Intergovernmental Oceanographic Commission

Workshop Report No. 220

Geo-Marine Research on the Mediterranean and European-Atlantic Margins

International Conference and
TTR-17 Post-Cruise Meeting of the
Training-through-Research Programme

Granada, Spain
2-5 February 2009

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A. Suzyumov

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PREFACE

Geo-Marine Research on the Mediterranean and European-Atlantic Margins- International Conference and TTR-17 Post-Cruise Meeting of the Training-through-Research (TTR) Programme was held from 2 to 5 February 2009 at the University of Granada, Spain. It was organized and hosted by "Instituto Andaluz de Ciencias de la Tierra" – IACT (CSIC and Granada University).

The Conference/Post-Cruise Meeting was focused on the results of the TTR-17 (2008) cruise. Its goal was to stimulate interdisciplinary work by bringing together the participants in this and other TTR cruises, as well as other scientists interested in all fields of marine research with the focus on the Mediterranean and European-Atlantic continental margins. It also contributed to the European project on "Hotspot Ecosystem Research on Margins of European Seas" (HERMES, 2005-2009).

Reflecting main sectors of research activities of TTR, the Conference covered the following aspects of science related to:

- **Mud Volcanoes**: Geological setting; Causes and consequences; Seafloor expression; Mud and mud-breccias composition; Fluids and gases; Living & dead ecosystems; Environmental controls.
- **Carbonate Mounds**: Geological setting; Causes and consequences; Seafloor expression, Mound composition and related facies; Living & dead ecosystems; Environmental controls.
- **Pockmarks, Hydrocarbon seepages and Gas Hydrates.**
- **Pelagic realms**: Facies; Biostratigraphy; Environmental & Climate proxies.
- **Turbidite Systems & Submarine slides**: Geological setting; Causes and consequences; Seafloor expression; Turbidite facies; Controlling factors.

The Conference programme was set up by the Scientific Committee composed of:

- Menchu Comas, IACT, CSIC and University of Granada, Spain
- Mikhail Ivanov, Moscow State University, Russia
- Jan Sverre Laverg, University of Tromso, Norway
- Luis Pinheiro, University of Aveiro, Portugal

The Organizing Committee of the Host Institution included:

- Prof. Dr. Menchu Comas
- Dr. Francisca Martínez-Ruiz

Secretarial assistance was provided by Manuel J. Román-Alpiste.

The meeting was attended by over 40 participants from the following countries: Brazil, Italy, Japan, Norway, Portugal, Russia, Spain, Switzerland, Turkey and UK. Attending were researchers and students with different specialties (sedimentology, geophysics, geochemistry, microbiology, biology, paleontology, structural geology) and research interests falling in the area of the Conference theme. Altogether, 24 oral and 12 poster presentations were made. A fieldtrip to the Guadix Basin (External Betic Cordillera, north of Granada), leaded by Profs. Dr. C. Viseras and Dr. J. Fernandez (University of Granada), followed the Conference. At the closing session the participants expressed great satisfaction with the Conference as having fully accomplished its objectives and facilitated fruitful contacts between the attendees. Special words of gratitude were addressed to Prof. Dr. Menchu Comas and her team for excellent organization of the meeting.

In order to selected three best students' presentations, the Nomination committee was established as follows: Luis M. Pinheiro, Mustafa Ergun, Martin Hovland.

The first prize was attributed to Mikhail Tsypin for his study of Mud Volcano fluids of the Gulf of Cadiz: chemical and isotope variations and factors of control. The 2nd one was attributed to Maria Makarova and the 3rd one to Yulia Kolganova. In the concluding remark a very high level of presentations by students was noted.

For the Conference, the book of abstracts was compiled by Menchu Comas assisted by Manuel J. Román-Alpiste (Granada University). For the present Report, it was further edited by A. Suzyumov (IOC Consultant). To emphasize the importance of many presentations for regional studies, the abstracts have been grouped according to three geographical areas: the Mediterranean Sea; Gulf of Cadiz; and NE Atlantic and the Norwegian Margin. One more grouping combines various information materials submitted to the Conference. Within each grouping, the abstracts are given in the alphabetic order by first author (with the exception of two introductory lectures related to the TTR-17 cruise). Reporting authors are marked with asterisks. Annex I contains the Conference programme. The participants are listed in Annex II.

The Conference was supported by the Instituto Andaluz de Ciencias de la Tierra (CSIC and University of Granada) and the Ministry of Science and Innovation, Spain. Research work, travel and accommodation of individual participants were also supported by various national and international programmes and projects (reflected in Acknowledgements in each abstract).

Abstracts

Introduction to the TTR-17 results

M. Ivanov[1]*, N. Kenyon[2], M. Comas[3], L. Pinheiro[4], J.-S. Laberg[5] and shipboard Scientific party

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The TTR-17 cruise was subdivided into three Legs. Leg 1 focused on study of sea mounds and hydrocarbon seeps in the West Alboran Sea (Fig. 1). The Melilla Sea mounds discovered by Spanish scientists in 2006 (Comas et al., 2007) were studied in detail with high resolution seismic, deep towed sidescan sonar, underwater TV system and sampling. These investigations confirmed the presence of large coral buildups comparable by their dimensions to carbonate mud mounds of the Porcupine Seabight. This is the first and very important documentation of large-scale cold water coral reefs in the Alboran basin.

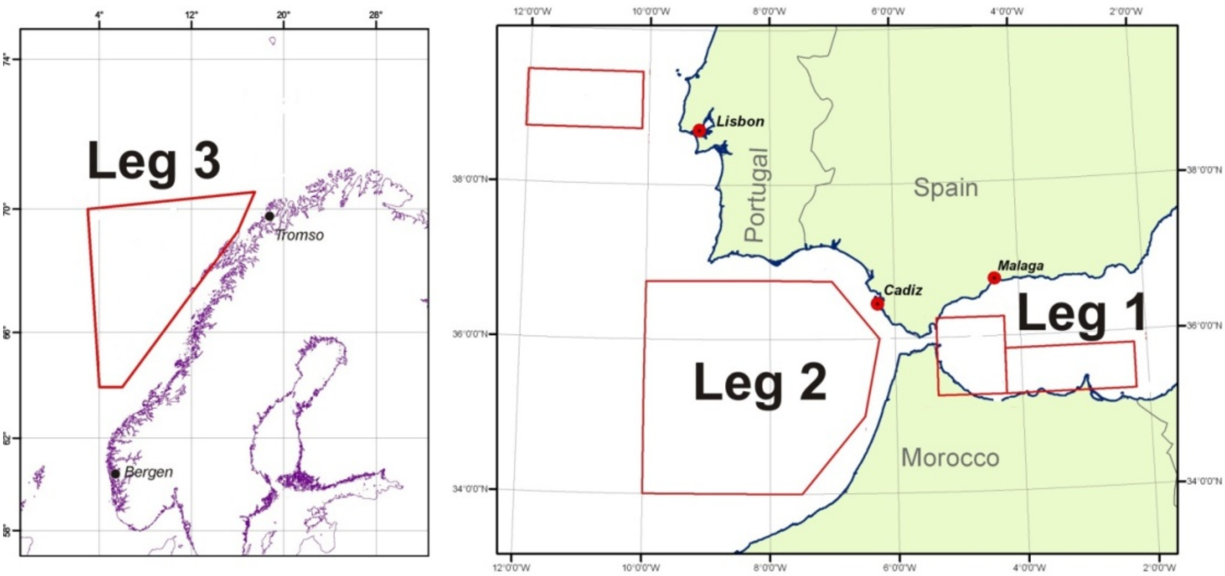

Fig. 1. Location map of study areas, TTR-17 cruise.

Detailed investigations of the Carmen structure (recorded for the first time in the TTR-14 cruise, Kenyon et al., 2006) revealed that this is a relatively small, but extremely active deep water mud volcano (MV). According to our observations the Carmen MV is the most active one in the entire region including the Alboran Sea and the Gulf of Cadiz. This fact undoubtedly will attract attention of many investigators. The Carmen structure is characterized by a very strong gas emission, predominantly methane. Bubbling of free gas from the sea bottom was observed during underwater TV runs. Sediment cores from the crater of this mud volcano are presented by very fresh mud volcanic breccia with a very high gas and water saturation. Free gas bubbling from a large TV-grab sample (about 0,25 m^3) continued for no less than 10 minutes and has been recorded on video. It leads us to a suggestion that gas most probably was stored in structure II gas hydrates form which are normally stable in temperature-pressure conditions of the sea bottom at the crater area. After lifting sediments on the deck of the ship hydrates started rapidly decomposing producing a lot of free gas and water.

Abundant chemosynthetic fauna included two types of pogonofora and living chemosynthetic shells. Various methane derived carbonates have been documented and sampled in the Alboran basin for the first time.

Leg 2 in the Gulf of Cadiz was devoted to studying mud volcanoes, coral settlements, gas hydrate accumulations and relationships between large mud/salt diapirs (diapiric ridges) and seepage structures. The crest of a large diapiric body located to the east of the Mercator MV was surveyed with seismic, sidescan sonar, underwater TV, and sampled. The top of this structure is strongly eroded and lately covered by carbonate crusts, coral settlements and partially buried with recent sediments. A gravity core collected from this structure showed increasing pore water salinity with depth similar to those observed earlier in a crater of the Mercator MV and on some other structures. This fact can probably characterize this structure as a salt diapir or at least a diapiric structure containing some salt. The same observations were done on the Renard Ridge N-E of the Gemini mud volcano. This suggests that a chain of topographic highs including the Don Quichotte MV, the Alfa and Betta mounds, the top (plateau) of the Pen Duick escarpment are just shallow crest position or outcrops of elongated salt diapiric ridges. In this case such structures as the Fiuza MV, the Gemini MV and a chain of small seepage structures at the foot of the Pen Duick escarpment were generated due to fluid migration (front) along the southern side of a salt diapiric ridge. Yet another remarkable new discovery on the Moroccan margin during this Leg is an extensive field of cold water coral settlements located along the shelf break east of the Mercator and Al Idrisi mud volcanoes. They were mapped firstly in 2002 during the TTR-12 cruise (Kenyon et al., 2003) but we were not able to interpret these peculiar features at that time. Now they were mapped with high resolution sidescan sonar, surveyed with a TV camera, and sampled.

One new mud volcano has been discovered in the Portuguese deep water area. A big number of different kinds of deep water chemosynthetic fauna were collected on the Portuguese margin. One of the most exciting events of this part of the cruise was sampling for the first time gas hydrates from the deepest in this area Porto mud volcano. Most of hydrate samples look very surprising for us, because they have been represented by perfect cubic or prismatic crystals semitransparent for the first several seconds after subsampling; they look very similar to crystals of quartz or calcite.

A few last days of Leg 2 were spent on dragging alkaline igneous rocks of the Late Cretaceous age from outcrops of the Estremadura Spur area offshore Lisbon. In addition to different kinds of igneous rocks, remnants of huge (probably very old) cold water corals have been collected. These samples may have significant interest to specialists studying history of deep water coral distribution in the Atlantic Ocean.

Leg 3 aimed mainly to studying Cenozoic sandy systems on the Norwegian continental slope and abyssal plain of the Lofoten Basin. Mapping of the modern system, the Andoya Canyon – Lofoten Basin Channel with deep towed sidescan sonar started in 2003 (TTR-13). It was continued and accompanied with very successful sampling. Spectacular records of large recent submarine slides have been obtained during this Leg on the Norwegian continental slope as well.

Origin of small but numerous positive structures broadly distributed on the Vøring Plateau raised a lot of discussions and open questions in previous years. During this Leg these structures were sampled with a TV-controlled grab and proved to be thick bacterially induced iron hydroxide crusts and chimneys with sufficient presence of phosphates.

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Comas, M.C and Pinheiro, M. L. (2007). Discovery of Carbonate Mounds in the Alboran Sea: The Melilla Mound Field. 1st International Conference of the Moroccan Association of Petroleum Geologists (MAPG) in association with the American Association of Petroleum Geologists (AAPG), Marrakesh, October 28-31, Abstract Book:73

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Kenyon N.H., M.K. Ivanov, A.M. Akhmetzhanov and G.G. Akhmanov (Eds.) (2003). Interdisciplinary Geoscience Research on the North East Atlantic Margin, Mediterranean Sea, and Mid Atlantic Ridge During the TTR-12 Cruise of RV *Professor Logachev*, June–August 2002, IOC Technical Series No. 67, UNESCO, 156 pp.

Mediterranean and Black Sea Studies

Active mud volcanism in the Alboran Sea: Preliminary results of hydrocarbon fluids composition from TTR-17 Leg 1 Cruise

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Five multidisciplinary Training Through Research (TTR) cruises visited the Western Alboran Sea between 1999 and 2008 for detail investigation of mud volcanism in the area. The TTR-17 Leg 1 cruise of the R/V *Professor Logachev* (June, 2008) was carried out to explore new fluid escape structures and to supplement with geological and geochemical data some geophysical data on previously discovered mud volcanoes (MV). Two main mud volcanic fields are known in the area. The northern field is located on the beam of the Gibraltar Strait and includes two mud volcanoes: Perejil and Kalinin. The southern one is situated at the Moroccan margin, it includes four structures (Granada, Dakha, Mulhacen, Marrakech) (Fig. 1). The latter four structures and three newly discovered buried mud volcanoes (Maya and two more structures, which have not been sampled) were studied on the Moroccan margin during the survey (Fig. 1). In addition the Carmen mud volcano (situated in between the above-mentioned two fields) discovered in 2005 during the TTR-15 cruise was sampled for the first time.

The aim of this work is to present newly received geochemical and geological data from gravity cores and TV-controlled grab samples. Previous investigations (1999-2004) have shown buried inactive or relatively passive mud volcanoes (compared to active ones in the Gulf of Cadiz and Eastern Mediterranean), which have led to the assumption of the "dead" mud volcanic province of the Western Alboran Sea.

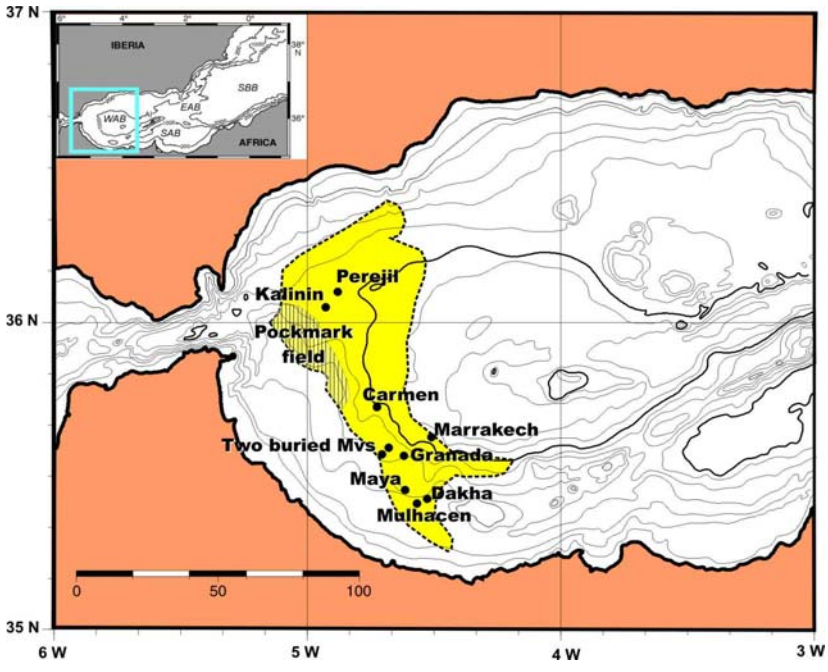

Fig. 1. Location map of the study area in the western part of the Alboran Sea. Mud volcanoes are indicated with dots. The mud diapir province is highlighted. The pockmark area in its western part is indicated.

However our study of the Carmen MV and several pockmarks situated to NW of the Granada MV discovered intensive discharge of hydrocarbon fluids. During underwater television observations episodic gas bubbling was documented on the top of the Carmen MV. Most of the collected gravity cores were accompanied by active gas escaping during the retrieving. The mud breccia samples yielded an extremely gas saturation with a high abundance of *frenulates*.

Head-space gases and pore water samples were collected from mud breccia in order to understand the composition and possible origin of fluids. Methane concentration from the Dakha, Mulhacen and Maya MVs (the newly discovered structures south of the Granada MV) is less than 1 ml/l (aver. 0,015 ml/l). Saturated homologues are presented by ethane and propane. Unsaturated ones are abounding: ethane (C_2H_6/C_2H_4) is about 1.5, propane (C_3H_8/C_3H_6) varies from 1.6 to 7.0 and isobutene is detected in sediments and mud breccias of all mud volcanoes at the level of 0.4 ml/l. Most probably it has the biogenic origin.

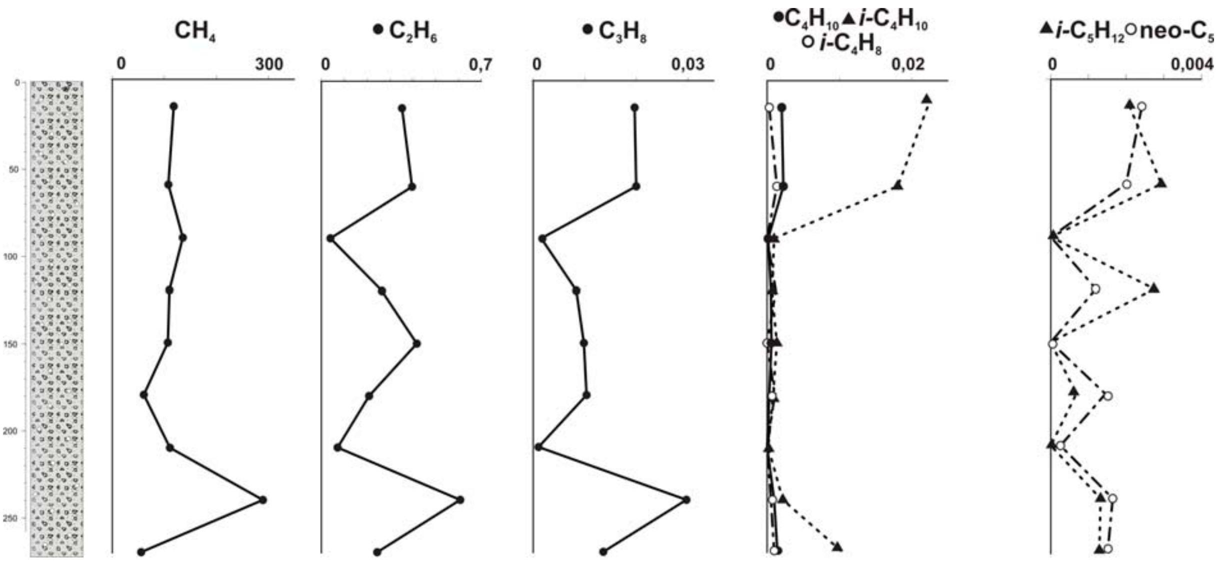

Fig. 2. Hydrocarbon gas composition from Carmen mud volcanic breccia.

Gases from the Carmen MV breccia mostly consist of methane (up to 290 ml/l) with a set of homologues up to pentanes (Fig. 2). Wetness of gas is about 0.4%. Unsaturated C_2 and C_3 homologues are below the detection level. C_2/C_3 is about 20. Isobutene is two times higher than the normal butane, which suspects its active migration. Isopentane is at the level of 0.001 ml/l. $\delta^{13}C$ of methane from mud breccia is -58.4‰ VPDB and does not change along the core (±0.4). $\delta^{13}C$ of methane from gas bubbles is more enriched in 13C up to -54.3‰ VPDB. Pore-water analyses reveal strong Cl^- depletion from 600 mM at the subbottom water to 160 mM in the mud breccia. Decreasing of the SO_4^{2-} ion concentration up to almost zero is observed at the first 20-50 cm, with simultaneously increasing in alkalinity up to 50mM. All above characteristics clearly point to the migrated thermogenic fluids from the depth and active microbial processes of anaerobic methane oxidation and sulfate-reduction at the uppermost sedimentary section.

Concentration of methane collected from pockmark sediments is also very high (up to 130 ml/l). All samples are characterized by dry gas composition. There is no any signal of unsaturated homologues (C_2, C_3) in gases from pockmark sediments. $\delta^{13}C$ of methane from sediments is increased in ^{13}C from the top toward to the bottom of the core from -85.3 to -61.4‰ VPDB, which point to the microbial gas input at the first 300 cm of the core.

Intensive gas bubbling, the level of the methane concentration and abundance of chemosynthetic fauna on the top of the Carmen MV assume high volcanic activity. Hydrocarbon gases composition and pore water analyses clearly point to the deep thermogenic source of the fluids. All investigations already bring to the conclusion that active seepage still exists in the Alboran Sea and occurs in the central part of the Western Alboran basin.

Deep-water coral mounds in the Alboran Sea: the Melilla mound field revisited

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A cluster of Holocene deep-water carbonate mounds - the Melilla Mound Field (MMF) - was discovered in the southeastern margin of the Alboran Sea (Morocco margin) during the MARSIBAL-06 Cruise (R/V *BIO Hespérides*, 2006). The carbonate-mound field was revisited during the TTR-17 Leg 1 survey. Up to now, swath bathymetry, acoustic sub-bottom profiling, side-scan sonar, multichannel seismic, high-resolution seismic, and coring have investigated the MMF. The mound cluster occurs from the upper to the middle slope, with NW-SE trending, on a gentle-dipping margin segment and covers an area of more than 20 km^2. Based on acoustic and swath-bathymetry images the mounds seem to be largely biogenic accumulations made up of carbonates and mud (modern coldwater carbonate knolls). We provide for the first time seafloor images of the MMF, and data about its nature and composition. Deep-water carbonate mounds, comparable to those of the MMF, have not been documented before in the Alboran Sea.

Corals sampled by TTR-17 Leg 1 in the Melilla Mound Field (Alboran Sea)

As showed by sub-bottom profiles, buried or partly buried mounds are elongated and domed families of buildups (transparent acoustic facies) rooted on highly reflective sedimentary layers and surrounded by dark reflective moats, with dome-size increasing seaward. They grow beneath the upper slope (water depth from 200-230 m), producing bulges in the seafloor, and give way with depth to seabed mounds. At least three generations of successive mound-growth are observed. Some ridged-mounds nucleated upon former ones so that buried constructions (columnar appearance in acoustic sections) grow up to 150 m high.

On the seafloor, mounds appear as ridge-like buildups 100–250 m wide, 2-6 km long, and 20–60 m (up to 100 m) high above the seabed; which lie in water depths ranging from 250 to 450 m. They are also surrounded by elongated erosional moats, probably caused by bottom currents on the sea floor, which are 5-10 m deep and 50-100 m wide. Some ridges have no linear but branched shapes.

Sampling by coring, TV grab and dredging during TTR-17 Leg 1 encountered that mounds are formed of biogenic accumulations made up of corals (*Madrepora occulata, Caryophyllia sp, Desmophyllum sp, Lophelia pertusa)* and other common associated fauna. Colonies of dead *scleratinean* corals and a diverse community dominated by soft corals, sponges and asteroids were observed in TV runs. So that TTR-17 Leg 1 results proved that mounds from the Melilla Mound Field correspond to modern cold-water carbonate knolls.

The mound field occurs in a region about 200 km to the east of the Alboran Mud Diapir Province, were seepages, pop-marks, and mud volcanoes are widespread in the Moroccan margin. Seismic profiles across the MMF show that faults may exist beneath the mound ridges, so that mounds nucleation would have some influence from fluid venting via fractures that may leak thermogenic gas or cold hydrocarbon seepages in addition to any likely oceanographic control in mound’s origin.

Acknowledgements. Contribution from Projects SAGAS CTM2005-08071-03-01, MARCAL CGL2006-13327-C04-04 and TOPO-IBERIA CSD2006-00041 (Funded by R & D National Plan of the Ministry of Science and Technology and FEDER funding, Spain) and Research Group RNM 215 (Junta de Andalucía).

Cold-water corals in the central Mediterranean Sea during the Holocene

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For long time, reef-forming cold-water corals from the Mediterranean Sea appeared to be restricted to a Pleistocene age only and it was assumed that their occurrence was mainly restricted to glacial periods (see Taviani et al., 2005). After discovering living *Lophelia pertusa* colonies on a gently dipping shelf off Apulia at Santa Maria di Leuca (Ionian Sea, central Mediterranean) in 2000 this cold-water coral mound area got into the focus of scientific investigations.

Sediment cores collected during an expedition with the German RV *Meteor* (M70-1) to the Mediterranean Sea in 2006 from the top of coral mounds from the area of Santa Maria di Leuca reveal sequences with abundant coral fragments (e.g. *Lophelia pertusa, Madrepora oculata*) embedded in hemipelagic fine grained sediments. AMS radiocarbon ages determined on coral fragments collected from these cores show that they comprise a time frame of the past ~12,000 years. Thereby coral ages point at two different phases of coral growth in this region. The older period coincides with the Younger Dryas (YD) including a short post-YD interval, while the younger period starts around 5.000 yrs BP up to the present. During the interval in between, which corresponds partly to the deposition of Sapropel 1 in the eastern Mediterranean, the environmental conditions must have been unfavourable for coral growth.

For a better understanding of coral growth history, also sediment cores from adjacent off-mound sites have been investigated. Since this material was apparently deposited continuously and undisturbed by any interference with coral framework it provides the possibility to compare changing ambient environmental conditions recorded in these hemipelagic sediments with the development of cold-water coral growth documented in those sediment cores taken directly from the coral mounds.

Reference

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Composition of the mud breccia at Dhaka and Maya Mud Volcanoes in the West Alboran Basin

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The West Alboran Basin is characterized by the occurrence of widespread mud diapirs and mud volcanoes (MV), which were first discovered during cruise TTR-9 Leg 2 and further investigated during the following cruises TTR-12 Leg 3, TTR-14 Leg 2 and TTR-17 Leg 1. Mud diapirism and mud volcanism in the area are supposed to originate in the lowermost sedimentary sequence on the basis of both seismic interpretation (e.g., Jurado and Comas, 1992) and micropaleontological analysis of the extruded mud breccias (Sautkin et al., 2003).

A new micropaleontological study was undertaken to better constrain the foraminiferal composition in samples from the Dhaka and Maya Mud Volcanoes cored during the SAGAS 08 (TTR-17 Leg 1) cruise.

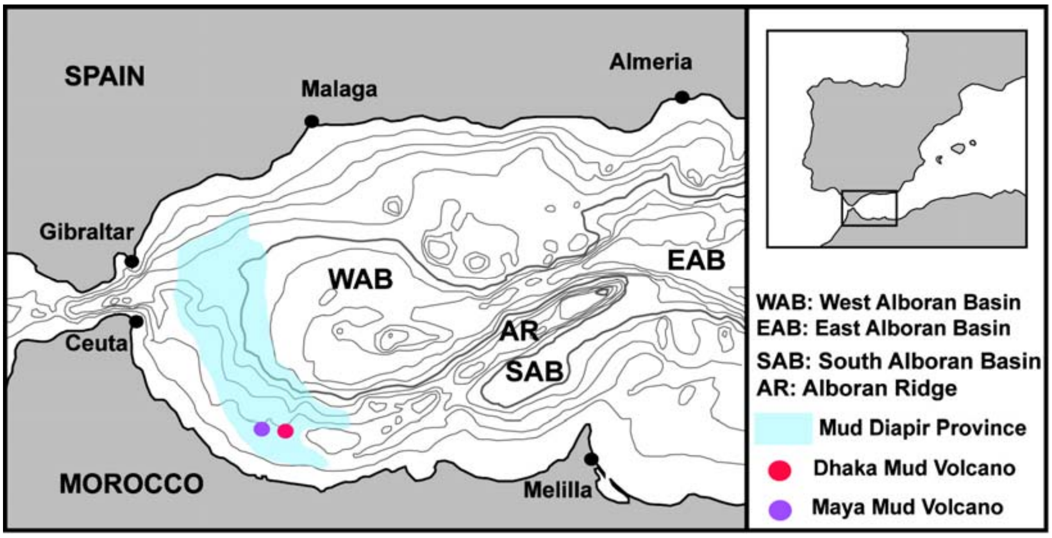

Fig. 1. Location map of the study area.

The Dhaka MV is located at a water depth of around 370 m. The cored material, from top to bottom, includes a hemi-pelagic cap, a cold-water coral fragments-rich unit, a typical mud-breccia layer and possibly a lowermost level of pelagic sediments mixed with the mud breccia. It was sampled at 5 cm intervals for planktonic and benthic foraminifera assemblages determination.

The mud breccia matrix results to be mostly composed by Miocene planktonic foraminifera (mainly Serravallian), Late Cretaceous (Lower and Late Maastrichtian), and very few Middle – Late Eocene and Oligocene specimens, together with very rare shallow water forms such as *Amphistegina* sp. and *Elphidium* spp.

The Maya MV is located at a water depth of around 410 m. It was sampled at 10 to 2 cm intervals for micropaleontological analyses. The pelagic cap spans the interval from the top of the core down to about 105 cm. A cold-water coral-rich interval containing also abundant planktonic and benthic foraminifera is found in a 10 cm layer between 105 and 115 cm. The mud breccia is observed from this level down to the bottom of the core. Relatively rare recent benthic and planktonic foraminifera typical of the pelagic facies characterize this breccia, associated with reworked shells. Planktonic foraminifera of Late Cretaceous (Late Maastrichian) are dominant, while Miocene and Oligocene forms are very rare.

We identify the lowermost olistostromic sedimentary unit as the main source of the extruded material at the Dhaka and Maya Mud Volcano (cfr. Sautkin et al., 2003) and we bring new information about the microfossils components from the sediment of this tectonic unit.

Ongoing analyses of AMS^{14}C at the base and at the top of the breccia layers will clarify the age of the mud volcanoes activities.

Acknowledgements. This study is funded by the Swiss National Science Foundation Projects 200021-111694 and 200020-117928. Cruise TTR 17- Leg 1 (SAGAS-08 Cruise) was funded by UNESCO, the Spanish Projects CTM 2005-08071-C03-01 and CGL200613327-C04-04. The R & D National Plan of the Ministry of Science and Innovation (Spain) co-founded the cruise.

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Paleoceanographic and paleoclimate conditions in the Western Mediterranean during the last 20 kyr: new insights from a TTR core transect in the Alboran Sea basin

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Extensive paleoclimate research in the Mediterranean region has demonstrated the exceptional nature of Mediterranean records for paleoceanographic and paleoclimatic reconstructions at regional and global scales. The westernmost Mediterranean is of particular interest since high sedimentation rates have allowed records of climate variability to be developed at sufficiently high resolution to reveal millennial and even centennial scale oscillations (e.g., Moreno et al., 2005; Jimenez-Espejo et al., 2008). Thus, in the Alboran Sea basin the elevated detrital supply has resulted in exceptional paleoarchives. Moreover, the Alboran Sea is the transition zone between Atlantic- and Mediterranean-type waters and strong vertical and horizontal hydrological gradients are present as a consequence. Regarding past circulation and water mass exchange, comparisons of different sediment cores and site correlation are of key importance. However, most of the reconstructions of past paleoceanographic and paleoclimatic conditions are highly based on single core studies (e.g., Moreno et al., 2004, Jimenez-Espejo et al., 2007). In spite the valuable information obtained, limitations are very important especially for the study of water masses and bio/geochemical fronts' oscillations (Rogerson et al., 2008). Consequently, in order to reconstruct paleoceanographic and paleoclimatic conditions in the Western Mediterranean Sea during the last 20.000 yr, we have used a multi-proxy approach based on mineral and chemical composition of sediments from a core transect along the Alboran and the Algero-Balearic basins that was completed during several TTR cruises (TTR-9 Leg 2, TTR-12 Leg 3, TTR-14 Leg 2, and TTR-17 Leg 1).

This multiproxy approach has allowed establishing two different modes of circulation: (1) during the LGM and from 8.0 cal. ka B. P. onward, no surface gradient in $\delta^{18}O_{G.\ bulloides}$ is found associated with low productivity, in close analogy to modern conditions; (2) during the Bølling-Allerød and early Holocene, significant surface isotopic gradients are found with periods probably indicating an unstable water column, associated with enhanced productivity and low bottom oxygen conditions. The close synchrony between the occurrence of the surface isotopic offset and organic rich layer formation implicates that the origin of these features is linked, probably via shoaling of the regional thermohaline circulation (Jimenez-Espejo et al., 2008). Paleo-SSTs, derived from planktonic foraminifer assemblages, indicate abrupt changes in surface conditions during the analyzed time interval. Fluctuations in marine productivity based on Ba and total organic carbon are related to water column stability and atmospheric conditions. A sharp warming and $\delta^{18}O_{G.\ bulloides}$ excursion at the end of the Younger Dryas are probably linked to glacial meltwater influence. The riverain input has been reconstructed using the Mg/Al ratio, and Mg/Al peaks during arid periods (Greenland Stadial-2a and Younger Dryas) related to ''bypass'' margin processes.

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Acoustic imaging of possible carbonate mounds in the Chella Bank (Eastern Alboran Sea - SW Mediterranean)

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This study focuses on a first characterization of possible cold-water carbonate mounds acoustically detected and mapped in the Chella Bank, off the Almeria Margin, along the Eastern Alboran Sea (SW Mediterranean). The Chella Bank is a seamount and is one of the prominent highs present in the slope domain of the study area, representing the morphological expression of middle Miocene to Pleistocene calc-alkaline K-rich volcanism (Duggen et al., 2004). The study is based on a compilation of acoustic data coming from many surveys. Nevertheless, the most relevant data come from the IMPULS cruise (June 2006 - RV Hesperides, Gràcia et al., 2006) and the EVENT-Shelf cruise (September 2008 - RV Garcia del Cid, Bartolomé and Lo Iacono, 2008). The available dataset comprises large-scale sidescan sonar (TOBI), high-resolution swath-bathymetry, TOPAS and high-resolution sparker seismics. Swath-bathymetry was collected using the full water depth Simrad EM12S, the EM120 12 kHz and the double frequency Elac Seabeam 1050D 50-180 kHz multibeam echo-sounders. The precision of measurement of the acoustic received signal ranges between 0.6 and 2 m. The seismic system used was a high-resolution 6 kJ GeoSpark source able to acquire data with 50 centimetres of resolution in up to 1.5 kilometers of water depth.

The acoustic dataset has been ground-truthed with images from a ROV and a deep-towed video-camera. Carbonate mounds range from 10 to 60 m in height and from 150 to 300 m in width, displaying a sub-circular to elongated shapes (Fig. 1). They are found within a depth range of 80-400 m and generally occur along the structural ridges of the Chella Seamount (Lo Iacono et al., 2008). Some of the mounds are distributed NW-SE and N-S, coinciding with the orientation of the active fault lineations observed North and West of the study area (Gràcia et al., 2006). A 250 m large and 20 m high relief was observed along the rim of a circular depression, likely to be a pockmark, 400 m large and 20 m deep, suggesting a potential relationship between fluid seepage and mound evolution. On the other hand, the orientation of some other mounds suggests that the presence of strong bottom currents and reduced sedimentary fluxes are environmental factors suitable for their development. High-resolution seismics allowed to recognize the internal structure of carbonate mounds, showing an alternation of opaque and stratified facies. Unfortunately, the video inspections did not allow a detailed imaging of the rocky outcrops observed in the mounds area. Video stills have been key for the characterization of the macro-benthic species identified along the mounds. A wide and dense patch of the gorgonian *Callogorgia verticillata* has been observed on the top of the seamount, on a sub-horizontal terrace, well imaged with the MB echo-sounder. The sponge *Fakelia ventilabrum* prevails along the rocky steep walls of the potential mounds. Except for few and small colonies probably belonging to the coral species *Madrepora oculata*, not more cold-coral species were not directly observed in the videos. However, the elongated morphology of some of the mounds, developing along the directions of strong bottom currents, and the sedimentary environment that characterize the study area suggest that cold-corals probably contributed to the formation of the carbonate mounds. Additionally, "sub-fossil" *Madrepora oculata* and *Lophelia pertusa* have been previously sampled in the area by Taviani et al., (2004). The integration of different high-resolution geophysical methods allowed to image in detail the morphology of carbonate mounds in the Chella Bank, and to define the sedimentary and hydrodynamic constraints suitable for their development. Further investigations will be required to highlight their formation and evolution.

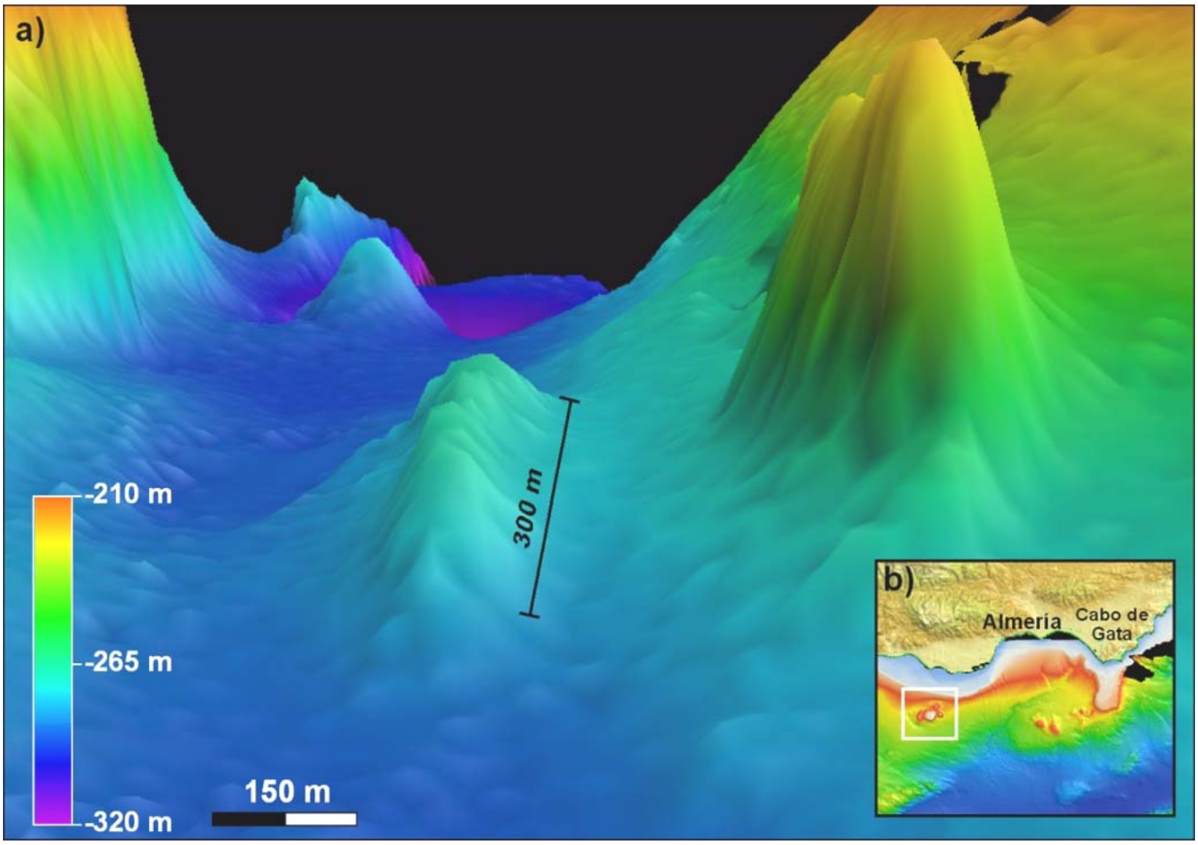

Fig.1: a) 3D bathymetric model showing some of the carbonate mounds detected in the Chella Seamount. Vertical exaggeration: x5. b) Location of the Chella Bank, in the Almeria Margin.

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Geochemical, mineralogical and sedimentological analyses of mud breccia materials from the Alboran Sea basin: Preliminary results from Perejil mud volcano

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During several TTR cruises of the R/V *Professor Logachev* in the westernmost Mediterranean (TTR-9 Leg 2, TTR-12 Leg 3, TTR-14 Leg 2, and TTR-17 Leg 1), the mud volcano field in the West Alboran basin (WAB) was surveyed. Mud diapirism and associated mud volcanoes in this basin are related to an extensive Mud Diapir Province, which occupies the major sedimentary depocenter in the basin (up to 7 km in thickness). The mud diapirs are formed of under compacted shales and olitostromes from the lowermost marine sedimentary sequences early to middle Miocene in age, which overlie the metamorphic basement of the basin (Talukder et al., 2003). High-resolution side-scan sonar imaging during TTR surveys has showed mud volcanoes morphology and high-resolution seismic profiling recognized their internal structure. Multi-channel seismic reflection has also demonstrated that volcano feeder channels are rooted in deep diapir bodies (Comas et al., 2003). Extruded materials were cored during the TTR-12 cruise and some sediment cores were sub-sampled for high-resolution geochemical, mineralogical and sedimentological analyses. Here we present preliminary results of core 283G recovered from the top of the Perejil Mud Volcano (Comas et al., 2003).

The Perejil MV is located in the Northern Mud Diapir Province at a water depth of 841 m. The volcano morphology is showed as a positive structure, having dimensions of about 300 m in diameter and a maximum elevation about 90 m (Line MAK-63MS and Seismic Line PS 199a-200-MS). The analyzed core has a total length of 233 cm. The top 14 cm correspond to a thin hemipelagic watersatured layer. Below this depth, the typical mud breccia layer is observed down to the bottom of the core. Continuous samples were taken from the hemipelagic sediments and every 2 cm at the top of the mud breccia. The rest of the mud breccia was sampled every 5 or 10 cm at 2 cm intervals. These samples were processed for geochemical and mineralogical analyses. Additional samples of 3 and 8 cm thick intervals were taken from the mud breccia for grain size analyses.

Breccia materials are matrix-supported, being the matrix of grey dark colors, and mostly composed of clays (smectites, illite, chlorite and kaolinite). Geochemical results reveal a significant change in composition at ~ 115 cm, likely related to the different composition of the extruded materials. Clasts and pebbles are also abundant and have been divided into three main groups: white marls, grey siltstones and sandstones. These clasts have different ages (ranging from Middle Miocene to Cretaceous), and according to their lithologies can be correlated with different Neogene sedimentary units outcropping on land in the Betic and Rifean Cordilleras (among them Paleogene flysh units from the Gibraltar Arc). All of them are fragmented in others smaller clasts and they have moderate roundness. Eventuality pyrite is present in some of these clasts.

Composition of the studied material supports the Perejil mud volcano has extruded material (probably from olistrotromes) from older and deeper sediments in the basin from more than 5 km depth.

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Biogeochemistry of methane-related carbonates from the Western Black Sea and Nile Deep Sea fan (Eastern Mediterranean)

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Anaerobic oxidation of methane (AOM) is the main process inducing the formation of authigenic carbonates due to an increase of alkalinity level resulted from the production of bicarbonate ions. AOM is a process accomplished by a consortium of methanogenic archaea and sulfate reducing bacteria (SRB) (Boetius et al., 2000; Hinrichs and Boetius, 2002) which metabolic interactions are still open question. We studied lipid biomarkers from these carbonates to reveal peculiar molecular patterns that can mark specificity in composition of AOM-microbial communities. The research was done within the framework of the NWO/RFBR Dutch-Russian cooperation project between the Royal Netherlands Institute for Sea Research (NIOZ) and the UNESCO-MSU Center for Marine Geology and Geophysics.

Methane-derived carbonate crusts and surrounded sediment were collected from different seepage and mud volcano areas with diverse geological history and present fluid venting environments. Samples from the Western Black Sea taken during the TTR-11 cruise were compared with samples from the Nile Deep Sea fan (Eastern Mediterranean). The methods used included gas chromatography, gas chromatography – mass spectrometry, isotope ratio monitoring gas chromatography mass spectrometry, and high performance liquid chromatography – mass spectrometry.

Studied carbonates exhibited diverse range of ^{13}C-depleated lipid biomarkers which indicate that they harbor a diverse microbial community, which are, at least in part, based on AOM. Biomarker composition revealed the presence of two distinct types of ANaerobic MEthanotrophic archaea ANME-1 and ANME-2. However, the composition of archaeal lipids indicated difference in the community structures from one crust to another. Distinct sets of biomarkers indicated different environments characterized by high and low methane partial pressures during the formation of these carbonates. Lipid biomarkers from non-identified sulfate reducing bacteria, i.e. non-isoprenoidal dialkyl glycerol diethers were also detected almost in all samples although their content varied.

Our investigation supports the role of methanotrophic archaea and SRB in the formation of authigenic carbonates. We show that specific sets of AOM-derived lipid biomarkers can be used as an indicator of specific methanotrophic communities that thrive at high or low methane partial pressures in the vent systems. The comparison of our results with already published work suggests that the mode of methane transport is the dominant ecological factor that rules the selective presence of one methanotrophic guild over the another.

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Cold-water corals and mud volcanoes in the West Alboran Basin

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Mud diapirs and mud volcanoes were cored in the West Alboran Seas during the SAGAS 08 (TTR-17 Leg 1, 2008) cruise (for the location see G. Gennari et al., this volume). The Dhaka mud volcano (MV) has been investigated in detail to characterize the mud breccia. The sedimentary succession is composed by a layer of possibly pelagic sediments at the base (150 cm), covered by a mud-breccia layer, a coral fragments-rich unit and a hemi-pelagic cap. Therefore, a micropaleontological study on benthic and planktonic foraminifera was carried out to investigate in particular the pelagic sediments covering and underlying the mud breccia layer.

The co-occurrence of mud volcanoes and cold-water coral ecosystems has already been documented in the Gulf of Cadiz (e.g., Pinheiro et al., 2003); however, a direct correlation between these structures, gas or fluid seepage and cold-water coral development has so far not been established (Foubert et al., 2008).

In order to better define the co-existence of cold-water corals and mud volcanoes in the West Alboran Sea, core TTR17-MS411G, retrieved on the Dhaka MV was studied with a 5 cm resolution from the top of the core down to 75 cm and at 150 cm.

Immediately above the mud breccia, the unit containing coral fragments displays benthic foraminiferal assemblage typical of active cold-water coral mound (Margreth et al, subm.). In particular, samples are characterized by the epifaunal benthic species *Discanomalina coronata* and *D. semipunctata*, that have been observed in close relationship to active coral mounds along the Atlantic European margin (Hawkes and Scott, 2005; Rüggeberg et al., 2007). Thus, it seems that the top of the mud volcano acted as a favourable substrate for the growth of cold-water coral, as it has been already observed in several mud volcanoes in the Gulf of Cadiz (Pinheiro et al., 2003). The hypothesis of the development of coral mound ecosystems on mud volcanoes in the West Alboran Sea appears consistent. Ongoing analyses of AMS^{14}C at the top of the breccia interval and at the top coral-rich layer will clarify the age of the cold-water coral colonization at the end of the mud volcanic activity and the timing of its definitive decline.

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Submarine instability processes associated with active faulting, Eastern Alboran Sea.

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The Alboran Sea Basin, in the Gibraltar Arc is affected by present-day deformations as result of the convergence between the African and Eurasian Plates. Its eastern sector connecting with the Algerian

Basin exhibits complex seafloor morphology (Fig. 1) resulting from recent to active tectonic processes (Comas et al., 1999). We have compiled high resolution geophysical data including bathymetric mosaics and high resolution seismic profiles in the Eastern Alboran Sea. From this dataset we have carried out a detailed geomorphological study characterizing the most recent fault escarpments.

The Alboran Ridge is the most prominent morphological feature in the Alboran Sea. It corresponds with a large structural alienation, SW-NE trending, which measures more than 130 km long. Its recent tectonic evolution has been reported as result of left lateral strike-slip faulting, coherent with the actual NW-SE plate convergence (e.g. Burgois et al., 1992). Towards the East, the Yusuf Basin is a "pull-apart" basin bounded by two sub-parallel right-lateral fault zones along the Yusuf lineament and Ridge that show WNW-ESE orientation (Álvarez-Marrón, 1999).

Slides and slumps morphologies are evident on the bathymetry where headslides are 10-25º steep and show associated scars. Successions of slide scars are visible on the Yusuf lineament and on the Alboran Ridge, suggesting dismantlement of the fault escarpments by retrogressive mass movements. Slides cover areas from tens to hundreds km^2 wide. Their internal structure is observable in high-resolution profiles and corresponds with chaotic semi-transparent seismic facies. Some of them are composed of a superposition by several slides. Fig. 2 shows a seismic image from the Yusuf lineament where different outcropping and sub-outcropping slides can be observed. We suggest that many of the mass wasting structures are recent deposits as they are not draped by hemipelagic sediments. Succession of gravitational deposits may be related to different faulting pulses. The present study reveals that seismogenic faults in the Alboran Sea induce submarine instability processes that should be considered as sources of potential tsunami hazard in the western Mediterranean.

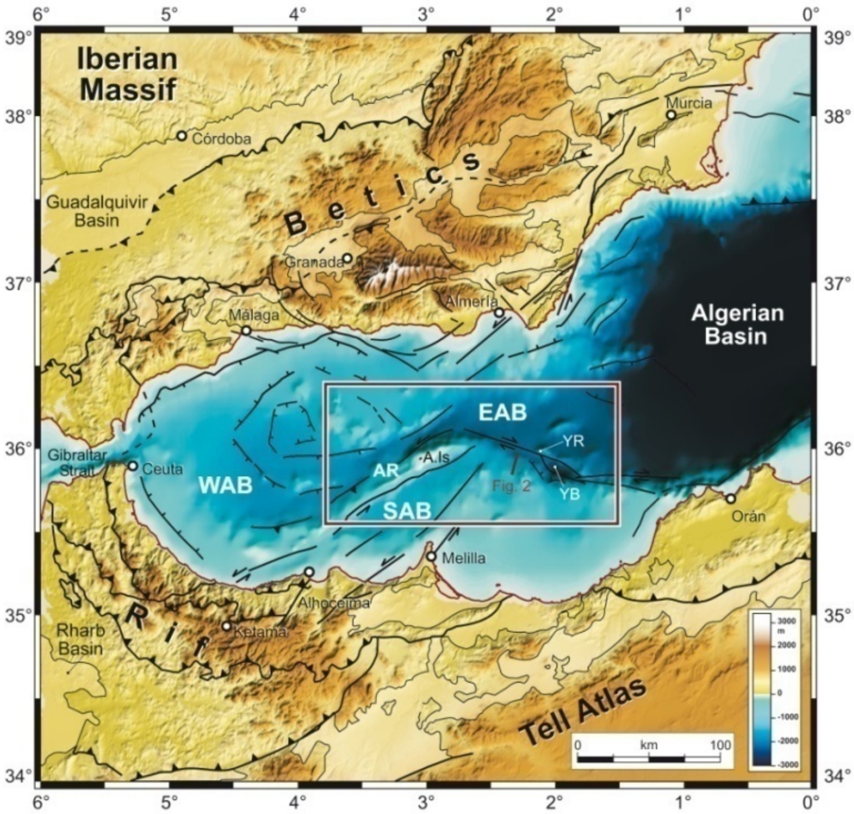

Fig. 1. Topography of the Gibraltar Arc and major tectonic features (simplified from Comas et al., 1999). Rectangle delimitates the studied area in the Eastern Alboran Sea. A.Is, Alboran Island; AR, Alboran Ridge; EAB, East Alboran Basin; SAB, South Alboran Basin; YB, Yusuf Basin; YR, Yusuf Ridge; and WAB, West Alboran Basin.

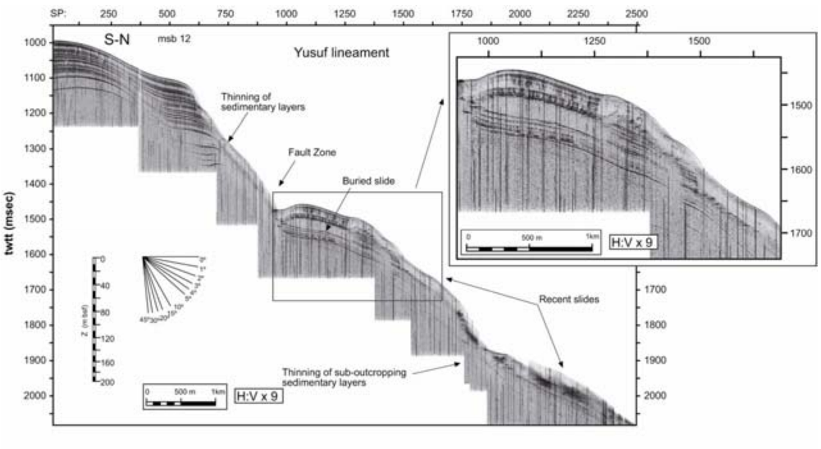

Fig. 2. High-resolution TOPAS parametric sub bottom profile showing submarine slides related with faults along the Yusuf Lineament. Location in Fig. 1

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Late Holocene climate variability in the Western Mediterranean: mineralogical and geochemical record from the Alboran Sea basin.

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The westernmost Mediterranean (Alboran Sea basin) is a key location for paleoceanographic and paleoclimatic reconstructions since high sedimentation rates in this region provide ultra high-resolution records at centennial and millennial scales. Additionally, the semi-enclosed nature of the Mediterranean Sea makes this area highly sensitive to climate variability. Consequently, the Alboran Sea basin has provided excellent records for the reconstruction of climate recent evolution. Here, we present a paleoenvironmental reconstruction for the last 4000 yr, which is based on a multi-proxy approach that includes major and trace element-content fluctuations and mineral composition of marine sediments. Although relatively more attention have been devoted to major climate changes during the last glacial cycle, such as the Last Glacial Maximum, deglaciation and abrupt cooling events (Heinrich and Younger Dryas) (e.g. Bárcena et al., 2001; Cacho et al., 2006), the late Holocene has also been punctuated by significant rapid climate variability including polar cooling, aridity and changes in the intensity of the atmospheric circulation (e.g. Mayewski et al., 2004; Wanner et al., 2008).

In order to investigate rapid climate changes during this time interval, we have analyzed marine sediment cores spanning the last 4000 years that correspond to several gravity and box cores recovered in the Alboran Sea basin during Training Through Research oceanographic cruises (TTR-14 and TTR-17). For this work, we have selected two of them (305G, 306G) which have been sampled at very high resolution. A preliminary age model for these cores has been obtained from correlation with other radiocarbon-dated cores within the basin. Samples were processed for chemical and mineralogical analyses and different techniques were used: X-Ray Diffraction, Transmission and Scanning Electron Microscopy, Atomic Absorption and Inductively Coupled Plasma-Mass Spectrometry.

Analyzed sediments are predominantly composed of clay minerals (20-70%), calcite (15-45%) and quartz (10-30%), with minor amounts of dolomite and feldspars (<10%). Clay mineral assemblages consist of detrital mica (50-90%), kaolinite+chlorite (<50%) and smectites (<20%). Additional fibrous clay minerals, such as palygorskite, were also identified using Transmission Electron Microscopy.

Late Holocene climate oscillations coincide with significant fluctuations in chemical and mineral composition of marine sediments. Thus, bulk and clay mineralogy, REE composition and Rb/Al, Zr/Al, La/Lu ratios provide information on the sedimentary regime (eolian-fluvial input and source areas), Ba-based proxies on fluctuations in marine productivity and redox sensitive elements on oxygen conditions at time of deposition.

A decrease in fluvial-derived elements/minerals (e.g. Rb, detrital mica) takes places during the so-called Late Bronze Age-Iron Age, Dark Age, and Little Ice Age Period. Meanwhile an increase is evidenced during the Medieval Warm Period and the Roman Humid Period. This last trend runs parallel to a decline of element/minerals of typical eolian source (Zr, kaolinite) with the exception of the Roman Humid Period where Zr/Al ratio increases. These climate oscillations (wet and dry periods) are also accompanied by changes in marine productivity rates, as suggested by the Ba/Al ratio. Additionally, anthropic contribution during the Industrial Period is also evidenced by a significant increase in Pb content in most recent sediments.

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Morphologic characterization of Submarine Canyons in the Palomares Margin (western Mediterranean).

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Morphological analysis on the Palomares Margin has been accomplished using high-resolution swath bathymetry collected during the MARSIBAL-06 cruise (on board of the R/V *BIO Hespérides*), GEBCO 2000, Ifremer bathymetry data (Medimap Group, 2007), and side-scan sonar acquired on board R/V *Professor Logachev* during the TTR14 (2004) cruise. These data provides the first complete bathymetric morphological analysis in the Palomares Margin and allows us to differentiate physiographic provinces of the Palomares Margin. The mayor morphological elements recognized within the study area correspond with two main sediment-transfer conduits: the Gata and the Alias-Almanzora Canyons.

The Gata Canyon extends for 64 km from the outer shelf to the base of the slope with a general W-E direction. A tributary system of canyons originates at the shelf break and continues on the slope until they merge at 1230 m water depth. The walls of the canyons are characterized by repeated slides. Perpendicular profiles to the Canyon pathway reveal gentle "V" asymmetrical shapes with a marked axial incision on the canyon floor. Relief of the canyon ranges between 65 and 103 m in the southern flank, and between 40-90m in the northern flank. The transition from an erosional canyon to a deposition channel is located at 2100m water depth, and is characterized by trapezoidal transversal profiles and a shallowing of relieves (40-65 m). At the mouth of the canyon-channel system no sedimentary lobes are observed.

The Alias-Almanzora canyon is 73 km long and preferential direction W-E, is located north of the Gata Canyon and extends from the inner continental shelf to the base of the slope. A tributary system to the Alias-Almanzora canyon-head locates less than 150 m from the coast, in front of a fluvial drainage system onland. Tributary canyons and gullies feed the main canyon until they merges in the continental slope at 1500m water depth. The tributary system exhibits a marked "V" shape in transverse profiles and marked axial incision. Longitudinal profiles show convex-up sections along the tributary system and concave-up sections from the merge in the main canyon down slope. The transition from an erosional canyon to a depositional channel is located at 2100m water depth. The mouth of the Alias-Almanzora Canyon-channel system is characterized by distributaries channels and lobated features.

Morphological analyses from these Canyons indicate their location and morphology are controlled by multiple factors, including the lithology and structural fabric, regional tectonism, sea-level variations and sediment supply. The connection of the Alias-Almanzora Canyon to a fluvial drainage system onshore suggests the canyon formed by fluvial erosion of the continental shelf edge during sea level low-stand periods. During the present high-stand the entrapment of sediment on deltas has reduced sediment transport through the Alias-Almanzora. The Gata Canyon has instead developed by head-ward erosion through gravitational instabilities.

Both canyon systems are highly influenced by recent tectonics, and structural trends influence their location and changes in pathways (Comas and Ivanov, 2006; Marro et al., 2005; Marro et al., 2006).

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XRF geochemistry of selected mud volcano's cores from the SAGAS 08 cruise (Alboran Sea): preliminary results

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Mud ascent as the result of active diapirism and mud volcanoes on the seafloor are common features in the Alboran Sea. It is thought that these have been developed during a compressional tectonic setting that produced folding and wrench tectonics throughout the basin. During the TTR 17 cruise of the R/V *Professor Logachev* (2008), several new and previously discovered mud volcanoes and structure mounds were sampled in the southwest sector of the Alboran Basin. Most of the investigated mud volcanic deposits, such as Melilla and Maya structures, were covered by a thick drape of hemipelagic mud, suggesting that volcanoes are currently inactive.

The aim of this paper is to demonstrate the ability of high-resolution XRF core scanning based geochemical depth profiles to discriminate between mud volcanoes, mounds and hemipelagic sediments, and also to investigate if evidence for the presence of authigenic carbonates and sulphides within mud volcanoes sediments is discernible solely from solid-phase sediment geochemistry.

For our purpose U-channels were subsampled from the centre of half-split gravity cores. High-resolution XRF data of 28 major and trace elements were acquired for each core on an Itrax Core Scanner at the University of Vigo. The acquisition was performed with in this case a 300 µm resolution provided about 100,000 data point (i.e. XRF spectra) for each meter of core.
The results show that down-core high resolution XRF scanner based geochemical profiles represented a good and quick screening tool for identifying authigenic methane-related carbonate-rich layers that may represent paleo-indicators for ancient methane seepage. Sedimentary Sr/Ca and Mg/Ca ratios have also been explored to infer the presence of authigenic aragonite (Sr-rich) and Mg-rich carbonate phases (high-Mg calcite, dolomite). In contrast to the more hemipelagic facies, significant S peaks were detected in mud volcanoes associated facies. This finding is consistent with the occurrence of redox-sensitive elements peaks such as Cu and Zn in this facies, suggesting the presence of sulphidic phases in the anoxic levels. We also noted the appearance of maximum chlorine concentrations at

some horizons, with some potential as an inert tracer for the interpretation of transport processes occurring at these mud volcanoes and mounds but this aspect certainly deserves deeper research.

Eolian input fluctuations in the Westernmost Mediterranean during the last 20 Kyr: geochemical and mineralogical records

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The reconstruction of past atmospheric circulation, winds strength, and the consequent fluctuations in dust deposition, are essential to understand our climate system and the response of its different components (Guerzoni et al., 1999). In this context, the western Mediterranean is a key location to investigate atmospheric activity because it has received a high volume of eolian input from the African margin (e.g., Moreno et al., 2002).

We present here a multi-proxy approach for reconstructing eolian input fluctuations during the last 20.000 yr in the westernmost Mediterranean, which is based on mineral and chemical composition of marine sediments from the East Alboran basin. We obtained a high-resolution record from core 293, recovered during the cruise Training Trough Research cruise TTR-12 Leg 3 (Lat. 36´10.414N, Long. 2`26.071W, water depth 1840 m). At this site, sediments are composed of homogeneous green-brownish hemipelagic mud. The preliminary age model has been based on stable oxygen isotope measurements on the planktonic foraminifera *Globigerina bulloides* and correlation with radiocarbon-dated cores from this basin. A continuous sampling every 1.5 cm was done for the interval spanning the last 20 kyr. Samples were dried and homogenized for mineralogical and geochemical analyses. Analytical techniques include X-Ray Diffraction (XRD), Scanning electron microscopy (SEM) and Transmission electron microscopy (TEM), X-Ray Fluorescence (XRF) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

The obtained mineral composition corresponds to the usual for Mediterranean pelagic sediments, mostly composed of clays, calcite and quartz with minor proportions of dolomite, feldspar and pyrite. The clay mineral assemblages are mainly composed of illite, smectite, caolinite and clorite with minor proportions of fibrous clays as palygorskite. This last mineral has revealed as a reliable proxy for eolian input from the African margin (Bout-Roumazeilles et al., 2007), recording alternate wet and dry periods. Grain size and quartz morphological features have also been utilized as eolian-input proxies.

Additionally, different major and trace ratios have been used to establish fluvial and eolian input oscillations. Detrital elements such as Si/Al, Ti/Al, and Zr/Al ratio particularly, reveal major climate fluctuations with a significant increase during cold periods such as the last Heinrich event (H1) (Jiménez-Espejo et al., 2008). Wet periods such as that corresponding to the S1 sapropel deposition in the eastern Mediterranean, are also recorded in the Alboran Sea by a decreasing trend in the Zr/Al ratio. Other element ratios such as Mg/Al, K/Al and Rb/Al have been used as proxies for changes in river runoff and support rapid climate changes in the western Mediterranean borderlands. These fluctuations are also accompanied by changes in paleoproductivity (as suggested by the Ba/Al ratio and organic matter content), that registers two major peaks during cold periods (Younger Dryas and H1).

In summary, this multi-proxy approach sustains major millennial climate oscillations, as well as brief fluctuations at shorter time scales which provide new insights into the causes, timing, and mechanisms of atmosphere-ocean interactions in the western Mediterranean during the last 20 kyr.

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Prospects for Revealing Gas Hydrates in the Guria Depression (Georgian Sector of the Black Sea)

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Gas hydrates of the Ocean Margin make part of the so-called non-traditional forms of the hydrocarbon stock. Their exploitation (thus the inclusion in the total balance of the power potential) requires principally new methodical and engineering-technological approaches.

Analysis of geological-geophysical and geochemical data indicates that within the Georgian Sector of the continental slope, namely the Poti-Batumi section, it is possible to reveal active sources of intensive hydrocarbon gas flows from the sea bottom, as well as gas hydrates, downslope to 0.5-1.0 km water depth.

In this region, the underwater prolongation of the Guria foot-hill's trough draws our specific attention. The trough runs along the extension of rivers Supsa and Kintrishi in the direction of Trabzon.

At the same time, among the Black Sea troughs of Paleogenic age (such as Tuapse, Sorokin, Sinop, Burgas etc.) and within the deepening diapiric structures, active and ancient mud volcanoes, active sources of hydrocarbon gases and gas hydrates are found. The Guria trough resembles them from the point of view of its age and the filling by Quaternary sediments that are poorly investigated.

The following geological factors point at a possibility of discovering gas hydrates in the Guria trough: (i) focused sources of hydrocarbon gas flows on the sea bottom (at 20-600 m depth); (ii) high velocities of sediment accumulation making this favorable (avalanche sedimentation of terrigenous materials provided by the rivers Supsa, Natanebi, Kintrishi, Cholokhi, where the thickness of Quaternary sediments is between 750-1100 m); (iii) wide net of submerged canyons and the development there of land slides; (iv) the existence of tectonically weakened zones: faults and diapiric structures (Oligocene-Miocene); (v) most of the diapirs are clearly expressed in the sea-bed topography; (vi) Quaternary sediments, mostly sandy, cover them and do not participate in the structure of diapirs; (vii) discharge of underground waters within the shelf and continental slope, etc. The investigated gases from the shelf zone are mainly represented by methane; small amounts of its heavier homologues, helium and hydrogen have been discovered as well.

In the whole, within the Georgian sector of the Black Sea all geological preconditions exist to discover traditional and non-traditional hydrocarbons resources. In order to reveal resources of gas hydrates specialized complex geological-geophysical and geochemical investigations are needed.

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Deep-sea bedform and ecosystem response to cascading shelf waters in the south Adriatic

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At present, increasing attention is devoted to the study of canyon systems under the influx of cascading processes and their potential consequences on deep-water ecosystems. In the Mediterranean basin, one of such cases is offered by the Adriatic Sea. North Adriatic Dense Water (NAdDW) generates in the broad and shallow North Adriatic shelf through intense winter cooling and evaporation, flows southward along the Italian coast, attains the shelf break, and cascades across the slope.

Cascading NAdDW impinges the seafloor of the topographically complex SW Adriatic margin, eroding and depositing large amounts of fine-grained sediment below a markedly erosional upper slope, thus forming a variety of bedforms, such as furrows, moats, comet marks and large-scale mud waves; it also produces a vast seafloor erosional region. These bedforms are active during interglacial times under suitable climatic conditions. A branch of the cascading NAdDW is accelerated through the Bari Canyon where it may reach down-slope velocities greater than 60cm/sec, resulting erosional and depositional settings with strong consequences on the deep-sea life. In fact, the interplay of seasonal cascading and complex topography promotes the creation of a myriad of habitats variously exploited by benthic organisms, that include deep-water coral (i.a., Lophelia, Madrepora, Desmophyllum, Dendrophyllia) and sponge communities.

Deep-sea cold seeps and corals of the Mediterranean basin, Cenozoic to Present

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The Mediterranean basin holds a fabulous geo-biological legacy of chemosynthetic and coral deep-sea ecosystems beginning from the Oligocene up to Present. This record is of paramount importance to understand a number of problems linked to the setting, evolution and biogeography of some of the Earth's most complex deep marine systems.

The abundant traces of former chemosynthetic deep-sea habitats (both hot and cold) are a response to a variety of tectonic scenarios, topographic modifications, oceanographic and climatic changes that affected the Mediterranean basin through time. Ocean-type communities, chemosynthetic communities hosting large lucinid, modiolid mussel vesicomyid and solemyid bivalves together with pogonophoras colonized the Mediterranean basin until the upper Miocene but did not survive the Messinian Salinity Crisis (MSC). Similar communities still occur at present associated with deep-water cold seeps in the Atlantic Ocean.

The Pliocene to Present Mediterranean equivalents are characterized by smaller lucinids and vesicomyids as documented by bivalves and tubeworms recorded from Eastern Mediterranean mud volcanoes and the Nile Fan, and the Alboran Sea. Similarly, deep-water framebuilding coral communities containing extant genera such as Lophelia, Madrepora, Desmophyllum among others, are well documented in the Mediterranean basin, albeit somewhat discontinuously, since the middle Miocene. As for the chemosynthetic communities they were very likely eradicated from this basin by MSC. However, they recolonized the Mediterranean in the Pliocene and more or less continuously inhabited this basin up to present times although their paleogeographic situation was strongly modulated by climatic changes.

Gulf of Cadiz Studies

Preliminary results from the TTR-17 Leg 2 cruise in the Gulf of Cadiz

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During the TTR-17 Leg 2 cruise, in June 2008, three main areas of the Gulf of Cadiz were investigated: (1) the Moroccan Mud Volcano Field, (2) an area SE of Portimão Bank between the Cornide and Carlos Ribeiro mud volcanoes, and (3) the Deep Portuguese Mud Volcano Field. The investigation in the Moroccan Mud Volcano Field concentrated on carbonate mounds, the SE end of the Vernadsky Ridge, the Mercator and Gemini mud volcanoes, the D. Quijote structure and the Fiuza and Darwin mud volcanoes. The Vernadsky Ridge was investigated with seismic profiles, 100 kHz sidescan sonar MAK lines, gravity cores and TV-controlled grab profiles and stations. Clear evidence of strike-slip faulting was found. In the area between Cornide and Carlos Ribeiro mud volcanoes a new mud volcano was discovered, the Sagres mud volcano, at a depth of about 1550 m. This is the shallowest mud volcano discovered in Portuguese waters. Mud breccia and chemosynthetic fauna were retrieved from this structure. In the same area, several other structures visible on the side-scan sonar images could also be mud volcanoes and await investigation. Finally, in the Deep Portuguese Mud Volcano Field, several structures in the vicinity of the Bonjardim Mud Volcano were investigated with 100 kHz MAK side-scan sonar, and the Semenovich, Soloviev, Bonjardim, and Porto Mud volcanoes were revisited. Gas hydrates forming euhedric crystals with cm size were recovered from the Porto Mud Volcano. These were analysed at the Chemistry Department of the University of Aveiro and show that the gas composition is 99.5% methane. Taking into account that the Porto Mud Volcano is associated with a major deep strike-slip fault that marks the Africa-Eurasia Plate Boundary Zone, there is the possibility of a contribution from methane resulting from serpentinization at depth; this needs further investigation.

Benthic macrofauna from mud volcanoes in the Gulf of Cadiz – diversity and distribution

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The Gulf of Cadiz is and extensive seepage area on the NE Atlantic that encompasses over forty mud volcanoes emplaced both in the SW European and N African margins at depths ranging from 200 to 4000 m. The faunal communities have been studied with varying sampling effort. There is practically no information on the faunal distribution in the Spanish mud volcanoes, a few samples have been taken from the deep Portuguese margin and the best studied sites are located at relatively shallow depths in the Moroccan margin (Figures 1 and 2). Besides the variation of depth and properties of the

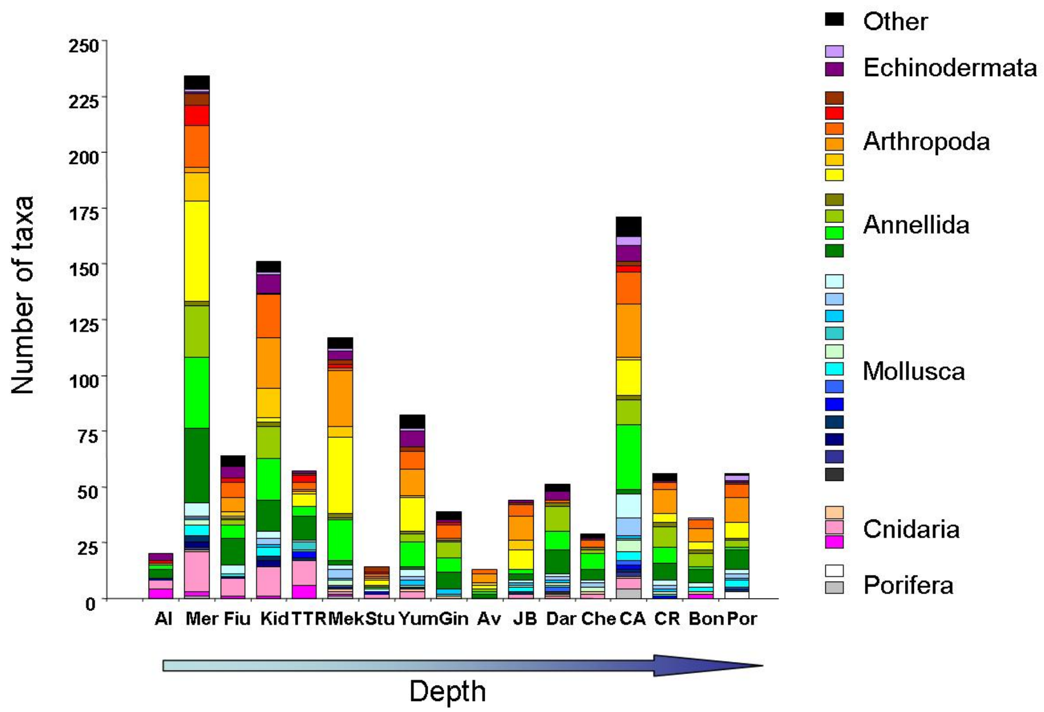

Fig. 1. Taxa richness in different mud volcanoes of the Gulf of Cadiz based on the compilation of quantitative and non-quantitative sampling data. The sampling effort per mud volcano is variable.

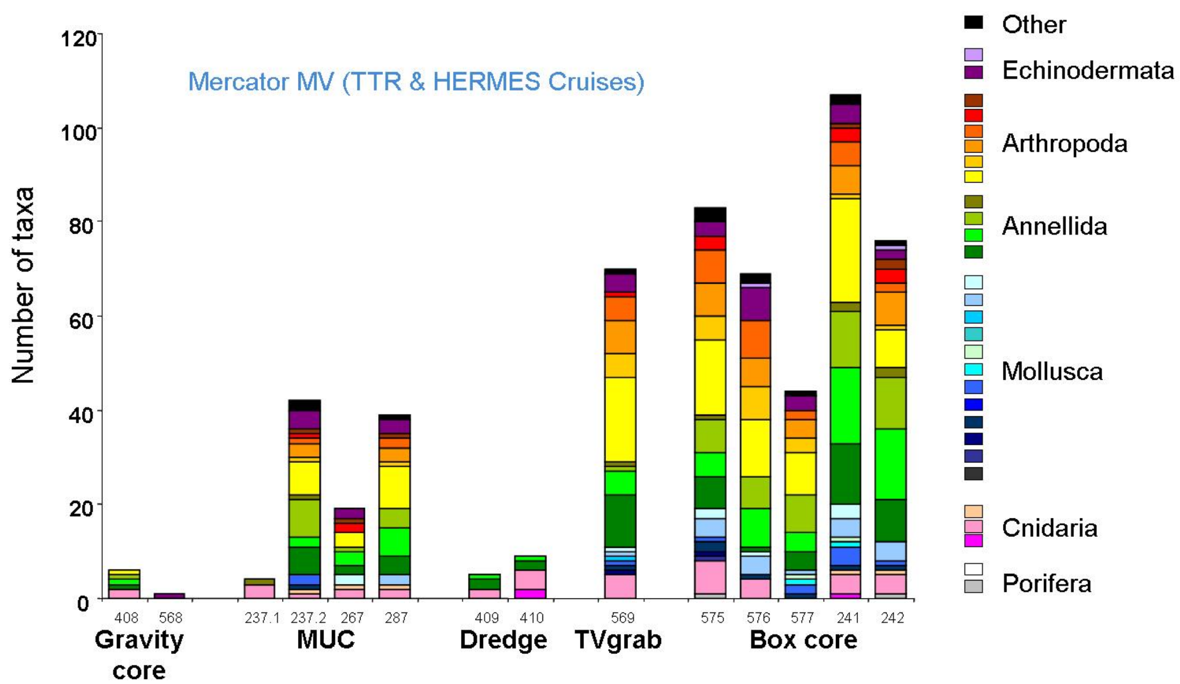

Fig. 2.Variability in taxa richness from samples taken with different sampling gear.

associated water masses, the mud volcanoes present other major sources of heterogeneity. Fluxes of methane and sulphide are relatively mild with the higher values found in the deeper mud volcanoes (>1200 m) where gas hydrates have also been frequently sampled. At intermediate depths (600-1200 m) the studied mud volcanoes are located along an extensive province of carbonate and mostly dead cold water coral mounds. The presence of authigenic carbonates and also extensive mussel cemeteries appear to indicate past strong seepage activity in the area. The proximity to the euphotic zone and to the African coast add to the great productivity observed in the shallower mud volcanoes that are also characterised by the frequent occurrence of scattered rock blocks, and sometimes carbonate crusts at the surface of the sediments. A dataset of over 700 taxa collected in 64 samples from 17 mud volcanoes was used to study distributional patterns and rates of species addition and loss plotted against increasing depth.

The abrupt discontinuities in the regional species accumulation curve reflect the faunal turnover at each mud volcano or group of mud volcanoes. The best sampled mud volcanoes showed the highest faunal richness (Mercator, Kidd, Meknès and Captain Arutyunov with 259, 166, 190 and 178 taxa respectively) but despite the sampling bias there is a clear decreasing trend with increasing depth. The

Eastern Moroccan shallow field (Al Idrisi, Mercator, Fiuza and Kidd) accumulate 62% of the recorded taxa, at intermediate depths the coral group (TTR and Meknès) and the Western Moroccan field (Student, Yuma, Ginsburg, Darwin and Chechouen) adds more 12 and 8% of the species, respectively, Captain Arutyunov alone adds another 11 % and the remaining 7% new records are contributed by the deep Portuguese field.

The benthic community of the mud volcanoes in the Gulf of Cadiz is characterized by a wide variability in species composition and structure. Densities vary commonly from a few hundreds to thousands per m^2 but local patches of >20000 ind.m^{-2} often occur. The shallower mud volcanoes of the Moroccan field (200-1000 m depth) show higher densities and species richness but low degree of endemicity, while the few samples taken from the Portuguese field (2000-3000 m depth) show lower densities and species richness. Nevertheless endemicity is clearly higher at these deeper mud volcanoes as many of the species collected (including the chemosynthetic ones) do not match the available descriptions of similar taxa.

The influence of sedimentary processes and climatic changes on cold water corals at carbonate mounds of the Pen Duick Escarpment, SE Gulf of Cadiz

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There are a few locations known in the Gulf of Cadiz where the cold water corals still growing. At the moment mostly debris of cold water corals are found at small carbonate mounds and on the flanks of mud volcanoes in the Gulf of Cadiz. Remains of coral species, that are similar to those in the Rockall Through *(Lophelia pertusa* and *Madrepora oculata)* are found along the Pen Duick escarpment, but are all dead and buried by sediment (De Haas et al, 2005).

The Pen Duick escarpment, a fault related structure about 4.5 km long, forms the steep southern slope of the Vernadsky Ridge west of the Gemini MV in the El Araish mud volcano field (south-eastern part of the Gulf of Cadiz). The region has complex geological history and is characterized with compressional tectonics and active hydrocarbon seapage that results in forming numerous mud volcanoes (MV), fields of autigenic carbonates and other typical structures (Van Resenberg et al, 2005).

The sedimentary processes and climate changes are investigated using samples from a carbonate mound at the top of the escarpment and the area aside the bottom of the escarpment. A 2 m long section of sediments taken by three piston corers were analyzed with a complex of methods, including lithological descrption, color and x-ray imagery, vertical grain-size distribution analysis, XRF Core-Scanner analysis and stable Oxygen isotope analyses on planctonic foraminifera. The sediment structure and composition, distribution and quality of coral debris, paleo-oceanographic changes were analyzed as well.

The sediment at the mound shows much similarity and consist of silty clay with some coarse admixture. The sediment at the top of the mound contains slightly higher amount of coarse material, especially in the interval 0-65 cm. Coral debris have been detected in the sediment of both cores. The intervals containing abundant coral debris alternate with the intervals containing few coral fragments. The upper part of the cores is enriched with well-preserved *Dendrophyllia alternata* fragments. Downcore corals of various alteration degree were detected, represented by *Lophelia pertusa* and *Madrepora oculata* species.

The sediment from the area aside the mount is represented with silty clay with high amount of coarse poorly sorted bioclastic admixture increasing to the bottom of the core. Low Ca/Sr values in the interval 83-200 cm can signify the presence of sand-sized coral debris in the sediment.

The presence of buried cold water corals was detected in several locations along the Pen Duick escarpment. Abundant coral debris (mostly *Lophelia pertusa* and in some intervals also *Madrepora oculata)* found in the sediment of the carbonate mound at the edge of the escarpment suggest that in the past the vast colonies of cold water corals inhabited this area. The dominating *Dendrophyllia* specie debris in the sediment characterized with low δ^{18}O values in the upper interval of the sediment suggest that climatic changes during the transition of the last glacial-interglacial influenced the dominance of individual species of cold-water corals.

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Relationship between diapiric ridges and mud volcanoes on the Moroccan margin (Gulf of Cadiz) by interpretation of seismic data

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Primary processing and preliminary interpretation of seismic data (cruises TTR-15, TTR-17 and the *Pelagia* 2006-2007 cruises) from the region were made. Seismic profiles PSAT 388, PSAT 389 (TTR-17) and PSAT 267-270 (TTR-15), side scan sonar data from the TTR-12, TTR-14 and TTR-17 cruises and 2D *Pelagia* data were used. The seismic source in the TTR cruises was a 3,5 litre airgun at a pressure of 120-150 atm. The streamer consisted of 8 channels. Central frequency of the source signal was 70 Hz. Three airguns with a volume of 10, 20 and 40 cubic inch were used in the *Pelagia* cruises. Central frequency of the source signal was 250 Hz.

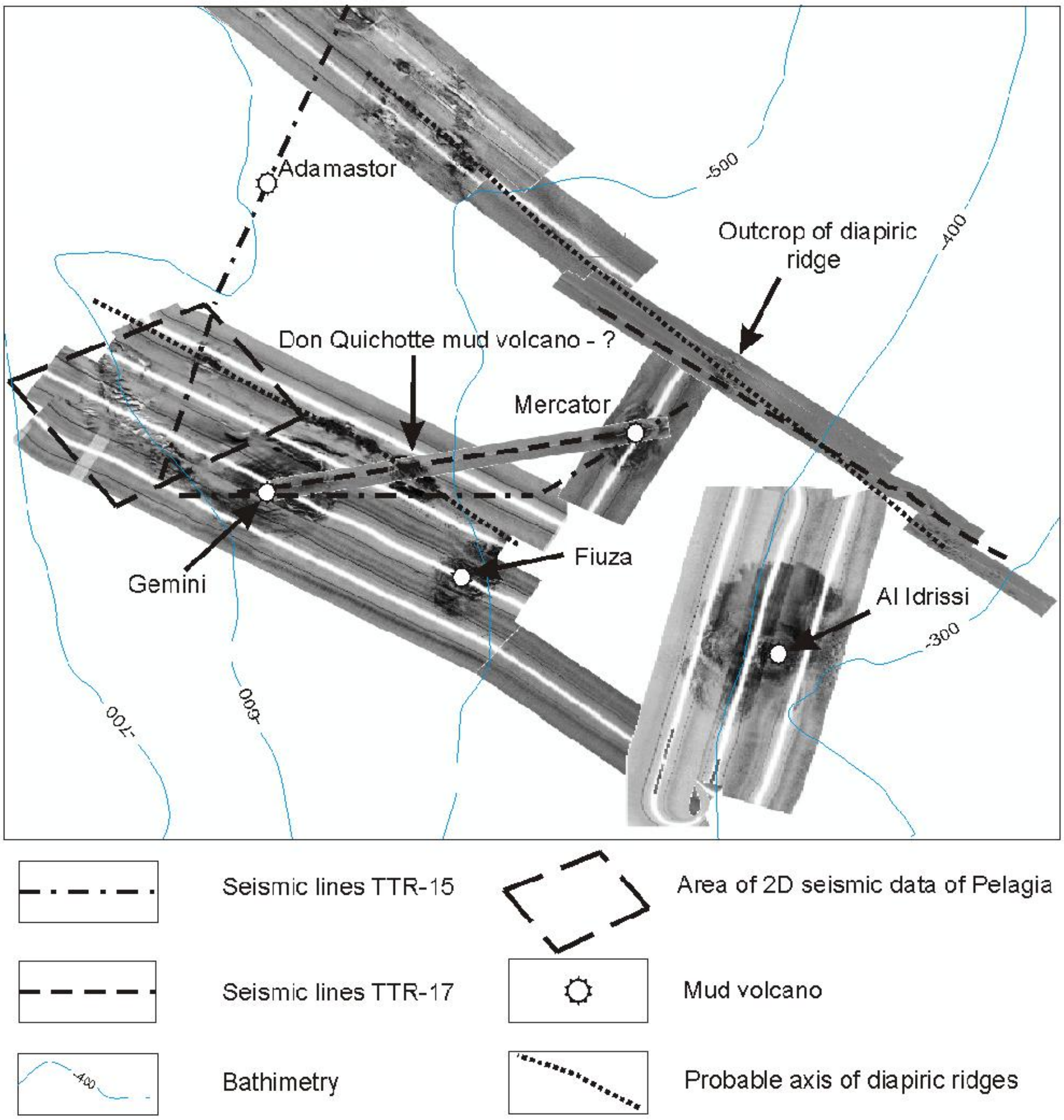

Fig. 1. TTR (RV Professor Logachev*) acoustic data and morphological features in the area of research (Gulf of Cadiz).*

After preliminary processing of seismic records several strong reflectors were selected for geological reconstructions. Two types of structures are present in the region. In the bottom relief they are expressed as seamounts. The first type is a chain of mud volcanoes. On sonograms they have a well rounded shape with flows and a relatively weak back scattering. Structures of the second type are diapirs with carbonate mounds on the top. These structures have a more angular shape and a strong back scattering.

Several diapiric ridges have been identified based on the seismic data. First of them – the Renard ridge (about 1 km wide in axial part) – consists of a chain of strongly eroded diapirs having north-west extension. The Don Quichotte MV is one of the structures that compose this ridge. On the eastern side of the diapiric ridge there is a chain of mud volcanoes (Fiuza, Gemini, etc). They have the rounded shape from 1 to 2,5 km in diameter. Further to the east approximately in 12 km there is the next diapiric ridge called the Vernadskii ridge. It is nearly 10 km in length and less than 2 km in width in its axial part. By its structure it looks very similar to the Renard diapiric ridge mentioned above. In 3,5 km to the south-west from the second diapiric ridge there is one more chain of mud volcanoes (Al

Idrissi, Mercator, Adamastor). They also have rounded shapes and similar sizes like the Fiuza and Gemini MVs.

Analysis of seismic lines has shown that there are no mud volcanic feeder channels in the area of the Renard diapiric ridge. Tracks of mud-volcanic flows on the MAK mosaic are not observed. During the bottom sampling mud-volcanic breccias were not detected. Due to these facts we can suggest that the Don Quichotte MV and similar structures extended in the north-west direction are not mud volcanoes but diapiric structures occupied by coral settlements. Most probably, the Vernadskii diapiric ridge also has the similar structure. Bottom sampling, side scan sonar survey and seismics do not confirm mud volcanic activity on this ridge.Thus in the studied area there are two diapiric ridges covered with coral upbuilds with the absence of mud volcanic activity. Mud volcanoes are distributed predominantly on slopes of diapiric ridges.

Carbonate chimney study: the Gibraltar Diapiric Ridge area (NE Atlantic)

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Dredging on the Gibraltar Diapiric Ridge (NE Atlantic, Strait of Gibraltar) during the TTR-14 cruise aboard R/V *Professor Logachev* yielded a large amount of carbonate chimneys. Two of them conventionally named the “Big” and the “Small” ones were studied during this work. The U-Th age of the chimneys was established as Early Pleistocene (Ivanov et al., 2004). The main goal of the study was to reveal possible sources of carbon and oxygen incorporated into the bulk carbonate material.

Subsamples for isotopic $\delta^{13}C_{VPDB}$, $\delta^{18}O_{VPDB,}$ and X-ray diffraction (XRD) analysis were picked out according to the scheme presented on Fig. 1. Mineralogical composition of 24 carbonate subsamples was studied by powder XRD at the Kitami Institute of Technology (Rigaku Rint 1200, monochromatic Cu K-alfa radiation). More than 70 subsamples were measured for $\delta^{13}C$ and $\delta^{18}O$ values at the Stable Isotope Laboratory of the Free University of Amsterdam and in the Kitami Institute of Technology.

The conducted XRD analysis of subsamples allowed to reveal heterogeneity in their mineralogy. The following minerals are determined in the studied chimneys: brown spar (Fe content was defined by 113/104Å peaks ratio (Carbonates: mineralogy …, 1987), low-Mg calcite ($MgCO_3$<4-5 mol %), quartz, and goethite (traces). The carbonate mineralogy was considered in details by hkl=104 reflex (in the range of corners 20–50º; 2 Θ CuK α) position on diffractograms. d104 values vary from 3.003Å for low-Mg calcite to 2.898Å for brown spar, respectively. Relative variability of terrigenous admixture is defined under the relation of the peak areas of quartz to carbonate phase (calcite + dolomite).

The measured values of carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) of the carbonates vary in the ranges of -30…0‰ and -3.5…5.5‰, respectively. Based on the present-day characteristics of the seawater at the study area ($\delta^{18}O_{SMOW}$ = 0‰ and T = 13ºC) (Diaz-del-Rio et al., 2003) and using equation presented in Fritz and Smith (1970) the calculated theoretical composition of $\delta^{18}O$ for the dolomite is -3.7‰ (VPDB). Whereas paleotemperatures of the formation of the brown spar calculated by the same equation (taking into account isotope fractionation between dolomite and phosphoric acid (Rosenbaum, Shepard, 1986) are in the range of +12…+30°C. One exception is the sample 1a (see Fig. 1A) which gives the temperature of formation +64°C.

Both carbonate chimneys consist mainly of brown spar with the greatest concentrations measured along the fluid-discharge channels. Reflexes of dolomite and calcite on diffractograms in some samples are split up suggesting the presence of different phases of the minerals. That may be due to rejuvenation of crystals taking place on the seafloor at present.

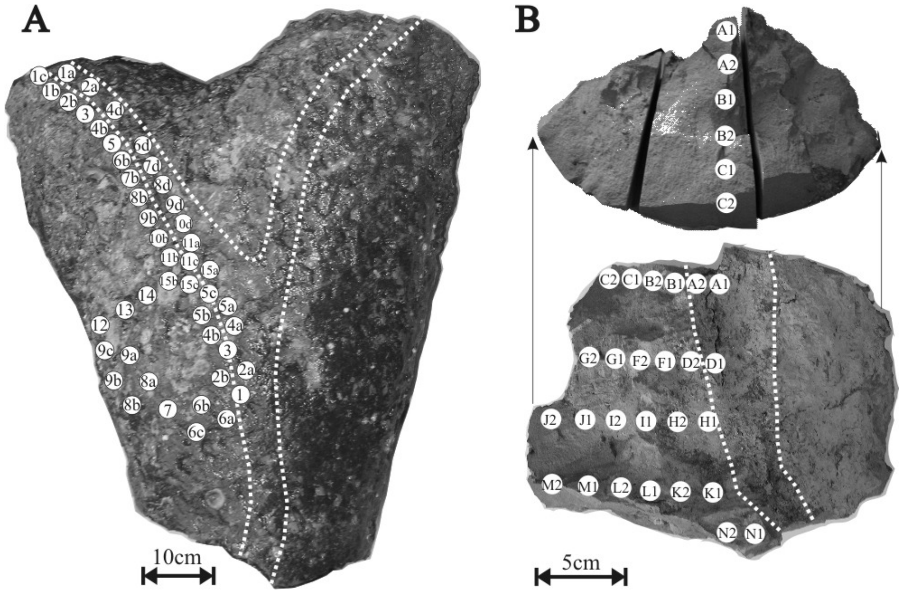

Fig. 1. Sketch representing position of studied subsamples on the (A) "Big" and (B) "Small" chimneys. The broken curve shows the fluid-discharge channels of the chimneys

Our data suggest that both mature thermogenic methane and that formed due to oil biodegradation were the main sources of the carbon for the "Big" chimney formation. Whereas, the main source of the "Small" chimney formation is carbon of organic matter being supplied from the surrounding sediments. The measured $\delta^{18}O$ values allow concluding that discharge of water with heavy oxygen (relative to seawater $\delta^{18}O$ - 0 ‰ (SMOW); -29.89‰ (PDB)) occurred during the phase of formation of the studied chimneys. Thus our data testify that both chimneys were formed under the same temperatures but according to the different scenarios and from carbons different in their origin.

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Changes in gas hydrate stability conditions and fluid escape structures in the Gulf of Cadiz as result of climate changes

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The occurrences of mud volcanoes, diapiric ridges, pockmarks and methane seepages (both active and fossil, as interpreted from occurrences of methane-derived authigenic carbonates) in the Gulf of Cadiz are characterized by high methane contents in shallow sediments and the presence of gas hydrates on the most active structures. These features indicate preferential areas for the escape of deep fluids enriched in hydrocarbons, mainly methane. Numerous fluid escape structures occur along the upper and mid-continental slope, where the Mediterranean Outflow water is in direct contact with the seafloor. This area is especially sensitive to paleoceanographic changes and the estimated ages of some of the methane-derived authigenic carbonates indicate formation over discrete episodes that correspond to periods of rapid paleoceanographic changes (such as the onsets of glacial stages terminations).

In this work, calculations for the depth of the gas hydrate stability zone were done using gas compositions based on measurements from active mud volcanoes, which reflect a mixture of biogenic and thermogenic sources. The depths of the gas hydrate stability zone were calculated for different paleoceanographic scenarios, both present day conditions and at the Last Glacial Maximum, using variable intensities of the Mediterranean Outflow.

Modeling results indicate that pressure variations have negligible effects on gas hydrate stability, but temperature variations can have significant impacts. The geological significance of the delay effect of the temperature perturbations on the gas hydrate stability zone was also evaluated. Seabottom warming by 2°C, as resulting from changes of the Mediterranean Outflow pathway under present-day similar conditions, can destabilize potential shallow gas hydrates occurrences in the northern margin of the Gulf of Cadiz. The transition from glacial to interglacial conditions significantly reduces the depth of the gas hydrate stability zone, and at several sites the stability zone disappears entirely for both gas compositions. Therefore, increases in the seafloor temperature associated with glacial to interglacial transitions and changes of the position of the Mediterranean Outflow as a bottom current, are processes that can efficiently trigger episodes of dissociation of potential gas hydrates that would result in intense flux of methane rich fluids to shallow sediments or even into the sea bottom.

Methane-derived authigenic carbonates from the Darwin and Porto mud volcanoes (the Gulf of Cadiz)

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Detailed investigation of fluid venting and mud volcanism in the Gulf of Cadiz, carried out during several cruises of the Training Through Research (TTR) Programme, revealed that authigenic carbonates occur widespread within mud volcanic structures and diapiric ridges. In this paper the results of the study of carbonate crusts from the Darwin and Porto mud volcanoes (MV) are presented.

The Darwin MV is a conical structure located at the Moroccan margin at a water depth of 1000 m. It is barely active: mud breccia was not sampled but carbonate buildups are widely spread. The Porto MV is situated in the deep Portuguese margin (3800 m water depth) and it is active now. Crusts from the Darwin and Porto mud volcanoes differ in morphology. The Darwin MV crusts are massive. They contain a lot of cemented shells and are yellowish in color. In the other hand crusts from the Porto MV are smaller in size, tube-like in shape. There are less shell fragments in them. They are greyish in color.

To compare the processes of authigenic carbonate cementation in two different environments (which are the relatively shallow inactive Darwin MV and deep-sea active Porto MV) carbonates from both locations were studied with a number of methods such as polished thin sections, X-ray diffraction (XRD), oxygen and stable isotope measurements. In total 23 samples were examined.

The study in the thin-sections reveals several differences in the composition of the crusts. There are a lot of foraminifera and fragments of bivalvia shells cemented with micritic carbonate in the Darwin MV crusts. In the other hand samples from the Porto MV are poor with shell fragments, in some samples there are no them at all. There are a lot of pyrite spots in the both types of crusts. All crusts from the Porto mud volcano are cemented with mictitic calcite. Cement in crusts from the Darwin mud volcano is usually botryoidal and fibrous high magnesium and aragonite. These cements can be interpreted as originally high magnesium.

XRD and thin-section investigations indicate that carbonates from the Darwin structure are mainly aragonite and high magnesium calcite with transitional varieties up to calcite. In the Porto MV calcite dominates. The Porto mud volcano is too deep and water mineralization is not sufficient for aragonite and high magnesium calcite accumulations. Degassing in the Porto mud volcano in comparison with the Darwin mud volcano is certainly more intensive.

Stable carbon isotopic composition of the crust varies greatly, from -29 to -16,5 ‰ VPDB (-20 is an average) in the Darwin mud volcano and from -26,4 to -25 ‰ VPDB in the Porto mud volcano (Fig. 1).

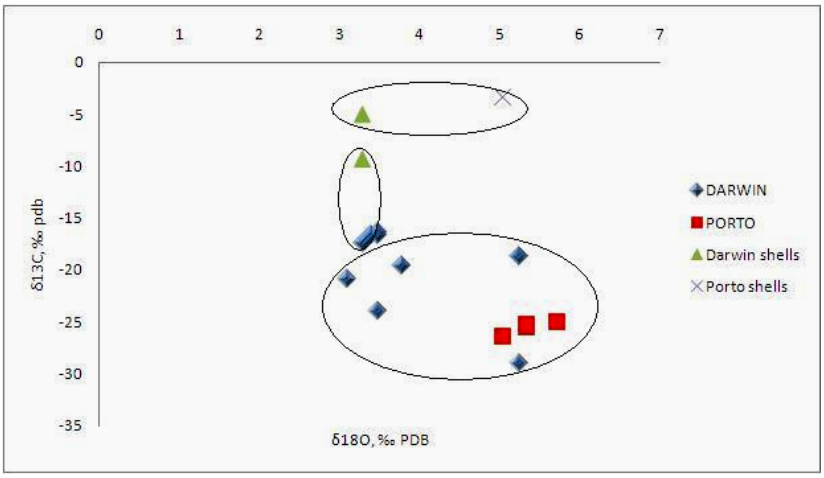

Fig. 1 Isotopic data for carbonate crusts from the Darwin and Porto mud volcanos.

There are three main groups of isotopes. They are: in shells – up to -6 $\delta^{13}C$, ‰ VPDB; in bioherms and cemented chemosynthetic shells - from -8 to -16 $\delta^{13}C$, ‰ VPDB (bulk samples); in authigenic carbonates from mud volcanoes - from -20 to -30 $\delta^{13}C$, ‰ PDB. In spite of great variation in isotopic composition $\delta^{13}C$ of carbonates, they are greatly different from usual oceanic carbonates. It shows formation of carbonates in studied areas in conditions of anaerobic oxidation of discharging hydrocarbons. The source of heavy $\delta^{18}O$ (5-6 PDB) in the Porto MV could be gas hydrates.

Mud volcano fluids of the Gulf of Cadiz: chemical and isotope variations and factors of control

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Mud volcanoes (MV) were identified in different areas on the Moroccan, Portuguese, and Spanish continental margins of the Gulf of Cadiz at water depths of 700–3500 m. All mud volcanoes and diapirs are found within the region of the accretionary wedge first described by Roberts (1970). Sediments from mud volcanoes often show clear indications of gas-saturation: degassing structures, a strong smell of H_2S, chemosynthetic fauna (Mazurenko et. al., 2002) evidenced their activity. MVs in the Gulf of Cadiz have been discovered and studied during several cruises of the UNESCO-IOC Training-Through-Research Program onboard R/V *Professor Logachev* from 1999 to 2008 (Kenyon et. al., 2000, 2001, 2003, 2007; Akhmetzhanov et. al., 2007). In this study 18 MVs discovered during TTR cruises were investigated in order to determine peculiarities of the MV fluids over the study area and to reveal factors controlling these peculiarities. Pore waters from MV sediments were analyzed for major element geochemistry and isotopic compositions of oxygen and hydrogen.

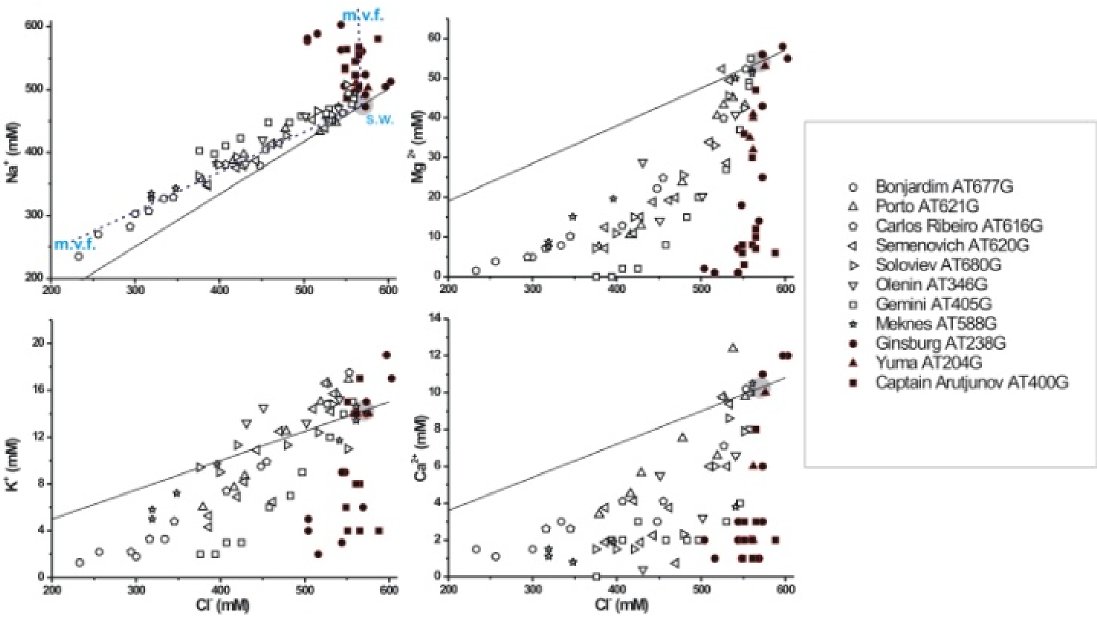

Fig. 1. Cl^- versus major element concentrations in the pore fluids from MV sediments characterized by low-salinity (hollow symbols) and elevated salinity (black symbols). Solid lines indicate constant seawater ratios. Gray circles represent bottom water values. Dashed line indicates mixing line between seawater and MV fluids of these two types.

Published and original data allow to subdivide the studied MVs into three groups according to their activity: low (Bomboca, Tasyo, Jesus Baraza, Rabat, Shouen, Kidd, Sagres), medium (Yuma, Olenin) and highly active (Bonjardim, Porto, Carlos Ribeiro, Semenovich, Soloviev, Gemini, Meknes, Ginsburg, Captain Arutjunov) (Fig.1). Interstitial waters from sediments of 11 from 18 studied MVs appeared to be characterized by differences in chemical and isotope compositions as compared to both seawater, and pore water from "normal" hemipelagic sediment. Consideration of the element

distribution profiles with depth suggests the presence of two groups of the active MVs: discharging of low-saline fluids and those discharging the fluid with elevated salinity (as compared to seawater).
As a rule, MV waters are characterized by significantly heavy oxygen and strongly light hydrogen isotope compositions. In addition, some variations in the isotope composition of the water were revealed between different MVs suggesting different sources of the MV fluid within the comparatively small area.

Cl^-/element ratios were used in order to reveal peculiarities in fluid composition for the medium and highly active MVs. The Cl^-/element distributions in most cases do not coincide with the constant seawater ratios. From the Cl^- *vs.* Na^+ plot it is obvious that the elements distribution represents two mixing lines with different end-members: hypothetical MV fluid waters (low-saline as function of chlorinity and high-saline as function of sodium) and the seawater (see Fig.1). The expulsion of saline fluid within the study area obviously related with salt diapirs outcropping at the Spanish-Moroccan margin (Medialdea et. al., 2004). Enrichment of K^+ is, probably, the result from submarine weathering occurring in first centimeters of subbottom depth (Aloisi et. al., 2004) that is supported by the shape of potassium profiles with depth. Depletion of Ca^{2+} and Mg^{2+} may be explained by MV water-rock interactions (Hensen et. al, 2007) along the flow path of MVs and probably related to carbonate minerals precipitation in MV sediments. It should be noted, that no relationship between geographical location of the MVs and peculiarities in their fluid geochemistry was established. Obviously, the main factors controlling the MV fluids chemistry and isotopy are related to tectonic structures (diapirs, faults) and composition of the strata adjacent to feeder channels of the MVs.

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NE Atlantic and the Norwegian Margin Studies

Geochemical observations of pockmark-related *Lophelia*-reef at Morvin, off Mid-Norway

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Numerous deep-water coral reefs occur on the seafloor at the offshore hydrocarbon field, Morvin, off Mid-Norway. One of these reefs, 'MRR', occurs inside a 120 m long and 100 m wide, 10 m deep pockmark depression (Fig. 1). The general water depth is 360 m and the ambient temperature is 7.1ºC. Upon visual inspection, this reef proves to have a high bio-density and biodiversity. Besides *Lophelia pertusa*, which is the major reef-building species, there are abundant *Paragorgia arborea* octocorals, abundant clusters of the large bivalve *Acesta excavata* (estimated at up to 400 individuals per cubic m) and a relatively large colony of the rare purple octocoral *Anthelia borealis*.

Sediment samples were acquired from the upper 50 cm within the pockmark. The sediments contain above-background concentrations of light hydrocarbons, ranging from methane to hexane, indicating

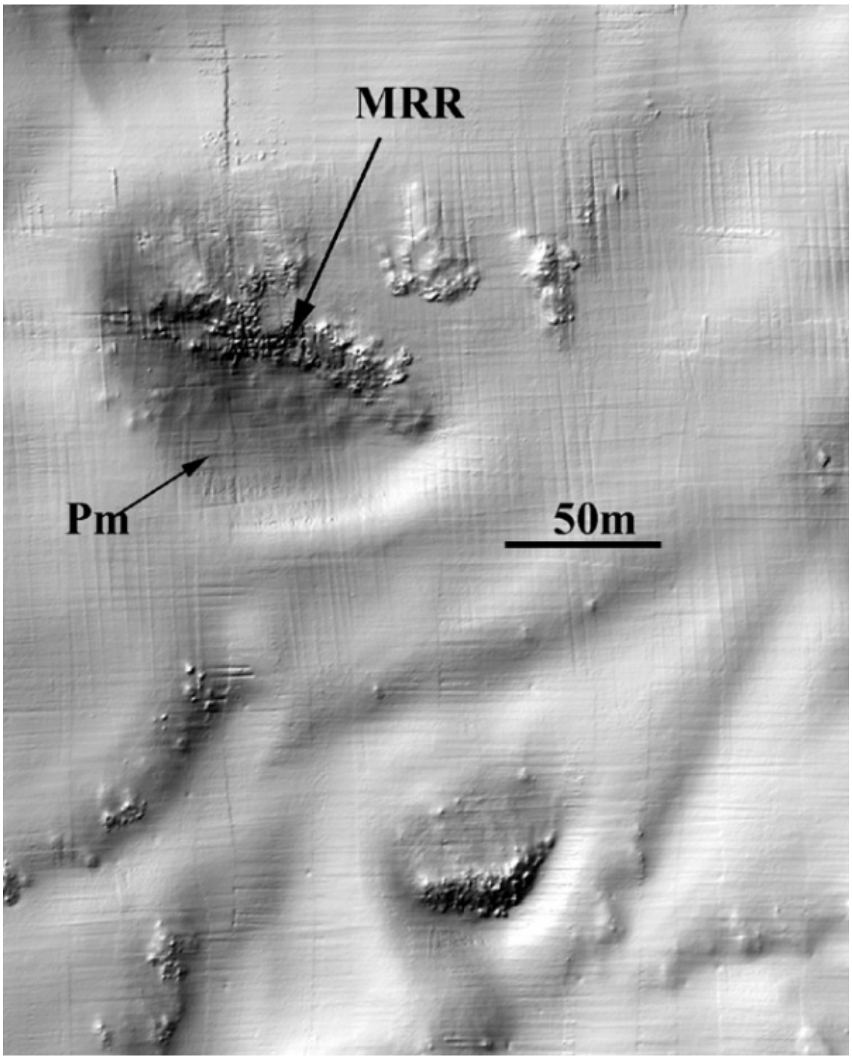

Fig. 1. The 80 m long Morvin Reference Reef (MRR) is located inside a normal pockmark (Pm). This image is a shaded relief image of a DTM from multi-beam echosounder mapping with ROV. The resolution (gridding) is about 0.5 m x 0.5 m.

active hydrocarbon micro-seepage. These results support the hydraulic theory for deep-water coral reefs (Hovland, 1990; Henriet et al., 1998; Hovland and Risk, 2003; Hovland, 2008).

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ORIGIN OF SMALL SCALE SEABED MOUNDS ON THE VØRING PLATEAU (NORWEGIAN MARGIN)

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Two types of structures are widely distributed on the bottom of the deep water Vøring Plateau: relatively large (up to 300 m in diameter) complex pockmarks covered with methane-derived carbonates that occupy modern and ancient seeps, and small (from a few to about 20 m in diameter, up to 5 m in height) rounded positive structures of unknown origin. During three TTR cruises (TTR-8, 10 and 16) a big number of such small dome like structures were mapped with deep towed side scan sonar operated with frequencies of 30 and 100 kHz. Deep towed 5.5 kHz subbottom profiler has shown that they sit on a very strong shallow (1 to 5 m deep) continued acoustic reflector (Fig. 1).

Sampling carried out during the TTR-16 and 17 cruises revealed that this reflector most probably corresponds to a black layer enriched in hydrotroillite (monosulfide) and ice rafted material. These structures are especially numerous in areas where this strong reflector is located very closely to the sea bottom (less than 3 m). They are getting sparser when the reflector goes down to 3 – 5 m subbottom and completely disappear if the reflector is situated on depths of 5 m and deeper. Samples collected from one of such domes by a large grab sampler navigated with the underwater TV system are represented by different kinds of very porous and poorly cemented crusts, and chimney-like structures. Generally crusts are yellow and dark brown in color, however they include thin layers of grey (greenish), white and black materials (Fig. 2, a-d). Yellow and brown materials are typical for the upper section of the crusts and gray, white and black ones are typical for lower sections. The underwater TV observations have shown that the crusts are covered with a very thin sedimentary layer and the edges of the crusts have partially been outcropping.

These samples were studied with an optical microscope, SEM with a microprobe analyzer, X-ray difractometer, chemical and isotopic analysis. Composition of the crust and chimney samples is rather uniform. They consist of clay minerals with quarts and feldspar admixture, carbonates and sufficient amount of X-ray amorphous material. Studies of this material under the optical microscope and SEM with microprobe analyzer revealed strong iron hydroxide and phosphate mineralization. SEM images with typical biogenic structures suggest that the mineral formation took place under a sufficient influence of Fe oxidizing bacterial consortium (Fig. 2, e). This process is well known and described as the formation of ferric hydroxides in association with microbial biomass in any environment where Fe(II)-bearing waters come into a contact with O_2 (Konhauser, 2007). Phosphates can also be concentrated by a microbial community due to high adsorptive affinity of Fe(III) for phosphate anions.

Carbonate minerals that constitute about 3-10% of the samples presented by calcite and siderite. Calcite and siderite have slightly lighter carbon isotopic values varying between -2 and -11‰ VPDB. This probably indicates the source of isotopically light CO_2. One of the samples has shown $\delta^{13}C$ value -23.9‰ VPDB (calcite -35.5‰, siderite -18‰) clearly indicating methane as the source of carbon.

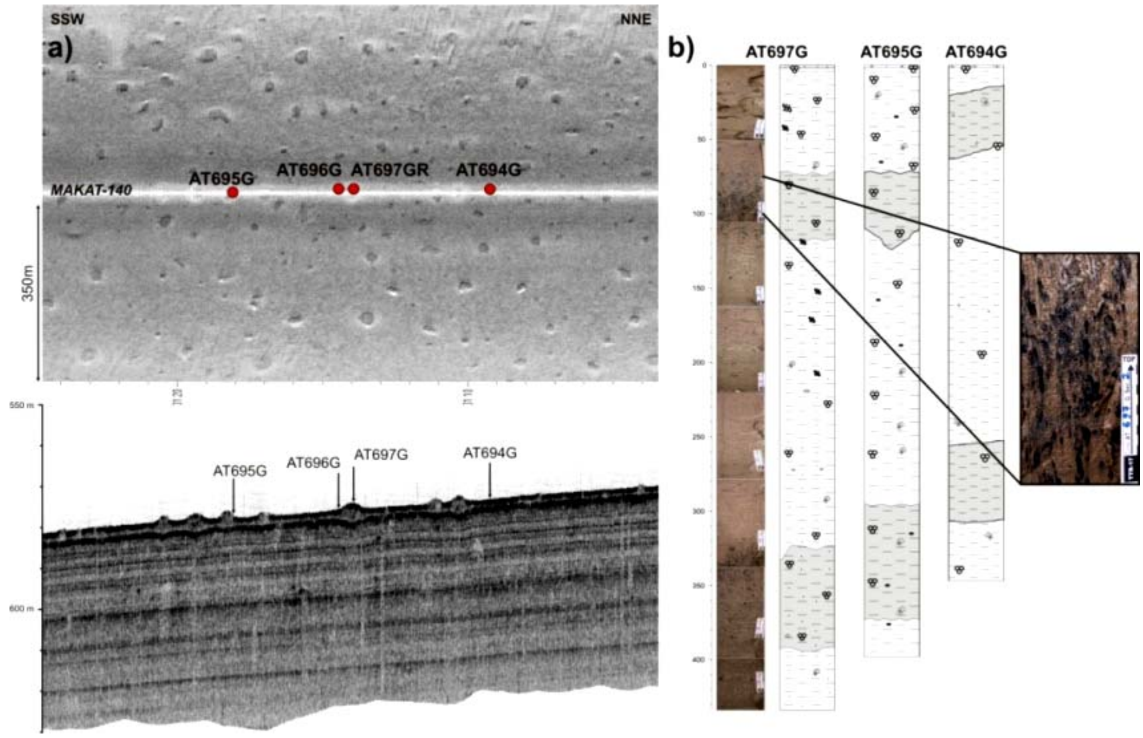

Fig. 1: (a) Fragment of a side scan sonar and subbottom profiler line with the location of sampling stations; (b) photo and core-logs of the collected gravity cores with Fe-monosulfide layers

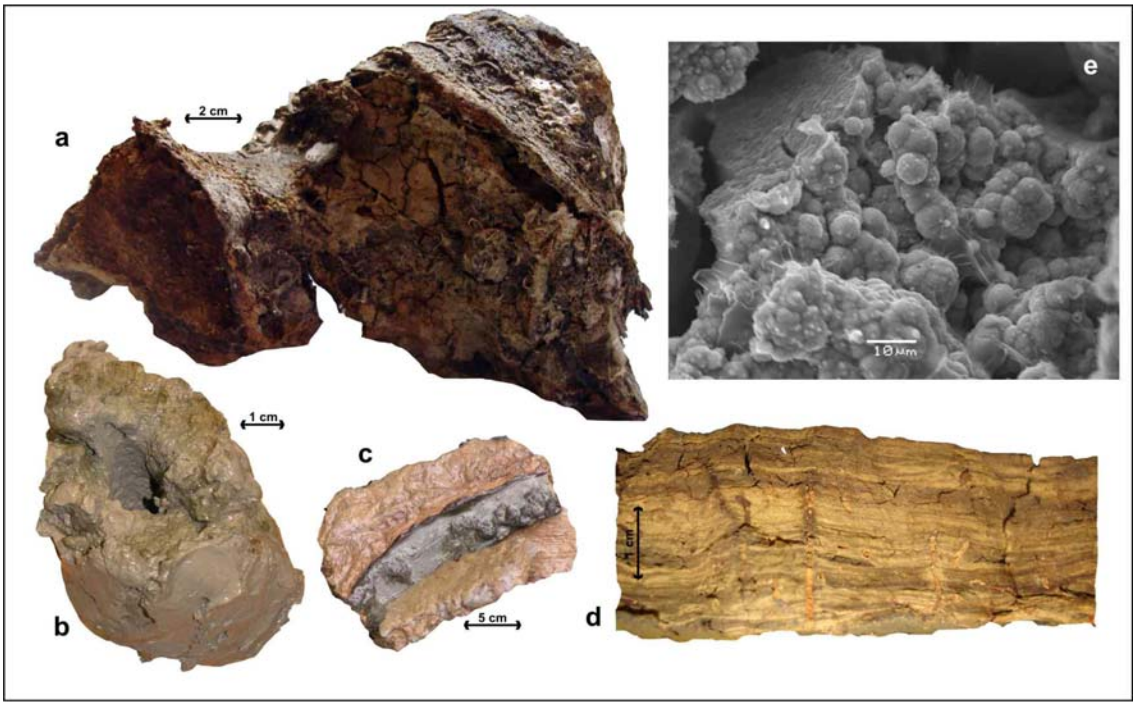

Fig. 2: Fe-rich crusts collected from the Vøring plateau: a- dome-like crusts; b- soft grey tubes; c- solid brawn tubes; d- cross-section of a piece of crust; e- SEM image of a mineralized bacterial community

We propose the following model of the origin of small positive structures on the Vøring Plateau. Places where focused hydrocarbon fluid flows were discharging in the area in the past have presently been occupied by a relatively large complex pockmarks with extensive authigenic carbonate formation. However, there were in parallel numerous weak diffused flows that were reaching the sea bottom. Filtration of these fluids through the monosulfide contained sediments delivered to the surface (sea bottom) solutions enriched with Fe(II). On contacts with oxygen-rich environments such solutions (springs) were heavily colonized by iron oxidizing bacterial communities producing ferric hydroxides and ferric phosphates. Some carbonate minerals as calcite and siderite also precipitated. This intensive mineralization with bacterial fossilization has leaded to the origin of mineralized microbial buildups.

Reference
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Small-scale mass wasting on the continental slope offshore Norway

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In the study of submarine mass wasting, much focus has been given to the large slides, their age and origin as well as the sedimentary processes involved. We present swath bathymetry and high-resolution side-scan sonar data, co-registered with high-resolution seismic records, from the continental slope offshore northern Norway (about 1400 – 1800 m water depth) providing evidence of repetitive small-scale mass wasting.

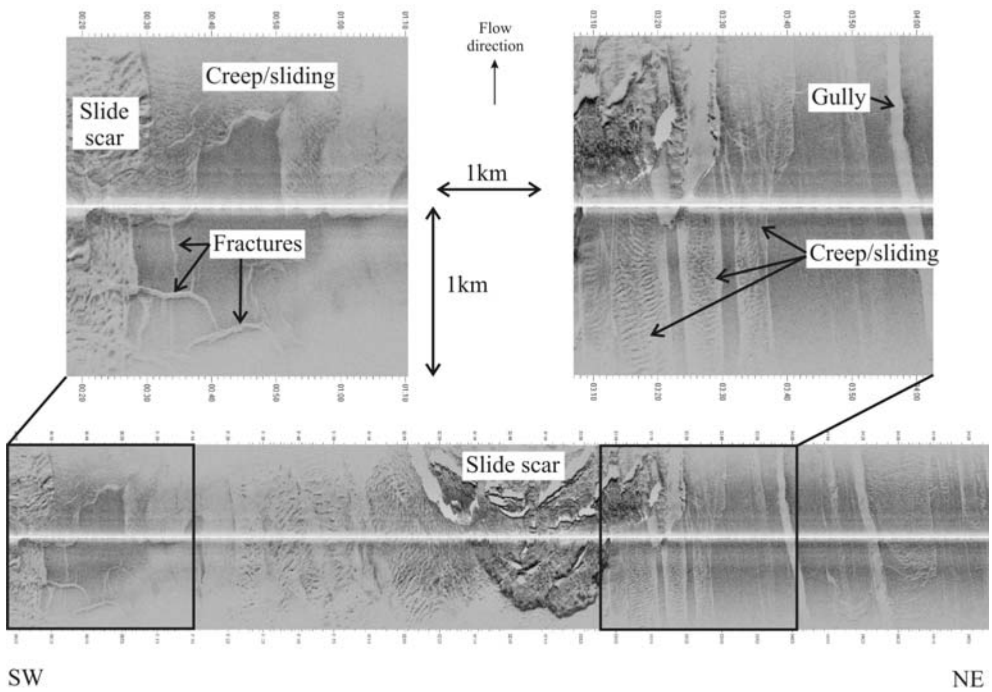

Fig. 1: MAK side-scan sonar record showing slide scars, creep/sliding and gullies on the continental slope of northern Norway.

The upper parts of several slide scars have been identified (Fig. 1). They are up to 4 km across and up to 80 m deep. Their morphology is very similar to large slide scars. They vary in 'freshness' due to variations in the thickness of draping sediments. This is inferred to reflect different ages of the events.

A second type of mass wasting seen on the side-scan data is a slope-parallel lineated fabric, comprising densely spaced, long and narrow depressions (Fig. 1). Alongslope, these areas are several hundred meters wide and sharply delineated. In upslope direction, the distance between the depressions becomes larger and in some cases only a few depressions display a complicated orientation pattern. This fabric, which is not seen on the swath bathymetry data, is inferred to be to the result of sediment creep and sliding. The base of the remobilised sediments seems to occur at the same depth for several of these events, only a few meters below the present seafloor. Downslope-oriented, shallow and narrow gullies form a third type of features formed by sediment remobilisation (Fig. 1). The gullies differ in acoustic backscatter signature from the surrounding seafloor. Coring of one gully revealed more sandy sediments compared to the surroundings, indicating that they form by remobilisation of sandy sediments further upslope. In conclusion, analyses based on submarine-landslide databases indicating that large landslides dominate in the eastern North Atlantic are probably not correct but biased because of the lack of high-resolution acoustic data.

Morphological elements of the Lofoten Basin Channel - implications for the properties of the latest turbidity currents

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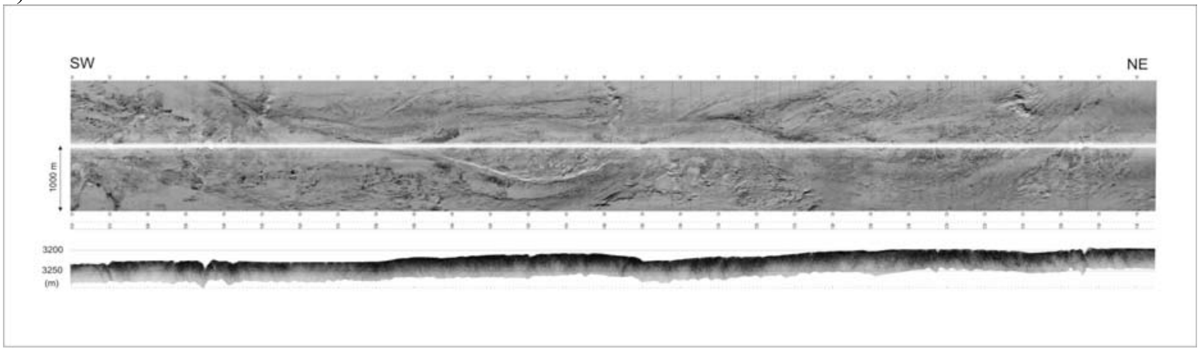
A modern turbidite system, the Andøya Canyon – Lofoten Basin Channel and associated deposits, is located on the continental margin offshore northern Norway (Laberg et al., 2005; 2007). Based on swath bathymetry, side-scan sonar records, and high-resolution seismic data, the Lofoten Basin Channel can be followed from the mouth of the canyon at the base of the continental slope into the abyssal plain of the Lofoten Basin. The proximal part of the channel is a straight erosional feature, up to 30 m deep and about 3 km wide with poorly developed levees. Coring retrieved sandy turbidites deposited both on the channel floor and on its levees. Thus, some of the most recent flows were sandy, up to 3 km wide and more than 30 m high in order to overspill the channel. About 50 km off the mouth of the Andøya Canyon, the Lofoten Basin Channel joins with another channel entering from the northeast. Beyond there is a complex sea floor morphology including one main channel, several smaller channels and various erosional features. The main channel terminates 20 – 30 km to the southwest. Further into the basin an elongated, positive lobe-formed deposit is located. In front of it part of an older, smaller lobe is seen. The main channel is continuing into the deepest part of the Lofoten Basin where it terminates at about 3200 m water depth. About 20 - 25 km from its termination the channel splits into several smaller (up to 500 m wide and 10 – 30 m high), meandering channels (Fig. 1a – c). The inter-channel areas are dominated by down-flow elongated scour marks, some located near and in parallel with the channels (Fig. 1c). These were probably formed by smaller flows confined by the meandering channels. Other scour marks are oriented parallel to the overall flow direction (Fig. 1c) and were probably formed by larger unconfined flows that overtopped and moved independently of the meandering channels. The latter may have been up to an order of magnitude wider and higher compared to the confined flows. A depositional lobe is located beyond the mouth of the meandering channels. Its areal extent is yet unknown. High-resolution sub-bottom profiler records show units of some meter thickness that can be followed for several tens of kilometres. They are a)



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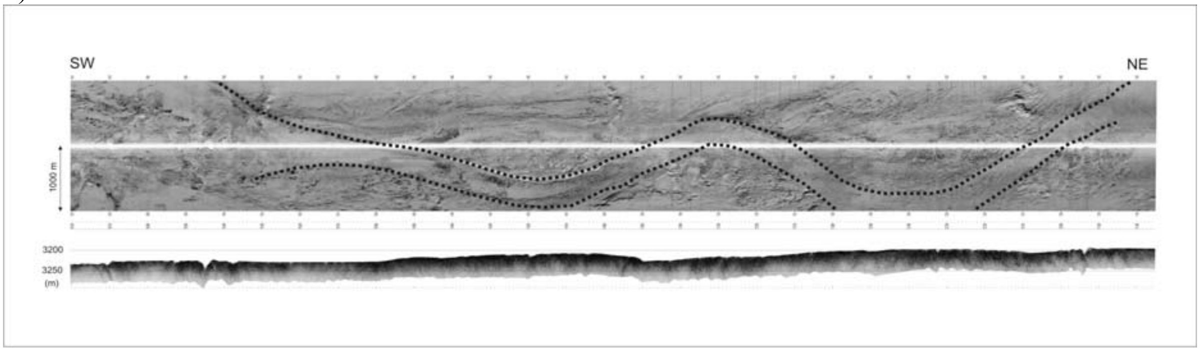

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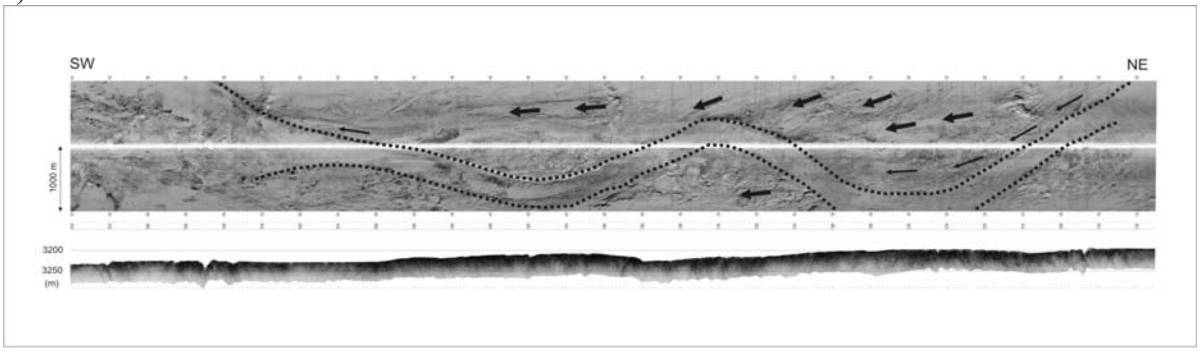

Fig. 1: a) MAK high-resolution side-scan record and co-registered sub-bottom profile (located along the white line of the MAK record), b) outline of part of one of the meandering channels, and c) arrows indicating flow direction of turbidity currents interpreted from scour mark orientation. Thicker arrows indicates scour marks that are inferred to have been formed by flows moving independently of the meandering channel while thinner arrows shows scour marks originating by erosion from smaller flows confined to the channel.

separated by continuous to slightly discontinuous medium to high amplitude reflections. Recent coring has identified up to 4 m thick intervals of sand between units of mud.

Acknowledgement. This work is a contribution to the Democen project (http://www.ig.uit.no/Democen/). Financial support from the Research Council of Norway and StatoilHydro is greatly acknowledged.

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Mineralogical and grain size analyses of recent sediments in the Lofoten Basin Channel, Norwegian Sea

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The Lofoten Basin is situated to the west of the northern Norwegian continental margin at the water depth of about 3200 m. There is the Lofoten Basin Channel within it, which drains from east to west. First investigations of this area were realized during TTR13 cruise (leg 1). During TTR17 Leg3 cruise onboard R/V Professor Logachev the study of the Lofoten Basin Channel is proceeded using geophysical and geological methods. Based on deep-towed high-resolution MAK -1 side-scan sonar and subbottom profiler data collected during TTR17 and TTR13 cruises in the proximal and distal parts of the channel, locations of sampling stations were chosen. Seven box-cores were taken in the distal part of this channel (AT711 B – AT717B) and three box-cores in the proximal part (AT718B – AT720B) (Fig. 1, A).

A series of box-cores were retrieved in order to infer turbidite activity in the Lofoten Basin Channel. Recovery of sediments usually was about 50 cm. All cores showed positive gradation (Fig. 1, B) and have the similar description. The lower part of the cores is represented by grey and very stiff medium and fine-grained sand. The next interval consists of fine and very fine sand. The uppermost part of the cycle is represented by light brown water saturated in upper part clay with silty and sandy admixture. Sediments with these characteristics can be interpreted as turbidites. Intervals for subsampling and further investigations were chosen according to primary description of the cores. The graphic representation of the results of grain size analysis is shown in Fig. 1(C and D). The fundamental attributes were calculated. There are "average" size or central tendency of the distribution (median); "sorting" or dispersion of the values about the median; and symmetry (skewness).

Thus, for sample AT 717 B (61-63 cm) Q_1 = 0,10625; Md(median) = 0,15; Q_3 = 0,2 (fig. 3); coefficient of sorting S_o = 1,371989 ($S_o=\sqrt{Q_3/Q_1}$); coefficient of skewness S_k = 0,971825 ($S_k=\sqrt{Q_1 * Q_3/Md^2}$).

After that, samples were separated on heavy and light mineral fractions, using specific liquid with density of 2,89 g/cm^3 (bromoform) and identified under the microscope. According to this study, the most common heavy minerals are hornblend (>50%), epidote (15%) and garnet (12%). Clinozoisite, sphene (titanite), enstatite, hypersthenes, calcite, kyanite (disthene), apatite, rutile, augite, zircon and andalusite were also observed.

Thus, the distributions of the grain size fractions for investigated intervals are markedly asymmetrical and show typical positive gradation for the turbiditic layers. The coefficient of sorting is very well. Distribution's maximum varies from silt to very fine sand. Based on the microscopic study of the heavy minerals the main sand source belongs to high-matemorphic and partly magmatic provenance.

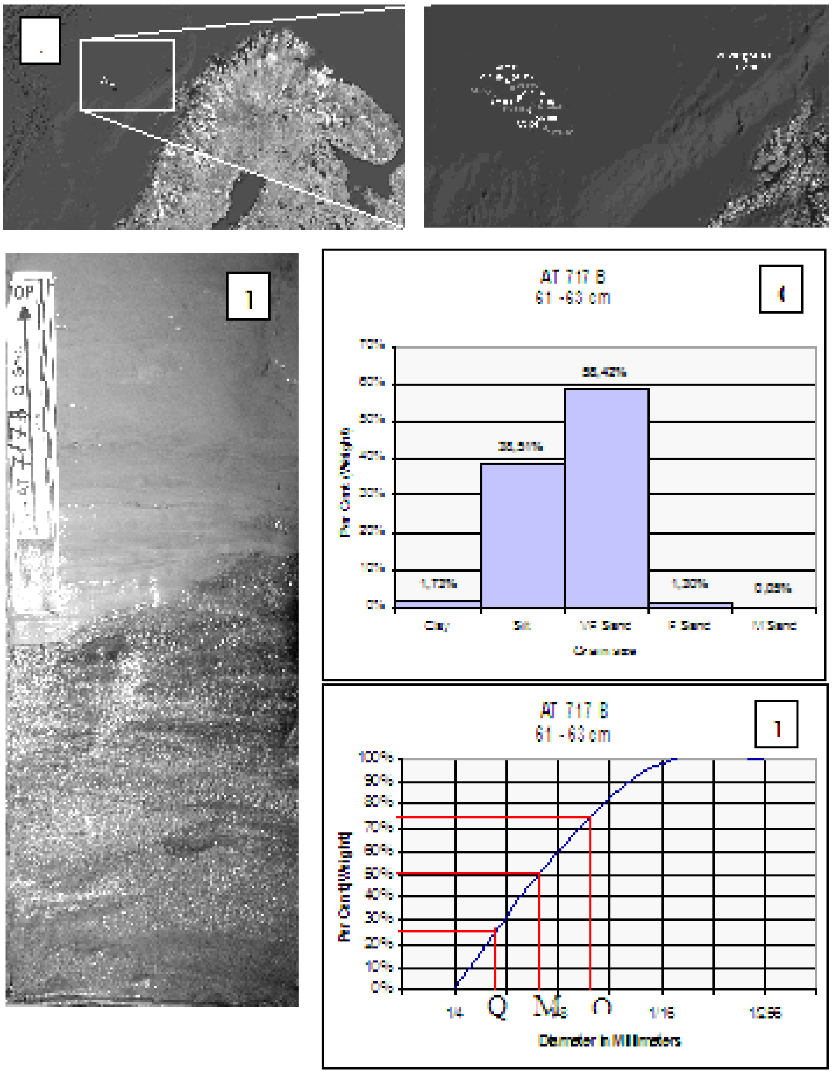

Fig. 1. A- Locations of sampling stations (light-cores were taken during TTR-17cruise; dark -during TTR-13 cruise). B, C, D- Distribution of the grain size fractions for the core AT 717 B: A- photo of the core; B-histogram of grain size distribution analyzed in interval 61 – 63 cm; C- size composition of clastic sediments represented by cumulative curves.

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Information materials

Facilities of SeisLab Seismic Laboratory at the Institute of Marine Sciences and Technology, Dokuz Eylül University, Turkey

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Seismic laboratory has been activated in early 2005 to collect, process and interpret the multichannel seismic reflection, multibeam bathymetry, deep tow side scan sonar and Chirp subbottom profiler data collected by R/V *K. Piri Reis*. SeisLab has also necessary hardware and software to process and interpret all these different types of data. Primary purpose of the laboratory is to investigate gas hydrates in the surrounding waters of Turkey.

The facilities of the Seislab can be grouped into 4 categories: (i) multichannel seismic reflection system which consists of 600 m digital seismic streamer, 96 channel seismic recording system, 210 inch3 GI gun, and other necessary auxiliary systems such as streamer depth controller and gun control unit etc.. (ii) Side-mount multibeam bathymetry system includes two separate transducer systems, one is 180 kHz transducer for shallow waters (up to 600 m) and the other is 50 kHz transducer for deeper waters (up to 3000 m), (iii) Deep tow combined side scan sonar and Chirp subbottom profiler system includes dual frequency (110-410 kHz) side scan sonar and a 2-7 kHz Chirp system to obtain the backscattering of the sea bottom up to 2000 m water depths and (iv) Side-mount Chirp subbottom profiler system has 9 transducers which work at 2.75-6.25 kHz and can be operated up to full ocean depths.

Several cruises has been completed since 2005 using high resolution multichannel seismic reflection system in the western and mid-Black Sea, the Marmara sea, the Aegean and the eastern Mediterranean seas for a primary object of tectonism and fault mapping, and more than 14000 km of seismic data were collected. The multibeam system was successfully used in the Aegean Sea, the Black Sea outlet of Bosphorus and in the Marmara Sea to map large geomorphological features on the seabed. Deep tow side scan sonar system was also used in the northern Marmara shelf and in the İzmir bay to map the active fault surfaces as well as gas flares along the faults.

TTR-Flanders project (2004-2008): main results

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UNESCO Medium Term Strategy for 2002-2007 called *inter alia* for "spreading and replicating successful examples of alternatives to traditional formal education". The priority areas established by this and the relevant IOC documents were youth, Africa and women (gender equality). A successful non-traditional mechanism for advancing knowledge on complex systems of the ocean deep has been established by the IOC: the TTR programme with its dual approach and function (research and training in science). The TTR-Flanders project[1] (June 2004 - December 2008, Geosphere-Biosphere… 2008) was launched by IOC to support the participation of young researchers from the South in various TTR activities. It provided for training in marine sciences focused on processes at ocean margins. The development of a concept of interaction between the geosphere and the biosphere was the major research goal of the project.

Through annual research cruises, post-cruise conferences, specialized capacity-building field actions for group training, as well as through individual training the TTR programme as the whole attracted in 2004-2008 a considerable number of researchers and trainees from the North while the TTR-Flanders project involved many participants from the South: 25% approx. were from the South. In the previous years this figure did not exceed 10%. Countries of Africa that benefited from the project were: Morocco (selected as the pilot country), Cote d'Ivoire, Mauritania, Mozambique and Senegal. Other countries that were involved, in one way or the other included: Belgium (the major counterpart), Italy, The Netherlands, Portugal, Russia, Saudi Arabia, Spain, and the United Kingdom.

R/V *Professor Logachev* (Russia) R/V *Belgica* (Belgium) R/V *Pelagia* (the Netherlands)

Fig. 1. Major research vessels used for ship-board training.
Sources: R/V Professor Logachev*: photo by E. Kozlova, Moscow State University;*
R/V Belgica*: http://en.wikipedia.org/wiki/RV_Belgica;*
R/V Pelagia*: http://www.nioz.nl/nioz_nl/386d4f0fee290da945fd7d7b8c235733.php*

Left: "Do as I do!" Prof. J-P. Henriet (left) and Prof. N. Hamoumi (centre) with trainees extracting a sedimentary core from the gravity corer in a TTR cruise (RV Professor Logachev*). Right: At a training seminar onboard the* Logachev*: a participant from Morocco discussing the newly obtained data (TTR17 cruise, 2008).*

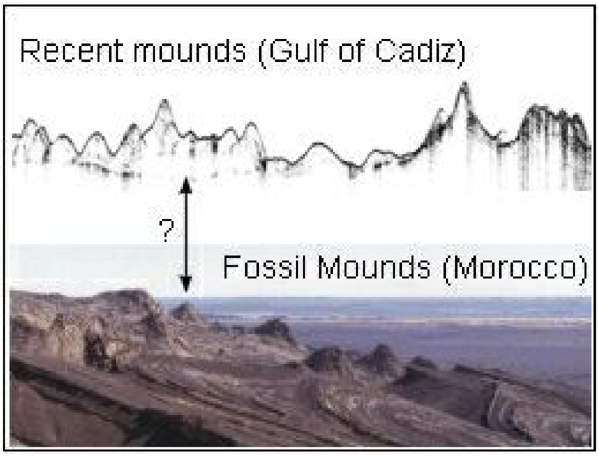
Fig. 2. At-sea training (photos courtesy of E. Kozlova, Moscow State University)

[1] Full title: Geosphere-Biosphere Coupling Processes in the Ocean: the Training-through-Research approach towards Third World involvement

For research and training purposes the Moroccan EEZ was selected as the primary target. In 2004 a consortium of universities and research institutions was created, named “Geosphere-Biosphere Coupling Processes-Morocco” (GBCP-Morocco). It gathered four major research groups: from “Université Abdelmalek Essaaddi” (Tangier); Department "Physique du Globe, Institut Scientifique” (Rabat); “Faculté des Sciences, Département de Géologie Université Mohamed V-Agdal” (Rabat) and “Université Cadi Ayyad” (Marrakech). The participants benefited from the TTR-14 (2004), TTR-15 (2005), TTR-16 (2006) and TTR-17 (2008) cruises of the R/V *Professor Logachev*, as well as from a number of cruises organized and convened by institutions-partners in the TTR programme (but not necessarily formal partners in the TTR-Flanders project). The latter has represented the project’s important synergy effect. Useful cooperation was established with several EU- and ESF-funded undertakings like HERMES, MICROSYSTEMS and EUROMARGINS projects.

Ship-board training was coupled with field courses that looked at ancient marine environments: this helped understanding processes happening now in the ocean deep. Three field training-through-research workshops were organized: in November 2005 in the NW Rif belt of Morocco, in December 2006 in the Anti-Atlas Mountains of Morocco and in October 2008 in South Africa. During the workshops the trainees from Morocco, Mauritania, Mozambique and other countries were able to gain experience on the field under the guidance of experts.

To give an example, during the December 2006 fieldtrip young researchers of Morocco, Mozambique, Mauritania and Russia were guided on the field under the supervision of experts from Belgium, Italy, Morocco, Switzerland and the Netherlands. The trainees were introduced to the world of the Devonian Kess Kess mounds in Morocco according to the ‘Training-Through-Research’ philosophy. By making their own observations and discussing them with the scientists, they discovered the various problems and burning questions that are still surrounding the carbonate mounds, both fossil and recent ones. The course was attended by a group of 13 DESA trainees from Mohamed V–Agdal University (Rabat) and a trainee from Tangier.



Comparison between recent and fossil mounds


One of the world-famous Kess Kess mud mounds

The Kess Kess Mounds Capacity Building Field Action
Source: http://www.vliz.be/projects/classatdesert/index.php

An important event was the international TTR-14 post-cruise research conference on ‘Geosphere-Biosphere Coupling Processes: the TTR interdisciplinary approach towards studies of the European and North African margins’ (Marrakech, February 2005). It had dual but complementary tasks: to discuss the most recent achievements in interdisciplinary research on ocean margins and to widen the impact on the Moroccan marine science community at large. By all means, this approach has reached the objectives. The participation of trainees in this and other research conferences has been considered as an important added value to their training in science.

A workshop in South Africa (October 2008) was the closing event of the project but also a forward-looking one. The participants discussed a potentiality of developing a GBCP "troika" Morocco - South Africa - Brazil, fully framing the most interesting South Atlantic cold-water coral and carbonate mound provinces. This can pave the way towards a comprehensive and balanced N-S Atlantic research effort.

The TTR-Flanders project has contributed to unveil to the North African academic world the study of mud volcanoes, giant carbonate mounds and the remarkable deep-water coral reef ecosystems. It has advanced knowledge on Geosphere-Biosphere coupling processes and contributed to knowledge transfer and sharing by bringing together partners from various countries of the North and the South, from academia, universities, industry and other relevant public sectors. It also supported and shaped the first in Morocco Master course on "Géodynamique et valorisation des Marges océaniques (littoral et zone économique exclusive") established at Mohamed V-Agdal University (Rabat).

Acknowledgements. The TTR-Flanders project was financed from the UNESCO/ Flanders Funds-in-Trust for the Support of UNESCO's Activities in the Field of Science (FUST) and was the integral part of the Capacity Development programme of IOC. Our special thanks go to so many scientists from Europe, Morocco and Russia who contributed with their knowledge and time to meeting the project's goals.

Reference

Geosphere-Biosphere Coupling Processes in the Ocean: the Training-through-Research Approach towards Third World Involvement, 2004-2008. TTR Flanders project, UNESCO project 513RAF2005; final report (2008). IOC/INF-1253, UNESCO, 40 pp. (also available at http://unesdoc.unesco.org/ulis/cgi-bin/ulis.pl?catno=178770&set=49A136B5_1_280&gp=1&mode=e&lin=1)

ITRAX XRF core scanning integration in multidisciplinary, high-resolution non-destructive core analyses of marine sediments

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The arrival of the Itrax XRF Core Scanner from COX analytical System in the University of Vigo, opens new doors for the entire Spanish oceanographic community to analyze ancient sediments at great speed and resolution. The state of the art instrument simultaneously captures digital photographs and X-ray images of samples, while detecting measurable amounts of any of 80 chemical elements from sodium (atomic number 11) to uranium (atomic number 92) without breaking the surface of the core. With a total time for analysis of only some hours for 1.8 meter of core, the instrument capacity is high enough for large projects and multi-user environments.

The Marine Environmental and Geoscience Research Group (GEOMA) took the initiative within the context of the Ciudad del Mar, the future Atlantic reference oceanographic centre in Spain that will be located at Vigo. Backed by the entire Spanish marine geology community, the group has invested a lot of their own valuable research time on setting up the instrument and figuring up ways of opening access for the whole research community before the Ciudad del Mar becomes fully operative in coming years. It is credit to the University of Vigo, the Xunta de Galicia and to the support of the Ministry of Science and Innovation of Spain to make this possible.

This instrument is, however, only the first element of an ambitious plan to complement the elemental analysis with a 2G cryogenic magnetometer and a Geotek core scanner to acquire geophysical data such as magnetic properties, bulk density, natural gamma, p-wave speed, resistivity to carry out a true multidisciplinary, non-destructive core analyses of marine sediments with unparallel high-resolution and speed. GEOMA is convinced that a centre of this sort -capable of gathering key data to reconstruct the Earth's past climate and history in a matter of hours- will fundamentally change the experience of studying sediments. Scientist will be able to ask bigger and broader questions.

ANNEX I

Conference Programme

MONDAY, 2nd February

9:30	Registration
9:45	Welcome by the director of the IACT Dr. Alberto López Galindo
Session 1	
Morning	**Chair: M. Comas**
10:00	M. Ivanov, N. Kenyon, M. Comas, L. Pinheiro, J.-S. Laberg and shipboard Scientific party. INTRODUCTION TO TTR-17 RESULTS. (Invited Talk)
10:30	L.M. Pinheiro, M. Ivanov, V. Magalhães, C. Roque, C. Lemos, R. Bezerra, A. Antunes, N. Alaoui , B. Aguado, J. Coutinho, C. Gonçalves and the TTR-17 Leg Shipboard Scientific Party. PRELIMINARY RESULTS FROM THE TTR-17 LEG-2 CRUISE IN THE GULF OF CADIZ
10:50	J.S. Laberg, M. Forwick, H.B. Johannessen, M. Ivanov, N.H. Kenyon, T.O. Vorren. MORPHOLOGICAL ELEMENTS OF THE LOFOTEN BASIN CHANNEL - IMPLICATIONS FOR THE PROPERTIES OF THE LATEST TURBIDITY CURRENTS
11:10	Coffee Break
11:40	Poster Session
12:00	V. Blinova, M.C. Comas, M. Ivanov, T. Matveeva. ACTIVE MUD VOLCANISM IN THE ALBORAN SEA: PRELIMINARY RESULTS OF HYDROCARBON FLUIDS COMPOSITION FROM TTR-17 LEG 1 CRUISE.
12:20	V. H. Magalhães, L. M. Pinheiro, B. Buffett, D. Archer. CHANGES IN GAS HYDRATE STABILITY CONDITIONS AND FLUID ESCAPE STRUCTURES IN THE GULF OF CADIZ AS RESULT OF CLIMATE CHANGES
12:40 – 13:00	Discussion
13:30 – 15:00	Lunch
Session 2	
Afternoon	**Chair: F. Martínez-Ruiz**
15:00	M. Tsypin,T. Matveeva, M. Ivanov, V. Blinova, E. Prasolov. MUD VOLCANO FLUIDS OF THE GULF OF CADIZ: CHEMICAL AND ISOTOPE VARIATIONS AND FACTORS OF CONTROL
15:20	E. A. Logvina, A.A. Krylov, T. V. Matveeva, A. N. Stadnitskaia, T. C.E. van Weering, M. K. Ivanov and V. N. Blinova. CARBONATE CHIMNEY STUDY: THE GIBRALTAR DIAPIRIC RIDGE AREA (NE ATLANTIC).
15:40	V. Nekhorosheva, V. Blinova, M. Ivanov. METHANE-DERIVED AUTHIGENIC CARBONATES FROM THE DARWIN MUD VOLCANO AND PORTO MUD VOLCANO IN THE GULF OF CADIZ
16:00	M. Makarova, A. Stadnitskaia, M.K. Ivanov, and J.S. Sinninghe Damsté. BIOGEOCHEMISTRY OF METHANE-RELATED CARBONATES FROM THE WESTERN BLACK SEA AND NILE DEEP SEA FAN (EASTERN MEDITERRANEAN)

16:20	M. Taviani. DEEP-SEA COLD SEEPS AND CORALS OF THE MEDITERRANEAN BASIN, CAINOZOIC TO PRESENT (Invited Talk)
16:40 - 17:10	Discussion

TUESDAY, 3rd February

Session 3
Morning Chair: L. Pinheiro

9:30	M. Hovland, Å. O. Ekrheim, and I. Ferriday. GEOCHEMICAL OBSERVATIONS OF POCKMARK-RELATED *LOPHELIA*-REEF AT MORVIN, OFF MID-NORWAY (Invited Talk)
10:00	M. Comas, L. M. Pinheiro, M. Ivanov, and TTR-17 Leg 1 Scientific Party. DEEP-WATER CORAL MOUNDS IN THE ALBORAN SEA: THE MELILLA MOUND FIELD REVISITED.
10:20	S. Margreth, G. Gennari S. Spezzaferri, M.C. Comas, L.M. Pinheiro and A. Rüggeberg. COLD-WATER CORALS AND MUD VOLCANOES IN THE WEST ALBORAN BASIN.
10:40	H. G. Fink, D. Hebbeln, C. Wienberg, H. McGregor, M. Taviani and A.Freiwald. COLD-WATER CORALS IN THE CENTRAL MEDITERRANEAN SEA DURING THE HOLOCENE
11:00	Coffee Break
11:30	Poster Session
11:50	Yu. Kolganova, M. Ivanov, H. de Haas, F. Mienis, T. C. E. van Weering. THE INFLUENCE OF SEDIMENTARY PROCESSES AND CLIMATIC CHANGES ON COLD WATER CORALS AT CARBONATE MOUNDS OF THE PEN DUICK ESCARPMENT, SE GULF OF CADIZ.
12:10	M.R. Cunha, C.F. Rodrigues, L. Génio, A. Hilário, C.J. Moura, A. Ravara. BENTHIC MACROFAUNA FROM MUD VOLCANOES IN THE GULF OF CADIZ – DIVERSITY AND DISTRIBUTION.
12:30 – 12:50	Discussion
13:30 – 15:00	Lunch

Session 4
Afternoon Chair: M. Ivanov

15:00	F. J. Jimenez-Espejo, F. Martinez-Ruiz, M. Rogerson, J. M. Gonzalez-Donoso, O. E. Romero, D. Linares, T. Sakamoto, D. Gallego-Torres, M. Rodrigo-Gámiz, V. Nieto-Moreno, M. Ortega-Huertas. PALEOCEANOGRAPHIC AND PALEOCLIMATE CONDITIONS IN THE WESTERN MEDITERRANEAN DURING THE LAST 20 KYR: NEW INSIGHTS FROM A TTR CORE TRANSECT IN THE ALBORAN SEA BASIN.

15:20	J.S. Laberg, M. Forwick, M. Ivanov, N.H. Kenyon, T.O. Vorren. SMALL-SCALE MASS WASTING ON THE CONTINENTAL SLOPE OFFSHORE NORWAY
15:40	I. Yurchenco, E. Kozlova, J.S. Laberg . MINERALOGICAL AND GRAIN SIZE ANALYSES OF A RECENT SEDIMENT IN THE LOFOTEN BASIN CHANNEL, NORWEGIAN SEA
16:00 - 16:30	Discussion
21:00	Conference Dinner at “PILAR DEL TORO” RESTAURANT

Wednesday 4th February

Session 5	
Morning	**Chair: J. S. Laberg**
9:30	M. Ivanov, V. Blinova, J.-S. Laberg, E. Kozlova. ORIGIN OF SMALL SCALE SEABED MOUNDS oN Voring Plateau (Norwegian margin)
9:50	N. Krylov, T. van Weering, A. Volkonskaya. RELATIONSHIP BETWEEN DIAPIRIC RIDGES AND MUD VOLCANOES ON MOROCCAN MARGIN (GULF OF CADIZ) BY INTERPRETATION OF SEISMIC DATA
10:10	C. Lo Iacono, E. Gràcia, R. Bartolomé, M. Comas, J.J. Dañobeitia and EVENT-Shelf Team. ACOUSTIC IMAGING OF CARBONATE MOUNDS IN THE CHELLA BANK (EASTERN ALBORAN SEA - SW MEDITERRANEAN)
10:30	G. Çifçi, D. Dondurur, S.Okay, S. Gürçay, S. Coşkun, P. Güneş Özer, H. M. Küçük, S. D. Akhun, M. Ergun. FACILITIES OF SEISLAB SEISMIC LABORATORY AT THE INSTITUTE OF MARINE SCIENCES AND TECHNOLOGY, DOKUZ EYLÜL UNIVERSITY, TURKEY
10:50	D. Rey, B. Rubio, A. Bernabeu, F. Vilas, I. Rodríguez-Germade. ITRAX XRF CORE SCANNING INTEGRATION IN MULTIDISCIPLINARY, HIGH-RESOLUTION NON- DESTRUCTIVE CORE ANALYSES OF MARINE SEDIMENTS
11:10	Coffee Break
11:30 – 13:00	General Discussion and Closing

Thursday, 5th February

Field Trip	
9:30	Departure from Granada
18:00	Arrival

ANNEX II

List of participants

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No.	Title	Languages
1	CCOP-IOC, 1974, Metallogenesis, Hydrocarbons and Tectonic Patterns in Eastern Asia (Report of the IDOE Workshop on); Bangkok, Thailand, 24-29 September 1973 UNDP (CCOP),	E (out of stock)
2	CICAR Ichthyoplankton Workshop, Mexico City, 16-27 July 1974 (UNESCO Technical Paper in Marine Sciences, No. 20).	E (out of stock) S (out of stock)
3	Report of the IOC/GFCM/ICSEM International Workshop on Marine Pollution in the Mediterranean; Monte Carlo, 9-14 September 1974.	E,F E (out of stock)
4	Report of the Workshop on the Phenomenon known as 'El Niño'; Guayaquil, Ecuador, 4-12 December 1974.	E (out of stock) S (out of stock)
5	IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources; Kingston, Jamaica, 17-22 February 1975	E (out of stock) S
6	Report of the CCOP/SOPAC-IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific; Suva, Fiji, 1-6 September 1975.	E
7	Report of the Scientific Workshop to Initiate Planning for a Co-operative Investigation in the North and Central Western Indian Ocean, organized within the IDOE under the sponsorship of IOC/FAO (IOFC)/UNESCO/ EAC; Nairobi, Kenya, 25 March-2 April 1976.	E, F,S, R
8	Joint IOC/FAO (IPFC)/UNEP International Workshop on Marine Pollution in East Asian Waters; Penang, 7-13 April 1976	E (out of stock)
9	IOC/CMG/SCOR Second International Workshop on Marine Geoscience; Mauritius 9-13 August 1976.	E, F, S, R
10	IOC/WMO Second Workshop on Marine Pollution (Petroleum) Monitoring; Monaco, 14-18 June 1976	E, F E (out of stock) R
11	Report of the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions; Port of Spain, Trinidad, 13-17 December 1976.	E, S (out of stock)
11 Suppl.	Collected contributions of invited lecturers and authors to the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions; Port of Spain, Trinidad, 13-17 December 1976	E (out of stock), S
12	Report of the IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects; Fort-de-France, Martinique, 28 November-2 December 1977.	E, F, S
13	Report of the IOCARIBE Workshop on Environmental Geology of the Caribbean Coastal Area; Port of Spain, Trinidad, 16-18 January 1978.	E, S
14	IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas; Abidjan, Côte d'Ivoire, 2-9 May 1978	E, F
15	CPPS/FAO/IOC/UNEP International Workshop on Marine Pollution in the South-East Pacific; Santiago de Chile, 6-10 November 1978.	E (out of stock)
16	Workshop on the Western Pacific, Tokyo, 19-20 February 1979.	E, F, R
17	Joint IOC/WMO Workshop on Oceanographic Products and the IGOSS Data Processing and Services System (IDPSS); Moscow, 9-11 April 1979.	E
17 suppl.	Papers submitted to the Joint IOC/WMO Seminar on Oceanographic Products and the IGOSS Data Processing and Services System; Moscow, 2-6 April 1979.	E
18	IOC/UNESCO Workshop on Syllabus for Training Marine Technicians; Miami, U.S.A., 22-26 May 1978 (UNESCO reports in marine sciences, No. 4 published by the Division of Marine Sciences, UNESCO).	E (out of stock), F, S (out of tock), R
19	IOC Workshop on Marine Science Syllabus for Secondary Schools; Llantwit Major, Wales, U.K., 5-9 June 1978 (UNESCO reports in marine sciences, No. 5, published by the Division of Marine Sciences, UNESCO).	E (out of stock), S, R, Ar
20	Second CCOP-IOC Workshop on IDOE Studies of East Asia Tectonics and Resources; Bandung, Indonesia, 17-21 October 1978	E
21	Second IDOE Symposium on Turbulence in the Ocean; Liège, Belgium, 7-18 May 1979.	E, F, S, R
22	Third IOC/WMO Workshop on Marine Pollution Monitoring; New Delhi, 11-15 February 1980.	E, F, S, R
23	WESTPAC Workshop on the Marine Geology and Geophysics of the North-West Pacific; Tokyo, 27-31 March 1980.	E, R
24	WESTPAC Workshop on Coastal Transport of Pollutants; Tokyo, Japan, 27-31 March 1980.	E (out of stock)
25	Workshop on the Inter-calibration of Sampling Procedures of the IOC/ WMO UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters; Bermuda, 11-26 January 1980.	E (Superseded by IOC Technical Series No.22)
26	IOC Workshop on Coastal Area Management in the Caribbean Region; Mexico City, 24 September- 5 October 1979.	E, S
27	CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific; Nouméa, New Caledonia, 9-15 October 1980.	E
28	FAO/IOC Workshop on the effects of environmental variation on the survival of larval pelagic fishes. Lima, 20 April-5 May 1980.	E
29	WESTPAC Workshop on Marine Biological Methodology; Tokyo, 9-14 February 1981.	E
30	International Workshop on Marine Pollution in the South-West Atlantic; Montevideo, 10-14 November 1980.	E (out of stock) S
31	Third International Workshop on Marine Geoscience; Heidelberg, 19-24 July 1982.	E, F, S
32	UNU/IOC/UNESCO Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the context of the New Ocean Regime; Paris, France, 27 September-1 October 1982.	E, F, S
32 Suppl.	Papers submitted to the UNU/IOC/ UNESCO Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime; Paris, France, 27 September-1 October 1982.	E
33	Workshop on the IREP Component of the IOC Programme on Ocean Science in Relation to Living Resources (OSLR); Halifax, 26-30 September 1963.	E
34	IOC Workshop on Regional Co-operation in Marine Science in the Central Eastern Atlantic (Western Africa); Tenerife, 12-17 December 1963.	E, F, S
35	CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-scientific Marine Research Required for Assessment of Minerals and Hydrocarbons in the South Pacific; Suva, Fiji, 3-7 October 1983.	E
36	IOC/FAO Workshop on the Improved Uses of Research Vessels; Lisbon, Portugal, 28 May-2 June 1984.	E
36 Suppl.	Papers submitted to the IOC/FAO Workshop on the Improved Uses of Research Vessels; Lisbon, 28 May-2 June 1984	E
37	IOC/UNESCO Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs; Colombo, 8-13 July 1985.	E
38	IOC/ROPME/UNEP Symposium on Fate and Fluxes of Oil Pollutants in the Kuwait Action Plan Region; Basrah, Iraq, 8-12 January 1984.	E
39	CCOP (SOPAC)-IOC-IFREMER-ORSTOM Workshop on the Uses of Submersibles and Remotely Operated Vehicles in the South Pacific; Suva, Fiji, 24-29 September 1985.	E
40	IOC Workshop on the Technical Aspects of Tsunami Analysis, Prediction and Communications; Sidney, B.C., Canada, 29-31 July 1985.	E
40 Suppl.	First International Tsunami Workshop on Tsunami Analysis, Prediction and Communications, Submitted Papers; Sidney, B.C., Canada, 29 July-1 August 1985.	E
41	First Workshop of Participants in the Joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2); Dakar, Senegal, 28 October-1 November 1985.	E
43	IOC Workshop on the Results of MEDALPEX and Future Oceanographic Programmes in the Western Mediterranean; Venice, Italy, 23-25 October 1985.	E
44	IOC-FAO Workshop on Recruitment in Tropical Coastal Demersal Communities; Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986.	E (out of stock) S
44 Suppl.	IOC-FAO Workshop on Recruitment in Tropical Coastal Demersal Communities, Submitted Papers; Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986.	E
45	IOCARIBE Workshop on Physical Oceanography and Climate; Cartagena, Colombia, 19-22 August 1986.	E
46	Reunión de Trabajo para Desarrollo del Programa "Ciencia Oceánica en Relación a los Recursos No Vivos en la Región del Atlántico Sud-occidental"; Porto Alegre, Brasil, 7-11 de abril de 1986.	S
47	IOC Symposium on Marine Science in the Western Pacific: The Indo-Pacific Convergence; Townsville, 1-6 December 1966	E
48	IOCARIBE Mini-Symposium for the Regional Development of the IOC-UN (OETB) Programme on 'Ocean Science in Relation to Non-Living Resources (OSNLR)'; Havana, Cuba, 4-7 December 1986.	E, S
49	AGU-IOC-WMO-CPPS Chapman Conference: An International Symposium on 'El Niño'; Guayaquil, Ecuador, 27-31 October 1986.	E
50	CCALR-IOC Scientific Seminar on Antarctic Ocean Variability and its Influence on Marine Living Resources, particularly Krill (organized in collaboration with SCAR and SCOR); Paris, France, 2-6 June 1987.	E
51	CCOP/SOPAC-IOC Workshop on Coastal Processes in the South Pacific Island Nations; Lae, Papua-New Guinea, 1-8 October 1987.	E
52	SCOR-IOC-UNESCO Symposium on Vertical Motion in the Equatorial Upper Ocean and its Effects upon Living Resources and the Atmosphere; Paris, France, 6-10 May 1985.	E
53	IOC Workshop on the Biological Effects of Pollutants; Oslo, 11-29 August 1986.	E
54	Workshop on Sea-Level Measurements in Hostile Conditions; Bidston, UK, 28-31 March 1988.	E
55	IBCCA Workshop on Data Sources and Compilation, Boulder, Colorado, 18-19 July 1988.	E
56	IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP); Cleveland, Australia, 24-30 July 1988.	E
57	IOC Workshop on International Co-operation in the Study of Red Tides and Ocean Blooms; Takamatsu, Japan, 16-17 November 1987.	E
58	International Workshop on the Technical Aspects of the Tsunami Warning System; Novosibirsk, USSR, 4-5 August 1989.	E
58 Suppl.	Second International Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness,	E

No.	Title	Languages
	Observation and Instrumentation. Submitted Papers; Novosibirsk, USSR, 4-5 August 1989.	
59	IOC-UNEP Regional Workshop to Review Priorities for Marine Pollution Monitoring Research, Control and Abatement in the Wider Caribbean; San José, Costa Rica, 24-30 August 1989.	E, F, S
60	IOC Workshop to Define IOCARIBE-TRODERP proposals; Caracas, Venezuela, 12-16 September 1989.	E
61	Second IOC Workshop on the Biological Effects of Pollutants; Bermuda, 10 September-2 October 1988.	E
62	Second Workshop of Participants in the Joint FAO-IOC-WHO-IAEA-UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region; Accra, Ghana, 13-17 June 1988.	E
63	IOC/WESTPAC Workshop on Co-operative Study of the Continental Shelf Circulation in the Western Pacific; Bangkok, Thailand, 31 October-3 November 1989.	E
64	Second IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP); Phuket, Thailand, 25-31 September 1989.	E
65	Second IOC Workshop on Sardine/Anchovy Recruitment Project (SARP) in the Southwest Atlantic; Montevideo, Uruguay, 21-23 August 1989.	E
66	IOC ad hoc Expert Consultation on Sardine/ Anchovy Recruitment Programme; La Jolla, California, U.S.A., 1989	E
67	Interdisciplinary Seminar on Research Problems in the IOCARIBE Region; Caracas, Venezuela, 28 November-1 December 1989.	E (out of stock)
68	International Workshop on Marine Acoustics; Beijing, China, 26-30 March 1990.	E
69	IOC-SCAR Workshop on Sea-Level Measurements in the Antarctica; Leningrad, USSR, 28-31 May 1990.	E
69 Suppl.	IOC-SCAR Workshop on Sea-Level Measurements in the Antarctica; Submitted Papers; Leningrad, USSR, 28-31 May 1990.	E
70	IOC-SAREC-UNEP-FAO-IAEA-WHO Workshop on Regional Aspects of Marine Pollution; Mauritius, 29 October - 9 November 1990.	E
71	IOC-FAO Workshop on the Identification of Penaeid Prawn Larvae and Postlarvae; Cleveland, Australia, 23-28 September 1990.	E
72	IOC/WESTPAC Scientific Steering Group Meeting on Co-Operative Study of the Continental Shelf Circulation in the Western Pacific; Kuala Lumpur; Malaysia, 9-11 October 1990.	E
73	Expert Consultation for the IOC Programme on Coastal Ocean Advanced Science and Technology Study; Liège, Belgium, 11-13 May 1991.	E
74	IOC-UNEP Review Meeting on Oceanographic Processes of Transport and Distribution of Pollutants in the Sea; Zagreb, Yugoslavia, 15-18 May 1989.	E
75	IOC-SCOR Workshop on Global Ocean Ecosystem Dynamics; Solomons, Maryland, U.S.A., 29 April-2 May 1991.	E
76	IOC/WESTPAC Scientific Symposium on Marine Science and Management of Marine Areas of the Western Pacific; Penang, Malaysia, 2-6 December 1991.	E
77	IOC-SAREC-KMFRI Regional Workshop on Causes and Consequences of Sea-Level Changes on the Western Indian Ocean Coasts and Islands; Mombasa, Kenya, 24-28 June 1991.	E
78	IOC-CEC-ICES-WMO-ICSU Ocean Climate Data Workshop Goddard Space Flight Center; Greenbelt, Maryland, U.S.A., 18-21 February 1992.	E
79	IOC/WESTPAC Workshop on River Inputs of Nutrients to the Marine Environment in the WESTPAC Region; Penang, Malaysia, 26-29 November 1991.	E
80	IOC-SCOR Workshop on Programme Development for Harmful Algae Blooms; Newport, U.S.A. 2-3 November 1991.	E
81	Joint IAPSO-IOC Workshop on Sea Level Measurements and Quality Control; Paris, France, 12-13 October 1992.	E
82	BORDOMER 92: International Convention on Rational Use of Coastal Zones. A Preparatory Meeting for the Organization of an International Conference on Coastal Change; Bordeaux, France, 30 September-2 October 1992.	E
83	IOC Workshop on Donor Collaboration in the Development of Marine Scientific Research Capabilities in the Western Indian Ocean Region; Brussels, Belgium, 12-13 October 1992.	E
84	Workshop on Atlantic Ocean Climate Variability; Moscow, Russian Federation, 13-17 July 1992	E
85	IOC Workshop on Coastal Oceanography in Relation to Integrated Coastal Zone Management; Kona, Hawaii, 1-5 June 1992.	E
86	International Workshop on the Black Sea; Varna, Bulgaria, 30 September – 4 October 1991	E
87	Taller de trabajo sobre efectos biológicos del fenómeno «El Niño» en ecosistemas costeros del Pacífico Sudeste; Santa Cruz, Galápagos, Ecuador, 5-14 de octubre de 1989.	S only (summary in E, F, S)
88	IOC-CEC-ICSU-ICES Regional Workshop for Member States of Eastern and Northern Europe (GODAR Project); Obninsk, Russia, 17-20 May 1993.	E
89	IOC-ICSEM Workshop on Ocean Sciences in Non-Living Resources; Perpignan, France, 15-20 October 1990.	E
90	IOC Seminar on Integrated Coastal Management; New Orleans, U.S.A., 17-18 July 1993.	E
91	Hydroblack'91 CTD Intercalibration Workshop; Woods Hole, U.S.A., 1-10 December 1991.	E
92	Réunion de travail IOCEA-OSNLR sur le Projet « Budgets sédimentaires le long de la côte occidentale d'Afrique » Abidjan, côte d'Ivoire, 26-28 juin 1991.	E
93	IOC-UNEP Workshop on Impacts of Sea-Level Rise due to Global Warming. Dhaka, Bangladesh, 16-19 November 1992.	E
94	BMTC-IOC-POLARMAR International Workshop on Training Requirements in the Field of Eutrophication in Semi-enclosed Seas and Harmful Algal Blooms, Bremerhaven, Germany, 29 September-3 October 1992.	E
95	SAREC-IOC Workshop on Donor Collaboration in the Development of Marine Scientific Research Capabilities in the Western Indian Ocean Region; Brussels, Belgium, 23-25 November 1993.	E
96	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Zanzibar, United Republic of Tanzania, 17-21 January 1994.	E
96 Suppl.	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Submitted Papers 1. Coastal Erosion; Zanzibar, United Republic of Tanzania 17-21 January 1994.	E
96 Suppl	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Submitted Papers 2. Sea Level; Zanzibar, United Republic of Tanzania 17-21 January 1994.	E
97	IOC Workshop on Small Island Oceanography in Relation to Sustainable Economic Development and Coastal Area Management of Small Island Development States; Fort-de-France, Martinique, 8-10 November, 1993.	E
98	CoMSBlack '92A Physical and Chemical Intercalibration Workshop; Erdemli, Turkey, 15-29 January 1993.	E
99	IOC-SAREC Field Study Exercise on Nutrients in Tropical Marine Waters; Mombasa, Kenya, 5-15 April 1994.	E
100	IOC-SOA-NOAA Regional Workshop for Member States of the Western Pacific - GODAR-II (Global Oceanographic Data Archeology and Rescue Project); Tianjin, China, 8-11 March 1994.	E
101	IOC Regional Science Planning Workshop on Harmful Algal Blooms; Montevideo, Uruguay, 15-17 June 1994.	E
102	First IOC Workshop on Coastal Ocean Advanced Science and Technology Study (COASTS); Liège, Belgium, 5-9 May 1994.	E
103	IOC Workshop on GIS Applications in the Coastal Zone Management of Small Island Developing States; Barbados, 20-22 April 1994.	E
104	Workshop on Integrated Coastal Management; Dartmouth, Canada, 19-20 September 1994.	E
105	BORDOMER 95: Conference on Coastal Change; Bordeaux, France, 6-10 February 1995.	E
105 Suppl.	Conference on Coastal Change: Proceedings; Bordeaux, France, 6-10 February 1995	E
106	IOC/WESTPAC Workshop on the Paleographic Map; Bali, Indonesia, 20-21 October 1994.	E
107	IOC-ICSU-NIO-NOAA Regional Workshop for Member States of the Indian Ocean - GODAR-III; Dona Paula, Goa, India, 6-9 December 1994.	E
108	UNESCO-IHP-IOC-IAEA Workshop on Sea-Level Rise and the Multidisciplinary Studies of Environmental Processes in the Caspian Sea Region; Paris, France, 9-12 May 1995.	E
108 Suppl.	UNESCO-IHP-IOC-IAEA Workshop on Sea-Level Rise and the Multidisciplinary Studies of Environmental Processes in the Caspian Sea Region; Submitted Papers; Paris, France, 9-12 May 1995.	E
109	First IOC-UNEP CEPPOL Symposium; San José, Costa Rica, 14-15 April 1993.	E
110	IOC-ICSU-CEC regional Workshop for Member States of the Mediterranean - GODAR-IV (Global Oceanographic Data Archeology and Rescue Project) Foundation for International Studies, University of Malta, Valletta, Malta, 25-28 April 1995.	E
111	Chapman Conference on the Circulation of the Intra-Americas Sea; La Parguera, Puerto Rico, 22-26 January 1995.	E
112	IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials (GESREM) Workshop; Miami, U.S.A., 7-8 December 1993.	E
113	IOC Regional Workshop on Marine Debris and Waste Management in the Gulf of Guinea; Lagos, Nigeria, 14-16 December 1994.	E
114	International Workshop on Integrated Coastal Zone Management (ICZM) Karachi, Pakistan; 10-14 October 1994.	E
115	IOC/GLOSS-IAPSO Workshop on Sea Level Variability and Southern Ocean Dynamics; Bordeaux, France, 31 January 1995	E
116	IOC/WESTPAC International Scientific Symposium on Sustainability of Marine Environment: Review of the WESTPAC Programme, with Particular Reference to ICAM, Bali, Indonesia, 22-26 November 1994.	E
117	Joint IOC-CIDA-Sida (SAREC) Workshop on the Benefits of Improved Relationships between International Development Agencies, the IOC and other Multilateral Inter-governmental Organizations in the Delivery of Ocean, Marine Affairs and Fisheries Programmes; Sidney B.C., Canada, 26-28 September 1995.	E
118	IOC-UNEP-NOAA-Sea Grant Fourth Caribbean Marine Debris Workshop; La Romana, Santo Domingo, 21-24 August 1995.	E
119	IOC Workshop on Ocean Colour Data Requirements and Utilization; Sydney B.C., Canada, 21-22 September 1995.	E
120	International Training Workshop on Integrated Coastal Management; Tampa, Florida, U.S.A., 15-17 July 1995.	E
121	Atelier régional IOC-CERESCOR sur la gestion intégrée des zones littorales (ICAM), Conakry, Guinée, 18–22 décembre 1995	F
122	IOC-EU-BSH-NOAA-(WDC-A) International Workshop on Oceanographic Biological and Chemical Data Management, Hamburg, Germany, 20-23 May 1996	E
123	Second IOC Regional Science Planning Workshop on Harmful Algal Blooms in South America; Mar del Plata, Argentina, 30 October–1 November 1995.	E, S
124	GLOBEC-IOC-SAHFOS-MBA Workshop on the Analysis of Time Series with Particular Reference to the Continuous Plankton Recorder Survey; Plymouth, U.K.,4-7 May 1993.	E
125	Atelier sous-régional de la COI sur les ressources marines vivantes du Golfe de Guinée ; Cotonou, Bénin, 1-4 juillet 1996.	E

No.	Title	Languages
126	IOC-UNEP-PERSGA-ACOPS-IUCN Workshop on Oceanographic Input to Integrated Coastal Zone Management in the Red Sea and Gulf of Aden. Jeddah, Saudi Arabia, 8 October 1995.	E
127	IOC Regional Workshop for Member States of the Caribbean and South America GODAR-V (Global Oceanographic Data Archeology and Rescue Project); Cartagena de Indias, Colombia, 8-11 October 1996.	E
128	Atelier IOC-Banque Mondiale-Sida/SAREC-ONE sur la Gestion Intégrée des Zones Côtières ; Nosy Bé, Madagascar, 14-18 octobre 1996.	E
129	Gas and Fluids in Marine Sediments, Amsterdam, the Netherlands; 27-29 January 1997.	E
130	Atelier régional de la COI sur l'océanographie côtière et la gestion de la zone côtière ;Moroni, RFI des Comores, 16-19 décembre 1996.	E
131	GOOS Coastal Module Planning Workshop; Miami, USA, 24-28 February 1997	E
132	Third IOC-FANSA Workshop; Punta-Arenas, Chile, 28-30 July 1997	S/E
133	Joint IOC-CIESM Training Workshop on Sea-level Observations and Analysis for the Countries of the Mediterranean and Black Seas; Birkenhead, U.K., 16-27 June 1997.	E
134	IOC/WESTPAC-CCOP Workshop on Paleogeographic Mapping (Holocene Optimum); Shanghai, China, 27-29 May 1997.	E
135	Regional Workshop on Integrated Coastal Zone Management; Chabahar, Iran; February 1996.	E
136	IOC Regional Workshop for Member States of Western Africa (GODAR-VI); Accra, Ghana, 22-25 April 1997.	E
137	GOOS Planning Workshop for Living Marine Resources, Dartmouth, USA; 1-5 March 1996.	E
138	Gestión de Sistemas Oceanográficos del Pacífico Oriental; Concepción, Chile, 9-16 de abril de 1996.	S
139	Sistemas Oceanográficos del Atlántico Sudoccidental, Taller, TEMA;Furg, Rio Grande, Brasil, 3-11 de noviembre de 1997	S
140	IOC Workshop on GOOS Capacity Building for the Mediterranean Region; Valletta, Malta, 26-29 November 1997.	E
141	IOC/WESTPAC Workshop on Co-operative Study in the Gulf of Thailand: A Science Plan; Bangkok, Thailand, 25-28 February 1997.	E
142	Pelagic Biogeography ICoPB II. Proceedings of the 2nd International Conference. Final Report of SCOR/IOC Working Group 93; Noordwijkerhout, The Netherlands, 9-14 July 1995.	E
143	Geosphere-biosphere coupling: Carbonate Mud Mounds and Cold Water Reefs; Gent, Belgium, 7–11 February 1998.	E
144	IOC-SOPAC Workshop Report on Pacific Regional Global Ocean Observing Systems; Suva, Fiji, 13-17 February 1998.	E
145	IOC-Black Sea Regional Committee Workshop: 'Black Sea Fluxes' Istanbul, Turkey, 10-12 June 1997.	E
146	Taller Internacional sobre Formacíon de Capacidades para el Manejo de las Costas y los Océanos en le Gran Caribe, La Habana, – Cuba, 7–10 de Julio de 1998 / International Workshop on Management Capacity-Building for Coasts and Oceans in the Wider Caribbean, Havana, Cuba, 7–10 July 1998	S/E
147	IOC-SOA International Training Workshop on the Intregration of Marine Sciences into the Process of Integrated Coastal Management, Dalian, China, 19-24 May 1997.	E
148	IOC/WESTPAC International Scientific Symposium – Role of Ocean Sciences for Sustainable Development Okinawa, Japan, 2-7 February 1998.	E
149	Workshops on Marine Debris & Waste Management in the Gulf of Guinea, 1995-97.	E
150	First IOCARIBE-ANCA Workshop Havana, Cuba, 29 June-1 July 1998.	E
151	Taller Pluridisciplinario TEMA sobre Redes del Gran Caribe en Gestión Integrada de Áreas Costeras Cartagena de Indias, Colombia, 7-12 de septiembre de 1998.	S
152	Workshop on Data for Sustainable Integrated Coastal Management (SICOM) Maputo, Mozambique, 18-22 July 1998	E
153	IOC/WESTPAC-Sida (SAREC) Workshop on Atmospheric Inputs of Pollutants to the Marine Environment Qingdao, China, 24-26 June 1998	E
154	IOC-Sida-Flanders-SFRI Workshop on Ocean Data Management in the IOCINCWIO Region (ODINEA project) Capetown, South Africa, 30 November-11 December 1998.	E
155	Science of the Mediterranean Sea and its applications UNESCO, Paris 29-31 July 1997	E
156	IOC-LUC-KMFRI Workshop on RECOSCIX-WIO in the Year 2000 and Beyond, Mombasa, Kenya, 12-16 April 1999	E
157	'98 IOC-KMI International Workshop on Integrated Coastal Management (ICM), Seoul, Republic of Korea 16-18 April 1998	E
158	The IOCARIBE Users and the Global Ocean Observing System (GOOS) Capacity Building Workshop, San José, Costa Rica, 22-24 April 1999	E
159	Oceanic Fronts and Related Phenomena (Konstantin Fedorov Memorial Symposium) – Proceedings, Pushkin, Russian Federation, 18-22 May 1998	E
160	Under preparation	
161	Under preparation	
162	Workshop report on the Transports and Linkages of the Intra-americas Sea (IAS), Cozumel, Mexico, 1-5 November 1997	E
163	Under preparation	
164	IOC-Sida-Flanders-MCM Third Workshop on Ocean Data Management in the IOCINCWIO Region (ODINEA Project), Cape Town, South Africa, 29 November – 11 December 1999	E
165	An African Conference on Sustainable Integrated Management; Proceedings of the Workshops. An Integrated Approach, (PACSICOM), Maputo, Mozambique, 18 –25 July 1998	E, F
166	IOC-SOA International Workshop on Coastal Megacities: Challenges of Growing Urbanization of the World's Coastal Areas; Hangzhou, P.R. China, 27 –30 September 1999	E
167	IOC-Flanders First ODINAFRICA-II Planning Workshop, Dakar, Senegal, 2-4 May 2000	E
168	Geological Processes on European Continental Margins; International Conference and Eight Post-cruise Meeting of the Training-Through-Research Programme, Granada, Spain, 31 January – 3 February 2000	E
169	International Conference on the International Oceanographic Data & Information Exchange in the Western Pacific (IODE-WESTPAC) 1999, ICIWP '99, Langkawi, Malaysia, 1-4 November 1999	***under preparation***
170	IOCARIBE-GODAR-I Cartagenas, Colombia, February 2000	***under preparation***
171	Ocean Circulation Science derived from the Atlantic, Indian and Arctic Sea Level Networks, Toulouse, France, 10-11 May 1999	E
172	(*Under preparation*)	
173	The Benefits of the Implementation of the GOOS in the Mediterranean Region, Rabat, Morocco, 1-3 November 1999	E, F
174	IOC-SOPAC Regional Workshop on Coastal Global Ocean Observing System (GOOS) for the Pacific Region, Apia, Samoa, 16-17 August 2000	E
175	Geological Processes on Deep-water European Margins, Moscow-Mozhenka, 28 Jan.-2 Feb. 2001	E
176	MedGLOSS Workshop and Coordination Meeting for the Pilot Monitoring Network System of Systematic Sea Level Measurements in the Mediterranean and Black Seas, Haifa, Israel, 15-17 May 2000	E
177	*(Under preparation)*	
178	*(Under preparation)*	
179	*(Under preparation)*	
180	Abstracts of Presentations at Workshops during the 7th session of the IOC Group of Experts on the Global Sea Level Observing System (GLOSS), Honolulu, USA, 23-27 April 2001	E
181	*(Under preparation)*	
182	*(Under preparation)*	
183	Geosphere/Biosphere/Hydrosphere Coupling Process, Fluid Escape Structures and Tectonics at Continental Margins and Ocean Ridges, International Conference & Tenth Post-cruise Meeting of the Training-through-Research Programme, Aveiro, Portugal, 30 January-2 February 2002	E
184	*(Under preparation)*	
185	*(Under preparation)*	
186	*(Under preparation)*	
186	*(Under preparation)*	
187	Geological and Biological Processes at deep-sea European Margins and Oceanic Basins, Bologna, Italy, 2–6 February 2003	E
188	Proceedings of 'The Ocean Colour Data' Symposium, Brussels, Belgium, 25-27 November 2002	E
189	Workshop for the Formulation of a Draft Project on Integrated Coastal Management (ICM) in Latin America and the Caribbean (LAC), Cartagena, Colombia, 23–25 October 2003 Taller de Formulación de un Anteproyecto de Manejo Costero Integrado (MCI) en América Latina y el Caribe (ALC), Cartagena, Colombia, 23–25 de Octubre de 2003	E F ***(electronic copy only)***
190	First ODINCARSA Planning Workshop for Caribbean Islands, Christchurch, Barbados, 15–18 December 2003	E ***(electronic copy only)***
191	North Atlantic and Labrador Sea Margin Architecture and Sedimentary Processes — International Conference and Twelfth Post-cruise Meeting of the Training-through-research Programme, Copenhagen, Denmark, 29–31 January 2004	E
192	Regional Workshop on Coral Reefs Monitoring and Management in the ROPME Sea Area, Iran I.R., 14–17 December 2003	E ***(under preparation)***
193	Workshop on New Technical Developments in Sea and Land Level Observing Systems, Paris, France, 14–16 October 2003	E ***(electronic copy only)***
194	IOC/ROPME Planning Meeting for the Ocean Data and Information Network for the Central Indian Ocean Region	***(under preparation)***
195	Workshop on Indicators of Stress in the Marine Benthos, Torregrande-Oristano, Italy, 8–9 October 2004	E
196	International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean within a Global Framework, Paris, France, 3–8 March 2005	E
197	Geosphere-Biosphere Coupling Processes: The TTR Interdisciplinary Approach Towards Studies of the European and North African Margins; International Conference and Post-cruise Meeting of the Training-Through-Research Programme, Morocco, 2-5 February 2005	E
198	Second International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean, Grand Baie, Mauritius, 14–16 April 2005	E
199	International Conference for the Establishment of a Tsunami and Coastal Hazards Warning System for the Caribbean and Adjacent Regions, Mexico, 1–3 June 2005	E
200	Lagoons and Coastal Wetlands in the Global Change Context: Impacts and Management Issues — Proceedings of the International Conference, Venice, 26–28 April 2004 (*ICAM Dossier N° 3*)	E
201	Geological processes on deep-water European margins - International Conference and 15th Anniversary Post-cruise Meeting of the Training-Through-Research Programme, Moscow/Zvenigorod, Russian Federation, 29 January–4 February 2006	E
202	Proceedings of 'Ocean Biodiversity Informatics': an international conference on marine biodiversity data management Hamburg, Germany, 29 November–1 December 2004	E
203	IOC-Flanders Planning Workshop for the formulation of a regional Pilot Project on Integrated Coastal Area Management in Latin America, Cartagena de Indias, Colombia, 16–18 January 2007	*E* ***(electronic copy only)***
204	Geo-marine Research along European Continental Margins, International Conference and Post-cruise Meeting of the Training-through-research Programme, Bremen, Germany, 29 January–1 February 2007	E
205	IODE/ICAM Workshop on the development of the Caribbean marine atlas (CMA), United Nations House, Bridgetown, Barbados, 8–10 October 2007	E ***(electronic copy only)***
206	IODE/JCOMM Forum on Oceanographic Data Management and Exchange Standards, Ostend, Belgium, 21–25 January 2008	*(Under preparation)*
207	SCOR/IODE Workshop on Data Publishing, Ostend, Belgium, 17–18 June 2008	*(Under preparation)*
208	JCOMM Technical Workshop on Wave Measurements from Buoys, New York, USA, 2–3 October 2008 (IOC-WMO publication)	*(Under preparation)*

No.	Title	Languages
209	Collaboration between IOC and OBIS towards the Long-term Management Archival and Accessibility of Ocean Biogeographic Data, Ostend, Belgium, 24–26 November 2008	*(Under preparation)*
210	Ocean Carbon Observations from Ships of Opportunity and Repeat Hydrographic Sections (IOCCP Reports, 1), Paris, France, 13–15 January 2003	E ***(electronic copy only)***
211	Ocean Surface pCO_2 Data Integration and Database Development (IOCCP Reports, 2), Tsukuba, Japan, 14–17 January 2004	E ***(electronic copy only)***
212	International Ocean Carbon Stakeholders' Meeting, Paris, France, 6–7 December 2004	E ***(electronic copy only)***
213	International Repeat Hydrography and Carbon Workshop (IOCCP Reports, 4), Shonan Village, Japan, 14–16 November 2005	E ***(electronic copy only)***
214	Initial Atlantic Ocean Carbon Synthesis Meeting (IOCCP Reports, 5), Laugavatn, Iceland, 28–30 June 2006	E ***(electronic copy only)***
215	Surface Ocean Variability and Vulnerability Workshop (IOCCP Reports, 7), Paris, France, 11–14 April 2007	E ***(electronic copy only)***
216	Surface Ocean CO2 Atlas Project (SOCAT) 2nd Technical Meeting Report (IOCCP Reports, 9), Paris, France, 16–17 June 2008	E ***(electronic copy only)***
217	Changing Times: An International Ocean Biogeochemical Time-Series Workshop (IOCCP Reports, 11), La Jolla, California, USA, 5–7 November 2008	E ***(electronic copy only)***
218	Second Joint GOSUD/SAMOS Workshop, Seattle, Washington, USA, 10–12 June 2008	E ***(electronic copy only)***
219	International Conference on Marine Data management and Information Systems (IMDIS), Athens, Greece, 31 March–2 April 2008	E
220	Geo-marine Research on the Mediterranean and European-Atlantic Margins. International Conference and TTR-17 Post-cruise Meeting of the Training-through-research Programme, Granada, Spain, 2–5 February 2009	E ***(electronic copy only)***