Intergovernmental Oceanographic Commission

Workshop Report No. 201

Geological processes on deep-water European margins

International Conference and 15th Anniversary Post-Cruise Meeting of the Training-Through-Research Programme

Moscow/Zvenigorod, Russian Federation
29 January–4 February 2006

UNESCO

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Editors: G. Akhmanov
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PREFACE

"Geological Processes on Deep-Water European Margins" - International Conference and 15th Anniversary Training-through-Research Post-Cruise Meeting was held from 29 January to 4 February, 2006 at the Faculty of Geology, Moscow State University and at "Solnechnaia Poliana" Resort Hotel (ca. 50 km from Moscow). It was hosted by Moscow State University (MSU).

The Training-through-Research (TTR) Programme, designed in 1990 by an international group of scientists under the auspices of UNESCO, as of 1996 has been executed as part of the Capacity Building Programme of the UNESCO's Intergovernmental Oceanographic Commission (IOC). It has been successfully operated at sea around Europe, as well as along the North African and NE American coasts for all these 15 years making sophisticated multidisciplinary research together with advanced on-the-job training of students and young scientists in the field of marine science. These activities led to numerous exciting discoveries, and have also built a new multicultural community of young geomarine scientists with high expertise and broad seagoing experiences.

Since 1993 TTR Post-Cruise Meetings have been held regularly being hosted by universities actively involved in the programme. They aim to facilitate exchange of information between participants in the TTR expeditions, to summarise the collected data, and also to provide students and young scientists with opportunities to present the results of their research to a broad academic audience. And, of course, it is always a way to meet old friends and to make new ones.

This Conference/Post-Cruise Meeting, being devoted to the 15th Anniversary of the TTR programme, was focussed on all aspects of marine geosciences that have been studied – in all TTR cruises for the last 15 years. The intent was to obtain an overview of what have been done and also to outline directions for future activities.

The meeting brought together over 70 participants from 12 countries (Belgium, Germany, Italy, Morocco, the Netherlands, Norway, Portugal, Russia, Spain, Switzerland, United Kingdom and USA). Attending were researchers and students with different specialities (sedimentology, geophysics, geochemistry, microbiology, biology, palaeontology, structural geology) and research interests falling in the area of the Conference theme.

In total some 50 oral presentations and 10 poster presentations were made. Reflecting main sectors of research activities of TTR, the Conference was divided into three regional sections:

The Black Sea;
The Gulf of Cadiz;
The Mediterranean Sea, Atlantic Ocean and other regions.

The Conference started with the Inaugural Session. Prof. V.T. Trofimov, Vice-Rector of MSU, opened the meeting by welcoming the participants on behalf of Moscow State University, and Prof. D.Yu. Pushcharovsky, Dean of Faculty of Geology, welcomed the participants on behalf of the Faculty. Prof. I.F. Glumov and Dr R.R. Murzin addressed the meeting on behalf of the Ministry of Natural Resources, Russian Federation and Mr. V.N. Zhivago addressed on behalf of the Ministry of Education and Science, Russian Federation. Mr. A.A. Shaggin addressed the participants on behalf of the Polar Marine Expedition, St. Petersburg, Russian Federation. Dr A. Suzyumov welcomed the participants on behalf of Dr P. Bernal, Executive Secretary, Inter-governmental Oceanographic Commission and Dr M.I. Prchalova addressed the meeting on behalf of the UNESCO-Moscow Office and its Director a.i. Mr. Dendev Badarch. The IOC Sertificates of Appreciation were delivered to Prof. Naima Hamoumi (Mohamed V - Agdal

University, Rabat, Morocco) and Dr Elena Kozlova (MSU) for their outstanding contributions to the Capacity Building Programme of IOC, through TTR.

Priority scientific topics highlighted during the scientific sessions of the Conference included:

- Deep-sea depositional systems and modern analogues of hydrocarbon reservoirs;
- Geomorphology and neo-tectonics;
- Diapirism, mud volcanism, and hydrocarbon potential of deep sedimentary basins;
- Shallow gas, cold seeps and gas hydrates;
- Biosphere–geosphere interaction;
- Pelagic and hemipelagic sedimentation.

The participants expressed great satisfaction with the Conference as having fully accomplished its objectives and facilitated fruitful contacts between the attendees.

During the Conference discussion of plans for the future TTR research took place and, on 2 February, meeting of the TTR Executive and Scinetific Committees was organized which considered a number of items related to the organisation of the TTR cruises, as well as publication of the TTR data.

The Conference programme was set up by the Organizing Committees:

- Prof. M.K. Ivanov (Moscow State University, Russia)
- Dr A.E. Suzyumov (IOC of UNESCO)
- Dr O.V. Krylov (Moscow State University, Russia)
- Dr G.G. Akhmanov, (Moscow State University, Russia)
- Dr E.V. Kozlova (Moscow State University, Russia).

The book of abstracts was compiled by the above Organizing Committee. For the present Report, it was further edited by Dr G.G. Akhmanov (Moscow State University) and Dr A.E. Suzyumov (IOC of UNESCO). The abstracts are in the alphabetic order by first author. Annex I contains the programme showing the titles and authors of presentations, along with the division into different sessions and chairpersons of the sessions. The participants are listed in Annex II in the alphabetical order by country.

The conference was supported by the Intergovernmental Oceanographic Commission of UNESCO, Moscow State University, Ministry of Natural Resources and Ministry of Education and Science of the Russian Federation and DECO Geophysical (Russia). Travel and accommodation of international participants was also supported by various national and international programmes and projects.

MESSAGE TO PARTICIPANTS OF THE CONFERENCE

from Maria Prchalova, UNESCO-Moscow Office

DISTINGUISHED PARTICIPANTS, HONORED GUESTS, LADIES AND GENTLEMEN,

On behalf of the UNESCO-Moscow Office and its Director a.i. Mr. Dendev Badarch, and my own as the Programme Specialist for Science, I am delighted to have the opportunity to address you today at the occasion of the International Conference and 15the Anniversary Training-through-Research Post-Cruise Meeting which topic is devoted to Geological Processes on Deep-Water European Margins.

The TTR is an excellent example where interrelations and complementarities of education, research and science have been performed. As you may certainly know, education is one of the principal goals of UNESCO. Through education the results of science and technology are delivered to key target groups and audience. Moreover, education for peace-building is the primary goal of UNESCO and international cooperation is one of the mechanisms to reach it.

Please let me tell you a few words regarding a history of TTR Programme. The unique UNESCO Programme Training-through-Research (launched in 1991) was designated early in 1995 as a UNESCO contribution to the celebration of the UN 50th Anniversary. This contribution was made in view of its achievements in education, research and the development of a universal culture of peace and tolerance - fundamental objectives of the United Nations.

To come back to the presence, I would like to highlight some key issues related to TTR in a broader context of UNESCO. In accordance with this important conference it should be again mentioned the role of IOC (as already highlighted in the contribution of Mr. A. Suzuymov).

Recently the IOC has developed its Guidelines for Capacity Building in which the TTR experience has been included. These Guidelines on best practices have been developed with three primary goals to:

- Embed a process of ongoing learning an improvement by capturing and sharing best practices that are relevant and applicable to the IOC's mandate for a capacity building (CB).
- Provide a record of solid experience and reference points on CB that can be used to guide decision-making.
- Provoke further thought and dialogue on Best Practices in IOC CB in a quest to constantly improve delivery, relevance and impact for the benefit of member Nations and other participating institutions, organizations and parties who are committed to informed governance and management of the ocean and coasts.

The sprit and intent is to augment and support IOC polices and procedures by focusing on practical experiences that facilitate effective deliveries. Thus, this has been a great opportunity for the Training-through-Research Programme to perform and share widely its lessons learnt and best practices.

Lessons learnt from TTR which have been included in these guidelines are:

- Using the appropriate tools for the task, in this case a sophisticated vessel;
- Research is exciting when for scientific problems addressing emerging global issues;

- Getting skills and knowledge for participation in science debates;
- Students can see their results published in peer-review journals.

Thus, esteemed ladies and gentlemen, I wish this Conference and its follow-up will have at least the same success as the TTR Programme itself. Moreover, I wish this event will further enhance the international cooperation to reach the UNESCO objectives in science and education for peace.

As I had a possibility to take part in some events related to TTR cruises and to meet students participating in the programme and to discuss with them key topics, expectations and to see their great enthusiasm, capability and accountability, I am fully confident that the success will be ensured.

Thank you very much for your kind attention.

ABSTRACTS

GEOCHEMICAL AND SEDIMENTOLOGICAL CHARACTERISTIC OF THE MOROCCAN ATLANTIC MARGIN AND THE GULF OF CADIZ

N. Alaoui Mhammedi[1], B. El Moumni[1], and M. Ivanov[2]

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During the TTR14 cruise, on the research vessel *Professor Logachev*, sampling by gravity coring was made on crators of mud volcanoes already known and on the newly discovered ones like the Meknes mud volcano.

After description and sampling on board, the sediments have been separated on superior and inferior 63 µm fraction.

On the sand fraction (>63 µm), the determination and counting of the planktonic foraminifera species are on the way, in the collaboration with the laboratory of Geology and Oceanology Bordeaux 1.

On the inferior fraction (<63 µm), the determination of some major and trace elements (Si, Mg, Al, Ca, Fe, Ti etc.) were made by using the spectrometry of fluorescence X. The evolution of this elements toward the tops on the cores are not evident, in the exception of the Si, Mg, Na and Cl which fluctuate between 35 and 45 cm for cores 531G and 532G.

In collaboration with the Institute of Marine Science of Bologna, Italy (from 1 to 24 December 2005) the analysis of the heavy metals have been made on the total sediment of the top cores (521G, 522G, 525G, 531G, 532G, 535G), and on the two others cores sampled on the board of the oceanographic vessel URANIA (August 2004); the analysed metals are Ti, V, Cr, Ni, Cu, Zn, As, Mo, Ag, Cd, Sb, Tl, Pb, U; a major change was observed on the core 525G that show an increase of the Ti value (120,75mg/g), while the value of Ti on the others cores is inferior to 86 mg/g.

For the clay mineralogy analysis, the interpretation is on the way, the minerals found are characteristic of the Atlantic margin (smectite, chlorite, illite and kaolinite); these preliminary results due to the delay of the analysis in the Ismar laboratory will be completed in the future.

Aknowledgment. We are indebted to the UNESCO-IOC and the TTR14 team; our special thanks are to the Ismar laboratory and the laboratory of DGO of the University Bordeaux 1.

RECENT STUDIES OF MODERN DEEP-WATER DEPOSITIONAL SYSTEMS AS HYDROCARBON RESERVOIR ANALOGUES: FROM BASIN-WIDE TO OUTCROP COMPATIBLE SCALES

A. Akhmetzhanov[1], R.B. Wynn[1], P.J. Talling[2], M. Frenz[1], N. Kenyon[1], M. Ivanov[3] and UK TAPS group

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Modern deep-water depositional systems have long been considered as analogues for subsurface hydrocarbon reservoirs. Unfortunately, the resolution of available datasets collected during earlier studies limited their impact compared to other analogues e.g. outcrops. However, recent advances in data collection techniques have made depositional systems in modern deep-water settings more attractive as analogues, and they are now regularly used to better understanding industry subsurface data at both the exploration and production stage. Particularly effective are integrated studies which include bathymetric and high-resolution geophysical surveys calibrated with shallow cores. Several recent UK-TAPS (Turbidite Architecture and Process Studies) group and TTR projects, dealing with modern deep-water depositional systems of different scales, have been supported by the hydrocarbons industry and successfully executed, delivering new knowledge on the processes and deposits of deep-water gravity flows.

The Agadir Basin offshore Morocco was chosen as a location for a UK-TAPS cruise in late 2004, with the main aim being to understand gravity flow processes and deposits at a basin-wide scale. This cruise was funded by NERC and a consortium of four companies. Data collected included two multibeam bathymetry surveys and a total of 50 piston cores. Previous techniques outlined in Wynn et al. (2002) enabled individual turbidite and debris flow deposits in these cores to be correlated across the whole basin, over hundreds of kilometres. Initial results show that turbidites sourced from the Moroccan margin flow down the Agadir Canyon-Channel and turn a sharp 90° bend before entering the basin. Significant erosion occurs on the outer part of this bend, even at heights of >300 m above the channel floor. Turbidite deposits preserved in the channel mouth are often discontinuous and truncated by erosional scours and hiatuses. Overall the channel mouth is characterised by high complexity and abundant cut-and-fills, indicating significant bypassing. Beds deposited in the Agadir Basin display a wide range of deposit volumes and bed geometries. One of the flows contained both debris flow and turbidity current phases, leading to development of a turbidite-debrite 'sandwich' bed. Subtle variations of the slope gradient in the range of 0.05°-<0.01° are apparently responsible for the major facies and thickness changes in turbidite deposits along the basin axis.

Active sand lobes found in the Gulf of Cadiz (Habgood et al., 2003) are small enough to be studied at resolutions compatible with outcrop-based datasets. The SPECULOBE Project was set up in collaboration with three companies. One of the lobes was mapped in its entirety using a high-resolution sidescan sonar (100 kHz) and a seismic profiler (5 kHz) that were towed near to the seabed during TTR11 and 12 cruises. The resulting planform imagery is spectacularly detailed and shows a complex bifurcating system of multiple, narrow sinuous channels. The profiles have enabled isopachs of lobe thickness to be drawn at 2 m intervals, with a maximum sand thickness of about 9 m. In 2004 the acoustic and seismic data were calibrated by 11 piston cores collected during a UK-TAPS cruise. The coring confirmed the widespread character of uniform sandy deposits within the lobe. Cores from the lobe fringe recovered deposits that are believed to be from individual flows. Their homogeneous character and sharp upper and lower contacts indicate that they are probably sandy debris flows. Sands with graded bedding were also recovered from the system, in the bypass area dominated by erosional channels.

The results and knowledge of gravity flow deposits and processes obtained during these two projects are hoped to be further advanced during the next project of the UK-TAPS group, which is intended to be executed during the forthcoming TTR16 cruise. The project will focus on an area in the outer part of the Rhone Neofan (Western Mediterranean) where a 30 kHz side scan sonar image, obtained during TTR2 cruise (Kenyon et al., 2003), showed a terminal depositional lobe with a characteristic feather-edged planform geometry. A single preliminary core from this area encountered ~2 m of medium to coarse sand located a few centimetres below the sea floor (Mear, 1984). This ungraded sandy interval contained mud clasts and may represent a sandy debris flow. The aim of the project will be to 1) map this (and similar features which are expected to be found in the vicinity) with high-resolution deep-towed sidescan sonar, and 2) to core the key sites in order to calibrate sediment facies of fan-fringe deposits that display lobate or feather-edged planform geometry. This 'ground-truthed' information can be implemented in reservoir models of sandbody architecture, at locations where lobate or feather-edged geometries are observed in 3-D seismic reflection data.

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GEODYNAMIC ACTIVITY OF THE AL ARRAICHE REGION

A. Belova

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The Al Arraiche mud volcano field (situated just below the Moroccan shelf edge) consists of eight mud volcanoes of varying size and shape. The field was described in details after the TTR12 surveys (2002). This is the area of the Gulf of Cadiz where the largest mud volcanoes are found (e.g. Al Idrisi, Mercator, Gemini). Several areas of carbonate mounds, often covered with cold water coral communities, as well as fault-controlled ridges are also found in this area. During the TTR15 Leg 4 cruise lines shot in this area aimed at investigating new structures and also at revisiting several mud volcanoes and tectonic structures for more detailed work.

Data description and interpretation. Seismic line PSAT-266 and MAK line MAKAT113 were run cross the Tangier mud volcano, they are NNW-SSE lines aproximately 9km long. The volcano is clearly seen in the NW end of the line and also on the MAK profile. This volcano was first investigated in 1999 during the TTR9 cruise. It has a typical “christmas-tree” structure indicating multiple pulses of past activity which is seen on the seismic line. Mud volcano structure appears to be bounded by steeply-dipping strong reflections, which could represent faults, which limit a wide mud intrusion zone. The sedimentary section is slightly deformed, with some evidence of faulting, in particular near the mud volcano and also in the SE portion of the seismic line. They may have acted in places as fluid conduits. On the MAK profile, at the north end of the line is an alignment of small pinnacles oriented ENE. They may be on a ridge that was not crossed by the profile. There is a line of higher backscattering that may mark the foot of the ridge. The Tangier mud volcano was crossed very near to its summit and is about 100m high. It is a fairly conical mud volcano as the flows radiate out in all directions. Those on the SE half of the volcano have higher backscattering and thus presumed to be younger. Those to the northwest have the lowest backscatter levels and are presumed to be the oldest.

Seismic line PSAT-267 and MAK profile MAKAT114 are approximately 15km long, they cross the Kidd and the Adamastor mud volcanoes. The Adamastor mud volcano is fairly symmetric with a collapse moat around it. The Kidd mud volcano, in contrast, is strongly asymmetric on this line and it appears to be fault-controlled by active north-dipping ENE-WSW thrusts. The thrusts appear to be active, since they deform the uppermost layers and the seafloor. They can also be traced on the MAKAT114 profile. In the NNE end of the profile occur several approximately E-W trending lines of small high backscattering patches with low relief. The seismic line, PSAT 267, indicates a possible fault but no buried diapiric structure. It may be a line of carbonate crust. Several fields of small high backscatter patches occur nearby. There is a faint line of these patches along a fault seen on PSAT267. The Kidd mud volcano is conical, it is surrounded by a moat and has a seabed that is 50m deeper to the north than to the south. There are concentric fractures marking the crater, which is up to 500m in diameter. There are no obvious radial flows and a generally medium level of backscatter, indicating that any flows are buried by hemipelagic sediments. The Adamastor mud volcano is also conical in shape, with a summit crater. There are radial patterns due to downslope flows but the level of backscatter is uniformly medium.

The MAKAT116 and PSAT269 profiles are E-W trending lines approximately 9km long. These lines cross the Gemini mud volcanoe and the Don Quichot structure. The Gemini has two similar large circular summit craters with marked concentric patterns that have fused together. Three major faults, two trending in NNW-SSE and one in NW-SE directions cut the craters. The overall backscatter level is medium. The Don Quichot structure is a NW-SE trending ridge that has high backscatter level. It represents a diapric ridge, and it is bounded by moats.

MAKAT116 and PSAT270 are NE-SW trending lines aproximately 3km long that cross the Mercator mud volcano, which is set at the southern flank of the Vernadsky Ridge. On the seismic line, the mud volcano exhibits the typical "christmas tree" structure and the moat at the base. Side scan sonar data show a semi-concentric pattern rather than a radial outward mud flow pattern. There are no obvious signs of recent activity such as fresh flows or very high backscattering areas. A NE-SW trending lineament north of the volcano may be longitudinal current formed bed form.

Conclusions. It is suggested that all features are strongly structurally controlled. The mud volcanoes seem to be associated with extensional fault systems, which facilitate vertical upward fluid and sediment injections. The exact location of the mud volcanoes depends on the local and regional stress directions. Sediment injections will occur along fault sections or fractures perpendicular to the direction of minimum horizontal stress. Orientation of most elongated structures like ridges and faults, which control distribution of mud volcanoes is ENE and WSW. Focal mechanism solutions show that the stress regime along the Africa-Eurasian plate boundary in the Gulf of Cadiz is a combination of dextral strike-slip and a NW-directed compression near the Gorringe Bank and the Gulf of Cadiz. Presently the direction of maximum horizontal compressive stress along this segment of the plate boundary is estimated to be approximately WSW-ENE in the Gulf of Cadiz leading to a general transpressive regime in this area.

GAS HYDRATES AND HYDROCARBON GASES OCCURRENCE IN THE BLACK SEA (TTR15 LEGS 1-2)

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TTR15 Leg 1-2 took place in the different parts of the Black Sea. Several new and already known structures have been studied. Here new data of the hydrocarbon gases of the Black Sea is presented. Four main areas of the hydrocarbon seepage were investigated in details:

1. Turkish margin close to the Bosfor strait
2. Russian margin (Shatskii raise, Tuapsinskii trough)
3. Georgian margin
4. Turkish margin close to the city of Samsun

At the Turkish margin close to the Bosporus Strait new mud volcano has been sampled. Core recovered first two units and possible mud breccias. Total organic carbon (TOC) content shows about 1,8% at the Unit 1, up to 4% at the sapropelic Unit 2 and about 0,5% without serious variation at the mud breccia layer. Hydrocarbon gases were analyzed from methane to butanes. Methane is about 4000 mkM/l (up to 6016.5 mkM/l at the Unit 2). Homologues of methane present in low concentration (C_1/C_{2+} is about 200). High butylene content has been detected along this core (up to 12 mkM/l) where as iso-butane and n-butane presents only up to 0.025 mkM/l.

$\delta^{13}C$ of methane is gradually depleted from depth to the surface (from -56.67‰PDB at 340 cm to -85.07‰PDB at 20 cm). It is nearly stable at the mud breccia unit and upper - at the Unit 2 and Unit 1 depletion is much rapid.

Two already known structures have been sampled at the Russian sector of the Black Sea. There is Dolgovskoi mound at the Shatskii raise and Neftianoi mound at the Tuapsinskii trough. Close to the Neftianoi mud mound oil patches have been observed on the water surface. Recovered sediments revealed several layers filled with oil. TOC content varies from 0.33% to 0.88% at the Unite 3 and reaches 5.59% at the sapropel unit. Gas analyses show compounds from methane to butanes and up to hexane at some intervals.

Methane concentration is relatively stable (about 4000 mkM/l) with maximum 6258,4mkM/l at 170cm. Ration C1/C2+, which is more than 1000 point to the dry gas. At the Neftianoi mound we did not find high butylene concentration. All C4 compounds are at the level of 0.01 mkM/l.

$\delta^{13}C$ of methane is lighter than at the Turkish mud volcano (about -69‰PDB) and similar gradually depleted from depth to the surface (from -68.53‰PDB to -83.91‰PDB).

At the Georgian margin four structures have been investigated during TTR15 Leg1-2 cruise. Several stations have been collected from the already known Batumi see (Klaucke et al., 2005). TTR15 BS350G station recovered normal hemipelagic sediments with gas hydrates all along the core. TOC content does not vary much (about 0.5%) and reaches 2.1% at the upper most sediments presented by coccolithic ooze.

Methane concentration is high (up to 7601mkM/l) and does not vary much with depth. Homologues of methane are detected up to butanes but their concentration is relatively low (C_1/C_{2+} is about 300). At this site high butylene concentration have been observed (up to 5.9 mkM/l), and saturated butanes are only up to 0.03mkM/l.

Studies of natural gas hydrates show methane composition (99,5% of methane from all HCs). Also ethane, propane, butanes and sometimes pentanes have been detected. Most likely C4 and C5 compounds were at the porous of the gas hydrate structure and got to the probe during gas hydrate decomposition. $\delta^{13}C$ of methane similar values about -52.5‰PDB. The same results have been found from methane of the head-space probes (Blinova et al., 2005).

At the newly discovered Pechory and Colkety mud mounds oil-saturated sediments and gas hydrates have been collected. Heaver hydrocarbons were detected at high concentrations (C_1/C_{2+} is about 5), which is thermogenic wet gas. Methane is also high up to 6481 mkM/l.

Two seismic lines simultaneously with side-scan sonar OKEAN have been done at the Turkish margin close to Samsun. Discovered rounded patches which characterized by strong backscatter on the sonograms have been checked with sub bottom side-scan sonar MAK-1 and profiler. These patches have been interpreted as gas related. Coring showed highly gas-saturated sediments with plates of gas hydrates. Gas from gas hydrates consists mostly from methane with light stable carbon isotope value -71.75‰PDB.

At the Bernal diagram (C_1/C_{2+} versus $\delta^{13}C$ of methane) mixed origin of the gas is shown. However methane and its homologues concentration, molecular and stable carbon isotope distribution, presence oil and gas hydrates suggest thermogenic origin of the gas. Presence of unsaturated butylene most probably points to the biodegradation processes of the oil at the reservoir or high temperature generation of the gas (Starobinec, 1976).

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COMPOSITION AND ORIGIN OF THE MUD VOLCANIC MATRIX: EXAMPLES FROM THE GULF OF CADIZ MUD VOLCANOES

V. Blinova, M. Ivanov, E. Kozlova, and V. Shlykov

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In order to find potential fluid source rocks at the mud volcanoes from the Gulf of Cadiz 30 samples of the mud matrix and mud clasts from ten mud volcanoes were studied by XRD-analyses. Mud samples were chosen firstly because mud can absorb a lot of organic matter and later produces huge amount of gas and oil and secondary a lot of water can appear due to smectite-illite transformation. Gas and water are generated at the nearly same temperature interval (80-110°C). The main goal of this work was to find out mud rocks that are situated at this condition and could be potential source for mud volcanoes.

Mud matrix was studied from the 8 mud volcanoes in the Gulf of Cadiz. Clay minerals (kaolinite, chlorite, mixedlay, illite), quartz and carbonate minerals (calcite, dolomite) are predominant in the composition. The clay composition of the matrix from different mud volcanoes is similar which points to the same source rock.

Mud clasts were collected from the same mud volcanoes as mud matrix. Three main types of the clasts were determined. The first is "kaolinite" type with admixture of chlorite and huge amount of mixedlay. The second "chlorite" type is characterized by higher maturity than type 1, absence of kaolinite and less amount of mixedlay. The third type is "illite" where smectite-illite transformation was observed. This type is the most maturated and prospective.

The “kaolinite” type is widely distributed and was found at all studied mud volcanoes. The types 2 and 3 were found only at three mud volcanoes. Comparison of mud composition from matrix and clasts suggests that mud matrix mostly consists of the mud clasts belonging to type 1.

It seems to be mud clasts of type 3 is a possible source for gas and water in the mud volcanoes. Mud clasts of type 1 are saturated with water and gas, migrated from below.

HYDROCARBON GASES AND THEIR POSSIBLE SOURCE ROCKS FROM MUD VOLCANOES OF THE GULF OF CADIZ

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During the TTR cruises on board R/V *Professor Logachev* more than 20 mud volcanoes were discovered and investigated in details. Large set of geophysical and geochemical methods was applied in order to study cold seeps in the Gulf of Cadiz. Bottom deposits were taken to study molecular and isotopic composition of hydrocarbon gases, pore water composition and total organic carbon content (TOC).

Firth manifistation of gas emission was observed in the Gulf of Cadiz at the crater of the Mercator mud volcano where pulsating bubbling was found. Using the TV-controled grab gas sample was collected. The main component of the gas was CH_4. The $\delta^{13}C$ of methane (-39,12 ‰PDB) points to its thermogenic origin. The $\delta^{13}C$ of CO_2 is -29,02‰PDB which is a signature of the microbial processes of methane oxidation in the uppermost sediments. Methane concentration from the mud breccia is high and constant along the core (up to 3369,75 mkM/l). The $\delta^{13}C$ of methane is characterized by heavy values up to -36,3‰PDB. Homologues of methane were detected in high concentration up to pentanes (C_1/C_{2+} less than 50).

Four more mud volcanoes were discovered at the deep Portuguese margin during the TTR15 cruise. Mud breccia was obtained only from the Porto mud volcano. At the mud breccia interval high methane concentration was detected (7019,5 mkM/l). Heavy hydrocarbons (C_2-C_5) were found in the lower part of the core. $\delta^{13}C$ of methane becomes heavier with depth and reaches -53 ‰PDB, which is a thermogenic signature.

A lot of heavy hydrocarbons (C_2-C_6) were analyzed in the mud breccia deposits from the Bonjardim mud volcano. Such wet gas (C_1/C_{2+} about 5) shows that the oil compounds migrate along the feeder channel of this mud volcano.

Basing on the geophysical and geochemical data, relatively active and passive mud volcanoes were distinguished. Maximum methane concentrations, detected from different mud volcanoes, show three main areas of active gas seepage in the Gulf of Cadiz: the Al Araiche area, the Ginsburg-Captain Arutynov mud volcanoes area and the Carlos Ribeiro-Porto mud volcanoes area. The same $\delta^{13}C(CH_4)$ values as well as close to each other values of concentration of methane in mud volcanoes of the Al Araiche field prove their similar origin, or the same source for all the mud volcanoes.

The distribution of $\delta^{13}C(CH_4)$ values with depth from the studied mud volcanoes reveals at least two different sources: with values (1) -40,5 ~ -37,2‰PDB for the eastern group of mud volcanoes (the Al Araiche field and the Ginsburg mud volcano) and (2) -53 ~ -49‰PDB for the central and western mud volcanoes (Captain Arutynov, Meknes and all deepwater Portuguese mud volcanoes). Calculated possible source rock's maturity level shows immature organic matter for both types, which coincides with mud clasts data.

Molecular and isotopic proportion of C_1, C_2 and C_3 from the Bonjardim, Porto, Ginsburg and Gemini mud volcanoes suggest that the migrated gas possibly occurs due to secondary cracking of the already formed oil and gas and thus possibly points to the existance of an oil/gas field below these mud volcanoes.

AUTHIGENIC CARBONATE CRUSTS FROM THE DOLGOVSKOI MOUND (RUSSIAN SECTOR OF THE N-E BLACK SEA)

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TTR15 Leg 1 investigated several areas of the Black Sea in order to discover new areas of active hydrocarbon seepage and gas hydrates accumulations. In the Russian sector of the Black Sea the Dolgovskoi mud mound has been investigated in detail. TV lines crossed the top of the mound in the S-N and W-E directions. The area covered by the TV runs is mostly covered by hemipelagic sediments. At the beginning and at the end of the TV-lines dark (brownish to black in color) patches and stripes were observed. Escarpments up to 1-2m high were found at the central part of the mound. Big blocks of rocks and small pebble-like features buried by sediments were detected as well. A lot of wood remains were seen littering the seafloor. The TV-controlled grab sampled the central part of the structure where some irregular shaped features occur. The top of the structure was also explored with the TV-grab.

Large amount of microbial mats were observed on the surface. Large slabs (up to 60cm in size) of authigenic carbonates were retrieved mixed with the soupy Unit 1. Carbonates were observed both on the surface and at depth forming laterally extensive carbonate cemented sections. These slabs are covered on both sides with microbial colonies of differing colours (i.e. whitish, yellowish, pinkish). Cavernous structures carbonate-coated are observed on the lower part of the slabs. Thickness of the carbonate crusts appears to be highest in the points where presumably more focussed seepage occurs and reaches 20-25cm. At the bottom of the crusts black (Fe-rich) minerals were observed. The processes of oxidation go very fast there, and the day after the sampling orange colour appeared.

Two large crusts located one above another, were taken for detail mineralogical and stable carbon isotope study. Ten thin-sections were made from the top to the bottom of the crusts. They revealed different structures, which inherited after sediment structure (Unit 1 or Unite 3). At the top of the both crusts a cemented Unit 1 (samples 1 and 7) was observed. There thin lamination of the mud and coccolite ooze was seen. There is abundance of organic material along these layers. Lower carbonate cemented mud sediments were observed (samples 2, 8 and 9). Black rounded Fe-aggregates (probably pyrite) were seen at the back of the crusts and at the cavernous of the central part (samples 3, 6 and 10). Aragonite crystals were observed at the porous of the crusts and at the big cavernous, where aragonite aggregates reach several centimetres in size.

Stable carbon and oxygen isotope studies were done from the same intervals. $\delta^{13}C$ varies from -29.4‰PDB to -38.2‰PDB. $\delta^{13}C$ from the uppermost sediments (Unit 1), which covers the carbonate crust, is characterized by heavy values (+1.7‰PDB). $\delta^{18}O$ changes from +1.2‰SMOW to -0.4‰SMOW. In distribution of stable carbon and oxygen isotopes two cycles have been distinguished. Most likely (based on the mineralogical and stable isotope composition) the two stages of carbonate precipitation took place at the top of the Dolgovskoi mud mound. They consist of calcite, which cemented muddy sediments, and aragonite, which mostly appears in free pore space.

PROPERTIES OF SEA FLOOR HYDRATES FROM VARIOUS GEOLOGICAL SETTINGS

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Near-surface methane hydrates were found at seep sites on active and passive continental margins. The hydrates exhibit a characteristic macroscopic and microscopic fabric as shown by samples recovered from a large range of water depths. At Hydrate Ridge, Cascadia margin, samples were taken at 600-800 m water depth. From the Black Sea samples were obtained from 2000 m of water depth and from the Congo fan region hydrate samples were taken from 3000 m of water depth. In the Gulf of Mexico methane hydrates have been sampled at the northern and southern slopes at water depth between 500-3300 m water depths. Fabric analyses of such samples indicate that at least parts of the hydrate are formed from free methane gas. Free gas migrates upwards through the sediment column and is also indicated by gas bubbles emanating at the seafloor. These bubbles form plumes in the water column. The most comprehensive data set is documented from Hydrate Ridge. In most cases pure white hydrate occurs here in layers millimeters to several decimeters thick. On a macroscopic scale the fabric varies from highly porous, with pore diameters of up to several cm, to massive with no visible pores. Bulk densities range from 0.35-0.75 g/cm^3 and are inversely correlated with the pore volume, which ranged from 10 - 70 vol %. A total end-member density of pure natural methane hydrate of 0.79 ±0.13 g $/cm^3$ is estimated differing considerably from the theoretical value of 0.9 g/cm^3. The low bulk density and the porous fabric result from the formation of hydrate from bubbles of methane which is documented by cryo field-emission scanning electron microscopic investigations on gas hydrate samples. All samples show undistinguishable porous microstructures with pore diameters of several tens to a few hundred nm and grain sizes of a few microns. In contrast, larger and less frequent pores of a size of several microns typically occur in regions of hydrate decomposition, as evidenced by controlled decomposition experiments, and are indicative of a retarded degassing process due to the memory effect in water resulting from hydrate decomposition. Gas hydrate decomposition and ice formation is also documented by cryo-stage X-ray diffraction and Rietveld analyses. Preservation of structure I hydrates various between 40-70% and has a average preservation of 60%. Preservation of structure II hydrates from the Gulf of Mexico is much better, which is explained by shallower stability curve of such hydrates.

GAS HYDRATES ASSOCIATED WITH OIL AND GAS SEEPS IN THE EASTERN BLACK SEA - PRELIMINARY RESULTS FROM TTR CRUISE 15 LEGS 1 AND 2

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Seafloor seepage and methane emissions to the water column were studied by several groups and projects during the last five years in the western and central parts of the Black Sea. Investigations on fluid and gas discharge in areas of the eastern Black Sea are very rare. Due to the close relationship to the Greater Caucasus thrust belt and the Eastern Pontides such locations like the Shatsky Ridge, Tuapse Trough and Rioni Basin are of great interest because of their difference in geologic composition in comparison to the western Black Sea. During TTR cruise 15 Legs 1 & 2 we investigated active seep sites in the Russian, Georgian and Turkish Sectors of the Black Sea. An interdisciplinary approach was used that included long-range ORKEAN sidescan sonar and deep-towed high-resolution MAK-1M sidescan sonar mapping as well as seismic profiling to locate sites of active fluid and gas discharge. Detailed observations by video-guided instruments and ROV investigations were performed before seafloor sampling by a gravity corer and a TV-grab occurred. Seeps where free gas bubbles are escaping from the sea floor were successfully observed on the Kobuleti Ridge (Georgia) at water depths between 1100 - 850 m by acoustic anomalies in the water column on raw sonar data and as high backscatter intensity areas. Since free gas should become converted to gas hydrate in depth below 750 m of the Black Sea, the presence of free gas is explained by fast transport from a large gas reservoir below the lower boundary of the gas hydrate stability field in the sediments. Bottom-seismic reflections are well imaged in the area. The seeps on the Kobuleti Ridge, as well as on the first anticline of the Tuapse Foldbelt and the Shatsky Ridge are characterised by carbonate and shallow gas hydrate deposits. At four distinct mound locations, three on the Kobuleti Ridge and one on Shatsky Ridge, oil and other higher hydrocarbon gases have been detected for the first time, indicating seepage from deeper petroleum reservoirs.

DEEP-WATER ECOSYSTEM RESEARCH - AN OVERVIEW OF THE BIOLOGICAL RESULTS FROM THE COLLABORATION WITH TTR OVER THE PAST FIVE YEARS

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Since the very beginning of the TTR programme the main objective was the study of geological processes on deep-sea European Margins (Ivanov et al, 2001). The focus on geologically active areas has been a TTR focus, and most of these areas harbour interesting ecosystems - discontinuous environments that are constrained by chemical, physical, topographic and geological factors and that contain a wealth of biodiversity.

In the year 2000 (TTR10) we initiated habitat studies in the mud volcanoes of the Gulf of Cadiz and hydrothermal vents of the Lucky Strike area. Since then, the Gulf of Cadiz has been revisited regularly (TTR11, 12, 14 and 15) and besides the mud volcanoes other habitats such as carbonate chimneys' fields, cold-water coral stands and submarine channels have been investigated. TTR11 and 12 provided opportunities to visit seamounts off Madeira and Azores Islands and to revisit the Lucky Strike vent field, while TTR13 lead us to the icy landscape off West Greenland where we investigated the flanks of canyons and valleys extending into the Labrador basin.

The biological dataset collected over the past five years is invaluable and its study will need many researchers and many years of hard work. A Biological Research Collection is being built in order to harbour the thousands of specimens belonging to hundreds of different species. The management of this collection will ensure the optimal preservation of the specimens for research in a broad area of biological studies (e.g., taxonomy, genetics, reproduction, ultrastructural morphology).

At present, nine new species of crustaceans have been described based on TTR material (Meyers & Cunha, 2004; Larsen et al. submitted; Cunha & Wilson, submitted), two other descriptions are being prepared (one decapod and one hydrozoan) and surely, many others will follow. The genetic coding of the species was also initiated with the study of the hydrozoan collection from the Gulf of Cadiz and the 16S RNA fragment was already successfully sequenced in over 30 species. Soon, we will start coding the COI DNA sequence in crustaceans. These molecular data will be available to the scientific community in the near future through the International Barcoding of Life initiative (http://www.barcodeoflife.org/).

Besides these strictly biodiversity studies, ecological work is also being carried on. The long hours of video footage provides information on the distribution of megafaunal invertebrates that can be related to environmental parameters (e.g.: depth, topography, sedimentary facies - Pannemans, 2003). The visual information on distributional ecology is complemented by the study of macrofaunal samples collected with dredges, cores and TV-assisted grab. In the area of the Gulf of Cadiz the annual visits provided the opportunity to enhance the study of ecological processes related to chemosynthetic communities. Our first results on stable isotopes (13C, 15N, 34S) show evidence of the importance of chemoautotrophic production in the food web of mud volcanoes and are indicative of methanotrophic and/or thiotrophic symbioses in the most common chemosynthetic species, the siboglinid polychaetes (*Siboglinum sp*) and solemyid bivalves (*Acharax sp*). We will attempt now to prove the occurrence of prokaryotic endosymbionts using molecular microbiological analysis (a collaborative work with University of Cardiff).

The biological activities within the TTR program have been extremely fruitful and provided numerous opportunities for collaboration with researchers and institutions focused on deep-sea research and opened new perspectives for future investigations. Definitely, the TTR program is playing an important role in generating integrated research that ties biodiversity and biological processes to the environmental drivers of the ecosystems (geology, sedimentology, physical oceanography and biogeochemistry).

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INTERPRETATION OF THE TTR14 SEISMIC DATA FROM THE EASTERN ALBORAN BASIN

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Eastern Alboran Basin has been the area of investigations TTR14 Leg 2 cruse. Throughout continuous seismic profiling six lines were made (PS219MS to PS224MS), two of them cross ODP hole #978. PS223MS and PS224MS lines, for instance, crossed an interesting structure that contains very strong reflection factor (bright spots) (Fig.1.).

The main targets of this work are to define the origin of the structures observed on the seismic profiles and to construct a 3D model of the investigated area.

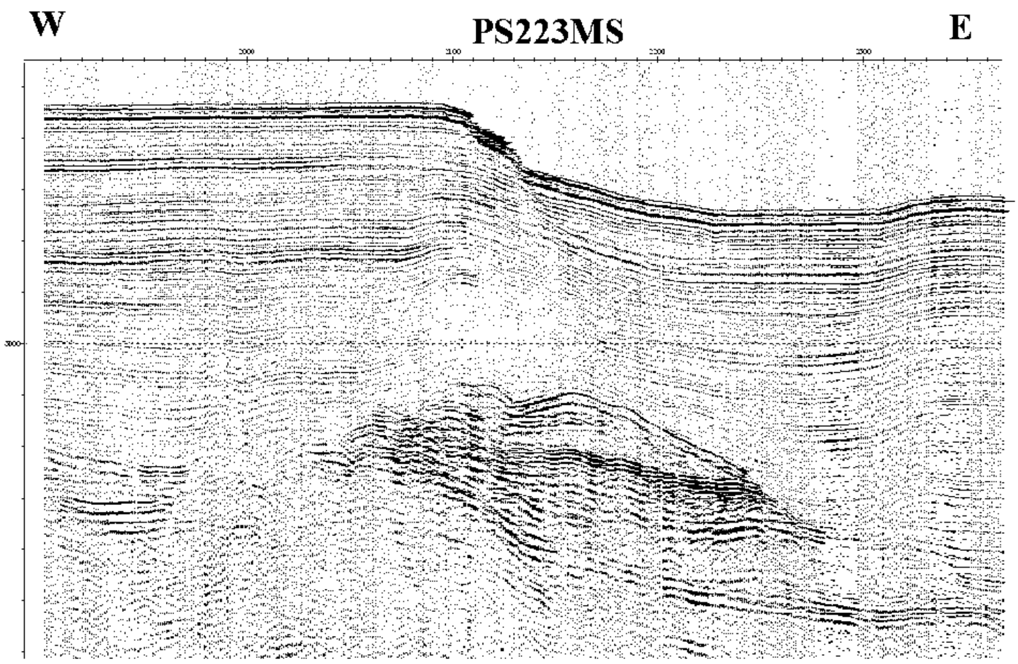

Figure 1. Bright spots on a fragment of PS223MS line

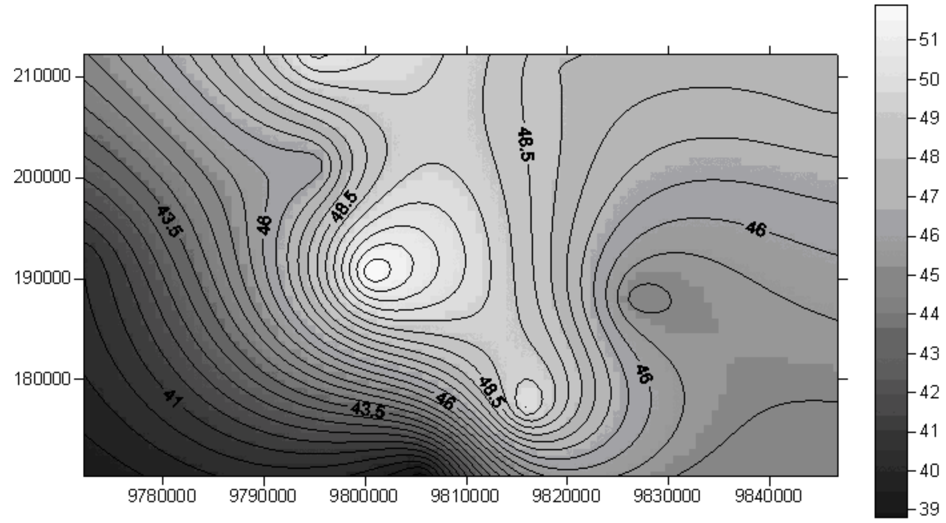

Figure 2. Porosity map of the Miocene formation

Initially this Miocene structure was supposed to be a fluid trap (most probably gas trap). In fact lithological information from the ODP wells shows the Miocene unit presented by highly porous sandy gravel sediments overlapped by clays. The strong reflections and sub-parallel boundaries confining the anticline structure also partially support the gas hypothesis. However due to a very long direct wavelet it is very difficult to determine an extremely important gas indicator such as polarity, which should change on the top of gas-saturated rocks. Other hypotheses of the origin of this structure were also considered such as, for instance, an underwater landslide or salt diapiric processes.

Unfortunately the ODP978 well did not contain any log information which could help to estimate lateral distribution of reservoir properties. However it was decided to use log information from the ODP977 well situated in 30 km to SE from the ODP978 well. Well-seismic tie was made according to lithology and taking into account the same conditions of the sedimentary rock forming. This allowed to construct velocity laws for both wells separately and then to recalculate them to the Time-Depth curves (velocity increases from approximately 1500 m/s at the top of the hole to 2300 m/s at the bottom). Synthetic seismic trace calculated using acoustic and density logs did not show good matching with real seismic data but contained the similar reflections from the main litho-stratigraphic units. That is why it was decided to characterize this basin with only four layers. These four main litho-stratigraphic units of Miocene to Pleistocene age recovered from ODP data (units 1-4 from the top to the bottom of the sedimentary sequence) were indicated on the seismic profiles and boundaries were traced.

The 3D surfaces of the main geological units and also thickness maps were constructed. At this stage a velocity model had no lateral variance and time-depth conversion was just a scaling.

The pseudo acoustic inversion algorithm was adapted for this conditions and this type of dataset. This new algorithm was realized with the Matlab programming space and applied to all seismic data. As a result seismic sections were inverted to acoustic impedance. Then the band limited impedance was averaged vertically inside the main litho-stratigraphic units. Averaged impedance values were laterally sampled according to wells' distance and then interpolated with kriging method. Impedance values from the well were not used during interpolation. The difference between an average Miocene impedance from the well and predicted by kriging was less than 0.2 standard deviation. Using linear regression rather good correlation dependence (Ccor=-0.66) between acoustic impedance and porosity was found from the well data. Then acoustic impedance data was transformed to porosity through the found relation.

The obtained result is rather interesting cause the area of increased porosity of the Miocene layer is good consistent with the location of the initial structure (Fig. 2). Thus it is this structure that is the best reservoir for the gas in case of its presence.

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50 HZ NOISE FILTERING IN SEISMIC DATA OF THE TTR15 CRUISE

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Seismic data obtained during the TTR15 cruise (June - August 2005) have an essential electric noise due to the power supply peculiarities of the R/V *Prof. Logachev* and the cable insufficient shielding. All the data have a harmonic interference of the 50 Hz frequency and multiples of it. In the seismic profiles such noise appears as parallel strips superimposed on the seismic record and that complicates the further analysis and interpretation of the profiles.

The standard notch filter does not suite erasing the noise due to its influence on the rest of the signal spectrum that appears at the seismic record as "ringing". In this paper we consider two methods of the noise reduction which influence only the noise and do not interfere into the signal dynamic properties.

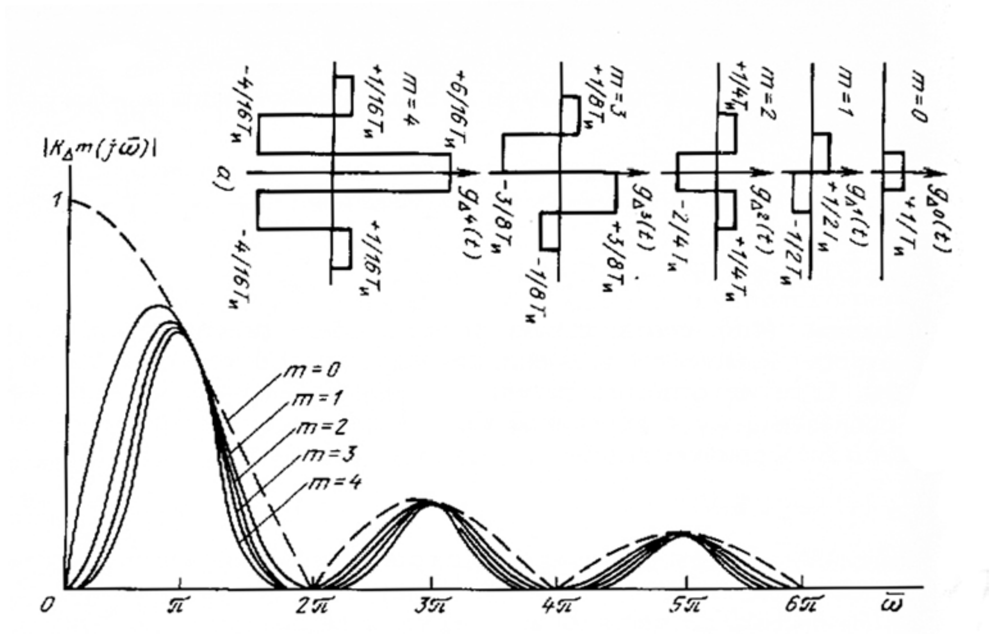

Figure 1. ACF of filter determined by the integrating unwrapping transformation

The first method is filtering the signal with the help of the filter specially synthesized for every concrete type of the noise. The weighting functions of the filter are determined by the integrating unwrapping transformation. The noise frequencies are the initial data for this method and they must be fixed first. The advantage of this methodic is that the chosen frequency is cut off not as a narrow band (as the standard notch filter does) but in substantially wider band that helps eliminating the noise liable to fluctuations. Such a noise characterise the power supply sources. The amplitude-frequency characteristic (AFC) of the filter is presented on Fig. 1. For filtering it is necessary to transform the filter coefficients so that zeroes of the AFC coincide with the noise frequencies. Fig. 1 shows that the AFC comes to its zeroes quite flatly and this procedure cuts off the noise frequency and those close to it. The AFC steepness could be changed by choosing the filter parameters.

The second method is a consecutive analysis of every seismic trace of the profile. In the course of the analysis the amplitudes and the phases of the noise are determined as functions of time. Further on the base of the data obtained the noise signal is synthesized (by composing the frequency equation) and the noise is subtracted from the signal recorded. In the context of this method several ways of the signal analysis are considered. Among them are: selective transformations, correlation methods, methods of statistical evaluation and differential methods. This method is more labor-consuming but if the choise of the noise frequency ranges is correct the results prove themselves.

Within the limits of each method the possible errors are estimated and the means of their elimination are proposed as well as the estimation of the quality and effectiveness of the methods' application. The discussion of their expediency in concrete cases and comparison of the results obtained.

SEDIMENTARY PROCESSES IN THE CALABRIAN AND SICILIAN MARGIN (PRELIMINARY RESULTS OF THE TTR15 LEG 3)

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During Leg 3 of the TTR15 cruise, the Southeastern Tyrrhenian Sea was investigated with the aim of studying the sedimentary processes acting along two sectors of the Calabrian and Sicilian margins.

In the Calabrian margin, a sidescan sonar mosaic was acquired over the Angitola slope valley from a depth of around 700 m down to its junction with the Stromboli valley at around 2500 m; a single seismic line, crossing the Angitola valley and the surrounding slope, was also shot. The sidescan sonar data, integrated with already available multibeam bathymetry show that the Angitola slope valley is composed of three tracts with different gradient, planform, cross section and sedimentary processes. The upper tract of the Angitola valley has a low gradient, a meandering planform and a flat bottom. The side scan sonar data show a series of terraces hanging at different heights above the present day channel floor that represent abandoned meander loops evidence of an ongoing deepening of the valley floor. The valley floor entrenchment is also accompanied by gullying along most of the flanks. The valley is in general devoid of levees; small levees are present exclusively in the outer sides of two meander bends. The intermediate tract of the Angitola valley ensues in coincidence with the crossing of an extensional fault, at a depth of around 1000 m, where a sudden increase in the valley floor gradient occurs. It has a V-shaped cross section, a straight planform and has a relief of around 200 m. Mass wasting processes are widespread on the flanks of the slope valley as evidenced by frequent circular slump scars; a dendritic pattern of erosion is also present along some portions of the slope valley. Slump deposits accumulate on the floor of the valley that has often a blocky pattern. Along the flanks of the valley, terracing corresponds in general with the areas of sediment removal but the entrenchment of an inner thalweg is responsible for the lowermost terrace along much of the length of the intermediate tract of the Angitola slope valley. The lower tract of the Angitola valley departs from the intermediate one only in having a meandering planforms. The sidescan sonar data and the seismic line furnishes also a coverage of the slope surrounding the Angitola slope valley. In particular, at the base of the Capo Vaticano high, a subtle escarpment bounds an area with hummocky seafloor overlying a 100 m thick packages of sediments that present evidence of internal deformation. It has been interpreted as an area characterized by incipient slope instability where the recent sediments are undergoing a slow downslope movement. Smaller scale slump deposits are also found as blocky seafloor portion at the base of the major faults that surround the Angitola slope valley.

In the Sicilian margin, the focus of the investigations, through the acquisition of a sidescan sonar mosaic was the Cefalu basin where multibeam data shown that a slope apron consisting of coalescing channel levee deposits is present. In the eastern part of the basin only the distal portion of the slope apron, characterized by the convergence at the base of slope of channels and canyons from the Aeolian and Sicilian slope, was imaged. Here, flows spread over a 10 km wide area originating fields of sediment waves and scours. In the western portion of the basin, sediment waves and scours are also present in the high backscatter floor of the channels. However, the salient feature of the Cefalu basin slope apron is the high degree of instability that affects the levees. Ubiquitous small scale landslide scars are present in the inner sides of the levees. Larger scale mass wasting processes are on the contrary taking place in the outer sides of some of the levees affected for their whole length by downslope elongated areas of sediment removal. In some cases, landslides scars connect contiguous channels and likely represent incipient avulsion points. Large blocks of displaced undeformed levee sediments are sometimes found in close associations with the removal area. More often, however, the instability processes originate debris flow deposits with a variety of surface texture and corresponding in the subbottom profiles with transparent, up to 10 m thick layers that pinch out in the distal part of the basin plain.

SULPHATE-REDUCING BACTERIA AS A NUCLEATION SITES FOR PYRITE IN CARBONATE CHIMNEYS FROM THE VERNADSKY RIDGE, MOROCCAN MARGIN OF THE GULF OF CADIZ

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A number of hydrocarbon-derived carbonate chimneys and crust were sampled during the TTR15 cruise in the Atlantic Moroccan Margin of the Gulf of Cadiz. A large variety of carbonate chimneys was recovered from the Vernadsky Ridge (sampling station AT 574 D), where an extensive field of carbonate chimneys and crusts was discovered in a high backscattering area at 500 m of depth. Observations from an underwater camera revealed a high density of pipe-like chimneys. Some of them are longer than 2 m and 3 m in diameter, laying over the sea floor, and some protruding from muddy sediment. More than 40 chimneys, crusts and their fragments have been recovered. The collected chimneys show a wide range of morphological types (spiral, cylindrical, branched, conical, massive, etc). The cylindrical type is the most abundant chimney morphology. Most of them vary from 5 to 30 cm on length and up to 30 cm in diameter. Longitudinal canals vary in size from millimetres to 4 cm in diameter. These conduits can be open or full-cemented. The surface texture generally is irregular and very porous in the chimneys recovered. Cracks are frequent, which are in different inclination with respect to the chimneys walls. Based on the external colour these chimneys were divided into two groups:

Group I: Chimneys with a dark brown external colour. These samples, with oxidised surface, consist in chimneys situated in an oxygen rich environment. They are speckled with iron oxides and show colour gradation (oxidation front) from a dark brown, in the external part of the sample, to a rather grey brownish colour at the interior side of the chimney. We have sampled various fragments of these chimneys.

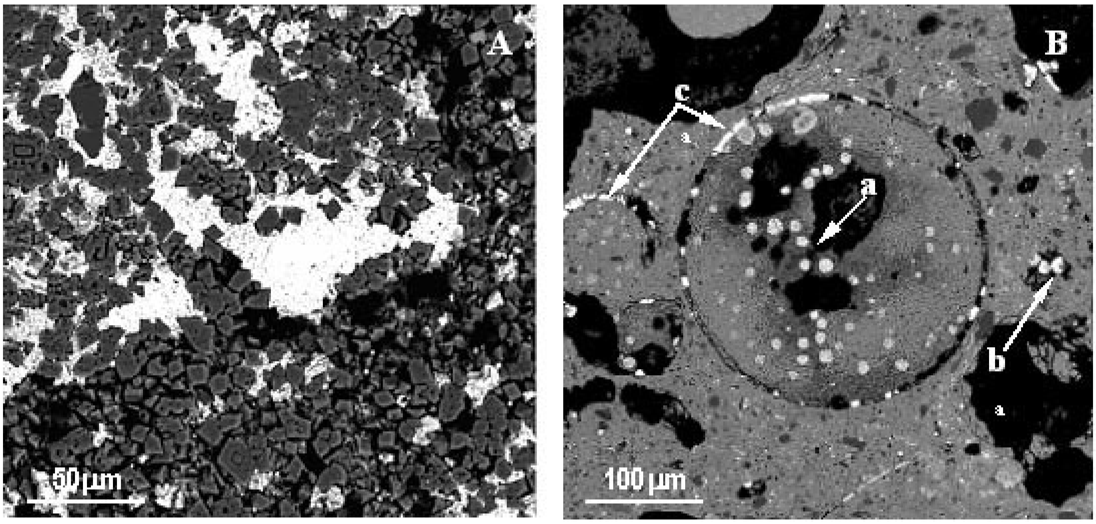


Figure 1. (A) Massive biogenic pyrite (bright areas) cementing a micritic mosaic of subidiomorph Fe-dolomite in a chimney from the group II. (B) Filling of porosity within a chimney from the group I. Various types of pyrite filling can be observed: intra-clast framboidal aggregates in foraminifera's chambers (a), interclast framboidal aggregates (b) and pyrite speudomorphs in bioclasts frameworks (c). Back scattered electron images

Group II: Chimneys with a greyish-green surface colour. Carbonate chimneys from the second group are samples situated in an oxygen depleted environment. They are speckled with sulphides micro-crystals. Only two big fragments were recovered.

Sampled chimneys were studied with thin and polished sections, X-ray diffraction (XRD), scanning electron microscopic analysis (EPMA and SEM), sulphur isotopes analysis, X-ray fluorescence (XRF) and Inductively Coupled Plasma Mass Spectroscopy (ICP-MS) in order to determinate their petrographical, mineralogical and geochemical characteristics.

The chimneys from the Group I are mainly composed of intrapelbiomicritic authigenic carbonates (Mg-calcite and Fe-dolomite) with a minor quantity of opaque minerals (goethite, Mn-oxides, pyrite and chalcopyrite), apatite forming micro-crystalline agregates and detritical minerals (quartz, feldspars, clays, apatite and zircon). Bioclasts of planktonic foraminifera, ostracods and pellets were observed. SEM observations reveal microbes like structures, which indicate microbial activity in the carbonates generation (methanotrophs activity).

The chimneys from the Group II are composed of intrapelbiomicritic authigenic carbonates (Mg-calcite and Fe-dolomite to ankerite) and pyrite as essential minerals. Apatite, quartz, feldspars and clays are accessory minerals.

Pyrite appears in four different manners in the chimneys from the Group I (fig. 1B):

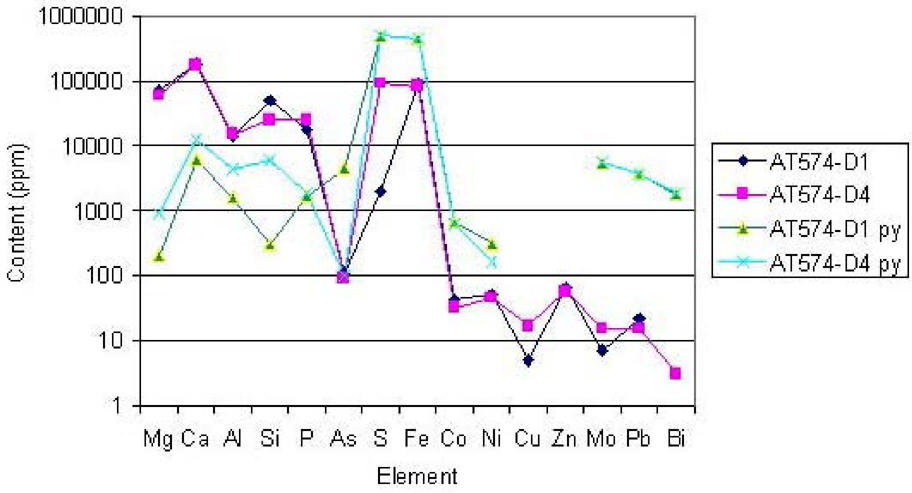
1. Pyrite filling intra-clast porosity of foraminifera and ostracoda bioclasts (filling of chambers).

2. Pyrite frequently infills and forms speudomorphs in the bioclast skeletons.

3. Pyrite disseminated in the carbonate matrix.

4. Pyrite filling inter-clast porosity and secondary porosity (cracks, burrows).

Framboidal aggregates (< 100 m), spherical, are the most typical pyrite morphology in the samples from the Group I of chimneys. They are formed by a variable number of subidiomorph to idiomorph micro-crystals (< 5 m) of pyrite. Organic matter around and within pyrite micro-crystals was observed. Framboidal aggregates can be isolated or forming groups. Framboids described in this work correspond to the first stages of the textural, mineralogical and geochemical evolution proposed in Merinero et al., 2005. Fe-Mn oxy-hydroxides speudomorphs (generally goethite) after pyrite are present, especially in the external part of the chimneys affected by oxidation. Pyrite monosulphide precursors (mackinawite and greigite) could not be detected.



Sample	Mg	Ca	Al	Si	P	As	S	Fe	Co	Ni	Cu	Zn	Mo	Pb	Bi
AT574-D1	71400	183000	14300	50400	17700	109	2000	90900	42	51	5	66	7	22	<DL
AT574-D4	60600	178500	15300	25600	24900	93	92700	84000	32	46	17	57	15	15	3
AT574-D1 py	200	6100	1600	300	1700	4500	497900	455800	660	310	0	0	5500	3700	1800
AT574-D4 py	900	12200	4500	5900	1900	100	501600	442900	640	160	0	0	5700	3700	1900

Figure 2. Numerical and graphical representation of geochemical data of total rock and pyrites from the Group I of chimneys (AT574-D1 and AT574-D1 py) and the Group II of chimneys (AT574-D4 and AT574-D4 py). Elemental contents are in ppm

In the chimneys from Group II, pyrite is filling and cementing the space exist between carbonates crystals (fig. 1A). In these samples we can not observe framboidal aggregates. Pyrite forms heterogeneous massive cement between subidiomorph to idiomorph Fe-dolomite and it could represent an advantage stadium of textural evolution between framboids and euhedral crystals. Pyrite replacements (Fe-Mn oxyhydroxides) were not observed.

Pyrites from the first and second group of chimneys have similar geochemistry (Fig. 2). They are characterised by the high contents in trace metals (Mo, Pb, Bi, Co) and negative $\delta^{34}S$ isotopic composition (-34‰). Sulphur isotopes compositions are clearly linked to sulphate-reducing bacteria activity. The process by which methane and other hydrocarbons are consumed in anoxic marine sediments is directly linked to sulphate reduction through a syntrophic interaction between methanotropic archaea and sulphate-reducing bacteria (Hinrichs and Boetius, 2002). Bacterial cell walls could act as a nucleation sites for pyrites, and probably the framboidal aggregates represent bacterial colonies. These samples present a micro-crystalline aggregate of apatite surrounding framboidal aggregates and massive pyrites. It could be related with products expelled by bacterial activity.

Sulphides precipitation is related with anoxic sediments (sulphate-methane interface) or anoxic micro-niches in oxidised sediments where bacterial sulphate reduction is very active and an amount of available metals, especially iron, is sufficient. Incorporation of trace metals into pyrite may proceed both by co-precipitation and adsorption, and it depends on concentration of metals in the environment of deposit.

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FLUID FLOW FROM MUD VOLCANOES AND SEEPS IN THE BLACK SEA: GEOCHEMICAL COMPOSITION - FIRST RESULTS FROM THE TTR15 CRUISE

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On the TTR15 cruise with R/V *Professor Logachev* in the Black Sea we cored several different geological structures, such as mud volcanoes, mud diapirs, fluid and gas seeps. The locations were chosen based on seismic and side-scan sonar surveys suggesting potential fluid and gas seepage at the seafloor as well as the existence of near-surface gas hydrates. We focussed on 4 working areas: (1) the area of Shatsky Ridge and Tuapse Trough in the north-eastern part of the Black Sea, off the Russian coast (Petroleum and Dolgovskoy Mound); (2) off the coast of Georgia (Pechori and Iberia Mound, Colkheti Seep and the Batumi Seep area); (3) off the coast of Samsun, Turkey; and (4) the Trakya Area, west of the Bosporus entrance.

The geochemical composition varies significantly between the different working areas and the investigated structures. A classification of the origin of the fluid sources has been attempted based on geochemical characteristics. In general, fluids expelled in the north-eastern part of the Black Sea (off Russia) appear to be distinctively different from those fluids venting in the southern part, off Georgia and Turkey. Fluids from the Petroleum and Dolgovskoy Mounds are enriched in Ca, Sr, Ba, and also moderately in Li, whereas the Georgian fluids are significantly depleted in Ca and Sr, but enriched in Ba, Li, and B. The fluids expelled at structures off the Turkish coast, i.e. Samsun and Trakya, fall in a line with the Georgian fluids, though the signatures are less pronounced in the before-mentioned elements. In addition, these fluids are more saline than the general background porewaters of Black Sea sediments. Generally, salinities decrease below the surface from present day bottomwater Cl values of ~350 mM to ~250 mM in a sediment depth of 600 cm, as observed in reference cores. This marks the transition to sediments deposited during the limnic phase of the Black Sea between 21-8 ka b.p. (Manheim and Chan, 1974). Considerably different from all the other fluids are those of the Pechori Mound, off Georgia. These fluids are highly enriched in Li (~200 M) and B (~4 mM) as well as depleted in Cl. This geochemical signature suggests a deep source depth, where clay mineral reactions at elevated temperatures altered the original fluid composition.

Finally, fluid flow rates will be inferred from the geochemical gradients near the sediment surface using numerical modelling techniques.

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TUBOTOMACULUM OF NW RIF BELT: MODE OF GENESIS AND GEOLOGICAL SETTING

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The "Tubotomaculum" occurs in the under-Numidian varicoloured clays ("argiles tubotomaculum") of El Hajra, Zinat, Zhirou and Ziaten/Labranes Numidian successions of NW Rift belt (Morocco). The under numidian varicoloured clays that lies at the top of mud volcanic deposits, correspond to the prodelta of the Oligo-Miocene wave, storm and /or tide influenced Numidian delta system as suggested by facies associations and sequences (Hamoumi et al., 1995).

Sedimentological study of these "Tubotomaculum" using macroscopic (visual) description, petrologic and mineralogical studies (thin and polished section), X-Ray diffraction on bulk sediment and chemical analysis, allows their identification for the first time as fossil corals epigenized and coated by Fe and Mn oxides under hydrothermal activity (Hamoumi, 2005).

Added chemical analysis of the "Tubotomaculum" confirm a hydrothermal origin according to the genetic classification based on the ratio of Fe/Mn/ (Cu+Ni+Co) established by Bonnati et al.(1972). Nevertheless these encrustations lie at the base of the diagram, rather close to Fe-rich sediment from the East Pacific rise than to hydrothermal deposits associated with volcanism. They also fall outside the field of hydrothermal Fe-Mn deposits associated to volcanism in the diagram of Ba versus Fe /Mn established by the same authors. On the other hand low values of (Cu+Ni+ Co), indicate the non contribution of volcanism. However, X ray diffraction revealed the manganite together with goethite and hematite in the cortex of the tubotomaculum. Considering these results and the fact that the manganite typically occurs in hydrothermal vein deposits (J. E. Post, 1999), a new hypothesis concerning the genesis of these encrustations is proposed here.

The Numidian deltaic system of NW Rif and associated mud volcanoes may be compared to the Nile domain whose deep terrigenous cone, contains wide mud volcanoe calderas (several km in diameter) all occuring at the base of the continental slope and upper slope (Dupre et al., 2005). Similarly the fossil corals (tubotomaculum) were probably associated to oligocene mud volcanoes as today cold water corals of the Larache mud volcanic province (Van Rensbergen et al., 2005).

These Numidian deltaic systems took place in the African passive margin of the "Maghreban basin" under the interplay of climate (glaciation), eustatism, and tectonics and subsidence. The Oligocene glaciation induced a cold climate that favoured rhexistasy and erosional process and a lowering of sea level that resulted in sufficient input of fluvial water which carried a concentration of Mn and Fe from leaching of the continental rocks.

Manganese supplied into the ocean may dissolve in reduced sediments mixed with hot fluids spreading from mud volcano. Heat flow measurements in the Nile mud volcanoes indicated temperature around 40°- 57°C (in Dupre et al., 2005). In a second step, manganese might go in solution and migrate upwards and concentrate gradually in coral fragments. The authigene ankerite and calcite recognized by (Kozlova et al., 2005) in the dead corals collected in the Gulf of Cadiz may correspond to an early stage of the diagenetic evolution of such encrustations.

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ATLANTIC CARBONATE MOUNDS: CHALLENGES FOR OCEAN DRILLING, FROM PORCUPINE TO THE MOROCCO MARGIN

J.P. Henriet [1], A. Foubert [1], L. Maignien [1,2], the Proposals '573-Light' and '673-Pre2' Teams and Expedition 307 Shipboard Party

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IODP Expedition 307, which drilled in May 2005 "Challenger Mound" in the Belgica Mound Province off western Ireland, has - even before the main analytical homework got started - lifted a tip of the veil on carbonate mounds in the recent ocean. Challenger Mound is a young fossil mound, partly buried. Its labeling as a 'dead' mound had positively influenced the drilling decision. The mound body consists of a 155 m thick sequence of cold water coral-bearing sediments of Pleistocene age, characterized by a cyclic alternation of light gray and dark green horizons (1). The carbonate-rich and light-coloured layers are partially lithified and feature poor coral preservation or even dissolution. The mound base, virtually identical in the on-mound and off-mound holes, is a sharp erosional unconformity, separating coral-bearing mud from a glauconitic and partly sandy siltstone. All holes on Challenger mound were drilled on the seaward slope of the buried escarpment, on which the mound nucleated. The substratum comprises several carbonate-rich lithified horizons, some of which to be correlated with the roof reflectors of sigmoidal cells within the basal drift sequence. Methane appears first below the mound, with a broad zone of anaerobic oxidation of methane (AOM) coupled to sulfate reduction. This mound site seems to bear witness of the subtle intertwining of microbial sulfate reduction and carbonate diagenesis. Stable isotope and biomarker analyses will refine this picture.

The success of Expedition 307 paves the way for the further exploration of the diverse world of Atlantic carbonate mounds. A comparative study of Challenger mound with a juvenile mound, featuring active fluid flow processes, is the logical second step. IODP Proposal 673-Pre2 focuses on young mounds on the newly discovered Pen Duick Escarpment (2), off Morocco. These mounds occur amidst giant mud volcanoes and various emanations of methane seepage. Within the targeted mounds, horizons with fresh corals alternate with layers featuring coral dissolution (3). The front between the AOM and sulfate reduction zones is found at a depth of 4m below seafloor. Below 4m, the methane concentration rises sharply. The front coincides with a peak in precipitation of sulfides and carbonate (4). Emanations of H2S are very strong.

A major scientific question, which can get an answer from the comparative analysis of Challenger Mound and the Pen Duick mounds, is how, inside a mound, the sedimentary template generated by the cycles of Ocean, Climate and Life becomes overprinted by the beat of internal geochemical fronts. Microbial mediation may play herein a primordial role. When this gets elucidated, we will have put the finger on a fundamental process that transforms major oceanic structures into Geology.

Technically, mound drilling may benefit from some improvements: logging while drilling (LWD) for instance might be considered to avoid the loss of data in the casing (first 80mbsf).

Strategically, these mound studies should be regarded as the stepping stones towards a comprehensive, circum-Atlantic mound research programme, to include the mound provinces off Angola and Congo, Mauritania, Brazil, Blake Plateau, Orphan Knoll, Norway, and more to be unveiled.

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GEOACOUSTIC INVESTIGATIONS OF COLD SEEPS IN THE EASTERN BLACK SEA

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Several new gas seeps and near-surface gas hydrate deposits have been identified in several areas of the Eastern Black Sea. These sites are located in the Russian, Georgian and Turkish sectors of the Black Sea and include mud volcanoes, dome-like structures and cold seeps without apparent morphology. They have been studied and identified using multibeam bathymetry data and various types of sidescan sonar (OKEAN, MAK-1A and DTS-1).

Some of the most spectacular sites are located on the continental slope offshore Batumi (Georgia) in 850-900 metres water depth. These seeps are located on a ridge named Kobuleti Ridge separating two canyons. The walls of one of these canyons show signs for additional, smaller gas seeps. Gas seeps are shown by acoustic anomalies in the water column on raw sonar records and as high backscatter intensity area on processed data.

The seeps on Kobuleti Ridge are characterised by carbonate deposits at the centre and a much wider area where gas hydrates are present. Fractures of a NW-SE direction are present at the seeps site and are probably related to the formation and decomposition of gas. Individual sites of gas emission apparently exert their influence for a circular area of up to 40-m in diameter. Gas geochemistry from gravity cores shows high gas content and a mixture of biogenic and thermogenic gases together with the presence of gas hydrates.

The continental slope offshore Georgia also shows two dome-like structures that show the presence of gas and oil seepage. Oil seepages have also been observed in the Russian sector of the Black Sea, where dome-like structures similar to those offshore Georgia have been observed.

EXPERIMENTAL ESTIMATION OF ACOUSTIC PROPERTIES OF FROZEN GAS HYDRATE BEARING SEDIMENTS

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[3]*Department of Geocryology, Faculty of Geology, Moscow State University, Vorobjevi Gory, Moscow, Russia.*

The objective of the work was to measure acoustic wave velocities in frozen gas hydrates bearing sediments. Three sets of samples (samples of ice, artificial frozen gas hydrate bearing sand and frozen natural gas hydrate bearing sediments, collected at site BS380Gr during the TTR15 cruise in the Black Sea) were chosen for the experiment (fig. 1). All measurements were done on the PUMA-650 analyser of permeability and acoustic properties of rocks in thermobaric conditions. For this experiment special block of the analyser was installed. The core holder and acoustic sensors (fig. 2) were cooled down to -15°C. Measurements were done at the equal swaging pressure (about 100 atm) on cylindrical samples about 30 mm in diameter. The artificial gas hydrate bearing sediments were grown in the geocryological laboratory of Moscow State University using the technology and method elaborated by E. Chuvilin (Chuvilin, Kozlovz 2005). These samples originally have cylindrical shape and do not require special preparations. Cylindrical samples of ice and natural gas hydrate bearing sediments were drilled off for measurement on the PUMA-650 analyser.

The samples of the ice (density 0,885 g/cm^3, porosity about 3%, length 38 mm) were measured to calibrate the equipment. The samples showed V_P=3600 m/s and V_S=1600 m/s. The low value of wave velocities can be explained by porosity and heterogeneity of the ice. Artificial frozen gas hydrate bearing sand (density 1,64 g/cm^3, porosity about 47%, length 34 mm) is characterized by wave velocities values 1600 and 700 m/s, accordingly. Low velocities (V_P of the sample is very close to V_P of water) may be caused by two reasons: by microcracks formed inside the sample resulting from swaging pressure or by decomposition of gas hydrate resulting in

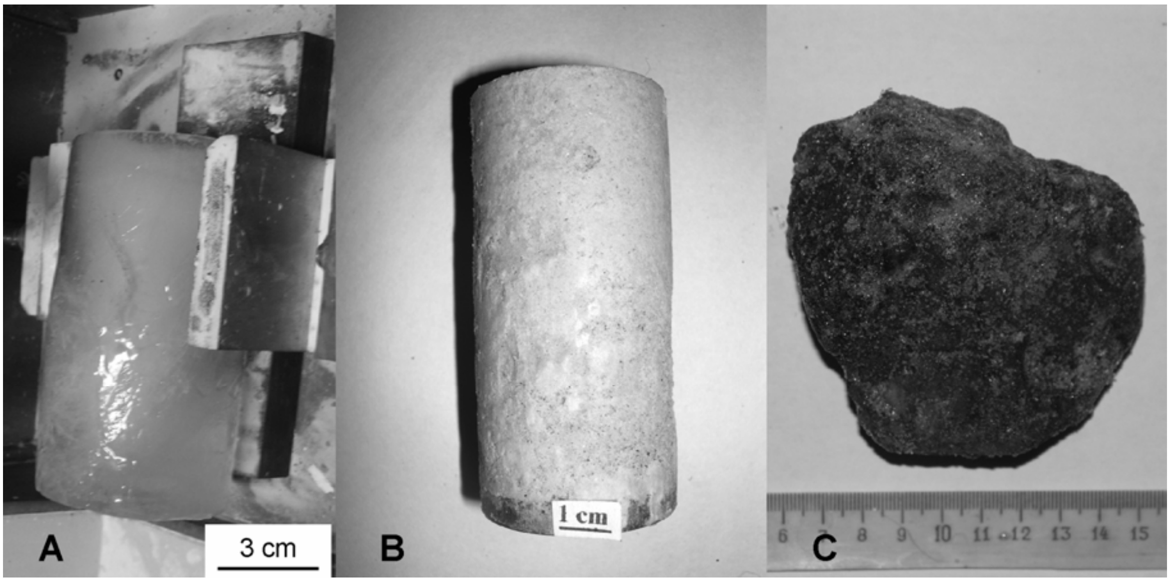

Figure 1. Studied samples: A - the sample of ice, B - the sample of artificial frozen gas hydrate bearing sand, C - the sample of frozen natural gas hydrate bearing sediments

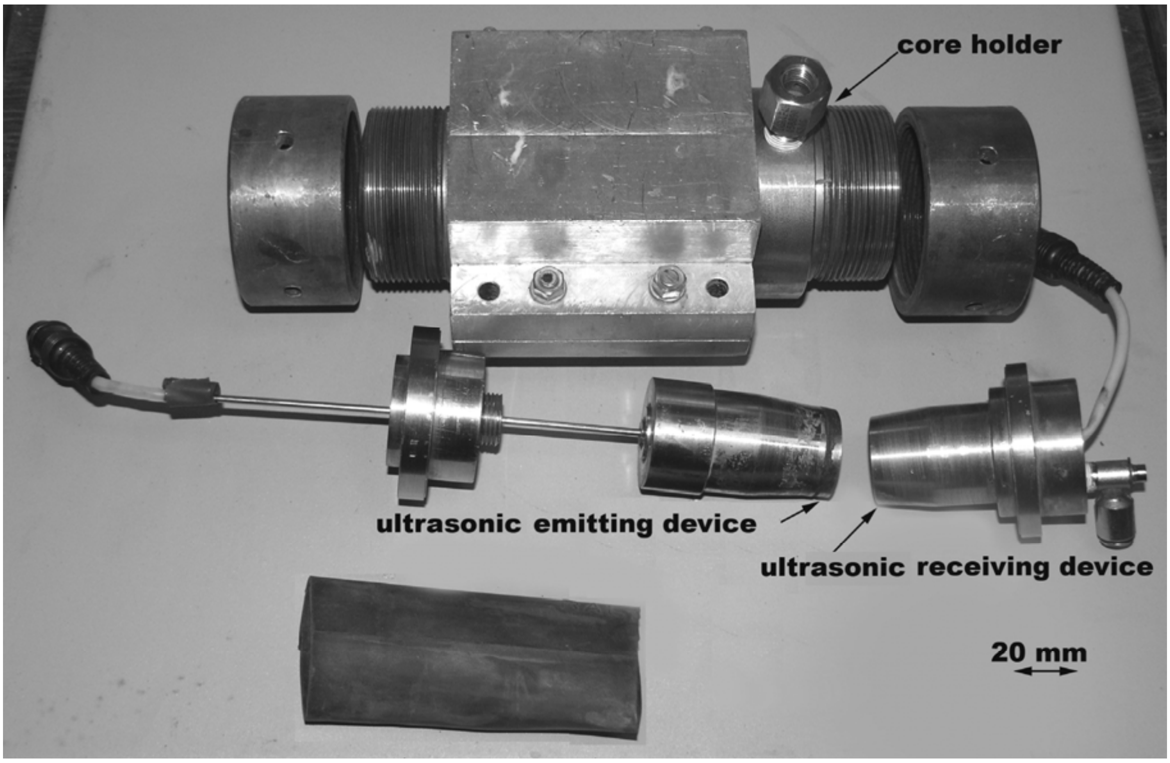

Figure 2. Acoustic measurement block of the PUMA-650 analyser

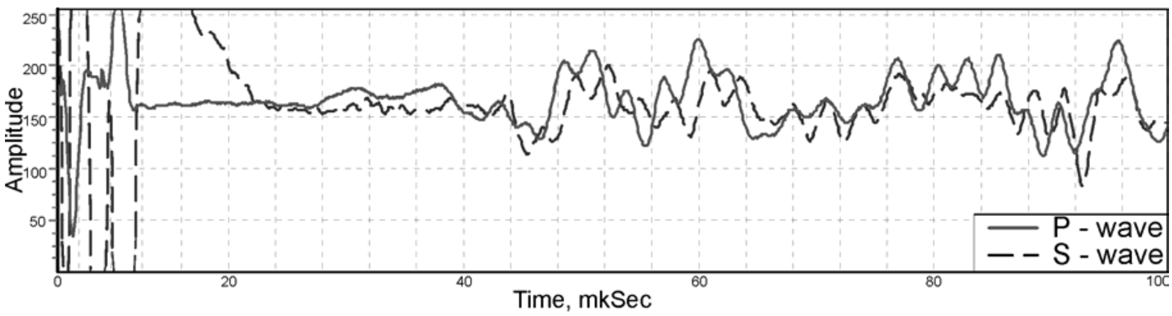

Figure 3. Pattern of P and S waves in the sample of frozen natural gas hydrate bearing sediments

replacing solid phase by gas phase. Presence of transverse waves implies solid structure of the sample.

Data obtained at the samples of the third type (natural frozen gas hydrate bearing sediments) are more complicate for understanding and analysing. Three samples of such type were measured. Two of them are only 15 and 20 mm long and the measurements led to lower accuracy of the experiment. The third, most qualitative sample (density 0,88 g/cm^3, length 30 mm) has V_P=1900 m/s and V_S=850 m/s. Anomalous pattern of P and S waves on the third set of samples were observed (fig. 3). The P and S waves in the sample of ice and sample of artificial frozen sand show characteristic shapes; P and S waves measured in the sample of frozen natural gas hydrate bearing sediment are very similar in shape. This effect is not clear for understanding yet. At the moment we suppose that extreme heterogeneity of sample causes very fast S wave with low amplitude signal. And P wave signal can suppress this kind of S wave.

Further experimental work is planed and, we believe, will lead us to better understanding of acoustic properties of gas hydrate bearing sediments.

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NEW DISCOVERY OF CARBONATE CHIMNEYS IN THE GULF OF CADIZ: RESULTS OF THE TTR15 CRUISE

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Carbonate chimneys were discovered in 2000 during the Anastasia/2000 cruise on the Iberico Ridge, in the Gulf of Cadiz (Diaz-del-Rio et al., 2003). Since that, few other fields with carbonate chimneys were found within the Gulf of Cadiz during the TASIO (2000), TTR11 (2001), TTR12 (2002) and TTR14 (2004) cruises. Newly discovered areas of carbonate chimneys were documented in the northern (the Guadalquivir Ridge), eastern and southern parts of the Gulf, as well as close to the Gibraltar Strait. Chimneys were collected from the slope and top of diapiric ridges using a dredge system at water depths from 370 to1300 m.

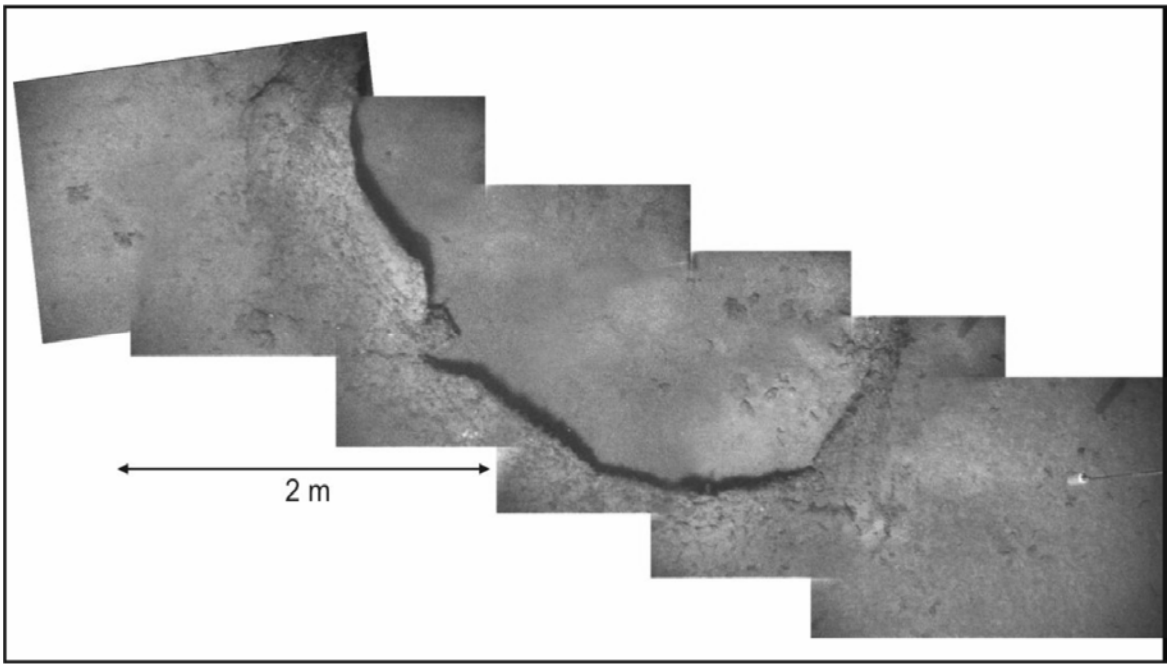

Figure 1. Giant tube detected on the TV-line TTR15 TVAT 62

Recovered chimneys are characterized by various colors, shapes and morphologies. They are represented by brown and dark-brown tubes from few cm to >1 m in length, and from few mm to 0.5 m in diameter. Some chimneys have different shape - double and triple small and thin tubes, conical and pyramidal, spiral forms etc. All studied chimneys from different fields show similar petrographic characteristics, being mainly formed by authigenic carbonates with distinctive contents of Fe-Mg (ankerite, dolomite and Mg-calcite). Authigenic carbonates occur as micrites and coatings around detrital grains and framboidal agglomerates of iron oxides.

Two more areas of carbonate chimneys and crusts were discovered during Leg 4 of the TTR15 (2005) cruise. These areas are located at the Portimao Canyon (Portuguese Margin) and on the top of the Vernadsky Ridge (Moroccan Margin).

From the underwater observations (TTR15 TVAT-69), the deepest-ever-found carbonate chimneys from the Portuguese Margin are located at the Portimao Canyon. Interestingly, chimneys are dominantly concentrated in those parts of the canyon where current activity has been depleted. Observed carbonate chimneys are vertically sited, partially buried with sediments. Besides, color of chimneys is also different from that previously observed, i.e. from brown to grey and to light grey. Few light grey, soft chimneys, collected from water depths of 1418-1275 m, were analyzed in laboratories of Moscow State University. Petrographic and XRD studies have showed that these tubes consist of detrital quartz, feldspar, glauconite, fragments of metamorphic and magmatic rocks and bioclasts of planctonic and benthic foraminifera cemented by soft micritic carbonate material.

At the Vernadsky Ridge (Moroccan Margin) fragments of carbonate chimneys and crusts were found at the depth of 510 m. Chimneys are characterized by ankerite-dolomite composition reach in Fe-oxides minerals. Unique photo image of a giant tube was taken on the TV-line TTR15 TVAT 62 (fig. 1).

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Diaz-del-Rio V., Somoza L., Martinez-Frias J., et al., 2003. Vast field of hydrocarbon-derived carbonate chimneys related to the accretionary wedge/olistostrome of the Gulf of Cadiz. Mar.Geol. 195, pp. 177-200.

DEEP-TOWED HIGH-RESOLUTION SEISMIC SYSTEM FOR INVESTIGATION OF THE UPPERMOST SUBBOTTOM SEDIMENTS AT SHALLOW WATERS

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The most common technique of the offshore seismic surveying suggests that both seismic streamer and a source are towed at a depth of l/4, where l is the dominated wave length in the exited wavelet. Normally, such an arrangement ensures meeting of the penetration and resolution requirements at any water depths. However, sometime it is needed to ensure high resolution (tens of cm) with relatively low penetration (10-15 m) at relatively deep water (tens of m). This situation is typical for inspection of sites for drilling platform construction, as well as for lithological, biological and environmental investigations etc.

The proposed technique suggests that both the source (in our case, a sparker) and a streamer (16 channels) are deepened on a steel rope with a 25-30 kg load down to 10-15 m water depth, depending on the vessel speed.

This technique possesses the following advantages:

1. High repitability of the exited wavelet;
2. Water-air surface does not affect amplitude-frequency characteristics of the source and receiver;
3. Low, relative to the conventional technique, noise level;
4. The frequency band can be controlled by changing the sparker towing depth as well as by changing the number of emitting electrodes;
5. Reflection from the sea surface provides a way to control the emitted wavelet and thus to perform deterministic deconvolution with an individual wavelet for each trace;
6. Possibility to directly determine the reflectivity and AVO;
7. Robustness to rough weather conditions.

A standard processing from for this technique should include the following routines:

1. Geometry assignement;
2. De-ghosting;

3. Static corrections for reduction of the data to one and the same depth;
4. Deterministic deconvolution;
5. Velocity analysis and CDP stacking;
6. True amplitude recovery, determination of reflectivities and AVO.

The paper discusses specific aspects of the acquisition and processing technology being illustrated with raw, corrected and CDP-processed data acquired at various offshore areas. The proposed technique can be used either separately or together with the conventional seismic techniques for a more detailed investigation of the uppermost subbottom sediments.

INFLUENCE OF GAS-HYDRATE-FORMING FLUID ON THE ISOTOPIC COMPOSITION OF AUTHIGENIC CARBONATES: COMPARATIVE STUDY OF THE BLACK SEA AND THE GULF OF CADIZ

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Samples for this work were taken during TTR11, TTR12 and TTR14 cruises onboard of R/V *Professor Logachev* and during 55th cruise of R/V *Professor Vodyaniskiy*. More than 50 samples from fluid venting sites of the Black Sea (Northernwestern and Central parts and the Sorokin Through area) and the Gulf of Cadiz (on the Moroccan margin and near the Strait of Gibraltar) were studied.

The $\delta^{13}C$ measured in the carbonate samples from the fluid venting sites in the NW part of the Black Sea varies from -43.5 to -35.4‰ (SMOW). These values testify that biogenic gas was the main source of carbon for carbonate formation. Obtained data values for $\delta^{13}C$ (from -44.7 to -33.5‰) of carbonates from the Odessa and NIOZ mud volcanoes (the Sorokin Through) also testify the biogenic source of the carbon. Isotopic composition of $\delta^{13}C$ from the authigenic carbonate crust recovered in the Vassoevich and Kovalevskiy mud volcano sediments (Central Black Sea) varies from -2.7 to -10.5‰. We can suggest that these carbonates were formed from the mixed fluid (biogenic and thermogenic). The $\delta^{18}O$ values in carbonates from all regions of the Black Sea varie from -2.7 to 1.4‰. Most probably that sea water is the main source of $\delta^{18}O$ in these carbonates.

Data of $\delta^{13}C$ of carbonates in the Gulf of Cadiz mud volcanoes show significant variations from -30 to 0.7‰. This wide range of values testifies the presence of several sources of carbon for carbonate formation: biogenic, thermogenic and mixed in origin. $\delta^{18}O$ of the samples varies from -10.6 to 5.9‰. These data allow us to suggest the presence of the isotopically anomalous light and heavy $\delta^{18}O$ of water discharged. This idea is supported by the latest observations of anomalous mud volcano fluids in the Gulf of Cadiz (Mazurenko et al., 2002). Value of $\delta^{18}O$ in different parts of the carbonate chimneys from the region near the Strait of Gibraltar (from -1,8 to 11‰) testify that the composition of the discharged fluids has changed in time. The $\delta^{13}C$ measurements in the same samples (from 1,3 to -39,6‰) also support this model.

Thus, the processes of carbonate formation in the Gulf of Cadiz are more complicated in comparison within the Black Sea region. The main reason for that is the diversity of fluid discharge. The anomalous $\delta^{18}O$ and $\delta^{13}C$ values in the studied carbonate samples suggest tectonic activity in the Gulf of Cadiz mud volcano province.

ESTIMATING OF NATURAL HYDROCARBON FLUX IN MARINE BASINS BASED ON REMOTE SENSING DATA

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Remote sensing observations and measurements of seep dynamics can constrain the magnitudes of the carbon released from natural seeps. Backscatter anomalies (slicks) in satellite synthetic aperture radar (SAR) images occur when thin (~0.1 µm) layers of floating oil dampen capillary waves, thereby increasing specular reflection away from the detector and generating radar-dark regions. Oil surfacing from a seafloor seep is advected by wind and current and is attenuated in a long, curvilinear trace until it becomes too dilute to affect the sea surface. Slicks naturally released from seafloor sources are distinguished from other surfactants because their shapes are consistent with observed confirmed seeps and they persist in the same locality among multiple images. Inventories of seeps that generate slicks have been compiled for the entire Gulf of Mexico basin (Mitchell et al. 1999; MacDonald et al. 2004). These targets emanate from ~400 separate sources distributed from the basin margins to the abyss. The SAR images indicate that water is covered with oil amounts to, conservatively ~850 sq. km of the in the northern Gulf of Mexico and ~150 sq. km in the southern Gulf of Mexico. A review of the available satellite data indicates that similar coverage is available for the Black Sea, so it may be possible to complete a similar inventory of oil seeps for this region. Compiling regional estimates for the input of oil to the ocean from natural sources using satellite data will require revision of estimates obtained from modeling basin maturity (Kvenvolden and Harbaugh 1983) and will probably increase estimate for global oil seep magnitudes.

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BIOGEOCHEMISTRY OF CARBONATE MOUNDS FROM THE PEN DUICK ESCARPEMENT, GULF OF CADIZ

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Carbonate mounds are conspicuous features of the continental margins. Since the discovery of large provinces of deep-see carbonate mounds, e.g. in the Porcupine Sea Bight, they were recognized as unique ecosystems and became a topic of interest within the scientific community.

Although a decade of thorough studies in this area provided remarkable insight on mound processes, the question of their origin and stabilization over geological times remains still widely open.

Our work hypothesis is that carbonates, produced by oxidation of light hydrocarbons including methane, may contribute to the sediment cementation and stabilization of the mound. Recently, on top of the Pen Duick escarpment (Gulf of Cadiz), carbonate mounds were discovered in the close vicinity of structures such as pockmarks, carbonate crusts and mud volcanoes, bearing witness of fluid migration. This provides a new opportunity to test our work hypothesis. Hence, pore water profiles of methane, sulphate, sulfide and carbonate, were measured within the sediments of a mound and compared to background concentrations.

First results indeed indicate a methane flux that occurs through the mound. A sulphate-to-methane transition zone is observed at 3.5 meters below the sea floor within the mound. The base of the sulphate reduction zone occurs significantly deeper in the surrounding sediments. At the same depth, carbonates are released with $\delta^{13}C$ values as low as -21 permil vs. PDB, indicating a methane and probably other light hydrocarbons origin. Hence anoxic oxidation of hydrocarbons, and subsequent carbonate production, may play a key role in the mound formation and/or stabilization. The quantification of this process, as well as its significance for the total mound carbon budget, remains to be assessed and is the next step in the mound processes studies. Interestingly, *Lophelia* coral rubbles were present all along the sediment column suggesting that this mound is a potential habitat for cold water corals and associated communities.

GEOCHEMICAL CHARACTERISTICS OF ORGANIC MATTER FROM MUD VOLCANO MATRIX (THE GULF OF CADIZ)

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Samples used for the present work were collected during the TTR15 cruise in the Gulf of Cadiz from the Porto, Olenin, Mercator, Bonjardim, Pen Duick and Meknes mud volcanoes. The work is devoted to analyzing different methods of organic matter (OM) extraction and to revealing the most applicable one, as well as investigation of geochemical characteristics of OM of mud volcanic breccia.

During investigations the following methods were used:

- Fluorescent analysis
- Determination of TOC content
- Extraction of organic matter:
    - chloroform extraction ("cold")
    - chloroform extraction in Sokslet ("hot")
    - ultrasonic extraction
- Gas chromatography (GC)
- Gas chromatography- mass-spectrometry (GC-MS) analysis.

When choosing the extraction method we have to remember that different solvents dissolve different compounds. Quantity of EOM depends on temperature and time of extraction. Hot extraction gives the most complete results and draws out maximum quantity of a substance, although "light" compounds will be lost. Cold extraction draws out basically light hydrocarbons. Ultrasonic extraction draws out biggest quantity of acids, sulfur and other compounds that are not interesting for further geochemical investigations.

Results of fluorescent analysis show capillary extract to be characterized by 8-9 ball (percentage of EOM from 0,005% to 0,04%), with sulfur admixture. Most EOM is characterized by oil-waxy compounds in the composition. So, we may suppose that different mud volcanoes are represented by similar extractable organic matter.

samples	% EOM, fluorescent analysis	% EOM, cold extraction	EOM/TOC x100 %	% EOM, hot extraction	EOM/TOC x100 %	% EOM, ultrasonical extraction	EOM/TOCx 100 %
AT570G Pen Duick#7	0.02	0.045	15.51	0.547	188.62	0.035	12.06
AT568G SW slope, Mercator#1	0.04	0.125	52.08	0.172	71.66	0.0119	4.95
AT567G Mercator#3	0.02	0.003	1.3			0.027	11.73
AT567G Mercator#2/0-20cm	0.04	0.004	1.66	0.496	206.66	0.0431	17.95
AT569G Mercator	0.04	0.004	1.48	0.39	144.44	0.05	18.5
AT568G SW slope Mercator#3	0.04	0.765		0.0085		0.122	
AT567G#1 Mercator, pelagic		0.002	0.47			0.049	11.66
AT591G Olenin#4	0.001	0.001	0.58	0.7728	454.58		
AT591G Olenin#2	0.02	0.127	74.7	0.447	262.68	0.319	187.64
AT591G Olenin, pelagic		0.024	6.31			0.298	78.42
AT584K Meknes	0.04	1.122	320	0.068	19.42	0.0697	19.9
AT585Gr Meknes	0.08	0.271	123	0.068	30.42	0.0851	38.68
AT581Gr Meknes	0.005	0.012	4.6	0.69	265.38		
AT579G Meknes, slope	0.04	0.004	1.66	0.417	173.75	0.00153	0.64
AT596G Porto	0.01	0.104	47.27	0.418	190	0.01226	5.57
AT597Gr Bonjardim	0.04	0.083	39.52	0.017	8.09	0.004	1.9
AT578G #1,bottom,pelagic		0.0002	0.08			0.0023	0.92

Figure 1. Extractable organic matter of mud volcanic deposits defined in samples using different methods: cold extraction, hot extraction, ultrasonic extraction

TOC content is not high (around 0,2-0,3%). Lower concentrations are observed in matrix of the Olenin mud volcano, higher concentrations are common in pelagic samples. Samples are characterized by para-autochtonous bitumen where compounds of OM have moved within the sequence plus migratory part of OM from the underlying sequences.

Percentage of EOM drawn out by cold extraction is compared with percentage of EOM drawn out by fluorescent analysis (fig. 1). Conservative value of EOM content may be due to just partial extraction. Big difference of these data with those obtained after hot extraction is due to more complete extraction which draws out a lot of sulfur. The best correlation with data of the fluorescent analysis show results after ultrasonic extraction although it draws out not all compounds. In the extract sulfur is observed as crystals sunk on the walls of the glass.

Samples from the Bonjardim mud volcano were taken for comparison of different methods of extraction. Chromatogram of OM extracted by "cold" extraction is characterized by C17 to C36 linear alkane distribution with maximum on C27. Pr/Ph=1,27; Pr/nC17=1,27; Ph/nC18=0,56; CPI> 1 which could suggest high maturity of OM and oxidizing conditions of its formation (fig. 2).

Geochemical indexes of OM chromatogram extracted by hot extraction are similar. Peak C19 value is observed in low-molecular area. N-alkanes are registered from C17 to C36 with bi-modal distribution and peak values C19 and C27. Pr/Ph=1,21, Pr/n-C17=1,15, Ph/n-C18=0,88, CPI> 1 (prevalence of odd n-alkanes) shows oxidizing condition, and Ki>1 points to immature OMs. There are phthalates on the chromatogram that could be explained by that hot extraction is more complete and draws out more substance, as well as phthalates can be formed in the thermal retort during extraction.

Chromatogram of ultrasonically-extracted OM has some differences in geochemical coefficients. N-alkanes are registered in the area C17-C29 with bi-modal distribution and maximum on C18. Interpretation is very difficult due to small amount of OM. Pr/Ph=1.64; C17=9.28; Ph/n-C18=0.62 point on oxidizing conditions. Very high prevalence of iso-under n-alkanes, CPI, Ki indicate immature OM.

Gray mud breccia from the Meknes mud volcano was investigated by cold extraction (hot and ultrasonic extract include big amount of sulfur and small amount of OM thus it was not possible to make these analysis). Chromatograms of the cold extract are represented by bi-modal

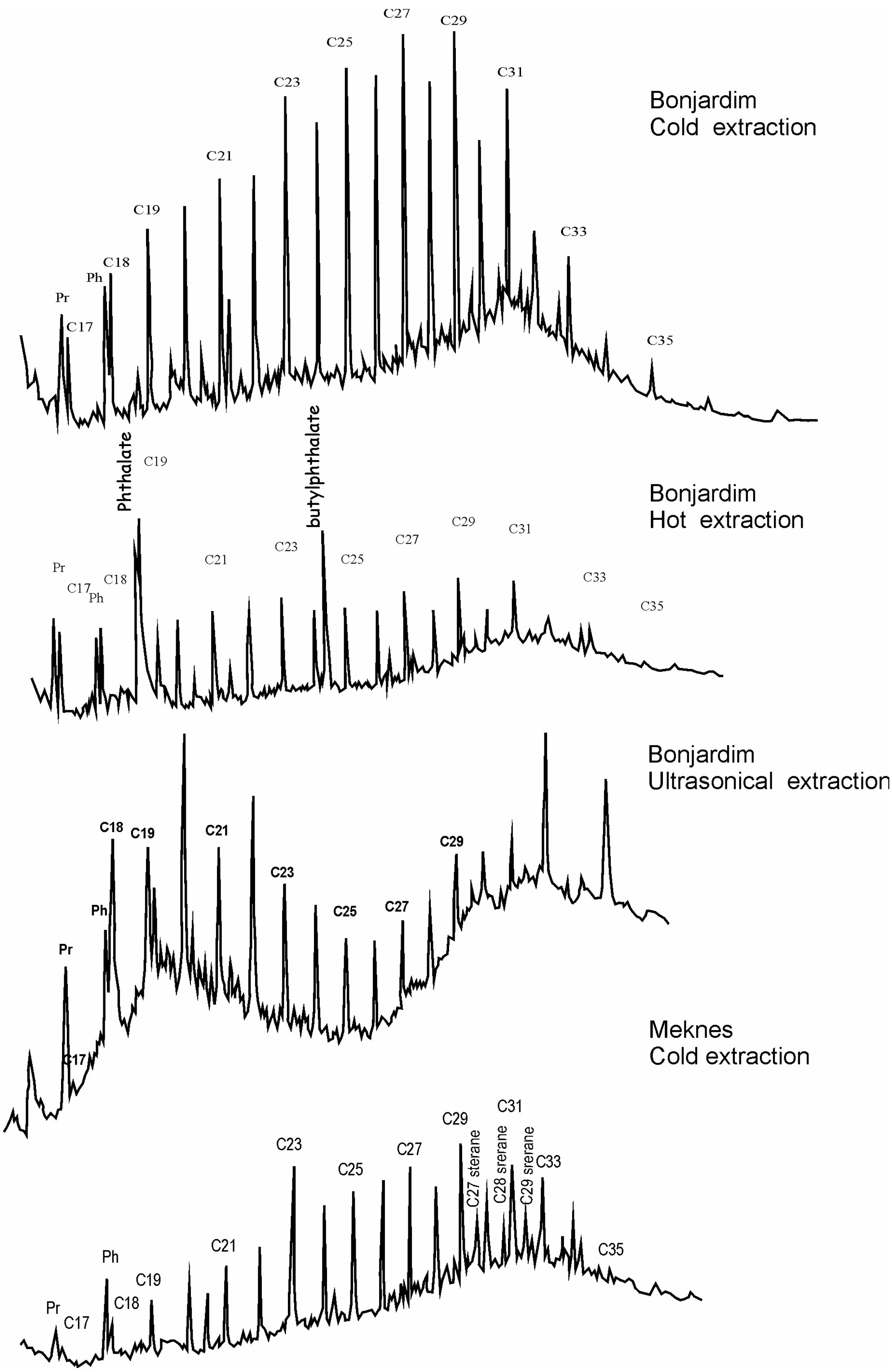

Figure 2. Chromatograms of cold, hot, and ultrasonic extract from the Bonjardim and Meknes mud volcanic deposits

distribution of n-alkanes from C17 to C35 with maximum on C23 and C35. Pr/Ph< 1; Pr/n-C17=2.2; Ph/n-C18=2.6; CPI> 1; Ki=2.5 show very immature OM and reducing conditions. On the chromatograms C27, C28, C29 steranes are observed. Triangular Shanmugam diagram of sterane distribution shows the estuarine environment.

Chromatograms of cold extractions from the Bonjardim and Meknes mud volcanoes have similar shape although with some differences in geochemical coefficients.

Geochemical investigations showed the following results:

- We can suppose that matrix from the studied mud volcanoes belongs to the same sequence.
- Organic matter is of mixed type.
- TOC content is low.
- Cold extraction draws out enough quantity of OM necessary for research and small amount of sulfur.
- Hot extraction draws out big quantity of OM, as well as asphaltenes and sulfur that are not necessary for further geochemical investigations.
- So, cold extraction for investigation of organic matter from mud volcanic matrix (the Gulf of Cadiz) is much more appropriate.

DEEP-SEA TRANSPORT AND DEPOSITION OF THE STROMBOLI 30/12/2002 LANDSLIDE - RESULTS OF THE TTR15 CRUISE

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On 28 december 2003, lava emission and slope movements of the Sciara del Fuoco preceded the tsunamigenic landslide that took place three days later, on 30 December 2002, involving 25-30 x 10^6 m^3 of volcanic material.

Deposits of the landslide in both its distal and proximal facies were investigated during two high resolution marine surveys conducted offshore the SdF (TTR14 and TTR15) on board the R/V *Prof. Logachev*. Results indicate that the thickest, coarse-grained landslide deposit extends over an NNW elongated area at water depths between 1600 and 2000 m at a distance of 6 to 8 km from the shoreline. The deposit consists of several discrete, mainly chaotic assemblages of fresh cobble-sized scoriae and lava flow clasts within a coarse sand matrix. Down-slope and laterally, the coarse-grained deposit grades to black volcaniclastic sand often arranged in ripple bed forms. The landslide material contrasts with the surrounding seafloor in being completely devoid of a hemipelagic sediment cap. Extensive sampling of landslide derived material was performed in both its proximal and distal facies utilising TV-guided grabs, gravity and box cores. Initial interpretation of depositional textures indicate that the proximal, coarser deposits derive from low-coherence, granular debris flow processes. Distally, box coring performed about 24 km north from the NW shoreline of the Sciara del Fuoco, in a site located on the right side of the Stromboli canyon, sampled a sediment sequence capped by a 2-3 cm-thick sandy layer. Sedimentological and compositional features of the layer are consistent with an origin from a volcanogenic turbidity current cogenetic to the debris flow generated by the 2002 landslide.

GAS-HYDRATE-FORMING FLUIDS OF THE KOVALEVSKY, KAZAKOV AND ODESSA MUD VOLCANOES (THE BLACK SEA)

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Three regions of the Black Sea with different types of fluid venting were investigated during the TTR11 Cruise (2001). Results of studies of pore water from mud volcano sediments containing gas hydrates are presented in this work.

The Black Sea mud volcanoes are characterized by anomalous hydrogeochemical composition of ascending fluids. Results of the pore water studies testify that gas hydrate dissociation in samples has insignificant influence on the distribution of the major ions and $\delta^{18}O$ - δD water isotopes. Nevertheless, single gas hydrate-related hydrogeochemical and isotopic anomalies are observed in the studied pore water samples. Observed fluctuations of Ca^{2+}, $SO_4{}^{2-}$, $HCO_3{}^-$, and $CO_3{}^{2-}$ are mostly explained by anaerobic methane oxidation and precipitation of authigenic carbonates. Decreasing δD in the pore waters from the Odessa and Kovalevsky mud volcano with depth could also be explained as a result of anaerobic methane oxidation that generates water rather light in hydrogen.

Based on the element/chloride ratio distribution we can conclude that the Kazakov mud volcano is more active than the Kovalevsky and Odessa mud volcanoes. The Kazakov mud volcano is characterized by high-salinity fluid with high concentrations of sodium and alkalinity. This fluid is light by hydrogen and enriched by oxygen eighteen isotopes. We can conclude that fluid with such composition is formed due to illite-smectite dehydratation of Maycopian clays.

ORIGIN OF THE NOBLE GASES IN GAS-HYDRATE ACCUMULATIONS ASSOCIATED WITH FLUID VENTING

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Five gas hydrate accumulations associated with fluid venting were studied: the Haakon Mosby mud volcano in the Norwegian Sea, gas venting in the Sea of Okhotsk, at the Dvurechensky mud volcano in the Black Sea and cold water seep in the South Basin of the Lake of Baikal. Hydrated gases were obtained from the gas hydrate aggregates during spontaneous degassing in salt-saturated water. The isotopic and component compositions of noble gases (He, Ne, Ar, Kr and Xe) were studied from these samples. The study of component and isotopic composition of noble gases from natural gas hydrates and hydrate bearing sediments is interesting by two reasons:

a) Light noble gases (He and Ne) cannot form gas hydrates because of their small molecules. Therefore, relative content of noble gases can serve as indirect indication of gas hydrate presence and direction of hydrate forming processes.

b) Noble gases isotopic composition can testify about sources and genesis of gas hydrate forming fluids.

The content of the air argon is significant in all samples and the isotopic composition of argon does not differ considerably from the air in most of the samples. At the same time, excess helium relatively to its air content was found in all samples excluding one sample from the Sea of Okhotsk. The isotopic $^3He/^4He$ ratio varies between $0.009X10^{-6}$ and $1.52X10^{-6}$ and differs from the air in most cases. This can testify about the presence of three end-members mixing: air component ($^3He/^4He$ = $1.4X10^{-6}$), radiogenic (crustal) component ($^3He/^4He$ = $0.009X10^{-6}$ in our case) and upper mantle source ($^3He/^4He$ = $12X10^{-6}$ and $^4He/^{20}Ne$ = 500-1000). Therefore, in the framework of the model we can estimate the contribution of mantle gases in studied samples. The contribution is of 0.1-1.2% for samples from the Haakon Mosby Mud Volcano to 8-10% for samples from the Black Sea, the Sea of Okhotsk and the Lake of Baikal.

One of the samples from the Haakon Mosby mud volcano demonstrated extremely high helium content in excess of air by 3 order of magnitude. Extremely high helium content, revealed in sample from gas hydrate bearing sediments of the Haakon Mosby Mud Volcano, is probably an indication of gas hydrate formation activity. As helium does not enter in hydrate structure, the residual gas becomes enriched with helium. Gas enriched with helium will saturate pore water. Taking into account that helium has very strong diffusibility, we can conclude that the presence of extremely high helium testifies active gas hydrate formation existing in the present time.

GAS HYDRATES OF THE SEA OF OKHOTSK: RESULTS FROM THE CHAOS PROJECTS

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The area of focused fluid venting off NE Sakhalin was investigated in 2003 and 2005 during the 31, 32 and 36 international expeditions of R/V *Akademik Lavrentyev* within the framework of the CHAOS Projects. Great number of structures related to gas venting was discovered. Gas hydrates were sampled within nine of them named CHAOS, Hieroglyph, Kitami, KOPRI, VNIIOkeangeologia, POI, KIT, Gisella (which was discovered by KOMEX Cruises) and Dungeon. Some of gas-hydrate-bearing cores contain massive gas hydrate layers (up to 35 cm thick).

The shallowest submarine gas hydrate accumulations in the world (up to 385 m water depth) were discovered during the CHAOS-2005 cruise. Originating from determinations of the organic matter content, composition of hydrated gas, and carbon-oxygen isotope composition of authigenic carbonates, it is possible to recognize two main sources of gas involved in the formation of gas hydrates:

a) Microbial biogenic methane that was generated in situ in the uppermost horizons of sediments of the Deriugin Basin enriched by organic matter;

b) Methane migrating from deep buried hydrocarbon reservoirs along faulting zones. This methane most probably is also biogenic in origin.

A distinct relationship between isotopic composition of oxygen and hydrogen indicates that both isotopes are altered by the same process leading to increase of δD and $\delta^{18}O$. Observed isotope anomalies of hydrogen and oxygen are higher than fractionation coefficient under gas hydrate formation. These features could be explained by two processes:

a) influence of residual water during gas hydrates formation;

b) involving the process of gas hydrate formation of deep-sourced water.

Based on the first idea, gas hydrates most probably have been formed from in situ pore water and seawater. This is not supported by the presence of positive chloride and other major ion anomalies from the residual water after rapid gas hydrate formation. In the second case, the original gas hydrate-forming water could be different from seawater of the basin.

Thus, we can conclude that not only free gas is expulsed offshore Sakhalin but also seeping of gas saturated water takes place. Studied pore water samples consist of three end-members: gas hydrate water, seawater (or in situ pore water of the basin) and deep-sourced water. Results of isotopic studies of water testify that discharged fluids are characterized by light δD (up to -11‰) and $\delta^{18}O$ (up to -1.2‰). At the other hand, results of $\delta^{18}O$ measurements of carbonates suggest that "isotopically heavy" water is discharged within the study area. It is possible also to conclude that two types of water (different in isotopic composition from each other and seawater as well) took part in the formation of carbonates and gas hydrates. Therefore, the sources of fluids uprising from the depth changed with time.

Most probably, gas hydrates have been formed after the authigenic carbonates formation; gas hydrates filled voids at the contact of these carbonates with sediments and filled the bivalve shells. Consequently, composition of fluids venting at present time off NE Sakhalin is "isotopically lighter" than it was earlier.

COMPLEX PLUMBING SYSTEMS IN THE NEAR SUBSURFACE: GEOMETRIES OF AUTHIGENIC CARBONATES FROM NW BLACK SEA

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During the Training Through Research 15 cruise, seepage structures were located and sampled in the Black Sea (Russian sector). The summit of the Dolgovskoy Mound is situated along the Shatsky Ridge oriented NW-SE. At this location a large amount of escarpments (up to 1-2m high) and authigenic carbonates (tubular, irregular and tabular shaped) were observed. The TV remote controlled grab revealed the presence of microbial mats on the sea floor. Onboard were retrieved large blocks of authigenic carbonates allowing to discover some of the structures characterizing the plumbing system in the near subsurface.

Up to 60 cm wide slabs of carbonate cemented Unit 1 (consisting of alternating coccolithic ooze and clayey sediment laminae) were collected. The samples revealed that these authigenic carbonates are laterally extensive and have a complex geometry in the subsurface. Deformed and staked cemented slabs control the plumbing system characterized by carbonate-coated cavernous structures (up to 25-30 cm^2 in size).

The top part of these large voids terminates with chimneys indicating more focussed vertical seepage of gas. At these sites carbonate thickness and vertical deformation is prominent and positive relief and high concentration of microbial mat are observed on sea floor. "Chimney like" tubes (up to 5 cm in diameter) were also observed in the subsurface forming a network that extends horizontally indicating that fluids seep vigorously not only on a vertical mode. All these features are commonly coated by microbial colonies of differing colours (i.e. whitish, yellowish, pinkish). Inside these thick mats millimetre scaled layers of calcite were observed forming distinct horizons.

In the laterally extensive slabs carbonate precipitation occurs prevalently along the coccolith-rich layers of Unit 1 where pyrite framboids are highly concentrated. The large cavernous features in the subsurface are almost entirely coated by large crystals of sparitic calcite.

Where fluids seepage is more active (e.g. chimneys) framboidal pyrite forms thick coats up to 1 cm.

Carbon isotope measurements on the authigenic carbonates reveal ^{13}C depletion varying from -27.4‰ to -36.7‰ and $\delta^{18}O$ from -0.8‰ to 0.2‰.

Observations reveal that considerable amount of free gas is seeping at these locations. The laterally extensive and impermeable clayey layers of Unit 1 were likely to impede the immediate release of significant amount of gas. The gas entrapped in the subsurface deformed the soft sedimentary layers forming large voids areas where microbial colonies were growing inducing the precipitation of carbonate minerals via AOM. Since seepage of fluids at the seafloor could not cope with the amount of gas rising from depth, the subsurface plumbing system had to further adjust forming complex networks of tubes, pipes and cavernous structures that extend laterally.

THE BLACK SEA AND RESOURCES: ECOLOGICAL ASPECTS OF ANOXIDAL SEDIMENT BASINS

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It is well known that with the help of geological methods one can model processes and past conditions on the Earch, as well as predict future changes. Geological history of the lithosphere is retained in sediment basins. On the basis of the comparative geological method, the Maykopian (Oligocene-Lower Miocene) sediments of the Black-Caspian Sea region are considered as ancient homologues of the Black Sea sediments also rich in organic substance formed under the condition of hydrogen-sulphides infections (N. Andrusov, A. Arkhangelski, N. Strakhov, L. Davitashvili and other).

Anoxidal physical-chemical conditions of the marine environment like in the Black Sea, the ability to accumulate organic substances, as well as multicomponental collection of chemical elements, lead to the fact that bottom sediments and marine waters of the zone under constant cereoxigenal infection, on the stage of sedimentogeneze become oversaturated with these elements. Later on with the lithogeneze, the basin deposits become a prospective resourse-carring source for forming hydrocarbons, ore and nonmetallic accumulations. As a whole, anoxidal sediment basins are presented as distinct "capturing" geochemical systems. In this connection the problem of studying and comparison of these two intercontinental marine basins (Oligocene and Holocene), with characterizing permanent hydro-sulphides injection of paleo- and contemporary deposits, of marine water and against the background of all these, the reconstruction of geodynamical changes is actual. The problem of decoding geochemistry of deposited formations which leads to understanding of evolution of biochemical, ecological, paleontological parameters and and forming mineral resources is of great importance.

ENVIRONMENTAL CONTROLS ON CARBONATE MOUND DEVELOPMENT ALONG THE EUROPEAN CONTINENTAL MARGIN

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Three mound areas on the continental margin of the Northeast Atlantic Ocean were visited during cruises with R/V *Pelagia* between 2000 and 2005; two on the SW and SE Rockall Trough margins and a mudvolcano area in the Gulf of Cadiz. In all three areas cold water corals are present on the mounds, but the areas differ strongly in geological setting, as well as in sedimentology and hydrography. Measurements of near bed hydrodynamics and watercolumn observations show that currents in mound areas have a major influence on the shape of the mounds and on the presence of living cold water corals. To investigate the water mass properties, free falling BOBO landers were deployed and (24 hour (jojo)) CTD stations and CTD transects were carried out near and at the mounds.

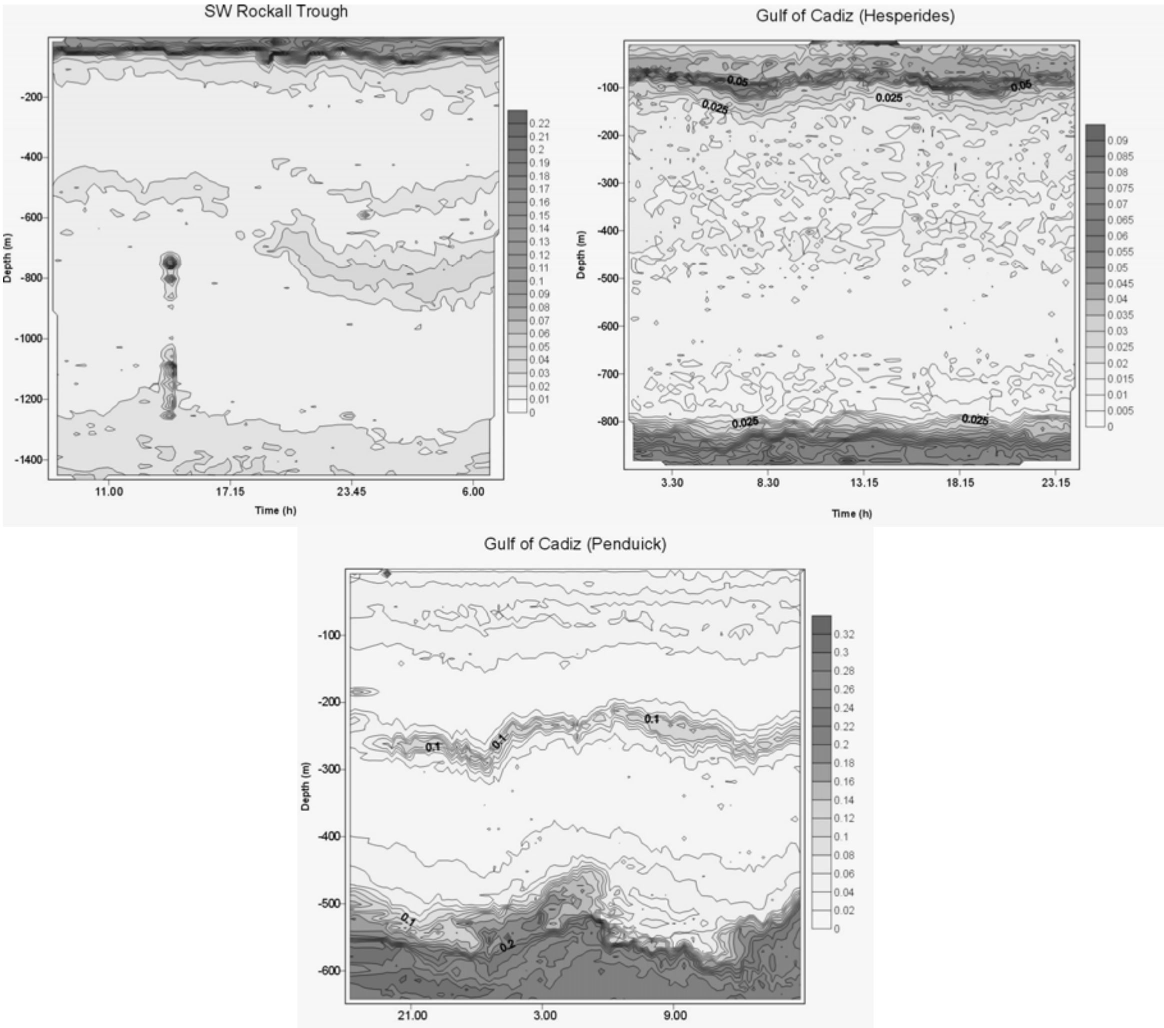

Figure 1. Turbidity profiles measured with 24 hour (jojo) CTD casts in three different mound areas, showing tidal currents, INLs and BNLs. Note different scale bars

At the SW RT Margin large mound clusters of several kilometres long and located between 600 and 900m water depth are observed on seismic profiles. Here a diurnal current caused by internal waves is measured with current speeds of up to 45cm/s. With increasing current speed the temperature and optical backscatter increase as well, resulting in considerable temperature variations of up to 3°C. A zone of high turbidity is found at the seasurface and between 700 and 800 m water depth, exactly coinciding with the depth of the peaks of the carbonate mounds. At the SE RT Margin mainly single mounds are found between 600 and 1200 m water depth. Here the mounds can be related to the presence of a BNL around 600 m water depth, which detaches from the seafloor, forming an INL, causing increased turbidity at this depth. Mound morphologies in the Gulf of Cadiz are related to a different tectonic setting, where some of the mounds structures actively vent gasses. In the Gulf of Cadiz single living coral colonies and coral debris has been found on the flanks of several small mounds of up to 60m high near the Penduick escarpment and at the Faro and Hesperides mudvolcanoes. Hydrographically the Gulf of Cadiz can be roughly divided in two areas. The northern area shows a water column with outflow of MOW below 800m depth. Near the Penduick escarpment the water column shows the presence of an internal wave with a 6-hour cycle that induces changes in temperature (~0.5°C), salinity (~0.05°/oo) and current velocity (peaks of ~15cm/s). Another striking difference is found in the optical backscatter of the water column: where in the northern area high surface production is present, shows the southern area an intense INL around 300m water depth.

While at the SW and SE RT margins a dense cover of live corals has been demonstrated, only isolated living colonies and coral debris covered with mud occur on the mounds in the Gulf of Cadiz, indicating that watermass properties and dynamics on the SW RT are at the moment most favourable for coral growth. High current velocities around the mounds (45cm/s) prevent the corals from sedimentation, while high productivity on top of Rockall and Porcupine Bank increases the food supply around the mounds.

SORPTION OF METHANE TO THE MINERAL PHASE OF MARINE SEDIMENTS: AN APPROACH TO DETERMINE THE QUANTITY OF SORPTION, ITS ASSOCIATED EXCHANGE DYNAMICS, AND CONSEQUENCES FOR BIOGEOCHEMICAL PROCESSES

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Dissolved and free gas and gas hydrates are well-studied pools of carbon in marine sediments. By contrast, the amount of methane and other low-molecular-weight hydrocarbon gases adsorbed to the sediment's solid phase is poorly constrained. To a holistic understanding of methane in the geo/biosystem, it is crucial to get a better idea of the quantities of sorbed gas and its geochemical processes while adsorption and desorption. Considering the adsorption of hydrocarbon gases and/or dissolved organic matter (DOM) to mineral particles, numerous geological and biogeochemical ques-tions arise. For example, sorption of dissolved organic matter is considered to be a major process in the preservation of organic matter in marine or other sediments (Kennedy et al., 2002; Kaiser & Gug-genberger, 2000; Baldock & Skjemstad, 2000). Clay minerals and their large internal surface area are discussed as the appropriate candidates for adsorption. The structure and mobility of aqueous and organic fluids in swelling clay minerals can be crucial for the location and migration of petroleum hy-drocarbons in the soil (Titiloye & Skipper, 2005). The role of sorption for both biologically mediated methanogenesis and methanotrophy is likely but not constrained. It is not clear which sedimentary components support the adsorption of methane. Three-layered clay minerals, such as smectites with the ability to swell, are likely adsorbents.

In this PhD-project, sediments from seep-environments from the Black Sea obtained during TTR15 cruise have been investigated. Concentration data of desorbed methane, ethane and propane, and their isotopic composition before and while desorption are being compared with laboratory desorption data. On-board analyses of dissolved hydrocarbon gases (see TTR15 cruise report), and the shore-based measurements of their carbon isotopic composition provide a basis to compare with data ob-tained from desorbed gases in the future. The quantity of desorbed gases is being investigated within a period of 4 to 6 month. An isotopic fractionation during desorptive processes is assumable. To date, the exact geochemical processes of sorption remain unclear. After 2 weeks of desorption, the investigated samples show a methane concentration of 0.5 to 1 mmol/g dry sediment. More gas is expected to come off the sediment after weeks and month due to highly basic conditions, according to the results obtained from ODP Leg 201 sediment samples (Hinrichs et al., 2003). An isotopic frac-tionation seems to take place while desorbing, but only a few samples could be measured so far; more data points are needed to confirm a fractionation.

The portion of methane (and other gases) sorbed to the mineral phase of marine sediments measured in this PhD-project will contribute to a comprehensive methane/gas budget for Black Sea sediments. Together with data on free gas, gas hydrates and dissolved gas measured with in-situ pressure technology (TTR15 cruise report); the distribution and exchange dynamics of methane between the four sedimentary carbon pools will be compiled in a complete gas budget in the future. The processes of adsorption and desorption of Black Sea sediments will be compared with other world-wide locations, such as the Gulf of Mexico, the Mediterranean Sea and others. Incubation experiments of methano-genic bacteria with the addition of different clay minerals are planned to figure out the interaction be-tween microbes and minerals.

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USE OF REMOTE TECHNIQUES FOR INVESTIGATION OF SEAFLOOR BILOGICAL COMMUNITIES OF THE KANDALAKSHA BAY, WHITE SEA

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This paper reviews recent investigations of the seafloor biological communities performed with remote techniques. Sidescan sonar imagery and high-resolution seismic profiling are used for mapping both separate contrast biological objects (laminaria, shell banks) and bottom sediments. Possibilities for biological interpretation of the sidescan sonar and seismic data are discussed, with the examples of first successful investigations of the subject. Advantages and disadvantages of different approaches are analyzed. Some general principles for using remote methods for marine

benthos research are proposed. The paper is illustrated by numerous examples from the Kandalaksha Bay, White Sea.

DE-NOISING OF TTR15 MARINE SEISMIC DATA WITH USE OF WAVELET ANALYSIS

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Seismic data obtained during the TTR15 show high level of noise. There are several possible reasons of this problem. First, the streamer was too close to the ship. Because of it the ship's working engine created essential noise. Second, it was possibly the influence of working equipment on board (50,100 Hz). The data demand suppression of noise.

Preliminary processing included: bandpass filtering, ensemble stack, and also, if necessary, alignment of amplitudes on all traces. For de-noising of our data we can use a wavelet analysis. As against the Fourier analysis, the one based on wavelet-functions allows to allocate not only frequency component of information, but also its position in the data.

The powerful arsenal for the suppression of noise has the MATLAB wavelet toolbox. Having applied the converter to sgy-file to make it clear for the toolbox, we can load data, take one separate trace and set a wavelet. The signal will be analyzed with this wavelet. Then we set a level of decomposition and type of visualization on the screen of wavelet-coefficients, and then could begin procedure of de-noising.

There are a number of possibilities for the set of parameters of de-noising. First of all we have selected the thresholding method. It is characterized by two types - soft and hard. We can zoom every fragment of a signal and set interval dependent threshold. After that we can see the signal before and after de-noising. The smoother wavelets create a smoother approximation of the signal. Vice versa, "short" wavelets keep better track of peaks of the approximable function. The depth of decomposition influences the scale of details to be discarded. In other words, with larger depth of decomposition the model subtracts noise of a larger level until the scale of details gets "overenlarged" and the transform begins distorting the initial signal shape. It is noteworthy that with further increase of the decomposition depth the transform proceeds to forming a smoothed version of the initial signal, i.e. not only the noise gets filtered out, but also some local singularities (peaks) of the initial signal. Having chosen optimum filtering, it is necessary to repeat all transformations for each trace of a profile.

The method allows to enhance resolution of seismic records and to reduce noise level.

DISTRIBUTION OF DEAD AND LIVING COLD-WATER CORALS IN THE GULF OF CADIZ (TTR 9-12, 14, 15 CRUISES)

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Coral build-ups are important reservoirs of marine biodiversity and are essential nursery habitats for many fish species. At the same time coral ecosystems are long lived, slow growing and fragile, which makes them especially vulnerable to any kind of damage.

During several TTR cruises to the Gulf of Cadiz many coral colonies were observed. Most of them seemed to be dead cold-water corals. But core samples and underwater TV data often showed twigs of living corals on the edges of dead ones. Here comes an actual question about the distribution of dead and living corals in the Gulf of Cadiz. Is there any regularity of distribution that can prove all doubts connected with the extinction of living coral constructions? Another problem illustrated in the report touches the relief peculiarities of corals: whether they are confined to some forms of relief or tend to form relief features themselves. In the end, there are several suggestments about the major coral habitat factors in the Gulf of Cadiz: whether corals thrive only on mud volcanoes in a particular depth range or they might be faced in other environments and in different depthrange conditions.

Current survey might be useful because we are still only beginning to understand the principal ecological aspects of corals, including the environmental factors (temperature, salinity, nutrition) and biological processes (reproductive biology, molecular genetics, predation, parasitism and bioerosion) which regulate their life and distribution.

Lophelia pertusa and *Madrepora oculata* are the most abundant habitat-forming, reef-building corals. We faced these coral forms during the Gulf of Cadiz surveying. Thus we are able to compare digital video and still images gathered by underwater TV surveying and some coring results with any disposable data concerning concrete coral forms.

The first glance on digital data provides an opportunity to distinguish the common settlements of coral constructions: mostly rigid surfaces (mud breccia, carbonate crusts, various debris features).

Corelogs often show coral rubble features, confined to debris flows or mud breccia occasions on slopes of mud volcanoes (TTR12, AT-413G). On the other hand, coral debris is often inserted in highly bioturbated clayish matrix (TTR12, AT-414G) or represented in sandy sediments (TTR14, AT-351G).

Underwater TV observations showed a lot of evident indications for dead coral constructions. But in some occasions probably alive features were situated above dead ones.

Most scientists suggest that coral features survive only in mud volcano fields of the Gulf of Cadiz. It might be proved by favourable conditions for cold-water corals. But several TV-lines taken near the shelf part of the Gulf of Cadiz (Vernadsky ridge) and in some absolutely leveled surface areas (approaching Meknes mud volcano) also have also shown the presence of corals.

But the most designing question regarding the distribution of cold-water corals in the Gulf of Cadiz is driving motives for their throughout extinction. There are some main natural threats for coral mass mostly induced by climate change, for example, episodes of higher than normal sea temperatures leading to more widespread and lethal coral bleaching. Temperature changes might be caused by water discharge from the Mediterranian Sea. The salinity of this water does not match the normal level of salinity in the Gulf of Cadiz.

ELIMINATION OF MULTIPLES ON SINGLE-CHANNEL SHALLOW-WATER SEISMIC DATA

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When water depth is smaller than subbottom depth of the target horizons, multiples can interfere with primaries hindering interpretation of the off-shore seismic data. Fig. 1 shows an example of such a situation. There are a number of techniques aimed to eliminate multiple reflections which have been elaborated in both on-shore and off-shore seismics (Denisov et al., 2002). All these techniques can be divided into two groups: (1) travel-time based wave discrimination, and (2) modeling of multiples with subsequent subtraction of the modeled wave field from the real one. Subtraction includes adaptation of the model to the observed data. This paper demonstrates that implementation of the latter approach is suitable for application to single-channel marine seismic data.

Modeling of multiples. There are two different approaches to modeling of multiples. The first one (Delft project) lies in modeling of all multiple reflections related to a free surface and does not require knowledge of the velocity model of the media. The second approach assumes that the velocities down to the multiple generator are known. Both approaches are based on a possibility to evaluate an observed wave-field in a model of multiples, using the fact that the multiple wave comes up to the free surface, reflects from it, and then goes down back to the media, while when on the surface it is registered by seismic receivers which are densely enough located.

Talking about single-channel seismic profiling, the first approach would lie in using of auto-convolution of a trace with removed direct wave as a model of multiples. This would model all possible multiple reflections. The second approach in case of single-channel seismics can be used for instance for modeling of the sea-floor multiples. For that, shifting of the recorded wave-field on the arrival time of the bottom reflection is enough.

Subtraction of multiples. Obviously, the above mentioned modeling approaches would result in the modeled reflections with wrong wavelets and not very precise arriving time. Thus, the main problem to be solved is the adoptive subtraction of such a model from the real wave-field.

The modeled wave-field is adopted by a dedicated shaping-filter calculated through the least-square method. As a matter of fact, this filter is multichannel, with the additional channels used for its calculation and subsequent convolution being evaluated from the initial trace by adding parametrized time-domain nonstationarity. The nonstationarity is defined through multiplying the initial trace by time polynomials. Construction of such a filter is discussed in detail in the paper by Poluboyarinov and Finikov (2006).

Fig. 2 shows the result of applying the described algorithm to the seismic section shown on Figure 1. The multiples have been efficiently eliminated without significant disturbance of the primary reflections.

Conclusions. A relatively simple and efficient technique of elimination of multiples on the single-channel off-shore data has been proposed. The efficiency of the technique is demonstrated on the shallow-water data from the Barents and Black Seas.

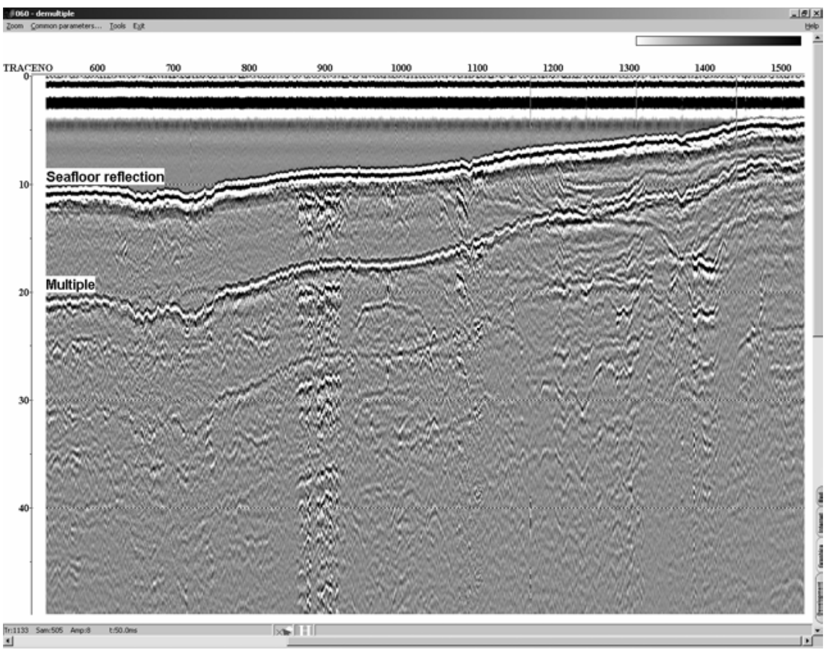

Figure 1. Seismic section with multiples interfering with target reflections

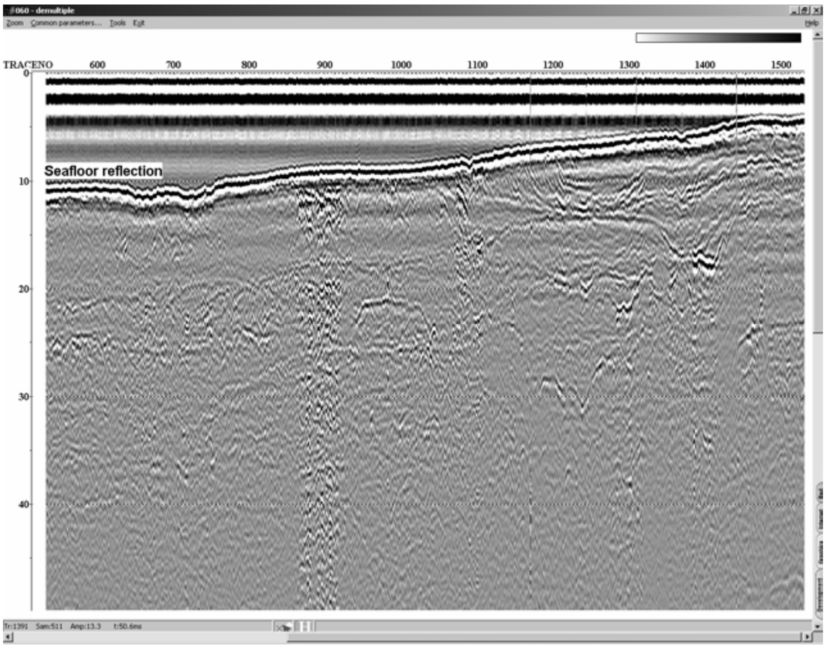

Figure 2. Seismic section from Figure 1 after elimination of multiples

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THE STRUCTURE AND FORMATION OF COMPLEX POCKMARKS IN THE NYEGGA AREA, MID-NORWEGIAN MARGIN

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The Nyegga area is located on the mid-Norwegian margin in a region characterized by major landslide excavations and deposits (the Storegga Slide), fault scarps, and pockmarks. Shallow free gas and gas hydrate deposits are also present in this area. Detailed interpretation of industry-standard 3D seismic data reveals the presence of numerous pipe structures imaged as vertical cylindrical zones with disrupted seismic facies. We have mapped 68 pipes in the Nyegga area. Most of these pipes terminate at the seafloor, whereas 10 pipes are classified as buried. The typical pipe diameter is a few hundred meters. All pipes are located in the northernmost part of the survey area, outside the region directly influenced by the Storegga Slide.

Seismic attribute maps (amplitude and dip) of the seafloor show that most pipes are characterized by very high-amplitude seafloor reflections and minor or no depressions. Almost all pipes are located in a region with a very high-amplitude shallow reflection (B1). This high-amplitude event likely represents free gas beneath the gas hydrate stability zone. The pipes are clearly defined as domes on the B1 dip attribute map. Most pipes seem to originate from depths of

500-1000 m beneath the seafloor (B3 and B4 levels). However, special seismic processing is required to determine if some of the deep seismic disturbance is due to overburden effects.

Four pockmarks (A, C, G8, G11) located a few kilometers north of the interpreted 3D cube have been surveyed and sampled during three ROV cruises in 2003 and 2004. The key characteristics of these pockmarks are:

- rounded and elliptical depressions with diameters of 200 to 300 m,
- up to 10 meter high carbonate ridges in the central parts,
- a distinct fauna with tubeworms, stalked crinoids, pycnogonids (sea spiders), and possibly bacterial mats,
- the presence of light hydrocarbon gases (C1-C5) in clay-rich sediments, and
- no fluid flow was seen during a two-day observation period.

Three carbonate samples from pockmark G11 (G11-A, G11-B, and G11-C) have been analyzed in detail. XRD analyses show that the major carbonate phase is aragonite. There are however structural and compositional differences between the samples. Sample G11-A shows three main stages of mineralization. Aragonite and Mg-calcite precipitated before a later stage of fibrous aragonite formation. Zoned Mg-calcite and dolomite crystals are common. Samples G11-B and G11-C also contain three distinct zones. The first two stages are represented by micritic carbonate and/or aragonite with a high clastic content. A later stage with fibrous aragonite cement is also recognized. The carbonates in the samples suggest a first phase of calcite and/or fine gained aragonite precipitation followed by at least two stages of fibrous aragonite growth. This zonation is likely caused by precipitation at different depths below the seafloor. Iron oxide rims on pyrite show that the carbonate rocks have been exposed to varying red-ox conditions. This documents an uplift of the carbonate to the seafloor and exposure to oxidizing seawater.

Isotope analyses show a coexistence of low $\delta^{13}C$ (-52 to -49 ‰ PDB) aragonite together with pyrite. This suggests that the carbon was derived from oxidation of biogenic methane, most likely sourced from gas hydrates. The carbonate precipitated in the seawater sulphate reduction zone at shallow depths (commonly <10 m). The Sr isotopic composition of the aragonite ($^{87/86}Sr$ = 0.709) suggests that the cations in the carbonates were derived from seawater. The oxygen isotopic composition of the waters that precipitated the aragonite was enriched in ^{18}O (about 0.30 to 2.0 permil) compared to normal seawater. A similar enrichment is commonly found in areas where carbonates are associated with gas hydrates.

We propose the following qualitative model for pockmark and pipe formation in the Nyegga region:

- pipes originate at different stratigraphic levels - many as deep as the Kai Formation,
- pipes were formed rapidly by explosive eruptions,
- landslide processes, pipe/pockmark formation, and bottom-simulating reflection (BSR) formation are likely related processes,
- a link between these processes is pressure build-up possibly related by sea-level changes,
- earthquakes, severe weather changes, and/or bottom-water temperature increases may have facilitated pipe formation,
- seep activity in the pipes goes on for 100's of years after the pipe formation leading to precipitation of methane-derived aragonite within the sediments, and
- the pockmarks are currently dead or with low seep activity.

GEOCHEMICAL PRECONDITIONS OF OIL-BEARING STRATA ON THE WESTERN GREENLAND MARGIN

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West Greenland has been perspective object for searching of hydrocarbons for the last 30 years. Oil seepages are widely spread on northwestern Disco and Nuussuaq, central part of West Greenland. Geochemical analyses suggest existence of several petroleum systems in the underlying Cretaceous and Paleocene fluvio-deltaic to marine sediments and even in the deeper strata. Thus, the tasks of investigation during the 4th Leg of the TTR13 cruise (2003) was concerned to searching of possible indications of hydrocarbon fluids unloading to the sea bottom and investigation of source-rock formations on the western Greenland margin. A collection of rocks from the outcrops (presumably, original deposits) was gathered and investigated.

Depositional environments and sedimentation history of the studied rocks have been interpreted from organic geochemical data (extraction, GC, MS, pyrolysis Rock Eval, bituminological analysis), lithological investigations and age determination. Igneous rocks were studied in order to verify possible migration of oils through them. As a result, in the studied basalts allochtonous bitumoid ($\beta \rightarrow 100\%$), probably migrated from the underlying sedimentary sequence was found.

Sedimentary samples observed are represented mainly by gray to dark gray high maturity limestones with clayey-silty admixture, and by carbonate clays, siltstones and sandstones. TOC content is changing in different samples from 0,1% to 0,7%. By Rock-Eval data practically all the rocks have low genetic potential S1+S2 (0,1-0,41 $^{kg,\ HC}/_{t,\ rock}$). HI=10-500 $^{mg,\ HC}/_{TOC,\ g}$, PI=0,02-0,38; Tmax varies from 410 to 450°C with minor deviations - therefore thermal maturity of the source rocks is low, corresponding to the upper part of the oil window or even less. MS investigations showed that practically all the samples are situated in the area of marine OM with admixture of continental OM. Differences are observed in Ordovician black clayey limestones: S1+S2=3,2-16,5 $^{kg,\ HC}/_{t,\ rock}$; TOC=0,8-3,2%, Tmax=429-432°C. By character of n-alkane distribution we can assume first stage of bitumoid biodegradation. Pr/Ph=2,6, the chromatogram is characterized by large quantity of Pr and Ph. Pr/nC17==2,4; Ph/nC18=1,85 ratios tells about OM of mixed origin. Ro=0,81 - 0,83 and Ki ratios approve that these rocks are situated in the upper part of the oil window.

Concluding, litho-geochemical investigations allowed to characterize practically all the rocks from the studied stations to be with low oil-gas-generating potential. But in the studied strata there is layer (layers) of Late Ordovician with high oil-generating potential characterized by the samples with high TOC content and high HI value (up to 488). Clayey-limestone rocks of this type are characterized by mixed kerogen with continental admixture, thermal maturity is corresponding to the upper part of the oil window. Oil-and gas-generating potential of these rocks could be estimated as high (7,9 - 48,2 $^{mg,\ HC}/_{g,\ TOC}$). So presumably such rocks in the basins of the Labrador Sea and West Greenland can generate both gaseous and liquid hydrocarbons nowadays. Such implications are very encouraging for future exploration offshore Labrador and West Greenland, since it demonstrates the source rock capable to generate liquid hydrocarbons exists in the region and contradicts the idea that this area is being only gas-prone.

COGENETIC DISTAL TURBIDITY CURRENT DEPOSIT DOCUMENTS THE 30 DECEMBER 2002 TSUNAMIGENIC LANDSLIDE OF STROMBOLI VOLCANO (AEOLIAN ISLANDS, ITALY)

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On 28 December 2002, an effusive eruption started at Stromboli volcano from vents opened on the NW flank at about 600 m a.s.l. inside the horseshoe-shaped depression of the Sciara del Fuoco (fig 1) (SdF).

Since the very early stage the effusion was accompanied by substantial seawards displacement of the SdF slope due to intrusion of lava into the infilling loose material (Tommasi et al., 2003). Lava emission and slope movements progressed on 29 December 2002 and culminated on December 30, in a submarine slide, followed by a subaerial one with a total volume of 25-30*10^6 m^3(La Rocca et al., 2004). Both slides detached from the NW flank of the volcano producing several minutes-lasting tsunami waves (Tinti el al., 2005). After about five minutes the tsunami wave reached the north-eastern coast of the island with a maximum run-up of 10 m and a maximum flooding of 100 m causing severe damage to Stromboli village and to the neighboring islands (Maramai et al., 2005).

Deposits of the 2002 landslide in both its distal and proximal facies were investigated during the R/V *Prof. Logachev*, TTR14 and TTR15 MS cruise, in September 2004 and in July 2005, by means of a 30/100 kHz MAK1 high resolution deep-towed sidescan sonar system with subbottom profiler (3.5-7 kHz) and a deep-towed digital video survey system. Preliminary results indicate that thickest, coarse-grained proximal landslide deposit extends over an elongated area facing the SdF, at water depths between 1600 and 2000 m at a distance of 6 to 8 km from the

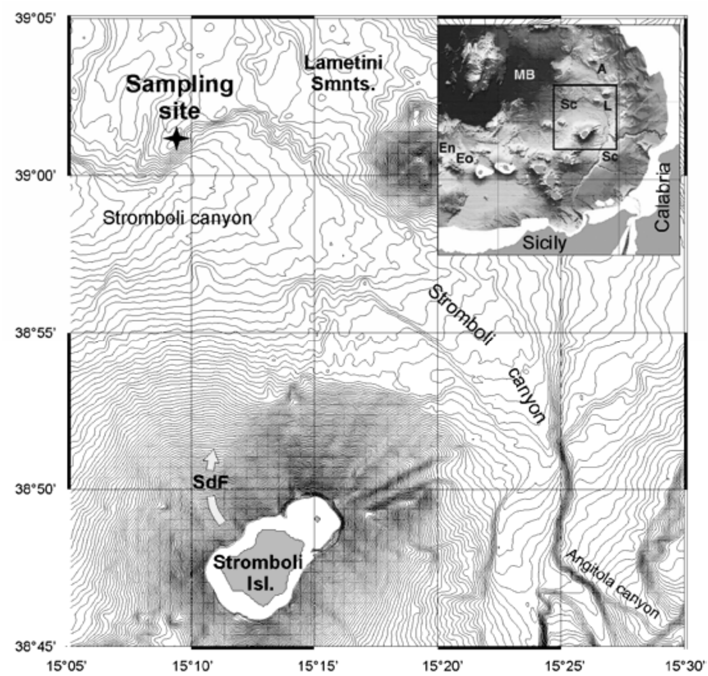

Figure 1. Multi-beam bathymetry of the main features of the submarine sedimentary system of Stromboli area and the sampling site. Upper inset shows the location of Stromboli Island in the South Tyrrhenian sea

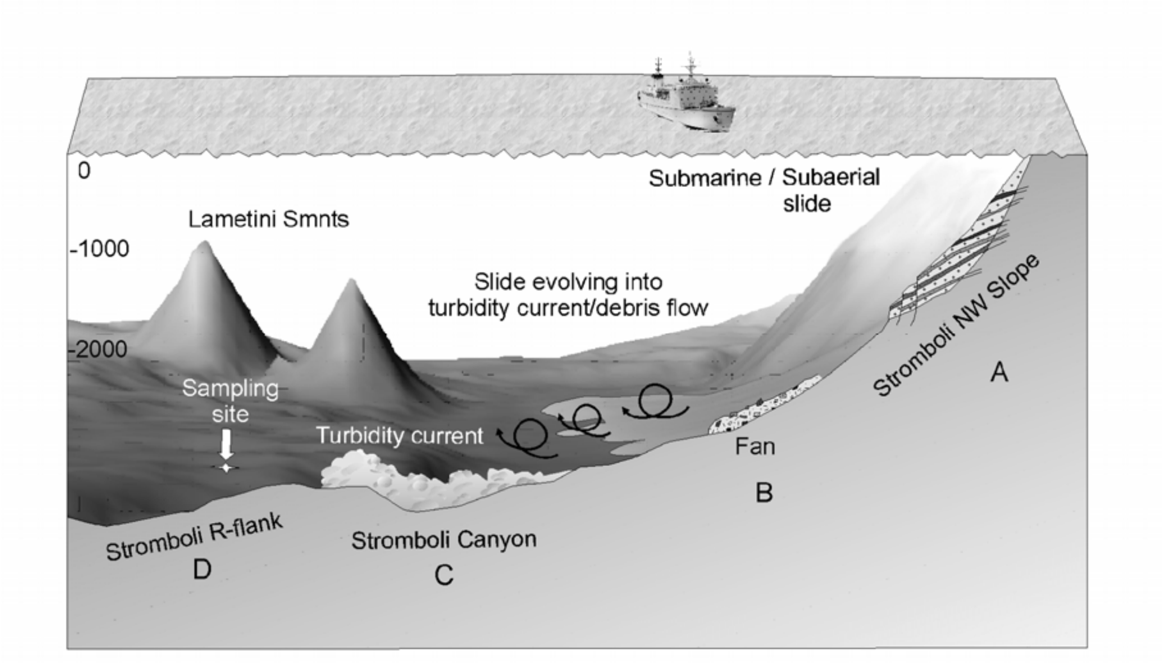

Figure 2. The likely model of formation of the volcaniclastic turbidite deposit, on the right flank of Stromboli canyon. a) Accumulations of unstable volcaniclastic material (lava flows and loose volcaniclastic sediments) on the NW flank of Stromboli volcano collapse when perturbed (ex: magma dike intrusion, gravity instabilities, earthquake activity…) , resulting in a sub aerial-submarine landslide inside the Sciara del Fuoco depression, b) the slide consist of a coarse grained debris avalanche, accumulating on the sedimentary fan covering almost the whole NNW volcano flank c) coarse deposit evolves in a high energy turbidity currents down the volcano slope d) thanks to their great mobility the turbidity currents override the 200 m-high flank of Stromboli Canyon deposing the volcaniclastic turbidite sequences

shoreline (Marani et al., 2005). The deposit consists of a mainly chaotic assemblage of fresh, massive and scoriaceous lava blocks that contrasts with the surrounding seafloor in being completely devoid of a hemipelagic sediment cap. The coarse-grained deposit grades downslope and laterally to black volcaniclastic sand often arranged in ripple bed forms. Several sites were sampled with box cores during the 2004 cruise. In particular, a sample was collected in a site that had already been cored during the VST2002 cruise aboard R/V Urania of the Italian National Research Council, in September 2002, three months before the December 30 slide.

The site is located on a flat area on the right side of the Stromboli canyon about 200 m above the canyon floor along the path of the landslide (fig.2) (Gamberi et al. in press). Box coring sampled a sediment sequence (fig.3) capped by a 2-3 cm-thick sandy layer. In the same sampling site, the topmost sandy layer was not present in September 2002. Sedimentological (grain size analysis, componentry) and compositional features (volcanic glass and crystals) of the layer indicate that it is a thin turbidity current deposit likely representing the distal equivalent of the 2002 landslide. An important result of this study is the identification of a marine site, in which turbidity current deposits effectively record the larger landslide events of the SdF with volumes greater than tens x106 m3. The site is in general characterized by hemipelagic deposition that is punctuated by discrete turbidity current deposits cogenetic of the landslides. This depositional setting is at variance with that of the area facing the SdF where the input of volcaniclastic material, is continuous also in periods of volcano stability.

Deeper corings in this site will provide identification of past turbidity current events and will eventually give us the opportunity to identify the relative scale of that events by comparison with the well documented 2002 event. This study shows that material of the 2002 deposit has

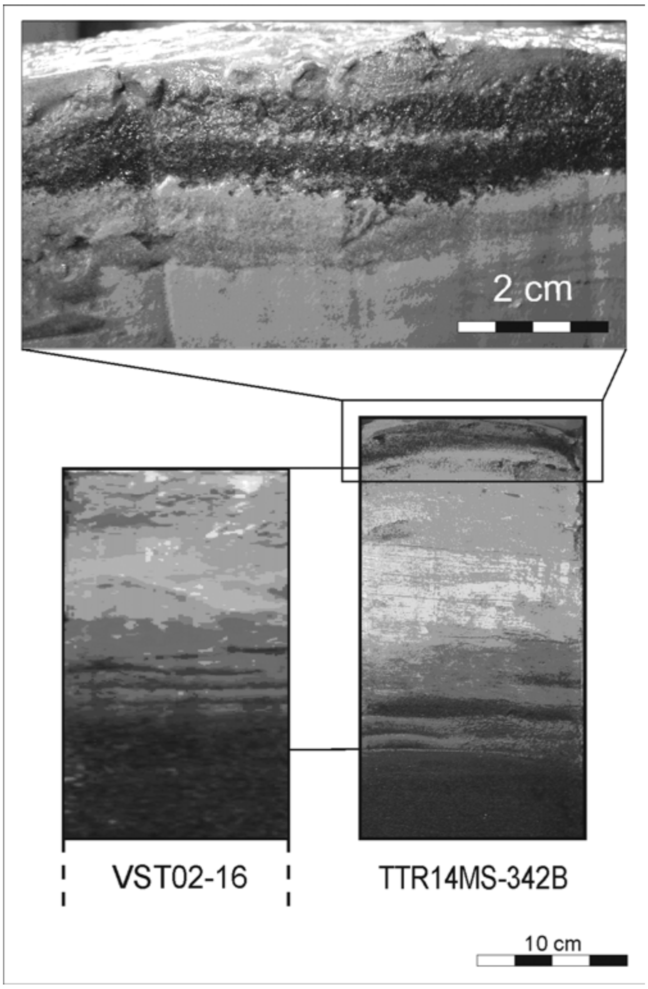

Figure 3. Stratigraphy of cores collected on the right side of Stromboli canyon. (a) VST02-16 gravity core sampled about 4 months before the Dec. 30, 2002 Stromboli landslide; (b) TTR14-342 box core sampled about 2 years after Dec. 30, 2002 Stromboli landslide. (c) Detail of the 2-3 cm-thick topmost layer of fine-medium sand interpreted as the turbidity current deposit of the Dec. 30, 2002 Stromboli landslide. Note: the deformation of the upper part of the core is due to sampling

composition that tightly matches that of the parent landslide thus a similar relationships can be expected for older events; considering that Stromboli has been characterized by significant variation through time of the composition of volcanic products (Hornig-Kjarsgaard et al., 1993), the identification of eventual past turbidity current deposits in deeper penetration coring, will provide a further opportunity to assess the age of different landslide events.

The relationship between on-shore slope failures and landslide deposits on active volcanic islands has proved particularly controversial for the scarce preservation of landslide scars due to their burial under younger volcanic deposits. Our study stresses the potential of the marine environment in recording landslide events as the turbidites that characterize the distal deposition of collapse-derived fine-grained products.

The research shows that the complete documentation of past potentially tsunami-producing landslide events of Stromboli is possible and opens new perspectives for the assessment of the tsunami hazard in the Southern Tyrrhenian Sea.

GAS SEEPAGE AT BATUMI SEEP OFF GEORGIA: RESULTS FROM ROV INVESTIGATIONS

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The first evidence for gas seepage at the continental margin off Georgia in the eastern Black Sea was based on hydroacoustic anomalies ("gas flares") recorded by echosounding systems from vessels. During the R/V Poseidon cruise 317/4 the area with gas flares was mapped by multibeam swath bathymetry and sidescan sonar (Klaucke et al. 2005). Gas flares were detected in the real-time display of the backscatter data. The processed data show distinct backscatter facies in an area of 500 to 900 m associated with the gas emissions at water depth of about 850 m. Samples taken by gravity corer revealed the presence of gas, gas hydrates and carbonates in near-surface sediments in the area named Batumi Seep.

During TTR15 cruise on board R/V *Professor Logachev* the seeps were explored using the German ROV Cherokee performed by the Research Center Ocean Margins (RCOM) at the University of Bremen. Three dives were conducted at Batumi Seep and an additional high-backscatter feature in the direct vicinity named Kobuleti Seep. The dives gave a very new insight into the process of methane seepage. Most remarkably, we found several individual sites of gas escape. The intensity varies between a few released bubbles every second to a very vigorous stream of bubbles of about 20 cm in diameter (named "Bubble Hole"). The smaller streams escape from the seafloor which is perforated by holes of a few centimetres in diameter. We interpret these holes as evidence for recent to sub-recent seepage activity. Only a few of these holes showed active bubble escape during our observations. The vigorous escape site Bubble Hole was located in a disturbed seafloor area. This is probably the surface expression of a fault system imaged by sidescan sonar.

The ROV-mounted horizontally looking sonar system (frequency 325 kHz) was a powerful tool to detect gas. The sonar is normally used to image the seafloor morphology. For detecting gas bubbles the ROV was moved above the seafloor until the seafloor morphology was not visible anymore. The gas bubbles, however, showed up as very strong reflections in the water column. It was very easy to move with the ROV to these sites and follow the stream of bubbles down to the seafloor. We used the sonar to map large areas of Batumi Seep and found that many individual gas streams occur in this area.

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DISTRIBUTION, ACTIVITY, AND DIVERSITY OF MICROBIAL COMMUNITIES FROM SEDIMENTS OF THE MUD VOLCANO MERCATOR (GULF OF CADIZ)

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During the TTR15 cruise to the Gulf of Cadiz, in July-August 2005, microbial communities from the crater, slope and base of the mud volcano Mercator were studied along vertical profiles. The bacterial communities were characterized in terms of abundance, living biomass, enzymatic activities and phylogenetic diversity. The enumeration of viruses was also attempted.

Samples from down to 1 m below sediment surface were obtained from box-cores. Total microbial number was determined by epifluorescence microscopy after staining with acridine orange (Hobbie et al., 1977) and living microbial biomass was estimated from the ATP concentrations determined by the luciferine-luciferase method (Karl and Craven, 1980). The composition of the communities of bacteria and archaea in sediments from the volcano crater was assessed by fluorescence in situ hybridization (FISH) using oligonucleotide probes (DSS658) for the bacterial group *Desulfosarcina-Desulfococcus* (Manz et al., 1998) and for the archaeal groups ANME-1 and ANME-2 (EelMSMX932) (Boetius et al., 2000), as well as general archaeal (Arch915) and bacterial (Eub338) probes (Amann et al., 1990). Viruses were counted by epifluorescence microscopy after staining with SYBR Gold (Fischer et al., 2005). Potential rates of ectoenzymatic activities involved in the degradation of polymeric substrates were analysed in sediment slurries as the maximum hydrolysis rates of model substrates (Boetius et al., 2000).

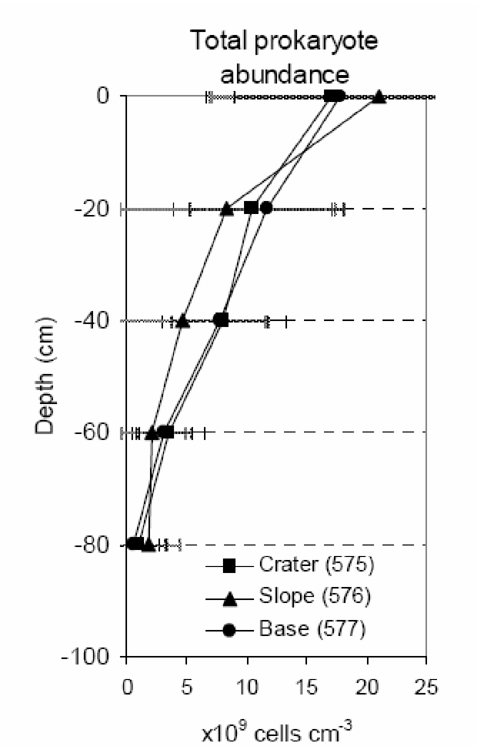

Figure 1. Depth profiles of total prokaryotic abundance (AODC) at the crater, slope and base of the mud volcano Mercator

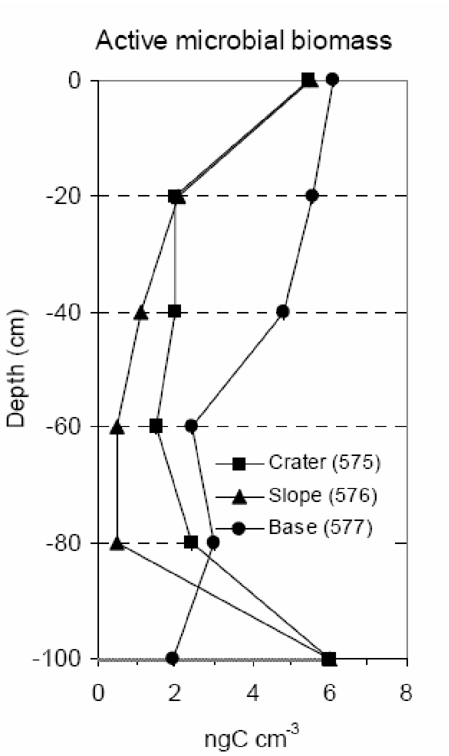

Figure 2. Depth profiles of active microbial biomass at the crater, slope and base of the mud volcano Mercator

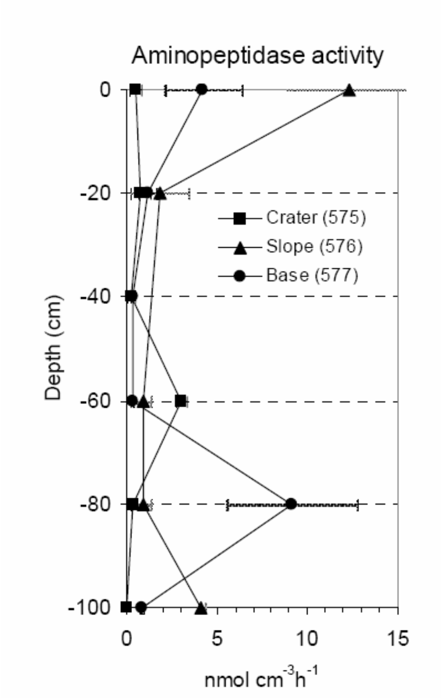

Figure 3. Depth profiles of aminopeptidase activity at the crater, slope and base of the mud volcano Mercator

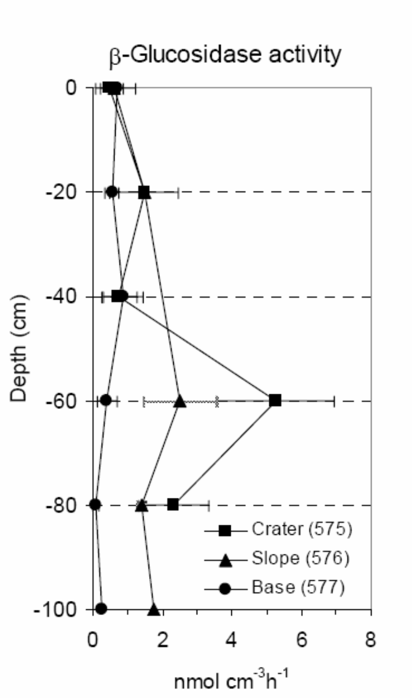

Figure 4. Depth profiles of b -glucosidase at the crater, slope and base of the mud volcano Mercator

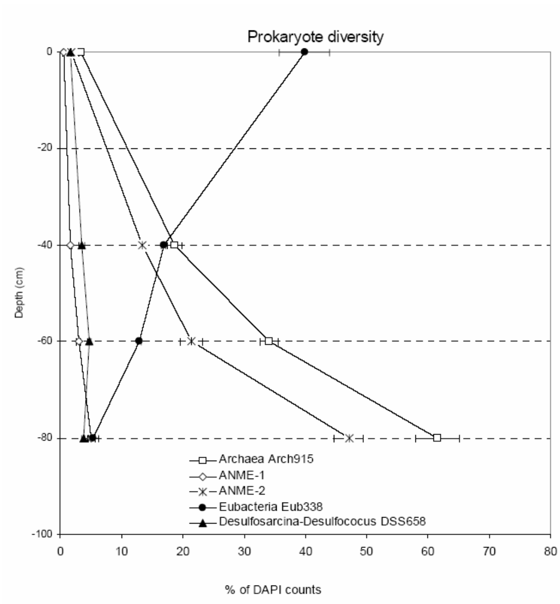

Figure 5. Depth profile of the relative abundance of relevant prokaryote phylogenetic groups determined by FISH, as percentage of total cells stained with DAPI, at the crater of the mud volcano Mercator

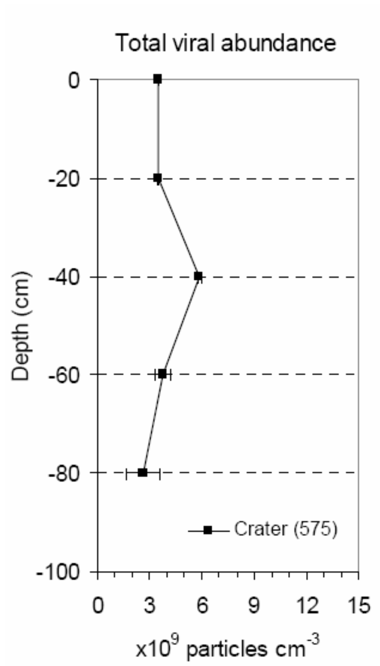

Figure 6. Depth profiles of total viral abundance (SYBR Gold counts) at the crater of the mud volcano Mercator

Total cells counts (0.60-21.0 x 10^9 cell cm^{-3}) (Fig. 1) and total living microbial biomass (0.5-6.1 ngC cm^{-3}) (Fig. 2) configure a vertical pattern of decrease of microbial abundance with increasing depth. However, at the crater and at the base, the profiles of living biomass show an inflection towards higher values that is not observed in the profiles of total cell abundance. The rates of aminopeptidase activity ranging 0.3-12.3 nmol cm^{-3} h^{-1} (Fig. 3) and β-glucosidase activity ranging 0.1-5.3 nmol cm^{-3} h^{-1} (Fig. 4) were generally higher in surface sediments but marked peaks of activity between 60 and 100 cm below sediment surface also occurred denoting a change in potential heterotrophic activity of the microbial community at these sediment levels.

The detection of the domain specific sequences Eub338 (Bacteria) and Arch915 (Archaea) varied between 35.6 and 66.9% of the total DAPI-stained cells (Fig. 5). Bacteria (Eub338) decreased with increasing depth (5.4-39.9% of DAPI-stained cells detected). In contrast, the detection of Archaea (Arch915) increased with increasing depth (3.4-61.6% of DAPI-stained cells). The number of cells detected with the oligonucleotide probe targeting *Desulfosarcina-Desulfococcus* bacterial group (DSS658) varied between 1.7 and 4.8% of the total DAPI-stained cells, the lowest value was observed at surface and the highest value at 60 cm of depth. The number of cells detected with probes targeting the archaeal AMNE-1 (0.6-5.2%) and AMNE-2 (1.8-47.1%) groups increased with depth (Fig. 5). Viral abundance in the crater ranged from 3.47-5.86 x 10^9 particles cm^{-3}, showing a peak at 40 cm below sediment surface (Fig. 6).

Total cell numbers and rates of enzymatic activities in mud volcano sediments show values that are similar to other marine sediments. Total cell numbers consistently decrease with depth. However, the peaks of aminopeptidase and β-glucosidase occurring at deeper sediments indicate that there is a shift in the heterotrophic potential of sub-surface communities, probably responding to changes in the availability of organic substrates. ATP values show that living biomass in these sediments in lower than in other marine sediments. This may indicate that many of prokaryote cells counted on the microscope are dormant or dying cells. The vertical profiles of bacterial and archaeal distribution in the crater sediment were similar to other sulphate and methane rich sediments. The *Desulfosarcina-Desulfococcus* bacterial group comprised only less than 5% of the total DAPI-stained cells. The AMNE-2 group was the most abundant archaeal group.

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A SURVEY OF PROKARYOTIC DIVERSITY IN SEDIMENTS FROM TWO GULF OF CADIZ MUD VOLCANOES, AS REVEALED BY CULTURE-DEPENDANT AND CULTURE-INDEPENDENT METHODS. PRELIMINARY RESULTS FROM TTR15 LEG 4

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Submarine mud volcanoes are an interesting type of cold seep environment where argillaceous sediment, hydrocarbons and other reduced compounds are channelled upwards from significant depth to the seafloor. At some of these seep sites geosphere energy sources are utilized by a variety of highly-specialised chemosynthetic microorganisms, which through a series of metabolic reactions, provide the energy basis for a ecosystem of higher organisms. Observations of the macro- and mega fauna indigenous to specific mud volcanoes in the Gulf of Cadiz area have revealed notable differences (Cunha et al. 2003), which are interpreted as reflecting different mud volcanoes' physical and geochemical characteristics. How the chemosynthetic microorganisms themselves differ according to a mud volcano's characteristics has not been studied and to investigate this was a major aim of the study presented here.

Further to previous sampling of material from the Captain Arutyunov and Bonjardim mud volcanoes on board the R/V Sonne Dec 2002, new samples were collected on board the R/V *Professor Logachev* during Leg 4 of TTR15, which re-visited the same area. The sampling campaign on Leg 4 was designed to allow an investigation of how prokaryotic community structure may change spatially across a transect of a mud volcano (crater, flank and off flank), and also to allow a comparison between two physically and geographically distinct mud volcano vents.

Sediment sub-cores were taken aseptically from several depth horizons from the ~750m water depth Meknes mud volcano on the Moroccan margin (transect of samples) and the newly discovered ~4,000m water depth Porto mud volcano on the Portuguese margin (crater only).

Direct microscopic cell counts (Acridine Orange staining, AODC) were conducted to both estimate cell abundance and characterise the morphotypes present. The results generally showed cell numbers to be lower than would be predicted for the sediment's in situ depth when samples were from mud breccia units, which is consistent with the mud breccia having a much deeper source. Counts at the boundary of the upper predicted limit were recorded from the near surface site within the Meknes crater, which may reflect a horizon of stimulated prokaryotic activity, as this is where substrate and efficient electron acceptor availability is presumably highest. Observation of cell morphotype revealed some very unusual filamentous cells, which have not been previously reported for submarine sediments.

DNA was extracted from several horizons through four different sediment cores using a modified protocol and analysis of the visual intensity of the extracted DNA showed good correlation with relative cell abundance as determined by AODC. The bacterial 16S gene was successfully amplified by Polymerise Chain Reaction (PCR) from the sediment DNA and the products were screened by Denaturing Gradient Gel Electrophoresis (DGGE). DGGE screening revealed a relatively low bacterial diversity, which is consistent with previous findings. Comparison of the profiles from the transect samples taken across the Meknes mud volcano, suggests different organisms dominate different horizons, according to both sediment depth and relative location to the crater. Sequencing of 16S genes from the different DGGE bands will reveal the identity of the dominant bacterial community and allow inferences to be made regarding their function. Comparison of the DGGE profiles from the deep water Porto mud volcano samples suggests different communities from those present at Meknes, and ones which differ from that of a near by 'off mud volcano' reference core. Again gene sequencing is necessary to identify the dominant species and draw conclusions as to their environmental function.

Enrichments targeting various metabolic groups of interest were set up in defined anoxic medium, some of which have successfully yielded significant growth. It is noteworthy that the greatest number of positive enrichments occur from crater (as opposed to flank or off-mud volcano) sites, where the greatest energy supply is expected. The organisms present in the enrichments will be identified by 16S gene sequencing and isolation and characterisation conducted for environmentally-relevant and interesting organisms.

Radio-labelled isotopes were injected into sediment minicores and incubated under in situ conditions to measure potential activity of CO2 methanogenesis, acetoclastic methanogenesis and thymidine incorporation. Processing of these samples is still underway but will provide valuable information regarding the potential of the prokaryotic community to perform metabolic reactions capable of modifying mud volcano fluxes, while thymidine incorporation will indicate the potential population growth of the heterotrophic component of the community.

Once completed the microbiological data will be synthesised with geochemical and geological data to attempt to understand the environmental control on prokaryotic diversity, how their activity modifies mud volcano fluxes and their impact on chemosynthetic benthic communities.

Acknowledgements: The authors wish to acknowledge HERMES for funding the sample collection and also the kind help received on board the R/V *Professor Logachev* from fellow participants of Leg 4.

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IMAGING MUD VOLCANOES AND TECTONIC STRUCTURES IN THE GULF OF CADIZ - FIRST SEISMIC RESULTS OF TTR15/4

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During the cruise TTR15/4, 15 seismic lines were acquired in the Gulf of Cadiz on the Moroccan continental slope in water depths between 800 and 4000 m. The main target was to image several mud volcanoes as well as tectonic features with high-resolution seismics.

For this purpose the Bremen multichannel seismic system was used, which is especially designed to collect high-resolution seismic data. As main seismic source acted a Sodera GI Gun equipped with 2x1.7 l chamber volume. The multichannel seismic streamer includes a lead-in and 2 active sections of 50 m length each. Each section is subdivided into 8 hydrophone groups that finally 16 channels are available. To keep the streamer in a constant depth, 3 cable levellers (MTC Birds) were attached. The data acquisition was carried out with a new system designed at the working group marine technology/environmental research at the University of Bremen. The data were recorded with 4 kHz sample rate over lengths of 4-6 seconds.

Altogether, 7 mud volcanoes were imaged on TTR15/4. The seismic data allow to describe the architecture and internal structure of the mud volcanoes, which differ significantly. Also the stratigraphy of the sedimentary basins in between and faults are imaged in detail. In the southern profile at the shallower slope, a complicated sedimentary pattern is observed. Here, the slope is characterised by numerous faults, channels (partly filled) and diapiric structures. The sedimentary basins between the diapiric structures reveal several unconformities, suggesting that beside tectonics also bottom currents shaped this part of the Moroccan Slope. The profiles from the deeper water depths crossing faults in oblique angle, and the rough surfaces cause scattering of the seismic energy as well as side echoes and limit in that way the penetration. Beside the faults sedimentary basins with well stratified reflectors occur. Again, faults could be identified, and areas with nearly zero reflections suggesting a very rough surface which may explained by the existence of carbonate mounds there.

LITHOLOGICAL ASPECTS OF CARBONATE CHIMNEY FORMATION IN THE GULF OF CADIZ

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The main purpose of this work is to understand carbonate chimneys' formation in the Gulf of Cadiz based on the results of studied that have been carried out since the TTR11 (2001) cruise.

Carbonate chimneys are hydrocarbon-derived. They consist mostly of autigenic calcite, Mg-calcite and dolomite with admixture of iron oxides and terrigenous material.

Carbonate chimneys have been discovered in different parts of the world such as on the Oregon margin (1987), in the North Sea (1987), Gulf of Mexico (1994, 1997), Monterey Bay (1999), Kattegat straight (1992), Nankai Trough (1992), on the Otago continental slope (1997), Markan accretionary wedge (1996).

The first place in the Gulf of Cadiz where carbonate chimneys were discovered and sampled is the Iberico fluid seepage structure investigated during the TASYO cruise (2000) of the Spanish Geological Survey. During the TTR11 & 12 cruises this same carbonate chimneys field was sampled four times (stations AT335D, AT339D, AT388GR, AT389D).

During the TTR14 cruise yet another area of carbonate chimneys development was discovered (to SW of the Gibraltar Straight). Three sampling stations were done there (AT550D, AT551D, AT552GR). Two other areas were found during the TTR15 cruise. The first one is situated to the SW from the Gibraltar Srait (Vernadsky Ridge, station AT574D). The second is situated on the Portuguese margin in a channel close to the Iberico field (AT599D).

X-ray diffraction (XRD) analysis, analysis of oceanographic data and thin section slides analysis were made to study the sampled chimneys.

When all analyses' results were obtained the authors made a conclusion that the best way to make chimneys' classifications is to compare the same characteristics of chimneys. There are four ways to classify the chimneys. The first one is based on analyzing terrigenous material value in carbonate chimneys. The second is based on analyzing carbonate crystals' shape which is visible in thin section slides. The third way is XRD analysis of parts of the same chimney. The fourth is XRD analisys of chimneys with the same location.

Way 1 has shown dependence of terrigenous material value from a distance to the Mediterranean outflow main stream. The longer the distance the lower is terrigenous admixture value, except for a canyon close to the Iberico field (it is related to a possibility for the canyon to be a transport way of material carried by the Mediterranean outflow to the canyon).

Way 2 has shown that the Iberico carbonate chimneys are younger than others as they sometimes contain a big amount of well-shaped carbonate crystals. However it can also mean better conditions to form the crystals in chimneys and not their older age.

Way 3 gives different ratios of carbonates in chimneys which are shown by XRD results. These ratios are not related with the environment. XRD shows also big amount (11%) of magnesite in chimneys of the Gibraltar field. It can be related with huge Mg being introduced by the Mediterranean outflow. Siderite in the Vernadsky and Gibraltar chimneys can be a result of Fe input from Africa.

Way 4 gives no any regularities causing carbonates saturation in one chimney. The content of carbonate minerals in chimneys increases in any directions of a cross section.

After all analyses done it is possible to make a conclusion that the chimneys' formation depends more on "birthplace" conditions than on general regularity for the chimneys.

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BIOGEOCHEMICAL PROCESSES OCCURRING AT FLUID/METHANE VENTING SITES AT THE SEAFLOOR

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In the totally dark environment of the deep-sea, constant and focused fluid supply induces development of marked biological activity depending on chemosynthetic nutrition. The most important processes fuelling these light-independent ecosystems are anaerobic (i.e. in the absence of oxygen) oxidation of methane (AOM), which subsequently results in the precipitation of carbonates. AOM is a key-process in the global carbon cycle, since it prevents the escape of vast quantities of methane to the atmosphere. Methane is also a very important greenhouse gas besides carbon dioxide. We have shown that the microbial diversity involved in AOM is complex and involve ecologically contrasting types of microbes. AOM activities occur below the surface of the deep-sea floor, and where AOM-induced carbonates were found, the highest AOM activities were detected WITHIN these precipitants and not in the surrounding sediments.

Fluid/methane seepage and mud volcanoes (MVs) are distributed world-wide on- and offshore. Migrating fluids contain organic and inorganic components offering sources of carbon and energy and other essential nutrients for the microbial chemosynthetic communities of the deep biosphere up to several km of water depth. Chemosynthesis is a process that certain organisms use to produce energy, similar to photosynthesis, but without the utilization of sunlight. Instead, the necessary energy comes from the oxidation of chemicals which seep from the subsurface. MVs and fluid/methane venting locations in general are hot-spots for very diverse but still largely unknown chemosynthetic macro- and microbial life. More than 90 percent of the methane uprising from the subsurface of the World's Oceans is consumed (eaten) anaerobically (i.e. without any presence of oxygen) with sulfate (SO_4^{2-}) as electron acceptor (i.e. a compound that receives or accepts an electron during cellular respiration). It is an outstanding fact that the process of Anaerobic (e.g. a process progressing without oxygen) Oxidation (utilization, consumption) of Methane (AOM), significantly controls atmospheric concentrations of methane. This is fundamental for keeping our atmosphere in a balance in terms of greenhouse factor. AOM now is considered one of the dominant methane sinks in marine environments. AOM can be accomplished by microorganisms belonging to the domain of Archaea. These archaea occur mostly in a consortium with sulfate reducing bacteria (SRB) of different phylogenetic groups developing in symbiotic aggregations of unknown functioning. AOM results in the production of sulfide and carbonates in anoxic sediments. Such methane-related carbonates can occur in the form of crusts, concretions, pavements and chimneys. They are frequently observed in areas of active seepage and are known in geological record from ca. 350 million years ago.

We have visited and sampled a number of AOM "hot-spots" in the Black Sea, the North and Northeast Atlantic and the Eastern Mediterranean; the latter by diving with the submersible Nautil (R/V *L'Atlante*, France) of IFREMER to up to 3 km of depth in the area of active fluid venting within the Nile deep-sea sedimentary fan, allowed us to discover, observe and study several of such unique deep-sea environments.

The key factors determining the biogeochemical pathways and microbial mutual benefits in the various seepage environments are still largely unknown and our research is anxious for understanding and characterizing microbial processes based on the oxidation of methane, their regional or sequential variability, enzymatic capacities of microorganisms/microbial consortia performing AOM and inducing carbonate formation under extreme, fluid seepage environments. Using chemical analyses of methane, biogeochemical proxies of organic molecules from microorganisms, and molecular biological techniques, we have obtained the following results:

- The study of different fluid venting environments revealed a different intensities and duration of AOM, most likely forced by the intensity of the local seepage activity, pathways, and migrated products.

- The presence of diverse bacterial and a variety of archaeal biomarkers signifies different syntrophic and symbiotic interactions among prokaryotes. For instance, the occurrence of specific sterols, previously found in cultures of aerobic methanotrophic bacteria *Methylococcus capsulatus* (Bird et al., 1971) and *Methylosphaera hansonii* (Schouten, et al., 2000), signifies aerobic methanotrophy whereas hydroxyarchaeol and specific glycerol dialkyl glycerol tetraethers (GDGTs) are characteristic for methane consumption in anaerobic environments. Simultaneously, the $\delta^{13}C$ values of the sterols, diplopterol, and hydroxyarchaeols are all substantially depleted (-60‰ to -90‰), indicating that carbon from methane is used for biomass production. The co-occurrence of these biomarkers would imply local changes in the seepage environments reflected in consequent alteration of syntrophic associates. This indicates that either archaeal lipids or the specific sterols are "relicts" from prior times when the redox zones in the sediment were differently positioned or it points to a co-existence of contrasting ecological groups of microorganisms in the same environments, using methane as a carbon source.

- Difference in $\delta^{13}C$ values between archaeol and hydroxyarchaeol indicates presence at least two types of archaea. Archaea biosynthesing hydroxyarchaeol were using methane as a carbon source, whereas archaea producing archaeol clearly did not.

- On the basis of combined lipid biomarker and 16S rRNA study, we found out that archaea performing AOM are not limited to the currently known SRB partners.

- Relation between archaeal biomarkers (archaeol, hydroxyarchaeols, GDGTs) indicates variability of archaeal populations in the sediments with depth, whereas carbonates show more stable signal most likely associated with certain archaeal group.

- The precipitation of methane-related carbonates via AOM takes place below the sediment water interface, i.e. where methane and sulfate are abundant. AOM processes are most active within the neoformed carbonates and are substantially reduced in the host sediments.

WHAT'S NEW IN TTR GEODATABASE

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The first version of the TTR GeoDatabase was presented at the TTR14 Post-Cruise Meeting in 2005, in Marrakech. After that the work has continued and before the TTR15 cruise the database was enlarged significantly (fig. 1). All TTR data from the Black Sea cruises, starting from the TTR1 cruise, were incorporated into the database. During the TTR15 cruise the Black Sea and Gulf of Cadiz geodatabases were updated with obtained data as well as with some data from previous cruises.

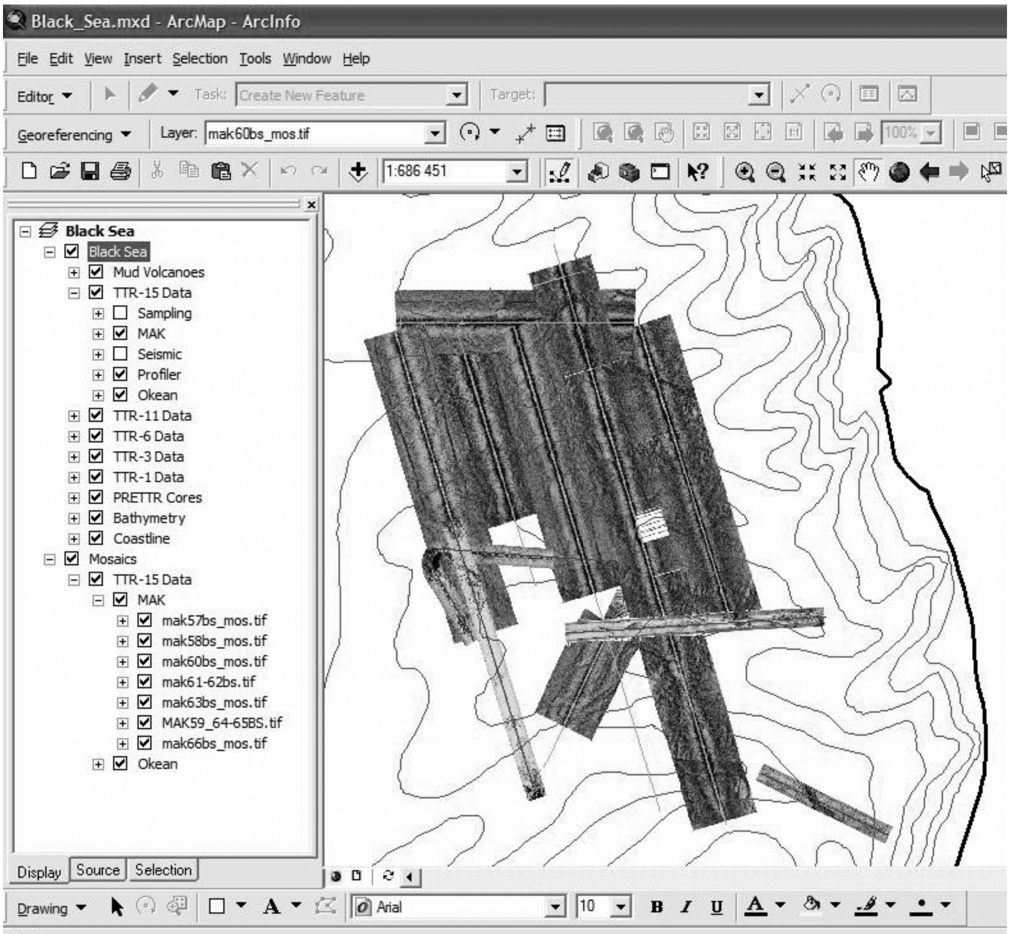

Figure 1. Interface of the TTR GeoDataBase

The database was added with new data type - video records of underwater TV surveys in MPEG format.

The algorithm of georeferencing became faster and more accurate due to use of GeoTiff data format.

Aims of the geodatabase are as follows:

- To allow a faster access to any TTR data;
- To allow plotting on map any types of data, evaluating relations between them (e.g., to illustrate how TV-profiles lay on sonar mosaics);

The main task of these databases is convenience. User should be able:

- To browse, view and analyze large amounts of different data;

- To update databases with acquired data straightway aboard R/V *Professor Logachev* for further work;
- To provide user friendly system - "easy-to-use" for users with different level of computer skills.

The geodatabase includes:

- Geographical information of seismic, acoustic, underwater TV lines, positions of sampling stations;
- Time marks for the lines (10 minutes points);
- Seismic and acoustic profiles;
- Screenshots and video records from underwater television;
- Lithology columns and photos of sampling stations;
- MAK mosaics with reduced resolution.

ANALYSIS OF SEISMIC DATA OBTAINED ON DIFFERENT SPEEDS OF THE SHIP

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Seismic work is a standard operation during TTR cruises. Seismic acquisition is normally done simultaneously with the employment of the long range sonar OKEAN. The velocity of the ship is about 5-6 knots. So we obtain acoustic image of the bottom surface as well as a seismic cross section at the same place.

During Leg 1 of the TTR15 cruise (Black Sea) the decision was made to do a seismic line simultaneously with the deep- towed hydroacoustic system MAK-1M. The difference between this and previously described methods is that the vessel moves slowly, with the velocity about 2 - 2.5 knots. Such kind of work was done for the first time on board of R/V *Professor Logachev*, so it is interesting to compare seismic data, obtained on different ship’s velocities.

The seismic wave can be considered as the analog of the light wave. So the well-known concept in optics, the Fresnel zone, is suitable for the seismic wave. The wave front reflects not from just one point. It reflects from the reflection segment, which is called the Fresnel zone. There are several such zones, but the most part of energy of the seismic wave reflects from the first zone. We could not take into consideration reflections from other zones.

The radius of the Fresnel zone depends on frequency, depth of water in the area under investigation and a velocity of the seismic wave. (In our case the velocity is 1500 m/sec in water.)

$$R_f = (V*H/2f)^{1/2} \qquad (1)$$

R_f - the radius of the first Fresnel zone
V - velocity
H – water depth
f - master frequency of the seismic wave.

For example the radius of the first Fresnel zone can be calculated for a place in the Black Sea, Georgian sector, Batumi - Poti area. Line number PS306BS. The water depth is about 1000 - 1500 meters. Master frequency of the seismic wave is about 90 Hz. Radius of the Fresnel zone changes from 91 meters to 111 meters.

Other examples are from the Gulf of Cadiz, line number PSAT280, water depth is approximately 4000 metres. Radius of the first Fresnel zone is 180 meters. Line PSAT270, water depth is about 400 metres, the radius is approximately 55 meters. Seismic lines were made with the shooting interval 10 and 12 seconds (in some rare cases this interval increased to 14 or 16 second when we had problems with the shipboard compressor).

For investigation with shooting interval 10 seconds on the velocity about 5 - 6 knots distance between traces is 25-30 meters; and for 2-2.5 knots it is 10 meters.

The covering of the Fresnel zone for neighbor shoot points on line PS306BS (velocity 5-6 knots, shoot interval 10 seconds, distance between traces - 30 meters) is 70%. For comparison the covering was estimate for velocity 2 knots and it is equal to 83,6 %.

Thus, there is no any essential difference between data, obtained on different velocities in such conditions, with such goals, depth of water etc. But if the aim is to explore a shallow part of the sea, the difference in speed may play an important role.

SEISMIC INVESTIGATIONS OF THE BATUMI SEEP AREA OFFSHORE GEORGIA (BLACK SEA)

M. Wagner[1], H. Keil[1], E. Bulgay[1], G. Bohrmann[1], and M. Ivanov[2]

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[2] *UNESCO Center for Marine Geosciences, Moscow State University, Moscow, Russia*

Along the continental slopes of the Black Sea numerous gas and gas hydrate occurrences as well as gas seeps have been observed during the last decades. In the frame of the METRO-Project (2004-2007) three cruises take place into the Black Sea to study the distribution, structure and dynamic of near surface gas and gas hydrate occurrences. The main working area is located in the south-eastern Black Sea offshore Batumi/Poti (Georgia), which is barely studied till now.

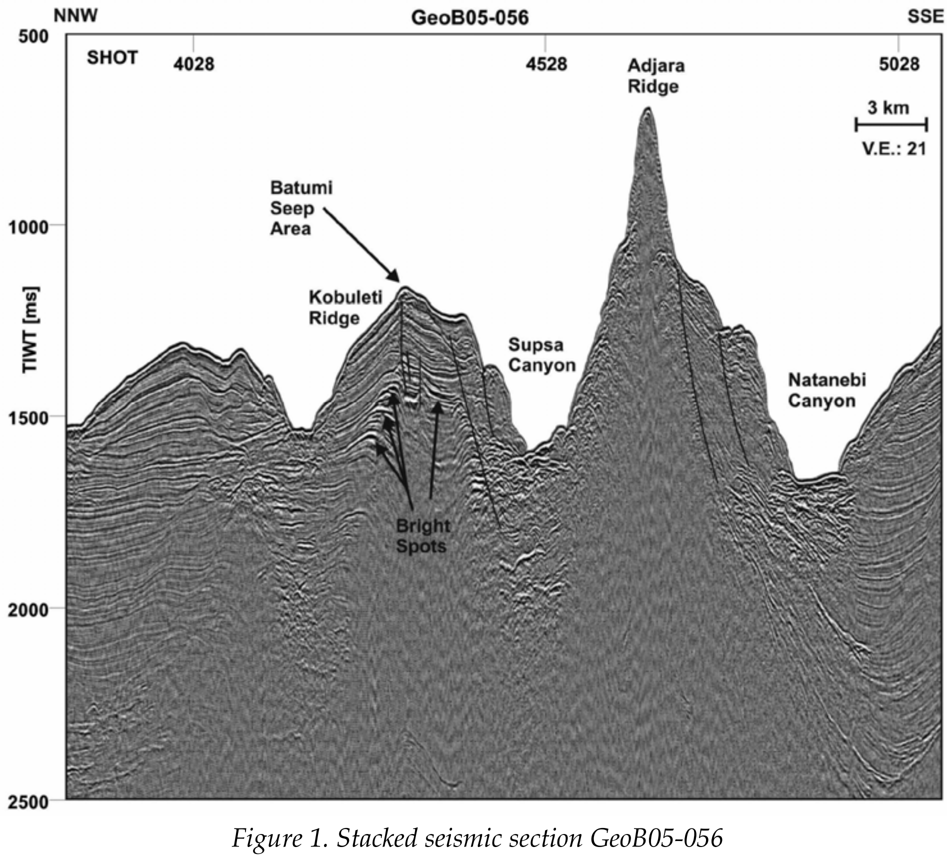

Figure 1. Stacked seismic section GeoB05-056

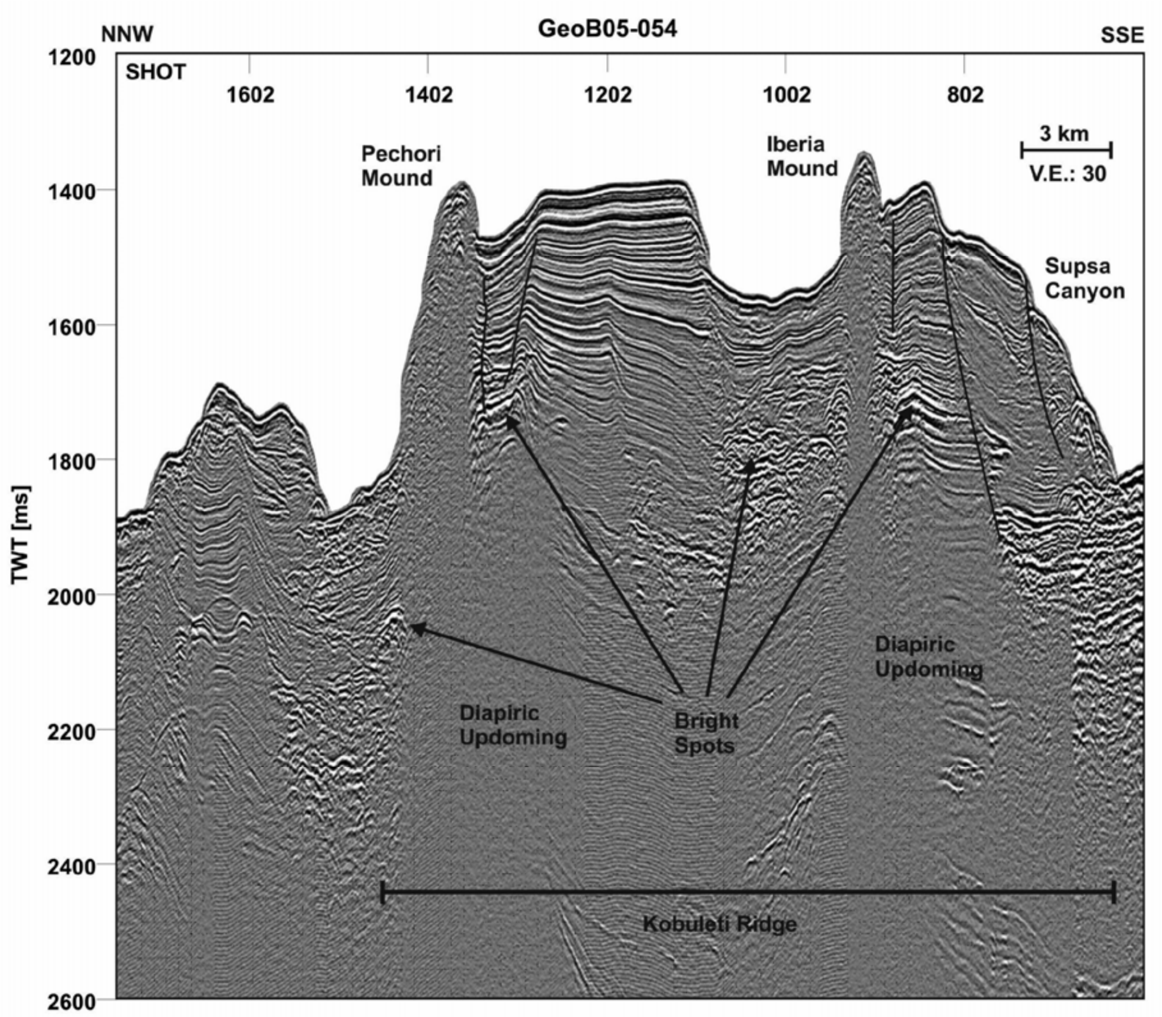

Figure 2. Stacked seismic section GeoB05-054

The Georgian continental slope morphological is characterized by a complex system of W-E striking canyons and ridge structures, in the study area offshore Batumi structured by three main canyons and ridges. At the ridges numerous gas seeps were recorded as acoustic anomalies in Side Scan Sonar data collected during the first METRO-cruise in October/November 2004 with the German R/V *Poseidon*. During the 2nd METRO-cruise, which proceeded within the TTR15 cruise, a multichannel seismic survey was carried out in the Batumi area to study the distribution of gas and gas hydrates occurrences, gas seeps and mound structures. Figure 1 shows a section of the NNW-SSE trending seismic line GeoB05-056, covering the central study area. The ridges, in particular the Adjara Ridge in the South, are characterized by steep flanks, partly showing slump scars. The sediments of the ridges are represented by well stratified bedding, but are tectonically stressed by several near vertical faults. Most gas flares observed during the 1st METRO-cruise with R/V *Poseidon* are located at the so named Batumi Seep area, placed on a local high that rises about 10 m at 855 m water depth on the Kobuleti Ridge. In the seismic section the Batumi Seep area can be identified as small buildup. At a depth of about 225 ms TWT bsf Bright Spots indicate shallow free gas accumulations beneath the seep area. Several near vertical faults can be traced from the Bright Spots towards the seafloor, partly piercing the seafloor reflection. Hence we suggest that the upward gas migration and gas discharge are presumably bound to the faults. Due to the focussed gas/fluid migration towards the seafloor near surface gas hydrates are formed and sampled gas hydrates let us presume that the Bright Spots coincide with the base of gas hydrate stability zone. The lateral extension of the Batumi Seep area is about 800 m in the N-S direction and 1200 m in the W-E direction.

Further indications for gas/fluid migration towards the seafloor are mound structures. In the western study area two cone-shaped mounds are formed on the northern and southern edge of the Kobuleti Ridge (Fig. 2). The area beneath the mounds is characterized by an acoustic transparent zone with a width similar to the diameter of the mounds and is interpreted as main feeder channel for upward rising gas and fluid saturated material. In the subsurface diapiric structures are imaged beneath the mounds.

The flanks of the diapiric structures are onlapped by weak reflections of the stratified sediments and Bright Spots are observed at the top and the flanks of the diapirs.

SEAFLOOR FLUID EMISSIONS IN THE EASTERN MEDITERRANEAN: VARIETY AS A FUNCTION OF ENVIRONMENT

J. Woodside[1], V. Lykousis[2], J.-P. Foucher[3], S. Dupre[1], S. Alexandri[2], G. de Lange[4], J. Mascle[5], T. Zitter[6], and Scientists of the ANAXIMANDER, MEDIFLUX, and MEDINAUT projects

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[2] *National Centre for Marine Research, Anavyssos, Greece*
[3] *Ifremer Centre de Brest, Plouzan?, France*
[4] *Utrecht University, Faculty of Geosciences, Utrecht, the Netherlands*
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[6] *College de France, Aix-en-Provence, France*

Mud volcanoes and seafloor cold seeps have been found in most parts of the eastern Mediterranean in different geological environments following focussed work by TTR in the early 1990s. Most have been found on the Mediterranean Ridge accretionary prism but they have also been found on the Nile deep sea fan and in the Anaximander Mountains. Fluid emissions take place in a variety of ways and in association with a range of structures from small seeps through pockmarks and mud pies to large conical mud volcanoes. Differences in sites of fluid emissions are determined more by differences in their geological environment than by their stage of development. Thus, brine rich fluid seeps and brine pools are often found in association with underlying Messinian evaporites; and gas hydrates have not been found at these sites. Factors contributing to the geological control of seeps and mud volcanoes include permeability and width of escape channels, availability of fluids and fluidity of mud, temperature and salinity of fluids, gas concentrations and fluxes to the water column, presence or not of gas hydrates and evaporitic formations, and degree of overpressure driving the emissions/eruptions. It seems difficult therefore to draw conclusions about the mechanisms of mud volcanism and fluid seeping and venting without determining local conditions in each case; but we can gain a great deal of information about mechanisms through study of the variety of manifestations of mud volcanism under different conditions. In order to create good models and to better determine mechanisms of mud volcanism at the seafloor, we also need either to use novel equipment for in situ seafloor measurements of physical properties of mud breccias erupted from mud volcanoes or to bring samples to surface labs for analysis under in situ conditions (using, for example, autoclave sampling technology). Otherwise models based on physical properties on normal cores at sea surface conditions should be viewed with extreme skepticism.

ANALYSIS OF SEISMIC DATA AT THE GEORGIAN SECTOR OF THE BLACK SEA

A. Zotova

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During TTR15 Cruise Legs 1-2 western and eastern parts of the Black Sea in the Russian, Turkish and Georgian sectors were investigated. Studied area of Georgian sector is located at the continental slope and is relatively badly explored. According to investigations done in this area by the Russian, Georgian, German and Turkish scientists seeps are quite common features there. Indications of such zones were discovered in the water column and in the bottom samples.

In the Georgian Sector 12 seismic lines were made with multi-channel seismic streamer (8 lines with the long range side scan sonar OKEAN, 4 lines with the deep-towed hydroacoustic system MAK1-M), 22 bottom sampling stations were done (gas hydrates were sampled). The basic processing graph consists of a band pass filtering, f-k filtering, spherical divergence corrections and summing.

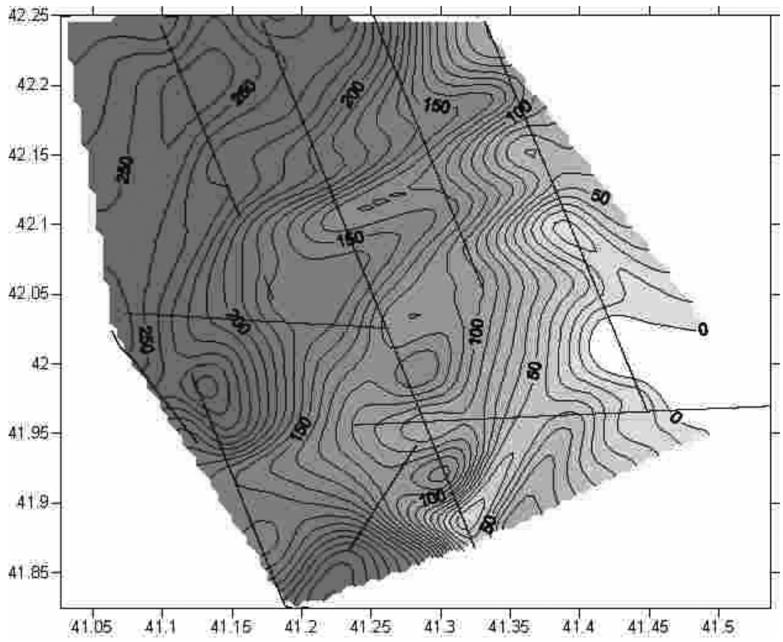

Figure 1. Thickness of gas hydrate stability field

The seismic profiles allow to study the sedimentary sequence and gas presence. Gas hydrate stability field was calculated using temperature at the seafloor equal 9°C and temperature gradient equal 29°C/km. Thickness reaches 260 m in the western part of the area and decreases in the eastern part, where depth is lower than 500 m (fig. 1).

At the part of the seismic cross-section under BSR or BS frequency decreases because of presence of gas below this boundary. On some profiles it clearly seen on the image, but some profiles are characterized by good stratification that produces problems with the definition of characteristics of seismic records. To recognize such places an algorithm is suggested: impulse spectrum is compared with spectrum, calculated in time-windows on each trace (using cross-correlation function). In parts of the seismic cross-section where gas presence is observed the cross-correlation function reaches its minimum: this can help to interpret the data.

ANNEX I

CONFERENCE PROGRAMME

<u>29 January</u> (Sunday)

11:00-15:00 Moscow-city tour. Bus excursion
19:00-21:00 Registration of participants
Icebreaker

<u>30 January</u> (Monday)
Moscow State University, Main Building, 6th floor, room 611

9:15–10:00 Registration of participants

<u>Plenary Session</u>:
10:00 Official opening
Welcoming addresses by:
V.T. Trofimov, Vice-Rector of Moscow State University
D.Yu. Pushcharovsky, Dean of Faculty of Geology, Moscow State University
A.E. Suzyumov, IOC of UNESCO
I.F. Glumov, Ministry of Natural Resources, Russian Federation
R.R. Murzin, ZARUBEZHNEFT
V.N. Zhivago, Ministry of Education and Science, Russian Federation
A.A. Shaggin, Polar Marine Geosurvey Expedition, St. Petersburg
M.I. Prchalova, UNESCO Moscow Office

11:00 *<u>M. Ivanov</u>*
The Role of TTR in the Study of Mud Volcanoes, Methane Seeps and Gas Hydrate Accumulations around Europe

11:30-12:00 Coffee break

12:00 *<u>N. Kenyon</u>*
The Contribution of TTR to the Study of Sand Body Architecture
12:30 *<u>J. Woodside</u>, V. Lykousis, J.-P. Foucher, S. Dupre, S. Alexandri, G. de Lange, J. Mascle, T. Zitter, and Scientists of the ANAXIMANDER, MEDIFLUX, and MEDINAUT projects*
Seafloor Fluid Emissions in the Eastern Mediterranean: Variety as a Function of Environment
13:00 *<u>J.-P. Henriet</u>, A. Foubert, L. Maignien, the Proposals '573-Light' and '673-Pre2' Teams and Expedition 307 Shipboard Party*
Atlantic Carbonate Mounds: Challenges for Ocean Drilling, from Porcupine to the Morocco Margin
13:30 *<u>G. Bohrmann</u>, F. Abegg, and W. Kuhs*
Properties of Sea Floor Hydrates from Various Geological Settings

14:00-15:00 Lunch

15:00-16:00 Time to look around the Main Building of Moscow State University
16:00 Coach leaves for “Solnetchnaya Polyana” resort hotel

19:00-20:00 **Dinner**

20:30 TTR video presentation

31 January (Tuesday)

8:30-9:30 **Breakfast**

10:00 An Introduction to the Conference
Tj. van Weering
Challenges in Marine Research

Section 1: **The Black Sea**
Convenor: *Tj. Van Weering*

10:30 *G. Bohrmann, M. Ivanov and TTR15 Legs 1 and 2 Shipboard Scientific Party*
Gas Hydrates Associated with Oil and Gas Seeps in the Eastern Black Sea - Preliminary Results from TTR Cruise 15 Legs 1 and 2

10:50 *H. Sahling, A. Nolte, F. Abegg, G. Bohrmann, I. Klaucke, and M. Ivanov*
Gas Seepage at Batumi Seep off Georgia: Results from ROV Investigations

11:10 *M. Haeckel*
Fluid Flow from Mud Volcanoes and Seeps in the Black Sea: Geochemical Composition - First Results from the TTR15 Cruise

11:30 *L.L.Mazurenko, V.A.Soloviev, M.K.Ivanov, E.A.Logvina, A.N.Stadnitskaya, and T.C.E.vanWeering*
Gas-Hydrate-Forming Fluids of Kovalevsky, Kazakov and Odessa Mud Volcanoes (the Black Sea)

11:50-12:10 **Coffee break**

12:10 *I. Klaucke, H. Sahling, and M. K. Ivanov*
Geoacoustic Investigations of Cold Seeps in the Eastern Black Sea

12:30 *A. Mazzini, M. K. Ivanov, and G. Bohrmann*
Complex Plumbing Systems in the Near Subsurface: Geometries of Authigenic Carbonates from NW Black Sea

12:50 *M. Wagner, H. Keil, E. Bulgay, G. Bohrmann, and M. Ivanov*
Seismic Investigations of the Batumi Seep Area Offshore Georgia (Black Sea)

13:10 *D. Titkova*
Analysis of Seismic Data Obtained on Different Speeds of the Ship

13:30-14:30 **Lunch**

16:00 Conference Lecture
A. Akhmetzhanov, R.B. Wynn, P.J. Talling, M. Frenz, N. Kenyon, M. Ivanov, and UK TAPS group
Recent Studies of Modern Deep-Water Depositional Systems as Hydrocarbon Reservoir Analogues: from Basin-wide to Outcrop Compatible Scales

Section 1 (continuation): **The Black Sea**
Convenor: *J.-P. Henriet*

16:30 *T. Mohr, K. Heeschen, G. Bohrmann, and K.-U. Hinrichs*
Sorption of Methane to the Mineral Phase of Marine Sediments: an Approach to Determine the Quantity of Sorption, its Associated Exchange Dynamics, and Consequences for Biogeochemical Processes

16:50 *E. Logvina, L. Mazurenko, V. Soloviev , V. Blinova, M. Ivanov, and E. Prasolov*
Influence of Gas-Hydrate-Forming Fluids on the Isotopic Composition of Authigenic Carbonates: Comparative Study of the Black Sea and the Gulf of Cadiz

17:10 *A. Zotova*
Analysis of Seismic Data aquired in the Georgian Sector of the Black Sea

17:30-17:50 Coffee Break

17:50 *R.L. Pevzner, M.A. Poluboyarinov, and D.B.Finikov*
Elimination of Multiples on Single-Channel Shallow-Water Seismic Data

18:10 *D.V. Korost, R.A. Khamidullin, A.N. Oshkin, and S.Yu. Petrakova*
Experimental Estimation of Acoustic Properties of Frozen Gas Hydrate Bearing Sediments

18:30 *S. Planke, H. Svensen, M. Hovland, C. F. Forsberg, and A. Mazzini*
The Structure and Formation of Complex Pockmarks in the Nyegga Area, Mid-Norwegian Margin.

19:00-20:00 Dinner

20:30 TTR video presentation

1 February (Wednesday)

8:30-9:30 Breakfast

10:00 Conference Lecture
I.R. MacDonald
Estimating of Natural Hydrocarbon Flux in Marine Basins Based on Remote Sensing Data

Section 2: The Gulf of Cadiz
Convenor: *G. Bohrmann*

10:30 *V. Blinova, M. Ivanov, and L. Pinheiro*
Hydrocarbon Gases and Their Possible Source Rock from Mud Volcanoes of the Gulf of Cadiz

10:50 *J. Sas, G. Webster, A. J. Weightman and R. J. Parkes*
A Survey of Prokaryotic Diversity in Sediments from Two Gulf of Cadiz Mud Volcanoes, as Revealed by Culture-Dependant and Culture-Independant Methods. Preliminary Results from TTR15 Leg 4

11:10 *F.J. Gonzalez, L.M. Pinheiro, V.H. Magalhaes, M. Ivanov, L. Somoza, and R. Merinero*
Sulphate-Reducing Bacteria as a Nucleation Sites for Pyrite in Carbonate Chimneys from the Vernadsky Ridge, Moroccan Margin of the Gulf of Cadiz

11:30 *L. Maignien, N. Wouters, and J.-P. Henriet*
Biogeochemistry of Carbonate Mounds from the Pen Duick Escarpement, Gulf of Cadiz

11:50-12:10 Coffee Break

12:30 *T. Schwenk, F. Ding, L. Pinheiro, C. Roque, I. Fokin, C. Pinto and TTR 15/4 scientific crew*
Imaging Mud Volcanoes and Tectonic Structures in the Gulf of Cadiz – First Seismic Results of TTR15/4

12:50 *Yu. Malykh*
Geochemical Characteristics of Organic Matter from Mud Volcano Matrix (the

Gulf of Cadiz)
13:10 *A. Belova*
Geodynamic Activity of El Arraiche Region

13:30-14:30 Lunch

16:00 Conference Lecture
M. R. Cunha, C. F. Rodrigues, A. Ravara, and C. F. Moura
Deep-Water Ecosystem Research - an Overview of the Biological Results from the Collaboration with TTR over the Past Five Years

Section 2 (continuation): The Gulf of Cadiz
Convenor: *J. Woodside*

16:30 *E. Kozlova, M. Ivanov, V. Blinova, and D. Nikonov*
New Discovery of Carbonate Chimneys in the Gulf of Cadiz: Results of the TTR15 Cruise
16:50 *V. Blinova, M. Ivanov, E. Kozlova, and V. Shlykov*
Composition and Origin of the Mud Volcanic Matrix: Examples from the Gulf of Cadiz Mud Volcanoes
17:10 *A. Sharapova, V. Blinova, and E. Kozlova*
Lithological Aspects of Carbonate Chimneys Formation in the Gulf of Cadiz

17:30-17:50 Coffee Break

17:50 *D. Nikonov, V.Blinova, and M.Ivanov*
Distribution of Dead and Living Cold-Water Corals in the Gulf of Cadiz (TTR 9-12, 14-15 Cruises)
18:10 *N.F. Kuzub and M.Yu. Tokarev*
Deep-Towed High-Resolution Seismic System for Investigation of the Uppermost Subbottom Sediments at Shallow Waters
18:30 *V.O.Mokievskiy, V.A.Spiridonov, M.Yu.Tokarev, and A.B.Tsetlin*
Use of Remote Techniques for Investigation of Seafloor Bilogical Comunities of the Kandalaksha Bay, White Sea

19:00-20:00 Dinner

21:00 TTR Barbecue in the Russian Winter Forest

2 February (Thursday)

8:30-9:30 Breakfast

9:30-11:00 **Poster section**
11:00-17:00 Local site-seeing tour. Excursion to Savvino-Storodgevsky Monastery

19:00-20:00 Dinner

21:00 TTR Executive and Scientific Committees meeting

3 February (Friday)

8:30-9:30 **Breakfast**

10:00 Conference Lecture
M. Marani, F. Gamberi, A. Di Roberto, H. Pirlet, and TTR15 Teams
Deep-Sea Transport and Deposition of the Stromboli 30/12/2002 Landslide - Results of the TTR15 Cruise

Section 3: **The Mediterranean Sea, Atlantic and other regions**
Convenor: *N. Kenyon*

10:30 *F. Gamberi, M. Marani, A. Di Roberto, N. Hurting, R. Lecci, E. Leidi, R. Moremon, E. Morris, and H. Pirlet*
Sedimentary Processes in the Calabrian and Sicilian Margin (Preliminary Results of the TTR15 Leg 3).

10:50 *D. Daudin*
Interpretation of the TTR14 Seismic Data in the Eastern Alboran Basin.

11:10 *M. Rosi, A. Di Roberto, A. Bertagnini, M.P. Marani, and F.Gamberi*
Cogenetic Distal Turbidity Current Deposit Documents the 30 December 2002 Tsunamigenic Landslide of Stromboli Volcano (Aeolian Islands, Italy).

11:30 *F. Mienis, H. de Stigter, H. de Haas, T. Richter, C. van der Land, T. van Weering*
Environmental Controls on Carbonate Mound Development along the European Continental Margin.

11:50-12:10 **Coffee break**

12:10 *I. Fokin, V. Kalinin, and E. Tolstukhin*
50 Hz Noise Filtering in Seismic Data of the TTR15 Cruse

12:30 *R. Murzin*
De-Noising of Marine Seismic TTR15 Data with Use of Wavelet Analysis

12:50 *A. Sungurov*
What's New in the TTR GeoDatabase

13:10 *E. Poludetkina and J. Bojesen-Koefoed*
Geochemical Preconditions of Oil-Bearing Strata on the Western Greenland Margin

13:30-14:30 **Lunch**

16:00 Conference Lecture
N. Hamoumi and M. Chafik
Tubotomaculum of NW Rif Belt: Mode of Genesis and Geological Setting

Section 3(continuation): **The Mediterranean Sea, Atlantic and other regions**
Convenor: *M. Marani*

16:30 *M. Kaviladze, N. Gubadze, E. Sakvarelidze, and E. Gamtsemlidze*
Isotope Content of Gases from the Deep and Possibilities of the Existance of Primary Hydrogen

16:50 *M. Chafic*
Morphostructural Alysis of NW Rif Belt

17:10 *L. Mazurenko, Y.Jin, H.Shoji, A.Obzhirov and CHAOS2003-2005 Scientific Teams*
Gas Hydrates of the Sea of Okhotsk: Results from the CHAOS Projects

17:30-18:00 **Coffee Break**

18:00 Closure of the meeting

20:30 Conference Dinner

4 February (Saturday)

8:30-9:30 Breakfast

11:00 Coach leaves for Moscow

ANNEX II

LIST OF PARTICIPANTS

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

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

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