OCEAN DRILLING PROGRAM

LEG 114 PRELIMINARY REPORT

SUBANTARCTIC SOUTH ATLANTIC

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SCIENTIFIC REPORT

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INTRODUCTION

The high southern latitudes have played a critical role in the evolution of global climatic, glacial and oceanographic systems since the late Mesozoic. Changes in these systems have resulted from a number of tectonic events in the high southern latitudes which led to the thermal isolation of Antarctica, the initiation and growth of the antarctic ice sheets, and the development of modern abyssal circulation.

Prior to the development of shallow and deep teleconnective passageways in the circum-antarctic, northward transport of cold surface and deep polar waters was restricted. The increase of thermal gradients in the southern hemisphere is linked to the development of the circum-antarctic circulation system (Kennett, 1977, 1978), first by the onset of deep water flow through the Tasman Seaway between Australia and Antarctica during the late Eocene, followed by the opening of the Drake Passage between South America and West Antarctica during the Oligocene (Barker and Burrell, 1977, 1982; LaBrecque and Rabinowitz, 1977; OMD Region 13 Synthesis, 1986). The result of a fully developed circum-antarctic current was thermal isolation of the antarctic margins. This led to the growth and expansion of the ice sheets on Antarctica and to climatic deterioration and colder climatic conditions. Prior to the development of these passageways, Paleogene thermal gradients may have steepened at different rates within the Pacific, Indian and Atlantic basins. In order to unravel the evolution of surface and bottom water masses in this region and the roles the changing circulation patterns played in Late Cretaceous to Neogene paleoenvironments, it is critical to obtain undisturbed sedimentary sequences along meridional, latitudinal and depth transects through the Southern Ocean.

The major objective of ODP Leg 114 was to investigate the development and influence of teleconnective passageways to oceanic circulation within the Atlantic Sector of the Southern Ocean. This general objective involves the interrelationship of the paleoceanographic record and the Mesozoic and Cenozoic regional geologic history. The primary tectonic objectives of the leg were to document the ages and subsidence histories of the Islas Orcadas and Meteor rises, and the basin between these two rises which formed a gateway between the Weddell Basin and the South Atlantic. Other tectonic objectives included determining the age and nature of basement on the Northeast Georgia Rise and the role this feature played in the evolution of the Malvinas Plate. The major paleoceanographic objectives of this leg were to document the Late Cretaceous to Holocene paleoenvironmental evolution of the passageway linking the South Atlantic and Weddell basins, to determine the latitudinal and vertical temperature gradients in the subantarctic South Atlantic during the Paleogene, to document the establishment of the Antarctic Circumpolar Current which resulted from the opening of the Drake Passage, to record more fully the middle to late Cenozoic Polar Front migrations, and to obtain records of changes in antarctic climate and ice volume. As a necessary precursor to the interpretation of the tectonic and paleoenvironmental history of the subantarctic South Atlantic, a major goal of Leg 114 was to obtain a high resolution biostratigraphic-paleomagnetic chronology of the Late Cretaceous-Holocene.

Leg 114 of the Ocean Drilling Program began on 14 March 1987 in East Cove, Falkland Islands, and ended sixty days later on 13 May 1987 in Port

Louis, Mauritius. During this period, seven sites (698 to 704) were drilled in the subantarctic South Atlantic (Figure 1; Table 1). The severe weather conditions encountered during this cruise tested the drilling capabilities of JOIDES Resolution and her crew. Strong gale force winds (greater than 41 kts) were encountered during 29 days of the cruise (Figure 2). Maximum wind speeds of 86 kts and combined seas of 40-50 ft were experienced during the transit from Site 702 to Site 703. A wind of 71 kts occurred while on location at Site 703, which together with the seas, required 7.2 megawatts of power to keep the ship on station. For roughly one third (28%) of the cruise the combined seas exceeded 18 ft. The maximum roll taken by the vessel was 26°.

Despite these extreme operating conditions the vessel remained remarkably stable and drilling operations were suspended for only 1.5 days total during the cruise because of weather. Although the heave of the ship affected coring operations, recovery for the leg averaged 63.4% and the advanced piston corer (APC) and the extended core barrel (XCB) corer recovered relatively undisturbed cores that are suitable for high-resolution paleoceanographic studies.

One of the greatest successes of Leg 114 was to recover a virtually complete stratigraphic representation of the Upper Cretaceous-Holocene (Figure 3) with rich assemblages of calcareous and siliceous microfossils. Calibration of the biostratigraphy and magnetostratigraphy of these sequences provides a nearly complete geochronologic framework which will be the basis for further paleoenvironmental and tectonic interpretations. The presence of carbonate sequences spanning a period of 90 m.y. (Figure 3) will provide stable isotopic documentation of subantarctic climatic and oceanographic history.

DRILLING RESULTS

SITE 698

Site 698 lies near the eastern edge of the shallowest portion of the Northeast Georgia Rise (NEGR) ($51^{\circ}27.51'$ S, $33^{\circ}05.96'$ W) and at a water depth of 2128 m. The primary objectives of the site were largely tectonic in nature: to determine the age, nature, and subsidence history of basement; to establish the possible role of the NEGR as a Late Cretaceous-early Tertiary convergent boundary between the Malvinas Plate and the South American Plate; and to determine the temporal relationship between subduction at the NEGR and southern Andean orogeny. These objectives are also important for evaluating the influence of the NEGR and other regional plateaus and ridges as Late Cretaceous-Paleogene obstructions to deep water interchange between the Weddell and South Atlantic basins.

Early departure from port and rapid transit resulted in the gain of 2.3 days of operational time used to drill this lower priority site. A single hole was rotary drilled (to ensure basement penetration in the time allotted) in 2 days and 9 hours, from 17 to 19 March 1987. Hole 698A consists of 27 rotary core barrel (RCB) cores to a depth of 237 meters below seafloor (mbsf) with 22% recovery. Drilling conditions were excellent. Drilling terminated 27.6 m into basement.

Site 698 sampled a surface residual lag deposit of ice-rafted detritus above a thick pelagic carbonate sequence of nannofossil ooze, nannofossil chalk, and limestone. Frequent chert stringers and nodules occur throughout the carbonate section which hampered sediment recovery. Basement consists of a fine grained, sparsely pyroxene-plagioclase-phyric basalt overlying a hematite rich regolith. The dominant lithologies in the stratigraphic sequence and their ages are as follows:

0-4.25 mbsf:	Ice-rafted gravel of mixed lithologies and rock types and of probable Pliocene-Holocene age;
4.25-42 mbsf:	Foraminifer-bearing nannofossil ooze of late early to early middle Eocene age;
42-146.5 mbsf:	Foraminifer-bearing chalk of Maestrichtian to middle Eocene age;
146.5-190.5 mbsf:	Very fine-grained limestone of Campanian to Maestrichtian age;
190.5-200.0 mbsf:	Unrecovered interval;
200.0-200.15 mbsf:	Sandy mud of probable Campanian age;
200.15-209.5 mbsf:	Unrecovered interval;
209.5-219.28 mbsf:	Basalt; fine-grained, sparsely plagioclase-pyroxene-phyric, exhibiting evidence of alteration and mineralization;
219.28-237 mbsf:	Extremely weathered basalt (regolith) in which the original Fe-Mg minerals have been completely altered to hematite.

The smooth and layered acoustic basement on the NEGR may be attributed to, at least in its upper part, interbedded altered basalt flows and highly weathered (subaerially?) basalt regolith. A sandy mud above basement may represent a transgressive sand incorporating some eroded weathered basalt. Sparse nannofossils in this sandy mud suggest a Campanian age, if they are not downhole contaminants. A 9.5 m recovery gap occurs between the sandy mud and the base of the overlying pelagic carbonate sequence of probable Campanian age. Initial subsidence of the NEGR must have occurred during the Campanian or earlier as benthic foraminifers throughout the carbonate sequence overlying basement are indicative of water depths no less than lower bathyal (>1000 mbsl). If the NEGR was a Cretaceous convergent boundary between the Malvinas Plate and South American Plate, the cessation of any subduction must have occurred prior to or during the early Campanian.

An apparently uninterrupted sequence of pelagic carbonate accumulated on the subsiding basement of the NEGR during the Campanian/Maestrichtian to early middle-late early Eocene. Unfortunately, the Cretaceous/Tertiary boundary went unrecovered in adjacent cores of late Maestrichtian and Danian age. The sequence contains nodular chert horizons and displays progressive lithification from nannofossil ooze to limestone. Sedimentation rates for the early Paleogene are 6-9 m/m.y. The Late Cretaceous-early Paleogene surface waters were well oxygenated and a low energy benthic environment periodically under oxygen reduced conditions is indicated. Relative climatic warmth is indicated by calcareous microfossil assemblages which include discoasters.

In spite of poor recovery, the section is relatively undisturbed. The section will provide an important Late Cretaceous to early Paleogene reference point for biostratigraphic, biogeographic, and isotopic studies of the antarctic-subantarctic region by Leg 113 and 114 scientists.

Correlation of the Site 698 to site survey seismic lines reveals a major deformational episode in the western part of the NEGR which has down-faulted post-early middle Eocene strata. The similarities in the seismic character of the younger affected strata with sections drilled on the Maurice Ewing Bank suggest this deformation occurred during the Miocene. This event may be related to Miocene compression between the South Georgia block and the NEGR.

SITE 699

Site 699 is located on the northeastern slope of Northeast Georgia Rise (51°32.537' S, 30°40.619' W) at a water depth of 3716 m. This site was selected to obtain a high quality continuously cored sequence of Late Cretaceous to Neogene age which records the history of deep water communication between the Weddell and Georgia basins and the South Atlantic Basin. Site 699 overlies crust which predates the formation of Islas Orcadas Rise and Meteor Rise and the deep water gateway which formed between these features. Comparison of the sedimentary record of Site 699 with Site 701 (within the early gateway) will provide a means of interpreting the influence of gateway opening on the paleoenvironment in the subantarctic and other regions south and north of the gateway. Other objectives are to document the development of the Antarctic Circumpolar Current and the southern high latitude biosiliceous province. Carbonate bearing sequences of Late Cretaceous and Paleogene age from Site 699 and other Leg 114 sites will document the evolution of vertical water mass structure in the subantarctic.

A single hole was drilled at Site 699 with 22 APC cores recovered to a depth of 205.1 mbsf and 34 XCB cores to a depth of 518.1 mbsf where the core barrel became jammed with sand. After careful consideration of the hole condition and danger to the drill string, the hole was terminated without logging. The sediment recovery rate was varied, averaging 81% above 224.1 mbsf, but was significantly reduced to 54% below this depth owing to the presence of gravel. The overall recovery for Hole 699A was 68.6%. The site was occupied between March 20 and 26 in generally moderate to rough seas. Drilling was hampered by 18 hours waiting on weather with the drill string in the hole.

Site 699 sampled a thick pelagic section with an upper unit of siliceous ooze above nannofossil ooze with numerous variations of clay and biosiliceous content. The lower portion of the sequence is calcareous nannofossil chalk grading into a basal unit of zeolite-bearing claystone and clay-bearing micritic calcareous nannofossil chalk. The dominant lithologies and ages of the stratigraphic sequence are as follows:

0-85.7 mbsf: Diatom clay and clayey diatom ooze of early Miocene through Pleistocene age;
85.7-233.6 mbsf: Siliceous nannofossil ooze and nannofossil siliceous ooze with numerous variations in clay and biogenic constituents, early Oligocene to early Miocene age;
233.6-235.7 mbsf: Graded gravel bed of poorly sorted subangular to

	subround material containing fragments of basalt, andesite, quartz arenite, granite, quartz diorite, schists and other metamorphic rocks, early Oligocene age for deposition;
235.7-243.1 mbsf:	No recovery;
243.1-335.4 mbsf:	Siliceous nannofossil ooze grading downward into nannofossil ooze of late Eocene to early Oligocene age;
335.4-487.9 mbsf:	Nannofossil chalk and nannofossil micritic chalk of early Eocene to middle Eocene age;
487.9-496.6 mbsf:	No recovery;
496.6-516.3 mbsf:	Zeolite-bearing claystone and clay-bearing micritic nannofossil chalk of late Paleocene age;
516.3-518.1 mbsf:	Granitic gravel and redeposited volcanic rich quartz sand of unknown age.

Hole 699A contains a remarkably complete Paleogene pelagic sedimentary sequence (426 m thick) representing a 40 m.y. period, above basal sediments assigned to foraminifer zone P3 (64 Ma). In contrast, only 90 m of Neogene biosiliceous sediments were cored and these are punctuated by numerous hiatuses. No significant hiatuses were noted in the Paleogene, although there is some evidence that brief hiatuses occurred during the earliest Eocene (NP10) and perhaps late Oligocene. A major hiatus of regional significance occurs between the lower Miocene and the uppermost middle Miocene (9 m.y. duration; 69 mbsf). Other Neogene hiatuses span the middle upper Miocene-lowermost Pliocene (50 mbsf), upper Gilbert-lower Gauss chronozones of the Pliocene (3.9-3.3 Ma, 38 mbsf), and within the Matuyama to basal Brunhes chronozones (exact depth and duration undetermined). Sedimentation rates were greater than 4.3 m/m.y. for the late Paleocene, 11 m/m.y. during the early Eocene, 7.6 m/m.y. during the middle Eocene, 3 to 14 m/m.y. during the late Eocene, 11.7 to 20 m/m.y. during the early Oligocene and 16 to 19 m/m.y. during the late Oligocene. Neogene sedimentation rates were as high as 100 m/m.y. for brief episodes (early Pliocene) but repeated episodes of non-deposition and erosion have diminished this record to only 69 m.

Calcareous nannofossils provide a high degree of biostratigraphic resolution for most of the Paleogene, whereas diatoms provide excellent stratigraphic control for the upper Paleogene and Neogene. A high quality paleomagnetic record was obtained for the upper Oligocene, Pliocene and Quaternary. The 200 m thick upper Oligocene sequence will provide the first southern high latitude calibration of biosiliceous stratigraphy to the Geomagnetic Polarity Time Scale (GPTS).

The sedimentologic, micropaleontologic, and erosional history of Site 699 provides the most detailed record of large-scale Paleogene-early Neogene paleoenvironmental changes in the Southern Ocean obtained to date. Warm water foraminifers (including some Morozovella spp.) and calcareous nannofossils (discoasters and sphenoliths) are indicative of maximum surface water temperatures during the late Paleocene-early middle Eocene. Progressive cooling eliminated warm water calcareous nannofossils by the early late Eocene (NP 18), leaving a low diversity assemblage of cool water species lingering into the earliest Miocene. No major change in lithology or assemblages was noted across the Eocene/Oligocene boundary. Diatoms with lower latitude affinities persist into the early Oligocene. High frequency changes occurred in the deposition of clay, biogenic silica, and carbonate during the late early Oligocene to late Oligocene.

A dramatic decrease in carbonate sedimentation occurred during the late Oligocene which culminated in the complete disappearance of carbonate just after the Oligocene/Miocene boundary (23 Ma). The latest Oligocene-earliest Miocene decrease and disappearance of carbonate is interpreted to reflect the northward advance of the Antarctic Convergence (Polar Front) and high latitude biosiliceous province to near its modern-day position.

The earliest Miocene advance of the Polar Front and biosiliceous province appears to have been intimately related to the early phase of the opening of the Drake Passage and the advent of a less restricted Antarctic Circumpolar Current. Much more vigorous circulation of deep and bottom water quickly followed the opening of a deep water passage between Antarctica and South America, resulting in lower sedimentation rates at Site 699 and the formation of a series of regional hiatuses formed by Antarctic Circumpolar Deep Water and Antarctic Bottom Water.

Multiple disconformities and the thin (85 m) late Miocene through Pleistocene section are a testimony to the vigor of Neogene circum-antarctic circulation. The first ice-rafting of detritus to Site 699 occurred during the late Miocene and increased significantly during the Gauss Chron.

The provenance of granitic and quartz diorite cobbles in the gravel deposited during the early Oligocene is intriguing. Several lines of evidence indicate that this gravel may be in place, in which case a crustal fragment of continental nature must be part of the structural framework that forms the Northeast Georgia Rise.

SITE 700

Site 700 is located in the western region of the East Georgia Basin ($51^{o}31.992'$ S, $30^{o}16.697'$ W, water depth 3611 m) on the northeastern slope of the Northeast Georgia Rise (NEGR). Site 700 is a companion site to Site 699 which was prematurely terminated at 518.1 mbsf in upper Paleocene strata about 250 meters above basement. To obtain the deeper objectives not reached at Site 699, Site 700 was occupied at a location 21 km east of the previous site where post-Eocene sediments are greatly attenuated (<50 m thick), allowing for rapid penetration of the Upper Cretaceous-Paleogene. The objectives for Site 700 were complementary to those for Site 699. Foremost of these was to obtain an Upper Cretaceous-Paleogene section which records the possible role of the Georgia Basin as an avenue for deep water communication between the Weddell Sea and the South Atlantic. An additional objective was to obtain an older Cretaceous section than recovered at Site 698 which might further constrain the nature, age, and subsidence history of the NEGR.

Site 700 consists of two rotary drilled holes: Hole 700A with only two cores penetrating to 9.6 mbsf with a recovery of 0.19 m, and Hole 700B with 54 RCB cores penetrating to 489 mbsf with a recovery of 245.4 m (50.2%). Both holes were terminated as a result of premature bit release. Hole 700B reached to within 100 meters of basement. Hole 700B was logged using the standard Schlumberger stratigraphic and geochemical tools. The site was occupied between 26 March and 3 April in moderate to rough seas.

The stratigraphic section at Hole 700B consists of a thin unit of ooze above a thick section of chalks and limestones. The pelagic carbonates of Hole 700B show a progressive lithification with depth from ooze, to friable chalk, to indurated chalk, and finally limestones. The dominant lithologies and ages of the stratigraphic sequence are as follows:

0 - 0.29 mbsf:	Diatom ooze of late Pliocene through Pleistocene age;
0.29 - 26.4 mbsf:	No recovery;
26.4- 45.4 mbsf:	Nannofossil ooze of late middle Eocene age;
45.4-168.9 mbsf:	Nannofossil chalk of late early Eocene to middle middle Eocene age;
168.9-228.5 mbsf:	Micritic nannofossil chalk of early Eocene to middle middle Eocene age;
228.5-319.0 mbsf:	Indurated micritic nannofossil chalk of late Paleocene to early Eocene age;
319.0-359.0 mbsf:	Micritic nannofossil-bearing limestone of Maestrichtian to late Paleocene age;
359.0-441.5 mbsf:	Micritic limestone alternating with clay-bearing/clayey limestone of late Santonian to Maestrichtian age;
441.5-489.0 mbsf:	Micritic limestone alternating with clay-bearing/clayey micritic limestone with dispersed and discrete ash layers, late Turonian(?) to late Santonian age.

A condensed (<26.4 m) diatom ooze of late Pliocene through Pleistocene age disconformably overlies a thick sequence of Upper Cretaceous to upper middle Eocene oozes, chalks, and limestone. Between 26.4 and 228.5 mbsf, Hole 700B repeated the lower to upper middle Eocene recovered at Site 699 thus providing better stratigraphic representation of an interval poorly recovered at both sites (55.2% at Site 699 and 40.2% at Site 700). A 260.5 m thick Paleocene to Santonian-late Turonian(?) section provides a greatly expanded section for a 32 m.y. interval only sparsely represented at Sites 698 and 699. Site 700 and companion Site 699 provide a Late Cretaceous-Paleogene pelagic record spanning 66 m.y. within a combined stratigraphic thickness of 640 m. These two sites provide the most continuous record of this period obtained from the Southern Ocean.

A clear succession of magnetic polarity zones was identified in Upper Cretaceous to lower Paleocene chalks and limestones below 270 mbsf. Good recovery (69%) and relatively little core disturbance in this interval resulted in identification of latest Campanian to early Paleocene Chrons C33N to C26R. This section will allow the first calibration of high latitude siliceous and calcareous microfossil assemblages to the GPTS and will provide a temporal framework for interpretation of Southern Ocean paleoceanography during the Late Cretaceous-Paleocene.

Sedimentation rates were about 26 m/m.y. during the Maestrichtian and 10 m/m.y. during the Paleogene. The only recognized hiatuses occur within the late Santonian to Campanian, at the Cretaceous/Tertiary boundary (Chron C29R, 330.7 and 331.0 mbsf), and a late middle Eocene-late Pliocene hiatus.

Siliceous microfossils are abundant and well preserved in the Paleocene and late Pliocene through Pleistocene. Abundant and well preserved radiolarians occur from the lower Maestrichtian to the base of the hole. All calcareous microfossil groups are represented throughout the Upper Cretaceous and Paleogene, although there is evidence for secondary calcite overgrowths and recrystallization below the lowermost Eocene.

Faunal and floral assemblages provide a detailed record of the paleoenvironmental evolution of this region. Late Cretaceous assemblages are distinct from the low latitudes but have some low latitude affinities. Variations in Late Cretaceous climate are represented by fluctuations in the abundance of globotruncanids and radiolarians. Maximum Paleogene climatic warmth occurred during the early Eocene, introducing low latitude fauna and flora. As at Site 699, the middle Eocene represents a period of transition from the warmer water assemblages of the Paleocene-early Eocene to late Eocene assemblages with a more definite high latitude affinity.

There is no evidence for major erosional events at Sites 699 and 700 which pre-dates the Eocene opening of the Islas Orcadas Rise-Meteor Rise gateway. Therefore, if the East Georgia Basin served as a deep-water passage between the Weddell Sea and South Atlantic, then thermohaline convection in the Antarctic was too weak to cause significant erosion during the early Paleogene.

Post early Oligocene to pre-Quaternary faulting has vertically displaced corresponding stratigraphic levels at Sites 699 downward by about 500 meters relative to Site 700. Adjacent scarps form major north-south trending lineaments which may be related to the same tectonic episode. This faulting left Site 700 as an isolated bathymetric high more susceptible to deep cutting erosion (Neogene?) that is estimated to have removed 300-500 m of post-late middle Eocene sediments at Site 700.

SITE 701

Site 701 is located on the western flank of the Mid-Atlantic Ridge (51°59.07' S, 23°12.73' W, water depth 4647 m) about 160 km east of the Islas Orcadas Rise on oceanic crust of middle Eocene age (Chron C22). The major objective at this site was to obtain a continuous sediment record of the development of an oceanic gateway for deep circulation between the South Atlantic and the Weddell Basin. Site 701 is situated within the gateway itself and will, in conjunction with the shallower Sites 699 and 700, provide the basis for interpretation of the history of deep water circulation through the gateway as a result of its increasing width and the subsidence of the surrounding seafloor. In addition, this and other Leg 114 sites will give the opportunity for evaluating the development of vertical temperature gradients during the Paleogene.

Three holes were drilled at Site 701: Hole 701A with 8 APC cores taken to a depth of 74.8 mbsf with 69.66 m recovered (93.1%), Hole 701B with 10 APC and 4 XCB cores between 70 to 203 mbsf with 96.4 m recovered (72.5%) and Hole 701C with 24 APC and 27 XCB cores which penetrated to 481.47 mbsf with 331.1 m (68.8%) recovered. A flared XCB bit prevented retrieval of the core barrel after penetration of a hard layer. Subsequent preparations to log through the pipe were abandoned after the drill string temporarily became stuck above the jars.

The stratigraphic section at Hole 701C consists of 400 m of mostly biosiliceous and diatom ooze, siliceous clay/mud, and clay-bearing diatom ooze overlying a 72 m thick sequence which shows increasing carbonate content with depth. The dominant lithologies and ages of the stratigraphic sequence are as follows:

0-145.5 mbsf:	Diatom ooze and mud-bearing diatom ooze, muddy diatom ooze with intervals of dispersed ash and numerous discrete ash layers. Ice-rafted detritus present throughout of late Miocene to Holocene age;
145.5-176.8 mbsf:	Monospecific diatom ooze with an interbedded sand and gravel unit containing quartz, biotite, metapelites, iron-coated schists, pumice and mud clasts, of late Miocene age;
176.8-243.8 mbsf:	Clay-bearing and mud-bearing diatom ooze of middle to late Miocene age; volcanic ash is present as discrete and disseminated horizons throughout this unit;
243.8-395.15 mbsf:	Diatom-bearing mud/clay and siliceous mud/clay with altered ash horizons throughout, of early/late Oligocene to early Miocene age;
395.15-452.8 mbsf:	Alternating intervals of nannofossil ooze, siliceous ooze and clay of late Eocene to early/late Oligocene age;
452.8-481.3 mbsf:	Indurated nannofossil chalk of middle Eocene age;
481.3-481.47 mbsf:	Single piece of highly altered amygdaloid olivine basalt.

The sedimentary record of Site 701, the only Leg 114 site under the influence of Antarctic Bottom Water (AABW), differs significantly from our previous sites which are under the influence of Circumpolar Deep Water. The Neogene sequence is thicker and the Paleogene is more attenuated than at previous sites. The biogenic sedimentation was dominantly calcareous during the middle Eocene and biosiliceous during the late Eocene to Holocene. Siliceous microfossils provide a detailed biostratigraphy of the Neogene which is complemented by a paleomagnetic record of the Brunhes Chron to Chron C3AR. Biostratigraphic resolution of the middle Eocene to early Oligocene is provided by calcareous and siliceous microfossil groups.

Hiatuses were found to bracket the boundaries of the middle to late Eocene (2-5 m.y. duration, 453 mbsf), early to late Oligocene (6-7 m.y. duration, 390 mbsf), late Oligocene to early Miocene (>2.0 m.y. duration, 257 mbsf), and early to middle Miocene (8.0 m.y. duration, 249 mbsf). Other hiatuses occurred during the late Miocene (2.6 m.y. duration, 178 mbsf) and Pliocene (0.4-0.6 m.y. duration, 76 mbsf). Sedimentation rates were 4.4 m/m.y. during the middle Eocene through early Oligocene and increased significantly to 21.5 m/m.y. during the late Oligocene. Neogene sedimentation rates were as follows: late Miocene (23 m/m.y.), early Pliocene (23 to 38 m/m.y.), late Pliocene (24 m/m.y.), and Quaternary (24-33 m/m.y.).

The sedimentary record of Site 701 documents the opening of the deep water gap between the Islas Orcadas and Meteor rises and the accompanying changes in benthic circulation. Nannofossil ooze began accumulating over basement during the initial stages (early middle Eocene) of the opening of the passageway between the rises. At this time, current intensity was low as a consequence of still weak latitudinal temperature gradients which allowed the deposition of warm water assemblages of planktonic foraminifers and calcareous nannofossils above the CCD. A major increase in benthic current velocity took place between the middle middle Eocene and late Eocene, resulting in a 2-5 m.y. hiatus. Deposition was renewed by 40 to 38 Ma; however, sedimentation was slow and probably discontinuous resulting in an accumulation of only 60 m of upper Eocene to lower Oligocene sediment. A late Eocene shallowing of the CCD and subsidence of the site (to 4000 m by the early Oligocene) led to the last consistent occurrence of foraminifers and calcareous nannofossils by the early Oligocene. A thick sequence of upper Oligocene biosiliceous muds and clays overlies the attenuated sequence of the upper Eocene-lower Oligocene. A significant increase in sedimentation rates occurred during the late Oligocene at Sites 699 and 701 which is attributed to a higher rate of terrigenous supply by Circumpolar Deep Water (CPDW) and Antarctic Bottom Water (AABW). The formation of a deep water gap in the Drake Passage led to the development of a true Antarctic Circumpolar Current by the early Miocene. Shortly after the earliest Miocene northward advance of the Polar Front (Site 699), a regional hiatus was formed between early Miocene to late middle or late Miocene sediments. This hiatus occurs at Sites 699, 701 and other regional sites, suggesting an age equivalent increase in the intensity of CPDW and AABW.

The almost uninterrupted late Miocene to Holocene sedimentation at this site contrasts greatly with our previous sites which are under the influence of CPDW, indicating that CPDW was a more active agent of erosion or non-deposition than AABW. Discrete and dispersed volcanic ash occurs throughout the late Miocene-Holocene in such quantity that this atmospherically transported ash may have had a significant impact on Antarctic climate.

SITE 702

Site 702 is located on the central part of the Islas Orcadas Rise ($50^{o}56.786'$ S, $26^{o}22.117'$ W, water depth 3093 m), a NNW trending aseismic ridge more than 500 km long, 50-100 km wide which rises over 1000 m above the adjacent sea floor. The Islas Orcadas Rise and Meteor Rise were once conjugate features prior to seafloor spreading that separated them in the Eocene. The major objectives of this site were to determine the age, nature and subsidence history of the Islas Orcadas Rise, and to investigate the influence of the shallow Islas Orcadas and Meteor rises on oceanic watermass communication between the southern high latitude region and the South Atlantic. The objectives of this site originally were intended to be addressed on the Meteor Rise; however, the basal stratigraphic sequence and basement of these once conjugate features were considered more accessible at Site 702 on the Islas Orcadas Rise. Bad weather and problems with deep holes during Leg 114 made for the cautious decision to attempt to pursue these objectives at two sites (target sites SA6 and SA8). An additional consideration for selecting this site was the prospect of reaching basement to test the Navi-drill coring system.

Site 702 consists of two holes: Hole 702A with four APC cores taken to a depth of 33.1 mbsf with 100% recovery and Hole 702B with 3 APC and 29 XCB cores to 294.3 mbsf with 195.2 m recovered (66.3%). Sediment recovery was good (87%) to a depth of 205 mbsf but dropped sharply below this depth due to the occurrence of numerous chert stringers. The Navi-drill was deployed and tested on a silicified limestone encountered at 294 mbsf, but no material was retrieved and the site was abandoned.

The stratigraphic section in Hole 702B consists of a thin layer of diatom ooze and nannofossil-diatom ooze overlying a thick sequence of pelagic carbonates with increasing downhole lithification. The dominant lithologies and ages of the stratigraphic sequence are as follows:

0-6.15 mbsf:	Diatom ooze and mud with frequent dropstones, manganese nodules and staining; late Miocene to Holocene age;
6.15-21.1 mbsf:	Nannofossil-diatom ooze with dropstones, manganese nodules and dispersed ash layers; late middle to late Miocene age;
21.1-32.8 mbsf:	Nannofossil ooze; late Eocene age;
32.8-202.45 mbsf:	Nannofossil chalk; earliest Eocene to late Eocene age;
202.45-294.3 mbsf:	Indurated nannofossil chalk with thin chert layers and a basal silicified limestone; early late Paleocene to earliest Eocene age.

Most of the older sedimentary sequence of the Islas Orcadas Rise-Meteor Rise aseismic ridge system was obtained at Site 702. This predominantly early late Paleocene-late Eocene section represents a 23 m.y. history of pelagic carbonate sedimentation during a period which precedes and post-dates the rifting of these aseismic ridges. Although basement was not reached, the age of the Islas Orcadas Rise was further constrained to be older than 61 Ma. A Late Cretaceous age for the rise is suggested by reworked planktonic foraminifers and calcareous nannofossils present in the basal 20 m of the section about 150 m above basement. An early Eocene episode of extension generated numerous small half-grabens over much of the rise, and a major post late Eocene to pre-late middle Miocene tectonic event formed a N-S trending horst through the location of Site 702.

A relatively complete succession of magnetic polarity zones was identified between approximately 20 and 205 mbsf. Good core recovery (86%) and relatively little core disturbance of this interval resulted in identification of early to late Eocene Chrons C22R through C16N. This magnetostratigraphic framework adds to our previous paleomagnetic representation of the Late Cretaceous-earliest Paleocene, late Oligocene, late Miocene, and Pliocene to Holocene. These sections will make a significant contribution towards age-calibration of high latitude biozones and paleoenvironmental history.

Sedimentation rates at Site 702 were about 12 m/m.y. during the late Paleocene and decreased during the Eocene from a high of 17 m/m.y. during the early to middle Eocene to 12 m/m.y. during the late middle Eocene, and further declined to 6 m/m.y. during the late Eocene. A possible hiatus occurs in the lower Eocene and a major hiatus of 26 m.y. (24 mbsf) spans the uppermost Eocene-upper middle Miocene. Additional hiatuses of yet undetermined duration occur in the 24 m of upper middle Miocene to Holocene sediments.

Calcareous microfossils are abundant throughout the Eocene section where the carbonate content is generally 85-95% but are less abundant in the upper middle Miocene to upper Miocene where the carbonate content declines to no more than 40-70%. Siliceous microfossils are abundant in the Neogene, persist down to the upper lower Eocene, and are absent in the remainder of the sequence, except for the lower upper Paleocene where they are again present. As was the case at the previous sites, Paleogene sequences without biosiliceous microfossils were attributed to dissolution of biosiliceous opal and its downward diffusion to form zeolites, chert, or porcellanite.

Calcareous microfossils record a similar history of surface water cooling as observed at Sites 699 and 700. Assemblages reveal relative warmth during the late Paleocene, a brief but not severe cooling near the Paleocene/Eocene boundary, maximum warmth during the early Eocene, cooling during the middle Eocene, and the establishment of yet cooler conditions during the late Eocene when assemblages developed a true high latitude affinity. Benthic foraminifers suggest a Paleocene water depth of 2000 m; however, sediments of this age contain transported shallow water organisms such as bivalves, echinoid spines, and ostracods. If the Islas Orcadas Rise is Cretaceous in age as reworked faunas and floras suggest, intermediate to deep water exchange of antarctic waters with the South Atlantic may have been severely inhibited during the Late Cretaceous to early Paleogene by the Falkland Plateau and Falkland fracture zone, the Islas Orcadas Rise and Meteor Rise, and the Agulhas Plateau and Agulhas Fracture Zone.

SITE 703

Site 703 is located on the Meteor Rise (47°03.042' S, 07°53.679' E, water depth 1807 m), an aseismic ridge extending southwest from the Agulhas Fracture Zone. The Islas Orcadas Rise (Site 702 location) and the Meteor Rise are both bounded by lower Eocene oceanic crust generated at the Mid-Atlantic Ridge. These rises were formed at the locus of a new spreading center following a Late Cretaceous westward shift of the ridge axis in the Agulhas Basin. The major objectives of drilling at this site were to determine the nature, age and subsidence history of the rise and to investigate the influence of the shallow Paleogene Meteor Rise, Islas Orcadas Rise and the adjacent fracture zones on oceanic communication between the high and temperate latitudes of the South Atlantic.

Site 703 focused on the deep objectives. A single hole was drilled at Site 703 with 15 APC cores to 137.9 mbsf (97.5% recovery) and 26 XCB cores (24.2% recovery) to the total depth of 377.4 mbsf with a total recovery of 51%. Further tests of the Navi-drill coring system were carried out, but no sediments were obtained. The hole was logged with a single run using the Schlumberger sonic, dual induction, natural gamma ray and caliper tools. Drilling was hampered by heavy seas with 12 hours waiting on weather (maximum roll = 15°, maximum pitch = 10°).

The stratigraphic section at Site 703 consists of calcareous ooze and chalk with intervals of mass flow deposits of clay, ooze, sand/gravel and volcanic breccia in the lower part. The dominant lithologies and ages of the stratigraphic sequence are as follows:

0-71.4 mbsf: Siliceous foraminifer-bearing nannofossil ooze of early

	Oligocene to Holocene age;
71.4-162.4 mbsf:	Foraminifer-bearing nannofossil ooze of late Eocene to early Oligocene age;
162.4-228.9 mbsf:	Nannofossil ooze containing mass flow deposits of clay, foraminifer ooze and gravelly sand of middle Eocene age;
228.9-364.0 mbsf:	Nannofossil chalk containing mass flow deposits of gravel of early(?) to middle Eocene age;
364.0-365.65 mbsf:	Weathered amygdaloidal basalt.

Site 703 is located between the Subtropical Convergence and the Antarctic Convergence and has received predominantly calcareous biogenic sedimentation since the early Eocene, but with significant biosiliceous input in the late Eocene, the late Oligocene to early Miocene and particularly in the Pliocene and Quaternary.

The middle Eocene through Oligocene sequence of this site is the sixth consecutive representation of Paleogene sediments recovered by Leg 114. An additional succession of paleomagnetic polarity zones was identified in the lower Oligocene to lower Miocene where recovery was good (98.2%).

Sedimentation rates are not yet determined for the middle Eocene to late Oligocene, but were 15 m/m.y. during the early Miocene, and 6 m/m.y. during the late Pliocene to Holocene. Hiatuses occur between the upper Oligocene and lower Miocene (5.5 m.y. duration) and also separate the lower Miocene from the upper Pliocene (15.5 m.y. duration).

Microfossil assemblages record a history of surface water cooling during the middle Eocene to late Oligocene. There is some indication at this easternmost site that surface waters remained warmer during the late Paleogene, although the general middle Eocene to late Oligocene cooling trend is the same as observed in the western sites drilled during Leg 114.

Paleodepth estimates based on benthic foraminifer assemblages suggest a depth >600 mbsl during the Eocene and >1000 mbsl during the Oligocene. Redeposited shallow water microfossils occur throughout the Eocene and Oligocene section; in the Eocene these include neritic diatoms suggesting the presence of nearby islands.

It is uncertain if the early(?) or early middle Eocene age of basement is indicative of the age of the Meteor Rise because of the elevated position of this site. Redeposited microfossils are no older than Eocene, unlike the Islas Orcadas Rise where Upper Cretaceous microfossils are reworked in the upper Paleocene. The igneous rocks recovered are weathered porphyritic plagioclase rich basalts and basaltic tuffs and may represent basement or part of a volcanic rubble zone.

SITE 704

Site 704 (46°52.757' S, 07°25.250' E, water depth 2532 m) is located on the southern portion of the Meteor Rise, an aseismic ridge formed by extensive Paleocene-Eocene volcanism at a propagating extension of the Mid-Atlantic Ridge. The major Leg 114 objective of determining the age, nature, and subsidence history of Meteor Rise and its conjugate feature, the Islas Orcadas Rise, was largely met by drilling at previous Sites 702 and 703. For this reason, Site 704 was located on a region of the Meteor Rise where a maximum thickness of Neogene and upper Paleogene sediment could be obtained in order to provide a high-resolution paleoceanographic-paleoclimatic record of an interval not well represented in previous Leg 114 sites (Figure 4).

Two holes were drilled at Site 704 using the APC and XCB coring systems. Hole 704A was cored continuously (16 APC cores, 14 XCB cores) through an upper Miocene to Holocene sequence to a depth of 282.7 mbsf and recovered 224.55 m (79.4%). After offsetting, Hole 704B was cored continuously (15 APC cores, 57 XCB cores), penetrating 671.7 m of lower Oligocene to Holocene sediments, recovering 502.75 m (74.8%). The composite section of both holes recovered more than 99% of the upper Miocene to Quaternary sequence above 282.7 mbsf. Coring operations were suspended to allow 2 days for logging and half a day for Navi-drill testing prior to departure from this last site to Mauritius. Three logging runs were made using the seismic-stratigraphic, litho-density, and geochemical combinations. Site 704 was occupied between 25 April and 3 May in generally high seas.

Site 704 was a fitting end to Leg 114. After having already recovered thick Paleogene carbonate sequences at the prior sites, a thick mixed carbonate and biosiliceous sequence of early Oligocene-Holocene age was obtained at Site 704. In conjunction with our previous sites, Leg 114 recovered a remarkably complete representation of the Upper Cretaceous-Holocene, most of it carbonate-bearing. Site 704 is potentially a very important reference section for the interpretation of Neogene southern high latitude paleoenvironment. The Neogene sequence at this site is the thickest (576 m) and most complete section at high southern latitudes with (1) the presence of carbonate throughout which offers an extended stable isotopic record of planktonic and benthic environments; (2) little or no terrigenous component; (3) the continuous presence of all calcareous and siliceous microfossil groups; and (4) a relatively complete paleomagnetic record.

The sediments recovered at this site dramatically reflect the major stages of Neogene paleoclimatic evolution. The characteristics and ages of the recovered lithologies are as follows:

0-101.7 mbsf:	A wide range of biogenic lithologies between diatom ooze and calcareous ooze with high frequency carbonate variations, Pleistocene age;
101.7-175.7 mbsf:	Dominantly calcareous ooze with a biosiliceous component and large amplitude fluctuations in carbonate content, early Pliocene-early Pleistocene age;
175.7-251.7 mbsf:	Diatom-bearing calcareous ooze becoming more siliceous between 219-251.7 mbsf, late Miocene-early Pliocene age;
251.7-451.2 mbsf:	Uniform nannofossil ooze with a minor biosiliceous component, middle to late Miocene age;
451.2-491.2 mbsf:	Micrite-bearing nannofossil chalk with a minor biosiliceous component, early to middle Miocene age;
491.2-671.7 mbsf:	Micritic nannofossil chalk with a minor biosiliceous component, early Oligocene to early Miocene age.

Sedimentation rates were about 22 m/m.y. during the late Oligocene and early Miocene, 13 m/m.y. during the middle Miocene, 37 m/m.y. during the late Miocene, and 20 m/m.y. during the Pliocene. Early to middle Pleistocene sedimentation rates were a remarkable 120 m/m.y. but dropped to >25 m/m.y. during the late Pleistocene. A hiatus occurs at the base of the Pliocene (4.7-5.1 Ma) and another separates the lower and middle Miocene (3 m.y duration, 18-15 Ma). A third hiatus possibly occurs between the lower and upper Oligocene.

In contrast to other Leg 114 sites, Site 704 remained north of the Antarctic Convergence throughout most of the Miocene without major periods of non-deposition or erosion associated with the opening of the Drake Passage. The Oligocene to middle Miocene was a period of environmental stability with nearly continuous productivity dominated by calcareous microfossil groups. Little change in sedimentation occurred during the middle Miocene; however, cooler assemblages of calcareous nannofossils began appearing by 13 Ma. A more pronounced cooling trend began during the late Miocene (9.0 Ma), after which there was a strong cyclicity, reflected in the sediment record and seen in carbonate fluctuations and in the geochemical logs. A severe cooling episode occurred during the latest Miocene (6.5 Ma to earliest Pliocene) followed by the last brief period of climatic stability during the early to mid-Gilbert Chron.

During the late Pliocene (2.9 Ma) the Antarctic Convergence moved closer to Site 704, leading to an increase in the deposition of biogenic silica and the advent of strong cyclic sedimentation. Late Pliocene-Quaternary cyclic deposition was controlled primarily by glacial-interglacial fluctuations in calcareous and biosiliceous productivity. Logging results and detailed carbonate analyses confirm the presence of a strong high resolution climatic signal with cycles on the scales of tens-of-thousands to hundreds-of-thousands of years. The isotopic stratigraphy, paleontology, sedimentology, and logs of this site should provide an unequaled southern high latitude reference section of late Neogene climatic history.

CONCLUSION

Drilling by JOIDES Resolution on Leg 114 was very successful, operating under weather conditions which tested the operational capabilities of the vessel. The recovered sediments provide an almost complete composite section spanning 90 m.y., from the Late Cretaceous to the Quaternary (Figure 5). Two-thirds of the recovered sediments are of Late Cretaceous-Paleogene (90 to 23.7 Ma) age and are primarily pelagic carbonates which may provide a valuable oxygen and carbon stable isotopic record of the subantarctic region. These sites and those recently drilled by Leg 113 in the Weddell Sea provide the first detailed sedimentary record of the paleoenvironmental evolution of a single sector of the Southern Ocean.

The geochronologic framework provided by Leg 114 is crucial to interpreting the influence of the Cenozoic glacial history of the Antarctic ice sheet on global oceanography and climate. Until now a detailed chronology of the paleoenvironmental evolution of the Southern Oceans has been unavailable, preventing recognition of the dynamic relationship of the Antarctic region with the global oceanographic-climatic system.

Within the well-constrained stratigraphic framework established by Leg 114 we intend to evaluate critically changes in the subantarctic paleoenvironment during the Late Cretaceous-Quaternary, a period which has transformed the climate of this area from subtropical to temperate, to finally subpolar. Within this context, ancillary post-cruise studies will evaluate the influence of regional tectonics on the glacial and paleoceanographic history of the Southern Ocean and exchange of antarctic water masses with the South Atlantic.

The combined paleomagnetic data from all seven sites provide a near complete history of geomagnetic polarity reversals which extends from the Late Cretaceous (Santonian) through the Quaternary, with gaps only in the late Paleocene-early Eocene and the early and middle Miocene. Previous Southern Ocean magnetostratigraphic data were limited almost entirely to the late Neogene (last 8 m.y.).

Generally well preserved microfossil assemblages of all major siliceous and calcareous microfossil groups were obtained from the Upper Cretaceous-Quaternary sedimentary sequences. The recovery of thick and relatively complete Paleogene sequences will allow the initial detailed biostratigraphic zonation of many portions of this interval for the Southern Ocean region. The new information from Leg 114 will provide the first complete magnetostratigraphic time-framework for calibration of Cenozoic, high latitude biostratigraphic zones.

Sediments recovered by Leg 114 provide a rich repository of a 90 m.y. history of the subantarctic region. Future studies of this resource will provide a better understanding of the important role that the antarctic region has played in the evolution of the Cenozoic biota and in the dynamics of the atmosphere and hydrosphere.

REFERENCES

Barker, P.F., and Burrell, J., 1977. The opening of Drake Passage. Mar. Geol., 25:15-344.

Barker, P.F., and Burrell, J., 1982. The influence upon Southern Ocean circulation, sedimentation, and climate of the opening of Drake Passage. In Craddock, C. (Ed.), Antarctic Geoscience: Madison, WI (Univ. Wisconsin Press), 377-385.

Kennett, J.P., 1977. Cenozoic evolution of Antarctic glaciation, the circum-Antarctic Ocean, and their impact on global paleoceanography. J. Geophys. Res., 82:3843-3860.

Kennett, J.P., 1978. The development of planktonic biogeography in the southern ocean during the Cenozoic. Mar. Micropaleontol., 3:301-345.

LaBrecque, J.L., and Rabinowitz, P.D., 1977. Magnetic Anomalies--Argentine Continental Margin, Argentine Basin, North Scotia Ridge, Falkland Plateau: AAPG Spec. Map Ser.

OMD Region 13 Synthesis, 1986. South Atlantic Ocean and Adjacent Continental Margin Atlas 13, J.L. LaBrecque (Ed.): Mar. Sci. Int., Woods Hole, MA.

TABLE CAPTION

Table 1. Leg 114 Site Summary.

FIGURE CAPTIONS

Figure 1. Leg 114 drilled 12 holes at 7 sites along a west-to-east transect across the subantarctic South Atlantic.
Top, center: Map showing locations of Leg 114 sites. Sites are identified on the cross-section. The contour is the 1500-m isobath.
Top: Composite stratigraphic columns of each site showing ages, lithologies, and stratigraphic thicknesses.
Bottom: Schematic cross-section of the seafloor showing Leg 114 drilling sites along the transect in the map above.

Figure 2. Wind conditions in the central subantarctic South Atlantic (47°S-52°S) experienced by JOIDES Resolution during drilling operations on Leg 114. Average wind is measured over a 24-hour period, and maximum wind is wind speed sustained over a 5-minute interval.

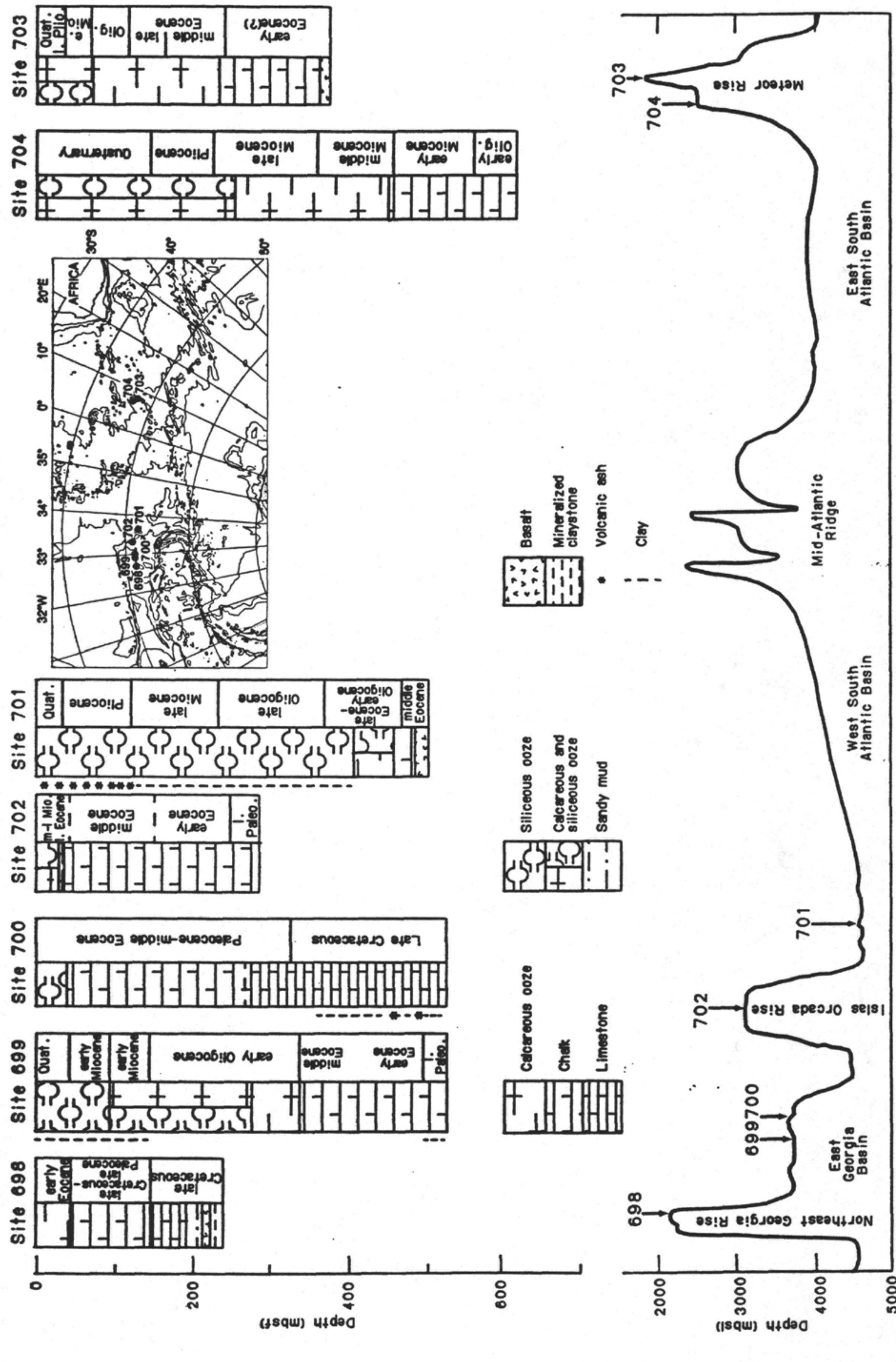
Figure 3. Top: Histogram showing the thickness of sediments of various ages penetrated by Leg 114 drilling.
Bottom: Histogram showing the thickness of the various lithologies penetrated by Leg 114 drilling.

Figure 4. Fluctuations in the percentage of calcium carbonate in the section from the middle Miocene through the upper Pleistocene at Site 704 on the Meteor Rise. Calcium carbonate percentages remain relatively constant from 400 mbsf to the bottom of the hole. The advent of high-frequency, large amplitude fluctuations in carbonate content represents the beginning of strong glacial-interglacial variations.

Figure 5. Sedimentation rate curves for the seven sites drilled during Leg 114.

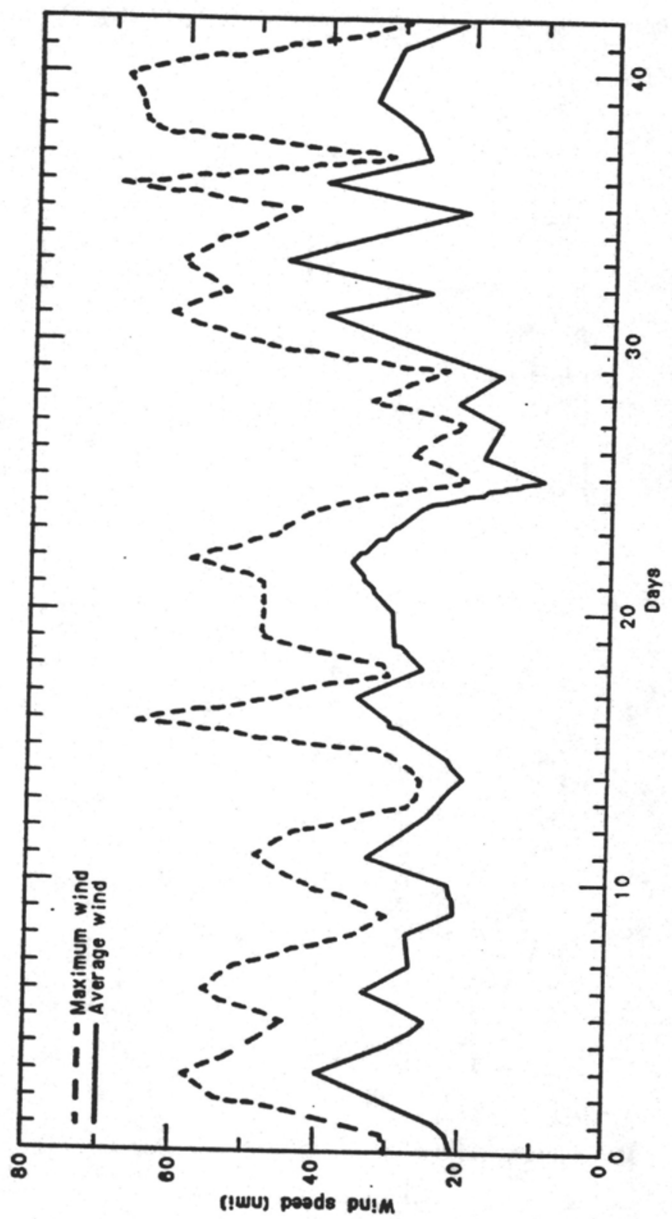
TABLE 1. LEG 114 SITE SUMMARY

HOLE	LATITUDE	LONGITUDE	WATER DEPTH (m)	NUMBER OF CORES	METERS CORED	METERS RECOV'D	PERCENT RECOV'D	METERS TOTAL PENET.
698A	51°27.51'S	33°05.96'W	2128.0	27	237.0	52.30	22.1	237.0
699A	51°32.537'S	30°40.619'W	3716.0	56	518.1	356.52	68.6	518.1
700A	51°31.992'S	30°16.697'W	3630.6	2	9.6	0.19	2.0	19.1
700B	51°31.977'S	30°16.688'W	3611.5	54	489.0	245.40	50.2	489.0
701A	51°59.076'S	23°12.736'W	4647.2	8	74.8	69.66	93.1	74.8
701B	51°59.077'S	23°12.735'W	4647.2	14	133.0	96.36	72.5	203.0
701C	51°59.085'S	23°12.700'W	4647.2	51	481.3	331.06	68.6	481.3
702A	50°56.786'S	26°22.127'W	3093.9	4	33.1	34.21	103.4	42.6
702B	50°56.786'S	26°22.117'W	3094.2	32	294.3	195.10	66.3	294.3
703A	47°03.042'S	07°53.679'E	1806.6	41	377.4	192.29	51.0	377.4
704A	46°52.757'S	07°25.250'E	2532.3	30	282.7	224.55	79.4	282.7
704B	46°52.758'S	07°25.231'E	2530.8	72	671.7	502.75	74.8	671.7



Site 698
Site 699
Site 700
Site 702
Site 701
Site 704
Site 703
Depth (mbsf)
Depth (mbsl)
Northeast Georgia Rise
East Georgia Basin
Islas Orcada Rise
West South Atlantic Basin
Mid-Atlantic Ridge
East South Atlantic Basin
Meteor Rise
1000 km
AFRICA
Calcareous ooze
Chalk
Limestone
Siliceous ooze
Calcareous and siliceous ooze
Sandy mud
Basalt
Mineralized claystone
Volcanic ash
Clay

Figure 1



Maximum wind
Average wind
Wind speed (nmi)
Days
0
20
40
60
80
0
10
20
30
40

Figure 2

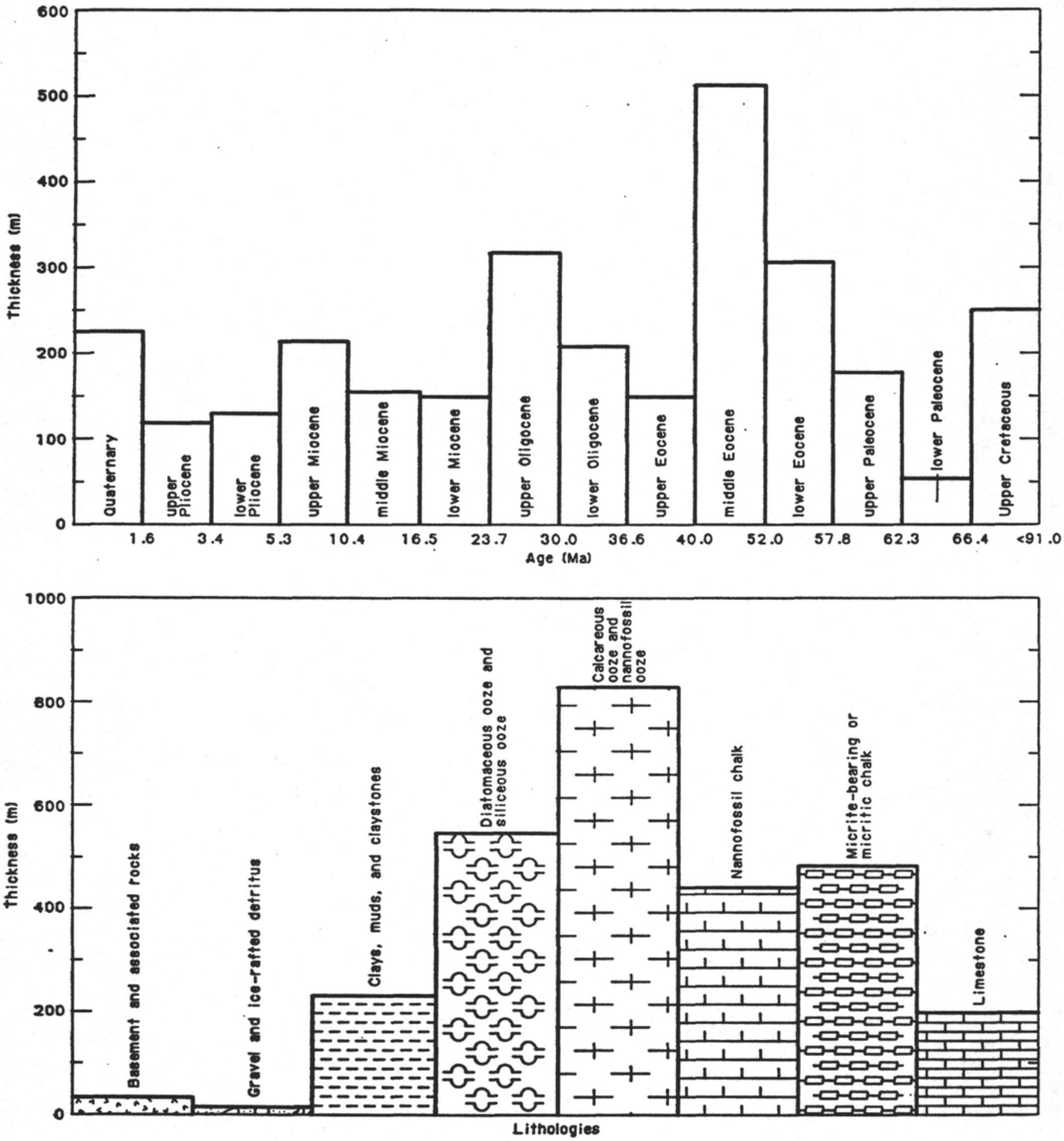

Thickness (m)
600
500
400
300
200
100
0
Quaternary
upper Pliocene
lower Pliocene
upper Miocene
middle Miocene
lower Miocene
upper Oligocene
lower Oligocene
upper Eocene
middle Eocene
lower Eocene
upper Paleocene
lower Paleocene
Upper Cretaceous
1.6
3.4
5.3
10.4
16.5
23.7
30.0
36.6
40.0
52.0
57.8
62.3
66.4
<91.0
Age (Ma)
Thickness (m)
1000
800
600
400
200
0
Basement and associated rocks
Gravel and ice-rafted detritus
Clays, muds, and claystones
Diatomaceous ooze and siliceous ooze
Calcareous ooze and nannofossil ooze
Nannofossil chalk
Micrite-bearing or micritic chalk
Limestone
Lithologies

Figure 3

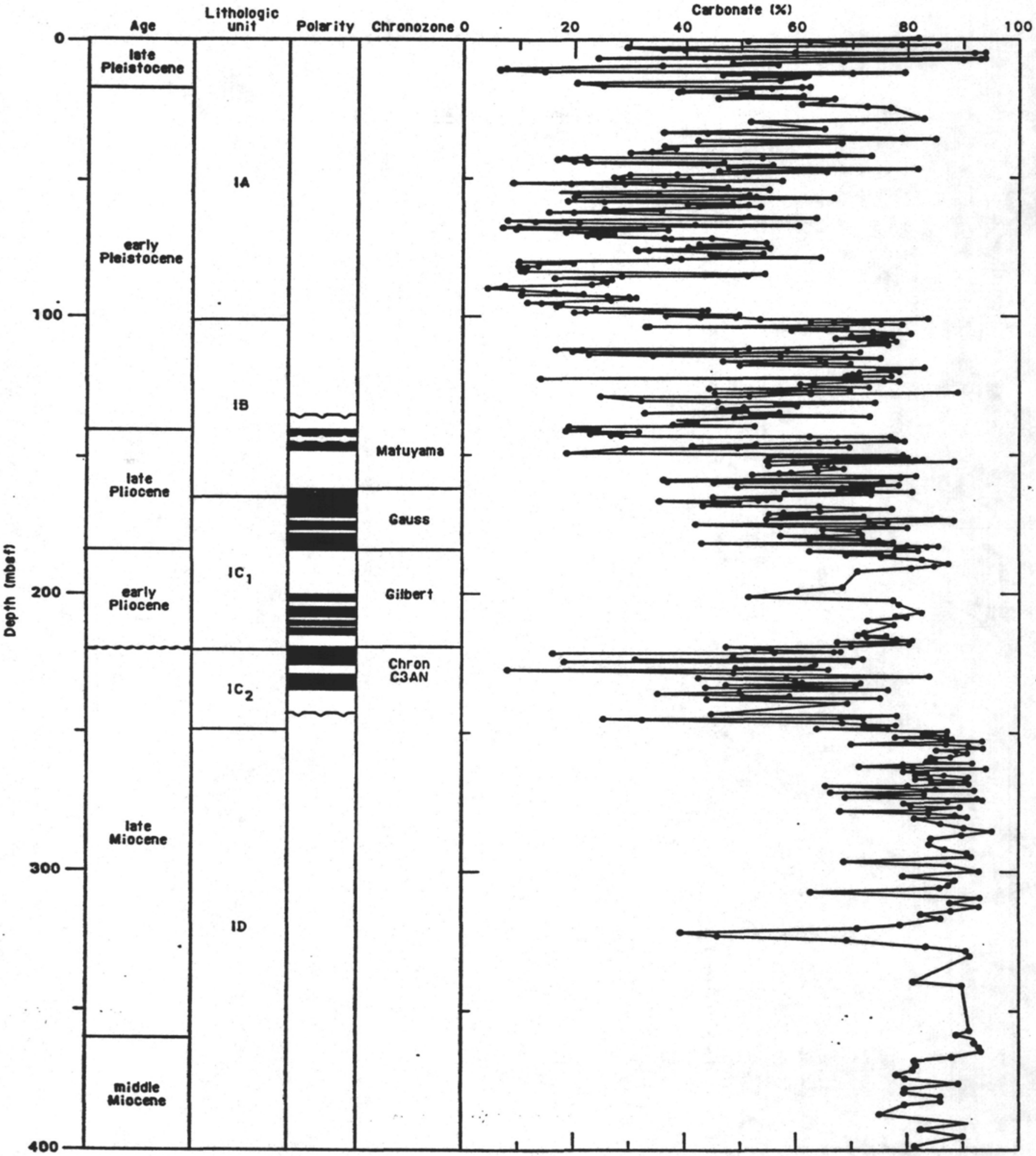
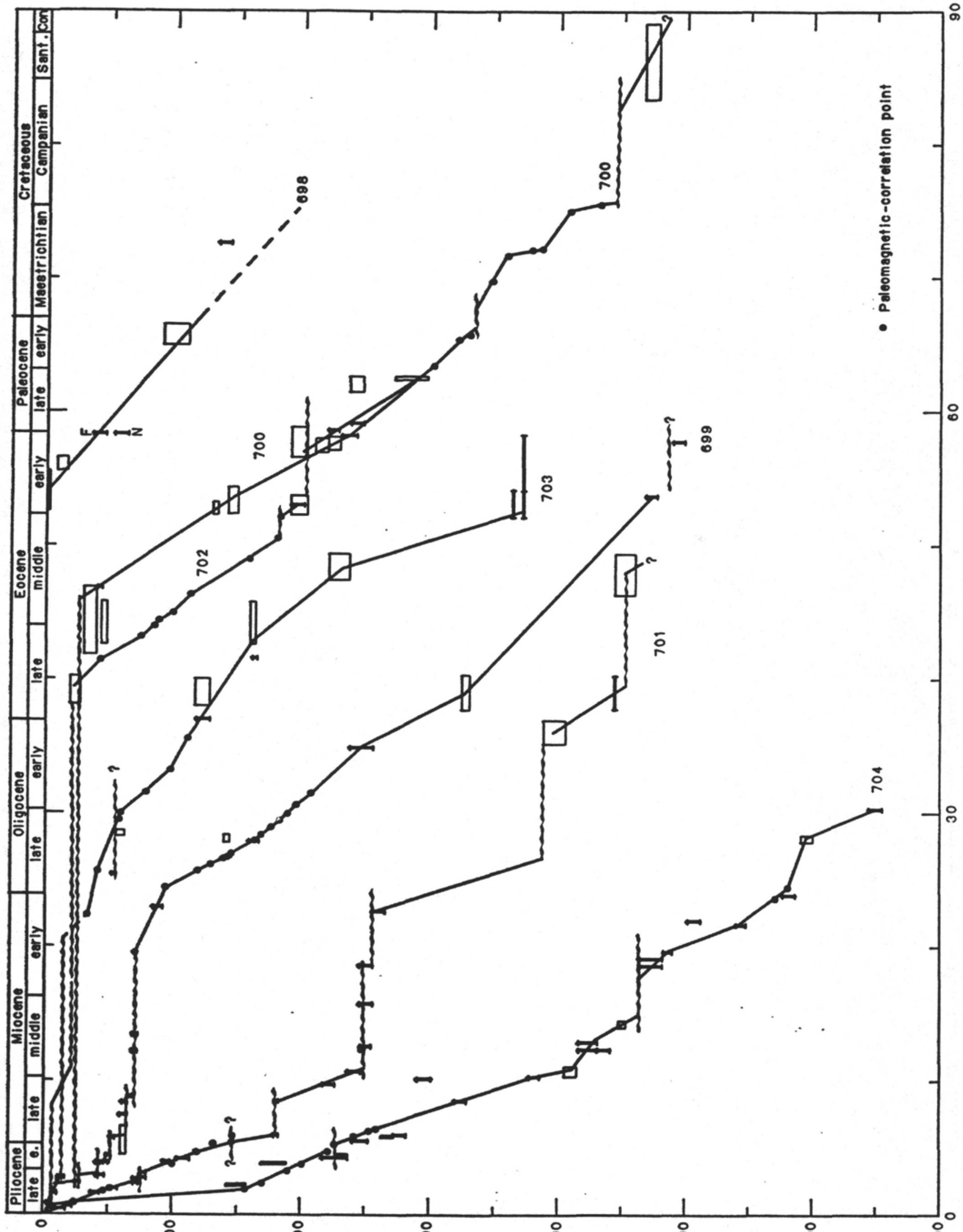

Age
Lithologic unit
Polarity
Chronozone
Carbonate (%)
0
20
40
60
80
100
Depth (mbsf)
100
200
300
400
late Pleistocene
early Pleistocene
late Pliocene
early Pliocene
late Miocene
middle Miocene
IA
IB
IC1
IC2
ID
Matuyama
Gauss
Gilbert
Chron C3AN

Figure 4



Pliocene
late
e.
Miocene
late
middle
early
Oligocene
late
early
Eocene
late
middle
early
Paleocene
late
early
Cretaceous
Maestrichtian
Campanian
Sant.
Con
Depth (mbsf)
0
100
200
300
400
500
600
700
Age (Ma)
0
30
60
90
698
699
700
701
702
703
704
F
N
• Paleomagnetic-correlation point

Figure 5

OPERATIONS REPORT

The ODP Operations and Engineering personnel aboard JOIDES Resolution for Leg 114 were:

Operations Superintendent: Mike Storms

Special Tools Engineer: Frederic Young

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OPERATIONS REPORT

SITE 698 OPERATIONS SUMMARY

Site 698 (SA5C-ALT) was a bonus site for Leg 114. JOIDES Resolution left port on 14 March 1987, nearly two days ahead of schedule. En route to the first site the vessel was able to make an average transit speed of 12.6 kt. At this point Leg 114 was well ahead of schedule and the decision was made to drill proposed Site SA5C-ALT. The objective was to continuously core from the mudline into basement. Because time was extremely limited the hole was cored only with the rotary core barrel system (RCB). The advanced hydraulic piston corer (APC) and extended core barrel (XCB) systems would have recovered a higher volume of core with less disturbance but would not have successfully recovered basement. There was not enough time to trip the drill string and change coring systems; the Navi-drill (NCB2) coring system was considered too new and developmental to deploy at this site.

Hole 698A was spudded in 2128 m of water on 17 March 1987. A total of 237 m of penetration was achieved recovering 52.3 m (22.1%). Spudding took place on a lag deposit pavement directly overlying foraminifer-nannofossil ooze. The soft, easily washable, nature of the ooze did not lend itself well to the rotary coring method. To complicate matters the formation was laced with chert stringers which played havoc with the coring system. Recovery was good in a core barrel until chert was reached, at which point the core catcher would become jammed preventing further recovery. On several occasions chert fragments became packed in the throat of the drill bit. This resulted in a zero recovery core and necessitated an additional wireline run with a bit deplugger before coring operations could continue. Another problem experienced in this hole was chert fragments (assumed) becoming lodged above the bit throat preventing proper seating and latching of the next core barrel. Presumably this material became dislodged from the previous core barrel during retrieval. After Core 114-698A-23R came up empty a chisel nose center bit was deployed. Upon retrieval it was determined that this assembly did not latch in. A second barrel, this time with a hollow bit deplugger on the end, was dropped. This barrel became lodged in the Outer Core Barrel (OCB) and could not be retrieved. After an over-pull of about 3000 lb the overshot disengaged and the sandline was retrieved. A second attempt to retrieve the stuck barrel ended in success after pulling in excess of 7500 lb over line weight. Upon retrieval the deplugger was found to contain approximately 10 cm of highly altered basalt. Fresh basalt was subsequently recovered in Core 114-698A-24R at 209.5 meters below seafloor (mbsf). Three more cores were taken recovering alternating fresh and highly weathered basalt until a total depth of 237.0 mbsf was reached. Then coring operations were ceased and the drill string tripped. At 2230 hours on 19 March, the vessel was secured and under way. Several hours were taken to conduct a post-site geophysical survey prior to setting a course for the next site.

The weather experienced at Site 698 was extremely favorable up until the trip out of the hole. At this time the seas began building and the wind velocity continued to climb. While under way the weather climaxed in a full-fledged force 10 storm with winds gusting to 53 kt.

SITE 699 OPERATIONS SUMMARY

Upon dropping the beacon at 1045 hours on 20 March 1987, Site 699 (SA2-ALT A) was established. Arrival was four hours ahead of schedule and within three hours the vessel was dynamically positioned over the beacon. The operating plan for this site was to APC/XCB core to basement then use the prototype Navi-drill Core Barrel (NCB2) to core into basement. Prior to running the bottom hole assembly (BHA) we tested the NCB2 system. We intended to verify that the tool would not unlatch upon impact following deployment of the go-devil and also to ensure that the NCB2 would fit within the BHA without jamming. However, when the tool was dropped inside the outer core barrel/non-magnetic drill collar assembly, the impact caused the tool to unlatch, scope out, and a pin thread failed, allowing the lower assembly to fall to the sea floor.

As the drill string was tripped into the hole, weather conditions deteriorated into another force 10 storm. Fortunately the pipe was not in the hole, as occasionally the thrust from the main screws reached 100% of available power and the vessel continued to lose ground.

The weather improved by morning and Hole 699A was spudded at 0630 hours on 21 March 1987. The first APC recovered 8.66 m, including chert, and established the mudline at 3716 m. Piston coring operations continued until 205.1 mbsf when a 90,000-pound pullout was recorded for Core 114-699A-22H. Recovery was substandard to the historical average for piston coring. Several conditions were responsible. The cored formation was infiltrated with glacial erratics and drop stones that jammed the core catcher and prevented additional recovery. From the mudline down, the formation contained chert stringers that also tended to fracture and lodge in the core catchers, inhibiting core entry. The weather conditions caused a considerable amount of heave and bit motion, even with the heave compensation system in use. Piston coring on the "up heave" or "down heave" historically influences both the quantity and quality of the cores. In spite of these factors the APC still managed to recover a respectable 80.3% of good quality core.

Coring continued with the XCB system, which did not fare as well as the APC system. The XCB coring system had to deal with the same conditions as the APC and in addition had to constantly be adjusted for flow rate, weight on bit and RPM to deal with the varying degrees of hardness in the chalk formation. The XCB system finished the hole to a total depth of 518.1 mbsf, with a recovery of 61.2%.

Several gravel layers and sand layers were encountered in the hole but gave surprisingly little trouble. As insurance against future problems, since this hole was to be terminated fairly deep in the section and then logged, several high viscosity mud pills were circulated. After penetrating a particularly auspicious gravel layer, we made a short wiper trip to check, clean and condition the hole.

By 2200 hours on 23 March, weather conditions deteriorated until coring operations had to be suspended. The real "fall in the South Atlantic" weather was beginning to manifest itself. The drill string was secured with three knobby pipe joints through the guidehorn of the ship and waiting-on-weather (WOW) commenced. Winds gusted to 55 kt that evening, leading to sea and swell conditions that resulted in a maximum roll condition of 9°. By early the following morning conditions had deteriorated even further. Due to a significant wind shift of nearly 90°, there now existed two predominant swells. Automated station keeping (ASK) requirements dictated that the vessel keep her nose nearly into the wind which put us virtually broadside to the large secondary swell. The geometry of the situation resulted in average rolls of 10°-12° with several 15°-18° rolls. After a total of seventeen hours of WOW, conditions improved and continuous XCB coring operations resumed.

Coring operations ceased at 0115 hours on 26 March when Core 114-699A-56X could not be retrieved. After one hour of retrieval attempts the decision was made to jar off (sever the overshot shear pin) and attempt to dislodge the barrel with another core barrel. The overshot pin refused to shear, however, and another couple of anxious hours passed with the status of the drill string in the hole now becoming a paramount worry. All circulation ability was lost immediately upon sticking the core barrel. With the sandline attached to the barrel we did not have the ability to rotate the string. At this time we deployed the Kinley line severing tool, severed the sandline, and retrieved the remaining line.

The core barrel remained stuck in the pipe preventing the deployment of logging tools. The inability to circulate coupled with drill string drag and torquing indicated that attempts at logging 'through-the-pipe' would have constituted an extreme risk of drill string or BHA loss. Hole conditions at the surface were suspected of being poor due to the WOW time experienced earlier. This fact, in addition to the frequency of poor weather conditions, made the deployment of a mini-cone a poor risk. The decision was made to terminate the hole without logging and move to proposed Site SA2-ALT B (Site 700).

After clearing the rotary table with the drill bit, an additional 4.5 hours was expended refueling prior to departing the site. This was the first of two loads of fuel required before the trip to Mauritius. The tanker originally contracted to refuel the ship in the Falkland Islands was significantly late. By choosing to attempt "at sea" refueling later in the leg, the ship was able to leave port nearly two days early rather than more than a week late. The support vessel Maersk Master took on the first load of fuel from the tanker Sunny Trader in King Edward Cove, South Georgia Island, and using her unique dynamic positioning capabilities, transferred the load to JOIDES Resolution while on site. Hole 699A was terminated when the vessel got under way at 2000 hours on 26 March 1987.

SITE 700 OPERATIONS SUMMARY

The transit to Site 700 (SA2-ALT B) was accomplished quickly as this site was only 12 nmi from Site 699. It was decided to attempt reaching basement at this site rather than respudding at Site 699 for two reasons. First, fairly abundant sand/gravel layers created recovery problems and led directly to the loss of Hole 699A; therefore, it was felt that the chances of reaching basement and having a stable, loggable hole were greater at the SA2-ALT B location (Site 700). Secondly, this site was thought to have a shallower basement that could be reached in less time. The geology at this basement high was projected to be nearly identical to the original Site 699 hole except that the upper, younger, material was missing. This was acceptable to the scientific party since this part of the section had already been successfully cored and the older section (not recovered at Site 699) could be rapidly penetrated.

En route to the site, the rig crew continued to work feverishly at removing the sanded-up core barrel from the Seal Bore OCB. At 2315 hours on 26 March 1987 a beacon was dropped initiating Site 700.

Immediately upon deploying the positioning beacon, the profiling gear was retrieved and the vessel returned to the site. By 0115 hours the vessel was stabilized over the location and the rig crew began preparing to run in the hole. Since the upper, softer sediments had already been successfully cored in Hole 699A, basement and the Cretaceous to Paleocene were the primary objectives at this site. The RCB coring system was used to ensure penetration of expected limestones and basement. It was anticipated that the total penetration of the hole would be in excess of 400 m, so a Hydraulic Bit Release (HBR) system was deployed, allowing the hole to be logged upon completion of coring operations.

At 1000 hours on 27 March 1987, Hole 700A was spudded. Two cores were recovered before it became evident that something was wrong downhole. The driller reported difficulty in engaging the core barrel for Core 114-700A-3R. After the second wireline run came up without the barrel the overshot was changed out in the hope that it was only a pulling neck engagement problem. About this time, the driller reported that his pump pressures were reading much lower than earlier and it was suspected that the pipe was now open-ended. Since all of the string weight was accounted for, it appeared that the HBR had prematurely released the core bit. In an effort to salvage the core barrel, the drill string was slacked off and another unsuccessful attempt was made to engage the core barrel. The sandline was retrieved and the drill string was tripped out of the hole. At 1600 hours the pipe was pulled clear of the mudline and by 2245 hours on 27 March the working end arrived at the rotary table, minus the bit. Although analyses are continuing, early indications are that the HBR dogs were never fully engaged in the bit disconnect. After repeated blows with the core barrel assembly the bit simply fell off. Design modifications have since been made and components are being modified to allow dog engagement verification prior to deployment.

Weather conditions were deteriorating as the new bit and release assembly were made up. Since it was unknown at that time why the HBR pre-released (three successful deployments had been made during Leg 113 operations) a Mechanical Bit Release (MBR) assembly was used. The bottom-hole assembly (BHA) was run in the hole along with a partial string of drill pipe before operations were halted to cut and slip the drilling line. With the weather continuing to deteriorate the pipe was run to bottom but the spudding of Hole 700B was delayed until more favorable operating conditions were at hand. A stand of wear-knotted drill pipe was put in the string directly below two (20' plus 30') drilling joints. Waiting on weather (WOW) commenced on the second site in a row after we successfully completed the first site (698) without experiencing any lost time due to weather. This storm, although milder than the one experienced on Site 699, still packed winds gusting to 54 kt and was associated with several swells causing the vessel to roll 8^{o}-12^{o}.

After a delay of three hours the pipe trip was resumed and Hole 700B was spudded at 1430 hours on 28 March 1987. Coring continued, with the driller being watchful of a potentially dangerous sand layer as experienced in Hole 699A. A sudden influx of sand/gravel from this zone led to the loss of Hole 699A. At approximately the same stratigraphic level in the formation, the driller noticed a sharp increase in pump pressure associated with a loss of circulation. He responded by ceasing coring operations and immediately picking up off bottom with the drill string. We decided to go ahead and pull the core barrel and then proceed with pumping a high viscosity mud pill in an attempt to clean and stabilize the hole. An over-pull of 3000 lb was experienced while unseating the core barrel but to everyone's relief it did come free.

Continuous coring operations continued through Core 114-700B-23R. While attempting to retrieve Core 114-700B-24R from 489.0 mbsf, the adapter sub crossover from the sinker bars to the wireline swivel backed off, leading to a downhole fishing operation. Three attempts with a homemade shipboard fishing tool were made before the fish was recovered. The first attempt did not engage the fish. The second attempt engaged the fish, but it fell off while coming out of the hole. Modifications were made to the tool and on the third try the fish was both engaged and recovered from the string, allowing coring to resume once again. An inspection of the sinker bar string indicated that the connection had been baker-locked, as is standard practice, but it apparently did not cure properly, allowing the connection to back off during retrieval. The condition was aggravated by a wireline swivel that had locked up. The swivel had just been greased and checked prior to the core run. Upon inspection in the tool room, it was found that the snap ring retaining the grease seal had come out of its groove, creating a metal to metal contact and virtually locking up the swivel. This condition was confirmed in the shop. Design modifications are being explored to prevent this from happening in the future.

On 29 March at 2300 hours, Maersk Master returned from South Georgia Island with the second and final load of fuel destined for JOIDES Resolution. By 1300 hours on 30 March this load of fuel was taken aboard the vessel and Master was under way for her third rendezvous with the tanker Sunny Trader, waiting at anchor in King Edward Cove, South Georgia Island. This third load of fuel was for Maersk Master herself.

Continuous coring continued through Core 114-700B-38R with signs of hole problems beginning while coring Core 114-700B-35R. At that time a 20 bbl pill of viscous mud was pumped. Upon tagging bottom for Core 114-700B-36R nearly 5.5 m of fill was encountered. The formation showed signs of intruding the borehole while this core was being cut so another 30 bbl pill was circulated to the mudline before retrieving the core. Again a pill was circulated while coring on Core 114-700B-37R and the hole showed signs of stabilizing since it was clean of fill at the start of Core 114-700B-38R. Normal coring operations continued until 1030 hours on 1 April 1987. At that time severe hole problems again began to manifest themselves. Apparently the previously stabilized zone was deteriorating or another bad zone was penetrated. The pipe began torquing and pump pressures were again elevated. A high viscosity pill was circulated while the decision was being made to make a short wiper trip in an attempt to again clean and stabilize the hole. The feeling was that this should be done before attempting to make any additional hole or resuming coring operations. Three hours were used to make approximately a 200 m wiper trip. The hole was circulated continuously and swept periodically with mud to condition it as well as possible. The wiper trip appeared to be successful because there were no additional torquing problems or bridges encountered except in the lowermost 9 m of the hole. After cleaning out the hole to bottom it was found that the wash barrel could not be retrieved and was apparently stuck down hole. After three wireline attempts the barrel came free. A conventional core barrel was deployed and while cleaning the hole to bottom the driller again noticed drill pipe torquing, this time associated with pump pressures significantly lower than normal. The wash barrel, upon breaking off the bit deplugger, was found filled with medium to coarse sand. Several runs with the sandline were made to no avail. The core barrel could not be located. It appeared that the shifting sleeve in the MBR had shifted while pulling the stuck wash barrel.

One additional wireline run was made to verify that the bit disconnect was indeed gone and that the pipe was free of any obstructions. The pipe was then tripped to 3750 m with one additional knobby joint added to the string. The logging sheaves were rigged and two successful suites of tools were run. Logging operations were completed by 0215 hours on 3 April 1987. The hole was displaced with heavy mud and abandoned. The pipe cleared the rotary table at 1245 hours after an arduous trip in very rough weather.

SITE 701 OPERATIONS SUMMARY

Site 701 (SA-3) was located on Polar Duke seismic line 0186 about 6 nmi east of proposed Site SA3A. The new location provided a seismic sequence which appeared to be more laterally uniform than that observed at the originally designated location. The approach to the site and the geophysical survey were hampered by strong following seas. During the turn to position over the beacon, the ship rolled a hard 20^{o}. By 1435 hours, 4 April, the vessel was operating in dynamic positioning mode and the rig crew went to work.

After a slow but safe drill string trip, Hole 701A was spudded at 0430 hours, 5 April, and some very eventful piston coring proceeded to take place. Enormous swells, remnants of the storm we had just sailed through and fed from a lingering low hanging overhead, caused havoc with the piston coring operation. The second and third cores required two wireline trips to recover because the overshot shear pins failed. The piston corer shear pins were consistently shearing during deployment as well, even with three pins installed. One core barrel came up slightly bent, but amidst freezing temperatures and snow flurries, operations continued. The hole crept deeper until Core 114-701A-8H. This barrel was found to be jammed tightly downhole. All efforts at freeing the barrel were unsuccessful. After shearing the overshot pin twice and trying all available options the barrel showed no signs of coming loose. Therefore, the pipe was tripped back to the vessel. The bit cleared the mudline at 2225 hours on 5 April and was on deck at 0630 hours, 6 April. The reason for the stuck barrel turned out to be a shear pin stub wedged down beside the APC landing shoulder and the outer core barrel (OCB) landing/saver sub. The stub had apparently moved into this position after shearing during deployment.

Early that morning, while tripping pipe out of the hole, the seas again calmed and weather conditions allowed transfer of the remaining ODP/SEDCO equipment from Maersk Master. This included a fuel hose borrowed for refueling from Sunny Trader, "yokohama" fenders that were used during the refueling, and the massive iceberg tow rope used during Leg 113 operations.

After offsetting the ship 10 m to the east, the pipe was again tripped to bottom and Hole 701B was spudded at 1645 hours, 6 April. In an attempt to prevent or reduce the incidents experienced in Hole 701A, the APC shear pins were knurled and then peened to rough up the surface. These pins had to be installed with a hammer and no additional cases of lost or partially protruding pins were experienced. In addition to eliminating the shear pin jamming potential, the sandline operators were told to slow down significantly in an attempt to minimize the surging and resultant cyclical loading on the overshot and APC shear pins. This technique seemed to help dramatically and operations continued in heavy swell conditions with the incidence of sheared overshot pins significantly reduced.

During the early morning hours of 6 April, the Datasonics positioning beacon became erratic and the signal degraded. We watched this condition closely because during the previous evening there had been times when we had temporarily lost acoustics causing brief positioning problems. Thruster noise, interfering with the acoustic signal, proved to be a continual nemesis throughout operations on this site, but a repeat of the particular problems experienced that night did not occur. By 0230 hours the beacon was definitely diagnosed as defective and a second beacon was dropped to the seafloor as a back-up. At 0330 hours the vessel began positioning on the new beacon. Weather conditions began moderating towards the end of Hole 701B. Hole 701B was terminated at 203 mbsf.

After offsetting the ship 10 m to the northeast, Hole 701C was spudded at 0230 hours, 8 April 1987. Operating conditions for Hole 701C were some of the best experienced during the cruise. In the South Atlantic, at this time of year, we had come to consider 20-30 kt winds and 10-15 ft seas good conditions from our perspective.

Piston coring operations on the first day of this hole went extremely well, coring nearly 111 m with 95%+ recovery. Quality was good and spirits were high. Exceptional performance from all coring systems continued for the next two days. The much improved weather conditions were a significant factor in the improved operations. In an effort to maintain good hole conditions and hopefully avoid a recurrence of the earlier failures, a program of spotting high viscosity mud pills was initiated. This appeared to be working quite well as several coarse sand and gravel layers were penetrated without any significant hole problems or fill encountered.

With the recovery of Core 114-701C-51X, from 481 mbsf, the situation changed. The cutting shoe on this barrel was severely worn. The check valve seat was found in the barrel and the ball was missing. The driller acknowledged that a very hard layer had been encountered approximately 2 m in on this core run. The resistant formation was approximately 1 m thick and required 45 minutes to penetrate. Earlier cores had been cut at 35 strokes per minute (SPM), with 10,000-18,000 lb weight on bit (WOB) and 400-500 psi pump pressure. This core was cut with 18,000 WOB; however, 50 SPM and 600 psi pressure were recorded. Immediately below this layer, the formation appeared to become softer again. Some torquing was experienced and recovery in the barrel was a mere 0.14 m. Another XCB barrel was deployed to core into the softer material and see if we had possibly broken through a sill or massive chert layer and back into sediment. Attempts at getting back down to the original hole to total depth were fruitless. The original hard layer was penetrated but approximately 4 m off bottom all progress was halted, the drill string began to torque up, and the barrel was found to be securely stuck. All efforts to recover the barrel were unsuccessful. Again efforts to reach basement and deploy the prototype Navi-drill coring system were thwarted.

Because the hole was reasonably stable while drilling, we decided to pull above the zone that had caused sticking problems at the bottom (approximately 23 m) and then log through the pipe. Only one suite of tools could be run and we anticipated that this would take approximately 12 hours. While pulling up to the logging point and rigging the sheaves, the pipe became stuck above the drilling jars. After fifteen minutes of working the pipe and circulating, the drill string was freed, but it was deemed unwise to attempt through-the-pipe logging under those circumstances. The logging tools were rigged down, the hole filled with weighted mud and the pipe was tripped out of the hole. At 2115 hours the bit cleared the rotary table. The bit was missing one cone, and the others were severely damaged with most inserts either broken or missing. The XCB wash barrel was in place, but the cutting shoe was flared making retrieval impossible. After using a torch to cut off the damaged XCB shoe, the barrel was retrieved. The barrel was laid aside so that the vessel could get under way for the next site. At 0745 hours the vessel was under way for Site 702 (SA6). A pass over the beacon was made to supplement the poor geophysical records obtained upon arrival on site during rough weather. Four hours were required to remove the core liner from the damaged core barrel. A large chunk of basalt was found wedged inside the core liner indicating that the hole had indeed bottomed on basement or on a volcanic sill overlying basement.

SITE 702 OPERATIONS SUMMARY

We dropped the beacon for Site 702 (SA6) at 0200 hours on 13 April 1987, retrieved the gear and by 0355 hours the vessel was operating in dynamic positioning mode.

The major objectives of coring at this site were to core basement and to test the Navi-drill (NCB2) coring system. Both of these goals had been elusive throughout the cruise and it appeared that the only chance of reaching basement and/or finding a shallow formation hard enough to allow an NCB2 test would be at this site. We intended to drill one hole at this site using the APC and XCB coring systems down to hard rock or basement then drilling with the Navi-drill.

Hole 702A was spudded at 1110 hours, 13 April 1987. The formation was extremely firm near the surface so operations progressed slowly and tenderly for fear of breaking off a BHA. The fourth piston core required 25,000 pounds to pull free of the formation, which is unusually high for this depth of penetration. Incredibly, the fifth core barrel required 125,000 pounds to pull out of the sediment, an increase of 100,000 pounds over the previous core. The pin thread failed on the 12 1/4 inch inner barrel sub, leaving the core barrel stuck in the formation. Altogether only four APC cores were taken with a 100.3% recovery. The bit was pulled clear of the seafloor at 1545 hours on 13 April, ending Hole 702A.

After offsetting 10 m to the east, Hole 702B was spudded at 1616 hours on 13 April. The APC coring depth for this hole was staggered by 2 m to overlap the cores taken from Hole 702A. This time only three APC cores were taken before switching to the XCB coring system. The next eight cores were cut with caution because we needed to penetrate approximately 90 m before all of the drill collars were buried below the mudline. Coring continued remarkably well for the next 200 m. Exceptionally good weather and sea state contributed to efficient, trouble-free handling of the XCB system. Cores were recovered at a rate of every 40-50 minutes for the first 200 m, which is exceptional for this water depth (3100 m). The advantages of the XCB coring system in chalk formations also was demonstrated with excellent recovery of 89.5%.

The lower 100 m of the section proved difficult to recover. We encountered numerous chert layers 7-14 cm thick. Sometimes several chert layers were recovered in one core. Penetration rates slowed, then increased again as each layer was penetrated. Recovery in this part of the formation dropped to 26%. The use of diamond cutting shoes did little to improve recovery, but they were able to cut through some of the chert layers and recover them where the other shoes would not.

While cutting Core 114-704C-32X, the penetration rate stalled with literally no advancement for 10 minutes. The decision was made to rig down the XCB tools and try the NCB2 system at last. At 0330 hours on 15 April, 1987 the NCB2 was run in the hole for its first coring attempt. After two unsuccessful runs with the core barrel jamming downhole and pump pressures significantly below normal, the test was abandoned. The hole was filled with weighted mud and the drill pipe was tripped out of the hole. At 2300 hours, 15 April, the bit cleared the rotary table, the rig floor was secured and the ship got under way for Site 703.

SITE 703 OPERATIONS SUMMARY

Heavy seas and strong winds which hampered the survey of Site 703 (target Site SA-8) also prevented an expeditious return to the beacon. Nevertheless, within 3 hours the vessel was operating in dynamic positioning mode. Because the NCB2 coring system was to be deployed again at this site, the landing/saver sub and head-sub with a double window latch sleeve were replaced with those ready in the core tech shop. Replacement core barrels made up during the transit were checked for proper spacing. Prior to running pipe, a Navi-drill flow test was conducted at the rig floor. As a result of the test a bearing sub on the mud motor was found to be oversized, causing the tool to jam and preventing the seals from seating properly. The sub was ground down and the test continued. The main OCB assembly was held above the rotary table, and tension was held on the sandline to prevent scoping of the NCB2. Circulation through the motor initiated rotation of the diamond NCB2 core bit and the tool appeared to be functioning properly. The test was rigged down, the top drive set back and the pipe was run in the hole.

At 1955 hours on 21 April, Hole 703A was spudded in 1806.6 m of water. APC coring continued until the #2 (short) sandline broke at the rope socket while retrieving Core 114-703A-9H. APC coring resumed until 0530 hours when the weather forced coring operations to cease. The pipe was pulled several stands off the bottom and a stand of wear-knotted drill pipe was picked up and placed in the guidehorn. We spent 12.5 hours waiting on weather while the seas built, the winds gusted to 63 kt and the vessel rolled 10^{o}-15^{o}. By now all aboard were quite accustomed to these "little blows" and scant attention was given to the storm until a large wave broke over the bow. Caught somewhat unaware the mate and DP operators instinctively ducked while the wooden ice observer's shack, secured forward on the bridge deck, was completely demolished. By 1830 hours on 22 April the weather was still not good but had improved enough so that it was safe for operations to resume. APC coring was halted after Core 114-703A-15H arrived on deck with the core barrel bent and sanded up. Heavy circulation eventually freed the barrel and XCB operations were initiated at that point. Continuous XCB coring took place with 15 bbl mud pills being spotted every third core to aid in maintaining good hole condition. The multiple chert and sand layers were worrisome, but they seemed to affect core recovery more than hole stability. Recovery was affected tremendously by a very soft foraminifer ooze that was extremely water sensitive. All known coring techniques were tried. Circulation rates, weight on bit and RPM were all varied in an attempt to improve recovery, but without success. We even tried laying down the core barrel immediately upon arrival rather than placing it in the handling shuck. This seemed to help in some instances where the heavy surging in the moon pool area was removing what little core was recovered. There was a reluctance to return to the APC system because of the previously encountered numerous chert and sand layers and because the risk was judged to be too high. Operations continued until the overshot 2-lug quick release disengaged while cutting Core 114-703A-40X. An unsuccessful fishing attempt was made with a standard Bowen spear and grapple. It was determined that the nut terminating the spear had to be reduced in length because of the shallow depth of the Q/R bore. While modifying the spear the pipe became stuck and the bit plugged. One half hour later the pipe was freed, the bit unplugged and the second fishing attempt was made. This time the barrel, containing approximately 1.5 m of basalt core, was recovered without incident. The hole was swept with a mud pill and one final XCB core was cut (with nil recovery) while readying the NCB2 for deployment.

Several modifications were made to the NCB prior to this site. The tool was equipped with a solid landing shoulder to allow free-falling the tool downhole. The o-ring spring pack was replaced with a solid metal spacer. No latching system was used. The main XCB bit was set on bottom prior to landing so that no tensile load was transmitted through the male spline. The tool was dressed with new shipboard fabricated, non-jamming, steel torque segments. Upon landing the standpipe pressures were normal. Coring pressures were abnormally low and no pressure spike (indicating full stroke) was evident after coring for approximately 30 minutes. The tool was retrieved without any problem and the barrel was not stuck as on earlier runs. Inspection of the landing shoulder and torque segments indicated that the barrel had landed and latched properly. The diamond bit was somewhat damaged, most likely due to impacting the actuation balls in the lockable float valve assembly. There was no evidence to indicate that any rotation of the bit had taken place and it was believed that the mudmotor had stalled out resulting in no rotation. Since there was no additional NCB penetration, the hole depth remained at 2184.0 mbsl (377.4 mbsf).

The top drive was set back and the drill pipe was pulled to a logging depth of 1910 mbsl (103.4 mbsf). The suite of logging tools to be deployed was one which did not accommodate the actuation bull plug for the LFV assembly so an expendable actuation go-devil was deployed at 60 SPM. There was no indication that the flapper was locked open so an XCB core barrel was deployed to ensure that the go-devil had indeed gone through the LFV. As was feared might happen, the expendable go-devil was recovered with the XCB core catcher engaging the pulling neck. The logging suite was changed to one with an actuating bull nose. Logging with the DIT-D, BHC, MCD, and SGT tools was conducted to 2121 mbsl (314.4 mbsf). Upon reaching the BHA with the logging tools an overpull was experienced and the tools would not enter the drill string. Indications were that the lockable flapper had not locked open and was preventing the tools from being retrieved any further. Eventually the tools were recovered by pumping the flapper open with 40 strokes/minute while simultaneously retrieving the logging cable. This was done with great care so as not to cause the cable head weak point to fail and result in tool loss. Once the tools were started into the BHA, pumping was ceased and the tools were brought to the surface. After rigging down the logging sheaves, the hole was displaced with heavy mud and the drill string was POOH. The pipe cleared the seafloor at 0320 hours on 25 April and the bit cleared the rotary at 0715 hours the same day, terminating Hole 703A. As suspected, when the LFV assembly was inspected it was found to be sanded up with sand and coarse gravel preventing the mechanism from functioning as designed.

SITE 704 OPERATIONS SUMMARY

The transit from Site 703 to Site 704 (target Site SA-8) was relatively uneventful as the new site was just a few short miles away, going from the upper slope of a seamount to an adjacent plain on Meteor Rise. The location was distinctive and covered a relatively large area and seismic data were acquired under way to tie the two sites together. With Site 703 completed, the deep objectives at Meteor Rise had been met and Site 704 focused on the younger part of the section. All went according to plan as the vessel passed over the location and at 1100 hours on 25 April the beacon was dropped. The vessel continued past the site for another 2 nmi. As the sediments kept dipping westwards the upper part of the section kept increasing in thickness. The co-chiefs requested we continue surveying on the same course to locate maximum thickness. The seismic gear was retrieved after 1.5 hours and it was decided to move the site to a new location where the sedimentary section of interest had doubled in thickness. The vessel returned to the location over the thicker sequence and a new beacon was dropped at 1245 hours, initiating the final site of the leg.

After dropping the second beacon the thruster pods and hydrophones were lowered. Less than one hour later the vessel was operating in dynamic positioning mode, and the rig crew began to pick up the OCB assembly. A non-magnetic drill collar was used because oriented coring was planned for at least one hole. Because the lockable float valve assembly had sanded up on both previous deployments of this leg, a mechanical bit release was run below the OCB assembly.

Again, prior to running in the hole, a Navi-drill deck test was conducted. This test was required to ensure that the mudmotor had not been damaged pumping past the stator with the bearing sub jammed and unable to rotate. The test demonstrated that the coring system was indeed functioning well enough to core through the steel cover plate on the rotary table. Operating pressures were still somewhat below normal but not as significantly as experienced downhole on the earlier deployments. Assured that the tool was performing correctly, we laid down the hardware and picked up the rest of the BHA.

At 0155 hours on 26 April Hole 704A was spudded in 2532.3 m of water. Continuous oriented APC cores were recovered through Core 114-704A-16H when an overpull of 80,000 pounds was recorded. The coring operation was switched to XCB mode after a core recovery of 99% with the APC. Hole 704A was terminated at 2815 mbsl (282.7 mbsf) after five consecutive cores (114-704A-26X to -30X) recovered a total of only 0.44 m of core. This hole has the same lithology type as Hole 703A where similar recovery problems were experienced. The hole was displaced with heavy mud and the pipe pulled out of the hole. At 0645 hours on 27 April the bit cleared the seafloor ending Hole 704A.

After offsetting the vessel 10 m to the east, Hole 704B was spudded at 0810 hours on 27 April. The water depth was determined to be 2530.8 m. Continuous APC coring, this time without orientation, continued until Core 114-704B-15H. Below this we switched to XCB coring, one core shallower than the APC depth in Hole 704A, just to be safe. Recovery was a respectable 98%. The XCB coring system did an admirable job of recovering core as well until Cores 114-704B-19X to -22X. This interval was 50 m above the low recovery zone in the previous hole and a reason for the almost total lack of recovery was not immediately known. Weather conditions had been deteriorating for most of the afternoon. Excessive vessel heave may have been partially responsible for the problem because the formation being cored was still reasonably soft and low bit weights were required. It was apparent that if any recovery was to be had at all in this zone drastic measures would have to be taken. Because the formation appeared to be extremely water soluble a 9 3/4" inner barrel sub was used to extend the XCB cutting shoe farther ahead of the main XCB jets. This was an extremely risky proposition, requiring a close eye on the break out torque of the cutting shoes as well as any significant wear. The drillers were alerted to stop coring and pull a barrel at the first sign of a hard or penetration-resistant layer. This technique worked extremely well and a total recovery of 102.5% was achieved using the long extension sub. The subs were removed periodically to see if the formation could be cored without the extension. In every case recovery dropped dramatically. After Core 114-704B-45X the 9 3/4" sub was replaced with a 4" version that was somewhat safer to use. A close watch was maintained and coring continued. Recovery was not quite as good as with the longer sub, only 80.8%, but still appreciably more than the 62.6% recovery achieved without using any extension sub at all.

Three heat flow measurements were taken on this hole using the Uyeda system spaced out on an extra 15 foot core barrel to help decouple the heave motion of the drill string from the temperature probe. Two of the measurements were successful and one run failed to collect usable data. The last HF measurement was taken at 481.7 mbsf. Upon attempting to recover the tool, we found that it was stuck inside the smooth bore OCB. Apparently an influx of sand caused the tool to become stuck, because after a few minutes of heavy circulation the tool came free and was recovered without any sign of damage. Coring continued with the XCB system until Core 114-704B-68X at 633.7 mbsf. The weather began to deteriorate rapidly at this time. The barometer fell 21 millibars in 6 hours. The seas were building again, something we had learned to put up with most of the leg. This time, however, the storm was projected to be worse than those experienced earlier in the leg and the decision was made to cease coring and pull up closer to the mudline. We had planned a wiper trip for hole conditioning soon anyway, and we positioned the pipe up closer to the seafloor in case conditions got significantly worse. The pipe was pulled to 2684 mbsl (151.7 mbsf) and a stand of wear-knotted drill pipe was picked up placing the bit at 2713 mbsl (180.7 mbsf). Conditions remained bad and 3 hours were spent WOW in a force 10 storm before the second half of the wiper trip was continued. Upon running the pipe to bottom the hole was swept with a mud pill to prepare for another NCB2 coring test. Two runs were made with the NCB2, both unsuccessful. On each occasion the operating pressures were again significantly below normal and on neither occasion was there any indication that rotation had occurred or that the diamond bit contacted the formation. Navi-drill testing was terminated and the remaining available coring time was spent with the XCB system. At 2245 hours on 30 April, Core 114-704B-72X from 3202.5 mbsl (671.7 mbsf) was recovered and coring operations for Leg 114 were terminated. This was an extremely important hole scientifically and time was allotted for three complete logging runs before abandoning the hole. The hole was swept with a high viscosity mud pill and the shifting tool for the mechanical bit release was run. When the moment of truth arrived, the sleeve shifted effortlessly and the bit released without resistance. Back flow was encountered almost immediately indicating the pipe was open-ended.

A total of four logging runs were made before abandoning the hole. The first run made with the DIT-D, SGT, BHC and MCD tools was remarkably successful, reaching to within 4 m of the bottom of the hole. The second run, made using the LDT, CNT-G, NGT and GPIT tools, also reached to within 4 m of bottom and was successful except for a few momentary crashes of the Masscomp computer. This problem led to some serious errors in running the logging cable and led to an overrun of 22 m of cable after the tools had set down. Upon recovering the cable a knot was found approximately 420 m from bottom and led to 520 m of cable having to be cut off. When running the third suite of tools (GST, ACT, CNT-G and NGT) into the hole, a bridge was encountered directly below the open-ended pipe. The tools were recovered and the drill string lowered to bottom periodically, picking up the circulating head during the trip. After reaching bottom a 25 bbl mud pill was circulated. Because of the high probability of the pipe being plugged after the trip we decided to leave the pipe in the hole and log through the pipe for the final suite of logs. This was successfully done and by 0015 hours on 3 May the logging tools were rigged down and the hole was filled with mud. The pipe was pulled clear of the mudline and a final test of the Navi-drill was conducted. The HWD4 core barrel was removed to allow higher flow rates without the risk of extending below the pipe and rotating at high RPM. The intention was to try and determine once and for all why the operating pressures were so much lower than the design and test pressures. The test was unsuccessful. The pressures remained low despite repeated attempts at seating and the use of ultra-high flow rates. The tool was recovered and then run without the mudmotor. This was to verify if the motor itself, due to tight tolerances in the seal bore OCB, was preventing the proper landing and sealing of the external seals. Again the test was inconclusive. The only pressure difference was that lost by not having the pressure drop through the motor. The test was abandoned and the pipe pulled until the top of the BHA was just below the rig floor. Here the abbreviated NCB2 assembly was dropped into the pipe where it remained until recovery with the BHA. When the tools reached the rig floor the NCB was found resting on the proper landing shoulder, seals in place and torque segments latched in. The mystery of downhole pressure loss remained unsolved. After disassembly of the tool evidence was found indicating that the profile seals on the hex male spline had rotated out of position. This was responsible for at least some of the pressure loss but just how much is still to be determined. The bit cleared the rotary table at 1015 hours on 3 May, the rigfloor was secured and the vessel was under way at 1100 hours.

Because the seismic records upon arrival at Site 703 were poor due to rough following seas, a 7-hour post-site survey was conducted prior to setting a course for Mauritius. At 1800 hours, the evening of 3 May 1987, the vessel finally took a heading towards Mauritius.

OCEAN DRILLING PROGRAM
OPERATIONS RESUME
LEG 114

TOTAL DAYS: (March 14, 1987 - May 13, 1987)[1]	64.00
TOTAL DAYS IN PORT:	4.12
TOTAL DAYS UNDERWAY: (Including site survey time)	20.82
TOTAL DAYS ON-SITE:	39.06

TRIP TIME:	7.83
CORING TIME:	21.92
DRILLING TIME:	0.02
LOGGING/DOWNHOLE SCIENCE TIME:	3.52
REENTRY TIME:	0.00
MECHANICAL REPAIR TIME: (CONTRACTOR)	0.06
STUCK PIPE/HOLE TROUBLE:	0.03
WAITING ON WEATHER (W.O.W.) TIME:	1.48
OTHER: MUD DISPLACEMENT, NCB2 TESTING, ETC.	4.20

TOTAL DISTANCE TRAVELED: (Nautical Miles)	5916
AVERAGE SPEED: (Knots)	11.7
NUMBER OF SITES:	7
NUMBER OF HOLES:	12
NUMBER OF CORES:	391
TOTAL INTERVAL CORED: (Meters)	3602.0
TOTAL CORE RECOVERY: (Meters)	2300.4
PERCENT CORE RECOVERED:	63.9
TOTAL INTERVAL DRILLED: (Meters)	89.0
TOTAL PENETRATION: (Meters)	3691.0
MAXIMUM PENETRATION: (Meters)	671.7
MINIMUM PENETRATION: (Meters)	19.1
MAXIMUM WATER DEPTH: (Meters from drilling datum)	4647.2
MINIMUM WATER DEPTH: (Meters from drilling datum)	1806.6

1. Clock advanced a total of 7.0 hours during the Leg.

OCEAN DRILLING PROGRAM
SITE SUMMARY
LEG 114

HOLE	LATITUDE	LONGITUDE	WATER DEPTH METERS	NUMBER OF CORES	METERS CORED	METERS RECOVERED	PERCENT RECOVERED	METERS DRILLED	METERS TOTAL PENET.	DAYS ON HOLE
698A	51°27.51' S	33°05.96' W	2128.0	27	237.0	52.30	22.1	-	237.0	2.35
	SITE 698 TOTALS			27	237.0	52.30	22.1	-	237.0	2.35
699A	51°32.537' S	30°40.619'W	3716.0	56	518.1	356.52	68.6	-	518.1	6.39
	SITE 699 TOTALS			56	518.1	356.52	68.6	-	518.1	6.39
700A	51°31.992'S	30°16.697'W	3630.6	2	9.6	0.19	2.0	9.5	19.1	0.98
700B	51°31.977'S	30°16.688'W	3611.5	54	489.0	245.40	50.2	-	489.0	6.58
	SITE 700 TOTALS			56	498.6	245.59	49.3	9.5	508.1	7.56
701A	51°59.076'S	23°12.736'W	4647.2	8	74.8	69.66	93.1	-	74.8	1.74
701B	51°59.077'S	23°12.735'W	4647.2	14	133.0	96.36	72.5	70.0	203.0	1.80
701C	51°59.085'S	23°12.700'W	4647.2	51	481.3	331.06	68.8	-	481.3	4.24
	SITE 701 TOTALS			73	689.1	497.08	72.1	70.0	759.1	7.78
702A	50°56.786'S	26°22.127'W	3093.9	4	33.1	34.21	103.4	9.5	42.6	0.57
702B	50°56.786'S	26°22.117'W	3094.2	32	294.3	195.10	66.3	-	294.3	2.30
	SITE 702 TOTALS			36	327.4	229.31	70.0	9.5	336.9	2.87
703A	47°03.042'S	7°53.679'E	1806.6	41	377.4	192.29	51.0	-	377.4	4.21
	SITE 703 TOTALS			41	377.4	192.29	51.0	-	377.4	4.21
704A	46°52.757'S	7°25.250'E	2532.3	30	282.7	224.55	79.4	-	282.7	1.75
704B	46°52.758'S	7°25.231'E	2530.8	72	671.7	502.75	74.8	-	671.7	6.15
	SITE 704 TOTALS			102	954.4	727.30	76.2	-	954.4	7.90
			LEG TOTALS	391	3602.0	2300.39	63.9	89.0	3691.0	39.06

OCEAN DRILLING PROGRAM
BEACON SUMMARY
LEG 114

SITE	MAKE	MODEL	FREQ KHZ	SERIAL NUMBER	HOURS SITE TIME	DEPTH METERS	REMARKS
698	DATASONICS	352DC	16.5	226	56.4	2138.0	STRONG PULSE-GOOD BEACON
699	DATASONICS	351DC	16.5	304	153.3	3716.0	STRONG PULSE-GOOD BEACON
---	DATASONICS	351DC	14.5	287	0.0	----	FAILED ON-DECK AFTER 20 HRS
700	DATASONICS	351DC	14.5	302	181.5	3611.5	STRONG PULSE-GOOD BEACON
701	DATASONICS	351DC	16.5	341	62.8	4647.2	SIGNAL DEGRADED-TOO WEAK
701	DATASONICS	351DC	14.5	338	124.3	4647.2	STRONG PULSE-GOOD BEACON
702	DATASONICS	351DC	16.5	303	69.0	3094.2	STRONG PULSE-GOOD BEACON
703	DATASONICS	352DC	14.5	236	101.0	1806.6	STRONG PULSE-GOOD BEACON
704	DATASONICS	352DC	14.5	340	----	----	CORED AT ALTERNATE SITE
704	DATASONICS	352DC	15.5	237	189.5	2530.8	STRONG PULSE-GOOD BEACON

OCEAN DRILLING PROGRAM
BIT SUMMARY
LEG 114

HOLE	MFG	SIZE	TYPE	SERIAL NUMBER	METERS CORED	METERS DRILLED	TOTAL PENET	CUMULATIVE METERS	HOURS THIS HOLE	TOTAL HOURS	CONDITION	REMARKS
698A	MSDS	9 7/8	F94CK	S-59	237.0	----	237.0	237.0	13.0	13.0	T1-B1-I	WEAR PADS BADLY WORN
699A	SEC	11 7/16	KV37	469676	518.1	----	518.1	518.1	12.0	12.0	T1-B1-I	RE-RUNABLE
700A	MSDS	9 7/8	F94CK	S-59	9.6	9.5	19.1	256.1	0.0	13.0	UNGRADED	RELEASED DOWNHOLE
700B	RBI	9 7/8	C-3	AT 124	489.0	----	489.0	489.0	26.0	26.0	UNGRADED	RELEASED DOWNHOLE
701A	SEC	11 7/16	KV37	469676	74.8	----	74.8	592.9	0.5	12.5	T1-B1-I	RE-RUNABLE
701B	SEC	11 7/16	KV37	469676	133.0	----	203.0	795.9	1.5	14.0	UNGRADED	ONLY CLEARED ML
701C	SEC	11 7/16	KV37	469676	481.3	----	481.3	1277.2	5.0	19.0	T7-B8-0	ONE CONE MISSING
702A	RBI	10 1/2	C-37	AV 716	33.1	9.5	42.6	42.6	0.2	0.2	UNGRADED	ONLY CLEARED ML
702B	RBI	10 1/2	C-37	AV 716	294.3	----	294.3	336.9	6.1	6.3	T2-B4-I	RETURNED F/TFAC
703A	SEC	11 7/16	M84F	469666	377.4	----	377.4	377.4	5.0	5.0	T1-B2-1/8	RE-RUNABLE
704A	RBI	11 7/16	C-3	GREENY	282.7	----	282.7	1154.7	2.0	17.0	UNGRADED	ONLY CLEARED ML
704B	RBI	11 7/16	C-3	GREENY	671.7	----	671.7	1826.4	9.5	26.5	UNGRADED	RELEASED DOWNHOLE

OCEAN DRILLING PROGRAM
LOGGING SUMMARY
LEG 114

HOLE	TOTAL DEPTH (M)	WATER DEPTH (M)	OPEN ENDED PIPE AT	FLUID IN HOLE	BIT SIZE	TOTAL TIME F/LOGGING (HOURS)	RUN NO.	LOGS RECORDED	FROM (M)	TO (M)	REMARKS
700B	4100.5	3611.5	3750.0	SEA WATER	9 7/8	7.25	1	-0-	----	----	NOTE 1
	4100.5	3611.5	3750.0	SEA WATER	9 7/8	10.50	2	DIT-E, SDT, MCD, NGT	4061.5	3750.0	NOTE 2
	4100.5	3611.5	3750.0	SEA WATER	9 7/8	9.75	3	GST, ACT, NGT	4028.5	3750.0	----
				TOTAL HOURS		27.50					
703A	2184.0	1806.6	1910.0	SEA WATER	11 7/16	10.80	1	DIT-D, BHC, MCD, SGT	2121.0	1880.0	NOTE 3
704B	3202.5	2530.8	2656.0	SEA WATER	11 7/16	8.50	1	DIT-D, SGT, BHC, MCD	3188.0	2656.0	NOTE 3
	3202.5	2530.8	2656.0	SEA WATER	11 7/16	12.00	2	LDT, CNT-G, NGT, GPIT, CCC-B	3194.0	2682.0	NOTE 3
	3202.5	2530.8	2656.0	SEA WATER	11 7/16	7.00	3	GST, ACT, CNT-G, NGT, CCC-B	------	------	NOTE 3,4
	3202.5	2530.8	3177.0	SEA WATER	11 7/16	13.50	4	GST, ACT, CNT-G, NGT, CCC-B	3171.0	2530.8	NOTE 3,5
				TOTAL HOURS		41.00					

NOTE 1: POOH BEFORE REACHING THE BIT DUE TO PROBLEMS WITH THE AMS TOOL

NOTE 2: SDT TOOL FAILED NEAR THE BOTTOM OF THE DP. NO WAVE FORMS RECORDED.

NOTE 3: SEA STATE CONDITIONS EXCEEDED THE WIRELINE HEAVE COMPENSATOR OPERATING CRITERIA - HAD TO BE LOCKED OUT

NOTE 4: TOOLS COULD NOT GET BEYOND 2686 METERS. TRIP TO CONDITION HOLE.

NOTE 5: LOGGED THROUGH THE PIPE.

LEGEND

DIT-E DUAL INDUCTION - MODEL E
DIT-D DUAL INDUCTION - MODEL D
SDT DIGITAL SONIC TOOL
MCD CALIPER
NGT NATURAL GAMMA RAY
GST GAMMA RAY SPECTROMETRY
SGT GAMMA RAY

LDT LITHO-DENSITY TOOL
GPIT GENERAL PURPOSE INCLINOMETRY TOOL
CNT-G NEUTRON POROSITY TOOL - MODEL G
CCC-B TELEMETRY CARTRIDGE (C & L)
BHC SONIC TOOL
ACT ALUMINUM CLAY
AMS AUXILIARY MEASUREMENT SYSTEM

SCHLUMBERGER CABLE HEAD WEAK POINTS AVAILABLE: 1 @ 2900-3300 LBS SHEARING FORCE
2 @ 3900-4500 " " " (USED ON LEG 114)
3 @ 4800-5500 " " "
4 @ 5700-6600 " " "

OCEAN DRILLING PROGRAM
TIME DISTIBUTION (DAYS)
LEG 114

DATE	TRIPS	DRLG	CORING	STUCK PIPE	WOW	DN HOLE MEAS.	MECH. REPAIR	REENTRY	OTHER	TOTAL TIME	REMARKS
IN PORT, EAST COVE FALKLAND ISLANDS											
3/10-3/14/87										4.12	
TRANSIT TO SITE 698											
3/14-3/17/87										2.99	NOTE NR 1
HOLE 698A											
3/17-3/19/87	0.60		1.58				0.06		0.11	2.35	
TRANSIT TO SITE 699											
3/19-3/20/87										0.56	
HOLE 699A											
3/20-3/26/87	0.99		3.90		0.71				0.79	6.39	NOTE NR 2,3
TRANSIT TO SITE 700											
3/26/87										0.16	NOTE NR 2
HOLE 700A											
3/26-3/27/87	0.67		0.23						0.08	0.98	
HOLE 700B											
3/27-4/3/87	1.07		3.59		0.12	1.15			0.65	6.58	
TRANSIT TO SITE 701											
4/3-4/4/87										1.00	
HOLE 701A											
4/4-4/6/87	0.95		0.63						0.16	1.74	
HOLE 701B											
4/6-4/8/87	0.41	0.02	1.31						0.06	1.80	
HOLE 701C											
4/8-4/12/87	0.52		3.52	0.01					0.19	4.24	
TRANSIT TO SITE 702											
4/12-4/13/87										0.78	
HOLE 702A											
4/13/87	0.27		0.18						0.12	0.57	
HOLE 702B											
4/13-4/15/87	0.37		1.41						0.52	2.30	NOTE NR 3
TRANSIT TO SITE 703											
4/15-4/21/87										5.06	NOTE NR 1
HOLE 703A											
4/21-4/25/87	0.80		1.74	0.02	0.52	0.45			0.68	4.21	NOTE NR 3
TRANSIT TO SITE 704											
5/3-5/13/87										0.24	
HOLE 704A											
4/25-4/27/87	0.39		1.14						0.22	1.75	NOTE NR 3
HOLE 704B											
4/27-5/3/87	0.79		2.69		0.13	1.92			0.62	6.15	NOTE NR 3
TRANSIT TO MAURITIUS											
5/3-5/13/87										10.03	NOTE NR 1
LEG TOTALS	7.83	0.02	21.92	0.03	1.48	3.52	0.06	0.00	4.20	64.00	

NOTE NR 1: CLOCKS ADVANCED DURING TRANSIT (1/2 HOUR EACH ON 3/16, 3/17, 4/16, 4/17, 4/18, 4/19, 5/4, 5/6 5/8, 5/9, 5/11, 5/12 AND 1 FULL HOUR ON 5/5)

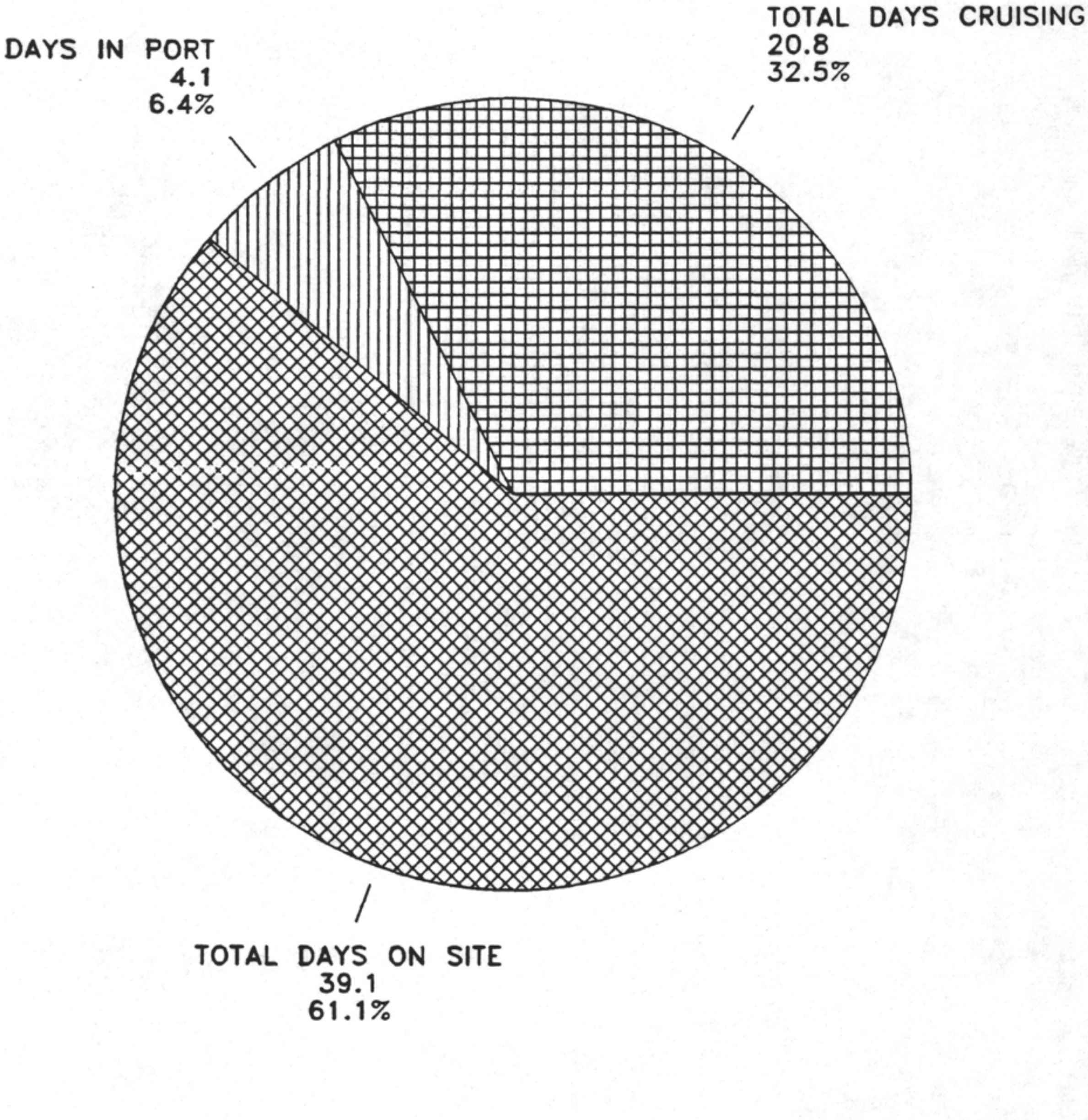
NOTE NR 2: ACTUAL DEPARTURE FROM THIS SITE WAS DELAYED 4.5 HOURS AFTER THE BIT CLEARED THE ROTARY TABLE DUE TO AT SEA REFUELING. THIS WAS RECORDED AS ON SITE TIME RATHER THAN TRANSIT TIME.

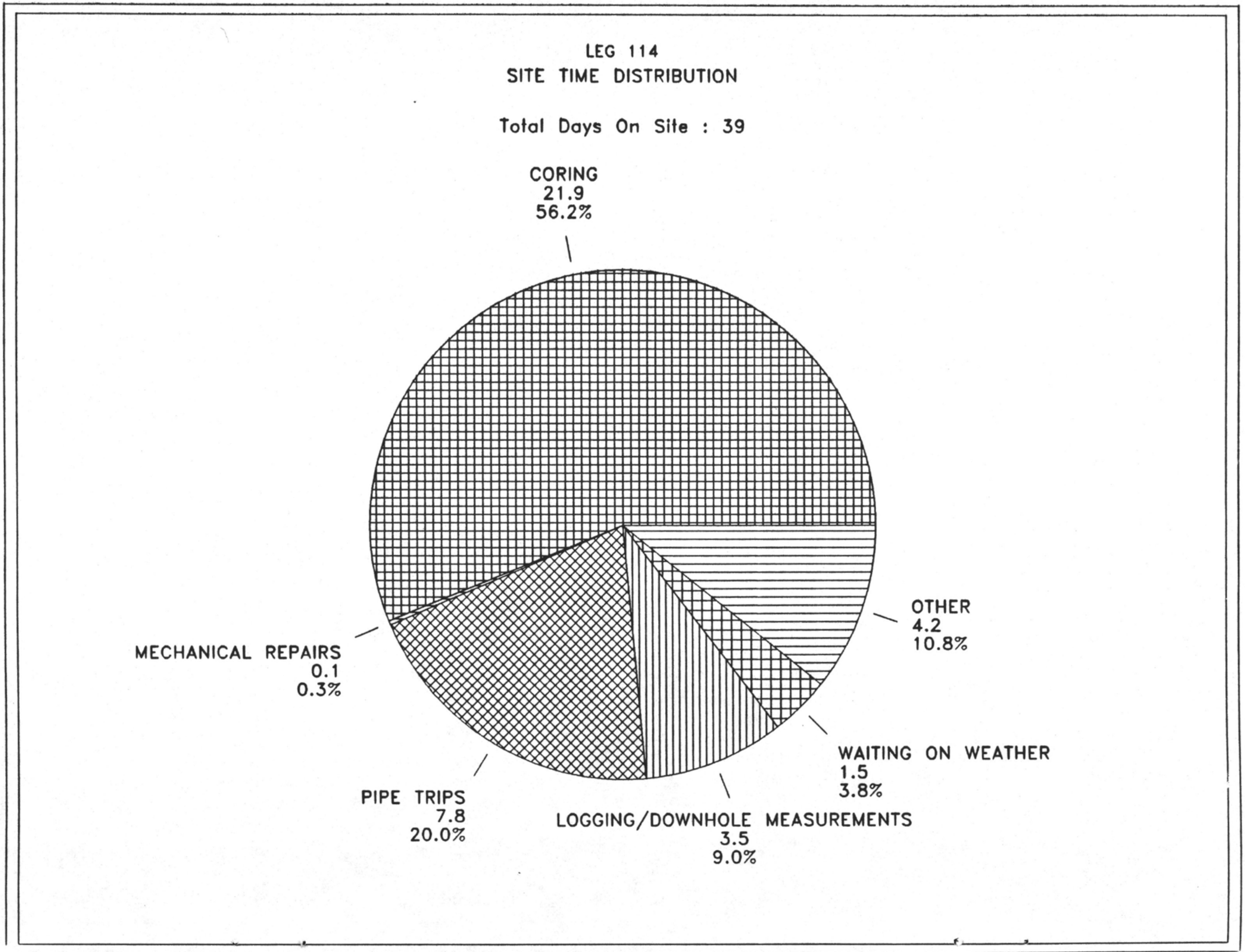
NOTE NR 3: NAVI-DRILL TESTING RECORDED UNDER 'OTHER'.

LEG 114

LEG TIME DISTRIBUTION

Total Days : 64




LEG 114
SITE TIME DISTRIBUTION
Total Days On Site : 39
CORING
21.9
56.2%
OTHER
4.2
10.8%
MECHANICAL REPAIRS
0.1
0.3%
WAITING ON WEATHER
1.5
3.8%
PIPE TRIPS
7.8
20.0%
LOGGING/DOWNHOLE MEASUREMENTS
3.5
9.0%

TECHNICAL REPORT

The ODP Technical and Logistics personnel aboard JOIDES Resolution for Leg 114 of the Ocean Drilling Program were:

Laboratory Officer:	Ted Gustafson
Computer System Manager:	John Eastlund
Curatorial Representative:	Dan Quoidbach
Yeoperson:	Michiko Hitchcox
Electronics Technician:	Mike Reitmeyer
Electronics Technician:	Berry Weber
Photographer:	Chris Galida
Chemistry Technician:	Matt Mefferd
Chemistry Technician:	Joe Powers
X-ray Technician:	Christian Segade
Marine Technician:	Jenny Glasser
Marine Technician:	Skip Hutton
Marine Technician:	Kazushi Kuroki
Marine Technician:	Mark Neschleba
Marine Technician:	Jeff Payne
Marine Technician:	Kevin Rogers
Marine Technician:	Don Sims
Weather Observer:	Ferrell Johnson

INTRODUCTION

Leg 114 began 12 March 1987 at East Cove Military Dock facility on East Falkland Islands and ended 64 days later in Port Louis, Mauritius on 14 May 1987. Twelve holes were drilled at seven site locations. Over 2300 meters of core was recovered from which more than 15,000 samples were taken for shipboard and shorebased analyses. Three holes were logged and APC cores from two holes were oriented.

FALKLANDS PORT CALL

Due to the shortage of commercial flights to the Falklands all ODP, SEDCO and scientific personnel along with incoming and outgoing freight were flown via a commercial charter flight originating and terminating in Houston, Texas. Transportation for personnel as well as freight handling was handled by the British Military.

Because of the relatively quick charter flight turnaround, minimal time was available for technician crossovers. The offgoing Lab Officer remained after the charter flight left, to answer questions that were not addressed during technician crossovers. For the oncoming technician group the port call was 2-1/2 days long, during which most efforts were directed towards the handling and stowage of freight and supplies.

Following repairs in the USA, the shipboard cryogenic magnetometer was forwarded to the UK with a technician escort and flown to the Falklands on an R.A.F. flight. Prior to sailing, the cryogenic magnetometer was installed and filled with liquid helium.

Repairs were made to the bridge GPS navigator, and a disc drive was installed in the computer facility.

CRUISE ACTIVITIES

Geophysical data were collected during site approaches and departures. No geophysical data were collected within 200 nautical miles of the Falkland Islands or South Georgia Island. Adverse sea conditions affected PDR and seismic data collection during transits at higher speeds. Magnetometer data were collected during most transits at high speed without difficulty. Several tests with our towed hydrophone arrays were conducted. We were able to collect 3.5-kHz signals using the port array in heavy following seas at 12 knots. Signals received were mostly of a bottom trace. At slower speeds where penetration is evident, resolution is poor compared with the hull-mounted 3.5-kHz transducer array. A double length active section array was tested and seismic signals were comparable to our good array. A high-speed array from L-DGO was tested.

OPERATIONS

Leg 114 exceeded everyone's expectations for success. Sufficient operating time was gained in various areas to permit drilling sites of secondary priority. The ship departed East Cove earlier than planned, and wind and currents worked in our favor, enabling us to make greater than expected speed during transits. Down time due to weather was reduced because of good ship stability, power management and station-keeping abilities during adverse conditions. Wireline time was greatly reduced by chasing the core barrel with the overshot, a technique developed during Leg 112. It was also possible to refuel Resolution while on site during a break in the weather. Both the fuel tanker Sunny Trader and Maersk Master went to South Georgia Island to transfer fuel to Master who twice transferred to Resolution.

Weather observations and predictions were made on a regular basis.

On two occasions heavy seas caused water to leak into the lab stack stairwell at the main deck level where the lab stack is flanged to the old main deck. Water also seeped into the Photo Lab from a main deck H.U.A.C. duct penetration. Salt water from a leaking escape hatch cover on the main deck caused some damage to entertainment equipment in the gym. This problem has been satisfactorily addressed.

APC cores from two sites were oriented using the multishot tool. Two successful downhole heat flow measurements were made at the last hole.

LABORATORY ACTIVITIES

Over 2300 meters of core were recovered, from which more than 15,000 samples were taken for shipboard and shorebased analysis. Laboratory operations were routine throughout the leg. A marine technician was assigned to assist in the paleontology laboratory in addition to regular duties in the core lab. Sufficient time was available during the leg to complete some non-routine tasks and effect technician cross training in several laboratories.

Bridge Deck

The cryogenic magnetometer was installed and set up during the Falklands port call. A blockage of the vent line was discovered two weeks following installation. The blockage was bypassed and venting now is accomplished via an access point in the fill line.

Foc'sle Deck

In addition to routine pore water sampling and analysis in the chemistry lab, fluoride determinations were made using an ion specific electrode brought aboard for that purpose. Silica determinations were made using the spectrophotometer. Carbonate determinations were made on most samples taken for physical properties analyses. Total carbon analyses were run on one sample per core; sample density was increased in areas showing evidence of increased organic carbon. As expected, gas values were low; head-space samples were taken routinely. Attempts to analyze for potassium using the Dionex were unsuccessful. The spectrophotometer was used extensively until problems developed at the last site. Spares and a comprehensive service manual were ordered.

The thin section lab was moderately active throughout this leg with no major equipment problems.

Scanning Electron Microscope spares ordered by Leg 113 were unavailable for use this leg, and the unit was inoperable for Leg 114.

The XRD was used extensively for three weeks until difficulties indicated CPU and communication board problems. Spares were ordered. Following this was a problem with detectors. Replacement detectors were ordered and along with computer boards are scheduled for installation during the Mauritius port call.

XRF samples were run for major elements. Special samples were run for the logging scientists as a cross check of the percentages of various elements logged.

Other Areas

The Vax computer system withstood the rough seas and motion with no serious problems. The replacement disc drive installed in the Falklands worked well. System usage was high. Disc space appears to be approaching capacity; additional C.P.U. capacity will be considered. ETHERNET is proving to be a valuable time saver for the automatic transfer of data to the Vax from the Physical Properties work stations. The potential need in other areas (such as the magnetics lab) for ETHERNET capabilities is becoming apparent.

The task of automating the operation of the auxiliary air handler system in the computer rooms was completed by SEDCO engineers. The system is now fully operational.

Photo lab work was routine. Specialty work was accomplished as needed. In line water pressure regulators and a digital electronic water temperature control valve were installed.

ODP blast messages were sent by way of the SEDCO IBM-PC instead of the shipboard VAX computer. This cut down on the system manager's work load and functioned smoothly throughout the leg.

Storage areas were reorganized to make room for increased volumes of incoming supplies. Physical counts were made of selected items in the storage areas. An additional storekeeper responsibility was initiated this leg. It involves conducting a partial physical inventory of capital equipment and will be an on-going job each leg.

The Marine Emergency Technical Squad (M.E.T.S.) continued training with the SEDCO emergency squad on a regular weekly basis. The shipboard emergency manual was updated to include the International Maritime Organization Code classification for hazardous goods stored throughout ODP spaces. Emergency procedures for the computer facility were addressed as well as provisions for the retention of Halon within the computer facility. Removable door louvre covers have been installed and special door seals were ordered.

Personnel

Morale and work relationships among ship and scientific crews remained high throughout the leg even under the most adverse weather conditions. HAM radio patches helped to keep spirits high. The entire team is to be complimented on their professionalism.

WEATHERMAN'S REPORT

The weather for Leg 114 was about as expected for the season and location. The conditions at the drillsites and transits between sites are as follows:

WINDS

10 knots or less.................06%
11-21 knots......................22%
22-33 knots......................47%
34-40 knots......................14%
41-47 knots......................07%
48-55 knots......................04%
56-63 knots...........less than 01%
64 or greater.........less than 01%

Number of days that strong gale (force 9 or greater) winds occurred:

41-47 knots..................29 days
48-55 knots..................23 days
56-63 knots..................14 days
64 knots or greater.........7 days

Maximum winds were 86 knots on 4/19/87 and 71 knots on 4/24/87

SEAS/SWELL

Percentage of days the combined seas were:

less than 8 feet.............18%
8-12 feet....................22%
12-15 feet...................20%
15-18 feet...................12%
18-22 feet...................12%
22-30 feet...................10%
30 feet or greater...........06%

Largest combined seas/swell were 40-50 feet on 4/19/86

FOG Occurred on 24 days

RAIN/SNOW/SLEET Fell on 38 days

TEMPERATURE A low of 36°F at the southernmost site and a high of 50°F at the northernmost/last site

PRESSURE Ranged from 1022 millibars to 960 millibars

Maximum pressure changes:

6 hours......fell 21 millibars
12 hours.....fell 32 millibars
24 hours.....fell 41 millibars

With very few exceptions, the storm systems passed well to the north or south of the drill sites. Therefore, we had few abrupt wind directional changes. The vast majority of the storms were accompanied with gradual and predictable wind shifts.

The strongest storm occurred during a transit between sites; otherwise, we would have probably been blown off station. The gradual wind directional shifts and persistent wind directions allowed the ship to remain on station with apparent ease...even in 50-knot winds and 25-30 feet seas.