Leg 104 came to its official end at 1935 hrs, August 23 with the first line at Pier 11, St. John's Harbor, Newfoundland, Canada.

Drilling Technology

The use of polymer mud for hole cleaning was investigated, with alternate slugs of "XP4000" polymer and high viscosity bentonite mud used at Hole 642E. The polymer was mixed with seawater and a small amount of bentonite, whereas the bentonite gel was mixed with (fresh) drill water. Results were encouraging from a technical standpoint, with indications that both types of mud slugs were carrying cuttings out of the hole under the existing conditions. There was no indication of superior performance in either case. The amount of dry polymer required to produce the specified high viscosity exceeded the expected quantity and increased the cost of the polymer slugs. The cost of the dry polymer will have to be balanced against savings in costs of fresh water, bentonite and transporting/loading in evaluating the desirability of polymer for ODP operations.

Drilling and Coring Equipment

Leg 104 employed virtually the entire array of ODP coring and drilling systems and was not particularly gentle with them. The standard RCB, XCB and APC systems were all effective in collecting core in the situations for which they were designed. The debut of the new Navidrill core barrel (NCB) system could not be called a successful coring operation, but it was a solid and valuable first step in the development of downhole motor technology for the ODP. Details of the Leg 104 NCB project may be found in the report prepared by M.A. Storms.

Coring bottom-hole assemblies contained from six to fifteen drill collars, depending upon the bit and coring system in use. Special BHA's were used for deploying the reentry cone, running surface casing and logging. In all coring BHA's, the top drill collar was 7-1/4" diameter to provide a tapered bending section from the 8-1/4" collars below to the drill pipe above. In all cases, one stand of 5-1/2" drill pipe was run between the BHA and the 5" pipe above. A bumper sub was run on only one occasion--with the reentry cone, directly above the casing running tool. In that case the bumper sub may have saved the BHA, cone and casing by bending and preventing a connection failure, but the new block-mounted motion compensator may make it possible to phase out the use of bumper subs in standard ODP BHA's.

The new removable upper guide horn bushing proved to be a major improvement in terms of trip time and safety. It saves an estimated two hours per round trip over the previous arrangement. The lower portion of the upper guide horn still must be handled whenever anything having a diameter larger than a HPC/XCB bit is run through the moonpool, adding about two hours per round trip.

Problems remain to be solved with the oil saver/quick release system atop the wireline BOP. There was considerable difficulty getting the oil saver to latch into and stay latched into the quick release ball latch. The situation of the grease line fitting which protrudes from the side of the oil saver body has not been satisfactorily resolved. As a result there have been delays in wireline trip time, and excessive "rig rain" has fallen due to backflow and/or swabbing action.

The most serious mechanical problem experienced with rig equipment was the scoring of both piston rods, which became catastrophic by the end of pipe operations (but did not delay them). Oil leakage from the lower seal of the forward piston rod began on about July 24 during operations at Hole 642E. Scoring was observed, but the cause of it could not be determined without disassembly. During subsequent operations, scoring appeared on the other rod and eventually became worse than the initial damage (which had also progressed). Upon disassembly and inspection in Stavanger, several apparent contributing factors were observed, but the primary causative factor was not readily apparent. The rods were sent for replating while the inspection data are under study. The performance of this machine has been impressive, and a straightforward solution to the problem will be needed to make the compensator available for Leg 105.

Other problems developing during the leg or discovered during the transit inspection included a failed bladder in one of the top drive retractor accumulators, three shorted field coils in the forward electromagnetic auxiliary brake and excessive wear in the crown crossover sheave bearing and on the block connector attachment pins.

ODP coring equipment also suffered casualties. Two holes were lost due to failure of APC components and one by the failure of the NCB. Neither of the APC failures was strictly caused by a mechanical or design weakness, and changes in procedure will help to avoid future incidents of that nature. The sinker bar failure that nearly caused the loss of Hole 643A has already resulted in a design change to the component involved. The operation was also affected by an inordinate number of plastic core liner failures and by a lack of effective means of removing stuck cores from inner barrels (many of which resulted from liner failures). The search for an improved material for liners will be given a higher priority than in the past. A detailed treatment of coring/wireline equipment difficulties and suggested improvements is contained in the Leg 104 Engineering Report by Special Tools Engineer M.A. Storms.

Bits

Nearly the entire array of ODP bits was brought into play during the voyage. Most performed up to expectations, but there were exceptions. The only new RBI model C-4 bit remaining aboard was run as the first 9-7/8" bit in the reentry hole. There were positive indications that the bearings failed in the process of drilling out the casing shoe and cementing plug--drilling that should not be a challenge to a sealed-bearing TCI bit. As a manufacturing defect is indicated, the bit is being returned for study.

Two RBI model C-57 bits were deployed in Hole 642E with the intent of comparing the performance of the longer conical insert shape with the short conical inserts of the F99CK and the short chisel inserts of the C-4 and F94CK models. A direct comparison with the F99CK was especially desired. Unfortunately the two C-57 bits were the two bits that were subject to the throat-plugging difficulties, and both were pulled long before failure of either bearings or cutting structure. Their rate of penetration was lower than that of the F99CK bits, but the BHA weight was never applied to them that was later found to be necessary to make the F99CK perform. All the RBI bits were equipped with larger-than-specified nozzles, and it remains unclear whether the plugging was due to inadequate hydraulics or to contact with hole fill during core retrieval wireline trips.

A 14-3/4" Reed S62-J bit was deployed with the reentry cone and casing for the purpose of drilling the hole for the 11-3/4" casing into basalt. Great difficulty was experienced in jetting in the casing with the tri-cone bit, and the bumper sub was bent in the process. The drill string had to be tripped because of the BHA damage, and the S62-J could not be rerun because it had no passage for the reentry sonar. Instead, an old 14-7/8" core bit was used. There was concern for the safety of the hole, as a bit of that design had broken up while drilling basalt during DSDP. The veteran performed well, however, through 74m of basalt and other volcanic rocks, and some valuable core was recovered.

Two 11-7/16" HPC/XCB bits were used, both with Smith cutters. The one at Site 642 was in excellent condition after 30 hours and the one at Site 644 was worn out (bearings) after 35 hours.

Reentry Hardware

The dual-casing reentry cone system was deployed from the ship without major difficulties. The design or the 16" casing hanger makes it extremely awkward to handle and make up to the casing, and interference from the mezzanine deck platform aft of the moonpool prohibits installing the two aft reflectors until after the cone has been lowered partially through the moonpool doors. The DSDP paddle type running tool was used for the first time on the new rig. Only "learning curve" difficulties were experienced until it was necessary to run the shifting tool through the bent bumper sub, when one of the advantages of the double-jay running tool became clearly apparent. The first string of 11-3/4" casing to be handled on the rig also went relatively smoothly. Rig personnel introduced the concept of preassembly of the upper portion of the stinger and its storage in the derrick. This permitted latchup at the rig floor level without the requirement for hanging off the casing string on the moonpool doors.

A mounting bracket was fabricated to attach a (commandable) beacon to the rim of the reentry cone. The addition of the beacon worked well, as it could be activated for reentry to save time by using zero offsets. It could also be available as a backup for the other beacon(s) in use without sacrificing its own battery life. The cone-mounted beacon was left turned off for possible future referencing if investigators should return to the site. Two of the reflectors on the cone were modified slightly to make them more reflective sonar targets. Results were inconclusive.

The problem of jetting efficiency with the 14-3/4" tri-cone bit has been encountered on Legs 103 and 104 and is one that will require research in the near future. It is considered likely that the prolonged high-volume jetting at Hole 642E eroded the soft sediment around the conductor casing to the extent that reconstitution had not occurred when the load of the surface casing string was applied to it. The added weight then simply pulled the conductor and cone down with it. Possibly aggravating the situation was the limited area of the "mud skirt" of the cone. At eight feet square, the base is much smaller than could be accommodated by the moonpool opening. Design calls for all the load to be supported by skin friction of the 16" casing, but an increased base area would be a comforting backup. A skirt extension will be provided for the Leg 105 cones.

Reentry Electronics

Nine reentry attempts were made with the obsolescent EDO-Western sonar system and six attempts were made with the new Mesotech unit. There was one confirmed misstab with each of the systems. There were two misruns with the Mesotech due to equipment problems. No significant problems occurred with the EDO units, except for the damage sustained on the rig floor. The Mesotech continues to be an impressive system, with remarkable detail visible from ten meters or more. It is only in the final stages of the approach that the target becomes unrecognizable because of reflections that merge into a solid ring, "ghost" reflectors that appear at 180° from the real ones and apparent bright seafloor and cone reflections. On the hypothesis that the receiver preamplifier was being overdriven, internal gain reduction adjustments were made and plastic shims were inserted at the rotating transducer head to attenuate the signal. These steps appeared to be in the right direction, but it is possible that familiarity enabled us to tune out extraneous reflections mentally. It is felt that the 90° vertical beam width of the Mesotech transducer contributes to the problem by presenting target reflections that lie outside the area of the cone rim. The EDO sonar shows much less than the new system, but it displays the reflectors clearly and, in essence, will give the clearer presentation for reentry until the needed improvements are made to the Mesotech.

Logging Winch

Through fifteen reentry attempts and various logging and downhole experiment runs, the TAMU logging winch proved absolutely trouble-free without so much as a leaky hydraulic line. During the transit to St. John's, tests were conducted on the hydraulic drive motor and the spare motor was installed to pursue the problem of the unit's inability to operate at a slow enough line speed for certain logs.

Positioning

The performance of the vessel's automatic station-keeping system was dependable for the duration of site operations despite some severe environmental conditions and a few equipment problems. During severe weather on July 12-14, ASK computer (CPU) number one dropped off line repeatedly. It was found to be sensitive to vibrations from thrusters 3-6, and the problem was managed by limiting RPM on those thrusters. New components are on order to eliminate the fault. Water leaking into the termination at the hydrophone end of the cable to hydrophone "B" caused the cable to short out on July 27. The cable was not field repairable and the use of the hydrophone was lost until a replacement cable was received in Stavanger. The short initially resulted in blown fuses which caused the loss of two hydrophones and reversion to the backup short baseline system for positioning. The circuit has been rewired so that it is no longer shared by two hydrophones.

A total of nine acoustic positioning beacons were used during Leg 104. Two were dropped out of position, two failed soon after launch, two were deployed on the taut wire and one was attached to the reentry cone. The first beacon dropped at Site 463 was used for initial positioning, but the signal was found to too weak for pipe operations. Pulse characteristics were also poor and the beacon failed completely after four hours. The beacon dropped to replace it failed abruptly only five minutes after drop. That failure mode has been seen on other units earlier in the Program and is believed to be the result of an O-ring seal or other pressure case leakage. Because of the shallow water depths at Sites 642 and 644, it was feasible to use the taut wire system to deploy beacons which could be retrieved after DP operations were finished. The beacon used in this manner at Site 642 had performed for over 32 days, but had weakened considerably as it was retrieved in preparation for getting under way. The taut wire cable snapped as the beacon and weights were being lifted from the water and they were lost. That unit was originally set on the 16.5 kHz frequency, but was retrieved and reset to 14.0 khz after it was observed to obscure the weaker signal of the 15.5 khz beacon that had been dropped 450m away. Thus the more distant beacon could also be used for reference. The commandable unit deployed on the reentry cone gave an added dimension of flexibility to the operation. It was turned on and off repeatedly without difficulty.

Ship's Machinery

The ship's engineers and electricians were also kept well occupied. On the first day out of Bremerhaven, propulsion motor 14A was taken out of service because of copper imbedded in the field coils and propulsion motor 15B developed a short in the armature winding. The transit to the first site was completed on the remaining ten motors. Motor 14A was repaired shortly after arrival on site, but 15B was not field repairable. The armature was shipped from Stavanger for rewinding. Shorted field coils put thruster motor number 9 out of commission on July 29, but it was repaired within five days.

On June 30, a faulty valve in number 2 mud pump caused the bonnet of the sea suction strainer/pulse dampener to be blown off. The failure resulted in flooding of the pump room with seawater. The water had reached a depth of three feet before the flooding was discovered and the seachest valve was closed. The motors of the main pumps and the centrifugal transfer pumps were wet and required over a day to dry out. No operating time was lost, as APC operations were in progress and they were sustained by using the cementing unit to pressure the pipe.

On July 27, the thermostatic valves on number 2 main engine were found to be damaged and inoperative. The engine remained out of service until spares were received in Stavanger.

On August 20, during the transit to St. John's, a hydraulic hose burst on the ship's steering system. The failure caused the loss of all steering capability, emptied the hydraulic fluid reservoir into the steering compartment and resulted in damage to two geophysical tow cables during the emergency retrieval. The casualty was repaired and the vessel was again under way after 1-1/2 hours. After 3-1/2 hours, the same hose failed again, with the loss of another 1-1/4 hours without steering. The steering arrangement is a matter of concern because there is no redundant system for the hydraulics, and the hydraulics are required to operate even the emergency "hand steering" system.

Weather and Currents

The following comments were submitted by Weather Observer F. Johnson:

> "The weather at the drill sites was pretty much as expected based upon the climatic data provided by ODP, climatic, atlas and pilot charts.
>
> "There were two noteworthy exceptions. The first occurred on 13 July when a squall line associated with an occluded front passed over the ship increasing the winds to 40 knots with several gusts in excess of 50 knots for about 2 hours. The second incident happened on 22-24 July and was a bonafide gale which deepened rapidly between Site 642 and the Norwegian coast. This gale persisted for about 48 hours with sustained winds of 30-40 knots and some gusts as high as 48 knots. Both of these events exceeded the maximum expected winds but neither system produced extremely high seas due to their short duration and/or short swell fetch areas.
>
> "The average swell was about 6 feet with the highest swells about 13 feet on 23 July and swells over 10 feet from early morning on 23 July until late afternoon on 24 July.
>
> "The average winds were somewhat stronger than expected with winds of 30 knots or greater 13% of the time and 20 knots or greater about 50% of the time. The prevailing winds were about evenly divided between northeast and southeast with the strongest gusts from the southwest. Northwest winds were rare--occurring only about 2% of the time.

> "The temperature held no surprises with observed data closely agreeing with the climatological data. The air temperature ranged from 47 to 57 degrees F. and the sea water temperature ranged from a low of 47 degrees F. at Site 642 to a high of 54 at Site 644."

The operating area lay near the axis of the Norwegian Current, and a current of about one knot toward the north or northeast was typical. The current was never strong enough to adversely affect the operation, though its effects on the drill string were sometimes evident during reentry operations. The current was beneficial to an extent by providing an "environmental force" for the ASK system to act against for stable positioning. Major ocean currents influenced nearly all of Leg 104, with the Norwegian Current prevailing at the drill sites and the vessel's westward transit track crossing first the warm North Atlantic (Gulf Stream) Current and then the cold Labrador Current with its icebergs and fog. (Only one iceberg was detected--at 11 miles on radar in foggy conditions about 165 miles out of St. John's.)

Communications

The voyage was an eventful one, and there was much to communicate about. The COMSAT Maritime Communication System carried a heavy load and possibly made communication a bit too easy. ODP-related traffic accounted for over 300 messages (mostly telex) out and over 200 in. UDI telex traffic was lighter, but their telephone and facsimile (FAX) load exceeded that of ODP. Several of the longer ODP messages were transmitted by FAX, but communication with the FAX receiver at ODP Headquarters was difficult and a number of those messages had to be retransmitted or sent via the receiver in UDI's College Station office. Due to the lack of "ham" radio patch capability, all personal telephone traffic had to be handled through either the satellite link or the Norwegian commercial radio station at Rogaland. Both involved considerable expense. The satellite system proved quite reliable and there was little or no indication that it was approaching its high latitude limitation, even at 67° 43'N.

Personnel

Leg 104 was demanding on people as well as equipment. A very full eight-week leg was followed by a hectic three-day port call in Stavanger and an eight-day transit which had its own heavy work load of maintenance and special projects. The sustained hard work, unpleasant weather and duration of the voyage combined to affect both the morale and the efficiency of personnel in all categories of the shipboard party. To the credit of all concerned, work on the ship and in the laboratories was carried out in a professional manner to the final day of the leg.

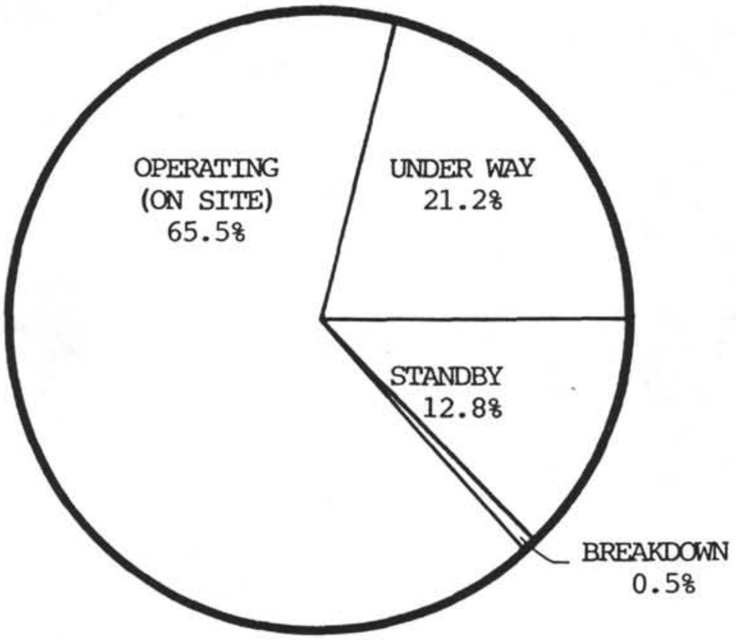
A helicopter flight was made to the rig on July 17 for the exchange of scientists. The timing was fortuitous, as the return flight was utilized for the medical evacuation of a roughneck with a back injury and a marine technician with a neurological condition. The latter patient was taken to a hospital in Bodo, Norway, where she remained for several weeks in intensive care before returning to the United States.

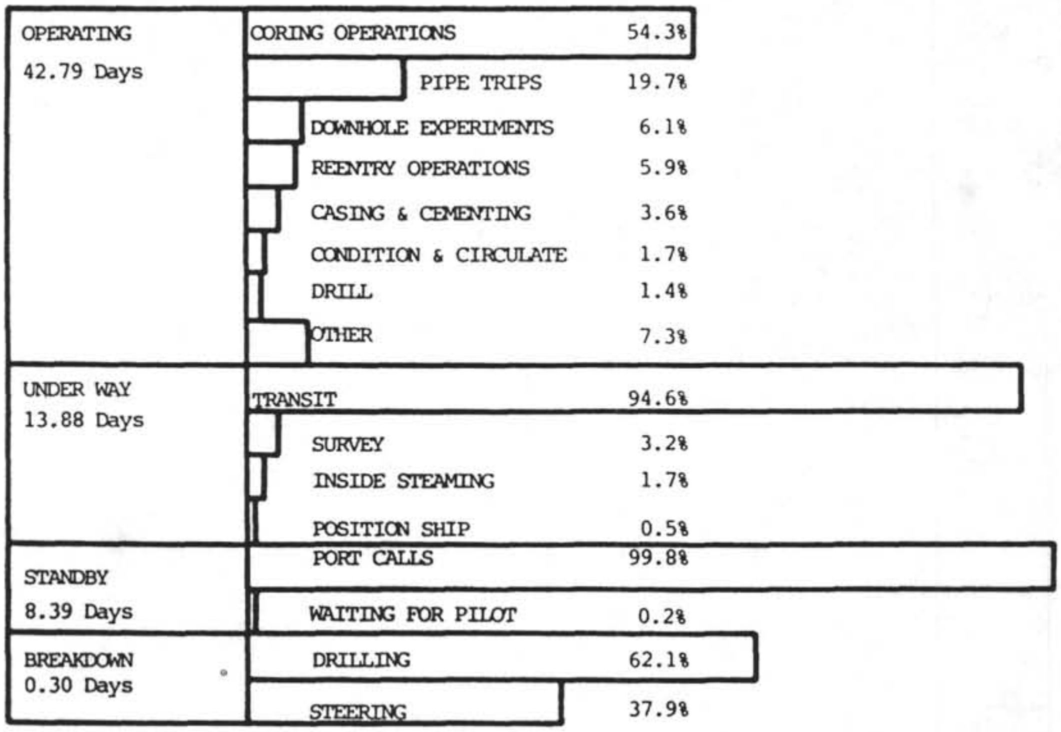
Another roughneck suffered a fractured finger in a rig floor accident. All other illnesses and injuries were of a relatively minor nature.

Glen N. Foss
Operations Superintendent

TIME DISTRIBUTION
LEG 104

START LEG	19 JUNE 1985
FINISH LEG	23 AUGUST 1985
TOTAL TIME	65.4 DAYS





OCEAN DRILLING PROGRAM
SITE SUMMARY
LEG 104

HOLE	LATITUDE	LONGITUDE	DEPTH METERS	NUMBER OF CORES	METERS CORED	METERS RECOVERED	PERCENT RECOVERED	METERS DRILLED	TOTAL PENET.	TIME ON HOLE	TIME ON SITE
642A	67°13.5'N	2°55.7'E	1292.7	1	9.5	9.9	104	1.3	10.8	11.0	
642B	67°13.5'N	2°55.7'E	1292.7	25	221,1	215.6	98	0	221.1	30.0	
642C	67°13.2'N	2°55.8'E	1292.1	24	199.6	192.8	97	0	199.6	43.75	
642D	67°13.2'N	2°55.8'E	1292.1	20	139.0	117.0	84	189.9	328.9	56.25	
642E	67°13.2'N	2°55.8'E	1289.0	107	906.9	372.6	41	322.5	1229.4	695.75	
TOTALS FOR SITE 642				177	1476.1	907.9	62	513.7	1989.8		836.75
643A	67°42.9'N	01°02.0'E	2779.8	61	565.2	449.2	79	---	565.2	139.75	139.75
644A	66°40.7'N	04°34.6'E	1266.3	34	252.8	238.4	94	---	252.8	34.75	
644B	66°40.7'N	04°34.6'E	1225.9	15	127.7	103.6	81	---	127.7	20.25	
TOTALS FOR SITE 644				49	380.5	342.0	89	---	380.5		55.0
GRAND TOTALS				287	2421.8	1699.1	70	513.7	2935.5		1031.5

OCEAN DRILLING PROGRAM
BIT SUMMARY
LEG 104

HOLE	MFG	SIZE	TYPE	SERIAL NUMBER	METERS CORED	METERS DRILLED	TOTAL PENET.	CUMULATIVE METERS	HOURS THIS HOLE	TOTAL HOURS	CONDITION	REMARKS
642A	MSDS	11-7/16	HPC/XCB	S-11	9.5	1.3	10.8	10.8	---	---	Respud w/o trip	APC only
642B	MSDS	11-7/16	HPC/XCB	S-11	221.1	0	221.1	231.9	4	---	Respud w/o trip	APC only
642C	MSDS	11-7/16	HPC/XCB	S-11	199.6	0	199.6	431.5	3	7	Respud w/o trip	APC only
642D	MSDS	11-7/16	HPC/XCB	S-11	140.0	189.9	329.9	761.4	23-1/4	30-1/4	T1-B1 0-1/16 Flattened	APC/XCB/NCB ins.
642E	REED	14-3/4	S62-J	R21167	---	56.0	56.0	56.0	---	(5 Min)	New	Jet in + 4m Pulled for bent B.S.
642E	SMITH	14-7/8	F94CK	177FK	61.2	266	327.2	807.7	25.7	45.5	T0-B2SE	74m basalt and volcanic
642E	RBI	9-7/8	C-4	AS004	12.6		12.6	12.6	4.5	4.5	T2-B7- 0-1/4	3 loose cones; failed while drilling out shoe
642E	MSDS	9-7/8	F94CK	(NONE)	163.6	---	163.6	44.8	44.8	44.8	T0-B6- 0-1/4	All basalt; excellent run
642E	RBI	9-7/8	C-57	AS007	73.0		73.0	23.0	23.0	23.0	T0B1SE 0-1/16	All basalt; pulled for plugged throat
642E	RBI	9-7/8	C-57	AS006	85.5		85.5	85.5	27.8	27.8	T0-B5 0-1/16	Pulled for plugged throat; good for recovery
642E	SMITH	9-7/8	F99CK	846BP	173.5		173.5	173.5	41.8	41.8	T0-B5 0-1/16	All basalt; but much scoriaceous; great run
642E	SMITH	9-7/8	F99CK	841BP	211.8		211.8	211.8	45.5	45.5	T0-B2SE	All basalt; but much scoriaceous; great run
642E	MSDS	9-7/8	F94CK	S-65	127.5		127.5	148.5	30.8	33.3	T4-B2SE-I	Some very hard basalt-also volcanic sediment
643A	R & I	11-7/16	HPC/XCB	JENNY	565.2		565.2	565.2	26.5	26.5	T1-B3SF-I	Very low ROP in basalt at T. D.
644A	R & I	11-7/16	HPC/XCB	JENNY	252.8		252.8	818.0	9.0	35.5	Not Inspected	APC only
644B	R & I	11-7/16	HPC/XCB	JENNY	127.7		127.7	945.7	2.2	37.7	T1-B4SF-I	Retired

OCEAN DRILLING PROGRAM
BEACON SUMMARY
LEG 104

SITE NUMBER	MAKE	FREQUENCY KHz	SERIAL NUMBER	SITE TIME HOURS	WATER DEPTH	REMARKS
642A	Datasonics	16.5	188	15	1309	Dropped out of position on Decca
642A/B	Datasonics	15.5	190	832	1293	Still out of position
642C	Datasonics	16.5/14.0	191	775	1292	Taut wire; changed to 14 KHz after intefernce with #190; lost when taut wire failed 1 August
642E	Datasonics	17.5	177	∿335	1289	Attached to R/E cone; commandable; good beacon Turned off on departure
643A	Datasonics	15.5	193	4	2780	Signal too weak to use; failed after four hours
643A	Datasonics	16.5	194	0	2780	Failed five minutes after drop
643A	Datasonics	14.5	192	136	2780	Good Beacon
644A	Datasonics	16.5	197	35	1226	Run on taut wire
644B	Datasonics	16.5	197	20	1226	55 hours total; reusable

TECHNICAL REPORT

The ODP Technical and Logistics personnel aboard *JOIDES Resolution* for Leg 104 of the Ocean Drilling Program were:

Laboratory Officer: Burney Hamlin

Laboratory Officer/XRD-XRF: Bill Mills

Curatorial Representative: Jerry Bode

System Manager: John Eastlund

Chemistry Technician: Gail Peretsman

Chemistry Technician: Katie Sigler

Electronics Technician: Michael Reitmeyer

Electronics Technician: Dan Larson

Yeoperson: Michiko Hitchcox

Photographer: Kevin DeMauret

Marine Technician: Jenny Glasser

Marine Technician: Linda Mays

Marine Technician: Matt Mefferd

Marine Technician: Joe Powers

Marine Technician: Kevin Rogers

Marine Technician: Christian Segade

Marine Technician: Don Sims

Marine Technician: John Tauxe

Weather Observer: Farrell Johnson

Other technical personnel aboard *JOIDES Resolution* were:

Colleen Barton, Logging Specialist Technician (Lamont-Doherty Geological Observatory, Palisades, NY)

Hugh Winkler, Vertical Seismic Profile Technician (Univ. of Texas, Austin, TX)

TECHNICAL REPORT

LEG 104

PORT CALL-BREMERHAVEN, GERMANY

The technical staff arrived in Germany on June 18 to meet JOIDES Resolution which docked the afternoon of June 19. Crossover between the technicians commenced June 20, after which the majority of the Leg 103 staff was released. The lab officers and specialists in chemistry and the cryogenic magnetometer stayed longer.

Leg 103 samples and cores, equipment for service, and frozen organic geochemisty samples were off-loaded and shipped. Vendor sevices included liquid helium delivery, 2G Enterprises working on the cryogenic magnetometer and supervising topping the system off with liquid helium, Phillips for the X-ray diffraction system, and Xerox Corporation. An air freight shipment and a surface shipment consisting of one forty-foot container of supplies were received.

The Burgermeister, representing the city of Bremen/Bremerhavn, hosted a champagne reception at the city's Naval Museum for the scientists, ship's officers, and lab officers.

The ship sailed down the River Weser June 24 at 1852 hours and proceeded to our site area above the Arctic Circle on the Voring Plateau. Seismic gear was streamed at noon on June 26 to evaluate a new magnetometer sensor and to prepare for a site survey. The weather was windy and rainy with water on the maindeck. One wave broke over the bridge. By 2300 on June 27 the ship was positioning over the beacon for Site 642.

LABORATORY OPERATIONS

This was the first real experience with sediment and hard rock for this technical staff. They proved competent and expedient in receiving and moving cores through the lab stations and into storage.

Core entry: The core extruder was put into service when a method of holding the core catchers was made. A chain vice was installed on the workbench to service and clean the various coring shoes and subs.

Sedimentology lab: Two projects being worked on are a stronger, lower core cart with locking casters and another design for microscope bases.

Physical properties: The existing equipment worked well and was used extensively. The GRAPE held up the flow of cores a few times; the arrival of the faster replacement unit is anticipated. The new GRAPE is at Texas A & M, where software for it is being developed. A new shear vane was installed and worked very well. Instructions were written for its use and filed in the area and in the L.O. files. A PVC and plexiglass enclosure for the parallel blade trim saw reduced spray satisfactorily. A practice was made of sending all sediment samples to the chemistry lab for carbonate analysis and then to the XRD lab to initiate a data base for correlating mineralogy and physical properties.

Core cutting room: An enclosure for a Felker rock cutting saw was made and installed adjacent to the core splitter. Some plumbing fittings will be purchased to refine the drain line. A fan and filter pack will be purchased from College Station. The core lab noise level was substantially reduced by using the Felker saw in the cutting room. All doors in the cutting room were open during all phases of hard rock cutting. Free passage in and out of the room with cores eliminates awkward maneuvers with doors.

Sampling benches: The sampling pattern developed on Leg 103 continued this leg: paleomagnetics and physical properties samples were taken at the forward half of the sampling table and all others were taken at the aft half. Hard rock sample parties required two mini-core stations for the area. The second station was reassigned from the casing hold work bench.

Photo table: Many boxes of cores were photographed twice because of technician inexperience with 4 X 5 operations. The problem was compounded by several other factors, including sunlight falling on the cores being photographed, reflections from portable furniture, and incorrect information being copied. The latter refers to the directive to include sub-bottom depths in the photo. Several times the techs were given incorrect information; the corrections were not made at the LO's direction to expedite the flow of cores. We are convinced that this information belongs in the core log data base where it can be corrected as necessary.

Chemistry lab: Work progressed smoothly and the few problems were quickly overcome. A new software version for the Lab Automation System (LAS) replaced a defective edition. The LAS handles output from the gas chromatographs and ion analyzers. Our second chemist was trained in the use of the LAS and a technician was trained to help with some analytical instruments. Several technicians assisted with total carbonate determinations. The geochemists this trip were invited to develop organic geochemistry and safety procedures, and they trained our chemistry technicians in these new procedures.

Thin section lab: Work progressed routinely with the production of 315 polished petrographic slides for shipboard study. Some were made for the east and west coast repositories.

XRF/XRD lab: The XRF unit failed before the first site and remained out of use. Service was requested for Stavanger, Norway, and the XRF was repaired. The XRD was used extensively; at one time for three consecutive weeks. A technician was trained in its use and was made responsible for the lab. Four hundred forty-six samples were made with 1038 scans. Quantitative analysis of carbonates, quartz, illite, chlorite, and plagioclase was initiated and is being developed. Routine physical properties analysis dominated the machine's time, which made spot samples or spontaneous use difficult. The problem was brought up at the end of the cruise.

Computer system (JAX): The system worked without problems. The systems manager taught word processing and data field management classes for all interested personnel. The manager also carried out a systematic program of recording all regulated and unregulated power in the labs. Analysis of the recordings will be done ashore.

Photo lab: Over five thousand prints were made during the leg. A major plumbing problem with a print processor's drain was repaired in port. Routine maintenance of the print processors was performed and some modifications made to simplify print production. Some of the processing tanks support pernicious biological growth that has survived all efforts to eradicate it. The visible level of rust in the photo lab's hot water has again initiated speculation that the lab is somehow being serviced with drill water instead of potable water. No other rusty potable water has been observed. Filters in the photo lab system are changed frequently.

Electronics lab: Operations and maintenance by the ET staff was routine for the scientific objectives of the leg. Re-entry tools were dressed, fixed, and modified as needed.

Underway Geophysics lab: The underway geophysical equipment gave good to usable records at speeds under six knots and and acceptable to poor records at transit speed up to 14 knots. The magnetometer sensor signal leads were connected directly to the magnetometer console. The original wiring was fine on shakedown leg so this solution to the problem is puzzling. The seismic digitizing system continues to be disturbed by unstable regulated power while underway. A Masscomp disk drive failed and is being exchanged. Satellite navigation positions on site and underway were collected on floppy disk using a PRO-350 microcomputer station.

Several days of preparation were made to ensure the Vertical Seismic Profile (VSP) experiment would run smoothly. A Benthos hydrophone was spliced to a cable and run forward to the positioning taut line. The taut line weight was lifted and the hydrophone and cable were attached to the wire at 500 feet with nylon tie wraps. The BOLT 1500 air gun was fitted with a Norwegian provided GECO 1250 cu in chamber. This gun assembly was shackled to a chain sling and forty feet of wire rope. It was then swung over the water by the number 3 crane with its boom perpendicular to the ship and horizontal to the water. The gun was then lowered into the water and fired at various depths to optimize the power output as displayed on the oscillograph in the underway lab. The best depth was 30 feet. The BOLT 1500 airgun with a 300 cu in chamber was also tested but was not as powerful as the 1250 cu in package and was therefore not used. Oscilloscope measurements indicated the gun with the 1250 cu in chamber produced a 13 mv pressure peak on the primary pulse while the 300 cu in chamber peak was measured at 8 mv. These measurements were made at 30 feet, with the Ithaco amplifier at 40 db gain.

Tests were also made to determine how fast the gun could be fired with the large chamber, keeping the air pressure regulated to 1800 psi. This proved time-consuming with the large air accumulator banks on board. Our normal firing rate of 10 seconds brought a slow downward pressure creep which could not be stopped until a 30 second firing rate was selected. This experiment was allotted only a 12 hour time window and with this limitation it was obvious that data from half or less than half the hole could be collected. We were told that one compressor had failed and the remaining one was weak. Spare parts to rebuild the failed compressor were not available. Eventually the airgun was suspended under a large tethered Norwegian buoy to keep the gun at a constant depth.

The two three-component Phillips Petroleum Company seismometers were connected to a Schlumberger cable head and tested in the down hole shop.

Deck pre-amp gains of 10 and 100 were set in tools #1 and #2 respectively. The clamping arm was extended and retracted through its full 13 inch reach. The units were then hydrostatically tested to 500 psi in an on-deck pressure vessel. Tool #2 (100 gain and an optimum 6 volt output) was selected to be the primary tool.

The experiment was conducted 1 Aug. A JIC air fitting on the air gun backed off and leaked a couple of times before the loops of leads and air lines were reconfigured from below the gun to near the top of the bridle. Wire was also wrapped into the air fitting to keep it from backing off. The repairs were done at opportune intervals to limit the experiment's down time. After six sets of recordings the clamping arm on tool #2 was damaged; tool #2 was pulled and replaced by tool #1 with a pre-amp gain of 50. Tool #1 was noisier, with 60 HZ noise being induced from somewhere.

During the short seismic lines made on 104A, the equipment worked without trouble. Worn lines were replaced and the S-80 water guns and BOLT 1500 air gun maintained. Spare and backup equipment and supplies were moved to the lower sack storage area and organized. The parts we use regularly are organized in the fantail cabinets.

Enroute to St. John's, Newfoundland, the hydrophone depth depressors and transducers were checked. Hydrophone depths were adjusted to 45 feet, which resulted in 15 feet at 12 knots. At slower speed the eel towed at the selected depths. The port hydrophone cable and water gun trigger cables failed separately with no visible damage. The hydrophone cable will be returned to the factory for inspection and repair; the water gun trigger lead was replaced. The 300 cu in air gun was towed a short while until an air coupling failed. New couplings are on order.

Prior to the VSP experiment, a Gai-tronics phone was installed in the underway geophysics lab. A longer extension cord was added later as communication from the Masscomp station was awkward.

Two air compressors supply the fantail with high pressure air for underway activities and VSP experiments. One compressor failed early in the cruise, after being recently rebuilt. There were too few parts left to repair the compressor again. As a result, the VSP experiment was tailored around the problem by reducing the sample density. And on part of a underway day on the transit to Canada the seismic system was operated at 1000 psi to allow the air pressure to rebuild after an air leak. One compressor, which was also weak, does not have the margin necessary to operate the seismic system at its greatest potential. It is therefore vital that the parts inventory for the compressors be increased in depth to accommodate major failures and routine wear.

Storekeeping: Arriving shipments and off going freight and cores were handled promptly in Bremerhaven and Stavanger. Organization of stores and development of the Matman data base continued. North American air freight and a surface shipment from Canada were also prepared. The majority of the storekeeper's time this leg was spent working in the core lab.

Second Look Lab: The lab was used by the curatorial technician to package and inventory samples. The lab remains under-utilized, however, as the air conditioning condensation problem remains to be solved. Humid weather results in the benches being deluged with water, which precludes setting up instruments or a computer terminal. The chemists and storekeeper could both benefit from the space in this lab if this situation can be resolved.

SAFETY

Hydrofluoric acid: The following policy was used this leg to reduce the hazards of using hydrofluoric acid (HF) aboard JOIDES Resolution:

> "Whenever HF is to be used, the Laboratory Officer, Operations Superintendent, Dynamic Positioning operator, and Mate on watch are notified. The heading of the vessel is changed as necessary to carry the fumes away from work areas. The LO does a smoke flare test to confirm the path of the fumes before the HF operation begins. HF cannot be used if weather/sea conditions or rig operations prohibit changing heading, including anytime winds exceed 30 knots."

Since little HF work was done after the first few times, it is my belief that the necessary hassle of using hydrofluoric acid forced the palynologist to use alternate procedures. Hot HCL digestion, labor- intensive 10micron sieving to remove clays, and skillful panning to remove "heavies" were successful techniques. Zinc halides in HCl were mentioned as candidates to remove heavies from future samples, but they too are dangerous. The resultant pollen sample is dilute but still useful. It is anticipated that the samples will be treated further with HF in shore labs to insure that nothing important was missed.

Training: Five members of the technical staff were selected last cruise to participate with the SEDCO emergency squad. They are Burney Hamlin, Bill Mills, Matt Mefford, Mike Reitmeyer, and Kevin Rogers. Mills and Mefford were sent to the TAMU fire fighting school for a week of training; others will be schooled in the future. This team participated in the emergency squad training during fire drills and at weekly meetings.

A selection of safety videos was made by the First Mate for all the technicians to review. We also received two ODP videos on lab safety. These motivated the team to label flammables and chemicals with more stringent safety precautions.

PROBLEMS

Water: The problem of air in the labstack drill water has been helped by the addition of a de-aereator in the hot water system by the water heaters in the Koomey room. It is not completely solved, however. The engineering staff on watch would run the hot water in the core lab several times a day while the paleo lab was in operation to bleed off air to alleviate this problem. As the hot water is very hot, $130^{O}F$, it is usually blended with cold water and the problem remains: rapidly changing water temperature, samples blasted from beakers, the danger of an accident if someone were startled by a burst of air, and binding while cutting samples with the water-cooled diamond saws and drills. Relieving the entrained air from the cold water could be achieved by several methods. A cold water storage tank is to be installed in the Koomey room on the transit to Canada.

We have had an occasional problem with losing water pressure in the lab stack and having air sucked into the water lines when the mud tanks are being filled. An orifice plate is to be installed in a mud room water valve during the transit, which should create enough back pressure to keep lab stack water pressures positive.

Also of concern is the visible rust coloration in the photo lab's hot water, which we have been told is due oxidation in the iron piping. Expanding the filtering capabilities of the photo lab is a likely solution.

Underway Geophysics Air Conditioning: Following is the heart of a letter requested of me by Drilling Superintendent Bob Caldow, for SEDCO engineer Dan Reudelhuber:

> "The air conditioning problem in underway geophysics was listed by Gus in a 28 January 1985 list of deficiencies forewarded to Bill Reinhardt. Basically, there is too little air conditioning capacity to keep the computer system, seismic recorders, geophysical equipment, and people who work there at an optimum 68-70°F under typical conditions. This AC problem was discussed in a early port call meeting attended by Glen Foss, Operations Superintendent. It had been understood that the problem was being addressed. The underway lab's heat load was added to a system originally installed for the SEDCO warehouse. The lab was cut out of the warehouse space and a duct run into it. A second duct was terminated without penetrating into the geophysics lab. We suggest that the terminated duct be extended into the geophysical lab.

"The controlling thermostat remains in the warehouse. Leg 104 has been cool, with temperatures in the high forties. This means the thermostat in the cool warehouse would never turn on the AC while the temperature climbs in the insulated lab with the computer system and peripherals operating. If the thermostat is turned down to a point where the temperature is acceptable in the underway lab, the warehouseman must wear a coat. A degree of compromise has been achieved by covering some warehouse ducts and using a space heater there.

"The chief engineer has suggested that the thermostat could be moved to the underway geophysics lab and that the ducting be modified. No action has been taken."

Hatch Leaks: Underway from Bremerhaven in heavy seas we found that the hatch into the casing hold was leaking, as on Leg 101. SEDCO had ordered gasket material and the leaking hatch cover was lined, though only on two sides. It was disconcerting to find water again leaking into the hold area when the ship was being cleaned for port.

Trash: A new burn basket was fabricated to hang over the aft maindeck starboard rail while on site. This is more acceptable than the situation we found when we came aboard, but it is still inconvenient. The few days spent piston coring generated one or two elevator loads of cardboard trash a day, much of it 5' D-tube boxes. Getting to the burn basket from the core lab with these boxes is a laborious task that takes technicians away from their scientific assignments. Trash piled on the core lab catwalk is a nuisance to walk around, sogs up in inclement weather, and is discouraged.

The even leg cruise activities have not placed a demand on the stewards to develop a routine for maintaining the lab stack. The arrangements agreed upon during the shakedown leg have fallen into disuse. We hope to have a policy statement for upcoming cruises.

For convenience, we would hang a burn basket from the posts at the catwalk outside the core lab. Now that we have stairs to the top of the core lab, a burn basket could be spotted up there. Efforts to minimize points of irritation like this can only contribute to the overall genial atmosphere necessary for a totally successful cruise.

Liners: Late in the cruise SEDCO Captain Oonk realized that short core liners were being discarded on site. He expressed his concern for thruster damage and requested that liners be discarded underway only. We were able to comply on our short last sites but a problem of storage would have surfaced during our month on Site 642.

Internal Antenna: Considerable effort and expense went into planning and installing antenna outlets in all the cabins and lab spaces on the ship. This is to eliminate a proliferation of "pirate" antennas being taped up for temporary use, yet allow people to tune in news and music on personal receivers. To date the system has been dead awaiting the installation of an antenna and adequate amplification for the system.

TRANSIT 104B

PORT CALL-STAVANGER, NORWAY

JOIDES Resolution docked in Stavanger August 12, 1985 to disembark scientists and to offload cores to the East Coast Repository, regular and frozen samples to Europe, and a few pieces of air freight to other locales. A forty-foot container of supplies and expendables was brought aboard and stored. Xerox and ARL made service calls to the ship. The ship sailed August 15 for St. John's, Newfoundland, an expected eight-day transit.

TRANSIT TO CANADA

In Norway, we received supplies to apply a sealer coat to the floors in the laboratory areas. The floors were sanded, scrubbed, and cleaned before two applications of the two-part color coat were brushed and rolled on.

A Satellite Navigation system from Magnavox was installed in the underway geophysics lab. It will be replaced soon with a Global Positioning System (GPS) from the same manufacturer. Efforts continue to improve the underway records.

A spectrophotometer was installed in the chemistry lab and operational procedures were developed.