United Nations
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Intergovernmental
Oceanographic
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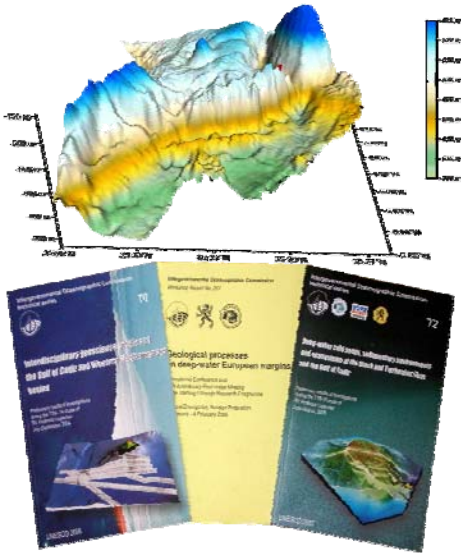
IOC/INF-1253

Geosphere-Biosphere Coupling Processes in the Ocean: the Training-through-Research approach towards Third World involvement, 2004–2008

(TTR-Flanders project)
UNESCO project 513RAF2005

Final report
December, 2008



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If not otherwise specified, photos used in the Report have been provided by E. Kozlova (Moscow State University, Russia), Deputy Head of the TTR cruises for ship-board training.

Pictures on the cover page (from left to right):

Horizontal:

1- Cold-water corals

2- Trainees hard at work logging cores on the deck.

3- "Do as I do!" – Prof. Henriet (Gent University) and Prof. Hamoumi (Rabat University) with trainees.

4- Cold-water corals (same as 1)

Vertical:

5- Visualization of the Pen Duick escarpment at the Morocco Margin (courtesy of Gent University).

6- Sample of publications resulting from the project.

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GENERAL INFORMATION

Project title:	*Full title*: Geosphere-Biosphere Coupling Processes in the Ocean: the Training-through-Research (TTR) approach towards Third World involvement. *Short title*: TTR-*Flanders* project
Target Region:	Third-world countries (focus on Africa)
Budget code:	513RAF2005
Funding source:	UNESCO/Flanders Funds-in-Trust for the Support of UNESCO's Activities in the Field of Science (FUST)
Total Budget approved:	US$ 285,000
Implementation period:	July 2004 – December 2008
Implementing partners:	Universities and Research Centers in Europe (Gent University, Belgium - major partner) and Third-world countries (Consortium of Moroccan Universities for studying Geosphere-Biosphere coupling processes - major partner). For full list of partners see Annex 1.
Responsible Sector:	Intergovernmental Oceanographic Commission (IOC) of UNESCO
Project officer:	Ehrlich DESA, Head of Capacity Development Section, IOC

Name of Person completing Report: A. Suzyumov, IOC Consultant, through E. Desa, Head of Capacity Development Section, IOC

Acknowledgements

The IOC is grateful to the Flemish Authorities for accepting the TTR-*Flanders* project under the FUST scheme. Dr Rudy Herman (Science and Innovation Administration, Brussels) was helpful at various stages of the project e.g. by putting it in the FUST perspective at the TTR-14 Post-cruise Conference in Marrakech (2005). Prof. Dr. Jean-Pierre Henriet (Gent University, Belgium) efficiently played the role of the project's coach. He succeeded in bringing together various research groups in Morocco in a Consortium for studying Geosphere-Biosphere Coupling Processes (GBCP) in the Ocean. He was instrumental in putting the project in the European and global context by establishing its collaboration with several European and international projects and programmes. He himself, as well as his collaborators Dr. D. Van Rooij (Gent University) and Dr. A. Foubert (Catholic University Leuven, Belgium) and some other colleagues provided for indispensable contribution in research, training and knowledge-sharing.

The Morocco Authorities supported the project in various ways. Thus permissions were granted at the diplomatic level to several TTR and similar cruises for the research work in the EEZ of Morocco, with the participation of the Moroccan trainees. Prof. Hafid Boutaleb Joutei, President of the University Mohamed V-Agdal, Prof. Mohamed Jebli, President of the University Cadi Ayyad, Prof. Mustapha Bennouna, President of the University Abelmalek Saadi, Mr. M'hamed El Mostaine, Director of Exploration at ONHYM and other personalities have placed the full weight of their authorities behind the project.

Prof. Naima Hamoumi (Mohamed V-Agdal University, Rabat, Morocco) was indeed the driving force from the Morocco side. As the Coordinator of the GBCP-Morocco Consortium, Chairperson of the Organizing Committee of the TTR-14 Post-cruise Conference in Marrakech (2005) and co-organizer of a few field capacity-building actions in Morocco she established fruitful collaboration within the country, at various levels and enthusiastically promoted the participation of trainees in the project's activities. She launched the first in the country DESA course in «Géodynamique et valorisation des marges océaniques (littoral et zone économique exclusive)». Prof. Bouchta El Moumni (Abdelmalek Essaâdi University, Tangier, Morocco), Prof. El Hassane Boumaggard (Cadi Ayyad University, Marrakech), Prof. Irakliy Khomeriki (Chair holder of the UNESCO/IOC Chair at Tbilisi University, Georgia) and Dr Rasul Najeeb (Director of the Marine Geology Department, Geological Survey of Saudi Arabia) have become enthusiastic supporters of the project and assisted their young colleagues in getting training through its various activities.

Our special thanks go to those scientists who contributed with their knowledge and time in meeting the project's goals. These are: Prof. Dr. Mikhail Ivanov (Chair holder of the UNESCO/IOC Chair at Moscow State University, Russia, Co-chief Scientist and the principal organizer of the TTR cruises) and his collaborator Dr Elena Kozlova (Deputy Head of the TTR cruises for ship-board training), Dr Neil Kenyon (TTR Co-ordinator, NOC Southampton, UK), Prof. Dr Menchu Comas (Granada University, Spain), Professors Luis Pinheiro and Marina Cunha (both from Aveiro University, Portugal), Prof. Dr Tjeerd van Weering (Royal NIOZ, The Netherlands), Prof. Dr Roberto Barbieri (Bologna University, Italy) and many other researches from various countries whose names are mentioned in the Report.

I. SUMMARY AND BACKGROUND

UNESCO Medium-Term Strategy for 2002-2007 (UNESCO, 2001) called the various Programmes for "mobilizing, and acting as catalysts for, international cooperation …by fostering exchange and cooperation… in order to establish a sustainable culture of peace and ensure sustainable development in Africa"; and also "spreading and replicating successful examples of alternatives to traditional formal education" (p.7). It also specified: "UNESCO through its IOC… will continue to play a leadership role in the development of the knowledge necessary to manage ocean resources" (p. 9). The priority areas established by the Medium-Term Strategy for 2002-2007 were youth, Africa and women (gender equality).

In line with these strategies and priority areas, a project funded by FUST, the TTR-*Flanders* project (513RAF2005), was launched in mid-2004 with a view of assisting researchers from Third-world countries (with the focus on Africa) in discovering the new frontiers of marine sciences, strengthening their involvement in truly new disciplines (such as biogeology, biogeochemistry and geomicrobiology) and training young scientists, including women, in the research methods that provide for better recognition and management of the resource potential of Exclusive Economic Zones (EEZ) of the respective coastal States.

The research focus of the project was on ocean margins: the new frontiers where many exciting discoveries were made over the past decade or so. Ocean margins harbor an immense pool of living species. Recent research has demonstrated that fluids seeping from the Earth's crust into the oceans – or from the geosphere to the hydrosphere - contribute substantively to the entire Life System on Earth (biosphere). The development of a concept of interaction between the geosphere and the biosphere was the major approach within the project.

The UNESCO Medium-Term Strategy for 2002-2007 also specified: "…given the enormous speed of scientific discoveries and advances, there is an increasing need for international scientific and intellectual cooperation" (item 18, p. 4). The project's operations were fully in line with this strategy. Through annual international research cruises, post-cruise conferences, specialized capacity-building field actions for group training, as well as through individual training the project involved a considerable number of researchers and trainees from the North and the South. They were provided with access to large research facilities, rarely available to Third-World nations. Through the entire lifetime of the project the trainees were guided by knowledgeable scientists. Knowledge sharing was ensured by including the trainees in interdisciplinary, multinational research teams.

The project has created a considerable synergy effect. Co-funding was its major operational principle: relatively limited resources provided through FUST were combined with important additional funds from various sources, international (such as from IOC, EU, ESF[1] etc.) and national.

Through the above-mentioned arrangements the TTR-*Flanders* project has become an integral part of the overall innovative, alternative to traditional formal education "Training-through-Research" (TTR) undertaking of IOC, part of the Capacity Development Programme of the Organization referred to in the UNESCO Medium-Term Strategy for 2002-2007 under items 116-117 (p. 33).

[1] European Union (EU), European Science Foundation (ESF)

I.1. Development problems.

Exploitation of resources within the Exclusive Economic Zone (EEZ) of coastal States already is, or will soon become economically feasible. At issue are the natural resources beneath the ocean floor, on the first place those of ocean margins, of which the Third Word countries have limited knowledge and to which they have even more limited access. National policies and guidelines regarding the geomarine resources are rarely available. In order to establish guidelines for their exploitation in a responsible and sustainable manner it is necessary to increase, on the first place, scientific understanding of the abundance and diversity of resources and of geosphere-hydrosphere-biosphere interactions that shape the marine environment.

In too many countries national capacities are insufficient to evaluate and manage the sea-bed resources. The situation is particularly worrying in developing countries where, with minor exceptions, there is no any critical mass of trained specialists who could follow the research results in the said domain in their countries and who would be able to advise their governments and the stakeholders on matters related to furthering research leading to the exploitation of the resources.

In order to increase the level of responsibility in the use of and to widen access to the ocean-margin resources at national levels the recognized priority is developing national capacities through (i) training and knowledge-sharing and (ii) provision of access to research facilities and data.

The way of bringing together research on the new frontiers with training efforts has been proposed, tested and applied through the IOC-sponsored 'Training-through-Research' (TTR) programme, in operation since 1991. The programme's dual approach and function (research and training in science) has been recognized internationally as an adequate mechanism for advancing knowledge on complex systems of the ocean deep.

I.2. Objectives of the project.

The primary objective of the project was developing, in a pilot way, national capacities in the selected Third World countries of Africa and elsewhere and more specifically to provide substantive contribution to:

- advancing knowledge, in an interdisciplinary way, on processes and their coupling that happen between the geosphere, the biosphere and the hydrosphere, that shape the sea-bed environments and ecosystems;
- providing for capacity building in specific domains of marine science, including on sea-bed processes, resources and ecosystems, and supporting gender equality;
- contributing to knowledge transfer and sharing by bringing together partners from various countries of the North and the South, from academia, universities, industry and other relevant public sectors.

The project specific objectives were two-fold:

- interdisciplinary research on geosphere-biosphere coupling in relation to marine resources, international sharing of knowledge and expertise, and
- advanced training, through TTR as a successful example of non-traditional acquisition of knowledge, provided to young researches with the specialization in marine (geo)sciences, focused on the third-world countries.

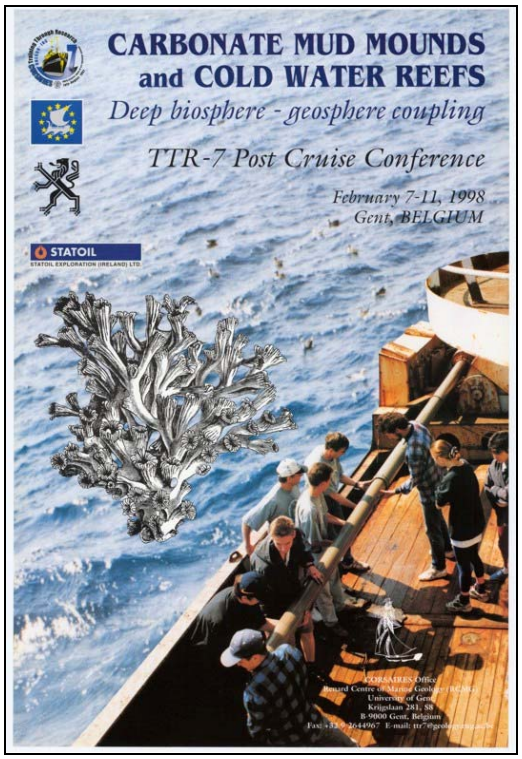


Fig.1. Poster of the TTR-7 Post-cruise conference (produced by Gent University)

The subject of Geosphere-Biosphere coupling processes was introduced into the TTR programme of IOC by Prof. J.-P. Henriet (Gent University, Belgium) at the TTR-7 Post-cruise conference that took place at the said university in February 1998. It has become one of the major TTR focuses throughout the next decade. It has also become the research focus of the TTR-*Flanders* project.

I.3. Beneficiary countries.

Countries of Africa that have benefited from the project are as follows: Morocco (selected as the pilot country), Cote d'Ivoire, Mauritania, Mozambique and Senegal. Other countries that were involved, benefited from or provided in-kind contribution to the project, included: Belgium (the major counterpart in the project), Argentina, Brazil, Georgia, Italy, The Netherlands, Portugal, Russia, Saudi Arabia, Spain and the United Kingdom.

II. PROJECT EXECUTION.

II.1. Training-through-Research philosophy and approach within the project.

At the start of the project it was recognized that the Moroccan institutions that should have been the sourse of national expertise in marine resource management in fact have limited capacities and do not have access neither to large research facilities for offshore investigations (such as research vessels) nor to adequate data on the Moroccan EEZ and its resources. It was decided to use all available facilities of the TTR programme of IOC in order to compensate the existing limitations. These included:

- participation of researchers, in particular young scientists, in the TTR cruises and other capacity-building field actions for:
  - training in the use of sophisticated range of research instruments and methods;
  - on-the-job training in data collection and analyses;
  - knowledge-sharing through their participation in seminars;
  - data synthesis and presentation of the research results through the participation in the TTR post-cruise conferences and other forums;
  - visits to internationally recognized research laboratories and training centres for further training and co-operation;
- participation, as the added value, in research work of institutions-partners in the TTR programme that were not necessarily formally involved in the TTR-*Flanders* project.

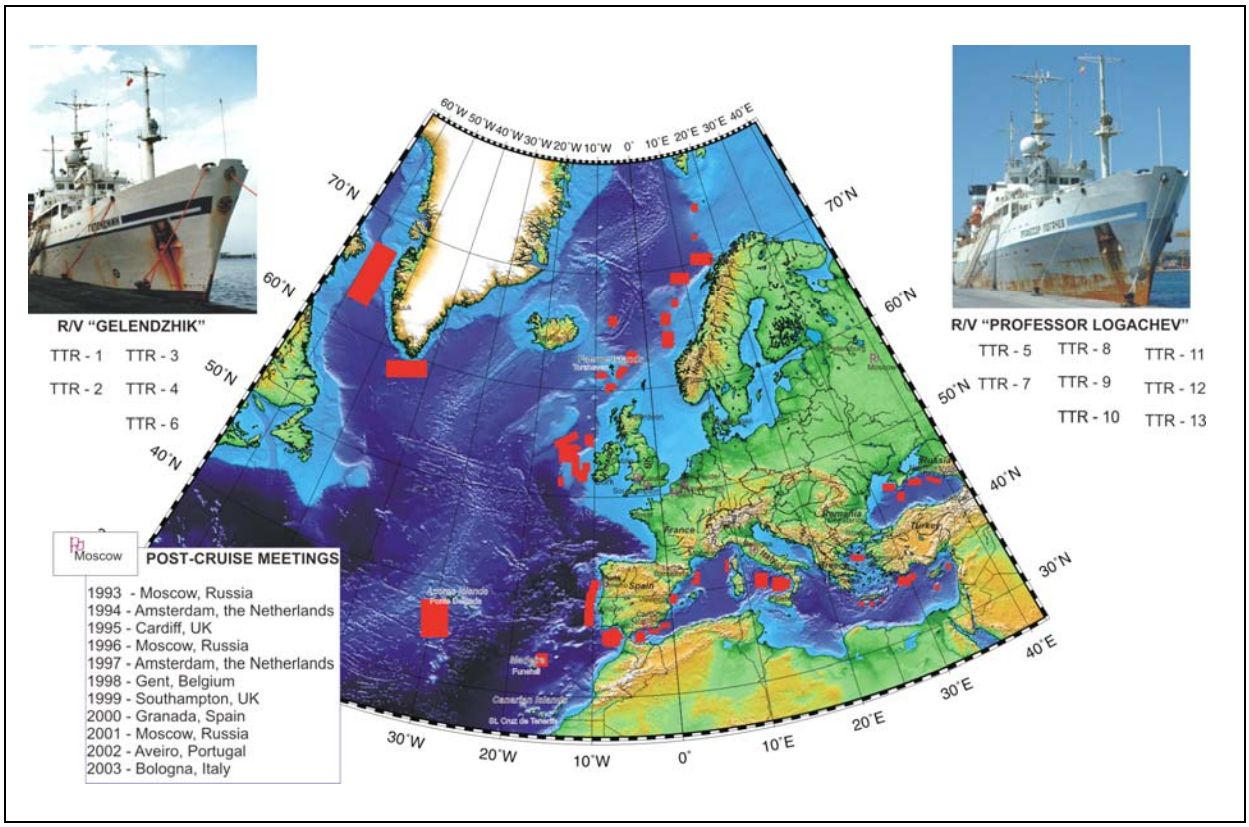


Fig.2. Pre-project TTR activities (cruises and conferences): a basis for success of the Third-World involvement (by M. Ivanov, presented at the OMARC Conference, Paris, 2003)

Fig.3. Trainees at work: history of the Planet Earth is recorded in marine sediments

Within TTR, trainees take part in cutting edge investigations, organized and carried out by senior scientists from a variety of international organizations ─ academic, governmental, and industrial. Through TTR they become research leaders.

For research and training purposes the Moroccan EEZ was selected as the primary target of the project. However training was also provided in some other geographical areas such as in the Mediterranean Sea and the Gulf of Cadiz (Atlantic Ocean). The ship-board training was supported by field courses to look at ancient marine environments. The comparison between the modern and ancient geological situations helps understanding what happens now in the ocean deep.

II.2. Project activities, 2004-2008

II.2.1. Establishment of the GBCP-Morocco Consortium (2004) and furthering actions.

For practical reasons Morocco was selected as the first country to become fully involved in the TTR-*Flanders* project. Prof. J-P. Henriet (Gent University), the project coach, undertook (under contracts between IOC and Gent University) a few missions to Morocco (in 2004, 2005 and 2008) to create, in 2004, a consortium of universities and research institutions interested in marine science education and research and to follow the results. The consortium, named "Geosphere-Biosphere Coupling Processes- Morocco" (GBCP-Morocco), gathered four major research groups that deal with marine research in Morocco: from "Université Abdelmalek Essaaddi" (Tangier); Department "Physique du Globe, Institut Scientifique" (Rabat); "Faculté des Sciences, Département de Géologie Université Mohamed V-Agdal" (Rabat) and "Université Cadi Ayyad" (Marrakech). Through the consortium, cooperation between Gent University and the Moroccan institutions has been significantly reinforced.

The last (within the project) mission was undertaken by Prof. Henriet between 28 July-1 August 2008 in order to discuss the furthering of GBCP research in Morocco and to organize the Moroccan participation in a strategic workshop on GBCP processes as a side event of the AAPG International Conference and Exhibition in Cape Town. Three days had been scheduled to allow meetings at ONHYM ("Office National des Hydrocarbures et des Mines") and at the University of Rabat, to directly negotiate and book at local travel agencies the financially optimal travel opportunities for the Moroccan delegation to Cape Town, as well as to carry out a brief reconnaissance of a coastal site North of Rabat (Kenitra), where carbonate chimney-like features had been spotted by Prof. M.A. Gutscher from Brest University (pers. comm.).

The meeting took place at ONHYM July 29th in presence of Mr. Haddou Jabour, Promotion and Partnership Manager, Mr. Mohamed El Alji, petroleum engineer and Senior Project Manager, and Prof. Naima Hamoumi. Prof. J.P. Henriet was also received by Mr. M'hamed El Mostaine, Director of Exploration, who confirmed the full support of ONHYM to the GBCP initiative. Various opportunities opening for Moroccan GBCP research with Industry were reviewed. Of particular interest seemed "source-to-sink" studies sponsored by Erdöl-D, open for cooperation with Moroccan universities, as well as studies envisaged by Repsol YPF.

A field reconnaissance was carried out in the Rharb Basin North of Rabat (N of Kenitra), where Prof. M.A. Gutscher had reported the occurrence of small carbonate chimney-like features along the coast. The field party consisted of Prof. N. Hamoumi, L. Terhzaz and Prof. J.P. Henriet. Considering the discovery of extensive fields of reworked small carbonate chimneys in recent years off the Moroccan coasts (TTR campaigns), any discovery of equivalent structures onshore could fuel stimulating joint research opportunities.

Small chimney-like features were indeed spotted within a carbonate-rich horizon on top of a cliff. Samples were taken for further analysis at Rabat University and in Belgium (Gent and Leuven universities). Isotope analyses at Leuven University, jointly interpreted by Prof. R. Swennen and Dr. Vitor Magalaes (Chicago University), suggest meteoric water discharge in shallow submarine springs. The encasing, tubular carbonate rock displays striking affinities with tube-worm reefs, as already reported elsewhere in the world. The interest of such findings substantiates further joint research. A more extensive field survey is planned early in 2009.

II.2.2. Field training, 2004–2008.

Field training has been recognized within the project as the major step in developing national capacities in geosciences. While working in multi-national research groups and guided by experienced scientists trainees became exposed to modern research methods and up-to-date scientific knowledge. They got access to large research facilities like research vessels.

R/V Professor Logachev *(Russia)*

R/V Belgica *(Belgium)*

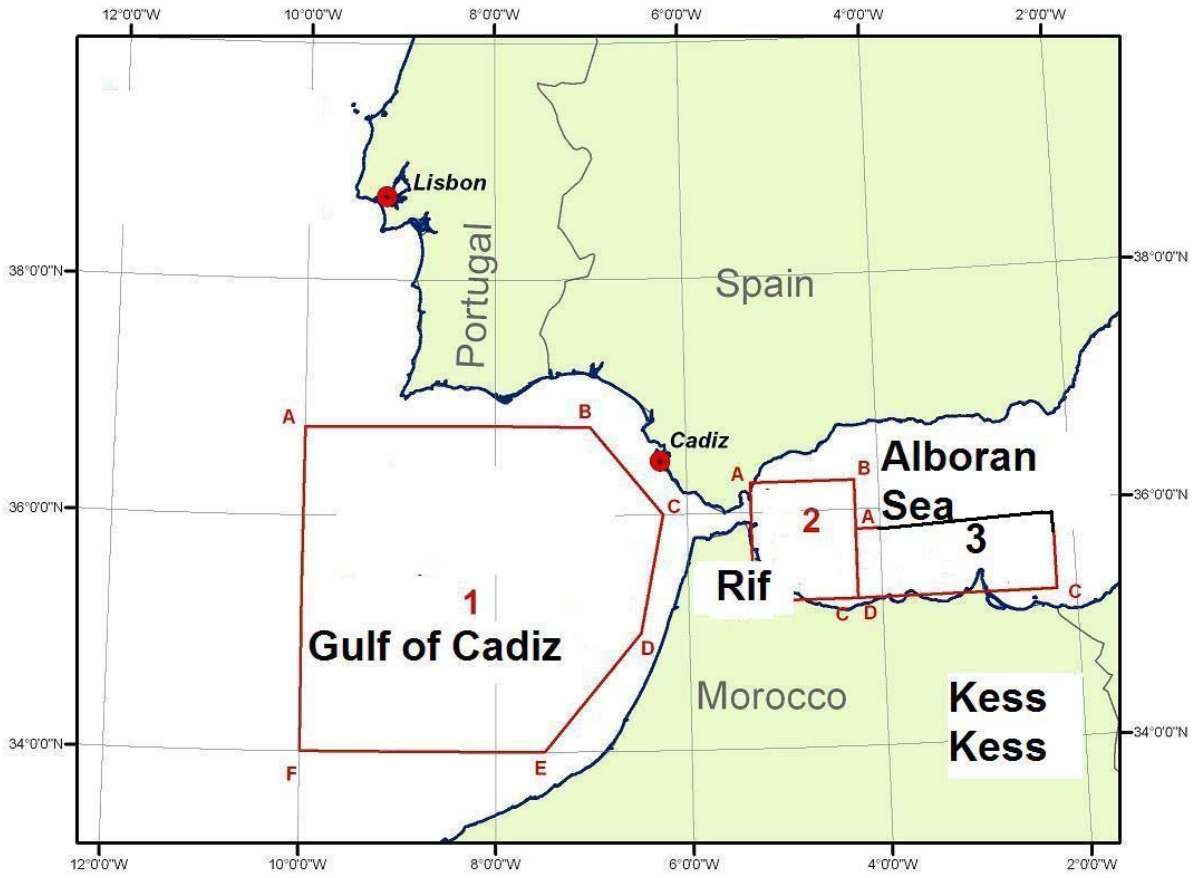
R/V Pelagia *(the Netherlands)*

Fig.4. Major research vessels used for ship-board training:
Sources: R/V Professor Logachev*: photo by E. Kozlova, Moscow State University;*
R/V Belgica*: http://en.wikipedia.org/wiki/RV_Belgica*;
R/V Pelagia: *http://www.nioz.nl/nioz_nl/386d4f0fee290da945fd7d7b8c235733.php*.

(i) TTR and other cruises.
The project has benefited from the TTR-14 (2004), TTR-15 (2005), TTR-16 (2006) and TTR-17 (2008) cruises of the R/V *Professor Logachev*, as well as from a number of cruises organized and convened by organizations-partners in the TTR programme (but not necessarily formal partners in the TTR-*Flanders* project), Annex 3. The latter has represented the project's synergy effect.

For over the last ten years the TTR programme has been using the R/V *Professor Logachev* (Russia) as its major platform for sea-going operations. This ship has been selected in view of its big size permitting to put on board up to 50 participants with a mixture of nationalities, disciplines and research interests, and a good range of ship-board equipment for research work such as: a single-channel high-resolution seismic system with airgun sources, a long-range side-scan sonar, a hull-mounted 3.5 kHz profiler, a MAK deep-towed system containing a high- to middle-resolution side-scan sonar and a 5.1 kHz sub-bottom profiler. A 6-m gravity corer, a box corer, a kasten corer, a CTD system, an under-water digital TV camera, a TV-controlled grab and a dredge have been used for more detailed studies.

A recognized particularity of the TTR cruises is their interdisciplinarity: from biology, microbiology and biogeochemistry to geochemistry, geological history and geohazards. During cruises the participants have been exposed to a wide range of disciplines and research methods. The above-mentioned cruises were carried out (at least in part) at the Moroccan Margin and were organized according to a similar scheme: on-the-job training in the use of the equipment for data collection and processing was completed with a team work on data analyses and interpretation. The trainees also attended daily lectures and seminars through which they got the necessary knowledge on research methods, geosphere-biosphere coupling processes in the ocean and sea-bottom processes in areas under study.



Fig,5. Moroccan Margin: research focus of the project (1-3: study areas)

"Do as I do!" Prof. J-P. Henriet (Belgium, left) and Prof. N. Hamoumi (Morocco, centre) with trainees extracting a sedimentary core from the gravity corer in a TTR cruise.

"What is there, beneath the sea bottom?" Discussion with trainees over the newly acquired seismic data at a ship-board seminar

Fig.6. Training in science: the TTR approach

Sub-sampling going under the guidance of Prof. M. Comas (Spain). The trainees on this photo come from Morocco and Spain

At a shipboard seminar: a participant from Morocco discussing the cruise data

Fig.7. Shipboard training, TTR-17 cruise (2008)

Sample of the trainees' impressions regarding their participation in the TTR cruises:

The subject of my studies is mud volcanoes at the ocean margin of Morocco. On board the Professor Logachev, *I admired the quality of interpretation of this phenomenon, the secrets of which are not yet well understood by researchers. With the assistance of the TTR programme, I have an opportunity to continue my studies and carry out research in a domain that requires heavy equipment and considerable resources, otherwise unavailable to me.* Merouane Rachidi, post-graduate student, University Mohammed V (Rabat, Morocco).

The TTR-17 cruise was very interesting and I learned so many things, I enjoyed the cruise very much and I met new friends. It was one of the most interesting oceanographic research cruises; everything was very well first the organisation for my visa and my travel and then the cruise itself. I believe that the cruise was very short, 12 days, even if it seems to me that it was more than a month, I guess because the research was 24/24h and I learned so many new things about the Alboran Sea area. We had chance to discover a lot such as new carbonate mounds and mud volcanoes in this area and we also benefited from presentations and seminars from Spanish scientists who had so many cruises before in this zone and know quite a lot which they shared with us on board. I also had a nice souvenir of young Russian students very motivated and cleaver, and also all the other scientists from the other countries who were on board and had different scientific research interests which they introduced to me. During this Leg, I could practice my experience in sedimentary core description and corals identification, I had also chance to have some notion from Russian students about seismic processing, and with Spanish students I could learn about methods and software for the seismic profile interpretation where my knowledge was very limited. I also would like to mention that during this cruise all students beneficed from a good pedagogic approach of the Co-Chief Scientists Mikhail Ivanov, Menchu Comas, Luis Pinheiro and Elena Kozlova, I would like to say thanks a lot to all of them to give me and all the students their time and to supervise us during the cruise. At the end I would like to thank all people who work hard and participate in the organisation of this cruise and give opportunity to students and professors to meet each other and share there knowledge in a good ambiance. So I guess if they invite me to participate in the next cruise on board the Professor Logachev *I would be always glad to be there without hesitation.* Loubna Terhzaz, MSc student, Département des sciences de la terre, Faculté des sciences, Université Mohammed V- Agdal (Rabat, Morocco).

Other cruises to the Gulf of Cadiz and the Moroccan Margin organized and convened by institutions-partners in the TTR programme and attended by the Moroccan participants included: (i) in 2004: the R/V *Marion Dufresne* (France) cruise; (ii) in 2005: the R/V *Belgica* (Belgium), the R/V *Meteor* (Germany) and the R/V *Pelagia* (The Netherlands) cruises; (iii) in 2006: the R/V *Poseidon* (France), the R/V *Charles Darwin* (UK) cruises and two cruises of the R/V *Pelagia* (The Netherlands); (iv) in 2007: the R/V *Belgica* (Belgium) cruise, (iv) in 2008, the R/V *Marion Dufresne* (France) cruise. These activities were complementary to the TTR cruises, but fully in line with the TTR-*Flanders* project. They represent a synergy effect that has been produced by the project.

Resulting from the above-mentioned cruises (TTR and non-TTR), a number of research projects have been launched by the trainees at their home institutions (Annex 2). The list of the trainees is given in Annex 3.

(ii) Field workshops.
Yet another form of capacity building developed and implemented within the project was field training-through-research workshops. Three such workshops were organized: in November 2005 in the coastal Morocco, in December 2006 in the Anti-Atlas Mountains of Morocco and in October 2008 in South Africa (Annex 3).

First International Field Workshop on the "Flysch Domain of the N-W Alpine Rif Belt" was organized between 13-15 November 2005 in co-operation with the GBCP-Morocco Consortium (Faculty of Sciences, Rabat and Faculty of Sciences and Techniques, Tangier) and Gent University. It took place in the NW Rif area (see Fig.5 for location), Morocco and brought together 14 participants from four countries: Belgium, Morocco, the Netherlands and Russia. Six Moroccan trainees attended.

The Workshop had dual tasks: (1) to discuss the new results related to the recognition of mud volcanoes onshore and the identification of fossil corals epigenized and coated by Fe and Mn oxides ("Tubotomaculum"), as well as their geological setting and (2) to illustrate the facies of all the representative flysch successions outcropping in the NW Rif belt that are reworked in the onshore and offshore mud volcanoes. Two scientific documents were prepared for the participants:

- a guidebook presenting the geological setting of the NW Rif Belt and the description of the stops (author: N. Hamoumi, Mohamed V-Agdal University, Rabat, Morocco) and
- a report on the TRANSMED Transect I from the Iberian block down to the Sahara domain (author: D. Depreiter, Gent University, Belgium).

Geological samples were collected for further laboratory analyses. Knowledge on Geosphere-Biosphere coupling processes throughout the geological time has been increased. Assistance was provided in research on paleo-oceanographic processes to a research team from Rabat University. Training in data collection, analyses and interpretation was provided to trainees from Morocco and Europe.

This activity was a good example of North-South co-operation in the research field. It also assisted researchers from Morocco in better understanding geological processes in the northern Morocco. Thus the research potentiality of Morocco has been increased.

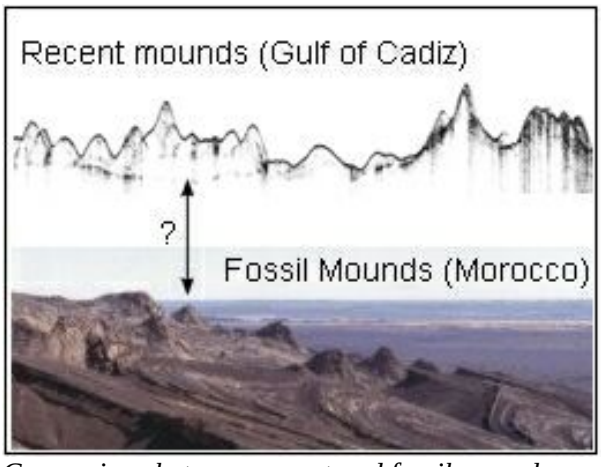
Second International Field Workshop "The Kess Kess Mound Capacity Building Action" took place in the eastern Anti-Atlas Mountains of Morocco (see Fig.5 for location), 1 to 5 December 2006. It was a joint venture between this project and the ESF EUROCORES EuroDiversity 'MICROSYSTEMS' project for a comparative study of fossil and recent carbonate mounds. It benefited from an extraordinary local logistic support of the Ibn Batouta Centre of the European Space Agency (ESA) in Marrakech and co-operation with the University of Bologna and the International Research School of Planetary Sciences (IRSPS), University of Annunzio (Italy).

Around the world, very old structures are found resembling the recent coral mounds that are found along the Atlantic margin (Rockall Through, Porcupine Seabight, Gulf of Cadiz etc.) and studied by the TTR and other cruises. By studying these old bioherms, such as the world-famous Early Devonian (some 400+ million year old) Kess Kess Mounds, scientists try to find out whether the organisms and processes that are responsible for building the structures in the present and past are similar; they want to know how life evolved and how the building process (origin, life and death of a mound) took place.

During this fieldtrip young researchers of Morocco, Mozambique, Mauritania and Russia were guided on the field under the supervision of experts from Belgium, Italy, Morocco, Switzerland and the Netherlands. The trainees were introduced to the world of the Devonian Kess Kess mounds in Morocco according to the 'Training-Through-Research' philosophy. By making their own observations and discussing them with the scientists, they discovered the various problems and burning questions that are still surrounding the carbonate mounds, both fossil and recent ones.

During the workshop an educational outreach was made by Gent University to three classes from Belgium, Germany and Morocco. On the Class@Desert website the students of these classes were able to follow the proceedings on the field.

The course was attended by a group of 13 DESA trainees from Mohamed V–Agdal University (Rabat) and a trainee from "Département de Géologie Université Abd El Malek Essaadi Faculté de Sciences et Techniques" (Tangier). One trainee came from Mozambique



Comparison between recent and fossil mounds

One of the world-famous Kess Kess mud mounds

Fig.8. The Kess Kess Mounds Capacity Building Field Action (see Fig.5 for location)
Source: http://www.vliz.be/projects/classatdesert/index.php

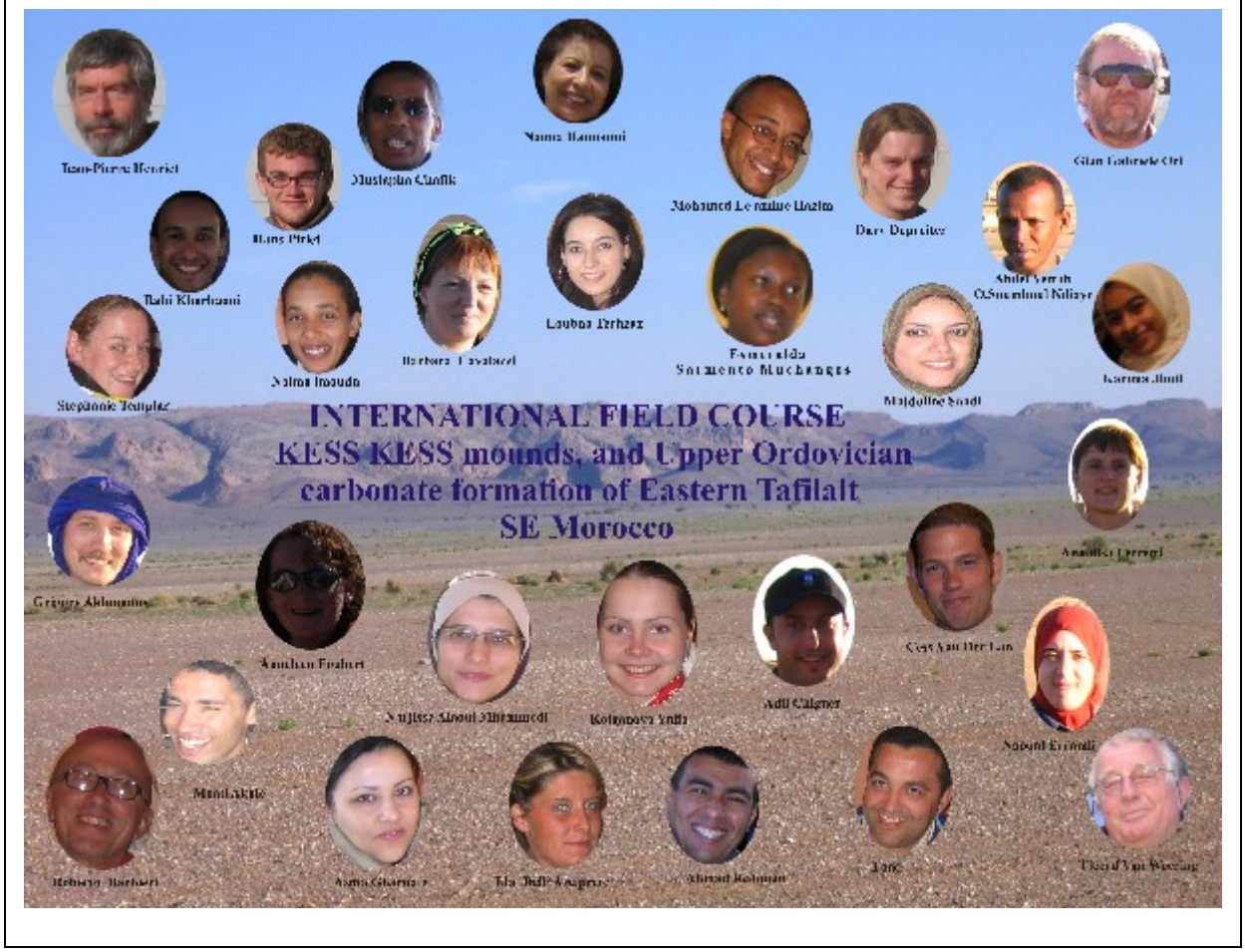


Fig.9. Participants in the Kess Kess Mound Capacity Building Action (poster produced by the participants during the field trip)

and two from Mauritania. Other participants came from Belgium (4), Italy (5), the Netherlands (2), Russia (2) and Switzerland (1), financed by European projects.

During the workshop the trainees from Morocco, Mauritania, Mozambique and Russia were able to gain experience on the field under the guidance of experts. This course was also an excellent opportunity to introduce the research on carbonate mounds to a new group of young and ambitious geologists.

This fieldtrip provided the scientists with a chance to make a comparison between the recent carbonate mounds and the Devonian fossil examples in Morocco. Some differences in the fauna, growth and geometry of the mounds were observed. There were also similarities found between the ancient and recent mounds. The inner section of the Hollard mound, for example, strongly resembles some seismograms that were taken in the Gulf of Cadiz. The observation of the fossil mounds broadened the perspectives of the scientists concerning the growth, life and death of the recent carbonate mounds.

A workshop on "Cold-water carbonate mounds: fundamental and applied research perspectives" was organized 26 October 2008 prior to the AAPG (American Association of Petroleum Geologists) Conference Opening Session, the premier conference in petroleum geology. Prof. J.P. Henriet set the stage, introducing the goals of the full action, comprising the workshop, the day-by-day representation and contact strategy with Industry at the AAPG

Conference, the Cold-water Carbonate Session (Oral and Poster) and a post-conference geological field activity. He invited the participants to frame significant highlights of their research, relevant to the GBCP theme.

On 31 October the workshop was followed by a **geological field course** under the theme "Hermanus Whale Bay Route Geology Field Excursion". A highlight was the visit of famous outcrops of Ordovician sequences, which thrilled Ordovician-expert Prof. Naima Hamoumi. Vivid discussions on the field dealt with the debated glacial nature of some deposits. The field excursion was directed by Prof. John Rogers from Cape Town University.

In a post-excursion discussion, Prof. Rogers confirmed his interest to join a possible next phase of the GBCP programme, to contribute to develop a pan-African programme (building in particular upon the regional cooperation schemes between South Africa and other African states). Considering next year's AAPG meeting in Rio de Janeiro (Brazil), the development of a GBCP "troika" Morocco - South Africa - Brazil, fully framing the most interesting South Atlantic cold-water coral and carbonate mound provinces, could pave the way towards a comprehensive and balanced N-S Atlantic research effort.

Prof. John Rogers explaining the geology of the Ordovician outcrops at Hermanus Whale Bay to Prof. Naima Hamoumi and Loubna Terhzaz.

Prof. Hamoumi reacting ecstatically at the confrontation of Moroccan and South African Ordovician facies.

Fig.10. At a field workshop in South Africa
(photos provided by J-P. Henriet, Gent University)

(iii) Other training activities.

As a matter of co-operation between various IOC programmes, arrangements were made to train three persons from Morocco (Annex 3) in the oceanographic data handling at the IOC/IODE Centre in Ostend (Belgium). This training took place successfully in the period 7-21 November 2005. A very encouraging evaluation of the participation of the Moroccan trainees was made by the organizers of the course (see box below). Their participation in the activity was at no cost to the TTR-*Flanders* project representing its synergy effect.

Sent: Monday, November 14, 2005 8:37 AM
To: Pissierssens, Peter; Snoussi, Maria
Cc: Vladymyrov, Vladimir; Suzyumov, A.; Martinez, Rodney; Reed, Greg
Subject: Our Moroccan students in the ODINCARSA workshop

I want to report that the students (see below) are doing an excellent job. They have integrated themselves smoothly into the group, crossing every border in the process (cultural, oceanic, etc.). This is one of the sociable, well-bonded groups I've ever taught, but the immediate adjustment of all parties was truly remarkable. Late last week I learned that all 3 Moroccan students are alumni of the Floating University program, about which they speak highly. I don't know if it was that experience alone, or the FU selected process, but we're fortunate to have such talented young oceanographers also in our workshop.

There are 2 lessons here: We should not hesitate in the future to mix regional groups, as the occasion arises. So long as the English language is shared, regional origin is a non-issue among talented students. Also, we might want to tap into the talent pool that the FU is developing, as partner training programs.

Murray Brown (m.brown@odinafrica.net)

II.2.3. International TTR and other conferences: yet another way of training in science.

Participation of trainees in research conferences has been considered as an important step in their overall training in science. The TTR programme provides such an opportunity through its annual Post-cruise Conferences. Other research conferences (such as that of the Mediterranean Science Commission, CIESM) have also been considered as important events exposing the trainees to the world of modern science.

(i) TTR-14 Post-cruise Conference (Marrakech, Morocco, 2-5 February 2005).
Following the project's start in mid-2004 and the participation of a group of trainees from Morocco in the TTR-14 cruise, and in view of widening the impact on the Moroccan marine science community at large, it was decided to organize the TTR-14 Post-cruise Conference in Morocco. By all means, this approach has reached the objectives – this can be seen, for example, from the list of national authorities and eminent scientists involved (Annex 4).

The annual international post-cruise research Conference on 'Geosphere-Biosphere Coupling Processes: the TTR interdisciplinary approach towards studies of the European and North African margins' took place in Marrakech, Morocco (2-5 February 2005) following the invitation from the GBCP-Morocco Consortium. It was organized by the IOC and its Training-through-Research (TTR) programme together with the Geosphere-Biosphere Coupling Processes Consortium of the universities and research institutions of Morocco and Gent University (Belgium). It considered results of the TTR-14 (2004) cruise to the Gulf of Cadiz and the Mediterranean Sea, results of some other TTR cruises carried out at the European and North Atlantic margins and in the Central Atlantic, and other national and international projects relevant to subjects of the TTR research and the research subject of the TTR-*Flanders* project.

The Conference had dual but complementary tasks: to discuss the most recent achievements in interdisciplinary research mostly on ocean margins and to provide young researchers with a forum to present and discuss their research results. It had yet another target: to promote the

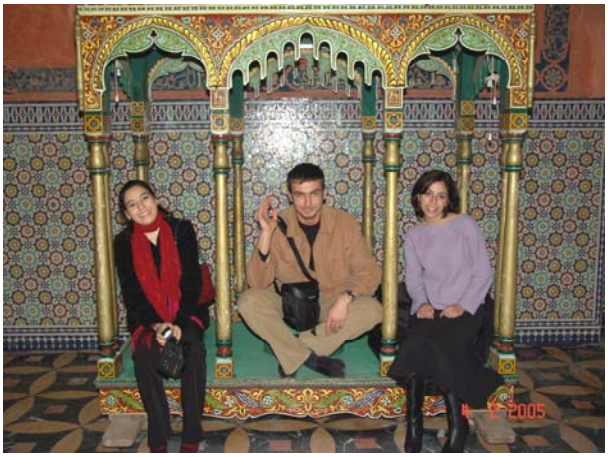
TTR approach in the Third World countries, especially in Africa, and thus to extend training-through-research operations and to contribute in a wider sense to capacity building in countries of the South.

The TTR annual conferences are of particular value to students involved in the programme as they enable participants to present and discuss results of studies shortly after a cruise, to agree on further data processing and to orient joint research. For young scientists, it is an integral part of their training in science. It is also an opportunity to present the results to the international scientific community, and to facilitate cooperation and co-ordination with other relevant national or international research initiatives.

Conference participants

Prof. N. Hamoumi, Chairperson of the OrgCom

Presentation of the TTR-14 cruise data by a trainee from Morocco



Discovering the Moroccan culture

Fig.11. At the TTR-14 Post-cruise conference in Marrakech

The meeting brought together nearly 70 participants from 16 countries: Belgium, France, Germany, Greece, Ireland, Italy, Morocco, the Netherlands, Norway, Portugal, Russia, Saudi Arabia, Senegal, Spain, Switzerland and the UK. Attending were researchers and students with different specialties (geology, sedimentology, geophysics, geochemistry, microbiology, biology, etc.) and research interests. In total 37 oral and nine poster presentations were made grouped around several themes like mud volcanoes, fluid venting, carbonate mounds, slope processes, geohazards etc.

In total, the Conference was attended by 17 researchers (including young researchers) from Morocco. They made (individually or in co-authorship) ten (10) presentations. One participant was invited from Senegal. It was Dean of Geology Faculty, University of Dakar who in addition to a presentation on his research subject also made a presentation of his Faculty. Through his participation and exposure to the TTR programme and the TTR-*Flanders* project an attempt was made to involve Senegal. Regrettably this attempt has failed, in spite a few more attempts that were made by the UNESCO-Dakar Office, on the request by IOC. A conclusion can be made that this country is not yet ready to start developing its own national capacity for studying off-shore environments and resources.

On 3 February the TTR Executive Committee met at an open session. Plans and timetable for the TTR-15 cruise (2005) to the Gulf of Cadiz and the Mediterranean Sea were presented and discussed contributing to the TTR-*Flanders* project's objectives and planning.

On 5 February a geological trip under the theme "The Ourika Valley (High Atlas of Marrakech, Morocco): a natural geological section through typical intracontinental chain" was organized. It was efficiently guided by the eminent Moroccan scientists H. Ouanaimi and K. Taj-Edine, in co-operation with N. Hamoumi and served the purpose of short-term geological training provided to all the participants.

The Organizing Committee (Chairperson Prof. N. Hamoumi, Mohamed V-Agdal University, Rabat) was responsible for the local arrangements. Efficient secretarial assistance was provided by a group of young researchers from Mohamed V- Agdal University who *inter alia* composed and published the book of abstracts. The meeting Proceedings were published in 2005 in the IOC Workshop Series as No.197.

The meeting was also an excellent opportunity for cultural exchanges. For many participants from the North it was there first visit to Morocco, and they enjoyed very much the traditional Moroccan hospitality. For many Moroccan young participants it was their first involvement in an important international conference with wide representation from countries of Europe. It was a chance to establish useful contacts and make new friends across the continent.

Fig.12. Tongues of flame under the black sky of Marrakech: a very touching closing event organized by the Moroccan hosts

(ii) Other TTR Conferences and the relevant international meetings.

The TTR-15 Post-cruise Conference on "Geological Processes on Deep-Water European Margins" was held from 29 January to 4 February, 2006 hosted by Moscow State University (Russia). Two Moroccan participants attended, with presentations.

The TTR-16 Post-cruise Conference on "Geo-marine Research along European Continental Margins" was hosted by Bremen University (Germany), 29 January to 1 February 2007. It was attended by two participants from Morocco, with presentations.

One participant from Morocco (Prof. N. Hamoumi) attended (at no cost to the TTR-*Flanders* project) the ***CIESM workshop on mud volcanoes in the Mediterranean Sea*** (Bologna, Italy, October 2005), with a presentation made at the basis of the TTR data.

The TTR results obtained at the Moroccan Margin were presented at a special TTR session of the ***First International Conference of the Moroccan Association of Petroleum Geologists, MAPG*** (Morocco, Marrakech, 28-31 October 2007). The TTR participants made in total five presentations (two by the participants from Morocco). By this action the TTR data have been introduced not just to the international scientific community but to the quickly growing Moroccan petroleum industry.

(iii) Morocco GBCP on the "African Energy – Global Impact" Scene: the final action of the project and a forward-looking event

(a) Background, Context and Objectives

The TTR-*Flanders* project has contributed to unveil to the North African academic world the study of giant carbonate mounds and the remarkable deep-water coral reef ecosystems, fringing in particular the continental margins of both Europe and North-Africa.

A significant number of young researchers from the Morocco-GBCP Consortium Universities in Rabat, Marrakech and Tangier have joined international oceanographic cruises and have co-organized training events both in academic centers and on field locations in Morocco. This capacity building effort deserves a future, an effort towards a sustainable development.

Besides the evident contribution to the identification of potential deep-water protected areas in view of safeguarding this world natural heritage, Moroccan GBCP Science has the potential to significantly contribute to fundamental insights in Geosphere-Biosphere Coupling Processes, and in particular in the genesis and development of giant carbonate mounds. Morocco indeed features outstanding examples of carbonate mounds, both in the fossil record onshore and "live", on the present seabed, as highlighted by TTR research. Numerous carbonate mound provinces, frequently associated with expressions of fluid flow (methane seeps, mud volcanoes, authigenic carbonate crusts) have been documented by now both on the Atlantic and Mediterranean continental margins, to the level where they could be developed into true international "natural laboratories".

In parallel, the hydrocarbon industry displays an increasing interest for deep-water energy resources. In very recent times, fossil cold-water carbonates have moved to the foreground for their significance as potential deepwater hydrocarbon reservoirs. Modern carbonate mounds may to some extent provide models for fossil reservoirs.

This shapes an opportunity to bring together Academia and Industry around research topics of common interest, with a significant potential towards capacity building. This is the goal of a concept of JIP (Joint Industry Project) named "COCARDE" (Cold-Water Carbonate Reservoir Systems in Deep Environments), which may be regarded as an antenna, and hopefully a bridgehead of IOC-UNESCO's "Geosphere-Biosphere Coupling Processes" Programme towards Industry.

The surge of industrial interest in cold-water carbonates is exemplified by the fact that Prof. J-P. Henriet, the coach of the present project, jointly with Miriam Andres (Chevron), proceeded with success with the organization of a special session "Deepwater Carbonate Systems and Reservoirs" at the premier conference in petroleum geology, the AAPG (American Association of Petroleum Geologists) International Conference and Exhibition.

Strategically, this event was most significant in three aspects:

(1) organized in Cape Town 26-29 October 2008, it had a focus on Africa and sailed under the banner of "African Energy – Global Impact",
(2) it immediately follows the founding of the Morocco Association of Petroleum Geologists (MAPG), which held a successful first Conference in Marrakech, October 2007 (referred to on p. 20),
(3) the next AAPG International Conference and Exhibition will be in Brazil, where deepwater reservoirs, very recently also of carbonate nature, are high on the agenda.

The MAPG Conference had been for many Moroccan researchers and students an important first window on industrial research. It is however important that Moroccan GBCP students and researchers would keep contact with this industrial world, especially in an African context and that they would be in a position to contribute to the further promotion of Moroccan and African GBCP research overseas, in particular towards the Brazil 2009 event.

This was the rationale to build into this "finale" of the TTR-*Flanders* project a significant action in Cape Town, with the participation of Moroccan researchers. This initiative can lay the base for shaping a win-win action between Industry and Moroccan GBCP research teams, to foster with new resources a sustainable, long-range academic research and capacity building effort, well beyond the TTR-*Flanders* project. If we succeed in this venture, the IOC-UNESCO TTR-*Flanders* project will have demonstrated its seminal value.

(b) The AAPG Conference: highlights

The AAPG (American Association of Petroleum Geologists) Conference was attended by some 1600 participants, mainly from the hydrocarbon industry. ONHYM had a small booth at the Exhibition, which was used as hub and meeting place of the GBCP attendants for the daily debriefing and brain-storming moments.

On Monday 27th (African Energy, Global Impact theme), the "Deepwater Carbonate Systems and Reservoirs" session (conveners M. Andres, Chevron, and J.P. Henriet, Gent University) was attended by some 80 participants, a very good score, considering the numerous parallel sessions. A significant interest was displayed by high-level officers of Chevron, Phillips-Conoco, Petrobras and ENI.

On Tuesday 28th the "Deepwater Carbonate Systems and Reservoirs" Poster Session was attended by the GBCP team the whole morning. Copy of the "Cold Water Carbonate

Reservoir Systems in Deep Environments" poster is accompanying this report as Fig.14. On the poster, the Moroccan GBCP delegates have briefly presented their main research themes.

Wednesday 29th, sessions on gas chimneys and mud volcanoes, deepwater exploration models and gas hydrates were attended. Useful contacts could be laid by the Moroccan scientists with Dr. Joan Flinch, Repsol Co.

Throughout the Conference, the Moroccan delegates could lay promising contacts with the Industry representatives. Loubna Terhzaz passed interviews, which could be determining for her future career.

Impression of a participant from Morocco

Cher Jean Pierre Henriet,
Au nom de l'équipe marocaine, j'aimerais te transmettre nos plus vifs remerciements pour tous les efforts et les moyens que tu as mis en oeuvre pour nous permettre de participer au meeting de l'AAPG. Cette expérience qui a constitué une première pour la plupart d'entre nous a été très bénéfique sur le plan scientifique. En plus, de faire connaître notre projet, nous avons pu suivre des conférences et des communications de haut niveau et faire la connaissance de nombreux scientifiques des secteurs académique et industriel. L'excursion géologique a été également très riche en enseignement en particulier pour moi qui travaille sur la glaciation ordovicienne depuis 1978. Par ailleurs, grâce au choix judicieux de notre hôtel dans le quartier le plus beau de Cap Town, nous avons pu mettre à profit tout les moments de libre durant notre séjour pour découvrir et apprécier la beauté des sites et la gentillesse et la qualité de l'accueil des africains du sud. J'aimerais te remercier également pour les livres de l'AAPG que tu as acheté pour nous et à cet effet, je propose que soit inscrit sur chaque livre "Don de l'Université de Gent- Projet GBCP/UNESCO-IOC 2008"
Amitiés
Prof. Naima Hamoumi, Université Mohamed V – Agdal, Rabat, Maroc

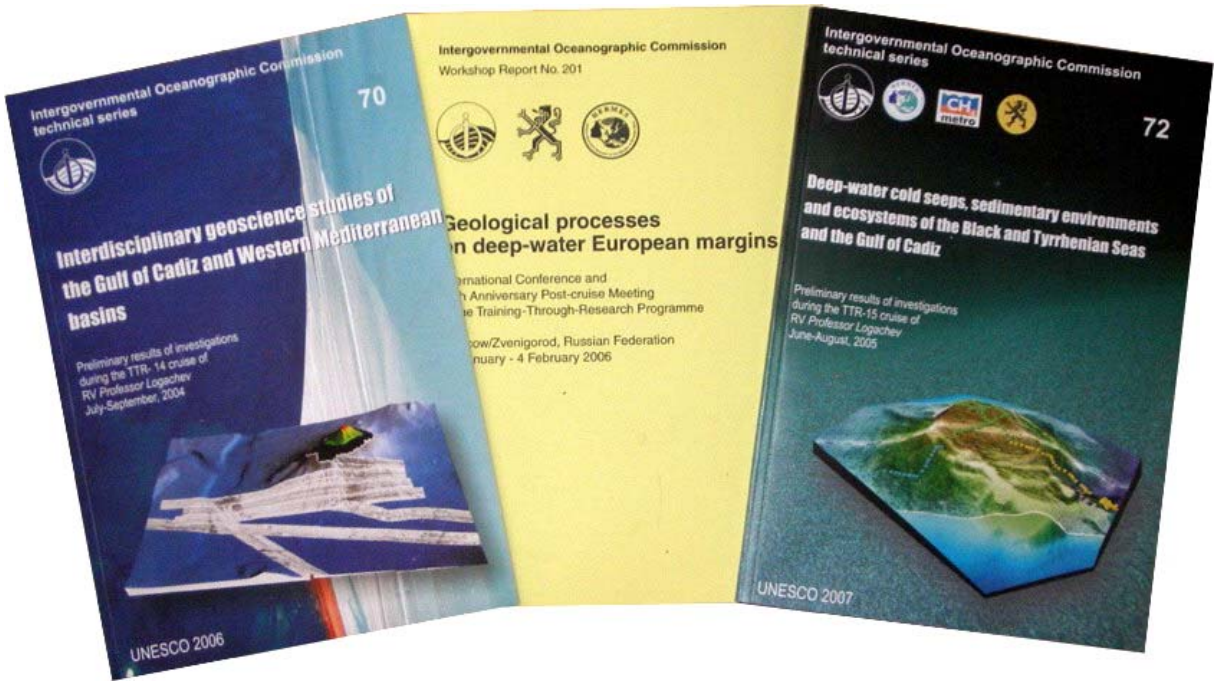


Fig.13. Sample of reports resulting from the project (see Annex 5 for details)

II.2.4. Training in data synthesis and reports' writing.

Research results that come out of the TTR-*Flanders* project have regularly been published by IOC in its Technical and Workshop Reports series. Training in research papers' and reports' writing has always been considered as an important part of training in science. In the scientific report of the TTR-14 cruise published by IOC in its Technical Series (TS) as No. 70, 2006, five (5) chapters have been co-authored by trainees from Morocco. In the TTR-15 report, published as TS No.72, 2007, three (3) chapters have been co-authored by five trainees from Morocco. In the TTR-16 report, published as TS No.76, 2008, one chapter has been co-authored by a trainee from Morocco. Much more individual papers and abstracts have been published in the IOC Workshop Series (list of publications resulting from the project is given in Annex 5) and in research journals.

III. DIFFICULTIES AND PROBLEMS ENCOUNTERED AND MEASURES TAKEN, CHANGES IN IMPLEMENTATION

1. There were no major problems met in the pilot country, Morocco. Considerable interest in the project's subject has been raised in a few countries outside Africa, like in Saudi Arabia and Georgia. However the project's attempts to raise interest in offshore research and the corresponding training in Senegal failed. The UNESCO Office in Dakar (Senegal), requested for assistance, was also unable to get any positive move from the local university. One may conclude that this country, due to a variety of reasons, is not yet interested in developing its own expertise in the specific field of the project.

2. Fully on schedule with the execution between 2004 and early 2007, the project had to cancel its field training activity in the summer of 2007 due to technical problems with the R/V *Professor Logachev,* the project's major research and training platform. This activity was moved to the summer of 2008 (successfully implemented). The corresponding request for the project's extension was submitted to and approved by the Donor (see Minutes of the UNESCO/Flanders Funds-in-Trust for the Support of UNESCO's activities in the Field of Science Eleventh Meeting of the Steering Committee, 28 February 2008, *http://www.iode.org/fust/sessions/session14/session14.html*).

IV. RESULTS PRODUCED

IV.1 Summary of the research results

The Project has advanced knowledge on Geosphere-Biosphere coupling processes at Ocean Margins (i.e. the Moroccan Margin). It also contributed to knowledge transfer and sharing by bringing together partners from various countries of the North and the South, from academia, universities, industry and other relevant public sectors. Trainees from Third-Word countries have (co)authored the resulting reports and research papers.

1. Active programme on geosphere-biosphere coupling processes has been established focused on the Gulf of Cadiz in the Eastern Atlantic and specifically the Moroccan Margin, where manifestations of these interactions are clearly seen.

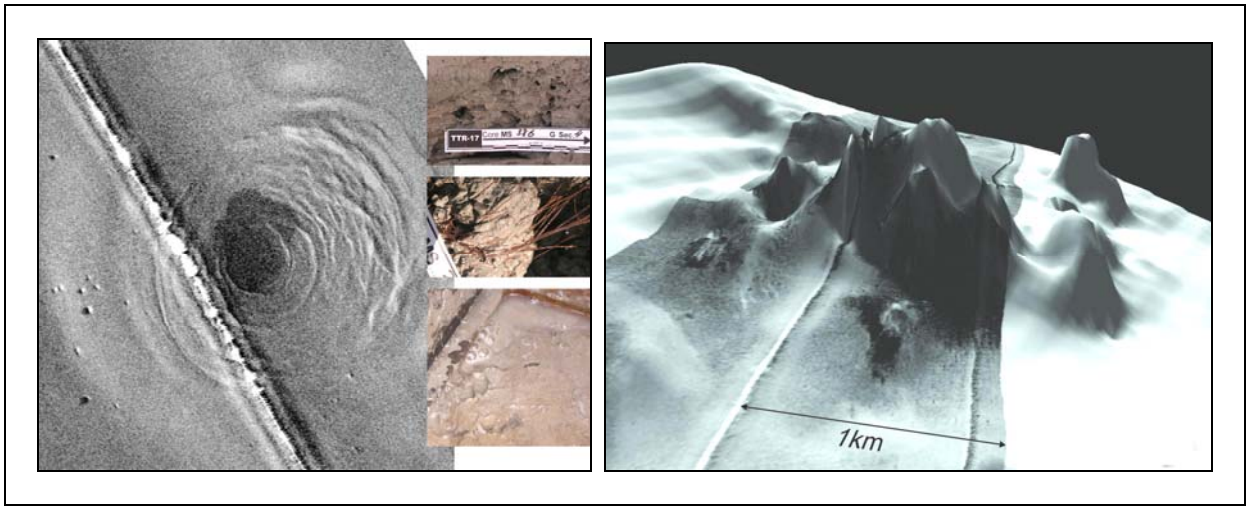


Fig.14. Research targets of the project: mud volcanoes (left) and carbonate mounds (right). Left: sonograph of Carmen mud volcano (Alboran Sea) with inserts showing recovered Pogonophora and bubbling gas, probably from dissolving hydrates. TTR-17 cruise (2008). Source: HERMES Newsletter No.13. Summer 2008, pp.5-6 (http://www.eu-hermes.net/). Right: the world of underwater carbonate mounds. A side view reconstructed from deep-towed sidescan sonar survey and detailed bathymetry (courtesy of M. Ivanov, Moscow State University, Russia). See also Fig.8 for comparison.

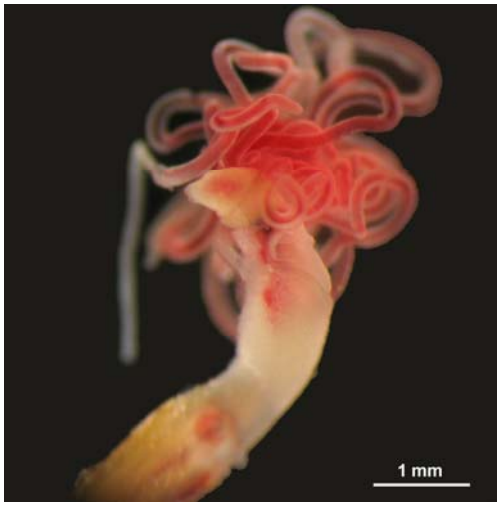
2. Many intriguing underwater features were discovered and studied in detail. Among these are ridges, mud volcanoes, carbonate mounds, cold-water coral reefs etc. One of research targets was gas hydrates: a potential source of energy of the future. Specific environments and ecosystems resulting from interactions between the geosphere, the hydrosphere and the biosphere in zones of active seepage of geofluids were revealed.

Bottom sampling and analysis of video materials collected in the Gulf of Cadiz has revealed that although not much living corals are present there, in the recent past cold water corals were far more abundant in the area. Temporal changes in the cold-water coral faunal assemblages indicate a link between the composition of the coral fauna and climate variability.

Carbonate crusts can be characterized as being precipitated from the thermogenic gas forming different morphologies depending on the material that is being cemented, and the depth of their formation meaning the activity of the bioturbation processes in different levels of the sediments. High microbial activity at the uppermost part of the mud volcanoes and rapid decreasing with the depth in concentration of certain ions at the pore water profiles point to intensive authigenic carbonate precipitation. Data on stable carbon isotopic composition of carbonate clearly point to its origin due to anaerobic methane oxidation.

High resolution sidescan sonar survey has covered the Pen Duick escarpment (the Morocco Margin) and imaged two extensive faults bounding the structure from east and west. Video survey and sampling showed the western fault to be the more active seepage site and large carbonate crusts and chemosynthetic fauna were recovered here by a grab sampler. The preliminary results of these studies clearly demonstrate that changes in the sedimentary geology are accompanied by changes in the benthic assemblage.

Ana Hilario (Portugal) and Francisco Jose Jimenez Espejo (Spain) looking at a Pogonophora tube



New species of a tube worm

Fig.15. Are they alive? Yes, and new to science! (TTR-17 cruise, 2008, see also Fig.13, left). Source: HERMES Newsletter No.13. Summer 2008, pp.5-6 (http://www.eu-hermes.net/).

The results of the SEM observations and the biomarker analysis show that microbes were involved in the formation of the authigenic carbonates. Lipid biomarker distributions and maturity properties from the mud breccias on mud volcanoes show the presence of petroleum-derived hydrocarbons. In contrast, lipid biomarker distributions in the pelagic sediments from the Pen Duick escarpment show no deep fluid inflow within the sampling location and immature, dominantly terrestrial organic matter. Accordingly, received data suggest a non mud volcanic origin of the Pen Duick escarpment.

Samples from several of the studied seep sites in the Gulf of Cadiz collected specimens for chemosynthetic endosymbiont identification and for genetic and stable isotope studies. Studies of faunal assemblages have shown that chemosynthetic communities in most of the mud volcanoes are dominated by frenulate siboglinids. Preliminary observations show that *Siboglinum* is the genus with the widest geographical distribution, being present in all the studied mud volcanoes, and that Porto mud volcano has the largest diversity of frenulate siboglinids, with species from at least 4 genera. Molecular and morphological analysis of specimens collected from several mud volcanoes showed that there are at least 8 different species of 5 different genera, from which at least two species and one genus are new to science.

3. The research results of the TTR-*Flanders* project have been presentations at various national and international forums (Annex 4) and documented in many published reports (Annex 5) and research papers.

4. Knowledge regarding resources, oceanographic and geological processes in the Moroccan EEZ, e.g. a territory under the national jurisdiction, has been considerably increased in the pilot country. Data collected within the project (bottom samples, geophysical materials) were provided to the Moroccan and other trainees for further analyses at their home institutions. They have also been used for training purposes within the DESA course at Mohamed V-Agdal University, Rabat.

COLD-WATER

JEAN-PIERRE HENRIET, Renard Centre of Marine Geology, Ghent University, Belgium.
CHRISTIAN DULLO, IFM-GEOMAR, Kiel, Germany.
ANNELEEN FOUBERT, Leuven University, Belgium.
NAIMA HAMOUMI, Mohamed V University Rabat-Agdal, Morocco.
HANS PIRLET, Renard Centre of Marine Geology, Ghent University, Belgium.
ANDRES RÜGGEBERG, IFM-GEOMAR, Kiel, Germany.
SILVIA SPEZZAFERRI, Fribourg University, Switzerland.
DAVID VAN ROOIJ, Renard Centre of Marine Geology, Ghent University, Belgium.
TJEERD VAN WEERING, Royal NIOZ, The Netherlands.

IODP exp. 307 Porcupine Basin Challenger Mound

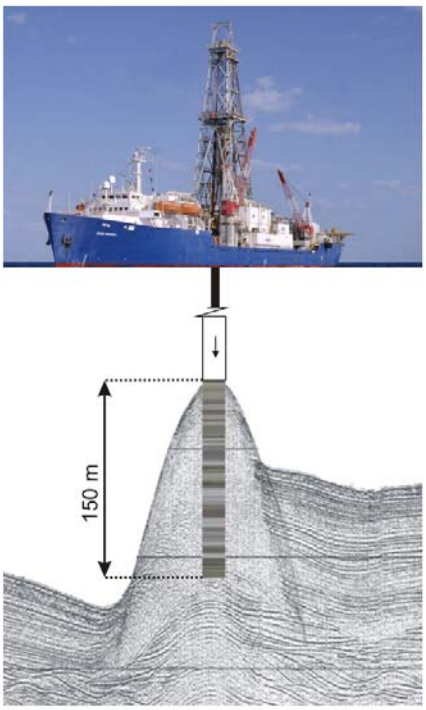


Fig. 1) Drilling vessel: The Joides Resolution. Fig. 2) A high resolution seismic profile of Mound Challenger. The stack of the core-pictures clearly highlights the cyclic structure of the mound with alternating lighter and darker layers.

April 2005: the Integrated Ocean Drilling Program's (IODP) research vessel Joides Resolution (Fig. 1) drills Challenger Mound, a 155 m high carbonate mound in the middle of the "Belgica Mound Province" discovered in 1997 in water depths of 900 m in Porcupine Seabight, W of Ireland (Henriet et al., Nature 1998). For the first time in history, a giant carbonate mound, fully exposed on the seafloor (Fig. 2, Henriet et al. 2002), is drilled and sampled at very high resolution in an integrated palaeo-environmental and biogeochemical/microbiological core flow. Teams from Europe, the US and Japan joined forces to unravel both a 2.5 million year record and the actual signature of pore fluids (Fig. 3 and 9, Kano et al., 2007). Cold-water corals are found from top to base (Fig. 4), arguing for the role of the ocean and external drivers in mound growth.

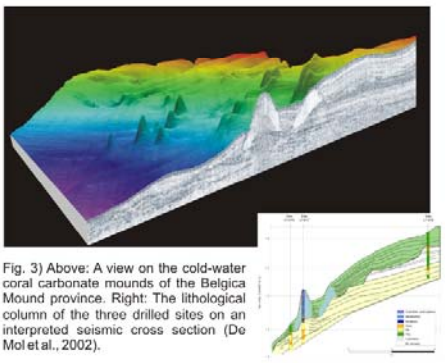
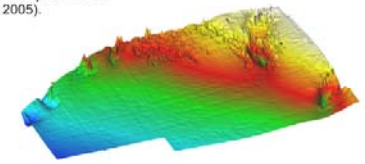


Fig. 3) Above: A view on the cold-water coral carbonate mounds of the Belgica Mound province. Right: The lithological column of the three drilled sites on an interpreted seismic cross section (De Mol et al., 2002).

Shipboard party:

Ferdelman, T., Kano, A., Williams, T., Gaillot, P., Abe, K., Andres, M.S., Bjerager, M., Browning, E., Cragg, B.A., De Mol, B., Foubert, A., Frank, T.D., Fuwa, Y., Gharib, J.J., Gregg, J.M., Huvenne, V.A.I., Léonide, P., Li, X., Mangelsdorf, K., Tanaka, A., Novosel, I., Sakai, S., Samarkin, V.A., Sasaki, K., Spivack, A.J., Takashima, C., Titschack, J.,

Fig. 5) Under: The Viking Mound Province, North-eastern Porcupine Basin (De Cock 2005).



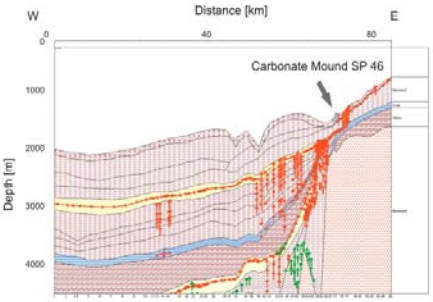


Fig. 6) The modelled migration of gas (red vectors) and oil (green vectors) towards the Belgica Mound Province (Naeth et al. 2005).

The Porcupine and Rockall mound provinces are located on the rims of basins with recognized hydrocarbon potential. The North Porcupine Basin alone hosts over 3000 mounds, clustered in sharply delineated provinces such as the buried Magellan (Fig. 7) and Viking (Fig. 5) provinces and the outcropping Hovland and Belgica mound provinces. The latter are located right above a modelled hydrocarbon migration pathway (Naeth et al. 2005, Fig. 6). Still, the possible link with fluid flow remains elusive and debated. On the Challenger Mound site, a zone of anoxic oxidation of methane (AOM) has been identified below the base of the mound (Fig. 9). Methane had a mixed biogenic and thermogenic signature (Mangelsdorf et al. 2008).

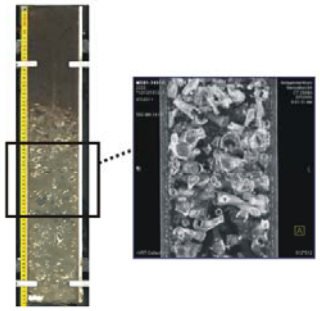


Fig. 4) The visualization of the coral content in Mound Challenger using medical CT-scans.

Both Challenger Mound and other prominent mounds in Porcupine Basin, such as Mound Perseverance (an outcropping Magellan mound) feature horizons of intense carbonate dissolution and precipitation (Fig. 8, Pirlet et al., in prep.), reflecting the important role of geochemical processes in the early development of carbonate mounds, exposed at the seabed.

The Magellan Mounds

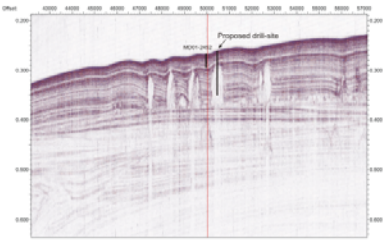


Fig. 7) Above: A high-resolution seismic profile of the buried Magellan mounds at the northern slope of the Porcupine Basin.

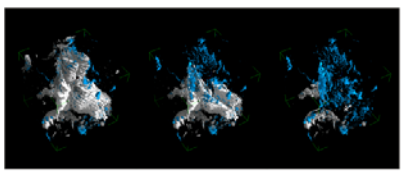


Fig. 8) Micro-CT scans visualizing the dissolution of corals (white) in Mound Perseverance (Magellan mound province) creating a moldic porosity (blue).

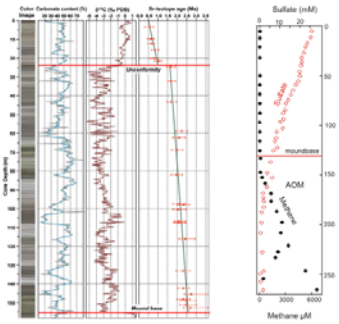


Fig. 9) Left: Chronostratigraphy (Kano et al., 2007) and geochemical profiles (Williams et al., 2006) of IODP 307 Hole U1317E through Challenger mound.

Fig.14(a)

CARBONATE RESERVOIRS

IODP 673-Full proposal Morocco Mounds

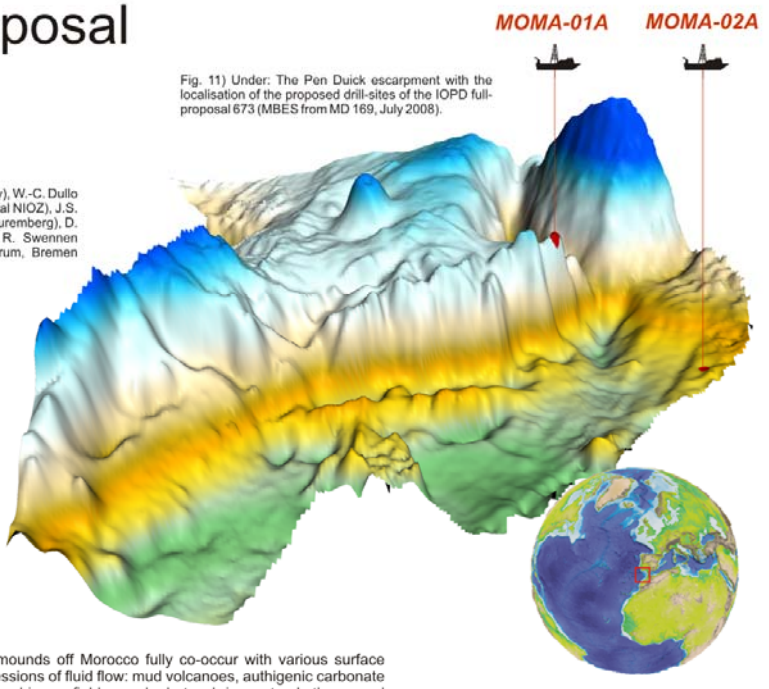


Fig. 11) Under: The Pen Duick escarpment with the localisation of the proposed drill-sites of the IOPD full-proposal 673 (MBES from MD 169, July 2008).

Proponents:

D.Van Rooij (RCMG, Ghent University), J.-P. Henriet (RCMG, Ghent University), W.-C. Dullo (IFM-GEOMAR, Kiel), J.A. McKenzie (ETH, Zurich), T.C.E. van Weering (Royal NIOZ), J.S. Sinninghe Damsté (Royal NIOZ), A. Freiwald (IPAL, University of Erlangen-Nuremberg), D. Blamart (LSCE, Gif-sur-Yvette), S. Spezzaferri (University of Fribourg), R. Swennen (Leuven University), N. Hamoumi (Rabat University) & D. Hebbeln (Marum, Bremen University).

Waiting for Joides Resolution, RCMG successfully proceeded with the exploration of the European and North-African margins further south, which led to the discovery in 2002 of clusters of carbonate mounds with associated cold-water coral reefs in the middle of a field of giant mud volcanoes on the Moroccan margin (Fig. 11, Van Rensbergen et al. 2005). The setting of the Pen Duick mounds on the rim of a Neogene basin (Fig. 10) is strikingly similar to that of the Belgica mounds on the rim of the Mesozoic/Cenozoic Porcupine Basin (Fig. 6). The "Pen Duick Escarpment" mounds (Foubert et al. 2008) form the target of a new IODP proposal (673-Full, Fig. 11).

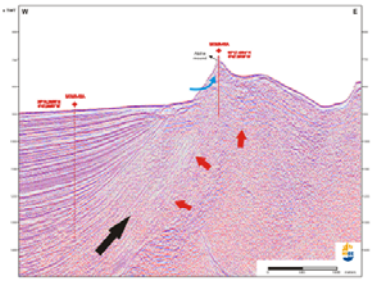


Fig. 10) A seismic profile (courtesy of Royal NIOZ) of Pen Duick escarpment with the proposed drill site of IODP Full proposal 673. Black arrow: advective transport of thermogenic and biogenic methane from the Neogene basin. Red arrow: diffusive transport from mud volcanoes (hydrocarbons and brines). Blue arrow: convective transport of sulfate.

The mounds off Morocco fully co-occur with various surface expressions of fluid flow: mud volcanoes, authigenic carbonate crusts, chimney fields, gas hydrates, brines, etc. In the mound targeted by IODP 673-Full, coral-stuffed cores released a very strong smell of hydrogen sulphide. An AOM was found at a depth of 3.5 m below the top of the mound. Horizons with strongly corroded corals alternate with horizons of carbonate precipitation (Foubert et al., 2008). Authigenic dolomite is formed in significant proportions (S. Templer, ETH-Zürich, in prep.) (Fig. 13). An early open system diagenesis, where carbonate dissolution largely exceeds precipitation, is postulated (Foubert et al. 2008). This model supports the view of mounds as active hydrogeological systems, moreover sites of competition between internally driven advection and diffusion of hydrocarbons and externally driven convective fluxes of sulfate-rich seawater (Depreiter 2008) (Fig.12).

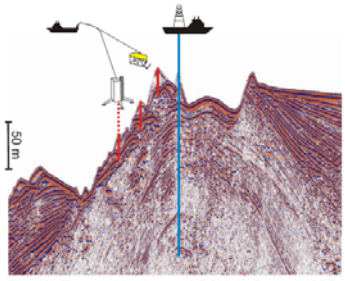


Fig. 16) The combined use of ROV, MeBo and IODP-Drilling on the carbonate mounds of the Pen Duick escarpment.

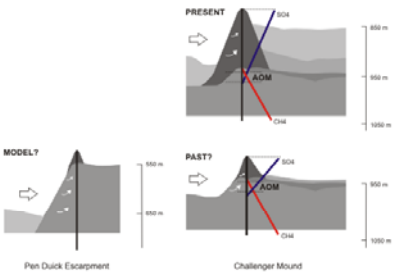


Fig. 12) A schematic figure highlighting the importance of fluid flow in the carbonate mounds on Pen Duick Escarpment and in the Porcupine Basin.

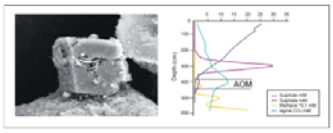


Fig. 13) The formation of authigenic dolomite through microbial mediation (courtesy of Stefanie Templer, ETH Zurich) in the AOM zone (Maignien et al., in prep) of the carbonate mounds.

In 2007, a cruise of R/V Hesperides unveiled an outcropping mound province off Melilla in the Alboran Sea (Fig. 14), which displays striking affinities with the buried Magellan mound province in Porcupine Seabight. Remarkably, the Pen Duick and Melilla mound provinces stand as sentinels of the former Rifian Corridor, the Mediterranean-Atlantic gateway that preceded Gibraltar Strait (Fig. 15) (Benson et al. 1991, Duggen et al. 2003).

Meet the Morocco COCARDE team at the AAPG

The **Morocco COCARDE Task Group** is a core team of both experienced and young, men and women researchers from Academia and Industry. Jointly, they represent a pool of expertise that ranges from oceanic studies in cold-water coral habitats to Palaeozoic and Mesozoic carbonate systems and the petroleum geology of carbonate reservoirs. Backed by the **IOC-UNESCO "Geosphere-Biosphere Coupling Processes" (GBCP) Programme** and the **European Science Foundation (ESF)**, they endeavour to develop in Morocco within an international partnership leading-edge studies and capacity building in carbonate systems, bridging research in cold- and warm water carbonates, in present and past carbonate factories.

Prof. Naima Hamoumi is head of the "Oceanology and Geodynamics of Sedimentary Basins" laboratory at the Mohamed-V University at Rabat-Agdal. She is expert in the Upper Ordovician carbonate mounds of the eastern Tafilalt, where she organised the 2001 Int. Comm. on Stratigraphy **IUGS** Field Excursion. She sailed on several oceanographic cruises studying the Strait of Gibraltar and the Moroccan margins, the recentmost one targeting the Pen Duick Escarpment carbonate mounds (R/V Marion Dufresne "**MiCROSYSTEMS**" cruise 2008, ESF EuroDiversity Programme).

Mohamed El Alji (petroleum engineer, ENIM, IFP) is Senior Project Manager at the National Office for Hydrocarbons and Mines (ONHYM) in Rabat. He is involved in the study of various carbonate systems of potential hydrocarbon relevance in Morocco: the Liasic Guercif Basin, the carbonate platform off Essaouira, the Jurassic pre-Rifian Ridges, the Foum Messaoud structure and the reefal structure of Mechkakor, High Plateaus. He contributes to a synthesis of the tectono-sedimentary evolution of Jurassic palaeo-environments in Morocco, both onshore and offshore.

Loubna Terhzaz graduated in 2008 as Master in "Geodynamics and Valorization of Oceanic Margins, Littoral and EEZ" at Mohamed-V University in Rabat. Within the framework of the "**MoundForce**" project (ESF Euromargins Programme), she analyzed at Royal-NIOZ (The Netherlands) the distribution of cold-water corals and associated biota on Pen Duick Escarpment (video footage), thus contributing to the **IODP**-673 Pre-drilling environmental impact assessment. She sailed on many oceanographic cruises on R/V Pelagia, R/V Charles Darwin and recently on the **TTR**-17 cruise (IOC-UNESCO) which targeted the Melilla carbonate mounds in Alboran Sea.

Prof. Driss Chafiki from Cadi Ayyad University at Marrakech investigates the Lower Liasic deep-water carbonate mounds with sponges and microbialites on a transect in the central High Atlas, between Midelt (N) and Errachidia (S). He focuses on the anatomy of the mounds, their rise and decay and their significance in the tectono-sedimentary plot of the Liasic basin, as well as on the nature and genesis of the prominent micrite fraction.

The Melilla Mounds

Fig. 14) A high resolution seismic profile of the Melilla Mounds.

Fig. 15) The former Rifian Corridor, preceding Gibraltar Strait with the localisation of the Melilla mounds and Pen Duick Escarpment.

Fig.14(b)

IN DEEP ENVIRONMENTS

Over the past ten years, the "modern mound" research community has accumulated new insights in (i) the structural and basinal setting of mound provinces, (ii) mound province landscapes, (iii) mound size and composition, (iv) key players and oceanic controls, (v) possible primary templates for mound reservoir compartments, (vi) fluid migration pathways and implications for reservoir connectivity, (vii) early diagenesis, carbonate dissolution and precipitation, dolomitization, and hence (viii) controls on reservoir porosity, permeability and compartmentization. This research community now plans a comprehensive study through a multi-platform strategy on the mound provinces offshore Morocco, mobilizing the right tool for the right objective, in a simple, robust and economic scheme (Fig. 16).

The study of microbial mediation in mound processes on the Pen Duick Escarpment is ongoing within the ESF project MiCROSYSTEMS (Microbial Diversity and Functionality in Cold-Water Coral Ecosystems), which has brought together leading mound and Deep Biosphere research laboratories from Europe and overseas. A flag action was the July 2008 cruise of R/V Marion Dufresne (Fig. 17), which cored the IODP 673 sites and sampled them in a hybrid palaeo-environment/Deep Biosphere core flow. MiCROSYSTEMS captures the surface biogeochemical exchanges in the mound factory – from coral/microbe interaction to bio-erosion, organo-mineralisation and microbially mediated diagenesis. A specific target are the thick coralline graveyards (Fig. 19) on the Pen Duick mounds, unveiled by RCMG's ROV Genesis (Fig. 18).

Fig. 17) The Marion Dufresne.

ESF MICROSYSTEMS
Morocco Mounds

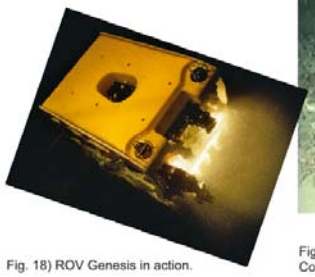


Fig. 18) ROV Genesis in action.

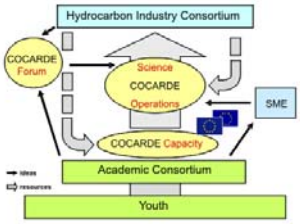

Fig. 19) Coral rubble plates, observed at the surface of Conger Cliff, offshore Morocco.

Partners:

J.-P. Henriet (RCMG, Ghent University), W. Verstraete (LabMET, Ghent University), D. Blamart (LSCE, Gif-sur-Yvette), J. A. McKenzie (ETH, Zurich), C. Vasconcelos (ETH, Zurich), C. Wild (LMU, München), J. S. Sinninghe Damsté (Royal NIOZ), T.C.E. van Weering (Royal NIOZ), A. Freiwald (IPAL, University of Erlangen-Nuremberg), R. Barbieri (Bologna University), F. Neuweiler (Laval Univeristy, Québec), S. Schöttner (MPI, Bremen).

COCARDE JIP

IODP 673-Full optimally draws on the depth drilling capacity of Joides Resolution to study the plumbing system of the Pen Duick mound province and the palaeoenvironmental record, locked in the adjacent Neogene and Quaternary drift sequences. In parallel, it is proposed to core the body of additional key mounds on both Pen Duick Escarpment and in the Melilla mound province with the "MeBo" seafloor drill rig (Fig. 20) within the framework of the Joint Industry Project COCARDE (Cold-Water Carbonate Reservoir Systems in Deep Environments). Key topics are early diagenesis, mound reservoir compartmentization and mound/mound sole connectivity.



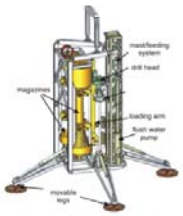


Fig. 20) The deployment of the MeBo, a remotely controlled drilling and coring device (MARUM, Bremen).

COCARDE is a proposal for a flexible and modular Industry-Academia partnership towards sustainable cold-water carbonate reservoir research and capacity building:
(i) Spirit: "Open Innovation" in mutual respect of the academic and industrial cultures, which implies opportunities of publication of scientific results,
(ii) Plan: a flexible and modular scheme of science-driven flag actions – 4 years Science Plan & Joint Industry Project or JIP – structured in two-years operation and exploitation phases, to generate a continuous flux of PhD's,
(iii) Resources: industrial support plus add-on funding and co-funding from ERC, EC, ESF and national funding agencies, to be addressed at the pace of the calls.

Announcement:

COCARDE Magellan workshop
21-25 January 2009
Fribourg
Switzerland
More information:
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Expression of interest:

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Henriet, J.P., Guidard, S. & the ODP "Proposal 573" Team, 2002. Carbonate mounds as a possible example for microbial activity in geological processes. In: Weter, G., Billet, D., Hebbeln, D., Jørgensen, B. & Van Weering, T. (Eds.) Ocean Margin Systems. Springer-Verlag, Heidelberg. 439-455.

Kano, A., Ferdelman, T.G., Williams, T., Henriet, J.P., Ishikawa, T., Kawagoe, N., Kakizaki, Y., Sakai, S., Browning, E.L., Li, X. & the IODP Expedition 307 Scientists, 2007. Age constraints on the origin and growth history of a deep-water coral mound in the northeast Atlantic drilled during Integrated Ocean Drilling Program Expedition 307. Geology, 35(11), 1051–1054.

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Fig.14(c). A three-panel poster discussing GBCP research at the European and Morocco Margins (presented at the AAPG Conference, Cape Town, October 2008) (courtesy of the authors)

5. The research potentiality of Morocco has been increased. Within the lifetime of the project there was no any significant brain drain recorded among the trainees coming from the pilot country.

IV.2 Results in capacity development

The project provided for capacity development in specific domains of marine science, including on sea-bed processes, resources and ecosystems. This was achieved by providing trainees from Morocco, Mauritania, Mozambique and some other Third-Word countries with ship-board and field training, establishment of specific courses, knowledge-sharing and exchanges.

1. The project supported various activities of, and focused the first in Morocco DESA course (Diplôme d'étude supérieures approfondies) in marine science (UFR: OCEANOLOGIE ET GEODYNAMIQUE, DESA "Géodynamique et valorisation des Marges océaniques (littoral et zone économique exclusive- GéoMar", Accréditation N°: ST 05/05, Résponsable: Prof. Naima Hamoumi) established at the Mohamed V-Agdal University (Rabat, Morocco).

2. It contributed to the capacity development in Morocco by bringing together a number of universities in a consortium for studying Geosphere-Biosphere coupling processes (GBCP-Morocco).

3. Through the TTR approach and practice, training in science was provided to various groups and levels of trainees from post-graduate students to research and teaching staff, from Mauritania, Morocco, Mozambique in Africa, as well as Argentina, Brazil, Georgia and Saudi Arabia in other regions. In a much more limited way Cote d'Ivoire and Senegal have also become involved.

4. The Moroccan Authorities started nominating the project's trainees as official observers[2] to follow operations by foreign research ships in the Moroccan EEZ. Indeed they have become best trained for such a mission.

5. The project supported gender equality by including in research teams an important number of female trainees from Third-World countries (Georgia, Morocco and Mozambique).

IV.3. Comparison between the project's objectives and the fulfilments

The primary objective of the project: developing, in a pilot way, national capacities in the selected Third World countries- in Africa and elsewhere and more specifically to provide substantive contribution to:

[2] According to the international rules and regulations, the permission shall be requested from and granted by a coastal State to enable a foreign research vessel operating within the EEZ. Many countries send on board their observers to follow research operations of foreign ships.

advancing knowledge, in an interdisciplinary way, on processes and their coupling that happen between the geosphere, the biosphere and the hydrosphere, that shape the sea-bed environments and ecosystems;	fulfilled
providing for capacity building in specific domains of marine science, including on sea-bed processes, resources and ecosystems, and supporting gender equality;	fulfilled
contributing to knowledge transfer and sharing by bringing together partners from various countries of the North and the South, from academia, universities, industry and other relevant public sectors.	fulfilled

The project's specific objectives:

interdisciplinary research on geosphere-biosphere coupling in relation to marine resources, international sharing of knowledge and expertise;	fulfilled
advanced training, through TTR as a successful example of non-traditional acquisition of knowledge, provided to young researches with the specialization in marine (geo)sciences, focused on the third-world countries.	fulfilled

In 2004-2008 the TTR programme involved a considerable number of researchers and trainees from the North while the TTR-Flanders project involved an important number of participants from the South: in total approx. 400 of which 99 or 25% were from the South (44 were women). In the previous years this figure did not exceed 10%. Ninety (90) of them came from the Arab Region (incl. 78 from Morocco, 41 were women), three from the African Region (1 woman), two from South America and 1 from Asia.

V. LESSONS LEARNED AND SUSTAINABILITY

1. The project assisted in various ways the first in Morocco DESA (Diplôme d'étude supérieures approfondies) course in marine sciences (UFR: Oceanologie et Géodynamique, DESA "Géodynamique et valorisation des Marges océaniques (littoral et zone économique exclusive- GéoMar", Accréditation N°: ST 05/05) established by the Moroccan Authorities at Rabat University. Thanks to the project interventions, part of the course was focused at Geosphere-Biosphere coupling processes at the Morocco Margin. This has made the results of the project sustainable in the pilot country.

2. One shall fully understand that a single project cannot solve a problem of the existing gap in capacities of countries of the North and the South. This enormous task is a standing subject at the agenda of the IOC and other international bodies. However targeted and well focused efforts may provide for improving the current situation in one or a few selected countries. These efforts shall not be abandoned after the end of a particular project.

3. In 2007 and 2008 the project established contacts with the national (Morocco) and international oil industries. This opens a good perspective for further capacity development in the pilot country through e.g. JIP (Joint Industry Project) named "COCARDE" (Cold-Water Carbonate Reservoir Systems in Deep Environments), which may be regarded as a bridgehead of the GBCP-Morocco programme towards Industry.

VI. EVALUATION RECOMMENDATIONS

J-P. Henriet (Belgium) and H. Monteiro (Portugal)

N. Kenyon (UK), M. Ivanov (Russia), C. Dullo (Germany), J. Woodside (the Netherlands), M. Marani (Italy), U. Unluata (UNESCO/IOC) and M. Comas (Spain)

Fig.16. TTR Executive Committee meets twice a year to evaluate progress and for cruises' planning

1. In view of coordinating the overall TTR programme activities with that of the project its plans and results were presented to and discussed at every meeting of the TTR Executive Committee (TTR-EC) that normally meets twice a year. This helped focusing the project's actions within TTR. All recommendations approved by TTR-EC (mostly related to the project's research targets) were applied in the course of the project's execution.

2. Following comments of the FUST Steering Committee meeting (2006), the TTR-*Flanders* project, earlier subordinated to the Science Section of the IOC, has become subordinated to the Capacity Development Section. This helped with lining the project's actions with that of the "Training, Education and Mutual Assistance" Programme of IOC.

VII. VISIBILITY

1. The project was made highly visible in the pilot country due to the TTR-14 International Post-cruise conference that took place in Marrakech, 2 to 5 February 2005. A good number of high-level national authorities and eminent scientists were involved (Annex 4). A representative of the Donor attended the meeting.

2. During the Kess Kess Capacity Building Field Action an educational outreach was made by Gent University to three classes from Belgium, Germany and Morocco. On the Class@Desert website the students of these classes were able to follow the proceedings on the field (*http://www.vliz.be/projects/classatdesert/index.php*).

3. The research results were published in six issues of the IOC Technical Papers and Workshop Reports (plus one issue in preparation) (Annex 5) and widely disseminated throughout the world according to the IOC distribution policy. These publications are also available in the electronic form at a site of the UNESCO documents, UNESDOC

(*http://unesdoc.unesco.org/ulis/fre/*), the SEARCH parameter is "TTR" that give the following address for the TTR publications (including those resulting from the TTR-*Flanders* project): *http://unesdoc.unesco.org/ulis/cgi-bin/ulis.pl?req=2&mt=100&mt_p=%3C&by=2&sc1=1&look=default_fr&ll=f&sc2=1&lin=1&mode=e&futf8=1&gp=1&text=TTR&text_p=inc&submit=Chercher*
The project-related publications hold the logo of the Donor.

Results of the TTR-15, 16 and 17 cruises have been highlighted in a few issues of Newsletters of the European project on "Hotspot Ecosystem Research on the Margins of European Seas" (HERMES) *(http://www.eu-hermes.net/).*

The project's Narrative Progress Reports have been made public through the IOC/IODE web site for FUST projects:
http://www.iode.org/fust/sessions/session13/513RAF2005%20report%20revision.doc

The project has also been highlighted in various IOC documents such as:
- in documents presented to the Governing Bodies of the Organization (see *http://unesdoc.unesco.org/images/0014/001461/146143f.pdf* , 2006; *http://ioc.unesco.org/iocms/files/2annex2_Report%20Budget%20excution.pdf* , 2006; http://unesdoc.unesco.org/images/0016/001605/160591f.pdf, 2008) and
- in the IOC Annual Reports for 2006 (*http://www.unescobkk.org/fileadmin/user_upload/westpac/documents/Annual_Report/IOC_Annual_Report_2006.pdf*) and 2007 (in press).

Annex 1

MAJOR PARTNERS (INSTITUTIONS and INTERNATIONAL PROJECTS) IN THE EXECUTION OF THE TTR-*FLANDERS* PROJECT

Partners organizations:

BELGIUM
University of Gent
Catholic University, Leuven

FRANCE
Institut français de recherche pour l'exploitation de la mer (IFREMER), Brest

GEORGIA
Tbilisi State University

GERMANY
University of Bremen
Leibniz-Institut für Meereswissenschaften (IFM-GEOMAR)

ITALY
Institute for Marine Geology, Bologna
University of Bologna
International Research School of Planetary Sciences (IRSPS), University of Annunzio

MOROCCO
Université Abd El Malek Essaadi, Tanger
Institut Scientifique, Département Physique du Globe, Rabat
Université Mohamed V-Agdal, Rabat
Université Cadi Ayyad, Marrakech
Ibn Batouta Centre of the European Space Agency (ESA), Marrakech

THE NETHERLANDS
Royal Netherlands Institute for Sea Research, Den Burg

PORTUGAL
Geological and Mining Institute, Lisbon
University of Aveiro

RUSSIA
Moscow State University
Polar Marine Geophysical Expedition, St. Petersburg

SAUDI ARABIA
Saudi Geological Survey, Jeddah

SPAIN
Instituto Andaluz de Ciencias de la Tierra, Universidad de Granada

UNITED KINGDOM
National Oceanography Centre, University of Southampton

International projects:

- European project on "Hotspot Ecosystem Research on the Margins of European Seas" (HERMES*) (http://www.eu-hermes.net/)*;
- ESF EUROCORES EuroDiversity 'MICROSYSTEMS' project for a comparative study of fossil and recent carbonate mounds (*http://www.esf.org/activities/eurocores/programmes/eurodiversity/projects/microsystems.html*);
- ESF EUROCORES Euromargins project on "Tectonic control, deep crustal structure and fluid escape pathways in the Gulf of Cadiz mud volcanic field" (MVSEIS) (*http://www.esf.org/activities/eurocores/programmes/euromargins/projects/fp24.html*).

Annex 2

SAMPLE OF RESEARCH PROJECTS LAUNCHED BY TRAINEES AT THEIR HOME INSTITUTIONS

Planktonic Foraminifera Assemblages: an Indicator of Pleistocene – Holocene Paleo-environmental Changes in South-Eastern Sardinia Margin and Stromboli Basin;

Acoustic Seafloor Observations and Carbonate Sedimentology off Morocco;

Origin and Activity of Giant Mud Volcanoes on the Moroccan Margin;

Geofluid Pumping in Carbonate Mound Systems;

Geophysical Evidence of Gas Hydrate Presence in Shallow Mud Volcanoes (El Arraiche Mud Volcano Field, Moroccan Margin);

Structural Control on Mud Volcano Occurrence on the Moroccan Margin;

Pen Duick Escarpment on the Moroccan Margin: a New Mound Lab;

Physical Properties of "Exotic" Sandstones from Mud Volcanic Deposits in the Moroccan Mud Volcanic Province (Moroccan Continental Margin, the Gulf of Cadiz);

Sea Floor Expression of Sediment Extrusion and Intrusion at the El Arraiche Mud Volcano Field, Gulf of Cadiz.

Study of onshore fields of carbonate chimneys, Rharb Basin, North of Rabat

Annex 3

THIRD-WORLD PARTICIPANTS IN TRAINING ACTIVITIES

1. TTR cruises with RV *Professor Logachev* (Russia):

TTR-14 cruise, *July 2004*:

ARGENTINA
Oscar Romero

GEORGIA
Giuli Kharkheli

MOROCCO
Bouchta El Moumni
Ilham Bouymetarhan
Nadia Mhammdi

SAUDI ARABIA
Fares Zaki Bahareth
Omar Al-hazmi
Najeeb Rasul

TTR-15 cruise, *July-August 2005*

GEORGIA
Nona Lursmanashvili
Irma Makalatia

MOROCCO
Bouchta El Fellah
Mohamed Laadraoui
Rabi Kharbaoui
Amine Hazim

CHINA
Feng Ding

MOZAMBIQUE
Esmeralda S. dos Muchandos

TTR-16 cruise, *June-July 2006*

MOROCCO
Mustapha Chafic

TTR-17 cruise, *June-July 2008*
MOROCCO
Loubna Terhzaz
Narjisse Alaoui Mhammedi

BRAZIL
Ronaldo Gomes Bezerra

2. Other cruises, trainees from Morocco:

R/V *Marion Dufresne* (France), *2004*
N. Hamoumi

RV *Belgica* (Belgium), *2005*
Ilham Bouymetarhan

RV *Meteor* (Germany), *2005*
Ilham Bouymetarhan

RV *Pelagia* (The Netherlands),
Loubna Terhzaz

RV *Poseidon* (Germany), *2006*
N. Hamoumi

RV *Charles Darwin* (UK), *2006*
M. Achab
L. Terhzaz

RV *Pelagia* (The Netherlands),
23 September -20 October 2006:
Loubna Terhzaz
25 October-5 November 2006:
Adil Chiger

RV *Belgica* (Belgium), *2-16 June 2007*
Majdouline Saadi

RV *Marion Dufresne* (France), *July 2008*
Naima Hamoumi

Training at the ODINCARSA Workshop, IOC/IODE Centre, Ostend, Belgium, 7–21 November 2005 (participants from Morocco)

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First Capacity Building Field Action (Workshop): "Flysch domain of the N-W alpine Rif belt", 12-16 November 2005, Morocco (participants from Morocco)

Prof. Dr. HAMOUMI, Naima
Prof. Dr. EL MOUMNI, Bouchta
ALAOUI, Narjiss (PhD student)
BOUIMETARHAN, Ilham (PhD student)
CHAFIK, Mustapha (M.Sc. student)
TERHZAZ, Loubna (M.Sc. student)

Second Capacity Building Field Action (Workshop): "The Kess Kess mound field course", 1-5 December 2006, Morocco

MOROCCO
HAMOUMI, Naima
AKALE, Moad
CHAFIK, Mustapha
CHIGUER, Adil
ERRAMLI, Naoual
GHARNATE, Asma
HAZIM, Mohamed El Amine
JIMIL, Karima
KHARBAOUI, Rabi
LMOUDN, Naima
RADOUAN, Ahmed
SAADI, Majdouline
TERHZAZ, Loubna
ALAOUI MHAMMEDI, Narjisse

MAURITANIA
O. SOUMBOUL NDIAYE, Abdel Vettah
GHALI OULD OUBEIDI, Mohamed

MOZAMBIQUE
Esmeralda S. dos Muchandos

GBCP Workshop and Field course in Cape Town, South Africa
26 October and 1 November 2008
(participants from Morocco)

Prof. N. Hamoumi, Mohamed V-Agdal University, Rabat
L. Terhzaz, Mohamed V-Agdal University, Rabat
Prof. D. Chafiki, Cadi Ayyad University, Marrakech
M. El Alji, Office National des Hydrocarbures et des Mines (ONHYM), Rabat

Annex 4

INTERNATIONAL CONFERENCES: IN SUPPORT OF THE TRAINING PROGRAMME

1. Geosphere-Biosphere Coupling Processes - the TTR interdisciplinary approach towards studies of the European and N. African margins. International Conference and TTR14 Post-cruise meeting, 1-5 February 2005, Marrakech, Morocco

National Moroccan authorities who were involved in the organization of the Conference

Prof. Hafid BOUTALEB JOUTEI, President, University Mohammed V-Agdal
Prof. Mohamed JEBLI, President, University Cadi Ayyad
Prof. Mustapha BENNOUNA, President, University Abelmalek Saadi
Prof Mohamed KNIDIRI, President, Association 'Le Grand Atlas', Marrakech
Mr. Ali FASSI FEHRI, Director General, ONEP
Ing. Mohammed Farid HAMMOUDA, Central Director, ONEP
Dr. Abdellatif BERRAHO, Director, INRH
Ing. Al Moundir MOURABET, Director of petroleum exploration, ONHYM
Prof. Mohamed ARSALANE, Dean, FST Gueliz

Moroccan eminent scientists - members of the Scientific Committee of the Conference

Prof. El Hassane BOUMAGGARD, Cadi Ayyad University, Marrakech
Prof. Bouchta EL MOUMNI, Abdelmalek Essaâdi University, Tangier
Mr. Mustapha FAIK, Inspector General, Departement of Marine Fisheries
Prof. Naima HAMOUMI, Mohamed V - Agdal University, Rabat
Dr. Abdellatif ORBI, Chief, Department of Oceanography and Aquaculture, INRH
Dr. Mahmoud ZIZI, Chief of Department, ONHYM

List of participants from Third-World countries

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rsarr@ucad.sn

2. Fluid seepages/mud volcanoes in the Mediterranean and adjacent domains (CIESM Workshop), Bologna, Italy, October 2005

Participant from Morocco
N. Hamoumi

3. Geological processes on deep-water European margins. International Conference and 15th Anniversary Post-Cruise Meeting of the Training-through-Research Programme. Moscow/Zvenigorod, Russia, 29 January-4 February 2006

Participants from Morocco
Chafik, Mustapha
Hamoumi, Naima

4. Geo-marine Research along European Continental Margin. International Conference and 16th Post-Cruise Meeting of the Training-through-Research Programme. 29 January – 1 February, 2007. University of Bremen, Germany. List of participants from Third-World countries

China
Ding, Feng

Cote d'Ivoire
Monde, Sylvain

Morocco
Hamoumi, Naima
Terhzaz, Loubna

Saudi Arabia
Abushosha, Mansour
Al-Hazmi, Omar
Rasul, Najeeb

5. First International Conference of the Moroccan Association of Petroleum Geologists (Morocco, Marrakech, 26-31 October 2007)

Morocco
Hamoumi, Naima
Terhzaz, Loubna

6. AAPG Conference (Cape Town, South Africa, 26 October- 1 November 2008)

Morocco
D. Chafiki
M. El Alji
N. Hamoumi
L. Terhzaz

Annex 5

TECHNICAL REPORTS, TRAINING MATERIALS AND PUBLICATIONS RESULTING FROM THE PROJECT

1. List of published materials

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. Marrakech, Morocco, 2 – 5 February 2005. Intergovernmental Oceanographic Commission, Workshop Report No. 197, UNESCO, 2005, 78 pp. & annexes.

Interdisciplinary Geoscience Studies of the Gulf of Cadiz and Western Mediterranean Basins. Preliminary results of investigations during the TTR-14 cruise of RV *Professor Logachev,* July-September, 2004. Intergovernmental Oceanographic Commission, Technical Series No. 70. UNESCO, 2006, 115 pp. & annexes.

Geological Processes on Deep-Water European Margins. International Conference and 15th Anniversary Post-cruise meeting of the Training-through-Research programme. Moscow/Zvenigorod, Russia, 29 January- 4 February 2006. IOC Workshop Report, 201, UNESCO, 2007, 73 pp.

Deep-water Cold Seeps, Sedimentary Environments and Ecosystems of the Black and Tyrhenian Seas and the Gulf of Cadiz. Preliminary results of the TTR-15 cruise of RV *Professor Logachev*, June-August 2005. IOC Technical Series, 72, UNESCO 2007, 99 pp & annexes.

Geo-marine Research along European Continental Margin. International Conference and Post-Cruise Meeting of the Training-through-Research Programme. Bremen, Germany 29 January - 1 February 2007. IOC Workshop Report, 204, 64 pp.

Deep-water depositional systems and cold seeps of the Western Mediterranean, Gulf of Cadiz and Norwegian continental margins: preliminary results of investigations during the TTR-16 cruise of RV *Professor Logachev*, May-July, 2006. IOC. Technical Series, 76, UNESCO 2008; 91 pp & annexes.

Geomarine Research in the Alboran Sea, Gulf of Cadiz and at the Norwegian Margin during the TTR-17 cruise of RV *Professor Logachev*, June-July, 2008. *In preparation.*

2. Sample list of individual presentations and the corresponding abstracts (co)authored by participants from Third-World countries presented at the Marrakech Conference (2 – 5 February 2005) and published in:

"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. Marrakech, Morocco, 2 – 5 February 2005. Intergovernmental Oceanographic Commission, Workshop Report No. 197, UNESCO, 2005, 78 pp. & annexes."

A. Ammar, B. El Moumni, H. Semlali. STRATIGRAPHIC AND TECTONIC EVOLUTION OF THE MOROCCAN MEDITERRANEAN MARGIN: LATE MIOCENE TO RECENT

N. Hamumi. CORAL BUILD-UPS OF THE STRAIT OF GIBLALTAR: DEPOSITIONAL MODEL AND ENVIRONMENTAL CONTROL

N. Hamoumi. THE “TUBOTOMACULUM”: A FOSSIL RECORD OF DEEP SEA CORALS

P. Van Rensbergen, D. Depreiter, B. Pannemans, M. Rachidi, M. Ivanov, and J-P. Henriet. SEA FLOOR EXPRESSION OF SEDIMENT EXTRUSION AND INTRUSION AT THE EL ARRAICHE MUD VOLCANO FIELD, GULF OF CADIZ

R. Sarr, B. Sarr, El Hadji Sow and A. K. Fofana. LES MICROFAUNES (FORAMINIFERES ET OSTRACODES) DU LAC MBAWANE (CAP VERT) ET LES VARIATIONS DU NIVEAU MARIN DANS L’HOLOCENE SUPERIEUR DU LITTORAL NORD DU SENEGAL

I. Bouimetarhan, A. Foubert, A. Slimane, J-P. Henriet, M. Ivanov and N. Hamoumi. PLANKTONIC FORAMINIFERA ASSEMBLAGES: AN INDICATOR OF PLEISTOCENE – HOLOCENE PALEOENVIRONMENTAL CHANGES IN SOUTH-EASTERN SARDINIA MARGIN AND STROMBOLI BASIN

N. Hamoumi, M. Ivanov & J. Gardner. SEDIMENTOLOGICAL STUDY OF THE MOROCCAN FIELD MUD VOLCANIC DEPOSITS, GULF OF GADIZ

M. Achab , J.P. Moral Cardona and J.M. Gutiérrez Mas. ANALYSIS OF THE QUARTZ GRAINS SURFACE FEATURES PRESENT IN THE CADIZ BAY SEDIMENTS (SW OF SPAIN)

E. De Boever, D. Depreiter, A. Foubert, B. El Moumni, R. Swennen, J-P. Henriet. ACOUSTIC SEAFLOOR OBSERVATIONS AND CARBONATE SEDIMENTOLOGY OFF MOROCCO: INITIAL RESULTS

D. Depreiter, P. Van Rensbergen, M. Rachidi, J-P. Henriet. STRUCTURAL CONTROL ON MUD VOLCANO OCCURRENCE ON THE MOROCCAN MARGIN.

3. Training materials (non-published) prepared for specific training courses and provided to the participants

"The Ourika Valley (High Atlas of Marrakech, Morocco): a natural geological section through typical intracontinental chain" by H. Ouanaimi and K. Taj-Edine (2005)

“Guidebook presenting geological setting of the NW Rif Belt and the description of the stops” by N. Hamoumi (2005)

“Report on the TRANSMED Transect I from the Iberian block down to the Sahara domain” by D. Depreiter (2006)

“The Kess Kess mound province field guide” by N. Hamoumi (2006).

Annex 6

PROGRESS REPORTS PREPARED DURING THE CONTRACT PERIOD AND SUBMITTED TO THE FUST STEERING COMMITTEE

1. December 2004, Technical Report on the execution in 2004 of the TTR-*Flanders* project "Geosphere-Biosphere Coupling Processes in the Ocean: the Training-through-Research approach towards Third World involvement, 2004-2007" (UNESCO project 513RAF2005)

2. 29 September 2005, Technical Report on the execution of the TTR-*Flanders* project 513RAF2005 in 2005, Progress Report N° 2.

3. 13 April 2006, Implementation Status Report

4. 20 October 2006, Implementation Status Report

5. 3 September 2007, Narrative Progress Report

6. 28 February 2008, Narrative Progress Report

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