Les rapports de campagnes à la mer

MD 168 / AMOCINT
IMAGES XVII
on board R/V Marion Dufresne

Las Palmas 15th June 2008
Brest 10th July 2008

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MD168 – AMOCINT
IMAGES XVII

Cruise Report

15/06/08 – 10/07/08

LAS PALMAS – BREST

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The R. V. Marion Dufresne at the arrival at Brest at the end of the AMOCINT cruise; Photo P. Sangiardi and H. Leau

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Rainbow at the polar circle; Phto D. Catelain

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Acknowledgments

On behalf of the Shipboard Scientific Party, we thank all the persons who have contributed to the organization and scientific achievements of the Amocint cruise on board the R/V *Marion-Dufresne*, from Las Palmas to Brest.

We thank Gérard Jugie, Director of the French Polar Institute (IPEV) for his interest and support for the Amocint cruise on the *Marion Dufresne*. Hélène Leau, in charge of the oceanographic activites at IPEV helped us a lot with the preparation of the cruise. We also thank the Chief Operator, Xavier Morin and the IPEV group composed of Martin Mellet, Frederic Rigaut and Yvan Reaud who made the organization of the work on board easy and efficient. The work of the Malagasy team under the direction of the 3 boatswains Jean-Luc, Regis and Florent, was the key to the successful coring operations. The crew of the Marion Dufresne was under the commandment of François Duchêne.

This cruise was funded by IPEV with contributions from Norway, Germany and Portugal through the EUROMARC program.

Thanks to IPEV and the European Geoscience Union, we had during the cruise a “teachers at Sea” program coordinated by Carlo Laj and thanks to the Ministery of Education and IPEV, we had a “University of the Sea” program coordinated by Jacques Deverchère. All the scientists, school teachers and undergraduate students enjoyed spending that time together, sharing the work on the deck, the scientific conferences and the life on board.

Many thanks also to Daniel Catelain who designed the logo of the cruise.

Last but not least, we wish to express our gratitude to Carlo Laj and Jean-Louis Turon who assisted us at the scientific PC for the survey and the coring operations.

Catherine Kissel and Kikki Kleiven

1. INTRODUCTION

The AMOCINT (MD-168) cruise on board the French Vessel “Marion-Dufresne” has been organized as the first step to fill the objectives of the associated EuroCore/EuroMarc AMOCINT project. This project, coordinated by the Bjerknes Center for Climate Research in Norway involves different groups from France, Germany, Norway and Portugal. A total of 28 scientists, students and technicians participated to the cruise (see list on page 48). The Chief Scientist was Catherine Kissel (LSCE- CEA/CNRS/UVSQ, France) and the co-chief scientist, Kikki Kleiven (BCCR, Norway).

Alongside with the scientific work, an Education program coordinated by Carlo Laj and co-sponsored by IPEV and the European Geoscience Union was conducted on board with 5 teachers from Portugal, USA, France, Spain and Norway who were in contact, *via* e-mail, with 150 other school teachers from 22 different countries (see page 32). The 10^{th} edition of the "University of the Sea" which took also place during the cruise, largely sponsored by the Ministry of Education in France and by IPEV, brought together 6 students from the University of Brest (France) under the responsibility of Prof. Jacques Deverchère (Brest) (see page 37).

The Institut Polaire Paul-Emile Victor (IPEV) provided the ship and the scientific technology for the cruise and the scientific program was strongly supported by a team from the IPEV under the direction of Xavier Morin.

The cruise started on June 15th, 2008 from Las Palmas and ended on July 10th, 2008 at Brest. The scientific objectives of this cruise were defined in the EuroCore/EuroMarc AMOCINT project within the framework of the IMAGES (International MArine Global changES) program. The main scientific goal of the project (see below) is to monitor changes in the Atlantic meridional overturning circulation during interglacials using multidisciplinary approaches on sedimentary sequences characterized by high deposition rates.

We benefited at the beginning of the cruise of a nice weather and a calm sea. After the Azores sites, we crossed a rather high depression which slowed us in our route. We had two additional periods with bad weather and rough sea during the cruise. It impacted quite a lot on our steaming time and reduced our survey time. Despite this slowing down, suitable coring sites could be found and enough time was finally dedicated to the coring operation at each station.

Other problems were raised by the trigger system, mainly due to the different softness/hardness of the sediments. We also encountered problems due to the sediment itself and in particular to the presence of big dropstones (pebble size) damaging the core catcher and the liner. In a general way, casq and calypso could be done at almost each station and a very good correlation could be obtained between the two, based on the on-board measurements. The multicorer from BCCR allowed us to collect interface sediments at three different coring stations. At the Azores site, it triggered in the water due to rough sea conditions (station 3) and it did not trigger due to the softness of the sediment at station 5 at Charlie-Gibbs Fracture zone.

All the sites but one were made during the MD168-AMOCINT cruise. In order to save steaming time, the last coring station, off Portugal has been investigated during the next cruise (MD169-Microsystem cruise). However, as it is part of AMOCINT project, we also report here on this station.

The general map of cruise showing the geographical distribution of the 14 coring stations plus the one made during the following cruise off Portugal is reported in Figure 1.

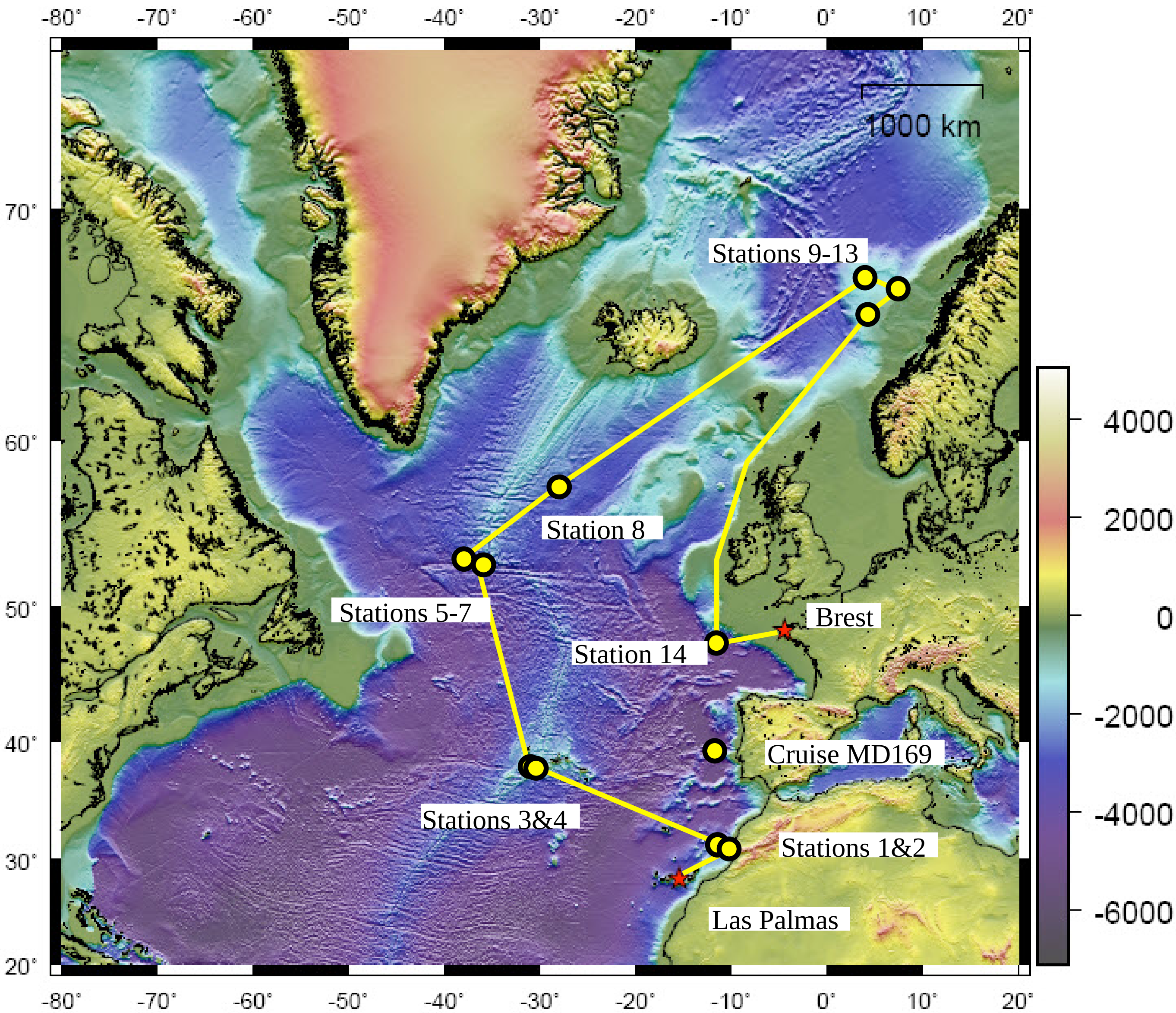

Figure 1: General map of the cruise (made by H. Pereira using Mirone software)

2. SCIENTIFIC OBJECTIVES OF THE AMOCINT CRUISE.

2.1 Oceanographic setting and Paleoceanographic Objectives.

Some of the key uncertainties in terms of future climate change is the sensitivity of the climate system to external forcing, uncertainties in key feedback factors (e.g. sea-ice/albedo, carbon cycle), and how ocean circulation may respond to forcings and to possible destabilisation of major ice sheets (Greenland and Antarctica). The latter aspect is the main goal of the AMOCINT project.

The melting of the Greenland ice sheet and the associated sea level rise, predicted in the context of global warming (Gregory et al, 2004) would release significant amount of fresh water to the North Atlantic Ocean. In addition to the impact on populations, this could also impact on the efficiency of the ocean circulation, to which climate is sensitive. We know from proxy data that during the past interglacial the global sea level was 3-6m higher than at present and the Greenland Ice Sheet might have been about 30% smaller than now, due to summer warming caused by the different parameters of the Earth orbit. This documents the potential sensitivity of ice sheets and sea level changing to occur due to continued global warming. It is therefore essential to evaluate the influence of this melting on the oceanic circulation and this constitutes one of the aim of the AMOCINT project.

The warm periods themselves (the interglacials) are key to our studies and another theme for AMOCINT thus concerns the stability of warm climates. Well chosen time periods will constitute the focus, because these are times when Greenland and possibly west Antarctica were smaller than today. Further studies will also be devoted to climatic transitions and in particular to the understanding of how the ocean interact with the atmosphere and the ice-sheets in glacial inceptions and deglaciations.

One key aspect of future climate scenarios is a pronounced polar amplification in the Northern Hemisphere, which to a large extent appears due to feedbacks from diminishing sea ice cover. The degree of polar amplification during previous periods of rapid warming of the mid-to high latitude Northern Hemisphere can be assessed. Also of importance are the changes in the seasonality due to the orbital forcing which may drive changes through increased seasonal contrasts. The recent sea ice retreat in the Arctic has in parts been attributed to atmospheric and oceanic heat advection.

We are thus at a time when key uncertainties in our understanding of climate change with high relevance for aiding in improving future climate predictability can be obtained from analyses of past climates. A key way of narrowing down such uncertainties is to identify the possible breadth of natural climate system behaviour and response to climate forcings using paleoclimate data and climate model experiments from a range of pre-Holocene warm phases with different mean states and external forcing. We lack, however, the detailed marine counterparts of the ice cores to permit assessments of the role and response of ocean circulation during interglacials (and impacts on oceanic productivity) and during the inceptions of glacials when relatively weak forcing drove the system into major climate disruptions.

The primary objective of the AMOCINT cruise was, therefore, to recover high sedimentation rates marine sequences along both the main surface trajectory involved in the Northward ocean heat transfer in the North Atlantic and Nordic seas, and in the main routes whereby deep water originating in the Nordic seas returns as a deep western boundary current in order to document paleo environmental, climatic, and oceanographic changes in the North Atlantic during key periods such as glacial inceptions, deglaciations and interglacials themselves. The cores taken during the cruise will allow us to investigate several warm periods with a range of climate forcings from the different orbital configurations of these times. It will thus broaden the base for model estimates of climate sensitivity and responses to major feedbacks.

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2.2 Off Northwest Morocco

Two coring stations were planned in that area, one with high sedimentation rate giving access to the Holocenen sequence and the deglaciation and the other one with much lower sedimentation rate, covering several interglacial periods in one core. The location of the two coring stations are reported in Figure 2.

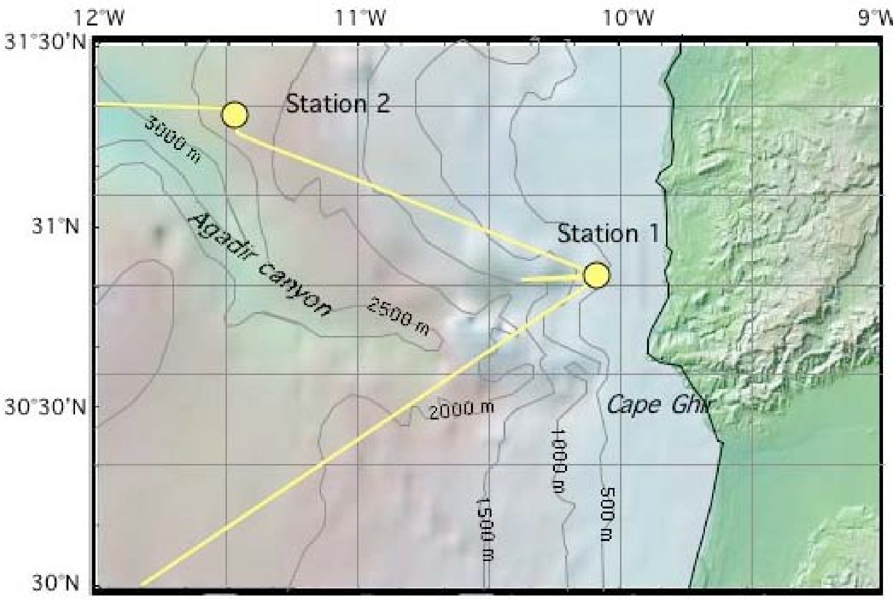


Figure 2: location of the two coring stations off northWest Morocco (stations 1 and 2)

2.2.1 Cape Ghir (Station 1)

Deep-sea sediments near continental margins are important archives to monitor land-ocean interactions and their variability related to climate oscillations in various timescales. The region along the eastern margin off NW Africa is dominated by costal upwelling, which develops when the predominately alongshore winds force offshore Ekman transport of surface waters, which leads to ascending of cooler, nutrient rich water. The sedimentary environment off NW Africa is also influenced by the southward transport of the relatively cold surface waters within the

Canary Current. The Sahara-Sahel zone is one of the most important source regions for dust supply and produce more aeolian dust than any other deserts. In addition, a number of permanent and ephemeral rivers transport sediments derived from the Atlas-Mountain hinterland to the continental shelf off Morocco. The resulting high production of biogenic particles and high terrestrial input are responsible for the high sedimentation rates (up to 2m/ky) observed in cores from the Cape Ghir region (McGregor et al., 2007).

Based on parasound profiles from Meteor cruise M45 (Hebblen and Meggers, 2000) and results from a short gravity core obtained by the University of Bremen paleoceanography group (McGregor et al. 2007) we targeted an undisturbed sediment package in a small basin along the very upper part of the continental slope off Cape Ghir at 30°50.7 N, 010°05.85W at 355 m water depth. We did a triple coring platform operation at this site, deploying a CASQ, a multicore and two Calypso cores. The 8.66 m long CASQ (MD08-3174Cq) is composed of homogeneous olive grey clay containing shell fragments and whole shells. To obtain an undisturbed water-sediment interface and to ensure that we can link the top of the high-resolution sediment package with instrumental time series, we also used the Bjerknes Centre for Climate Research's multicorer. The operation was a success and all four tubes in the multicore (MD08-3175Mc A-D) came up with ~45 cm of undisturbed sediments each and two of the tubes even had seaweeds growing *in situ* on the sediment surface. Calypso core MD08-3176 is 29.77 m long and came up slightly bent at the top due to trigger problems. It was decided to deploy a second Calypso MD08-3177, which penetrated 39.58 m sediment, but unfortunately also came up slightly bent at the top. However, with the undisturbed CASQ and with the multicores they ensured that a complete section has been sampled at the site. The sediments in the Calypso cores contained the same homogeneous olive grey clay, which was described in the CASQ. Some of the deepest sections contained some gas which led to 5-15 cm gaps in the sections.

If the sediment rates from Geob 6008-2 of ~2.2 m/1000 years taken from the exact same location (McGregor et al., 2007) continues through the Holocene, the sediment package from Cape Ghir should span the entire Holocene back through the Younger Dryas interval.

In modern observational NW Africa is out of phase with SSTs in the Nordic Seas and off the US East coast on the decadal time scale, a pattern associated with large-scale atmospheric patterns related to the North Atlantic Oscillation (NAO). Within the Holocene, similar out-of phase relationships exist on the millennial to centennial time scales, e.g. cold SSTs are reconstructed for the early Holocene when warm sub-Arctic temperatures prevail (DeMenocal et al., 2000), and during the last Millennium a similar pattern appears observed (McGregor et al., 2007). Our aim within the framework of AMOCINT is to investigate the consistency of such patterns that would document the larger scale modes of variability and their consistency over a range of boundary conditions and forcings on decadal scale resolution. The results will form the basis for an assessment of drilling strategy for IODP coring a longer series of interglacial deposits beyond the reach of the Calypso coring system.

2.2.2 North of Agadir canyon (Station 2)

Calypso core MD08-3178 with a core length of 31.66 m was retrieved at 31°17.09'N and 11°29.20'W and a water depth of 2184 m from a sediment drift on the northern rim of the Agadir canyon just north off Cape Ghir. The southern edge of the sediment drift was previously drilled for DSDP site 415, which, however, aimed to recover pre-Pleistocene sequences.

Today, surface waters at site MD08-3178 are advected with the Canary Current, the lower limb of the subtropical gyre's recirculation, but the northernmost extensions of the Cape Ghir filament can temporarily also influence the site. The Cape Ghir filament belongs to the Canary/ NW Africa Eastern Boundary Upwelling System (EBUS), so that the core will allow monitoring past changes in the strength of this EBUS. Typical for an EBUS, a subsurface to seasonally surface poleward undercurrent exists (Knoll et al. 2002). Subsurface waters in this region consist of the subtropical variety of the North Atlantic Central Water (NACW) and below that of Antarctic Intermediate Water (AAIW). Deeper water masses are the Mediterranean Outflow Water (MOW) and the upper North Atlantic Deep Water (NADW) (Knoll et al. 2002). As MOW flows in deeper than modern levels during glacials (Schönfeld and Zahn, 2000) and cold stages of abrupt climate change events (Voelker et al., 2006), site MD08-3178 from a water depth of 2184 m that today is below MOW range, might monitor a deeper flowing MOW during such times and thus a deepening of the MOW/ NADW interface.

The position of core MD08-3178 was selected for the AMOCINT project as it allows to close a gap in core sites underneath the major surface water currents of the North Atlantic's subtropical gyre; core sites that allow to study the surface to deep water hydrography during the late to mid-Pleistocene interval of Marine Isotope Stage (MIS) 9 to 22, the primary target interval for study at this site. Understanding climate's response to varying forcing mechanisms (e.g. orbital configurations, atmospheric greenhouse gas concentrations, sea level) during these older interglacial periods will help to define baselines for natural climate variability. The target interval not only includes the transition from the 41 ka to 100 ka world, but also the mid-Brunhes event (Jansen et al., 1986) at the base of MIS 11.

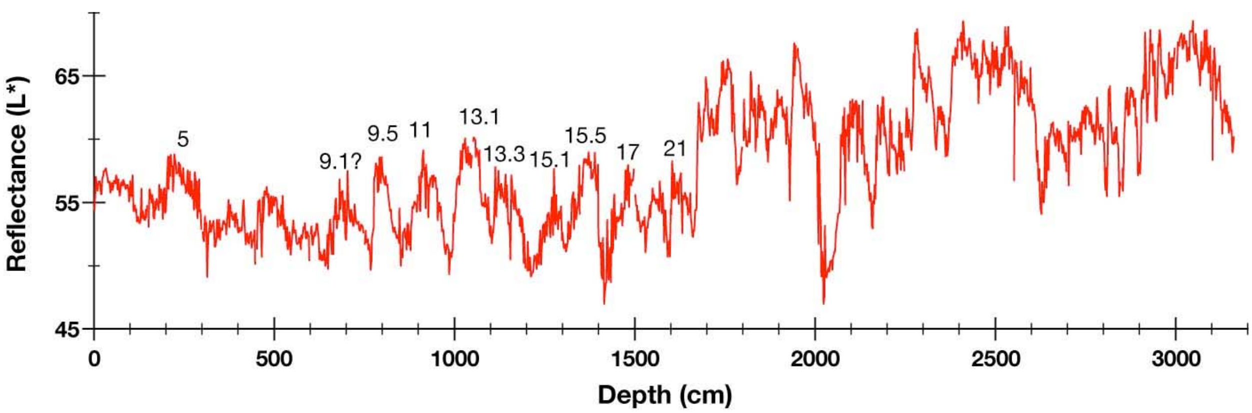


Figure 3: Reflectance record of core MD08-3879 where interglacial periods are noted.

Based on the L* data the interval from MIS 9.4 to 22 spans from 7.7 to 16.6 m with estimated sedimentation rates between 1.3 and 3.6 cm/ ka. The higher sedimentation rates occurred along with the acme of the coccolith *Gephyrocapsa caribbeanica* during MIS 13. A range of sediment rates of 1.5 to 2cm/ ka is typical for offshore sites of NW Africa (e.g. Moreno et al., 2001; Pflaumann et al., 1998) and with these rates the basal age of the core is estimated to be between 1.6 and 1.8 Ma (see Figure 3).

Besides establishing a low resolution oxygen isotope stratigraphy for the complete core to confirm the preliminary interglacial nomenclature and the estimated basal age, a higher resolution study of the MIS 9-22 interval will include stable isotope and trace element measurements in one surface and one deep dwelling planktonic foraminifer and in benthic foraminifer to reconstruct surface, subsurface and deep water variations. Special attention to subsurface conditions at site MD08-3178 will be given during Terminations IV and V when data from sites of Portugal (Voelker, unpubl. data) indicates advection of tropical waters with the poleward undercurrent.

2.3 West of Azores islands (Stations 3 and 4)

Within the frame of the AMOCINT project two subtropical sites at the eastern flank of the Middle Atlantic Ridge west of the Azores Islands will serve i) to trace the impact of changing interglacial NADW production at high latitudes downstream at the lower limb of AMOC and ii) to reconstruct the evolution of corresponding surface circulation and productivity regimes in the subtropical gyre over the Holocene and over MIS 5e and during last glacial inception at multidecadal to centennial time resolution. Where possible, records will be also be extended back to older interglacials (MIS 11-MIS15).

Objectives

To gain new core materials in the frame of “Marion Dufresne” - 168 core campaign in small basins with focused sedimentation at the eastern flank of the MAR enabling to trace the evolution of circulation and productivity regimes in the subtropical gyre over MIS 1, MIS 5e-d at multidecadal to centennial time resolution, and if possible extending back to MIS 11-15.

- High-resolution time series of proxies for AMOC intensity (i.e. surface, thermocline temperature and salinity, and deep water temperature and ventilation records).
- Reconstruction of paleoproductivity and CO_2 variables based on combined micropaleontological and biogeochemical approaches.
- Reconstruction of dust flux record as an indicator for changes in atmospheric circulation and fertilization.

Today, different from the western basin which is marked by well ventilated NADW down to 5000 m water depth with UNADW and LNADW centred at 2000 and 3500 waterdepth, respectively, the eastern basin is less well ventilated with NADW bathing the eastern flank of the MAR at 1800 to 3000m waterdepth and underlayered by poorly ventilated AABW derived deep water (Fig.4). A net decrease in heat transport from 1.3-1.4 PW in 1957 to 1.1 PW in 2004 is associated with slowing and shoaling recorded in a subtropical AMOC profile over the last 47 years, a response to a decrease in LNADW production (Bryden, 2005).

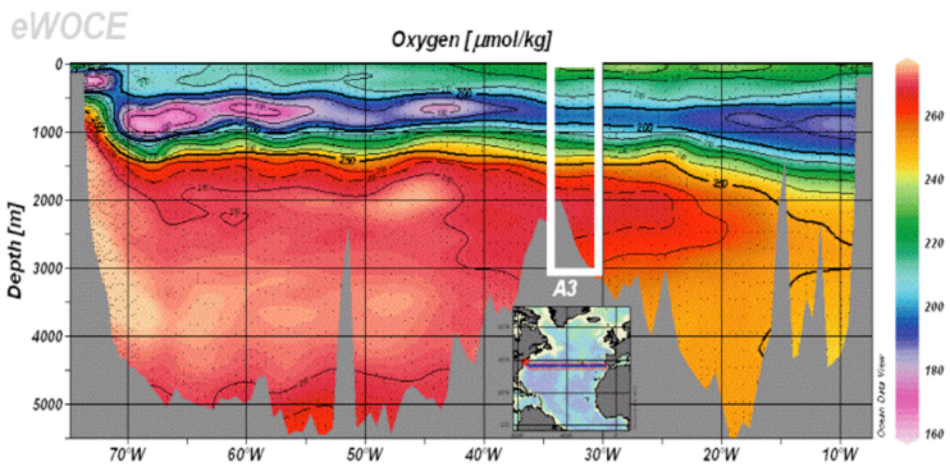


Fig. 4. Cross section at 35°N showing ventilation of North Atlantic water masses (from WOCE) with study area indicated

With its position at the northern rim of the subtropical gyre is well suited to monitor changes in the flow of subpolar and subtropical mode waters, which will affect the thermocline depth and phytoplankton productivity in the region. However, the interglacial variability of this system is not well known, especially due to a lack of high-resolution studies in this area.

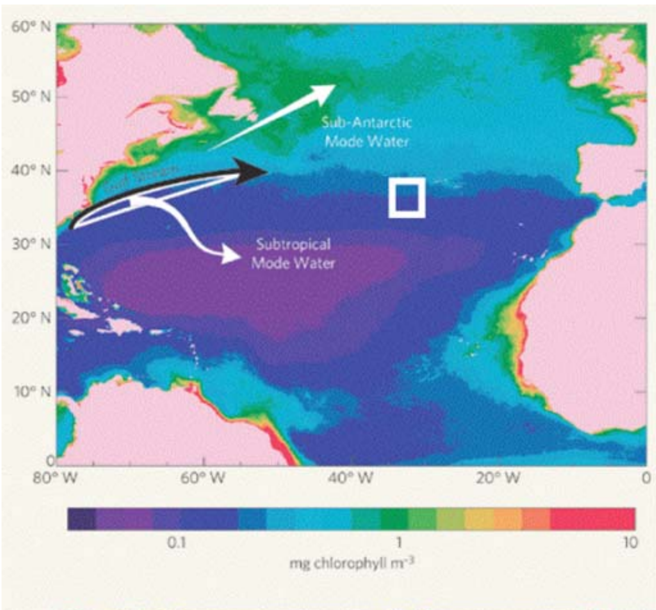


Fig. 5. Phytoplankton productivity in the North Atlantic subtropical gyre.

The proposed coring sites are situated beneath the northern rim of the oligotrophic subtropical gyre where productivity today is as low as 0.4mg/m^3 (Fig.5). Southward shift of the Azores front may however considerably change the productivity regime. Due to the remote location far from the influence of river or ice transported sediments the sites are moreover well suited to monitor changes in the intensity of dust transport under differential atmospheric circulation regimes.

While pelagic sedimentation rates at the MAR are notoriously low in general (i.e. less than 2cm/ky), small basins at the eastern flank of the MAR display enhanced sedimentation rates as high as 10 - 20 cm/ky as a result of sediment focussing. Diffussive accumulation processes appear to provide continuous sedimentation and thus enable high-resolution paeoceanographic records (Mitchel, 1995). Furthermore winnowing of sediments occurs in water depths above 1500m within this area depending on the strength of the Azores Current and the Gulf Stream (Dennielou 1997). Due to the narrow catchment area of the basins sampled it is not expected, that lateral transport take place over long distances.

Two basins were selected for coring with water depth of 2000 and 3000 m, respectively to trace NADW near to its upper and lower limits. The shallower basin contains a sediment series of approximately 500m (personal communication J. Escartin). For the deeper basin, a Holocene record at GEOFAR site KF 16 (Richter, 1996) suggests consistently high sedimentation reaching up to 30 cm/kyr as compared to the regional average of less than 2cm/kyr. Nearby core stations have revealed a sequence of 4 ash layers which were attributed to eruptions of Menez-Gwen main vulcano at 75 ky, 65ky, 60ky and 55 ky (Dennielou et al., 1995).

Two stations in the two basins at the eastern flank of the Middle Atlantic were sampled with Casq and Calypso corer (Fig 6).

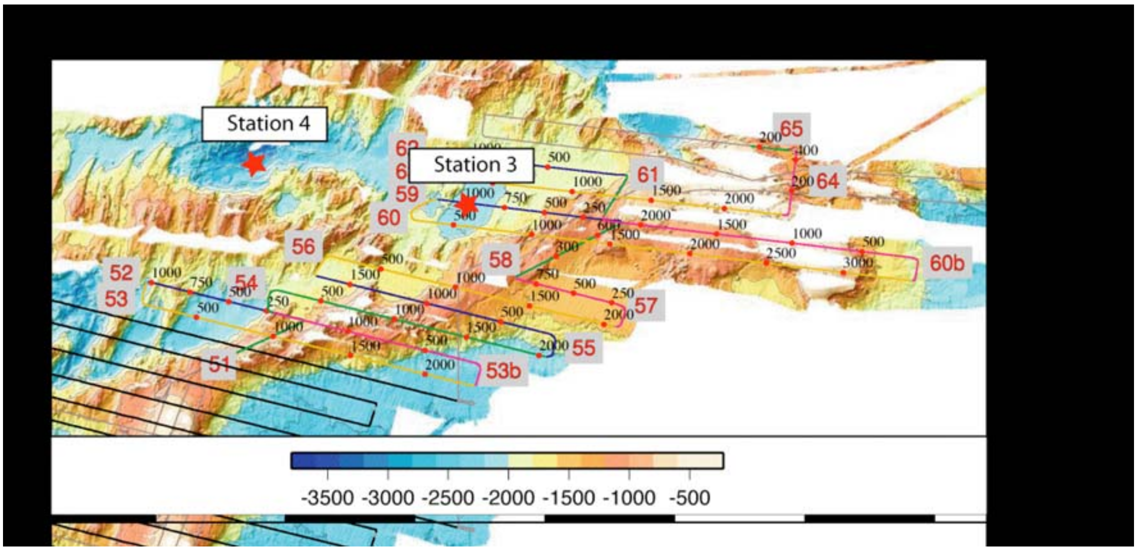


Fig. 6. Bathymetric map of the MAR with coring station 3 (37°50.96´N, 30°17.63W, 2032 m water depth) and station 4 (38°00.00´, 31°08.08´W, 3059 m water depth).

2.3.1 Station 3

Based on a 3.5kHz survey (Fig. 7) coring station 3 was identified in the shallower basin at 37°50.96´N, 30°17.63´W, at 2031 m water depth. Employment of a 9m-Casq yielded an 8.15 m long sediment core of light grey foraminifera bearing nannofossil ooze interbedded with grayish green layers. A repetitive sequence of oxidized sediments in the top part of the core suggests a double penetration of the Casq into the sediment, further supported by a repetitive sequence in the magnetic susceptibility record at corresponding depth. A single deep-sea glacial coral was collected at 141-142 cm core depth and saved for further analysis. High abundances of *Coccolithus pelagicus* and three major glacial interglacial cycles as represented in the spectrophotometric record suggest glacial stage 8 at the base of the core. Moreover the high abundance of *C.pelagicus*, which at present is only present with low abundances within the Azores front, indicate southward movement and enhanced productivity of the frontal system during glacials.

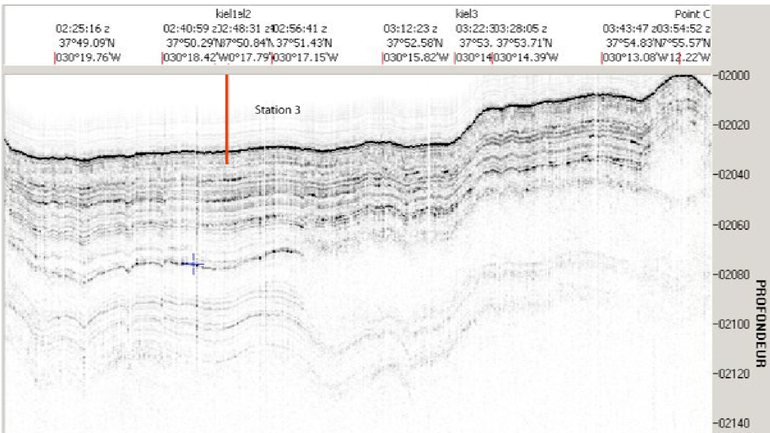


Fig7. 3.5 kHz profile of sediment basin at the MAR at 2000 m water depth.

A multicorer additionally employed at the first station triggered prior to reaching the seafloor, probably due to too strong water movement during coring, and thus could not recover any sediment samples.

Unfortunately, also the employment of a 37 calypso-corer failed resulting in a complete loss of the core. Again here, triggering in the water column above the seafloor prior to sediment penetration is suspected to have caused this loss.

2.3.2 Station 4

At station 4 in 3050 m waterdepth (Fig. 8) a Casq (MD08-3180cq) yielded a 10.05m long sediment sequence of foraminifera bearing nannofossil ooze. The top 2.6 m are moderately bioturbated throughout, below 2.6 sediments are increasingly distinct laminated, with colors alternating between olive grey to yellowish grey.

The 45m Calypso corer employed at the same station penetrated soft nannofossil ooze, before it was abruptly stopped at 25m, where a distinct reflector was present in the 3.5 kHz profile. This led to an unprecedented deformation of the core. However due to the efforts of the crew the core (MD08-3181) could be rescued on board and despite minor gaps resulting from the cutting of the core and slight bending in the upper part, the core contained 23 m of mostly laminated nannofossil oozes. The lamination varied in thickness throughout the core from mm to cm scale with distinct grading upwards bundles. The lamination in this core is probably caused by the small and deep size of the basin, which leads to rapid oxygen consumption under reduced inflow of NADW during glacial conditions.

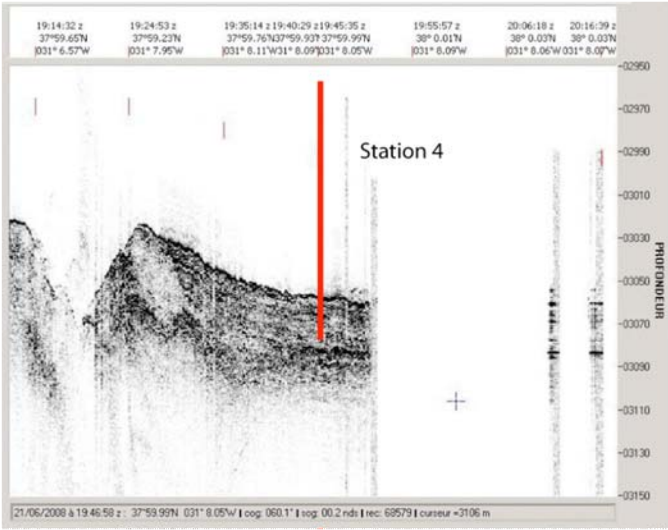


Figure 8. 3.5 kHz profile of sediment basin at the MAR at 3050 m water depth

The core revealed several ash beds (956, 1040, 1757, 1876 cm), which might be correlated to ashbeds found at a core nearby (KS04, Dennielou 1997), which occurred between late MIS 3 and MIS 5.1. Sampling of the three lowermost sections at 1 cm intervals was carried out on board

2.4 Charlie Gibbs Fracture zone and Gardar drift

The investigated area is located on the main path of the two major water masses in the North Atlantic which are also the main components of the thermohaline circulation: the surface North Atlantic Current transporting warm and saline waters from the Gulf Stream area northeastward across the Atlantic and into the Arctic Ocean and the North Atlantic Deep Water (NADW), formed in the Nordic Seas and spilled southwards through crevasses in the submarine sills that connect Greenland, Iceland and Great Britain. The Iceland-Scotland overflow waters flow into the deep abyssal plains of the Atlantic, first in a southerly direction along the Gardar and Bjorn drift on the eastern side of the Reykjanes ridge down to the Charlie-Gibbs fracture zone at about 52°N. There, it turns clockwise and goes back northward along the western side of the Reykjanes ridge. It then mixes with the Denmark strait overflow waters and goes back southward along the Irminger Basin.

In order to fulfill the AMOCINT goals and to analyze the changes in both the surface water and the deep water activity during interglacial periods including Holocene, two main areas have been selected as targets: the Charlie-Gibbs fracture zone, and the Gardar Drift (see figure 9).

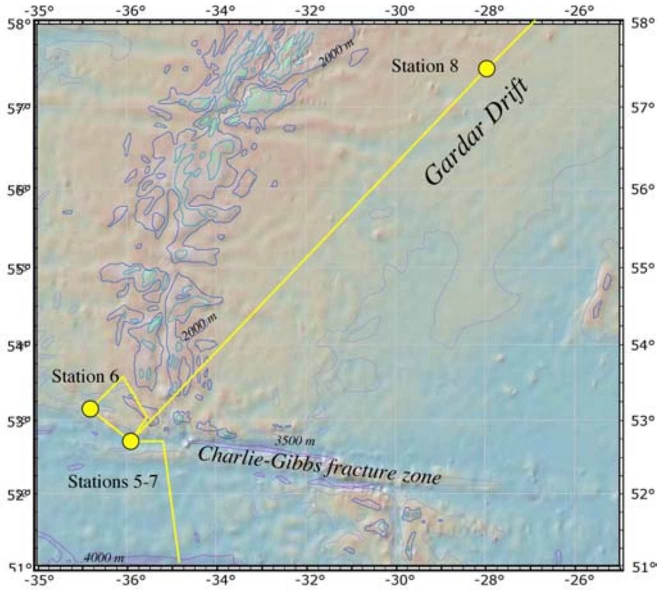


Figure 9: location of the coring stations at the Charlie-Gibbs fracture zone and on the Gardar Drift

2.4.1 Charlie-Gibbs fracture zone

At the Charlie-Gibbs fracture zone, our investigation was based on a short French core taken in 1977 on board the R. V. *Charcot*. This 6 m long core was covering the Holocene period with a high sedimentation rate. The difficulty is that the precise location of this deep core (more than 3700 m) was not known because the GPS positioning did not exist in 1977 so some survey was planned in this area. The other task was a rather extensive survey both in bathymetry and 3.5 kHz in this unexplored area in order to locate and to core two other potential sites at different water depths (around 3000 m and 2500-2000 m).

After about three hours survey, we could find a site similar to the one cored in 1977 at 52°42'N; 035°56'W, 3575 m water depth. A triple operation was planned at this site: a casq, a multicorer and a calypso. Out of the 12 m long casq, we could recover 11.47 m of perfectly preserved sediment (MD08-3182Cq). However, we did not see at the top the surface oxydized layer so after a successful 35.48 m long Calypso core (MD08-3183), we tried again another casq, stopping it quicker after it touched down the sea floor in order to preserve the top. Unfortunately, when the corer was brought back to the deck, the top part flowed backward in the corer and again, we lost the few centimeters at the top. The multicorer did not triggered at this site, due to the high softness of the sediment: obviously, the frame penetrated into the sediment because it was really muddy when we got it back on the deck but it did not encountered enough resistance to trigger. At the end of the Charlie-Gibbs area investigation, we came back to that site, attempting a long 53 m Calypso core. This core was successful and could be compared to both casq cores and to the previous, shorter, Calypso core.

The sediment in the casq cores is made of dark olive gray silty clays with some thin intercalation of diatom layers at the top. Dropstones of various sizes were also found around 9 m.b.s.f. In the two calypso cores, a thick diatom layer is found between 27.2 and 35.5 m in core

MD08-3183 and between 26.4 and 35.4 m in core MD08-3187. This layer is very clear in every record obtained on board and corresponds to nul low field magnetic susceptibility (Figure 10). This layer might correspond to stage 5e.

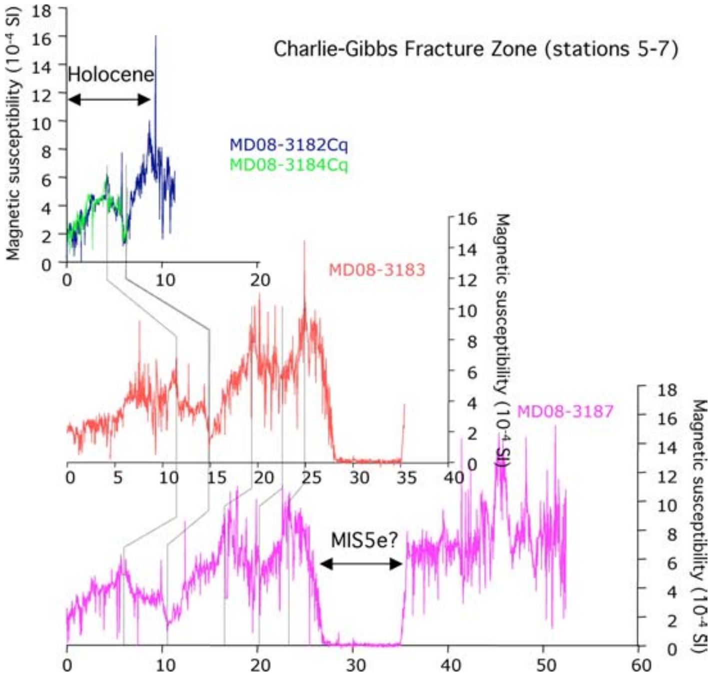


Figure 10: Correlation based on the magnetic susceptibility of cores collected at the Charlie Gibbs Fracture Zone (sations 5 and 7)

After the first site at the Charlie-Gibbs fracture zone, we had about 10 hours survey to find other sites at shallower depths. We selected a second site at 3140 m (53°11’N; 036°48’W) where we made a Casq (MD08-3185Cq) and a Calypso (MD08-3186) cores. The casq core is 9.65 m long with a nice top layer. According to the color and the description of the core, it is obviously a site with a low sedimentation rate and covering several climatic cycles. We had a very rough sea at that site with peak wind speeds reaching 55 knots and the coring operations were very delicate. The calypso triggered in the water and we could collect only 7.27 m long sediment in it. We continued our survey with no success and, as described above, came back to station 5 to make a long Calypso because, in between, the storm had stopped.

2.4.2 Gardar Drift

At the Gardar Drift, we selected a station taken in 2003 during the P.I.C.A.S.S.O cruise and covering the last 3 interglacials with a high sedimentation rate. Given the softness of the sediment and the 3.5 kHz profile showing a very thick sequence, we attempted a long core with a 52.95 m long tube. The penetration of the corer into the sediment was good and the core was straight. However, by bad luck, a dropstone damaged the core catcher which remains partially opened and part of the corer emptied while going back up to the surface. We could get only 22.75 m of sediment, repeating the previous core. So no improvement was obtained at that site.

The remaning program at the Vøring plateau was important for the AMOCINT project and the weather forecast was not good so we prefered to abandon this station and continued our route northward.

2.5 The Faeroe region

It has been initially planned in the AMOCINT project to take a core just north of the Faeore islands. However, this has not been accomplished because no reliable seismic data could be selected from previous cruises. Many different corings have been made in this area included by previous cruises on board the R. V. *Marion dufresne*. Our goal was not to repeat any of the *Marion Dufresne* sites for which long cores has already been obtained but to complete with a new location investigated only with short cores. In the available seismic profiles and data, it appeared that most of the sequences north of the faeroe are distrubed by turbidites layers which may reach large thicknesses. Therefore, because we did not have time for a long survey in this area, we decided to skip it and spend a little more time on the Vøring plateau

2.6 The Vøring plateau (Station 9-13)

The current system in the Nordic Seas (Greenland, Iceland and Norwegian Seas) consists of three main currents: the warm Norwegian Atlantic current (the northern continuation of the Atlantic Current), the cold east Greenland Current and the East Icelandic Current. There are two limbs of the Norwegian Atlantic current, one at the shelf edge and the other further west. These limbs merge into a single branch west of Lofoten and Vesterålen (Mork and Blindheim, 2000). The northward inflow of warm and saline Atlantic water to the Nordic Seas has great impact on climate in this region where the typical temperature of Atlantic water is 9.5-10ºC (Hansen and Østerhus, 2000). Atlantic water enters the Norwegian Sea through the Faeroe-Shetland Channel as well as between the Faeroe islands and Iceland (Figure 11).

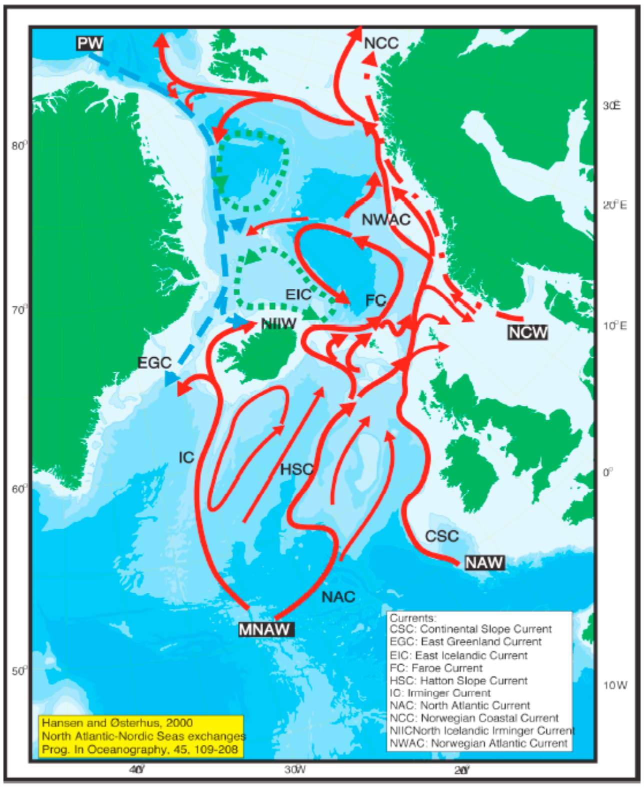
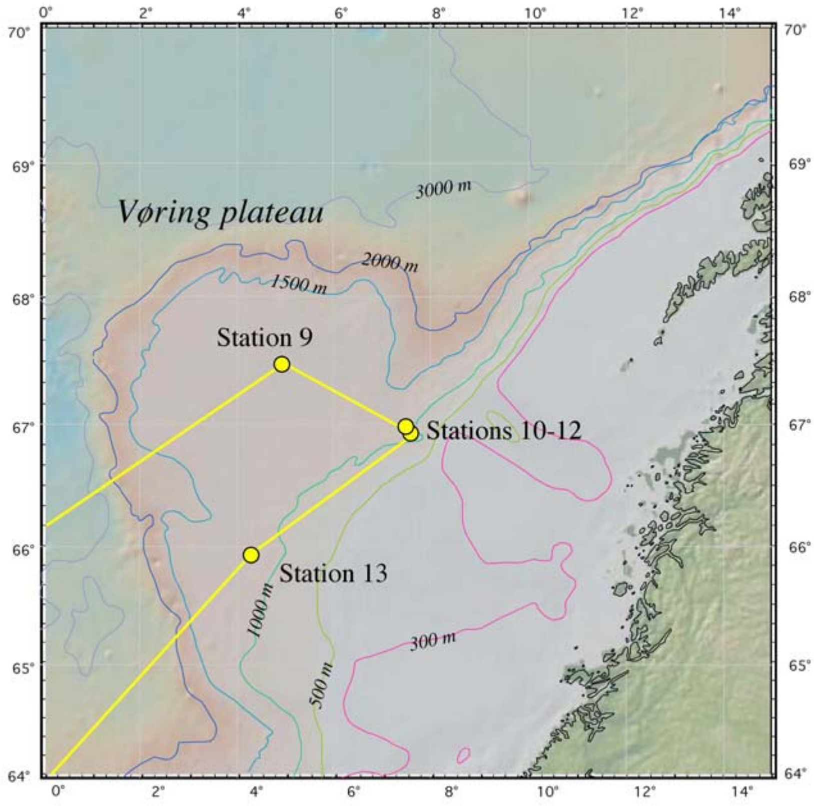


Figure11: Main surface currents in the North Atlantic and the Nordic Seas (after Hansen and Østerhus, 2000)

The objective of coring the Vøring plateau is to investigate climate variability along the route of warm water advection into the Nordic Seas. The coring targets (Stations 9-13) were selected to:

1. Recover expanded Holocene/MIS 5e sequences at centennial or better temporal resolution to test whether rapid climate anomalies during the Holocene and 5e are linked to changes in the flux of inflowing warm North Atlantic Water and test it's phasing with respect to low-latitude areas and ice core records.
2. Provide new insight into the mechanisms of interglacial climate variability through recovering sequences spanning several interglacial intervals. The aim is to identify the importance of the mechanisms, processes and feedbacks at work during the peak and at the end of the interglacials and specifically to analyze the interglacial leads and lags in the MOC response to different forcing as well as the subsequent entrance into the glacial periods.



Access to high resolution TOPAS PS18 (Parametric Sub-bottom Profiler System) seismic profiles collected onboard the University of Bergen R/V G.O. Sars (H. Haflidasson and A. Nygaard Pers. Comm., Cruise Report GS138-04) allowed us to target three specific coring areas to obtain our objectives: Vøring plateau west, Vøring plateau east and Vøring plateau south (Figure 12)

Figure 12: location of the different coring stations West, East and South of the Vøring plateau

2.6.1 Station 9 at Vøring plateau west

The coring site was selected to obtain a sediment package, which would span back to ~MIS 15 to ensure a detailed evolution of inflowing Atlantic water along the Norwegian coast over several interglacials towards the entrance to the glacial inceptions, with emphasis on assessing the specific role of the upper limb of the MOC in bringing the Earth System into a glacial modus operandi. The plan is to analyze the interglacial leads and lags in the MOC response to different forcing (insolation, greenhouse gas concentrations, temperature, and continental ice volume) as well as the subsequent entrance into the glacial periods.

The plan was to perform a double coring operation at this station with a Casq and a Calypso core to ensure full recovery of the sediment package at 1355 m water depth. The Casq, MD08-3189Cq (67°24.51'N, 004°49.91'E), recovered 8.17m of undisturbed sediments with a yellowish brown oxidized layer on the top 39 cm of the core. The rest of the Casq core contained olive gray to light olive gray silty clay with some layers consisting of coarse lithics. Calypso core MD08-3190 (67°24.51'N, 004°49.93'E) encountered trigger problem and came up slightly bent with a 27.43 m sediment recovery. The core contained silty clay and clay sand in different shades of olive gray with clear bending features throughout. Coarse lithics are common with single large dropstones and predominately polar cold species of foraminiferas. Because of the trigger problems, this core missed the top part and it was decided to deploy a second Calypso MD08-3191 (67°24.50'N, 004°49.92'E), which recovered 26.22 m of sediment. The core contained silty clay sand, foraminifera bearing with slight to moderate bioturbation. Coarse lithics, larger dropstones and mud pebbles are common, as is dark organic rich spots and sandy layers. With the addition of a second Calypso core, based on the on board color measurements, we achieved a continuous recovery of the top 42 m of the sedimentary package on the station (see figure 13).

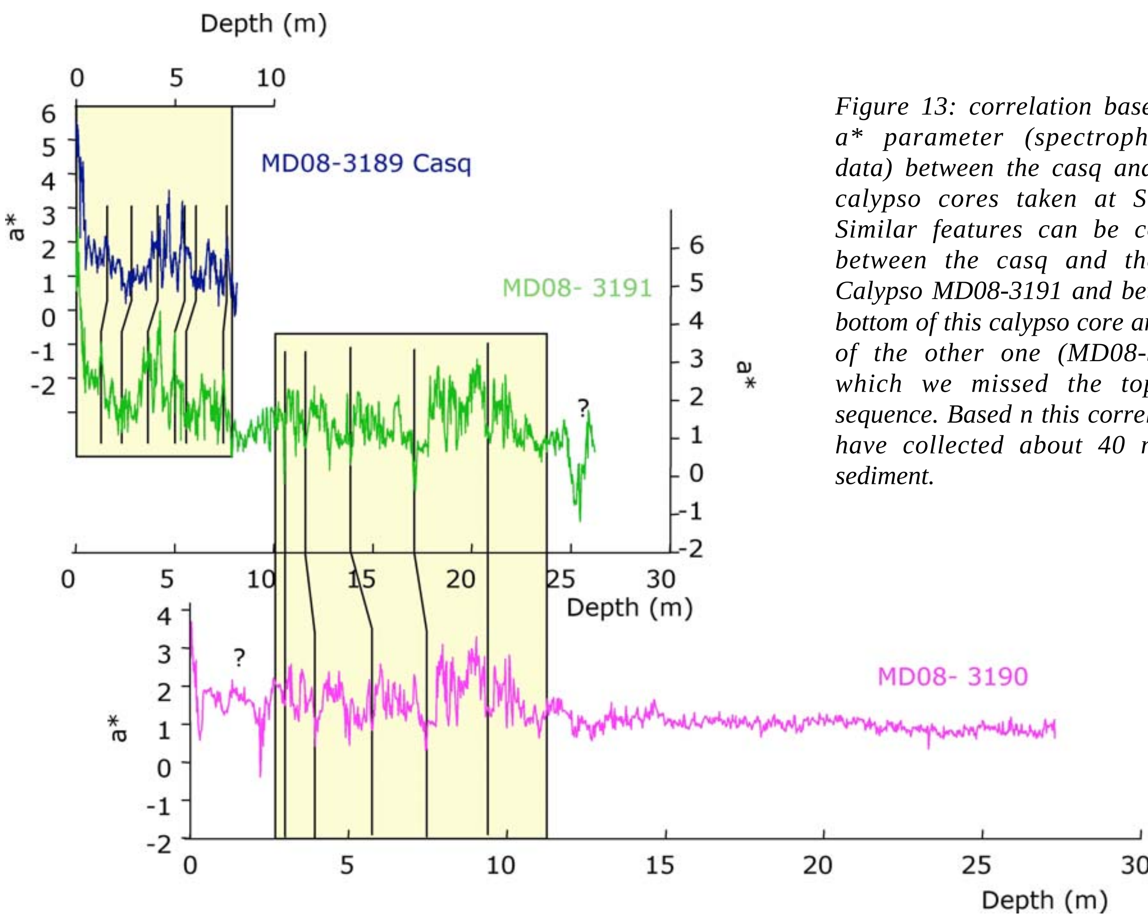


Figure 13: correlation based on the a parameter (spectrophotometer data) between the casq and the two calypso cores taken at Station 9. Similar features can be correlated between the casq and the top of Calypso MD08-3191 and between the bottom of this calypso core and the top of the other one (MD08-3190) in which we missed the top of the sequence. Based n this correlation, we have collected about 40 meters of sediment.*

2.6.2 Station 10-12 Vøring plateau east

Several projects within the IMAGES program have been devoted to obtain high-resolution Holocene time series related to ocean circulation with emphasis on high latitude regions of the North Atlantic/Nordic Sea. With the availability of new high quality acoustic imagery, we identified a target, which is highly likely to give data for MIS 5e with equal quality as the Holocene timeseries produced from core MD95-2011 at the Vøring plateau (Andersson et al. 2003, Risebrobakken et al. 2003). The aim is to perform multi-proxy studies of MIS 5 from the peak warmth of sub-stage 5e to the colder sub stages to define the thresholds for climate changes in warm periods providing the framework to assess potential future human-induced climate events.

Based on the onboard 3.5 kHz profile and the detailed TOPAS profile from G.O. Sars cruise GS138-04, we selected an area with both an expanded Holocene and MIS 5e section (stations 10-12 in Figure 14).

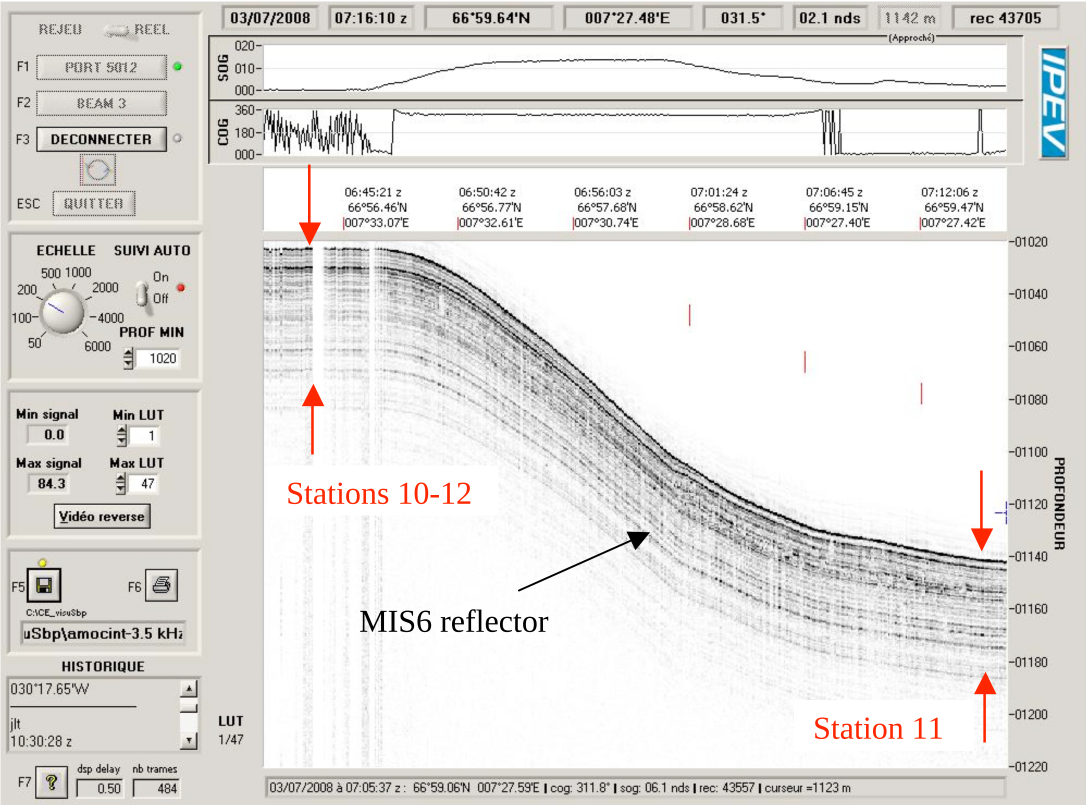


Figure 14: Echosondeur profile corresponding to station 10 (id section 12) and 11. Rthe arrows indicate where the coring stations have been made. The change in the thickness of the Holocene sequence appears very clearly.

To ensure a recovery of MSI 5e we chose to target the sediment package with a double coring station approach. A triple coring operation (12m Casq, 52m Calypso and Multicore) in the most expanded part of the sediment package (MIS 6 reflector is ~45 m sediment depth) and a double coring operation (9m Casq and a 45m Calypso) in the less expanded section (MIS 6 reflector is ~34 m sediment depth) along the seismic profile.

First we targeted the most expanded Holocene section at station 10 at 66°55.86’N, 007°33.92’E, 1010m water depth, with a 12m Casq (MD08-3192Cq) and successfully retrieved 8.20m of homogeneous olive gray silty clay with little sand with black spots common throughout. To obtain an undisturbed water-sediment interface and to ensure that we can link the top of the high-resolution sediment package with instrumental time series, we also used the BCCR multicorer. The operation was a success and all four tubes in the multicore (MD08-3193Mc A-D, 66°56.45’N, 007°32.99’E, 1028 m water depth) recovered ~50 cm of undisturbed sediment surface with living brittle stars in every tube and a 18 cm thick upper oxidized layer. To ensure a smooth operation, we delayed the 52m Calypso on this station, and moved slightly east to station 11 at 66°59.75’N; 007°28.18’E, 1141m water depth. Here we employed a 9 m Casq (MD08-3194Cq), which recovered 8.10m of sediment and a Calypso (MD08-3195, 66°59.75’N 007°28.18’E), which recovered 39.23m of sediment. The Calypso core came up slightly bent most likely due to the compact nature of the hemipelagic clays at great depth and/or the occurrence of a layer of drop stones (recovered in the core catcher). The sediments in both the Casq and Calypso were homogeneous silty clay of varying shades of olive gray. The sediment package down to 39.23 m had varying density of black spots throughout and intervals with dropstones. There was no clear indication of a thick interglacial interval on the visual core description, but the sediments above a major dropstone at 34.40 m contained intervals with warmer fauna. This is in agreement with the position of MIS§ at about 34 m.b.s.f at that location.

After this operation, we moved slightly west back to station 10 which was renamed for this core Station 12 at 66°56.46’N, 007°33.02’E, 1028 m water depth. The objective was to recover the expanded MIS 5e section with a very long core (52.95 m long tube). The operation failed as the core bent, probably due to the compact sediments and/or drop stones. A total of 27.59 m of the core were extruded (core MD08-3196), but the liner sections contained a void from 600-1094 cm and soupy intervals from 1972-2795 cm. According to the comparison between the casq (MD08-3192Cq) taken previously at this station and the Calypso sequence, the void is just a break into the sediment and not to any loss.

2.6.3 Station 13 Vøring plateau south

Through many years of detailed seismic survey operations on the Vøring plateau, the Bergen marine geology group led by Professor Haflidasson has obtained a detailed knowledge about areas with expanded and complete sediment sections in the area. Based on a TOPAS profile selected by H. Haflidasson, we targeted an area southeast on the Vøring plateau, in the Mosjøen area, which shows a sequence with well-developed reflectors indicating stacked glacial-interglacial packages. The objective of this coring station was twofold: to obtain a core which is situated in the eastern branch of the inflowing Atlantic water to get a detailed expression of this water mass over the Holocene and MIS 5e (BCCR) and to ensure a recovery of interglacial sequences over a range of boundary conditions (LSCE).

We did a triple coring platform operation at this site, deploying a Casq, a multicore and a Calypso core. The Casq (MD08-3197Cq) at 65°55.24’N, 004°15.67’E and 1300 m water depth recovered 8.02m of sediment. The Calypso (MD08-3198) at the exact same location, recovered 33.94 m of sediment. To obtain an undisturbed water-sediment interface, we also used the BCCR multicorer. Unlike the other multicoring operations onboard, we tested out using the small winch mid ship to ensure more stable conditions during operation. This test was highly successful and all four tubes in the multicore (MD08-3499Mc A-D) came up with ~50 cm of undisturbed sediments with a 2-3 cm oxidized surface layer and living brittle starts on the surface. Both the Casq and Calypso contained a top ~20 cm layer of moderate yellowish brown. Below this, the sediments contained alternating shades of olive gray silty clay with sand and pebbles and varying density of dark spots and dropstones throughout. The triple coring operation ensures that we have recovered a continuous sedimentary package down to ~33 meters sediment depth.

2.7 Southwest Ireland

The northern part of the Bay of Biscay is under the influence of two distinct sedimentary sources. The first area which is the easternmost one is related to the history of the paleoriver Manche, one of the most important European river system, draining a major part of western Europe including the catchments of the rivers Rhine, Thames, Seine and Loire. Numerous recent works, most of them issued from the EPOC Department at the University Bordeaux 1, have showed that this river system has been active mostly during glacial times and in particular during the period of melting of the main continental European glaciers (fennoscandian ice sheet, British ice-sheet and alpine glaciers).

The western area, at the southernmost part of the Irish margin, is only controlled by the British ice sheet. Although, no sequence is at present available to precisely monitor the high resolution history of this area, it seems clear that the British ice sheet has been the first one influenced again by the North Atlantic drift waters at the end of the glacial periods when the thermohaline circulation re-started. The aim of getting new sequences from this region was therefore to define the past history of this glacial complex, its chronology, its role and implication in the global dynamic of the different phases characterizing the last deglaciation in which the Fennoscandian and Laurentide ice sheets are involved.

For that goal, a promising site had been located during the ALIENOR cruise on board the R. V. *Marion Dufresne* in 2004 southwest of Ireland, 300 m above the abyssal plain. No time was available in 2004 to core this site, which is close enough to the boundary of the British ice sheet as it is described during glacial time but protected from the turbidites.

After 4 hours survey and 7 hours operation, we could collect two cores succcessfully: a casq (MD08-3200Cq) and a Calypso (MD08-3201). The casq core is 8.25 m long and the Calypso is 40.78 m long. The sediment is made of dark olive gray sitly clays with intervals of much light clays, rich in foaaminifera. No detailed sedimentary description was made on board because we were close to the port call at Brest but according to the change in color, we might have reached MIS8 at the bottom of the core. MIS5 is most probably between 22.5 and 26.5 m.b.s.f and MIS7 might be between 36 and 38.4 m.b.s.f.

The results which will be obtained from this site will complete those of the sparse topographic highs already recognized and studied in the Bay of Biscay and characterized by hemipelagic sedimentation. After coring, before finishing our route to Brest, a complete and unique multibeam survey of this area has been performed.

2.8 off Portugal

As mentioned in the introduction, this site was not investigated during the MD168 cruise but during the following MD169 cruise from Brest to Algeciras. However, we report here on this site as it is fully part of the Amocint project. A short description of it can also be found in the MD169 cruise report.

For the sites on the Tore Seamount off Portugal that were cored during MD169-MICROSYTEMS the aim was either to find a site with higher sedimentation rates as core MD01-2446, which was taken in the framework of the POP cruise (GEOSCIENCES1 cruise in 2001) or to extend the MD01-2446 record, which covers the last 542 ka (Voelker et al., in prep.), further back in time. A secondary site was planned for the seamount's central caldera to allow comparison between this potentially isolated deep-water environment (> 5000 m) and the shallower, open ocean sites. Unfortunately, no information on the set-up for coring of MD01-2446 was available during MD169.

As the pre-existing 3.5 kHz data did not reveal any suitable area with higher sedimentation rates or at water depths significantly shallower than the 3570 m of site MD01-2446, a small ridge north of site MD01-2446 was chosen as first target area. Even though the deep penetration seismic data of the ToreMadere cruise indicates a sediment cover of more than 400 m thickness, the 3.5 kHz survey with R/V Marion Dufresne only revealed a less than 40 m thick sediment cover with a strong reflector in about 20 m depth. Calypso core MD08-3209 was retrieved from this ridge. The core barrel was bent and based on the sensors attached to the Calypso coring system the core penetrated about 18 m and was initially bent by 90°. Pulling the core out of the sediment was difficult and in addition the winch gave problems, so that the pullout had to be interrupted until repairs on the winch cable had been made. Nevertheless the coring system was retrieved and a sediment sequence of 28.30 m recovered. As the recovered sediment sequence is 10 meters longer than the estimated penetration depth intensive stretching of the sediment column is to be expected and confirmed by the coring disturbances (see core description). The two lower most sections of the core are disturbed with vertical sediment alignment (see core photos). The first section contains 80 cm of brownish sediments indicating that core MD08-3209 recovered the Holocene with a similar length than in core MD01-2446 (S. Lebreiro, unpubl. data). Based on the grey reflectance data MD08-3209 extends back into MIS 14 and therefore covers about the same sequence as core MD01-2446 (Fig. 15) including a good MIS 5 sequence.

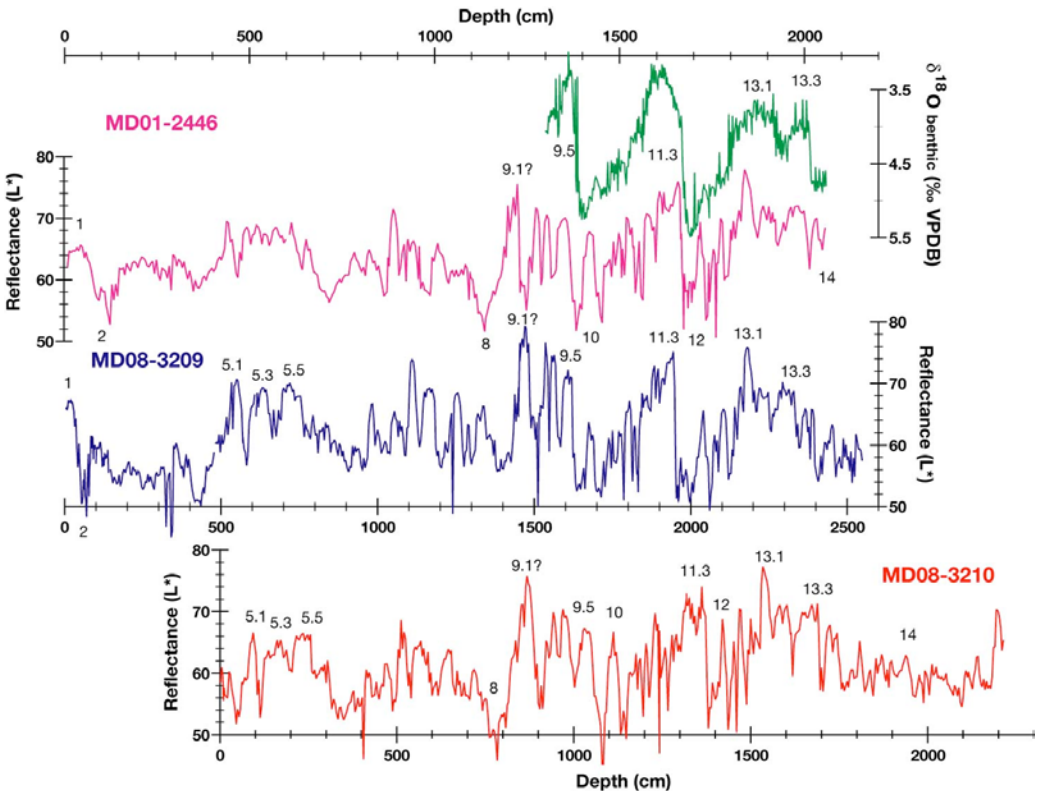


Fig. 15: *Comparison between the reflectance records of cores MD01-2446, MD08-3209 and MD08-3210. In the top panel, some of the available benthic d^{18}O data for core MD01-2446 (Voelker et al., in prep.) is shown for stratigraphic reference. Numbers refer to MIS.*

The seismic survey of the target area in the caldera revealed a strong reflector at the top and only diffuse signals underneath, in contrast to pre-existing processed 3.5 kHz data from the ToreMadere cruise. As the only coring option with this seismic record would have been a try with a short gravity core, coring in the caldera was abandoned in the hope to recover a longer sequence without coring disturbance at the position of MD01-2446. However, with the second coring site being shallower than the caldera site enough spare time was available to obtain a CTD profile down to 4500 m in the central caldera (Station 8; MD08-CTD_1). The CTD profile revealed a typical water mass sequence for the Portuguese margin with North Atlantic Central Water, Mediterranean Outflow Water and Northeast Atlantic Deep Water until the bottom depth of the cast. During the CTD's upcast water samples were taken at 5 depths and among other elements d^{18}O will be measured at LSCE in Gif-sur-Yvette on those samples (collaboration with D. Blamart).

Since the first section of core MD08-3209 had been opened and revealed a Holocene sequence similar to MD01-2446, the Calypso coring system for the recoring of site MD01-2446 was configured to obtain a good and less stretched sequence in the deeper part of the core thereby potentially disturbing or loosing the top meters of the cored sequence. This set-up was chosen with the aim of recovering a sequence extending MD01-2446 further back in time. Similar to MD08-3209, the coring system penetrated only about 17.8 m and the core was initially bent to 90°. Again it was hard to pull out the coring system. Calypso core MD08-3210 recovered a sediment sequence of 22.87 m. Likewise to MD08-3209 the sediment sequence in the core is stretched and reveals coring disturbances with the last section being totally disturbed (vertical sediment alignment; see core photos). Due to the set-up of the coring system the interval from MIS 1 to 3 was not recovered. Although MD08-3210 retrieved a slightly longer sequence than MD01-2446 and reaches potentially back to the MIS 15/ 14 boundary the MIS 14 interval is highly stretched (Fig. 15). Because Calypso core MD08-3210 showed such great similarities in the coring system's behavior and the core recovery, Jean-Francois Bourillet from IFREMER performed initial measurements for shear strength calculations at the freshly cut core sections. After the reflectance data revealed the preliminary stratigraphy it became obvious that the nannofossil oozes of MIS 11 and especially of MIS 13, the interglacials after the onset of the *G. caribbeanica* bloom, are the intervals with the higher shear strength. These oozes are highly cohesive causing on the one hand the coring system to be slowed down and stopped and on the other hand making the pullout of the coring system very difficult. Consequently, sediment recovery beyond MIS 14 in the Tore seamount region was not possible and none of the initial aims for the coring in this region could be fulfilled.

Future analyses on the two Calypso cores need to be discussed in the near future but will include biomarker measurements and Sr/ Ca in coccoliths.

2.9 Complementary Program (E. Douville, LSCE):

Within the framework of the precise reconstruction of the paleo-pHs from the measurement of boron isotopes (©^{11}B) in marine carbonates (foraminifera, corals for example) to precisely rebuild Ocean Acidification due to CO_2 released to the atmosphere during our industrial era, it is essential to precisely know the isotopic composition of the boron in the seawater for different water masses of the ocean. Boron is an element with a long time of residence (> 11 My) and its concentration and isotopic composition are considered to remain stable in the ocean, about 4.5 ppm and 40 ‰ respectively. However, today only few precise geochemical studies have been conducted on this element and their results showed isotopic composition values ranging between 38 and 40.5 ‰, variability particularly observed in the water column. Such potential variability may contribute to uncertainties of 0.2 unit-pH from the technique of paleo-pH reconstruction based on boron isotopes in marine carbonates.

The general idea is thus to collect and study many seawater samples from different oceans in order to observe the spatial variability of the boron isotopes at the surface (< 50 m) but also for sub-surface and deep waters (influence of the OMZ, etc). Isotopic analysis will be performed later using MC-ICPMS with an analytical uncertainty recently estimated to ± 0.2 ‰, corresponding to 0.02 unit-pH of precision for the technique of paleo-pH reconstruction described here.

During the Amocint cruise, surface waters were regularly collected during the cruise in 25 corning tubes of 15 ml (see table). A simple seawater sampling was sufficient without filtration or acidification.

N°	Date	time (TU)	Latitude	Longitude	Temp. water	Salinity	sampling
1	19/06/08	10:10	34°26.72 N	020°44.96 W	21.48	36.52	brion
2	20/06/08	9:58	36°27.27 N	026°27.33 W	22.07	36.14	brion
3	21/06/08	7:44	37°50.96 N	030°17.64 W	20.76	36.09	brion
4	22/06/08	10:18	39°13.18 N	031°25.39 W	20.61	36.18	brion
5	23/06/08	8:22	43°52.39 N	032°34.90 W	18.48	36.03	brion
6	24/06/08	8:12	48°36.19 N	033°51.40 W	15.46	35.6	brion
7	25/06/08	11:07	52°41.99 N	035°56.16 W	11.34	34.78	brion
8	25/06/08	13:09	52°41.99 N	035°56.15 W	11.51	34.79	bucket
9	26/06/08	12:57	53°11.45 N	036°48.98 W	10.08	34.65	brion
10	27/06/08	20:10	55°09.36 N	031°54.09 W	10.84	34.94	brion
11	28/06/08	7:53	56°48.92 N	029°01.98 W	11.28	35.04	brion
12	29/06/08	10:03	59°12.19 N	022°54.78 W	11.49	35.26	brion
13	30/06/08	12:37	62°12.36 N	013°45.35 W	10.72	35.31	brion
14	1/07/08	7:48	64°14.53 N	007°00.03 W	8.48	35.04	brion
15	2/07/08	11:21	67°24.50 N	004°49.92 E	10.45	35.05	brion
16	2/07/08	12:57	67°24.50 N	004°49.92 E	10.45	35.05	bucket
17	3/07/08	7:45	66°59.75 N	007°28.18 E	11.6	34.55	brion
18	4/07/08	7:29	65°55.24 N	004°15.67 E	12.09	34.38	brion
19	5/07/08	7:41	62°11.19 N	003°37.91 W	10.65	35.25	brion
20	5/07/08	18:35	59°58.74 N	006°31.71 W	11.6	35.45	brion
21	6/07/08	10:28	56°38.8 N	009°40.07 W	13.8	35.47	brion
22	7/07/08	7:22	51°40.49 N	011°01.38 W	14.51	35.43	brion
23	8/07/08	6:30	47°53.02 N	011°52.39 W	15.5	35.68	brion
24	8/07/08	7:	47°53.02 N	011°52.39 W	15.5	35.68	bucket
25	9/07/08	11:29	46°43.84 N	006°58.70 W	15.97	35.59	brion

2.10 References:

Andersson, C., et al (2003), Late Holocene surface ocean conditions of the Norwegian Sea (Vøring Plateau), *Paleoceanography, 18, 1044, doi:10.1029/2001/PA000654*

Bryden, H.L., Longworth, H.R., and S.A. Cunningham, (2005). Slowing of the Atlantic meridional overturning circulation at 25°N. *Nature*, 438, 555-557.

Cruise Report 100-02/04 from R/V G.O. Sars Cruise to the North Atlantic (University of Bergen (UoB) cruise No. GS138-04)

Dennielou, B. (1997): Dynamique sédimentaire sur le plateau des Acores pour les dernieres 400 ka. These de Doctorat de L´Université de Bretagne Occidentale, 215pp.

deMenocal, P., et al., Coherent High- and Low-latitude Climate Variability during the Holocene Warm Period, *Science*, *288*, 2198-2202, 2000.

Jansen, J.H.F., Kuijpers, A. and Troelstra, S.R., 1986. A Mid-Brunhes Climatic Event: Long-Term Changes in Global Atmosphere and Ocean Circulation. Science, 232: 619-622.

Hansen, B. and Østerhus, S. (2000), North Atlantic-Nordic Seas exchanges. *Prog. In Oceanography,* 45, 109-208.

Hebblen, D. and Meggers, H., Meteor berichte 00-4, Cruise M45

Knoll, M. et al., 2002. The Eastern Boundary Current system between the Canary Islands and the African Coast. Deep Sea Research Part II: Topical Studies in Oceanography, 49(17): 3427-3440

McGregor, H.V., et al. Rapid 20th-century increase in coastal upwelling off Northwest Africa. *Science, 315*, 637-639. 2007.

Mitchel, N.C. (1995): Diffusion transport Model for pelagic sediments on the Mid-Atlantic Ridge. JGR, 100 B10, 19991-20009.

Moreno, A. et al., 2001. Orbital forcing of dust supply to the North Canary Basin over the last 250 kyr. Quaternary Science Reviews, 20(12): 1327-1339

Mork, K.A. and Blindheim, J. (2000), Variations in the Atlantic inflow to the Nordic Seas, 1955-1996, Deep Sea Res. Part 1, 47(6), 1035-1057.

Pflaumann, U. et al., 1998. Variations in eolian and carbonate sedimentation, sea-surface temperature, and productivity over the last 3 M.Y. at site 958 off Northwest Africa. In: J.V. Firth (Editor), Proceedings of the Ocean Drilling Program, Scientific Results, Vol. 159T. Ocean Drilling Program, College Station (Tx), pp. 3-16.

Richter, T, 1998. Sedimentary fluxes at the Mid Atlantic Ridge, GEOMAR Report, 173 pp.

Risebrobakken, B., et al. (2003), A high-resolution study of Holocene paleoclimatic and paleoceanographic changes in the Nordic Seas, *Paleoceanography*, *18*, 1017, doi:10.1029/2002PA000764.

Schönfeld, J. and Zahn, R., 2000. Late Glacial to Holocene history of the Meditarranean Outflow. Evidence from benthic Foraminiferal assemblages and stable isotopes at the Portuguese margin. Palaeogeography Palaeoclimatology Palaeoecology, 159: 85-111

Voelker, A.H.L. et al., 2006. Mediterranean outflow strengthening during northern hemisphere coolings: A salt source for the glacial Atlantic? Earth and Planetary Science Letters, 245(1-2): 39-55

Voelker, A. H. L., Rodrigues, T., Stein, R., Hefter, J., Billups, K., Oppo, D., McManus, J., and Grimalt, J. (in prep.): Variations in mid-latitude North Atlantic surface water properties during the mid-Brunhes: Does Marine Isotope Stage 11 stand out?, to be submitted to Climate of the Past.

3. TEACHERS AT SEA - Educational Program for teachers on board the Marion Dufresne.

Carlo LAJ (Laboratoire des Sciences du Climat et de l'Environnement and Committee on Education, European Geosciences Union)

3.1 The Teachers at Sea program

With the support of the French Polar Institute (IPEV) and of the European Geosciences Union (EGU), a program for High Schools was conducted along side the scientific work on board the Marion Dufresne, during the MD168 AMOCINT, IMAGES-XVII cruise. 5 teachers from France, Norway, Portugal, Spain and the United States of America, were invited to participate to the cruise and to gather information on its scientific goals, to participate to the work going on in order to have a as precise and complete as possible grasp of the sciences being done on board.

From left to right:: Helder Pereira (Portugal), Angela Skeeles-Worley (USA), Gertrud Cigen (Norway), Carlo Laj (France, coordinator), Catalina Sureda (Spain), Jean Aufauvre (France)

Specifically, the teachers' program was to participate to the scientific activities on board and to relate these activities to their fellow teachers around the world by means of almost daily reports that were e-mailed to about 200 teachers. First, the teachers were introduced to the different aspects of the cruise, the characteristics of the Marion-Dufresne itself, its electric powered engines, its Dynamic Positioning System, and finally to the two unique coring systems, the Calypso and the Calypso Square corer. Then, in order to be fully immersed in the scientific work, the teachers participated together with the scientists and technician on board to two 4-

hours shifts per day (8h total per day). During these shifts, they were involved in every step of the process of obtaining the cores, cutting, opening and labeling them, archiving, and measuring some of the physical parameters, and finally sediment description.

Participation to the regular shifts was invaluable for realizing that there are many professional tasks that are absolutely necessary for an oceanographic cruise to be successful. This is true for the crew in charge of the navigation, that in charge of the vessel propulsion, and also for the people in charge of the coring process (the Malagasy team and the IPEV crew on board) and other aspects such as technical fitting of the tools, repairing and maintenance of the tools. This is certainly one aspect of the scientific cruise often ignored when reading reports or scientific publications only.

Participation to the shifts was also important to get the teachers in contact not only with the scientists leading the scientific aspects of AMOCINT, but also with the 6 students from the University of Brest participating to the second educational program that was going on during AMOCINT the 10th edition of the University of the Sea, under the direction of Prof. Jacques Deverchère of the University of Brest. The coexistence of these two programs was most exciting and constructive.

Using all the information gathered, and that obtained by their participation to the different shifts, it was possible to establish almost daily reports of the scientific progress of the cruise and to send regular logs to the participating land-based teachers. These reports were written by all the teachers together and e-mailed to as many teachers as possible in different schools mainly in Europe and in the USA, taking advantage of a list of addresses of teachers having participated to the Geosciences Information for teachers (GIFT) workshops of the European Geosciences Union. Although many schools were already closed for summer vacations during most of the cruise, we received some enthusiastic responses from many teachers, and the material sent will be used in the classrooms from the beginning of the 2008-2009 school year.

Also, taking advantage of the large amount of sediment collected by the CASQ corer, we have systematically taken part of the sediment for the schools. We have written some simple instructions on how to extract foraminifera from the sediment, how to identify the clearest warm and cold species, so that the teachers will be able to show that at any particular site there have been significant climatic fluctuations in the past.

In parallel with these activities, a power-point presentation describing all the different scientific and social aspects of the life on board was prepared, also containing a series of digital photographs that were too big to be sent via e-mail. This presentation will be recorded on CDs that will be distributed to the different teachers and also uploaded on the EGU and IPEV homepages, from where it will be possible to download them freely and used in the classrooms. Worldwide.

Finally, during the transit period between coring zones, I organized conferences given by scientists and PhD students on board, on different aspects of oceanographic and paleoclimatic research related to the AMOCINT cruise (the list is following). The students of the University of the Sea also attended these conferences and gave very interesting and lively oral reports on their scientific work (results of their first year stage of practical work).

The “Teachers at Sea” program gives the teachers a renewed sense of teaching science the way science is practiced. The 5 AMOCINT teachers have been informed on every detail of the cruise, from the scientific proposal to the details of the cruise, and finally to the analysis of the cores that, although limited on board, is what science is about. This is different from a textbook, which is mostly an accumulation of facts. Here the teachers are exposed to the practices of science and in turn we can expect them to motivate their students accordingly. Exposure to authentic science, such as that the 5 teachers have experienced during AMOCINT, may be a pivotal experience for them, causing them to change at least in part their teaching methods, possibly creating more future scientists or at least adults with positive attitudes towards science. This is particularly true for AMOCINT, which is part of a research program focused on future global climate change, with a special attention to interglacial periods such as the one we experience now. This is clearly of high societal importance and both the work done on board and the conferences held during the cruise stressed that there are a lot of questions for the future and there are difficulties in making predictions, a message to be transmitted to the next generation and especially to the teachers. Teachers as multiplicators in educational sectors and partners for students are the best actors to make students (the next generation) aware about these problems in the school.

The “Teachers at Sea” program started with the following message sent to all the land-based teachers for whom we had the email addresses (about 200) to invite them not only to use the material sent from the Marion Dufresne, but also to take this opportunity to ask all kind of questions which they would discuss with their students:

Dear teacher!

“The climate puzzle pieces are hidden in many obscure places around the globe including in the ocean sediments that have accumulated over recent and distant past. Removing these treasure latent cores from the ocean depths provides information about past climates including atmospheric and oceanic conditions. The focus of a 3 week research cruise of the Research Vessel Marion Dufresne, of the French Polar Institute (IPEV), in the North Atlantic from Gran Canaria to Brest, through the Açores, the Charlie-Gibbs fracture zone, and in the North on the

Voering plateau, will be to collect deep sea cores to help answer the puzzling questions about changes in the Atlantic Meridional Overturning Circulation during the last interstadials climatic stages, i.e. stages during which the climate was warm, similar to the present day climate. The goals of the AMOCINT cruise under the guidance of Catherine Kissel and Helga Kleiven (chief and Co-Chief Scientists) will be to survey and core sites for sampling high sedimentation rate interglacial sections available to the Calypso coring system of the RV Marion Dufresne, to produce time series of North Atlantic circulation parameters with century scale resolution for the last insterglacial and previous interglacials over the past 800.000 year and to provide detailed comparisons with ice core records from Antarctica and Greenland. Finally, one of the aims is also to conduct detailed site surveys for targed IODP (Integrated Ocean Drilling Program) drilling to recover thick marine sections over the past intergalcials at key locations for monitoring Atlantic Meridional Overturning Circulation (AMOC) variability

Besides a number of noted research scientists from around the world onboard will be 5 teachers immersing themselves in the experience of life at sea and research with the guidance of one scientist. Their students will be taking part in this cruise by sending emails, participating in blogs, and journaling about the daily exploits of those onboard. You can join the "Core-Education" Team as they journey over the ocean by sending them emails about the science and the research. Send your emails to coredu@marion.ipev.fr and they will enjoy getting back to you.

Hélder Pereira, Jean Aufauvre, Angela Skeeles-Worley, Gertrud Cigen, Catalina Sureda and Carlo Laj (advisor).

The reports sent out during AMOCINT are reported in the CD associated with this cruise report and a presentation is given in the Education session “Teacher Professional Development Programs Promoting Authentic Scientific Research in the Classroom” at the American Geophysical Union Fall meeting in December 2008 at San Francisco

Carlo Laj and Hélène Leau, A Teachers at Sea Program on Board the R. V. Marion Dufresne (IPEV) in the Atlantic ocean, *Fall AGU meeting, San Francisco*, Dec. 2008.

3.2 Acknowledgements

All the participants to the Teachers at Sea program wish to deeply thank the Institut Polaire Paul Emile Victor (IPEV) and the European Geosciences Union (EGU) for their generous financial contributions which made this program possible. The IPEV group on board, as well as the scientific team and the CMA-CGM crew, are also thanked for their constant help during the cruise. We particularly thank Gérard Jugie and Hélène Leau (IPEV), Catherine Kissel and Helga

(Kikki) Kleiven and Jacques Deverchère for their involvement and constant help to the Teachers at Sea program.

3.3 List of the conferences organized during the AMOCINT cruise

June 16

Presentation of the CALYPSO corer : how it works
Carlo Laj, LSCE, Gif-Sur Yvette

June 19

Basic concepts in Oceanography
Helga Kleiven, BCCR, Bergen

June 20

Marine Sedimentation
Helga Kleiven, BCCR, Bergen

June 23

Rapid Climate Changes
Helga Kleiven, BCCR, Bergen

June 24

Basics in Climate Changes Modelling
Charline Marzin, LSCE, Gif-sur-Yvette

June 29

Past vectorial variations of the Earth's Magnetic Field – Stratigraphic tool –Correlation sediment/sediment and sediment/ice
Catherine Kissel, LSCE, Gif-sur-Yvette

June 30

Climate Changes induced by human activities : The Monsoon
Charlin Marzin, LSCE, Gif-sur-Yvette

Climate and Ice Sheets,
Stefano Bonelli, LSCE, Gif-sur-Yvette

High-resolution modelling of bio-physical proxies
Laure Resplandy, LODYC, Paris

July 1st

Millenial scale water masses transfer in the Glacial Atlantic Ocean
Catherine Kissel, LSCE, Gif-sur-Yvette

July 5

A multi-purpose tool (MIRONE) for exploring grid data
Hélder Pereira, Escola Secundaria de Loulé, Portugal

July 6

Summary of the AMOCINT Cruise
Catherine Kissel, LSCE, Gif-sur-Yvette

July 7

Stable Isotopes in Paleoceanography
Elisabeth Michel, LSCE, Gif-sur-Yvette

Milankovitch cycles in the Mediterranean Landscape
Carlo Laj, LSCE, Gif-sur-Yvette

4. 10th University of the Sea

Jacques DEVERCHERE (Professor, Université de Bretagne Occidentale, Brest, Fance)

4.1. Clues for high-level education improvement

Today, scientific education, at least during the first four years of University, primarily consists of conventional classes and conferences, leading to limit the authenticity of scientific knowledge transmitted, as well as student interest in science. Additionally, students often fail to acquire enough confidence in their ability to decipher scientific reasoning and to apply their skills in their future professional life. This is especially true in the earth sciences, in which answers to theoretical and practical problems are found through collecting and analyzing data sets. A way to fill this gap is to involve students directly in the research process. Indeed:

- students learn how to behave in a group of scientists;
- students are actively involved in the process of data acquisition and processing;
- students take personal responsibility for the quality of the work done; and
- students have the opportunity to make the link between conceptual knowledge and the use of data to test and support it.

A scientific cruise at sea provides all of these opportunities in a relatively short period of time.

It is also important to underline that this experience is fully complementary of a personal research study generally offered during Masters program. A critical characteristic of the program is its collaborative nature, as students work with many groups of people, including other students, scientists, and crew members.

Finally, the English language is often not fluently understood and spoken by French students, so the prolonged involvement with international teams of foreign students and scientists (for whom English is the communication language), strongly enhances and improves their ability to communicate (listen, write and speak) in English. This will provide them with a great advantage in their professional life to come.

4.2. Previous "Universities of the Sea" organized with French Universities

The important training provided by a marine cruise is often included in educational programs in Europe. However, very few vessels can provide the conditions offered by the R/V *Marion Dufresne* of IPEV (Institut Polaire Paul-Emile Victor):

- unique coring system (world-record of the deepest piston core),
- room on board (hosting of up to 30 students and a scientific team of ~40 people jointly),
- exceptional facilities for a direct and continuous participation of students in the scientific tasks on board (deck, Conference room).

Since the end of the 1990's, IPEV has provided access of the R/V *Marion Dufresne* for educational programs. Students generally participate either as part of a scientific team of one of the participating institutions, or as part of a University at Sea program. The institutions which organize University at Sea programs are generally those which offer a focused Masters program in marine studies, such as Brest (Université de Bretagne Occidentale, Institut Universitaire Européen de la Mer) and Bordeaux I (UFR des Sciences de la Terre et de la Mer) Universities.

Nine "Universities of the Sea" have already taken place on board of R/V *Marion Dufresne* before this one. Four of them (1999, 2001, 2003, 2006) hosted groups of students from Bordeaux I and/or Brest Universities. However, the two most recent programs have been organized at an international level:

- The 6th edition (2003) hosted students from Brest, Bordeaux and Purdue (Indiana, USA) Universities in the Atlantic Ocean (Bay of Biscay, Galicia margin, Canarias), during the PICABIA cruise.
- The 8th edition took place between Shanghai and Jakarta, with Chinese, French, Dutch and Canadian students. This was part of the Marco Polo II cruise, which was focused on studying three regions of the South China Sea.

4.3. A practical and integrative way to approach high-level marine research

The main objective of this educational and scientific program is to expose Masters students to the many opportunities available in fields related to oceanography, and also to increase international collaboration with other universities. University at Sea provides a unique opportunity for students to not only be exposed to, but also be directly involved in the process of collecting scientific data on a research vessel. Students also develop an understanding of how to collect the proxy data used in climate modelling, and attend international lectures given by the scientists involved in the program.

One of the key aspects of the program is that students realize that there are many professional tasks on board that are absolutely necessary for a scientific mission to be successful. Everyone involved in these tasks must have a sense of responsibility for the success of the mission, and work together. For instance, without people focused on navigation, vessel propulsion, technical fitting of tools, repairing and maintenance tasks, cooking, and logistics, the scientific work would not be possible. The students must also feel personally invested and responsible for the quality of the work carried out on board. As a result of this experience, students are more sensitive to the importance and invaluable nature of data collection.

4.4. The challenge of past climate change

AMOCINT is a project supported by ESF (European Science Foundation), which is part of a large-scale research program focused on future global climate change. This project is dedicated to the sensitivity of climate change to external forcings such as albedo (sea and ice) and the

Carbon cycle, and to the responses of oceanic circulation and ice sheets to these forcings through time (especially during the interglacial periods).

Therefore, the AMOCINT cruise has allowed a high-level and current approach to global climate change research. This research has strong societal implications. This modern challenge is addressed through the sedimentary archives that have been captured through the unique coring system of the R/V *Marion Dufresne*. The specialists of the Research team on board, coming from various countries in Europe, but mainly France, Norway, and Germany, have therefore been able to transfer through conferences and direct contacts with the students their expert knowledge and skills in ocean circulation, climate forcings, climate modelling, and the use of sediment cores to reconstruct past climate changes.

4.5. Students involved

The 10th University of the Sea has been divided into two main parts. The first segment, which included six students, was the longer of the two (over three weeks), and took place during the AMOCINT scientific cruise. The second section of the program includes nine students (MICROSYSTEMS cruise). The first segment is the subject of this report.

The six participants from Brest (Université de Bretagne Occidentale, Institut Universitaire Européen de la Mer), all belong to the Masters program entitled "Sciences de la Mer et du Littoral". These students come from three different specialities of the first year of Masters program: "Sciences Biologiques Marines" (SBM), "Géosciences Océan" (GO), and "Sciences Chimiques de l'Environnement Marin" (SCEM). This cruise has enhanced and improved the multidisciplinary approach of Marine sciences in which they are currently being trained in during the first year of their program.

From left to right:

Romain BIVILLE
(GO, M1) (0-4)

Erwan CAMBRAI
(SCEM, M1) : (0-4)

Emmanuelle MEDRINAL
(SBM, M1) : (8-12)

Elodie BOUCHER
(GO, M1) : (8-12)

Sophie BERTHOLON
(GO, M1) : (0-4)

Camille ANDRE
(GO, M1) : (0-4)

Director:
Jacques DEVERCHERE

The students involved in the AMOCINT cruise were selected from a pool of applicants after an announcement was made to all students. The participants were selected according to their scholarship results and professional projects. The participants are listed above with specialization of their first year of Master and the watch to which they participated (0-4) or (8-12).

4.6. The Education Programme on board

During the AMOCINT Cruise (June 15, Las Palmas; July 10, Brest), the students participated in several activities:

- Perhaps the most important activity was participation in the scientific teams during two 4-hour shifts per day (8 h a day). During these shifts ("watches"), they participated in processing all three types of cores (Calypso, Casq, Multi-core). They were involved in the entire process from start to finish, which included tasks such as measuring, cutting, opening, labelling, archiving, physical parameter measurements, and finally sediment description. This activity was led together with a program called "Teachers at Sea": School teachers from France, Norway, Portugal, Spain, and the United States of America were invited on board in order to participate to the AMOCINT cruise. The teachers came to learn about the coring process, to enjoy the exciting life of scientists at sea, and to communicate about these experiences with their students and other teachers. Both groups worked with the scientists during the shifts.

- Students attended advanced lectures on marine environments, past climatic evolution and global changes. A total of twelve conferences took place on board. Lectures were held by the scientists involved in the cruise, and took place every afternoon during transit periods. The conferences were organized through the "Teachers at Sea" program, and specifically by the director of the program, Carlo Laj (LSCE). The ‘Teachers at Sea’ program was sponsored by the European Geophysical Union (EGU).
- Each student presented his or her scientific work (results of their first year research training period) in an oral presentation.
- The students built a web site including a cruise report, which includes the information they learned on board. All of this work was done in English, a common language to all the participants.
- Finally, students have designed posters concerning the aims of the AMOCINT scientific cruise and the technical work on board.

4.7. Funding and acknowledgements

The University of the Sea 2008 was funded by IPEV (food and accommodation on board) and by the French Ministry of "Enseignement Supérieur et Recherche" through the Programme "Universités Européennes d'Eté 2008", DREIC (Direction des Relations Européennes et Internationales et de la Coopération) for travels. We deeply thank these institutions and their

representatives (Gérard Jugie, Director of IPEV, and Hélène Leau, IPEV organization of the Cruises; Marc Foucault, Director of DREIC, and Martine de Nadaillac, DREIC) who have made this operation possible.

We are also strongly indebted to the Cruise Chief scientist, Catherine Kissel (LSCE, Laboratoire des Sciences du Climat et de l´Environnement, Gif-sur-Yvette, France), who invited us to join the scientific team, and to the director of the "Teachers at Sea" Program, Carlo Laj, for the nice experience of "mixing" teachers from different countries with students. We would like also to thank the IPEV Chief of operations on board, Xavier Morin, the Commandant of the Vessel, François Duchêne, and all the crew members who have made this journey a great experience.

This operation strongly strengthens the appeal, quality and exposure of our Masters Program at European and International levels.

Furthermore, the European and educational characters of this operation are particularly welcome in 2008 since this is the Year for celebration of the 4th International Polar Year (http://www.anneepolaire.fr), the cruise took place at the moment when France was called to hold the Presidency of the European Union, and also because the AMOCINT cruise is ending at Brest, place of the "Fête Internationale de la Mer et des marins" (BREST2008, see http://www.brest2008.fr/fr/).

photo Camille André

5. TIME LOG OF AMOCINT CRUISE

Date (UTC)	Station	Time (UTC)	Latitude	Longitude	Water Depth (m)	Operations
15.06.2008		15:00				Departure from Las Palmas

Date (UTC)	Station	Time (UTC)	Latitude	Longitude	Water Depth (m)	Operations
OFF MOROCCO						
16.06.2008	**1**	17:14				begin survey
		21:05				arrival at station 01
		21:54				begin coring operation
		22:17	30°50.70'N	010°05.83'W	361	touchdown **MD08-3174Cq** (Casq)
		22:55				core on deck, core length 8.66 m
	1	23:42				begin coring operation
17.06.2008		00:01	30°50.70'N	010°05.82'W	359	touchdown **MD08-3175Mc** (Multicore)
		00:21				multicore on deck (full)
	1	02:39				begin coring operation
		03:35				problem with triggering system
		03:38	30°50.67'N	010°05.82'W	360	trigger **MD08-3176** (Calypso)
		04:46				corer on deck (bent), core length 29.77 m
	1	06:58				begin coring operation
		07:50	30°50.67'N	010°05.82'W	361	trigger **MD08-3177** (Calypso)
		09:06				corer on deck (bent) core length 39.68 m
		09:14				departure from station 01
	2	15:06				begin survey
		17:30				arrival at station, begin coring operation
		19:10	31°17.09'N	011°29.20'W	2184	trigger **MD08-3178** (Calypso)
		20:31				corer on deck, core length 31.64 m
		20:33				departure from station 02
AZORES						
21.06.2008	**3**	01:14				begin survey
		05:30				Station 03
		05:58				begin coring operation

		06:53	37°50.96'N	030°17.64'W	2036	Touchdown **MD08-3179Cq** (Casq)
		08:00				corer on deck, core length 8.14m
	3	08:35				Multicorer at the surface
		10:02	37°50.96'N	030°17.63'W	2042	Touchdown
		10:54				Multicorer at the surface: empty
	3	12:04				begin operation
		13:37	37°50.96'N	030°17.63'W	2038	trigger Calypso
		14:35				corer at the surface, tubes lost
		14:35				departure from station 03
	4	17:54				begin survey
		19:50				at station 04
		19:51				begin operation
		20:42	37°59.99'N	031°08.07'W	3064	Touchdown **MD08-3180Cq** (Casq)
		22:15				corer on deck, length of the core 10.50m
	4	23:00				begin operation
		01:20	38°00.00'N	031°08.08'W	3059	trigger **MD08-3181** (Calypso)
		02:29				corer at the surface
		04:15				corer on deck. Length of the core 23.36m
		04:33				departure from station 4

CHARLIE-GIBBS FRACTURE ZONE

25.06.2008	**5**	02:08				Begin survey
		05:15				begin operation
		06:41	52°41.992'N	035°56.146'W	3757	trigger **MD08-3182Cq** (Casq)
		08:10				corer on deck, length of the core 11.47 m overpenetated
	5	08:30				begin operation
		09:05				multicorer at the surface
		10:28	52°41.991'N	035°56.160'W	3762	touchdown
						multicorer on deck, empty (not triggered)
		12:01				multicore on deck
	5	13:06				begin operation
		14:11	52°42.1'N	035°56.15'W	3757	trigger **MD08-3183** (Calypso)
		16:22				corer on deck, length of the core 35.48m
	5	16:30				begin operation
		18:17	52°41.98'N	035°56.15'W	3757	touchdown **MD08-3184Cq** (Casq)
		19:42				core on deck, length of the core 6 m
		19:46				departure from station 05
		19:46				begin survey
26.06.2008	**6**	05:53				arrival at station 6
		05:54				begin operation
		08:05	53°11.24'N	036°48.71'W	3140	trigger **MD08-3185Cq** (Casq)
		09:50				corer on deck, length of the core 9.65 m
	6	10:15				begin operation
		12:34	53°11.09'N	036°48.61'W	3140	trigger in water, **MD08-3186** (Calypso)
		14:15				corer on deck, length of the core: 7.27m
		14:25				departure from the station
		14:25				begin survey

	7	21:00				arrival at station 7 (same than station 5)
27.06.2008		00:27	52°41.99'N	035°56.17'W	3758	trigger **MD08-3187** (Calypso)
		03:04				corer on deck, length of the core 52.45m
		03:18				departure from station 7

GARDAR

28.06.2008	**8**	13:45				arrival at station 8
		13:55				begin operation
		16:35	57°26.82'N	027°54.48'W	2610	trigger, **MD08-3188** (Calyspo)
		18:23				core on deck, length of the core: 22.75 m core catcher damaged by dropstone, loss of sediment
		18:30				departure from station station 8

VOERING PLATEAU

02.07.2008		08:30				begin survey
	9	09:30				arrival at station 9
		09:39				begin operation
		10:16	67°24.51'N	004°49.91'E	1355	touchdown **MD08-3189** (Casq)
		11:12				core on deck, length of the core 8.17m
	9	11:30				begin operation
		13:24	67°24.51'N	004°49.93'E	1355	trigger, **MD08-3190** (Calypso) pb with triggering (too late)
		15:45				core on deck, corer bent, 27.09 m long
	9	17:20				begin opreation
		19:18	67°24.50'N	004°49.92'E	1352	Trigger in water **MD08-3191** (Calypso)
		20:20				core on deck, length of the core 26.22m
		20:44				departure from station 9
03.07.2008		01:38				begin survey
		02:49				arrival at station 10
		02:50				begin operation
	10	03:32	66°55.86'N	007°33.92'E	1010	touchdown **MD08-3192**(Casq)
		04:15				corer on deck, length of the core 8.30 m
		04:44				departure from station 10
		05:20				station a little downslope (10bis)
		05:20				begin operation
	10 bis	06:08	66°56.45'N	007°32.99'E	1028	touchdown **MD08-3193** (multicore)
		06:45				Multicore on deck, filled up
		06:45				departure from station 10
		07:38				arrival at station 11
		07:39				begin operation
	11	08:27	66°59.75'N	007°28.18'E	1147	touchdown, **MD08-3194Cq** (Casq)
		09:15				corer on deck, length of the core 8.12m
		09:36				begin operation
	11	11:53	66°59.75'N	007°28.18'E	1148	trigger, **MD08-3195** (Calypso)
		13:56				corer on deck, length of the core 39.23m
		14:20				return to station 10 bis
		16:52				begin operation
		18:01	66°56.46'N	007°33.02'E	1028	trigger, **MD08-3196** (Calypso)
	12	19:44				corer on deck, length of the core: 27.59 m

						corer bent on dropstones
		19:50				departure from station 12
04.07.2008	**13**	02:50				begin survey
		03:10				begin operation (during survey)
		03:51				arrival at station 13
		04:35	65°55.24'N	004°15.67'E	1300	touchdown, **MD08-3197Cq** (Casq)
		05:40				corer on deck, length of the core 8.02m
		05:50				begin operation
	13	07:15	65°55.24'N	004°15.67'E	1300	Trigger, **MD08-3198** (Casq)
		08:23				corer on deck, length of the core 33.49 m
		08:50				begin operation at the lateral winch
	13	09:28	65°55.24'N	004°15.66'E	1300	touchdown, **MD08-3199Mc** (multicore)
		10:09				multicore on deck, full
		10:13				departure from station 13
SW-IRELAND						
07.07.2008		23:57				begin survey
08.07.2008		03:15				station 14
	14	04:37	47°53.00'N	011°52.38'W	3704	trigger, **MD08-3200** (Casq)
		06:17				corer on deck, length of the core 8.25m
	14	06:30				begin operation
		08:44	47°53.00'N	011°52.40'W	3706	trigger, **MD08-3201** (Calypso)
		10:44				corer on deck, length of the core 40.78m
	14	11:20				begin operation multicorer
		12:40	47°53.00'N	011°52.40'W	3706	touchdown
		13:52				multicorer on deck, empty
		13:53				departure from station 14
BREST						
10.07.2008		08:00				arrival at Brest
END OF THE CRUISE MD168-AMOCINT						
TORE SEAMOUNT (MD169)						
19.07.2008		03:24				begin survey
		05:57				station 7 (MD169)
	7	07:22	39°23.20'N	012°25.34'W	3616	trigger, **MD08-3209** (Calypso)
		10:49				corer on deck, length of the core 28.3 m
	8	11:55				approach to station 8
		12:31				station 8
		13:11	39°24.80'N	012°49.10'W	5460	begin operation-CTD
		16:39				end of operation-CTD (**MD08-CTD**)
	9	18:27				station 9
		19:15				begin operation
		20:36	39°03.15'N	012°37.32'W	3545	trigger, **MD08-3210** (Calypso)
		22:28				corer on deck, length of the core 22.87m
END OF THE AMOCINT OPERATIONS						

6. CORE POSITIONS AND REPOSITORY INFORMATION

1: LSCE, CEA/CNRS, Avenue de la Terrasse, Bat 12, Gif-sur-Yvette, France (CK: Catherine Kissel, EC: Elsa Cortijo)
2: Bjerknes Centre for Climate Research, University of Bergen, Allegaten 41, Bergen, Norway (KK: Kikki Kleiven, EJ: Eystein Jansen)
3: Institut für Geowissenschaften, Christian-Albrechts-Universitaet zu Kiel, Ludewig-Meyn-Str.10, D-24118 Kiel, Germany (MW: Mara Wienelt)
4: Department of Marine Geology (DGM) – Instituto Nacional de Engenharia, Tecnologia e Inovação, Lisbon, Portugal (SN: Silvia Nave)
5: EPOC, Université Bordeaux 1, Ave. des Facultés, Talence, France (JLT: Jean-Louis Turon)

Station	Core	type	Water Depth (m)	Latitude °S	Longitude °W	Core length (m)	**PI** co-workers	core Reposit.
1	MD08-3174Cq	Casq	361	30°50.70'N	010°05.83'W	8.66	KK, EJ	2, 1
1	MD08-3175Mc	Multicorer	359	30°50.70'N	010°05.82'W	0.5	KK, EJ	2
1	MD08-3176	Calypso	360	30°50.67'N	010°05.82'W	29.77	KK, EJ	2
1	MD08-3177	Calypso	361	30°50.67'N	010°05.82'W	39.68	KK, EJ	2
2	MD08-3178	Calypso	2184	31°17.09'N	011°29.20'W	31.64	SN	4
3	MD08-3179Cq	Casq	2040	37°50.96'N	030°17.64'W	8.14	MW	3, 1
4	MD08-3180Cq	Casq	3064	37°59.99'N	031°08.07'W	10.5	MW	3, 1
4	MD08-3181	Calypso	3059	38°00.00'N	031°08.08'W	23.36	MW	3
5	MD08-3182Cq	Casq	3757	52°41.99'N	035°56.15'W	11.47	CK	1
5	MD08-3183	Calypso	3757	52°42.10'N	035°56.15'W	35.48	CK	1
5	MD08-3184Cq	Casq	3757	52°41.98'N	035°56.15'W	6.00	CK	1
6	MD08-3185Cq	Casq	3140	53°11.24'N	036°48.71'W	9.65	CK	1
6	MD08-3186	Calypso	3140	53°11.09'N	036°48.61'W	7.27	CK	1
7	MD08-3187	Calypso	3758	52°41.99'N	035°56.17'W	52.45	CK	1
8	MD08-3188	Calypso	2610	57°26.82'N	027°54.48'W	22.75	CK	1
9	MD08-3189	Casq	1355	67°24.51'N	004°49.91'E	8.17	EC	1
9	MD08-3190	Calypso	1355	67°24.51'N	004°49.93'E	27.09	EC	1
9	MD08-3191	Calypso	1352	67°24.50'N	004°49.92'E	26.22	EC	1
10	MD08-3192Cq	Casq	1010	66°55.86'N	007°33.92'E	8.3	KK, EJ	2,1
10	MD08-3193Mc	Multicore	1028	66°56.45'N	007°32.99'E	0.5	KK, EJ	2
11	MD08-3194Cq	Casq	1147	66°59.75'N	007°28.18'E	8.12	KK, EJ	2,1
11	MD08-3195	Calypso	1148	66°59.75'N	007°28.18'E	39.23	KK, EJ	2
12	MD08-3196	Calypso	1028	66°56.46'N	007°33.02'E	27.59	KK, EJ	2
13	MD08-3197Cq	Casq	1300	65°55.24'N	004°15.67'E	8.02	EC, KK	1, 2
13	MD08-3198	Calypso	1300	65°55.24'N	004°15.67'E	33.49	EC, KK	1, 2
13	MD08-3199Mc	Multicore	1300	65°55.24'N	004°15.66'E	0.5	EC, KK	1, 2
14	MD08-3200Cq	Casq	3704	47°53.00'N	011°52.38'W	8.25	JLT	5
14	MD08-3201	Calypso	3706	47°53.00'N	011°52.38'W	40.78	JLT	5
MD169-Amocint part								
7	MD08-3209	Calypso	3616	39°23.20'N	012°25.34'W	28.30	SN	5
8	MD08-CTD	CTD	5460	39°24.80'N	012°49.10'W	water	SN	5
9	MD08-3210	Calypso	3545	39°03.15'N	012°37.32'W	22.87	SN	4

7. COST OF MARION DUFRESNE FOR MD168/AMOCINT

All cost in euros, taxes included
Daily cost figures valid for 2008
* are estimated figures

SHIP TIME ASSESSMENT

	Activity	Days
Cruise	Operations	
Start of cruise @ Las Palmas : 14/06/2008		24
End of cruise @ Brest 10/07/2008		
Port calls	Calls	
Las Palmas		2
Brest		1
Transit	Transit	
Transit REUnion - Walvis Bay: 9 days to be split between 3 cruises (no weighting)		3
Transit Libreville - Las Palmas: 10 days to be split between 2 cruises		5
Total		***35***

SHIP COST ASSESSMENT

	Cost	Days	Daily cost (217 days)	Remarks
CMA-CGM Charter				
Ship charter	1 131 935 €	35	32341	
CMA-CGM Exploitation				
FO during transit	70 400 €	8	8800	22 mt / days @ 13 knots; 400 euros / mt
FO during cruise	70 392 €	24	2933	* Steaming 8h / 24h
FO during calls	8 400 €	3	2800	7 mt / day @ 400 euros / mt
"Regularisation" (extra personnel, passengers cost ob)	42 560 €	35	1216	
Communication (INMARSAT)	5 845 €	35	167	
CMA-CGM Exploitation - Port calls				
Las Palmas	7 500 €			*
Brest	9 000 €			*
Passage Suez: 95000 euros to be split between 3 cruises	31 666 €			
IPEV Travels				
Flight tickets	11 710 €			
IPEV team salary (not accounted for)	***0***			
Bonus at sea for IPEV team	36 900 €			*
Expenses	1 000 €			*
IPEV Logistics				
2 * 20' reefer (container) hire and transport	14 000 €			*
Air freight 4 boxes	2 000 €			*
Loading coring equipment from TTR in Reunion	15 000 €			*
IPEV Coring and MD equipment used during coring cruises				
Coring steel tubes + transportation	35 333 €	10 sites/15		Total 2008-B: 53000
Coring PVC tubes and caps + transportation	63 163 €	10 sites/15		Total 2008-B: 94745
core catchers	47 737 €	10 sites/15		Total 2008-B: 71606
Consummables / investment for coring and related equipmt	17 814 €	10 sites/15		Total 2008-B: 26722
Other consummables (stationnary, report printing and posting, IT parts and consummables)	884 €	35		Total 2008-B: 2433.5
IPEV R&D				
Calypso corer II	280 €	35	8	R&D cost depreciation over 10 years
Calypso corer III	280 €	35	8	R&D cost depreciation over 10 years
TOTAL COST	**1 623 799 €**			
IMAGES Contracts for MD168/AMOCINT	***421 400 €***	***26,0%***		
France contribution to IMAGES for MD168/AMOCINT	***1 202 399 €***	***74,0%***		

8. CRUISE PARTICIPANTS

8.1 The Scientific Party

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7.3 University of the Sea

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MEDRINAL	Emmanuellle	Master SML-SBM, UBO-IUEM	e_medrinal@hotmail.com

UBO: Université de Bretagne Occidentale
IUEM: Institut Universitaire Européen de la Mer
SML: Sciences de la Mer et du Littoral
GO: Mention Géosciences Océan
SCEM: Mention Sciences Chimiques de l'Environnement Marin
SBM: Mentions Sciences Biologiques Marines

8.4 The crew of R/V "Marion Dufresne"

Family Name	Given name	position
DUCHENE	Jean-Paul	Master
PIOTEYRY	François	Chief Mate
ROLLAND	Alain	Chief Engineer
PORCHER	Matthieu	second Engineer
JOURDE	Emily	Mate
BLANQUART	Jean-Luc	Boatswain
PANNEKOUCKE	Régis	Boatswain
PELLETIER	Thibault	Mechanic
CHAUVIN	Guillaume	Mechanic
CLEMENT	Gérard	Mechanic
LE BECHEC	Loic	Chief Cook
HERVE	Thierry	Sd Cook
COMBE	François	Stewart
SOLINAS	Eric	Stewart

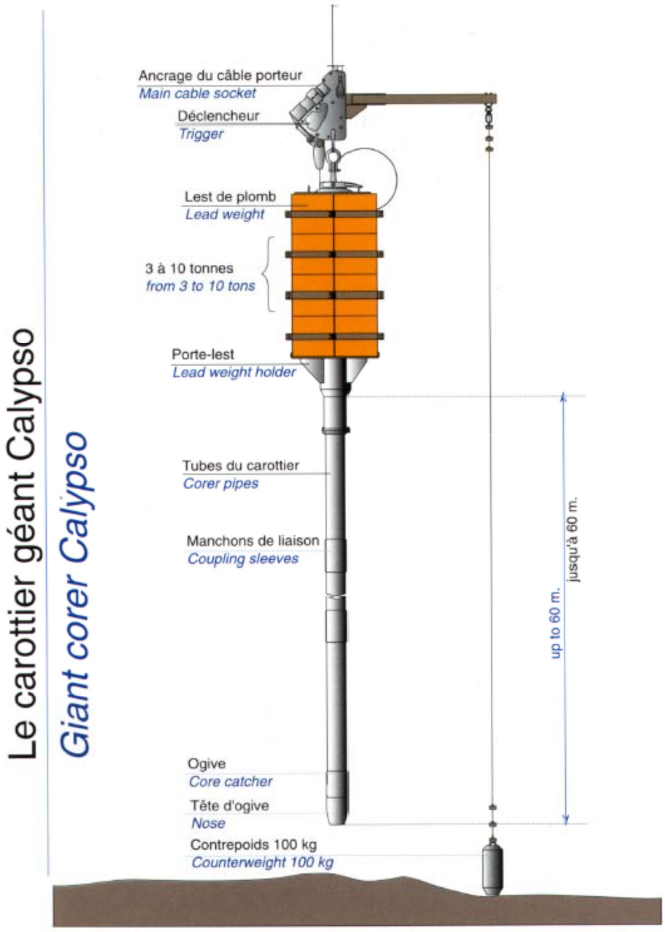
FRONTY	Damien	Mate
SOK	Colviri	Mate
DELAVACRIE	Julien	Mate
VARIN	Luc	Mate
JOSSET	Christophe	Mate
ROY	Henri	wireless
GIBLAIN	Frederic	cadet
DUPUY	Jean-Jacques	ass. Electric
COLIN	Eric	Ass Engineer
HERVE	Jean-Charles	Ass. Steward
THORAVAL	Julien	Mechanic
SAINT REQUIER	Pierrick	Electric.
GALIEN	Florent	Boatswain
GUIDA	Julien	waiter
The Malagasian team		
FAHAVIA	Clement	laundary
ALBERT	Marius	Deckhand
VELO	Patric	Foreman
RAFANOHARANA	Rodolphe	Carpenter
BERTHIN service	Jose	cleaning and restaurant
JEAN-LOUIS	Richard	Deckhand
RAMANANKILANA	Soloniaina	Deckhand
RAOELIARIMANITRA	Andre Marcel	Mecanician
RABEMANANJARA	Andry Lalaina	Deckhand
VELO	Thierry	Deckhand
RAFANOHARANA	Jean-Luc	Deckhand
TELOLAHY	Gervais	Foreman Ass.
RAZAFIMANANJAKASOA	Jean Nonnat	Deckhand
JERRY	Christophe	Deckhand
LETODY	Etienne	Cook ass.
RAKOTONIAINA	Olivier	Cook
BERTHIN		Foreman
LEVONY	Anthony	Deckhand

9. Coring and Sampling Methods, Core Handling

9.1 Coring

9.1.1 Piston Cores

The Calypso piston corer, developed on board Marion Dufresne (Figure 16), can be fitted with a tube of variable length. The corer is deployed with an aramide cable, virtually weightless in water, which significantly enhances the traction security margin and weight lifting capacity of the winch. The internal diameter of a Calypso core is about 10 cm.



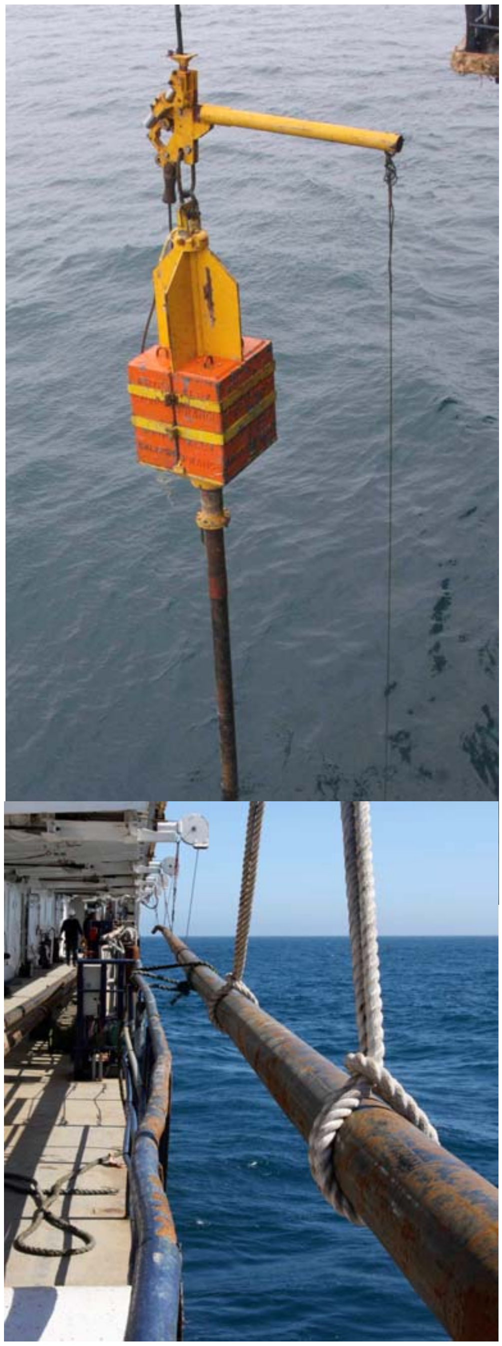


Fig.16: Above: rowing of the Calypso piston coring system (IPEV), right top: when going down into the water for coring, right bottom: tube of 53m long seen from the top weight. (photos: D. Catelain)

9.1.2 Calypso Square Cores

The Calypso square-corer (CASQ) is 25 cm * 25 cm * 1200 cm (Fig. 17). During the coring operation, the corer penetrates slowly into the sediment with no free fall. Therefore, it is able to take a huge amount of undisturbed sediment. The large surface of the opened core allows for improved studies of structures and textures.

Figure 17: Casq coring system (photo Nathalie Dubois)

9.1.3 Multicorer

The multicorer corer has been brought on board by the Bergen group for sampling the sediment interface. It is constituted of a frame and four plastic tubes of 50 cm long and with a 10 cm internal diameter (Fig. 18). When the platform touches down, a trigger system releases the tubes which penetrate into the sediment. When pulling the system out, caps are closing the tubes on both sides.

Figure 18: multicorer from BCCR (Bergen) filled in (and enlarged view on one of the tubes) (photos C. Kissel)

9.2 Core handling

9.2.1 Calypso Cores

When the core was secured on deck of the ship, the core catcher was unscrewed and the sediment that it contains was collected in a plastic bag, labeled with the cruise ID, core number and "core catcher." The liner was removed from the metallic pipe and the height to which the liner is filled with sediment was determined. A pipe cutter was used to cut the liner at the top of the sediment. When the sediment was likely to be water-rich, the first labeled endcap for the top (0 cm) of the core was positioned immediately at the top of the newly cut liner. The length of the core was measured and noted on the description form.

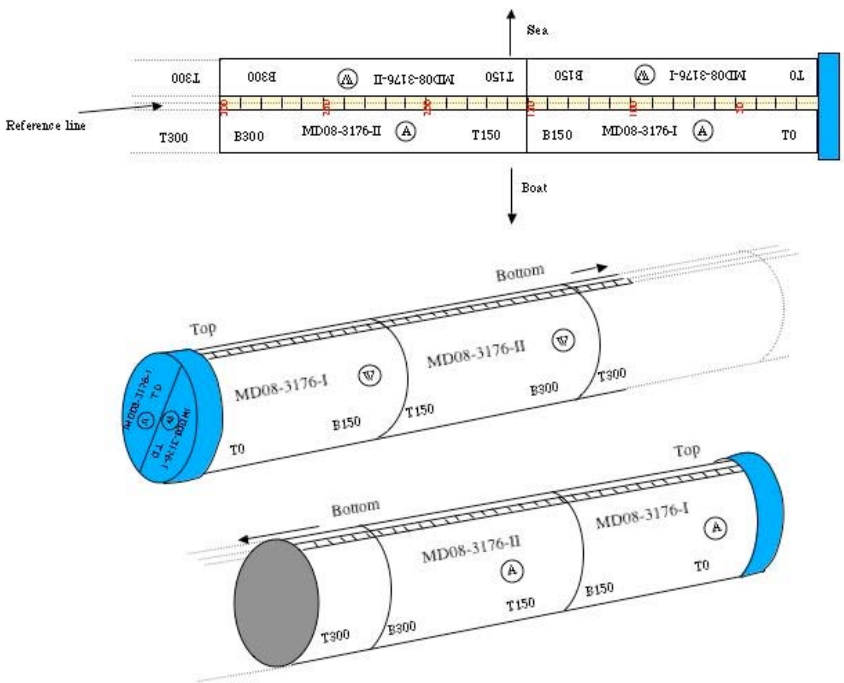


Fig.19: Sketch of the labelling of CALYPSO piston cores (drawing C. Kissel)

After the liner was well cleaned and dried, a mark was drawn every 1.5 m. This mark denoted the section breaks, and was a guideline for cutting the liner. Each 1.5 m section was labeled on both sides with (Fig. 19):

- the core number,
- section number in roman numbers (I is the first one at the top of the core),
- A or W (circled), (W when the writer is facing the ship, A when the writer is facing the sea)
- T x (=Top X cm) and B y (bottom Y cm).

The labels were written far enough away from the section breaks not to be covered by the endcaps. Similarly, the labels were far enough away from the reference line to leave room for the metric tape. A diameter line was drawn across every endcap to divide them into equal half circles. One half circle was labeled with the number of the core and section, T or B and the cm, and A for archive. The other half was labeled with the number of the core and section, T or B and the cm, and W for working. The line separating the two halves of the caps was aligned with the reference line on the liner. The core was cut into 1.5 m length, following the guide marks (Fig. 20).

Figure 20: Arnaud cutting the core on the deck.

For each section the cap was removed and an adhesive metric tape was stuck on the liner, on top of the reference line. Depths in cm were written on both halves every 20 cm, continuously all along the core, starting at 0 cm at the top. The metric tape was applied continuously on the sections. If section N was shorter than 150 cm, then the extra 1 cm of metric tape from section N was stuck at the top of section N+1 (see Fig. 21, 22). The caps were put back on and fixed with heavy tape so that each half cap is in correspondence with the respective half core (Figure 21,22).

Figure 21: metric tape is sticked on the sections and the caps and fixed with duck tape (photos: N. Dubois and R. Biville).

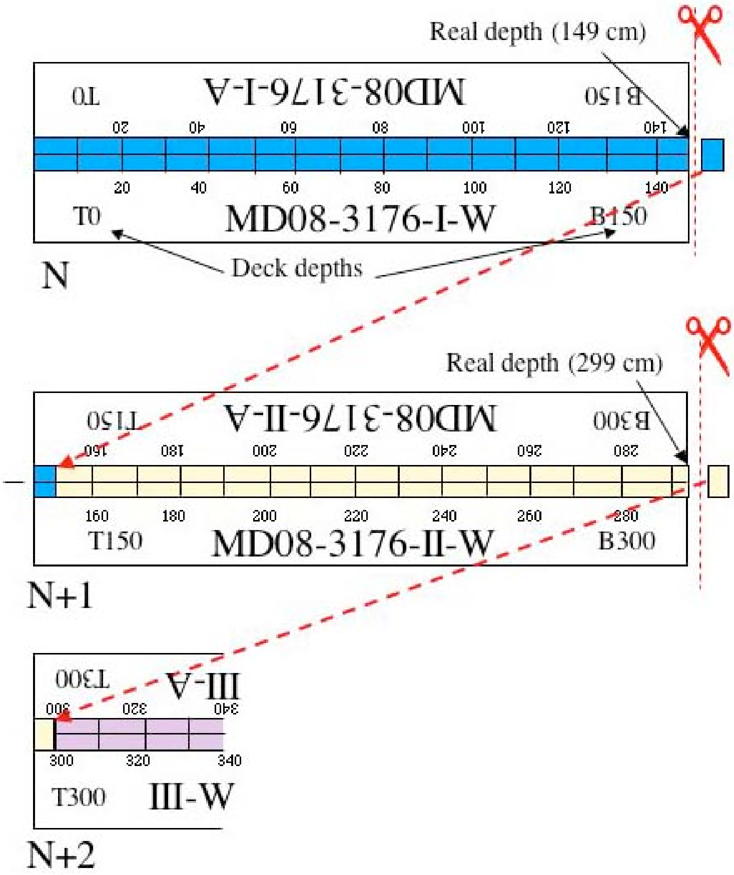


Fig. 22: Adjusting the measuring tape when dealing with uneven section lengths (drawing C. Kissel)

Each section was split into two halves, the working and archive halves, with the cut made along the reference line, the archive half on top (Fig. 23). After splitting the liner, the sediment is cut with a fishing line and the ssection opened into two halves (Figure 23).

Figure 23: splitting system (top right). Charline separates the two halves with a fishing line (left) and half cores ready for sedimentary description (bottom right). Photos D. Catelain and M. Sadovnik.

The surface of the sediment was cleaned and covered with a plastic film. The archive half was described and measured with the spectrophotometer, while the working half was used for the photo, MST track. Then the two halves were packed.

The packing consisted of covering the section with plastic film, then inserting the section into a long plastic bag with tie knots or tape in both ends. The section was then placed inside a D-tube. The D-tubes were labeled with the cruise ID and core number, section number, in the same way that the core itself was labeled. In addition, T x cm and B y cm was written on the D-tube and on each endcap as appropriate (see figure 24). The section was inserted so that the top of the core was at the T end of the D-tube and the bottom of the section was at the B end. Both archive and working halves were stored in cold containers.

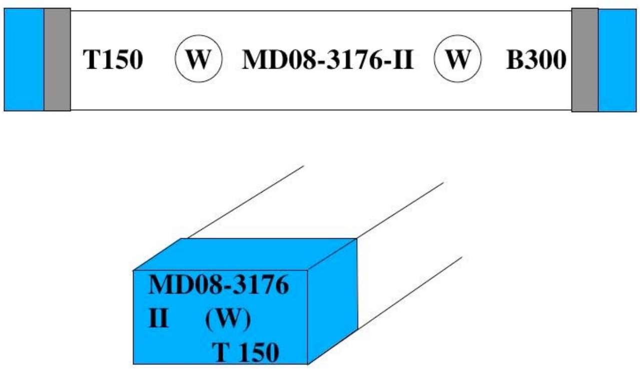


Fig. 24: Labeling of the D-tubes before they are stored in the container

9.2.2 CASQ Cores

The lid of the Casq corer was unbolted and the surface of the sediment was cleaned and flattened. D-tubes were previously cut for sampling. Some were cut along their largest side leaving U-tubes-12 cm wide and the others were cut perpendicularly leaving u-tubes-6 cm wide.

The first ones were pushed into the sediments in two parallel rows labeled set A and set B (Fig. 25). Metric tape was stuck continuously along the top of these U-tubes, and each section was labeled with the core number, the section number + A or B… depending on the row, T x cm and B y cm.

After the first two rows of U-tubes were pushed into the sediment, the corer was rotated sideways to allow an easier extraction of the sediment. The second row was made of 2 other U-tubes and 1 u-channel for paleomagnetism. The latters were taken in the central part of the corer. The two u-tubes were labeled C and D. In order to be able to measure them on the MST, the u-tubes of row D were previously cut to 150 cm in length. For this row, no metric tape was stuck onto the tubes because they were too narrow. Precise depths of the junctions between the different sections were written in the deck notebook.

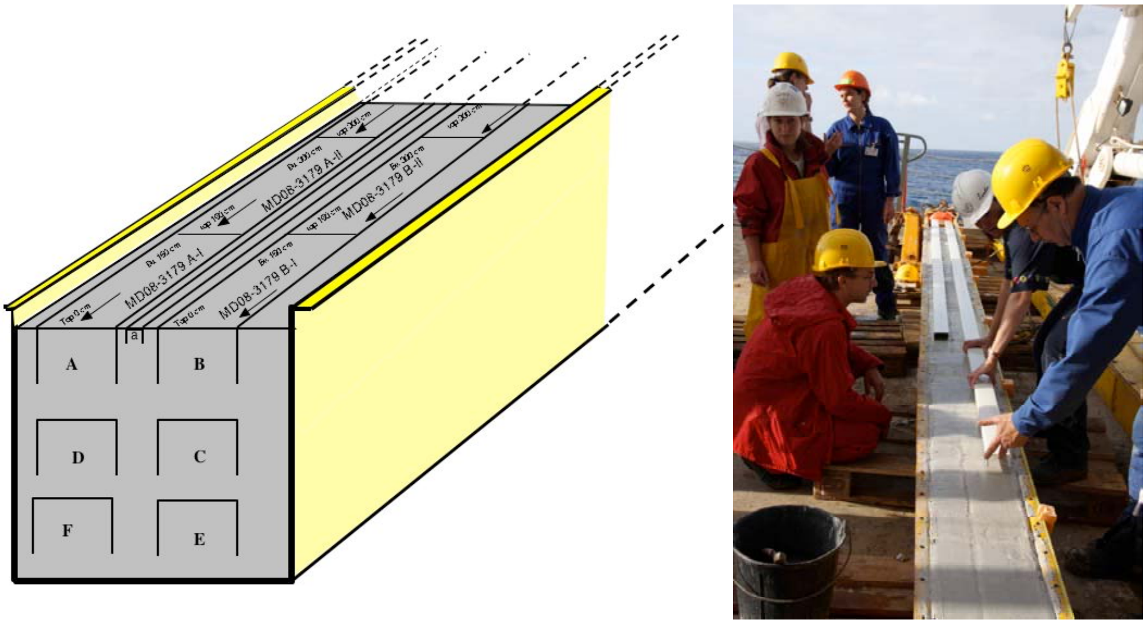


Fig. 25: Sampling of the CASQ cores. On the photo, the first row is positioned.
(photo: D. Catelain)

A fishing line was passed under each U-tube and u-channel to cut the sediment, and each U-tube was removed from the corer. All rows except two were immediately packed and stored as well as the u-channels. The remaining 6 cm wide U-tubes were scanned (MST container) and described, measured with the spectrophotometer and then packed and stored.

Casq sections were covered with plastic film. The lid was placed on top. The entire U-tube was placed into a long plastic bag and the caps (also labeled) were placed at each side and taped.

Depending on the location, we took between four and six U-tubes and they were labeled successively A, B, C, D, E etc.. This is reported in the ID form of each core in the data report.

10. Shipboard Data Acquisition and Handling

10.1 Multibeam bathymetry and sub-bottom profiling

The multibeam deep-water echosounder Thomson Seafalcon 11, installed on board "Marion-Dufresne" in 1995, is used for cartography and sediment profiling. It runs on two operating modes: the "bathymetry and imaging" mode and the "sub-bottom profiler" mode. Both modes can be run simultaneously.

Bathymetry and imagery In this operating mode, the echosounder uses transmitted frequencies around a 12 kHz carrier. The range of depths on which this mode can operate is 80 to 11000 meters. Five cross-track swaths are simultaneously created in order to generate data redundancy (as if five multibeam echosounders were simultaneously used). These swaths are separated by the use of active digital filters. Thus, measurement gaps are avoided. These five swaths are separated (along the boat-track axis) from each other by a 1.4 degree angle. The central swath is vertical. The large antenna 3 dB attenuation level (at transmission) and beam forming at reception allow images to be built and measure bathymetry at 120 degrees from the track axis of the boat (60 degrees to starboard and 60 degrees to portside). For bathymetry, the resolution across-track depends upon the measured depth H. The length across-track of a resolution cell is typically equal to H/100. The number of created soundings for one measurement is typically equal to 2000 (400 per swath). (Figure 26)

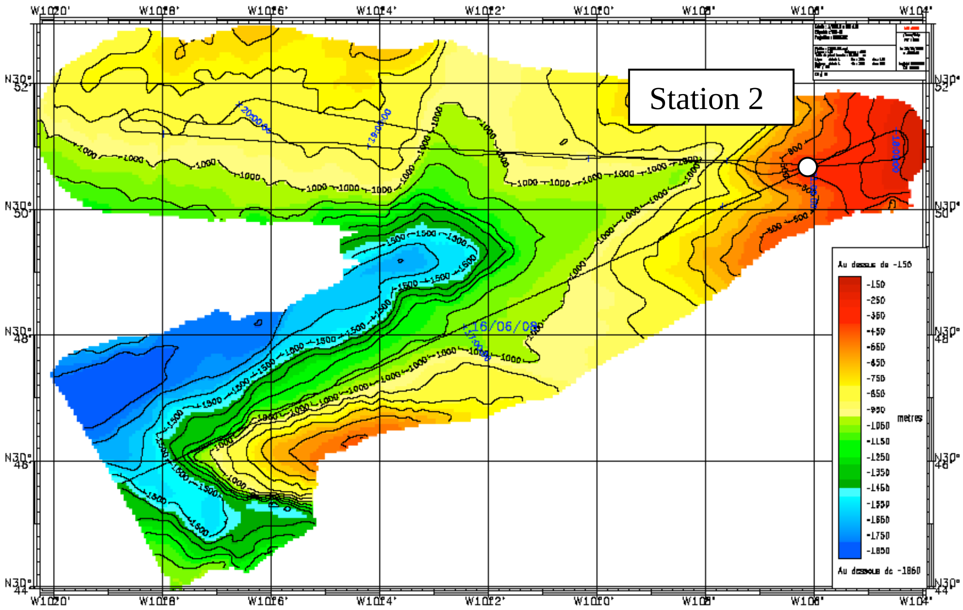


Fig 26: Part of bathymetric map created during AMOCINT cruise (station 2) (processed with Caraibes software).

The imaging system uses the reflectivity extracted from the five separated frequency swaths. A mosaic is created, geographically representing sea bottom level in the studied area. This mosaic is fed by the five sets of backscattered signal. The huge amount of data for each swath (18.000) and their redundancy allow a large geographic coverage and the relative increase of the signal-to-noise ratio.

Sub-bottom profiler The Seafalcon 11 echosounder also includes a sub-bottom profiler. This system is able to create reflectivity slices of the sub-bottom sea floor as a function of the geographical position of the boat. The central frequency used for this system is equal to 3.75 KHz. As for the "bathymetry and imaging" mode, the transmitted wave is linearly frequency modulated. The corresponding correlation gain is equal to 23 dB. The large transmitted bandwidth (1.6 KHz) achieves a small spatial resolution (0.31 metres).

As described above, beam forming from many signals received on each sensor provides a very narrow antenna diagram (high directivity), during emission (4.8 degrees) and reception (5.8 degrees). This beam formation also achieves a high acoustic signal level.

Five beams are created on reception (the central beam is vertical) and are separated from each other by 5 degrees. This diversity provides an opportunity to record good quality profiles when the across-track slope is steep. Typically, 100 meters penetrations are achieved for a 4000 meters depth (Fig. 27).

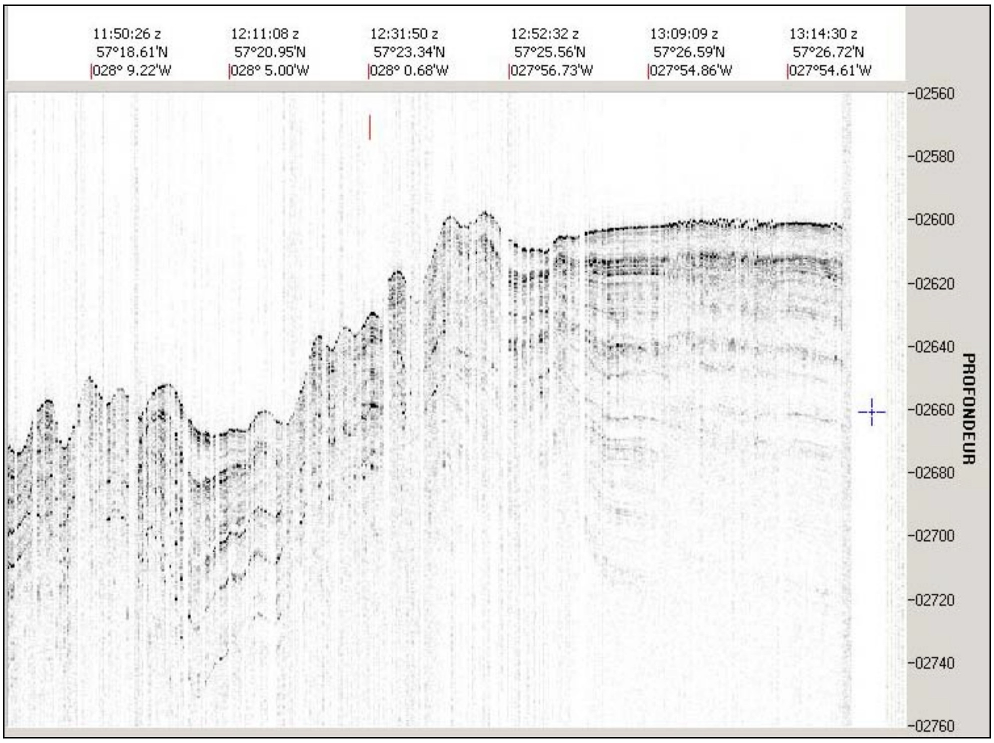


Fig 27: Sub-bottom profiling chart created at station 8 during AMOCINT cruise.

Post-processing The post-processing of bathymetry and imaging data is carried out with the "Caraibes" software, developed by I.F.R.E.M.E.R. This program enables:

• The creation of geographical digital data grids for bathymetry. Contour extraction, "spline" curves filtering and bi-dimensional digital filtering are examples of tools that can be used to remove any possible artefact. Delaunay triangulation (orthogonal method) was used during the MD168-AMOCINT cruise in order to remove noisy data**.** Three-D representations are possible.

• The creation of reflectivity mosaics for images. Filtering and contrast enhancement can then be applied. A version for real time display is also installed aboard " Marion Dufresne".

• To view sub-bottom profiles, IPEV has also developed a Windows-based software that is freely available to interested scientific teams.

10.2 Multi-Sensor track (Fig. 28)

The Geotek Multi-Sensor-Core-Logger installed on board the Marion Dufresne in the “MST” container is dedicated to the first measurements of physical properties of sediment cores. Measured properties are: P-Wave travel time, core diameter, and temperature; Gamma ray attenuation and low field magnetic susceptibility:

During the PACHIDERME cruise, we adopted the half core configuration. Working halves were passed through the MST. U-tubes taken from the Casq were analyzed only for the susceptibility because they necessitated a different calibration.

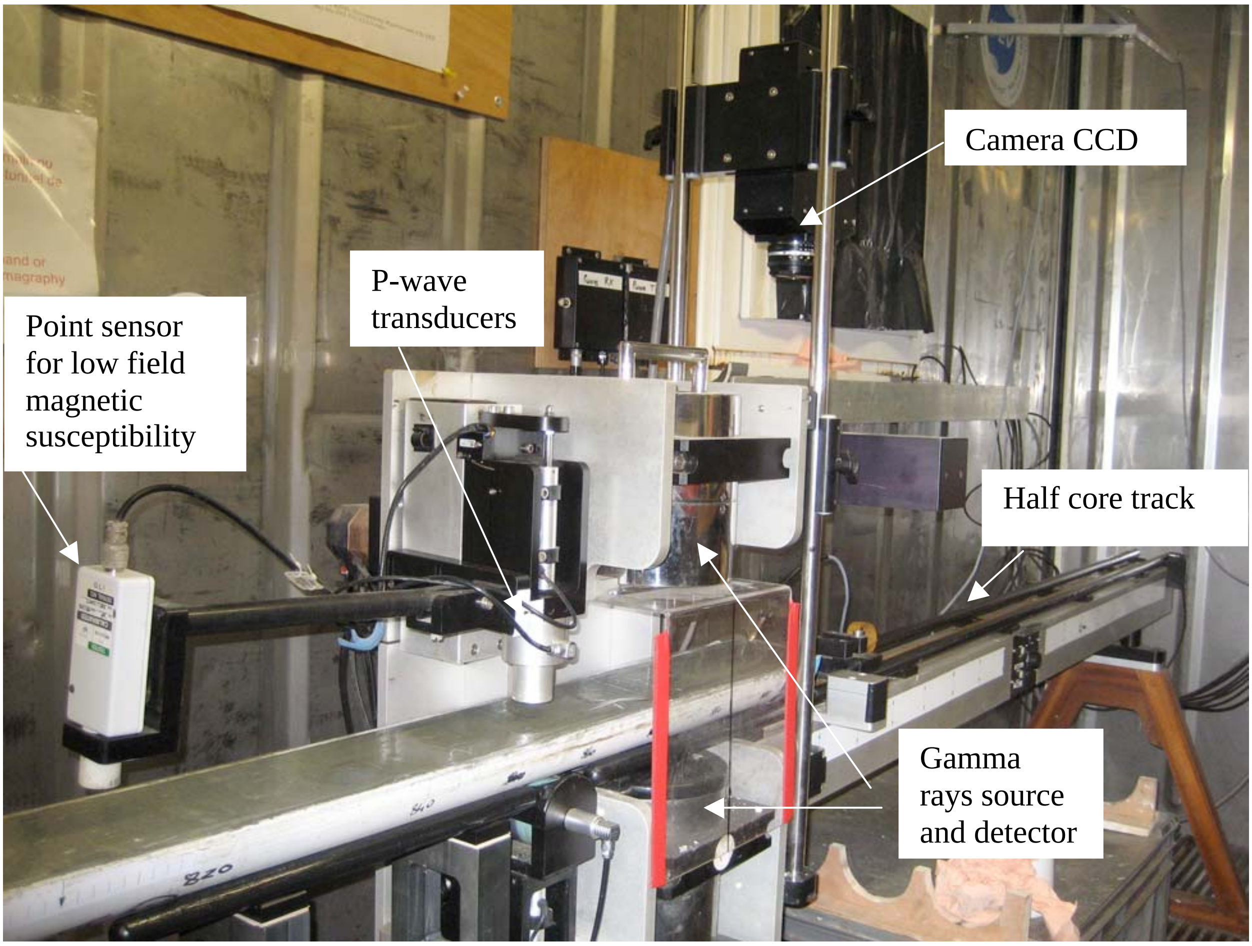


Figure 28: MST apparatus on board the Marion Dufresne during the AMOCINT cruise.

10.2.1. P-Wave travel time, core diameter, and temperature

A transducer generates ultrasonic compressional waves (P) and sends them across the sediment (Fig. 28). Another transducer receives the P-waves, which propagate across the sediment and core liner. The MST computer measures the travel time. The transducers are oil filled Acoustic Rolling Contact transducers. The active element is a piezo-electric crystal. The P-

Wave system is mounted vertically when the MST is configured for split cores. It features a moving vertical slide onto which the upper P-wave transducer is mounted. When split sections are measured, the upper transducer is moved up when sediment translates, and down for measurements.

A short P-wave pulse is produced at the transmitter. It propagates through the core and is detected by the receiver. Travel time of the pulse is measured with an accuracy of 50 ns. P-wave velocity can be calculated with a precision of about 1.5 m/s.

The upper transducer is lowered onto the split surface at each measurement step. The split surface is covered with a thin plastic film. A few drops of water spread along the surface of this film may improve the acoustic contact between transducer and sediment.

The P-wave velocity of the pulse through the sediments inside the core liner is given by:

V= H /TT where H is the sediment thickness and TT is the pulse travel time in the sediment.

The measured total travel time in the sediment is TOT = TT + PTO, where PTO is the P-wave Travel time Offset, which represents all the additional time delays. PTO includes the pulse travel time through the liner and the transducers faces, small electronic delays, etc…

Calibration allows us to determine the PTO. For that, a section of half liner is filled with distilled water and it is then placed between the transducers. The upper transducer is brought just in contact with the water surface.

Measured parameters are:

• Total Thickness D (cm)
• Total Liner Thickness W (cm)
• T = water temperature

Sound velocity in distilled water (V) at Temperature T is obtained from a table.

From TOT, PTO is calculated by PTO = TOT – (D-W)/V

PTO is then entered in the GEOTEK program when processing data.

The acoustic impedance is calculated as the product of the P-wave velocity and density.

A separate sensor measures changes in core diameter. This enables compression wave velocity and density to be corrected for changes in core diameter.

The temperature of the sediment is also recorded because temperature affects the calculation of P-wave velocity. Measurement of the sediment thickness is also routinely performed. Core thickness is the effective distance between the active faces of the two P-Wave transducers. In practice, deviation from a reference thickness is recorded. For halve cores reference thickness is 5 cm.

10.2.2 Gamma ray attenuation (Fig. 28)

A narrow beam of gamma rays (5 mm diameter) is emitted from a Cs-137 source with energy around 0.662 Mev. The photons pass through the core and are detected on the other side. The small Cs capsule is securely housed inside a 150 mm diameter lead filled cylinder.

The gamma ray detector consists of a scintillator and a photo-multiplier tube. Impulses from the detector unit are sent to a counter board in the main electronics rack. The basic equation for calculating bulk density is r = (1/µ *d) * ln (I0/I) where:

r = sediment bulk density

d = sediment thickness

µ = Compton attenuation coefficient

I0 = the gamma source intensity

I = the measured intensity through the sample.

Attenuation through the liner and the water is used to obtain the bulk density of the sediment. Calibration consists of counting the gamma rays passing through a known thickness of water (for instance close to the mean sediment thickness) and through water + pieces of aluminium of different thickness. The total thickness Al + water must remain constant.

A plot of Ln (count) versus average density (which of course depends on the thickness of Al) is then made and fit with a 2nd order (parabolic) polynomial (Figure 29).

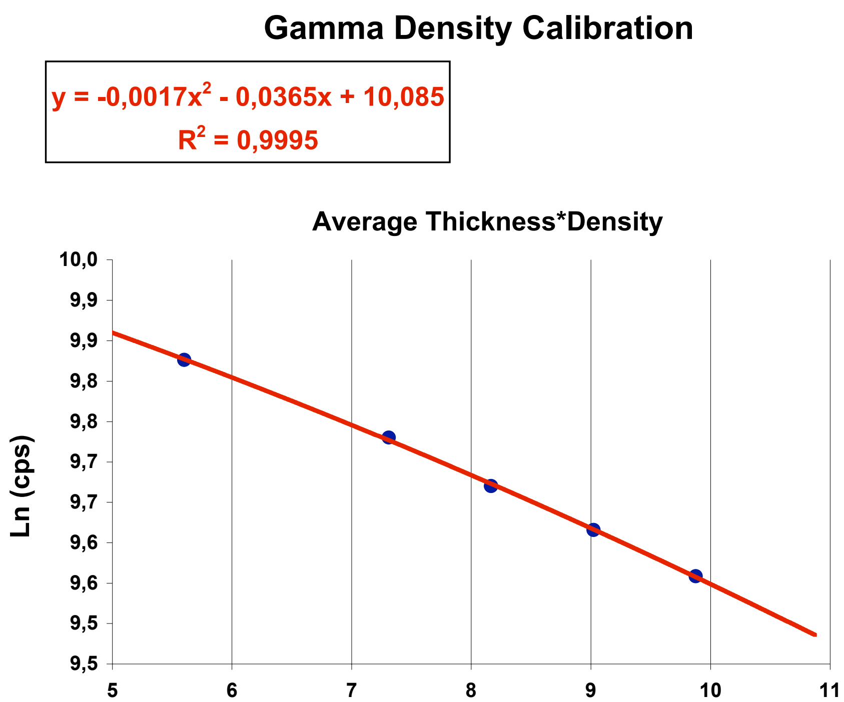


Figure 29: calibration curve of the gamma density during the Amocint

The polynomial coefficients give A, B and C, which have to be entered in the GEOTEK program when processing the data. Note that the curve is not exactly a straight line because of secondary effects (beam dispersion, etc.).

A count time of 20 s has been used when doing gamma attenuation calibration

Porosity can be calculated from sediment density assuming:

- the sediment is fully saturated
- the mineral grain density is known (MGD = 2.75)
- the fluid density is known (WD = 1.026)

Then, the fractional porosity is obtained by FP = (MGD- r)/(MGD-WD)

10.2.3 The low-field magnetic susceptibility (Fig. 28)

Magnetic susceptibility results from diamagnetism, a natural property of any matter (in general negligible), paramagnetism which is associated to the presence of magnetic spins at the atomic and/or molecular scale (clays), and ferro/ferri/antiferro magnetism, in which a magnetic order exists over long distances at the atomic scale (over thousand of atoms and more in crystalline matter). Metallic oxides may exhibit ferro/ferri/antiferro magnetism.

An oscillator circuit in the sensor produces a low intensity alternating magnetic field. The presence of magnetic material near the sensor changes the inductance of a small coil, which is detected by the electronics (change in the resonance frequency of an electric circuit which includes the coil). The Bartington point sensor is automatically lowered onto the core surface at each measurement. This sensor is used at a sampling rate of 1.0 Hz (1 s period). The unit of measurement is 10^{-5} SI. The point sensor (MS2E) has a rectangular sensibility area defined by 50% maximum response which is 3.8 mm x 10.5 mm. It measured only the surface of the sediment. When the latter is not flat or when the half core is not filled it completely, then the point sensor might measure air or water and give largely underestimated values. The Multi-Sensor-Core-Logger is mounted horizontally on floor. For the AMOCINT cruise, it was configured for half sections, obtained after longitudinal splitting of the core sections. Core sections (with plastic end caps sometimes for liquid sediments) are 150 cm long and about 50 mm height (half cylinder obtained after splitting).

Susceptibility measurements were done every 2 cm for all the cores. ASCII files with the raw data and the processed data were created for each core. Figures were then made from the processed data files by using Excel software.

10.3 GEOSCAN DIGITAL IMAGING *(adapted from the GEOTEK MSCL Manual)*

10.3.1 Introduction

The GEOSCAN colour line scan camera is a 3 CCD device using 3 * 1024 pixel CCD arrays. Light from the object passes through the lens and is split into 3 paths by the beam splitter to fall on the red, green and blue detectors which, when combined, reproduce a conventional colour image (Fig. 39).

All CCD detectors are sensitive to light in the 400 to 950 nm waveband. However they are relatively insensitive to light at shorter wavelengths (400-500nm - the blue end of the spectrum) than at the longer wavelengths of the visible spectrum wavelengths (600-700nm - the red end of the spectrum). Consequently the beam splitter is designed to direct 50% of the light towards the blue detector while 25% each is directed at the red and the green sensors.

To ensure that there is minimal overlap between the wavebands in the 3 channels (red, green and blue), the light leaving each exit face of the splitter passes through a dichroic colour interference filter before falling on the detector which is located at the focal plane of the lens.

For normal RGB imaging the Geoscan system uses high frequency fluorescent lamps which produce light in 3 main wavebands corresponding to the red, green and blue parts of the spectrum. The light unit uses 2 fluorescent tubes that illuminate the core evenly from both sides of the image line. This provides a flooded illumination that minimizes any shadow effects that could be caused from micro-topographic effects. The camera is arranged directly above the light and "looks" through a slot in the top surface of the light unit. Spurious reflections are eliminated by black anodising both the camera and light units.

Synchronisation between the camera and the track is achieved by using the stepper motor pulses to trigger the line acquisition of the camera with no optical distortion from the lens in the down-core direction. Motor speed defines the time between pulses and hence the integration period (exposure time). The software-controlled pulse divider allows the distance between scans, i.e. down-core resolution, to be defined.

A software convergence routine applies a correction that compensates for any minor mechanical differences between the 3 sensor arrays. Offset correction ensures that the 3 channels are referenced to a true black level. This is achieved by measuring the signal level of the black reference pixel for each sensor. Gain correction compensates for pixel-to-pixel response variation, uneven lighting, and lens effects. Lenses tend to darken the edges of the field of view, an effect which becomes more pronounced with increasing aperture. To correct for all of these the camera images a white tile and a software gain correction is calculated for each pixel. This correction is then applied to subsequently acquired image data.

10.3.2 Image data

The corrected data are stored in a BMP format with appended depth and calibration information that can then be read by the image replay software.

The files created by the GEOTEK Digital Imaging software are in the Windows bitmap format. The file structure that is used for the data files as stored in the core directory is im00X_01.bmp where X is the section number. RGB data are retrieved from the data files using the Geotek software: Images tools

The spectra are defined from a band of 5 cm width at the center of each section and they are stored as a text file: X. Then, a composite data file is made using Microsoft excel and the edge effects cleaned. The data are plotted together with the reflectance data (L*, a*, b*) obtained using the Minolta Spectrometer (see below).

The Images are first converted into JPEG format and modified (essentially made lighter). They are then reported in a template so that 15 sections are shown at the same time.

10.4 Colour reflectance using the Minolta Spectrometer

It is standard procedure onboard a research vessel for cores to be subject to visual description and a series of preliminary measurements, typically including magnetic susceptibility, GRAPE (Gamma Ray Attenuation Porosity Evaluator), P-wave velocity and video capture. An important and easily measurable sediment property, spectral reflectance (Mix et al, 1992; Balsam et al, 1997), allows a standardized examination of visual sediment-properties. In this mission, the data obtained by reflectance spectrophotometry analyses of sediment samples from AMOCINT cruise is used to identify changes in the optical sediment properties and use them for correlation between different cores and stations.

Spectral analysis of the cores were carried out onboard the *Marion Dufresne* using a Minolta CM-2006 spectrophotometer (device provided by French scientists on board the AMOCINT cruise: Savoie University and Lille University) (Fig. 30). This instrument measures spectral data by flashing light from an internal, pulsed, xenon arc lamp through an 8 mm circular aperture and measuring the wavelengths reflected by the sediment. Measurements were taken at 10 nm increments over the range 400 to 700 nm. The downcore interval usually was 2 cm, some cores (MD08-3180, -3181) were measured in 1cm steps, since they revealed fine scale laminations. Cores MD08-3209 and MD08-3210 were measured every 2 cm. These analyses were done immediately after the cores were opened. After opening, the surface of the cores were cleaned and covered with polyethylene film to prevent water loss, minimize color changes due to oxidation (Chapman and Shackleton, 1998) and avoid contamination of the spectrophotometer. The effects of water loss and/or oxidation during the thirty minutes that lapsed between core opening and spectral analysis can be considered negligible.

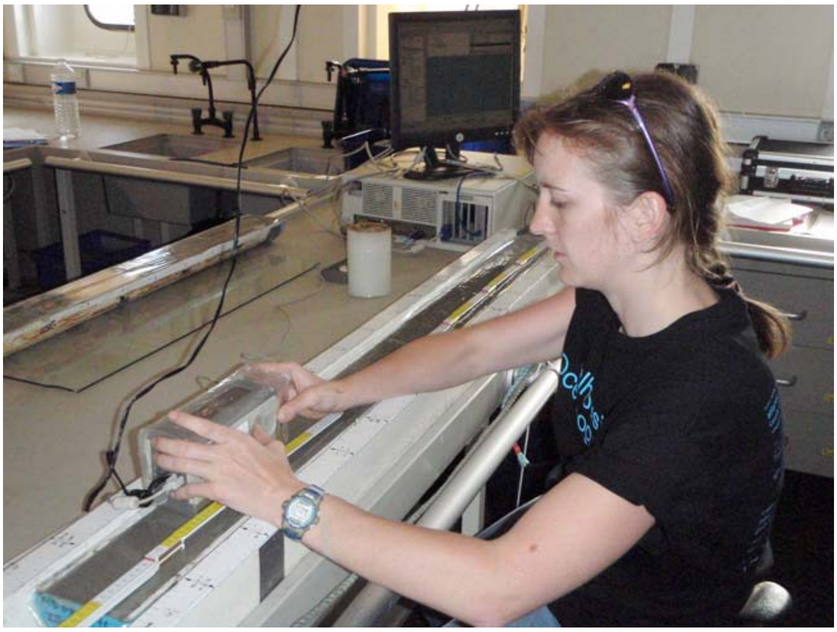


Fig. 30: measurements made (here by Nathalie) every 2 cm in each half core with the spectrophotometer.

Spectral measure-ments were taken directly on the core surface through the polyethylene film, however, care was taken to use a polyethylene film with physical and optical properties that would not bias the color (a*, b*) and brightness (L *) measurements.

We used the Specular Component Excluded - CIE L*a*b* mode (Minolta CM-2006 handbook) in order to eliminate any bias due to specular reflection. The L*a*b* mode covers the whole spectrum perceived by the human eye; it is independent of any color reproduction technology, and therefore of any peripheral apparatus. It includes the mode colors RGB and CMYK. Analyses were carried out using a D65 illuminant, which corresponds to average daylight, with a color temperature of 6504K. Chapman and Shackleton (1998) recommended calibrating the instrument with respect to a white standard covered with polyethylene film; although, we decided to calibrate the spectrophotometer without the polyethylene film because the instrument is set up to identify specific reflectance values stored in its internal memory (Debret et al., 2006). Calibration was performed using a white calibration tile referenced to an international $BaSO_4$ standard. A white and zero calibration were performed at the beginning of each core.

10.5 Sedimentology

The shipboard sedimentologists were responsible for describing the lithology and stratigraphy of sediments that were recovered by the RV Marion Dufresne. This providesthe first complete descriptions of the cores, which are used by shipboard and shore-based scientists. Immediately after opening and cleaning the surface from any cutting disturbance, the description of the sediments within the cores were carried out using the visual core description form (a detailed summary of stratigraphy, bed thickness, lithology and structures of the sediment) (Fig. 31.

Fig. 31: Janne and Sebastian describing a core during the AMOCINT cruise (photo M. Sadovnik).

Lithology, sedimentary structures, texture, fossil content and coring disturbances were described for each core section. In detail, four major characteristic of each bed are:

- Thickness and texture
- Sedimentary structure and bedding planes
- Lithology and color (according to the Rock Color Chart, GSA)
- Degree of disturbance by coring process

The original sedimentological description sheets have been stored and all descriptions were documented with the software package Adobe Illustrator ©, using a lithology template file containing patterns following the standard ODP sediment classification scheme, a modified version of the lithologic classification of Mazzullo et al. (1988); see below.

The location and nature of sedimentary structures, the occurrence of ichnofossils, major groups of macro- and microfossils, as well as lithologic accessories such as pyrite, lithoclasts, dropstones, laminae, shell debris and clusters of volcanic ash grains are shown in the core description sheet, which also includes a photo of each core section described. The symbols used to designate structures found in each core are shown in the legend to the core description. Sediments were named on the basis of color, composition and texture using a principal name together with major and minor modifiers. We used the classification of granular sediment: principal names are defined by granular sediment class and by color and state of bioturbation. The major and minor modifier describes the texture, composition, and fabric. Each granular sediment has a unique set of principal names (e.g. silty clay with sand). The visual inspection was supplemented by microscopic examination of smear slides and microscopic investigations of washed sand fractions with the shipboard ZEISS Microscope and binocular. These smear slides of unconsolidated material were prepared aboard ship to document the lithology of recovered sediment.

References

Balsam, W.L., Damuth, J.E., Schneider, R.R., 1997. Comparison of shipboard vs shore-based spectral data from Amazon Fan cores: implications for interpreting sediment composition. Ocean Drilling Program Science Vol. 155s, 193-215.

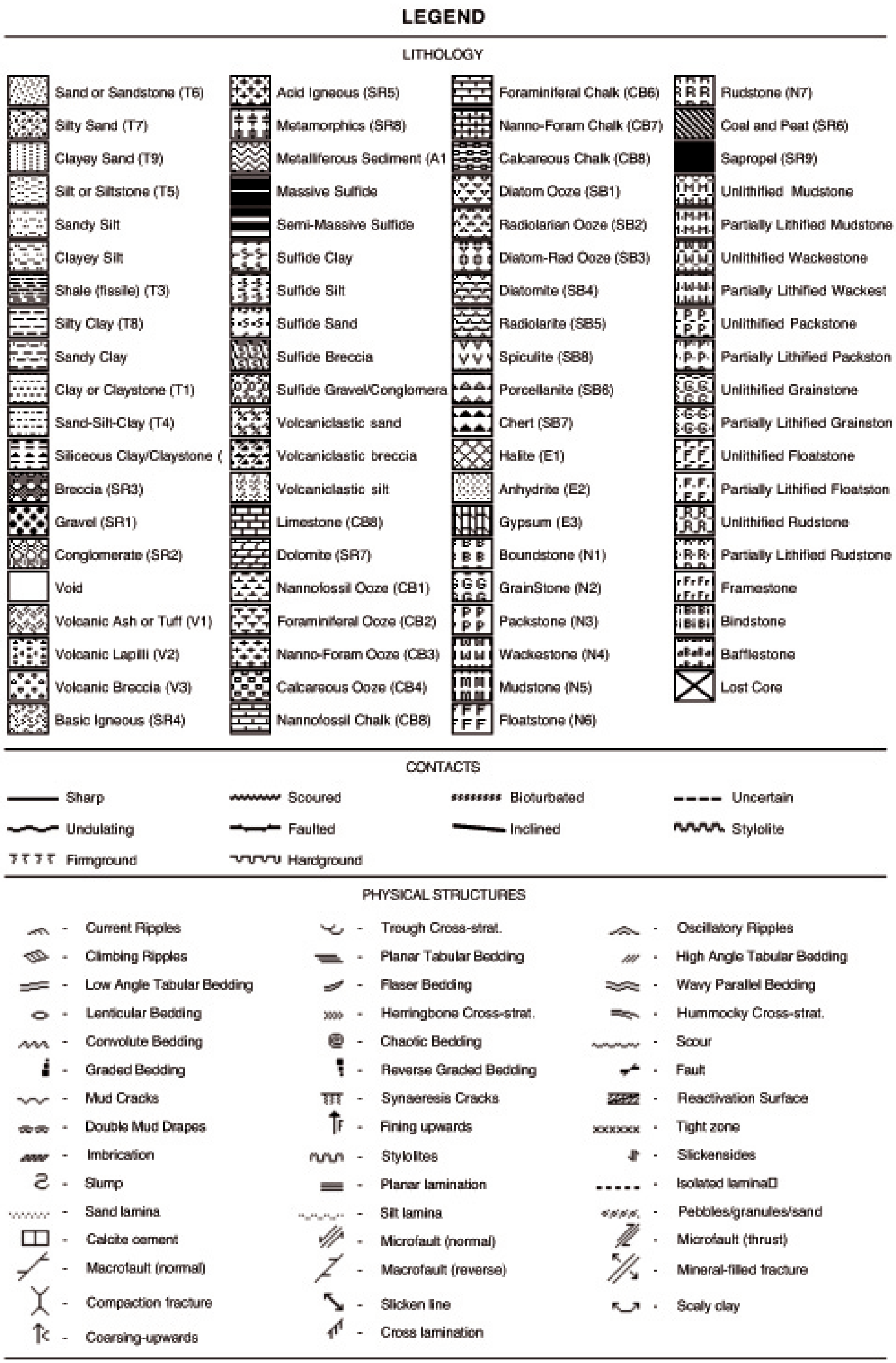
Chapman M.R., Shackleton J., 1998. What level of resolution is attainable in a deep-sea core? Results of a spectrophotometer study. Paleoceanography, 13 (4), 311-315.

Debret, M., Desmet, M., Balsam, W., Coppard, Y., Francus, P., Laj, C., 2006. Spectrophometer analysis of Holocene sediments from an anoxic fjord : Saanich inlet, British columbia, Canada. Marine Geol. 229, 15-28.

Mix, A.C., Rugh, W., Pisias, N.G., Veirs, S., Leg 138 Shipboard Sedimentologists (Hagelberg, T., Hovan, S., Kemp, A., Leinen, M.,Levitan, M., Ravelo, C.) and leg 138 Scientific Party 1992. Color reflectance spectroscopy: a tool for rapid characterization of deep-sea sediments. In Mayer, L., Pisias, N., Janecek, T.et al., Proc. ODP, Init. Repts., 138 (Pt. 1): College Station, TX (Ocean drilling Program), 66-67.

Mazzullo, J.M., Meyer, A., and Kidd, R.B., 1988. New sediment classification scheme for the Ocean Drilling Program. *In* Mazzullo, J., and Graham, A.G. (Eds.), *Handbook for Shipboard Sedimentologists*:.ODP Tech. Note, 8:45-67.

MD08- Core description Legend

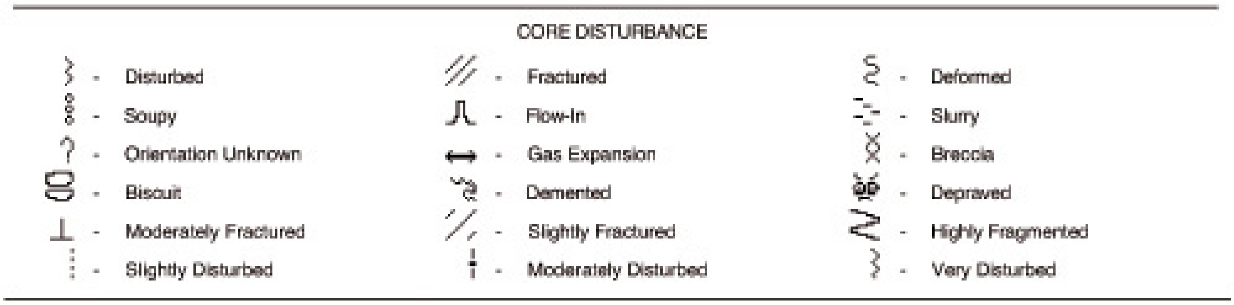


LITHOLOGIC ACCESSORIES

- Sand Lamina	- Silt Lamina	Shale Lamina
- Pebbles/Granules	- Coal Lamina	- Breccia Horizon
254 Organic Shale Lamina	- Calcareous	- Dolomitic
Sid - Siderite	- Bentonite	Sm - Smectite
Gl - Glauconitic	Fld - Feldspathic	Lth - Lithic
- Cherty	Kaol - Kaolinitic	Py - Pyrite
Fe - Ferruginous	- Rip Up Clasts	- Charcoal Fragments
Wd - Wood Fragments	- Shell Fragments	Palsl - Paleosol Horizon
Ch - Chlorite	Mc - Micaceous	S - Sulfur
Q - Quartz Crystals	- Oolitic	- Pisolites
- Grapestone	- Coated Grains	- Fecal Pellets
- Peloids	- Anhydritic	- Fossil fragments
- Hematite concretion	- Nodule/concretion, general	- Ferruginous concretion-
- Siderite concretion-	- Chalcedony/chert concretion-	- Undefined burrow
- Pteropods-	- Pelecypods	- Fining in both dir
- Calcite concretion-	- Dolomite concretion-	- Pyrite concretion-
- Birdseye structure,keystone vugs-	- Crystal ghost-	- Cone in cone structure-
- Boxwork structure-	- Chalcedony cement-	- Calcite cement-
- Cement, general-	- Fossil ghost-	- MOTTLED
- Mud Clasts	- Dropstone	- Lithoclast
- Water escape	- Clast imbrication	- Thin ash layer
- Coral fragment	- Gastropod	- Manganese precipitation-
- open burrow-	- lenticular foram-filled pockets (bioturbation)-	- clay filled lenticular pocket-
- volcanic ash pocket		- sand lens or pocket
- pumice clast	- black spot	
	- wood fragment-	

FOSSILS

- Algae, (undifferentiated)	- Algal Stromatolite	- Brachiopods
- Bryozoa (fenestrate)	- Bryozoa (tube-like)	- Calcispheres
- Chara	- Conodonts, Scolecodonts	- Corals (colonial)
- Corals (solitary)	- Crinoids	- Diatoms
- Echinoderms	- Fish Remains	- Fish Scales
- Foraminifera (undifferentiated)	- Foraminifera (pelagic)	- Foraminifera (benthonic)
- Graptolites	- Hydrozoa	- Molluscs (undifferentiated)
- Belemnites	- Cephalopods	- Gastropods
- Pelecypods	- Rudists (undifferentiated)	- Tentaculites
- Ostracods	- Plant Remains	- radiolarians
- Spicules	- Spines	- Sponges
Sp - Spores, Pollen	- Stromatoporoids (undifferentiated)	- Stromatoporoids (lamellar/tabular)
- Stromatoporoids (spherical/nodular)	- Stromatoporoids (hemispherical/massive)	- Stromatoporoids (branching/Stachyodes)
- Stromatoporoids (undiff. Amphipora)	- Stromatoporoids (Amphipora, lamellar)	- Trilobites
		- Bryozoa (flat robust branching)
- Vertebrates	- Bryozoa (foliose)	- Bryozoa (articulated zooidal)
- Bryozoa (delicate branching)	- Bryozoa (articulated branch)	- Bryozoa (vagrant)
- Bryozoa (encrusting)	- Bryozoa (nodular/arborescent)	- Rhodolith
- Coral (azooxanthellate)	- Serpulid	- Scaphopod
- Foraminifera (small benthic)	- Foraminifera (large benthic)	



11. Data Management and Long–Time Archive – IMAGES rules

All shipboard data was obtained, analyzed and plotted on board. Documentation for each core consists of an “identity” form giving all the characteristics of the coring operation and the problems/observations encountered/made on the deck. This is followed by a station map, a subbottom profile, the sedimentology description and core photography, as well as plots of the MST data and color-reflectivity data. The complete documentation in PDF format is included in the report on CD. It is also available at the IMAGES website: www.images-pages.org. As an example, the documentation of one complete site is included below. All shipboard data will be exclusively available to the scientific shipboard party for the next two years. Any request should be addressed to the PIs of each core within the 2-year moratorium period and also after in order to avoid any conflict of interest.

12. Example of data from a station as reported in the CD

The complete documentation of all sites and cores consists of numerous pages and is included in the CD (attached to the front cover). In the CD, the data are reported as described below and they are grouped region per region. The data from the two cores off Portugal and made during the MD169 cruise are reported at the end.

Here we give as an example of how the data are presented for each site, the three different types of cores taken at station 1. For each core, the following items are provided:

- an identification form of the core with the coring parameters and all the comments made on the deck while cutting the core.
- the main characteristics (location, length) of the core, the route of the ship during the short survey and the 3.5 kHz profile.
- the sedimentary description (not for the multicore)
- the photographs of the core (not for the multicore)

- the reflectivity curves from camera scan (R, G, B parameters) and from spectrophotometer measurements (L*, a*, b* parameters) (not for the multicore)

- the curves obtained from measurements at MST (P-wave amplitude and velocity, density, porosity and magnetic susceptibility) when measured (*i.e.* Calypso cores). For the Casq cores, only the susceptiblity was measured. No measurement for the multicore.

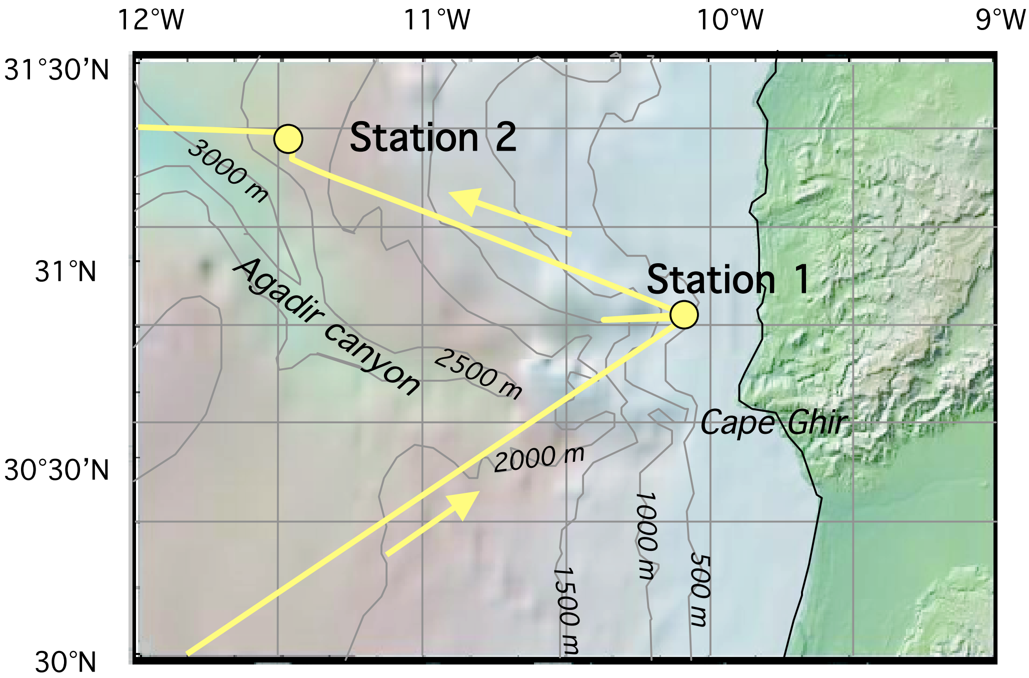
At the end of the CD the messages sent to the different school teachers within the Core-Education Program are also reported.

Photos A. Van Toer, D. Catelain, C. Kissel

MD168-AMOCINT

IMAGES XVII

2008



Station 1: MD08-3174Cq; MD08-3175Mc;
MD08-3176; MD08-3177

Station 2: MD08-3178

IMAGES XVII, 2008
MD 168/AMOCINT

Date : 16/06/08
N° de station : 01

Météo : (force) / Direction
Vent :
Mer :
Variation tension (maxi) :

CAROTTE (N°) :

MD08- 3174 Cq

(MD - année - milles - centaines)

CAROTTE (longueur) :

8.66 m

POSITION :

Latitude : **30°50.70'N**

Longitude : **010°05.83'W**

CAROTTIER (type) (1) **:** **CASQ**

Poids total (air) : **7,00 t**

Poids total (eau) : **6.5 t**

REGLAGES :

Tubes (longueur) : 12,00 m

CONTREPOIDS :
Type (2) :

Longueur PVC : m

Pénétration : m

Longueur de carotte : m
+ Ogive (+ 0,15 m)

PARAMETRES MESURES :

Sonde corrigée : 361 m

Ligne filée : 348 m

Arrachement/total *(tonne)* : 14,00 t

Arrachement/différentiel *(tonne)* : t

Pénétration/apparente *(m)* : m

Pénétration/tensiomètre *(m)* : m

HEURES (GMT)

En station : 21:05

Début manœuvre : 21:54

toucher 22:17

Fin de manœuvre :

Durée de manœuvre :

Départ station :

INSTRUMENTATION OPERATIONS ANNEXES

Pinger :

Flux de chaleur :

CTD (hydro) :

CTD (bouteilles) :

Filet à plancton :

Autres :

Description / incidents : 1 gasteropode at 865 cm (in plastic bag)

I	II	III	IV	V	VI

	raw	repository	I Top	I Bottom	II Bottom	III Bottom	IV Bottom	V Bottom	VI Bottom
U (6 cm)	A	BCCR	0	156	311	467	623	778	866
U (6 cm)	B	BCCR	0	156	311	467	623	778	866
U 6 cm)	C	Gif	0	150	300	450	600	750	866
u-channel paleomag	a	Gif	0	152	304	454	606	758	866

(1) CALYPSO - CALYPSO GRAVI/FLUX - BOX CORER 1/4m ou carré géant

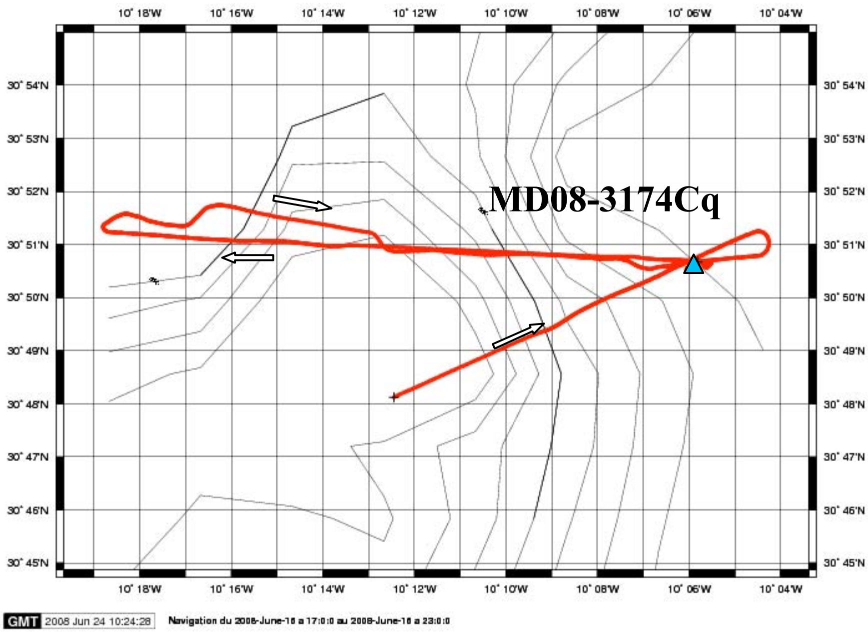
(2) Cylindrique 100 kg / Plat / Préleveur

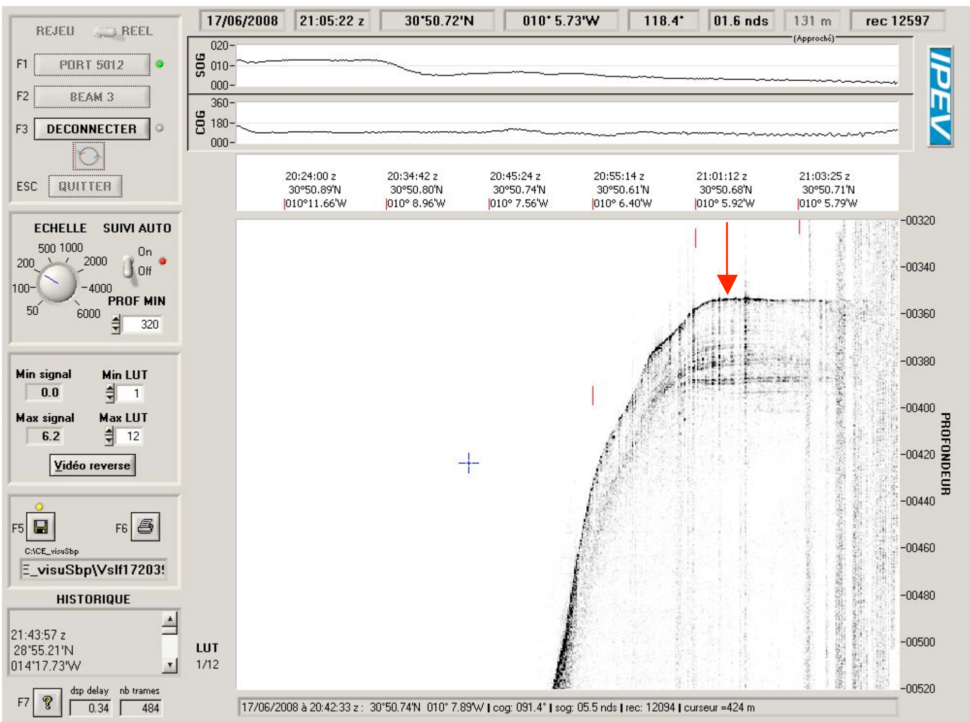
MD168- AMOCINT IMAGES XVII

MD08-3074Cq Casq **16/06/08, 22h17 UTC** **Station 1**

Core length : 8.66 m **Lat : 30°50.70'N** **Long : 010°05.83'W**

Water depth : 361 m



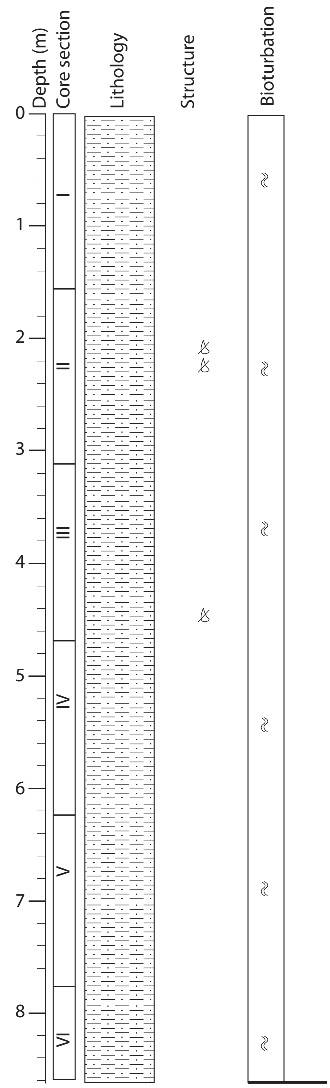


2008
MD 168 - AMOCINT

Sediment description

page 1/1

Station 1
Core MD 08-3174 Cq



Comments

silty clay, bioturbation throughout

0-156 cm: gradually changing from moderate brown (5 YR 4/4)
to grayish brown (5 YR 3/2)

156-311 cm: grayish brown (5 YR 3/2)
182 cm: shell fragment
224 cm: shell fragment

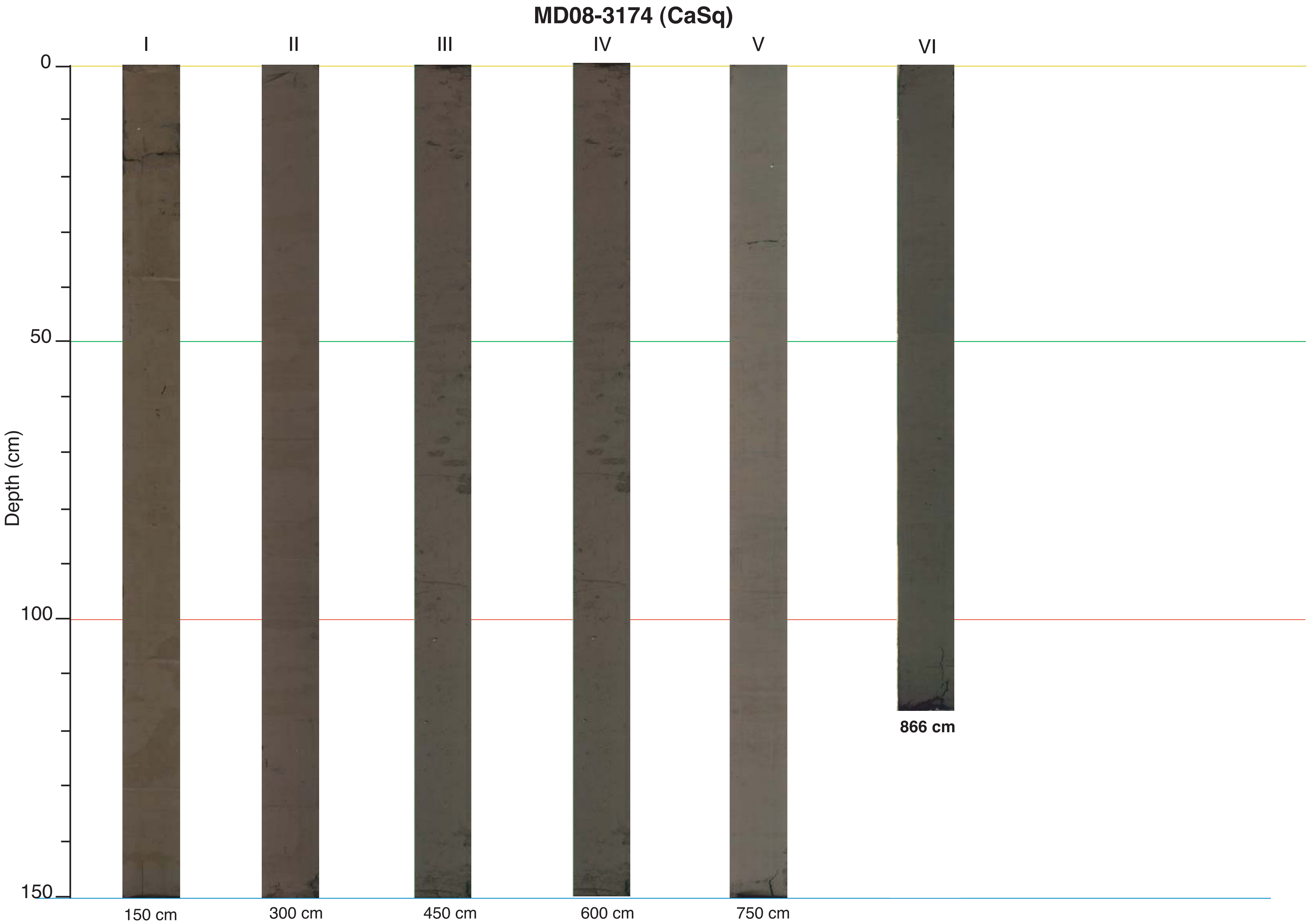
311- 467 cm: gradually changing from grayish brown (5 YR 3/2)
to dark yellowish brown (10 YR 4/2)

441 cm: shell fragment

623-778cm: gradually changing from dark yellowish brown (10 YR 4/2)
to a shade inbetween pale brown (5YR 5/2)
and grayish brown (5 YR 3/2)

778-866 cm: olive gray (5 Y 3/2)

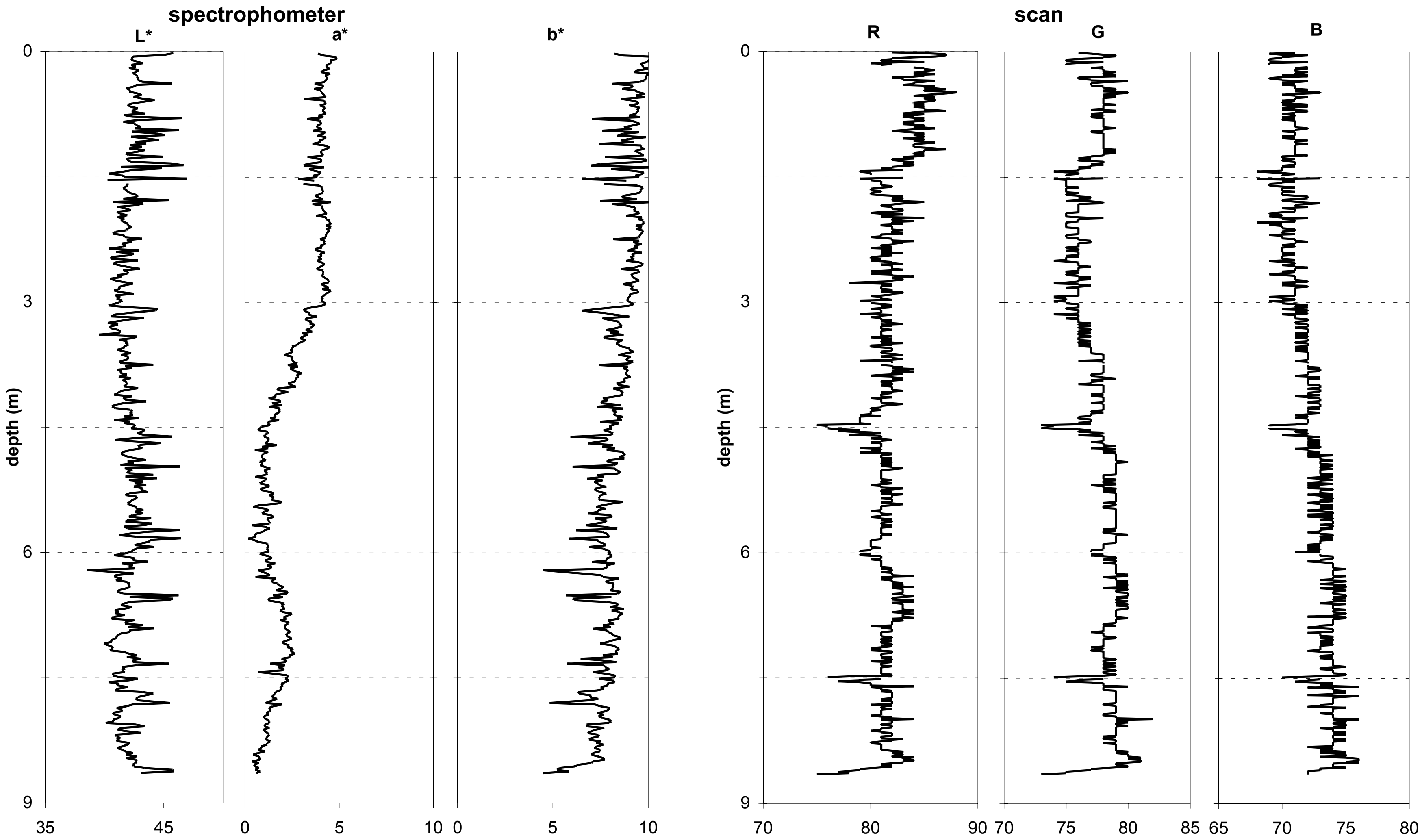
866 cm: end of core


MD08-3174 (CaSq)
I
II
III
IV
V
VI
0
50
100
150
Depth (cm)
150 cm
300 cm
450 cm
600 cm
750 cm
866 cm

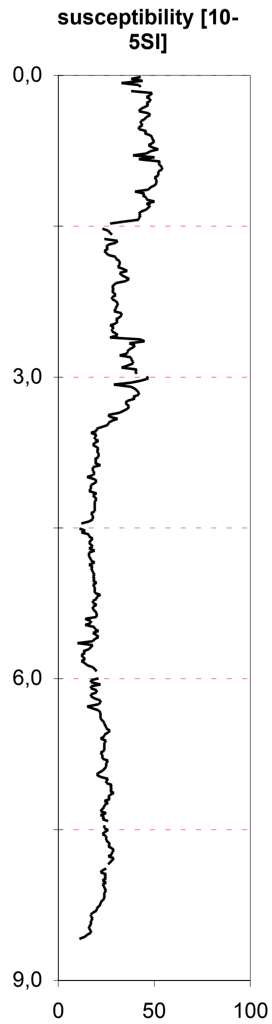
IMAGES XVII, 2008
MD168-AMOCINT

COLOUR REFLECTANCE

Station 1
MD08-3174Cq Calypso



Multi-sensor Core Logger



IMAGES XVII, 2008
MD 168/AMOCINT

Date : 17/06/08
N° de station : 01

Météo : (force) / Direction
Vent :
Mer :
Variation tension (maxi) :

CAROTTE (N°) :

MD08- 3175 MC

(MD - année - milles - centaines)

CAROTTE (longueur) :

4 x 0.5 m

POSITION :

Latitude : 30°50.70'N

Longitude : 010°05.82'W

CAROTTIER (type) (1) **:** **MULTICORE**

Poids total (air) : t

Poids total (eau) : 0.6 t

REGLAGES :

Tubes (longueur) : 0,50 m

Câbles :
Chute libre : m

Boucle : m

LC poids : m

CONTREPOIDS :
Type (2) :

Longueur PVC : m

Pénétration : m

Longueur de carotte : m
+ Ogive (+ 0,15 m)

PARAMETRES MESURES :

Sonde corrigée :	359	m
Ligne filée :	368	m
Arrachement/total *(tonne)* :	1.5	t
Arrachement/différentiel *(tonne)* :		t
Pénétration/apparente *(m)* :		m
Pénétration/tensiomètre *(m)* :		m

HEURES (GMT)

En station :	
Début manœuvre :	23:42
toucher	00:01
Fin de manœuvre :	
Durée de manœuvre :	
Départ station :	

INSTRUMENTATION
OPERATIONS ANNEXES

Pinger : OUI

Flux de chaleur :

CTD (hydro) :

CTD (bouteilles) :

Filet à plancton :

Autres :

Description / incidents : 4 FULL CORES TO BCCR

(1) CALYPSO - CALYPSO GRAVI/FLUX - BOX CORER 1/4m ou carré géant

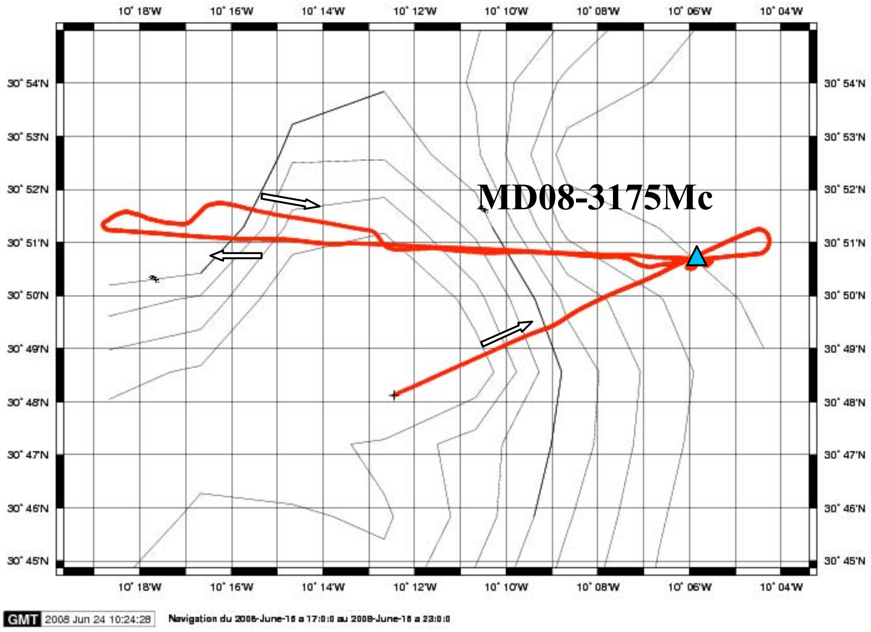
(2) Cylindrique 100 kg / Plat / Préleveur

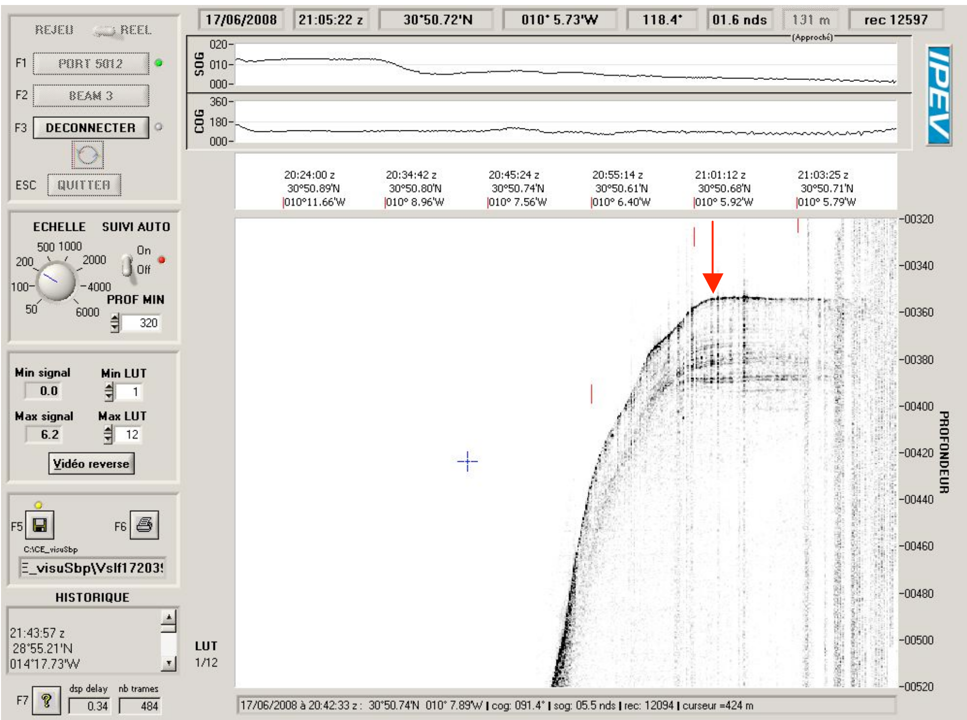
MD168- AMOCINT IMAGES XVII

MD08-3075MC Multicorer 17/06/08, 00h01 UTC Station 1

Core length : 0.5 m Lat : 30°50.70'N Long : 010°05.82'W

Water depth : 359 m





IMAGES XVII, 2008
MD 168/AMOCINT

Date : 17/06/08
N° de station : 01

Météo : (force) / Direction
Vent : 28 Nds
Mer : calme
Variation tension (maxi) :

CAROTTE (N°) :

MD08- 3176

(MD - année - milles - centaines)

CAROTTE (longueur) :

29.77 m

POSITION :

Latitude : **30°50.67'N**

Longitude : **010°05.82'W**

CAROTTIER (type) [(1)] **:** **CALYPSO II**

Poids total (air) : **6.7 t**

Poids total (eau) : **6.3 t**

REGLAGES :

Tubes (longueur) : **37.57 m**

Câbles :
Chute libre : **1.5 m**

Boucle : **3,00 m**

LC poids : **m**

CONTREPOIDS :
Type (2) :

Longueur PVC : **m**

Pénétration : **m**

Longueur de carotte : **m**
+ Ogive (+ 0,15 m)

PARAMETRES MESURES :

Sonde corrigée : **360 m**

Ligne filée : **328 m**

Arrachement/total *(tonne)* : **t**

Arrachement/différentiel *(tonne)* : **t**

Pénétration/apparente *(m)* : **m**

Pénétration/tensiomètre *(m)* : **m**

HEURES (GMT)

En station :

Début manœuvre : **02:39**

Déclenchement : **03:38**

Fin de manœuvre : **04:46**

Durée de manœuvre :

Départ station :

INSTRUMENTATION
OPERATIONS ANNEXES

Pinger :

Flux de chaleur :

CTD (hydro) :

CTD (bouteilles) :

Filet à plancton :

Autres :

Description / incidents : corer bent - gaz: extrusion of sediment (12 cm between sections XII and XIII)
liner damaged at the top of section I on about 10-15 cm

0–150	150–300	300–450	450–600	600–750	750–900	900–1050
I	II	III	IV	V	VI	VII

1050–1200	1200–1350	1350–1500	1500–1650	1650–1800	1800–1950	1950–2100
VIII	IX	X	XI	XII	XIII	XIV

2100–2250	2250–2400	2400–2550	2550–2700	2700–2850	2850–2977
XV	XVI	XVII	XVIII	XIX	XX

Working and Archive halves at Bergen, u-channels at Gif

(1) CALYPSO - CALYPSO GRAVI/FLUX - BOX CORER 1/4m ou carré géant

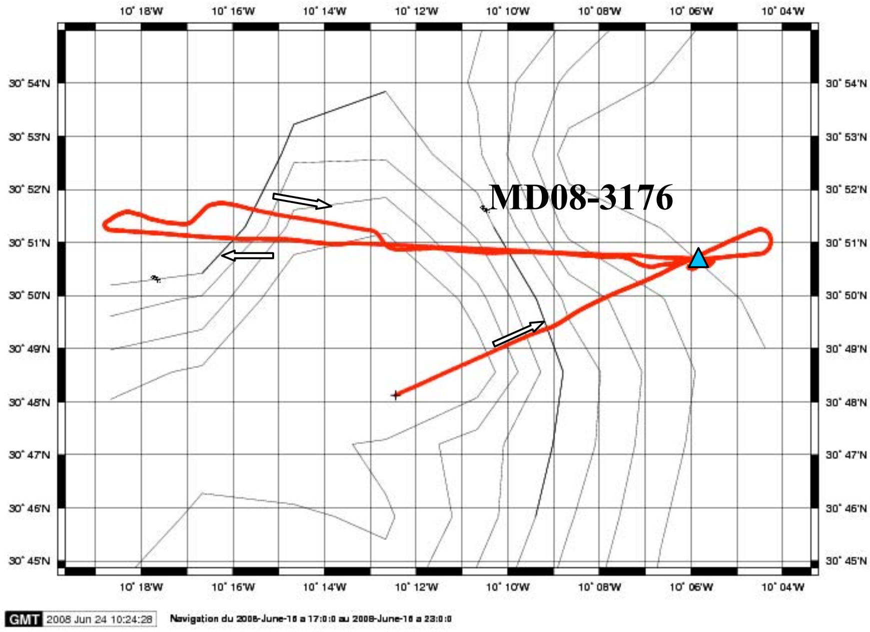
(2) Cylindrique 100 kg / Plat / Préleveur

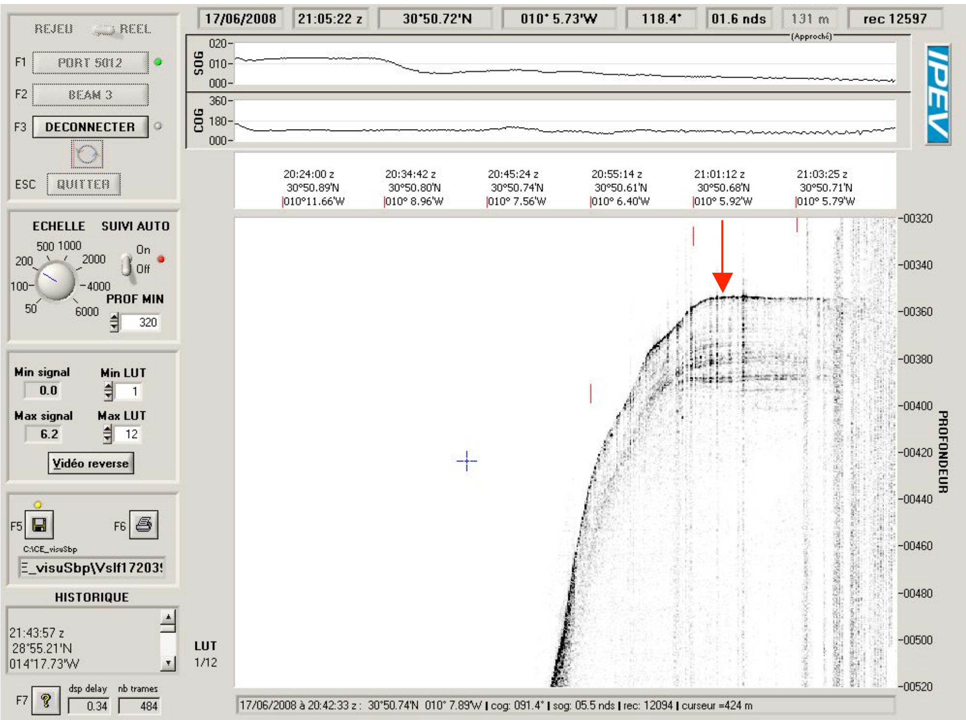
MD168- AMOCINT IMAGES XVII

MD08-3176 **Calypso** **17/06/08, 03h38 UTC** **Station 1**

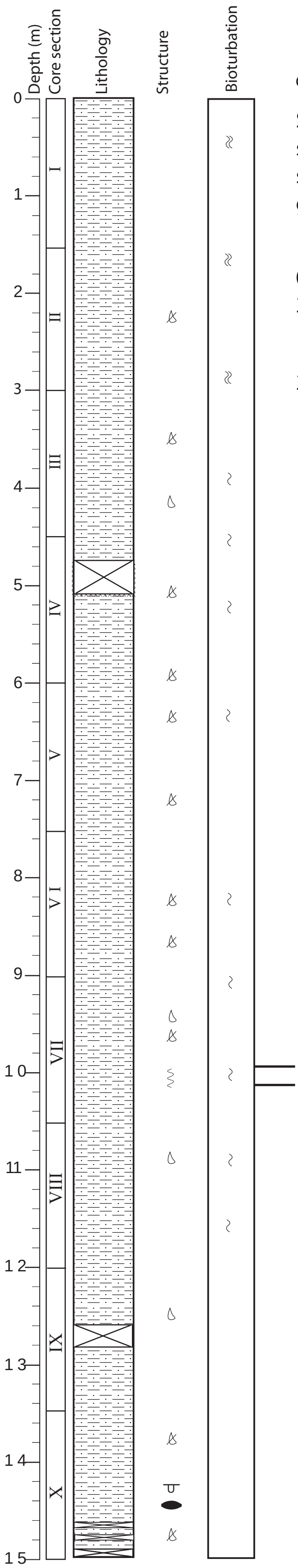
Core length : 29.77 m **Lat : 30°50.67'N** **Long : 010°05.82'W**

Water depth : 360 m





2008 MD 168 - AMOCINT	Sediment description page 1/2	Station 1 Core MD 08-3176



Comments

Silty clay with sand
slightly to moderately bioturbated throughout
shell fragments common (gastropods, echinoderms)
gas expansion voids frequent

0-30 cm: moderate brown (5YR 4/4)
30-300 cm: dark yellowish brown(10YR 5/2)

300-1350 cm: light to dark olive gray (5Y 5/2 to 5Y 3/2)

945 cm: complete bivalve (nacre preservation)

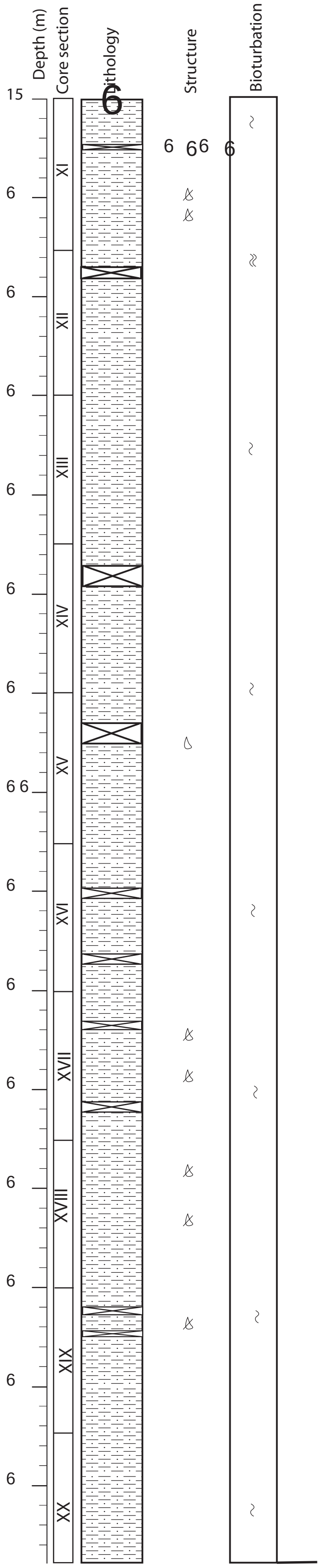
994-1114 cm: disturbed

1350 -1500 cm: grayish olive (10Y 4/2)

2008
MD 168 - AMOCINT

Sediment description
page 2/2

Station 1
Core MD 08-3176



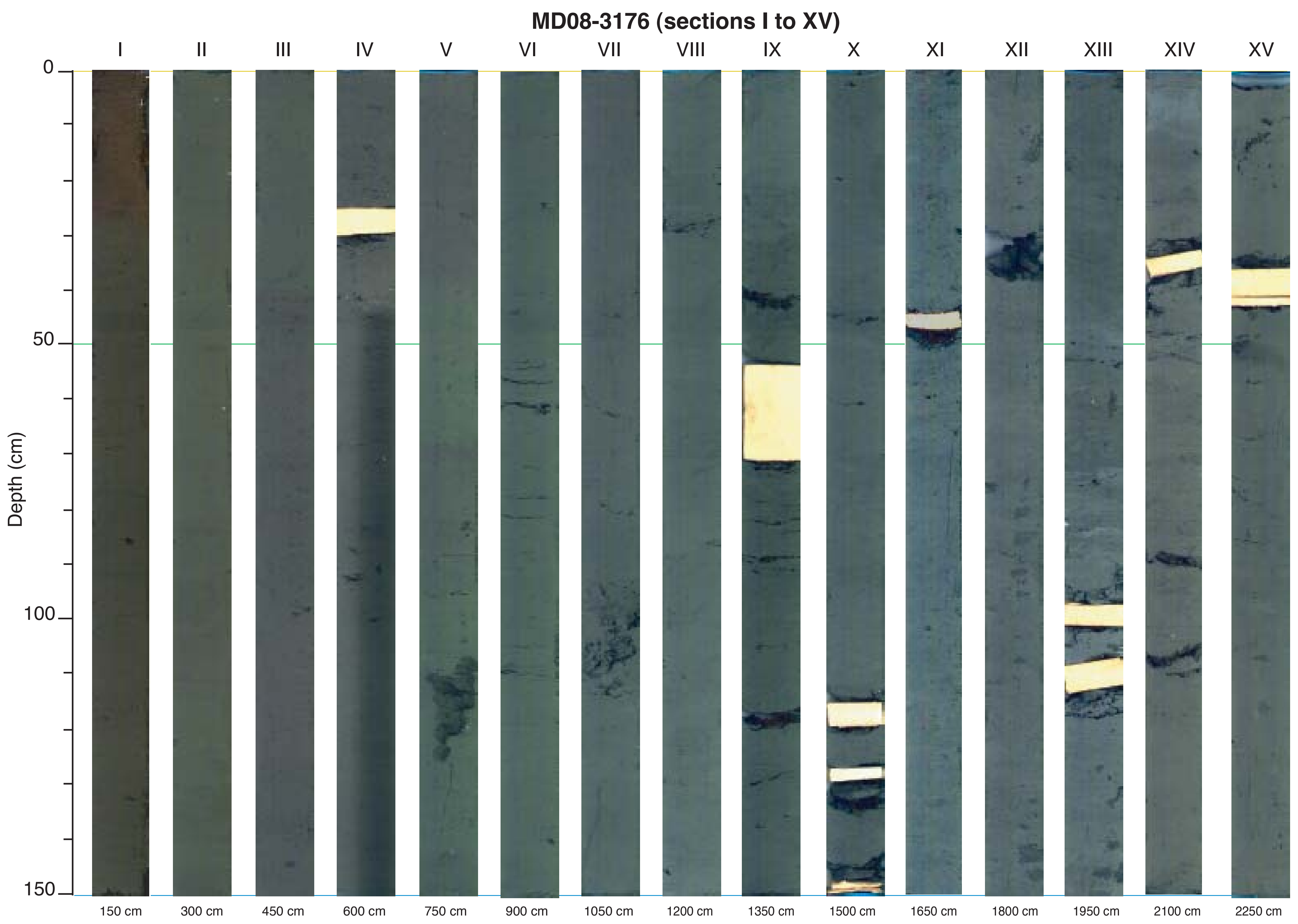
Comments

Silty clay with sand
slightly to moderately bioturbated throughout
grayish olive (10Y 4/2)
shell fragments common
gas expansion voids frequent

2148-2152 cm: in situ bivalve (both valves)

2550-2553 cm: large gastropod

2977 cm: end of core

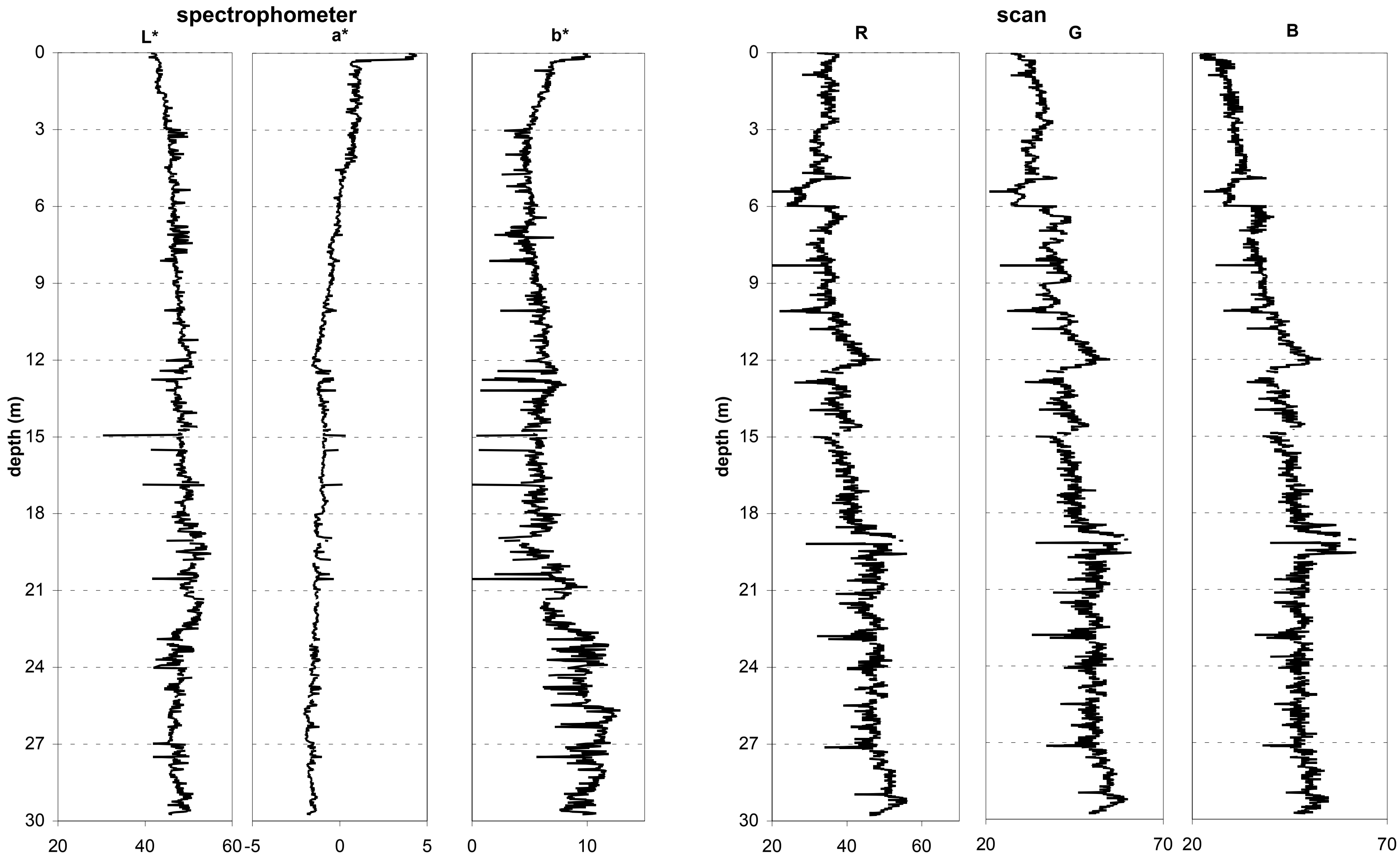

MD08-3176 (sections I to XV)
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
XV
Depth (cm)
0
50
100
150
150 cm
300 cm
450 cm
600 cm
750 cm
900 cm
1050 cm
1200 cm
1350 cm
1500 cm
1650 cm
1800 cm
1950 cm
2100 cm
2250 cm

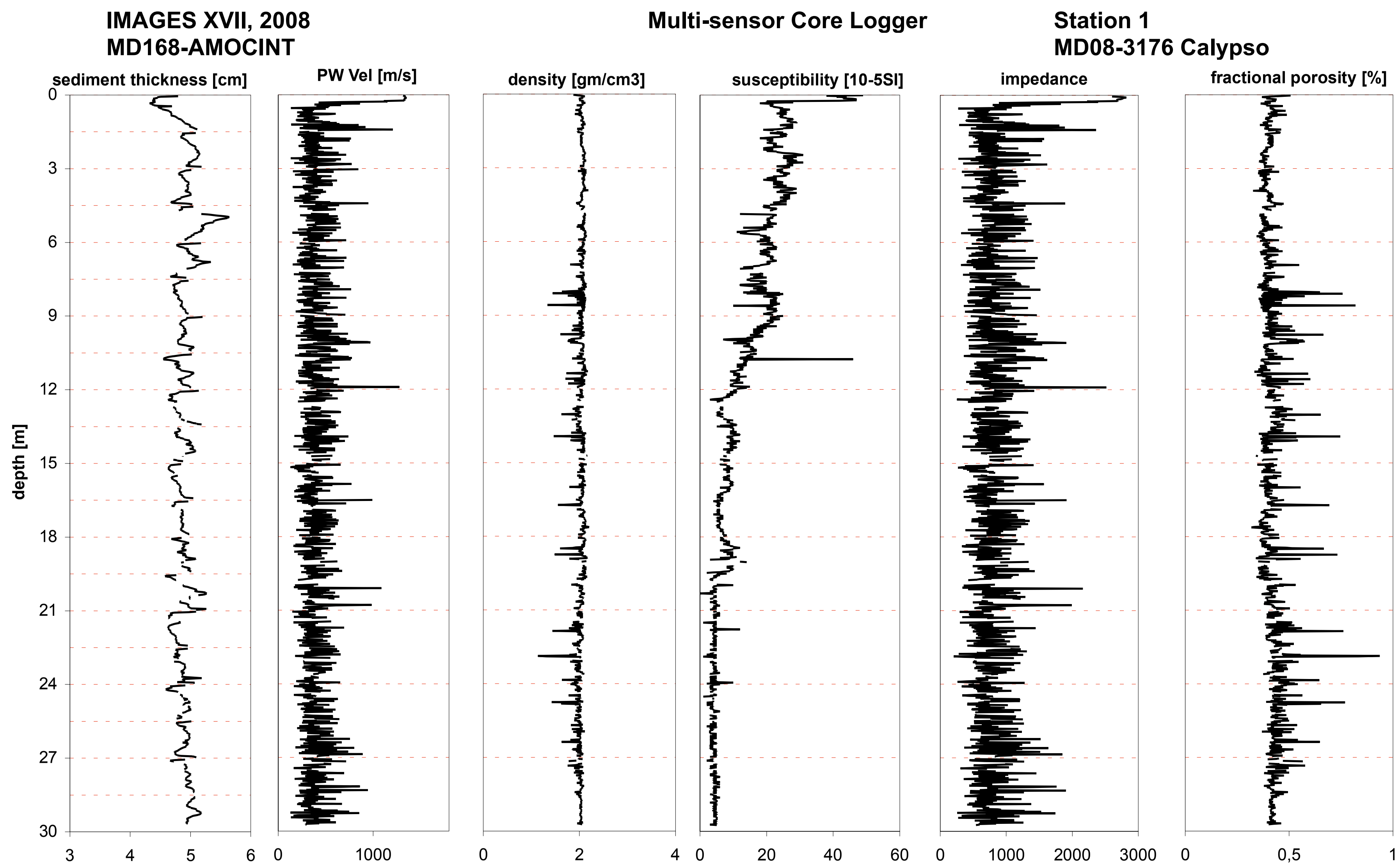
MD08-3176 (sections XVI to XX)

IMAGES XVII, 2008
MD168-AMOCINT

COLOUR REFLECTANCE

Station 1
MD08-3176 Calypso





IMAGES XVII, 2008
MD168-AMOCINT
Multi-sensor Core Logger
Station 1
MD08-3176 Calypso
sediment thickness [cm]
PW Vel [m/s]
density [gm/cm3]
susceptibility [10-5SI]
impedance
fractional porosity [%]
depth [m]

IMAGES XVII, 2008
MD 168/AMOCINT

Date : 17/06/08

N° de station : 01

Météo : (force) / Direction
Vent :
Mer :
Variation tension (maxi) :

CAROTTE (N°) :

MD08- 3177

(MD - année - milles - centaines)

CAROTTE (longueur) :

39.58 m

POSITION :

Latitude : **30°50.67'N**

Longitude : **010°05.82'W**

CAROTTIER (type) (1) **:** **CALYPSO II**

Poids total (air) : 6.7 t

Poids total (eau) : 6.3 t

REGLAGES :

Tubes (longueur) : 44.92 m

Câbles :
Chute libre : 1.5 m

Boucle : 3,00 m

LC poids : m

CONTREPOIDS :
Type (2) :

Longueur PVC : m

Pénétration : m

Longueur de carotte : m
+ Ogive (+ 0,15 m)

PARAMETRES MESURES :

Sonde corrigée :	360 m
Ligne filée :	314 m
Arrachement/total *(tonne)* :	t
Arrachement/différentiel *(tonne)* :	t
Pénétration/apparente *(m)* :	m
Pénétration/tensiomètre *(m)* :	m

HEURES (GMT)

En station :	
Début manœuvre :	06:58
Déclenchement :	07:50
Fin de manœuvre :	09:06
Durée de manœuvre :	
Départ station :	09:14

INSTRUMENTATION OPERATIONS ANNEXES

Pinger :

Flux de chaleur :

CTD (hydro) :

CTD (bouteilles) :

Filet à plancton :

Autres :

Description / incidents : same probem as for MD08-3175 (late triggering)

Corer bent

gaz

0	150	300	450	600	750	900	1050
I	II	III	IV	V	VI	VII	

1050	1200	1350	1500	1650	1800	1950	2100
VIII	IX	X	XI	XII	XIII	XIV	

2100	2250	2400	2550	2700	2850	3000	3150
XV	XVI	XVII	XVIII	XIX	XX	XXI	

3150	3300	3450	3600	3750	3900	3968
XXII	XXIII	XXIV	XXV	XXVI	XXVII	

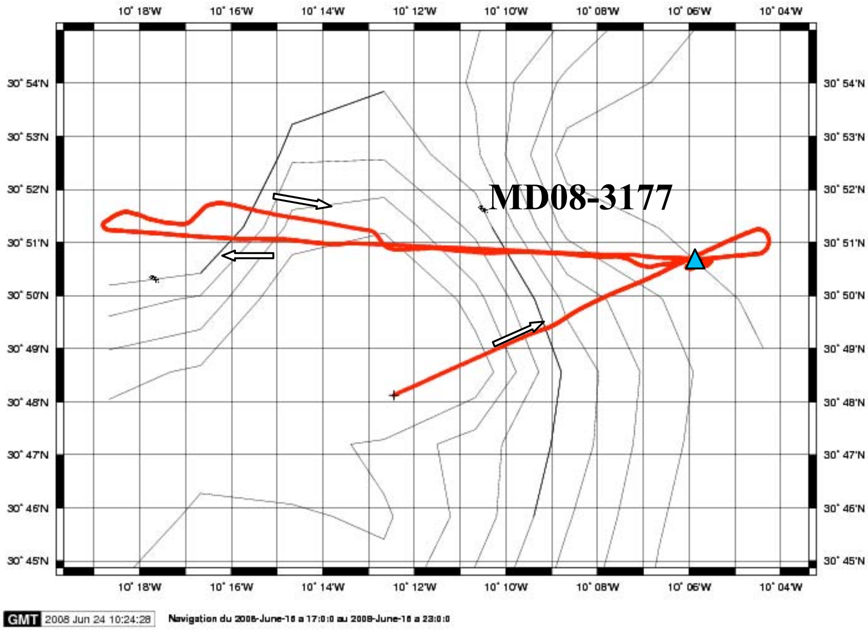
Working and archive halves at Bergen, u-channels at Gif

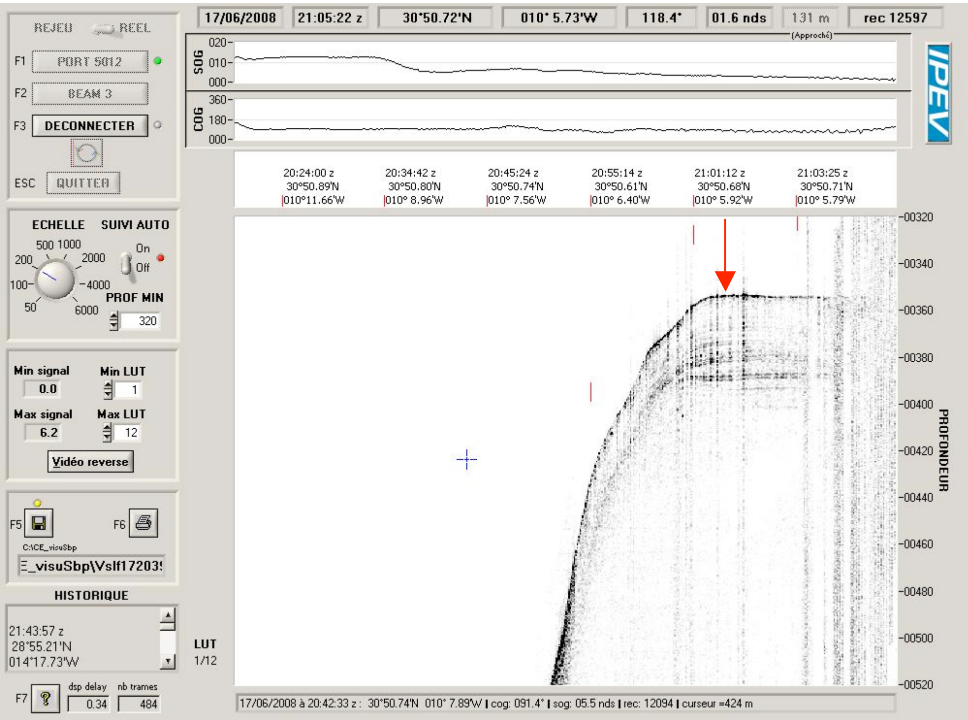
(1) CALYPSO - CALYPSO GRAVI/FLUX - BOX CORER 1/4m ou carré géant

(2) Cylindrique 100 kg / Plat / Préleveur

MD168- AMOCINT IMAGES XVII

MD08-3077 **Calypso** **17/06/08, 07h50 UTC** **Station 1**
Core length : 39.68 m **Lat : 30°50.67'N** **Long : 010°05.82'W**
Water depth : 361 m



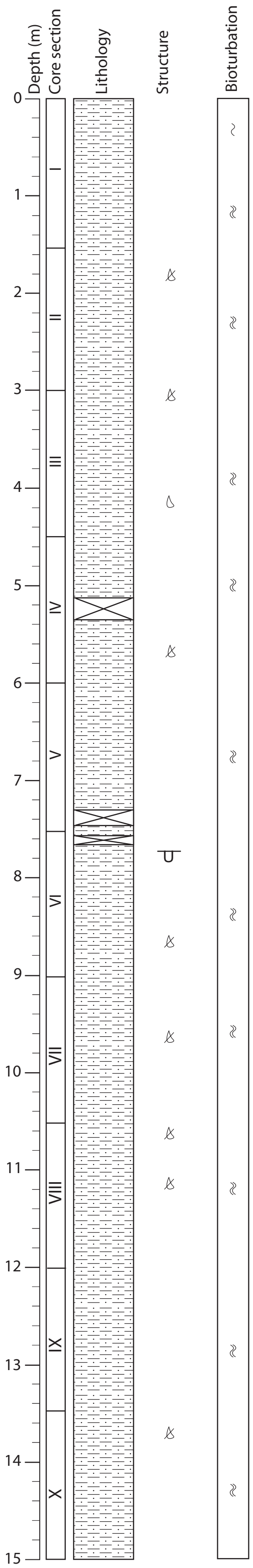


2008
MD 168 - AMOCINT

Sediment description

page 1/3

Station 1
Core MD 08-3177



Comments

silty clay with sand
slightly bioturbated throughout
olive gray (5Y 4/1) to grayish olive (10Y 4/2)
shell fragments common
cracks common, some voids

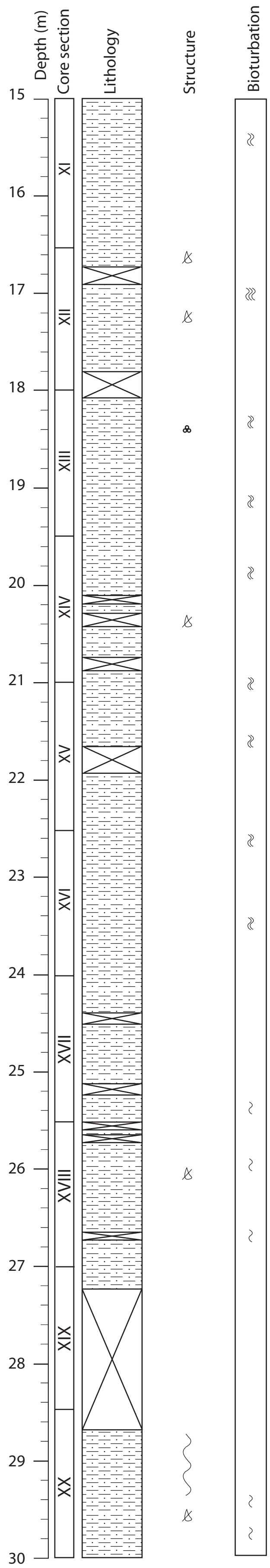
746- 756 cm: disturbed

784 cm: burrow

2008
MD 168 - AMOCINT

Sediment description
page 2/3

Station 1
Core MD 08-3177



Comments

silty clay with sand
bioturbated throughout
dark greenish gray (5GY 4/1) to grayish olive (10Y4/2)
shell fragments common
cracks common

1842-1843 cm: abundant benthic foraminifera and spicules

2250- 3000 cm: light olive gray (5Y 6/1)
few shell fragments
cracks common

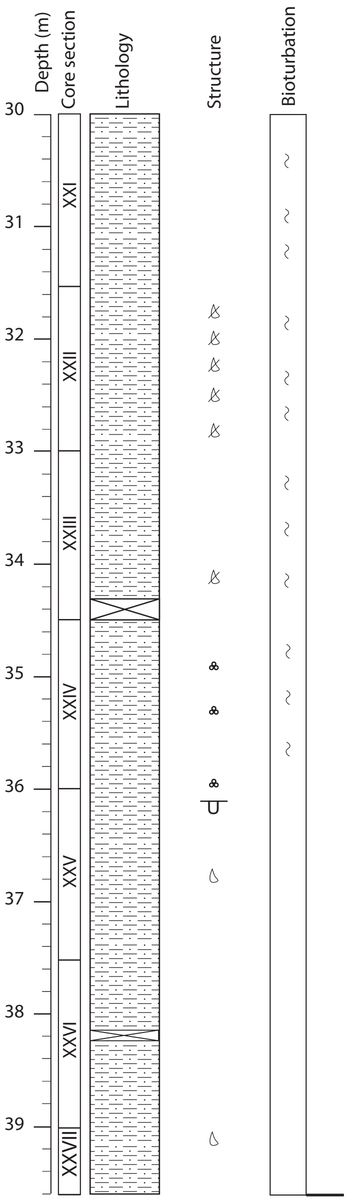
2700-2724 cm: cracked and crumbled

2870-2936 cm: disturbed

2008
MD 168 - AMOCINT

Sediment description
page 3/3

Station 1
Core MD 08-3177



Comments

silty clay with sand and foraminifera
bioturbated,
light olive gray (5Y 5/2)
shell fragments common
some cracks and small voids

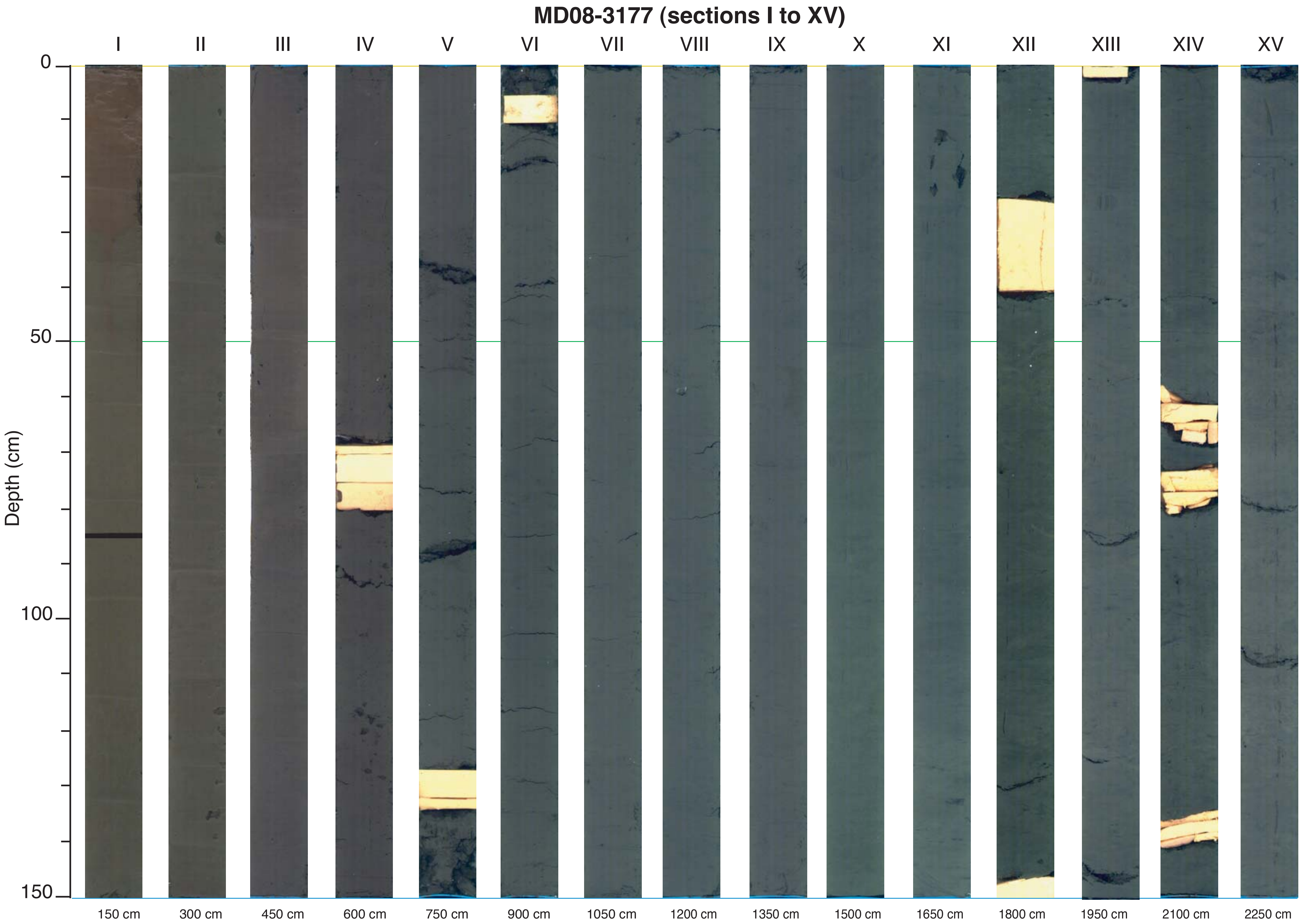
3610-1614 cm: burrow filled with sand (foraminifera)

3676-3678 cm: perfectly preserved gastropod

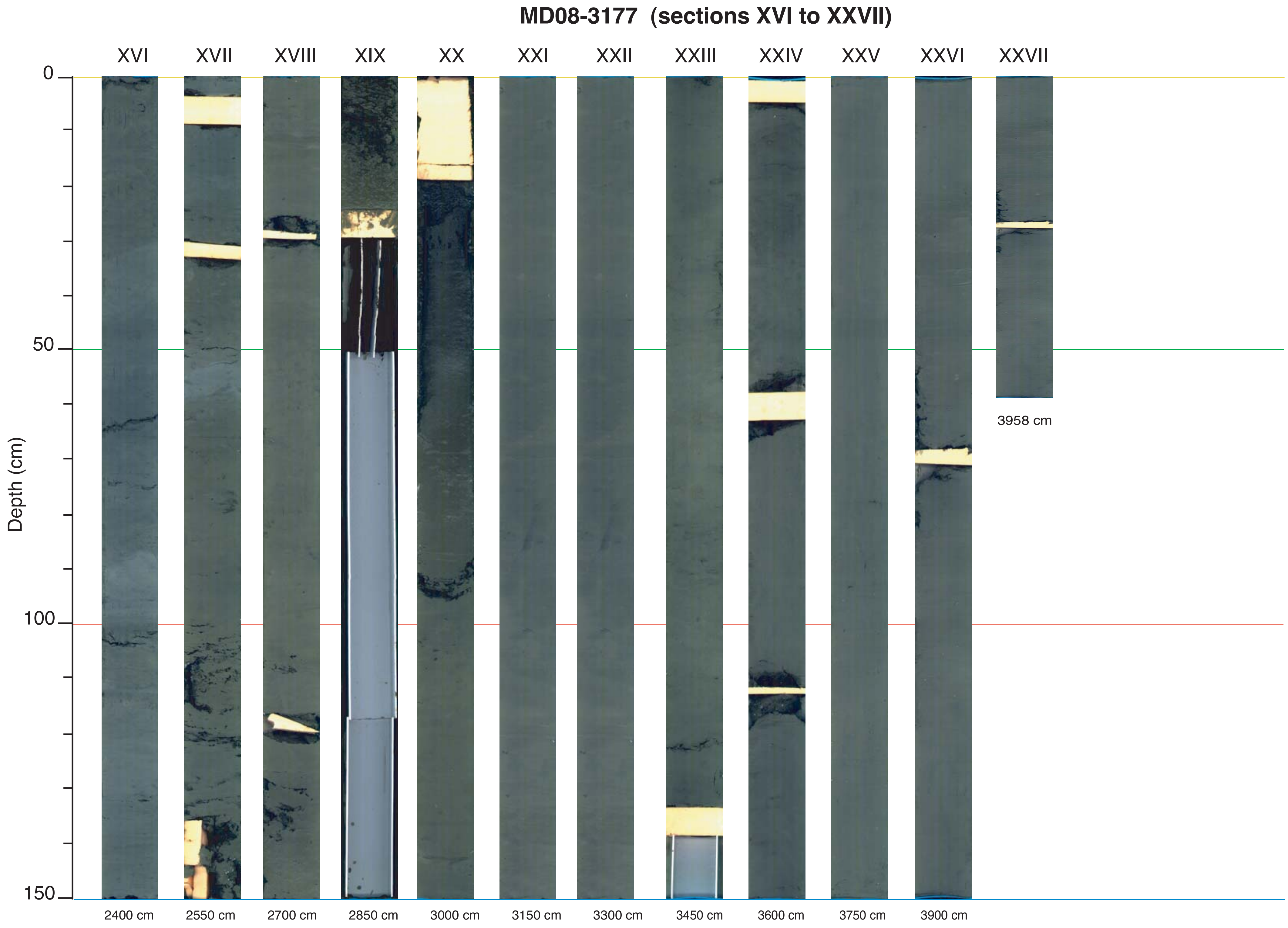
3775-3840 cm: disturbed and soupy

3912-3913 cm: large bivalve

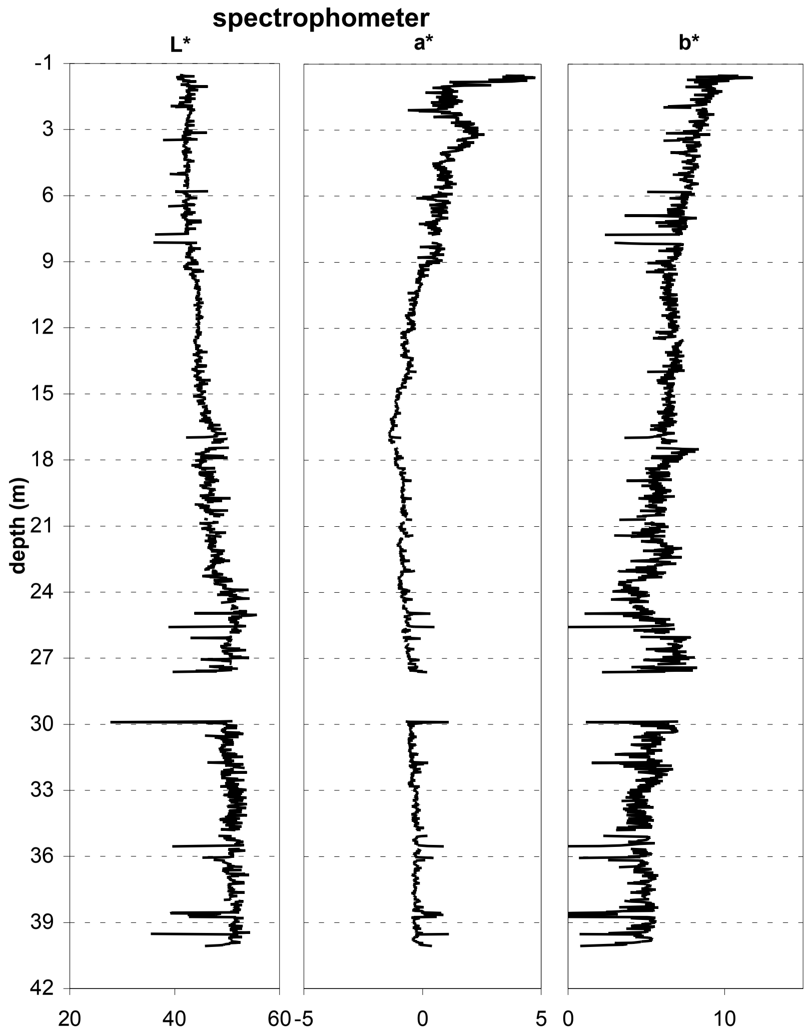
3958 cm: end of core

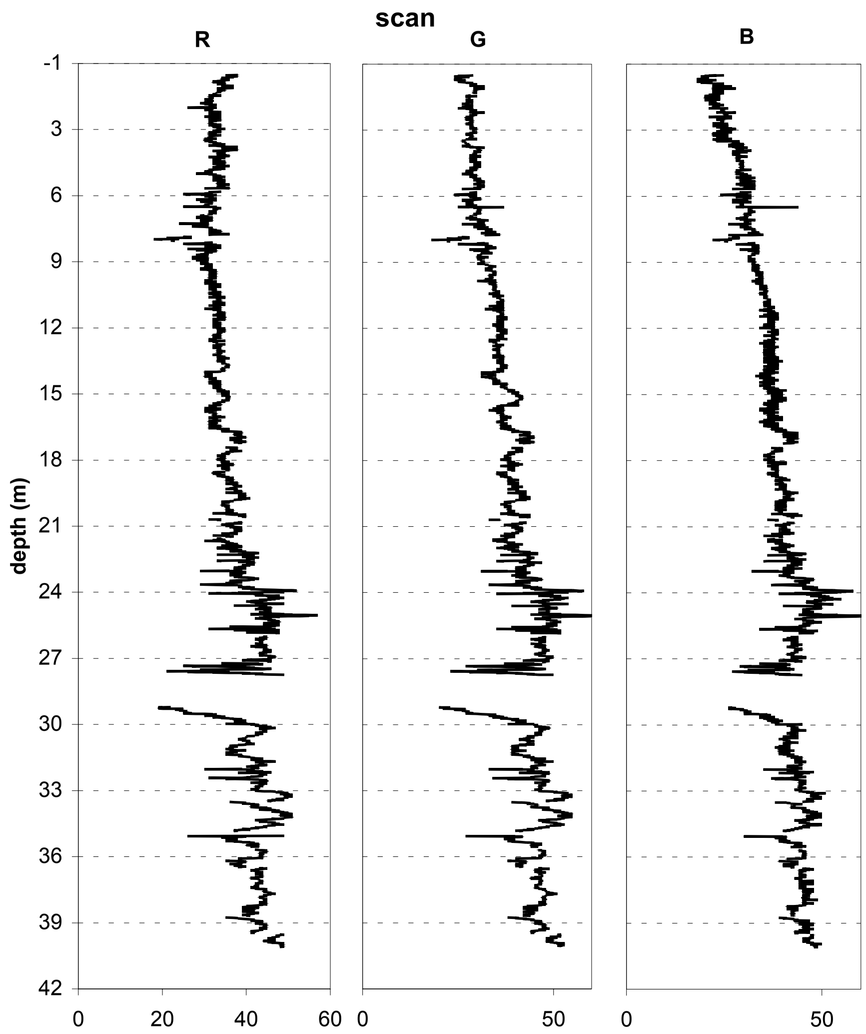


MD08-3177 (sections I to XV)
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
XV
0
50
100
150
Depth (cm)
150 cm
300 cm
450 cm
600 cm
750 cm
900 cm
1050 cm
1200 cm
1350 cm
1500 cm
1650 cm
1800 cm
1950 cm
2100 cm
2250 cm


MD08-3177 (sections XVI to XXVII)
XVI
XVII
XVIII
XIX
XX
XXI
XXII
XXIII
XXIV
XXV
XXVI
XXVII
0
50
100
150
Depth (cm)
3958 cm
2400 cm
2550 cm
2700 cm
2850 cm
3000 cm
3150 cm
3300 cm
3450 cm
3600 cm
3750 cm
3900 cm

COLOUR REFLECTANCE

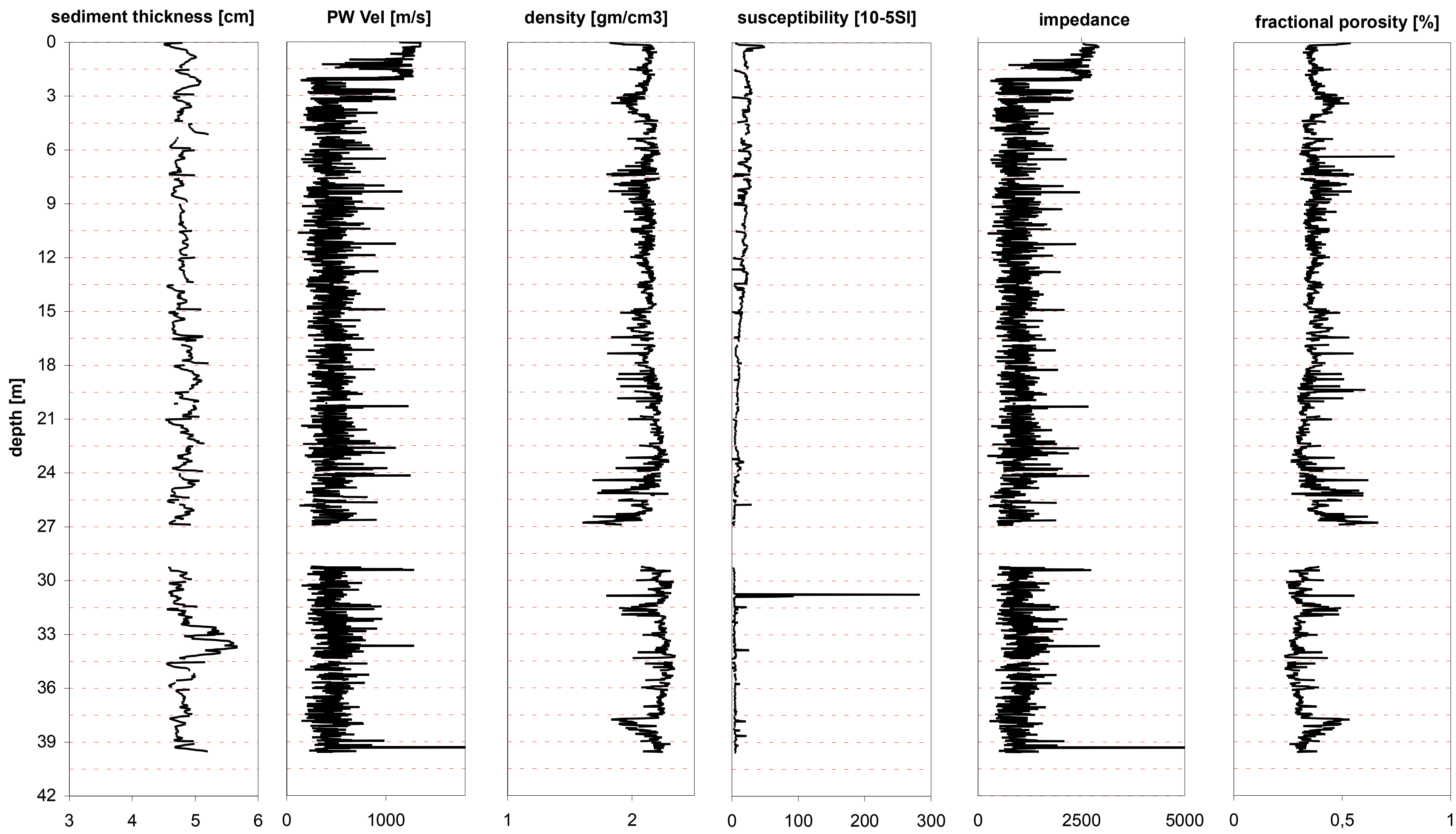




IMAGES XVII, 2008
MD168-AMOCINT

Multi-sensor Core Logger

Station 1
MD08-3177 Calypso



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