International Congress
CORING FOR GLOBAL CHANGE
ICGC '95
Kiel

28 - 30 June, 1995

Edited by
Jürgen Mienert and Gerold Wefer

Contributing Authors
G. Bond, D. Diepenbrook, H.-R. Kudrass, Y. Lancelot, K. Manchester, P. Mason, N. McCave, J. Mienert, V. Spiess, M. Sarnthein, F. Theilen, J. Thiede, P. Weaver, G. Wefer

GEOMAR
Forschungszentrum
für marine Geowissenschaften
der Christian-Albrechts-Universität
zu Kiel

Kiel 1996

GEOMAR REPORT 45

GEOMAR
Research Center
for Marine Geosciences
Christian Albrechts University
in Kiel

Redaktion der Serie:	Gerhard Haass	Managing Editor:	Gerhard Haass
Redaktion dieses Reports:	Gerhard Haass, Jürgen Mienert, Manon Wilken	Editors of this issue:	Gerhard Haass, Jürgen Mienert, Manon Wilken
Umschlag:	Kerstin Kreis, Harald Gross, GEOMAR Technologie GmbH	Cover:	Kerstin Kreis, Harald Gross, GEOMAR Technologie GmbH

GEOMAR REPORT
ISSN 0936 - 5788

GEOMAR REPORT
ISSN 0936 - 5788

GEOMAR
Forschungszentrum
für marine Geowissenschaften
D-24148 Kiel
Wischhofstr. 1-3
Telefon (0431) 600-2555, 600-2505

GEOMAR
Research Center
for Marine Geosciences
D-24148 Kiel / Germany
Wischhofstr. 1-3
Telephone (49) 431 / 600-2555, 600-2505

ICGC 95

INTERNATIONAL CONGRESS

" CORING FOR GLOBAL CHANGE "

An international forum was organized to identify scientific as well as coring needs and to channel the considerable efforts and collective planning of geomarine research towards creating new coring technologies for future research activities. This workshop provided the platform and brought together colleagues from the various marine science and technology disciplines. The organization of ICGC was kindly supported by the help of Ute Brennwald, Manon Wilken and the administrative staff of GEOMAR. ICGC 95 was sponsored by the Ministerium für Wissenschaft, Forschung und Kultur des Landes Schleswig-Holstein; DEMINEX DT. Erdölversorgungsgesellschaft mbH, Essen; J. Bornhöft Industriegeräte GmbH, Kiel; Deutsche Bank AG, Kiel; Erich Eydam KG Kiel; Fahrenkrog, Reisebüro, Kiel; Hauke Haardt Optik, Kleinbarkau; Hydrowerkstätten GmbH, Kiel; Industrie- und Handelskammer zu Kiel; Kieler Volksbank eG; Max Giese Bau GmbH, Kiel; Provinzial Brandkasse, Kiel; Sparkasse Kiel; and GEOMAR Forschungszentrum für marine Geowissenschaften, Kiel. The congress was made possible by a grant from the Deutsche Forschungsgemeinschaft (DFG).

The ICGC convenors

Jürgen Mienert (GEOMAR, Kiel) and Gerold Wefer (Bremen University, Bremen)

MAIN RECOMMENDATIONS FOR CREATING NEW CORING TECHNOLOGIES

The recommendations based on ICGC 95 provide a guideline for the development of a long-coring tool capable of retrieving up to 100 m long sediment cores for a worldwide investigation of global paleoceanographic and paleoclimatic changes for the last 500,000 years. The goal is unattainable using conventional coring technology and available samples and data.

- *ROBOTICS:* Until now, robotics are not being used on any research vessel to assist in the retrieval of cores. A guideline for the design of such robotics together with long piston coring devices is needed as these systems would get around the requirement of 20 to 50 meters of space along the side of the ship. It would provide an exceedingly valuable guideline to engineers and naval architects designing new ships with long piston coring requirements or adapting existing ships to more safely and efficiently handle large piston corers.

- *WINCHES:* A feasibility study is needed to ascertain that new winches (30 t capacity, 2.5 m/s speed) will satisfy the user in full ocean operation with a variety of cables.

- *SYNTHETIC CABLES:* It is crucial to find the most suitable cable type and construction to be used for long piston coring. Assuming a synthetic cable is satisfactory, the recommended fibre type, construction, jacket material and termination are to be defined. The synthetic cable would be nearly neutrally buoyant enabling a smaller existing winch to handle a large corer in deep water.

- *DRILLING/CORING FROM SUBMARINES:* An international feasibility study is needed to explore whether submarines could be refurbished for scientific operations in terms of technology and costs. This should be reviewed, particularly in relation to the various types of submarines, and with respect to surveys and deployment of heavy instrumentation.

- *LOGGING WHILE CORING:* High-resolution in-situ logging (LWC = Logging While Coring) together with on-board logging and ultra-high-resolution seismoacoustic data sets are encouraged for paleoclimatic/environmental studies.

- *SHIP NEEDS:* Progress is needed in the architecture of robotics, new generation of winches, on-board and sea floor logging systems, cables and moon pools.

- *CORE STORAGE, HANDLING, CURATION, DATA BANKS:* International standards should be followed (set by the SCOR mandate of Working Group 100, and IMAGES guide lines) to protect sediment core samples from physical deterioration and lost of information. State of the art of non-destructive core measurements should be made on the entire core. Continuous measurements on core surfaces of split cores including color imaging or color spectral analysis are needed. Split cores should be capped and sealed in D-tubes. Data acquired from sediment samples should be made available to the international scientific community to allow integration into numerical modelling experiments and to national and finally world data banks (i.e. Boulder, Colorado, USA).

TABLE OF CONTENTS

ICGC 95 OVERVIEW

The ICGC 95 report is derived from the material presented and discussed at the congress in Kiel held from June 28-30, 1995. The report contains the working group recommendations for the four themes (scientific needs and requirements, existing coring technologies, new deep-sea coring technologies, shipboard requirements and high-resolution sea floor studies) and the abstracts of oral and poster presentations.

CHAIRMEN: Gerold Wefer, Gerard Bond
SCIENTIFIC NEEDS AND REQUIREMENTS

Dieter Fütterer, Nick McCave
EXISTING CORING TECHNOLOGIES

Jürgen Mienert, Keith Manchester
NEW DEEP-SEA CORING TECHNOLOGIES

Dieter Meischner, Philip Weaver
SHIPBOARD REQUIREMENTS AND HIGH-RESOLUTION STUDIES

The objective of ICGC 95 is to promote new coring technologies enabling studies to quantify climate and chemical variability of the ocean for the last 500,000 years. Progress in reaching this goal can only be achieved through the collection and examination of marine sediment records recovered under well-designed sampling technologies, analyses and data assimilation and, equally important, high-resolution acoustic sea floor studies. Highly dedicated oceanographic coring expeditions are to be launched over the next decade to collect sediment samples from beneath the thermohaline conveyor circulation for establishing the natural variability of the oceanic system. This goal can be attained only through new technological developments, that will allow the international scientific community to build a new generation of research vessels and to take the next step in our understanding of rapid global changes in the climate system and of the role the ocean circulation plays in controlling climate.

Scientific needs and requirements for high-quality sediment sections contain the major elements:

- 500,000 years sedimentary records to cover major glacial/interglacial cycles
- temporal resolution of a few centuries or decades
- sedimentation rates of 5 - 10 cm/kyr or higher
- 600 cores (approx.) for a sufficient spatial resolution
- large diameter cores (12 cm and more) to provide sufficient sediment material for high-resolution studies
- applications of color and physical property screens for intercore correlations
- multiple overlapping coring.

Recommendations for new coring technologies contain ten major developments:

- *NEW WINCHES:* A feasibility study is needed to ascertain that new winches such as BAND WINCH (30 t capacity, 2.2 m/s speed) will satisfy the user in full ocean operation with a variety of cables.

- *SYNTHETIC CABLES:* It is crucial to find the most suitable cable type and construction to be used for long piston coring. If a synthetic cable is satisfactory, what is the recommended fibre type, construction, jacket material and termination to be used? The synthetic cable would be nearly neutrally buoyant enabling a smaller existing winch to handle a large corer in deep water.

- *ELASTIC CABLE PARAMETERS:* One of the primary operational problems effecting the quality of the core when using a piston corer is the elastic rebound of the lowering cable resulting from the quick release of the large weight. A wide range of variations in the elastic parameters of the cables used exists. The most suitable cable for reducing the severity or eliminating the problem in piston corers, coupled with necessary weight and strength, should be sought.

- *ROBOTICS:* Handling of coring equipment varies tremendously from ship to ship and country to country. To our knowledge, robotics are not being used on any ship to assist in this procedure. A recommendation should be made to what is considered the best way to design them and whether a moon pool is required. It would provide an exceedingly valuable guideline to engineers and naval architects when designing new ships with long piston coring requirements or adapting existing ships to more safely and efficiently handle large piston corers. This would get around the requirement of 20 to 50 meters of space along the side of the ship.

- *CORE LINER MATERIALS:* Many different core liner materials are or have been used such as PVC, CAB, Poly Carbonates and Hostalite. All of these have different mechanical properties. The one important property that varies in them, and is very important to their performance, is their coefficient of friction in relation to the sediment and piston passing up them. An investigation should be made on all the materials available to ascertain which is the best material to use in consideration of strength, friction, ease of availability, and cost.

- *CORE CUTTER AND VALVE DESIGN:* Many ways are used to retain the core in the core barrel. These are normally a core catcher in the core cutter, a device on the piston itself that is preventing it from sliding, as well as other valve arrangements in the top of the barrel to prevent the inflow of sea water above the core when the corer is being retrieved. The core catchers used are of many designs. It is not known which existing design is the best. Thus, the present types of core-retaining methods should be investigated and a recommendation should be made as to which is the most appropriate way in a variety of sedimentological settings.

- *CORE MOUNTED INSTRUMENTATION:* It is recommended to use corer monitoring instrumentation on all corers when obtaining long cores to record pressure (depth) as well as acceleration of both, the piston and the corehead and, if desired, the tilt. The instrumentation has been developed and used by the Geological Survey of Canada for five years, and the University of Bremen for the last few years. It has been shown that the data are easily gathered and that it is another independent way to assess the quality of the core. It has also been shown by this instrumentation that there are periods of selective stretching or compression of the core attained which can result in large errors in the calculation of sedimentation rates.

- *FACIES-DEPENDENT CORER CONFIGURATION:* An assessment should be made of whether the corer weight should all be maximized in the corehead with as light a barrel as possible to limit friction in penetrating the bottom, or whether it needs to be distributed in both the corehead and the barrel with a thicker stronger barrel or even a tapered barrel assembly. The optimum corer configuration for one area (i.e. equatorial basin) is not necessarily the optimum configuration for another (i.e. polar basin).

- *DRILLING FROM DYNAMICALLY POSITIONED SMALLER VESSELS:* It is recognized that the use of continuous wireline coring from dynamically positioned vessels provides presently approximately 63 mm diameter cores. It should be investigated whether this type of drilling technology could be used on a number of larger existing drill ships in areas deeper than the present 1500 meter drill string limitation and whether the diameter can be increased up to a maximum of 120 mm using this drilling method.

- *DRILLING FROM SUBMARINES FOR ARCTIC OCEAN STUDIES:* An international feasibility study is needed to explore whether submarines could be equipped for scientific operations in terms of technology and costs. This should be reviewed, particularly in relation to the various types of submarines, and with respect to surveys and deployment of heavy instrumentation.

Recommendations for high-resolution sea floor studies and data bases:

- *ACOUSTIC CONFIGURATION FOR PALEOCLIMATIC/ENVIRONMENTAL STUDIES:* Developments of quantitative comparisons between high-quality in-situ logging (LWC = Logging While Coring), on-board logging and ultra-high resolution seismoacoustic data sets are needed. Incorporation of new sensors in logging devices for geochemical studies are also recommended. Maximum precision of core logging, digital seismic recording, control of measuring geometry and optimization of signal penetration and reception still require significant technical developments.

- *MOBILE ACOUSTIC DEVICES:* Developments of mobile logging and ultra-high resolution seismoacoustic units for universal use on various research vessels are encouraged. Recommended are improvements of techniques and methodology of deep-tow seismoacoustics and side-scan sonar systems to get a better system resolution for specific targets and sediment facies. Common calibration techniques should be developed for logging tools using standard calibration materials. The manufacturers of the sensors should supply standards and calibration materials.

- *DATA BASES:* Already centralized data base facilities should be used and upgraded by the scientific community for data storage to allow a consistent storage of environmental data including paleoclimate and paleoceanographic data.

SCIENTIFIC NEEDS AND REQUIREMENTS

Working group (Gerard Bond, Palisades, USA; Nick McCave, Cambridge, UK; Mathieu Duvall, Boulder, USA; Jürgen Mienert, Kiel, Germany; Michael Sarnthein, Kiel, Germany; Jörn Thiede, Kiel, Germany; Gerold Wefer, Bremen, Germany)

The objective of the congress was to provide the preliminary preparation toward development of a long-coring tool capable of retrieving up to 100 m long sediment cores for a worldwide investigation of global paleoceanographic and paleoclimatic changes for the last 500,000 years. The goal is unattainable using conventional coring technology and available samples and data (Figure 1). Under the auspices of IMAGES (International Marine Global Change Study) and MESH (Marine Aspects of Earth System History) the aim of the working groups was to establish a joint concept for the development of long-coring tools and for the investigation of very high-resolution paleoceanographic and paleoclimatic fluctuations. Within the framework of the international initiatives, a total of about 600 "long sediment cores" should be taken in all major oceanic regions during the next decade (Fig. 2).

PRESENT STATE OF RESEARCH

Rapid climate changes, documented in continental ice cores as well as in deep-sea sediments from high-accumulation regions, provide evidence for a link between climatic events in the atmosphere and the heat and salt transport in the ocean (Broecker and Denton, 1990). This connection is the result of the thermohaline circulation conveyor, by which warm surface water masses flow into the North Atlantic and cold deep water masses flow out.

Significant variations in atmospheric CO_2, documented from gas bubbles in ice cores, are observed in glacial/interglacial reversals. Changes in the intensity of thermohaline circulation are considered to be a probable cause. With the transport of heat into the northern North Atlantic as a prerequisite for evaporation and salt enrichment, and the accompanying increased density of surface waters due to cooling, a deep-reaching convection is introduced. In addition, the influx of salt-rich water masses from the Mediterranean into the North Atlantic contributes to the thermohaline-driven formation of new water masses in the Norwegian/Greenland Sea and northern North Atlantic. From there, rapidly sinking water masses flow southward on the western side of the Atlantic as North Atlantic Deep Water and, flowing through the Antarctic Circumpolar region, arrive in the Indian and Pacific Oceans. The thermohaline circulation conveyor then closes its circuit through the ascent of warmer, more salt-enriched deep water from the North Atlantic, which contributes to the formation of Antarctic Intermediate Water and Bottom Water (Carmack and Foster, 1975), both of which then flow northward.

Using a number of different proxy-data methods, international research programs have been able to verify that this circulation pattern has changed in relation to Quaternary climate fluctuations from glacial to interglacial conditions (see Boyle and Keigwin, 1987; Charles and Fairbanks, 1988). Long-term restructuring was overprinted by short-term oceanographic and climatic events. A repeated and massive input of ice-rafted material to the North Atlantic during the last 65,000 years points to periodic maxima of iceberg formation at the Laurentide ice front. These maxima were very short-lived, and therefore could not be explained by orbitally forced climatic processes (Heinrich, 1988; Bond et al., 1993). Similar short-term climatic instabilities are documented in ice cores from the Greenland continental glaciers (Dansgaard et al., 1993), which influenced the climate over a large portion of the North Atlantic region (Veum et al., 1992; Lehman and Keigwin, 1992).

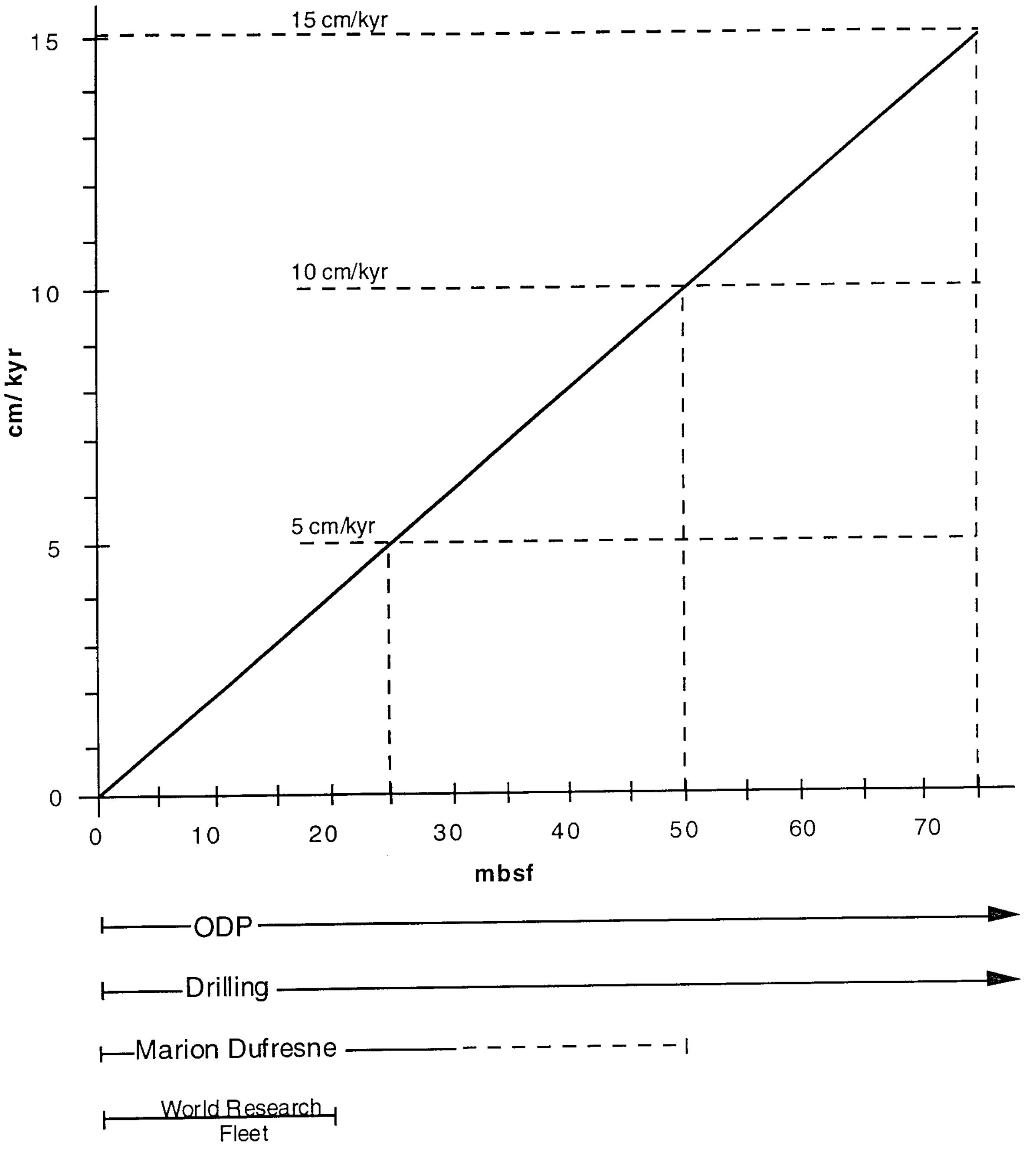
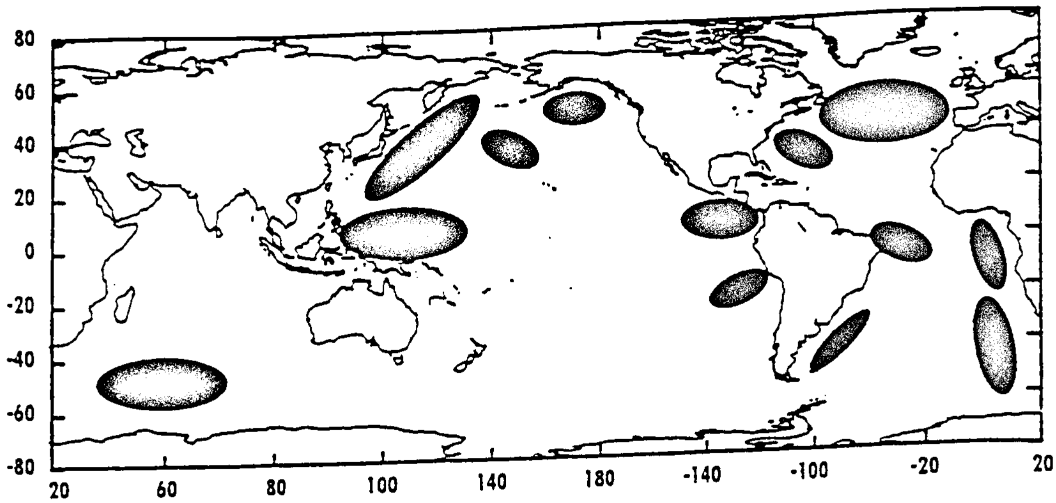
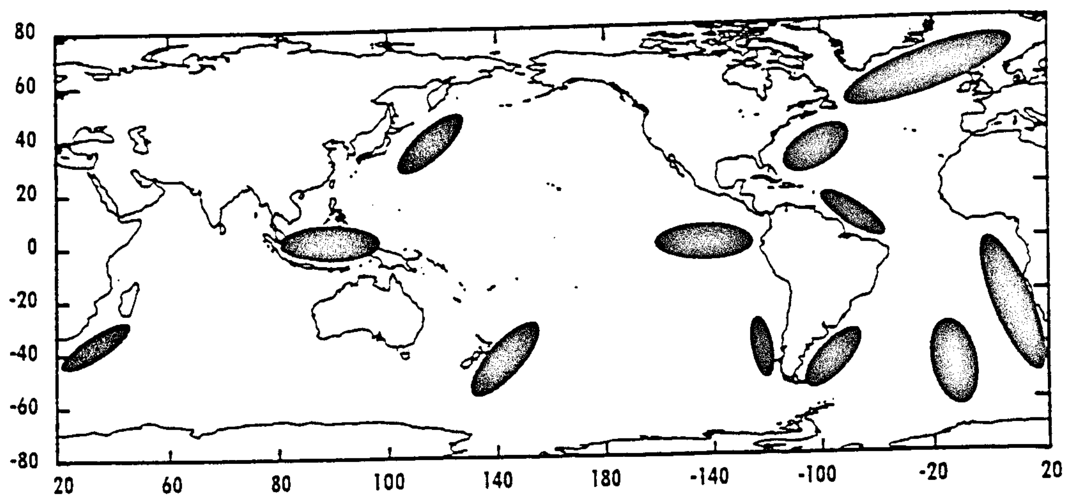


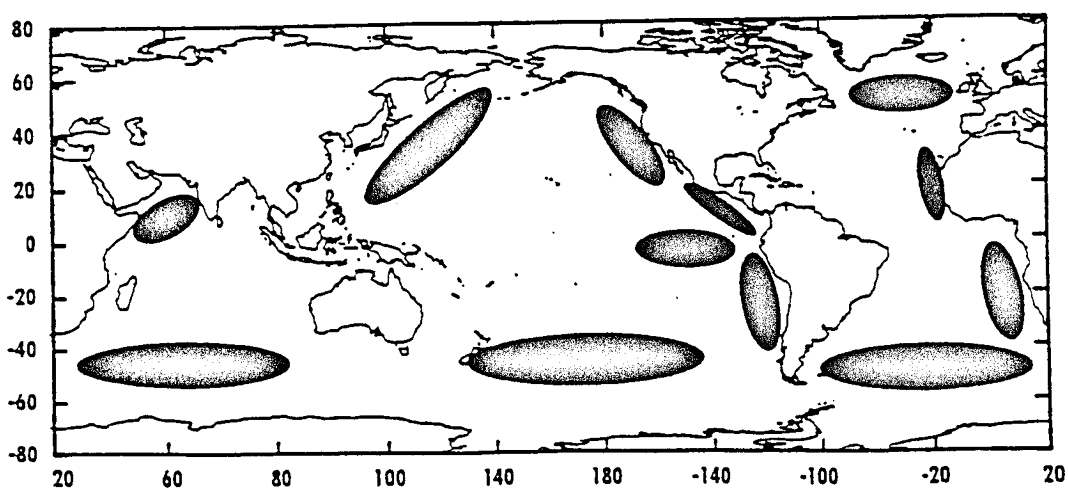
Figure 1: Sedimentation rate (cm/kyr) versus coring penetration (mbsf) for the various research vessels (bottom) and drilling vessels (top). For coring high-sedimentation („high-resolution") rate areas new long coring technologies on research vessels are required. The diagram aims at recovering 500,000 year records of ocean history.



Target regions for IMAGES vertical circulation studies.



Target regions for IMAGES heat transport studies.



Target regions for IMAGES productivity studies.

Figure 2: Generalized locations of IMAGES field program (adopted from PAGES workshop report, Series 94-3).

International research programs such as PAGES (Past Global Change Studies), NAD (Nansen Arctic Drilling Program), MESH (Marine Earth System History) and IMAGES (International Marine Global Change Study) are working toward the reconstruction of natural variability of the ocean-climate system for the Pleistocene. This work includes the quantification of climatic, chemical and biological variability of the ocean as well as its regulating effect on atmospheric CO_2. For the accomplishment of the top priority plans of these programs, the need for long-coring equipment to sample the upper 100 m of sediment is indicated. Stratigraphic resolution comparable to the ice cores over several 100,000 years can only be achieved with sediment cores from regions of high sediment accumulation.

HIGH SEDIMENTATION RATES: REQUIREMENTS AND PITFALLS

High sedimentation rates may be highly desirable but they should not be acquired indiscriminately. If the intention of seeking high sedimentation rates is to combat the influence of biological mixing (and it usually is), then it must be ensured through understanding of sedimentology that more problems are not created than are solved. Let us explain:

Most investigators looking for high sedimentation rates for global change research are hoping to have an inert filler that bulks up the foraminiferal record. It is the foraminifera they want. High sedimentation rate minimizes the parameter $G=D_B/SL$ (where D_B is the biological mixing diffusivity and L the mixing depth) (Guinasso and Schink, 1975). It is also reduced by low D_B which occurs under low organic carbon input to the bed (Shimmield, 1995). It is probable that high S (sedimentation rates) also minimizes stratigraphic displacement of foraminifera by biological pumping (i.e. McCave, 1988). The models of Guinasso and Schink show that even with $G = 0.03$, the spread of a thin layer becomes about half the mixed layer thickness. At a high sedimentation rate of 1 m/ka with $L = 100$ mm this amounts to smearing of a one-year signal through a sediment record corresponding to about 50 years. This value of G requires a very low D_B of 0.03 cm^2/a. So we need to think of finding sedimentation rates in the region of 1 m/ka.

Such rates are unlikely to be sustained at one place over the timescale of 500 a desired for a global change evaluation (because a $^1/_2$ km high mound would result!) We will therefore have to splice together segments of cores with high rate to achieve a composite. To find these high-rate segments a good acoustic system with resolution of about 1 m and penetration to 200 m is needed.

At present the highest temporal resolution in most deep-sea sediments is achieved with AMS radiocarbon dating. AMS radiocarbon chronologies, however, are limited to about the last 30,000 years and by 1 sigma errors of about ±50 years in younger sediments and from ±200 to ±300 years in older sediments. Hence, for high-resolution sampling at 1 cm intervals, the maximum temporal resolution of 100 to 600 years is reached at only moderate sedimentation rates of 5 to 6 cm/kyr. While the new long and large diameter cores from sediments with much higher sedimentation rates offer exciting possibilities for higher chronological resolution over more than one glacial-interglacial cycle, it is far from likely that time can be scaled between dated layers by simple linear interpolation. For example, estimates of sediment fluxes constrained by AMS radiocarbon dating demonstrate that sedimentation rates vary on short time scales, not uncommonly across sharp climatic boundaries. Hence, the degree to which higher sedimentation rate cores actually can provide higher temporal resolution will depend on how well variable sedimentation rates can be quantified in undated sediment. Moreover, to confirm the regional (or global) source of the signal it is necessary to replicate records in cores from different depositional environments. This is not easily done for the events beyond the reach of radiocarbon dating, either in sediments >40,000 years or in high sedimentation rate intervals in younger sediments where interpolation between radiocarbon ages is necessary to estimate ages.

High sedimentation rates are most commonly associated with deposits of sediment gravity flows - turbidites and debris flows. These clearly introduce an undesirable element into a hemipelagic sequence and should be avoided. Their deposition rates are very high, but do not fulfill the objective of giving higher resolution with regular increments to a foraminiferal record. They also obviously give a fast-slow-fast accumulation rate structure which makes age modelling difficult. This problem may well also exist in apparently ideal deposits on continental slopes down-drift from canyons from which the fine tails of turbidity currents spread out. These deposits may thus have an unrecognized episodic age structure. Far enough down-drift of canyons (>100 km) the episodic input will usually no longer be influential in deposition rate. It will be conditioned by the magnitude/frequency structure of sediment transporting events which, for deep currents, is sufficiently frequent to not introduce an irregular age structure. Gravity flows are of course slope processes and investigators must be vigilant to recognize their influence in slope locations which otherwise provide many examples of high sedimentation rate. Slope resuspension and transport processes also have a frequency structure which allows geologically continuous input of fine material to expand the foraminiferal record.

High sedimentation rates provided by currents, slope fall-out, turbidite tails or glacial ice-rafting may contaminate records in undesirable ways. Current transported coccoliths may relate to productivity some distance away in contrast to coexisting forams, turbidite fine particles are of mixed age structure (Weaver, 1994), slope deposits may be supplied with resuspended old refractory carbon (Anderson et al., 1994), ice-rafting supplies old carbonate (Balsam & Williams, 1993), and the grainsize spectrum of coarse current-controlled silt may look very similar to that of wind-blown silt. Many other potential problems lurk in the different origins of imported size fractions. Many of these problems are those with which palaeoceanographers and sedimentologists deal regularly, but the most difficult is the cryptic irregular age structure.

Finally, stretching and compression of the sediment during piston coring introduce apparent changes in sedimentation rates which can be quite large. This technical problem must also be addressed (perhaps by monitoring accelerations of the corer and piston core pressures) as part of the issue of scaling time in undated sediments.

EXISTING CORING TECHNOLOGIES AND NEW DEEP-SEA CORING TECHNOLOGIES

Working group (Steve Bremner, Cambridge, UK; José Diaz, Madrid, Spain; Jean-Pierre Henriet, Plouzané, France; Hermann Kudrass, Hannover, Germany; Keith Manchester, Dartmouth, Canada; Peter Mason, Barry, UK; Hiroshi Matsuoka, Tokyo, Japan; Dieter Meischner, Göttingen, Germany; Jürgen Mienert, Kiel, Germany; José Monteiro, Lisboa, Portugal; Jack Pheasant, Edinburgh, UK; Sigurd Ree, Ågotnes, Norway; Wolfgang Schneider, Kiel, Germany; Shinichi Takagawa, Yokosuka, Japan; Friedrich Theilen, Kiel, Germany; Gerold Wefer, Bremen, Germany)

SHALLOW DRILLING

It was recognized that the use of continuous wireline coring from such dynamically positioned vessels as the *MS BUCENTAUR* or *MV PHOLAS* has successfully been carried out in water depths to nearly 1000 meters. The present limitation of this system is the 1500 meter drill string length, which, depending on how deep the water is, puts a limit to the coring depth (i.e. 1200 meters of water depth means a maximum of 300 meters into the ocean bottom.)

Recommendations for investigations to improve this technique to meet the requirements of the IMAGES program are as follows:

- While it is recognized that the present approximate 63 mm diameter core attained is good for coring hard crystalline rock, it is considered too small in diameter for unconsolidated cores to meet all the scientific needs for the IMAGES or NAD program. Therefore, it should be investigated whether this core size for use in unconsolidated sediments can be increased in diameter up to a maximum of 120 mm using this drilling methodology.
- It should also be investigated whether the ODP Advanced Piston Coring (APC) type coring technology could be adapted to this type of smaller drill ship.
- It should be investigated whether this type of drilling technology could be used on larger existing drill ships to allow its deployment in areas deeper than the present 1500 meter drill string limitation of the above noted vessels.
- If a larger quantity of core samples is desired when this present drilling technology is used, one simple way would be to drill closely spaced holes.

IMPROVEMENTS TO PRESENT ODP CORING CAPABILITIES

The development and very successful use of the ODP Advanced Piston Coring (APC) technique is recognized as meeting most scientific needs. However, there has often been a requirement to attain more samples for scientific needs than obtainable from one APC core. This is, at present, only met by acquiring multiple closely spaced APC cores. It was suggested by Mike Storms of ODP that it may be possible to develop a giant piston corer for use on the *JOIDES RESOLUTION* by fixing a large diameter piston on the bottom of the existing drill string and allowing the core barrel, consisting of casing, to be around the drill string. This coring assembly would be deployed from the surface like a normal piston corer, but instead of having a cable to the piston, one would use the drill string as the cable. The whole assembly would be lowered to the bottom and then tripped like a normal piston corer. The potential advantage is a very large diameter and long core sample attained with essentially a fixed bottom referenced piston corer, i.e. STACORE type. This would require the drill string to be run each time for a core, but with the potential quantity and quality of core that could be attained in one operation. It was felt that this new technique should be further investigated as it could be used on any large existing commercial vessel as well as on the ODP ship.

It is not known how long a core could be attained using this technique, but it would be desirable to have the capability of attaining one as long as operational or geomechanical conditions allow.

IMPROVEMENTS TO PISTON CORING TECHNOLOGY

The piston coring technique has been in use for more than fifty years (after its invention by Kullenberg (1947) for the Swedish *Albatross* Deep-Sea Expedition organized by Pettersson (1957)), but while successfully meeting many scientific requirements, it still has many areas requiring improvements to meet the IMAGES program needs. Coring devices now exist in a wide range of sizes, shapes and designs, but to our knowledge there has not been any relatively recent detailed investigation of what is really required to have the optimum piston coring system. It should be pointed out that in fact the "piston coring system" consists of more than just the corer itself. Of equal importance to the corer are the lowering winch, cable limitations, as well as the handling facilities on the ship to safely, successfully and efficiently assemble, launch, retrieve and disassemble the corer and retrieve the core in as wide a range of sea conditions as possible. This increases in importance with the growth of the corer size. The following recommendations are presented for areas where improvements could result in longer, better quality cores and more efficient operational use.

- It is recommended that a minimum 12 cm diameter core is to be attained to provide an adequate quantity of core material. It is also recommended that this size must be considered in relation to the liner's wall thickness as well as staying with an international standard stock size for the barrel to reduce acquisition and machining costs. At present, large diameter piston corers capable of taking core lengths of 30 meters or more, exist in the French STACOR and CALYPSO corers, the Canadian AGC LARGE CORER, and the German GÖTTINGEN CORER. Also, the Norwegian SELCORE system promises to take this core length.

- It is generally assumed that the heavier the corer is, the deeper it is likely to penetrate the bottom strata. What is not really known is the best location to place the weight. Should it all be maximized in the corehead with as light a barrel as possible to limit friction in penetrating the bottom, or should it be distributed in both the corehead and the barrel with a thicker stronger barrel or even a tapered barrel assembly. This should be reviewed, particularly in relation to where the corer may be used. Again it must be stated that it is easy to attain long cores in deep equatorial basins, but much more difficult in more polar regions.

- It is agreed that one of the primary operational problems largely effecting the quality of the core when using a piston corer is the elastic rebound of the lowering cable resulting from the quick release of the large weight. This effects the motion of the piston, to which it is attached, during the few seconds time interval of the actual coring operation. This has often been shown to cause disturbance to the core in core stretching, core compacting, or liner implosion. Various methods have been used or suggested to overcome or limit the severity of this problem which is mainly due to the elastic properties of the cable. Examples of these methods are:

using a "soft piston" as the large French CALYPSO corer; putting an "anti drag" piston as the Dutch piston corer; and/or by the proper selection of the free fall distance. This appears to be more of an art than a science even though with an extensive geotechnical background. It should be investigated to find the best way of reducing the severity or eliminating the problem in piston corers other than a bottom-referenced piston coring system, such as the French STACORE, which is more difficult to handle on ships than other piston coring systems. This must be considered with the lowering cable specifications as it is certain that there is a wide range of variations in the elastic parameters of the cables used.

- It is recommended that corer monitoring instrumentation should be used on all corers when attaining long cores to record both pressure (depth) and acceleration of the piston and the corehead and, if desired, the tilt. The instrumentation has been developed and used by the Geological Survey of Canada for five years, and the University of Bremen for the last few years. It has been shown that the data are easily collected. This is another independent way to assess the quality of the core. It has also been shown by this instrumentation that there are periods of selective stretching or compression of the core attained, which can result in large errors to the calculation of sedimentation rates.

- Many different core liner materials are or have been used such as PVC, CAB, Poly Carbonates and Hostalite. All of these have different mechanical properties as well as cost and availability considerations. To our knowledge, the one important property that varies in them, and is very important to their performance, is their coefficient of friction in relation to the sediment and piston passing up them. An investigation should be made on all the materials available to ascertain which is the best material to use in consideration of the strength, friction, ease of availability, and cost. It is worth noting here that if there was a world standard in the size of the core barrels used and the liner specification, it could likely result in better performance at lesser costs. The inner diameter of the core cutter in relation to the inner diameter of the liner is also important. Some undercutting is desirable. Too much creates other problems. This should be investigated in relation to the core liner friction characteristics to determine a rule of thumb specification for various sediment types.

- Many ways are used to retain the core in the core barrel. These are normally a core catcher in the core cutter, a device on the piston itself that only allows it to go up the barrel and not slide back, as well as other valve arrangements in the top of the barrel to prevent the inflow of sea water above the core as the corer is being retrieved. The core catchers used are of many designs. It is not known which existing design is best. The performance of the core catcher becomes more important if the coefficient of friction of the liner is reduced, or the valve or piston above the core does not seal well. The present types of core-retaining methods should be investigated and a recommendation made as to which is the most appropriate for attaining piston or any other types of cores.

- When taking long cores on smaller ships, one of the primary encountered limitations is the space and facilities required to swing the corer assembly from the horizontal to the vertical and vice versa. A suggestion was made to assemble and disassemble the corer in a vertical position, obviously when the ship is stopped. This would get around the requirement of 20 to 50 meters of space along the side of the ship, which is particularly hard to find on many of the existing research vessels. It is recommended to carry out a feasibility study to ascertain if this is a practicable suggestion. If so, it may allow longer cores to be taken on some existing research vessels.

HAMMER-PERCUSSION CORING

It is recognized that piston corers are not applicable to coring hard high-shear strength sediments and that single impact energy is unsuitable. Multi-blow energy is required to satisfactorily core this type of sediment which is more often found in the higher latitude sediments.

Prototype developments exist in the Norwegian SELCORE hydrostatic corer and the EU funded HAMMERCORER. At present, both of these can take cores up to 20 meters or so with the present capability. It is recommended that the following investigations and testings are to be carried out:

- Investigation and testing are to be carried out to increase the core length capable of being attained up to 50 meters.
- Investigations are to be carried out and the design of methods resulting from this is to be tested to reduce the lifting force required to retrieve them from the sea floor once coring is completed. Improving effects of flushing of the core barrel by high-pressure water which is pumped through an inner space, as provisional by the hammer corer, has yet to be tested.

OCEAN BOTTOM MOUNTED DRILLING SYSTEMS

There have been, and still is, a number of ocean bottom mounted drilling equipments that were primarily designed for taking cores of less than 10 meters long in mainly crystalline rock. The following is a partial list of these:

- BIO Rock Core Drill
- Nordco Auger Drill
- BGS Rock Core Drill
- Williamson and Asso. Rock Core Drill
- Williamson and Asso. Benthic Multicoring System
- Wimpey-Atlas-Copco TEREDON drill
- A Russian multiple barrel Rock Core Drill
- The Australian PROD multiple barrel drill
- The Finnish Rauma-Repola Deep Ocean multiple barrel Corer

There are likely many more, but it is felt that as all of these were primarily designed for acquiring cores of diameters from 25 mm to 60 mm, and the only ones that exist take cores much smaller than the above stated needs of 120 mm. If a future development with a 120 mm core diameter coring capability with up to a 50 meter core length was considered, it would result in a very large and heavy piece of equipment that would have to be lowered with an umbilical to the ship holding station over it. This would probably result in a less than 1000 meter water depth capability. It is not recommended to put further effort into developing this type of technology to meet the IMAGES program requirements, as it could be done using existing shallow drill ship drilling techniques.

The one area where it may have some applicability is in drilling coral formations, but as this is being pursued by the Australians, this should just be watched as the technology is proven to see if it does have wider applications to global change coring requirements.

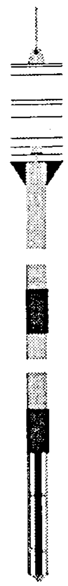
LOGGING WHILE DRILLING (LWD) & LOGGING WHILE CORING (LWC) TECHNOLOGY

This technology has become available for use in commercial oil industry drilling, primarily for drilling control purposes. It was felt that this type of development, if adaptable to large diameter piston coring or rotary coring of surficial sediments, may have valuable applications to data collection for the IMAGES program. It is recommended to investigate this future capability to ascertain its practicability to meet this requirement. Some developments for gravity coring devices such as penetration measurements for the assessment of physical parameters from the sea floor already exist (Theilen and Kögler, University of Kiel).

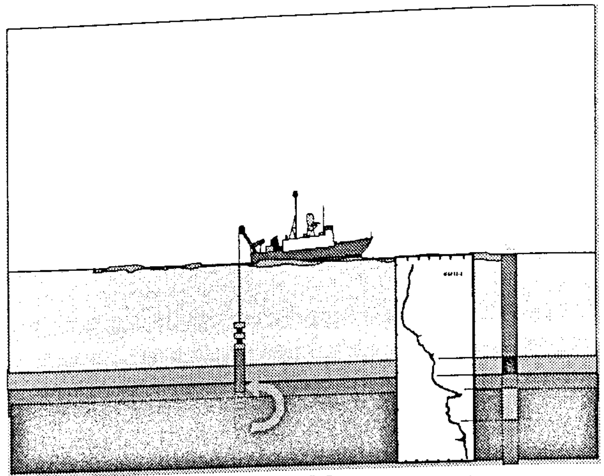
Many applications with respect to geotechnical and environmental research need special information on physical and chemical properties of the sediments, which cannot be deduced directly from seismic traces. They are normally assessed by conventional laboratory measurements on core samples. This procedure, however, is rather time-consuming and expensive. For this reason, penetration measurements are being developed combining borehole logging and coring techniques. The needs for higher resolution and additional parameters require the development of new types of sensors.

Different types of penetration devices are used. The first type consists of a frame as operational platform carrying the penetration devices. It is deployed on the sea floor, where it operates autonomously or controlled by cable to the ship. Penetration is performed by engines allowing a well-controlled insertion of the sensors into the sea floor with respect to speed and force. It has the advantage that the device is decoupled from ship movements. The low penetration speed guarantees a high vertical resolution in a range of less than 10 cm.

The second type is based on gravitational penetration. Such a system ("GISP - Geophysical in-situ Probe", Theilen and Kögler, University of Kiel) was developed under MAST II in Kiel. The sensors are mounted at the lower end of a 10 or 20 meter long penetration tube, which is loaded by a lead weight of 1.5 tons at the upper end. The system is operated by the ship's winch, which lowers it vertically to the sea floor and controls the penetration speed of about 10 cm/s. The penetration depth depends on the stiffness of the sediments, but 10 to 20 meters can be attained in soft sediments. The advantages of such a system are the high penetration and the efficiency of its deployment on the sea floor. Those parameters which depend on the effective pore pressure are not affected by the pressure release during the recovery of the core. The depth is controlled by a pressure sensor with an accuracy of 1 cm which is mounted directly above the sensors. All data are transferred by cable to the recording and controlling units on board of the ship. The following parameters are assessed with the penetration device: (i) wet bulk density, (ii) natural gamma radiation, (iii) electrical resistivity and (iv) compressional wave velocities. The density measurement is performed with a gamma-gamma sensor as it is used in borehole logging techniques. All sensors, with the exception of that for the electrical resistivity, are mounted in a protection tube with a wall strength of 9 mm in order to prevent mechanical damages during operations in the sea floor due to ship movements and wave activities.



GISP - Probe



Concept for Penetration Measurements

The first experiments in shallow water (< 30 m) have shown that the GISP-penetration system is a fast and effective tool to assess the physical parameters of the sea floor under in-situ conditions. The time for one measurement is only 2 - 3 minutes and can easily be repeated at the stations. The handling of the penetration system is rather safe. This allows a fast survey of sea areas with a dense net of stations, where only a few cores for calibration purposes are still necessary. Further improvements can be made by the development of multisensor probes which allow the acquisition of various parameters during the penetration phase. A heave compensated winch and a dip sensor would allow a better control of the vertical position of the probe in the sea floor.

The experiences which could be gathered up to now with the application of the probe are encouraging for the improvement of the penetration measurement concept by the development and adaption of new special sensors, among others one especially for shear wave velocities, which allows also the assessment of chemical parameters for geotechnical as well as environmental research. The penetration depth could be increased by using tubes of 20 or even 30 meters length, too.

CORING WINCH, CORING CABLE, AND SHIPBOARD CORER HANDLING EQUIPMENT

A productive and efficient coring system consists of more than just the corer at the end of the cable. The corer is important but of equal importance are the lowering cable, winch, deck handling system and the ship itself. This is particularly critical if the ship is small and has not been equipped for the sole purpose of coring. Also, if it is expected to complete other scientific survey or sample collection tasks, as this almost invariably results in compromises that reduce the coring capability.

If research vessels are using heavy equipment such as long coring devices then the cables are to be lighter and winches are to be developed for heavy equipment (>30 t). In order to follow the cable technology, KLEY-FRANCE has developed and patented a new type of winch, the BAND WINCH.

Advantages:

- works with all types of cable (steel, aramid, synthetic, electromechanical, fiber optic)
- works with several diameters
- no slipping between cable and drum (no contact)
- not affected by cable tension variations
- large D : d ratio (50 : 1)
- incorporated heave absorber
- capacity up to 30 t
- speed up to 2.2 m/s

Principles:

The BAND WINCH is composed of the following three parts:

Storage drum

- Drum with LEBUS shell for 8000 m of cable (or different lengths)
- Mechanical spooling device with double grooved screw and chain drive
- Electrical AC drive at constant tension (1/15 th of SWL)

Inboard accumulator

- Device with hydraulic cylinder to absorb speed differences between drum and capstan

Band capstan (most innovative part of the system)

- The principle consists in winding up the cable 4 wraps around a single capstan and in inserting a grooved plastic endless band between the cable and the capstan drum.
- The cable lies into the groove all around 4 wraps without any relative displacement between the cable and its support band. The torque is transmitted by contact. The cable protection is then at its optimum.
- The band lies on the drum. The torque is transmitted by friction. Following the cable elongation, the band supports the friction between the capstan drum and the band.
- The transversal fleetings are done by 2 fleetings ball bearings.
- The complex material of the band has been chosen after a 10 months trial in order to (i) have a good friction with all types of cable and (ii) have the optimum friction with stainless steel drum to transmit the torque and to permit relative displacement due to cable elongation, temperature and humidity and (iii) have the longest life time (100 operations to 4000 m depth).

The actual experience (1995) of this BAND WINCH are two hydrographic 4 t - 2 m/s Band Winches and 1 oceanographic 30 t - 2.2 m/s Band Winch used on the new French *RV Marion Dufresne* with great success and total satisfaction of the users and owners.

Clearly by retrieving long cores the pull-out force can be between 5 and 30 t. In full ocean operation it would be virtually impossible to carry out such an operation using a steel cable, due to its own weight. Hence, a synthetic cable has to be used.

CORING CABLE INVESTIGATION: DEVELOPMENT RECOMMENDATIONS

Presently, most research vessels use steel cables of a wide range of sizes and constructions for piston and gravity coring. The elasticity of the coring cable often produces major disturbances in the core quality due to the effects its rebound has on the corer piston dynamics. If this can be reduced or eliminated, it will have a large bearing on the quality of the future long piston cores collected.

It is recommended to carry out an investigation to determine the most suitable cable type and construction to be used for large piston coring. If a steel cable should be used, what is the best construction to minimize the cable rebound problem? If a synthetic cable is more satisfactory, what is the recommended fibre type, construction, jacket material and termination to be used? Is it possible to use a synthetic coring cable on a winch designed for steel cable for coring. The Dutch experience with the Seabed winch employed on *TYRO* seemed to be encouraging. If it can be done, it has major advantages because of the major reduction of the weight of the cable on the winch, but particularly in the water. This would mean that in deep water the winch would only have to handle the weight of the corer. The synthetic cable would be nearly neutrally buoyant enabling a smaller existing winch to handle a large corer in deep water.

CORING WINCH: DEVELOPMENT RECOMMENDATIONS

There is a large number of commercial vessels that may be available but do not have a winch capable of handling the requirements needed to acquire a 30 meter or longer core. This could be satisfied by having winch systems that are relatively transportable and could be mounted on selected ships. One of this type, the MOBIWINCH, has been designed and produced on the base of an ISO 20′ container frame by GEOMAR Technology GmbH.

This is a single drum winch which is fine for handling a wide range of steel mechanical and/or electrical mechanical cables but is unlikely to be satisfactory for handling long lengths of 6000 to 8000 metres of synthetic fibre cables, which have some real advantages in use when coring in deep water. However, the handling of long length of 6000 to 8000 meters of synthetic fibre cable has not been investigated yet.

It is recommended that investigations are to be carried out to see if a portable self-contained winch can be designed and produced. It would have to be capable of handling long lengths of synthetic cable necessary for coring in deep water and with enough strength to deploy and retrieve a minimum of a 30 m corer. It would be highly desirable if this could be contained in one ISO 20' container base, but a system consisting of more than one ISO 20' container base could be considered. Portable self-contained winches are available at the GEOMAR Technology GmbH and the Rijksgeologisk Dienst in Harlem.

An investigation to determine the suitability of converting existing single drum winches on research vessels to be capable of handling synthetic coring cables is also recommended. If applicable, it would allow a number of existing winches presently too small to take 30 meter or longer cores within deep water, because the synthetic cable would get around the cable weight in water.

It is also recommended to carry out an investigation as to the necessity or desirability to use a heave compensation system when piston coring. Will it provide any real benefits? Are the benefits large enough to compensate for the additional technology required to do it?

SHIPBOARD HANDLING SYSTEM: IMPROVEMENT RECOMMENDATIONS FOR CORING

The safe and efficient handling of large heavy coring devices over the side of the ship when deploying, retrieving, and removing the core requires a lot of skill to be successful, particularly on smaller ships. Proper handling equipment varies tremendously from ship to ship and country to country. To our knowledge, robotics are not being used on any ship to assist in this procedure.

It is recommended that a survey of the present methods and equipment used over a wide range of the world's research vessels should be compiled and evaluated as to the safest and most efficient way to accomplish this task of assembling, launching, retrieving and disassembling a piston corer. From the results of this survey, it should be assessed whether there are any safety and other considerations where the use of robotic methods could and should be employed. From the results of these investigations, a recommendation should be made to what is considered the best way to do it in the future. When this is completed, it would provide an exceedingly valuable guideline for use by engineers and naval architects when designing new ships with piston coring requirements or adapting existing ships to more safely and efficiently handle large piston corers.

SHIPBOARD REQUIREMENTS AND HIGH-RESOLUTION SEA FLOOR STUDIES

Working group (Monika Breitzke, Bremen, Germany; Dieter Diepenbrock, Bremerhaven, Germany; Dave Gunn, Southampton, UK; Gerhard Kuhn, Bremerhaven, Germany; Volkhard Spiess, Bremen, Germany; Friedrich Theilen, Kiel, Germany; Philip Weaver, Southampton, UK; Michael Weber, Hannover, Germany)

SEISMIC AND ACOUSTIC SURVEYING

Seismic and hydroacoustic measurements provide detailed information about the structural framework around sediment sampling sites. They are important to identify the dominating depositional processes and to understand the relationship between lithological, sedimentological and structural changes, and the acoustic impedance variations in the sediment.

For both pre-site survey activities of potential sampling sites and correlation of spot information from cores to local and regional depositional patterns high-quality seismic and acoustic data are required. The ultimate goal of the analysis of seismoacoustic survey data should be the resolution of vertical changes in the sediment column, which are on the same order as the lithologic variability, the average sample spacing and the resolution of geologic studies, as well as the lateral resolution of sedimentary structures to reconstruct in detail depositional processes. The results shall be finally integrated in the stratigraphic concept for a site or region.

SYSTEM CHARACTERISTICS OF ECHOSOUNDERS

For average sedimentation rates of 2 cm/ka climatically induced cyclical variations of Milankovitch mode affect the physical properties on scales of ten's of centimeters. Sediment echosounders with typical frequencies around 4 kHz and wavelength of ~40 cm are in principle suitable to trace the associated structural changes along profiles. In general the data quality depends on:

- signal wavelength
- signal length
- angular energy distribution of sound source
- angular energy distribution of reflections
- control of measuring geometry (pitch, roll, heave, geometry)

For conventional echosounder systems, which operate at the resonance frequency of the transducer, the source signal is naturally significantly longer than a single period, and the optimum resolution cannot be achieved. By application of correlation techniques on broadband sweep (chirp) signals, this deficit can be overcome at cost of the phase information. The same reduction in signal length is achieved with a parametric sound source, which operates outside the resonance of the transducer. Due to a significant increase in bandwidth, the signal form is much better controlled, and a signal length close to one wavelength can be reached. The phase information is preserved.

In case of conventional and chirp sonars, the emitted energy is distributed over a wide angle of at least 20° for a square transducer size of 1 m^2. With decreasing size, the diameter of the emission cone can reach 90°, as e.g. in deep-tow fishes. The parametric source, on the other hand, is characterized by two high-amplitude, high-frequency signals, which are emitted simultaneously. In case of the PARASOUND echosounder 18 and e.g. 22 kHz were used. Nonlinear interaction between the signals generates the difference frequency (e.g. 4 kHz), which travels within the narrow beam of the high-frequency component of 4° opening angle.

Alternatively, the footprint size can be reduced with deep-tow echosounders at small distances from the sea floor. Since the physical dimensions of the sound source are small, the beamwidth equals several 10s to 90 degrees, which requires distances of only a few hundred meters to provide the same spatial resolution as a narrow beam echosounder from the sea surface. A precise control of the measuring geometry is required to correct data for vertical and rotational movements of the fish, which is currently still difficult to achieve. The hull-mounted PARASOUND System for example compensates for pitch and roll within 0.5° and for heave within 10 cm and thereby represents a major improvement over uncompensated 3.5 kHz systems.

The angular characteristics of the sound source directly controls the spatial resolution and the seismic appearance of structures. Only for ideally reflecting flat layers the vertical structure of a sediment column is correctly imaged by both wide and narrow beam systems. Increasing roughness of a surface widens the opening angle of the reflection beam, increases the travel time difference within the effective footprint and creates hyperbolic echoes. The result is a reduced vertical resolution due to overlapping reflection bands of closely-spaced reflectors and a limited lateral resolution due to overlapping hyperbolae and masking of the original reflector geometry.

In addition to the roughness of a surface also the microtopography, whose dimensions are much larger than the signal wavelength, may cause a widening of the reflection beam. This is associated with an increasing number of reflecting elements at higher angles within the footprint area, e.g. due to undulations of reflectors, small scale mud waves or ripples. They provide much higher energy at larger angles than the scattering process, and are responsible for seismic patterns which are dominated by hyperbolic echoes.

For wide-beam conventional echosounders and chirp sonars, both vertical and lateral resolution are significantly reduced if energy is received from higher angles and the reflector characteristics are not ideally reflecting. A narrow beam echosounder suppresses all higher angle energy, the traveltime differences also from scattering or microtopographic surfaces are diminished and an extremely short signal is generated, which also allows polarity determinations.

To make optimum use of a high-resolution seismic data set, which is collected with a transducer-based echosounder system, the data should be acquired digitally. This is currently done routinely only with the ParaDigMA System from the University of Bremen, which is running on the German research vessels *Meteor*, *Polarstern* and *Sonne*.

HIGH-RESOLUTION SEISMICS

Reconstruction of vertical lithologic changes with echosounders can provide under optimum conditions the identification of glacial and interglacial stages and provide some estimates about the cyclicity. Gradual compositional changes, however, cause interference patterns and subdued amplitudes, which no longer allow the prediction of impedance contrasts directly from seismogram amplitudes. High-resolution physical property logs are required to calculate synthetic seismograms and to correlate geologic evidence with the seismic record. If a reflector spacing of half a wavelength can be theoretically resolved, the spacing of detectable events in acoustic impedance curves can vary between 20,000 and 2,000 years.

The second type is associated with depositional processes, which are identified by characteristic sediment structures. Stratigraphy is a greater problem, since those processes are typically discontinuous. Both echosounders, single and multichannel systems are appropriate to be used, depending on sedimentation rates, signal attenuation and desired penetration. The thickness of associated layers often does not go beyond tens of centimeters and a similar quality of seismic data sets is required.

The penetration of high-frequency signals is extremely dependant on the lithology and can vary from 0 to 200 meters in the frequency range from 2 to 6 kHz. Primarily, wet bulk density and grain size are controlling this parameter, and due to higher attenuation in sands and coarse silts an echosounder record may not provide sufficient penetration. In this case marine seismic systems must be used, which consist of a digital or analog recording unit, a streamer of varying length and group dimensions and an appropriate source.

Not only in sediments of limited or zero signal penetration high-resolution seismic systems are important, but also in environments of very high sedimentation rates, in particular on the continental margins. The temporal variability of land erosion or river systems and deltas can only be studied with sources of deeper penetration, lower frequency and higher energy than echosounder systems.

A variety of seismic sources covers the whole frequency range from some Hz up to 20 kHz (airgun, GI-Gun, sparker, boomer, watergun), but conventional seismic recording units were not capable of dealing with ultra high frequency sources until recently due to limitations in sample rate and recording length. High-frequency instruments have mainly been used in shallow water studies, with a short marine streamer as a single channel receiver. Typical high-resolution seismic studies were characterized by an order of magnitude smaller source frequency (up to ~200 Hz), which accordingly only resolves structures of several meters vertical extent.

Modern deep-tow systems, e.g. from the British Geological Survey, are suitable for studies in medium water depth and significantly improve seismic data quality due to proximity to the sea floor, an enhanced signal-to-noise ratio, the reduction of both source and receiver ghost signals and digital recording capabilities. The wide-angle sound emission makes the system less sensitive to rotational movements of the fish, but hyperbolic side echoes and larger scatter energy still affect the overall performance.

As discussed above, the requirements with respect to vertical and spatial resolution of climatic cycles in pelagic and hemipelagic environments cannot be fulfilled by the currently available seismic instrumentation, whereas in proximal terrigenous environments seismic systems are more appropriate.

High-frequency multichannel data are difficult to collect in shallow water due to the length of the hydrophone groups within conventional streamers. The low-pass filter characteristics for high- angle reflections reduce this important signal component. Only streamer systems with a combination of single, high-performance hydrophones and larger hydrophone groups will be able to collect both deep low-frequency and shallow high-frequency reflections with the same system and provide both high signal-to-noise ratios for longer hydrophone groups and the full source frequency spectrum for shallow signal penetration. Only the most modern recording systems, e.g. the new, *Spectra*-based marine system from Bison Company, can digitize the records at sufficiently high sampling frequencies up to 20 kHz and at the same time allow recording lengths of more than 10,000 to 160,000 samples.

In general, the control of the measuring geometry of a seismic system becomes much more important than for industry exploration work, where signal wavelengths are much larger than the variability in streamer and source depth. The sound sources and the streamer must be kept close to the surface to avoid both source and receiver ghost signals, which would significantly lengthen wavelets and reflections. Also temporal changes in towing depth should be avoided to maintain constant quality and signal characteristics or should be precisely measured for later static correction and deconvolution.

SWATH MAPPING, BACKSCATTER AND SIDE-SCAN SONAR SYSTEMS

In addition to ground penetrating systems deciphering the internal structure of the sea floor, the knowledge about the threedimensional shape of the surface is essential to evaluate the twodimensional seismic images in terms of sedimentary features, depositional processes and the location of individual sediment bodies in space. For a general overview of the bathymetry swath-mapping instruments as the SEABEAM or HYDROSWEEP systems with a swath width of 90° or more are now available on many research vessels. The resolution is limited to ~0.5% of the water depth, and thus fine-scale sedimentary features cannot be identified. But recent analyses of HYDROSWEEP records from deep basin have shown, that even surface variation on the order of 1 to 5 meters can be detected by careful processing. If this information becomes available during routine cruising activities at normal speed, it can be extremely valuable to determine the orientation or distinguish between linear and isolated features.

Side-scan and backscatter extensions of swath sounders, as they are currently tested e.g. for the HYDROSWEEP system, provide important additional insight into the surface sediment composition, the scattering strength of the surface and its microtopography. These can be used as independent boundary conditions for the interpretation of sediment echosounder data.

Further improvement of data quality can be expected from sophisticated deep-tow systems as the TOBI side-scan, which resolves surface features on the sub-meter scale. They are of particular importance, if sediment bodies originated from transport and flow processes and can be fitted into a general depositional pattern.

DATA PROCESSING

The high quality and high-resolution of geologic analyses on sediment cores have significantly increased the quality requirements for seismic and acoustic surveys to allow detailed quantitative studies. Core logging, which provides the acoustic impedance parameters wet bulk density and p-wave velocity at cm spacing, is essential to calculate synthetic seismograms and directly relate physical changes with variations in lithology and sediment composition.

Since currently most of the survey information from echosounders is still collected in analog form as paper records, quantitative comparisons, interpretation of absolute and relative reflection amplitudes or archival replay and rescaling of the collected data are not possible. In principle, echosounder data can be analysed with seismic processing packages, including deconvolution of the source signal to enhance resolution or the application of migration methods to improve lateral resolution and to correct the seismic image of structures. Only few attempts of digital acquisition and processing of 3.5 kHz data have been published, but routine processing is carried out on all ParaDigMA/PARASOUND data, which are collected by the University of Bremen and other German marine geoscience groups.

For the narrow beam PARASOUND system the processing effort can be reduced. Due to its technical design, side echoes are suppressed and energy from a structured surface is returned only from a small effective footprint of a few hundred meters diameter. Traveltime differences remain small, which preserves lateral coherence of reflectors. Even in the presence of microtopography, deconvolution has been successfully applied, as well as migration methods. The system characteristic of a parametric echosounder fulfills most of the requirements on a

[illegible]

- [illegible] (due to the parametric effect)
- [illegible] (deconvolution)
- [illegible] reached with extensive migration processing on multichannel data only
- [illegible] required (precise control of geometry through pitch, roll and heave compensation)
- operation at normal cruising speeds above 10 knots (not achievable for towed or deep-tow instrumentation)

Therefore, the needs for data processing are much less for the parametric echosounder than for conventional systems. With a recording system like ParaDigMA most of the processing as band-pass filter and optimal normalization can be carried out online. Postprocessing concentrates on the identification of structures through image processing, tracing and analysis of reflectors and their amplitudes and quantitative comparisons with synthetic seismograms derived from core logs.

For the specific target of global change studies in marine sediments with long sampling devices, which recover up to 100 meters of the uppermost sediment column, echosounders are in most cases the appropriate instrument to survey the vicinity of a sampling site, to at least theoretically identify major lithological changes on Milankovitch scale and to extrapolate the spot information of a core into an area.

The available instrumentation is in principle capable of fulfilling the requirements. The objectives of paleoclimatic and paleoceanographic reconstructions, on the other hand, demand maximum precision of core logging, digital seismic recording, control of measuring geometry and optimization of signal generation and reception, which still requires significant technical developments.

Conventional echosounders provide high quality, but mostly analog records for laterally homogenous, strongly reflecting sediment packages. Deep-tow instruments, which operate at low cruising speeds, allow very detailed measurements close to the object of interest. Both technologies reveal deficits in signal generation due to transducer operation in resonance and because of the wide angular energy distribution. Narrow-beam parametric echosounders combine many advantages, and signal enhancement is achieved by superior, but expensive technical solutions. Marine seismic systems fill gaps, where sediments are highly attenuating and signal-to-noise must be enhanced, high signal penetration is required or velocity information becomes important. In all cases additional information about the threedimensional shape of surfaces is important to be added to seismoacoustic profiles. This can be achieved by either detailed mission oriented, deep-tow measurements close to the sea floor or by improvements of available swath sounding systems.

For future work the following general perspectives can be derived from the discussion:

- increase the deployment of digital echosounder,
- make extensive use of advanced technologies (chirp sonar, deep-tow systems, narrow-beam parametric sources),
- develop mobile units of advanced echosounder systems for universal use on various vessels,
- allow combination of different source, signal and seismic sources to discriminate between interference and impedance-controlled reflection amplitudes,

- improve online processing for optimum use of [illegible] during [illegible] cruises.

- focus on quantitative comparisons between high quality [illegible] and ultra high resolution seismic acoustic data sets.

- intensify technical developments on single and multi-channel seismic instrumentation to improve geometry control, optimization of the lateral resolution in postprocessing and to allow multi-source, multi-frequency simultaneous recording with the same system.

- improve techniques and methodology of swath sounder systems to derive sedimentological and fine scale structural information from backscatter or side scan.

- improve techniques and methodology of deep tow seismoacoustic and side scan sonar systems to improve the system resolution for specific targets.

CORE STORAGE, CORE LOGGING, AND DATABASES

CORE STORAGE

Once collected sediment cores represent a valuable resource for global change research. If properly curated and archived this resource can be used for many tens of years. The Ocean Drilling Program, which collects tens of km of core per year, stores its cores in plastic boxes at +4° C. One half of each core is stored as an archive.

Many different data storage methods are in operation and there have been few attempts of standardisation. With the rapid development of the Internet and new more powerful relational database programs it should be possible to standardise data storage and make data more widely available.

A thorough review of databases is outside of the scope of this report. Nevertheless, it is important to note that ODP is currently designing a database to handle all new shipboard data together with some shorebased data and is including the possibility of adding data from earlier drilling legs. The database will be fully relational and will accommodate various data sets on the same topic, e.g. different age models. Problems of data quality control, addition of data by external users and assistance for users of the data base have not been fully solved. One important aspect will be that the data can be exported in a form which can be loaded into other databases. The recommendations are:

- Cores should be stored at +4° C and placed in plastic boxes. One half of each core should be preserved as an archive until the other (working) half is used up.
- To facilitate communication between different organisations and prevent duplication of coring sites, all primary information relating to core position, water depth, core type, core length and proposed analyses should be published within one year of core collection.
- Sample sharing protocols should be developed so that fuller suites of measurements can be made on good cores.
- Data collected through subsequent analysis of cores and core samples should be centrally collected.

CORE LOGGING

Over the last 15 years there have been significant developments in core logging techniques and many more developments are in the pipeline. The great advantage of most of these techniques is that they are non-invasive and thus non-destructive of the sediment. In many cases data can be collected rapidly following the arrival of the core on deck, and preliminary assessments made of its quality, sediment disturbances, and reworked sediment layers are easy to recognize on core logs. The logs however, have their greatest advantage in characterizing sediment type and pinpointing downcore changes.

Multi-Sensor core logging is, therefore, an essential process in the analysis of sediment cores and there are now over 20 such systems in use throughout the world, each measuring similar parameters. The most common sensors are p-wave velocity, magnetic susceptibility and gamma ray attenuation (GRAPE). Other sensors include colour, colour spectra, grey scale, and natural gamma. Sensors in limited use or under development include electrical resistivity, microwave, and geochemical logging. So far no intercalibration exercises have been carried out and no standard calibration tools have been developed. A variety of logging practices have also been developed, some cores being logged soon after recovery onboard ship, others being logged later and some being logged with split core loggers rather than whole core loggers.

The requirements are:

- Measuring tools onboard research vessels should include the following sensors: (i) Gamma ray attenuation sensor to calculate saturated wet bulk densities, porosities, water contents, and dry bulk densities; (ii) p-wave travel time sensor to estimate p-wave velocities; (iii) magnetic susceptibility sensor; (iv) sensors for colour scanning.

- Optional sensors can include, e.g. cryogenic magnetometer and resistivity. One important requirement for additional sensors is that the measurements can be made rapidly.

- The measuring increment should not exceed 2 cm (1 cm would be best).

- Common calibration techniques should be developed using standard calibration materials.

- Additional sensors and techniques should be developed.

The recommendations are as follows:

- After retrieving, sediment cores should be stored for several hours horizontally to let them thermally equilibrate with laboratory temperature.

- The nondestructive measurements should be made onboard on "fresh" cores.

- In addition, we encourage scientists to measure "old" cores.

- The data should be made available on a data base.

- The manufacturer of the sensor systems should be encouraged to supply standards and calibration materials.

- Centralized logging facilities should be made available to research institutes and universities that have no core logging systems. Basic mobile logging systems should be made available for research cruises and for temporary loan/hire to research institutes and universities.

- Data rescue. Efforts should be made to log old cores that have remained in good condition.

DATA BASES

The information system SEPAN (Sediment and Paleoclimate Data Network), initiated by the German IGBP/PAGES contributors, was designed to allow a consistent storage of sediment and paleoclimatic data, to make data sets and related metainformation available to the users, and to provide a tool for the modelling of paleoenvironments or large-scale reconstructions with time slices. The system ist developed at the Alfred Wegener Institute for Polar and Marine Research (AWI) in Bremerhaven, Germany.

The evolutionary variety of data is a major obstacle for their integrative use. SEPAN compensates the heterogeneity and dynamics of paleoclimatic data by a flexible and simple relational data model. The model follows the way data are produced. Different institutions/projects (PROJECT) carry out expeditions (CRUISE). During a cruise at a number of sites (STATION) different samples (CORE) may be taken. At distinct points a core is sampled/measured for different investigations (PROCESSING). From each sample a set of data (DATA SERIES) will be produced. The parameters are gathered up into parameter groups. Data types are defined as primary data (weights, counts...), secondary data (%, m/sec...) and tertiary data as they are evaluated by specific algorithms from the secondary data (e.g. paleotemperature, factors of assemblages). Secondary and tertiary data may be used as a source for time slices or models. In addition, the data include all necessary metainformation (latitude, longitude, depth, expedition, copyright...). Lists including standardized metainformation are related to the main data fields (e.g. gear, ship, method...). The essential part of the model is the combination of sample, parameter, method and the related data. Users may add new parameters or methods and thus are able to store all desired parameters in one of the available data types (numeric, text, picture). The data quality can be checked by parameter-specific validation routines. All data sets in SEPAN are copyright-protected within a hierarchy protection system (owner, group, world).

SEPAN uses client/server technology through the INTERNET/WIN network via online connection to the AWI main server enabling effective usage by groups of scientists in different institutions. This feature allows data producers to manage their data independently and also reduces the administrative work for the data center. The database server (SYBASE) runs on a DEC Alpha under OSF. Client software for access to the server is designed for Macintosh and will also be available on Windows platforms. To improve the access speed, all information down to the data series description (metainformation) is mirrored on local servers, which are also running on PC platforms. The mutual update of metainformation is made in the background. Only on request of "real data" the local server will have direct access to the main server at the AWI.

The client software was modularized on a database frontend together with tools individually developed for the processing of specific data sets. The modularization and the open environment facilitate future alterations of the system. The functionality of the database frontend comprises im- and export of data in common exchange formats (Text, NetCDF, NASA-DIF for metainformation) and a flexible retrieval and representation of all data in spreadsheets. The retrieval tool is uniformly designed for all tables and allows complex combinable search criteria relevant to the desired data. Spreadsheets can be configured individually with the contents being updated, sorted, or exported.

For geographical presentation of all data the SEPAN tool MACMAP was developed, which is either directly connected to the database frontend or can be used as a stand-alone application. Maps can be configured to different projections (Mercator, stereographic), styles of map elements can be changed. The standard bathymetric data source used in the maps is GEBCO or ETOPO, individual vector data or site informations can be imported. The graphic tool POLYPLOT enables users to plot multiple data sets at uniform scales. The program can also be called from the database frontend or used stand-alone. All graphics can be exported as postscript or pict files. The systems runs now in the Macintosh world and will be developed for MS-DOS/Windows in the near future.

CONFERENCES AND MEETINGS OF DIRECT IMPORTANCE TO ICGC 95

IMAGES: International Marine Global Change Study, 1995. Science and implementation plan, PAGES workshop report, Series 94-3, 37 pp., PAGES Core project office, Bärenplatz 2, CH-3011 Bern, Switzerland.

MESH: Marine aspects of Earth System History: proxy development workshop, 1995. Report January 1995 (supported by NSF grant OCE-9410900), 75 pp., ed. N.G. Pisias, College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis OR 97331-5503, USA.

PANASH: Paleoclimates of the Northern and Southern Hemispheres: the PANASH project - the pole - equator - pole transects, 1995. PAGES series 95-1, 92 pp., PAGES Core project office, Bärenplatz 2, CH-3011 Bern, Switzerland.

European research in the Arctic - Looking ahead, 1995. Report - ENRICH, European Network for research in Global Change, Orheim, O. et al. (eds.), Oslo, 60 pp..

Coral records of Ocean-Atmosphere variability: NOAA Climate and Global Change programme, 1993. Special report No. 10, , ed. R.B. Dunbar, J.E. Cole, Publ. of the University corporation for atmospheric research pursuant to NOAA award No. NA27, November 5-8, La Parguera, Puerto Rico, 38 pp. A core project of the international Geosphere-Biosphere programme IGBP, PAGES Core project office, Bärenplatz 2, CH-3011 Bern, Switzerland.

Low-cost drilling system for characterizing marine gas hydrate accumulations, 1994. QUEST technical report No. 634, ed. J.J. Kolle, 15 pp., QEST integrated, Inc. 21414 - 68th Avenue South Kent, Washington 98032, USA.

Down Hole Measurements in the Ocean Drilling Program, 1992. Ocean Drilling Program, Texas A&M University, 1000 Discovery Drive, College Station, TX 77845, USA, 24 pp..

References

Anderson, R. F., Rowe, G. T., Kemp, P. F., Trumbore, S., and Biscaye, P. E. (1994): Carbon budget for the mid-slope depocenter of the Middle Atlantic Bight. Deep-Sea Res. II, 41, 669-703.

Balsam, W. L., and Williams, D. (1993): Transport of carbonate sediment in the western North Atlantic: Evidence from oxygen and carbon isotopes. Marine Geology, 112, 23-34.

Bond, G., Heinrich, H., Broecker, W., Labeyrie, L., McManus, J., Andrews, J.T., Huon, S., Jantschik, R., Clasen, S., Simet, C., Tedesco, K., Klas, M., Bonani, G., and Ivy, S. (1992): Evidence for massive discharges of icebergs into the North Atlantic Ocean during the last glacial period. Nature, 360, 245-249.

Boyle, E. A., and Keigwin, L. D. (1987): North Atlantic thermohaline circulation during the past 20,000 years linked to high-latitude surface temperature. Nature, 330, 35-40.

Broecker, W. S., and Denton, G. H. (1990): The role of ocean-atmosphere reorganizations in glacial cycles. Quat. Sci. Rev., 9, 305-341.

Carmack, E. C., and Foster, T. D. (1975): Circulation and distribution of oceanographic properties near the Filchner Ice Shelf. Deep-Sea Res., 22 (2), 77-90.

Charles, C. D., and Fairbanks, R. G. (1988): Glacial-interglacial differences in the isotopic content of surface and deep water in the southern ocean. Eos Transactions American Geophysical Union, 69 (44), 1235

Dansgaard, W., Johnson, S. J., Clausen, H. B., Dahl-Jensen, D., Gundestrup, N. S., Hammer, C. U., Hvidberg, C. S., Steffensen, J. P., Sveinbjörnsdottir, A. E., Jouzel, J., and Bond, G. (1993): Evidence for general instability of past climate from a 250-kyr ice-core record. Nature, 364, 218-220.

Foster and Carmack, (1976):

Guinasso, N. L., and Schinck, D. (1975): Qualitative estimates of biological mixing rates in abyssal sediments. J. Geophys. Res., 80 (21), 3032-3034.

Heinrich, H. (1988): Origin and consequences of cyclic ice rafting in the northeast Atlantic Ocean during the past 130,000 years. Quat. Res., 29, 143-152.

Kullenberg, B. (1947). The piston core sampler. Svenska hydr. biol. komm. Skr. 3 ser: Hydrografi Bd. 1 H.2.

Lehman, S. J., and Keigwin, L. D. (1992): Sudden changes in North Atlantic circulation during the last deglaciation. Nature, 356, 757-762.

McCave, I. N. (1988): Biological pumping upwards of the coarse fraction of deep-sea sediments. J. Sed. Petrol., 58 (1), 148-158.

Pettersson, H. (1957): Reports of the Swedish Deep-Sea Expedition 1947-1948, vol. 1: The ship, its equipment, and the voyage, 159 pp.

Reid (1979):

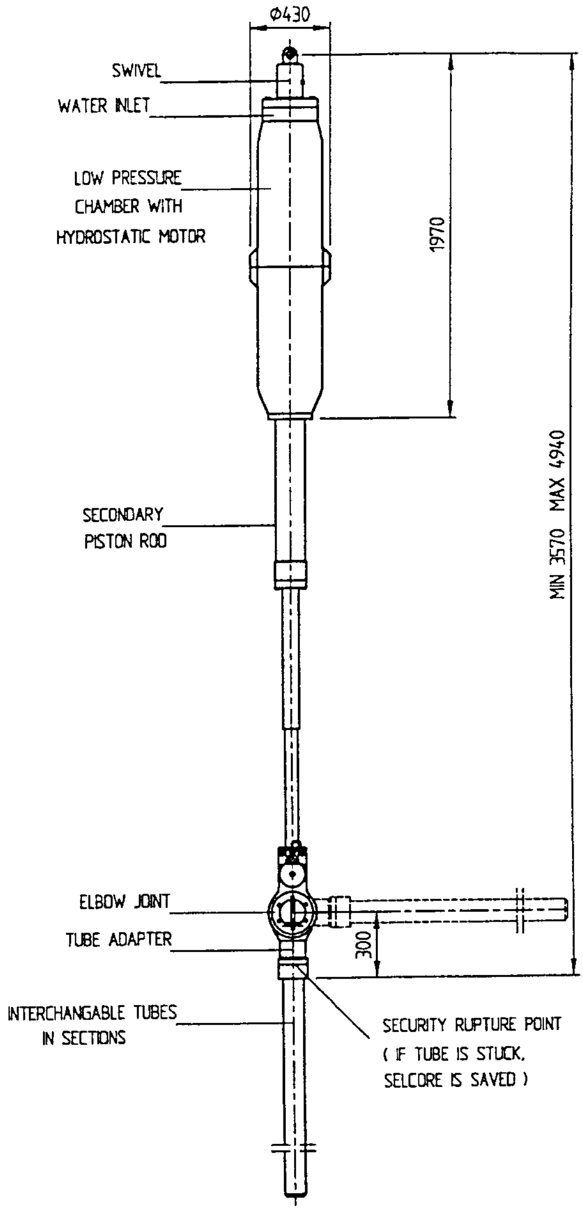
Shimmield, G.B., Brand, T.D., and Ritchie, G.D. (1995): The benthic geochemical record of late Holocene carbon flux in the northeast Atlantic. Phil. Trans. R. Soc. Lond., B348, 221-227.

Thomson, J., Cook, G.T. Anderson, R., Mackenzie, A.B., Harkness, D.D., and McCave, I.N. (in press): Radiocarbon age off-sets in different sized carbonate components of deep sea sediments. Radiocarbon.

Veum, T., Jansen, E., Arnold, M., Beyer, I., and Duplessy, J.-C. (1992): Water mass exchange between the North Atlantic and the Norwegian Sea during the past 28,000 years. Nature, 356, 783-785.

Weaver, P.P.E. (1994): Determination of turbidity current erosional characteristics from reworked coccolith assemblages, Canary Basin, north-east Atlantic. Sedimentology, 41, 1025-1038.

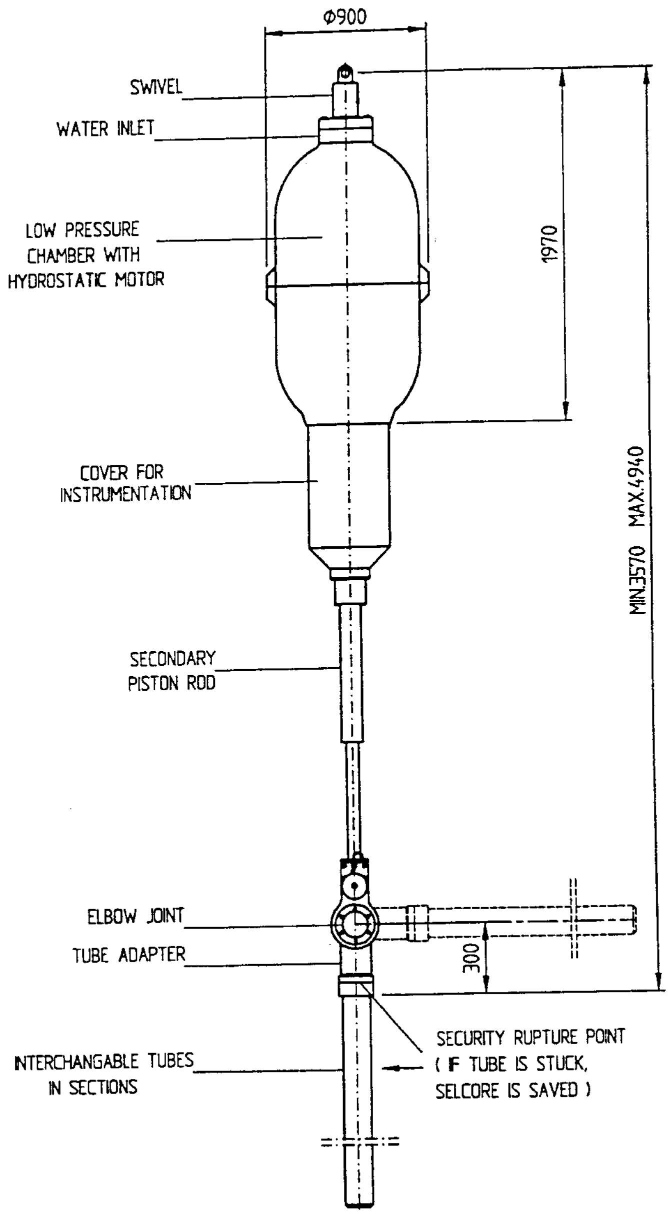
Zenk and Armi (1990):



Specifications

Dimensions:	Assembled: For transport: Tubes:	Length max. 4.94 m, Ø 0.43 m Biggest part 1.6 m x 0.4 m x 0.4 m (if critical). Normally 3 m long sections, others on request.
Weight:	Gross weight without tubes: Weight of striking parts:	750 kg 600 kg
Penetration energy:	Dependent on depth. Energy at 0 m (~ 120 kJ) can be used as reference, since it is similar to the energy of a gravity corer of same weight.	
Stroke frequency: Time for stroke: Length of stroke:	30 - 50 strokes/minute Up to 4 minutes, dependent on depth. 35 cm - 135 cm	
Tubes:	Interchangeable in order to match job specifications. Examples on request.	

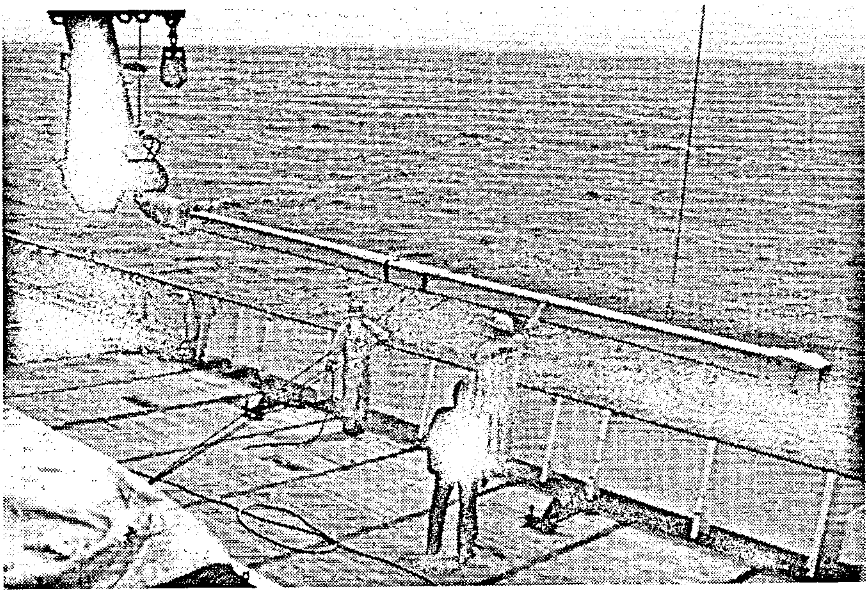
Figure 3: Selcore Slim Line

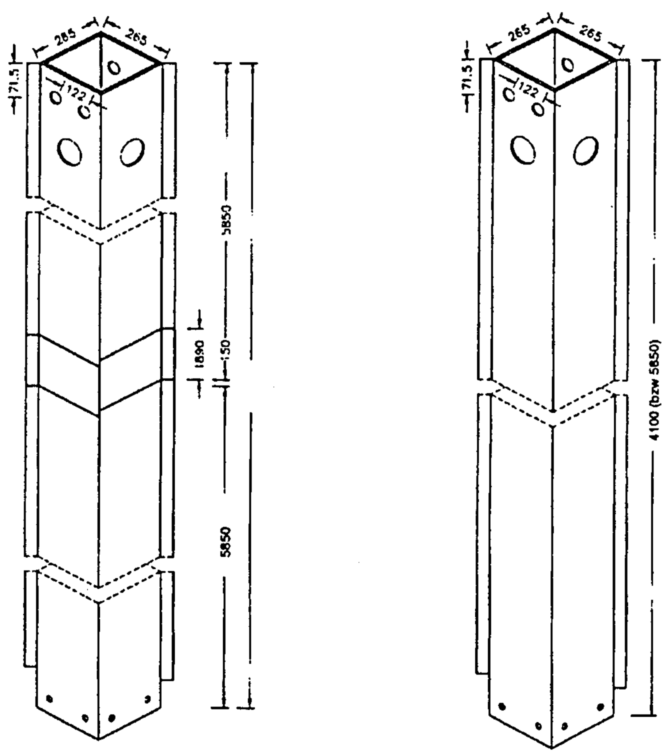


Specifications

Dimensions:	Assembled:	Length max. 4.94 m, Ø 0.9 m
	For transport:	Biggest part 1.6 m x 0.8 m x 0.8 m (if critical).
	Tubes:	Normally 3 m long sections, others on request.
Weight:	Gross weight without tubes:	1500 kg
	Weight of striking parts:	1290 kg
Penetration energy:	Dependent on depth. Energy at 0 m (~ 80 kJ) can be used as reference, since it is similar to the energy of a gravity corer of same weight.	
Stroke frequency:	30 - 50 strokes/minute	
Time for stroke:	Up to 13 minutes, dependent on depth.	
Length of stroke:	35 cm - 135 cm	
Tubes:	Interchangeable in order to match job specifications. Examples on request.	

Figure 4: Selcore Heavy Duty

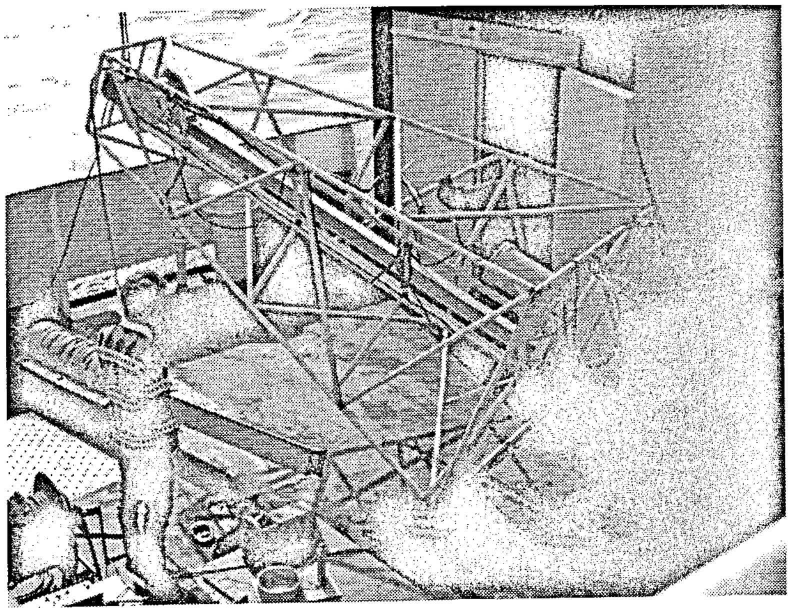




Specifications

Sampling area	250 x 250 mm
Core length	3000 mm
Core volume	188 l
Core length	5850 mm
Core volume	366 l
Core length	11700 mm
Core volume	731 l
Weights	2,3 t

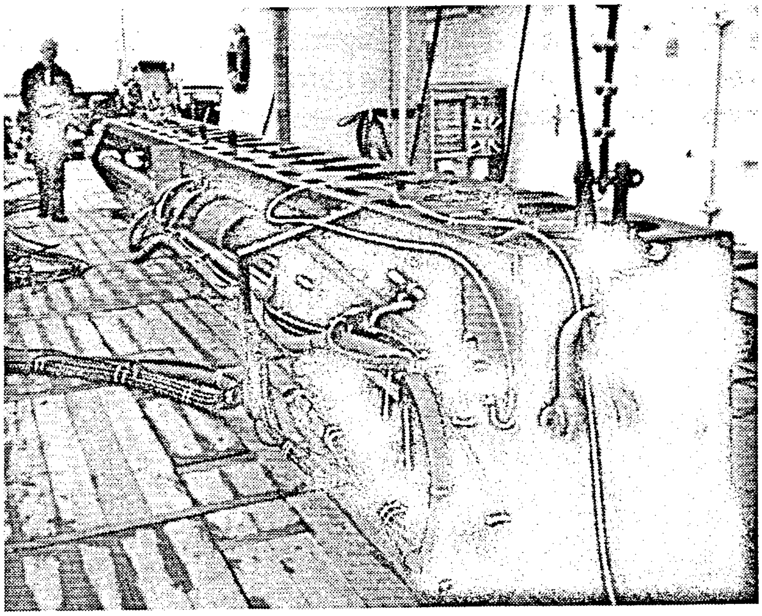
Figure 5: Super Heavy Box Corer

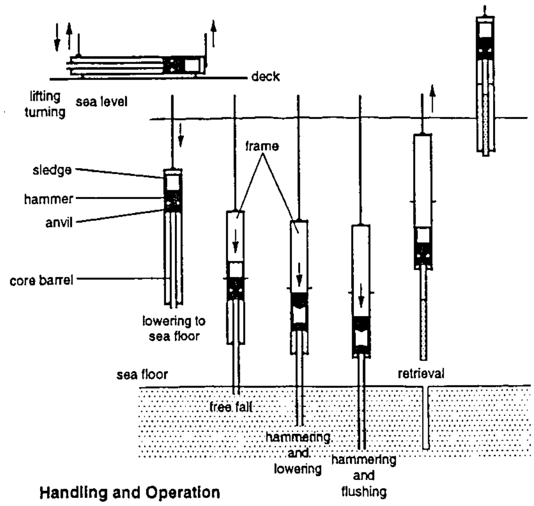


Technical data

Operational depth	down to 400 m
Length	up to 3 or 4 m
Striking force	approx. 700 kp
Total weight	approx. 600 kp
Electrical output	2 x 0,4 kW at 380 V
	multiphase current and 50 Hz
Energy source	at least 5 kW

Figure 6: Vibro Hammer Corer





Specifications

Rated working depth	5000 m
Frame length min.	10 m (2 sections)
Frame length max.	20 m (4 sections)
Barrel length min.	10 m (2 sections)
Barrel length max.	30 m (6 sections)
Top section mass	4.3 t
Extension section mass	0.7 t
Barrel section mass	0.4 t
CPT probe mass	0.3 t
Summary mass	5.8 - 8.8 t (6.1 - 9.1 t with CPT)
Electrical power supply	400 V 3≈, 50 Hz, 20 kVA
Core diameter	120 mm
Core length max.	30 m
Geotechnical logging	Cone resistance Sleeve friction Pore pressure (2 sensors) 1-5 pore fluid samples

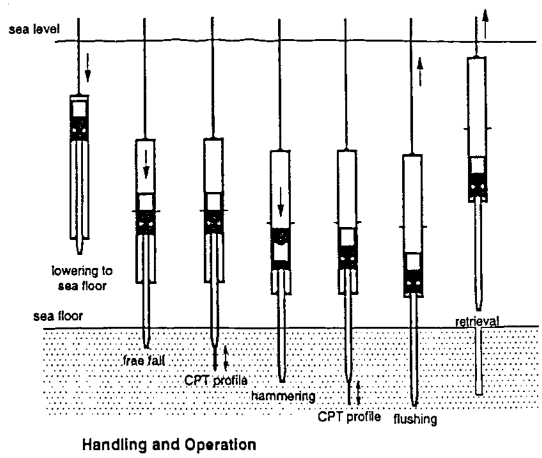
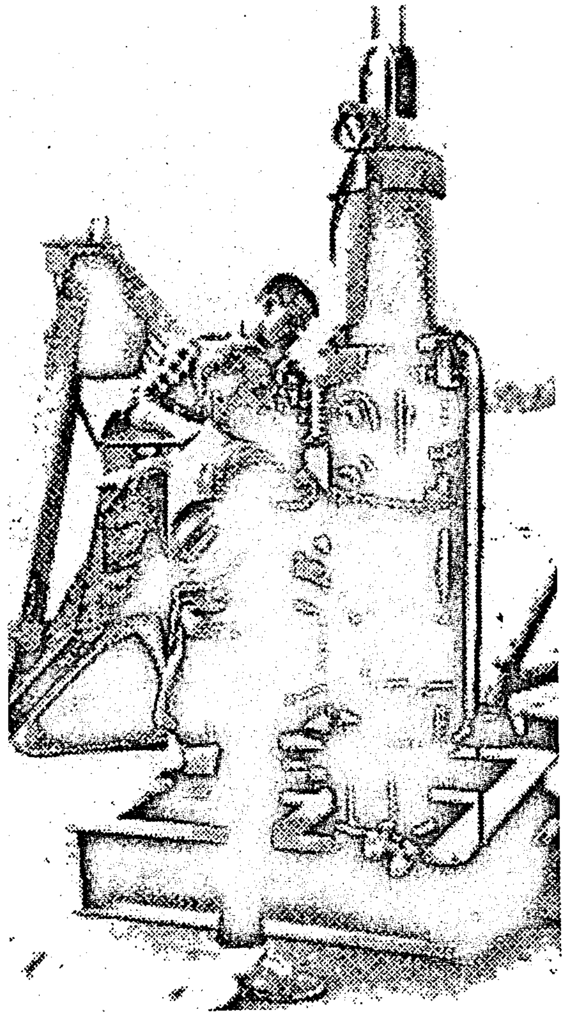


Figure 7: Deep Sea Hammer Corer



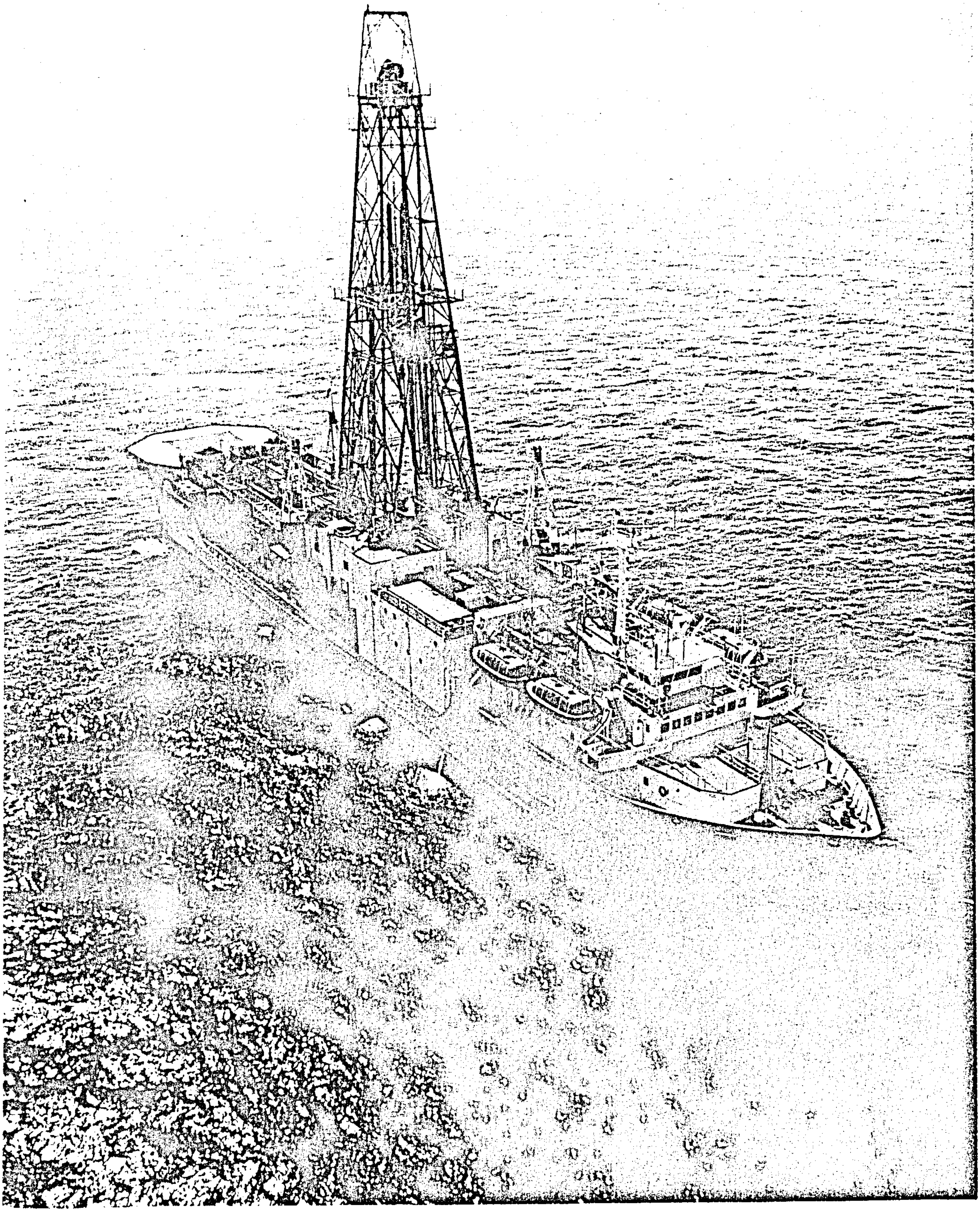
Technical data: Type 1

Height	11,5 m
Platform area	4 x 4 m
Core length	up to 9 m
Core diameter	110 mm
Total weight, max.	up to 2 t
Working depth	to 300 m
Electric power	11 kW, 380 V, 50 Hz

Technical data: Type 2

Height	17 m
Platform area	9 x 9 m
Core length	up to 12 m
Core diameter	136 mm
Total weight, max.	up to 10 t
Working depth	to 10 - 30 m
Electric power	11 kW, 380 V, 50 Hz

Figure 8: Electro Vibro-Impact Corer



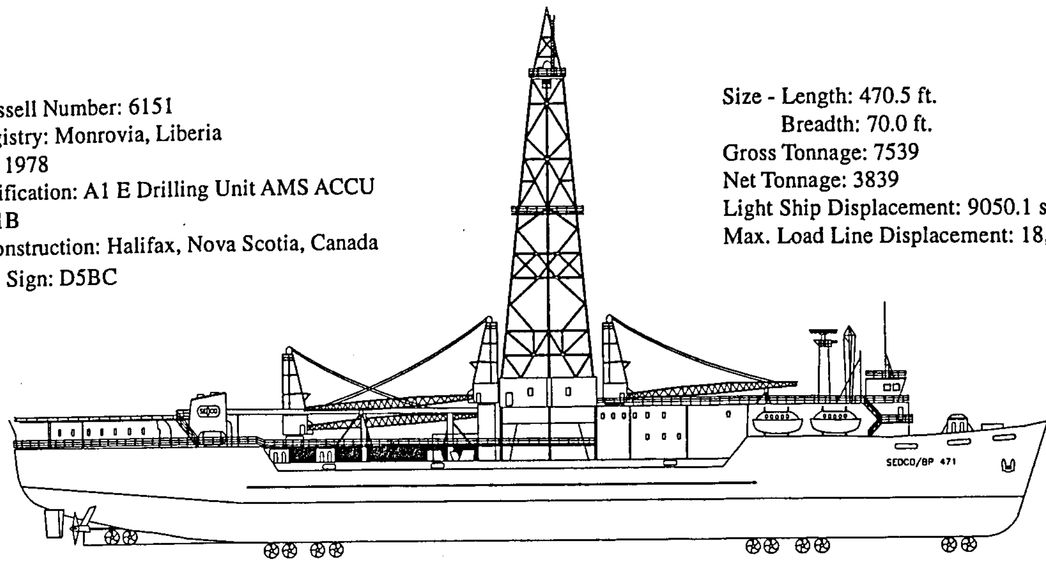
JOIDES Resolution, officially registered as Sedco/BP471, is one of the top-rated drill ships in the world.

SEDCO/BP471
JOIDES RESOLUTION
Dynamic Positioned Drill Ship

Investigating Earth's origin and evolution through scientific ocean drilling would not be possible without a uniquely outfitted ship capable of dynamic positioning over specific locations while drilling in water depths up to 27,000 feet.

Official Vessell Number: 6151
Port of Registry: Monrovia, Liberia
Year Built: 1978
ABS Classification: A1 E Drilling Unit AMS ACCU
Ice Class: 1B
Place of Construction: Halifax, Nova Scotia, Canada
Vessel Call Sign: D5BC

Size - Length: 470.5 ft.
Breadth: 70.0 ft.
Gross Tonnage: 7539
Net Tonnage: 3839
Light Ship Displacement: 9050.1 ston
Max. Load Line Displacement: 18,636.0 ston



Reach (maximum)
Water depth: 27,000 ft.
Total drill string: 30,000 ft.

Drilling Cargo
Drill pipe: 46,500 ft. (5" and 5½")
Drill collars: 2,300 ft. (8¼ x 4⅛ I.D.)
Casing: 7,350 ft. (20", 16", 13⅜", 11¾", 10¾")

Power
Engines/Generators: (7) 16 cyl. diesel,
5 @ 2100 kw (3000 hp)
2 @ 1500 kw (2200 hp)

Propulsion
Thrusters: 10 retractable/2 fixed, 750 hp each (9000 shp)
Main screws: (2) shafts, each powered by
(6) 750 hp (9000 shp)

Liquid Capacities
Diesel fuel: 25,395 bbls (1,066,590 gals.)
Drill water: 8,438 bbls (354,386 gals.)
Ballast: 5,124 bbls (215,208 gals.)
Potable water: 176 st.

Mud
Pump model: Oilwell A1700PT triplex
Pump power: (2) 750 hp motors
Pump liners: (2) 6½ in. (3,381 psi)
Pit volume: 3,740 bbls
Bulk capacity: 13, 300 cu. ft.

Passive Heave Compensator
Model: Western Gear 800-17-20
Lift capacity: 800,000 lbs. active/1,200,000 lbs. locked
Max. operating cond: 15 ft. vessel heave, 7½ sec. period
Total stroke: 20 ft.

Core Winch
Model: National, independent drive double drum
Motor: D79 electric, 750 hp
Capacity: 31,000 ft. (9,448m) per drum
Line: ½ in., 3 x 18 EIP swaged wire rope

Derrick
Model: Dreco, 147 ft.
Height: 202 ft. (62m) above waterline
Rating: 1,200,000 lbs. static/800,000 dynamic
Vee door: 70 ft.

Drawworks
Model: Oilwell, E3000
Motors: (2) EMD D-89-MB, electric,1,000 hp each
Line: 1¾ " wire rope
Brake: (2) Baylor Eddy, model 7838
117,000 ft.-lb. max. torque,
96,000 ft.-lb. @ 50 rpm

Dual Elevator Handler
Model: Varco DEHS/471
Horizontal Reach: 60 in.
Vertical Reach: 36 in.
Elevator Size: 350 or 500 ton, special modified side-door

Iron Roughneck
Model: Varco, IR2100
Wrench range: 4 in. - 8½ in. dia.
M/U torque: 63,000 ft./lbs.
B/O torque: 75,000 ft./lbs.
Vertical travel: 33 in.

Rotary Table
Model: Oilwell, A-49-½
Motor: EMD D79-MB, electric
Max. speed output: 325 rpm

Top Drive
Model: Varco, TDS3
Motor: EMD M89, electric, 1,000 hp
Continuous torque: 30,000 ft./lbs. @ 169 rpm
Intermittent torque: 40,000 ft./lbs.
Breakout torque: 60,000 ft./lbs.
Max. speed: 250 rpm

Cranes
Crane #1: Bucyrus Erie MK60 w/70 ft. boom
6 ton whipline,
25.5 ston @ 53 degrees
Crane #2: Bucyrus Erie MK60 w/80 ft. boom
6 ton whipline,
42 ston @ 67 degrees
Crane #3: Bucyrus Erie MK35 w/80 ft. boom
5 ton whipline,
25.5 ston @ 53 degrees

Pipe Rackers
Racker #1: Western Gear
Racker #2: Victoria Machine Works
Combined capacity: 30,000 ft. of 5" drill pipe

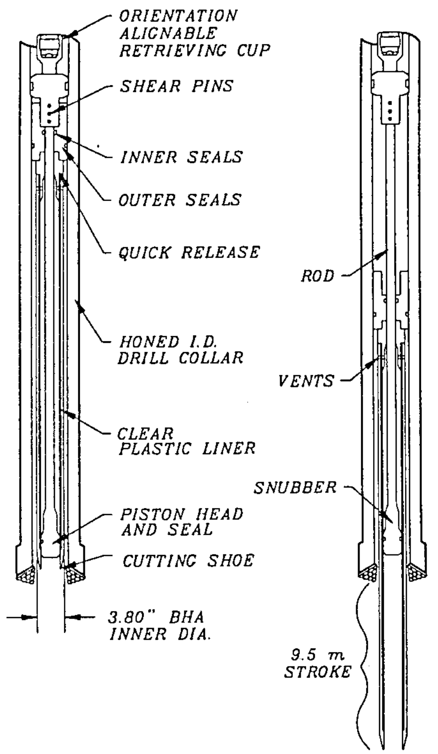
Miscellaneous
Deck load: 9,586 st.
Moon pool dia: 22 ft. (7m)

Normal Crew Compliment
SEDCO crew: 47
Catemar: 14
ODP: 25
Outside scientists: 25

ADVANCED PISTON CORER
APC

DESCRIPTION

The APC is a hydraulically actuated piston corer designed to recover undisturbed core samples from soft sediments. It is designed to be delivered through the drill string to the sediment to be cored whether at the seafloor or hundreds of meters below the seafloor.



DESIGN FEATURES

Speed Control
The speed of the APC piston is controllable, allowing core quality to be maximized.

Anti-Spiral System
The APC core barrel is held from turning while being driven into the sediment.

Core Orientation
APC cores can be oriented with respect to the magnetic poles of the earth.

In-Situ Temperature Measurement
A special APC cutting shoe allows in-situ temperature measurements to be recorded while recovering a core.

Drill-Over Option
An Anti-Spiral release mechanism allows the core barrel to be "drilled-over" for retrieval when driven into firmer sediments than it can safely be pulled out.

Interchangeability
The APC is compatible with the same bottom hole assembly as the extended core barrel (XCB) thus both can be used interchangeably depending on formation stiffness.

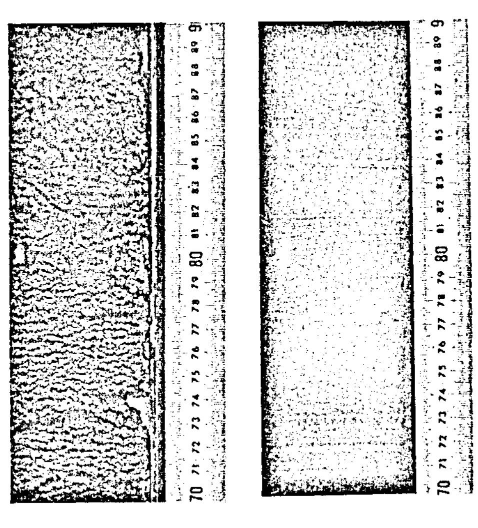
Wireline Deployable
The APC is deployed and recovered using the coring wireline.

SPECIFICATIONS

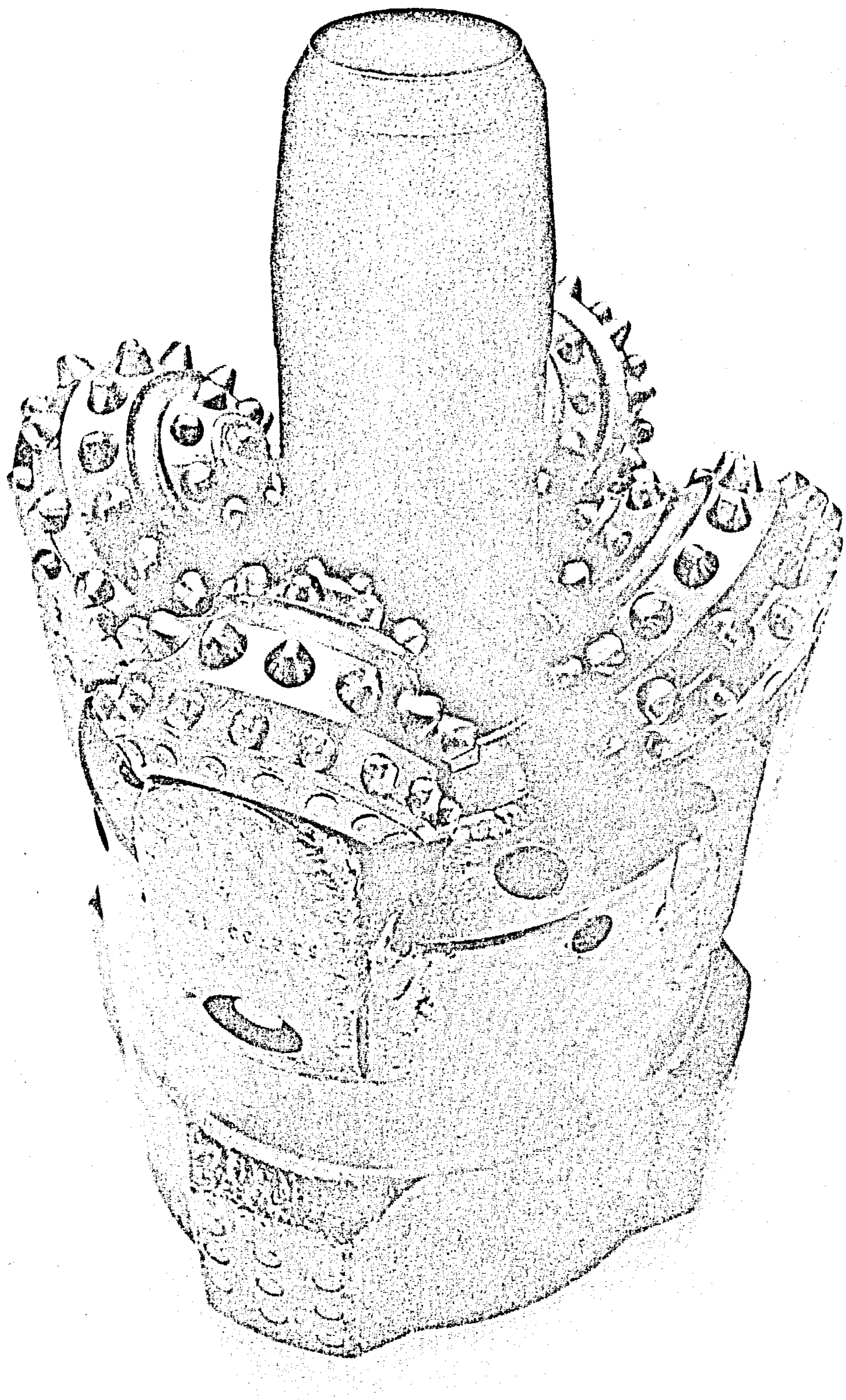
Maximum Core Length	9.84 meters
Core Diameter	6.60 centimeters
Maximum Piston Force	28,000 lbsf

NOTES

The APC has been used in depths greater than 250 meters beneath the seafloor.



The image on the left shows a typical core recovered by standard rotary coring methods. On the right is an example of the same formation using advanced piston coring techniques.



The APC „knife-edge“ cutting shoe shown partially extended beyond the roller cone bit.

CORING FOR GLOBAL CHANGE

Program

Theme 1: **SCIENTIFIC NEEDS AND REQUIREMENTS** Chairmen: Gerold Wefer, Gerard Bond

HIGH-RESOLUTION PALEOCEANOGRAPHY OF THE NORTH ATLANTIC, PRELIMINARY RESULTS OF THE *MARION DUFRESNE* GIANT CRUISE IMAGES MD 101 *(No abstract!)*
Laurent Labeyrie (CFR Laboratoire mixte CNRS-CEA, Gif-sur Yvette, France)

HIGH-RESOLUTION DEEP-SEA SEDIMENT RECORDS OF PALEOCLIMATE AND PALEOCEANOGRAPHY: A NEED OF LONG-CORE SECTIONS
Michael Sarnthein (Geologisch-Palaeontologisches Institut, Kiel, Germany)

MILLENNIAL-SCALE CLIMATE RECORDS: CORING AND CORE SAMPLING STRATEGIES
Gerard Bond (Lamont-Doherty Earth Observatory, Palisades, NY, USA)

HIGH SEDIMENTATION RATES: IS THE HOLY GRAIL A POISENED CHALICE
Nick McCave (Dept. of Earth Sciences, Cambridge, UK)

THE DRAFT OF ODP LONG RANGE PLAN 1995-2008
Kathy Ellins (JOIDES Office, Dept. of Earth Sciences, Cardiff, UK)

CORING FOR GLOBAL CHANGE WITH THE OCEAN DRILLING PROGRAM
Michael A. Storms (ODP, College Station, TX, USA)

CORING FOR ANTARCTIC TECTONIC AND CLIMATIC HISTORY: THE CAPE ROBERTS PROJECT
Peter -N. Webb (Dept. of Geological Sciences, Columbus, Ohio, USA)

CORING FOR NANSEN ARCTIC DRILLING
Jörn Thiede (GEOMAR, Kiel, Germany)

PALEOCLIMATES FROM ARCTIC LAKES AND ESTUARIES (PALE) SHELF SEDIMENTS: LINKING THE TERRESTRIAL AND MARINE SYSTEMS
Mathieu Duvall (INSTAAR, Boulder, Colorado, USA)

A EUROPEAN INITIATIVE FOR HIGH-RESOLUTION CORING : THE *CORSAIRES* PROJECT
Jean-Pierre Henriet (IFREMER, Plouzané, France)

WHAT IS THE TEMPORAL AND SPACIAL RESOLUTION NECESSARY TO RESOLVE OCEANOGRAPHIC PROCESSES OF CLIMATE CHANGE ON GLACIAL TO INTEGLACIAL CYCLES? AN EXAMPLE FROM THE EASTERN EQUATORIAL PACIFIC
Nick Pisias (College of Athmospheric Sciences, Corvallis, OR, USA)

Theme 2: **EXISTING CORING TECHNOLOGIES** Chairmen: Dieter Fütterer, Nick McCave

FRENCH CORING FACILITIES: THE CALYPSO PROJECT *(No abstract!)*
Laurent Labeyrie (CFR Laboratoire mixte CNRS-CEA, Gif-sur Yvette, France)

UK CORING AND CORE LOGGING FACILITIES
Phil Weaver and Nick McCave (Inst. of Oceanographic Sciences DL, Surrey, UK; Dept. of Earth Sciences, Cambridge, UK)

CORING EQUIPMENT AND TECHNOLOGY FOR GLOBAL CHANGE
Bilal N. Khakhaev (State Scientific Industrial Enterprise GNPP Nedra, Yaroslavl, Russia)

NORWEGIAN CORING FACILITIES: SELCORE - THE HYDROSTATIC PRINCIPLE REVISITED
Yngve Kristoffersen (Institute of Solid Earth Physics, Bergen, Norway)

CORING FOR GLOBAL CHANGE - A REPORT ON THE SWEDISH FACILITIES
Otto Hermelin (Deep Sea Geology Division, Stockholm, Sweden)

EXISTING CORING FACILITIES: RUSSIAN CORING FACILITIES
Sergey Krasnov (All Russia Institute for Geology and Mineral Resources of the Ocean, St. Petersburg, Russia)

DANISH CORING FACILITIES *(No abstract!)*
Naja Mikkelsen (Danish Geological Survey, Copenhagen, Denmark)

PORTUGUESE CORING ACTIVITIES *(No abstract!)*
José Monteiro (Serviços Geologicos de Portugal, Lisboa, Portugal)

EVIDENCE FOR CLIMATE CHANGES FROM DEEP-SEA SEDIMENT CORES: NATURAL OR ARTIFICIAL
Heidemarie Kassens (GEOMAR, Kiel, Germany)

OCEAN CORING FACILITIES IN THE NETHERLANDS
Fred Jansen (Netherlands Institute of Sea Research, Texel, the Netherlands)

Theme 3: **NEW DEEP SEA CORING TECHNOLOGIES** Chairmen: Jürgen Mienert, Keith Manchester

PISTON CORER DEVELOPMENT AND USE BY THE GEOLOGICAL SURVEY OF CANADA (ATLANTIC)
Keith S. Manchester (Geological Survey of Canada, Dartmouth, Canada)

ROCK CORING AT 2000 m AND BEYOND
Jack Pheasant (British Geological Survey, Edinburgh, UK)

THE ART OF PISTON CORING - KULLENBERG BROUGHT TO AN END
Dieter Meischner (Institut für Geologie und Palaeontologie, Göttingen, Germany)

CONCEPT AND DEVELOPMENT OF A DEEP-SEA HAMMER CORER
Hermann R. Kudrass (Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, Germany)

UNCONVENTIONAL APPROACHES TO GEOLOGICAL CORING
Harald Bäcker and Peter Seeliger (GEOMAR Technologie GmbH, Kiel, Germany; Seeliger & Partner Ingenieurgesellschaft mbH, Hamburg, Germany)

METHODS AND TOOLS FOR SIDEWALL CORING
J. Draxler (Hannover, Germany)

THE SHALLOW DRILLING CONCEPT, A SUCCESSFUL APPROACH TO MARINE STRATIGRAPHIC INVESTIGATIONS
Joar Saettem (IKU Petroleum Research, Trondheim, Norway)

MOBILE WINCH FOR DEEP SEA CORING AND MEASUREMENT (MOBIWINCH)
Wolfgang Schneider (GEOMAR Technologie GmbH, Kiel, Germany)

Theme 4: **SHIPBOARD REQUIREMENTS AND HIGH RESOLUTION SEA FLOOR STUDIES** Chairmen: Dieter Meischner, Phil Weaver

SHIPBOARD LABORATORY EQUIPMENT FOR TREATING LONG SEDIMENT CORES
Monika Breitzke (Fachbereich Geowissenschaften, Bremen, Germany)

A NEW MULTI-SENSOR CORE LOGGING SYSTEM
Dave E. Gunn (Institute of Oceanographic Sciences DL, Surrey, UK)

METHODS OF SEDIMENT CORE INVESTIGATIONS
Hannes Grobe (Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, Germany)

THE MULTI-SENSOR CORE LOGGER - A HIGH-RESOLUTION TOOL TO INVESTIGATE MARINE SEDIMENTS
Michael E. Weber (Bundesanstalt für Geowissenschaften u. Rohstoffe, Hannover, Germany)

IMPROVEMENT OF GEOLOGICAL STRUCTURAL ANALYSIS BY INTEGRATION OF OPTICAL CORE SCANNING AND BOREHOLE ACOUSTIC IMAGING
R. Schepers and G. Rafat (DMT-Gesellschaft für Forschung und Prüfung mbH, Bochum, Germany)

SURVEYING OF DRILL SITES WITH ULTRA HIGH-RESOLUTION SEISMIC TECHNIQUES
Volkhard Spieß (Fachbereich Geowissenschaften/SFB 261, Bremen, Germany)

PENETRATION OF MEASUREMENTS FOR THE ASSESSMENT OF PHYSICAL PARAMETERS FROM THE SEA FLOOR
Friedrich Theilen (Institut für Geophysik, Kiel, Germany)

THE WORLD RESEARCH VESSEL FLEET AND ITS DEVELOPMENT
Peter Otten (Kroeger Werft, Rendsburg, Germany)

POSTER SESSION

REMOTE OPERATED WORK CLASS VEHICLE (ROV) TRITON XL *(No abstract!)*
J. Bornhöft (Bornhoeft Industriegeraete GmbH, Kiel, Germany)

RECONSTRUCTION OF CORE PENETRATION USING ACCELERATION AND ABSOLUTE PRESSURE MEASUREMENTS
J. Grigel, H.Villinger, and B. Heesemann (Fachbereich Geowissenschaften, Bremen, Germany)

OPENING UP THE CORE - NEW POTENTIAL FOR AUTOMATED CORE ANALYSIS
Quentin Huggett

50-METER PISTON CORES TAKEN IN THE TROPICAL INDIAN OCEAN, SEYMAMA/SHIVA EXPEDITION *(No abstract!)*
Yves Lancelot, Yves Balut, and the shipboard scientific party

VERGLEICH HOCHAUFLÖSENDER SEDIMENTPHYSIKALISCHER KERNLOGS DER ODP BOHRUNG 690 MIT DIGITALEN PARASOUND REGISTRIERUNGEN *(No abstract!)*
B. Laser, V. Spieß (Fachbereich Geowissenschaften, Bremen, Germany)

MULTI-SENSOR CORE LOGGER - A HIGH-RESOLUTION TOOL FOR DETERMINATION OF PHYSICAL PROPERTIES IN MARINE SEDIMENTS AND THEIR POTENTIAL FOR PALEOCLIMATIC STUDIES *(No abstract!)*
F. Niessen, G. Kuhn, and M.E. Weber

EXPENDABLE DOPPLER PENETROMETER *(No abstract!)*
Christian Pröber (Nautilus Marine Service GmbH, Bremen, Germany)

IN-SITU ACOUSTIC PROFILES IN GASSY SEDIMENT: ECKERNFOERDE BAY
R.H. Wilkens, S.S. Fu, and L.N. Frazer (Hawaii Institute of Geophysics, Honolulu, USA)

SCIENTIFIC NEEDS AND REQUIREMENTS

HIGH-RESOLUTION PALEOCEANOGRAPHY OF THE NORTH ATLANTIC, PRELIMINARY RESULTS OF THE *MARION DUFRESNE* GIANT CORE CRUISE IMAGES MD 101

L. Labeyrie[1]. Y. Balut[2] , and the Scientific Staff of the IMAGES North Atlantic Cruise

[1]CFR Laboratoire mixte CNRS-CEA, Gif-sur Yvette, France
[2]IFRTP/TAAF, Gif-sur Yvette, France

HIGH-RESOLUTION DEEP-SEA SEDIMENT RECORDS OF PALEOCLIMATE AND PALEOCEANOGRAPHY: A NEW NEED OF LONG-CORE SECTIONS

Michael Sarnthein

Institute of Geology and Palaeontology, University of Kiel, Olshausenstr. 40, D-24118 Kiel, Germany

In the "happy" 1980s, when the Milankovitch orbital forcing of global climatic cycles was generally established, a time resolution of 3000-5000 years per datum was considered as largely sufficient for describing the important processes of climate change. Thus, no more than 6-10 years ago hardly any extended paleoceanographic time series was known of, which showed a time resolution better than 1500 years. The discovery of both Dansgaard-Oeschger cycles in the Greenland ice cores and Heinrich events in the North Atlantic deep-sea sediments, however, clearly demonstrated that the actual time span of the major climatic changes was much shorter, only requiring some ten to hundred years. Since the findings in the late 1980s, paleoceanographers started to report on high-resolution hemipelagic sediment sections from all oceans, especially from the ocean margins, where sedimentation rates may exceed 10-20 cm/ky and occasionally, 50-100 cm/ky. Some paleoceanographic records are discussed that have been recently obtained from the Nordic Seas, the Northwest African continental margin, the Arabian Sea, and the South China Sea. They reach a time resolution as good as 30-75 years per datum and better. Moreover, the records of warved sediments reach an annual resolution. Hence, these records can be directly compared with the climatic curves preserved in the Greenland ice cores, which permits a reconstruction of the global teleconnections of paleoclimate signals. This new order of time resolution has led, apart from the ODP approach, to the strong need of basically new coring techniques, such as the French long-core system, to obtain a new order of core length and core diameter which can provide sediment sections that (1) comprise the last 2 to 4 glacial cycles, equal to about 25 to 60 m sediment thickness, and (2) a core diameter sufficient for many parallel samples to pursue multi-tracer studies of climate change.

MILLENNIAL-SCALE CLIMATE RECORDS: CORING AND CORE SAMPLING STRATEGIES

Gerard C. Bond

Lamont-Doherty Earth Observatory, Rte. 9W, Palisades, NY 10964

We have been successful in resolving millennial-scale (1000 to 3000 years) events in piston cores from the subpolar North Atlantic. Sedimentation rates in the cores range from 6 cm to 10 cm per thousand years, demonstrating that millennial-scale climate structure can be identified even in moderate sedimentation rate cores. While higher sedimentation rate cores offer the potential for even higher resolution, the crucial limiting factor on chronology is dating, which with AMS radiocarbon techniques is rarely much better than 200 to 400 years. This tends to offset much of the potential of higher sedimentation rate sites.

Sampling strategies are a key part of recovering the high-resolution records from moderate sedimentation rate cores. These strategies include sampling with precision tools such as scalpels and dental drills. Through much of the glacial intervals burrowing is not a diffusive process as has commonly been assumed in modeling, but instead consists of easily identifiable structures that locally penetrate sharp climatic boundaries. Structures such as these can easily be avoided and still allow removal of sufficient material for most analyses.

HIGH SEDIMENTATION RATES : IS THE HOLY GRAIL A POISONED CHALICE

I.N. McCave

Dept. of Earth Sciences, University of Cambridge, UK

Like King Arthur's Knights of the Round Table, deep-sea corers have been searching for their holy grail, high sedimentation rate cores. But are cores with high sedimentation rates also extraordinary in other ways which would make the signals obtained from them misleading? The higher sedimentation rates on continental margins are in turbidite sequences, but is that what is sought? If not, what about regions down-drift of turbidity current pathways? To answer these and other questions we need to examine the sedimentary processes leading to high sedimentation rates to see what biases they introduce relative to what we think we are seeking.

From a sediment transport perspective, under most deep-sea current regimes sand, including foraminifera, is relatively immobile while silt and clay are frequently moved. Under regimes where sand is frequently moved the silt and clay do not accumulate rapidly, so sedimentation rates are low. Regions of high sedimentation rate lie under deep current systems down-drift from sediment supply points or on continental margins. By "high" one means tens of cm/ka, compared with the North Atlantic mean of 2 to 3 cm/ka (Balson & McCoy 1957, Paleoceanogr. 2: 531). Many of the sediment drifts are themselves on continental margins because that is where deep boundary currents erode, transport and deposit material originally emplaced by gravitational mechanisms. The other principal delivery mechanisms supply sediment via the sea surface - pelagic biogenic material (forams, coccoliths, diatoms, radiolaria etc), ice-rafted detritus, and wind-blown dust.

If one wishes simply to study properties of the relatively immobile foraminifera then rapid dilution with fine sediment from whatever source is a good thing. The mixing parameter DB/SL is minimised because higher sedimentation rate S reduces it for given values of mixing (DB) and mixed layer depth (L). It may also result in lesser degrees of vertical pumping advection of forams by small burrowers (Thomson et al., Radiocarbon, in press). However lateral transport of fine carbonate may mean that the forams do not coexist in the bottom sediment with the same coccoliths that they coexisted with in the surface waters. IRD information from sands will be congruent with foraminifera but IRD silts and clays are susceptible to resedimentation. Climate change information from clays is likely to be most faithfully preserved in regions where there is little chance of resuspension and where its resolution is maximised by codeposition with abundant pelagic carbonate. Upwelling regimes may be useful here as they are wind-driven. Care must be taken to match the inference to the sediment. It is probably that inference of all the possible changes suggested by variation in parameters from a given site is not valid. The chalice may not be poisoned but we shouldn't drink from it indiscriminately!

THE DRAFT ODP LONG RANGE PLAN 1995-2008

Kathy Ellins[1], Rob Kidd[1] & PCOM's LRP Subcommittee

[1]JOIDES Office, Dept. of Earth Sciences, University of Wales, Cardiff, UK

The Draft Long Range Plan (LRP) for the Ocean Drilling Program, that is to be presented to JOIDES-EXCOM on July 3rd, projects the Program's future science through two new phases into the first decade of the next millenium. ODP has led the revolution in geological techniques that allow us to read the record of environmental change held in the sediments and rocks of the ocean floor at increasingly higher resolution: moving our perception from tens-of-millions of years down to thousand-year, even decadal, time scales. In the draft Plan future ODP science goals and planning are focused into two major research themes, DYNAMICS of EARTH'S ENVIRONMENT and DYNAMICS of EARTH'S INTERIOR, recognising that our planet operates as a unified system driven by processes that intricately link the atmosphere, hydrosphere and geosphere. This presentation will address the scientific challenges outlined in the LRP, in particular those that relate to Global Change objectives, and discuss a possible phased approach to tackling them. Achieving the proposed scientific goals requires continued use of a drilling platform with capabilities similar to the *JOIDES Resolution*. There is also a need for future access to other platforms, in particular one having riser and blowout prevention capabilities. Interaction with other geoscience programs will be essential in order to realise this requirement for multi-platform operations and for innovative technological advances.

A three-phase strategy has been proposed with the phases defined to accommodate existing international agreements and available technology. The current Phase II ends in 1998 by which time we expect *JOIDES Resolution* using existing technology to have completed scheduled programs in the eastern Pacific and passed through the Atlantic and Indian Ocean drilling already highly ranked science programs and be operating in the Western Pacific. Between 1999 and 2003 (Phase III) other platforms, in addition to *JOIDES Resolution*, will be required to address shallow water and polar objectives. Phase III is envisaged as a major shift in ODP activities towards closer integration with other international multi-disciplinary earth science programs and a broadening of drilling platform capabilities in these cooperative initiatives. Phase IV (beyond 2003) will add a riser drilling platform to the core of operations with JOIDES Resolution or its successor, allowing scientists to reach depths previously accessible only to remote sensing. Riser drilling will provide the well control necessary to permit scientific drilling in critical areas of the oceans previously avoided by earth scientists for safety reasons.

CORING FOR GLOBAL CHANGE WITH THE OCEAN DRILLING PROGRAM

Michael A. Storms

Operations Superintendent, Ocean Drilling Program

After a decade of coring operations the Ocean Drilling Program (ODP) will soon complete its 61st internationally staffed research expedition. It can be argued that nearly every ODP leg, short of those devoted specifically to engineering testing, has had at least some relevance to the scientific study of "global change." Over the years, ODP engineering and drilling operations personnel have put a great deal of effort into developing and refining the coring techniques required to satisfy the demands of the global scientific community. High-resolution coring systems capable of recovering high quality samples from the marine environment have been continually refined to maximize recovery, minimize disturbance, extend depth of penetration, reduce handling/deployment time, reduce fabrication cost, and optimize compatibility with other down hole scientific measurements.

Three ODP coring systems in particular have made significant contributions to improving the quality of core samples and scientific data obtained over the last 10 years. Each of these systems has been refined numerous times to enhance their performance, greatly adding to their value to worldwide scientific research.

The ODP Advanced Piston Corer (APC) has recovered 46,648 meters - nearly 29 miles - of high quality core samples; over 98% of the total interval penetrated. This system has recently been modified to allow safer use of a "washover" technique, used for extracting the tool after penetration into stiffer, less yielding sediment. Although this technique had been refined during earlier operations, it was primarily used for emergency retrieval and not as a planned method to extend the ultimate depth of penetration. Recent design changes allow the APC to be safely extracted from indurated sediments. Risk of loss of the down hole tool or the drill hole has now been mitigated, thus expanding the tool's capability to recover deeper core sediment samples and thereby unlocking additional secrets frozen in geologic time.

The ODP Extended Core Barrel (XCB) continues to be the workhorse system for recovery of semi-indurated sediments too stiff to be recovered efficiently with the APC. Through 59 legs the system has recovered 31,179 meters - over 19 miles - of core; more than 61% of the interval penetrated. Like its predecessor, the XCB continues to be refined to improve performance in a broader range of geologic environments. Advances in brazing technology have resulted in the development of more reliable tungsten carbide tipped cutting shoes for coring in more indurated and/or interbedded formations. In addition, more emphasis is now being placed on the use of polycrystalline diamond compact (PDC) bits in the drilling of the primary borehole. Some benefits of this rapidly advancing technology are smaller hole diameters, 257 mm versus 291 mm, and more efficient cutting performance. This has resulted in significantly improved rates of penetration with the XCB system. Another advantage pertains to the cutting process itself. PDC cutters grind and cut their way through the rock, resulting in much less damage to the formation than that caused by conventional tungsten carbide insert (TCI) roller cone bits which advance by crushing and fracturing their way into the formation. This typically leads to greater borehole stability, paving the way for deeper penetrations and/or more satisfactory wireline logging results.

A third system in the ODP arsenal of coring tools is also compatible with the bottom hole assembly used with the APC/XCB systems, making the three tools completely interchangeable at any point in the coring operation. The MDCB, or Motor Driven Core Barrel, has been under development for several years. This tool uses a narrow kerf diamond cutting shoe to advance ahead of the primary bit used to advance the main borehole. Powered by a "slim" 95 mm positive displacement mud motor, the MDCB rotates at high rpm and uses relatively low weight on bit. It can be used to recover core samples from semi-indurated, indurated, interbedded, and/or crystalline formations including basalt or other basement rocks. The tool was notably successful in coring extremely massive and brecciated sulfides on Leg 158 (TAG). On this leg, when all other coring systems were unsuccessful at obtaining core, the MDCB was able to effectively core the dense, friable material. The nearly 30 meters of core samples recovered with the MDCB were heralded as having made a dramatic difference in the scientific results of the leg. Shipboard scientists, in fact, credited the tool with "saving" the leg scientifically.

While the above mentioned coring systems support the efforts of the international marine geology community on a regular basis, ODP continues to look for new and innovative ways to use the JOIDES Resolution as a resource in the quest for scientific knowledge. Ways to couple the existing XCB technology with the high speed diamond techniques used by the MDCB may be explored for developing a more efficient and versatile coring system of the future. The tremendous lifting capacity of the drill ship's drawworks or drill pipe hoisting equipment could be investigated for application to a large diameter (254 mm) giant piston coring system, recovering a single massive core at the end of the deployed drill string.

Technical innovation and creativity have been and continue to be the cornerstone of the ODP. Whether it concerns past, present, or future scientific operations, we at ODP renew our commitment to supporting the international scientific community in its quest for greater knowledge and understanding of the earth and its marine environment.

CORING FOR ANTARCTIC TECTONIC AND CLIMATIC HISTORY: THE CAPE ROBERTS PROJECT

P.-N. Webb[1], P.J. Barrett[2], F.J. Davey[3], M.B. Cita[4], F. Tessensohn[5], M.R.A. Thomson[6]

[1]Dept. of Geological Sciences, Ohio State University, Columbus, Ohio 43210
[2]Dept. of Geology, Victoria University of Wellington, P.O. Box 600, Wellington, New Zealand
[3]Institute of Geological and Nuclear Sciences Ltd, P.O. Box 30368, Lower Hutt, New Zealand
[4]Dip. Scienze della Terra, Universita degli Studi di Milano, Via Mangiagalli 34, 20133, Milano, Italy
[5]Bundesanstalt für Geowissenschaften und Rohstoffe, Stilleweg 2, 30655 Hannover, Germany
[6]British Antarctic Survey, High Cross, Madingly Road, Cambridge CB3 0ET, United Kingdom

The project is a joint venture by scientists and the national Antarctic programs of Germany, Italy, New Zealand, the United Kingdom, and the United States of America. The aim is to recover and analyse cores from the sedimentary strata beneath the sea floor off Cape Roberts in the Ross Sea, Antarctica. The drillsites are located approximately 125 km north-northwest of McMurdo Station (USA) and Scott Base (NZ), and 250 km south of the German and Italian bases at Terra Nova Bay.

The strata to be drilled are located just within a major rift, the West Antarctic Rift System, and have been close to the South Pole for the last 130 million years.The strata are over 1500 metres thick and represent parts of the time period between 30 (Oligocene) and more than 100 (Cretaceous) million years ago. The cores will be studied for two main reasons: to discover if there were ice sheets on Antarctica causing fluctuations in world-wide sea level before the glaciations of the last 40 million years; and to date the rifting of the Antarctic continent in order to help understand the formation of the Transantarctic Mountains and Ross Sea.

The complete 1500 metre succession of strata will be cored by drilling at three or four locations along an offshore transect. The drill rig will be set up on 1.5 m of sea ice over a marine water column that varies between depths of 150 and 500 m. The deep water sites have required the design of a special frame to support the drill rod and reduce the load of the drilling equipment on the sea ice. It is estimated that each 500 m site will take about 20 days to complete. Core is brought to the surface after each 3 m of drilling and past experience with this technology indicates that an almost 100 percent core recovery rate is possible.

Drilling off Cape Roberts will take place in the early Antarctic Spring (October-November) of 1996 and 1997. Preliminary geological and geophysical investigations will take place at the drillsites, at a logistic base on Cape Roberts, and at the Crary Science and Engineering Center, McMurdo Station.

CORING FOR NANSEN ARCTIC DRILLING

J. Thiede[1], D. K. Fütterer[2], L. Johnson[3], and Members of the NAD Committees

[1]GEOMAR, Kiel, Germany
[2]AWI, Bremerhaven, Germany
[3]GERG, Washington, D. C., USA

The Arctic Ocean has a profound influence on the global environment, both in real time and during the most recent geological past. The Nansen Arctic Drilling Program (NAD) has been established to persue the application of marine drilling techniques to sample Arctic stratigraphies with the aim to decipher past changes of the paleoenvironment. After the success of the Arctic-North Atlantic Gateway program of the Ocean Drilling Program (ODP) which in 1993 reached the Yermak Plateau to the North of Svalbard, NAD is following a triple strategy for drilling Arctic seafloors:

1. Suitable, relatively shallow areas of the continental margins such as the Yermak Plateau, the Morris Jesup Rise, Chukchi Plateau and Lomonosov Ridge will be probed as part of several expeditions supported by the efforts of national or international programs;

2. The sea floors of shallow, only seasonally ice-covered shelf seas can be probed from drill rigs operating from the ice or from available drill ships (drill sites are presently planned jointly with relevant Russian research institutions for the Laptev-Sea area in the area of the intersections of the Gakkel Ridge with the Laptev margin);

3. Evaluations of drilling techniques applicable to central and permanently ice-covered are presently under evaluation.

Oil company drill sites in the area of the Mackenzie delta are inlcuded into studies supported through the NAD program. NAD will mainly use established advisory structures and techniques of ODP and is therefore presently attempting to intensify its links to this successful and established international program of drilling the global sea floors.

PALEOCLIMATES FROM ARCTIC LAKE AND ESTUARIES (PALE): SHELF SEDIMENTS - LINKING THE TERRESTRIAL AND MARINE SYSTEMS

Mathieu Duvall, PALE Steering Committee

INSTAAR, University of Colorado, Boulder, CO USA 80309-0450; (303) 492-0246(v) (303) 492-6388(f)
email:duvall@colorado.edu

Paleoclimates from Arctic Lakes and Estuaries (PALE) and the Greenland Ice Core Project (GISP2) comprise the paleoclimate portion of the Arctic System Science (ARCSS) program, a component of the NSF portion of the US Global Change Research Program. PALE's major research objective is to develop multiproxy paleoclimate records from the Arctic (north of 60°N) over the last 2000, 20,000 and 150,000 year periods. Synthesis of these multiproxy records into regional and hemisphere scale records of paleoclimate change will illustrate how the Arctic system responds to and influences global climate change through strong feedback mechanisms. The members of PALE chose to focus their study on the vast resource provided by Arctic lakes in order effort to obtain high quality continuous paleoclimate proxy records from terrestrial settings. Although this idea is not new, PALE seeks to improve this practice and expand the study of Arctic lakes into a circumpolar network of sites. PALE members also set as an objective the study of Arctic estuarine and shelf sediments. Like their terrestrial counterparts, estuarine/shelf sediments are a relatively untapped resource of paleoclimate information. The study of the estuarine/shelf sedimentary environments compliments the terrestrial part of PALE research by providing a high-resolution environment with marine and terrestrial influences, thereby providing a link between the terrestrial and deep sea records. For example, Andrews et al. 1994 document a sedimentary record from Sunneshine Fjord in the Eastern Canadian Arctic that records dramatic changes in sedimentary conditions coincident with the Younger Dryas Chronozone (and Heinrich event H-0). These dramatic changes reflect a hemisphere scale climatic event. The sedimentological properties of the Holocene sequence following the Younger Dryas sediments (especially from about 8ka BP to present) show relatively stable marine conditions except for changes in the sediment organic carbon content which reflect changes in the local glacial conditions. Similar studies linking the local marine and terrestrial conditions to the global sytems are currently underway. In summary, estuarine sediments play a vital role for PALE's research: They provide high-resolution settings that link the terrestrial and oceanic systems.

Andrews, J.T., Jennings, A.E., Miller, G.H., and Williams, K.M., 1994. A Younger Dryas age event (?) and paleoclimatic conditions based on an estuarine fiord core, Sunneshine Fiord, E. Baffin Island. Proceedings of the 1994 Annual Meeting, Geological Society of America Abstracts with Programs. P. A-325.

A EUROPEAN INITIATIVE FOR HIGH-RESOLUTION CORING : THE *CORSAIRES* PROJECT

Jean-Pierre Henriet

IFREMER

From COSOD II, the Second International Conference on Scientific Ocean Drilling in Strasbourg 1987, to the European Conference on Grand Challenges in Ocean and Polar Sciences in Bremen 1994, the international scientific community involved in the study of the sea floor processes and the oceanic record of global climatic changes has repeatedly emphasized the need for access to specialized vessels, both for high-resolution coring of sedimentary records and for the safe handling of major instrument packages on the sea floor.

The broad European dynamic generated by both the highly successful and developing sequence of CEC Programmes and the ESF-animated brainstorming which introduces the Grand Challenges in Ocean and Polar Sciences is today forging a unique opportunity and geopolitical commitment to move from declarations of intention to action, by a well constrained but still significant pilot action.

CORSAIRES - Coring Stable And Instable Realms in European Seas - proposes to provide through a federating action access to existing industrial and scientific facilities for achieving the aforementioned objectives.

The CORSAIRES Initiative is endorsed by a fast but highly successful open call for interest, resulting in the identification of a prime core of 47 European institutes and laboratories, already proposing 98 well documented coring sites along the margins of Europe, which argues for the maturity of the scientific context in Europe.

In parallel to the open call for interest, a preliminary tender action has been carried out for budgeting purposes. Responses were received from 7 drilling operators, offering 9 vessels: the industrial potential is real. An important conjunctural factor for the latter response is the development of the deep offshore hydrocarbon exploration, down to 1000 to 2000 m water depths. CORSAIRES thus appears as an opportunity to Oceanic Science and Industry for advancing in phase.

The structure of the proposed CORSAIRES Project is two-fold :

- the Scientific Programme: the basic layer, structured in Core Groups linking scientific programmes concerned by regional operations (Legs)
    - NE Atlantic Core Group (Leg 1)
    - Mediterranean and SW Iberian Margin Core Group (Legs 2+3)
    - (prospective : Skagerrak and Baltic Core Group - Leg 4)
- the Auxiliary Programme, structured in Task Groups
    - Coordination
    - Operational Management and Safety Assessment
    - Core Measurements and Curation
    - Downhole Measurements
    - Technological Developments
    - Education, Training and Mobility

Strong concertation and coordination links with related programmes (Ocean Drilling Programme, Nansen Arctic Drilling Programme, ...) are an inherent part of the action, in particular through coordinated planning and through technological developments of mutual interest and benefits. Data valorisation should be through fast publication in high-level, open international literature.

WHAT IS THE TEMPORAL AND SPACIAL RESOLUTION NECESSARY TO RESOLVE OCEANOGRAPHIC PROCESSES OF CLIMATE CHANGE ON GLACIAL TO INTERGLACIAL CYCLES? AN EXAMPLE FROM THE EASTERN EQUATORIAL PACIFIC

Nick Pisias

College of Oceanic and Athmospheric Sciences, Corvallis, OR, USA

In two papers Imbrie and others (Imbrie et al., 1994 and 1995) demonstrate the spatial response of the oceanic system to changes in the distribution of solar radiation induced by changes in the dominant parameters of the earth's orbit. Three basic results are demonstrated by the analysis presented in these papers: 1) The phase of the response of oceanic and atmospheric processes at both the precession and tilt frequencies are similar; 2) The spatial phase progression is relatively simple and; 3) There is strong evidence for a very early high northern latitude trigger which is rapidly propagated to the southern ocean.

Taken together, these results strongly suggest that local response to solar insolation changes is not a major factor in the overall climates system response to changing insolation. The papers present a simple model to describe the processes which link various parts of the response of the high northern latitudes to orbital forcing. The similar pattern in the phase response at the dominate Milankovitch bands suggests that a similar set of processes are responsible of the linkages observed in the paleoceanographic records. This raises some important speculations and questions. If the phase progression seen at all Milankovitch frequencies reflects similar processes, would these be the same linkages which account for climate change at higher frequencies (i.e. at millennial bands)? A future challenge for paleoceanographers is to document these linkages acting within each frequency band. If indeed they are similar, then the question of temporal resolution becomes much less important than spacial resolution.

Our study from the eastern equatorial Pacific provides some insights into the importance of both having sufficient temporal resolution to document the time domain response of the regions but also the extreme importance of sufficient geographic resolution.

We might consider the possible factors which would contribute to oceanographic changes in this regions. Three possible factors include: 1) changes in atmospheric forcing; 2) changes in the advection of eastern boundary currents and; 3) changes in source waters associated with eastern boundary and equatorial upwelling (Antarctic Mode Water).

Results from time series analyses from two cores, one at the equator and one taken from the region of the Peru Current, suggest that the latter two factors need to be seriously considered. The phase response of the sea surface temperature time series spanning the last 500,000 years at the equator and in the Peru Current show an early, Southern ocean type, response relative to the global ice volume record as documented by the Imbrie et al. papers. Thus the eastern equatorial Pacific seems to be directly linked to oceanographic variability in the Southern ocean. However, the data from just two are not sufficient to distinguish between a linkage along the Eastern Boundary Current or through Antarctic Mode Water transported into the region in association with the Equatorial Undercurrent.

Short sea surface temperature time series from nine eastern equatorial Pacific sediment cores are used to examine the spatial response of the eastern equatorial Pacific for the past 150,000 years. Empirical orthogonal function (EOF) analysis is used on this geographic array of sediment cores to extract both the spatial and temporal patterns of variations. The first, dominate, mode of variation has a geographic pattern suggesting that changes in advection along the eastern boundary of the South Pacific is responsible for the majority of variability in the region. Unfortunately, the time series from these nine cores are too short to allow a full comparison with the longer 500,000 year records available from a few cores.

The results from this study show the importance of having sufficient temporal resolution to extract frequency domain information and the importance of having sufficient geographic coverage to define the regional pattern of variation to climate change.

EXISTING CORING TECHNOLOGIES

FRENCH CORING FACILITIES: THE CALYPSO PROJECT

Laurent Labeyrie[1] and Yves Balut[2]

[1]CFR Laboratoire mixte CNRS-CEA, Gif-sur Yvette, France
[2]IFRTP/TAAF, Gif-sur Yvette, France

UK CORING AND CORE LOGGING FACILITIES

P.P.E. Weaver[1] and I.N. McCave[2]

[1]Institute of Oceanographic Sciences DL, Brook Rd., Wormley, Godalming, Surrey GU8 5UB, UK
[2]Department of Earth Sciences, University of Cambridge, Cambridge CB2 3EQ, UK

The Cambridge Kasten Corer is a side-opening 15 cm square barrelled device with the novel feature of sideways extrusion. Moulded plastic trays 2.5 cm deep and 33.3 cm long are used to sample the core. These may be directly X-rayed, and then sampled knowing the internal structure of the sediment - burrows, dropstones etc. A 1 cm thickness yields about 35 cm^3, 15-20 g depending on water content, which is enough for most needs. Most of our cores are now sampled by taking three sets of slabs which allows enough material for archiving and external requests.

The Multicorer, developed at the Scottish Marine Biological Laboratory at Oban is a shallow penetration (~20 cm) device which takes up to 9 subcores simultaneously very gently through a hydraulic damping mechanism. This corer preserves the sediment-water interface and its overlying fluff layer intact. Oxygen micro-electrode profiles reveal negligible disturbance. The use of 9 tubes allows examination of small-scale spatial variability of biological, physical and chemical properties. A modification of this design to take a single large volume core is under development at IOSDL.

A video of the multicorer in operation will be shown and it is hoped that a second video of a box corer in action will also be available for comparison. The multicorer can be seen to cause little disturbance of the sediment-water interface.

Other UK coring systems include the British Antarctic Survey's STACOR (giant piston corer) similar to the early French system and encorporating a base plate connected to a stationary piston. A much simpler giant piston corer (modelled on the current French design) is being built at IOSDL using drillpipe and continuous liner. We hope to be able to recover ca. 30 m long cores on the *R.R.S. Discovery* and *R.R.S. James Clark Ross*.

The UK plans to provide a National facility for deep sea cores involving curation and storage at 4° C, logging and paleomagnetic analysis of all suitable cores, publication of core information and access for visitors.

CORING EQUIPMENT AND TECHNOLOGY FOR GLOBAL CHANGE

B.N. Khakhaev, V.V. Kochukov, D.V. Lykov

State Scientific Industrial Enterprise GNPP Nedra, Svoboda str., 8/38, Yaroslavl, 150000, Russia

For the last ten years scientific organizations and governments of the developed countries of the world have paid much attention to the problem of global change of environment including the problem of change of climate. Deep-water scientific drilling in floor sediments of lakes, seas and oceans can help to solve this problem. In Russia such drilling is carried out by State Scientific Industrial Enterprise "Nedra" (GNPP Nedra). GNPP Nedra is engaged in deep and super deep drilling.

Within the framework of the Program "Investigation of Global Change of the Environment in Central Asia Based on Scientific Drilling in the Baikal Lake and Baikal Type Depressions" GNPP Nedra is engaged in deep-water scientific drilling in the Baikal lake for recovery of continuous core material.

To provide deep-water scientific drilling GNPP Nedra has developed a technology of deep-water drilling in intercontinental lakes by means of "Nedra-Baikal-600", "Nedra-Baikal-1000" drilling modules mounted on the base of light drill rigs with a load capacity of 200-700 kN.

These drilling complexes allow to drill deep-water wells with continuous coring from the ice or vessels in lakes and marine shelves. Well depth is about 300-1000 m at a water depth of 500-1200 m.

GNPP Nedra has developed and implemented a number of corers to obtain continuous high quality core material. These are:
1) UKSB-178/56-75 "Baikal-Global" corers with a set of retrievable core receivers, which allow to obtain a continuous core from sediments with different physical and mechanical properties. Guaranteed core recovery is no less than 90%. While coring core is packed in plastic liners.
2) DVK-172/40, 195-60 special corers with a retrievable core receiver, inserted in a hollow rotor, and a spindle of positive displacement motor drive which allow to obtain a continuous high quality core from dense and hard sediments.
3) For drilling of deep-water wells with a depth of 1000 m and more it is suggested to use a special technology if drilling is performed during more than one season. Coring is carried out by means of a retrievable corer with a hole opener and a positive displacement motor without pulling out drill pipes. This technology has been successfully used by GNPP Nedra while drilling super deep wells (Krivoy Rog) up to a depth of 4800 m.
4) GNPP Nedra together with VNIIBT (Moscow) has developed KBN-195/40 "Kaban" corer for the recovery of a continuous core from the walls of a borehole by "upward-technique". This corer allows to obtain core material from missed on different reasons intervals and to obtain additional core material if necessary.

The following corers for deep-water drilling are under improvement and will be tested in the near future:

1) KUZP-195/100 with a penetrating core receiver up to 20-30 m in length and an electromagnetic valve, which can be controlled from the surface.
2) UKSB-188/150 corer with a short positive displacement motor drive with a diameter of 150 mm for coring dense floor sediments.

The core bits of the corers allow to obtain continuous intact core material.

The following drill strings were developed and used to drill deep-water wells with continuous coring and to solve ecological problems of water environment protection:

1) a light-weight aluminium riser without tool joints with different sets of lower and upper sections which allow to deepen it and to keep it afloat.
2) a light-weight aluminium drill string, consisting of internal flush drilling pipes LBT with a diameter of 129, 147 and 168 mm, with strength properties comparable to those made of steel.

The developed technology enables to penetrate floor sediments with continuous coring and to form a stable borehole using fresh lake-water as a drilling mud.

In 1992-1993 within the framework of International Program "Baikal-Drilling" "Nedra-Baikal-600" and the new technology, developed by Nedra, for deep-water drilling with continuous coring from the ice or vessels, frozen into ice have been successfully used to drill a number of wells in floor sediments of the Baikal lake and to obtain continuous high quality core in sealed plastic coatings (with about 100% core recovery).

NORWEGIAN CORING FACILITIES: SELCORE - THE HYDROSTATIC PRINCIPLE REVISITED

Y. Kristoffersen[1], E. Lien[2], and S. Ree[2]

[1]Institute of Solid Earth Physics, University of Bergen, Norway
[2]Selantic Industrier A/S, Ågotnes, Norway

Tools lowered from the surface through the water column can exploit the large energy potential represented by the difference between ambient hydrostatic pressure and atmospheric pressure in a sealed reservoir. Selantic Industrier A/S, Selje in cooperation with University of Bergen and with partial support from Elf Aquitaine Norway A/S have developed a hydrostatic sediment corer (Selcore) which can operate in any water depth >100 m. Selcore is deployed like a conventional gravity corer. As the core barrel hits the sea bed, a patented hydrostatic motor is automatically activated and Selcore operates as a pile driver where the mass of the steel low pressure tank serves as the hammer head at 30-50 strokes/minute. The length of the stroke is 35-135 cm. The energy is derived from the differential pressure between the air at 1 bar in the steel tank and the ambient hydrostatic pressure at the sea bed, and the number of strokes depends on reservoir volume. In the current version, the number of strokes typically varies from 100 at 200 m depth to 200 at 500 m depth and more than 400 strokes at water depths >1000 m. This represents a maximum of 100-fold increase in energy available for penetration compared to a gravity corer of the same gross weight. The hammer action will stop when either full penetration is reached, solid bedrock is encountered or the energy potential is exhausted.

A number of field campaigns using a Selcore prototype (weight 800 kg, 60 strokes) have demonstrated that this hydrostatic corer generally recovers two times the length of the core obtained by a conventional gravity corer of the same weight. Selcore is particularly efficient in high shear strength sediments. So far core barrels of up to 15 m have been used on commercial jobs with 12.5 of recovery. With proper core barrels and handling arrangement, there should be sufficient energy available for at least 30 m of penetration in deep sea sediments using a core head assembly weighing 1.3 tons.

Sample quality has been investigated by X-ray of the cores and geotechnical parameters including sensitivity, direct simple shearing (DSS) and triaxial CAU tests to investigate disturbance indicated by volumetric and axial strain changes during consolidation. The latter indicate marginal differences compared to the 3" Fugro-McClelland piston sampler.

Designs are being evaluated for implementing a dynamic piston with sea bed reference in Selcore.

CORING FOR GLOBAL CHANGE - A REPORT ON THE SWEDISH FACILITIES

J. Otto R. Hermelin

Deep Sea Geology Division, Department of Geology and Geochemistry, University of Stockholm, S-106 91 Stockholm, Sweden

One of the peaks in Swedish deep sea geology dates back to the late 40's and the vessel *Albatross* which circumsailed the world during the Swedish Deep-Sea Expedition. The aim was to penetrate deep into the bottom sediment. Börje Kullenberg, one of the expedition leaders invented the piston corer and the expedition brought back up the 30 meter long cores from the tropical oceans. The ship was sold but the KULLENBERG corer, that revolutionized the deep sea research is still in use at the University of Göteborg.

Today Swedish research vessels solely dedicated to deep marine research are nonexistant, although the icebreaker *Oden* proved during the Arctic '93 Expedition to be an excellent platform for research in the Arctic Ocean. For the Arctic '96 Expedition is a large diameter (90 mm) gravity corer under development. The concept is new, with 2.5 meter long segments can the gravity corer easily be turned into a piston corer.

Smaller ships (< 30 m) for research in more coastal areas in the Baltic Sea and on the westcoast are available both at the universities in Stockholm (*Strombus* and *Aurelia)* and Göteborg (*Svanic* and *Nereus*) and at the Geological Survey in Uppsala (*Ocean Surveyer*). In order to obtain longer sediment cores, piston corers (KULLENBERG corer; 50-75 mm diameter) of various length are available in Stockholm, Göteborg, and Umeå.

Equipment for obtaining shorter (< 2 m) cores, i.e. gravity cores, are available at the universities in Umeå, Luleå, Stockholm, and Göteborg and at the research centers at Askö (on the eastcoast) and Tjärnö (on the westcoast).

EXISTING CORING TECHNOLOGIES: RUSSIAN CORING FACILITIES

A.V. Lukoshkov[1] and S. Krasnov[2]

[1]Morskiye Tekhnologii Joint-Stock Company
[2]All-Russia Institute for Geology and Mineral Resources of the Ocean, St. Petersburg, Russia

Between 1986 and 1991 the national project for creation of the deep-sea drilling complex and vessel had been actively developed in the USSR. The work was performed in three directions aimed at the achievement of the single result.

1. Projection and building of a special vessel with the following specification: displacement 7.360 t, length 115 m, width 17.8 m, depth 9.4 m, draught 6.06 m, power of propulsion engine 4.560 HP, crew 120 (58+60+2), autonomy by supplies 90 days, speed 16 knots, quantity of scientific laboratories 17 (area 20 to 70 sq.m each).

2. Creation of the drilling complex capable of boring holes up to 1,500 m deep in the ocean at water depths of up to 6,000 m, or holes up to 7,000 m deep at the shelf. The complex included the equipment for the hole mouth and for casing with pipes up to 426 mm in diameter, and a unit of 6 cable winches for logging.

3. Creation of remotely operated underwater drilling units submerged to the seafloor and capable of coring holes 59 to 120 mm in diameter 50 m deep at water depths of up to 4,000 m.

Up to 1991 the vessel has been designed, its hull built and launched. In 1991 the prototype of the drilling complex was tested using a smaller ship for working out of drilling technology. Up to the same year four types of underwater drilling systems have been designed in different research institutions and the construction of experimental samples has begun.

However, beginning from 1992 the works were gradually stopped. The attempts of several large private companies to revive the project remained unsuccessful due to the problems of national affilation of the hull built in Ukraine. At present only the work on underwater drilling units according to the simplified technical design is continued.

Nevertheless, the existence of the complete design, the hull and the considerable anticipation in the construction of the drilling complex allows Russia and Ukraine to suggest a real substantial contribution to the European deep-sea drilling project.

DANISH CORING FACILITIES

Naja Mikkelsen

Danish Geological Survey, Copenhagen, Denmark

PORTUGUESE CORING ACTIVITIES

José Monteiro

Servicos Geologicos de Portugal, Lisboa, Portugal

EVIDENCE FOR CLIMATE CHANGES FROM DEEP-SEA SEDIMENT CORES: NATURAL OR ARTIFICIAL

H. Kassens[1], N. Mühlhan[2], F.C. Kögler[2] and J. Thiede[1]

[1]GEOMAR Forschungszentrum für marine Geowissenschaften der Christian-Albrechts-Universität zu Kiel
[2]Geologisch-Paläontologisches Institut der Christian-Albrechts-Universität zu Kiel

High-resolution stratigraphical, sedimentological, and physical property measurements were carried out on hemipelagic deep-sea sediments at the same site in order to compare the quality and quantity of four different coring tools. These investigations were supported by high-resolution PARASOUND records.

The major objective was to show how reliable sedimentary records are in terms of interpreting paleoceanographic changes inferred from deep-sea sediment cores. Therefore, four sediment cores were taken at 1300 m water depth in the Norwegian-Greenland Sea by using common coring tools, such as spade box core (50*50*60 cm), kasten core (type: 390: rectangular cross section 30*30 cm; core barrel segment length 5.75 m; penetration weigth 3500 kg), gravity core, and piston core (combined type 446: barrel diameter 12 cm; core barrel segment length 5.75 m; penetration weigth 2000 kg).

In general, the sediments recovered are dominated by dark brown to olive grey, silty clays. In addition, they are characterized by distinct, often closely spaced facies changes. Remarkable are indurated, dark grey to black sandy-clayey sediment layers (2 to 14 cm), in which ice-rafted material is present and in which mud clasts are accumulated.

The comparison of four different coring tools taken at the same site can be summarized as follows:

- The length of the long sediment cores varies between 9.68 (piston core) and 6.06 m (gravity core) below the sea floor. More important for the quality of the sedimentary records is the ratio of sediment recovery to sediment penetration, which is excellent for the kasten corer (0.96) in comparison with the gravity corer (0.51).

- X-ray investigations have shown shear planes and inflow structures in sediment slides of the gravity and piston cores. For the spade box and the kasten core none of these coring disturbances were observed.

- Sediment recovery of the piston and gravity core converted to the sub-bottom depth of the kasten core has demonstrated (i) distinct increase of compaction versus depth (up to 65 %) for the gravity core, and (ii) compaction (between 0 and 2.5 m up to 85 %) as well as extention (between 2.5 and 6.6 m up to 8 %) for the piston core.

- The vertical distribution of physical properties, e.g. shear strength, wet bulk density, porosity and thus the state of consolidation differs obviously between the sediment cores. This can be clearly confirmed by variations in thickness of the facies.

- Drastic and even not comparable variations in sediment accumulation rates were estimated for the long sediment cores.

In conclusion, the comparison of sediment cores has shown that three paleoceanographic scenarios can be described for the same location, with the box and kasten core records seeming to be most confident.

OCEAN CORING FACILITIES IN THE NETHERLANDS

J.H. Fred Jansen

Netherlands Institute for Sea Research, PO Box 59, 1790 AB Texel, the Netherlands

Two Dutch research vessels are equipped for coring operations in the world ocean: the RV *Pelagia* and *Tydeman*. The *Pelagia*, owned by the Netherlands Institute for Sea Research (NIOZ) at Texel, was built in 1991. Being 66 m long, she is designed for expeditions over all continental shelves and oceans except the Arctic and Antarctic Seas. There is room for 15 scientists and 9 containerised laboratories. The *Tydeman*, owned by the Royal Navy, is available for scientific expeditions on an ad hoc basis. She is 90 m long, is allowed to sail in all oceans apart from the Arctic and Antarctic, and offers room for 25 scientists and 9 laboratory containers.

For coring operations, a piston-corer set, a box corer and a vibro corer are used on a routine basis. The piston corer has a standard weight of 1450 kg, diameter 90 mm and its liners are made of hostalite, a strong synthetic material that is easily cut and has a low penetration resistance. Its maximum length is 24 m. Filling one truck, the PC set may change any ship with sufficient deck space into a coring vessel. The PC is equipped with an anti-drag piston. When pulling the corer out of the sediment, a one-way valve in the piston maintains a constant underpressure below of 0.8 bar. As a result, over 90 % of the cores do not show a trace of dragging. We use a 20-t super aram cable of 17.3 mm diameter. The hydro-electric vibro corer, weight 3 t, is designed for water depths down to 1000 m, but can be adapted for deeper water. The distortion is negligible in many sandy and tough-clayey cores. The box corer for deep-sea operations is equipped with a rectangular or circular (diameter 130, 320 or 500 mm) sampler. The rectangular one can be opened for sedimentological purposes. With the circular design, developed for incubation experiments by biologists and chemists, we can store any desired volume of sea water over the sediment surface.

The CORTEX (Core scanner Texel) is a computer-controlled instrument for the semi-quantitative measurement of chlorine and elements of higher atomic number in piston cores, box cores and other types of samples with X-ray fluorescence (XRF). The CORTEX offers the opportunity to get a good impression of the chemical composition of the solid phase already on board ship within half an hour after the opening of a core section. So, the coring and chemical sub sampling program can be adapted if necessary. In hemipelagic sediments, the Ca radiation may provide a detailed calcium carbonate stratigraphy. The CORTEX is able to do rapid measurements at small intervals. This implies that uncommon features will not easily escape from observation. Any desired step size can be ordered. A measurement takes one minute, so a 1 m long core section is scanned with 5 cm steps in 20 minutes.

I will try to give an overview of available Dutch cores. Most cores come from the North and equatorial Atlantic Ocean, Mediterranean, Arabian Sea and Indonesian waters. Future Dutch expeditions will probably focus on the same regions. During the last years, paleoceanography is successful in reconstructing and understanding processes that change the climate. The knowledge of continental climatic change, however, does not keep pace with this development. Moreover, the only global calender is the marine O-18 record. I will make a plea for coring at sites, usually continental slopes, where continental climatic signals can be studied in marine cores.

NEW DEEP SEA CORING TECHNOLOGIES

PISTON CORER DEVELOPMENT AND USE BY THE GEOLOGICAL SURVEY OF CANADA (ATLANTIC)

W.G. MacKinnon, D.E. Heffler, K.S. Manchester

Geological Survey of Canada (Atlantic), Bedford Institute of Oceanography, Dartmouth, Nova Scotia B2Y 4A2, Canada

The piston coring system developed at the Geological Survey of Canada (Atlantic) resulted from initial cooperation between the GSC (Atlantic) and the University of Rhode Island (URI) as part of the URI Long Coring Facility (LCF) project in the early 1980's. When the LCF project was terminated, the GSC purchased the remaining LCF system parts in 1989 and continued alone on further development of an AGC CORING SYSTEM. This 11 cm diameter AGC Corer is capable of taking cores up to 30 meters long. It has primarily been used on the *CSS HUDSON* but was also used on the *RV POLARSTERN* in 1991. It has been shown that due to excessive support cable movement there is often a high frequency of core disturbance resulting in foreshortening and stretching of core sedimentary units. This disturbance has been measured and identified using small data loggers (CHATS & PAL) on the corer and the corer piston to record the movements and pressures that are present during the coring process. A small (5.5 meter) "fixed reference" piston corer has been built, which has the piston isolated from the support cable and referenced to the seabed. Cores obtained with this corer are described and compared to a "standard" piston corer.

ROCK CORING AT 2000 m AND BEYOND

Jack Pheasant

British Geological Survey, Murchison House, West Mains Road, Edinburgh EH9 3LA

In the course of marine geological survey, the BGS (British Geological Survey) have encountered areas where hard rock formations have not been buried by thick, unconsolidated, sediment sequences. In particular, recent surveys in the N.E. Atlantic have revealed Palaeogene and older strata cropping out at or near to seabed in areas beyond the major Neogene and Quaternary depocentres.

The development and use of the sea floor rockdrill as a stratigraphical tool has permitted calibration of these strata which, in areas of deeper burial, would otherwise require extensive boreholes to be undertaken in an ODP (Ocean Drilling Program) type approach. Although the remote tool will never replace the continuously cored borehole, with good recovery, significant benefits can derive from use of such a development.

The present rockdrill, capable of deployment on an electro-mechanical umbilical to 2000 metres from a dynamically positioned survey ship, will penetrate up to 5 metres below sea floor recovering 44 mm and 52 mm diameter core. Electrically powered from the survey vessel by high voltage transmission, the rockdrill has an infinitely variable range of drilling speeds - up to 500 RPM to accommodate a range of drill bits and rock types. It is instrumented to provide the operator with real time data on status and performance.

The paper will also present the concepts being developed to further this technology development, allowing deployment to 4000 metres, for the recovery of short, oriented, hard-rock cores for palaeomagnetic, structural and physical property measurements from a range of volcanomorphic settings.

THE ART OF PISTON CORING — KULLENBERG BROUGHT TO AN END

Dieter Meischner

Abteilung Sediment-Geologie, Institut für Geologie und Paläontologie, Universität Göttingen, Goldschmidt-Strasse 3, D 37077 Göttingen, Germany

The piston corer after KULLENBERG (1947) is still the most effective deep-sea coring device. However, the principles that control the length and the quality of piston cores are little understood. Contrary to common belief, the force that pushes the core into the barrel is not vacuum, but the ambient pressure that acts on a potential vacuum under the piston. For a corer of 110 mm inner diameter in 5,000 m water depth this amounts to an equivalent of 47.5 tons dead weight of a gravity corer.

A piston corer is mechanically more stable than any gravity corer. When the free-falling instrument touches the bottom, the piston is abruptly stopped, while the barrel penetrates the sediment further. The increasing force that is needed to fill the barrel keeps the piston rope tight and so prevents lateral bending. In fact, bent core barrels are a rare experience in piston coring. The free-falling instrument is also independent of swell-induced ship movements and elastic bounces of the wire which often interfere with gravity coring.

A thoroughly simplified version of the KULLENBERG-corer is described here that has proven its effectiveness since 1983 in the North Atlantic, the Antarctic Ocean, Red Sea/Gulf of Aden, in the Baltic Sea, and in lakes. The instrument comes in 2 versions.

1.5 t dead weight, barrel 120/110 mm ø, 12 m standard length, 18 m extension proven
3.0 t dead weight, barrel 200/190 mm ø, 24 m standard length, 36 m extension possible

The corer features seawater-resistant aluminium barrels without liners. The cores remain in the barrels for transport and storage, but may be cut into arbitrary pieces.

The stainless steel piston is equipped with polybutylene O-rings and a split-piston technique with copper shear-pins. When the corer has reached its final position in the sediment, the piston splits on hoisting, and its upper part is pulled through to the upper end of the barrel where it forms a tight stopper. The lower part of the piston is prevented from slipping by a blockage. This double sealing precludes any backslipping of the core during extraction, when counteracting forces are greatest. It also allows to use the corer without any core catcher in consistent sediment.

The performance of the corer is unique even on difficult, strongly layered or partly indurated sediments like turbidites or partly cemented calcarenites (e.g.: aragonite crusts in the Red

Sea). A typical series of cores taken with the heavy instrument shows > 90 % success (No. of cores/No. of attempts), and 85 % recovery (core length/barrel length), i.e. over 20 m on the average. Never was an instrument lost or destroyed, nor were the ropes entangled during operation. The corer is safe against premature triggering in the water column. This is also a safety argument.

The quality of the cores is excellent as is testified by the undeformed preservation even of most delicate sedimentary structures and the completeness, in fine detail, of the stratigraphic record in cores from one and the same basin (e.g.: the Red Sea).
A larger version of the same corer, 6.0 t, 400/380 mm ø, 48 m standard length, was proposed to the German Ministery of Science and Technology, but the proposal was turned down.

CONCEPT AND DEVELOPMENT OF A DEEP-SEA HAMMER CORER

H.R. Kudrass[1], W. Schneider[2], D.J. Smith[3] and K. Tronstad[4]

[1]Bundesanstalt für Geowissenschaften und Rohstoffe/Hannover
[2]GEOMAR Technology GmbH, Kiel
[3]British Geological Survey/Edinburgh
[4]Norwegian Geotechnical Institute/Oslo

Five European partners develop and build a novel deep-sea coring system within the MAST programme. The system is designed to sample undisturbed cores of up to 30 m length from semiconsolidated or partly consolidated sediments in water depths ranging to 5000 m. The corer is monitored and controlled from the surface with power and communications transmitted through a combined power and lift umbilical.

The mechanical system consists of frame, sledge, hammer and double-walled core barrel including a stationary piston. The core barrel is mounted on the sledge and driven by controlled strokes of the hydraulically lifted 750 kg hammer creating peak forces of up to 800 kg. Water flushing reduces outer wall friction during penetration and suction forces at retrieval. In addition, real-time geotechnical information can be obtained by replacing the core barrel with a cone penetrometer and fluid sampler.

First results of a test in the North Sea will be presented.

UNCONVENTIONAL APPROACHES TO GEOLOGICAL CORING

Harald Bäcker[1] and Peter Seeliger[2]

[1]GEOMAR Technologie GmbH, Kiel
[2]Seeliger & Partner Ingenieurgesellschaft m.b.H., Hamburg

A hundred years ago ocean sediment coring developed as a by-product of water depth measurements. A tube was added to the weight at the end of the piano wire of the Sigsbee machine. This principle, a steel tube pushed into the seafloor by headweight, is still applied by most marine geologists. Tube lengths and weight have been increased to either their physical or practical limits. The main penetration problem, friction, could be overcome, to a certain extent, by the use of pistons or by vibration and hammering. Nevertheless, sediment penetration and sample quality have remained below expectation in general. Some sea floor types could not yet be appropriately sampled.

Therefore, new approaches should be considered and evaluated, which could lead to deeper penetration or to the recovery of samples from "difficult" formations.

Rotary drilling, widely used in the mining and oil industries, could be adapted to deep water application by miniaturization and automatization. Other less conventional approaches should be investigated as well, and possibly tested as prototypes. They too can be based upon certain experiences gained in other technical fields and promise to be useful for solving specific sampling problems. The following four proposals are designed for automatic operation in deep water using an electrical cable.

1. Coring Screw
   This principle is applied on land for soil sampling. The screw will be fixed outside the steel tube.
   Application: Soft sensitive sediments.

2. Scout Corer (Mole)
   This principle is applied for cable laying under obstacles. A torpedo-like instrument vibrates into the seafloor from a winch placed on the ocean floor. The sample is taken when target depth is reached.
   Application: Verification of acoustic layers, gas sampling, etc.

3. High-pressure Water Cutting
   This principle is applied for surface cleaning, concrete cutting, etc. High pressure sea water is ejected through a nozzel rotating at the core tip.
   Application: Long cores in semi-consolidated sediments, including permafrost soils.

4. Punching Sampler
   This principle is applied in machine tools and for borehole side wall sampling. The punching gun is tele-guided from a tripod support onto the surface to be sampled. The sampler is then launched into the rock by explosives or by spring load.
   Application: Selected sampling of hard rock surfaces.

METHODS AND TOOLS FOR SIDEWALL CORING

J.K. Draxler

Wulspark 38, 30559 Hannover, Germany

One of the principle goals of scientific or commercial drilling on land or at sea is to recover rock samples for geological and petrological studies. Only from such samples important information about the rock structure, texture fabric and content can be obtained. No geologist, mining or reservoir engineer would ever attempt to make a reservoir evaluation without having rock samples from this reservoir analysed.

The standard method to recover rock samples from deeper sections of the earth is to cut cores. This is done by drilling out cylinders of the rock from the bottom of a borehole along the borehole axis and retrieving these samples to surface either with the drill pipes or by pulling them by cable. Depending on rock types, different drilling techniques are used. The best recoveries are received by applying the so-called mining technique which uses diamond coring bits and cable retrieval systems. Still, all core drilling systems suffer from the fact, that recovery is seldom 100 %.

Industry has acted accordingly and has developed methods to attempt to recover cores out of the wall of a borehole in sections where standard coring has failed or has been too expensive.

Wireline conveyed tools:

The first devices introduced are the Core Sample Taker Tools (CST). These are tools which are run on wireline like any other borehole logging tool. On a steel carrier - the gun - bullets are conveyed into the borehole. With explosive charges these cylindrical hollow bullets are shot one by one into the wall of the borehole at pre-selected depth levels. Due to the force of the shots the bullets will penetrate the rock and cut out the samples. The bullets are fastened to the carrier by flexible wires. When pulling the gun with the logging cable, the bullets are extracted from the formation and sidewall core are recovered. A single gun can carry 30 bullets. Several guns can be combined in one run into the borehole. Different gun sizes and bullet types are available to suite the local conditions. In the oil industry sidewall coring of this form is common in soft and medium hard formations.

Tools are available in sizes from 101.6 to 133.3 mm (4.0" to 5.25"). For present ODP operations the application of the percussion coring system is too risky and due to tool sizes not possible. The system could be beneficial when riser drilling will be introduced to ODP.

For coring in hard formations tools have been developed to drill samples from the borehole wall. End of the sixties the Mechanical Core Slicing Tool (MCT) from Schlumberger became operational. With two diamond-studded rotating disks a triangular shaped 91.4 cm (36") long "slice" of the formation was cut from the sidewall. Four cuts could be made on one trip in the borehole. The drawback of this tool was the high power consumption, often damaging the logging cable. The tool has been taken out of service - even after having cut several cores in the KTB deep hole.

The new tools offered by companies of the logging industry (Halliburton, Schlumberger, Western Atlas) use diamond coring bits rotated by electrically given hydraulic motors. The tools are set at coring depth by an anchor arm pushing them to the wall. The drilling assembly - motor, core barrel with bit - is tilted by 90° from the transport to operating position. After starting the motor, the assembly will hydraulically be advanced and the core will be cut. After penetrating the full length of the core barrel the core is broken by tilting the barrel and retrieved by pulling it back. The motor bloc is rotated back from operating to transport position. A hydraulically activated stinger will push the core out of the barrel into the core magazine. The anchor arm is retracted and the tool can be moved to the next coring depth. All steps of the coring operations are surface controlled. On one run in the borehole up to 20 cores of 2.3 cm (0.9") diameter and 5 cm (2.0") length can be recovered if standard equipment is used. Special arrangements can be made to cut more cores on one trip in the hole (Schlumberger tool). For different rock types corresponding coring bits can be selected to obtain best results.

In both the KTB boreholes more than 170 sidewall cores have been cut with 98 % recovery.

At present, these tools can not be used for ODP operations. The outside diameter of the tools is between 120.7 and 136.4 mm (4.7" and 5.37"). For future riser drilling operations these tools could qualify as an important addition.

Sidewall coring on wireline is a very versatile and powerful tool. ODP should ask the service industry to design a slimhole tool on the same principle and technique as the standard tools.

Drill pipe conveyed tools:

The Institute for Drilling Technology, Oil- and Gas-Production (ITE) of the University Clausthal-Zellerfeld has developed a sidewall core drilling system using drill pipes and downhole motor. The complete coring system consists of a bulkhead packer assembly, telescopic joint, circulation valve run on 5.0" drill pipes and the coring assembly with Moineau motor, flexible shaft, core barrel and coring bit. This assembly is run on cable through the 5.0" drill pipes down to a whipstock which is at the end of the drill string in front of a pre-cut window in the drill pipes and placed at coring depth. The packer is set by mud pressure at coring depth to anchor the system. Through mud circulation the Moineau motor is driven and the coring assembly is advanced along the slope of the whipstock cutting a 60 cm (2 feet) core. After coring is completed only the coring assembly is retrieved to surface on the cable and the core recovered. The core has a diameter of 41 mm (1.625") and is fully cylindrical only over half of the length.

The packer can be released and the whole system moved to the next coring depth. After setting the packer the coring assembly is run again in the hole on cable for the next core.

A prototype tool has been tested by the Institute in a 8.5" borehole with good results.
For ODP operations the tool could be applied. This system is less sensitive to heave variations than the Diamond Coring System under development. Without the whipstock it even could be used to drill cores along the borehole axis.

Eastmann Christensen has developed a sidewall core drilling system for Statoil, Norway. The system consists of the core drilling assembly, the hydraulic drive mechanism, the valve system, computer and battery pack. The core is cut at 90° to the borehole axis, has a diameter of 38 mm (1.5") and a length of 80 mm (3.15"). The power is transmitted via mud circulation and a Moineau motor and controlled via cable connected to the control unit at surface. The maximal outside diameter of the tool is 209.6 mm (8.25").

THE SHALLOW DRILLING CONCEPT, A SUCCESSFUL APPROACH TO MARINE STRATIGRAPHIC INVESTIGATIONS

Joar Saettem and Karl Oscar Sandvik

IKU Petroleum Research, N-7034 Trondheim, Norway

Continuous wireline coring in shallow stratigraphic boreholes has been combined with high-resolution and conventional reflection seismic data to study Paleozoic to Cenozoic sedimentary rocks offshore Norway. The coring has been performed from dynamically positioned coring vessels (*M/S Bucentaur* and *M/V Pholas*) in waterdepth ranging from about 100 m to nearly 1500 m. Maximum subbottom penetration has been 560 m. The main coring method has been a piggyback wireline technique with a diamond coring string run inside an outer 4" ID drillstring that has acted as a casing through unconsolidated strata and support through the water column. This method has been used during about 60 weeks of operation between 1982 and 1994, and about 7 km of core has been collected. The technique has proven efficient in a wide range of lithologies, with an average bedrock core recovery of about 93%. In some instances even unconsolidated gravelly sand has been sucessfully cored. An accurate control of the drilling process, and careful use of high viscosity polymer mud has been important for this result. Maximum length of the piggyback string has so far been 910 m, with no active compensation of differential motions between the outer and inner string. This length could probably be increased significantly depending on solution of the drilling and coring system weight problems. The high quality core data, accompanied with wireline logs and high-resolution seismics (allowing accurate positioning and correlation of the cores) form the basis for a wide range of exploration related contract research work and other geo-scientific studies.

MOBILE WINCH FOR DEEP SEA CORING AND MEASUREMENTS (MOBIWINCH)

Wolfgang Schneider

GEOMAR Technologie GmbH, Kiel

There exists a variety of instruments for deep-sea research, such as coring equipment, towed sensor packages and remotely operated vehicles. Several sophisticated instrument packages have been developed during the last years. An appropriate winch is required on board the research vessel for the handling of this deep-water equipment. The winch must be of heavy duty type for coring and sampling devices.

Only a few major research vessels are equipped with winches for several kilometers of rope or cable with suitable diameter. To improve this situation, an universal and mobile winch has been developed to enable safe equipment handling on a variety of ships for deep-water research and intervention.

This winch includes some innovations: To achieve high mobility and wide applicability, the basic frame is dimensioned such as a standard ISO 20' container flat. The cable drum can be exchanged within a few hours in order to adapt the winch to different cable requirements. Drums can be equipped with ropes, wires, armoured coaxial, multi-conductor or fibre-optic cables with diameters ranging between 10 and 40 mm. The standard drum holds 6700 m of 18 mm cable, special drums even more.

Direct electric drive was chosen due to its high efficiency and clean operation as compared to hydraulic systems. Digital drive control with solid state power electronic components provides flexible operational features. The cable spooling sledge is driven by an own electric motor, its digital control can be programmed for different cable diameters without making mechanical modifications.

In addition to the explanation of the winch design a report will be given about first operational experiences at sea.

SHIPBOARD REQUIREMENTS AND HIGH-RESOLUTION SEA FLOOR STUDIES

SHIPBOARD LABORATORY EQUIPMENT FOR TREATING LONG SEDIMENT CORES

M. Breitzke

Fachbereich Geowissenschaften, Universitaet Bremen, Postfach 33 04 40, D-28334 Bremen, FRG

Physical property studies on marine sediment cores usually comprise three parameters: P-wave velocity, wet bulk density and magnetic susceptibility. As the p-wave velocity and wet bulk density are significantly affected by the water saturation, measurements are routinely carried out onboard to minimize data quality reduction due to core transportation, storage and loss of interstitial water. Indicating varying sedimentation environments physical property studies can be used as a stratigraphic tool for paleoceanographic reconstructions. Additionally, as impedance contrasts cause reflections in high-frequency seismic and sediment echosounder surveys they allow to correlate lithological changes in the sediment column with reflection horizons in the seismic profile line.

While early physical property measurements used small chunk samples taken at coarse sampling increments high-resolution logs required the development of non-destructive automated logging systems. Hence, in current p-wave logging systems a pair of piezoelectric transducers is automatically moved along the whole or split core by a stepping motor control. The first arrival detection of the ultrasonic waves is performed on-line either by electronic hardware or PC-based software and determines the quality of the p-wave velocity log. Its accuracy usually ranges from ~3-5 m/s.

Current automated density logging systems evaluate the gamma ray attenuation in the sediment (GRAPE) and derive the wet bulk density by assuming an appropriate mass attenuation coefficient. The integration time for the determination of the gamma ray count rate and the mass attenuation coefficient essentially affect the accuracy of the density logs. It is in the order of several percent.

The current measuring equipment for the magnetic susceptibility consists of a commercial Bartington M.S.2 susceptibility meter with loop sensors of various diameters (M.S.2.C) and a non-magnetic core conveyor system. Due to the loop sensor's size its sensitive volume covers an interval of several centimetres. Consequently, sharp susceptibility changes in the sediment column appear as smooth, gradual changes in the susceptibility log so that thin layers cannot be resolved sufficiently. The downcore resolution can be increased to ~1 cm by using the M.S.2.F probe. It is directly lowered to the sediment surface of split or u-channel subcores.

Recent developments in ultrasonic sound transmission acquire the full transmitted waveforms. Including wavelengths of few millimetres these waves contain information on the lithology, the microstructure and the elastic parameters of the sediment along their travel path. Appropriate processing routines evaluate quasi-continuous attenuation logs and relate them to sedimentological parameters, particularly the grain size distribution.

A recently developed system for electrical resistivity measurements uses a miniature Wenner configuration and provides an indirect method for a wet bulk density determination. Based on Archie's law porosity and wet bulk density logs can be computed from the formation factors assuming an appropriate cementation factor and a constant grain density. Comparisons with gamma ray attenuation measurements indicate an accuracy of ~3 % for this indirect method.

A NEW MULTI-SENSOR CORE LOGGING SYSTEM

D.E. Gunn

The Institute of Oceanographic Sciences Deacon Laboratory, Brook Road, Godalming, Surrey, GU8 5UB, UK

Recent advances in marine sediment coring technology have produced improvements in the length and quality of the cores obtained. These improvements come at a price and the financial cost in terms of ship time and coring technology has increased at a similar pace. It follows that sediment cores form an expensive data resource and there is an increasing demand to obtain as much data as possible from core material collected. To meet this demand the Institute of Oceanographic Sciences Deacon Laboratory (IOSDL) has produced an innovative new non-destructive multi-sensor core logging system. This new core logging system can make accurate measurements of p-wave velocity, gamma ray attenuation and magnetic susceptibility with a sampling resolution of only a few millimetres. The system is designed around a computer controlled multi-sensor track, this allows complete automation of the logging process and the unitary design of the system facilitates further developments with the addition of extra sensors. Colour logging and resistivity logging are currently under development. A major innovation in this system is the ability to log split cores, this permits the retrospective logging of archived core collections and can also improve the data quality from freshly cut cores. The non-destructive nature of this system allied with computer automation enables rapid, routine and precise logging of cores without compromising any sampling or analysis strategy. A long term policy of routine multi-sensor logging of sediment cores will produce valuable database that will assist in a wide variety of applications such as stratigraphic correlation, seismic correlation, glacial/interglacial intervals, terrigenous-pelagic fluxes, sediment provenance, turbidite correlation, synthetic seismograms, and core quality assessment.

METHODS OF SEDIMENT CORE INVESTIGATIONS

Hannes Grobe

Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, Germany

Since the invention of sediment sampling in the oceans, the amount of samples as well as the number of analytical technics have increased tremendously. Sampling technologies to get undisturbed surface samples and long sediment cores of high quality or to measure sediment properties in-situ have been developed and improved. Core repositories around the world store hundreds of kilometers of cores, representing a comprehensive library of the earth history. Today, hundreds of different parameters can be evaluated from the sediment: sedimentology, micropaleontology, physical properties, geochemistry and age determinations just to name the essential groups. The measurements of oxygen and carbon isotopes on foraminiferal tests as introduced by Emiliani 40 years ago became the most important method to reconstruct paleoclimate.

Some of the highly sophisticated techniques to investigate sediments were developed during recent years. Multi-sensor core logger allow the determination of different physical properties on an unopened core in a short time, sample changer for masspectrometers, carbon analytical devices, X-ray diffraction or magnetometers increased the number of samples to be analyzed by an order of magnitude. The use of masspectrometers gives us the opportunity to determine absolute ages on very small samples or increase the accuracy in geochemical analysis. The development of new methods allows ascertaining new parameters as e.g. the extraction of specific biomarkers, useful to calculate paleotemperatures.

Besides the analysis of samples, the analysis of data also increased in significance since the use of statistical methods for the calculation of paleotemperatures from microfossil assemblages (CLIMAP) and the comprehensive analysis of time series (SPECMAP). Other tools as the modern analog technique or software for the development of age models or the modeling of geochemical processes are used routinely in the interpretation of sediment data. As a further step toward the investigation of sediments the ongoing use of databases will provide an effective tool for solving new scientific questions concerning the geological history of the earth.

THE MULTI-SENSOR CORE LOGGER - A HIGH-RESOLUTION TOOL TO INVESTIGATE MARINE SEDIMENTS

Michael E. Weber[1], Frank Niessen[2], Gerhard Kuhn[2], and Michael Wiedicke[1]

[1]Bundesanstalt für Geowissenschaften und Rohstoffe, Stilleweg 2, D-30655 Hannover, Germany
[2]Alfred-Wegener-Institut für Polar- und Meeresforschung, Columbusstrasse, D-27568 Bremerhaven, Germany

The multi-sensor core logger (MSCL, P. Schultheiss, GEOTEK, Surrey, UK) enables continuous geophysical measurements to be made on unsplit sediment cores. The system provides three measurement sensors: a pair of compressional wave transducers to estimate the velocity of compressional waves in the core; a gamma ray source and detector for measuring the attenuation of gamma rays through the core; a magnetic susceptibility sensor to determine the amount of magnetic material present in the sediment. In Germany two MSCL were recently installed at the Bundesanstalt für Geowissenschaften und Rohstoffe in Hannover and at the Alfred-Wegener-Institut für Polar- und Meeresforschung in Bremerhaven. We will present data from the Southern ocean and from the Bengal Fan.

We will focus on different approaches to calculate saturated wet bulk densities (WBD) from gamma ray measurements. The problem with gamma ray determinations is that not all material attenuate gamma rays at the same rate (e.g., water and quartz differ by 10%). Because the attenuation of a water saturated sediment core is not known, calculations are usually related to either quartz or water. We will present a new iteration method to calculate mass attenuation coefficients for each gamma ray measurement. Thus, our WBD values are better than those calculated from the GRAPE tool, which is used by ODP.

Furthermore, we will present several applications for the MSCL. (I) From the gamma ray determined WBD. We calculated related physical properties like dry bulk density, porosity, and water content. In order to evaluate the precision and the limitation of these estimations, the data from terrigenous cores of the Bengal Fan and biogenic cores from the Southern ocean will be compared to physical properties determined on discrete sediment samples. (II)

Terrigenous sediments from the Bengal Fan show a close relationship of the MSCL WBD and p-wave velocity to the grain-size distribution of discrete samples. We used this correlation to estimate clay contents from the log. (III) The susceptibility record from a core of the lower part of the Bengal Fan can be tuned to orbital obliquity during for last 600 kyr.

IMPROVEMENT OF GEOLOGICAL STRUCTURAL ANALYSIS BY INTEGRATION OF OPTICAL CORE SCANNING AND BOREHOLE ACOUSTIC IMAGING

R. Schepers and G. Rafat

DMT-Gesellschaft für Forschung und Prüfung mbH, Bochum, Germany

A novel method of acquisition, evaluation and display of structural elements of drill cores is described (OPTICAL CORESCAN). The method functions on optical scanning produced under standardised conditions. By using digital image processing all existing structures are logged threediamentionally and then memorised. A conversion programme allows spatial allocation of the structural elements in a relative system of coordinates e.g. based on a reference line on the core. Orientation of these dates in absolute terms is possible by interaction, depending on the state of knowledge achieved as persuant to dipmeter or borehole televiewer (FACSIMILE 40 BOREHOLE TELEVIEWER) measurements. Advantages of the method will be discussed.

SURVEYING OF DRILL SITES WITH ULTRA HIGH-RESOLUTION SEISMIC TECHNIQUES

Volkhard Spieß, Monika Breitzke and Bernd Laser

Fachbereich Geowissenschaften/SFB 261, Universität Bremen (email: a13g@mtu.uni-bremen.de)

The behaviour of the Earth's global atmospheric and oceanic circulation systems as well as processes and events in the local sedimentary environment influence the physical structure of deep sea sediments. Associated changes in the acoustic parameters wet bulk density and p-wave velocity can be analyzed by seismic methods, which provide a spatial image of structures within the sedimentary column. Quality and resolution of seismic techniques depend on the main frequency and the angular energy distribution of seismic sources. Wavelenghts of a few tens of centimeters and a high lateral resolution are required to reconstruct high frequency changes of only a few thousand years in typical deep sea depositional regimes. The modern PARASOUND/ParaDigMA system (STN Atlas/Univ. Bremen) combines the echosounder technology of parametric, narrow beam sound sources with digital data acquisition and processing systems. Signal frequencies between 2.5 and 5.5 kHz and a signal length down to 300 µs together with a beamwidth of less than 5° allow detailed comparisons of stratigraphic, physical property and logging data in the vicinity of drill holes. Seismic reflectors can be directly related to changes in lithology and sediment composition through the calculation of synthetic seismograms. Examples are presented from different depositional environments to illustrate the power of ultra high-resolution seismic data for the detailled interpretation and identification of sediment structures. Digital PARASOUND sections from the western South Atlantic reveal current-related sedimentation processes like erosion and winnowing, mud wave development and sediment drifts. The influence of microtopography on the image quality is discussed and compared to conventional 3.5 kHz echosounder records. Since hyperbolic echos are basically suppressed

by the narrow acoustic beam, complex sediment structures, microtopography and interference patterns can be directly viewed with the PARASOUND system. Digitally acquired seismograms allow quantitative analyses of reflection amplitudes and their spatial variations and a direct correlation with climatically induced variations. A basic requirement for future drilling activities is the integration of seismic data with wireline logging results and in particular physical property core logs. To illustrate the potential of this approach, a pilot study was started to compare a PARASOUND survey near ODP drill site 690 with synthetic seismograms derived from high-resolution core logs. Electrical resistivity measurements, carried out on archive core halves, provide a superior quality compared to shipboard GRAPE density measurements. The wet bulk density data sets at 2 cm spacing were used together with the shipboard velocity logs to determine acoustic impedance. First results reveal a detailled correlation to the PARASOUND seismograms, which can be used to transfer the information from the drill site into a regional acoustostratigraphic concept.

PENETRATION OF MEASUREMENTS FOR THE ASSESSMENT OF PHYSICAL PARAMETERS FROM THE SEA FLOOR

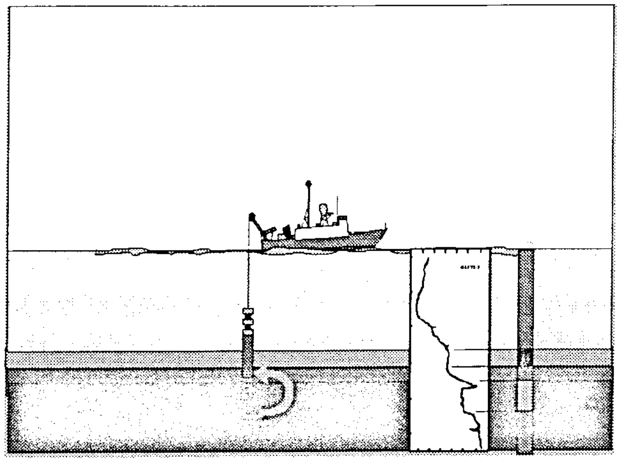
F. Theilen

Institut für Geophysik der Christian-Albrechts-Universität zu Kiel

The subsurface structure of the sea floor can well be investigated using conventional high-resolution reflection seismic methods. They yield additionally information on seismic velocities and reflection coefficients, which can be used for the estimation of sediment types and properties. Many applications with respect to geotechniques and environmental research, however, need special informations on physical and chemical properties of the sediments, which cannot be deduced directly from seismic traces. They are normally assessed by conventional lab measurements on core samples. This procedure, however, is rather time consuming and expensive. For this reason penetration measurements are being developed combining bore hole logging and coring techniques. The needs for higher resolution and additional parameters require the development of new types of sensors. The combination of high-resolution reflection seismic and penetration mesurement techniques yields a unique tool for a 3-dimensional modelling of the sea floor with respect to subsurface structures and physical properties.

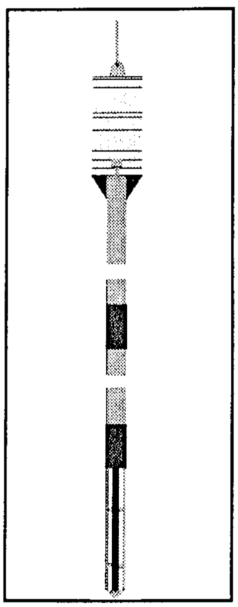
Different types of penetration devices are used. The first type consists of a frame as operational platform carrying the penetration devices. It is developed on the sea floor, where it operates autonomously or controlled by cable to the ship. Penetration is performed by engines allowing a well controlled insertion of the sensors into the sea floor with respect to speed and force. It has the advantage that it is decoupled from ship movements. The low penetration speed guarantees a high vertical resolution in a range of less than 10 cm.

The second type is based on gravitational penetration. Such a system was developed and constructed within the MAST-I-project "GISP - Geophysical in-situ Probe". The sensors are mounted at the lower end of a 10 to 20 meter long penetration tube, which is loaded by a lead weight of 1.5 tons at the upper end. The system is operated by the ships winch, which lowers it vertically to the sea floor and controls the penetration speed of about 10 cm/s. The penetration depth depends on the stiffness of the sediments, but 10 to 20 meters can be attained in soft sediments. The advantages of such a system are the high penetration and the effieciency of its deployment on the sea floor. The depth is controlled by a pressure sensor with an accuracy of 1 cm which is mounted directly above the sensors. All data are units on board ship. The following parameters are assessed with the penetration device: (i) wet bulk density, (ii) natural gamma radiation, (iii) electrical resistivity, and (iv) transferred by cable to the recording and controlling compressional wave velocities. The density measurement is performed with a gamma-gamma sensor as it is used in bore hole logging techniques. All sensors, with the expection of that for the electrical resistivity, are mounted in a protection tube with a wall strength of 9 mm in order to prevent mechanical damages during operations in the sea floor due to ship movements and wave activities.



Concept for Penetration Measurements

Test measurements have been performed in the Arkona Basin, which is situated north of Rügen Island in the Baltic Sea. This basin is filled with Holocene muds, which are characterized by a clear stratificaton reflecting the different phases of transgressions in the Baltic Sea after the last glaciation period. They are clearly delineated in the reflection seismic sections. The results of the penetration measurements show a good correlation with the seismostratigraphic units near the test sites. Nearly all these parameters are characterized by strong gradient zones below the sea floor reflecting obviously compaction with time and sediment load. Velocity gradients are loss expressed for compressional than for shear waves as could be shown by lab measurements on Kastenlot cores. For this reason such gradients can hardly be revealed by reflection seismic measurements alone. It was surprising that the electrical sensor showed a strong signal although it was operated in a salt water environment.



GISP - Probe

The first experiments have shown that the GISP-penetration system is a fast and effective tool to assess the physical parameters of the sea floor under in-situ conditions. The time for one measurement is only 2-3 minutes and can easily be repeated at the stations. The handling of the penetration system is rather safe. This allows a fast survey of sea areas with a dense net of stations, where only a few cores for calibration purpose are still necessary. This encourages to improve the penetration measurement concept by development and adaption of new special sensors, which allow also the assessment of chemical parameters for geotechnical as well as environmental research.

THE WORLD RESEARCH VESSEL FLEET AND ITS DEVELOPMENT

P. Otten

Kröger Werft Rendsburg, Germany

The size of the world RV-fleet has increased from around 700 in the mid-seventies to around 1000 in the mid-eighties. Since then there has been no significant increase. The considerable reduction in newbuildings, which had a peak in '80/'81 at 45 and is now somewhere between 5 and 10 p.a. is balanced by the reduction in number of RV's taken out of service. Thus the age distribution of RV's is changing. We have developed a database "RV Master", which is able to evaluate any relation between vessel features, institutional data and functional vessel codes, the latter being the result of a taxonomical approach on various types of vessels supposed to belong to the RV-group.

The future market demand for research vessels is determined by the production function of marine research with various capital and labour inputs as parameters and a number of critical macroeconomic parameters like price of newbuildings, real interest rates etc. Since this theoretical approach does not allow a quantitative forecast of overall demand for research vessels a number of projections can be made based on principal data like age distribution and service lifetime estimations together with some other assumptions.
The result of these projections is however not reflecting the trends which actually exert significant influence on the scope and direction on future demand for research vessels like regional integration, supplies capacity and secondary market, economic changes in the area of the former Soviet Union (the owner of the largest number of RV's) and in Central Europe, a potential growth in geophysical exploration and others.

While trends like the above mentioned together with critical macroeconomic parameters may determine the long term demand, the short term planning, design and construction of the few remaining RV-newbuildings is only the end of many year long struggles for funding and an endless series of compromises on original and intermediate concepts. Thus as the smallest common denominator the RV's built presently are very conventional ships, although the academic discussions are on new concepts for coastal vessels, SWATH-ships, RAMFORD-type vessels, icebreking RV's, nuclear submarines and conversions of existing surplus RV's.

The speed of evolution towards new concepts is very slow and new RV's will not be the result of some new epic study but the new RV's will be increasingly better seagoing laboratories and deck facilities with comfortable accomodations. Thus the academic discussion drives the evolution and details of the concept will eventually find their way into realisation after some time.

POSTERS

REMOTE OPERATED WORK CLASS VEHICLE (ROV) TRITON XL

J. Bornhöft

Bornhoeft Industriegeräte GmbH, Kiel, Germany

RECONSTRUCTION OF CORE PENETRATION USING ACCELERATION AND ABSOLUTE PRESSURE MEASUREMENTS

J.Grigel, H.Villinger, and B.Heesemann

Universität Bremen, Fachbereich Geowissenschaften, Bremen, Deutschland

Gravity or piston coring is the standard method for obtaining long sediment cores from the bottom of the ocean. One of the basic assumptions when interpreting the depth variations of various sediment parameters is that the core is an undisturbed sample of the sedimentary layers. Investigations show, that the process of coring itself may result in a more or less severe disturbance of the core i.e., compression of the core or even selective coring. These disturbances have serious consequences on the calculation of sedimentation or accumulation rates as well as on the spectral analysis of cyclic variations of sediment parameters.

One possibility to reconstruct the total penetration of the core barrel into the sediment is to monitor the penetration process by measuring and recording the acceleration during penetration of the core into the sediment. We developed a system that is capable of recording up to three acceleration components, the tilt of the core, as well as the absolute pressure. Acceleration is measured with a resolution of 0.001 g and the absolute pressure with a resolution equivalent to 0.5 m. The data are acquired with a Tattletale Lite (Onset, USA) with a digital resolution of 13 bit and a total memory of 512 kB which results in a recording time of 29 minutes at a sample rate of 50 Hz. To save memory data recording is started at a preset water depth which is close to the total water depth at the coring site. After identification of the penetration time window in the acceleration record the twofold integration of the vertical acceleration gives the penetration versus time curve of the core barrel into the sediment. Changes of the absolute pressure during core penetration provide an additional constraint for the penetration process. The result of a measurement is the total penetration depth of the core which in comparison with the recovered core length allows to quantify the core shortening.

During cruise ANT XI/4 on *RV POLARSTERN* in the spring of 1994 10 measurements were made during gravity and piston core deployments. Penetration velocities vary from about 1.5 m/s (gravity core) to almost 8 m/s (piston cores). Penetration histories of gravity cores reveal the pronounced impact of ship's heave on the penetration process. All results show that the penetration depth derived from acceleration is in good agreement with the penetration depth derived from pressure. In general core loss for gravity cores is larger than for piston cores with maximum values for gravity cores of up to 30%. Prominent changes of acceleration during penetration can be correlated with physical properties variations measured on cores which in turn help to calculate the correct in-situ depth.

OPENING UP THE CORE - NEW POTENTIAL FOR AUTOMATED CORE ANALYSIS

Quentin Huggett

GEOTEK, Haslemere Surrey, UK

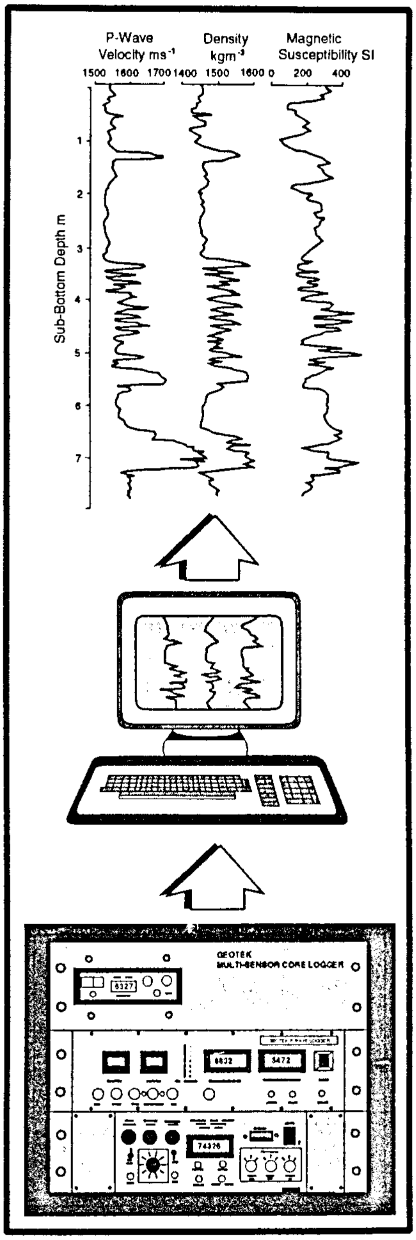
Core samples are collected on land or at sea by the hydrocarbon, mining and construction industries, as well as by the military. For Academia they are now an essential part of climatic research. The cores come as exposed hard rock samples or as soft sediment encased in plastic sleeves. Correctly analysed, they can yield crucial information about the properties of rock or sedimentary strata. The hydrocarbon industry, for example, needs accurate data on the porosity, grain size, type and chemistry of the geology they are investigating, whereas the construction industry and the military may be interested in geotechnical properties such as p-wave velocities, density and water content.

The problem of analysis

The problem facing all these potential users is how to make their core samples yield the widest possible range of information in a consistent, accurate and cost-effective manner.

A unique answer

GEOTEK's MSCL is the first commercially-available tool for gathering all these data in an automated and quality-controlled way. The range of parameters that can be measured includes p-wave velocity, gamma density, magnetic susceptibility, colour imaging and gamma spectroscopy. Typically, the MSCL can log material at a rates of 12 metres per hour and at sampling intervals of down to 1 mm. Its flexibility is such that it can analyse either whole or split (D-section) cores, while clients' own sensors can be added to the system as required. Moreover, the MSCL comes in a variety of rugged configurations for work in the field, at sea, or in the laboratory.



APPLICATIONS

• Geological •

-rapid, permanent, high resolution visual archives-

- sediment accumulation rates and chemistry-

-impedance, permeability, water content profiles-

-seismic stratigraphy and synthetic seismograms-

-rapid assessment of core quality-

-rapid inter core correlations-

-data rescue from existing core repositories-

-ice core logging-

• Industrial •

-production line monitoring-

-food industry-

-materials testing-

The Multi-Sensor Core Logger (MSCL) How it works:

A conveyor system pushes each core section past whatever sensors the client requires which scan it as it passes. The conveyor is driven by a stepper motor which can position a core to an accuracy of better than 0.5mm. The computer controlling the conveyor also controls the sensors, so that all the data are automatically correlated. The computer also measures the length of each core section and can automatically subtract the thickness of the end caps. This allows the sections to follow sequentially, producing an unbroken stream of data. Such a system not only saves time; by ensuring that the core sections butt up against each other, the data are not corrupted by the air gaps which normally spoil measurements such as those for magnetic susceptibility. So, continuous core logging means exactly what it says: a continuous, automated and uninterrupted process.
The MSCL can handle core sections up to 150mm in diameter, at a rate which depends upon the sampling frequency.

Alternative conveyors

GEOTEK have also made moving sensor/stationary core systems for specialist applications in the oil industry. Equally, vertical tracking systems can be built for samples that must be held upright.

Basic range of sensors available
Each sensor is described in more detail on another data sheet. For these or for details of new sensor developments, please call us.

Core diameter measurements:
Either rectilinear displacement transducers, with a resolution of 0.05mm (sleeved core), or a laser micrometer, with a resolution of 0.02mm (bare rock).

P-wave measurements:
500 kHz piezo-electric ceramic transducers, spring-loaded against the sample. Accurate to ± 0.2%, depending on core condition.

Gamma Ray Attenuation (bulk density):
^{137}Cs gamma source in a lead shield with optional 2.5mm or 5mm collimators. Density resolution of better than 1% depending upon count time.

Magnetic susceptibility:
Bartington loop sensor 60-150mm diameter, or point sensor (on split cores) giving 5% calibration accuracy over two ranges; $1X10^{-6}$ & $10X10^{-6}$ cgs.

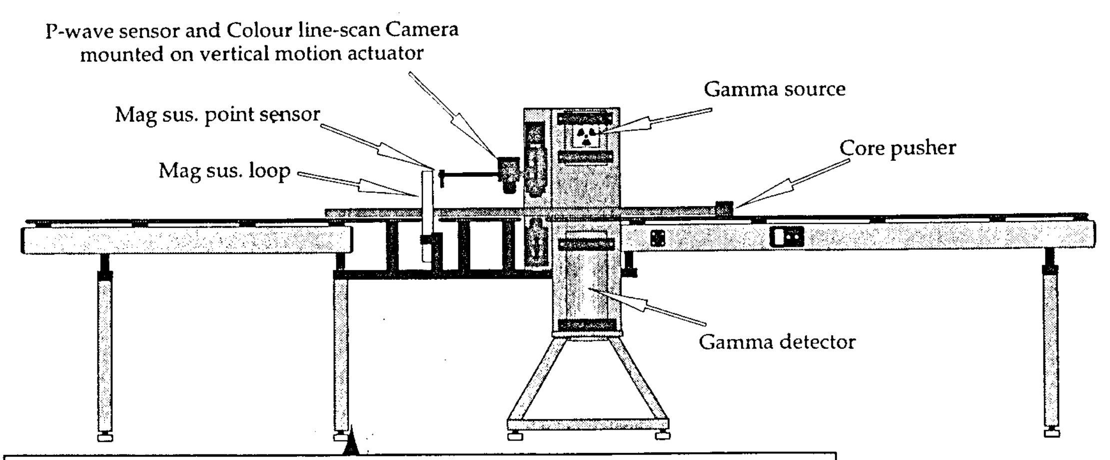
Colour imaging (nominal specification):
Line-scan colour CCD camera synchronised with stepper motor. Up to 600dpi resolution of 3 X 8 bit colour. Software provided for data replay and viewing on PC , BMP format for export to other documents.

Natural Gamma:
Total natural gamma count or 1024 channel gamma spectra from two or more 2"X2" NaI(TI) crystals. Automatic batch file management of spectral data.

Sensors being considered for development

Radar scattering (= water content)
Electrical resistivity (= porosity/permeability)
UV, visible and IR spectroscopy (= core mineralogy)
Permeability (cf. Pro-permeameter)
High frequency acoustic imaging (= through-liner porosity/grainsize)
X-ray imaging (= sediment structure)

A typical MSCL Split/Whole-Core configuration for soft sediments



50-METER PISTON CORES TAKEN IN THE TROPICAL INDIAN OCEAN, SEYMAMA/SHIVA EXPEDITION

Yves Lancelot[1], Yves Balut[2] and the shipboard scientific party

[1]Laboratoire de Géologie du Quaternaire, Marseille, France
[2]IFRTP/TAAF, Gif-sur Yvette, France

VERGLEICH HOCHAUFLÖSENDER SEDIMENTPHYSIKALISCHER KERNLOGS DER ODP BOHRUNG 690 MIT DIGITALEN PARASOUND REGISTRIERUNGEN

B. Laser, V. Spieß

Fachbereich Geowissenschaften, Bremen, Germany

MULTI-SENSOR CORE LOGGER - A HIGH-RESOLUTION TOOL FOR DETERMINATION OF PHYSICAL PROPERTIES IN MARINE SEDIMENTS AND THEIR POTENTIAL FOR PALEOCLIMATIC

F. Niessen[1], G. Kuhn[1], M.E. Weber[2]

[1]Alfred-Wegener-Institut, Bremerhaven, Germany
[2]Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover, Germany

EXPENDABLE DOPPLER PENETROMETER

Christian Pröber

Nautilus Marine Service GmbH, Bremen, Germany

IN-SITU ACOUSTIC PROFILES IN GASSY SEDIMENT: ECKERNFOERDE BAY

R.H. Wilkens[1], S.S. Fu[1] and L.N. Frazer[2]

[1]Hawaii Institute of Geophysics and Planetology, University of Hawaii at Manoa, USA
[2]Department of Geophysics and Geology, University of Hawaii at Manoa, USA

Gas-bearing sea floor sediments have been found in many areas. Acoustic attenuation, propagation speed, and sediment reflective properties differ significantly between gas-free and gas-bearing sediments. Gas bubbles, present even in small amounts, can dominate the acoustic properties of sediments.

The Acoustic Lance has been developed to obtain in-situ compressional wave velocity and attenuation profiles for a sedimentary layer of several meters thickness at the sediment-seawater interface. Lance was deployed in Eckernfoerde Bay (Baltic Sea) in July, 1994, as part of the Coastal Benthic Boundary Layer Research Program. In-situ acoustic properties - velocity, attenuation and signal characteristics - are presented in this study.

Velocities in the gas-bearing sediments are both higher and lower than those in the gas-free sediments. Small amounts of gas appear to cause signal reverberation without much attenuation whereas large amounts of gas cause substantial attenuation. Bubble resonance frequency plays an important role in attenuation by selectively damping limited frequency ranges.

ADDRESSES

Tania-Maria Anders
Christian-Albrechts-Universität
SFB 313
Heinrich-Hecht-Platz 10
24118 Kiel
Germany
ph: 49 (431) 880 1401
e-mail: tania@piggy.sfb313.uni-kiel.de

Dr. Dennis A. Ardus
Marine Geology
British Geological Survey
Murchinson House, West Mains Rd.
Edinburgh EH9 3LA
United Kingdom
ph: 44 (131) 667 1000
fax: 44 (131) 669 4140

Christian Baars
Kasseler Str. 37 K2/8
28215 Bremen
Germany
ph: 49 (421) 376 1078

Dr. Harald Bäcker
GEOMAR - Technologie GmbH
Wischhofstraße 1-3, Geb. 11
24148 Kiel
Germany
ph: 49 (431) 72096 12
fax: 49 (431) 72096 99

Dr. Yves Balut
Institut Français pour la Recherche et la Technologie Polaire
F-91198 Gif-sur Yvette, Cedex
France

Christian Berndt
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2317
fax: 49 (431) 600 2941
e-mail: cberndt@geomar.de

Dr. Michael Bobsien
Christian-Albrechts-Universität
SFB 313
Heinrich-Hecht-Platz 10
24118 Kiel
Germany
ph: 49 (431) 880 1571
e-mail: michael@sfb313.uni-kiel.d400.de

Dr. Gerhard Bohrmann
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2109
fax: 49 (431) 600 2941
e-mail: gbohrmann@geomar.de

Dr. Gerard Bond
Lamont - Doherty Earth Observatory
Palisades, New York 10964
USA
ph: 1 (914) 356 8478
fax: 1 (914) 356 8154
e-mail: gcb@lamont.ldgo.columbia.edu

Dr. A. Brauer
GeoForschungsZentrum Potsdam
Abt. Sedimente und Beckenbildung
Telegrafenberg A 26
14473 Potsdam
ph: 49 (331) 288 1377
fax: 49 (331) 288 1302
e-mail: brau@gfz-potsdam.de

Dr. Monika Breitzke
Fachbereich Geowissenschaften
Universität Bremen
P.O. Box 330440
28334 Bremen
Germany
ph: 49 (421) 218 3936
fax: 49 (421) 218 7008
e-mail: a13f@alf.znf.uni-bremen.de

Dr. Steve Bremner
British Antarctic Survey
High Street, Madingley Road
Cambridge CB3 0ET
United Kingdom
ph: 44 (1223) 251 528
fax: 44 (1223) 62616

Dr. José Diaz
Comision Interministerial de Ciencia y
Technologia (CICYT)
C/ Rosario Pino 14-16
28020 Madrid
Spain
ph: 34 (1) 3360 467
fax: 34 (1) 3360 435
e-mail: diaz@masagran.uab.es

Dipl.-Ing. Johann K. Draxler
Wulfspark 38
30559 Hannover
Germany
ph: 49 (511) 513067

Dr. Mathieu Duvall
INSTAAR
University of Colorado
Boulder, Colorado 80309-0450
ph: 1 (303) 492 0246
fax: 1 (303) 492 6388
e-mail: duvall@colorado.edu

Dr. Kathy Ellins
JOIDES Office
Dept. of Earth Sciences
University of Wales, College of Cardiff
Cardiff CF1 3YE
United Kingdom
ph: 44 (222) 874 541
fax: 44(222) 874 943
e-mail: joides@cardiff.ac.uk

Sven-Oliver Franz
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2253
fax: 49 (431) 600 2941
e-mail: sofranz@geomar.de

Dr. Shung Sheng Fu
Hawaii Institute of Geophysics
University of Hawaii
Honolulu, Hawaii 96822
USA
e-mail: ssfu@soest.hawaii.edu

Prof. Dr. Dieter K. Fütterer
Alfred-Wegener-Institut für Polar- und
Meeresforschung
Postfach 12 01 61
27515 Bremerhaven
Germany
ph: 49 (471) 4831 200
fax: 49 (471) 4831 149
e-mail: dieter_fuetterer@awi-bremerhaven.de

Mikhail Gelfgat
Drilling Technique Research Institute
7/9 Letnikoskaya str.
Moscow 113114
Russia
ph: 7 (95) 235 1270
fax: 7 (95) 235 8922

Dr. Hannes Grobe
Alfred-Wegener-Institut für Polar- und
Meeresforschung
Postfach 12 01 61
27568 Bremerhaven
Germany
ph: 49 (471) 4831 220
fax: 49 (471) 4831 149
e-mail: grobe@awi-bremerhaven.de

Dr. David E. Gunn
Institute of Oceanographic Sciences Deacon
Laboratory (IOSDL)
Brook Road, Wormley
Godalming Surrey GU8 5UB
United Kingdom
ph: 44 (428) 684141, ext. 243
fax: 44 (428) 683066
e-mail: deg@ua.nwo.ac.uk

Dr. Bilal U. Haq
National Science Foundation, Room 725
4201 Wilson Boulevard
Arlington, VA 22230
USA
ph: 1 (703) 306 1586
fax: 1 (703) 306 0390
e-mail: bhaq@nsf.gov

Prof.Dr. William W. Hay
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2842
fax: 49 (431) 600 2941
e-mail: whay@geomar.de

Dr. Georg Heiss
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2834
fax: 49 (431) 600 2941
e-mail: gheiss@geomar.de

Prof.. Dr. Jean-Pierre Henriet
IFREMER
Dépt. Geosciences Marines
B. P. 70
F 29280 Plouzané
France
ph: 33 (98)22 42 74
fax: 33 (98) 22 45 49
e-mail: henriet@ifremer.fr

Dr. J. Otto R. Hermelin
Deep Sea Geology Division
Department of Geology and Geochemistry
University of Stockholm
10691 Stockholm
Sweden
ph: 46 (8) 16 47 34
fax: 46 (8) 16 47 34
e-mail: hermelin@geol.su.sc

Dr. Kay Heyckendorf
Forschungszentrum Jülich GmbH BEO
Seestr. 15
18112 Rostock-Warnemünde
Germany
ph: 49 (381) 5197 293
fax: 49 (381) 51509

James S. Holik
Antarctic Support Associates
61 Inverness Dr. E. #300
Englewood, CO 80112
USA
ph: 1 (303) 790 8606
fax: 1 (303) 792 9006
e-mail: holikij.asa@asa.org

Martin Honold
Grafenwerthstr. 11
50937 Köln
Germany
ph: 49 (221) 461488
fax: 49 (221) 7003768

Dr. Quentin Huggett
GEOTEK
Fern Cottage
Marley Lane
Haslemere
Surrey GU27 3RF
UK
ph: 441 (428) 642524
fax: 441 (428) 645137

Dr. Fred Jansen
Netherlands Institute for Sea Research
(NIOZ)
P. O. Box 59
1790AB Texel
The Netherlands
ph: 31 (2220) 69300
fax: 31 (2220) 19674
e-mail: jansen@nioz.nl

Dr. Bradley Julson
Ocean Drilling Program
1000 Discovery Drive
College Station TX77840
USA
ph: 1 (409) 845 5716
fax: 1 (409) 845 2380
e-mail: julson@nelson.tamu.edu

Dr. Heidemarie Kassens
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2850
fax: 49 (431) 600 2941
e-mail: hkassens@geomar.de

Dr. Robin Keir
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2105
fax: 49 (431) 600 2941
e-mail: rkeir@geomar.de

Dr. Bilal N. Khakaev
NEDRA
Svoboda St. 3/38
L50000 Yaroslavl
Russia
ph: 7 (852) 222301
fax: 7 (852) 328471
e-mail: postmaster@nedra.yaroslavl.su

Markus Kienast
Hohenrade 5
24106 Kiel

Dr. Sergey Krasnov
All-Russia Institute for Geology and Mineral Resources of the Ocean
Maklina Pr. 1
190121 St. Petersburg
Russia
fax: 7 (812) 1141470
e-mail: hydroth@g-ocean.spb.su

Dr. Yngve Kristoffersen
University of Bergen
Allegaten 41
5007 Bergen
Norway
ph: 47 (55) 213407
fax: 47 (55) 320009
e-mail: yngve.kristoffersen@ifif.uib.no

Dr. H.R. Kudrass
Bundesanstalt für Geowissenschaften und Rohstoffe
Postfach 51 01 53
30631 Hannover
ph: 49 (511) 6432782
fax: 49 (511) 6433663
e-mail: kudrass@gate1.bgr.d400.de

Dr. Gerhard Kuhn
Alfred-Wegener-Institut für Polar- und Meeresforschung
Postfach 12 01 61
27515 Bremerhaven
ph: 49 (471) 4831204
fax: 49 (471) 4831149
e-mail: gerhard_kuhn@awi-bremerhaven.de

Dr. Laurent Labeyrie
CFR Laboratoire mixte
CNRS-CEA
Avenue de la Terrasse
91198 Gif sur Yvette, Cedex
France
ph: 33 (169) 823536
fax: 33 (169) 823568
e-mail: labeyrie@eole.cfr.cnrs-gif.fr

Dr. Klas Lackschewitz
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2846
fax: 49 (431) 600 2941
e-mail: klackschewitz@geomar.de

Prof. Dr. Y. Lancelot
Laboraoire de Géologie du Quarternaire
CNRS Luminy Case 907
13288 Marseille Cedex 09
France
ph: 33 (91) 269650
fax: 33 (91) 266638
e-mail: lancelot@lgq.univ.mrs.fr

Bernd Laser
Universität Bremen
Fachbereich Geowissenschaften
Klagenfurter Str
28359 Bremen
ph: 49 (421) 2187 286
fax: 49 (421) 2187 008
e-mail: bela@mtu.uni-bremen.de

Dr. Wolfram Lemke
Institut für Ostseeforschung Warnemünde
Postfach 301038
18111 Rostock-Warnemünde
ph: 49 (381) 5197 360
fax: 49 (381) 5197 352
e-mail: lemke@geo.io.warnemuende.d400.de

Dr. Saulwood Lin
Institute of Oceanography
National Taiwan University
P.O. Box 23-13
Taipei
Taiwan
ph: 886 (2) 3636 424
fax: 886 (2) 3626 092
e-mail: swlin@ccms.ntu.edu.tw

Dr. Keith S. Manchester
GCS Atlantic Bedford Institute of Oceanography
P.O. Box 1006
Darmouth
Nova Scotia B2Y 4A2
Canada
ph: 1 (902) 426 2367
telex: 01931552/BIO DRT
e-mail: manchest@agc.bio.ns.ca

Dr. Peter Mason
N.E.R.C. Research Vessel Services
No. 1 Dock
Barry, South
CF6 6UZ
UK
ph: 44 (1446) 737451
fax: 44 (1446) 720562

Jean-Luc Mathieux
Kley France
Av. Pablo Picasso 74
92000 Nanterre
France
ph: 33 (1) 41376075
fax: 33 (1) 47254068

Dr. Hiroshi Matsuoka
JDC Japan Drilling Co., Ltd
No. 11 Mori Bldg. , 6-4, Toranomon
2-Chome Minatoku
Tokyo 105
Japan
ph: 81 (3) 3501 7396
fax: 81 (3) 3591 1460

Prof. Dr. I. Nick McCave
University of Cambridge
Department of Earth Sciences
Downing Street
Cambridge CB2 3EQ
U. K.
ph: 44 (1223) 333 422
fax: 44 (1223) 333 450
e-mail: mccave@esc.cam.ac.uk

Prof. Dr. Jens Meincke
Universität Hamburg
Institut für Meereskunde
Troplowitzstr. 7
22529 Hamburg
ph: 49 (40) 4123 5985
fax: 49 (40) 4123 4644
e-mail: meincke@meer.ifm.uni-hamburg.de

Prof.. Dr. Dieter Meischner
Geologisch- Paläontologisches Institut
der Universität Göttingen
Goldschmidtstr. 3
37077 Göttingen
Germany
ph: 49 (551) 397 920
fax: 49 (551) 397 996
e-mail: dmeisch@gwdg.de

Dr. Jürgen Mienert
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2319
fax: 49 (431) 600 2941
e-mail: jmienert@geomar.de

Dr. José Monteiro
Servicos Geologicos de Portugal
Nucleo de Geologia Marinha
Rua de Academia das Ciencias 19-28
1200 Lisboa
Portugal
fax: 351 (1) 3424609

Thomas Nähr
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2114
fax: 49 (431) 600 2941
e-mail: tnaehr@geomar.de

Dr. Robert Olivas
Ocean Drilling Program
1000 Discovery Drive
College Station TX 77840
USA
ph: 1 (409) 845 2363
fax: 1 (409) 845 2380
e-mail: olivas@nelson.tamu.edu

Peter Otten
Kröger Werft GmbH & Co KG
Hüttenstr. 25
24790 Schacht-Audorf
Germany
ph: 49 (4331) 951 207
fax: 49 (4331) 951 205

Dr. Reidar Otter
Norwegian Geotechnical Institute
Ullevaal Hageby
N-0806 Oslo
Norway
ph: 47 (22) 023000
fax: 47 (22) 230448

Prof. Dr. Byong-Kwon Park
Polar Research Center
Korea Ocean Research & Development
Institute
Ansan P. O. Box 29
Seoul 425-600
South Corea
ph: 82 (345) 400640
fax: 82 (345) 4085825
e-mail: bkpark@sari.kordi.re.kr

Dr. Jack Pheasent
Marine Geophys. & Offshore Survey Prog.
British Geological Survey
Murchinson House
West Mains Road
Edinburgh
EH9 3LA
UK
ph: 441 (31) 6671000
fax: 441 (31) 6684140

Prof.. Dr. Nicklas G. Pisias
College of Oceanic & Atmospheric Sciences
Oregon State University
Corvallis
OR 97331
USA
ph: 1 (503) 7373504
fax: 1 (503) 7372064
e-mail: pisias@oce.orst.edu

Dr. Christian Pröber
Nautilus Marine Service GmbH
August Bebel Allee 1
28329 Bremen
Germany
ph: 49 (421) 2380619
fax: 49 (421) 239462
e-mail: nms@bremen.rf-gmbh.de

Dr. G. Rafat
DMT-Gesellschaft für Forschung und Prüfung mbH
Westhoffstr. 17
44791 Bochum
Germany
ph: 49 (234) 9683 631
fax: 49 (234) 9683 607
e-mail: rafat@ilg.dmt.de

Dr. Sigurd Ree
Selantic Subsea AS
N-5363 Ågotnes
Norway
ph: 47 (56) 326 000
fax: 47 (56) 326 010

Dr. Joar Sættem
IKU Petroleum Research
S. P. Andersens vei 15b
7034 Trondheim
Norway
ph: 47 (73) 591 100
fax: 47 (73) 591 102
e-mail: joar.settem@iku.sintef.no

Prof. Dr. Michael Sarnthein
Geologisch- Paläontologisches Institut
der Christian-Albrechts-Universität zu Kiel
Olshausenstr. 40 - 60
24118 Kiel
Germany
fax: 49 (431) 880 4376
e-mail: ms@gpi.uni-kiel.de

Dr. R. Schepers
DMT-Gesellschaft für Forschung und Prüfung mbH
Westhoffstr. 17
44791 Bochum
Germany
ph: 49 (234) 9683 269
fax: 49 (234) 9683 607

Dipl.Ing. Wolfgang Schneider
GEOMAR Technology GmbH
Wischhofstr.1-3
24148 Kiel
ph: 49 (431) 7202 364
fax: 49 (431) 7297108

Peter Seeliger
Seeliger & Partner Gesellschaft mbH
Escheburger Weg 3
21039 Hamburg
ph: 49 (40) 7235 051
fax: 49 (40) 7235 052

Dr. Alexander Shor
National Science Foundation, OCE
Division of Ocean Sciences
4201 Wilson Boulevard Room 725
Arlington, VA 22230
USA
ph: 1 (703) 3061581
fax: 1 (703) 306 0390
e-mail: ashor@nsf.gov

Dr. Dorothee Spiegler
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2888
fax: 49 (431) 600 2941
e-mail: dspiegler@geomar.de

Dr. Robert Spielhagen
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2855
fax: 49 (431) 600 2941
e-mail: rspielha@geomar.de

Prof. Dr. Volkhard Spieß
Universität Bremen
Fachbereich Geowissenschaften
Postfach 330440
28334 Bremen
Germany
ph: 49 (421) 2183 387
fax: 49 (421) 2183 116
e-mail: a13g@mtu.uni-bremen.de

Prof. Dr. Karl Stattegger
Geologisch- Paläontologisches Institut
der Christian-Albrechts-Universität zu Kiel
Olshausenstr. 40 - 60
24118 Kiel
Germany
ph: 49 (431) 880 2881
fax: 49 (431) 880 4376

Dr. Michael A. Storms
Ocean Drilling Program / Texas
A&M University
1000 Discovery Drive
College Station
TX 77845 - 9547
USA
ph: 1 (409) 8452 101
fax: 1 (409) 8452 308
e-mail: storms@nelson.tamu.edu

Dr. Shinichi Takagawa
Deep Sea Technology Department
Japan Marine Sci & Tech Center (JAMSTEC)
2-15 Natsushima-cho
237 Yokosuka
Japan
ph: 81 (468) 66381 1262
fax: 81 (468) 660970

Dr. Friedrich Theilen
Institut für Geophysik
der Christian-Albrechts-Universität zu Kiel
Leibnitzstr. 40
24118 Kiel
Germany
ph: 49 (431) 880 3912
fax: 49 (431) 8804422

Prof. Dr. Jörn Thiede
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2215
fax: 49 (431) 600 2941
e-mail: jthiede@geomar.de

Dr. Gunnar Tietze
GEOMAR Technology GmbH
Wischhofstr. 1-3
24148 Kiel
Germany
ph: 49 (431) 72096 10
fax: 49 (431) 72096 99
e-mail: tietze@geomar-gtg.de

Prof. Dr. H. Villinger
Universität Bremen
Fachbereich Geowissenschaften
Postfach 330440
28334 Bremen
Germany
ph: 49 (421) 218 4509
fax: 49 (421) 218 7163
e-mail: vill@alf.uni-bremen.de

Dr. Thomas Voigt
Umweltbundesamt
Abteilung II 4.2
Bismarkplatz
14193 Berlin
Germany
ph: 49 (30) 8903 2093
fax: 49 (30) 8903 2285

Antje Völker
Christian-Albrechts-Universität zu Kiel
SFB 313
Olshausenstr. 40
24118 Kiel
Germany
ph: 49 (431) 880 4685
fax: 49 (431) 880 1569
e-mail: antje@sfb313.uni-kiel.d400.de

Dr. H.-J. Wallrabe-Adams
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2845
fax: 49 (431) 600 2941
e-mail: hjwallrabe@geomar.de

Dr. Philip Weaver
Institute of Oceanographic Sciences
Brook Rd.
Wormley, Godalming
Surrey GU8 5UB
UK
ph: 441 (428) 684141
fax: 441 (428) 683066
e-mail: ppew@ua.nwo-ac.uk

Prof. Dr. Peter-Noel Webb
Department of Geological Sciences
The Ohio State University
155 South Oval Mall
Columbus
OH 43210
USA
ph: 1 (614) 292 8746
fax: 1 (614) 292 1496
e-mail: pnwebb@magnus.acs.ohio-state.edu

Dr. Michael Weber
Bundesanstalt für Geowissenschaften und Rohstoffe
Stilleweg 2
30655 Hannover
ph: 49 (511) 6432 791
fax: 49 (511) 6432 304
e-mail: weber@gate1.bgr.d400.de

Prof. Dr. Gerold Wefer
Universität Bremen
Fachbereich Geowissenschaften
Postfach 330440
28334 Bremen
Germany
ph: 49 (421) 2183 389
fax: 49 (421) 2183 116

Hildegard Westphal
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2825
fax: 49 (431) 600 2941
e-mail: hwestphal@geomar.de

Dr. Carol A. Williams
Ocean and Polar Secretariat
European Science Foundation
1 Quai Lezay Marnesia
67080 Strasbourg, Cedex
France
ph: 33 (88) 767100
fax: 33 (88) 370532

Dr. Thomas Wolf-Welling
GEOMAR
Wischhofstr. 1-3
24148 Kiel
ph: 49 (431) 600 2854
fax: 49 (431) 600 2941
e-mail: twolf@geomar.de