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
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  

Editors: M. Comas  
A. Suzyumov  

UNESCO 2009
For bibliographic purposes
this document should be cited as:

# Table of Contents

**Preface** ................................................................................................................................. 1

**Abstracts** ................................................................................................................................. 3

* M. Ivanov, N. Kenyon, M. Comas, L. Pinheiro, J.-S. Laberg and shipboard Scientific party. Introduction to the TTR-17 results ................................................................. 3

### Mediterranean and Black Sea Studies

* 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 ............................. 6

* 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 .............................................. 8


* G. Gennari, S. Spezzaferri, M.C. Comas, L.M. Pinheiro and A. Rüggeberg. Composition of the mud breccia at Dhaka and Maya Mud Volcanoes in the West Alboran Basin ............ 10


* C. Lo Iacono, E. Gràcia, R. Bartolomé, M. C. Comas, J.J. Dañobeitia and EVENT-Shelf Team. Acoustic imaging of carbonate mounds in the Chella Bank (Eastern Alboran Sea - SW Mediterranean) ........................................................................................................... 13

* C.F. López-Rodríguez, M.C. Comas, F. Martinez-Ruiz. Geochemical, mineralogical and sedimentological analyses of mud breccia materials from the Alboran Sea basin: Preliminary results from Perejil mud volcano ........................................................................................................... 15


* 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 .......................................................................... 17


* S. Pérez-Hernández, M.C. Comas, C. Escutia, P. Martínez-Garcia. Morphologic characterization of Submarine Canyons in the Palomares Margin (Western Mediterranean) ........................................................................................................... 22

* I. Rodriguez-Germade, C.F. López Rodriguez, B. Rubio, M. Comas and D. Rey. XRF geochemistry of selected mud volcano’s cores from the SAGAS 08 cruise (Alboran Sea): preliminary results ....................................................................................................................... 23


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

Gulf of Cadiz Studies


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

N. Krylov, T. van Weering, A. Volkonskaya. Relationship between diapiric ridges and mud volcanoes on the Moroccan margin (Gulf of Cadiz) by interpretation of seismic data


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

V. Nekhorosheva, V. Blinova. Methane-derived authigenic carbonates from the Darwin and Porto mud volcanoes (the Gulf of Cadiz)

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

NE Atlantic and the Norwegian Margin Studies
M. Hovland, Á. O. Ekrheim, and I. Ferriday. Geochemical observations of pockmark-related Lophelia-reef at Morvin, off Mid-Norway

M. Ivanov, V. Blinova, J.-S. Laberg, E. Kozlova. Origin of small scale seabed mounds on the Voring plateau (Norwegian Margin)

J.S. Laberg, M. Forwick, M. Ivanov, N.H. Kenyon, T.O. Vorren. Small-scale mass wasting on the continental slope offshore Norway


I. Yurchenko, E. Kozlova & J.S. Laberg. Mineralogical and grain size analyses of recent sediments in the Lofoten Basin Channel, Norwegian Sea

Information materials
G. Çifçi, D. Dondurur, S. Okay, S. Gürcay, S. Coşkun, P. G. 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

N. Hamoumi, J-P. Henriet, A. Suzyumov. TTR-Flanders project (2004-2008): main results

D. Rey, B. Rubio, A. Bernabeu, F. Vilas and I. Rodríguez-Germade. ITRAX XRF core scanning integration in multidisciplinary, high-resolution non-destructive core analyses of marine sediments

Annex I. Conference Programme
Annex II. List of Participants
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; Biostatigraphy; 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 Martinez-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), led 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. Ivanov¹*, N. Kenyon², M. Comas³, L. Pinheiro⁴, J.-S. Laberg⁵ and shipboard Scientific party

¹ UNESCO-MSU Centre for Marine Geology and Geophysics, Faculty of Geology, Moscow State University, Vorobyevy Gory, Moscow 119899, Russia *(fu@geol.msu.ru)
² Southampton Oceanography Centre, Empress Dock, Southampton, SO14 3ZH, United Kingdom
³ Instituto Andaluz de Ciencias de la Tierra, C.S.I.C. and University of Granada, Campus Fuentenueva, 18002 Granada, Spain
⁴ Departamento de Gecociencias and CESAM, Universidade de Aveiro, 3800 Aveiro, Portugal
⁵ Department of Geology, University of Tromsø, N-9037 Tromsø, Norway

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.

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 m³) 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.

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

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

V. Blinova1*, M.C. Comas2, M. Ivanov1, T. Matveeva3

1UNESCO-MSU Centre for Marine Geology and Geophysics, Faculty of Geology, Moscow State University, Vorobjevy Gory, Moscow 119899, Russia *(vnblinova@mail.ru)
2Instituto Andaluz de Ciencias de la Tierra (C.S.I.C.-Universidad de Granada) Granada, Spain
3All-Russia Research Institute for Geology and Mineral Resources of the Ocean (VNIIOkeangeologia), Angliyskiy ave., 1, St.Petersburg, 190121, Russia

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$_2$H$_6$/C$_2$H$_4$) is about 1.5, propane (C$_3$H$_8$/C$_3$H$_6$) 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.

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, δ$^{13}$C of methane from mud breccia is -58.4‰ VPDB and does not change along the core (±0.4). δ$^{13}$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. δ$^{13}$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

M. Comas1*, L. M. Pinheiro2, M. Ivanov3, and TTR-17 Leg 1 Scientific Party

1Instituto Andaluz de Ciencias de la Tierra, CSIC and University of Granada. Granada, Spain
2Department of Geosciences, University of Aveiro. Aveiro, Portugal
3UNESCO-MSU Centre for Marine Geosciences, Moscow State University, Moscow, Russia

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 km². 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 oculata, 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 (Fundied 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

H.G. Fink¹,²*, D. Hebbeln¹,², C. Wienberg¹, H. McGregor³, M. Taviani⁴ and A. Freiwald⁵

¹MARUM - Center for Marine Environmental Sciences, University of Bremen, Germany *(Hiske@uni-bremen.de)  
²GLOMAR - Bremen International Graduate School for Marine Sciences, Univ. of Bremen, Germany  
³ANSTO - Australian Nuclear Science and Technology Organisation, Univ. of Wollongong, Australia  
⁴ISMAR-Istituto di Scienze Marine-CNR, Bologna, Italy  
⁵GZN-GeoZentrum Nordbayern, University of Erlangen, Germany

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

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

G. Gennari1*, S. Spezzaferri1, M.C. Comas2, L.M. Pinheiro3 and A. Rüggeberg4

1University of Fribourg, Department of Geosciences, Earth Sciences, Ch. du Musée 6, 1700 Fribourg, Switzerland, *(giordana.gennari@unifr.ch)
2Instituto Andaluz de Ciencia de la Tierra (C.S.I.C. University of Granada), Campus Fuentenueva s/n, 18002 Granada, Spain
3Departamento de Geociências and CESAM, Universidade de Aveiro, 3810-193 Aveiro, Portugal
4Leibniz-Institut für Meereswissenschaften (IFM-GEOMAR), Wischhofstrasse 1-3, D-24148 Kiel, Germany

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 Maastrichtian) 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.

References
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


1Instituto Andaluz de Ciencias de la Tierra, CSIC-Universidad de Granada, Granada, Spain * (fjjspejo@jamstec.jp.go)
2Institute for Frontier Research on Earth Evolution, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan.
3Department of Geography, University of Hull, Cottingham Road, Hull HU6 7RX, UK. 4Departamento de Ecología y Geología, Universidad de Málaga, Campus de Teatinos, s/n, E-29071, Málaga, Spain.
5Departamento de Mineralogía y Petrología, Facultad de Ciencias, Universidad de Granada, Granada, Spain.

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 δ18O 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 δ18O 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.

Acknowledgements. This work has been funded by Projects Marcal CGL2006-13327-C04-04, Sagas CTM2005-08071-C03-01 (R & D National Plan of the Ministry of Science and Technology and
References


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

C. Lo Iacono1*, E. Gracia1, R. Bartolomé1, M. C. Comas2, J.J. Dañobeitia1 and EVENT-Shelf Team

1Unidad Tecnologia Marina – CMIMA, CSIC, Barcelona, Spain *(loiacono@utm.csic.es)
2Instituto Andaluz de Ciencias de la Tierra, CSIC, Granada, Spain

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, Gracia 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 seisms. 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 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.](image)

**Acknowledgements.** We acknowledge funding from the Spanish National Project EVENT (CGL2006-12861-C02-02) and complementary actions CTM 2008-03346-E/MAR and CTM2008-03208-E/MAR.
Geochemical, mineralogical and sedimentological analyses of mud breccia materials from the Alboran Sea basin: Preliminary results from Perejil mud volcano

C.F. López-Rodriguez, M.C. Comas, F. Martínez-Ruiz

Instituto Andaluz de Ciencias de la Tierra (CSIC and University of Granada), Campus Fuentenueva, University of Granada. 18002 Granada, Spain.

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 olistostromes 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 watersaturated 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 Rifian 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 Pe rejil mud volcano has extruded material (probably from olistrotromes) from older and deeper sediments in the basin from more than 5 km depth.

**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).

**References**


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

M. Makarova1*, A. Stadnitskaia2, M.K. Ivanov1, and J.S. Sinninghe Damsté2

1UNESCO-MSU Center for Marine Geosciences, Moscow State University, Faculty of Geology, Vorobijevi Gory 1, 119899 Moscow, Russia *(fu@geol.msu.ru)
2NIOZ Royal Netherlands Institute for Sea Research, PO Box 59, 1790AB, Den Burg, the Netherlands

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-depleted 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 other.

References

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

S. Margreth1*, G. Gennari1, S. Spezzaferri1, M.C. Comas2, L.M. Pinheiro3 and A. Rüggeberg4

1University of Fribourg, Department of Geosciences, Earth Sciences, Ch. du Musée 6, 1700 Fribourg, Switzerland *(stephan.margreth@unifr.ch)
2Instituto Andaluces de Ciencias de la Terra (C.S.I.C. University of Granada), Campus Fuentenueva s/n, 18002 Granada, Spain.
3Departamento de Geociências and CESAM, Universidade de Aveiro, 3810-193 Aveiro, Portugal.
4Leibniz-Institut für Meereswissenschaften (IFM-GEOMAR), Wischhofstasse 1-3, D-24148 Kiel, Germany.

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 *Discomalina coronata* and *D. semipunctata*, that have been observed in close relationship to active coral mounds along the Atlantic European margin (Hawkes and Scott, 2005; Rueggeberg 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.

**Acknowledgements.** This study is funded by the Swiss National Science Foundation Projects 200021-111694 and 200020-117928. Cruise TTR 17- Leg I (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.

**References**


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

P. Martinez-Garcia1*, J. I. Soto1,2, M. C. Comas1, S. Perez-Hernandez1

1*Instituto Andaluz de Ciencias de la Tierra (CSIC and University of Granada), Facultad de Ciencias, Granada, Spain, *(matez@ugr.es)
2 Departamento de Geodinámica (University of Granada), Facultad de Ciencias, Granada, Spain.

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 10-25° 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 km² 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 seismic 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.
Acknowledgements. Contribution from Projects SAGAS CTM2005-08071-03-01 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).

References

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


1Instituto Andaluz de Ciencias de la Tierra (CSIC-UGR), Granada, Spain * (vanesanieto@ugr.es).
2Institute for Frontier Research on Earth Evolution, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan
3Departamento de Mineralogía y Petrología, Facultad de Ciencias, Universidad de Granada, Granada, Spain
4Leibniz-Institut für Ostseeforschung, Warnemünde, Germany
5Departament de Física, Institut de Ciencia y Tecnología Ambientals (ICTA), Universitat Autònoma de Barcelona, Bellaterra, Spain.

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.

Acknowledgments. This work was funded by Projects Marcal CGL2006-13327-C04-04, Ministerio MARM 200800050084447, Sagas CTM2005-08071-C03-01 (R & D National Plan of the Ministry of Science and Technology and FEDER funding, Spain) and Research Group RNM 0179. We also thank TopoIberia CSD2006-00041. We are grateful to the Centro de Instrumentación Científica (CIC-UGR), IOW and JAMSTEC for the analyses.

References


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

S. Pérez-Hernández*, M.C. Comas, C. Escutia, P. Martínez-García

Instituto Andaluz de Ciencias de la Tierra (C.S.I.C. and University of Granada). Campus de Fuentenueva, Faculty of Sciences, University of Granada. 18002 Granada, Spain
*(silviaperez@ugr.es)

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 merge 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 headward 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).
Acknowledgements. Contribution from Projects SAGAS CTM2005-08071-03-01 and TOPO-IBERIA CSD2006-00041 (R & D National Plan of the Ministry of Science and Technology and FEDER funding, Spain).

References


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

I. Rodríguez-Germade*, C.F. López Rodríguez, B. Rubio, M. Comas and D. Rey

Dpto. Geociencias Marinas Universidad de Vigo, 36310 Vigo, Spain *(igermade@uvigo.es), (http://geoma.net/)

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

M. Rodrigo-Gámiz*, F. Martínez-Ruiz†, F. J. Jiménez-Espejo‡, D. Gallego-Torres§, V. Nieto-Moreno$, D. Ariztegui¶, O. Romero*

*Instituto Andaluz de Ciencias de la Tierra, CSIC-Universidad de Granada, Granada, Spain  
†Institute for Frontier Research on Earth Evolution, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan.  
‡Departamento de Mineralogía y Petrología, Facultad de Ciencias, Universidad de Granada, Granada, Spain.  
¶Section of Earth & Environmental Sciences, University of Geneva, Geneva, Switzerland.

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, kaolinite 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.

Acknowledgements. This work has been funded by Projects Marcal CGL2006-13327-C04-04, Sagas CTM2005-08071-C03-01 (R & D National Plan of the Ministry of Science and Technology and FEDER funding, Spain), Ministerio MARM 200800050084447, Research Group RNM 0179 and Topolberia CSD2006-00041. We also thank the “Centro de Instrumentación Científica” (University of Granada) and Geneva University for analytical facilities.

References

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

E.A. Sakvarelidze*, G. P. Tumanishvili, I.T. Amanatashvili, V.Sh. Meskhia

Seismic Monitoring Centre of Ilia Chavchavadze State University, Tbilisi, Georgia
*(evgenysak@rambler.ru)

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 diapirc 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.

References

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

F. Trincardi¹, M. Taviani¹, G. Verdicchio², A. Asioli³, E. Campiani¹, G. Dalla Valle¹, F. Foglini¹, F. Gamberi¹, A. Piva¹, L. Angeletti¹

³Istituto di Scienze Marine ISMAR - CNR – Bologna, Italy
²Edison S.p.A. – Milano, Italy
¹Istituto di Geoscienze e Georisorse IGG- CNR – Padova, Italy

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**

M. Taviani

*Istituto di Scienze Marine (ISMAR)-CNR, Bologna, Italy*

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 solenomyid 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

Pinheiro¹ L.M., Ivanov² M., Kenyon³, Magalhães¹ V., Roque⁴ C., Lemos¹ C., Bezerra¹ R., Antunes¹ A., Alaoui⁵ N., Aguado¹ B., M. Nuzzo⁶ and the TTR-17 Leg-2 Shipboard Scientific Party.

¹ Departamento de Geociências e CESAM, Universidade de Aveiro, 3800 Aveiro, Portugal.
² UNESCO-MSU Centre for Marine Geology and Geophysics, Moscow State University, Geology Faculty, Moscow, Russia
³ National Oceanography Centre, Southampton, UK
⁴ EMEPC – Estrutura de Missão para a Extensão da Plataforma Continental, 2770-047 Paço de Arcos, Portugal
⁵ Université de Tanger, B.P. 416, 90 000 Tangier – Morocco
⁶ Dep. Geologia Marinha, INETI, Estrada da Portela, Alfragide, Portugal

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 euhedral 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


Centro de Estudos do Ambiente e do Mar, Departamento de Biologia, Universidade de Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal *(mcunha@bio.ua.pt)

The Gulf of Cadiz is an 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
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 m² 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

Yu. Kolganova¹*, M. Ivanov¹, H. de Haas², F. Mienis², T. C. E. van Weering²

¹UNESCO-MSU Center for Marine Geosciences, Moscow State University, Faculty of Geology
²Royal Netherlands Institute for Sea Research, P.O. Box 59, AB, 1790 Den Burg, The Netherlands

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 seepage 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 description, 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 δ¹⁸O 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.

References

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

N. Krylov¹*, T. van Weering², A. Volkonskaya¹

¹UNESCO-MSU Centre for Marine Geology and Geophysics, Faculty of Geology, Moscow State University, Russia *(fiu@geol.msu.ru)*
²Nederlands Institute for Sea Research, Den Burg, The Netherlands

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 diapirc 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 diapirc 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)**

E. A. Logvina¹*, A. A. Krylov¹, T. V. Matveeva ¹, A. N. Stadnitskaia ², T. C.E. van Weering ²,³, M. K. Ivanov ⁴ and V. N. Blinova ⁴

¹All-Russia Research Institute for Geology and Mineral Resources of the Ocean (VNIIOkeangeologia), 190121, 1, Angliyskiy ave., St.Petersburg, Russia *(Liza_Logvina@mail.ru)

²Royal Netherlands Institute for Sea Research (NIOZ), P.O. Box 59, 1790 AB Den Burg, Texel, The Netherlands

³Department of Paleoclimatology and Geomorphology, Free University of Amsterdam, de Boelelaan 1085, 1081 HV Amsterdam, The Netherlands

⁴Geological Faculty, UNESCO-MSU Centre for Marine Geosciences, Moscow State University, Vorobjevy Gory, Moscow 119899, Russian Federation

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 δ¹³CVPDB, δ¹⁸OVPDB, 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 δ¹³C and δ¹⁸O 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 (MgCO₃<4-5 mol %), quartz, and goethite (traces). The carbonate mineralogy was considered in details by hkl=104 reflex (in the range of corners 20–50°; 2θ 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 (δ¹³C) and oxygen (δ¹⁸O) 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 (δ¹⁸OSMOW = 0‰ and T = 13°C) (Diaz-del-Rio et al., 2003) and using equation presented in Fritz and Smith (1970) the calculated theoretical composition of δ¹⁸O 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 1а (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.

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 δ¹⁸O values allow concluding that discharge of water with heavy oxygen (relative to seawater δ¹⁸O - 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.

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

V. H. Magalhães¹,²*, L. M. Pinheiro¹, B. Buffett², D. Archer²

¹Departamento de Geociencias and CESAM, Universidade de Aveiro, 3810-193 Aveiro, Portugal
²Department of the Geophysical Sciences, The University of Chicago, 5734 S. Ellis Avenue, Chicago IL 60637, USA *(vmagalhaes@uchicago.edu)

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)

V. Nekhorosheva*, V. Blinova

UNESCO-MSU Center for Marine Geosciences, Faculty of Geology, Moscow State University, Russia *(cyrkon@rambler.ru)

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).

There are three main groups of isotopes. They are: in shells – up to -6 δ13C, ‰ VPDB; in bioherms and cemented chemosynthetic shells - from -8 to -16 δ13C, ‰ VPDB (bulk samples); in authigenic carbonates from mud volcanoes - from -20 to -30 δ13C, ‰ PDB. In spite of great variation in isotopic composition δ13C 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 δ18O (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

M. Tsypin1,2*, T. Matveeva1, M. Ivanov3, V. Blinova3, E. Prasolov1,4

1All-Russia Research Institute for Geology and Mineral Resources of the Ocean (VNIIOkeangeologia), Angliyskiy ave., 1, St.Petersburg, 190121, Russia *(mikhail_tsypin@mail.ru)
2St.Petersburg State University, University emb. 7/9, St.-Petersburg, 199034 Russia
3Geological Faculty, UNESCO-MSU Centre for Marine Geosciences, Moscow State University, Vorobjevy Gory, Moscow 119899, Russia
4All-Russian Geological Research Institute (VSEGEI), St. Petersburg, 199106, Russia

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 H2S, 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 RV 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.

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

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.
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 Ca²⁺ and Mg²⁺ 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 isopy are related to tectonic structures (diapirs,
faults) and composition of the strata adjacent to feeder channels of the MVs.

References
Aloisi, G., K. Wallmann et. al. (2004). Evidence for the submarine weathering of silicate minerals in
Black Sea sediments: possible implications for the marine Li and B cycles, Geochem., Geophys.,
Geosys. 5, 4.
Kenyon, N.H., Ivanov, M.K. et. al. (2008). Deep-water depositional systems and cold seeps of the
Western Mediterranean, Gulf of Cadiz and Norwegian continental margins: preliminary results of
investigations during the TTR-16 cruise of RV Professor Logachev, May-July 2006. IOC
Technical series, 76, UNESCO.
Mazurenko, L.L., Soloviev, V.A. et. al. (2002). Mud volcano gas hydrates in the Gulf of Cadiz. Terra
Medialdea, T., Vegas, R. et. al. (2004). Structure and evolution of the ‘olistostrome’ complex of the
Gibraltar Arc in the Gulf of Cadiz (eastern Central Atlantic): evidence from two long seismic
NE Atlantic and the Norwegian Margin Studies

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

M. Hovland\textsuperscript{1*}, Å. O. Ekrheim\textsuperscript{1}, and I. Ferriday\textsuperscript{2}

\textsuperscript{1}StatoilHydro, Stavanger, Norway *(mhovland@statoilhydro.com)\textsuperscript{*}
\textsuperscript{2}GeolabNor, Trondheim, Norway

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 7.1°C. 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).

References


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

M. Ivanov1*, V. Blinova1, J.-S. Laberg2, E. Kozlova1

1UNESCO-MSU Centre for Marine Geology and Geophysics, Faculty of Geology, Moscow State University, Vorobjevy Gory, Moscow 119899, Russia *fu@geol.msu.ru
2Department of Geology, University of Tromsø, N-9037 Tromsø, Norway

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 hydrotroilite (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 diffractometer, chemical and isotopic analysis. Composition of the crust and chimney samples is rather uniform. They consist of clay minerals with quartz 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 O2 (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 CO₂. One of the samples has shown δ¹³C 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 Voring 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

Small-scale mass wasting on the continental slope offshore Norway

J.S. Laberg1*, M. Forwick1, M. Ivanov2, N.H. Kenyon3, T.O. Vorren1,

1Department of Geology, University of Tromsø, N-9037 Tromsø, Norway
* (jan.laberg@ig.uit.no)
2UNESCO-MSU Centre for Marine Geology and Geophysics, Moscow State University, Moscow 119899, Russia
3National Oceanography Centre, Empress Dock, Southampton SO14 3ZH, UK

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 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**

J.S. Laberg¹*, M. Forwick¹, H.B. Johannessen¹, M. Ivanov², N.H. Kenyon³, T.O. Vorren¹

¹Department of Geology, University of Tromsø, N-9037 Tromsø, Norway
*jan.laberg@ig.uit.no
²UNESCO-MSU Centre for Marine Geology and Geophysics, Moscow State University, Moscow 119899, Russia
³National Oceanography Centre, Empress Dock, Southampton SO14 3ZH, UK

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
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 indicate 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.

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

I.Yurchenko¹*, E. Kozlova¹ & J.S. Laberg²

¹UNESCO-MSU Centre for Marine Geology and Geophysics, Faculty of Geology, Moscow State University, Vorobjevy Gory, Moscow 119899, Russia, *(fu@geol.msu.ru)
²Departament of Geology, University of Tromso, N-9037 Tromso, Norway (jan.laberg@ig.uit.no)

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) Q₁ = 0,10625;  Md(median) = 0,15;  Q₃ = 0,2 (fig. 3); coefficient of sorting Sₒ = 1,371989 (Sₒ=√Q₃/Q₁);  coefficient of skewness Sₖ = 0,971825 (Sₖ=√Q₁*Q₃/Md²).

After that, samples were separated on heavy and light mineral fractions, using specific liquid with density of 2,89 g/cm³ (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 (titantite), 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-17 cruise; 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.

References
Information materials

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


Dokuz Eylül University, Institute of Marine Sciences and Technology, Baku Street, No: 100, Inciralti, İzmir, Turkey

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

N. Hamoumi¹, J-P. Henriet², A. Suzyumov³*

¹Département des sciences de la terre, Faculté des sciences, Université Mohammed V- Agdal, Avenue Ibn Battouta- B.P 1014, Rabat. Morocco
²University of Ghent, Renard Centre of Marine Geology, Krijgslaan 281 S8, B-9000 Ghent, Belgium
³IOC of UNESCO, 1 rue Miollis, 75015 Paris, France *(suzyumov@gmail.com)

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 project¹ (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.

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

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

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

D. Rey*, B. Rubio, A. Bernabeu, F. Vilas and I. Rodriguez-Germade

Dpto. Geociencias Marinas Universidad de Vigo, 36310 Vigo, Spain
*(danirey@uvigo.es) (http://geoma.net/)

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)


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 – Discussion

13:00

13:30 – Lunch

15:00 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


15:40 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)
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.


11:00 Coffee Break

11:30 Poster Session


12:30 – Discussion

12:50

13:30 – Lunch

15:00

Session 4
Afternoon Chair: M. Ivanov

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 -  Discussion
16:30  
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)
10:50 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 –  General Discussion and Closing
13:00  
Thursday, 5th February

Field Trip

9:30  Departure from Granada
18:00  Arrival
## ANNEX II

### List of participants

<table>
<thead>
<tr>
<th>Surname</th>
<th>Name</th>
<th>E-Mail</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANTUNES</td>
<td>Ana Isabel</td>
<td><a href="mailto:tunes.antunes@gmail.com">tunes.antunes@gmail.com</a></td>
</tr>
<tr>
<td>BEZERRA</td>
<td>Ronaldo</td>
<td><a href="mailto:Ronaldogomes@ufc.br">Ronaldogomes@ufc.br</a></td>
</tr>
<tr>
<td>BLINNOVA</td>
<td>Valentina</td>
<td><a href="mailto:vblinova@mail.ru">vblinova@mail.ru</a></td>
</tr>
<tr>
<td>CHAFIK</td>
<td>Mustapha</td>
<td><a href="mailto:chafik_moustapha@yahoo.fr">chafik_moustapha@yahoo.fr</a></td>
</tr>
<tr>
<td>ÇİFÇİ</td>
<td>Günüy</td>
<td><a href="mailto:gunay.cifci@deu.edu.tr">gunay.cifci@deu.edu.tr</a></td>
</tr>
<tr>
<td>COMAS</td>
<td>Menchu</td>
<td><a href="mailto:mcomas@ugr.es">mcomas@ugr.es</a></td>
</tr>
<tr>
<td>CUNHA</td>
<td>Marina R.</td>
<td><a href="mailto:marina.cunha@ua.pt">marina.cunha@ua.pt</a></td>
</tr>
<tr>
<td>DONDURUR</td>
<td>Derman</td>
<td><a href="mailto:derman.dondurur@deu.edu.tr">derman.dondurur@deu.edu.tr</a></td>
</tr>
<tr>
<td>ERGUN</td>
<td>Mustafa</td>
<td><a href="mailto:mustafa.ergun@deu.edu.tr">mustafa.ergun@deu.edu.tr</a></td>
</tr>
<tr>
<td>FINK</td>
<td>Hiske</td>
<td><a href="mailto:Hiske@uni-bremen.de">Hiske@uni-bremen.de</a></td>
</tr>
<tr>
<td>GALLEGRO TORRES</td>
<td>David</td>
<td><a href="mailto:davidgt@ugr.es">davidgt@ugr.es</a></td>
</tr>
<tr>
<td>GENNARI</td>
<td>Giordana</td>
<td><a href="mailto:giordana.gennari@unifr.ch">giordana.gennari@unifr.ch</a></td>
</tr>
<tr>
<td>GONÇALVES</td>
<td>Daniela</td>
<td><a href="mailto:danielamsg@gmail.com">danielamsg@gmail.com</a></td>
</tr>
<tr>
<td>HAMOUMI</td>
<td>Naima</td>
<td><a href="mailto:naimahamoumi@yahoo.fr">naimahamoumi@yahoo.fr</a></td>
</tr>
<tr>
<td>HOVLAND</td>
<td>Martin</td>
<td><a href="mailto:mhovland@statoilhydro.com">mhovland@statoilhydro.com</a></td>
</tr>
<tr>
<td>IVANOV</td>
<td>Michael</td>
<td><a href="mailto:fu@geol.msu.ru">fu@geol.msu.ru</a></td>
</tr>
<tr>
<td>JIMENEZ ESPEJO</td>
<td>Francisco Jose</td>
<td><a href="mailto:fjspejo@jamstec.go.jp">fjspejo@jamstec.go.jp</a></td>
</tr>
<tr>
<td>KENYON</td>
<td>Neil</td>
<td><a href="mailto:kenyon@marinegro.demon.co.uk">kenyon@marinegro.demon.co.uk</a></td>
</tr>
<tr>
<td>KOLGANOVA</td>
<td>Julia</td>
<td><a href="mailto:juliamail@list.ru">juliamail@list.ru</a></td>
</tr>
<tr>
<td>KRYLOV</td>
<td>Nikita</td>
<td><a href="mailto:nik-bur@mail.ru">nik-bur@mail.ru</a></td>
</tr>
<tr>
<td>LABERG</td>
<td>Jan Sverre</td>
<td><a href="mailto:jan.laberg@ig.uit.no">jan.laberg@ig.uit.no</a></td>
</tr>
<tr>
<td>LEMOS</td>
<td>Catarina</td>
<td><a href="mailto:catarinalemos@ua.pt">catarinalemos@ua.pt</a></td>
</tr>
<tr>
<td>LO IACONO</td>
<td>Claudio</td>
<td><a href="mailto:loiacono@utm.csic.es">loiacono@utm.csic.es</a></td>
</tr>
<tr>
<td>LOGVINA</td>
<td>Elizaveta A.</td>
<td><a href="mailto:Liza_Logvina@mail.ru">Liza_Logvina@mail.ru</a></td>
</tr>
<tr>
<td>LOPEZ RODRIGUEZ</td>
<td>Carmen Fátima</td>
<td><a href="mailto:carmina@ugr.es">carmina@ugr.es</a></td>
</tr>
<tr>
<td>MAGALHÃES</td>
<td>Vitor H.</td>
<td><a href="mailto:vmagalhaes@uchicago.edu">vmagalhaes@uchicago.edu</a></td>
</tr>
<tr>
<td>MAKAROVA</td>
<td>Maria</td>
<td><a href="mailto:geomak.msu@gmail.com">geomak.msu@gmail.com</a></td>
</tr>
<tr>
<td>MARTINEZ GARCIA</td>
<td>Pedro</td>
<td><a href="mailto:matez@ugr.es">matez@ugr.es</a></td>
</tr>
<tr>
<td>MARTINEZ RUIZ</td>
<td>Francisca</td>
<td><a href="mailto:fmruiz@ugr.es">fmruiz@ugr.es</a></td>
</tr>
<tr>
<td>NEKHEROSHEVA</td>
<td>Vasilisa</td>
<td><a href="mailto:cyrkon@rambler.ru">cyrkon@rambler.ru</a></td>
</tr>
<tr>
<td>NIETO MORENO</td>
<td>Vanesa</td>
<td><a href="mailto:vanesanieto@ugr.es">vanesanieto@ugr.es</a></td>
</tr>
<tr>
<td>PINHEIRO</td>
<td>Luis</td>
<td><a href="mailto:lmp@ua.pt">lmp@ua.pt</a></td>
</tr>
<tr>
<td>REY GARCIA</td>
<td>Daniel</td>
<td><a href="mailto:danirey@uvigo.es">danirey@uvigo.es</a></td>
</tr>
<tr>
<td>RIBEIRO</td>
<td>Tiago</td>
<td><a href="mailto:a38406@ua.pt">a38406@ua.pt</a></td>
</tr>
<tr>
<td>RODRIGO GAMIZ</td>
<td>Marta</td>
<td><a href="mailto:martarodrigo@ugr.es">martarodrigo@ugr.es</a></td>
</tr>
<tr>
<td>RODRIGUEZ GERMADE</td>
<td>Isabel</td>
<td><a href="mailto:igermade@uvigo.es">igermade@uvigo.es</a></td>
</tr>
<tr>
<td>ROMAN ALPiste</td>
<td>Manuel Jesus</td>
<td><a href="mailto:mjroman@ugr.es">mjroman@ugr.es</a></td>
</tr>
<tr>
<td>RUBIO ARMESTO</td>
<td>Belén</td>
<td><a href="mailto:brubio@uvigo.es">brubio@uvigo.es</a></td>
</tr>
<tr>
<td>SPEZZAFERRI</td>
<td>Silvia</td>
<td><a href="mailto:silvia.spezzaferri@unifr.ch">silvia.spezzaferri@unifr.ch</a></td>
</tr>
<tr>
<td>TAVIANI</td>
<td>Marco</td>
<td><a href="mailto:marco.taviani@bo.ismar.cnr.it">marco.taviani@bo.ismar.cnr.it</a></td>
</tr>
<tr>
<td>TSYPIN</td>
<td>Mikhail</td>
<td><a href="mailto:mikhail_tsypin@mail.ru">mikhail_tsypin@mail.ru</a></td>
</tr>
<tr>
<td>VILAS MARTIN</td>
<td>Federico</td>
<td><a href="mailto:fvilas@uvigo.es">fvilas@uvigo.es</a></td>
</tr>
<tr>
<td>YURCHENKO</td>
<td>Inessa</td>
<td><a href="mailto:yurchenko-inessa@rambler.ru">yurchenko-inessa@rambler.ru</a></td>
</tr>
</tbody>
</table>
IOC Workshop Reports

The Scientific Workshops of the Intergovernmental Oceanographic Commission are sometimes jointly sponsored with other intergovernmental or non-governmental bodies. In most cases, IOC assures responsibility for printing, and copies may be requested from:

Intergovernmental Oceanographic Commission – UNESCO
1, rue Mollius, 75732 Paris Cedex 15, France

<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
<th>Languages No.</th>
<th>Title</th>
<th>Languages No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Title</td>
<td>Languages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>----------------------------------------------------------------------</td>
<td>-----------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>209</td>
<td>Collaboration between IOC and OBIS towards the Long-term Management Archival and Accessibility of Ocean Biogeographic Data, Ostend, Belgium, 24–28 November 2008</td>
<td>(Under preparation)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>210</td>
<td>Ocean Carbon Observations from Ships of Opportunity and Repeat Hydrographic Sections (IOCCP Reports, 1), Paris, France, 13–15 January 2003</td>
<td>E (electronic copy only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>211</td>
<td>Ocean Surface pCO2, Data Integration and Database Development (IOCCP Reports, 2), Tsukuba, Japan, 14–17 January 2004</td>
<td>E (electronic copy only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>212</td>
<td>International Ocean Carbon Stakeholders' Meeting, Paris, France, 6–7 December 2004</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>213</td>
<td>International Repeat Hydrography and Carbon Workshop (IOCCP Reports, 4), Shonan Village, Japan, 14–16 November 2005</td>
<td>E (electronic copy only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>214</td>
<td>Initial Atlantic Ocean Carbon Synthesis Meeting (IOCCP Reports, 5), Laugavatn, Iceland, 28–30 June 2006</td>
<td>E (electronic copy only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>215</td>
<td>Surface Ocean Variability and Vulnerability Workshop (IOCCP Reports, 7), Paris, France, 11–14 April 2007</td>
<td>E (electronic copy only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>217</td>
<td>Changing Times: An International Ocean Biogeochemical Time-Series Workshop (IOCCP Reports, 11), La Jolla, California, USA, 5–7 November 2008</td>
<td>E (electronic copy only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>218</td>
<td>Second Joint GOSUD/SAMOS Workshop, Seattle, Washington, USA, 10–12 June 2008</td>
<td>E (electronic copy only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>219</td>
<td>International Conference on Marine Data management and Information Systems (IMDIS), Athens, Greece, 31 March–2 April 2008</td>
<td>E (electronic copy only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>220</td>
<td>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</td>
<td>E (electronic copy only)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>