1. INTRODUCTION

Peter F. Barker, Department of Geology, University of Birmingham, Birmingham, England,
Ian W. D. Dalziel, Lamont-Doherty Geological Observatory of Columbia University,
Palisades, New York,
and
Sherwood W. Wise, Jr., Antarctic Marine Geology Research Facility,
Department of Geology, Florida State University, Tallahassee, Florida

INTRODUCTION

Leg 36 started in Ushuaia, Argentina, on 4 April, 1974 and finished in Rio de Janeiro, Brazil on 22 May, 1974. It completed the second of three austral summer seasons of drilling planned for Antarctic waters during Phase III of the Deep Sea Drilling Project. In fact, Leg 36 brought the Antarctic drilling program of Phase III to an end, because the plan to drill south of Africa during the austral summer of 1974-75 had to be abandoned for want of a suitable escort vessel.

DSDP IN ANTARCTIC WATERS

As a result of the enthusiastic response of the scientific community to the initial proposal for *Glomar Challenger* to operate in Antarctic waters (Ewing and Hayes, 1970), a drilling program of at least five 56-day cruises in high southern latitudes was planned for three austral summers: 1972-73, 1973-74, and 1974-75. In order to best complement the existing marine geophysical survey data, the first Antarctic drilling season was planned to concentrate on problems in the southeast Indian and southwest Pacific oceans, and the second to drill holes in the southeastern Pacific including the Bellingshausen Basin, and in the Scotia and Weddell seas. Scientific sites for these two seasons were selected by the Antarctic Advisory Panel late in 1971 (Hayes and Edgar, 1972, fig. 1). However, plans for the third season in the southeastern Atlantic Ocean and the southwestern Indian Ocean were more tentative due to the paucity of marine survey data in those waters.

The program for the 1972-73 season was highly successful. Eleven sites were drilled on Leg 28 from Fremantle, Australia, to Christchurch, New Zealand, including eight sites south of 60°S latitude; 10 sites were drilled in the course of Leg 29 from Christchurch, New Zealand to Wellington, New Zealand (Figure 1). It was reasonably considered at the end of this season that with careful planning and preparation, not to mention a certain amount of luck with the weather, Antarctic drilling from *Glomar Challenger* was perfectly feasible. The experiences of Legs 35 and 36 bore out this conclusion, but in a less happy manner. Equipment failures on immediately preceding legs and the conflicting priorities of long-term Project planning imposed a late start of the Antarctic drilling, shortened the legs and established starting and finishing ports only just in the southern hemisphere. Leg 35 started at Valparaiso on 13 February and Leg 36 ended in Rio de Janeiro on 22 May 1974. The much worse weather prevailing at this time, combined with the longer nights, resulted in only 10 sites being drilled. Of these only 8, 4 on each leg, produced scientifically significant results. Even worse, perhaps, weather, darkness, and ice combined to ensure that Leg 36 drilled no sites successfully south of 51°S, despite its stated primary objective of studying the evolution of the Scotia Arc. Because of the great importance of the Southern Ocean for global tectonics, paleooceanography and biostratigraphy, it is to be hoped that an opportunity will be sought at a later stage during Phase 1 of IPOD, of reinstating these amputated legs.

LEG 36—BACKGROUND AND ORIGINAL OBJECTIVES

The two main objectives of the leg as originally conceived by the Antarctic Advisory Panel were to investigate the geologic histories of the Scotia Arc and of the Argentine Basin. The Scotia Sea area is a distinctive part of the Antarctic margin, and as such has important bearings on the geologic history of the continent and its surroundings. However, the region has geologic significance far beyond its own boundaries. Problems that can be addressed through a drilling program in the Scotia Sea area, in addition to the tectonic evolution of the Scotia Arc itself, include: (a) The nature of the upper part of the arc-trench gap in a very young and relatively simple island arc; (b) Tectonics, sedimentation and lava geochemistry in a back-arc basin of known spreading rate and age; (c) Evolution of Drake Passage and the Scotia Sea with their implications for faunal migration and climatic change; (d) History of Antarctic Bottom Water production and circulation and their effect on climatic and sedimentologic processes in the South Atlantic.

Accepting that extremely desirable sites in the Weddell and southern Scotia seas were inaccessible because of the high latitude involved, a total of six sites in the Drake Passage, the Scotia Sea, and the South Atlantic Ocean were planned with the above objectives in mind. In addition, three sites were selected in the southwest Atlantic Ocean basin and on the Falkland (Malvinas) Plateau with the following objectives: (a) To elucidate the geologic history of the southwestern part of the Atlantic Ocean basin which had been extensively studied geophysically but never drilled; (b) To test the age of magnetic anomaly number 34; (c) To date the major reflecting horizons of the Argentine Basin; and

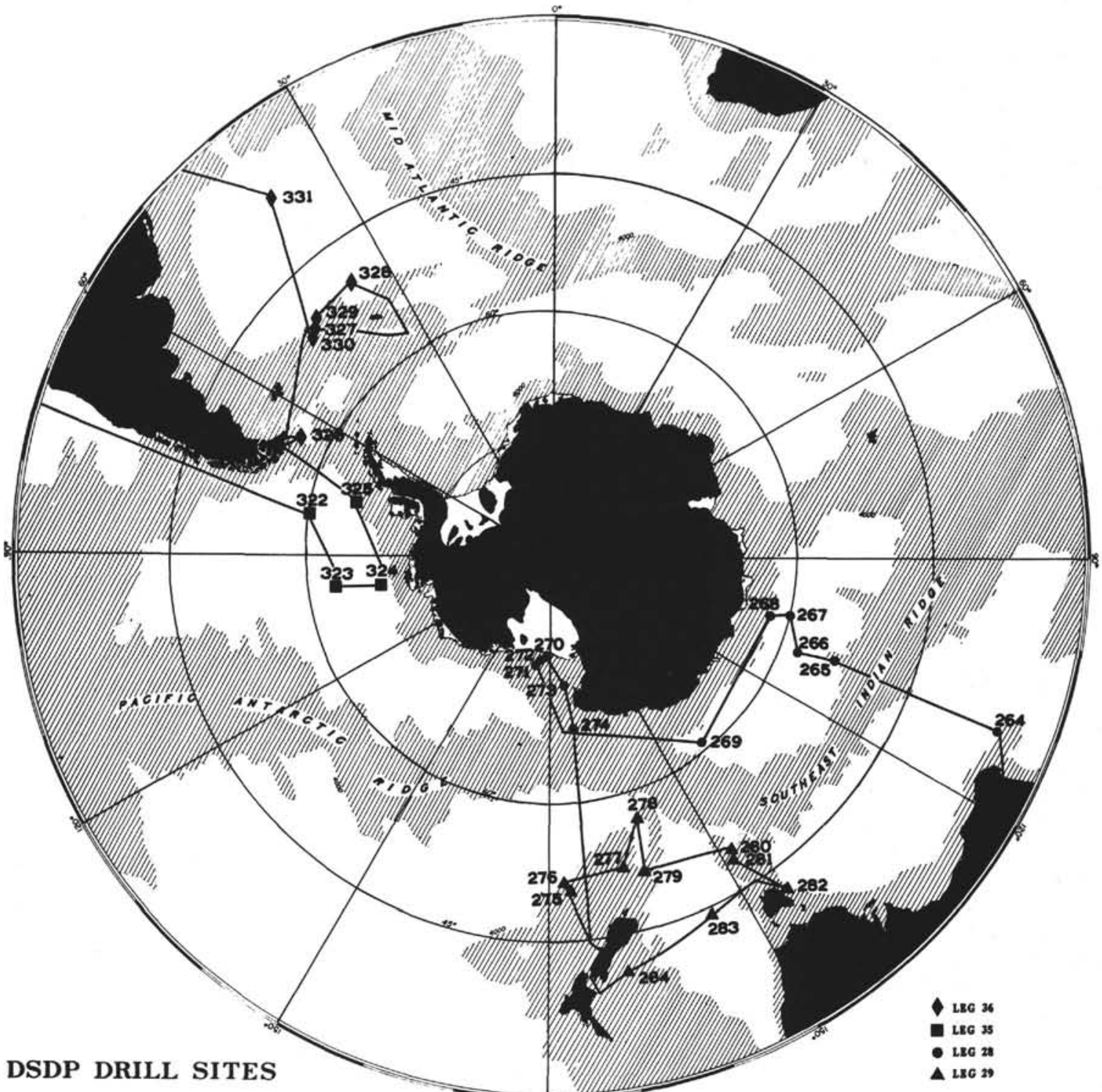

Figure 1. *DSDP drill sites, Southern Ocean 1972-74.*

(d) To compare the biostratigraphy of the southwestern Atlantic with that of the southeastern Pacific and thereby to help date the opening of the Drake Passage and onset of the circum-Polar current.

LEG 36—MODIFIED PROGRAM

Weather conditions and icebergs forced complete mid-cruise modifications of the Leg 36 scientific program as originally planned. They even played havoc with the modified program so that only 2 of the 10 holes spudded were voluntarily abandoned with all the scientific objectives achieved. A track and site location chart can be found in the rear pocket of this report.

The problems started at the first site in the Drake Passage (Site 326 at 56°35′S, 65°18.2′W in 3812 m of water) where the drill string parted directly beneath the vessel in heavy seas with the loss of 389 joints of 5 in. drill pipe and a complete bottom-hole assembly. The need to pick up a new drill string in sheltered waters forced the abandonment of Site 326 and of the other site planned for Drake Passage, and resulted in three days delay before operations could be resumed. The loss also prompted DSDP to impose new operational limits to guard against drill string loss for comparable reasons at a subsequent site. In addition, detention by the Argentine authorities while the new string was being assembled in Bahia Aguirre on the north side of the Beagle Channel had serious consequences for the planned program as a number of proposed sites were in waters claimed by Argentina.

Site 327 on the Falkland (Malvinas) Plateau at 50°52.3′S, 45°47′W was also abandoned due to bad weather, occasional rolls of the ship over 9° being beyond the new DSDP limits. Extremely bad weather and iceberg conditions were encountered while on passage to other proposed sites in the central Scotia Sea and in the general vicinity of the South Sandwich Islands. The vessel was unable to hold head wind and sea in the central part of the Scotia Sea and the Captain was forced to head northeastward away from the prospective site. Continuing high seas and strong winds, in the presence of numerous icebergs, also persuaded the Captain, Cruise Operations Manager, and Co-Chief Scientists to abandon an attempt to head for another southerly site in the South Atlantic east of the South Sandwich Islands. Hence, as DSDP had already decided following the detainment of the vessel, to cancel two sites near the Argentine-claimed South Sandwich Islands, a complete reappraisal of the cruise program was undertaken. The Co-Chief Scientists in consultation with the entire Shipboard Scientific party, the Captain, and the Cruise Operations Manager decided to concentrate the remainder of the leg on the scientific objectives attainable at sites in the Malvinas Outer Basin, on the Falkland Plateau, and in the Argentine Basin. It seemed likely that weather suitable for operating would be more likely to be encountered at these more northerly locations. Experience and satellite pictures received up to that point in time indicated that major depressions travelling eastward through the Drake Passage were too closely spaced to allow drilling in the Scotia Sea region. Meanwhile, after the abortive trip into the Scotia Sea, the vessel had rounded South Georgia and returned north towards Site 328 (49°48.7′S, 36°39.5′W) in the Malvinas Outer Basin. While in passage, additional sites were selected on the Falkland Plateau and in the Argentine Basin, and permission to drill them was sought from DSDP.

Even at the more northerly sites, weather and icebergs continued to plague operations. At Site 328 the first two holes were abandoned because of bad weather without significant penetration. Hole 328B was abandoned before the scientific goals had been achieved after the near approach (0.5 n.mi.) of an iceberg had forced partial withdrawal from the hole and pipe had been bent in an attempt to continue drilling. An extended poor weather forecast precluded continued operation at the site. Numerous icebergs resulted in long delays on passage from Site 328 to the new sites on the eastern Falkland Plateau near Site 327. The only real break in the weather on the whole leg came at this point. A ridge of high pressure remained stationary over the plateau long enough for successful coring at Site 329 (50°39.31′S, 46°5.73′W) and Site 330 (50°55.2′S, 46°53′W) to supplement the results already obtained from Site 327 and provide stratigraphically overlapping sections of the entire sedimentary cover of the eastern end of the plateau and samples of the (continental) basement.

Weather again deteriorated as Hole 330A was abandoned (due to pieces of the igneous and metamorphic basement cored at Hole 330 being retained above the drill bit).

Considerable on-site time (7 days) had been kept in hand for the important Argentine Basin location, Site 331 (37°53′S, 38°7′W). Once again, however, the weather was to defeat us. Unexpected heavy seas and strong winds developed just after the hole had been spudded, the vessel was blown 5-6 miles off-site and the motor for the man-lift was irreparably damaged when a stand of pipe fell across the rig floor while being elevated with the ship pitching and rolling. The site was abandoned with no improvement in the weather forecast and with little time remaining for the cruise.

The final blow came when an attempt to drill a site in the Vema Channel through the Rio Grande Rise was thwarted by failure of the power supply to the vertical reference gyro of the automatic positioning system. Drilling and coring operations were thus abruptly concluded for Leg 36.

Despite the problems outlined above we drilled 10 holes at six sites with a total penetration of 2481 meters and recovered 580 meters of 1007 meters cored (57.6% recovery). Data from four of the sites—327, 329, and 330 on the Falkland (Malvinas) Plateau and 328 in the Malvinas Outer Basin—constitute a major contribution to knowledge of the tectonic and oceanographic evolution of the southernmost Atlantic Ocean Basin (Table 1).

The back pocket of this volume contains an orthographic drawing of the Falkland Plateau with positions of the sites.

LEG 36—GEOLOGIC SETTING AND SUMMARY OF RESULTS

Site 326, drilled on a sediment pod on the oceanic crust generated at a northeast-southwest-trending spreading center in the Drake Passage, and Site 331, in the Argentine Basin, resulted in the recovery of surface cores only and will be considered only briefly here. The four successful sites of the leg were drilled on the Falkland (Malvinas) Plateau and the Malvinas Outer Basin. The Falkland (Malvinas) Plateau extends eastwards from the continental shelf of the South American continent (Figure 2, located in back pocket). The 500-fathom submarine contour lies east of the Falkland Islands which consist of a metamorphic complex overlain by Paleozoic-Triassic sedimentary strata deformed in the early Mesozoic and cut by mafic dykes (Greenway, 1972). The strata can be correlated with rocks of comparable age in South America and southern Africa. There is therefore no reason to doubt that the western portion of the plateau at least is underlain by continental crust. It has been treated in this way in considering the geometric "fit" of South America and Africa (Bullard et al., 1965). The eastern prolongation of the Falkland (Malvinas) Plateau, however lies at considerably greater depths, and although it has been considered to be floored by continental basement (Ewing et al., 1971), this could not be proved, particularly since DSDP Site 249 on the Mozambique Ridge which adjoins it in continental reconstructions, terminated in tholeiitic basalt. The Malvinas Outer Basin is part of the floor of the South Atlantic Ocean Basin. At the time of Leg 36 magnetic anomalies in the basin had not been identified.

A brief summary of the principal findings at each site is given below.

Site 326

Site 326 (Drake Passage) was drilled in 3812 meters of water about 150 km southeast of Cape Horn. Our main objective here was to check the magnetic-reversal dating of the opening of Drake Passage by determining basement age. Unfortunately, we obtained only one core before the very bad weather, strong currents and loss of 3800 meters of drill pipe caused us to abandon the site.

TABLE 1
Leg 36 Coring Summary

Hole	Date (1974)	Latitude	Longitude	Water Depth (m)	Penetration	No. of Cores	Cored (m)	Recovered (m)	Recovery %
326	5-6 April	56°35.00'S	65°18.20'W	3812	9.5	1	9.5	0.5	05
327	13-14 April	50°52.28'S	46°47.02'W	2400	5.5	1	5.5	5.5	100
327A	14-17 April	50°52.28'S	46°47.02'W	2400	469.5	27	256.5	128.1	50
328	24-27 April	49°48.67'S	36°39.53'W	5103	397.0	12	112.0	62.1	55
328A	27-28 April	49°48.67'S	36°39.53'W	5103	17.0	2	17.0	7.4	44
328B	28-30 April	49°48.67'S	36°39.53'W	5103	471.0	8	67.0	63.0	94
329	4-6 May	50°39.31'S	46°05.73'W	1519	464.5	33	312.5	215.1	69
330	6-8 May	50°55.19'S	46°53.00'W	2626	575.5	17	161.5	85.5	53
330A	8 May	50°55.19'S	46°53.00'W	2626	53.0	5	47.5	4.0	08
331	13-16 May	37°53.00'S	38°06.92'W	5067	18.0	2	18.0	8.5	47
Total					2480.5	108	1007.0	579.7	57.6

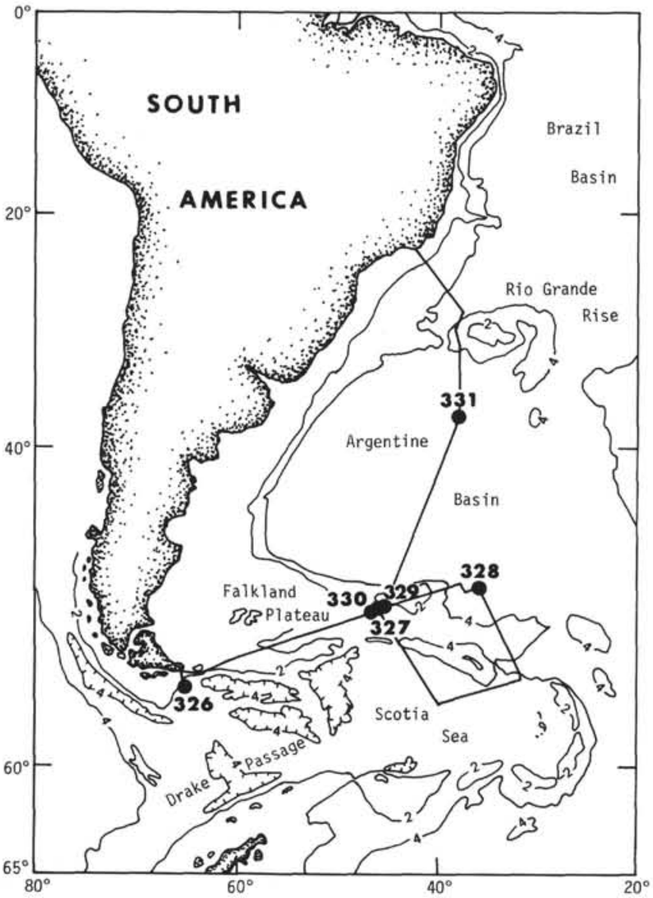

Figure 2. *Bathymetry of the southwestern Atlantic Ocean Basin, Drake Passage and the northern Scotia Sea showing track of* Glomar Challenger *and Leg 36 drill sites. (Bathymetry after Lonardi and Ewing, 1971.)*

Site 327

Site 327, in 2400 meters of water on the western nose of the elevated eastern part of the Falkland Plateau, the Maurice Ewing Bank, was chosen to examine Southern Ocean shallow-water pre-Neogene biostratigraphy and to identify seismic reflectors of regional extent. The first hole was abandoned in bad weather after recovery of only a surface core, but the second was cored continuously to 118 meters and intermittently to 469.5 meters before also being abandoned due to excessive ship motion. Twenty-eight cores were taken, with 50% recovery. Ten meters of Quaternary ice-rafted terrigenous debris with manganese nodules overlie a sequence of mid-Paleocene to lower Eocene alternating siliceous ooze and zeolitic clay 80 meters thick. Hiatuses occur above this sequence (Eocene to Quaternary) and below (late Maestrichtian to mid-Paleocene). Below 52 meters of Maestrichtian foram-nanno ooze lies a condensed section, up to 12 meters, of Santonian zeolitic clay with probably a Turonian-Coniacian hiatus. Below 154 meters subbottom, about 170 meters of a mostly Albian nanno claystone (uppermost part is Cenomanian) overlies an Aptian to ?Neocomian sapropelic claystone which extends to the base of the hole. Thus, restricted circulation in Aptian times gave way to more open ocean conditions in the Albian, following the development of a deep-water connection between the Atlantic and Indian oceans as the Falkland Plateau cleared southern Africa. Subsidence and improved circulation followed, with the CCD largely above the sea bed at the site. Possible Late Cretaceous, and very probable Neogene, submarine erosion result from changes in circulation patterns, the latter possibly consequent upon opening of the Drake Passage 20 to 30 m.y. ago. Cores contain unique siliceous flora and fauna at the Paleocene-Eocene boundary, with many new forms, and excellently preserved Maestrichtian calcareous fossils. Hole 327A penetrated about half of the sedimentary cover at the site.

Site 328

Site 328, in 5103 meters of water in the Malvinas Outer Basin immediately to the east of the Falkland Plateau and to the south of the Falkland Fracture Zone, was chosen to examine correlatives of Argentine Basin acoustic reflectors, to obtain a deep-water southerly biostratigraphic section, and if possible, to date the underlying oceanic basement. Three holes were drilled at the site. The deepest penetrated 471 meters and bottomed in Upper Cretaceous gray zeolitic claystone.

The top 13.5 meters consists of late Miocene-Quaternary diatomaceous ooze with abundant manganese nodules, sand, and large clasts. The lithology of these presumably ice-rafted clasts does not identify a specific source area. All are found around the Weddell Sea margin and the Antarctic Peninsula. The underlying 34 meters of silty, biogenic siliceous clay is of late Eocene-late Miocene age. Below this sediment Upper Cretaceous or Paleocene-upper Eocene siliceous clay and claystone extends to about 300 meters subbottom. The remainder of the section consists of Upper Cretaceous zeolitic claystone.

The reflector correlated with Horizon "A" of the Argentine Basin appears to represent a gradual diagenetic change from clay to claystone rather than a distinctive lithic layer. Extrapolation of sedimentation rates suggests that the uncored acoustic basement is of Albian age. The relatively high rate of sedimentation represented by the Upper Cretaceous-upper Eocene clay and claystone is believed to have been related to the mid-Cretaceous uplift of the Andean cordillera. A substantial reduction in sedimentation rate, decrease in clay content, and major breaks in the stratigraphic record indicate increase in bottom current velocity in the late Eocene continuing through the Miocene. Cold water microfossils become dominant in the middle Miocene, and certain ice-rafted material appears in the upper Miocene.

Site 329

Site 329, in 1519 meters of water some 55 km northeast of Site 327 on the Maurice Ewing Bank, was chosen to obtain the shallow-water Neogene biostratigraphic section deliberately avoided at the earlier site. The single hole was cored continuously to 179.5 meters and intermittently to 464.5 meters, yielding 33 cores with 69% recovery and bottoming in Paleocene nanno chalk. It thus provides some stratigraphic overlap with the section cored at Site 327.

Apart from ice-rafted terrigenous debris in the uppermost 4.5 meters of Quaternary diatomaceous ooze, the entire section is biogenic. About 220 meters of upper Miocene nanno and diatom ooze overlies 125 meters of more consolidated middle to upper Miocene ooze and chalk. Beneath this, a Paleocene to lower or middle Miocene nanno chalk, locally silicified, extends to the base of the hole. The sedimentation rate is about five times as high in the uppermost 350 meters of Miocene sediments as in the older sediments beneath. Hiatuses probably span the late Oligocene and early or middle Miocene, and the middle to early Eocene. The former represents an unconformity which reflection profiles show to form the base of a 100-km-long bank of Miocene oozes. This and the presence of reworked Oligocene fossils in the Miocene sediments indicate that strong bottom currents swept the region in the Neogene, possibly as a result of the opening of the Drake Passage.

Site 330

Site 330, in 2626 meters of water at the western end of the elongate rise forming the eastern end of the Falkland Plateau, the Maurice Ewing Bank, was selected to elucidate the pre-Aptian history of the Falkland Plateau and to obtain a biostratigraphic section older than that cored at Sites 327 and 329. Two holes were drilled, the deepest penetrating gneissose and granitic continental basement at 550 meters subbottom.

Silty clay and ooze containing Eocene to Oligocene and Recent diatoms were recovered above 34 meters. At this level 166 meters of Albian-Cenomanian zeolite-rich nanno clay was penetrated. The clay overlies 225 meters of sapropelic claystone which extends to 425 meters subbottom. This claystone contains Oxfordian and Aptian fossils. A drastic reduction in sedimentation rate, nondeposition, or even erosion must have taken place here, even allowing for a 19-meter coring gap. Beneath the sapropelic claystone is 115 meters of Oxfordian interbedded silty clay and clayey silt with layers of sandstone and limestone. A terrigenous source is apparent for these sediments which overlie a subarkosic sandstone at least 20 cm thick thought to be a beach sand reflecting a basal marine transgression. The underlying siltstone and sandstone contain lignite interbeds and indicate fluviatile deposits. These sediments are 3 meters thick, extending from 547-550 meters subbottom. At 550 meters they unconformably overlie the gneissose and granitic basement of which 19.5 meters were cored. The top of the basement has been calcretized.

The basement rocks were clearly part of an extensive continental igneous and metamorphic complex of Precambrian age affected by thermal events at various times during the Paleozoic. This is in keeping with their regional setting prior to the opening of the South Atlantic Ocean. The calcrete formation suggests alteration of the basement under Mediterranean-type climatic conditions prior to the deposition of the overlying nonmarine Jurassic sediments. The sedimentary succession indicates a subsequent history of Mid-Late Jurassic (probably Oxfordian) marine transgression, a period of restricted circulation until the end of the Aptian, establishment of open marine conditions by the early Albian, and subsidence to the present depth of the site during the Late Cretaceous and Paleogene.

Site 331

At Site 331 (Argentine Basin), to our great regret, a combination of bad weather—both experienced and forecast—and damage to the drill rig caused us to abandon the hole after penetrating only 18 meters in 4 days of drilling. None of the major goals was achieved.

The recovered sediment consists of lower Pleistocene diatomaceous clay with quartz-silt layers, containing large and robust diatoms and radiolarians endemic to cool, circumpolar waters as well as more temperate forms, suggesting transport of Antarctic Bottom Water. However, some brackish-water diatoms, together with the coarse fraction and heavy minerals in the silt and sandy silt layers, are more probably derived from the continental margin of South America.

EXPLANATORY NOTES

Organization and Authorship

The organization of this Initial Report of Leg 36 follows that of previous volumes. Following the Introduction are six chapters which summarize the basic findings at each site drilled. The third part contains twenty-one papers describing work done on samples or data from one or more sites by the shipboard party, and by others at their request. Part IV is a multi-authored Cruise Synthesis which deals with the geologic evolution of the southwest Atlantic.

The six appendices, which follow, include an operations report and the reports from shore laboratories which analyze DSDP material from every leg. Finally, a paper from Leg 28 is included. A further shore-lab report on Leg 36 material (Bukry, 1976) was published early, in Volume 35, in contravention of usual DSDP publication policy (see also Busen and Wise, this volume).

The entire shipboard scientific party and one or two others authored the site chapters (2 to 7). The format of the site chapters stems from the shipboard division of responsibility, as in most instances, does the authorship of individual sections. Overall responsibility is the co-chief scientists' (Barker and Dalziel), who also wrote Background and Objectives, and Survey and Operations sections. For each site a different "lead" sedimentologist wrote the Lithologic Summary. The lead sedimentologists are as follows: von der Borch, Site 327; Plafker, Site 328; Elliot, Site 329; and Thompson, Site 330. Similarly, a shipboard lead paleontologist was appointed, Wise (nannofossils), Tjalsma (foraminifers), Gombos (diatoms), and Dinkelman (radiolarians). Each paleontologist contributed his subsection to the Paleontology section, but the biostratigraphic summaries were written collectively and with the additional help of Sliter (Mesozoic foraminifers, Sites 327 and 330) and Harris (palynomorphs, Sites 327, 328, and 330) where appropriate. Tarney described Site 330 basement rocks, Lonardi wrote Physical Properties and Barker wrote the correlation of profiles with lithology. After discussion and consultation, the co-chief scientists wrote the Summary and Conclusions. After the cruise had ended, the main responsibility for production of this volume devolved upon the Science Editor (Wise).

Core Labeling

The following material should aid in understanding the terminology, labeling, and numbering conventions in use at the Deep Sea Drilling Project. Also included are explanations of the core logs and of some of the data that have been assembled up to this time. The sediment classification used on Leg 36 and a sample distribution policy appear near the end of this section.

Numbering of Sites, Holes, Cores, Samples

Drill site numbers run consecutively from the first site drilled by *Glomar Challenger* in 1968. The site number is unique; thus, use of a leg number is optional. A site refers to the hole or holes drilled from one acoustic positioning beacon. Several holes may be drilled at a single locality by pulling the drill string above the sea floor ("mud line") and offsetting the ship some distance (usually 100 m or more) from the previous hole. For purposes of compiling the stratigraphy of the site, the stratigraphic sections at each of the holes are assumed to be similar or identical, although this has not always proved to be the case.

Holes drilled at a site take the particular site number, and are distinguished by a letter suffix. The first hole has only the site number; the second has the site number with suffix A; the third has the site number with suffix B, and so forth. It is important, for sampling purposes, to distinguish the holes drilled at a site, since recovered sediments or rocks usually do not come from equivalent positions in the stratigraphic column at different holes.

Cores are numbered sequentially from the top down. In the ideal case, they consist of 9 meters of sediment or rock in a plastic liner of 6.6 cm diameter. In addition, a short sample is obtained from the core catcher (a multifingered device at the bottom of the core barrel which prevents cored materials from sliding out during core-barrel recovery). This usually amounts to about 20 cm of sediment and is stored separately. It represents the lowest stratum recovered in the particular cored interval. The core-catcher sample is designated by CC (e.g., 319A-4, CC = core-catcher sample of the fourth core taken in the second hole at Site 319).

The cored interval is the interval in meters below the sea floor, measured from the point at which coring for a particular core was begun to the point at which it was terminated. This interval generally spans 9.5 meters (nominal length of a core barrel), but may be shorter if conditions dictate. Cores and cored intervals need not be contiguous. In soft sediments, the drill string can be "washed ahead" without recovering core by applying sufficiently high pump pressure to wash sediment out of the way of the bit. In a similar manner, when drilling hard formations, a center bit filling the opening in the bit face can replace the core barrel if drilling ahead without coring is necessary. This, however, is seldom used and continuous coring is generally practiced.

When a core is brought aboard *Glomar Challenger*, it is labeled and the plastic liner and core cut into 1.5-meter sections. A full, 9-meter core would thus consist of six sections, numbered from the top down 1 to 6. Generally something less than 9 meters is recovered. In this case, the sections are still numbered with one at the top, but the number of sections is the number of 1.5-meter intervals needed to accommodate the length of core recovered. This is illustrated in Figure 3.

Thus, as shown, recovery of 3.6 meters of sediment would result in a core with three sections, with a void of 0.9 meters at the top of the first section. By convention, and for convenience in routine data handling at the Deep Sea Drilling Project, if a core contains a length of material less than the length of the cored interval, the recovered material is arbitrarily placed at the top of the

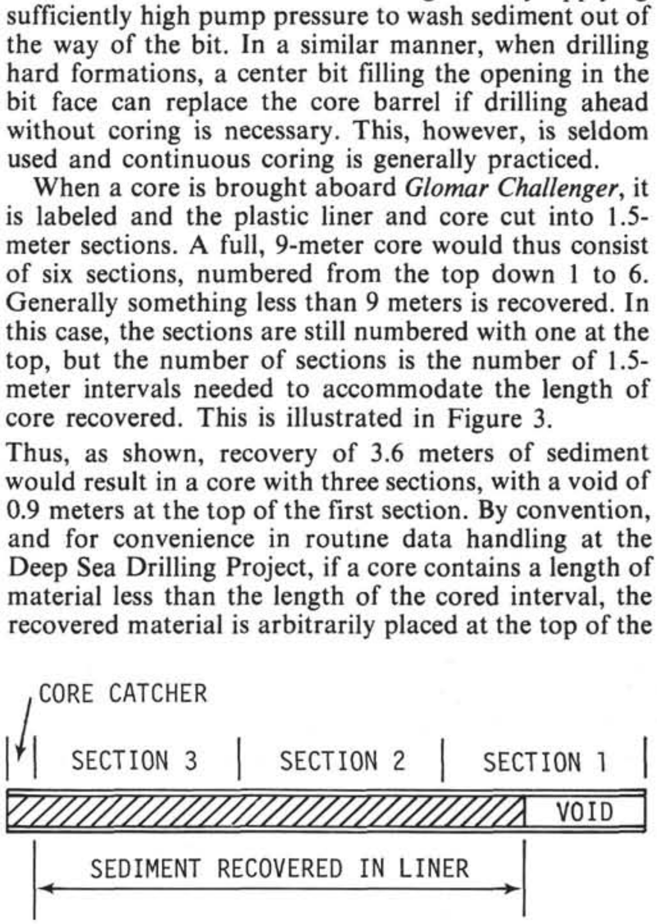

Figure 3. *Core section number convention.*

cored interval, with the top of Section 1 rather than the top of the sediment being the top of the cored interval. This is shown in Figure 4 for the core in the above example.

Thus, the depth below the sea floor of the top of the sediment of this hypothetical core would lie at 150.9 meters (not 150.0 m) and the bottom at 154.5 meters, with the core-catcher sample being regarded as dimensionless.

A discrepancy may exist between the usual coring interval of 9.5 meters and the 9-meter length of core actually recovered. The core liners used are 9.28 meters in length, and the core catcher accounts for another 0.2 meter. In cases where the core liner is recovered full to the top, the core is still cut into six 1.5-meter sections, measured from the bottom of the liner, and the extra 0.28-meter section at the top is designated Section 0, or the "zero section." The zero section is ignored in calculations of depth below the sea floor of cores or levels within cores, unless it contains some sediment, when the other sections of that core are considered to lie 0.5 meters deeper. On Leg 36 the zero section was never described; where it was collected, the letters ND occur in the lithology column of the core logs.

In the core laboratory on *Glomar Challenger*, after some steps of routine processing, the 1.5-meter sections of sediment core and liner are split in half lengthwise. One half is designated the "archive" half, which is photographed, described, and then stored. The other is the "working" half, which is sampled by the shipboard sedimentologists and paleontologists for further shipboard and shore-based analysis.

Samples taken from core sections are designated by the interval in centimeters from the top of the core section from which the sample was extracted. Sample volume, in cc, is also given. Thus, a full sample designation would consist of the following information:

Leg (Optional)
Site (Hole, if other than first hole)
Core Number
Section Number
Interval in centimeters from top of section

Sample 567A-4-3, 122-124 cm (10 cc) designates a 10-cc sample taken from Section 3 of Core 4 from the second hole drilled at Site 567. The depth below the sea floor for this sample would then be the depth to the top of the cored interval—150 meters in the example above—plus 3 meters for Sections 1 and 2, plus 122 cm (depth below the top of Section 3), or 154.2 meters. (Note, however, that sample requests should refer to a specific interval within a core section rather than level below sea floor.)

Core Disturbance

The rotary drill-coring technique quite often results in a high degree of disturbance of the cored sediments. This is especially true in the case of the softer unconsolidated sediments. Core disturbance has been treated at great length in volumes of the Initial Reports of the Deep Sea Drilling Project, and will not be elaborated upon here. A qualitative estimate of the degree of deformation is given on the core logs.

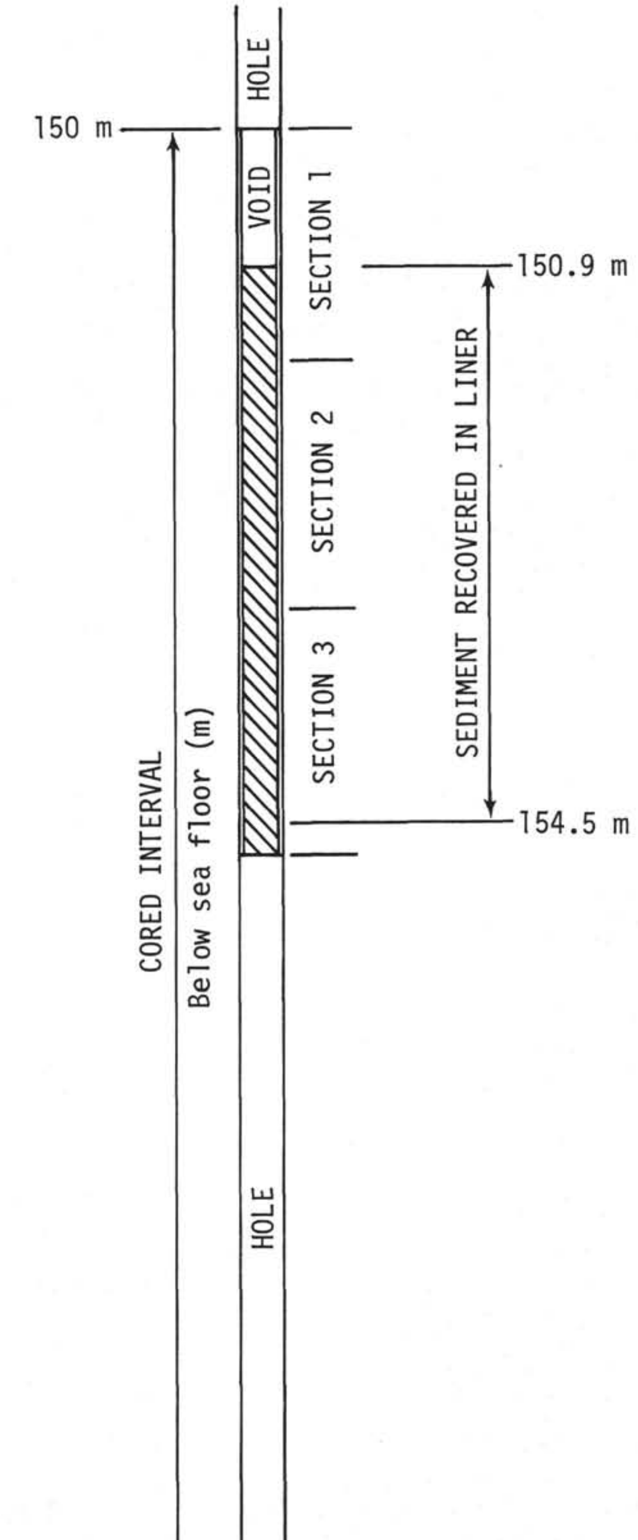

Figure 4. *Core section depth convention.*

Downhole Contamination

Downhole contamination is a serious problem. Hard objects (manganese nodules, chert, lithic fragments, and pebbles) are often washed or dragged hundreds of meters downhole. They commonly are lodged in the top of cores or will become incorporated into the middle of cores at levels far below their proper stratigraphic position. Displaced manganese nodules can usually be recognized. However, displaced chert, lithic fragments, and pebbles are more difficult to recognize as such. This information is recorded on the core forms.

Carbon-carbonate

Sediment samples are analyzed on a Leco 70-Second Analyzer following procedures outlined in Volumes 9 and 18 of the Initial Reports of the Deep Sea Drilling Project. Accuracy and precision of the results are as follows:

Total carbon	±0.3% (absolute)
Organic carbon	±0.06% (absolute)
$CaCO_3$	±3% (absolute)

X-Ray Mineralogy

Semiquantitative determinations of the mineral composition of bulk samples are tabulated on the core logs. In each listing the percentage of "amorphous scattering" (noncrystalline, unidentifiable material) is shown along with the crystalline, identified fraction. The percentages of identified minerals sum up to 100%. The analytical methods used are described in Volumes 1 and 2 of the Initial Reports of the Deep Sea Drilling Project and in Appendix III of Volume 4.

Grain Size Analyses

The grain size analyses presented on the core logs are performed by standard sieve and pipette techniques, described in detail in Appendix III of Volume 4 of the Initial Reports (p. 745), with modified settling times as in Volume 9.

X-ray Diffractometer Analyses

X-ray data are those collected by the DSDP X-ray mineralogy laboratory at the University of California, Riverside.

Sediment Classification for Leg 36

I. Rules for class limits and sequential listing of constituents in a sediment name
   A. Major constituents
      1. Sediment assumes name of those constituents present in major amounts (major defined as >25%). See example in Rule IA3.
      2. Where more than one major constituent is present, the one in greatest abundance is listed farthest to the right. In order of decreasing abundance, the remaining major constituents are listed progressively farther to the left.
      3. Class limits when two or more major constituents are present in a sediment are based on 25% intervals, thusly: 0-25, 25-50, 50-75, 75-100.
      Example illustrating Rules IA and IB and the resulting sediment names:

% Clay	% Nannos	
0-25	75-100	= Nanno ooze
25-50	50-75	= Clayey nanno ooze
50-75	25-50	= Nanno clay
75-100	0-25	= Clay

   B. Minor constituents. At the discretion of the geologist, constituents present in amounts of 10%-25% may be prefixed to the sediment name by the term rich.
   Example: 50% nannofossils, 30% radiolarians, 20% zeolites would be called a **zeolite-rich rad nanno ooze.**
   Similarly, constituents present in amounts of 2%-10% may be prefixed to the sediment name by the term **bearing.**
   C. Trace constituents. Constituents present in amounts of <10% may follow the sediment name with addition of the word trace. This again is at the discretion of the geologist.

II. Specific rules for calcareous and siliceous tests
   A. Nannofossil is applied only to the calcareous tests of coccolithophorids, discoasters, etc.
   B. The term calcareous or siliceous, depending on skeletal composition, is applied where no attempt is made to distinguish fossils as to major subgroup. Thus, if no percent estimate is made, a mixture of radiolarians, diatoms, and silicoflagellates would be called siliceous ooze. Where this distinction is made, the appropriate fossil name is used.
   C. Fossil tests are not qualified by a textural term unless very obviously redeposited.
   D. Abbreviations, as nanno for nannofossil, rad for radiolarian, etc., may be used in the sediment name.
   E. The term **ooze** follows a microfossil taxonomic group whenever it is the dominant sediment constituent.
   F. The term chalk is used to designate a compacted calcareous ooze. The form limestone is used to designate a completely indurated calcareous sediment.

III. Clastic sediments
   A. Clastic constituents, whether detrital, volcanic, biogenous, or authigenic, are given a textural designation. When detrital[1] grains are the sole clastic constituents of a sediment, a simple textural term suffices for its name. The appropriate term is derived from Shepard's triangle diagram. The textural term can be preceded by a mineralogical term when this seems warranted. Such mineralogical terms are applied as per Rules IA and B.
   B. When the tests of a fossil biocoenosis or authigenic and detrital grains occur together, the fossil or authigenic material is not given a textural designation (as per Rule IIC). However, the detrital material is classified texturally by recalculating its size components to 100%. With the presence of other constituents in the sediment, the detrital fraction now requires a compositional term.
   C. Clastic volcanics
   Redeposited pyroclastics also become a clastic component. They are again recognized by the term volcanic and receive a textural term such as gravel, sand, silt, etc. It is particularly difficult at times to differentiate between volcanic sand (i.e., transported by tractive mechanisms) and crystal ash (i.e., direct outfall resulting from explosion of a volcano).
   D. Clastic authigenic constituents
   Where authigenic minerals are recognized as being a redeposited constituent, they are given a textural designation in addition to their mineral names.

IV. Volcanic and authigenic constituents
   A. Volcanic constituents
   Pyroclastics are given textural designations already established in the literature. Thus, volcanic breccia = >32 mm, volcanic lapilli = <32 mm to >4 mm, and volcanic ash = <4 mm. It is at times useful to further refine the textural designations by using such modifiers as coarse to fine. An ash wholly, or almost wholly, of glass shards is termed vitric ash.
   B. Authigenic constituents
      1. Authigenic minerals enter the sediment name in a fashion similar to that outlined under Rules IA and B. Normally, as with a fossil biocoenosis, the authigenic minerals are not given a textural designation and texture.

[1]**Detrital** = all clastic grains derived from the erosion of preexisting rocks except for those of biogenous, authigenic, or volcanic origin.

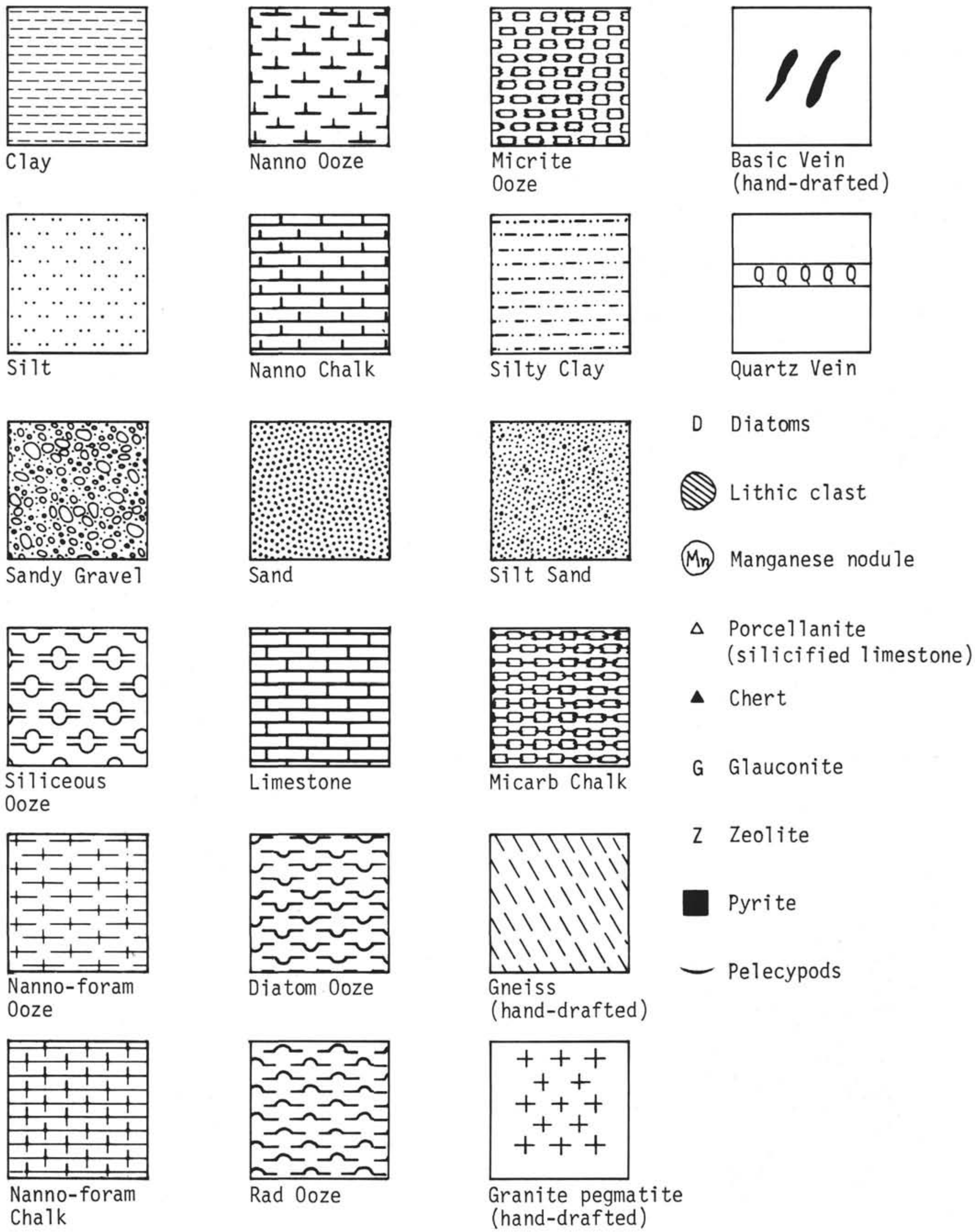

Figure 5. *Standard lithological symbols.*

Site Hole Core Cored Interval: Meters below sea floor.

AGE	ZONE	FOSSIL CHARACTER: FOSSIL	FOSSIL CHARACTER: ABUND.	FOSSIL CHARACTER: PRES.	SECTION	METERS	LITHOLOGY	DEFORMATION	LITHO.SAMPLE	LITHOLOGIC DESCRIPTION
		D=Diatom, F=Foraminifera, N=Nannoplankton, R=Radiolaria, S=Silicoflagellate	B=Barren, R=Rare, C=Common, F=Few, A=Abundant	VP=Very Poor, P=Poor, M=Moderate, G=Good	0, 1, 2, 3, 4, 5, 6, Core Catcher	0.5, 1.0	SEE EXPLANATORY NOTES	Undisturbed (blank); Slight deformation ——; Moderate deformation – – –; Intense deformation ~~~~~; Brecciated o o o	Smear slide depth in centimeters within a section.	See description below

Sediment or rock name.

General description: lithologies, colors, and specific characteristics.

Smear slide descriptions of representative lithologies. Abbreviations are:

qtz.	=	quartz
feld.	=	feldspar
rads.	=	Radiolaria
zeol.	=	zeolites
nannos	=	nannofossils
spic.	=	sponge spicules
palag.	=	palagonite
glauc.	=	glauconite
silico.	=	silicoflagellates
forams	=	foraminifera
micronod.	=	micronodules
dolom.	=	dolomite
pyr.	=	pyrite

Grain size, carbon-carbonate, bulk X-ray, and smear slide intervals are given by section and centimeter depth within the section. For example, 6-40 is a sample that was taken at 40 centimeters in Section 6.

Grain size determinations are given in wt percent sand, silt, and clay.

Carbon/carbonate determinations are given in percent total carbon, organic carbon, and calcium carbonate.

Bulk X-ray determinations are given in percentages of amorphous and crystalline components. Percentages of minerals listed are from the crystalline component and are summed to 100%.

Zero sections were not described. Where present, they are indicated by N.D. (not described).

Note: Smear slide descriptions are reported as in shipboard report; no corrections have been made for X-ray determinations, even when these show disagreement with equivalent smear slide descriptions.

Figure 6. *Sample core form and descriptions.*

2. The terms ooze and chalk are applied to carbonate minerals of all types using the same rules that apply to biogenous constituents.

V. Color

A. Color is not formally part of the sediment name. However, its employment for sediment description is important particularly as it provides one of the criteria used to distinguish pelagic and terrigenous sediments.

B. Common usage dictates that it is no longer expedient to employ the term red for sediments (*usually* pelagic) which are various shades of red, yellow, and brown. The proper color designation should be used.

Accompanying the above classification is a set of standard Deep Sea Drilling Project lithologic symbols (Figure 3) which are used on core barrel, and hole logs.

Smear slides are the basic means of mineral identification for sediments on shipboard, while thin sections and mineral grain mounts are used in studies of indurated sediments and igneous rocks.

Smear slide estimates of mineral abundances are based on a visual estimate of the area of the smear slide covered by each component. Past experience has shown that an absolute accuracy no better than 10% to 20% can be expected for these estimates. Of more importance to the geologist than absolute accuracy are relative changes in component abundances.

The smear slide descriptions include very fine-grained micrite or clay. X-ray analysis suggests that micrite may also include amorphous silica, cristobalite, tridymite, and clay minerals, whereas clay may include amorphous silica and other clay-sized particles. Smear slide estimates of zeolite have not always been confirmed by X-ray analysis.

Biostratigraphy

Biostratigraphic boundaries given in this initial description are of a preliminary nature. Although no major changes in age assignments are anticipated, adjustments of some boundaries are likely to be made prior to issuing of the Initial Report Volume for Leg 36.

Microfossil assemblages recovered on Leg 36 are high latitude. Low latitude biostratigraphic zonations are not applicable for most groups other than calcareous nannofossils of Mesozoic and early Paleogene age. Zonal schemes used are as follows:

1. Planktonic foraminifera: Cenozoic—Jenkins, 1971.

2. Calcareous nannofossils: Cenozoic—Bukry, 1973; Wise, this volume. Mesozoic—Roth and Thierstein, 1972; Thierstein, 1973; Thierstein, personal communication, 1974.

3. Radiolarians: Hays, 1965; Chen, 1975.

4. Diatoms: McCollum, 1975; Gombos, this volume.

A sample core form is given in Figure 6. It is designed to show the organization, abbreviations, and symbols that are used on core forms in the subsequent part of this report.

Time Scales

The Mesozoic time scale used in this volume is that of Larson and Hilde (1975); for the Cenozoic that of Berggren (1971) is used.

REFERENCES

Berggren, W.A., 1971. A Cenozoic time scale: Some implications for regional geology and biogeography: J. Foram. Res., v. 1.

Bullard, E., Everett, J. E., and Smith, A. G., 1965. The continents around the Atlantic. *In* Blackett, P.M.S., Bullard, E., and S. K. Runcorn (Eds.), A symposium on continental drift. Phil. Trans. Roy. Soc. London, Ser. A., v. 258, p. 41-51.

Bukry, D., 1973. Coccolith stratigraphy, eastern equatorial Pacific, Leg 16 DSDP. *In* van Andel, T. H., Heath, G. R., et al., Initial Reports of the Deep Sea Drilling Project, Vol. 16: Washington (U. S. Government Printing Office), p. 653-711.

Bukry, D., 1976. Cenozoic silicoflagellate and coccolith stratigraphy, South Atlantic Ocean, DSDP Leg 36. *In* Hollister, C. D., Craddock, C., et al., 1976. Initial Reports of the Deep Sea Drilling Project, Volume 35, Washington (U.S. Government Printing Office), p. 885-917.[2]

Chen, P., 1975. Antarctic Radiolaria, Leg 28, Deep Sea Drilling Project. *In* Frakes, L. A., Hayes, D. E., Initial Reports of the Deep Sea Drilling Project, Volume 28: Washington (U.S. Government Printing Office) p. 437-513.

Ewing, M. and Hayes, D. E., 1970. Deep Sea Drilling in Antarctic waters: Geotimes, v. 5, p. 15-16.

Ewing, J. I., Ludwig, W. J., Ewing, M. and Eittreim, S. L., 1971. Structure of the Scotia Sea and Falkland Plateau: J. Geophys. Res., v. 76, p. 7118-7137.

Greenway, M. E., 1974. The geology of the Falkland Islands: British Antarctic Survey Sci. Rept., no. 76, p. 1-42.

Hayes, D. E. and Edgar, N. T., 1972. Extensive drilling planned for *Glomar Challenger* in Antarctic waters: Ant. Jr. U.S., v. VII, p. 1-4.

Hays, J. D., 1965. Radiolaria and late Tertiary and Quaternary history of Antarctic seas: Am. Geophy. Union Antarc. Res. Ser. 5, p. 125.

Jenkins, D. G., 1971. New Zealand Cenozoic planktonic foraminifera: New Zealand Geol. Surv. Paleontol. Bull. 42, p. 1-278.

Larson, R.L. and Hilde, T.W.C., 1975. A revised time scale of magnetic reversals for the Early Cretaceous and Late Jurassic: J. Geophys. Res., v. 80, p. 2586-2594.

McCollum, D. W., 1975. Diatom stratigraphy of the Southern Ocean. *In* Hayes, D. E. and Frakes, L. A., et al., Initial Reports of the Deep Sea Drilling Project, Volume 28: Washington (U. S. Government Printing Office).

Roth, P. H. and Thierstein, H. R., 1972. Calcareous nannoplankton: Leg 14 of the Deep Sea Drilling Project. *In* Hayes, D. E., Pimm, A. C., et al., Initial Reports of the Deep Sea Drilling Project, Volume 14: Washington (U. S. Government Printing Office), p. 421-485.

Thierstein, H. R., 1971. Tentative Lower Cretaceous calcareous nannoplankton zonation: Eclog. Geol. Helv., v. 64, p. 459.

———, 1973. Lower Cretaceous calcareous nannoplankton biostratigraphy: Abh. Geol. B. A. (Wien), v. 29.

Thierstein, H. R., Franz, H. E., and Roth, P. H., 1972. Scanning electron and light microscopy of the same small object: Micropaleontology, v. 17, p. 501.

[2]This paper, based on Leg 36 data, was published early, in Volume 35 (see also Busen and Wind, this volume).