Istituto per l'Ambiente Marino Costiero (IAMC)
Consiglio Nazionale delle Ricerche (CNR)

Horseshoe_2005
Cruise Report

R/V Urania, Naples-Funchal-Civitavecchia
October 18 - November 15, 2005

IAMC–CNR, Naples
January, 2006

….gridando: Dottore, Dottore Trelawney!
Mi prenda con sé ! Non può lasciarmi qui dottore !
Ma già le navi stavano scomparendo all'orizzonte
E io rimasi qui,
in questo mondo
pieno di responsabilità e di fuochi fatui.

(from "*Il Visconte Dimezzato*", Italo Calvino, 1951)

….I've seen things you people wouldn't believe.
Attack ships on fire off the shoulder of Orion.
I watched C-beams glitter in the dark near the Tannhauser gate.
All those moments will be lost in time, like tears in rain.
Time to die…

(from "Blade Runner", 1982)

Authorship

Giovanni de Alteriis and Marco Sacchi are responsible for the text and material of this report that is based on the work and cooperation of all members of the scientific party*.

(*)
Jean-Marie Auzende, M. Alessandra Conti, Luigi Ferranti, Gabriella Di Martino, Marcello Tola Sara Innangi, Maria C. Marino, Mauro Caccavale, Michela Cigliano, Andrea Fienga, Rossella De Sanctis, Piero Toscano, Marco Barra, Imma D'Errico, M. Enrica Mazzella, Alessandra Mercorella, Benedetta Del Prete, Fabrizio Esposito, Raffaele Castaldo, Marco Trovato, Erica Szeghy, Daniele Gitto, Fabrizio Occhiena.

Acronyms used in this report

HS	Horseshoe seamount region
Smt	Seamount
MB	Multibeam echosounder bathymetry
MG	Magnetometry
CH	Sub-bottom chirp profiling
SP	Sparker seismic profiling
GR	Grab bottom sampling
DR	Dredge bottom sampling
CTD	Sea-water Conducibility, Temperature, Depth
SVP	Sea-water Sound Velocity Profile
CARIS	MBeam processing software
PDS 2000	MBeam survey acquisition and processing software
GMT	Global Mapping Tool, Wessel and Smith, 1995
IAMC	Istituto Ambiente Marino Costiero, Naples, Italy
DST	Dipartimento Scienze della Terra
SZN	Stazione Zoologica "Anton Dohrn", Naples, Italy

Acknowledgments

The Urania ship is a relatively small vessel, working almost always in the Mediterranean and not particularly fit for long oceanic cruises, especially during the winter season. We thank Captain Vincenzo Lubrano Lavadera and all members of the crew for their professionalism, expertise and spirit of cooperation even during rough sea conditions which we encountered on two occasions.
Luca Gasperini and Giovanni Bortoluzzi (ISMAR-CNR, Bologna, Italy) are acknowledged for their assistance for sparker acquisition (hardware and software) and web publishing.
Giorgio Ruta (GeoLab srl, Naples) kindly reviewed and re-edited the text.

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1. Cruise summary

Cruise name:	Horseshoe_2005
Ship:	R/V Urania, Owner: So.Pro.Mar. SpA, Fiumicino (Rome), Italy
Departure:	Oct, 18 2005 Naples (Italy)
Port Call :	Nov, 2-4 2005 Funchal (Madeira, Portugal)
Return:	Nov, 15 2005 Civitavecchia (Italy)
Geographic area:	Eastern Atlantic Ocean, 30°- 35° N, 10°- 15° W
Target site:	Horseshoe Seamount Chain
Objectives:	Acquisition of geophysical (bathymetric, reflection seismics, magnetic) and geologic (basement rock, surface sediments, benthic associations) data.
Coordinating Institution:	IAMC – CNR, Italy
Chief Scientists:	Giovanni de Alteriis and Marco Sacchi (IAMC-CNR)
Participating Institutions:	IAMC – Istituto per l'Ambiente Marino Costiero, CNR, Italy; Dipartimento Scienze della Terra, Università La Sapienza, Rome, Italy; Dipartimento Scienze della Terra Università Federico II, Naples, Italy; Stazione Zoologica Anton Dohrn, Naples, Italy; Dipartimento di Geologia, Università di Catania, Italy; Università Parthenope, Naples, Italy; Coastal Consulting and Exploration Ltd. , Bari, Italy, GeoLab Ltd., Naples, Italy
Acquired data:	Multibeam bathymetry, magnetic profiles, medium to high-resolution single-channel, (4 kJ sparker and subbottom CHIRP) seismic reflection profiles, dredges, grabs.

2. Introduction and scientific objectives

The submerged chain of the Horseshoe (hereafter HS) seamounts in the north-eastern Atlantic is located along the eastern sector of the Açores-Gibraltar lineament, within a zone of convergence and strike-slip motion between Eurasia and Africa lithospheric plates. The Açores-Gibraltar belt is also characterized by present-day high seismicity and structural deformation. The HS seamounts raise until shallow depths (few hundreds to few tens metres) above Tagus, HS and Seine abyssal plains 4000 to 5000 m deep. They are all volcanic edifices apart from the Gorringe bank including Gettysburg and Ormonde seamounts where sub-oceanic mantle rocks crop out (Auzende et al., 1978). Despite the several geological and geophysical investigations carried out at the regional scale over the HS chain and the SW Iberian margin (see Sartori et al., 1994; Banda et al., 1995; Hayward et al., 1999; Gracia et al., 2004) and apart from several direct observations and sampling (see next section) swath bathymetric exploration over the HS summit areas was initiated only very recently (de Alteriis et al., 2004).
HS seamounts are also present-day natural laboratories for temperate-waters carbonate sedimentology and oceanography. Their peculiar physiography favours the production and accumulation of biogenic sands (Conti et al., 2004) derived from the algal benthonic communities and from the associated invertebrated faunas. Upwelling currents, as well as interaction with Mediterranean waters eddies (*Meddies*) characterise their oceanographic regime (Bower, 1994; Richardson et al., 2000). For these reasons some Atlantic seamounts have been chosen as protected ecosystems (see links to other projects).

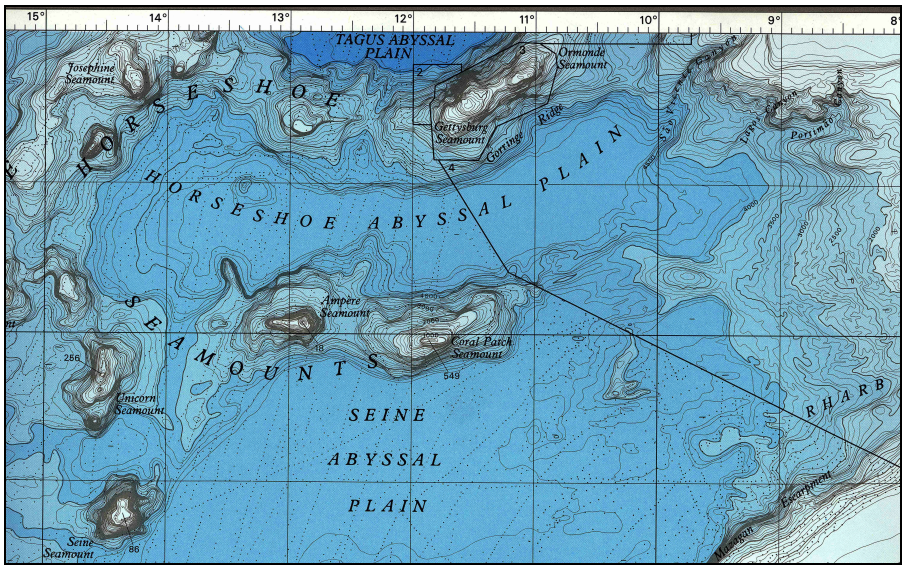


Fig. 1 Bathymetry of the cruise area (from *Bathymetry of Northeast Atlantic, sheet 5, scale 1:2.400.000,* 1983, P.M. Hunter, R.C. Searle and A.S. Laughton eds.).

The expected results of the Horseshoe_2005 Cruise were:

- High-resolution swath bathymetry survey (at depths shallower than 2500 m) of oceanic seamounts in particular Ampère, Coral Patch, Unicorn and Seine (this last seamount does not belong to the HS chain).
- Contribution to the compilation of the oceanic bathymetry according to the IHO standards.
- Sea bottom acoustic mapping and acoustic "mosaics" based on side scan sonar survey and high resolution sub-bottom profiles.
- Magnetic survey and signature of volcanic and non-volcanic seamounts.
- Reconstruction of relative sea-level fluctuations and evaluation of tectonic and eustatic components in sites located on oceanic crust, characterized by high seismicity during the last glacio-eustatic cycle (120 ky).
- Distribution of benthonic algae and faunas and of the resulting associations of "Rhodalgal-Bryomol" type in the warm temperate waters of the Atlantic Ocean and of their variations along the bathymetric gradients.
- Rock/sediment samplings and benthos sampling along transects on the slope in the photic and aphotic zone.

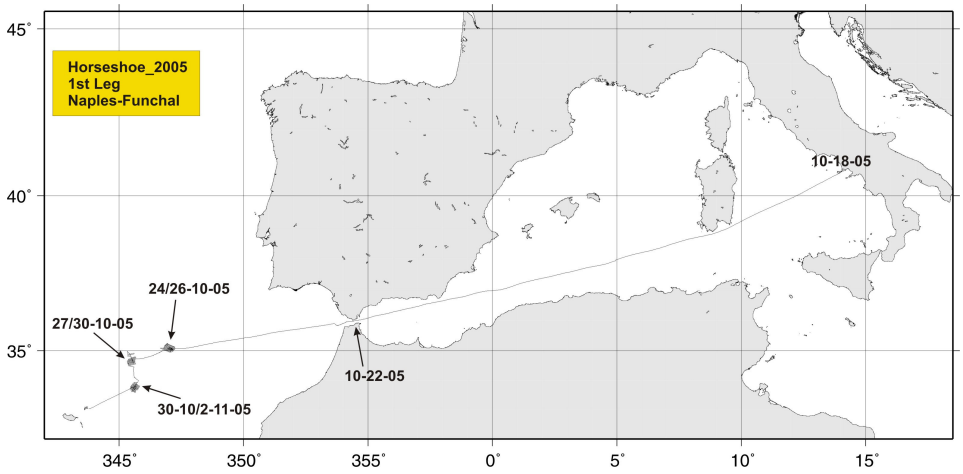


Fig. 2. 1st Leg, Naples-Funchal (Madeira) routes map. GMT 4.0 software.

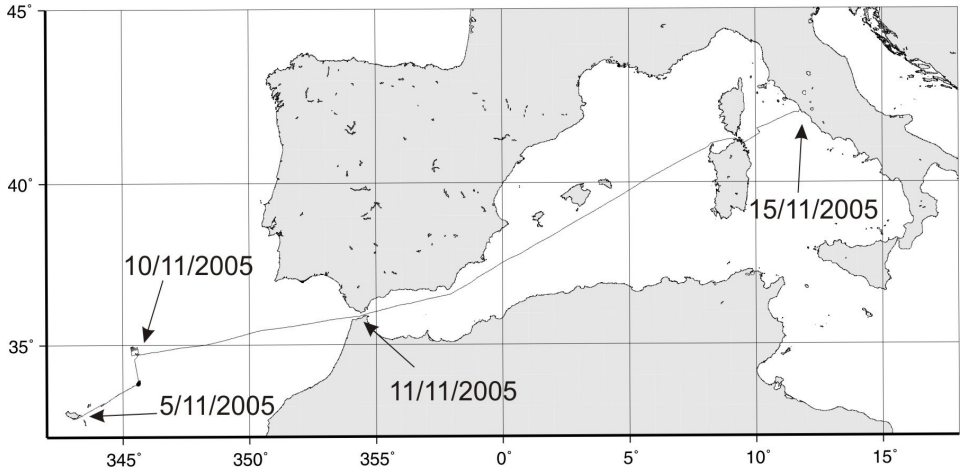


Fig. 3. 2nd Leg routes map. GMT 4.0 software.

3. Previous geological investigations of Ampère, Unicorn and Seine seamounts.

The tops of the seamounts in the HS region are still relatively poorly known apart form large scale geophysical surveys, mostly regarding the SW Iberian margin (cited in the previous section). In the past 25 years Ampère and Unicorn seamounts have been objects of several geophysical/geological expeditions including manned submersible dives, coring operations especially by Russian teams. The top of Seine seamount has been sampled mostly for biological purposes. The following are the most relevant expeditions:

- Cruise R/V Akademik Kurchatov n°30, 1979-80. Institut of Oceanology-Soviet Academy of Sciences, Mosow, URSS. Single-beam bathymetry, dives with submersible Pisces. Area: Ampère.

- Cruise R/V Vityaz n°7, 1984. Institut of Oceanology- Russian Academy of Sciences, Moscow. Russia. Single-beam bathymetry, dives with submersible. Area: Ampère.

- Cruise R/V Bavenit, 1991. Institut of Oceanology "P.P. Shirsov". Russian Academy of Sciences, Moscow. Russia. Geotechnical essays. Drilling cores. Zone: Gorringe, Ampère, Josephine.

- Cruise R/V "Victor Hansen", 1997. Geomar, Kiel-Univeristat Tubingen. Bottom sampling (carbonate sediments and corals). Areas: Galicia Bank, Gorringe, Ampère, Unicorn, Coral Patch, Seine, Dacia.

- Cruise R/V Meteor n° 51, September-October 2001. University of Hamburg (Germany) chief scientist: Prof. K Hoernle. Extensive dredging of NE Atlantic seamounts for study petrogenesis and volcanism; 5 dredge hauls from Unicorn and Seine seamounts.

- Cruise R/V Discovery n° 282, June-August 2003. Southampton Oceanography Centre, UK. Chief scientist: B.J. Bett. Physical oceanography, biogeochemistry and ecology of seabed communities on and around Seine and Sedlo seamounts.

- On October 2005 just few weeks before our cruise the Coral Patch seamount, (east of the Ampère seamount) was surveyed through MB bathymetry during the SWIM_2005 Cruise, R/V Explora (Italy), chief scientist: Nevio Zitellini, ISMAR-Istituto di Scienze Marine, CNR, Bologna (Italy) (see Zitellini et al., 2005 data report).

To date the official cartographic documents with bathymetry regarding the working area were the following:

- Bathymetry of northeast Atlantic, sheet 5 (Hunter, Sarle and Taughton eds., 1983, scale 1: 2.400.000); published by the Institute of Oceanographic Sciences, NERC, UK.
- Admiralty Chart n° 3132 "Strait of Gibraltar to Arquipélago da Madeira", last update 1995, scale 1: 1.250.000, published by the Hydrographic Office, Taunton, UK.

It is worth noting that, according to these documents and to previous literature the minimum depths of both Ampère, Unicorn and Seine were controversial as shown below:

Seamount	Ampère	Unicorn	Seine
Minimum depths (in metres)	59 (1) 18 (2) 60 (3)	246 (2) 20 (3)	89 (2) 90 (3)

(1) Litvin et al., 1982; Marova et al., 1987; Matveyenkov et al., 1994
(2) Bathymetry of northeast Atlantic, 1983
(3) Admiralty Chart n° 3132, 1995

As we will see in the following sections our survey has confirmed that most minimum soundings reported on (2) and (3) charts were affected by errors far from negligible (e.g. in the order of hundreds metres for Unicorn smt).

4. Scientific parties and affiliations

1st Leg Naples-Funchal

1 Giovanni de Alteriis	Researcher, IAMC, CNR, Naples, Italy	Chief scientist, Marine geology
2 Jean Marie Auzende	Researcher, Ex IFREMER, Brest, France	Observer, Marine geology
3 Maria Alessandra Conti	Full Professor, DST, Università "La Sapienza", Rome, Italy	Sediment sample analysis, Biostratigraphy
4 Luigi Ferranti	Researcher, DST, Università "Federico II", Naples, Italy	Structural geology
5 Gabriella Di Martino	Associate researcher, IAMC, CNR, Naples, Italy	Navigation and multibeam acquisition
6 Marcello Tola	Senior surveyor, Coastal Consulting & Exploration Ltd, Bari, Italy	Navigation and mbeam processing
7 Andrea Fienga	Senior surveyor, GeoLab Srl, Naples, Italy	Side-scan and sub-bottom acquisition
8 Maria Enrica Mazzella	Student DST, Università "Federico II", Naples, Italy	Navigation
9 Fabrizio Esposito	Student DST, Università "Federico II", Naples, Italy	Sub-bottom acquisition
10 Raffaele Castaldo	Student DST, Università "Federico II", Naples, Italy	Navigation
11 Rossella De Sanctis	Graduated, University "Parthenope", Naples, Italy	Benthos
12 Michela Cigliano	PhD student, Stazione Zoologica Anton Dohrn, Ischia, Naples	Marine biology and benthos
13 Piero Toscano	Graduated, University "Parthenope", Naples, Italy	Physical oceanography, CTD measurements
14 Immacolata D'Errico	Student, University "Parthenope", Naples, Italy	Multibeam acquisition
15 Marco Barra	Student, University "Parthenope", Naples, Italy	Processing
16 Mauro Caccavale	Student, DST, University "Federico II", Naples, Italy	Charting
17 Daniele Gitto	On board engineer, So.Pro.Mar., Italy	Sparker, magnetometer, CTD
18 Fabrizio Occhiena	On board engineer, So.Pro.Mar.,Italy	Sparker, magnetometer, CTD

2nd Leg Funchal-Civitavecchia

1 Marco Sacchi	Researcher, IAMC, CNR, Naples, Italy	Chief scientist, Marine geology
2 Sara Innangi	IAMC, CNR, Naples, Italy	Navigation and multibeam acquisition
3 Marcello Tola	Senior surveyor, Coastal Consulting & Exploration, Bari, Italy	Navigation and mbeam processing
4 Alessandra Mercorella	Graduated, University "Parthenope", Naples, Italy	Navigation
5 Benedetta Del Prete	Graduated, University "Parthenope", Naples, Italy	Navigation
6 Maria C. Marino	DST, Università di Catania, Italy	Biostratigraphy
7 Marco Trovato		Computers maintenance
8 Erika Szeghy	University Eotvos Budapest, Hungary	geophysics
9 Rossella De Sanctis	Graduated, University "Parthenope", Naples, Italy	Benthos
10 Piero Toscano	Graduated, University "Parthenope", Naples, Italy	Physical oceanography, CTD measurements
11 Immacolata D'Errico	Student, University "Parthenope", Naples, Italy	Multibeam acquisition
12 Marco Barra	Student, University "Parthenope", Naples, Italy	Processing
13 Mauro Caccavale	Student, DSF, University "Federico II", Naples, Italy	Charting
14 Daniele Gitto	On board engineer, So.Pro.Mar., Italy	Sparker, magnetometer, CTD
15 Fabrizio Occhiena	On board engineer, So.Pro.Mar., Italy	Sparker, magnetometer, CTD

Crew

Vincenzo Lubrano Lavadera	Master
Ernesto Violetta	1st Mate
Salvatore Savarino	2nd Mate
Pietro Ciano	Chief Engineer
Marino Montis	2nd Engineer
Carmine Scotto di Covella	3rd Engineer
Luigi Mastronardi	Boatswain
Nicola Martiradonna	Seaman
Antonio Pinti	Seaman
Michele Armenia	Cook
Vincenzo De Pinto	Steward
Alessio Auletta	Deck-boy
Biagio Lubrano Lavadera	Deck-cadet

5. Vessel, instrumentation and acquisition

The Urania Research vessel is an oceanographic ship certified for the Mediterranean and in all oceanic waters apart from polar areas. The ship is equipped for geophysical and oceanographic purposes.

Fig. 4. Top: Urania R/V in the Naples harbour before sailing for the Atlantic, October 18, 2005 and bottom: in Funchal (Madeira) on November, 3, 2005.

Urania R/V technical specifications

Length OA (m)	61,30
Length BP (m)	52,50
Beam (m)	11,10
Draft (m)	4,00 (5,40 with echo-sounder)
Machinery	2x1360 BHP MAK (1000kW X2)
Cruise speed	10 Kn
Gross tonnage	1115 T
Lightweight (water displacement)	1300 M/T
Autonomy (at 9 Kn) 3t/day	30 days
Fresh water capacity	130 T
Fuel oil capacity	250 T
Classe	* 100-A-1.1-Nav. IL; st.
Navigazione	Int. Lunga
Port of Registry and number	N° 275 Napoli, Italia, International Registry
Identification N° (international)	9013220

Radar	Koden MDC 1810/P/Koden MD 3320S
Echo-sounder	Koden CVS 832
Transreceiver SSB	Skanti HF SSB TRP 8000
Magnetic Compass	Cassens e Plath NR. 2
Auto-pilot	Microtecnica Supernauta
Gyrocompass	Microtecnica Polaris MK2 NR.2

GPS	1) Koden KGP 900; 2) JRC NWZ 4570
GPS Differential	Fugro Omni Star
Multibeam echo-sounder	Reson SeaBat 8160, 50KHz
ADCP (Doppler currentmeter)	RDI 4 beams transducer 300 KHz
ADCP (Doppler currentmeter)	RDI Ocean Surveyor 75 KHz
Single-beam echo-sounder	1) Atlas DESO 25 12-33 KHz; 2) Atlas DESO 25 100-210 KHz;
Sub-bottom profiler hull mounted	CAP6600, Datasonics 3-7 kHz
Side Scan Sonar	Edgetech DF1000, 2 channels 100-500 KHz
Meteo-station	AANDERAA 3015

During the cruise the following equipment was employed:

- DGPS positioning: Omnistar, Fugro
- Multibeam echosounder Reson 8160
- Gyro-compass: SGBrown as Velocity Reference Unit (VRU)
- CTD: SeaBird
- Chirp Sub-bottom profiler: Datasonics CAP6600
- EG&G Geometrics proton magnetometer EG & G 811/13
- Single-beam analogic echo-sounder: Atlas Deso 25
- Monochannel seismic acquisition system (sparker source, 8 hydrophones GeoResources® streamer).

The following softwares were used during acquisition and data pre-processing on board:

- Multibeam data acquisition/processing PDS 2000 © (Thales-Geosolutions, Fugro)
- Multibeam processing software CARIS HIPS ©
- Side-scan-sonar acquisition and rendering software ISIS ©
- Seismic/sub-bottom acquisition software SwanPro© (Communication Technology, Ltd.Cesena, Italy)
- Seismic processing freeware SeisPro (L. Gasperini, ISMAR-CNR, Bologna, Italy)
- Generic Mapping Tool, GMT freeware, 4.0 Release (Wessel and Smith, 1995)

MB Echosounder Reson SeaBat 8160

The SeaBat 8160 is suitable for depths ranging from relatively shallow waters (50 m) to deep waters around 3500 m according to the maximum range allowed (5000 m). Operating at 50 kHz the system ensonifies the whole swath in a single ping, generating 126 simultaneous receive beams.

The system would allow a theoretical nadir depth of 3500 m, while the actual maximum depths of 2400-2500 m can be attained only in optimal oceanograpic conditions. During Horseshoe_2005 cruise only very rarely were satisfacory swaths at depths > 2200-2400 m collected. The system allows a maximum swath width of 4000 m at 1200-1600 m depths; at greater depths the swath narrows to hundreds of metres.

Frequency	50 kHz
Range	10 to 5000m
N° of beams	126 with spacing of 1.2°; total swath 150°
Beam angular widths	1.5° to 6° along 2.1° to 8° across
Pulse lenght	0.2 to 10 msec
Ping rate	15 to 0.141 depending on range
Sidelobe suppression	-25 dB
Vertical resolutions	1.4 cm at 750 m; 2.9 cm from 1000 to 1500 m; 8.6 cm at > 1750 m
Nadir footprints vs depths	2.61 m at 100 m; 26 m at 1000 m; 78.5 m at 3000 m
Side footprints vs. depths	9.95 m at 100 m; 99.5 m at 1000 m; 131 m at 3000 m

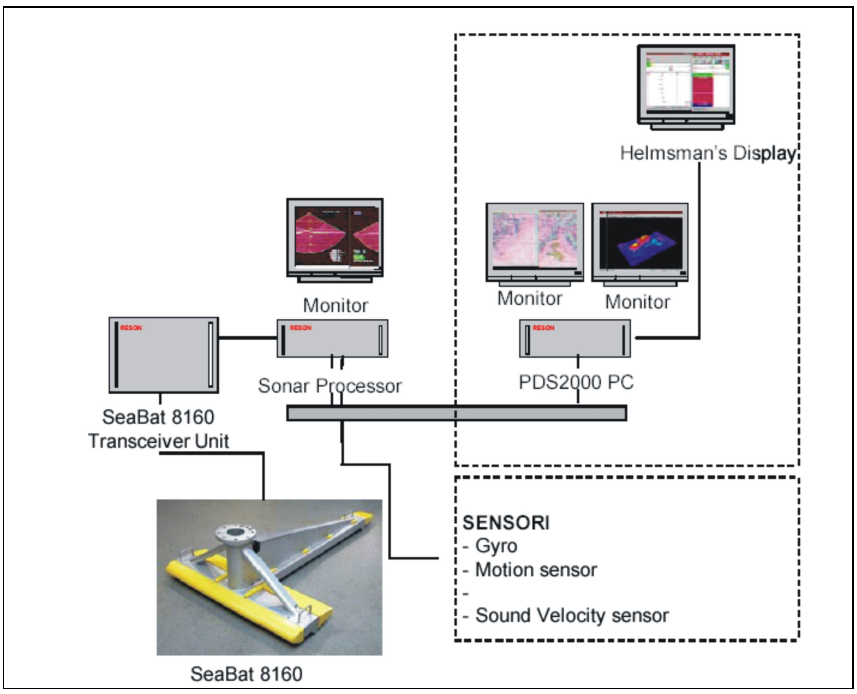


Fig. 5 Scheme of the interfaces of the MB echosounder system

Navigation and data logging, real time quality control on beams, display of data and guidance were carried out in the PDS2000© software (Thales GeoSolutions, The Netherlands). A completely independent navigation software package (NavPro©) was used as the secondary system.

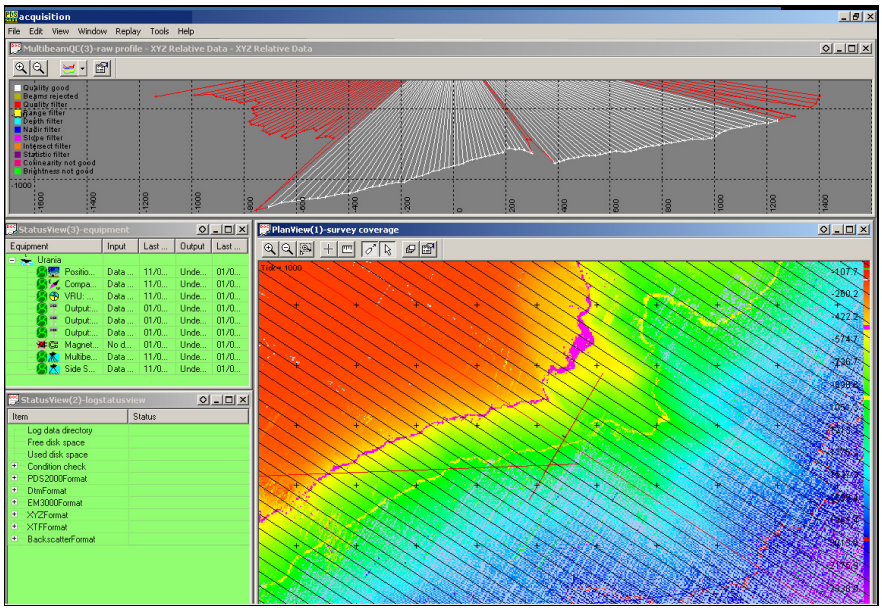


Fig. 6 Acquisition display of PDS2000. Top window: swath with quality (colour) assigned to each beam .

EG & G 811-13 proton magnetometer

The towed magnetometer has the following specifications:

Noise level	90% of all readings within the selected envelope
Absolute total field	± 0.5 gamma or less
Dynamic range	17.000 to 95.000 gammas
Tuning	Fully automatic after manual selection of the ambient field
Sampling rate	From 0. to 6 secs.

During the cruise the sensor was towed at a distance of 200 m from the stern (230 m from antenna) at an average speed of 6-7 knots. The cycle measurement (sampling rate) chosen was 1 sec. thus one measurement every 3-4 metres. The regional field in this area of NE Atlantic was around 41.000 gammas. A layback correction to the sensor position was applied by the navigation software.

Chirp subbottom profiler Datasonics CAP-6600

The sub-bottom chirp profiling has been achieved through the interfacing of a Datasonics transceiver and triggering with a the Swan-Pro© software-hardware package that allows a multi-ping insonifications at great depths by keeping high ping rates. The acoustic source is frequency modulated with two main bands: a lower between 2 and 7 kHz and an higher between 10 and 20 kHz.

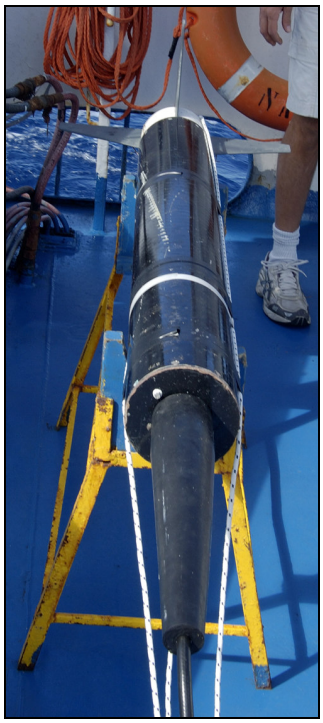


Fig. 8 EG & G 8111 Proton magnetometer

Fig. 9 Sparker source, Eg&G, 1 kJ

Sparker seismic profiling

The system included an Eg&G, Sparker array equipped with three electrodes and charged with 1 kJ power, a GeoResource® streamer with 8 hydrophones and a deck cable. The analog signal was firstly filtered by a Kron_Hite analogues filters in the 100-200 Hz and then sampled into a A/D board.
Due to the average sea conditions and in order to save time for the MB acquisition the sparker profiles were acquired only in a few instances over the top of the Seine smt with the following acquisition parameters: shot interval: 1 sec., recording time 1 sec. Sample rate: 0,25 msec. Onboard data processing and rendering from SEGY files to interpretable seismic sections was achieved through SeisPro © software (L. Gasperini, ISMAR-CNR, Bologna, Italy).

6. Summary of operations

1st Leg (Naples-Funchal)

Boarding operations and departure	Naples, Italy	18-10-05
Route for Cabo De Gata	Spain Mediterranean sea	21-10-05
Transit Gibraltar, seismic tests on sparker	Spain Mediterranean sea	22-10-05
Arrival on Ampère, starting operation	Atlantic ocean	24-10-05
Survey Ampère (CTD-MB-SB-MG)	Atlantic ocean	24/26-10-05
Stand by on weather and transit to Unicorn	Atlantic ocean	26-10-05
Survey onUnicorn (CTD-MB-SB)	Atlantic ocean	27/29-10-05
Lost the CTD probe	Atlantic ocean	29-10-05
Transit to Seine	Atlantic ocean	30-10-05
Survey on Seine (MB-SB-MG)	Atlantic ocean	30/31-10-05 01-11-05
Transit to Funchal, Madeira	Portugal, Atlantic ocean	02-11-05
Call in Funchal, Madeira	Portugal, Atlantic ocean	03/04-11-05

Smt area	Activity	km^2 MB and coverage	n° CTD/grabs/dredges
Ampère	MB/SB/MG/GR	989 from 40% to –100%	3CTD/5GR
Unicorn	MB/SB	1256 from 30% to –150%	2CTD
Seine	MB/SB/MG	789 from 10% to –200%	4DR

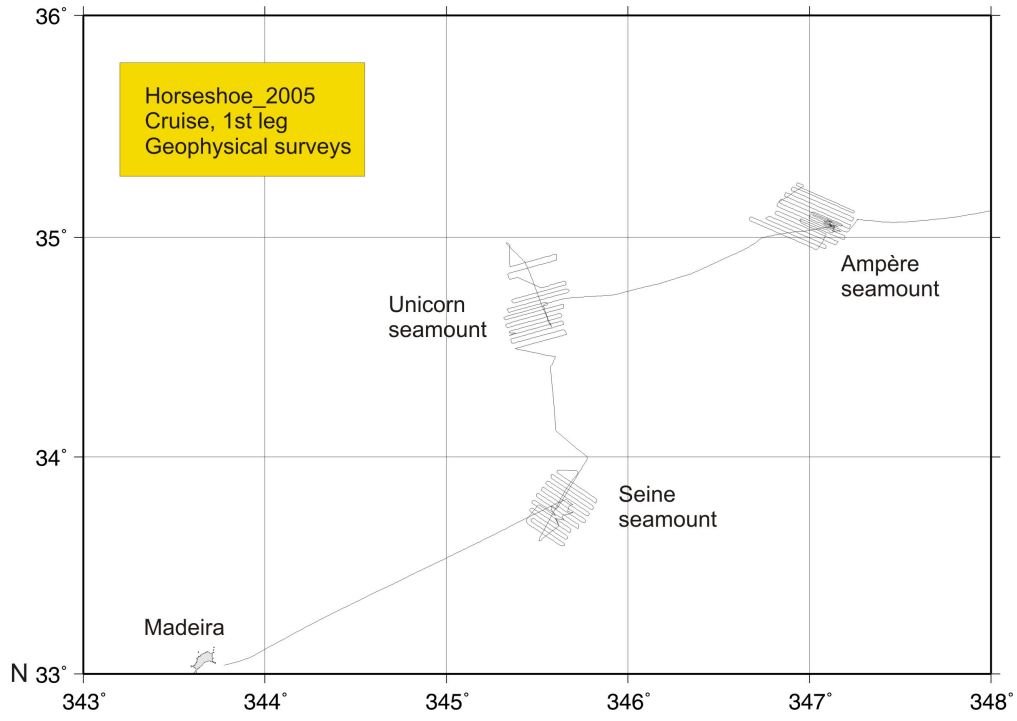


Fig.9. 1st Leg geophysical survey routes acquired over the three seamounts.
2nd Leg (Funchal-Civitavecchia)

Scientific crew turn-over and departure	Funchal, Madeira	04-11-05
Stand by on weather and transfer to Seine	Atlantic ocean	05-11-05
Survey on Seine (MB, CH)	Atlantic ocean	06-11-05
Survey on Seine (MB, CH, SP, DR, GR)	Atlantic ocean	07-11-05
Survey on Seine (MB, CH)	Atlantic ocean	08-11-05
Transit to Unicorn	Atlantic ocean	08-11-05
Survey on Unicorn (MB, CH, DR, GR)	Atlantic ocean	08-11-05
Survey on Unicorn (MB, CH)	Atlantic ocean	09-11-05
Transit to Gibraltar	Atlantic ocean	09/11-11-05
Transit to Civitavecchia	Mediterranean	11/14-11-05
Call in Civitavecchia	Civitavecchia, Italy	15 -11-05

Smt area	Activity	km^2 MB infilling	n° SVP/grabs/dredges
Seine	MB/SB/MG/GR	150 at 150%	3SVP, 4 GR
Unicorn	MB/SB	50	1SVP, 2 DR / 1 GR

7. Preliminary results: geophysics

MB survey

By default MB, MG and SB profiles were acquired simultaneously. When the sea-state was force 6 and above (Beaufort scale) the magnetometer was not deployed to avoid unsafe operations on the deck. In such conditions, not all SB profiles were recorded due to very poor signal to noise ratio. Survey speed during the MB/MG routes (towing the magnetometer) was 6 to 7 knots, this ensured sufficient spatial coverage and production. Prior to the start of the MB acquisition and each 24 hours, CTD probes were deployed. On Unicorn smt the CTD probe was lost and the remaining area was surveyed without water column data. At Funchal a smaller SVP probe (usable for water depths < 1000 m) was embarked and used for the last 4 measurements.
During the 2nd leg of acquisition geophysical operations mostly consisted of the infilling of the preliminary grid obtained from Seine and Unicorn Seamounts during the 1st leg.
Route lines, CTD casts location and the preliminary contour maps realtive to the three smts are illustrated in the following figures. The route lines spacing and their heading was chosen depending on the average depths, production/coverage strategy and wave direction. On Ampère smt. line spacing was ranging from 2000 to 400 m (over the summit). On Unicorn the lesser bathymetric range allowed an uniform 2000 m spacing while on Seine smt spacing varied from 2000 to 400 m. All this resulted in a sea-floor coverage varying from 50-75% (Ampère and Unicorn smts) to > 100% (Seine smt)..
A preliminary processing of the raw data acquired by the RESON 8160 was carried out on-board with CARIS HYPS© software allowing to generate 50x50 m grid files. The quality of the data varied from very good to acceptable, excluding swaths acquired at great water depths and under rough sea conditions.

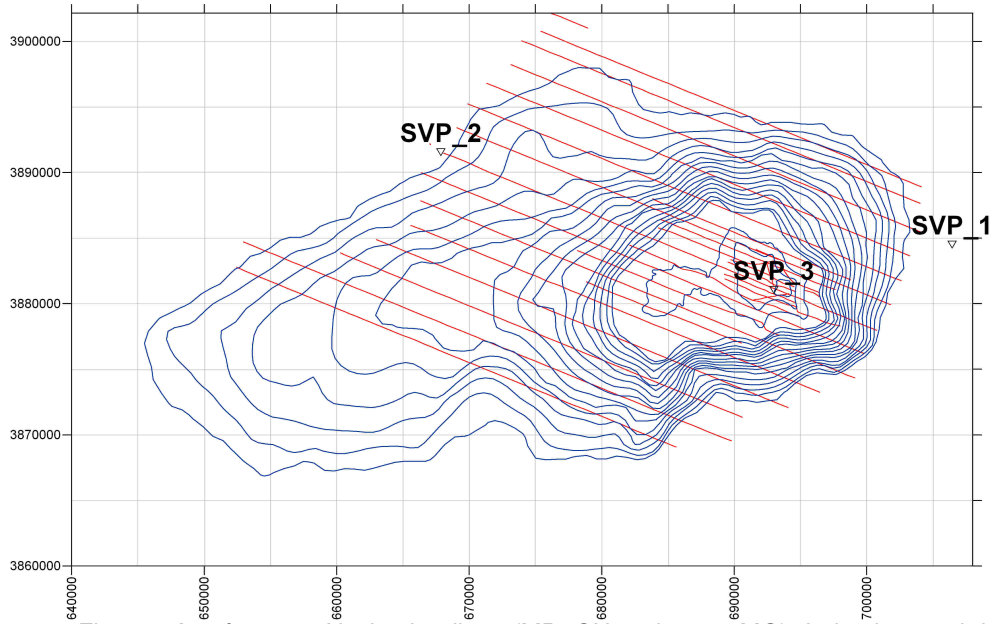


Fig. 10. Ampère smt. Navigation lines (MB, CH and some MG). In background the regional bathymetry from Gebco Digital Atlas. Coordinates chilometric UTM zone 28.

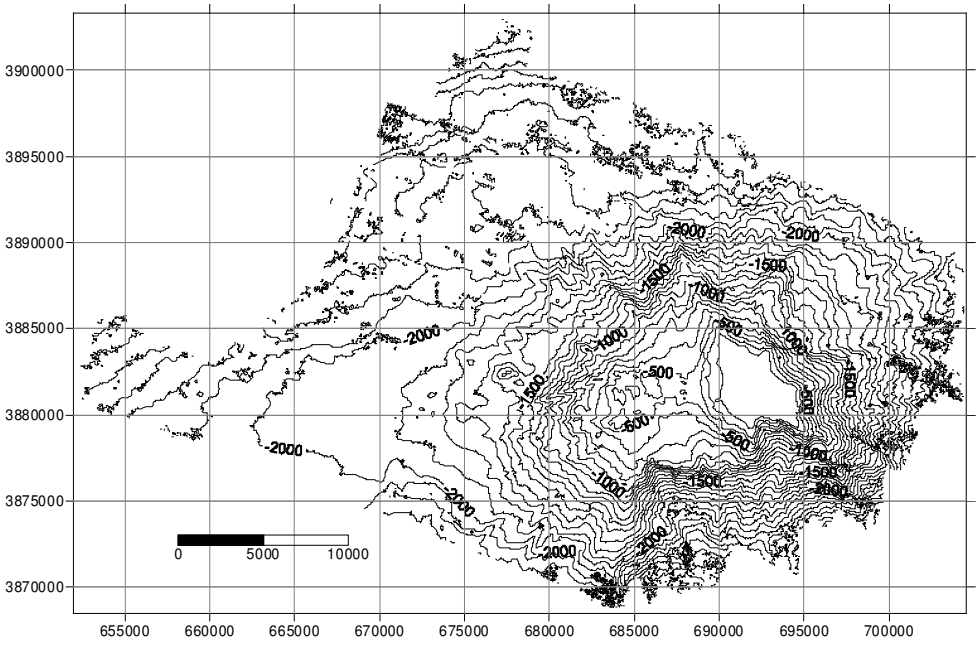


Fig. 11. Ampère smt, preliminary bathymetry. Contour interval 100 m Coordinates chilometric UTM zone 28.

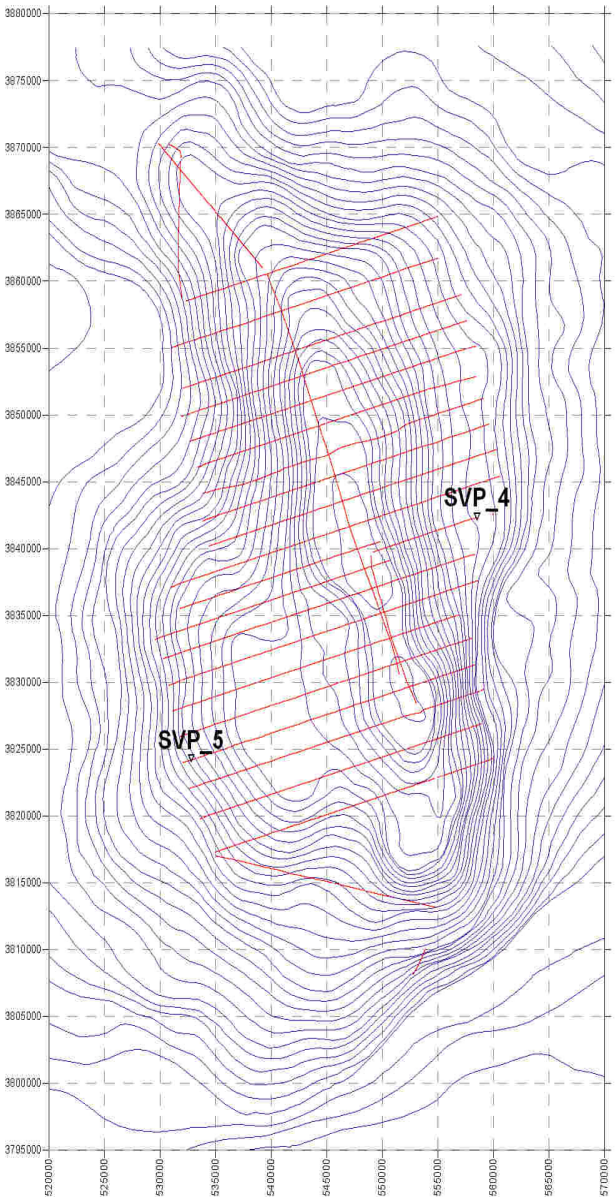


Fig. 12. Unicorn smt. Navigation lines (MB and CH). In background the regional bathymetry from Gebco Digital Atlas. Coordinates chilometric UTM zone 28.

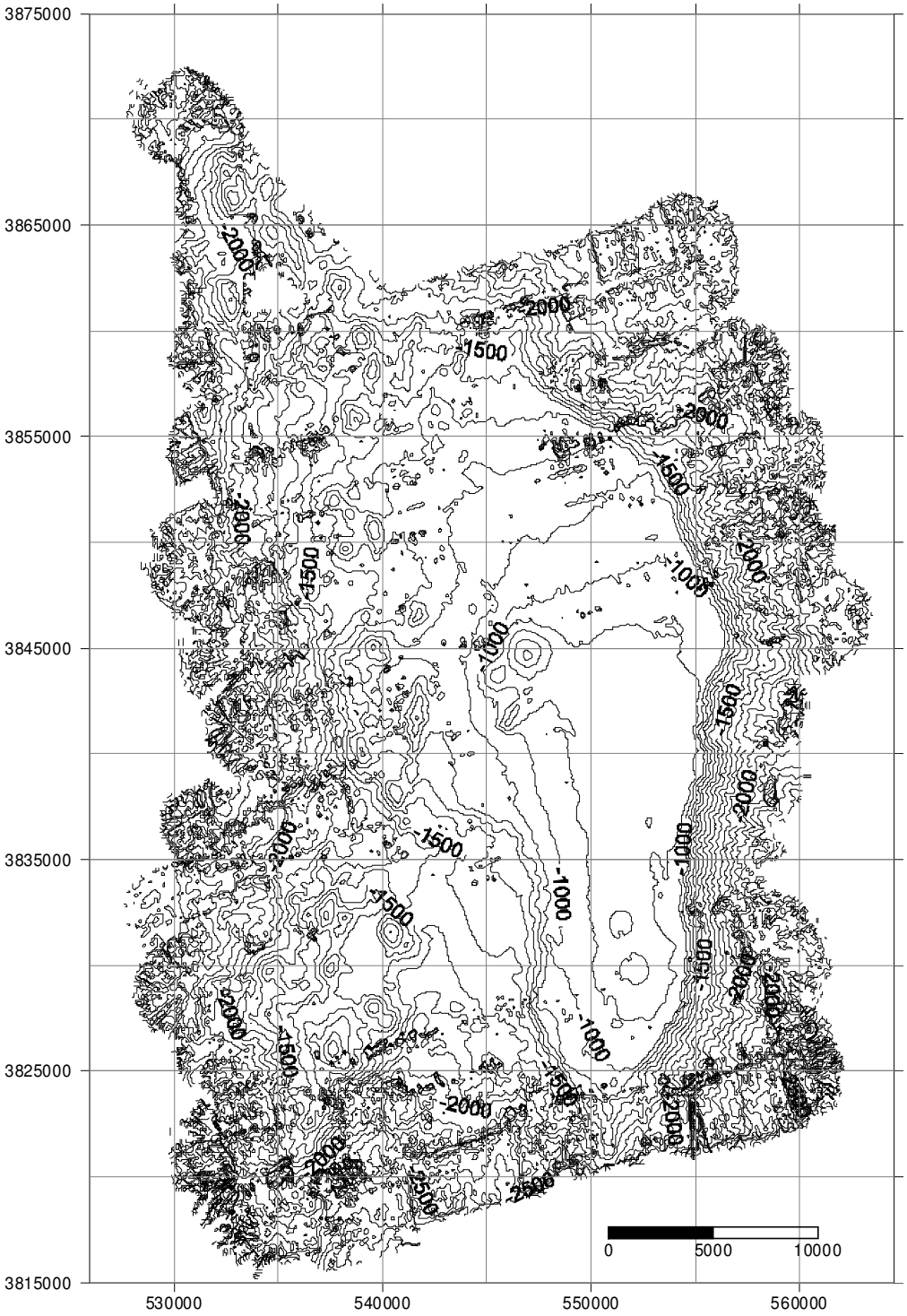


Fig.13 Unicorn smt, preliminary bathymetry. Contour interval 100 m Coordinates chilometric UTM zone 28.

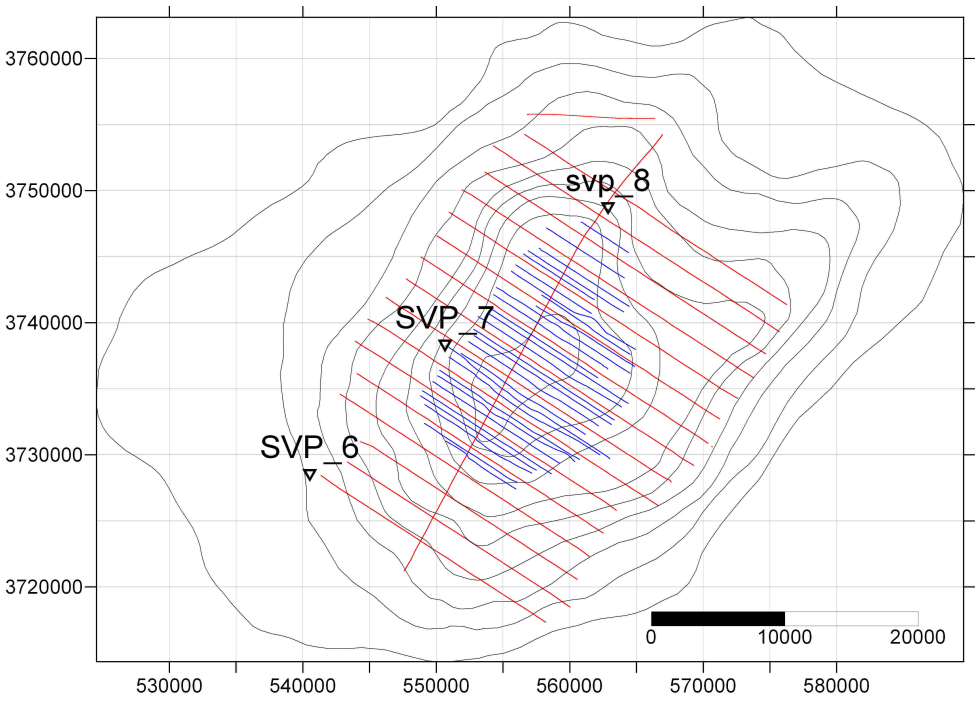


Fig. 14. Seine smt navigation lines (MB, CH and MG). Blue lines are the infilling routes over the top of the smt. In background the regional bathymetry from Gebco Digital Atlas. Coordinates chilometric, UTM zone 28.

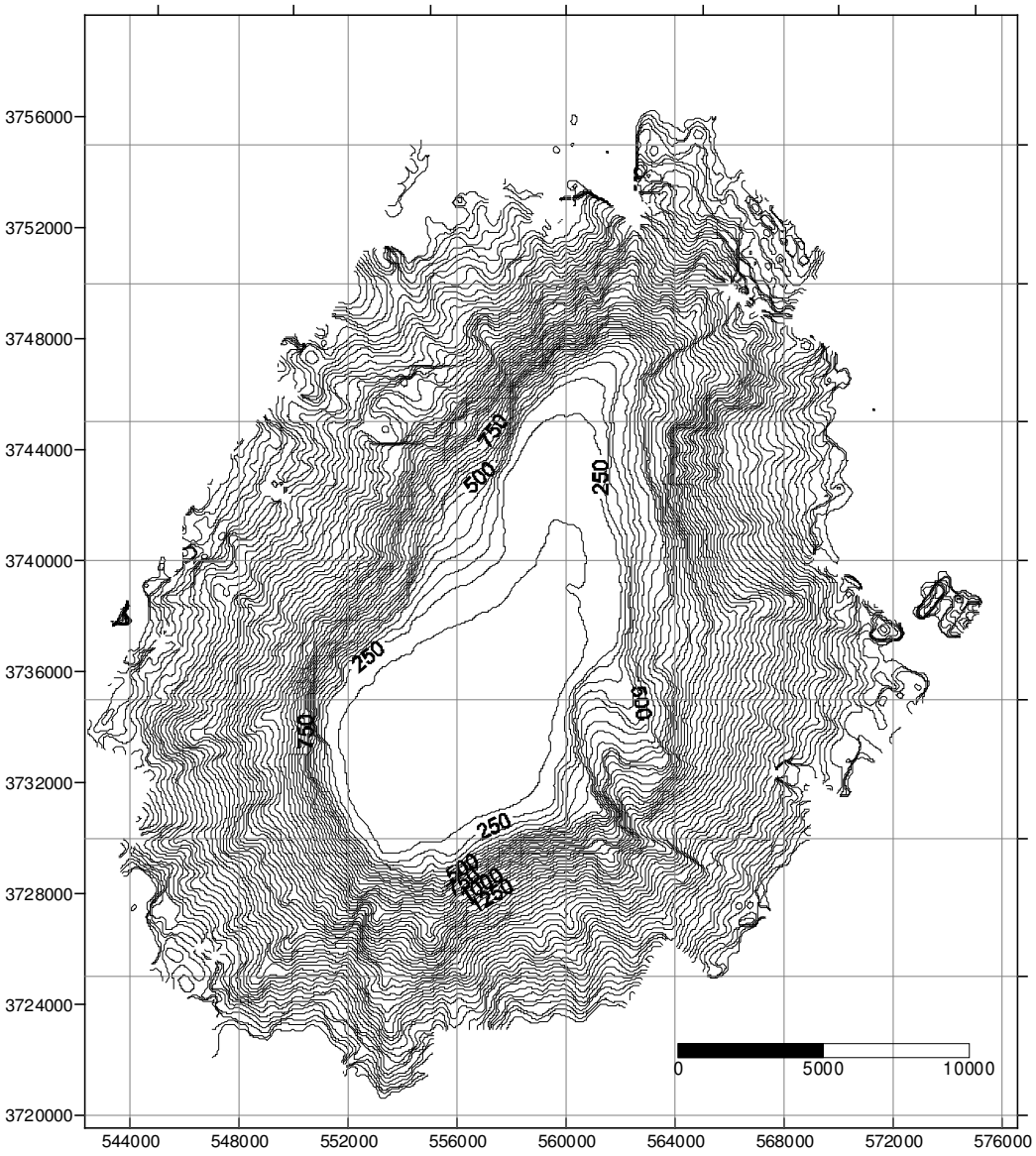


Fig. 15. Seine smt, preliminary bathymetry. Contour interval 50 m. Coordinates chilometric, UTM zone 28.

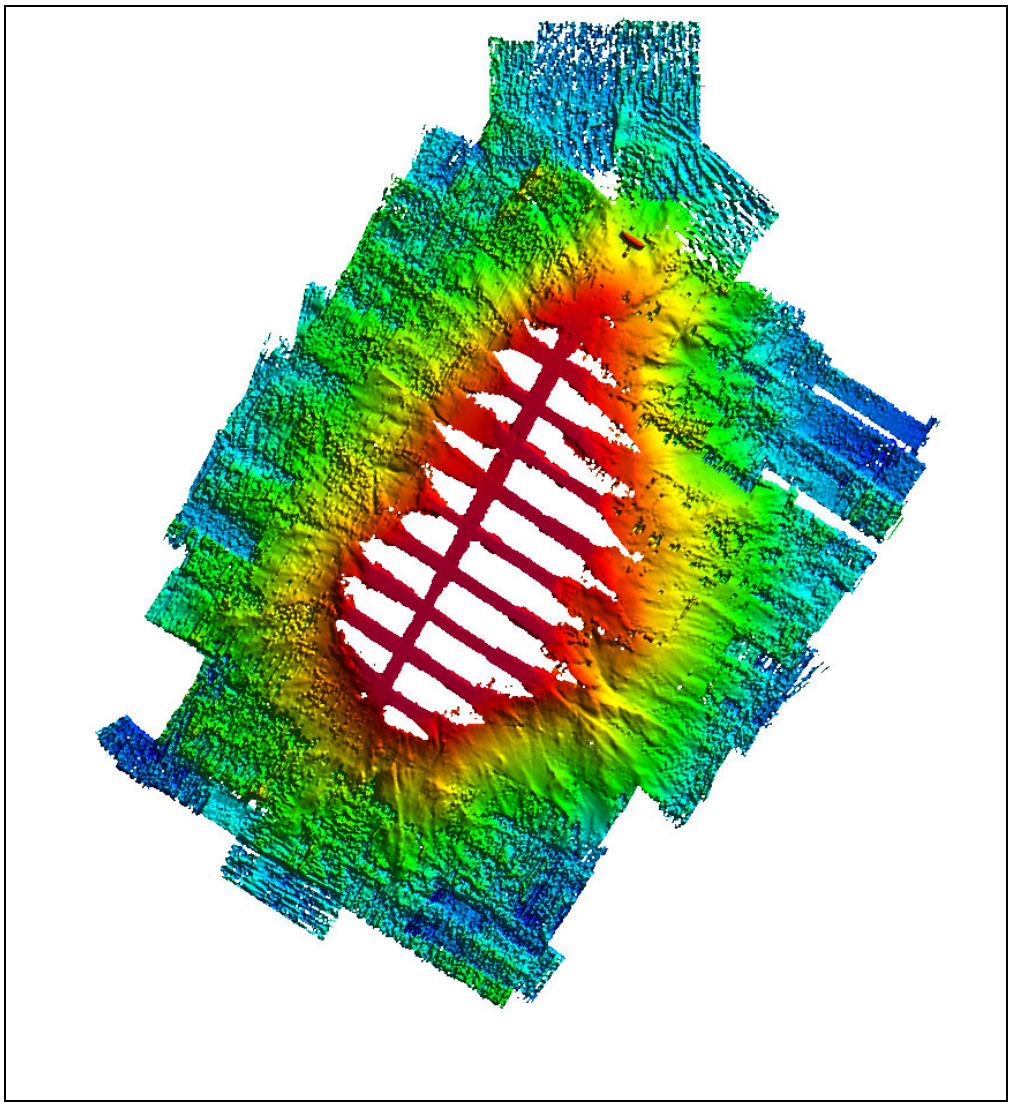


Fig. 16 Seine smt. Shaded relief map of the DTM at the end of the 1st leg. DTM cell size is 50x50m.

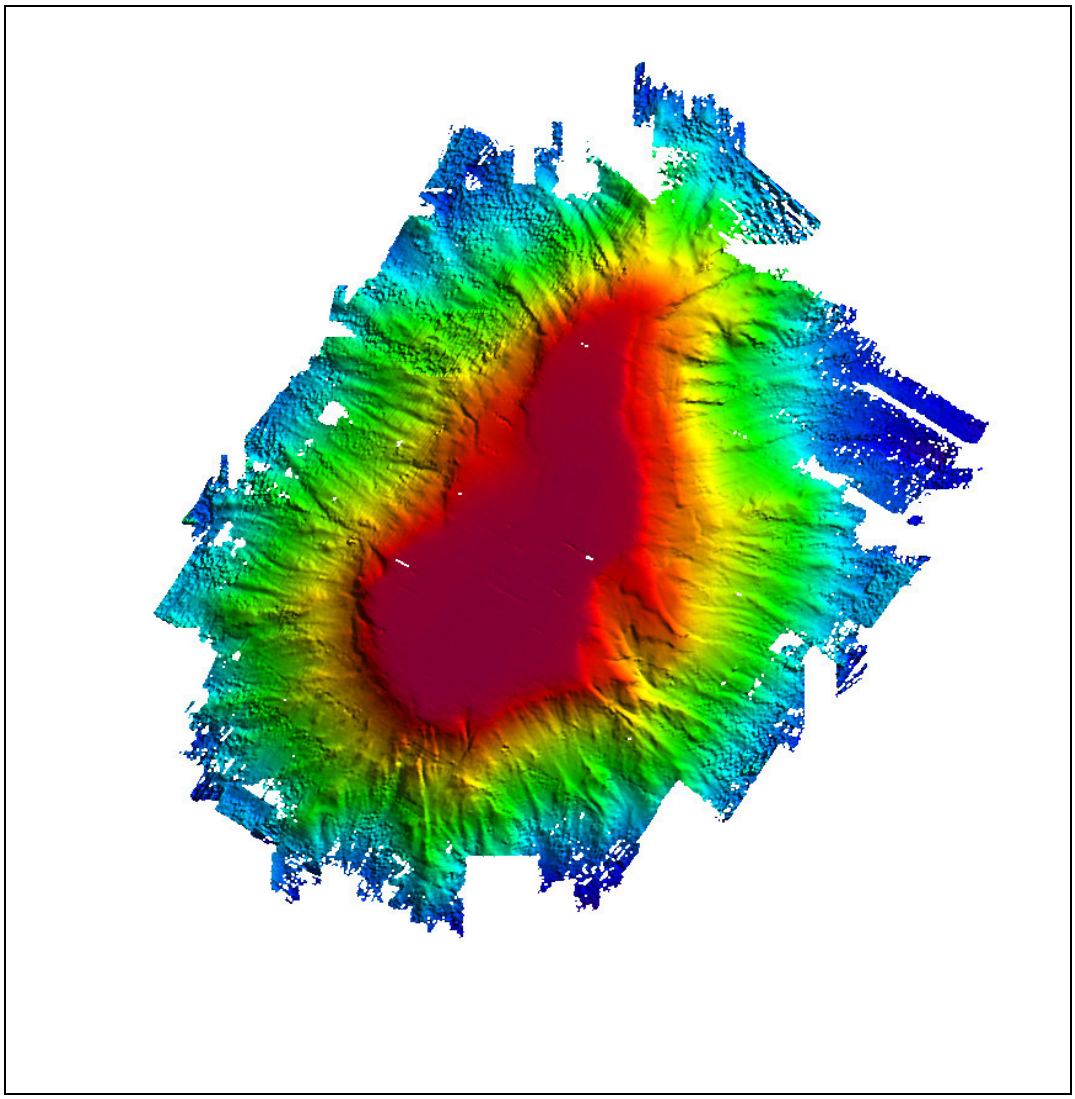


Fig. 17 Seine smt. Shaded relief map of the DTM after infilling and aboard pre-processing. DTM cell size is 50x50m.

Magnetometric survey

The Ampère smt was not completely surveyed with magnetometer due to rough sea. For the same reason Unicorn smt was not surveyed at all while Seine smt was surveyed with optimal line spacing. However, the very preliminary results indicate that Ampère smt has a strong magnetic signature with a > 700-800 nTesla anomaly with respect to the regional field which is in the order of 41600 nT while Seine smt is relatively poorly magnetized. Data pre-processing (temporal and diurnal corrections, IGRF correction, cross-over check; etc.) has not yet been completed so magnetic contour anomalies will not be presented in this report apart from some preliminary profiles (see figure 18).

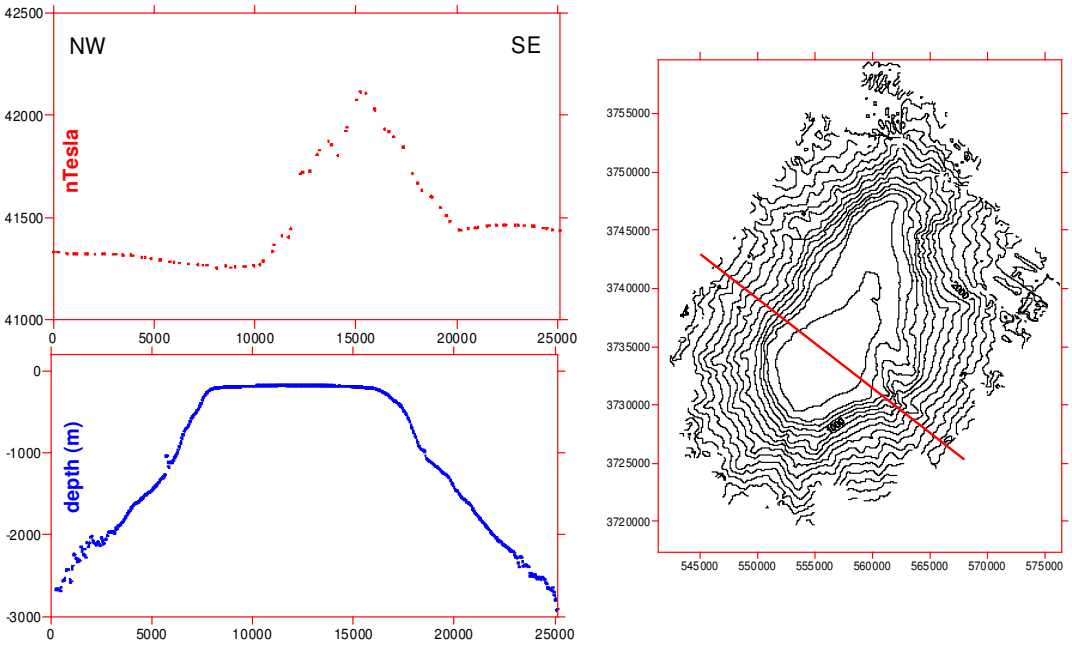


Fig. 18. Seine smt. Magnetic profile (above) matched with bathymetric profile. Trace of profile on the right. Although preliminary (not subtracted to the IGRF and not reduced to the pole) note that the magnetic anomaly is in the order of 400-500 nTesla.

SB profiling

The overall acoustic signature of the sea-bottom was poor due to the occurrence of rocky outcrops or bioclastic coarse sands. This prevented acoustic penetration (especially on Ampère and Seine smt that are shallower with a grater production of bioclastic material). However, in some instances, a fairly good acoustic response was detected.

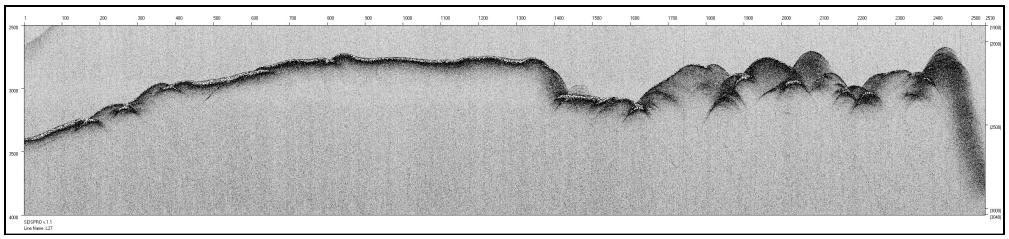


FIG. 19. Sub-bottom profile across the Ampère smt. Note poor or null penetration over the top of the seamount due to rocky outcrops or to coarse bioclastic sands.

Two sparker profiles have been acquired across the Seine Semount in order to get information on thickness and hopefully the internal geometry of stratigraphic units above the volcanic basement. The sparker system operated at 1 kJ, with shot rate of 1 sec. The acquired data revealed that the Seine Seamount is covered by a well-layered stratigraphic succession 60-80 m thick (unit 2) which over-lies a lower unit (unit 1) characterized by patchy occurrence and relatively modest stratigraphic thickness, mostly corresponding to sedimentary infill of pre-existing erosional scours or channels shaping the volcanic basement.

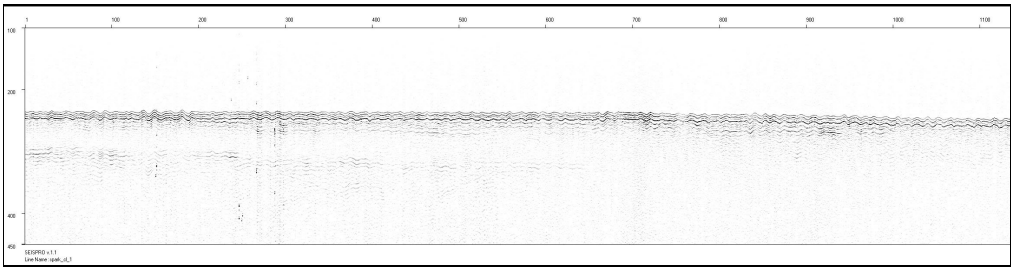


Fig. 20 Detail of sparker profile CL_1 acquired on Seine Seamount and preliminary interpretation. Note the gentle tilting of unit 2 , seemingly associated with low-angle truncation of strata at the sea-floor.

8. Preliminary results: seafloor sampling

The aim of the sampling operations was twofold: obtaining information of the volcanic basement rock) of this segment of the HS chain (through dredging) and sample the sedimentary cover and benthic fauna associations (through dredging and grabbing) at the top of the smts.
Four sites were dredged for rock samples from slope and escarpment, namely four on Seine smt and two on Unicorn smt.
A total of 13 grabs were sampled mostly over the tops of the smts in the upper hundreds metres depths. Only in a few cases (on the upper escarpment of Seine and at Unicorn) were grabs collected at greater depths. Almost every grab recovered, contained coarse to fine bio-clastic sands (planctonic and benthonic Foraminifera, Gasteropods Bivalves, Polychaetes, Echinids and Crustaceans rarely Bryozoans) and rarely basaltic clasts.

Summary of dredging stations

Date	Easting	Northing	Label	Location	Lat (North)	Long (West)	Depth (m)	Notes
01/11/2005	557078	3728481	S_DR_01	Seine	33°41.68'	14°23.04'	986	Start
01/11/2005	555792	3730456	S_DR_01	Seine	33°42.75'	14°23.87'	195	End
01/11/2005	558884	3730756	S_DR_02	Seine	33°42.91'	14°21.86'	470	Start
01/11/2005	559180	3731750	S_DR_02	Seine	33°43.45'	14°21.67'	209	End
01/11/2005	564268	3734087	S_DR_03	Seine	33°44.70'	14°18.37'	1040	Start
01/11/2005	562358	3734488	S_DR_03	Seine	33°44.91'	14°19.63	410	End
01/11/2005	564280	3738216	S_DR_04	Seine	33°46.92'	14°18.34'	870	Start
01/11/2005	561375	3740425	S_DR_04	Seine	33°48.13'	14°20.22'	220	End
07/11/2005	550032	3734774	S_DR_05	Seine	33°45.11	14°27.56	951	Lost
07/11/2005	554043	3742233	S_DR_06	Seine	33°49,13'	14°24,96'	1170	Lost
08/11/2005	554984	3838012	U_DR_07*	Unicorn	34°40,96'	14°23,98'	1017	Start
08/11/2005	554995	3838237	U_DR_07*	Unicorn	34°41,08'	14°23,98'	1101	End
08/11/2005	545254	3845188	U_DR_08*	Unicorn	34°44,87'	14°30,33'	1000	Start
08/11/2005	546643	3843651	U_DR_08*	Unicorn	34°44,03'	14°29,43'	800	End

(* in the photos U_DR_07 and U_DR_08 were named U_DR_01 and U_DR_02 respectively).

Summary of the grabbing stations

Date	Easting	Northing	Label	Lat (N)	Long (W)	Depth	Location	Findings
24/10/2005	692120	3881350	A_BN1	35°03.40'	12°53.60'	135 m	Ampère	bioclastic sand
24/10/2005	692975	3881045	A_BN2	35°03.23'	12°53.01'	100 m	Ampère	bioclastic sand, basalt
24/10/2005	693170	3881070	A_BN3	35°03.28'	12°52.91'	63 m	Ampère	brown algae
30/10/2005	557122	3737345	S_BN1	33°46.48'	14°22.98'	185 m	Seine	Serpulidae, Bryozoans
30/10/2005	556130	3735930	S_BN2	33°45.71'	14°23.63'	178m	Seine	bioclastic sand
30/10/2005	555763	3736134	S_BN3	33°45.83'	14°23.87'	182 m	Seine	empty
30/10/2005	553741	3737386	S_BN4	33°46.52'	14°25.18'	271m	Seine	bioclastic sand
30/10/2005	553503	3735437	S_BN5	33°45.46'	14°25.33'	187m	Seine	bioclastic sand

Date	Easting	Northing	Label	Lat (N)	Long (W)	Depth	Location	Findings
30/10/2005	554998	3733206	S_BN6	33°44.25'	14°24.38'	171m	Seine	bioclastic sand
30/10/2005	555518	3732468	S_BN7	33°43.85'	14°24.04'	173m	Seine	bioclastic sand
07/11/2005	556103	3740929	S_BN8	33°48.43'	14°23.63'	404m	Seine	fine bioclastic sand
07/11/2005	558209	3737992	S_BN9	33°46.83'	14°22.28'	183m	Seine	bioclastic sand
07/11/2005	561698	3733959	S_BN10	33°44.63'	14°20.03'	571m	Seine	fine bioclastic sand
07/11/2005	561718	3733666	S_BN11	33°44.47'	14°20.02'	614m	Seine	fine bioclastic sand
08/11/2005	545100	3845299	U_BN1	34°44.94'	14°30,45'	1024m	Unicorn	biocl. sand, volcanics
08/11/2005	553006	3845651	U_BN2	34°45.10'	14°25.25'	905 m	Unicorn	empty

Ampère smt

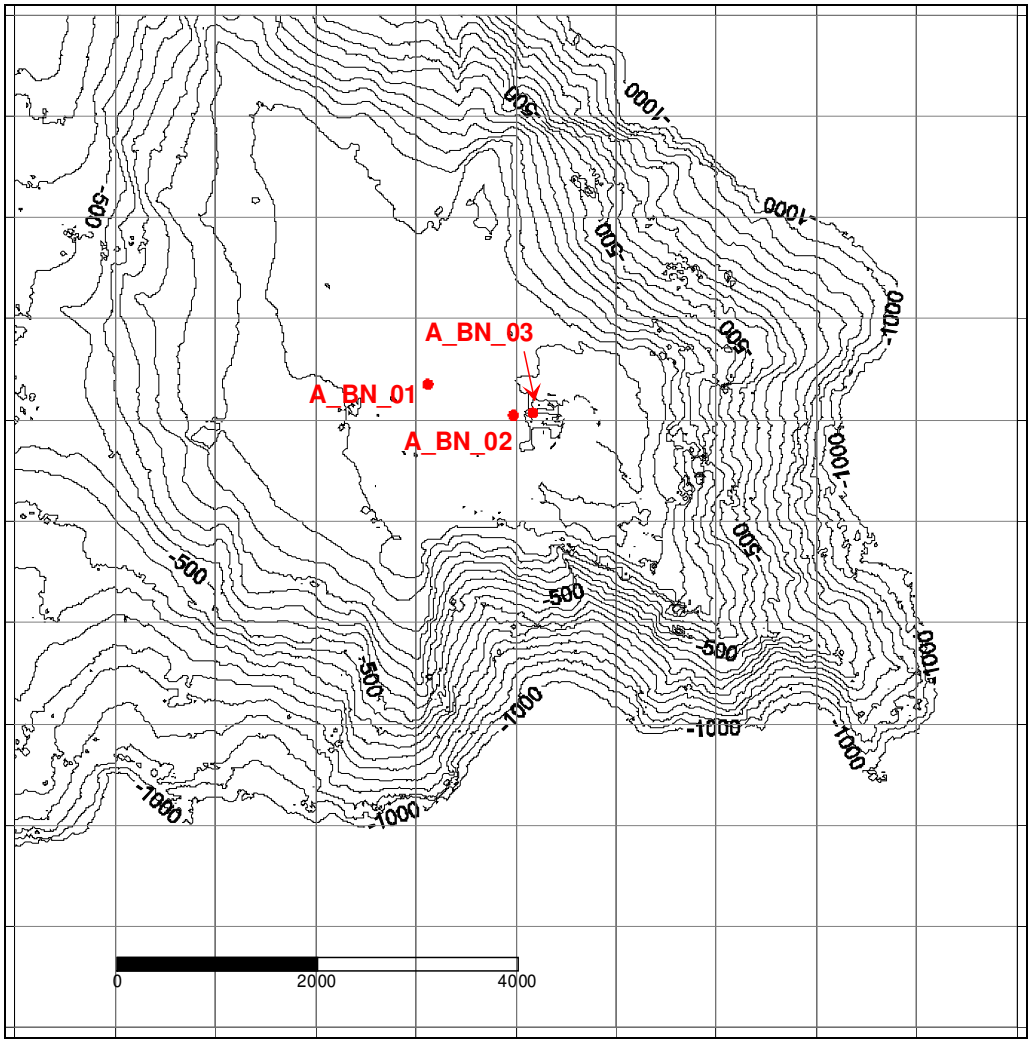


Fig. 21. Location of grab station on top of Ampère seamount.

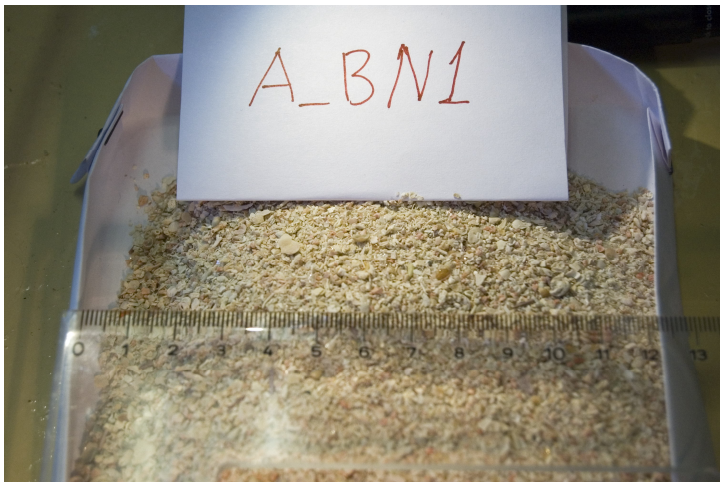


Fig. 22. Bioclastic sands from the top of Ampère seamount.
A-BN1 Grab - Depth: 135m

Bioclastic Assemblage			
Forams	Bivalves	Gastropods	others
Miniacina miniacea	Present but not determined	Present but not determined	Brachiopods.
Orbulina universa			Bryozoans
Globigerina bulloides			Echinoids
Elphidium crispum			
Textularidae			

Fig. 23. Bioclastic sands from the top of Ampère seamount.
A_BN2 Grab - Depth: 100 m. Fragments of micro-crystalline basalts.

Bioclastic Assemblage			
Forams	Bivalves	Gastropods	others
Miniacina miniacea	Barbatia barbata	Matildidae	Vermetidae
Orbulina universa		Rissoidae	Spirorbidae
Globigerina bulloides	Ostreidae	Astrea rugosa	Polychaetes Serpula vermicularis
Elphidium crispum		Pteropods (*Hyalocylis striata, Styliola subula, Cavolinia inflexa, Limacina inflata*)	Brachiopods Megathiris sp
Textularidae			Acmeidae
Nonionidae			
Pyrgo sp			

Seine smt

All dredgings made over the southern south-eastern flank of the smt in the 1000-200 depth range recovered vescicular and massive basalts (in two examples very fresh) with very few samples of pyroclastic rocks and one clast of an intrusive rock (gabbro ?). A "hardground-like" lithofacies, consisting of a bio-lithoclastic calcarenite, together with occasional shallow-water white foraminiferal-algal limestone were also sampled together with the benthic material (see detailed decription). Two dredges were lost during the sampling of the W-NW escarpment of the Seine.

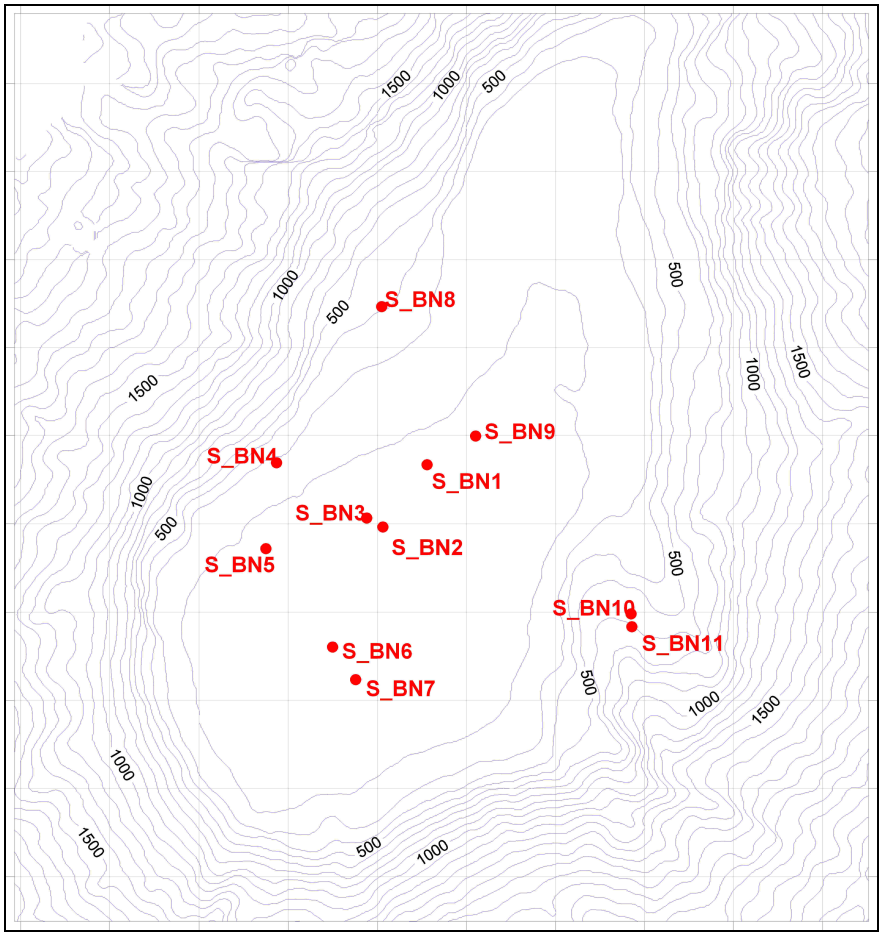
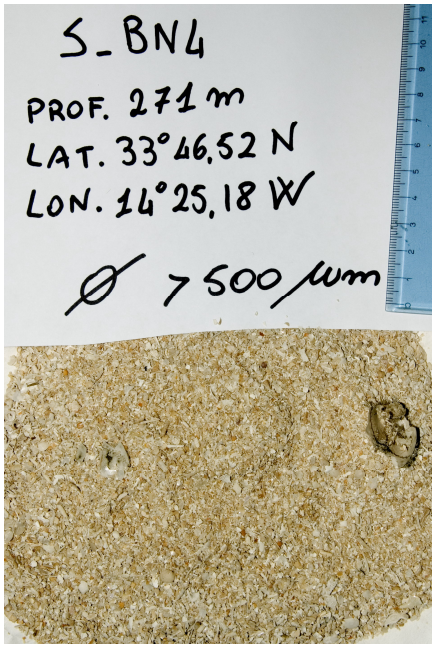


Fig. 24. Location of grab station on Seine seamount.



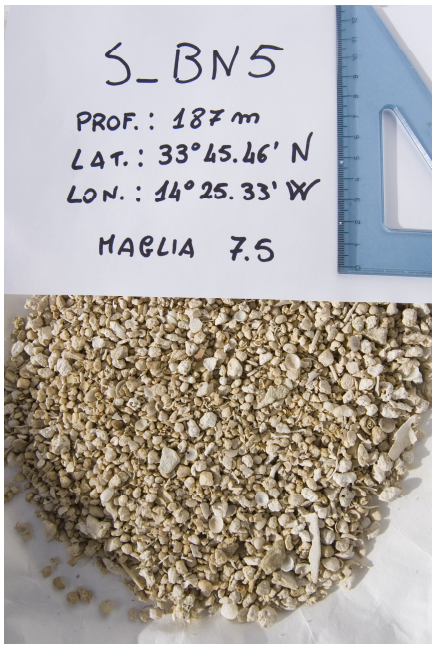


Fig.25 and 26. Bioclastic sands from top of Seine smt

Bioclastic Assemblage

S_BN4 Grab

Forams	Bivalves	Gastropods	others
Orbulina universa	Present but not determined	Rissoidae	Bryozoans
Globigerina bulloides		Scissurellidae	
Textularidae		Pteropods (*Creseis acicula; Clio piramidata; Cavolinia inflexa; Limacina inflata)*	Crinoids
Lagenidae			Crustaceans
Uvigerina sp			otolites

S_BN5 Grab

Forams	Bivalves	Gastropods	others
Orbulina universa	Cuspidaria	Rissoidae	Echinids
Globigerina bulloides	Arcidae	Scissurellidae	
Textularidae	Amusidae	Pteropods *(Clio piramidata; Cavolinia inflexa; Limacina inflata)*	Polychaetes
Lagenidae			Serpulidae
Uvigerina sp			

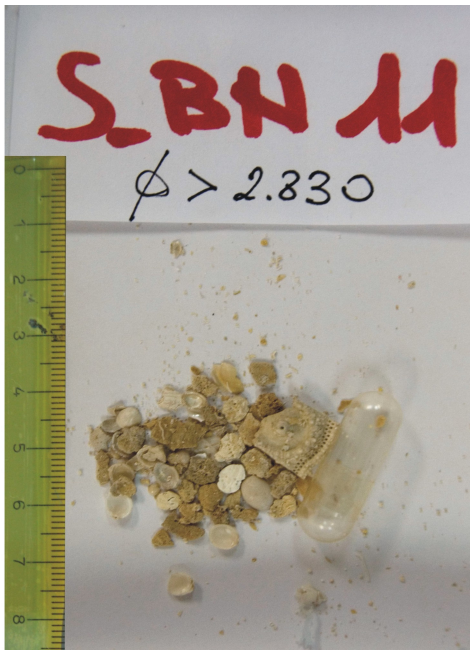


Fig.27 and 28. Bioclastic fine sands (and partly silts and clays) from the flank of Seine smt and coarse, selected fraction (right).

S_BN11_Grab - Depth: 614 m.

Bioclastic Assemblage

Forams	Bivalves	Gastropods	others
Orbulina universa	Nuculanidae	Rissoidae juv	Bryozoans
Globigerinoides ruber		Janthinidae	Serpulids
Globigerinella siphoniphera	*Lymopsis aurita*	Pteropods *(Limacina inflata, Styliola subula)*	Echinids
Globigerinoides sacculifer			Otolites.
Globorotalia inflata			Ophiuroids
Turborotalia truncatulinoides			
Sphaeroidinellopsis sp.			

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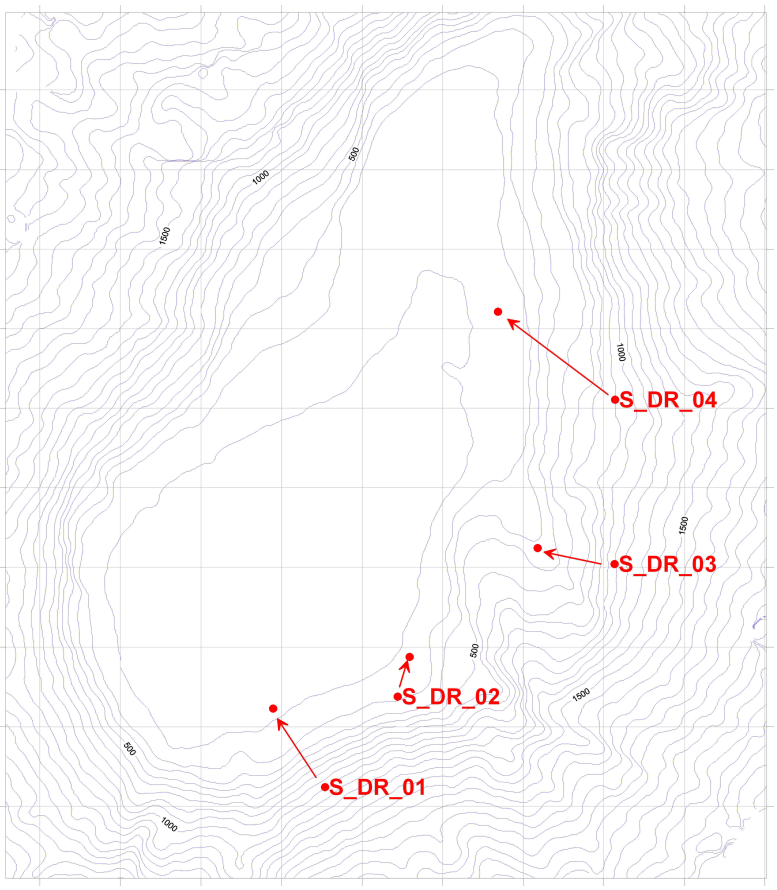

Fig. 29. Location of dredging stations over the south-eastern flank of Seine smt.

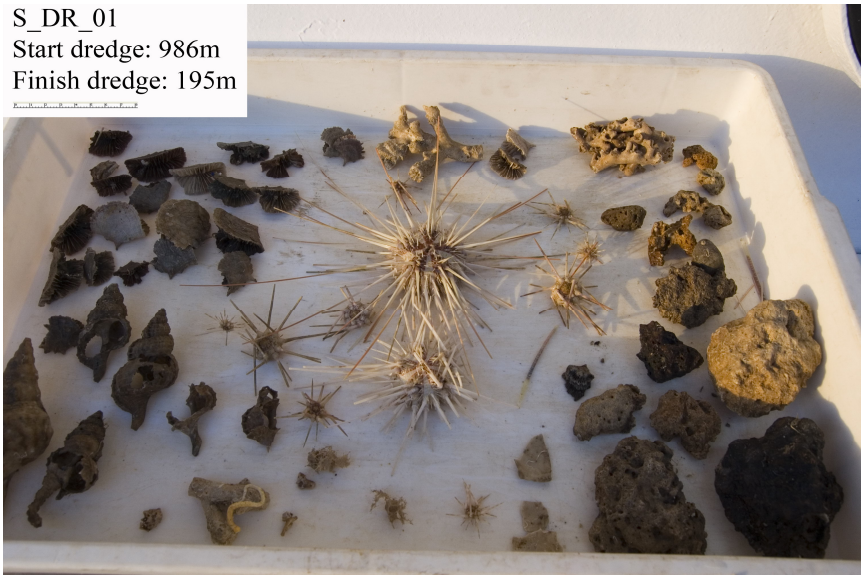

Fig. 30. Seine smt. DR_01_dredge haul

Rocks: Vescicular and massive, microcrystalline basalt; Clast-supported bioclastic "hardground" calcarenite. Benthos: Gastropods (*Ranella olearia, Charonia lampas);* Anthozoans (*Dendrophillia sp);* Solitary Corals; Echinids and small Ophiuridae.

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Fig. 31. Seine smt, DR_02 dredge haul.

Rocks: Clast-supported bioclastic "hardground" calcarenite. Benthos: Sponges; Anthozoans (*Callogorgia verticillata);* Brachiopods (Terebratulidae); Gastropods (*Neosimnia s);* Polychaetes.

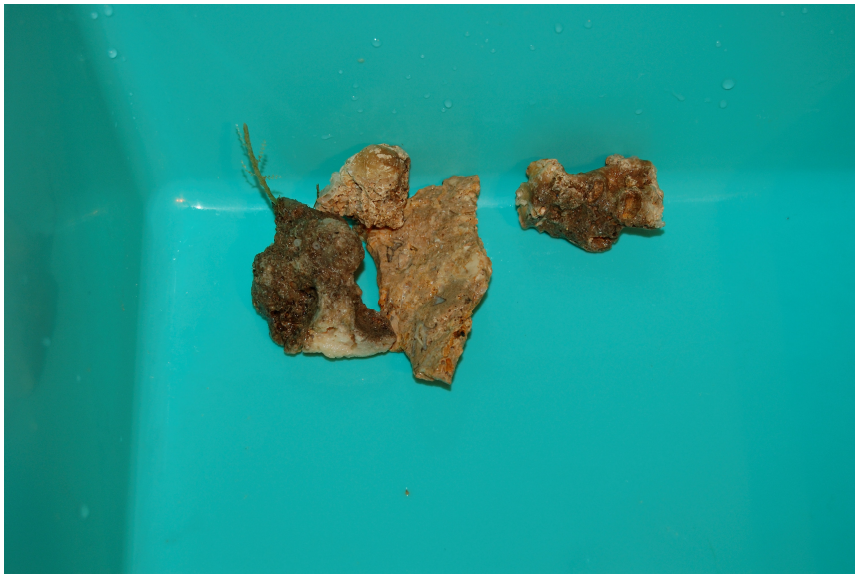

Fig. 32. DR_03 dredge haul . Seine smt. Depth 1040-410m.

Pyroclastic and lava rock fragments (cm size); Serpulids; weathered coral.

Fig. 33. Seine smt. DR_04 dredge haul.

Rocks:Vescicular, partly glassy, basaltic scoria (several samples very fresh); porphyritic intrusive rock (gabbro?). White foraminiferal-algal limestone. Hazelnut planktonic floatstone in packestone to mudstone matrix. Clast-supported, poorly cemented, beige bio-lithoclastic calcarenite recalling hardground. Bioclasts include gastropods bivalves, echinoid fragments, corals. Benthos: wheathered Ostrea shells; Porifera; Polychaetes.

Unicorn smt.

The two dredge samples collected from the Unicorn Seamount at greater depths (800-1000 m) contained fragments of glassy, blackish-greysh basalts with rare inclusions of carbonate ooze containing foraminifera; encrusted carbonate ooze and sand; fragments of fine-grained arenites containing abundant well-rounded quartz grains of probable aeolian origin.

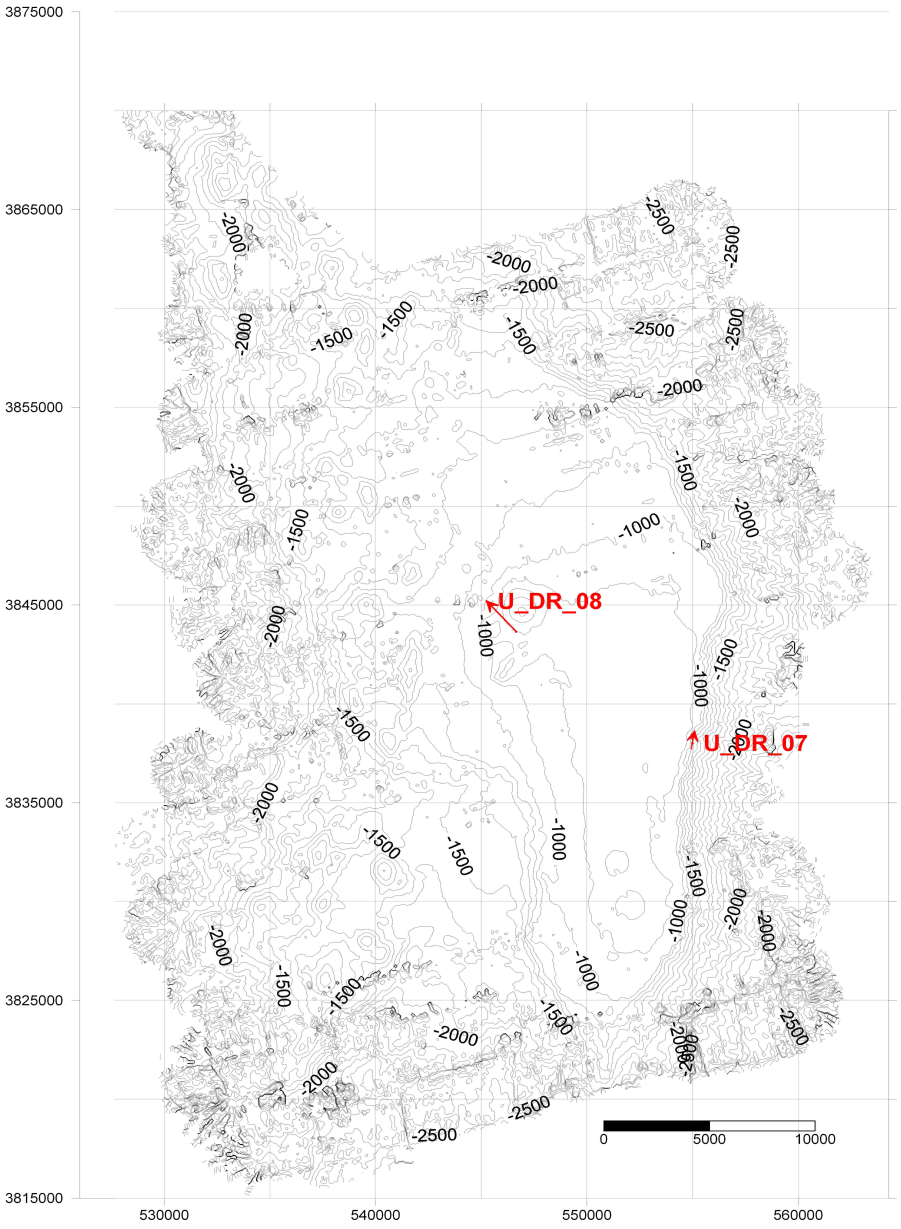

Fig. 34. Location of dredging stations on Unicorn seamount.

Fig. 35. Unicorn seamount. U_DR_07 (depth 1017-1101m)

Dredge haul with fragments of blackish, glassy basalts with intercalation of probably chert, with planctonic forams (*Orbulina* sp., *Globigerinatheka* sp., *Globigerina* sp., Globorotaliidae).

Fig. 36. Unicorn seamount, U_DR_08 (depth 1000-800) dredge haul.

Blackish basalts with fragments of fine-grained arenites-siltites containing abundant well-rounded quartz grains. "Hardground" crust incorporating planctonic forams, secondary benthonic (*Pyrgo* sp. and Miliolidae). Surface colonisation by sponge, bryozoans and serpulids.

9. Preliminary results: water column

The aim of the cruise was chiefly geological-geophysical; thus the main purpose of oceanographic. measurements was that of updating and correcting sound velocity for MB acquisition. CTD casts were collected with a SeaBird probe each 24 hours in the 0-2500m depth range. However, several anomalies with respect to modelled temperature/salinity profiles in this region of the North Atlantic mainly due to the influence of Mediterranean Water in the form of *Meddies* (Mediterranean eddies) were detected. The *Meddies* are coherent structures of warm and salt Mediterranean Water advected in the northeast Atlantic. Their thermo-haline properties are in the average 11.8°C, 36 psu with a radius between 25 and 110 km, and thickness between 500 and 1000 (see ref.). In almost all the water measurements such *Meddies* were detected in the proximity of Ampère, and Unicorn smts. at depths between 700 and 1300 m. Due to the lost of the CTD probe at the end of the 1st leg the remaining water measurements were done with the spare SVP probe usable only down to 1000 m depths. For this reason, no deep data over Seine smt was obtained nor the potential evidence for the existence of *Meddies* in this area.
The physical sensors installed under the ship hull allowed the continual measurement, with a sampling frequency of 5 minutes, of the surface water temperature and salinity. The mean sea-water temperature was around 21.5°C in the Atlantic (starting from 23.5 °C in the Mediterranean). Crossing the Gibraltar Strait, the water temperature decreased to 16-17 °C. A 2°C decrease was also detected at the passage of Bonifacio Strait (between Sardinia and Corsica).

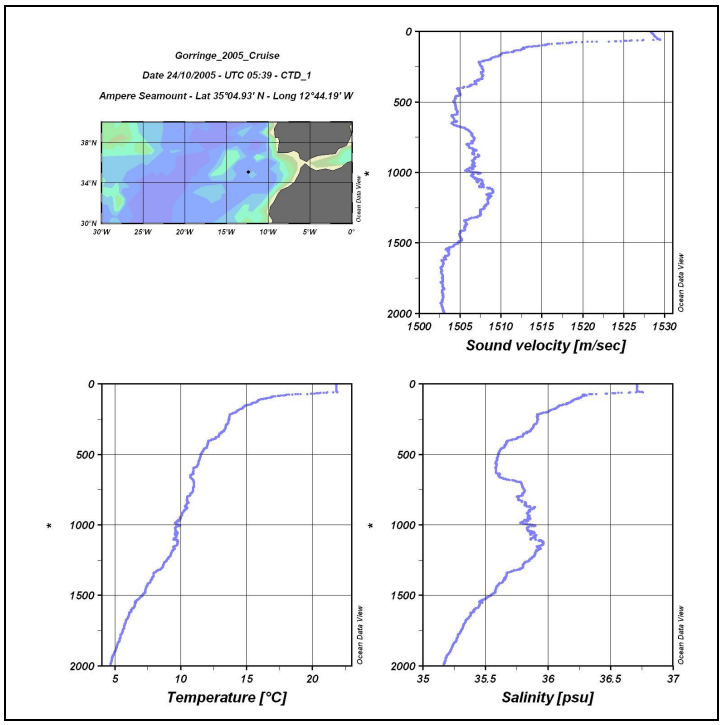

Fig. 37. CTD cast n°1, Ampère smt, 10-24-2005. Temperature and salinity departures from standard profile between 700 and 1200 m suggest occurrence of Mediterranean waters eddy.

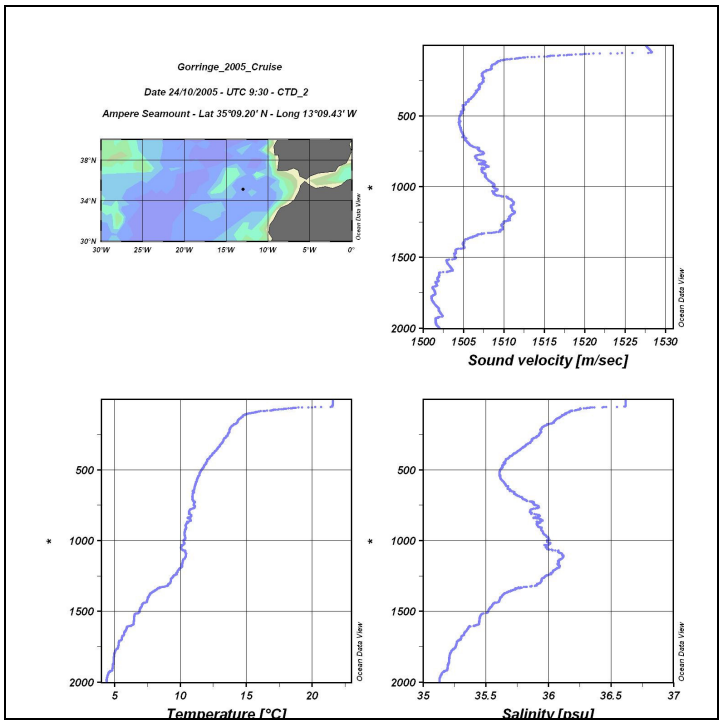

Fig. 38. CTD cast n°2, Ampère smt, 10-24-2005. Comments as in fig. 37.

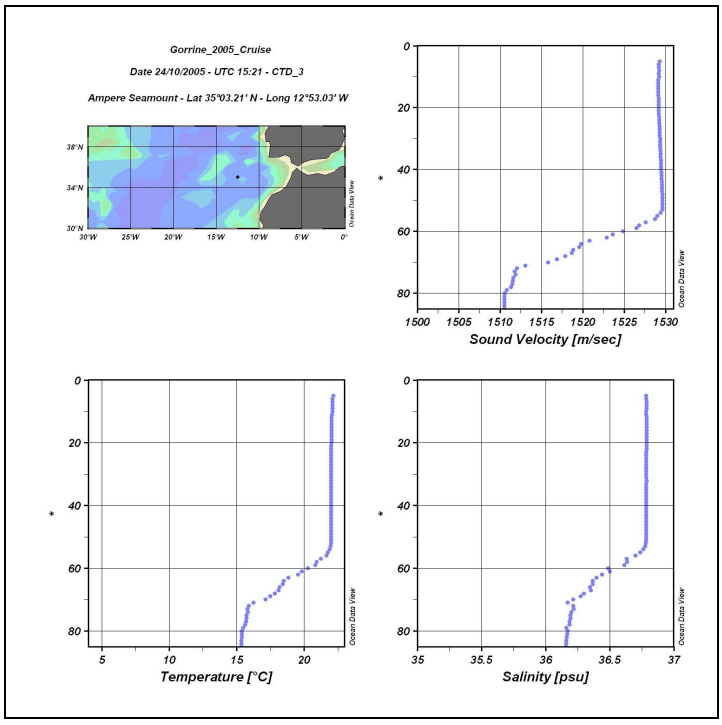

Fig. 39. Ampère smt, CTD cast n°3, 10-24-2005. Data were acquired only until 80 m just on top of the seamount.

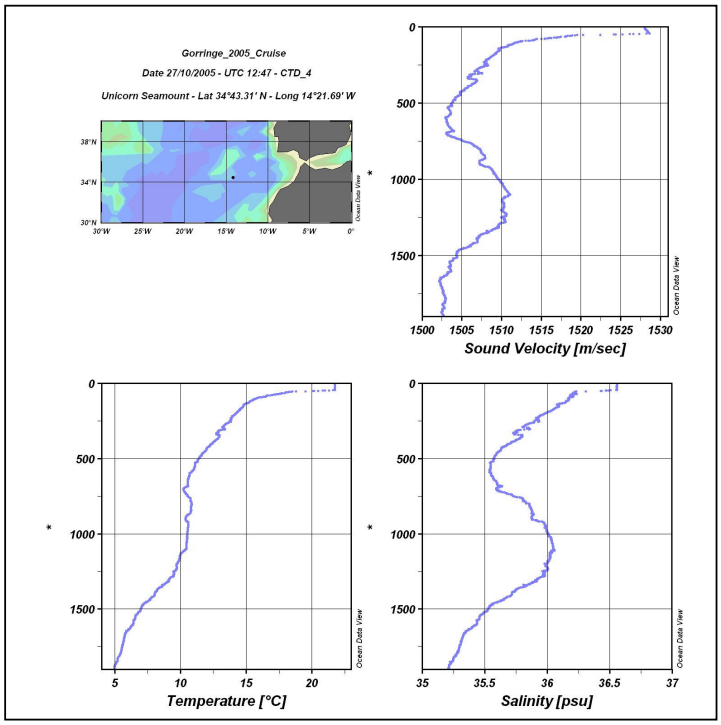

Fig. 40. Unicorn smt, CTD cast n°4, 10-27-2005. Also here the occurrence of a Meddy seems confirmed by data.

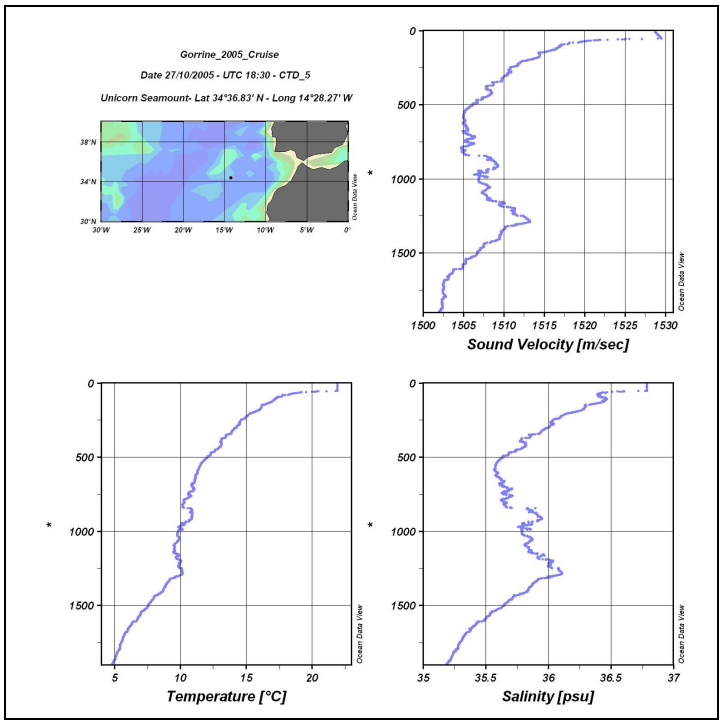

Fig. 41. Unicorn smt, CTD cast n°5, 10-27-2005. Also here the occurrence of a Meddy seems confirmed by data.

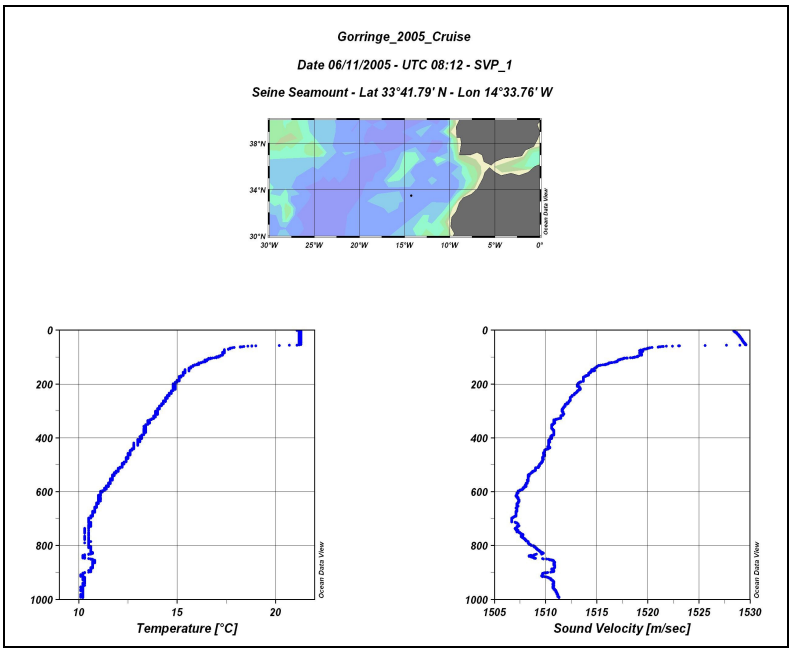

Fig. 42. Seine smt SVP n°1 (n° 6 in sequential order), 11-06-2005. Water column during the 2nd leg was explored until 1000 m with the SVP probe due to the lost of the CTD rosette.

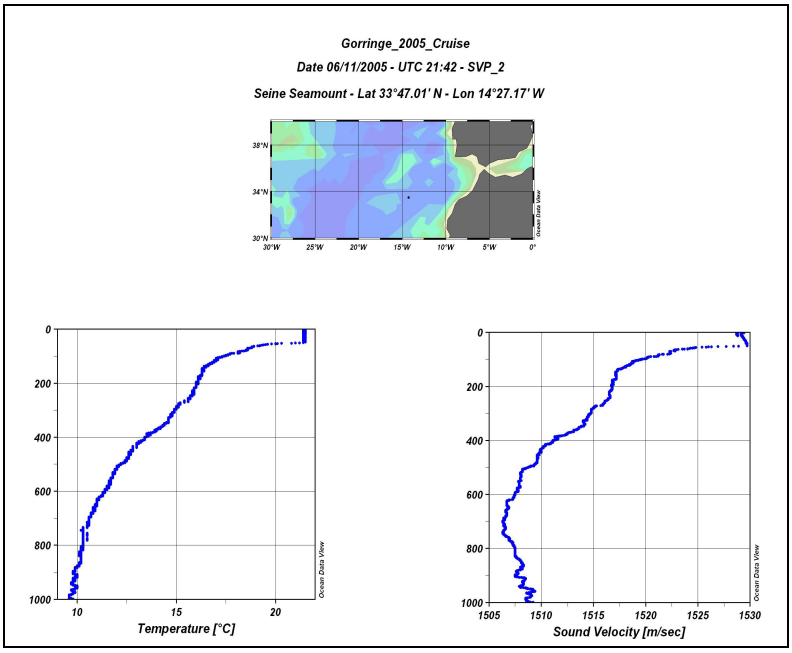

Fig. 43. Seine smt, SVP n°2 (n° 7 in sequential order), 11-06-2005. Comments as in previous figures.

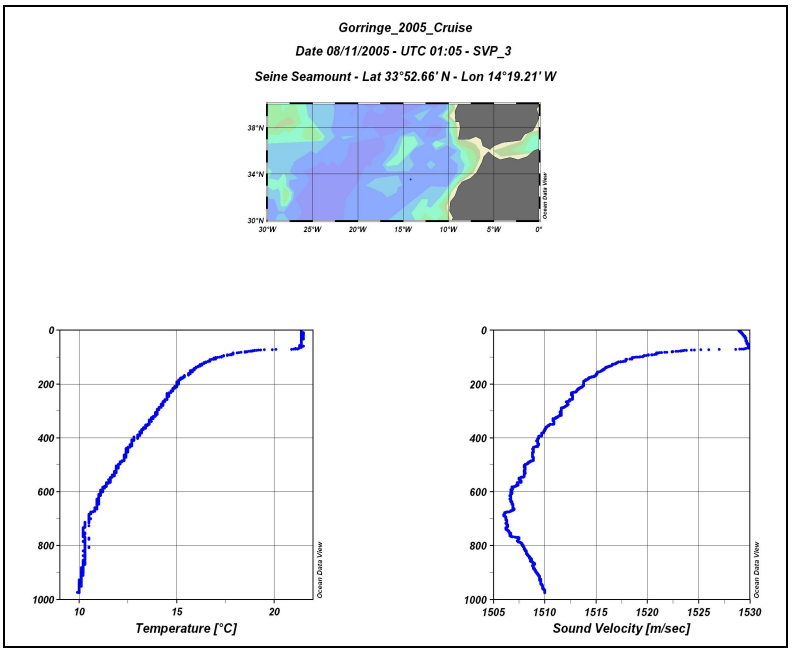

Fig. 44. Seine smt SVP n°3 (n° 8 in sequential order), 11-06-2005. Comments as in previous figures.

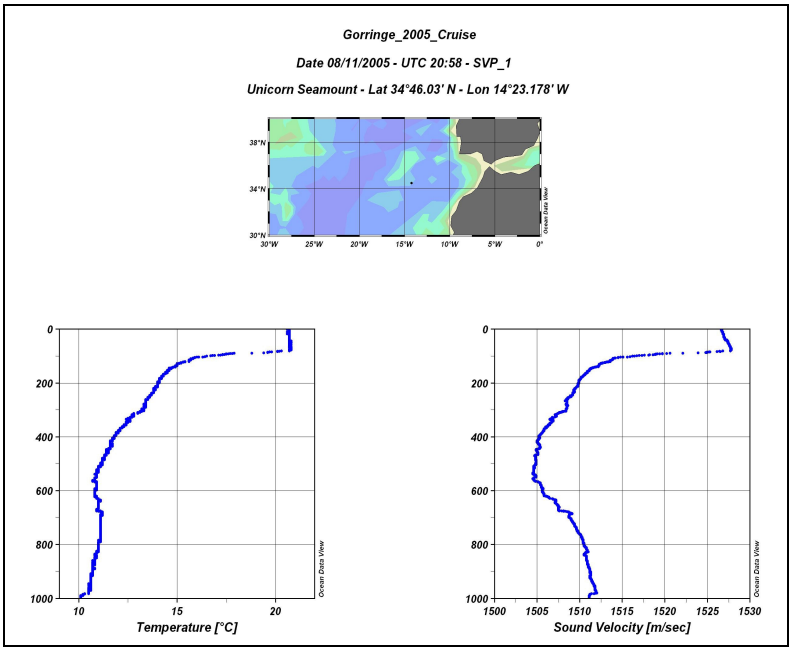

Fig. 45. Unicorn smt SVP n°1 (n° 9 in sequential order), 11-08-2005. Comments as in previous figures.

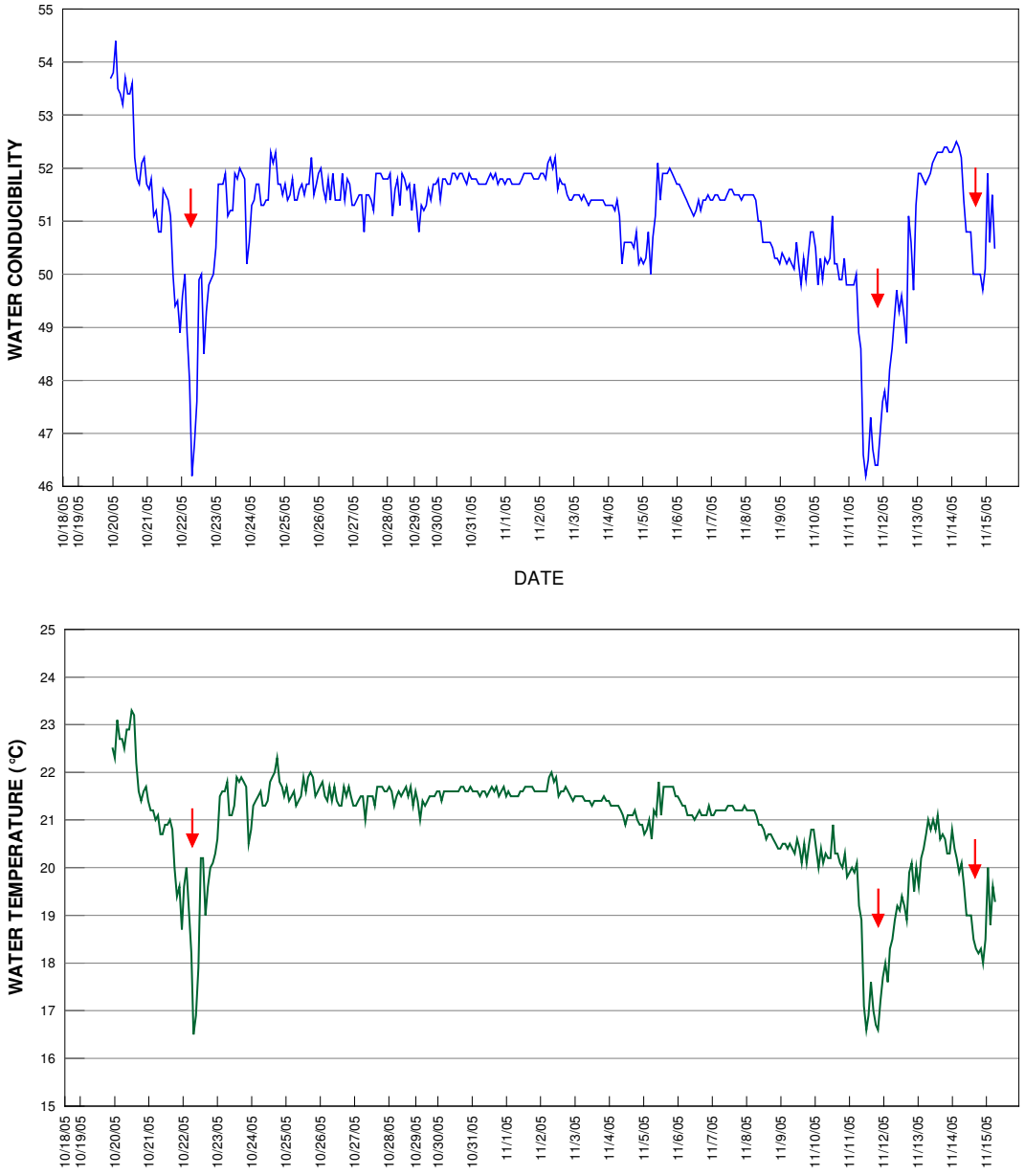

Fig. 46. Surface sea-water parameters while cruising. Note the temperature and salinity lows at Gibraltar and Bonifacio straits (arrows).

10. Weather conditions

The overall weather conditions were those typical of this region of NE Atlantic during the fall season. The main disturbances were due to the influence of those depressions developed at high latitudes in the NW Atlantic. Two of these cyclonic areas interested the survey area provocating two storms with force 8-9 (Beafourt) winds and very high sea-state. Apart from these two events the weather was moderate but with very frequent cross seas force 4-5.

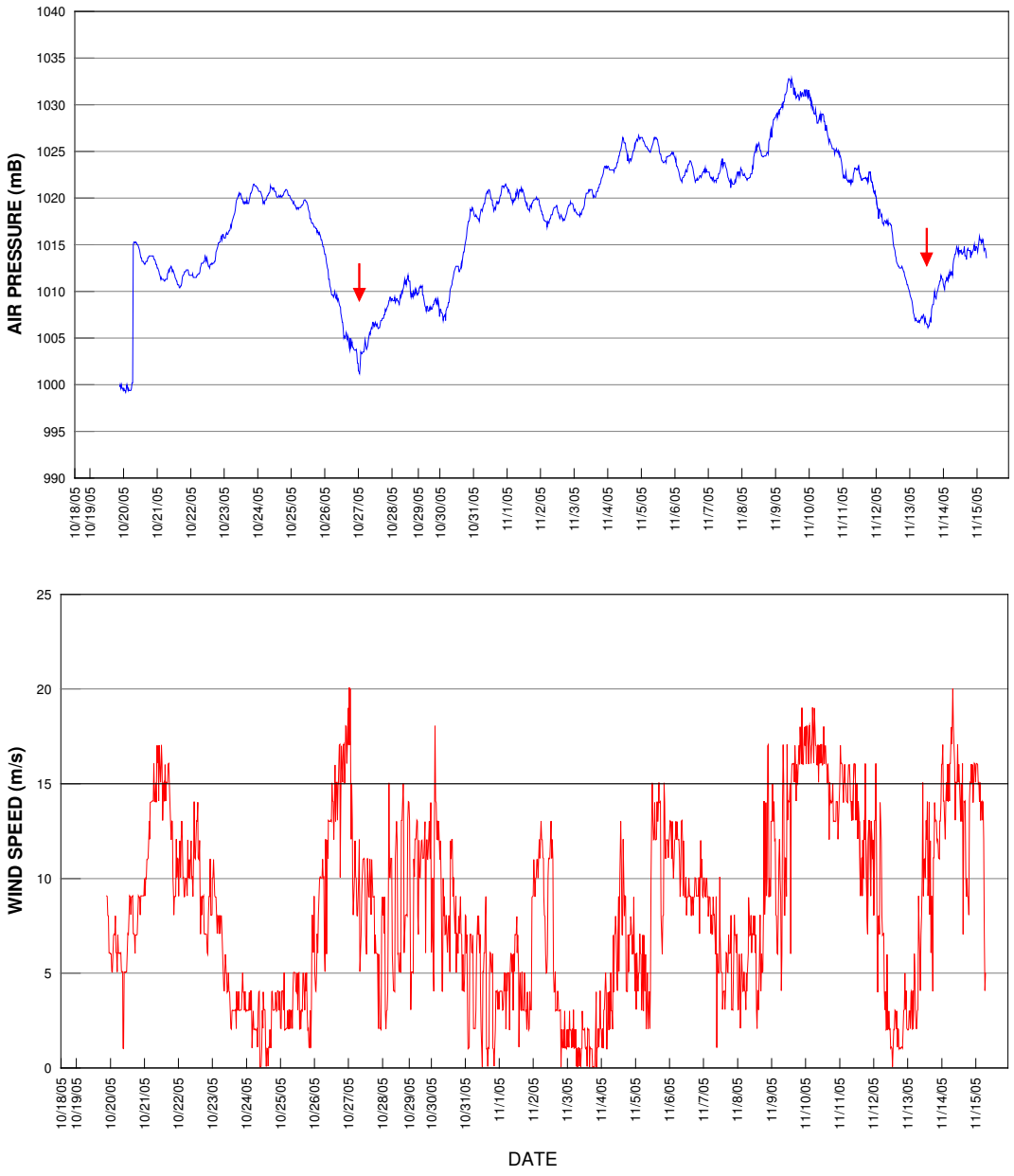

Fig. 47. Atmospheric pressure and true wind speed while cruising. Note the two cyclonic depressions (arrows).

11. Preliminary results

- A complete swath bathymetric survey has been carried out over Ampère, Unicorn and Seine seamounts in the NE Atlantic, the first two belonging to the Horseshoe submarine chain and the third, off Madeira archipelago.

- Grid lines spacing have ensured a sea-floor coverage in the order of 50-75% (for Ampère and Unicorn smts) up to more than 100% for Seine smt. The investigated depth range varied from few tens metres (top of Ampère) to 2500-3000m; the spatial resolution provided has been medium to high with an average grid cell size ranging from 20 m (at smts summits) to 50-100 m at depths > 1500 m.

- Ampère smt is an asymmetric volcanic edifice with southern flank affected by massive erosion in the form of some collapse scars that suggest sudden landslides. A flat topped summit is located over the eastern half of the seamount.

- Unicorn smt is a flat topped edifice with the summit surface located at around -400 m; it is crossed by small volcano alignements running N-S some raising to -330 m. These small volcanoes seem to be relatively recent basaltic edifices.

- Seine smt is flat topped volcanic edifice too, with the terraced surface located at -160 m. The shelf break is interested by incipient erosion along several small canyon heads.

- Poor or null acoustic penetration was achieved through sub-bottom chirp confirming the nature of rocky outcrops and of bioclastic loose or indurated sediments.

- On Seine smt a better penetration was obtained with sparker source seismic profiles. They have shown a relatively transparent seismic unit 40-50 m thick overlying an acoustic basement interpretable as the volcanic basement. The upper unit very probably consists of loose to lithified bioclastic sediments and possibly pyroclastic deposits.

- The bioclastic sand production seems inversely proportional to water depth and is higher on top of Ampère smt than on top of Seine smt. In this latter smt bio erosion and reworking prevail over the shelf area at -160-170 m; here a bio-calcarenite recalling an "hardground" litho-facies has been extensively recovered.

- The minimum depths detected for Ampère smt are around 60 m and confirm almost all previous investigations. On the contrary Unicorn smt has the summit at around 330 m depths. In previous bathymetric charts (Bathymetry of NE Atlantic, 1983; Admiralty Chart n° 3132, 1995) 256 m and 20 m minimum depths were reported. The density of our soundings rules out the case of having missed sea-bed information.

- Also Seine smt. has a minimum depth around -165 m contrary to what reported on these charts (-89 m).

12. References

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Links to other projects :

S.W.I.M. South West Iberian Margin, joint research project on marine geology-geophysics co-ordinated by :

- Dr. Nevio Zitellini, nevio@igm.bo.cnr.it, Istituto Scienze del Mare, ISMAR-CNR, Bologna, Italy
- Dr. Eulàlia Gràcia, egracia@utm.csic.es, Centre Mediterrani d'Investigacions Marines i Ambientals, CSIC, Barcelona, Spain,

O.A.S.I.S. Oceanic Seamounts : an Integrated Study. EC funded project co-ordinated by : Dr. Bernd Christiansen, Institut für Fischereiwissenschaft, Hamburg, Germany, b.christiansen@uni-hamburg.de

A.C.E.S. Atlantic Coral Ecosystem Study. EC funded research project, held by :
Prof. André Freiwald, andre.freiwald@pal.uni-erlangen.de, Institut für Paläontologie, Erlangen, Germany

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1st Leg Scientific party

2nd Leg. Scientific party. From left in the background: Maria, Sara, Alessandra, Nicola (sailor with helmet), Benedetta, Rossella, Imma, Erica; in the foreground: Mauro, Marco Barra, Marco Sacchi, Marco Trovato, Piero and Marcello. On the gangway: Sandra.