2. EXPLANATORY NOTES¹

Shipboard Scientific Party²

INTRODUCTION

The standard procedures for drilling operations and preliminary shipboard analyses of the material recovered during Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP) drilling have been regularly amended and upgraded since drilling began in 1968. In this chapter, we have assembled information that will help the reader understand the basis for our preliminary conclusions and also help the interested investigator select samples for further analysis. This information concerns only shipboard operations and analyses described in the site reports in the *Initial Reports* volume of the Leg 126 *Proceedings of the Ocean Drilling Program.* Methods used by various investigators for shore-based analysis of Leg 126 data will be detailed in the individual scientific contributions published in the *Scientific Results* volume.

Authorship of Site Chapters

The separate sections of the site chapters were written by the following shipboard scientists (authors are listed in alphabetical order in parentheses, and no seniority is necessarily implied):

Site Summary: Fujioka, B. Taylor Background and Objectives: B. Taylor

Dackground and Objectives. D. Taylor

Seismic Stratigraphy: Cooper, Klaus, B. Taylor

Operations: Grout, Huey, Janecek

Lithostratigraphy and Accumulation Rates: Colella, Hiscott, Janecek, Marsaglia, Nishimura, Rodolfo, Tazaki

Biostratigraphy: Aitchison, Firth, Herman, Isiminger-Kelso, Kaiho

Igneous Petrology: Gill, LaPierre, R. Taylor, Torssander Igneous Geochemistry: Gill, LaPierre, R. Taylor, Torssander Sediment/Fluid Geochemistry: Egeberg Paleomagnetics: Cisowski, Koyama Physical Properties: Dadey, Klaus Downhole Measurements: Lovell, Pezard

Following the text of each site chapter are summary core descriptions ("barrel sheets" and igneous rock visual core descriptions) and photographs of each core.

Survey Data

Survey data collected prior to Leg 126 and used in the site selection process are discussed in a separate chapter (see Taylor et al., this volume). The underway geophysics data collected aboard the *JOIDES Resolution* during Leg 126 are discussed in a separate chapter entitled "Underway Geophysics" (this volume). The underway data include bathymetry, magnetics, and seismic reflection profiles.

Drilling Characteristics

Water circulation down the hole is open; hence, cuttings were lost onto the seafloor and could not be examined. The only available information about sedimentary stratification in uncored or unrecovered intervals, other than from seismic data or wireline-logging results, is from an examination of the behavior of the drill string as observed and recorded on the drilling platform. Typically, the harder a layer, the slower and more difficult it is to penetrate. A number of other factors, however, determine the rate of penetration, so it is not always possible to relate drilling time directly to the hardness of the layers. Bit weight and revolutions per minute, recorded on the drilling recorder, influence the penetration rate.

Drilling Deformation

When cores were split, many showed signs of significant sediment disturbance, including the concave-downward appearance of originally horizontal bands, haphazard mixing of lumps of different rock types (mainly at the tops of cores), and the nearfluid state of some sediments recovered from tens to hundreds of meters below the seafloor. Core deformation probably occurred during any of several steps in which the core suffered stresses sufficient to alter its physical characteristics: cutting, retrieval (with accompanying changes in pressure and temperature), and core handling on deck.

Shipboard Scientific Procedures

Numbering of Sites, Holes, Cores, and Samples

ODP drill sites are numbered consecutively from the first site drilled by the *Glomar Challenger* in 1968. A site number refers to one or more holes drilled while the ship was positioned over one acoustic beacon. Multiple holes were drilled at a single site by pulling the drill pipe above the seafloor (out of hole), moving the ship some distance from the previous hole, and then drilling another hole.

For all ODP drill sites, a letter suffix distinguishes each hole drilled at the same site. For example, the first hole drilled was assigned the site number modified by the suffix A, the second hole took the site number and the suffix B, and so forth. Note that this procedure differs slightly from that used by DSDP (Sites 1 through 624), but it prevents ambiguity between siteand hole-number designations. It is important for sampling purposes to distinguish among the holes drilled at a site, because recovered sediments or rocks from different holes usually do not come from equivalent positions in the stratigraphic column.

The cored interval was measured in meters below seafloor (mbsf). The depth interval assigned to an individual core ranges from the depth below the seafloor that the coring operation began to the depth that the coring operation ended (Fig. 1). For example, each coring interval is generally up to 9.7 m long (the nominal capacity of a core barrel). Coring intervals may be shorter and may not necessarily be adjacent if separated by drilled intervals. In soft sediments, the drill string can be "washed ahead" with the core barrel in place without recovering sedi-

¹ Taylor, B., Fujioka, K., et al., 1990. Proc. ODP, Init. Repts., 126: College Station, TX (Ocean Drilling Program).

² Shipboard Scientific Party is as given in the list of participants preceding the contents.



Figure 1. Diagram illustrating terms used in discussing coring operations and core recovery. ments. This is achieved by pumping water down the pipe at high pressure to wash the sediment out of the way of the bit and up the space between the drill pipe and the wall of the hole. If thin, hard, rock layers are present, then it is possible to get "spotty" sampling of these resistant layers within the washed interval and thus to have a cored interval greater than 9.7 m. In drilling hard rock, a center bit may replace the core barrel if it is necessary to drill without core recovery.

Cores taken from a hole are numbered serially from the top of the hole downward. Core numbers and their associated cored intervals in meters below seafloor usually are unique in a given hole; however, this may not be true if an interval must be cored twice because of caving of cuttings or other hole problems. Maximum full recovery for a single core is 9.5 m of rock or sediment contained in a plastic liner (6.6-cm internal diameter) plus about 0.2 m (without a plastic liner) in the core catcher (Fig. 2). The core catcher is a device at the bottom of the core barrel that prevents the core from sliding out when the barrel is being retrieved from the hole. In certain situations (e.g., when coring gas-charged sediments that expand while being brought on deck), recovery may exceed the 9.5-m maximum.

A recovered core was divided into 1.5-m sections that were numbered serially from the top (Fig. 2). When full recovery was obtained, the sections were numbered from 1 through 7, with the last section possibly being shorter than 1.5 m (rarely, an unusually long core may require more than 7 sections). When less than full recovery was obtained, there will be as many sections as needed to accommodate the length of the core recovered; for example, 4 m of core would be divided into two 1.5-m sections and a 1-m section. If cores are fragmented (recovery less than 100%), sections are numbered serially and intervening sections are noted as void, whether shipboard scientists believe that the fragments were contiguous *in situ* or not. In rare cases, a section less than 1.5 m may be cut so that features of interest can be preserved (e.g., lithologic contacts).

By convention, material recovered from the core catcher was placed below the last section when the core was described and labeled core catcher (CC). In sedimentary cores, it was treated as a separate section. The core catcher was placed at the top of the cored interval in cases where material was only recovered in the core catcher. However, information supplied by the drillers or by other sources may allow for more precise interpretation as to the correct position of core-catcher material within an incompletely recovered cored interval.

A recovered rock (basalt, gabbro, peridotite, or serpentinite) core was also cut into 1.5-m sections and numbered serially; however, each piece of rock then was assigned a number. Fragments of a single piece were assigned a single number, and individual fragments were identified alphabetically. The core-catcher sample was placed at the bottom of the last section and treated as part of the last section rather than separately. The scientists who completed the visual core descriptions described each lithologic unit, noting core and section boundaries only as physical reference points.

When the recovered core was shorter than the cored interval, as was usually the case, the top of the core was equated with the top of the cored interval by convention so that consistency in handling the analytical data derived from the cores could be maintained. Samples removed from the cores were designated by the distance measured in centimeters from the top of the section to the top and bottom of each sample removed from that section. In curated hard-rock sections, sturdy plastic spacers were placed between pieces that did not fit together to protect them from damage in transit and in storage. Therefore, the centimeter interval noted for a hard-rock sample has no direct relationship to that sample's depth within the cored interval, but is only a physical reference to the location of the sample within the curated core.



Figure 2. Diagram showing procedure for cutting and labeling core sections.

A full identification number for a sample consists of the following information: leg, site, hole, core number, core type, section number, piece number (for hard rock), and interval in centimeters measured from the top of section. For example, a sample identification of "126-787A-10R-1, 10-12 cm" would be interpreted as representing a sample removed from the interval between 10 and 12 cm below the top of Section 1, Core 10 (R designates that this core was taken with the rotary core barrel) of Hole 787A during Leg 126.

All ODP core and sample identifiers indicate core type. The following abbreviations are used: R = rotary core barrel (RCB); H = hydraulic piston core (HPC; also referred to as APC, or advanced hydraulic piston core); <math>P = pressure core barrel; X = extended core barrel (XCB); B = drill-bit recovery; C = centerbit recovery; I =*in-situ*water sample; S = sidewall sample; W = wash-core recovery; and M = miscellaneous material. APC, XCB, RCB, and wash cores were cut on Leg 126.

Core Handling

Sediments

As soon as a core was retrieved on deck during Leg 126, a sample was taken from the core catcher and given to the paleontological laboratory for an initial age assessment. The core was then placed on the long horizontal rack, and gas samples were taken by piercing the core liner and withdrawing gas into a vacuum tube. Voids within the core were sought as sites for gas sampling. Some of the gas samples were stored for shore-based study, but others were analyzed immediately as part of the shipboard safety and pollution prevention program. Next, the core was marked into section lengths, each section was labeled, and the core was cut into sections. Interstitial water (IW) and organic geochemistry (OG) samples were taken. In addition, some headspace gas samples were scraped from the ends of cut sections on the catwalk and were sealed in glass vials for light-hydrocarbon analysis. Each section was then sealed at the top and bottom by gluing on color-coded plastic caps: blue to identify the top of a section and clear for the bottom. A yellow cap was placed on section ends from which a whole-round sample had been removed. The caps were usually attached to the liner by coating the end liner and the inside rim of the cap with acetone and then taping the caps to the liners.

From the deck, the cores were carried into the laboratory, where the sections were again labeled with an engraver to mark the full designation of the section more permanently. The length of the core in each section and the core-catcher sample were measured to the nearest centimeter; this information was logged into the shipboard CORELOG database program.

Next, the whole-round sections from the APC and XCB cores were run through the multisensor track (MST). This included the gamma-ray attenuation porosity evaluator (GRAPE) and *P*wave logger (PWL) devices, which measured the bulk density, porosity, and sonic velocity, as well as an additional meter that determined the volume magnetic susceptibility. After the core was equilibrated to room temperature (approximately 3 hr), thermal conductivity measurements were performed before the cores were split.

Cores composed of rather soft material were split lengthwise into working and archive halves. The softer cores were split with a wire or saw, depending on the degree of induration. Harder cores were split with a band or diamond saw. Since cores on Leg 126 were split with wire from the bottom to top, older material could have been transported up the core on the split face of each section. One should, therefore, be aware that the very near-surface part of the split core could be contaminated.

The working half was sampled for shipboard and shore-based laboratory studies. Each extracted sample was logged into the sampling computer database program by the location and the name of the investigator receiving the sample. Records of all samples that were removed are kept by the curator at ODP. The extracted samples were sealed in plastic vials or bags and labeled. Samples were routinely taken for shipboard physical property analyses. These samples were subsequently used for calcium carbonate determinations (coulometric analyses); these data are reported in the site chapters.

The archive half was described visually. Smear slides were made from samples taken from the archive half and were supplemented by thin sections taken from the working half. Sections from the archive half that did not show evidence of drilling disturbance were run through the cryogenic magnetometer. The archive half was then photographed with black-and-white and color film, a whole core at a time. Close-up photographs (black-and-white) were taken of particular features for illustrations in the summary of each site.

Each half of the core was then put into a labeled plastic tube, sealed, and transferred to cold-storage space aboard the drilling vessel. At the end of the leg, the cores were transferred from the ship in refrigerated airfreight containers to cold storage at the Gulf Coast Repository at the Ocean Drilling Program, Texas A&M University, College Station.

Igneous and Metamorphic Rocks

Igneous and metamorphic rock cores were handled differently from sedimentary cores. Once on deck, the core catcher was placed at the bottom of the core liner, and the total core recovery was calculated by shunting the rock pieces together and taking measurements to the nearest centimeter. This information was logged into the shipboard CORELOG database program. The core was then cut into 1.5-m-long sections and transferred to the lab.

The contents of each section were transferred into 1.5-mlong sections of split core liner, where the bottom of the oriented pieces (i.e., pieces that clearly could not have rotated top to bottom about a horizontal axis in the liner) were marked with a red wax pencil. This ensured that orientation would not be lost during the splitting and labeling process. The core was split into archive and working halves, and a plastic spacer was used to separate individual pieces, and/or reconstructed groups of pieces, in the core liner. These spacers may represent a substantial interval of no recovery. Each piece was numbered sequentially from the top of each section, beginning with number 1; reconstructed groups of pieces were assigned the same number, but they were lettered consecutively. Pieces were labeled on the rounded surface, rather than on the sawn surface. If the piece was oriented, an arrow that pointed to the top of the section was added to the label.

The working half was sampled for shipboard laboratory studies. Records of all samples are kept by the curator at ODP. Minicore samples were routinely taken for physical properties and magnetic studies. Some of these samples were later subdivided for X-ray fluorescence (XRF) analysis and thin sectioning, so that as many measurements as possible were made on the same pieces of rock. At least one minicore was taken per lithologic unit when recovery permitted, generally from the freshest areas of core. Additional thin sections, X-ray diffraction (XRD) samples, and XRF samples were selected from areas of particular interest. Samples for shore-based studies were selected at a sampling party held after the drilling ended. The archive half was described visually, then photographed with black-and-white and color film, one core at a time. Both halves of the core were shrink-wrapped in plastic to prevent rock pieces from vibrating out of sequence during transit, put into labeled plastic tubes, sealed, and transferred to cold-storage space aboard the drilling vessel. At the end of the leg, the cores were transferred from the ship in refrigerated air-freight containers to cold storage at the Gulf Coast Respository at the Ocean Drilling Program, Texas A&M University, College Station.

SEDIMENT CORE DESCRIPTION FORMS

Sediments and Sedimentary Rocks

Graphic and verbal core descriptions, smear-slide and thinsection petrographic data, sample locations, $CaCO_3$ concentrations, physical property measurements, and biostratigraphic information constitute the shipboard data summarized on the core description forms (barrel sheets) in this volume (Fig. 3). These sheets represent time-constrained field notes taken on board ship. Some ambiguities or discrepancies may be present.

The core description forms (Fig. 3), or "barrel sheets," summarize the data obtained during shipboard analysis of each sediment core, which have been recorded in detail on a section-bysection basis on visual core description forms, or VCDs. Information recorded on the VCDs is available as a searchable database through the ODP Data Librarian. The following discussion explains ODP conventions used in compiling the core descriptions and the exceptions to these procedures adopted by Leg 126 scientists.

Core Designation

Cores are designated as to leg, site, hole, core number, and core type, as previously discussed (see "Numbering of Sites, Holes, Cores, and Samples" section, this chapter). In addition, the cored interval is specified in terms of meters below sea level (mbsl) and meters below seafloor (mbsf). On the basis of drillpipe measurements (dpm), as reported by the SEDCO coring technician and the ODP operations superintendent, depths are corrected for the height of the rig-floor, dual-elevator stool above sea level to give true water depth and the correct mbsl.

Age Data

Microfossil abundance, preservation, and zone assignment, as determined by shipboard paleontologists, appear on the core description form under the heading "Biostratigraphic Zone/Fossil Character." The geologic age determined from paleontologic and/or paleomagnetic results is shown in the "Time-Rock Unit" column. Calcareous nannofossils and planktonic foraminifers provided most age determinations. Detailed information on zonations and terms used to report abundance and preservation is presented in the "Biostratigraphy" section (this chapter).

Paleomagnetic, Physical Properties, and Chemical Data

Columns are provided on the core description form to record paleomagnetic results, physical properties values (wet-bulk density, porosity, and compressional velocity), and chemical data (% CaCO₃ determined by coulometric analysis). Additional information on the shipboard procedures used in collecting these types of data is found in the "Paleomagnetism," "Physical Properties," and "Inorganic Geochemistry" sections of this chapter).

Graphic Lithology Column

The lithology of the recovered material is represented on the core description forms by a single symbol or by a group of two or more symbols (see Fig. 8, this chapter) in the column titled "Graphic Lithology."

EXPLANATORY NOTES

SITE	E HOLE CORE						CC	DRE	CORED INTERVAL								
	BIC	OSTF	AT.	ZO	NE/	ŝ	S					mi	mφ				
TIME-ROCK UNIT	FORAMINIFERS	NANNOFOSSILS	RADIOLARIANS	DIATOMS		PALEOMAGNETIC	PHYS. PROPERTIE	CHEMISTRY	SECTION	NETERS	graphic Lithology	RILLING DISTUR ED. STRUCTURE			LITHOLOGIC DESCRIPTION		
									1	0.5				XRF	X-ray fluorescence sample		
										1.0				XRD	X-ray diffraction sample		
									2								
1	PRE G=C M=N	SE	RV/ d	ATI	ON:				3					OG	Organic geochemistry sample		
	P=P	oor	bols (Figure 8)				E Cond C										
		osity, and densii				mholo in Elauro											
A V A C F R T	BUN =Ab =Co =Fe =Ra =Tra	NDA /ery ounc omn w are ace	NDANCE very abundant undant ww ww ww ww ww ww ww ww ww w		īW	Interstitial-water sample											
В	T=Trace B=Barren						6					*	← Smear slide				
									7					#	- Thin section		
										C	сс			11111		PP	Whole-round physical properties sample

Figure 3. Core description form (barrel sheet) used for sediments and sedimentary rocks.

Figure 4 illustrates the following discussion of how mixed rock types and very thin intercalated beds are drafted in the graphic columns as well as the special symbols used to describe Leg 126 cores. Where an interval is split by a solid vertical line, the sediment or sedimentary rock is an essentially homogeneous mixture of the two constituents, although each is represented by its own symbol. Examples are mixtures of biogenic and inorganic components, or mixtures of gravel and finer siliciclastic sediment. Carbonate content is not easily estimated from smear slides, and so, where chemical analyses are absent, carbonate values in the graphic column and the smear slide summary must be used only as first approximations. Where chemical analyses have been run, carbonate contents have been adjusted to conform to shipboard chemical analyses, as shown in Section 1, 30 cm, and Section 2, 10 cm, in Figure 4.

In a mixed biogenic-siliciclastic lithotype such as nannofossil-rich clay, the terrigenous constituent is noted on the right, the biogenic constituent(s) on the left side of the column, in proportions approximately equal to their respective abundances in the sediment. For example, in the uppermost interval of the core illustrated in Figure 4, the left 20% of the column has a nannofossil-ooze symbol, whereas the right 80% has a clay symbol, indicating nannofossil-rich clay or claystone composed of 20% nannofossils and 80% clay. The symbols do not indicate the quantity of primary volcanic material in the nonbiogenic



Figure 4. The graphic column and adjacent portions of the core description form (barrel sheet), illustrating Leg 126 modifications of standard ODP usage. See text for explanation.

fraction; this information is provided instead in the "Lithologic Description" column.

Intervals composed of two or more sediment types that are too finely interbedded for each layer to be depicted individually show the relative abundances of the lithotypes graphically by dashed lines that vertically divide the interval into appropriate fractions. Thus, the interval in Section 1, 50–130 cm, consists of thin intercalations of clay (30%), clayey silt and silty clay (collectively 40%), and silt (30%). Some sense of the thickness of the layers is provided by the bedding lines in the "Sed. Structures" column. The numerous thin ash layers in the Pliocene-Quaternary sediments and the sedimentary rocks of Leg 126 cores are significant and required special treatment. Rather than being lumped into a vertically subdivided fraction of a core interval, the presence of these layers is noted in the "Sed. Structures" column by the letter "A."

In cases where sediment types with significant biogenic components are finely interbedded with biogenic-free lithotypes, only the lithotype with biogenic content is divided into its components by a vertical solid line. Thus, the interval from Section 1, 130 cm, to Section 2, 20 cm, consists equally of thin sand and nannofossil clay intercalations; the nannofossil clay is composed of 50% nannofossils and 50% clay, even though only 25% of the full column width is occupied by the symbol for nannofossil ooze.

Three minor, but genetically significant, mineral components encountered in Leg 126 cores were given special symbols, which appear within circles in the "Graphic Lithology" column. These were pyrite (Py), manganese oxides (Mn), and gypsum (Gy). Some of the sedimentary rocks in Leg 126 cores are hydrothermally altered. This is represented in the graphic column, as shown in the lower portions of Figure 4, by a special pattern that runs vertically along the right side of the column if the protolith is obvious, or by a pattern that occupies the full column if the original lithology could not be recognized.

Some cores recovered on Leg 126 have intercalations of sedimentary material and igneous rocks. Intervals described by igneous petrologists are indicated by the symbol "IM" (see "Hard-Rock Core Description Forms" section, this chapter).

Sediment Disturbance

The coring technique, which uses a 25-cm-diameter bit with a 6-cm-diameter core opening, results in varying degrees of mechanical disturbance of recovered core material. This is illustrated in the "Drilling Disturbance" column on the core description form (using the symbols in Fig. 5). Blank regions indicate a lack of drilling disturbance. Drilling disturbance is recognized in soft and firm sediments according to the following categories:

1. slightly deformed: bedding contacts are slightly bent;

2. moderately deformed: bedding contacts have undergone extreme bowing;

3. highly deformed: bedding is completely disturbed, sometimes showing symmetrical diapirlike or flow structures; and

soupy: intervals are water saturated and have lost all aspects of their original bedding.

The degree of fracturing in indurated sediments and igneous rocks is described by means of the following categories:

1. slightly fractured: core pieces are in place and contain little drilling slurry or breccia;

 moderately fragmented: core pieces are in place or partly displaced, but original orientation is preserved or recognizable (drilling slurry may surround fragments);



forms.

3. highly fragmented: pieces are from the interval cored and are probably in the correct stratigraphic sequence (although they may not represent the entire section), but the original orientation is completely lost; and

4. drilling breccia: core pieces have lost their original orientation and stratigraphic position and may be mixed with drilling slurry.

Sedimentary Structures

The symbols used to describe the primary biogenic and physical sedimentary structures, as well as secondary structures such as microfaults, dewatering veinlets, and mineral-filled fractures, are given in Figure 6. The symbols appear in the "Sed. Structure" column of the core description form.

Figure 6. Sedimentary structure symbols for sediments and sedimentary rocks used on Leg 126 core description forms.

A common structure in the sediments from Leg 126 is a decreasing concentration upward or downward of approximately equivalent-sized particles; it occurs above and below beds of vitric ash, where the ash concentration decreases into the overlying and underlying background sediment. Termed "fining upward" or "coarsening upward" (in deference to existing definitions), or reduction of particle abundance, this structure is interpreted to be the result of animal activity redistributing ash into the sediment (Bramlette and Bradley, 1942). Gradual fining and coarsening upward are also indicated within very thick sand/sandstone or gravel/conglomerate beds that may span several cores or sections.

Color

Colors were determined by comparison with the Munsell and Geological Society of America soil-color charts (Munsell Soil Color Charts, 1975). Colors were determined immediately after the cores were split because chemical changes may occur when deep-sea sediments are exposed to the atmosphere (Moberly and Klein, 1976). Information on core colors is given in the text of the "Lithologic Description" on the core description forms and, where appropriate, in the site chapters.

Samples

The locations of samples taken from each core for shipboard analysis is indicated in the "Samples" column on the core description form. The symbol "*" indicates the location of smear slide samples. The symbols "#," "XRD," and "XRF" indicate the location of samples for shipboard thin sections, X-ray diffraction analysis, and X-ray fluorescence analysis, respectively. The symbols "IW," "OG," and "PP" designate the location of samples for whole-round interstitial water geochemistry, frozen organic geochemistry, and physical properties analyses, respectively.

Although not indicated in the "Samples" column, the positions of samples for routine physical property (porosity [%], wet-bulk density [g/cm³], and geochemical [% CaCO₃]) analyses are indicated by a dot, and the analytical results are presented in the "Physical Properties" and "Chemistry" columns. Paleomagnetic results (normal and reversed polarity intervals) are indicated in the "Paleomagnetics" column.

Shipboard paleontologists generally base their age determinations on core-catcher samples, although additional samples from other parts of the core may be examined when required. An examination of such samples may lead to the recognition of zonal boundaries in the core; these are indicated in the appropriate column. All paleontological sample locations are indicated, even if they are barren.

Lithologic Description—Text

The lithologic description that appears on each core description form (barrel sheet) consists of two parts: (1) a heading that lists all the major sediment types (see "Sediment Classification" section, this chapter) observed in the core; and (2) a more detailed description of these sediments, including data on color, location in the core, significant features, etc. In cases where there are thin beds of minor lithology, a description including location information is included in the text, but the beds may be too thin (<10 cm) to appear in the graphic lithology column.

Smear Slide Summary

A table summarizing data from smear slides and thin sections (where available) appears on each core description form. The table includes the section and interval from which the sample was taken, whether the sample represents a dominant ("D") or a minor ("M") lithology in the core, and the percentage of sand, silt, and clay, together with all identified components (total 100%). As explained in the following section, these data are used to classify and name the recovered material.

SEDIMENTARY AND PYROCLASTIC ROCK CLASSIFICATION

The sediment and pyroclastic classification scheme used during Leg 126 is descriptive in that it uses composition and texture as the only criteria to define rock types. Such genetic terms as pelagic, hemipelagic, turbidite, debris flow, ash, lapilli tephra, etc., do not appear in this classification. A primary name is based upon, and named after, a component or components that constitute 60% or more of the material. This classification scheme differs from some prior DSDP and ODP classifications in the use of compositional modifiers.

Data for classifying sedimentary and pyroclastic materials come principally from shipboard visual analyses of smear slides that use a petrographic microscope. These are qualitative optical estimates of particle characteristics (mineralogy, biogenic type, grain size, relative particle abundance, etc.) and differ from quantitative analyses of grain size, carbonate content, and mineralogy. Discrepancies between operators as well as operator inconsistencies are to be expected with these procedures.

Composition and Texture

The term "clay" is used for clay minerals and terrigenous or pyroclastic material $< 4 \,\mu$ m in size without regard to origin. Biogenic components of silt or clay size are not described in textural terms. Thus, a sediment with 50% silt-size nannofossils and 50% terrigenous clay is called a nannofossil clay, not a nannofossil silt. The shipboard sedimentologists have chosen to use this classification (1) to maintain an internal consistency in the naming of intermediate mixtures of nonbiogenic and/or biogenic components, and (2) to provide simple descriptive modifiers that indicate the important components and their abundance in the deposits.

We have made a special effort to avoid genetic terminology in the naming of volcaniclastic sediments and pyroclastic materials. Therefore, we do not use terms otherwise employed by volcanologists, such as ash/tuff, lapilli tephra/tuff, and breccia. Instead, we use the size terms of Wentworth (1922; see Fig. 7) and then indicate composition with a modifier. The sediments may consist entirely of volcanic ejecta, but their genesis does not play a part in description and is instead discussed only in the interpretative sections of this volume.

Induration

The determination of induration is subjective. For calcareous sediments and calcareous sedimentary rocks, three classes of induration or lithification are recognized (Gealy et al., 1971): (1) soft = ooze, which has little strength and is readily deformed under the pressure of a finger or the broad blade of a spatula; (2) firm = chalk, which is partially lithified, readily scratched with a fingernail or the edge of a spatula; and (3) hard = well-lithified and cemented limestone or dolomite that is difficult or impossible to scratch with a fingernail.

For terrigenous sediments and pyroclastic rocks, lithified varieties are generally indicated by the addition of the suffix "-stone" to the name for soft materials. For gravels, however, the precise origin is generally unambiguous, so we use different terms for their lithified epiclastic and pyroclastic equivalents: "conglomerate" for epiclastic rocks, and "lapilli tuff" or "agglomerate" for pyroclastic rocks, depending on their grain size (lapilli = 4-64 mm diameter).

Rules for Classification

1. The principal name is determined by the component or group of components (e.g., total biogenic silica or biogenic carbonate) that constitute(s) at least 60% of the sediment or rock, except for subequal mixtures of biogenic and nonbiogenic material. The main components are as follows:

a. Nonbiogenic: If the total of a nonbiogenic component is >60%, the main name is determined by the relative proportions of sand, silt, and clay sizes when plotted on a modified Shepard (1954) classification diagram (Fig. 8). Examples of nonbiogenic principal names are *clay, silt, silty clay,* or *sand*. For nonbiogenic sediments that are composed mainly of primary volcanic particles, the modifiers "vitric" (for glassy fragments), "volcanic-lithic" (for polycrystalline volcanic grains), and "crystal"

MILL	IMETERS	μm	РНΙ (Ø)	WENTWORTH SIZE CLAS	SS
	2020		-20		
	4096		-12	Boulder (-8 to -12 Ø)	
	1024		-10		
	256		+ ⁸	Cobble (-6 to -8 Ø)	Ц
	64		† -6 —		AVE
	16		4	Pebble (-2 to -6 φ)	3R/
	4		+ ·2		0
	3.36		-1.75		
	2.83		-1.5	Granule	
	2.38		-1.25		
	2.00		-1.0 -		
	1.68		-0.75		
	1.41		-0.5	Very coarse sand	
	1.19		-0.25		
	1.00		0.0 -		
	0.84		0.25		
	0.71		0.5	Coarse sand	
	0.59		0.75		
1/2 -	- 0.50	- 500	1.0 -		
	0.42	420	1.25	100 CB 10	0
	0.35	350	1.5	Medium sand	N
	0.30	300	1.75		ŝ
1/4 —	-0.25	— 250 —	2.0 -		
	0.210	210	2.25		
	0.177	177	2.5	Fine sand	
100	0.149	149	2.75		
1/8 -	-0.125-	125	- 3.0 -		
	0.105	105	3.25		
	0.088	88	3.5	Very fine sand	
	0.074	74	3,75		
1/16-	- 0.0625 -	- 63	4.0		
	0.053	53	4.25		
	0.044	44	4.5	Coarse silt	
· 1.4 · 17/2010/10	0.037	37	4.75		
1/32 —	0.031	31	- 5.0 -	Madium alla	
1/64	0.0156	15.6	6.0	Fine silt	
1/128	0.0078	7.8	7.0	Very fine silt	0
1/256 -	0.0039	3.9	- 8.0	COLORA COLORADO	M
	0.0020	2.0	9.0		
	0.00098	0.98	10.0	Clay	
	0.00049	0.49	11.0		
	0.00024	0.24	12.0		
	0.00012	0.12	13.0		
	0.00006	0.06	14.0		

Figure 7. Grain-size categories used for classification of terrigenous sediments (after Wentworth, 1922).

(for unit crystals) may be used for clarity. These modifiers are placed immediately before the textural name; both the textural and compositional terms form the principal name.

b. Biogenic: If the total of the biogenic components is >60%, the principal name is *ooze*, or an appropriate term that denotes the sediment induration (see below).

c. Mixed sediments: In mixtures of biogenic and nonbiogenic material where neither component exceeds 60%, we have established a convention that the principal name will consist of two parts: (1) the name of the major fossil component(s), hyphenated if necessary with the least common fossil listed first, followed by (2) the textural name appropriate for the terrigenous/volcanogenic components (Fig. 8). For example, if nannofossils form 40%-60% of a sediment that contains nothing else but clay, then the name is nannofossil clay, even if nannofossils are somewhat more abundant than clay. 2. A component with an abundance of 30%-60% qualifies for major modifier status. Major modifiers are:

a. Nonbiogenic: silty, clayey, sandy, vitric-sandy, etc.

b. Biogenic carbonate: *nannofossil, foraminifer,* or *calcareous* (should be as specific as possible).

c. Biogenic silica: *diatom, radiolarian,* or *siliceous biogenic* (should be as specific as possible).

Note that for sediments containing from 40%-60% biogenic material, this rule is partly redundant with Rule 1c.

3. A component with an abundance of 10%-30% qualifies for minor modifier status and is hyphenated with the word *rich*. Example: nannofossil-rich clay; vitric-rich silty clay.

4. An unusual, important component that constitutes 5%-10% (e.g., bioclasts, zeolite, granules, large foraminifers) can be indicated with a minor modifier that consists of the component name hyphenated with the word *bearing*. Example: zeolite-bearing clay. This is an optional modifier.

5. The most abundant accessory component appears closest to the principal name. Major and minor modifiers are listed in order of decreasing abundance to the left of the principal name.

Example: foraminifer-rich nannofossil clay (10%) (30%) (60%)

BIOSTRATIGRAPHY

General Remarks

The general correlation between the biostratigraphic zones and the magnetic polarity reversal record, the seafloor magnetic anomalies, and an absolute time scale is based on the scheme of Berggren et al. (1985). Some minor changes are discussed in the individual sections for each fossil group.

Age assignments are based mainly on core-catcher samples. Additional samples were studied when the core-catcher samples were found to be barren or restricted to narrow time intervals, or where boundaries or unconformities occur. Sample locations, preservation, and abundance for each fossil group are indicated on the barrel sheets.

Calcareous Nannofossils

The calcareous nannofossil zonations of Okada and Bukry (1980) and Sato et al. (1988) were used to identify nannofossil zones. The Pliocene/Pleistocene boundary is approximated by the first occurrence (FO) of *Gephyrocapsa oceanica* (Backman, Duncan, et al., 1988). The Oligocene/Miocene boundary is defined by the last occurrence (LO) of *Sphenolithus ciperoensis* or *Reticulofenestra bisecta* (at the top of Subzone CP19b). A list of nannofossil datums and ages, based on Berggren et al. (1985) and Backman, Duncan, et al. (1988), is given in Table 1.

Abundance and Preservation

Smear slides were prepared from all samples for the examination of calcareous nannofossils. The abundance of nannofossils was estimated as follows:

- A = abundant (>10 specimens/field of view),
- C = common (1-10 specimens/field of view),
- F = few (1 specimen/2-10 fields of view), and
- R = rare (1 specimen/>10 fields of view).

The state of preservation was estimated as:

G = good (minor or no signs of dissolution and/or overgrowth),









Silty sand, sandy silt

Muddy sand

Sandy mud

Clayey sand, sandy clay

T9 Clayey silt, silty clay

Gravel

SR2

TR

Conglomerate and breccia

Agglomerate, and breccia

Hydrothermally altered sedimentary rock

Figure 8. Textural classification scheme for clastic sediments and rocks; procedure for naming mixtures of biogenic and terrigenous/volcanogenic materials; and graphic symbols for lithologies, used on core description forms (barrel sheets; see Fig. 4, this chapter). The textural classification scheme is modified from Shepard (1954) by subdivision of the central triangular field into muddy sand and sandy mud. The sand-, silt-, and clay-sized fractions are defined according to the Wentworth (1922) grade scale. Asterisks indicate an unusual component, such as zeolite, that is present in amounts of 5%-10%, which give a sediment or rock the initial modifier "*-bearing," as in "zeolite-bearing silt-stone."

Table 1. List of calcarous nannofossil datums and associated ages for the Eocene to Pleistocene.

Event	Species	Age (Ma)
FO	Emiliania huxleyi	0.27
LO	Pseudoemiliania lacunosa	0.46
LO	Helicosphaera sellii	1.37
LO	Calcidiscus macintyrei	1.45
FO	Gephyrocapsa oceanica	1.6*
LO	Discoaster brouweri	1.89
LO	Discoaster pentaradiatus	2.35
LO	Discoaster surculus	2.41
LO	Discoaster tamalis	2.65
LO	Sphenolithus spp.	3.45
LO	Reticulofenestra pseudoumbilica	3.56
FO	Pseudoemiliania lacunosa	3.7
LO	Amaurolithus tricorniculatus	3.7
FO	Discoaster asymmetricus	4.1
LO	Amaurolithus primus	4.4
FO	Ceratolithus rugosus	4.6*
LO	Ceratolithus acutus	4.6*
FO	Ceratolithus acutus	4.9
LO	Triauetrorhabdulus rugosus	4.9
LO	Discoaster quinqueramus	5.5
FO	Amourolithus primus	6.5
FO	Discoaster herogranii	82
FO	Discoaster neorectus	8.5
FO	Discoaster loeblichii	8.5
10	Discoaster hamatus	8.9
FO	Catinaster calvculus	10.0
FO	Discoaster hamatus	10.0
FO	Catinaster coalitus	10.8
FO	Discoaster kugleri	11 5*
10	Sphenolithus heteromorphus	13.2*
10	Helicosphaera ampliaperta	16.2
FO	Sphenolithus heteromorphus	18.6*
LO	Sphenolithus belemnos	18.6*
FO	Sphenolithus belemnos	20.5*
FO	Discoaster druggii	23.2
LO	Reticulofenestra bisecta	23.7
LO	Sphenolithus cineroensis	25.2
IO	Sphenolithus distentus	28.2
FO	Sphenolithus cineroensis	30.2
10	Reticulofenestra umbilica	33.8*
LO	Coccolithus formosus	34.9*
LO	Discoaster saipanensis	36.7*
LO	Discoaster harhadiensis	37.0*
FO	Isthmolithus recurvus	37.8
FO	Chiasmolithus oamaruensis	39.8
LO	Chiasmolithus grandis	40.0
LO	Chiasmolithus solitus	42.3
FO	Reticulofenestra umbilica	44.4
LO	Nannotetrina fulgens	45.4
LO	Chiasmolithus gigas	47.0
FO	Chiasmolithus gigas	48.8
FO	Nannotetrina fulgens	49.8
LO	Discoaster lodoensis	50.4*
FO	Discoaster sublodoensis	52.6
LO	Tribrachiatus orthostylus	53 7
FO	Discoaster Iodoensis	55.3
LO	Tribrachiatus contortus	56 3
FO	Discoaster diastynus	56.5
	2. activities and stypus	2012

Note: FO = first occurrence and LO = last occurrence. The list is based on Berggren et al. (1985) and Backman, Duncan, et al. (1988), with the latter marked by an asterisk. The FO of *Pseudoemiliania lacunosa* is based on Knüttel (1986).

- M = moderate (slight to moderate dissolution and/or overgrowth), and
- P = poor (severe dissolution and/or heavy overgrowth).

Planktonic Foraminifers

For correlations among the biostratigraphic zones, the magnetic reversal record, and the absolute time scale, Blow's (1969) zonal scheme was used. The correlations of planktonic foraminifer datums to magnetic polarity stratigraphy summarized by Berggren et al. (1985) were adopted in this study (Table 2).

Abundance and Preservation

For abundance estimates of planktonic foraminifer species, the following scale was used:

- B = barren (no foraminifers),
- R = rare (1-5 tests in the residue),
- F = few (6–11 tests in the residue),
- C = common (12-25 tests in the residue), and
- A-VA = abundant to very abundant (>26 tests in the residue).

Preservational characteristics were divided into three categories:

Good: >90% of specimens unbroken and minor signs of dissolution or fragmentation,

Moderate: 30%-90% of specimens show dissolution effects (sugary white texture, broken chambers, preservation of only the most resistant structures), and

Poor: samples dominated by fragments and partially dissolved chambers.

Sample Preparation

Samples were disaggregated in a 30% hydrogen peroxide solution and then washed through a 63- μ m sieve. For consolidated sediments, the following procedure was used: the sample was (1) covered with 30% H₂O₂ for 10–14 hr in an oven at around 40°C; (2) decanted; (3) covered with kerosene for 4–6 hr; (4) decanted; (5) covered with H₂O for several hours in an oven at 50°-100°C; (6) decanted; and (7) wet sieved through a 250-mesh screen (63 μ m).

Benthic Foraminifers

The biostratigraphic determination of deep-water benthic foraminifer assemblages follows Kaiho (in press). Several large turnovers in deep-water faunas occurred during the Cenozoic: near the Paleocene/Eocene boundary (e.g., Tjalsma and Lohmann, 1983), near the middle/late Eocene boundary (e.g., Tjalsma and Lohmann, 1983), and near the middle middle Miocene (e.g., Woodruff and Douglas, 1981; Woodruff, 1985). Kaiho (in press) studied benthic foraminifers from DSDP samples of Cenozoic age from the world oceans and Paleogene samples from New Zealand and divided the Cenozoic into the following four zones in accordance with these turnovers.

Event	Species	Benthic foraminifer zone	Age
		CD4	estador maior
FO	Cibicidoides		middle middle
	wellerstorfi	CD1	Miocene
LO	Nuttallides	CDS	middle/late
	truempyi		Eocene
		CD2	
LO	Stensioina		Paleocene/
	beccariiformis		Eocene
		CD1	

Paleobathymetry

Paleobathymetric determinations were estimated by benthic foraminifers following Ingle (1980), Woodruff (1985), Kaiho and Hasegawa (1986), Van Morkhoven et al. (1986), Akimoto (1989), and Yasuda (1989).

Table 2. List of planktonic foraminifer species datums, zonal boundaries, and associated ages.

Event	Species	Zonal boundary	Age (Ma)
LO FO	Globigerinoides fistulosus Globigerina calida calida	N23/N22	1.6 ?
Pliocene/P	leistocene boundary		
FO	Globorotalia truncatulinoides	N22/N21	1.9
LO	Globoquadrina altispira		2.9
FO	Globigerinoides fistulosus		2.9
LO	Sphaeroidinellopsis spp.		3.0
FO	Globorotalia inflata		3.0
FO	Globorotalia tosaensis	N21/N19	3.1
LO	Pulleniatina primalis		3.5
FO	Sphaeroidinella dehiscens	N19/N18	5.1
FO	Globorotalia tumida	N18/N17	5.2
Miocene/P	liocene boundary		
FO	Globigerinoides conglobatus		5.3
LO	Globoquadrina dehiscens		5.3
FO	Pulleniatina primalis	N17b/N17a	5.8
FO	Globorotalia plesiotumida	N17/N16	8.0
FO	Neogloboquadrina acostaensis	N16/N15	8.6
LO	Globorotalia siakensis	N15/N14	10.4
FO	Globigerina nepenthes	N14/N13	11.3
FO	Sphaeroidinellopsis subdehiscens	N13/N12	11.8
FO	Globorotalia fohsi	N12/N11	13.5
FO	Globorotalia praefohsi	N11/N10	14.0
FO	Globorotalia peripheroacuta	N10/N9	14.6
FO	Orbulina suturalis	N9/N8	15.2
FO	Praeorbulina sicanus	N8/N7	16.3
LO	Catapsydrax dissimilis	N7/N6	17.6
FO	Globigerinatella insueta	N6/N5	17.9
FO	Globorotalia kugleri Globorotalia kugleri	N5/N4 N4/P22	20.1
Oligocene/	Miocene boundary		
10	Paraelahanatalia mandaais		22.7
EO	Globigarinoidas primordius		23.1
10	Paragloborotalia opima	D21/D22	24.3
10	Strentochilus cubensis	P21a/P21b	30.0
10	Globigering ampliaperturg	P20/P21	32.8
LO	Pseudohastigerina	P19/P20	34.0
Eocene/Oli	gocene boundary		
10	hantkeninids. Globigerinatheka	P17/P18	36.6
FO	Globigering tanuriensis		36.6
LO	Turborotalia cerroazulensis group		36.7
LO	Globigerinatheka semiinvoluta		37.6
LO	Acarinina	P14/P15	40.6
LO	Morozovella spinulosa		41.1
FO	Globigerinatheka semiinvoluta		41.3
LO	Subbotina frontosa		42.0
LO	Globigerinatheka beckmanni	P13/P14	43.0
LO	Acarinina bullbrooki		43.0
FO	Turborotalia pomeroli		44.7
FO	Globigerinatheka index		45.0
FO	Morozovella lehneri	P11/P12	46.0
LO	Morozovella aragonensis	P11/P12	46.0
FO	Hantkenina	P9/P10	52.0
FO	Morozovella aragonensis	P7/P8	55.2
FO	Morozovella formosa	P6/P7	56.1
Paleocene/I	Eocene boundary		
LO	Morozovella velascoensis		57.8
LO	Planorotalites pseudomenardii	P4/P5	58.8
FO	Planorotalites psuedomenardii	P3/P4	61.0
FO	Morozovella velascoensis	200 - 1020201	61.7
FO	Morozovella pusilla	P3a/P3b	62.0
FO	Morozovella conicotruncata	P3a/P3b	62.0
LO	Morozovella angulata	P2/P3	62.3

Note: The list is based on Berggren et al. (1985).

Dissolved Oxygen in Deep Water

Predominant morphologies of benthic foraminifers found in poorly oxygenated deposits differ from those present in highly oxygenated deposits. Therefore, the morphologies of benthic foraminifer tests were used to infer relative amounts of dissolved oxygen in Cenozoic deep-sea bottom water. All the calcareous benthic foraminifers were classified into three categories: aerobic, anaerobic, and intermediate forms (Kaiho, in press). Ratios of aerobic vs. aerobic plus anaerobic forms were calculated as estimates of changes in the oxygen content of deep oceanic waters.

Abundance and Preservation

For abundance estimates of benthic foraminifers, the following scale was used:

В	=	barren (no foraminifers),
R	=	rare (<1 specimen/10 cm ³),
F	=	few (1-10 specimens/10 cm ³),
С	=	common (10-100 specimens/10 cm3), and
A	=	abundant (>100 specimens/10 cm ³).

Preservational characteristics were divided into three categories:

Good: >90% of specimens unbroken,

Moderate: 30%-90% of specimens showing dissolution effects, and

Poor: samples dominated by fragments and partially dissolved chambers.

Sample Preparation

Samples approximately 20 cm³ in volume were washed through a 250-mesh screen ($63-\mu$ m opening) and dried. Unconsolidated sediments were soaked in water, and, when necessary, disaggregation was aided by the addition of small amounts of hydrogen peroxide. Hydrogen peroxide was also routinely added to more consolidated sediments. Kerosene was used to disaggregate highly consolidated sediments.

Radiolarians

The Cenozoic radiolarian zonation of Sanfilippo et al. (1985), derived for the tropical equatorial Pacific, was used at all sites. Sanfilippo et al. (1985) summarized the taxonomy and evolutionary lineages of all stratigraphically important radiolarian taxa commonly found in low-latitude regions of this zonation. In suggesting tentative "absolute" ages for radiolarian datum levels and zonal boundaries, the schemes of Nigrini (1985) and Barron et al. (1985), established on the basis of DSDP Leg 85 sites in the equatorial Pacific, were followed (Table 3).

The Quaternary biostratigraphic datums listed by Foreman (1981) were also used. Although much of the material obtained on Leg 85 could not be directly dated paleomagnetically, there were sufficient duplicate sites in which all major microfossil events could be identified, some of which had been correlated to the polarity time scale in nearby piston cores. Thus, the ages of Pacific radiolarian events estimated by Foreman (1981), Nigrini (1985), and Barron et al. (1985) provided a satisfactory working model.

Abundance

Qualitative assessments of the abundance (abundant, common, few, rare, trace, absent) and preservation (good, moderate, poor) of radiolarians in each slide were recorded. In assessing the relative abundances of individual taxa, the following semiquantitative criteria were used: Abundant: >20% (of the total assemblage), Common: 5%-20% (of the total assemblage), Few: 1%-5% (of the total assemblage), Rare: 0.1%-1% (of the total assemblage), Trace: <0.1% (of the total assemblage), and Absent: not found in an examination of the slide.

Sample Preparation

To obtain clean radiolarian concentrates for microscopic examination, the sediments were disaggregated, sieved to remove the clay-silt fraction, and acidified to eliminate the calcareous components. A 5-cm³ sample was placed in a 400-cm³ beaker containing 150 ml of 10% hydrogen peroxide and a small amount of calgon (to aid in disaggregating the sediment). If calcareous components were evident, they were dissolved by adding hydrochloric acid. The residue was sieved through a $63-\mu m$ sieve, and the remaining siliceous microfossils were pipetted evenly onto labeled glass slides. The accompanying water was then evaporated under a heat lamp, after which the remaining residue was mounted in a suitable medium (in this instance, Norland Optical Adhesive) and covered with a 22 \times 50-mm cover slip. One slide was prepared and examined for each sample. The wet residue was retained in the event that reexamination of the material proved to be necessary.

PALEOMAGNETISM

Paleomagnetic studies performed on board JOIDES Resolution included measurements of remanent magnetization and magnetic susceptibility of sedimentary, igneous, and metamorphic material. The measurement of remanence was generally accompanied by alternating field (AF) or thermal demagnetization to remove secondary magnetizations.

Instruments

Two magnetometers, a Molspin spinner magnetometer and a 2-G Enterprises (Model 760R) pass-through, cryogenic, superconducting rock magnetometer, were routinely available for the measurement of remanence on board *JOIDES Resolution*. An AF demagnetizer (Model 2G600) capable of alternating fields up to 25 mT was on line with the cryogenic magnetometer. Both were controlled by a FASTCOM4 multiserial communication board in an IBM PC-AT compatible computer. To measure the archive half of the core, Leg 126 paleomagnetists used a BASIC program (126CORE) modified from the SUPERMAG program written by M. Koyama and C. Helsley during Legs 124E and 126.

The spinner magnetometer was controlled by a Digital PRO350 computer and was used only to measure individual discrete samples. In addition to these two standard sample magnetometers, a prototypic, portable, fully automatic spinner (FAS) magnetometer with a built-in AF demagnetizer (maximum field = 50 mT) and magnetic susceptibility anisotropy meter, was available for discrete sample measurement on Leg 126. This instrument was designed and built by N. Niitsuma and M. Koyama of Shizuoka University.

The superconducting quantum interference device (SQUID) sensors in the cryogenic magnetometer measure magnetization over an interval approximately 20 cm long. Each axis has a slightly different response curve. The widths of the sensor regions imply that as much as 150 cm^3 of core contributes to the sensor signals, thereby blurring sharp magnetic transitions. The large volume of core material within the sensor region permits an accurate determination of remanence for weakly magnetized samples despite the rather high background noise related to the motion of the ship. The SQUID electronics operate at the $1 \times$ scale and use the flux-counting mode for most measurements.

Remanent Magnetization Measurements

The maximum AF demagnetizing field allowed for sections from the archive half is either 15 mT or the median destructive field, whichever is lower. Discrete samples from the working half of the core were demagnetized with the Schonstedt GSD-1 AF demagnetizer and the TSD-1 thermal demagnetizer as well as the AF demagnetizer that is built into the automatic spinner magnetometer.

Sediments

Remanence measurements of sediments were performed by passing continuous archive-half core sections through the cryogenic magnetometer. Measurements of NRM before and after AF demagnetization were generally taken at 3- and 5-cm intervals. At reversal boundaries, high-density measurements at 0.5cm intervals, at varying AF demagnetization levels, were performed. Because measurements are averaged over the broad response regions of the three sensors, deconvolution is required to recover highly detailed changes of magnetization. This work will be done during shore-based studies.

Discrete samples were taken from APC, XCB, and RCB sediment cores by pressing a standard plastic sampling box (7 cm³) into the soft core material. The uphole direction was marked on the box. For more consolidated sediments, cubes were cut out with a spatula or minicores were cut with a drill press. Up to three discrete samples per section were taken from APC, XCB, and RCB working cores when the archive half gave a consistent paleomagnetic signal, except at certain reversal boundaries, where an even greater sampling density was employed. Azimuthal orientation of discrete samples from selected XCB and RCB core intervals was attempted by noting bedding and structural feature dip directions, when detectable, in sample coordinates. These directions were referenced to the dip directions indicated by seismic profiles or to compass-oriented bedding and fracture-dip directions, as determined by the downhole formational microscanner, so as to derive field-coordinate directions.

Igneous and Metamorphic Rocks

Drilled minicores (1-in. diameter) of the igneous portions of the cores were obtained to determine the polarity of the various "hard rock" units encountered during drilling. Archive-half sections that contained igneous rock pieces >20 cm in length were measured in the cryogenic magnetometer at 5-cm intervals.

Magnetic Stratigraphy

The magnetostratigraphic time scale of Berggren et al. (1985) was adopted for use during Leg 126.

Magnetic Susceptibility Measurements

Magnetic susceptibility measurements were routinely made on all cores employing a Bartington Instrument magnetic susceptibility meter (model M.S.1) with a M.S.1/CX 80 mm wholecore sensor loop set at 0.47 kHz. The susceptibility meter was on line with the GRAPE, and the PWL with the MST. Because the susceptibility of most core material on Leg 126 was high, all measurements were made in the low-sensitivity mode. In addition to characterizing the cored sediments, susceptibility data were used for correlation among holes and sites. The correlation of susceptibility data was performed by observing peak-to-peak spacings and general trends in the susceptibility curve.

PETROLOGY

Core Curation and Shipboard Sampling

As standard procedure, basement rocks recovered during coring were examined by petrologists to determine where the core

Table 3. List of radiolarian species datums and zones,	and associated ages.
Approximate Top or	

Zone	age	bottom	Species
R invasinata	0		
D. Invaginara	0.17	в	Buccinosphaera invaginata
C. tuberosa	0.42	Т	Stylatractus universus
	- 0.45	В	Collosphaera tuberosa ————
	0.70	T	Pterocorys campanula
A. ypsilon	0.74	1 D	Anthocyrtidium nosicaae
	0.85	B	Antocyrtidium euryclathrum
	- 1.00	т	Anthocyrtidium angulare
	1.15	в	Lamprocyrtis nigriniae
A. angulare	1.15	Т	Lamprocyrtis neoheteroporus
	1.50	T	Anthocyrtidium michelinae
	- 1.55	T	Pterocanium prismatium —
	1.60	в	Anthocyrtialum angulare
P. prismatium	2.35	T	Anthocyrtidium ienghisi
	2.47	B	Pterocorys sabae
	2.5	в	Theocorythium trachelium
	- 2.6	Т	Stichocorys peregrina —
	3.27	T	Phormostichoartus fistula
	3.35	T	Lychnodictyum audax
	3.33	1 P	Amphishonglum unsilon
S. pentas	3.80	D T	Spongaster pentas
	3.80	B	Spongaster tetras
	3.88	Ť	Anthocyrtidium prolatum
	4.3	т	Solenosphaera omnitubus
	- 4.45		S. berminghami → S. pentas
	4.6	B	Pterocanium prismatium
S. peregrina	5.5	T	Acrobotrys tritubus
	2	1	Calocycletta caepa
	- 64	1	Suphostichartus corona S. delmontensis \rightarrow S. peregring
123 10000000000000	6.8	B	Solenosphaera omnitubus
D. penultima	6.9	5	D. antepenultima \rightarrow D. penultima
	- 7.0	Т	Diartus hughesi
		в	Spongaster berminghami
D. antepenultima	12.3	T	Dictyocoyne ontongensis
	7.6	в	Acrobotrys tritubus
	8.6	1	D petterssoni → D hughesi
	0.0		D. laticonus \rightarrow D. antepenultima
			L. neotera \rightarrow L. bacca
		Т	Cyrtocapsella japonica
		Т	Lithopera thornburgi
B	11.4	T	Cyrtocapsella tetrapera
D. petterssoni	11.4	T	Cyrtocapsella cornuta
		B	Carpocanopsis cristata Phormostichoartus doliolum
		т	Dorcadospyris alata
		T	Stichocorys wolffii
		в	Cyrtocapsella japonica
	- 11.5	в	Diartus petterssoni
			L. renzae \rightarrow L. neotera
		B	Lithopera thornburgi Phormostishoastur, corbula
		т	Dorcadospyris alata
		Ť	Calocycletta virginis
D. alata		Ť	Carpocanopsis bramlettei
		Т	Calocycletta costata
		Т	Didymocyrtis violina
		Т	Didymocyrtis tubaria
		B	Lithopera renzae
	16.2	1	D dentata $\Rightarrow D$ clata
	- 15.5	т	Eucyrtidium dianhanes
		Ť	Carpocanopsis cingulata
		в	Siphostichartus corona
C. costata	16.2	Т	Didymocyrtis prismatica
		в	Carpocanopsis cristata
	00000	Т	Carpocanopsis favosa
	16.5	T	Lychnocanoma elongata
ing the second	- 17.3	B	Calocyclella costala
S. wolffii	17.3	B	Calocycletta caepa
		D	Calocycletta caepa

Note: The list is based on Barron et al. (1985) and Nigrini (1985).

Table 3 (continued).

Zone	Approximate age	lop or bottom	Species
	- 18.2	в	Stichocorys wolffii
	20.2	T	Dorcadospyris ateuchus
S. delmontensis	20.3	B	Didymocyrtis tubaria
	21.1	B	Stichocorvs delmontensis
	- 21.3	T	Theocyrtis annosa
		в	Carpocanopsis bramlettei
		Т	Calocycletta serrata
C tetranera	21.5	В	Calocycletta virginis
e. tetrapera	21.9	1.22	C. pegetrum \rightarrow C. leptetrum
		B	Botryostrobus miralestensis
	22.1	B	Carpocanopsis cingulata
	- 22.1	B	Cyrtocapsella cornuta
	22.1	B	Carpocanopsis favosa
L. elongata		B	Calocycletta serrata
	22.6	T	Artophormis gracilis
	22.6	Т	Dorcadospyris papilio
	- 24.1	В	Lychnocanoma elongata —
		в	Carpocanopsis cingulata
		B	Dorcadospyris forcipata
D		T	Lithocyclia angusta
D. aleuchus		B	Dorcadospyris papilio
		Б	Lithocyclia crux
		Ť	Theocyrtis tuberosa
	- 33.0		T. triceros \rightarrow D. ateuchus
	0010	В	Didymocyrtis prismatica
		в	Lychnodictyum audax
T. tuberosa			A. barbadensis \rightarrow A. gracilis
		Т	Dictyoprora mongolfieri
	101010	в	Lithocyclia crux
	- 36.0		L. aristotelis → L. angusta —
		T	Calocylas turris
		1	Lychnocanoma banayca Thurseourtis bromia
		T	Thyrsocyrtis lochites
		Ť	Thyrsocyrtis tetracantha
		Ť	Thyrsocyrtis triacantha
T. bromia		T	Carpocanistrum azyx
		т	Eusyringium fistuligerum
		Т	Podocyrtis goetheana
		В	Lychnocanoma bandyca
		T	Podocyrtis chalara
		B	Calocyclas turris
	- 41.0	B	Carpocanistrum azyx —
		B	Thyrsocyrtis tetracantha
P soetheana		т	Theocotylissa ficus
1. goeineana		Ť	Sethochytris triconiscus
		1	L. ocellus \rightarrow L. aristotelis
	- 42.0	в	Podocyrtis goetheana
		Т	Podocyrtis trachodes
P. chalara		Т	Phormocyrtis striata striata
		В	Tristylospyris triceros
	- 43.0		P. milra → P. chalara
		в	Cryptoprora ornata Podocurtis ampla
		T	Fusyringium lagena
P mitra		B	Artophormis barbadensis
1. //////		B	Thyrsocyrtis lochites
		B	Sethochytris triconiscus
		Т	Podocyrtis fasciolata
	- 45.0		P. sinuosa → P. mitra
		В	Podocyrtis trachodes
100000000			E. lagena \rightarrow E. fistuligerum
P. ampla		Т	Podocyrtis dorus
		B	Podocyrtis fasciolata
	AC 8	1	I neocolyle venezuelensis
	- 40.5	т	P. physis → P. ampla
		T	Theocotyle conica
			P. diamesa \rightarrow P. physis
T. triacantha		т	Theocorys anaclasta
		Ť	Thyrsocyrtis hirsuta
		т	Thyrsocyrtis robusta
		10	T tonsa $\rightarrow T$ triacantha
			1. lensu · 1. linucuninu

Zone	Approximate age	Top or bottom	Species
D. mongolfieri		В	Podocyrtis dorus T. cryptocephala \rightarrow T. conica
		Т	Calocycloma castum
	- 49.0	в	Dictyoprora mongolfieri —
			P. aphorma $\rightarrow P. sinuosa$
		в	Thyrsocyrtis robusta
I. cryptocephala		в	Theocotyle venezuelensis
		т	Burvella clinata
	- 50.0		T. nigriniae \rightarrow T. cryptocephala —
		т	Podocyrtis platypus
		т	Lamptonium sanfilippoae
		B	Thyrsocyrtis rhizodon
P. striata striata		B	Podocyrtis platypus
		B	Podocyrtis diamesa
		B	Podocyrtis aphorma
			Phormocyrtis striata exauisita $\rightarrow P$ striata striata
	- 51.0	B	Theocorys anaclasta
		T	Theocotylissa fimbria
		Ť	Pterocodon ampla
		Т	Bekoma bidartensis
		Т	Burvella tetradica
		Ť	Thyrsocyrtis tarsines
B. clinata		B	Lithocyclia ocellus
		B	Thyrsocyrtis tensa
			T. alpha \rightarrow T. ficus
		в	Lamptonium sanfilippoae
		B	Theocotyle nigriniae
		B	Thyrsocyrtis hirsuta
	- 52.5		P. anteclinata \rightarrow B. clinata
		в	Theocotylissa fimbria
a		-	T. auctor \rightarrow T. alpha
B. bidartensis		В	Calocycloma castum
			Lamptonium pennatum \rightarrow L. fabaeforme fabaeforme
	- 55.5	B	Bekoma hidartensis

Table 3 (continued).

should be split that would best preserve unique features and/or to expose important structures. The core was split into archive and working halves using a rock saw with a diamond blade. Care was always taken to ensure that orientation was preserved during splitting and prior to labeling, usually by marking the original base of each piece with red crayon. Each piece was numbered sequentially from the top of each section on the top, uncut surface of the rock. Pieces that could be fitted together (reassembled like a jigsaw puzzle) were assigned the same number, but lettered consecutively (e.g., 1A, 1B, 1C, etc.).

Plastic spacers were placed between pieces with different numbers, but not between those with different letters and the same number. The presence of a spacer may or may not represent a substantial interval of no recovery. When the original unsplit piece was sufficiently long, such that the top and bottom could be distinguished before removal from the core liner (i.e., the piece could not have rotated top to bottom about a horizontal axis in the liner during drilling), an arrow was added to the label pointing to the top of the section. Because pieces were free to turn about a vertical axis during drilling, azimuthal orientation was not possible.

After the core was split, the working half was sampled for shipboard physical properties, magnetics, XRF, XRD, and thinsection studies. These samples were often of minicores and, when appropriate, were stored in seawater prior to measurement. When recovery permitted, samples were taken from each lithologic unit. The archive half was described on the visual core description (VCD) form, which is used for such nondestructive physical properties measurements as magnetic susceptibility, and was photographed before storage.

Visual Core Descriptions

Igneous VCD forms were used in the description of the igneous rock cores (Fig. 9). In Figure 9, the left column is a graphic representation of the archive half. A horizontal line across the entire width of the column denotes a plastic spacer glued between rock pieces inside the liner. Oriented pieces are indicated on the form by an upward-pointing arrow to the right of the piece. Shipboard samples and studies are indicated on the VCD in the column headed "shipboard studies," using the following notations: XRD = X-ray diffraction analysis, XRF = X-ray fluorescence analysis, TSB = petrographic thin section, and PP = physical properties analysis.

Because igneous and metamorphic rocks were classified mainly on the basis of macroscopic mineralogy and texture, shipboard petrologists followed a checklist of features that ensured consistent and complete descriptions. To this end, VCDs were entered directly into a computerized database (HARVI). The describer is prompted by the HARVI program with a set of questions pertaining to petrologic features that must all be diagnosed and entered in the database. The descriptions on the VCD forms will, to a certain extent, reflect the rigidity of the HARVI program. It is relevant, therefore, to discuss the organization of the database briefly. Fine-grained rocks were entered into a data set called HARVI-F, and coarse-grained rocks were entered into the data set HARVI-C. Each record was checked by the database program for consistency, and a hard copy was printed in a format that resembles the final barrel sheets. The "clean-copy" print-out was directly pasted onto a copy of the barrel sheet for subsequent curatorial record keeping.



126-793B-1R-1

UNIT II: DIABASE

Pieces 1-7

CONTACTS: Upper baked; lower chilled.

- PHENOCRYSTS: In glomeroporphyritic clots and at lower chilled margin. Olivine 5-7%; 1-3 mm; subhedral; altered to smectite.

 - Clinopyroxene 2-15%; 2-6 mm; euhedral; twinned, with exsolution lamellae.

Orthopyroxene - 1%; 1-2 mm; sometimes rounded. GROUNDMASS: Plagioclase (41%, 0.1-0.5 mm); clinopyroxene (18%, 0.1-0.5 mm); orthopyroxene (<1%, 0.1 mm); opaque (4%, 0.05-0.5 mm); glass (26%); vesicles (8%). VESICLES: 8%; 0.1 mm; equant; random.

Miaroles: In bands and inclusions. COLOR: Gray.

STRUCTURE: Sill.

ALTERATION: Smectite. VEINS/FRACTURES: 1%; 5-10 mm; subhorizontal; roughly at 10 cm spacing.



Figure 9. Sample visual core description (VCD) form used for metamorphic and igneous rocks.

When describing sequences of fine- to coarse-grained rocks, the core was subdivided into lithologic units according to the criteria of changes in petrographic types, mineral abundances, and rock-clast types. For each lithologic unit, section, and rock type, the following information was recorded as appropriate using the HARVI system:

A.1. Leg, site, hole, core number and type, and section.

A.2. Unit number (consecutive downhole), position in the section, number of pieces of the same lithologic type being described, the name of the describer, and rock name.

A.3. Color of the rock according to the Munsell chart (recorded when the rock piece was dry) as well as the presence of layering and deformation and the character of each.

A.4. The number of mineral phases and their distribution within the unit. For each mineral phase, abundance, average size in millimeters, shape, the degree of alteration, and any additional comments were given.

A.5. Groundmass texture: glassy, microcrystalline, finegrained (<1 mm), medium-grained (1–5 mm), or coarse-grained (>5 mm). Relative grain size changes within the unit (e.g., coarsening from Pieces 1 to 5) were also noted.

A.6. Presence of alteration and characteristics, including structures imposed during the formation of secondary minerals, type of alteration and abundance, and abundance of secondary minerals.

A.7. Vesicles: percentage abundance, distribution, size, shape, and fillings and their relationships (including proportion of vesicles that were filled by alteration minerals).

A.8. Structure: massive flow, pillow lava, thin flow, breccia, hyaloclastite, etc., and comments.

A.9. Alteration: fresh (< 2%), slight (2%-10%), moderate (10%-40%), high (40%-80%), very high (80%-95%), or complete (95%-100%). The type, form, and distribution of the alteration were also given.

A.10. Veins/Fractures: percent present, width, orientation, fillings, and relationships. The relationship of the veins and fractures to the alteration was also noted.

A.11. Comments: appropriate notes on the continuity of the unit within the core and the interrelationship of units.

Basalts are termed aphyric, sparsely phyric, moderately phyric, or highly phyric, depending upon the proportion of phenocrysts visible with the hand lens or binocular microscope (approximately 10X). Basalts were called aphyric if phenocrysts clearly amounted to <1% of the rock, sparsely phyric if they ranged from 1% to 2%, moderately phyric if 2%-10%, and highly phyric if phenocrysts amounted to >10% of the rock. Basalts were further classified by phenocryst type (e.g., a moderately plagioclase-olivine phyric basalt contains 2%-10% phenocrysts, mostly plagioclase, with subordinate olivine).

During Leg 126, the following volcanic rock names were used for the initial core descriptions. *Basalts* have any combination of olivine, augite, and plagioclase phenocrysts. *Andesites* differ in that they have essential orthopyroxene and plagioclase phenocrysts plus or minus augite and olivine. *Dacites* and *rhyolites* were not distinguished from each other petrographically. They differ from andesites either by containing essential quartz or by lacking orthopyroxene. *Boninites* lack plagioclase and have more orthopyroxene than clinopyroxene or olivine.

More specific nomenclature was determined from chemical analyses. For consistency, we used the MgO-SiO₂ fields adopted during Leg 125. However, we did name some fields differently (Fig. 10) to avoid using "picrite" for pyroxene-rich basalts and "boninite" for plagioclase-rich rocks. Broadly speaking, the "high-Mg series" corresponds to the "low-Ca boninitic series" of Crawford et al. (1989), and our "low-Mg series" corresponds



Figure 10. Nomenclature used to describe volcanic rocks recovered during Leg 126.

to the island-arc tholeiitic series of Jakes and Gill (1970). (However, the low-Mg series can be calcalkaline, low- to high-K, and low- or high-Al in detail.) Because of the delay that occurred between the initial core descriptions and the later chemical analyses, there are discrepancies between the lithostratigraphic and geochemical sections of this report. The geochemical classification is preferred.

Serpentinized rocks were classified on the basis of the original phase proportions present in the protolith, using the IUGS classification system for ultramafic rocks. For example, "serpentinized dunite" is a rock with >90% modal olivine originally present that has some specified proportion of serpentinization.

Synoptic versions of the Leg 126 igneous/metamorphic VCD forms are published with this volume and are available on microfilm at all three ODP repositories.

Thin-Section Descriptions

Thin-section billets of basement rocks were examined to (1) confirm the identity of petrographic groups in the cores; (2) understand the textures and interrelationships of the mineral phases better; (3) help define unit boundaries indicated by hand-specimen core descriptions; and (4) define the secondary alteration mineralogy. Percentages of individual mineral phases were estimated and were reported in the detailed thin-section description sheets (available on microform at the repositories). The terminology for thin-section descriptions. In cases where discrepancies arose between hand-specimen and thin-section analyses over the composition and abundance of mineral phases, the thin-section descriptions were used in preference.

X-Ray Diffraction Analyses

A Philips ADP 3520 X-ray diffractometer was used for the XRD analyses of the mineral phases. Instrument conditions in normal use were as follows: CuK-alpha radiation with a Ni filter, 40 kV, 35 mA, Goniometer scan from 2° to 70° 2θ , step size = 0.02°, with a count time = 1 s per step.

Samples normally were ground with the Spex 8000 Mixer Mill or, when the sample was very small, an agate mortar and pestle. The material was then pressed into the sample holders, or smeared on glass plates and placed in the sample holders, for analysis.

Diffractograms were interpreted with the help of a computerized search and match routine using Joint Committee on Powder Diffraction Standards (JCPDS) powder files.

X-Ray Fluorescence Analysis

Prior to analysis, samples were normally crushed in the Spex 8510 Shatterbox with a tungsten carbide barrel. This produced some tantalum and massive tungsten contamination of the sample. If post-cruise studies for these elements, or instrumental neutron activation analyses were envisaged with the shipboard XRF powders (as on Leg 125), samples were crushed with an agate-lined barrel.

A fully automated wavelength-dispersive ARL8420 XRF (3 kW) system equipped with a Rh target X-ray tube was used to determine the major oxide and trace element abundances of whole-rock samples. Analyses of the major oxides were carried out on lithium borate glass disks doped with lanthanum as a "heavy absorber" (Norrish and Hutton, 1969). The disks were prepared from 500 mg of rock powder, ignited for 2 hr at about 1030°C, mixed with 6.0 g of dry flux consisting of 80% lithium tetraborate and 20% La_2O_3 . This mixture was then melted at 1150°C in a Pt-Au crucible for about 10 min and poured into a Pt-Au mold using a Claisse Fluxer. The 12:1 flux-to-sample ratio, and the use of the lanthanum absorber, made matrix effects insignificant over the normal range of igneous rock compositions. Hence, the following linear relationship between X-ray intensity and concentration holds:

$$Ci = (Ii \times mi) - bi,$$

where

- Ci = the concentration of oxide *i* (wt%);
- Ii = the net peak X-ray intensity of oxide *i*;
- mi = the slope of the calibration curve for oxide i (wt%/ cps); and
- bi = apparent background concentration for oxide *i* (wt%).

The slope, *mi*, was calculated from a calibration curve derived from the measurement of well-analyzed reference rocks (BHVO-1, G-2, AGV-1, PCC-1, JGB-1, JP-1, BR, DR-N, UB-N). The background, *bi*, was determined on blanks or was derived by regression analysis from the calibration curves.

Systematic errors resulting from short- or long-term fluctuations in X-ray tube intensity were corrected by normalizing the measured intensities of the samples to those of a standard that was always run together with a set of six samples. To reduce shipboard weighing errors, two glass disks were prepared for each sample. Accurate weighing was difficult on board the moving platform of the *JOIDES Resolution* and was performed with particular care, therefore, since weighing errors can be a major source of imprecision in the final analysis. Loss-on-ignition (LOI) values were determined by drying the sample at 110°C for 8 hr and then weighing them before and after ignition at 1030°C.

Trace element determinations used pressed-powder pellets prepared by pressing (with 7 tons of pressure) a mixture of 5.0 g of dry rock powder (dried at 110°C for >2 hr) and 30 drops of polyvinylalcohol binder into an aluminum cap. A modified Compton scattering technique based on the intensity of the Rh Compton peak was used for matrix absorption corrections (Reynolds, 1967).

An outline of the computation methods is given below.

1. Input X-ray intensities: Dead-time corrected X-ray intensities were read into the program from an ARL result file.

2. Make drift corrections: All peak and background intensities were corrected for machine drift by using a one-point correction of the form:

$$Di = Si/Mi$$
, and
 $Idi = Ii \times Di$,

where

- Di = the drift factor for element *i*, generally 1.00 ± 0.01;
- Si = the peak intensity for element *i*, measured on a synthetic standard ("POOP") at the time of calibration;
- Mi = the measured peak intensity for element *i*, measured on "POOP" at any time after the calibration;
- *Ii* = the uncorrected peak or background intensity, element *i*; and
- Idi = the drift corrected peak or background intensity, element *i*.

3. Subtract backgrounds. Peak intensities were corrected for nonlinear backgrounds by measuring a peak to average background ratio (BFi). This was determined for each element, on synthetic and natural blank standards, at the time of calibration.

$$BFi = PKi/AVBgi.$$

Thus, when measuring unknowns, the true or modified background (MBgi) was calculated by multiplying the average measured background for element i (AVBgi) by the BFi. This new modified background value was then subtracted from the peak intensity (PKi) to arrive at the net peak intensity (NETPKi) for element i.

$$MBgi = AVBgi \times BFi$$
, and
 $NETPKi = PKi - MBgi$.

4. Remove spectral interferences. During calibration, interferences were measured on synthetic pellets containing pure quartz and the interfering element. A ratio of the interference intensity to the net peak of the interfering element was calculated and assumed constant with respect to concentration. When measuring an unknown, the net interference (INTFERi,j) was calculated and removed by

$$INTFER_{i,j} = NETPK_i \times IR_{i,j}$$
 and
 $CNETPK_j = NETPK_j - INTFER_{i,j}$,

where

- INTFERi, j = the net interference intensity of element *i* on element *j* and
- CNETPKj = the net intensity of element *j* with the interference element *i* removed.

In the case of mutually interfering elements, an iterative approach to this same calculation was used until all the elements involved converge on their respective corrected values.

5. Measure mass absorption coefficients. To correct for matrix differences between samples, three separate mass absorption coefficients were determined following a modification of the Compton scattering technique of Reynolds (1967). Measured intensities from the rhodium K-series Compton, FeKa, and TiKa lines were compared with the calculated absorption coefficients of Rb (ARb), Cr (ACr), and V (AV), respectively. From this comparison, three equations can be written to describe the relationship between each coefficient and its respective line. The three equations derived from the Leg 126 calibration were as follows:

 $ARb = 104/[(Rhcps \times 0.0698) + 57.79],$ $ACr = ARb/[(Fecps \times 1.044 \times 10^{-6}) + 0.081],$ and $AV = ACr/[(Ticps \times 6.140 \times 10^{-6}) + 0.778).$

By using this method, unknowns were measured and corrected for matrix differences without calculating the absorption coefficients for each sample.

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6. Calculate concentrations. Once all the spectral and matrix corrections have been calculated, the equation to calculate elemental concentrations reduces to:

$$Ci = (CNETPKi \times Ai)/Ki,$$

where

- Ci = the concentration of element *i* in parts per million;
- CNETPKi = corrected net peak intensity, element i;
 - Ai = mass absorption coefficient for element *i*; and
 - Ki = calibration factor (ppm/cps) for element i.

The value Ki is analogous to the calibration curve slope (*mi*) for major elements; it was determined in the same manner on natural rock (AGV-1, UB-N, G-2, BHVO-1, RGM-1, DRN) and synthetic (compressed, spiked quartz powders) standards.

Details of the analytical conditions for each element determined are given in Table 4. Tables 5-7 summarize information about the precision and accuracy of XRF analyses during Leg 126. Given the results presented in these tables, the major element data are precise to within 0.5%-2.5% and are considered accurate to $\pm 1\%$ for Si, Ti, Fe, Ca, and K, and to $\pm 3\%-5\%$ for Al, Mn, Na, and P. Periodic summations to 101-102 wt%occurred but were irreproducible and attributed to weighing errors or gremlins. The trace element data are considered accurate to $\pm 2\%-3\%$ or 1 ppm, whichever is greater, for Rb, Sr, Y, and Zr, and to $\pm 5\%-10\%$ or 1 ppm for the others, except for Ba and Ce. Precision also was within 3% for Ni, Cr, and V at concentrations >100 ppm.

The range of trace element concentrations over which these claims hold true encompasses those encountered during Leg 126—from basalts with 10% MgO to rhyolites with 75% SiO_2 —with the following exceptions: Zr may be systematically 5 ppm

too low, although agreement for BIR was excellent; Rb may be 0.5 ppm too low; Cr may be up to 5 ppm too low below 25 ppm; Ce contents are thought to be accurate to ± 15 ppm so that concentrations between 0 and 25 ppm are indistinguishable, which applies to most Leg 126 results; and Ba is accurate to within 10% at concentrations >250 ppm, but most Leg 126 results were <100 ppm where Ba was essentially uncalibrated. Moreover, BIR, with a nominal 6 ppm Ba concentration, gave results ranging from -10 to +35 ppm. Nonetheless, average concentrations for seafloor Sumisu Rift basalts agree with those measured at UCSC and L-DGO to within 5 ppm at ranges from 10 to 15 ppm. Consequently, Ce and Ba contents less than 20 and 30 ppm, respectively, indicate that these concentrations are indeed below those levels, but these values are too imprecise for us to be confident of more than that.

SEDIMENT/FLUID GEOCHEMISTRY AND ELECTRICAL RESISTIVITY

Fluid Geochemistry

Hydrocarbon Gases

As required by safety considerations, the concentrations of the hydrocarbons methane (C_1), ethane (C_2), and propane (C_3) were monitored in the sediment cores at intervals of about 10 m. The hydrocarbon gases were extracted from the bulk sediment by means of a headspace-sampling technique. A 5-cm³ plug of sediment was taken as soon as the core arrived on deck, using a No. 4 cork borer. This sample was placed immediately in a glass vial sealed with a septum and metal crimp and heated to 70°C. The gas driven off was drawn into a syringe and injected into a Hach-Carle AGC Series 100 model 211 gas chromatograph equipped with a thermal conductivity detector. Where high concentrations of propane were suspected, a second sample was taken by the same method and analyzed for C₁ through C₆ hy-

Table 4. X-ray fluorescence analytical conditions, Leg 126.

Element	Line	Crystal	Detector	Collimator	Peak angle (degrees)	Background offset (degrees)	Total co (peak bac	unt time s) ckground
SiO ₂	Κα	PET(002)	FPC	Coarse	109.25	0	40	0
TiO.	Kα	LIF(200)	FPC	Fine	86.14	0	40	0
Al ₂ O ₃	Κα	PET(002)	FPC	Coarse	145.27	0	100	0
aFe2O3	Kα	LiF(200)	FPC	Fine	57.52	0	40	0
MnO	Kα	LiF(200)	KrSC	Fine	62.98	0	40	0
MgO	Κα	TLAP	FPC	Coarse	44.87	± 0.80	200	200
CaO	Kα	LiF(200)	FPC	Coarse	113.16	0	40	0
Na ₂ P	Κα	TLAP	FPC	Coarse	54.71	-1.20	200	200
K ₂ Õ	Κα	LiF(200)	FPC	Fine	136.65	0	40	0
P205	Kα	Ge(111)	FPC	Coarse	140.94	0	100	0
Rh	K-C	LiF(200)	Scint	Fine	18.59	0	100	0
Nb	Kα	LiF(200)	Scint	Fine	21.37	±0.35	200	200
Zr	Kα	LiF(200)	Scint	Fine	22.53	± 0.35	100	100
Y	Kα	LiF(200)	Scint	Fine	23.78	± 0.40	100	100
Sr	Kα	Lif(200)	Scint	Fine	25.13	± 0.40	100	100
Rt	Kα	LiF(200)	Scint	Fine	26.60	± 0.60	100	100
Zn	Kα	LiF(200)	Scint	Fine	41.79	± 0.40	60	60
Cu	Kα	LiF(200)	Scint	Fine	45.02	± 0.40	60	60
Ni	Kα	LiF(200)	Scint	Coarse	48.67	± 0.60	60	60
Cr	Kα	LiF(200)	FPC	Fine	69.35	±0.50	60	60
Fe	Κα	LiF(220)	FPC	Fine	85.37	-0.40 + 0.70	40	40
V	Kα	LiF(220)	FPC	Fine	122.84	-0.50	60	60
TiO ₂	Kα	LiF(200)	FPC	Fine	86.14	± 0.50	40	40
^b Ce	Lα	LiF(220)	FPC	Coarse	137.92	±1.50	100	100
^b Ba	Lβ	LiF(220)	FPC	Coarse	128.53	± 1.50	100	100

Note: All elements were analyzed under vacuum on goniometer 1 at generator settings of 60 kV and 50 mA. FPC = flow proportional counter using P_{10} gas; KrSC = sealed krypton gas counter; and Scint = NaI scintillation counter.

^a Total Fe as Fe₂O₃.

^b Calibrated but not analyzed on basalts.

drocarbons using a Hewlett-Packard 5980A Natural Gas Analyzer, a gas chromatograph equipped with Poropak-Q, molecular-sieve, and silicone-oil-coated columns, and a flame ionization detector. After the headspace gas had been analyzed, the actual volume of the sediment sample was measured to the nearest 0.5 cm³ by the displacement method using water. Details of this method and the complete configuration of both gas chromatographs are given in the Explanatory Notes for Leg 112 (Suess, von Huene, et al., 1988).

Interstitial Water

On Leg 126, interstitial water was obtained by squeezing and by *in-situ* extraction using the Barnes pore-water sampler. We squeezed 10-cm-long, whole-round sections of cores that were cut from the core as soon as it arrived on deck by slicing the plastic core liner and capping both ends. Following the electrical resistivity measurements, the core was removed from the core liner, scraped with a stainless-steel spatula to remove the outer, contaminated layer, and placed in a stainless-steel squeezer (Manheim and Sayles, 1974). The squeezer was placed in a Carver hydraulic press and squeezed at pressures of up to 40,000 psi. Interstitial water was collected directly into a 50-mL plastic syringe, from which the various aliquots for analysis were ejected through an on-line 0.45- μ m polysulfone filter mounted in a Gelman "acrodisc" disposable filter holder. Squeezed interstitial waters are designated here as "IW" samples.

The in-situ pore-water sampler is the new version designed by Dr. R. Barnes and first used on Leg 110 (Barnes, 1988). This tool collects interstitial water while making simultaneous measurements of sediment temperature and pore pressure. It is lowered on the sand line to the end of the drill string, where it is locked into an assembly just above the bit. To keep the hole free of fill during the descent of the sampler, the hole is flushed with drilling fluid with the bit just off bottom. After the sampler is latched into place, the bit is lowered into the bottom with the sampling probe projecting about 20 cm through the bit. A timeroperated valve opens and interstitial water is drawn under negative pressure through two 40-µm stainless-steel filters and one $1-\mu m$ polyester filter into the sampler. There it passes through a stainless-steel entry tube of 12 mL volume into two sample coils arranged in series and separated by an open ball valve, and then into a steel overflow cylinder of 1200 mL volume that also contains the sample coils and valving. The length of time required to fill the Barnes sampler varies with the permeability of the sediment, but typically is about 15 min. Interstitial water samples collected with the Barnes tool are designated here as "BW". On removal from the stainless-steel coil, they are filtered at 0.45 μ m as for the squeezed samples.

Drilling Mud Filtrate

To evaluate the extent of contamination by drilling mud filtrate, samples of drilling mud were taken when new batches were prepared. The drilling mud filtrate was separated by centrifugation, filtered and treated similar to interstitial water samples. Drilling mud filtrate is designated here as "MW".

Sample Analysis

The waters were analyzed immediately on recovery for pH, alkalinity by potentiometric titration, salinity by refractive index, and, when an odor was detected, hydrogen sulfide by colorimetry using methylene blue. Aliquots were acidified to a pH of about 2 by adding concentrated HCl, refrigerated, and analyzed within a few days for sodium, strontium, lithium, potassium, iron, and manganese by atomic absorption spectrophotometry. When required, ionization suppressors were added to samples, blanks, and standards. All samples were diluted to within the linear range of the instrument. Calcium and magnesium were determined by titration as described by Gieskes and Peretsman (1986). A separate aliquot was taken for the determination of chloride, silicon, sulfate, and ammonium. The concentration of chloride was determined by means of argentiometric titration; sulfate by ion chromatography; and silicon and ammonium by colorimetry. All shipboard anion analyses were carried out using standard ODP techniques as detailed by Gieskes and Peretsman (1986) and described briefly in the Explanatory Notes for Leg 112 (Suess, von Huene, et al., 1988). IAPSO standard seawater was used as the primary standard for the determination of chlorinity, calcium, magnesium, and sulfate and as a secondary standard for lithium, potassium, strontium, and sodium.

Electrical Resistivity

The electrical resistivity and formation factor of the sediments was measured by means of a four-electrode configuration (Wenner configuration) similar to the one used by Manheim and Waterman (1974). The electrodes were made of 2-mm-diameter stainless-steel rods. Specially designed equipment allows the electrodes to be inserted into the short end of the whole-round sections in exactly (fraction of a millimeter) the same position relative to the core liner. A 20-kHz square-wave current was applied to the outer electrodes and the difference in potential between the two inner electrodes was measured. The size of the current (typically 50 mAmps) was measured over a resistor in the outer circuit. The temperature of the sediment was measured with a thermocouple. For an infinite and homogeneous medium the resistivity was given by the equation,

$$R = 2 \times \pi \times a \times \Delta V/I,$$

where

- R = the specific resistivity,
- a = the distance between the electrodes,
- ΔV = the difference in potential between the inner electrodes, and

I = the current (Jakosky, 1940).

However, because of edge effects and the large diameter of the electrodes relative to the distance between them (13 mm), the "2 $\times \pi \times a$ " term in the equation had to be replaced by a cell constant. The cell constant was determined by measuring the resistivity of a 35‰ NaCl solution held in a container made from a core liner and of the same length as the whole rounds on which the electrical resistivity was measured. Determination of the formation factor involved the following steps:

1. Correction of the measured apparent resistivity of the reference fluid to 25°C by means of the temperature calibration curve (Fig. 11).

2. Determination of the cell constant as the ratio between the theoretical resistivity of the reference fluid at 25° C (0.195 ohm-m) to the temperature-corrected theoretical resistivity of the reference fluid from Step 1.

3. Determination of the resistivity of the sediment at the measuring temperature by means of the cell constant and the measured current and voltage.

4. Correction of the sediment resistivity to 25° C by means of the temperature calibration curve (Fig. 11).

5. Making the assumption that the resistivity of the pore water of a given salinity (estimated from the chloride concentration) has the same resistivity as pure sodium chloride solution, and using the calibration curve (Fig. 12) to estimate the porewater resistivity at 25° C.

6. The formation factor is the ratio between the output from Step 4 to 5.

Table 5. Consensus	values and I	Leg 126	values (in	wt%)	obtained	for ma	or and	trace e	element	standards	during i	nitial	calibration	of s	hipboard
X-ray fluorescence.															

Element	BIR-1 anhydrou	ıs anl	JN-2 hydrous	JB-3 anhydrou	All 9 s anhy	2-29-1 drous	BHVO anhydrous	BEN anhydrou	s an	BR hydrous	UBN anhydrous	JA-1 anhydrous	DRN anhydro	I S ous and	TM-1 hydrous
SiO ₂ [1]	48.04*		53.4*	51.16*	49	.39*	49.69*	39.58*		39.43*	44.93*	64.75*	54.03	8* 6	60.63*
[4]	47.96	9	53.44	51.45	49	.48	50.15	39.87		39.8/	45.06	04.4	54.13		9.94
1102	0.96*		1.19	1.45*	1	.75*	2.7*	2.7*		2.7	0.13	0.88	1.08	57	0.153
41.0	0.97		1.10	1.43	1	14	2.14	2.71		2.1	0.12	0.90	1.1		0.14
A1203	15.55		14.73*	10.93*	15	.49*	13.0*	10.43+		10.49*	3.3	15.14*	17.84		0.02*
E. O	15.57		14.94	17.47	15	.51	13.65	10.24		10.23	3.17	15.37	18.05	. 1	8.74
re203	11.34*		14.39*	11.91*	10	.85*	12.3*	13.3*		13.31*	9.5	7.02+	9.84		5.3*
14-0	11.44		14.35	11.92	10	.96	12.49	13.23		13.17	9.5	0.92	9.85		5.31
MnO	0.18*		0.2	0.16	0.	18*	0.17*	0.21*		0.21*	0.14	0.154*	0.21	<u> </u>	0.22*
Mag	0.18		0.23	0.18	0.	.18	0.18	0.21		0.21	0.15	0.158	0.23		0.23
MgO	9.71*		4.08*	5.21*	1	.52*	1.26*	13.62*		13.71-	40.12	1.63*	4.42	7	0.092
0.0	9.4		4.8	5.25	6	.94	6.82	14.08		14.15	39.86	1.93	4.6		0.17
CaO	13.34*		9.93*	9.88*	11.	16*	11.39*	14.37*		14.23*	1.37	5.78*	7.10		1.12*
NaO	13.52		9.95	9.92	11.	07*	11.52	14.50	4	14.29	1.39	5.7	7.17		1.13
NaO ₂	1.82*		2.04*	2.83*	3.	.0/~	2.29+	3.3-		3.11*	0.11	3.9*	3.02		9.07*
KO	1.81		2.03	2.12	2	.8/	2.14	3.21		3.15	0.19	3.95	3.14		9.21
K ₂ 0	0.03		0.43*	0.8*	0.	1/*	0.52*	1.44*		1.45*	0.02	0.83*	1.73		4.38*
D O	0.023		0.424	0.786	0.	101	0.52	1.48		1.44	0.02	0.777	1.70	2	4.35
P205	0.021		0.14	0.29*	0.	10*	0.28*	1.09*		1.08*	0.05	0.16	0.22		0.10
II O I	0.0266)	0.103	0.291	0.	1/1	0.27	1.05		1.05	10.04	0.16	0.22		0.14
H ₂ O+	0.09		0.31	0.2			-0.69	2.24		2.48	10.84	0.8			
H ₂ O-	0.08		0.07	0.03				0.5			1.26	0.26			
101	0.17		0.30	0.00	0.	23	0.00	0.74		0.40	0.39	1.00	0		0
101	0.17		0.38	0.23	0.	.23	-0.69	3.48		2.48	12.49	1.06	0		0
lotal [1] [2]	100.8	10	00.71 01.05	100.39	99. 98.	.51	100.89	96.56 97.16	9	97.24 97.78	87.18 86.97	99.18 99.27	99.56 100.36	5 9	9.95 9.36
Element	DID 1	ID 0	ID 2	DUUIO	DEN			DBM	cu	CTT (Mica	DOM	Mica	62	101/1
Element	BIK-I	JB-2	1B-3	BHVO	BEN	BR	JA-1	DRN	GH	SIM-	I Mg	KGM-1	Fe	62	AGV-1
NB [1]	2.3	0.8*	2.3	19*	173	100*	1.7	6*	83*	270*	120*	9*	270*	12*	15*
[2]	0.4	0.8	1.7	17.5	105	103.8	1.8	7.5	95	268.5	128.4	9.8	281.4	12.2	13.6
Zr	18	52*	100*	180*	265*	250*	87*	125*	150*	130*0	20	245*	80*	300*	231*
	16	46.4	96.1	170	271.2	269.6	85.4	125	153	1337	11.7	243	76.5	319.5	229.7
Y	16*	26*	28*	26.5*	30*	30*	31.4*	29*	70*	46*	 .	22.4	25	10*	19*
~	16.7	25.1	28.1	27.9	29.7	2	31.8	28.3	88.8	51.5		25.7	34.9	9.6	19.5
Sr	10/*	178*	395*	420*	1370*	1320*	266*	400*	10	700*	2.5	106*	5	480*	656*
	107	1/2.2	410.9	386	1355	1330.7	262	395.7	9	726.9	27.2	108.7	5.6	500	645.9
KD	2.2	0.2	13	9.1*	4/*	4/*	11.8	70*	390+	120+	1300*	152*	2200-	170*	0/-
7-	0.5	5.0	14.2	8.4	46	4/	10.5	/3.1	411.0	120.4	1326	159.8	2057	1/8.9	0.00
Zn	70	109.5	106*	113*	120*	85*	90.6*	145	85	230	_	30		90*	107.0
0	54.7	108.5	90.5	100	100	[156.3]	85.0	[264]	40.8	[295.3]	_	[17.5]	_	83.88	12/.2
Cu	125-	230-	19/*	140*	12+	12+	41.7*	50+	14	4*	4	11-	4	11	59
NU	120.4	191	191	133.4	11.6	15.3	43.2	4/	2.8	4	0.0	11.8	10.7	11.0	57.5
NI	167.2	14.2	38.8	120*	26/*	260*	1.8	16*	5*	2.1	110	0	30 8	57	16-2
C-	157.5	13.3	38.8	115.3	2/4	265	2.7	15.8	5.3	4.7	123.6	1	40.8	5.3	15.3
Cr	3/37	21.4*	60.4*	300*	360*	380*	7.3	42	6	2.6	100*	4	90*	8	10
N	397	20.3	35.34	292.5	385	345.3	10.00	28.7	-	-	99.6	10.4	8/./	3.8	1054
v	312*	5/8*	3837	320*	235*	240*	105*	225*	2	2		13	153.0	30 6	125*
Ca	321.9	023	3/3	328.5	2/2	242.6	110.4	216	70	3.2		5.7	152.8	30.0	115.8
Ce	1.0	0.5	20.5	38-	152*	140	13	44	10	200*	—	49	100	100-	50 1
Do	~	3.1	2518	125*	145.2	144.5	2071	28	33.2	2/1.5	-	54	1000	1000#	1208#
Dd	-	208	242.6	129.8	1025-	1161	295	385	850	596	_	818.4		1880*	1102

Note: The consensus values are largely from Govindaraju (1984), revised in some cases to conform to experience in other XRF labs (Stork et al., 1987). The major element results from these sources were recalculated to an anhydrous basis by multiplying published values by 1.0 plus the sum of $(H_2O^+ + H_2O^- + CO_2)$ given at the base of each column. The Leg 126 entries are those obtained during calibration for ignited powders. The trace and major element calibration curves were based on the standards that have an asterisk for that element. [1] = consensus values and [2] = Leg 126 values. Entries in brackets are analytically uncertain.

The uncertainty introduced by making the assumption that the pore-water resistivity was the same as for a NaCl solution of the same salinity was small when the disturbance of the sediments caused by inserting the electrodes and by drilling and retrieval is considered.

Sediment Geochemistry

Sediments were analyzed on board ship for inorganic carbon and for total nitrogen, carbon, and sulfur. The organic carbon content of the sediments was calculated by difference. Inorganic carbon and total nitrogen, carbon and sulfur were determined on all sediment samples taken for physical properties measurements and on the squeezed sections. All samples were freeze dried prior to analysis.

Total inorganic carbon was determined using a Coulometrics 5011 Coulometer equipped with a System 140 carbonate carbon analyzer. Depending on the carbonate content, 15–70 mg of ground and weighed sediment was reacted in a 2N HCl solution. The liberated CO_2 was titrated in a monoethanolamine solution with a colorimetric indicator, while monitoring the change in light transmittance with a photo-detection cell.

Total nitrogen, carbon, and sulfur were determined with a N/C/S analyzer (Model NA 1500) from Carlo Erba Instruments. Bulk samples were combusted at 1000°C in an oxygen atmo-

Table 5 (continued).

NBS 688 anhydrous	GH anhydrous	Mica Mg anhydrous	JDF2 anhydrous	RGM-1 anhydrous	K1919 anhydrous	JGB-1 anhydrous	Mica Fe anhydrous	G2 anhydrous	AGV-1 anhydrous	JP-1 anhydrou
48.01*	76.42*	39.32*	50.33*	73.42*	49.73*	44*	35.65*	69.51*	59.96	43.74
48.43	76.28	39.08	49.9	73.41	49.25	43.76	35.13	69.06	59.84	43.31
1.16*	0.08	1.67*	1.95	0.28	2.83	1.64*	2.6*	0.48*	1.07*	0.01
1.16	0.08	1.68	1.88	0.28	2.83	1.6	2.56	0.5	1.06	0.02
17.22*	12.6	15.61*	13.68*	13.8*	13.75*	17.89*	20.21*	15.47*	17.29	0.64*
17.53	12.83	15.38	13.48	13.96	13.62	17.69	19.63	15.51	17.37	0.649
10.27*	1.35*	9.71*	13.41*	1.89	12.21*	15.35*	26.58*	2.68*	6.86*	8.61*
10.34	1.15	9.7	13.37	1.76	12.1	15.21	26.33	2.41	6.8	8.68
0.17*	0.05	0.27*	0.22*	0.04	0.18	0.17	0.36*	0.03	0.1*	0.12
0.17	0.05	0.27	0.22	0.03	0.17	0.17	0.36	0.03	0.1	0.12
8.33*	0.03	20.94	6.56*	0.29	6.83*	7.93*	4.71*	0.75	1.53	46.14
8.34	0.13	19.02	6.48	0.37	6.33	7.56	4.83	0.9	1.9	46.5
12.07*	0.7*	0.08	10.68*	1.2*	11.32*	12.13*	0.45	1.97*	4.97*	0.58*
12.62	0.69	0.01	10.75	1.2	11.25	12.09	0.38	1.92	4.92	0.57
2.13*	3.88*	0.123	2.74	4.16*	2.35*	1.25	0.31	4.08*	4.35*	0.022
2.1	4.04	0.18	2.86	4.24	2.28	1.36	0.19	4.09	4.39	0.03
0.19*	4.8*	10.27*	0.19	4.34*	0.53*	0.26	9.07*	4.48*	2.94*	0.003
0.19	4.81	10.4	0.23	4.35	0.53	0.23	9.21	4.48	2.96	0.005
0.13	0.01*	0.01	0.24*	0.05*	0.28*	0.05*	0.47	0.13*	0.51*	
0.1	0.01		0.21	0.05	0.26	0.05	0.39	0.13	0.48	
	0.46	2.09		0.38		1.23	2.91	0.5	0.78	2.68
	0.14	0.31				0.04	0.43			0.4
0.05	0.3	0.15					0.19	0.08	0.02	
0.05	0.9	2.55	0	0.38	0	1.27	3.53	0.58	0.8	3.08
99.63	99.02	95.45	100	99.09	100.01	99.4	96.88	99	99.78	96.79
100.93	99.17	93.17	99.38	99.27	98.62	98.45	95.48	98.45	99.02	96.80

sphere with the addition of vanadium pentoxide, converting organic and inorganic carbon to CO_2 and sulfur to SO_2 . These gases, along with nitrogen, were then separated by gas chromatography and measured with a thermal conductivity detector.

PHYSICAL PROPERTIES

Physical property measurements made on cores recovered during Leg 126 included MST logging (GRAPE, magnetic susceptibility, and compressional sonic velocity measurements), thermal conductivity, undrained vane shear strength, Hamilton Frame compressional velocity, electrical resistivity, index properties, and carbonate analyses. Downhole temperatures were measured at one site. Representative samples of the core or section were taken in areas of least disturbance. Sample selection and spacing depended on the rate of core recovery, the type of measurement (see below), as well as the thickness and homogeneity of the recovered sequences.

The testing methods employed during Leg 126 are discussed in the order in which they were performed on each core. The MST logging and soft-sediment thermal conductivity determinations were performed on whole cores. Other measurements were conducted on discrete samples taken from the split cores.

Gamma-Ray Attenuation Porosity Evaluator

The gamma-ray attenuation porosity evaluator (GRAPE) makes continuous measurements of wet-bulk density on whole cores by comparing the attenuation of gamma rays through the cores with attenuation through an aluminum standard (Boyce, 1976). Individual core sections were placed horizontally on the MST and moved on a conveyor belt through the GRAPE sensors. The attenuation of the gamma rays passing through the liner and core was measured every 2.5 cm, and bulk density was calculated from the attenuation values. The GRAPE data were filtered to remove values that resulted from gas, gaps, or end-cap effects before averaging over 0.2-m intervals. All bulk density data are reported in units of g/cm³.

P-Wave Logger

The *P*-wave logger (PWL), which also operates on the MST, produces a 500-kHz compressional wave pulse at a repetition rate of 1 kHz. Both signal and receiving transducers are aligned perpendicular to the core axis. A pair of displacement transducers monitor the separation between the compressional wave transducers, allowing variations in the outside liner diameter without degrading the accuracy of the velocities. Measurements were taken at 2.5-cm intervals.

Water was applied to the core liner to improve acoustic contact between the transducers and the liner. As with the GRAPE, generally only APC and the first few XCB cores were measured. The deeper XCB cores and all RCB cores have annular voids between the core and the liner which caused loss of transmission of compressional waves. The PWL data were filtered to remove data that resulted from gas, gaps, or end-cap effects. Weak returns with signal strengths below a threshold value of 200 also were removed. All velocity data are reported in units of km/s.

Thermal Conductivity

Whole-round cores were allowed to equilibrate to room temperature for at least 3 hr, until drift rates were reduced to less than 0.1 mV/min prior to running thermal conductivity measurements. The thermal conductivity techniques used are described by Von Herzen and Maxwell (1959) and Vacquier (1985). All thermal conductivity data are reported in units of W/m · K.

Soft-Sediment Thermal Conductivity

Needle probes connected to a Thermcon-85 unit were inserted into the sediment through holes drilled into the core liner and the thermal drift was monitored. An additional probe was inserted into a reference material. Once the temperature (estimated from voltage) stabilized, the probes were heated and the coefficient of thermal conductivity was calculated as a function of the change in probe resistance. When the sediment became

and of an and a stand and an an and an and an and an and an and an an and an an and an an and an an and an an an and an	Table 6.	Elemental	wt%	obtained	during	multipl	e analys	es of	major	element	standard	AII-92-19-	1 run	throughout	Leg	12	26
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Result file→	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Run 10	Run 11	Run 12	Run 13	Run 14	Run 15
SiO ₂	49.73	49.41	49.7	49.41	49.51	49.65	49.62	49.6	49.78	49.36	49.37	49.5	49.15	49.52	49.37
TiO ₂	1.74	1.73	1.74	1.73	1.73	1.74	1.73	1.74	1.73	1.74	1.73	1.74	1.72	1.74	1.74
Al_2O_3	15.46	15.47	15.47	15.43	15.5	15.59	15.41	15.5	15.68	15.38	15.41	15.46	15.42	15.56	15.5
Fe ₂ O ₃	10.89	10.91	10.86	10.76	10.87	10.9	10.87	10.9	10.91	10.85	10.77	10.92	10.77	10.84	10.83
MnO	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.14	0.15	0.15	0.15	0.15	0.14
MgO	7.14	6.96	7.5	7.08	7.12	7.08	7.08	6.97	6.93	7.17	6.6	6.95	6.83	6.91	7.22
CaO	11.06	11.06	11.1	11.04	11.09	11.11	11.11	11.06	11.1	11.06	11.09	11.08	10.97	11.1	11.11
NaO ₂	3.02	3.04	3.07	3.03	2.98	2.99	2.88	2.77	2.65	2.78	2.75	2.81	2.78	2.88	2.94
K ₂ O	0.17	0.17	0.17	0.17	0.17	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.16
P2O5	0.16	0.16	0.16	0.16	0.17	0.16	0.17	0.16	0.15	0.15	0.15	0.15	0.15	0.16	0.15
Total	99.52	99.06	99.92	98.96	99.29	99.54	99.18	99.01	99.24	98.79	98.18	98.92	98.11	99.03	99.18

Note: SD = standard deviation and Real dev. = real deviation.

too stiff to allow easy insertion of the probe, holes were drilled into the core material prior to insertion. An attempt was made to insert the probes at locations along each core section that appeared to be the least disturbed. However, an annulus of disturbed sediment and drill fluid was often present along the inside of the liner, preventing visual identification of disturbance and resulting in possible erroneous values.

Hard-Rock Thermal Conductivity

Thermal conductivity measurements on well-lithified sediments and rocks were conducted on split cores using the halfspace technique with a needle probe partially embedded in a slab of insulating material. The surface of a sample of split core was polished with 240-, then 600-grit sandpaper, and placed on top of the slab. Dow Corning 3 silicone was used to improve the thermal contact between the slab and the sample. The sample and the slab were immersed in a saltwater bath. After reaching thermal equilibrium, the probe was heated and measurements of resistance changes in the probe were made over a 6-min interval. Thermal conductivity was determined from the most linear portion of the resulting temperature vs. log-time plot.

Undrained Shear Strength

Undrained shear strength was determined by means of a Wykeham-Farrance motorized vane shear apparatus equipped with a four-bladed vane that has a diameter of 1.28 cm and a length of 1.28 cm. The vane was inserted into the split-core section perpendicular to the core axis, to a point where the top of the blade was covered by between 2 and 4 mm of sediment. The vane was then rotated at a rate of 89°/min until the sediment failed. The undrained shear strength was calculated from the peak torque (stress) obtained at failure. Shear strength testing was suspended at the point where significant disturbance occurred or where the material became too stiff for the vane to penetrate without severe cracking. No shear strength measurements were done on rotary-drilled cores. All shear strengths are reported in units of kPa.

Hamilton Frame Compressional Wave Velocity

Compressional-wave velocity measurements were taken on discrete samples that were sufficiently competent to provide adequate signal strength. Velocities were calculated from the determination of the travel time of a 500-kHz compressional wave through a measured thickness of sample, using a Hamilton Frame Velocimeter and Tektronix DC 5010 counter/timer system. Samples of soft sediment were taken with a special parallel-sided sampling tool. A double-bladed diamond saw was used in more lithified sediments. Basement rock samples were obtained using either a double-bladed diamond saw or a 2.5-cmdiameter rock corer. Sample thicknesses (distance) were measured directly with calipers.

Zero traveltimes for the velocity transducers were estimated by linear regressions of the traveltime vs. distance for a series of aluminum and lucite standards. Filtered seawater was used to improve the acoustic contact between the sample and the transducers. Velocities were not recorded when insufficient or extremely variable signals were obtained.

Electrical Resistivity/Formation Factor

The electrical resistivity of soft sediments was measured perpendicular and parallel to the core axis with a Wenner electrode array composed of two current and two potential electrodes. Alternating current with a voltage of 200 kHz was applied to the sediment and the resulting resistances were measured with a Wayne-Kerr Precision Component Analyzer. Formation factors were calculated as:

formation factor = sediment resistivity/pore-fluid resistivity.

Pore-water resistivity was measured with the same electrode array in a seawater-filled core liner; care was taken to simulate the same configuration as used for the sediment measurements.

Index Properties

Index properties, wet- and dry-bulk density, porosity, water content, and grain density were determined on samples of sediment and rock (Lambe and Whitman, 1969). Where possible, samples for index property analyses were taken adjacent to compressional wave velocity and/or vane shear strength measurements. Samples were weighed using two calibrated Scientech 202 electronic balances. An average of 200 sample weighings compensated for ship motion. Samples were freeze dried for at least 18 hr (Site 787) or oven dried at 105°C for 24 hr (Sites 788– 793). Wet and dry volumes were measured with a Quantochrome helium penta-pycnometer.

Porosities and water contents are reported as percentages; water contents are on a dry-weight basis (Lambe and Whitman, 1969). Wet- and dry-bulk densities and grain density are reported as g/cm³. All values were corrected for the salt content of the pore fluid, assuming seawater salinity of 35‰.

Calcium Carbonate

Calcium carbonate was calculated from weight percent inorganic carbon, assuming that all inorganic carbon is in the form of $CaCO_3$. Inorganic carbon was determined on index property samples with a Coulometrics Carbon Dioxide Coulometer.

Table 6 (continued).

Run 16	Run 17	Element	Average	SD	Real dev (%)
49.38	49.25	SiO ₂	49.49	0.18	0.36
1.74	1.73	TiO ₂	1.73	0.01	0.41
15.45	15.48	Al2Õ3	15.48	0.09	0.56
10.79	10.81	Fe ₂ O ₃	10.85	0.06	0.52
0.15	0.15	MnO	0.15	0	2.83
6.84	7.01	MgO	7.02	0.18	2.49
11.02	10.96	CaO	11.07	0.05	0.49
2.82	2.86	NaO ₂	2.89	0.08	2.75
0.17	0.16	K2O5	0.17	0	2.92
0.15	0.15	P205	0.16	0	2.69
98.5	98.56	Avg. total	99.00	0.40	

Freeze-dried samples were dissolved in 2.0 N HCl, and inorganic carbon was estimated from the amount of CO_2 evolved (see Backman, Duncan, et al., 1988).

Heat Flow

Downhole-temperature measurements were successfully completed at Site 792. The Uyeda probe, a $\frac{1}{2}$ -in.-diameter thermistor probe, was attached to the end of the coring shoe and extended beyond the shoe into undisturbed sediment. The electrical resistance in the sediment was recorded for approximately 20 min during each deployment at 1-min intervals. During this time, the temperature probe was effectively decoupled from ship motion by means of a heave compensator. Electrical resistance data was then converted into temperatures when the probe arrived back on deck. Reported temperatures are extrapolated to *in-situ* equilibrium values.

DOWNHOLE MEASUREMENTS

Measurement Descriptions

Downhole measurements determine the physical and chemical properties of formations adjacent to the borehole. Interpretation of these continuous, *in-situ* measurements can yield a stratigraphic, lithologic, structural, geophysical, and geochemical characterization of the site. After coring is completed, a combination of sensors are lowered downhole on a 7-conductor cable, and each of several measuring devices continuously monitored properties of the adjacent formation. Of the dozens of different combinations commonly used in the petroleum industry, four combinations of Schlumberger sensors were used on Leg 126: (1) the geophysical combination, (2) the geochemical combination, (3) the formation microscanner (FMS), and (4) a vertical seismic profile (VSP). Each combination was not neces-



Figure 11. Temperature calibration curve used for the correction of measured apparent electrical resistivity of a reference fluid and of sediment resistivity.



Figure 12. Calibration curve of pure sodium chloride solution used for the estimation of pore-water resistivity.

sarily deployed in each hole; reference should be made to individual site chapters for details.

The geophysical combination used on Leg 126 consisted of the dual induction tool (DIT), the sonic tool (LSS), the lithodensity tool (HLDT), and the L-DGO temperature tool (TLT). This tool combination measures electrical resistivity, compres-

Table 7. Elemental wt% obtained during multiple analyses of trace element standard BIR-1 run throughout Leg 126.

Result file→	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Average	SD
Nb	0.8	0.7	0.9	0.5	1	0.7	0.8	0.4	0.7	0.20
Zr	15.9	16.4	15.3	16.1	15.2	15.3	15	15.8	15.6	0.49
Y	16.5	17	16.6	16.5	16.2	16.8	17.3	16.4	16.7	0.35
Sr	106.5	107.5	105.9	106.1	106.6	106.9	108.1	106.3	106.7	0.74
Rb	0	0	0	0.6	0.1	-0.06	0	0.1	0.1	0.21
Zn	55.9	88.4	92.5	90.5	91.4	91	89.3	88.9	86.0	12.23
Cu	125.4	96.6	96.7	96.6	99.1	95.8	98.4	99.3	101.0	9.95
Ni	154.7	156.4	156.1	156.4	156.9	155.6	157.3	156.4	156.2	0.80
Cr	391.7	-	388.9	402.2	395.5	398.6	391	403.6	395.9	5.73
v	336.4	-	310.1	326.2	328.7	327.1	315.8	336	325.8	9.77
TiO ₂	0.94	$\sim \rightarrow \sim$	0.94	0.95	0.94	0.93	0.95	0.94	0.9	0.01
Ce	—	\rightarrow	-	-	-	-5	5.9	0	0.3	5.46
Ba	22.1	—	-	11	22.4	34.8	0	0	15.1	13.88

Note: SD = standard deviation.

sional wave velocity, formation density, and the spectral content of naturally occurring radiation.

The geochemical combination consists of a natural gammaray spectrometry tool (NGT), an aluminum clay tool (ACT), an induced gamma-ray spectrometry tool (GST), and the L-DGO temperature tool (TLT). This tool combination measures the *relative* concentrations of 11 elements, including silicon, calcium, iron, sulfur, manganese, hydrogen, chlorine, potassium, thorium, and uranium.

The FMS is a microresistivity imaging device that was deployed for the first time in the Ocean Drilling Program during Leg 126. It allows for the visual characterization of the borehole wall from measurements related to the formation's electrical resistivity in the vicinity of the borehole wall.

Vertical seismic profiles were conducted in two of the holes drilled. The VSPs can provide much information on the seismic nature of reflective interfaces penetrated by the borehole, as well as provide predictive information on the nature of, and depth to, interfaces below the total depth of the borehole.

Measurement Devices

A brief description of *in-situ* sensors used during Leg 126 is given below. A more detailed description of the physical principles of these sensors and their applications is provided in Schlumberger (1972), Hearst and Nelson (1984), and Ellis (1987).

Electrical Resistivity

The dual induction instrument (DIT) provides three different measurements of electrical resistivity, each one with a different radial depth of investigation. Two induction devices ("deep" and "medium" resistivity) send high-frequency alternating currents through transmitter coils, creating magnetic fields that induce secondary (Foucault) currents in the formation. These ground-loop currents produce new inductive signals that are proportional to the conductivity of the formation. The signals are recorded by a series of receiving coils, and the measured conductivities are converted to resistivities. A third device, the "spherically" focused resistivity (SFR), measures the current necessary to maintain a constant voltage drop across a fixed interval. The vertical resolution is on the order of 2 m for the two induction devices and about 1 m for the spherically focused resistivity.

To a first-order approximation, resistivity responds to the inverse square root of porosity (Archie, 1942). In addition, water salinity, clay content, and temperature are important factors controlling the electrical resistivity of rocks. Other factors that may influence the resistivity of a rock include the concentration of hydrous and metallic minerals, the presence of vesicles, and the geometry of interconnected pore spaces.

Sonic Velocity

The digital sonic measurement (LSS) uses two acoustic transmitters and two receivers to measure the time required for sound waves to travel along the borehole wall over source-receiver distances of 2.4, 3.0, and 3.6 m. The raw data are expressed as the time required for a sound wave to travel through 0.31 m of formation; these traveltimes are then converted to sonic velocities. First arrivals for the individual source-receiver paths are used to calculate the velocities of the different waves traveling in the formation (compressional, shear, etc.). Only compressional wave velocity is determined on board the ship, but the full sonic waveforms are recorded for postcruise processing to determine shear wave and Stoneley wave velocities. The vertical resolution of the tool is 0.61 m. Compressional wave velocity is primarily controlled by porosity and lithification; decreases in porosity and increases in lithification generally cause velocity to increase.

Temperature

The L-DGO temperature tool is a self-contained tool that can be attached to any of the sensor combinations. Data from two thermistors and a pressure transducer are collected every 0.5-5.0 s and stored within the tool. Once the *in-situ* measurement is completed the data are transferred to a shipboard computer for analysis. The fast-response thermistor, though low in accuracy, is able to detect sudden, very small temperature excursions caused by fluid flow from the formation. The slow-response thermistor has a high accuracy and can be used to estimate the temperature gradient. Data are recorded as a function of time, with conversion to depth being based on the pressure transducer (or preferably, on simultaneous recording by Schlumberger of both depth and time).

Lithodensity Measurement

The lithodensity tool (HLDT) uses a Ce¹³⁷ gamma-ray source to measure the resulting flux at fixed distances from the source. Under normal operating conditions, attenuation of gamma rays is chiefly caused by Compton scattering (Ellis, 1987). Formation density is extrapolated from this energy flux by assuming that the atomic weight of most rock-forming elements is approximately twice the atomic number. A photoelectric effect factor (PEF) is also provided. Photoelectric absorption occurs in the energy window below 150 Kev and depends on the energy of the incident gamma ray, the atomic cross section, and the nature of the atom. This measurement is almost independent of porosity and can therefore be used directly as a matrix lithology indicator. The radioactive source and detector array are placed in a tool that is pressed against the borehole wall by a spring-loaded caliper arm. Excessive roughness of the borehole wall allows drilling fluid between the skid and the formation. Consequently, the density measurement will give rise to false low values. Approximate corrections can be applied using caliper data. The vertical resolution of the measurement is about 0.30 m.

Gamma-Ray Spectrometry Measurement

This induced gamma-ray device (GST) consists of a pulsed source of 14 Mev neutrons and a gamma-ray scintillation detector. A surface computer performs spectral analysis of gammaray counts resulting from the interactions of neutrons emitted by the source with atomic nuclei in the formation. Characteristic sets of gamma rays from six elements dominate the spectrum: Ca, Si, Fe, Cl, H, and S. As their sum is always unity, they do not reflect the actual elemental composition. Consequently, ratios of these elements are used in interpreting the lithology and porosity of the formation and the salinity of the formation fluid.

Aluminum Clay Measurement

Aluminum abundance as measured by the aluminum clay tool (ACT) is determined by neutron-induced (Californium chemical source), gamma-ray spectrometry. The contribution to the gamma-ray spectrum by natural radiation is removed by placing NaI gamma-ray detectors above and below the neutron source; the one above measures the natural radiation before activation, and the one below, the induced radiation after activation. It is then possible to subtract the naturally occurring component from the total measured after activation. Calibration to elemental weight per cent (wt%) is performed by taking irradiated core samples of known volume and density and measuring their gamma-ray output while placed in a jig attached to the logging tool.

Natural Gamma-Ray Measurement

The natural gamma-ray measurement (NGT) measures the natural radioactivity of the formation. Most gamma rays are emitted by the radioactive isotope K^{40} and by the radioactive elements of the U and Th series. The gamma radiation originating in the formation close to the borehole wall is measured by a scintillation detector mounted inside the sonde. The analysis is achieved by subdividing the entire incident gamma-ray spectrum into five discrete energy windows. The total counts recorded in each window, for a specified depth in the well, are processed at the surface to give elemental abundances of K, U, and Th.

Radioactive elements tend to be most abundant in clay minerals, and consequently the gamma-ray curve is commonly used to estimate the clay or shale content. There are rock matrixes, however, for which the radioactivity ranges from moderate to extremely high values, as a result of the presence of volcanic ash, potassic feldspar, or other radioactive minerals.

Borehole Inclination Measurement

The general purpose inclination tool (GPIT) contains a threecomponent accelerometer and a three-component magnetometer. The device is used to measure the orientation of the downhole sensors within the borehole, and the orientation (or deviation) of the borehole itself, as well as to compensate for instrument accelerations in the axis of the borehole during data acquisition. It is included as a part of the FMS.

Formation Microscanner

The formation microscanner (Fig. 13) produces high-resolution borehole images from electrical conductivity measurements (Ekstrom et al., 1986; Pezard and Luthi, 1988). Its application in the context of the oil industry since 1986 has been precluded in the Ocean Drilling Program because of diameter constraints imposed by the internal diameter (4.125 in.) of the drill pipe. A modified sensor was consequently developed by Schlumberger for ODP and first deployed during Leg 126. The FMS has a vertical resolution of approximately 1 cm, but a detection threshold for conductive features on the order of microns. With this fine-scale detection ability (raw data points are recorded every 2.5 mm), it allows for the detailed study of subsurface structures. This compares with typical conventional downhole measurements that are averaged over 150 mm; the sampling rate of the FMS is consequently 60 times larger than most other logging devices. The FMS has four orthogonal pads that are pressed against the borehole wall. In the original version developed by Schlumberger, two adjacent pads each carry an array of 27 closely spaced electrodes, from which two electrical images are derived. The electrode currents probe the conductivity of the rock to a depth of a few centimeters into the borehole wall, thus responding to such variations in physical and chemical properties of the rock as porosity or surface conduction when clay minerals are present. The series of conductivity traces are displayed side by side, then coded into an image where black represents the most conductive values and white, the most resistive ones. The new ODP sensor was designed in such a way that four images (of 16 traces each), instead of 2, are recorded simultaneously (Fig. 14). In addition, the resolution of the images is improved because of the smaller size of the electrode array. Once the data have been acquired in the borehole, the images are processed on a devoted workstation to allow for on-site comparison with the cores.

Possible applications of the FMS-derived images include the orientation of cores, the mapping of fractures, foliations, sedimentary features, and the direct analysis of depositional environments (with information on transport direction, structure of the pore space, nature of contacts, and depositional sequences).



Figure 13. Sketch of the formation microscanner (FMS). Four images are recorded from four pad arrays of 16 electrodes each. The 4 antipodal arrays are located on separate pads that open up in the borehole just as an umbrella would.

Vertical Seismic Profiles

The technical specifications and experimental procedure for the vertical seismic profiles (VSP) are described in great detail by Phillips (Shipboard Scientific Party, 1988). During Leg 126 the sound source used was the *JOIDES Resolution*'s large-volume (400 in.), high-pressure (2000 psi/106 bar) water gun (SSI P400 Model 02). This choice was made on the basis of providing the best possible results from a single experiment within the time constraints of the program.





Figure 14. A. Sketch of an FMS pad with a 16-electrode array. B. Geometry of the FMS array. Dimensions are in millimeters.

Data Quality

Downhole data quality may be seriously degraded in excessively large sections of the borehole or by rapid changes in the hole diameter. Electrical resistivity and velocity measurements are least sensitive to such borehole effects. The nuclear measurements (of density, neutron porosity, and both natural and induced spectral gamma rays) are most seriously impaired because of the large attenuation by the borehole fluid. Corrections can be applied to the original data to reduce the effects of these conditions.

Different logs may have small depth mismatches, caused by either cable stretch or ship heave during recording. Small errors in depth matching can impair the results in zones of rapidly varying lithology. To minimize such errors, a hydraulic heave compensator adjusts for ship motion in real time. Downhole data cannot be precisely matched with core data in zones where core recovery is low because of the inherently ambiguous placement of the recovered section within the interval cored.

Data Analysis

Throughout the acquisition of downhole measurements, incoming data are observed in real time on a monitor oscilloscope and simultaneously recorded on digital tape. After the completion of a set of downhole measurements, tapes are reformatted to allow interpretation using shipboard software; an interactive log-interpretation software package with a versatile array of manipulative and plotting options is available for this purpose. The precise nature of the interpretation procedure varies for each site. Although initial appraisal of the downhole data is car-

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ried out on board ship, further analyses and interpretation are undertaken after the end of the leg.

Reprocessing of Downhole Data

Raw count rates for six elements (Ca, Si, Fe, S, Cl, and H) are obtained in real time by the Schlumberger data acquisition software. In the past, these count rates have commonly exhibited some inversion interference from chlorine; this is manifest as a strong but spurious correlation between chlorine and calcium, and weaker correlations with other elements. This interference, which is attributable to the dominance of the induced gamma-ray spectrum by chlorine, has until now been unavoidable in ODP holes because the minimum pipe diameter is too small to permit the use of a boron sleeve for chlorine count suppression (see Harvey and Lovell, in press). On Leg 126, however, a modification to the tool allowed the inclusion of a slimmer boron sleeve.

The data is reprocessed after the cruise using proprietary Schlumberger software. The gamma-ray spectrum at each depth is inverted for titanium, gadolinium, and potassium in addition to the six elements listed above. Though gadolinium is present in concentrations of only a few parts per million, its neutroncapture cross section is so large that gadolinium can account for 10%-30% of the total gamma-ray spectrum. Inclusion of these additional elements improves the quality of the overall inversion, particularly the accuracy of calculated calcium abundance, by converting sources of unaccounted variance to signals. The potassium concentrations determined, however, are less accurate than those from the NGT, and the hydrogen concentrations similarly are less accurate than those from the neutron tool (CNT).

Aluminum concentrations from the ACT require correction for variations in cable speed. Changes in speed affect the time lag between neutron irradiation of the formation and recording of the induced gamma-ray spectrum because the number of induced gamma rays decreases rapidly with time. Post-cruise correction for this effect is possible with techniques used in land holes; this correction may be less reliable in ODP holes where ship heave affects the measurement in spite of mechanical compensation devices.

After geophysical and geochemical downhole measurement combinations have been completed, it is possible to reprocess the geochemical downhole data further. The relative abundances of Ca, Si, Fe, Ti, Al, K, S, Th, U, and Gd are used to calculate a log of predicted photoelectric effect. The difference between this calculated curve and the actual photoelectric curve may be attributed to the only two major elements not directly measured, Mg and Na. Major elements are converted from volume percent to weight percent using downhole data curves of total porosity and density. Major elements are expressed in terms of oxide weight percent, based on the assumption that oxygen is 50% of the total dry weight.

If GST data are available, but not enough log types are run to permit complete solution for oxide weight percentage, one further processing step is made. Omitting chlorine and hydrogen, the yields of the other GST-derived elements (Ca, Si, Fe, Ti, S, K, and Gd) are summed, and each is expressed as a fraction of this total yield. This procedure corrects for porosity and count-rate variations. Although the absolute abundance of each element is not determined, downhole variations in relative abundance are indicated.

Downhole sonic data obtained in real time are not based on full-waveform analyses but on a threshold-measuring technique that attempts to detect the compressional wave arrival by firstbreak criteria. Occasionally, this technique fails, and either the threshold is exceeded by noise, or the amplitude of the first compressional arrival is smaller than the threshold. The latter of these effects is known as cycle skipping and creates spurious spikes on the sonic log. Such problems may often be eliminated by reprocessing the data.

In-Situ Stress Measurements

The FMS was used during Leg 126 to determine principal horizontal stress directions from elongation caused by stress-induced borehole breakouts. In an isotropic, linearly elastic rock subject to differential stresses, breakouts form along the borehole wall as a result of compressive stress concentrations exceeding the strength of the rock. Under these conditions, the breakout orientation will develop in the direction of the least principal horizontal stress. It has been demonstrated in different areas that stress orientations deduced from breakouts are consistent with other independent indicators (Bell and Gough, 1979; Zoback et al., 1988). See individual site chapters for detailed explanations of FMS operations.

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