

# EUROMARGINS

Imaging, monitoring and modelling  
the physical, chemical and  
biological processes in the  
European passive continental  
margins

Final Report



## European Science Foundation (ESF)

The European Science Foundation (ESF) was established in 1974 to create a common European platform for cross-border cooperation in all aspects of scientific research.

With its emphasis on a multidisciplinary and pan-European approach, the Foundation provides the leadership necessary to open new frontiers in European science.

Its activities include providing science policy advice (Science Strategy); stimulating co-operation between researchers and organisations to explore new directions (Science Synergy); and the administration of externally funded programmes (Science Management). These take place in the following areas:

Physical and engineering sciences; Medical sciences; Life, earth and environmental sciences; Humanities; Social sciences; Polar; Marine; Space sciences; Radio astronomy frequencies; Nuclear physics.

Headquartered in Strasbourg with offices in Brussels, the ESF's membership comprises 75 national funding agencies, research performing organisations and academies from 30 European nations.

The Foundation's independence allows the ESF to objectively represent the priorities of all these members.

## What is a EUROCORES?

The EUROCORES (ESF Collaborative Research) Scheme is an ESF instrument to stimulate collaboration between researchers based in Europe, and to maintain European research at an international competitive level.

The EUROCORES Scheme provides a framework for national research funding agencies (research councils and academies and other funding organisations) to fund collaborative research, in and across all scientific areas.

Participating funding agencies jointly define a research programme, specify the type of proposals to be requested and agree on the peer-review procedure.

The ESF, with funds from the EC Sixth Framework Programme under Contract no. ERAS-CT-2003-980409, provides support for programme coordination and for the networking activities of funded projects while research funding stays with national funding agencies.

# PART 1

## Final Report

# EUROMARGINS – A EUROCORES programme in the field of passive continental margins

## Origin of the programme

The EUROCORES scheme was proposed and adopted by the European Science Foundation (ESF) in 1999 and the April 2000 meeting of the Governing Council recommended that the scheme should be given the highest priority within the Foundation's activities. EUROMARGINS is one of the first EUROCORES launched by the ESF in the early 2000s and the first EUROCORES in geosciences. The programme focus was to study passive continental margins which mark the transition between continents and oceans. The margins develop as the consequence of the break-up of continents and the formation of new ocean basins, they are sites of some of the world's largest accumulations of sediments and are, among the best indicators that we have of past changes in climate, sediment flux and sea-level. Passive margins are prone to major natural hazards since a majority of the world's population lives within a short distance of the coastal zone. At the end of the 1990s, the scientific community had already identified the deep structure and rifting processes, the sedimentary processes and products, and fluid flow, seeps and deep-water biota at passive margins as high priority targets that needed to be addressed. Furthermore, the hydrocarbon industry regarded the slope and rise regions of passive margins as one of the few remaining frontiers for the production of oil and gas.

In May 1999, the Executive Council of the European Science Foundation (ESF) approved the establishment of a 2 year Network in 'Ocean Margins'. One of the main aims of the Network, which included representatives from 10 countries in Europe, together with two industry representatives and observers from ESF and the USA National Science Foundation (NSF), was to develop a new European-led programme in Ocean Margins. In February 2000, the NSF network hosted a workshop to which key members of the European scientific and industrial community interested in Ocean Margins were invited. The main outcome of the workshop was to develop a new, European-led, programme in Ocean Margins which was called EUROMARGINS. The main aim of the new programme was to address fundamental scientific questions concerning the origin, structure and evolution of passive margins. In May 2000, the proposal for a EUROCORES theme was submitted by A. Watts, chairman of the Ocean Margins Network. This programme was endorsed by the Life, Earth, and Environment Standing Committee (LESC) in June 2000, 10 funding organisations from 10 countries committed to this programme and the EUROMARGINS call for proposals was issued in July 2001. A total of 61 outline proposals were received in response to this call and 23 full proposals were invited by the Review Panel. From these proposals, 14 were recommended by the review panel and funded by the participating organisations as Collaborative Research Projects including a total of 76 individual projects. The funding started depending on the funding organisations between January and April 2003. The first EUROMARGINS conference and Scientific Committee took place in November 2003 and marked the official launch of the programme. The final Scientific Committee of the programme took place in Brussels in February 2008. Between the intention letter and the actual start of the programme, 3.5 years elapsed and the official programme duration has been 4 years and 3 months with a total research budget from the participating Funding Organisation of 13.7 M€ and an additional Networking and Dissemination budget provided by the European Commission under the 6<sup>th</sup> Framework Programme of 545 k€ representing 4% of the overall budget.

## Scope of the programme

Passive continental margins are the product of complex interaction between processes in the Earth's asthenosphere, lithosphere, hydrosphere and biosphere; an interaction evolving in both space and time. Passive margins, which are one of the most distinctive morphological features of the world's ocean basins, mark the transition between continental and oceanic crust. They are also the sites of some of the world's largest accumulations of sediments and are one of the few remaining frontiers for natural resources. The nations of Europe share one of the world's longest passive margin systems and one of the most distinctive morphological



features of the world's ocean basins. Passive continental margins, associated with unstable slopes, represent a major source of natural hazards, especially to the coastal communities of Europe.

The understanding of the processes that have shaped the passive continental margin system require broadly based inter-disciplinary studies, yet no one country within Europe currently has access to all the human resources and large-scale facilities needed to pursue this objective. The EUROMARGINS programme provided the international framework for promoting innovative, interdisciplinary work for the imaging, monitoring, reconstruction and modelling of the physical, chemical, and biological processes in the European passive continental margins. It encouraged the development of new technologies and conceptual models aiming at the advancement of integrated research into the mechanisms responsible for continental break-up and the world ocean margin formation.

EUROMARGINS focused on three main research themes: rifting processes, sedimentary processes and fluid flow. In particular, EUROMARGINS encouraged the development of both new technologies and conceptual models for passive margin evolution with the expressed aim of advancing, in a major way, integrated research into the mechanisms that are responsible for continental break-up and the formation of the world's ocean basins and their margins. The pooling of human resources, the training of a new generation of geoscientists, and the optimal sharing of national observational platforms (e.g. ships), analytical and modelling facilities as well as the development of new linkages that break down traditional discipline boundaries have been very important value-added ingredients of the EUROMARGINS programme.

### **Programme activities**

Networking and Dissemination activities are the key characteristics and the main objectives of the EUROCORES Programme. They are meant to encourage and facilitate scientific collaboration and diffusion across the Collaborative Research Projects (CRPs) within a given domain or if appropriate across different domains and programmes. These activities are flexible and can be tailored to the needs of a given programme.

During the course of the EUROMARGINS programme, three programme wide conferences took place in 2003, 2004 and 2006. These conferences have attracted as much as 130 participants from the different projects and from the different participating countries. These annual conferences were crucial to build the strong EUROMARGINS scientific community and to come up with suggestions for future activities across the various participants. In addition to these programme conferences, EUROMARGINS special sessions have also been organised during the European Geophysical Union annual assembly in 2005, 2006, 2007 and 2008. These sessions were a nice opportunity to present the EUROMARGINS results and achievements to a wider international community

The programme has also been active in organising topical workshops among 2 to 5 Collaborative Research Projects. In total, 8 of these workshops took place and have drained a large number of senior but also junior scientists. The aim of these small to medium size events was to cover specific scientific topics and increase exchange of ideas but also of scientific visitors between the different projects. An important objective of these workshops but also of the annual conferences has also been to encourage junior scientists to play an active role in the programme activities and strengthen the interactions of junior researchers across the projects and different participating countries.

### **Programme structure and management**

The Management Committee (MC) has the overall responsibility for the direction and governance of the EUROCORES Programme within the guidelines of the EUROCORES Scheme. The MC can request expert advice from the EUROCORES Scientific Committee, Review Panel or any other ad-hoc advisory group. Each MC member is responsible for liaison with their funding organisation, including supervision of the funding process for EUROCORES projects within their organisation. This includes: responsiveness to the requests of the coordinators for the confirmation of level of participation and funding, eligibility of applicants according to

national regulations, funding decision for Individual Projects (IPs), etc., Members may attend all meetings of the EUROCORES programme (Review Panel meetings, Science Committee meetings, science meetings) as observers. The EUROMARGINS programme has been overseen by a MC formed by representatives from each of the 10 national funding agencies (see list below). Dr. Johannes Karte from the Deutsche Forschungs Gemeinschaft (DFG) was nominated chair of this Management Committee.

The Scientific Committee (SC) of EUROMARGINS has been established once the funding decisions were finalised and when it was confirmed which CRPs would receive their grants and at which timeline. The first meeting of the SC in November 2003 marked the start of the research and networking phase of the programme. The SC members represent the Principal Investigators (IP), Associated Partners (PA) and Project Members of a CRP and are the main point of contact and communication flow from the Scientific Committee to Principal Investigators, Associated Partners and Project Members. For EUROMARGINS, the SC has been formed with the 14 project leaders of each CRPs (see list below) and Pr. Jurgen Mienert from the University of Bergen was elected chair of this committee for the whole project duration.

The Review Panel (RP) of EUROMARGINS was established soon after the publication of the Call for Proposals. It has been constituted by the ESF and through suggestions from the Management Committee members and the coordinator. The Review Panel Members were solely chosen for their scientific contributions to the Panel, and they were not representing the interest of their country or funding agency in the panel. The RP members had strong scientific background covering the full scientific spectrum set out in the call for proposals. It has been convened on request by the ESF during the Peer Review process and afterwards for the evaluation of the progress made by the programme. The submitted proposals have been internationally reviewed and finally recommended and prioritised by the RP. The EUROMARGINS review Panel was composed of 11 international experts in the field (see list below). The Review Panel members also participated to most programme activities during the course of the projet. Finally, 6 of these review panel members participated to the final programme evaluation.

### **The final report**

In addition to the annual reports provided individually by the participants to their national funding agencies, based on the standard EUROCORES practices and on behalf of the member organisations, the ESF conducts the final evaluation of the EUROCORES programme. The final evaluation concerns the overall achievements of the programme as a whole and as such complements the individual evaluations conducted at the national level. The purpose of the final report is to present the key scientific results of the individual Collaborative Research Projects but also to ask the projet leaders to provide their own feedback on their research and on the programme. Another very important aspect of the final report is to present and evaluate the networking activities which took place between the various projects and investigate the added value of the programme.

The final report report has been evaluated by the Review Panel of the programme. The review panel member evaluations are based not only on the report itself but also on the presentations made by the various project leaders during the final meeting in February 2008.

This report is constituted of two parts. The first part of the report provides the individual project reports from the 14 participating Collaborative Research Projects and presents the networking activities which took place during the course of the programme together with the list of publications at the programme level. The second part of the document is dedicated to the evaluation by the review panel. In this later section the individual assessments by the review panel members are provided together with a general and consensus report on each individual project. The review panel also provided suggestions for future activities which could be beneficial to continue the integration efforts undertaken by the EUROMARGINS community during the programme.

## Foreword by the chair of the Scientific Committee (J. Mienert)

To be written (1-2 pages would be enough).

# Crustal architecture and evolution of the conjugate volcanic margins off mid-Norway and East Greenland in a total rift context

## Abstract

Integrated studies of conjugate rifted continental margins are essential for a better understanding of the fundamental processes responsible for the breakup and separation of lithospheric plates. This project focuses on the conjugate volcanic margins off mid-Norway and East Greenland to establish the crustal architecture that provides key constraints for the understanding of the processes and the temporal sequence of events involved in volcanic margin formation and evolution. By using the existing databases and new two-dimensional regional deep seismic data off mid-Norway and East Greenland in addition to a detailed three-dimensional survey on the East Greenland margin the project investigated the crustal and uppermost mantle architecture (crustal thickness variations, rift polarities, distribution of extrusives, intrusives, magmatic underplating); the tectonic and magmatic interplays and styles prior to, during and subsequent to breakup; the regional extension and magmatism, including estimates of volume and rates; the along strike segmentation, magmatic and tectonic (a)symmetry, structural inheritance; and the interplay of sedimentation, magmatism and vertical motion.

## Partners

(CNRS, NFR, DFG)

### **Pr Jan Inge Faleide (project leader)**

Universitetet i Oslo, Oslo, Norway

### **Pr Laurent Geoffroy**

Université du Maine, Le Mans, France

### **Dr Wilfried Jokat**

Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, Germany



<b>Collaborative Research Project (CRP)</b>
<b>1. General information</b>
<p>Project Reference Number: 01-LEC-EMA01F</p> <p><u>Acronym / Short Title</u>: -</p> <p><u>Full Title</u>: <b>Crustal architecture and evolution of the conjugate volcanic margins off mid-Norway and East Greenland in a total rift context</b></p> <p><u>Project Leader name</u>: <i>Prof. Jan Inge Faleide</i></p> <p><u>Project Leader affiliation</u>: <i>University of Oslo, NO</i></p> <p><u>Institutional home page</u> (URL): <a href="http://www.geo.uio.no">www.geo.uio.no</a></p> <p><u>Project-related home page</u> (URL): -</p> <p><u>Reporting period</u>: 01/10/2004 to 30/09/2007</p>
<b>2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)</b>
<b>IP 1</b>
<b>Prof. Jan Inge Faleide</b> , University of Oslo, Oslo, Norway
Total Funding amount of the IP: EUR 730 000
<b>IP 2</b>
<b>Dr Wilfried Jokat</b> , Alfred-Wegener Institut Für Polar- und Meeresforschung, Bremerhaven, Germany
Total Funding amount of the IP: EUR 253 600
<b>IP 3</b>
<b>Pr Laurent Geoffroy</b> , Université du Maine, Le Mans, France
Total Funding amount of the IP: EUR < 20 000

### 3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

We have studied the conjugate volcanic margins off mid-Norway and East Greenland to establish the crustal architecture that provides key constraints for the understanding of the processes and the temporal sequence of events involved in volcanic margin formation and evolution.

The involvement in the CRP allowed us to collect substantial seismic and magnetic data sets on both the Norwegian and the East Greenland margin that enable us to study margin breakup processes beyond what earlier surveys have provided. Eleven new wide-angle seismic and magnetic profiles were acquired on the Norwegian margin, and off NE Greenland AWI acquired (under favourable ice conditions) a large data set comprising several deep seismic refraction profiles, multichannel seismic reflection profiles, airborne magnetic data and marine gravity and magnetic data. Unfortunately, due to lack of funding, only a limited part of this dataset (the two southern seismic refraction profiles) was analysed as part of the German EUROMARGINS project at AWI.

In addition to the newly acquired data on the Norwegian margin, we also added a wide-angle profile acquired in 2003 from the Møre Margin to the project due to its relevance to magma system development at the margin, and multichannel data at the distal part of the mid-Norwegian margin from year 1999 and 2000 surveys by the Norwegian Petroleum Directorate. This joint data set has proven very successful in the study of the magmatic processes of the volcanic passive margins by providing crustal thickness and structural control from velocity modelling of the wide-angle seismic data into the outer margin areas that were poorly covered. The Norwegian reflection seismic data further provided information on the development of the sedimentation system on the outer margin, which proved crucial in understanding the geodynamic development.

In the absence of a marine experiment (see 4. below), the French group focused on numerical modelling of volcanic-type margins as well as on onshore studies in NE Greenland. A preliminary field expedition was conducted in 2004 followed by a more comprehensive one in 2005.

The main target with the new profiles across the outer Vøring and Lofoten-Vesterålen margins off Norway was to get better control on the continent-ocean transition, and the spatial and temporal development of magmatism along the volcanic margin. The two Vøring profiles show a rapid transition from continent to oceanic crust (COT) located under the zone of seaward dipping reflectors and associated with a sub-vertical velocity transition in the middle and lower crust. Parts of the extrusive magmatic units are deposited over continental crust, and the COT in the lower crust starts approximately 15-20 km west of the Vøring Escarpment, the shallow lava delta front seen along the margin. West of the COT, the velocity models indicate a thick igneous section of typically basaltic/gabbroic velocity signature. From the COT the igneous crustal thickness decreases from 17-18 to 7-9 km over a distance of 90-120 km. Both profiles show lower-crustal P-wave velocities above 7 km/s. The COT decreases in width northward along the Lofoten-Vesterålen Margin. The Moho depth increases from typical oceanic crustal depth of 12 km near magnetic anomaly 23 in the oceanic Lofoten Basin to a 20-26-km continental crustal level at the shelf edge. Within the COT increased lower crustal velocities were modelled to be up to 7.1 km/s at the bottom of the crust, defining a possible limited lower crustal body. The lateral and vertical extent of this body is diminishing northward along the margin.

A major result from the study of the temporal development of the breakup magmatism is the realization that there is a strong correlation between the earliest seafloor-spreading rate and the magma productivity (Breivik et al., 2006, Breivik et al., Tectonophysics, submitted). This conclusion depends on both the new wide-angle seismic data as well as our new magnetic data. The new magnetic data proved invaluable as the existing data coverage of parts of the Norwegian margin is poor, and navigation in the old data is too inaccurate to allow high-resolution spreading-rate calculations. As the early magmatism is very voluminous and characterized by large lateral flows, the oldest seafloor

spreading anomalies are obscured at the Vøring margin, and cannot be reliably identified here. Early seafloor spreading rates can, however, be determined accurately from surrounding areas at the Møre and Lofoten-Vesterålen margins. We argue that a physical mechanism that can explain this correlation is only provided by a mantle plume model, in which hot and buoyant plume material flow into the inverted topography at the base of the lithosphere in the incipient rift zone. Buoyancy increases the plate-push force, which is rapidly reduced in time by the decompression melting during and a few million years after continental breakup. Other proposed models for the breakup-magmatism in the NE Atlantic do not readily explain this correlation, and thus our results provide important observational constraints to the discussion of the cause for excess magmatism in the NE Atlantic. We intend to follow up this angle of research in the future.

The high-resolution study of the continental breakup and early seafloor spreading also made it possible to estimate actual continental breakup time on the Norwegian margin. The Møre and Vøring margins formed at approx. 54 Ma, while the Lofoten-Vesterålen margin broke later, at approx. 53 Ma. Voss and Jokat (2007) argue for a younger, southward propagation of the continental breakup at the East Greenland margin conjugate to the Vøring margin. This discrepancy in interpretation remains to be resolved, and will be subject to further study. A possible source for this may be the chaotic magnetic anomaly pattern at central parts of the conjugate margin system, which may relate to the high-volume breakup magmatism here or possibly to overprinting by a later magmatic event.

Another major result is the realization that the magmatic development of the outer Norwegian Vøring margin is much more complex in space and time than previously thought. This result would not have been obtained without the data collected under the CRP: By correlating crustal thickness and seismic velocity with changes in the sedimentation pattern at the foot of the continental slope, we can demonstrate that there has been a Late Miocene magmatic addition to the oceanic crust off the Vøring margin. This highly unexpected discovery opens up a new direction in the research on intra-plate magmatic processes in the northeast Atlantic, and may challenge our understanding of melt behaviour and/or instability in the upper mantle (Breivik et al., G3, submitted).

While the analysis of the East Greenland data is not finished due to the underfunding, results so far shows that there is a strong asymmetry in crustal thickness across the ocean, which make a tectonic reconstruction difficult (Voss and Jokat, GJI, 2007). There may be several reasons for this, but a two-phase magmatic development of the East Greenland margin north of the West Jan Mayen Fracture Zone may have caused this. As there is field evidence for mid-Tertiary magmatism, this is a possible explanation, but the issue requires additional work.

The two EUROMARGINS profiles on the East Greenland margin are located in the prolongation of fjord profiles acquired during earlier investigations. Both profiles show a continental basement overlain by Devonian in the south and Mesozoic sediments in the north, and total crustal thicknesses of 25-29 km. The syn-rift Mesozoic sediments extend further east overlain by Cenozoic sediments. Along both profiles, a wide continent-ocean transition zone (COT) appears with lateral and vertical velocity variations. Furthermore, both profiles show a lower crustal body (LCB) with p-wave velocities of 7.1-7.4 km/s which is interpreted as underplated magmatic material. It extends across distances of 190 km to 230 km, respectively. The southern profile shows marked relief of both the Moho and the top LCB reflector and the lower crustal body shows variations in its thickness of up to 14.5 km. The Moho boundary along the northern profile shows much less relief and the thickness of the lower crustal body varies up to 15.5 km. The existence of voluminous underplating is direct evidence of rift-related magmatism that was not extruded like the adjacent flood basalts. Compared to the conjugate Vøring Margin off Norway, differences in the crustal thickness and degree of magmatic underplating are either evidence for different rift formation processes or of multi-stage magmatic events.

Modelling of the two OBS profiles acquired from the Vøring Basin, across the Trøndelag Platform and to the Norwegian mainland indicates that the top of the crystalline crust dips downwards from the seafloor near the coast to 12-13 km depths in the Vøring Basin. The lower crustal high-velocity layer, which characterizes most of the Vøring Basin and is generally interpreted in terms of mafic intrusions related to the last phase of rifting/break-up, is not present beneath the Trøndelag Platform.

The results from our CRP are used by other research groups both within (EMA16F) and outside EUROMARGINS. Regional crustal-scale profiles across the Norwegian margin (based on an integrated analysis of deep wide-angle seismic data, deep and standard multichannel seismic reflection profiles, potential field data, heat flow, and

scientific and commercial boreholes) have been distributed to groups that use them as constraints in their quantitative modelling to enhance understanding of key processes in volcanic margin formation and evolution. Collaboration between these groups was established during the Oslo workshop in April 2004, and has been further developed by contacts during conferences and research visits.

#### **4. What did you not achieve in the CRP and why? (max 1 p.)**

Please use the original proposal as reference and explain any deviations from the work plan

We faced several difficulties during our Collaborative Research Project, which caused considerable deviations from the original work plan and limited to what extent we have reached some of the overall goals in the conjugate margin study.

In Germany, DFG decided to fund only 1 PhD student despite AWI had requested funding for 3 PhD students to perform the data processing and interpretation of the comprehensive geophysical data acquired in 2003 off East Greenland. In total 120 OBS location and more than 4000 km of multichannel seismic data were impossible to process, analyse and interpret with the funded personnel. Thus, we decided that data and results only from the two southernmost seismic refraction profiles could be made available for the EUROMARGINS project within the given funding.

The lack of funding and progress in the data analysis on the East Greenland margin caused a delay in the integration part of the conjugate margin study. Thanks to industry funding the whole data set will be analyzed and when these results are ready we will do the final integration and comparison between the conjugate margins off East Greenland and mid-Norway.

In France, we had even larger difficulties to get their project up and going. It took a long time before a funding of only 10 k Euros was obtained – far from being enough to conduct any field operations in East Greenland. Université du Maine also requested funding for 1 post-doc to conduct numerical modelling of volcanic passive margins but with no success.

The initial purpose for the French partner of the CRP was to perform a detailed 3D wide-angle seismic experiment in NE Greenland associated with onshore studies. The scientific objective was to determine the 3D geometry of the high-velocity zone previously recognized in 2D profiles by AWI in the same area. We made three official and unsuccessful requests (2002, 2003, and 2004) for the use of national research vessels to conduct this survey.

#### **5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)**

**5. A.** Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

The results achieved in EUROMARGINS form the basis for new research initiatives, e.g. ongoing and proposed projects within the PETROMAKS programme funded by the Norwegian Research Council and industry partners, proposals submitted to TOPO-EUROPE, and an IODP drilling proposals.

**5. B.** Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

According to the importance of the North Atlantic/Arctic Ocean for the future changes in the environment, it would be appropriate if ESF supports a focussed efforts to find constraints to the major problems, e.g. long time series that can only be gained by long cores. This is especially important since activities are currently only funded on a national base, no EU programmes including a strong geoscientific component exists.

#### **6. Your feedback on the EUROCORES Programme (max 1 p.)**

**6.A.** What, in your view, is the added value of being part of a EUROCORES Programme

It has brought together scientists from several countries who work on similar problems with different data sets and methods. It enables us to take a broader scope both regionally and conceptually, and raises the multi-disciplinary awareness of the participants. The programme has helped to establish personal contacts between scientists that should prove valuable in future research. The joint meetings on a regular basis organized by ESF, were crucial for the ongoing discussions in this CRP.

**6.B.** Give any critical and constructive comments on the EUROCORES Programme and its procedures

The massive under funding of the German IP concerning the involved persons led to difficult internal discussions in justifying the provided ship time. Especially, since no convincing arguments for cutting the funds were provided to the proponents. In our CRP Norway received 85%, Germany 30% and France less than 10% of the requested funds. How can such imbalance in funding work? During the ESF meeting these became even more obvious by learning that other projects were not cut back that massive, if at all. In terms of science, the integration of all data could not be done. That the community needs such compilations and honors them, shows a recent Nature article of Lizzeralde et al., which did exactly for the Gulf of California the kind of integration that was planned in our joint CRP. Here, Euromargins missed to achieve such a world class result.

It is clear that the EUROMARGINS/EUROCORES agreement for the planned 3D experiment of the French IP had very little weight compared to the political conflicts associated with the share of marine facilities in France and that our country is not prepared to support European research projects. This could also be seen by the very low level of financial support dedicated to the EMA-01 project in France. No post-doc allocation could be obtained and the specific financial support did not exceed 20 k Euros during the whole period.

The entire procedures needs more transparency otherwise it looks from outside that a small circle of scientists decide on ESF programmes. Cut backs in projects are normal, and somehow acceptable, if the proponents are provided with a sound explanation. ESF would make a good job for the proponents, if they follow in general the recommendations of the reviewer. The experience from this CRP and some information on the TOPO-EUROPE, led to the decision that the German proponent did not submit a new proposal. It looked like that all the mistakes of the initial phase from the EUROMARGINS programme would be repeated.



## Appendix 1. List of Products of the CRP

### 1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more** CRPs (if any)

Scheck-Wenderoth, M., Raum, T., Faleide, J.I., Mjelde, R. and Horsfield, B. (2007) The transition from the continent to the ocean - a deeper view on the Norwegian Margin. *Journal of the Geological Society*, 164, 855-868.

### 1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

Breivik, A.J., Faleide, J.I., Mjelde, R. & Murai, Y., 2006. Rates of continental breakup magmatism and seafloor spreading in the Norway Basin–Iceland plume interaction, *J. Geophys. Res.*, 111, B07102, doi:10.1029/2005JB004004.

Geoffroy, L. (2005) Volcanic passive margins. Concise review paper, *CR Géosciences*, 337, 1395-1409.

Mjelde, R., Raum, T., Breivik, A., Shimamura, H., Murai, Y., Takanami, T., Brekke, H. & Faleide, J.I. (2005a) Crustal structure of the Vøring Margin, NE Atlantic derived from OBS-data: geological implications. In: Doré, A.G. & Vining, B. (eds) *Petroleum Geology: North West Europe and Global Perspectives - Proceedings of the 6<sup>th</sup> Petroleum Geology Conference*. Geological Society, London, p. 803-813.

Tsikalas, F., Faleide, J.I., Eldholm, O. & Wilson, J., 2005. Late Mesozoic-Cenozoic structural and stratigraphic correlations between the conjugate mid-Norway and NE Greenland continental margins. In: Doré, A.G. & Vining, B. (eds) *Petroleum Geology: North West Europe and Global Perspectives - Proceedings of the 6<sup>th</sup> Petroleum Geology Conference*. Geological Society, London, p. 785-801.

Raum, T., Mjelde, R., Shimamura, H., Murai, Y., Bråstein, E., Karpuz, R., Kravik, K. & Kolstø, H.J., 2006. Tectono-magmatic evolution of the southern Vøring Basin and Vøring Transform Margin, NE Atlantic. *Tectonophysics* 415, 167-202.

Voss, M. and Jokat, W. (2007) Continent–ocean transition and voluminous magmatic underplating derived from P-wave velocity modelling of the East Greenland continental margin. *Geophys. J. Int.* (2007) 170, 580–604, doi: 10.1111/j.1365-246X.2007.03438.x

#### In press:

Mjelde, R., Breivik, A.J., Raum, T., Mittelstaedt, E., Ito, G., Faleide, J.I. Magmatic and tectonic evolution of the North Atlantic. *Journal of the Geological Society* (in press).

Tsikalas, F., Faleide, J.I. and Eldholm, O., 2007. The NE Atlantic conjugate margins. In: Roberts, D.G. & Bally, A.W. (eds) *Principles of Phanerozoic Regional Geology*, Elsevier Publ. (in press).

#### Submitted:

Breivik, A. J., Faleide, J. I. and Mjelde, R. (submitted) Neogene magmatism northeast of the Aegir and Kolbeinsey Ridges, NE Atlantic: spreading ridge – mantle plume interaction? Submitted to *Geochem. Geophys. Geosyst.*

Breivik, A.J., and Faleide, J.I., Mjelde, R. and Flueh, E. (submitted) Magma productivity and early seafloor spreading rate on the northern Vøring Margin, Norway – constraints on mantle melting models. Submitted to *Tectonophysics*

Geoffroy, L., Aubourg, C., Callot, J.P. & Barrat, J.A. (submitted) Mantle melting at LIPs: the North-Atlantic case. Submitted to GSA Special Pub.

Gac, S. & Geoffroy, L. (submitted) 3D FEM-modelling of the soft-point theory of continental break-up. Submitted to Geophysical Journal International.

Voss, M. and Jokat, W. (submitted) From Devonian extensional collapse to Early Eocene continental break-up: an extended transect of the Keiser Franz Joseph Fjord of the East Greenland margin. Submitted to Geophysical Journal International.

### 1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

### 1 D. Patents and industry collaborations

On the Norwegian margin we have established a long-term and close collaboration with the petroleum industry. Our CRP has further strengthened the links between academia and industry.

### 1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

We have established a close network between the researchers of the CRP, in particular the post-docs. Instruments and personnel have been shared/exchanged during cruises. In addition to the EUROMARGINS workshops and conferences (see part 3) and other international conferences, we have visited each other for informal meetings to discuss progress and further work

### 1 F. Participation in other conferences

Please list only the most relevant

Results from the research carried out within the CRP has been presented as oral and poster contributions at many international conferences:

#### 2004

Faleide, J.I., Tsikalas, F., Breivik, A.J., Engen, Ø, Wilson, J., Eldholm, O. & Ren, S.: "NE Atlantic Late Mesozoic-Cenozoic evolution and links to the Arctic". 32<sup>nd</sup> International Geological Congress (IGC), August 20-28, 2004, Florence, Italy.

Tsikalas, F., Faleide, J.I. & Eldholm, O.: "Cenozoic development of the conjugate margins off NE Greenland and Norway". 32<sup>nd</sup> International Geological Congress (IGC), August 20-28, 2004, Florence, Italy.

Jokat, W. (2004). Preliminary results of the seismic investigations off East Greenland, ESF-Euromargins Workshop, 10-14. Nov. 2004, Barcelona.

Faleide, J.I., Mjelde, R., Tsikalas, F., Breivik, A.J., Raum, T., Wilson, J. & Eldholm, O.: "EUROMARGINS research on the Norwegian continental margin". EUROMARGINS Conference, November 11-13, 2004, Barcelona, Spain.

Breivik, A.J., Faleide, J.I. & Mjelde, R., 2004: "Late Miocene magmatic underplating of oceanic crust at the outer Vøring margin, Norway, Euromargins 2003 OBS experiment". EUROMARGINS Conference, November 11-13, 2004, Barcelona, Spain.

Raum, T., Mjelde, R., Faleide, J.I. & Breivik, A., 2004: "Crustal structure across the Trøndelag Platform, off Norway, from MCS and OBS data". EUROMARGINS Conference, November 11-13, 2004, Barcelona, Spain.

Breivik, A.J., Faleide, J.I. & Mjelde, R.: "Late Miocene magmatic underplating of oceanic crust at the outer Vøring

margin, Norway, Euromargins 2003 OBS experiment". American Geophysical Union (AGU) Fall Meeting, December 13-17, 2004, San Francisco, USA.

## 2005

- Faleide, J.I., Mjelde, R., Tsikalas, F., Breivik, A.J., Raum, T., Wilson, J. & Eldholm, O.: "EUROMARGINS research on the Norwegian continental margin – towards a regional 3D model of the crustal architecture and evolution". Norwegian Geological Society 19<sup>th</sup> Congress, January 9-12, 2005, Røros, Norway.
- Raum, T., Mjelde, R., Faleide, J.I. & Breivik A., 2005: "Evolution of the Vøring Margin from 2D OBS-profiles". Norwegian Geological Society 19<sup>th</sup> Congress, January 9-12, 2005, Røros, Norway.
- Tsikalas, F., Faleide, J.I., Wilson, J. & Eldholm, O.: "Late Mesozoic-Cenozoic evolution of the conjugate mid-Norway and NE Greenland continental margins". Norwegian Geological Society 19<sup>th</sup> Congress, January 9-12, 2005, Røros, Norway.
- Schroeder, M., Jokat, W. (2005). Modellierung und Interpretation der Krustenstruktur des Kontinent Ozean Übergangs von Ostgrönland zwischen 72°N und 76°N, DGG-Jahrestagung, 21.2.-25.2.2005, Graz, Österreich.
- Faleide, J.I., Andriessen, P.A.M., Jokat, W., Scheck-Wenderoth, M., Geoffroy, L., Hertogen, J., Mjelde, R., Tsikalas, F. & the NE Atlantic EUROMARGINS Team: "Dynamics of conjugate volcanic margins". European Geosciences Union (EGU) General Assembly, April 24-29, 2005, Vienna, Austria (Keynote oral presentation).
- Breivik, A. J., Faleide, J. I. & Mjelde, R.: "Late Miocene Magmatic Underplating of Oceanic Crust at the Outer Vøring Margin, Norway, Euromargins 2003 OBS Experiment". European Geosciences Union (EGU) General Assembly, April 24-29, 2005, Vienna, Austria.
- Mjelde, R., Raum T., Shimamura, H., Murai, Y. & Takanami, T.: "Continent-Ocean-Transition on the Vøring Plateau, NE Atlantic; a tectonomagmatic model derived from densely sampled OBS-data". European Geosciences Union (EGU) General Assembly, April 24-29, 2005, Vienna, Austria.
- Raum, T., Mjelde, R., Faleide, J.I., and Breivik, A.J.: "Deep crustal models across the entire Vøring Margin – from wide-angle (OBS) data". European Geosciences Union (EGU) General Assembly, April 24-29, 2005, Vienna, Austria.
- Scheck-Wenderoth, M., Eue, E., Faleide, J.I., Mjelde, R., Di Primio, R. & Horsfield, B.: "Deformation at the Norwegian Continental Margin". European Geosciences Union (EGU) General Assembly, April 24-29, 2005, Vienna, Austria.
- Schroeder, M., Jokat, W. (2005). P-Wave Modelling of the East Greenland Volcanic Margin North of the Jan Mayen Fracture Zone, EGU-2005 General Assembly, 24.- 29.April 2005, Vienna, Austria.
- Tsikalas, F., Faleide, J.I., Eldholm, O. & Wilson, J.: "Conjugate mid-Norway and NE Greenland continental margins: Late Mesozoic-Cenozoic tectono-stratigraphic correlations and margin evolution". EGU General Assembly 2005, April 24-29, 2005, Vienna, Austria.
- Tsikalas, F., Faleide, J.I., Eldholm, O., Breivik, A.J. & Mjelde, R.: "Crustal structure of the Lofoten-Vesterålen continental margin off Norway". European Geosciences Union (EGU) General Assembly, April 24-29, 2005, Vienna, Austria.
- Breivik, A.J., Mjelde, R. & Faleide, J.I.: "Continental breakup magmatism and transition to hot-spot influenced seafloor spreading from the Møre margin to the Norway Basin". AGU Chapman Conference on the Great Plume Debate: the Origin and Impact of LIPs and Hot Spots, August 28-September 1, 2005, Fort William, Scotland, UK.
- Jokat, W. (2005). Results and Perspectives of Marine Research off East Greenland and in the Northernmost Atlantic, InWaterTec2005 (31 Aug 2 Sept 2005) Session S-6 Frontier Exploration of Offshore Mineral and Energy Resources.
- Tsikalas, F., Faleide, J.I., Breivik, A.J., Mjelde, R., Eldholm, O. & Wilson, J.: "NE Atlantic breakup and evolution of the Norwegian-Greenland conjugate volcanic margins: field evidence to the Great Plume Debate". AGU Chapman Conference on the Great Plume Debate: the Origin and Impact of LIPs and Hot Spots, August 28-September 1, 2005, Fort William, Scotland, UK.
- Schroeder, M., Jokat, W. (2005). P-Wave Modelling of the ContinentOcean Transition of the East Greenland Volcanic Margin North of Jan Mayen Fracture Zone, 2nd International Alfred-Wegener Symposium, 30.10.- 2.11.2005, Bremerhaven, Deutschland.
- Breivik, A.J., Mjelde, R. & Faleide, J.I.: "Slow to ultraslow seafloor spreading in the Norway Basin under influence of the Iceland hotspot". American Geophysical Union (AGU) Fall Meeting, December 5-9, 2005, San Francisco, USA.

- Faleide, J.I., Tsikalas, F., Breivik, A.J., Mjelde, R., Wilson, J. & Eldholm, O.: "NE Atlantic breakup and evolution of the Norwegian-Greenland conjugate volcanic margins". American Geophysical Union (AGU) Fall Meeting, December 5-9, 2005, San Francisco, USA.
- Tsikalas, F., Faleide, J.I., Breivik, A.J., Eldholm, O., Mjelde, R. & Raum, T.: "New OBS data constrain the crustal structure of the Lofoten-Vesterålen margin off Norway". American Geophysical Union (AGU) Fall Meeting, December 5-9, 2005, San Francisco, USA.

## 2006

- Tsikalas, F., Breivik, A.J., Faleide, J.I., Raum, T., Mjelde, R. & Eldholm, O.: "OBS data constrain the crustal structure of the Lofoten-Vesterålen margin, off Norway". Gulf Seismic Forum 2006, February 19-22, 2006, Muscat, Sultanate of Oman.
- Voss, M., Jokat, W. (2006). Der Kontinentalrand Ostgrönlands: Erste Interpretation tiefeisemischer und Potentialfelddaten im Bereich zwischen der Jan Mayen und Grönlandbruchzone, 66. Jahrestagung der DGG, 6.-9. März, Bremen, Deutschland.
- Breivik, A. J., Mjelde, R. & Faleide, J. I.: "Magma-starved seafloor accretion in the Norway Basin caused by the Iceland hotspot". European Geosciences Union (EGU) General Assembly, April 2-7, 2006, Vienna, Austria.
- Breivik, A. J., Mjelde, R. & Faleide, J. I., 2006: "Continent-ocean transition at the northern Vøring Margin, Norway, Euromargins 2003 OBS Experiment". European Geosciences Union (EGU) General Assembly, April 2-7, 2006, Vienna, Austria.
- Faleide, J.I., Mjelde, R., Tsikalas, F., Breivik, A.J., Raum, T., Wilson, J. & Eldholm, O.: "A regional 3D model of the crustal architecture and evolution of the mid-Norwegian continental margin". European Geosciences Union (EGU) General Assembly, April 2-7, 2006, Vienna, Austria.
- Scheck-Wenderoth, M., Raum, T., Mjelde, R., Faleide, J. I., Di Primio, R. & Horsfield, B.: "Results from 3D structural modelling of the Norwegian Margin. European Geosciences Union (EGU) General Assembly, April 2-7, 2006, Vienna, Austria.
- Scheck-Wenderoth, M., Raum, T., Mjelde, R., Faleide, J. I., Di Primio, R. & Horsfield, B.: "Subsidence analysis based on a 3D structural model of the Vøring Margin". European Geosciences Union (EGU) General Assembly, April 2-7, 2006, Vienna, Austria.
- Tsikalas, F., Breivik, A.J., Faleide, J.I., Raum, T., Mjelde, R. & Eldholm, O.: "Crustal structure of the Lofoten-Vesterålen margin, off Norway, constrained by new OBS data". European Geosciences Union (EGU) General Assembly, April 2-7, 2006, Vienna, Austria.
- Voss, M., Jokat, W. (2006). Crustal Structure of the East Greenland Volcanic Margin - I: Voluminous Underplating North of the Jan Mayen Fracture Zone, EGU General Assembly 2006, 02.-07. April 2006, Vienna, Austria.
- Wilson, J., Raum, T., Mjelde, R., Faleide, J.I., Breivik, A.J., Murai, Y. & Flüh, E.: "Crustal structure and composition beneath the Trøndelag Platform, mid-Norwegian margin, derived from wide-angle seismic and gravity data". European Geosciences Union (EGU) General Assembly, April 2-7, 2006, Vienna, Austria.
- Breivik, A.J., and Faleide, J.I. & Mjelde, R.: "MORB hijacking by the Iceland plume". ILP Task Force VIII: Plume like instabilities in the upper mantle beneath Europe, 1<sup>st</sup> PLUME workshop, July 3-6, 2006, Mt. St. Odile, France.
- Faleide, J.I., Tsikalas, F., Breivik, A.J., Wilson, J. Engen, Ø. & Eldholm, O.: "Late Mesozoic-Cenozoic evolution of the NE Atlantic region and links to the Arctic". International Lithosphere Program "The History of Convergent and Passive Margins in the Polar Realm: Sedimentary and Tectonic Processes, Transitions and Resources", September 18-22, 2006, Université Laval, Québec, Canada (Keynote oral presentation).
- Scheck-Wenderoth, M., Faleide, J.I., Raum, T., Mjelde, R., Di Primio, R. & Horsfield, B.: "Results from 3D structural modelling of the Norwegian Margin. International Lithosphere Program "The History of Convergent and Passive Margins in the Polar Realm: Sedimentary and Tectonic Processes, Transitions and Resources", September 18-22, 2006, Université Laval, Québec, Canada
- Mjelde, R., Breivik, A. & Faleide, J.I.: "Crustal transect across the North Atlantic". SEISMIX, September 24-29, 2006, Hayama, Japan.
- Breivik, A. J., Mjelde, R. & Faleide, J. I.: "Continental breakup and magmatism at the mid-Norwegian margin, Euromargins 2003 OBS Experiment". EUROMARGINS Conference, October 4-7, 2006, Bologna, Italy.
- Mjelde, R., Breivik, A. & Faleide, J.I.: "Crustal profile across the North Atlantic". EUROMARGINS Conference, October 4-7, 2006, Bologna, Italy.
- Scheck-Wenderoth, M., Raum, T., Mjelde, R., Faleide, J.I., Primio, R.D. and Horsfield, B. 2006. Results from 2D/3D structural modeling of the Norwegian margin. EUROMARGINS Conference, October 4-7, 2006, Bologna, Italy.

- Voss, M., Jokat, W. (2006). Magmatism and formation of a wide continent-ocean transition at the East Greenland margin, Euromargins 2003 OBS Experiment, ESF Euromargins Workshop, 4-7 Oct., Bologna, Italy.
- Breivik, A.J., Faleide, J.I., Mjelde, R. & Tsikalas, F.: "Continental breakup and magmatic development of the mid-Norwegian margin, Euromargins 2003 OBS Experiment". American Geophysical Union (AGU) Fall Meeting, December 11-15, 2006, San Francisco, California, USA.
- Scheck-Wenderoth, M., Maystrenko, Y., Faleide, J.I., Mjelde, R. & Horsfield, B.: "The continent ocean transition at the Norwegian Margin - constraints from 3D structural and gravity modelling". American Geophysical Union (AGU) Fall Meeting, December 11-15, 2006, San Francisco, USA.
- Tsikalas, F., Breivik, A.J., Faleide, J.I., Mjelde, R. & Eldholm, O.: "Crustal structure, continental breakup and magmatism at the Lofoten-Vesterålen margin, off Norway, constrained by the Euromargins 2003 OBS Experiment". American Geophysical Union (AGU) Fall Meeting, December 11-15, 2006, San Francisco, USA.
- Voss, M., Jokat, W. (2006). Magmatism and a wide continent-ocean transition at the East Greenland volcanic rifted margin, American Geophysical Union Conference, San Francisco, 11.-15.12.2006.

## 2007

- Mjelde, R., Breivik, A.J. & Faleide, J.I. 2007. Crustal transect across the North Atlantic and evolution of the mid-Norwegian Margin. Norwegian Geological Society 20<sup>th</sup> Congress, January 8-10, 2007, Stavanger, Norway.
- Tsikalas, F., Breivik, A.J., Faleide, J.I., Mjelde, R. & Eldholm, O.: "Crustal structure, continental breakup and magmatism at the Lofoten-Vesterålen margin, off Norway, constrained by the Euromargins 2003 OBS Experiment". Norwegian Geological Society 20<sup>th</sup> Congress, January 8-10, 2007, Stavanger, Norway.
- Breivik, A.J., Faleide, J.I., Mjelde, R. & Tsikalas, F.: "Timing of continental breakup at the mid-Norwegian margin, Euromargins 2003 OBS Experiment". European Geosciences Union (EGU) General Assembly, April 15-20, 2007, Vienna, Austria.
- Jokat, W., Voss, M. (2007). Plumes and Continental Break-up: Some observations from the North and South Atlantic, EGU, Wien.
- Scheck-Wenderoth, M., Maystrenko, Y., Faleide, J.I., Mjelde, R. & Horsfield, B.: "The continent ocean transition at the Norwegian Margin - constraints from 3D structural and gravity modelling". European Geosciences Union (EGU) General Assembly, April 15-20, 2007, Vienna, Austria.
- Tsikalas, F., Faleide, J.I., Breivik, A.J., Mjelde, R., Wilson, J., Eldholm, O. & Kuznir, N.J.: "Structure and evolution of the northern Vøring and Lofoten-Vesterålen margins, and their conjugate NE Greenland margin". European Geosciences Union (EGU) General Assembly, April 15-20, 2007, Vienna, Austria.
- Faleide, J.I., Tsikalas, F., Breivik, A.J., Mjelde, R., Wilson, J. & Eldholm, O.: "NE Atlantic breakup and evolution of the Norwegian-Greenland conjugate volcanic margins". American Association of Petroleum Geologists (AAPG)-Hedberg Conference 2007 "Basin Modeling Perspectives: Innovative Developments and Novel Application", May 6-9, 2007, The Hague, The Netherlands.
- Voss, M., Schmidt-Aursch, M. C., Jokat, W. (2007). Constraints of break-up related magmatism of the North East Greenland rifted margin, ICAM V - Fifth International conference on Arctic margins.

## **Appendix 2. Scientific & technical personnel involved in the CRP**

### **Personnel directly funded by the EUROCORES Programme**

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

Asbjørn Breivik	postdoc	University of Oslo	01/07/2003 – 30/06/2006
Thomas Raum	postdoc	University of Bergen	01/01/2004 – 31/08/2005



Max Voss\*

PhD

AWI

01/02/2004 – 31/01/2007

\*After his marriage Max Schroeder changed his family name to Voss.

# Forcing of carbonate mounds and deep water coral reefs along the NW European continental margin (MOUNDFORCE)

## Abstract

Recent discoveries of carbonate mounds covered with cold water corals and related benthic communities along the NE Atlantic Ocean continental margin (Porcupine Bight and north of Porcupine Bank, southeast and southwest Rockall Trough Margin, Norwegian margin) and of actively venting mud volcanic areas along the continental margin surrounding the Gulf of Cadiz associated with authigenic carbonate crust formation and deep-water reef-like coral build-ups and carbonate chimneys margin, Galicia Bank as well as new discoveries of fossil and recent reef structures in the Mediterranean ), raises the question of their origin and development. A major objective of the proposed studies therefore is to establish the forcing conditions of carbonate mound formation and to test the hypothesis of a possible linkage between (hydrocarbon related) cold seeps and the development of carbonate mounds, cold water benthic communities and authigenic carbonate formation. This proposal is further directed towards a definition of the geological, geochemical and oceanographical conditions and processes forcing the development of carbonate mounds and establishing the benthic ecology and environmental conditions of carbonate mound and cold water coral reef formation in contrasting areas of the NE Atlantic Ocean and Mediterranean Sea. A third objective is to establish the factors governing lithification and stabilisation of carbonate mounds, and to use these as modern analogues of fossil carbonate build ups. Comparison between recent and past mound forcing conditions will allow development of a model of mound genesis in relation to tectonic, sedimentological, oceanographical and biological extant conditions.

## Partners

(NWO, DFG, FWO, MCyT, CNR)

### **Dr Tjeerd van Weering (Project leader)**

Netherlands Institute for Sea Research, Den Burg, The Netherlands

### **Pr Christian Dullo**

Leibniz-Institut für Meereswissenschaften an der Universität Kiel, Kiel, Germany

### **Pr André Freiwald**

Universität Tübingen Tübingen, Germany

### **Dr Dierk Hebbeln**

Universität Bremen, Bremen, Germany

### **Pr Jean-Pierre Henriët**

Universiteit Gent, Gent, Belgium

### **Dr Luis Somoza**

Instituto Geológico y Minero de España, Madrid, Spain

### **Pr Rudy Alin Swennen**

Katholieke Universiteit Leuven, Heverlee, Belgium

### **Dr Conxita Taberner**

Consejo Superior de Investigaciones, Científicas, Barcelona, Spain

### **Dr Marco Taviani**

<b>Collaborative Research Project (CRP)</b>
<b>1. General information</b>
<p><u>Project Reference Number</u> : 01-LEC-EMA06F  <u>Acronym / Short Title</u>: <i>MOUNDFORCE</i>  <u>Full Title</u>: <b>Forcing of carbonate mounds and deep water coral reefs along the NW European continental margin</b>  <u>Project Leader name</u>: <i>Pr Tjeerd van Weering</i>  <u>Project Leader affiliation</u>: <i>Netherlands Institute for Sea Research, Den Burg, NL</i>  <u>Institutional home page</u> (URL): <a href="http://www.nioz.nl">www.nioz.nl</a>  <u>Project-related home page</u> (URL): -  <u>Reporting period</u>: 01/10/2004 to 30/09/2007</p>
<b>2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)</b>
<b>IP 1</b>
<b>Pr Tjeerd van Weering</b> , Royal Netherlands Institute for Sea Research, Den Burg, The Netherlands
Total Funding amount of the IP: EUR 729 314
<b>IP2</b>
<b>Pr Christian Dullo</b> , Leibniz-Institut für Meereswissenschaften an der Universität Kiel, Kiel, Germany
Total Funding amount of the IP: EUR 147 500
<b>IP3</b>
<b>Pr André Freiwald</b> , Universität Tübingen Tübingen, Germany
Total Funding amount of the IP: EUR 21 450
<b>IP4</b>
<b>Dr Dierk Hebbeln</b> , Universität Bremen, Bremen, Germany
Total Funding amount of the IP: EUR 214 826
<b>IP5</b>
<b>Pr Jean-Pierre Henriët</b> , Universiteit Gent, Gent, Belgium
Total Funding amount of the IP: EUR 475 503
<b>IP6</b>
<b>Dr Luis Somoza</b> , Instituto Geológico y Minero de España, Madrid, Spain
Total Funding amount of the IP: EUR 137 000
<b>IP7</b>
<b>Pr Rudy Alin Swennen</b> , Katholieke Universiteit Leuven, Heverlee, Belgium
Total Funding amount of the IP: EUR 476 013
<b>IP8</b>
<b>Dr Conxita Taberner</b> , Consejo Superior de Investigaciones, Científicas, Barcelona, Spain
Total Funding amount of the IP: EUR 83 000
<b>IP9</b>
<b>Dr Marco Taviani</b> , Consiglio Nazionale delle Ricerche, Bologna, Italy
Total Funding amount of the IP: EUR 220 000

### 3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

#### Scientific achievements:

The main objectives of the MOUNDFORCE studies were:

1) To define the geological, geochemical and oceanographical conditions and processes forcing the development of carbonate mounds, and thus, to test the two existing hypotheses of (a) a linkage between cold seeps and carbonate mounds formation, and (b) a relation between external, i.e. oceanic and climate controls of mound development.

#### Re 1.:

a) Our CRP results (based on seismic, sidescan sonar, ROV, seabed imagery by video and hoppercamera as well as on watercolumn and bottom sampling and long term deployed seabed lander observations) show that the control on mound formation by methane seepage from the seafloor can be excluded as driving force for carbonate lithification and mound formation, at least for the mounds in the Porcupine Bight and margin and along the Rockall Trough margins. However, methane seepage appears to play an important role in carbonate formation associated with mud mounds in the Gulf of Cadiz.

b) Near-bed currents, and downward transport of (fresh phytodetritus containing) particles by internal tidal waves are shown to strongly enhance the growth and development of the cold corals and associated biota covering the tops and upper flanks of mounds. This conclusion was supported through the reconstruction of a local 3D flow-field (bottom current velocity and direction) at selected mounds allowing to directly relate the cold-water coral distribution to the local oceanographic setting (Dorschel et al., 2007; Mienis et al, 2007). The observed strong currents are further suggested to strongly affect hardground formation and to control carbonate mound shaping, thus emphasizing an oceanographic control on mound formation again, at least for the mounds in the Porcupine Bight and margin and along the Rockall Trough margins. The forcing of these carbonate mounds by environmental forcing factors (e.g. currents) revealed by these studies can also be projected into the distant past.

The IODP drilling results of the Challenger mound and recently acquired data on the presence of important hiatuses in the sedimentary record of mound sediments provides evidence for the impact of strong currents in mound shaping as well as for the importance of along slope directed contour currents and associated particle transport in halting mound development and final burial, thus suggesting a climatic longer term control. The observations point to a dramatic variability in mound growth rate which supports the postulated existence of a so-called booster stage in the early phases of mound development This aspect has been picked up for definition under the new Eurocores program "CARBONATE"

2) To establish the benthic ecosystems and environmental conditions of carbonate mounds and cold-water coral reefs in contrasting areas of the NE Atlantic Ocean and the Mediterranean Sea.

**Re 2)** A number of new coral occurrences has been identified in the Mediterranean and in the adjoining Strait of Gibraltar and Gulf of Cadiz, these could be partially mapped and sampled permitting an overview of distribution, age, and associated biodiversity. In the Gulf of Cadiz radiocarbon-dating of cold-water corals at the Hespérides mud volcano showed that four scleractinian cold-water coral species (*Dendrophyllia alternata*, *Lophelia pertusa*, *Madrepora oculata*, *Dendrophyllia cornucopia*) invaded the Gulf of Cádiz at different time intervals ranging from 1.000 (*D. alternata*) to 48.000 yrs (*D. cornucopia*).

Extensive U-series dating of cold-water corals from various locations (Alboran Sea, Tyrrhenian Sea, Strait of Sicily, Ionian Sea, S. Adriatic Sea, Levantine basin) reveals a surprisingly narrow range of ages, with the majority falling between 13,500 to 11,000 yrs BP, indicating that deep-sea corals flourished in the Mediterranean during the cooler conditions of the Younger Dryas (YD) period. Prolific deep-sea coral growth however ended abruptly at ~11,000 yrs BP, ~500 yrs after the cessation of the YD, with many of the coral mounds being draped by mud. On the "Pen Duick Escarpment", associated mounds and the newly surveyed "Conger Cliff" mounds thick "coral

cemeteries" have been observed covered by a mud layer of variable thickness. Coral Ages here vary from > 40.000BP to 8.000BP.

A new finding has been that phosphorous incorporated into the coral aragonite is a **new** proxy of ocean fertility. The application of this discovery to submerged coral occurrences demonstrates important climatically-driven variations in the availability of nutrients from the YD to present.

3) To establish the factors governing lithification and stabilisation of carbonate mounds and to use these as modern analogues of fossil carbonate build-ups, which are already known since Cambrian times. Comparison between recent and past mound formation will allow the development of a model of mound genesis in relation to tectonic, sedimentological, oceanographical and biological extant conditions.

**Re 3:** Extensive new knowledge about the small-scale facies distribution on carbonate mounds along the Celtic margin allowed compilation of detailed facies maps for two mounds, which enabled a much better understanding of the forcing factors driving the development of these mounds (Dorschel et al., 2007; Wienberg et al., 2007)

Summarizing: from MOUNDFORCE partners results it is clear that:

- Hardgrounds of investigated carbonate mounds in the Porcupine and Rockall area are the result of early diagenetic lithification of pelagic foraminiferal-nannoplankton oozes with admixed mound-derived invertebrate skeletons. Methane seepage is not involved.
- Carbonate lithification occurred under fairly oligotrophic conditions in a fertile well oxygenated, non-sulphuric and non-methanotrophic environment. An endogenic control by emanating methane from the seafloor can be excluded as driving force for carbonate lithification.
- Contour current velocities control hardground formation and mound shaping

#### **Other achievements:**

The CRP greatly facilitated to compete for ship-time resulting in the access to major oceanographic vessels on a regular base. The availability of ship-time and subsequent multi-institutional and disciplinary use was instrumental for the comprehensive exploration of deep-water coral build-ups in the Porcupine Bight, Rockall Trough margins, the Mediterranean from the Gulf of Cadiz, to the Levantine basin.

Trough MOUNDFORCE it was possible for the first time to integrate scientific results on the species composition of cold-water coral reef ecosystems along a wide latitudinal gradient along the North Atlantic margins. This work finalised many attempts to collate and harmonize earlier data sets specifically on the mollusc community embedded within a network of cross-cutting objectives by the other PIs.

MOUNDFORCE kept a strong group of young researchers together and allowed them to further develop the knowledge gained after they started their career in the former EU-FP V projects (ACES, ECOMOUND, GEOMOUND). This formed an internationally recognized well trained group of young scientists

Follow-up of the studies undertaken by the MOUNDFORCE project were realised by participation of most Moundforce partners in the EU FP6 IP project **HERMES** (Hotspot Ecosystems along the Margins of the European Seas), where a major focus is on the long-term development and ecological constraints of cold-water coral ecosystems and related development of carbonate mounds ( $10^2$  to  $10^5$  years) along the Celtic and Rockall margins.

The latter topic will be further investigated within the newly started EUROCORES EUROMARC project "**CARBONATE**" (Mid latitude carbonate systems: complete sequences from cold-water coral carbonate mounds in the northeast Atlantic), that aims at drilling several tens of meters into a variety of mound structures along the Irish margin by using the Bremen shallow (maximum penetration depth 75 M) rotating drilling device MEBO. In addition to this proposal, an **EU FP7** proposal "**MeBoTech**", an ROV-assisted MEBO support action has been submitted, intended to act as nucleus of improved co-operation between Science and Industry – paving the way to a Science/Industry 'Mound Research Forum'"

As during the project and associated studies the importance of high resolution time series measurements of parameters governing (and limiting) growth of the various cold water coral ecosystems studied during MOUNDFORCE, a number of MOUNDFORCE partners have joined forces to participate in the EU NoE **ESONET**, which presently is in the stage of reviewing a proposal on time series observations in the KOSTERfjord (**KOSTOBS**



project), where the Tisler reef will be focus.

New ideas generated through the partners of Moundforce, related to the importance of microbial activity for both mud mound and carbonate mound development, led to a successful application of another EUROCORES Eurodiversity project titled “**MICROSYSTEMS**”: Microbial Diversity and Functionality in Cold-Water Coral Reef Ecosystems, 2006-2009, led by J-P Henriët.

#### **4. What did you not achieve in the CRP and why? (max 1 p.)**

Please use the original proposal as reference and explain any deviations from the work plan

Part of WP 3 was directed to analyse the “bacterial mediation of lithification of crusts on carbonate mounds” which turned out to be inappropriate as collected hardgrounds from the Porcupine Bight and from the Rockall margin were identified as lithified planktonic oozes of Pleistocene origin rather than modern authigenic bacterial carbonates as originally assumed.

Therefore, the investigation concentrated on the characterization of assemblages on the dominant reef-building coral *Lophelia pertusa* with respect to its specificity, composition and metabolic implications. Samples from Gulf Of Cadiz and Moroccan mudmounds are still being studied and further age dated, conclusions regarding environmental and oceanographic constraints and oceanographic controls have been reported orally but are still being worked out. The impact and importance of methane seepage in this area is still being assessed.

#### **5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)**

**5. A.** Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

Part of the expertise gained through MOUNDFORCE flows into a FP VII proposal that is currently under review. Most expertise, however, goes into the new ESF CARBONATE project that deals with drilling through carbonate mounds. Again, these ESF networks are essential to recruit new young scientists and to keep the best experienced scientists in the system for Europe’s marine research in this case.

Efforts are deployed to shape a joint academia-industry initiative on carbonate mound drilling. Milestones are the first conference of the Moroccan Association of Petroleum Geologists (Marrakech, October 2007) and a special session on deep-water coral reefs and carbonate reservoirs at the Cape Town 2008 meeting of the American Association of Petroleum Geologists (session co-chaired by M. Andres and J.P. Henriët).

**Further see under other achievements above.**

**5. B.** Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

It would be very wise to keep ocean margin-related topics in the perspective of future ESF calls. These and the EU Framework Programmes are really strong strategic tools to create critical masses and new ideas and thoughts.

#### **6. Your feedback on the EUROCORES Programme (max 1 p.)**

**6.A.** What, in your view, is the added value of being part of a EUROCORES Programme

Cooperation and exchange of new scientific knowledge -well before publication-has strongly advanced progress and planning within projects and between projects through better awareness of and partial participation in

ongoing related EU and other EUROCORES programs.

Important is the forcing of intense networking between disciplines – and cultures within Europe.

**6.B.** Give any critical and constructive comments on the EUROCORES Programme and its procedures

While the application rules from pre-proposal to full-proposal submission are clear, sharp and effective, the duration until a positively evaluated proposal finally started can be (extremely) long. This is probably related to still complex decisive processes between the national funding agencies involved. This part of the handling procedure should be made more clear to proposers. Even if funded, many PIs (may) have lost excellent recruits over this period.

Marine research depends on ship time and mobilisation costs of large-scale tools such as ROVs, AUV's, drilling gear etc. At present, it seems possible, that after a positive signal to the project co-ordinator for funding, national funding agencies still can change their budget lines. At the end the individual PI has to negotiate with his/her funding agency to compensate a budget drop created by a decision of another funding agency we see a need for better and more transparent strategic decision taking at the level of the national funding agencies.

## Appendix 1. List of Products of the CRP

Remark Tj.C.E.v.W:

Only published contributions period 2005-2007 are included below.

### 1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more CRPs** (if any)

Costello, M.J., M. McCrea, A. Freiwald, T. Lundälv, L. Jonsson<sup>4</sup>, B.J. Bett, T. van Weering, H. de Haas, J.M. Roberts, D. Allen, 2005. Role of cold-water *Lophelia pertusa* coral reefs as fish habitat in the NE Atlantic. In: Freiwald, A., Roberts, J.M. (Eds). Cold-water corals and ecosystems. Springer-Verlag, Berlin, Heidelberg: 771-805.

Dorschel, B., Hebbeln, D., Rüggeberg, A. and Dullo, W.-Chr., 2005. Growth and erosion of a cold-water coral covered carbonate mound in the Northeast Atlantic during the Late Pleistocene and Holocene. Earth and Planetary Science Letters, 233: 33-44.

Dorschel, B., Hebbeln, D., Rüggeberg, A. and Dullo, W.-Chr., 2007. Carbonate budget of a cold-water coral carbonate mound: Propeller Mound, Porcupine Seabight. International Journal of Earth Sciences, 96: 73-83 (DOI: 10.1007/s00531-005-0493-0).

Dorschel, B., Hebbeln, D., Foubert, A., White, M., Wheeler, A. (2007) Hydrodynamics and cold-water coral facies distribution related to recent sedimentary processes at Galway Mound west of Ireland. Marine Geology, 244, 184-195, doi:10.1016/j.margeo.2007.06.010.

Henriet, J.P. and Dullo, W.-Chr. (eds.) 2007. Modern Carbonate Mound Systems: A Window to Earth History. – International Journal of Earth Sciences – Geologische Rundschau, Spec. Issue, Vol. 96.

Henriet, J.-P., Hamoumi, N., Ivanov, M., Pinheiro, L., Suzyumov, A.E., Swennen, R., Blinova, V., Bouimetarhan, I., De Boever, E., Depreiter, D., Foubert, A., Kozlova, E., Maignien, L., Poort, J., Van Rensbergen, P. & Van Rooij, D. (2006). The mud volcano province on the Atlantic Moroccan margin: towards a natural laboratory for joint European-Maghreb research. In: Fluid seepages/mud volcanoes in the Mediterranean and adjacent domains. CIESM Workshop Monographs, 29, 21-26

Huvenne, V.A.I., Bailey, W.R., Shannon, P., Naeth, J., Di Primio, R., Henriet, J.P., Horsfield, B., de Haas, H., Wheeler, A. & Olu-Le Roy, K. (2007) The Magellan mound province in the Porcupine Basin. International Journal of Earth Science, 96: 85-101

Huvenne, V.A.I., Beyer, A., de Haas, H., Dekindt, K., Henriet, J.-P., Kozachenko, M., Olu-Le Roy, K., Wheeler, A.J. and the TOBI/Pelagia 197 and CARACOLE cruise participants, 2005. The seabed appearance of different coral bank provinces in the Porcupine Seabight, NE Atlantic: results from sidescan sonar and ROV seabed mapping. In: Freiwald, A., Roberts, J.M. (Eds). Cold-water corals and ecosystems. Springer-Verlag, Berlin, Heidelberg: 535-569.

Loeffler S-B, Janssen R, Guers KR, Taviani M (2005). The genus *Axinus* Sowerby, 1821 in the Mediterranean basin (Bivalvia: Thyasiridae). JOURNAL OF CONCHOLOGY. vol. 38 (5), pp. 581-598

López Correa M, Freiwald A, Hall-Spencer J, Taviani M (2005) Distribution and habitats of *Acesta excavata* (Bivalvia: Limidae) with new data on its shell ultrastructure In: Freiwald A, Roberts JM (eds) Cold-water corals and ecosystems. Springer, pp 173-205.

Mienis, F., Van Weering, T., De Haas, H., De Stigter, H., Huvenne, V., Wheeler, A., 2006. Carbonate mound development at the SW Rockall Trough margin based on high resolution TOBI and seismic recording. Marine Geology, 233: 1-19.

Noé, S., Lembke-Jene, L., Reveillaud, J., and Freiwald, A., 2007. Microstructure, growth banding and age determination of a primnoid gorgonian skeleton (Octocorallia) from the late Younger Dryas to earliest Holocene of the Bay of Biscay. Facies, 53: 177-188.

Noé, S., Titschak, J., Freiwald, A. and Dullo, W.-Chr., 2006. From sediment to rock: diagenetic processes of hardground formation in deep-water carbonate mounds of the NE Atlantic. *Facies*, 52: 183-208.

Rüggeberg, A., Dorschel, B., Dullo, W.-Chr. and Hebbeln, D., 2005. Sedimentary patterns in the vicinity of a carbonate mound in the Hovland Mound Province, northern Porcupine Seabight. In: Freiwald, A. and Roberts, J.M., *Cold-water Corals and Ecosystems*, Springer, Berlin Heidelberg, pp. 87-112.

Rüggeberg, A., Dullo, W.-Chr., Dorschel, B. and Hebbeln, D., 2007. Environmental changes and growth history of a cold-water coral mound (Propeller Mound, Porcupine Seabight). *International Journal of Earth Sciences*, 96: 57-72 (DOI: 10.1007/s00531-005-0504-1).

Taviani M, Corselli C, Freiwald A, Malinverno E, Mastrototaro F, Remia A, Savini A, Tursi A (2005). First geo-marine survey of living cold-water *Lophelia* reefs in the Ionian Sea (Mediterranean basin). *FACIES*. vol. 50, pp. 409-417

Taviani M, Freiwald A, Zibrowius H (2005) Deep coral growth in the Mediterranean Sea: an overview In: Freiwald A, Roberts JM (eds) *Cold-water corals and ecosystems*. Springer, pp 137-156.

Van Rooij, D., Depreiter, D., Bouimetarhan, I., De Boever, E., De Rycker, K., Foubert, A., Huvenne, V., Reveillaud, J., Staelens, P., Vercruyse, J., Versteeg, W. & Henriët, J.-P. (2005). First sighting of active fluid venting in the Gulf of Cadiz. *EOS Transactions* 86(49), 509-511.

Wheeler, A.J., Beyer, A., Freiwald, A., de Haas, H., Huvenne, V.A.I., Kozachenko, M. & Olu-Le Roy, K., 2007. Morphology and environment of cold water coral carbonate mounds on the NW European Margin *International Journal of Earth Science*, 96: 37-56.

Wienberg, C., Beuck, L., Heidkamp, S., Hebbeln, D., Freiwald, A., Pfannkuche, O., Monteys, X. (2007) Franken Mound – facies and biocoenoses on a newly-discovered 'carbonate mound' on the western Rockall Bank, NE Atlantic. *Facies* 53, DOI 10.1007/s10347-007-0118-0.

## 1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

Beuck L, Freiwald A (2005) Bioerosion patterns in a deep-water *Lophelia pertusa* (Scleractinia) thicket (Propeller Mound, northern Porcupine Seabight) In: Freiwald A, Roberts JM (eds) *Cold-water corals and ecosystems*. Springer, pp 915-936.

De Boever, E., Swennen, R and Dimitrov, L., (2006). Eocene carbonate chimneys (Pobiti Kamani, Varna, NE Bulgaria): (a) biological mediation of chimney growth? *Sedimentary Geology*, 185, 159-173.

De Boever, E., Swennen, R. and Dimitrov, L., (2006). Lower Eocene carbonate cemented structures (Varna, Bulgaria) – control of seepage rates on their formation and geochemical signature. *J. Geochem. Explor.*, 89, 78-92.

Fernández-Puga M. C., Vázquez J. T., Somoza, L. Díaz del Río V., Medialdea T. and Mata M. P., León. R. (2007). Gas-related morphologies and diapirism in the Gulf of Cádiz. *Geo-Mar Lett.* doi: 10.1007/s00367-007-0076-0

González, F. J., Somoza, L., Lunar, R., Martínez-Frías, J., Martín Rubí, J. A., Díaz del Río, V. (2007). Fe-Mn nodules associated with hydrocarbon seeps: the new discovery of the Gulf of Cadiz (eastern Central Atlantic). *Episodes* Vol. 30, nº 3, 187-196.

Hernández-Molina, F. J.; Llave, E.; Stow, D.A.V.; García, M.; Somoza, L.; Vázquez, J.T; Lobo, F.; Maestro, A.; Díaz del

- Río, V.; León, R.; Medialdea, T. Gardner, J. (2006). The Contourite Depositional System of the Gulf of Cadiz: a sedimentary model related to the bottom current activity of the Mediterranean Outflow Water and the continental margin characteristics. *Deep-Sea Research II*, 53: 1420-1463.
- Könnecker G, Freiwald A (2005) *Plectroninia celtica* n.sp. (Calcarea, Minchinellidae), a new species of "pharetronid" sponge from bathyal depths in the northern Porcupine Seabight, NE Atlantic. *Facies* 51: 53-59.
- León, R., Somoza, L., Medialdea, T., Maestro, A., Díaz del Río, V. (2006). Classification of sea-floor features associated with methane seeps along the Gulf of Cádiz continental margin. *Deep-Sea Research II*, 53: 1464-1431.
- León R., Somoza L., Medialdea T., González F. J., Díaz-del-Río V., Fernández-Puga M. C., . Maestro A, Mata M. P. (2007). Sea-floor features related to hydrocarbon seeps in deepwater carbonate-mud mounds of the Gulf of Cádiz: from mud flows to carbonate precipitates. *Geo-Marine Letters* DOI 10.1007/s00367-007-0074-2
- Llave, E., Shönfeld J., Hernandez-Molina, F.J., Mulder, T., Somoza L., Diaz del Rio, V. and Sanchez-Almazo (2006). High-resolution stratigraphy of the Mediterranean outflow contourite system in the Gulf of Cadiz during the Late Pleistocene: The impact of Heinrich events. *Marine Geology* 227, 241-262.
- Llave, E., Hernández-Molina, F. J., Somoza, L., Stow, D., Díaz del Río, V. (2007). Quaternary evolution of the Contourite Depositional System in the Gulf of Cadiz. In: *Economic and Paleooceanographic Importance of Contourites*, Viana, A. and Rebesco, M. (Eds.). Geological Society of London Special Publication 276, pp. 49-80.
- Lobo F.J., Fernández-Salas L.M., Hernández-Molina F.J., González R., Dias J.M.A., Díaz del Río V. and L. Somoza, (2005). Holocene highstand deposits in the Gulf of Cadiz, SW Iberian Peninsula: A high-resolution record of hierarchical environmental changes. *Marine Geology* 219 (2-3): 109-131.
- Martín-Puertas, C., Fernández-Puga M.C., Mata M.P., Vázquez Garrido J.T., Díaz del Río V. y Somoza L. 2006. Naturaleza de la brecha fangosa de volcanes de fango del Golfo de Cádiz: sistema diapírico del Guadalquivir y zona Tasyo. *Revista de la Sociedad Geológica de España*, 19(3-4), 200-220.
- Martín-Puertas, M. P. Mata, M. C. Fernández-Puga, V. Díaz del Río, J. T. Vázquez, L. Somoza. 2007. A comparative mineralogical study of gas-related sediments of the Gulf of Cádiz. *Geo-Marine Letters* DOI 10.1007/s00367-007-0075-1
- Mienis, F., de Stigter, H.C., White, M., Duineveld, G., de Haas, H., van Weering, T.C.E., 2007. Hydrodynamic controls on cold-water coral growth and carbonate-mound development at the SW and SE Rockall Trough Margin, NE Atlantic Ocean. *Deep Sea Research Part I: Oceanographic Research Papers*, Vol. 54: 1655-1674
- Mienis, F., T. van Weering, H. de Haas, H. de Stigter, V. Huvenne, A. Wheeler, 2006. Carbonate mound development at the SW Rockall Trough margin based on high resolution TOBI and seismic recording. *Mar. Geol.*, 233:1-19
- Montagna P, McCulloch M, Taviani M, Mazzoli C, Vendrell B (2006). Phosphorus in cold-water corals as a proxy for seawater nutrient chemistry. *SCIENCE*. vol. 312, pp. 1788-1791 ISSN: 0036-8075.
- Montagna P, McCulloch M, Taviani M, Remia A, Rouse G (2005) High resolution trace and minor element compositions in deep-water solitary scleractinian corals (*Desmophyllum dianthus*) from the Mediterranean Sea and the Great Australian Bight. In: *Deep-water Corals & Ecosystems* (A. Freiwald & M. Roberts eds.), pp. 1109-1126; Springer-Verlag.
- Remia A, Taviani M (2005). Shallow-buried Pleistocene *Madrepora*-coral mounds on a muddy continental slope, Tuscan Archipelago, NE Tyrrhenian Sea. *FACIES*. vol. 50, pp. 419-425.

Somoza L., Vazquez T. (2005). 'The Geology of the Gulf Cádiz' Symposium held on VI Geological Congress of Spain. Episodes , vol, 28, no. 3, pp. 217-218.

Taviani M, Remia A, Esu D, Sami M (2007). Messinian Lago-Mare mollusc fauna from the Gorgona island slope, Tyrrhenian sea. GEOBIOS. vol. 40 (3), pp. 351-358.

**Publications in press/submitted:**

Beuck L., Freiwald A., Taviani M. Spatiotemporal bioerosion patterns successions in cold-water scleractinians from off Santa Maria di Leuca (Apulia, Ionian Sea). DEEP SEA RESEARCH (submitted 2007).

De Boever, E., Swennen, R. and Dimitrov, L., 2006, Lower Eocene carbonate cemented structures (Varna, Bulgaria) – control of seepage rates on their formation and geochemical signature. J. Geochem. Explor., 89, 78-92.

De Boever, E., Swennen, R., Muchez, Ph., Dimitrov, L., 2007, Hydrocarbon-related tubular concretions of the Pobiti Kamani area (Varna, Bulgaria) – A combined field and anatomic study. (submitted)

Depreiter, D., De Boever, E., Foubert, A., van Weering, T., Henriët, J.-P. and Swennen, R., 2008, Variety of authigenic carbonates in the Gulf of Cadiz as a key to different modes of fluid flow (submitted). Marine Geology.

Duineveld, G.C.A., Lavaley, M.S.S., Bergman, M.J.N., De Stigter, H.C., Mienis, F., (in press). Trophic structure of a cold water coral mound community (Rockall Bank, NE Atlantic) in relation to the near bottom particle supply and current regime. Bulletin of Marine Science.

Foubert, A., Depreiter, D., Beck, T., Maignien, L., Pannemans, B., Frank, N., Blamart, D. & Henriët, J.-P. (in press). Carbonate mounds in a mud volcano province off northwest Morocco: key to processes and controls. Marine Geology

Frank, N., Ricard, E., Paque, A., van der Land, C., Colin, C., Blamart, D., Foubert, A., van Rooij, D., Henriët, J.-P., de Haas, H. van Weering, Tj.C.E. Carbonate mound evolution on Rockall Bank and in Porcupine Seabight derived from <sup>230</sup>Th/U dating of deep-water corals.

López Correa M., Montagna P., Vendrell B., McCulloch M., Taviani M. Stable isotopes ( $\delta^{18}\text{O}$  &  $\delta^{13}\text{C}$ ), trace and minor element compositions of Last Glacial to Recent scleractinians and bivalves at Santa Maria di Leuca deep-water coral province, Ionian Sea. DEEP SEA RESEARCH (submitted 2007).

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Mastrototaro F., D'Onghia G., Corriero G., Matarrese A., Maiorano P., Panetta P., Gherardi M., Longo C., Rosso A., Sciuto F., Sanfilippo R., Gravili C., Boero F, Taviani M., Tursi A. - Biodiversity of the white coral ecosystem off Cape Santa Maria di Leuca (Mediterranean Sea): an update. DEEP SEA RESEARCH (submitted 2007).

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Montagna P., Devoti S., Antonioli F., Mazzoli C., McCulloch M., Parlagreco L., Scicchitano G., Silenzi S., Sparaini F., Taviani M. (in press 2008) . High-resolution natural archives provide new tools for climatic reconstruction and monitoring the Mediterranean Sea. ATTI ACCADEMIA NAZIONALE DEI LINCEI.

Reveillaud, J., Freiwald, A., Van Rooij, D., Le Guilloux, E., Altuna, A., Foubert, A., Vanreusel, A., Olu-Le Roy, K., Henriët, J.-P. (submitted 2007). Scleractinian cold-water corals of the Bay of Biscay: overview of the present day knowledge on their distribution. Facies.



Trincardi F, Fogliani F, Verdicchio G, Asioli A, Correggiari A, Minisini D, Piva A, Remia A, Ridente D, Taviani M (2007). The impact of cascading currents on the Bari Canyon System, SW-Adriatic Margin (Central Mediterranean). *MARINE GEOLOGY*, in press.

Van Rooij, D., Huvenne, V.A.I., Blamart, D., Henriot, J.-P., Wheeler, A. & de Haas, H. (submitted 2007). The Enya mounds: a lost mound-drift competition. *International Journal of Earth Sciences*.

**Submitted to EUROMARGINS Special Volume of Marine Geology (2007)**

Gonzalez, F. J., L. Somoza, R. Lunar, J. Martinez-Frias, J. A. Martin Rubi, T. Torres, J. E. Ortiz, V. Diaz del Rio, L. M. Pinheiro, and V. H. Magalhaes. Hydrocarbon-derived ferromanganese nodules in carbonate-mud mounds from the Gulf of Cadiz: mud-breccia sediments and clasts as nucleation sites

Magalhaes, V. H., L. M. Pinheiro, C. Vasconcelos, J. A. Mc Kenzie, S. M., Bernasconi, A. Kopf, M. K. Ivanov, V. Diaz-del-Rio, and L. Somoza. Morphological, mineralogical and geochemical characterization of methane-derived authigenic carbonates from the Gulf of Cadiz: a formation model

Medialdea, T., L. Somoza, L. Pinheiro, M. C. Fernandez-Puga, J. T. Vazquez, R. Leon, M. K. Ivanov, V. Magalhaes, V. Diaz-del-Rio, R. Vegas, and A. Maestro. Fluid escape pathways and tectonics in the Gulf of Cadiz

Somoza, L., J. Gardner, K. Loudon, R. Leon, V. Diaz del Rio, W. Jung, F. J. Hernandez-Molina, T. Medialdea, and F. J. Gonzalez. Anomalous heat flows at mud volcanoes and pockmarks in the Gulf of Cadiz: focused fluid venting, gas hydrates and Mediterranean undercurrent

**PhD. theses.**

De Boever, E. (2009) Dynamische evolutie van Eocene koolwaterstofmigratie en processen van carbonaatprecipitatie – Pobiti Kamani gebied (Varna, NE Bulgarije)

Foubert, A. (2007) – Nature and Significance of the Carbonate Mound Record: The Mound Challenger Code. Ghent, May 2007, 341 pp.

**In preparation.**

Depreiter, D. (defence 2008) Fluid flow and carbonates, Moroccan margin

Pirlet, H. (Cyclic record in carbonate mounds)

De Mol, L. (Mound 4D)

Mienis, F. (defence 2008) Mound development, environmental constraints.

## 1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

Henriet, J.-P., Van Rooij, D., De Rycker, K., Foubert, A., Guilini, K., Huvenne, V., Le Guilloux, E., Roose, F., Staelens, P., Verduyck, J., Versteeg, W., Wheeler, A., Appeltans, W. & the R/V Belgica staff (2006). R/V Belgica unveils the Celtic Margin's spectacular oyster cliffs. *Hermes News Update*, 5, 11.

Henriet, J.-P., Depreiter, D., Foubert, A. & the R/V Belgica "Genesis" shipboard party (2007). RV Belgica sheds new light on escarpment mound and mud volcano ecosystems off Morocco. *Hermes News Update*, 9, 7.

Radio interviews:

Deutsche Welle, NDR Info – August 2005: Interview with S. Flögel and A. Rüggeberg about POS325 cruise to cold-water coral reefs of N Norway

Newspaper articles:

Press release of IFM-GEOMAR about Meteor cruise M 61/1 (see homepage, in German, [http://www.innovations-report.de/html/berichte/biowissenschaften\\_chemie/bericht-28792.html](http://www.innovations-report.de/html/berichte/biowissenschaften_chemie/bericht-28792.html))

24.06.2005: geoscience-online.de: "Expedition zu den Kaltwasserriffen – Korallen im Nordmeer bedroht"  
(Expedition to the cold-water coral reefs – corals threatened in the Nordic Sea)

12.08.2005: geoscience-online.de: "Riffe im Nordmeer – Von Korallenwächtern und Kinderstuben" (Reefs in the Nordic Sea – about coral guards and nursery)

Public Lecture: Dierk Hebbeln: Korallenriffe vor Irland – noch nicht im Reiseführer und schon bedroht. Haus der Wissenschaften, Bremen, 2006.

Documentaries in the German TV from two marine expeditions (RV SONNE cruise SO-175 in 2003 and RV Meteor expedition M61/3 in 2004). Each one for ~45 minutes.

## 1 D. Patents and industry collaborations

## 1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

Intense networking was facilitated through good internal communication of news, events and cruises.

## 1 F. Participation in other conferences

Please list only the most relevant

AAPG 2006,2007, 2008 (co-convenor),

AGU 2007, 2008

EGU 2005, 2006, 2007,

IAS 2007

ESF Magellan Workshop on "Exploring escarpment mud mound systems and mud volcanoes with new European strategies for sustainable mid-depth coring", Murten, Switzerland (24 – 29 April 2007)

ESF SEECAM workshop 2008

HERMES 2<sup>nd</sup> Annual Meeting, Cavoeiro, Portugal

## Appendix 2. Scientific & technical personnel involved in the CRP

## Personnel directly funded by the EUROCORES Programme

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

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# Earthquake and tsunami hazards of active faults at the south Iberian margin: deep structure, high-resolution imaging and paleoseismic signature (SWIM)

## Abstract

Integrated, multidisciplinary, cooperative effort for the study of the fundamental geological processes that affected and are affecting the SW Iberian continental margin. In the last decade a large marine geophysical database has been acquired in the Southwest Iberian Margin by different European institutions. We intend to merge the existing data sets already available through this cooperative project. Based on this combined data set we will plan and carry out further geological and geophysical investigations focused on the Jurassic and Cretaceous rifting architecture of SW Iberia and on its Neogene reactivation. One of the main goals of the project is the study of the active processes occurring at continental margins (tectonic deformation, mass sediment flux, and fluid circulation), which determine a high concentration of natural hazards linked to seismicity, tsunami generation, and large submarine mass wasting. The mitigation of these hazards requires an in-depth knowledge of the dynamics along margins and surrounding basins, and requires multidisciplinary and high-resolution marine geophysics. The research work will be focused on the Southwestern Margin of the Iberian Peninsula, from the eastern border of the Tagus Plain, to the Gorringe Bank and to the Gulf of Cadiz. We shall also take into account the northern African margin and SE Spanish Margin for a global view. We intend, moreover, to carry out this project in firm collaboration and coordination with MVSEIS Euromargins proposal (Coordinator: Prof. Luis Pinheiro) and in collaboration with WEST-MED Euromargins proposal (Coordinator: Dr. M. Fernández) for the Alboran Sea.

## Partners

(CNR, CNRS, FCT, NERC, MCyT)

### **Dr Nevio Zitellini (project leader)**

Consiglio Nazionale Ricerche Istituto di Geologia Marina, Bologna, Italy

### **Dr Eulalia Gràcia**

Centre Mediterrani d'Investigacions Marines i Ambientals (CMIMA), Unitat de Tecnologia, Barcelona, Spain

### **Dr Marc-André Gutscher**

Intitut Universitaire Européen de la Mer, Université de Bretagne Occidentale, Plouzané, France

### **Dr Luis Matias**

Centro de Geofisica da Universidade de Lisboa, Lisboa, Portugal

### **Pr Mohamed Sahabi**

Université Chouaïb Doukkali, El Jadida, Morocco

### **Pr Philip Weaver**

Southampton Oceanography Centre, Southampton, United Kingdom

<b>Collaborative Research Project (CRP)</b>
<b>1. General information</b>
<u>Project Reference Number</u> : 01-LEC-EMA09F <u>Acronym / Short Title</u> : <i>SWIM</i> <u>Full Title</u> : <b>Earthquake and tsunami hazards of active faults at the south Iberian margin: deep structure, high-resolution imaging and paleoseismic signature</b> <u>Project Leader name</u> : <i>Dr Nevio Zitellini</i> <u>Project Leader affiliation</u> : <i>Consiglio Nazionale Ricerche Istituto di Geologia Marina, Bologna, IT</i> <u>Institutional home page</u> (URL): <a href="http://www.bo.ismar.cnr.it">www.bo.ismar.cnr.it</a> <u>Project-related home page</u> (URL): <a href="http://www.swim.ul.pt">www.swim.ul.pt</a> <u>Reporting period</u> : 01/10/2004 to 30/09/2007
<b>2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)</b>
<b>IP 1</b>
<b>Dr Nevio Zitellini</b> , Consiglio Nazionale Ricerche Istituto di Geologia Marina, Bologna, Italy
Total Funding amount of the IP: EUR <b>67.000</b>
<b>IP2</b>
<b>Dr Eulalia Gràcia</b> , Unitat de Tecnologia Marina- CSIC, Centre Mediterrani d'Investigacions Marines i Ambientals (CMIMA), Barcelona, Spain
Total Funding amount of the IP: EUR <b>68.000</b>
<b>IP3</b>
<b>Dr Marc-André Gutscher</b> , Intitut Universitaire Européen de la Mer, Université de Bretagne Occidentale, Plouzané, France
Total Funding amount of the IP: EUR <b>34.000</b>
<b>IP4</b>
<b>Dr Luis Matias</b> , Centro de Geofísica da Universidade de Lisboa, Lisboa, Portugal
Total Funding amount of the IP: EUR <b>2.520</b>
<b>IP5</b>
<b>Pr Philip Weaver</b> , Southampton Oceanography Centre, Southampton, United Kingdom
Total Funding amount of the IP: EUR <b>0.0</b>
<b>AP1</b>
<b>Pr Mohamed Sahabi</b> , Université Chouaïb Doukkali, El Jadida, Morocco
Total Funding amount of the IP: EUR <b>0.0</b>

### 3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

1) **key achievements:** The scientific objectives originally planned regarded the 1) study of the neogenic compression to enlighten the original structural setting of the SW Iberia passive margins, 2) the sampling of the Neogenic and pre-Neogenic stratigraphic units, 3) the Neotectonic map of SW Portugal, 3) the evaluation of the active deformation, 4) the determination sediment instability and sediment flux, 5) the evaluation the fluid circulation and thermal regime surrounding the fault zone, 6) the development of a model of potential geological hazards. SWIM reached most of the planned objectives, as can be seen from the list of publication and presentations and by the data acquisition performed at sea, with the exception of point 5. One of the most important outcome of the CPR was the complete mapping of the active and possible tsunamigenic structures of the SW Iberia and the location of the gravity instabilities of the margin. Among the major results obtained by SWIM is the hypothesis, put forward by Marc Andre Gutscher, for presence of an active subduction West of the Gibraltar Arc and the possibility of this subduction zone being the source of the 1755 earthquake and tsunami (Science, 2004, 305, 1247-1248). The main scientific results exceeded all expectations! SWIM project prepared a completely new high resolution bathymetric map, with grid resolution of 100 m, of SW Iberia (Fig.1) which was not foreseen in the original proposal. The map extends from the Straits of Gibraltar to the Gorringer Bank

2) **Marine Cruises:** The completion of several successful geological and geophysical acquisition campaigns have to be ascribed to one of the major achieving of the project. Throughout this new data set we reached a level of knowledge of the geological process active in the Gulf of Cadiz never reached before. These new data acquisition were also very powerful knowledge tool for the other two Euromargins project: MVSEIS (Coord. Luis Pinheiro) and WESTMED (Coord. Manuel Fernandez Ortiga) which were running in parallel with SWIM. The teams of SWIM, MVSEIS and WESTMED shared ideas, data and people adding great value to the research. The main SWIM actors in carrying out surveys in the Gulf of Cadiz were the follow. Spanish team: **PRIME 2003 cruise**. For the marine paleoseismic research, CSIC carried out a sediment coring cruise during July 2003 on board the RV Marion Dufresne, during which CSIC obtained 4 giant piston cores (MD03-2701 a 2704) up to 20 m long. In addition, CSIC collaborated in the GAP 2003 and SWIM 04 cruises to collect multicores and gravity cores; **SWIM 2006** cruise. CSIC carried out the SWIM 2006 (He 113) cruise on board the BIO Hespérides from 31st May to 14th June 2006, Chief Scientist: E. Gràcia (UTM-CSIC). During this cruise CSIC acquired 16 MCS profiles (2700 km of data) at the external part of the Gulf of Cadiz, essential for identifying the the active tectonic structures in the area from the Horseshoe Abyssal Plain and Fault, Coral Patch Ridge and Seine Abyssal Plain. French Team: **Cadisar2**, R/V Le Suroit, Aug. 2004 (PI T. Mulder) multi-beam mapping; **Delila**, R/V Don Carlos, Sept. 2004 (PI M.-A. Gutscher) multi-beam mapping; **DELSIS**, R/V Le Suroit, April 2005, (PI M.-A. Gutscher) 24-channel and high resolution chirp seismic profiles across the deformation front of the accretionary wedge; Portuguese team: **Matespro 2004** (P.I. P.Terrinha) multi-beam mapping; Italina team: **Voltaire 2002** (P.I. N.Zitellini) multi-channel seismic and sampling, **SWIM 2004** (P.I.N.Zitellini) geological sampling, **SWIM 2005** (P.I. Zitellini) multi-channel seismic and sampling.

3) **complete multi-beam mapping of the majority of the Gulf of Cadiz region.** The dataset consists of 11 surveys, totalling more than 200 days of ship time. The resulting bathymetric compilation (see previous interim report) reveals the distinct morphological provinces, including incised canyons on the steep Portugese continental margin, flat lying abyssal plains to the west, bounded by E-W trending basement highs and locally pierced by rising salt domes (particularly in the SE Seine abyssal plain). One of the most remarkable structural provinces is the convex shaped mound occupying the central Gulf of Cadiz, which shows a series of arcuate ridges and troughs, with a gently undulating surface morphology, sloping generally westward at a low angle (<1° on average). This fresh tectonic mega-structure is an accretionary wedge almost completely mapper for the first time by SWIM research.

4) **Identification of Active faults:** The swath bathymetry, the new MCS and the very high-resolution seismic (TOPAS) from SWIM cruises data reveal seafloor ruptures corresponding to W-verging thrusts (HF, CPRF) and WNW-ESE strike-slip faults cutting through the Quaternary units are active faults. These WNW-ESE strike-slip faults



were undetected before the SWIM investigations. They develop for hundred of kilometres and are key feature for the understanding of the present day Europe-Africa plate interaction. We have been solicited by the Editor Science to submit a paper concerning the discovery of these important structures. This paper is going to be submitted in the forthcoming days.

5) **Characterization of submarine landslides associated to active faulting.** SWIM teams have mapped mass movement features associated to the active fault areas of the SW Portuguese Margin: the Marques de Pombal (MPF) block and the Sao Vicente Canyon. It was determined the typology of the mass movements, interpreted the mechanisms of triggering and emplacement, modelled calculated the volume and provided a chronology for the age of emplacement of the landslides. Radiocarbon dating of a 250 km<sup>2</sup> submarine landslide associated to the MPF suggests that it was triggered by the 1755 Lisbon earthquake.

6) **Sedimentological, geochemical and magnetic analyses of MD sediment cores.** SWIM team have analyzed and interpreted sediment cores MD03-2701, MD03-2702, MD03-2703 and MD03-2704 acquired in the SW Iberian margin onboard the RV "Marion Dufresne". Detailed visual core description and standard physical properties (magnetic susceptibility, gamma-ray, Pwave velocity) using the Geotek Multi-Sensor Core Logging System helped us to identify the main sedimentary facies. We have done continuous measuring of the major elements (Ca, Fe, Ti, Mn) with the XRF scanner at the Research Centre for Ocean Margins (RCOM) in Bremen (Germany) to characterize the detrital and hemipelagic intervals as well as to characterized provenance of mass transport deposits. Environmental magnetic properties based on continuous u-channel measurements were achieved for each MD core as well as core MD03-2698 (property of INETI-Lisbon) in collaboration with Laboratoire de Paleomagnetisme (N. Thouveny) from CEREGE, Aix-en-Provence, France. The results comprise measurements of ARM, IRM, NRM at different fields, and mass-normalized magnetic susceptibility, which allow us to distinguish and characterize turbidite events from the late Pleistocene Heinrich events, reference datums in the Atlantic Margin.

7) **Turbidite paleoseismology of the SW Iberian Margin.** Widespread synchronous turbidites found in long distance apart basins (HAP, MPZ, IDHB, TAP) are related to large magnitude earthquakes in the Gulf of Cadiz, such as AD 1755 and BC 218, 5200 BP. The estimated recurrence interval of the 7 widespread Holocene events is of 1.7 kyr. Good correlation between turbidites and instrumental & historical seismic events and tsunami deposits suggests that the turbidite record can be used as a paleoseismic indicator, becoming a valuable tool to establish earthquake recurrence intervals of large magnitude events in the SW Iberian region.

8) **Discovery of a eastward dipping subduction zone beneath the straits of Gibraltar.** A high rugosity sea-floor slope with alternating ridges and troughs fills the central Gulf of Cadiz and is revealed by seismic reflection profiles to be an east-ward thickening accretionary wedge. This accretionary wedge is linked to the eastward dipping subduction zone beneath the straits of Gibraltar. The horseshoe-shaped deformation front can be traced continuously for >400 km and is offset at the west by the indentation of a 2000 m high E-W trending basement ridge. Seismic profiles across the deformation front show signs of folding of recently deposited sediments (and locally some faulting in the shallow platform regions).

9) **Why we reached these results:** there is no doubt that the breath needed by this research required to be developed within a CRP. Before the start of SWIM we had a very low knowledge of the region which, by is by contrast, now one of the best known of the Southern Europe. The burst in the understanding of the active geological process here could not be achieved so far, in few years, without the contribution of several working teams, possessing different expertise and carrying out several, multidisciplinary marine surveys.

10) **New ideas, new questions new formulations and new topics for research:** the complete mapping of the active faults together with the dense network of MCS and chirp data allowed to fully identify the possible tectonic sources for the generation of the 1755 Lisbon Earthquake. This knowledge allowed to the Italian (N.Zitellini), French (M.A.Gutscher), Spanich (E.Gracia) and Portuguese (L.Matias) teams to propose ond obtain from the EU the funding for the monitoring of one of these structures to test an Early Warning System prototype. This project is called NEAREST (Integrated observations from **N**ear **S**hore **S**ources of **T**sunamis. The discovery of the WNW-ESE strike-slip faults is now forcing to completely re-assets the Present-day plate tectonic kinematics. The mapping of the active versus the inactive faults is leading to a new concept for the lithospheric folding initiation.

#### 4. What did you not achieve in the CRP and why? (max 1 p.)

Please use the original proposal as reference and explain any deviations from the work plan

The main objectives SWIM were largely and satisfactorily achieved. This view is also testified a by the very good review received from the Spanish Ministry of Science and Education concerning the activities of the Spanish team within SWIM. Only a partial, secondary aspect could not be achieved during the CRP. It concerns to the localized heat flow survey across selected active faults as stated at point 5 of the SWIM proposal approved by ESF. The reduction of RV Hesperides shiptime allocated to SWIM together with the malfunctioning of the UTM-CSIC heat flow probe, made us to decide to devote the 13 survey days for MCS acquisition, essential for the project. Nevertheless, the SWIM team, based on the data set acquired and on the new ideas derived form this study submitted a specific proposal, acronym SHAKE (Seafloor HAZard observatory in southwest iberia for earthquakes and related processes), Within SHAKE it is planned to also to study the localized heat flow survey across a selected active fault.

#### 5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

**5. A.** Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

1) The complete mapping of the active tectonic structures that could have caused the generation of the big 1755 Lisbon Earthquake make within SWIM allowed to the Italian (N.Zitellini), French (M.A.Gutscher), Spanich (E.Gracia) and Portuguese (L.Matias) teams to propose the monitoring of one of these structures for and Early Warning System prototype. This project, called **NEAREST** (Integrated observations from Near Shore Sources of Tsunamis: towards an early warning system, is now running on behalf the EU, as Strep, with total funding of 2.85M€.

2) The identification of restricted area for fluid escape along the linear WNW-ESE strike-slip faults allowed to the Portuguese (L.Matias), the Italian (N.Zitellini) and Spanich (E.Gracia) to propose the design for a specific experiments to record the geochemical fluid fluxes with time along one of this faults to the EU. The proposal acronym is **SHAKE** (Seafloor HAZard observatory in southwest iberia for earthquakes and related processes), SHAKE was very well evaluated (score 13.5/15) and in now waiting to know if is going to be funded.

3) The Spanish team were involved in two follow-up activities: **a)** The National Projected EVENT (2007-2010) funded by the Spanish Ministry of Education and Science based on the Integration of new technologies in paleoseismology: Characterization of seismogenic and tsunamigenic faults in South Iberia (EVENT). PI. E. Gràcia. **b)** The ESF TopoEurope "TOPOMED" (2008-2010). The Spanish national workpackage is led by M. Fernández (ICTJA-CSIC). In this WP, E. Gràcia, SWIM-Spain team together with TOPOMED team are included to carry a MCS survey across the Gibraltar Arc (Gulf of Cadiz and Alboran Sea).

**5. B.** Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

1) Forthcoming developments should include a detailed neotectonic and paleoseismic studies of other active areas in the European Margins (i.e. Mediterranean region), as we have been doing in the SW Iberian Margin.

2) There are still important topics to be addressed in the Gulf of Cadiz, such as the role of fluids in faulting and relationship with mud volcanism, the relationship between large earthquakes and individual faults, etc. Future researches in the collaboration will pass for a joint drilling proposal to solve some of the still open problems in the region.

3) In general, in depth study of the geological hazards (earthquakes, tsunamis, landslides, floods, etc) generated along oceanic margins should be a high priority research area in the ESF and funding agencies. In addition, this

research should be based on highly specialized marine technology, as oceanic drilling, ROVs, AUVs, submersibles, only available through translational collaboration.

## 6. Your feedback on the EUROCORES Programme (max 1 p.)

### 6.A. What, in your view, is the added value of being part of a EUROCORES Programme

The fact of being part of an ESF Eurocores program has resulted in an excellent, real collaborative project, in which new data acquired from marine cruises has been shared among all partners of the CRP and joined publications will arise from this. Some examples are:

- The ESF EuroMargins swath bathymetric SWIM compilation, generated after more than 11 cruises since the year 2000.
- Exchange of unpublished data among members of the CRP and to participate in marine cruises from CRP partners.
- Funding to participate in the ESF EuroMargins conferences to interact with the rest of CRPs and to create a larger discussion group of interest; as well as the specific meetings also under the umbrella of EuroMargins to cluster 3 or 4 CRP by thematic or regional objectives (i.e. MEDIATIC workshops).
- Funding to participate in specific EuroMargins sessions of the EGU in Vienna during 3 consecutive years.

### 6.B. Give any critical and constructive comments on the EUROCORES Programme and its procedures

- The major difficulties was raised by the **TOTAL** lack of funding (United Kingdom, WP 5, Morocco, WP6) or **heavy under-funding** (Portugal, WP 3, only 13% of the requested amount) and different national funding schedule.

-In the case of Spain, since the first submission of the letter of intention until the project was granted by the Spanish Agencies, it passed almost three years, which is, by far, too long time for a challenging research project.

-In the case of Portugal, since July 2004 the IP4 project has not received any funds from the Portuguese funding agency. Thus only 13% of the original budget could be used. The IP4 coordinator interprets this fact as a consequence of the little information the Portuguese funding agency (FCT) had on the Eurocores Program that resulted in difficulties integrating it in the Portuguese funding schemes. Despite this fact the researchers involved in IP4 continued to work on the scientific subjects concerned using other sources of funding to support attendance to meetings and participation in cruises. It is the IP4 coordinator opinion that these difficulties are over and that future ESF sponsored programs will receive adequate follow-up from the Portuguese funding agency.

- It is important to stress the fact that the coordinator has no real coordination power which typically derives from the control of the funding, as in the case of the EU funds. In the case of SWIM, the fact that, at national level, United Kingdom and Morocco were not funded implied simply that the participation of these two team was only formal without involvement in the SWIM activities.

-Another critical aspect is the reporting. Each individual project was asked already to report to our own funding agencies, and ESF also request to report to them. This makes redundant the reporting aspect, discouraging the reserachers as we have already done it once.

- Another key aspect ifs the reviewing process implemented by the ESF. The project SWIM, even if provided a good amount of science in term of publications and presentation, as well as new ideas and data to built successful proposal (NEAREST) or potentially successful (SHAKE), was badly evaluated by the reviewer. The reviewer (or reviewers) did a lot of criticism to WP 5 (United Kingdom team): unfortunately United Kingdom team was not

funded (zero funds) and they did not give any contribution to SWIM. The reviewer (or reviewers) did a lot of criticism to WP 6 (Morocco team): again the finding was “zero” resulting in a very minor participation of Morocco to SWIM. The reviewer (or reviewers) did a lot of criticism to WP 3 (Portugal): they said that the report was quite rudimentary! I have to stress that Portugal received only 13% of the funding requested (2.520 € in total). Maybe, it was “rude” the cut and the Portuguese reporting was a consequence. I think that the amount of work done in SWIM, given the very low funding conditions, is really unexpected and not poor! Maybe the ESF should give to the reviewers the full amount of information to be able to correctly evaluate the proposal. In addition, we have one P.I. (France team, WP4 in SWIM) that is also P.I. in another Euromargins project (WP3, MVSEIS). The reviewer claims that figures and text are identical. The Coordinator, responsible for reporting, cannot check for this aspect and, at the same time, cannot act as a policeman. I have to notice that, given that the main goals of SWIM and MVSEIS are very different, the reviewer could easily figure out what belongs to who.

- The project gained great benefit from the data/expertise exchange that was ruled by an “collaborative agreement” signed by the P.Is. It is here suggested that such “Agreements” become a requirements for the future EuroCORES projects.

## Appendix 1. List of Products of the CRP

### 1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more** CRPs (if any)

- GOMEZ-SICHI, O., BLONDEL, P., **GRÀCIA, E., DAÑOBEITIA, J.J.**, and HITS 2001 science party (2005). Quantitative textural analysis of TOBI sonar imagery along the Almería Canyon (Almería Margin, Alboran Sea, SE Spain). *In*: D. M. Hodgson and S. S. Flint (eds). *Submarine Slope Systems: Processes and Products. Geol. Soc. Sp. Pub.*, 244, 141-154.
- GRÀCIA, E.**, PALLÀS, R., SOTO, J.I., COMAS, M., **MORENO, X.**, MASANA, E., SANTANACH, P., **DIEZ, S.**, GARCIA, M., **DAÑOBEITIA, J.J.**, and HITS Team (2006). Active Faulting offshore SE Spain (Alboran Sea): Implications for earthquake hazard assessment in the Southern Iberian Margin. *Earth Planet. Sci. Lett.*, 241, 734-749.
- GARCÍA, M., ALONSO, B., ERCILLA, G., **GRÀCIA, E.**, (2006). The tributary valley systems of the Almería Canyon (Alboran Sea, SW Mediterranean): Sedimentary architecture. *Marine Geology* 226, 207– 223.
- LO IACONO, C., GRÀCIA, E., DIEZ, S., BOZZANO, G., MORENO, X., DAÑOBEITIA, J.J.**, ALONSO, B., (2007). Seafloor characterization and backscatter variability of the Almería Margin (Alboran Sea, SW Mediterranean) based on high-resolution acoustic data. *Mar Geol.*, in press, 2008.

### 1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

#### PUBLICATIONS:

- M A Baptista, J M Miranda, F Chierici , N Zitellini (2003) New Study of the 1755 Earthquake Source Based on Multi-channel Seismic Survey Data and Tsunami Modeling, *NHESS*, 3, 333-340
- ERCILLA, G., GARCÍA-GIL S., GRÀCIA, E., ESTRADA, F., VIZCAINO, A., DÍAZ, S., VÁZQUEZ, T., VILAS, F., CASAS D., ALONSO, B., DAÑOBEITIA J., FARRAN, M., (2007). High-resolution seismic stratigraphy of the Galicia Bank and neighbouring Abyssal Plains (NW Iberian Margin). *Mar. Geol.*, in press, 2008.
- GARCIA-ORELLANA, J., GRÀCIA, E., VIZCAINO, A., MASQUÉ, P., OLID, C., MARTÍNEZ RUIZ, F., PIÑERO, E., SANCHEZ-CABEZA, J.A, DAÑOBEITIA, J.J (2006). Identifying instrumental and historical earthquake records in the SW Iberian Margin using <sup>210</sup>Pb turbidite chronology. *Geophys. Res. Lett.*, 33 (24), L24601, doi: 10.1029/2006GL028417.
- Gutscher, M.-A., Dominguez, S., Westbrook, G., Gente, P., Babonneau, N., Mulder, T., Gonthier, E., Bartolome, R., Luis, J, Rosas, F., Terrinha, P., and the Delila and DelSis Scientific Teams. (in press). Tectonic shortening and gravitational spreading in the Gulf of Cadiz accretionary wedge: observations from multi-beam bathymetry and seismic profiling. *Journal of Marine and Petroleum Geology*, Sp. Vol. on Submarine instabilities (in press).
- Gutscher, M.-A., 2006. The Great Lisbon earthquake and tsunami of 1755: lessons from the recent Sumatra earthquakes and possible link to Plato's Atlantis. *European Review*, v. 14, p. 181-191.
- Gutscher, M.-A., Baptista, M.A., and Miranda, J.M., 2006. The Gibraltar Arc seismogenic zone (part 2): constraints on a shallow east dipping fault plane source for the 1755 Lisbon earthquake provided by tsunami modeling and seismic intensity. *Tectonophysics Sp. Vol. "Natural laboratories on seismogenic faults"*, v. 427, p. 153-166, doi:10.1016/j.tecto.2006.02.025.
- Gutscher, M.-A., 2005. Destruction of Atlantis by a great earthquake and tsunami? A geological analysis of the Spatel Bank hypothesis. *Geology*, v. 33, p. 685-688.
- Gutscher, M.-A., 2005. The source of the Lisbon Earthquake. *Science*, v. 308, p. 51-52 (reply to letter by Joao Fonseca on "What caused the Great Lisbon Earthquake").
- Gutscher, M.-A., 2004. What caused the Great Lisbon Earthquake? *Science*, v. 305, p. 1247-1248.
- Matias, L., A. Ribeiro, M. A. Baptista, N. Zitellini, J. Cabral, P. Terrinha, P. Teves-Costa, and J. M. Miranda (2006). Comment on "Lisbon 1755: A Case of Triggered Onshore Rupture?" by Susana P. Vilanova, Catarina F. Nunes, and Joao F. B. D. Fonseca, *Bull. Seism. Soc. Am.*, vol 95(6), pp. 2534-2538.
- Mendes-Victor, L., A. Ribeiro, L. Matias, M.A. Baptista, J.M. Miranda, P. Miranda, N. Zitellini, E. Garcia, C. Corela, P. Terrinha, M. Rovere and F. Teixeira, 2005. Progresses in the assessment of tsunami genesis and impacts around

- the Portuguese coasts, in *Tsunamis, Case Studies and Recent Developments, Advances in Natural and Technological Hazards Research*, Vol. 23, Satake, Kenji (Ed.), VIII, 356 p., Hardcover, ISBN: 1-4020-3326-5.
- Rovere M., C. R. Ranero, N. Zitellini, R. Sartori & L. Torelli (2004) Seismic images and magnetic evidence of the Late Jurassic to Early Cretaceous Africa-Eurasia plate boundary off SW Iberia, *Geophysical Journal International*, 158, 554-568
- Terrinha, P., Pinheiro, L. M., Henriot, J.-P., Matias, L., Ivanov, M.K., Monteiro, J.H., Akhmetzhanov, A., Volkonskaya, A., Cunha, T., Shaskin, P., Rovere, M., and the TTR10 Shipboard Scientific Party, 2003. Tsunamigenic-seismogenic structure, neotectonics, sedimentary processes and slope instability on the southwest Portuguese Margin, *Marine Geology*, Vol.195, pp. 55-73.
- Thiebot, E., and Gutscher, M.-A., 2006. The Gibraltar Arc seismogenic zone (part1): constraints on a shallow east dipping fault plane source for the 1755 Lisbon earthquake provided by seismic data, gravity and thermal modeling. *Tectonophysics Sp. Vol. "Natural laboratories on seismogenic faults"*, v. 427, p. 135-152, doi:10.1016/j.tecto.2006.02.024.
- VIZCAINO, A., GRÀCIA, E., PALLÀS, R., TERRINHA, P., ESCUTIA, C., DAÑOBEITIA, J.J., JACOBS, C., & HITS cruise party (2004). Estudio de alta resolución de las fallas activas y procesos sedimentarios asociados al Cañón de São Vicente, margen Sudoeste de Iberia. *Geo-temas*, 6 (5), 215-218.
- VIZCAINO, A., GRÀCIA, E., PALLÀS, R., GARCIA-ORELLANA, J., ESCUTIA, C., CASAS, D., WILLMOTT, V., DIEZ, S., AND DAÑOBEITIA, J.J. (2006). Sedimentology, physical properties and ages of mass-transport deposits associated to the Marquês de Pombal Fault, Southwest Portuguese Margin. *Norwegian Journal of Geology*, 86, 173-182.
- VIZCAINO, A., GRÀCIA, E., ESCUTIA, C., ASIOLI, A., PALLÀS, R., GARCIA ORELLANA, J., GOLDFINGER, C., LEBREIRO, S., DIEZ, S., DAÑOBEITIA, J.J. Holocene record of earthquake events offshore Portugal (SW Iberia): Applying turbidite paleoseismology in a slow-convergence margin. *Quaternary Science Reviews*. To be submitted March 2008.
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#### MASTER THESIS:

VIZCAINO MARTÍ, A., (2005). *Caracterització morfoestructural i sedimentològica del Canyó de São Vicente (Marge Sud-Oest d'Ibèria)*. Diploma de Estudios Avanzados (DEA), Facultad de Geología, Universitat de Barcelona, Junio 2005. Dirección: E. Gràcia (CSIC).

BERTRAND DE SAINT-JEAN (research project, completed June 2004, Univ. Brest)

Title: Prisme d'accrétion de Gibraltar : structure profonde et évolution tectonique, Direction: M.A.Gutscher

#### PHD THESIS:

ALEXIS VIZCAINO MARTÍ Title: "Análisis de fallas activas, grandes deslizamientos submarinos e implicaciones paleosismológicas en el Margen SO de Iberia: Aplicación de métodos de alta resolución en geociencias marinas". Started: January 2004, will end: January 2009. Director: E. Gràcia (UTM-CSIC), Co-Director: C. Escutia (IACT-CSIC, Granada)

EMMANUELLE THIEBOT, thesis completed Dec. 2005, UBO Brest, PhD advisor: M-A Gutscher, Title: Structure profonde et remobilisation de la marge nordouest-Marocaine

HUGO CARLOS ROSA COELHO MATIAS, Hydrocarbon Potential of the Offshore Algarve Basin, Faculdade de Ciências da Universidade de Lisboa, 2007.

FRANCESCA CAMURRI, Struttura ed Evoluzione cenozoica del Margine atlantico del Marocco settentrionale e sua interazione con le porzioni esterne dell'Arco di Gibilterra. University of Parma, Italy, PhD Advisor: L.Torelli.

MARZIA ROVERE; Evoluzione tettonica del Margine SudOccidentale dell'Iberia, University of Bologna, PhD Advisor: Nevio Zitellini

## 1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

#### Outreach publications:

DIEZ, S., and GRÀCIA, E., (2005). Submarine Mapping using Multibeam Bathymetry and Acoustic Backscatter: Illuminating the Seafloor. *Instrumentation Viewpoint*, 3, Spring 2005, p. 10-14.

GRÀCIA, E., y DIEZ, S., (2005). Com s'explora en fons marí? Eines i aplicacions en Geociències Marines. *Mètode*, Univ.



de Valencia, Julio 2005.

**Dañobeitia, J.J.**, (2005): Invited talk on a series about "Tsunamis" in the Fundación Ramón Areces (Madrid, April):  
The physics of Tsunamis: Examples from the SW Iberian Margin.

**Matias L.**, Portuguese TV Channel 2: September 2005 (20m interview)

**Matias L.**, Newspaper articles Senior Magazine, nº2, February 2005, interview.

**Matias L.**, Conferences for the general public: The 1755 Lisbon Earthquake. Presented in 2005 to 8 High-Schools in Portugal, to an average 100 people assistance

#### **Articles in printed media (Newspapers, Magazines)**

**M.A.Gutscher, Le Figaro** 27 Aout, 2004, p. 8 (interview by telephone)

L'enigme du séisme historique de Lisbonne

<http://www.lefigaro.fr/sciences/20040827.FIG0330.html>

**M.A.Gutscher, Nouvel Observateur** 30 Aout, 2004

Quand Lisbonne tremblait

[http://sciences.nouvelobs.com/sci\\_20040827.OBS5718.html](http://sciences.nouvelobs.com/sci_20040827.OBS5718.html)

**M.A.Gutscher, The Scotsman** 27 August, 2004

Europe warned to expect massive earthquake as anniversary nears

<http://news.scotsman.com/scitech.cfm?id=1003432004>

**M.A.Gutscher, National Geographic News Online** 30 August, 2004 (interview by telephone)

Great Portugal earthquake may have a sequel, study says

[http://news.nationalgeographic.com/news/2004/08/0830\\_040830\\_portugal\\_quake.html](http://news.nationalgeographic.com/news/2004/08/0830_040830_portugal_quake.html)

**M.A.Gutscher, Neue Zuercher Zeitung**, Zurich Suisse 8 Sept. 2004 (interview by telephone)

Die Geologie bei Gibraltar als Taktgeber für Lissabons Erdbeben?

<http://www.nzz.ch/2004/09/08/ft/page-article9TNHD.html>

**M.A.Gutscher, Pour La Science (magazine)** (interviews by telephone)

Article imprimé: "Le Grand tremblement de terre de Lisbonne" v. 326, p. 24, Décembre 2004.

**M.A.Gutscher, Frankfurter Allgemeine Zeitung** (Francfort, Allemagne) 15 Sept. 2004

Der schwankende Boden von Lissabon

(paper article only - no web link)

**M.A.Gutscher, Sciences Ouest (magazine)**, no 242, Avril 2007 (interview at the institute)

Sous la mer, les cicatrices récentes d'une secousse, une enquête sur un séisme sous-marin mythique,

<http://www.espace->

[sciences.org/jsp/fiche\\_article.jsp?STNAV=&RUBNAV=&CODE=1180963090030&LANGUE=0&RH=MAGAZINE](http://www.espace-sciences.org/jsp/fiche_article.jsp?STNAV=&RUBNAV=&CODE=1180963090030&LANGUE=0&RH=MAGAZINE)

**M.A.Gutscher, Neue Zürcher Zeitung**, Zurich Suisse, 27 Oct. 2005 p. 47 (interview by e-mail)

Lissabon 1755 - das Erdbeben, das die Welt veränderte

<http://nzz.ch/2005/10/26/ft/articleD8ZKG.html>

**M.A.Gutscher, Le Telegramme de Brest**, 1 Nov. 2005, (interview at the editorial office)

p.1 Tsunami: Lisbonne rasée en 1755

p.44 Recherche. Un Breton chasseur de tsunami

**M.A.Gutscher, Le Figaro**, 1 Nov. 2005 p. 6 (interview by telephone)

Il y a 250 ans, Lisbonne était ravagée par un tremblement de terre

<http://www.lefigaro.fr/cgi/edition/genimprime?cle=20051101.FIG0136>

**M.A.Gutscher, Tagesspiegel**, Berlin Allemagne, 1 Nov. 2005, p.26 (interview by telephone)

Tod in den Wassermassen

**M.A.Gutscher, Le Monde**, 2 Nov. 2005 p. 15 (interview by telephone)

De nouvelles hypotheses sont avancées pour expliquer le tremblement de terre de Lisbonne

<http://www.lemonde.fr/web/article/0,1-0@2-3244,36-705413,0.html>

**M.A.Gutscher, Publico, Lisbonne**, Portugal, 4 Nov. 2005, (interview in Lisbon)

p.28 Cientista frances relaciona sismo de 1755 com a Atlantida

#### **Radio et Television appearances**

#### **Radio Interviews**

**M.A.Gutscher, Tsunamis in the Gulf of Cadiz and the Atlantis myth**

Radio Canada, Montreal, 2 Septembre 2005 (interview par telephone)

Le mythe de l'Atlantide

**M.A.Gutscher, Tsunami hazard in Morocco**

Radio Maroc, Casablanca, 4 Octobre 2007 (interview par telephone)

Reseau d'alerte au tsunami au Maroc et le projet Européen Nearest

**Television**

**M.A.Gutscher, The great Lisbon earthquake and tsunami**

Channel M6, 29 Nov. 2005 23:00 (following an interview à Lisbonne)

Tsunami en France, sommes-nous menaces? (produced et narrated by Mac Lesggy)

**Public Conferences**

**M.A.Gutscher**, Séisme et tsunami du 26 déc. 2004 en Sud-Est Asie: l'Europe est-elle aussi menacée?, 8 Fév. 2005

Conférence IUEM, Plouzané

**M.A.Gutscher**, Séisme et tsunami du 26 déc. 2004 en Sud-Est Asie: l'Europe est-elle aussi menacée?, 1 Mars 2005

Conférence Océanopolis, Brest

**M.A.Gutscher**, Séisme et tsunami du 26 déc. 2004 en Sud-Est Asie: l'Europe est-elle aussi menacée?, 5 Mars 2005

Conférence Journées Portes Ouvertes, Université de Bretagne Occidentale, Brest

**M.A.Gutscher**, Séismes et tsunamis en Sud-Est Asie: l'Europe est-elle aussi menacée?, 11 Mai 2005 Conférence,

Institut Supérieur de l'Electronique et Numerique (ISEN), Brest

**M.A.Gutscher**, Les tsunamis : regards croisés d'un écrivain et d'un scientifique, 18 Mai 2005 Discussion, Librairie

Dialogues, Rue de Siam, Brest

**M.A.Gutscher**, Les séismes et tsunamis, de Sumatra à l'Europe, 19 Janvier, 2006, Université du Temps Libre de

Quimper, Chapeau Rouge, Quimper

**M.A.Gutscher**, Les tsunamis : de l'Asie à l'Europe, 18 Avril, 2006, Association Gaïa - Association d'étudiants,

Amphiteatre, Université de Bretagne Occidentale, Brest

**M.A.Gutscher**, Les séismes et tsunamis, 8 Janvier, 2007, Université du Temps Libre du Pays de Carhaix, Cinema

Communale, Rostrenen

**M.A.Gutscher**, Les séismes et tsunamis, 17 Avril, 2007, Université du Temps Libre du Pays de Pontivy, Palais des

Congres, Pontivy

## 1 D. Patents and industry collaborations

None

## 1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

**a) Participation in meetings:**

- ESF EuroMARGINS, SWIM: Kick-off meeting, Nice, April, 2003.

- ESF EuroMARGINS, SWIM: 1st meeting, Bologna (Italia), 9-10 October 2003.

- ESF EuroMARGINS Programme Science Forum, Amsterdam (Holanda), 20-22 November 2003.

- ESF EuroMARGINS SWIM meeting & 2<sup>nd</sup> EUROMARGINS Conference, Barcelona 11-13 November 2004.

- Attending the EGU Meeting Vienna (Apr. 2005) EuroMargins Supported. A. Vizcaino attended and trip was funded by the ESF.

- 2 visits by E. Gràcia and A. Vizcaino to INETI, Lisbon (Portugal) in Nov. 2004 (1 week) to sample a sediment core from the Tagus Abyssal Plain.
- Attending the 2nd EuroMargins Conference and meeting in Barcelona 11-13 Nov. 2004 (funded by the ESF). E. Gràcia, J.J Dañobeitia, P. Santanach, A. Vizcaino attended.
- Attending the EGU Meeting Vienna (Apr. 2006) EuroMargins Supported. X. Moreno attended and trip was funded by the ESF.
- 3<sup>rd</sup> ESF EuroMARGINS Conference, Bologna (Italy), 4-6 Octubre 2006.
- Attending the EGU Meeting Vienna (Apr. 2007) EuroMargins Supported. C. Lo Iacono will attend and trip will be funded by the ESF.
- *ESF EuroMARGINS MEDIATIC Workshop (Mediterranean Atlantic Transition)*, Barcelona (Spain), 25-27 Marzo 2004.
- *ESF EuroMARGINS MEDIATIC-II Workshop (The Mediterranean - Atlantic Transition)*, Barcelona (Spain), 14-16 Febrero 2007.

**b) Participation in cruises:**

- Participating in the MATESPRO-04 mapping cruise in the Gulf of Cadiz on board the RV Don Carlos. S. Diez participated.
- Participating in the SWIM-04 sampling cruise in the Gulf of Cadiz on board the RV Urania. X. Moreno participated.
- Participating in the DELILA-04 mapping cruise in the Gulf of Cadiz on board the RV Don Carlos. R. Bartolomé participated.
- Participating in the SWIM-05 swath bathymetric cruise of the Coral Patch area on board the RV Explora. S. Diez participated.

**c) Oral Presentation within Euromargin conferences**

GRÀCIA, E., VIZCAINO, A., ESCUTIA, E., PALLÀS, R., LEBREIRO, S., GARCÍA-ORELLANA, J., DÍEZ, S., DAÑOBEITIA, J.J., 2004. High-resolution imaging of active faults and submarine landslides offshore Portugal (SW Iberian Margin): Paleoseismic implications. 2<sup>nd</sup> *EUROMARGINS Conference*, Barcelona 11-13 November.

GRÀCIA, E., BARTOLOMÉ, R., VIZCAINO, A., TERRINHA, R., DAÑOBEITIA, J., and SWIM-06 CRUISE PARTY (2006). Earthquake and Tsunami Hazards in the Southwest Iberian Margin (SWIM): High-resolution imaging of active faults and paleoseismic signature at the external part of the Gulf of Cadiz. *Third EUROMARGINS Conference*, Bologna (Italia), 4-7 October (Oral).

ZITELLINI, N., CAMURRI, F., GRÀCIA, E., MATIAS, L., TERRINHA, P., TORELLI, L., AND SWIM TEAM (2006). The tectonic evolution of the Gulf of Cadiz-SW Portugal's offshore and the seismogenesis of the 1755 Lisbon earthquake: the achievements of SWIM project. *Third EUROMARGINS Conference*, Bologna (Italia), 4-7 October (Oral).

## 1 F. Participation in other conferences

Please list only the most relevant

**a) Participations in related workshops:**

**WP 1, PI: Nevio Zitellini, ISMAR - CNR, Italy**

Attending the IMPACTS Workshop 16-18 March 2005, Brest, France (funded by the ESF). Nevio Zitellini attended and trip was funded by the ESF.

Attending the PICASSO workshop "The Euro Array Demo-experiment workshop in the South Iberian Margins",

Mecina Fondales, Granada, 27-28 June 2005. Nevio Zitellini attended

Attending the “250th Anniversary of the 1755 Lisbon Earthquake”, Lisbon, Portugal, 1-4 November 2005.

Attending the “Homenagem ao Professor Antonio Ribeiro”, Lisbon, Portugal, 5 November 2005.

**WP 2, PI: Eulàlia Gràcia**, CMIMA-UTM-CSIC, Spain

Attending the “250th Anniversary of the 1755 Lisbon Earthquake”, Lisbon, Portugal, 1-4 November 2005. E. Gràcia, S. Diez and A. Vizcaino attended.

Attending the PICASSO workshop “The Euro Array Demo-experiment workshop in the South Iberian Margins”, Mecina Fondales, Granada, 27-28 June 2005. E. Gràcia attended.

Attending the EGU Meeting Vienna (Apr. 2005). A. Vizcaino attended and trip was funded by the ESF.

Attending the IMPACTS Workshop 16-18 March 2005, Brest, France (funded by the ESF). A. Vizcaino attended and trip was funded by the ESF.

2 visits by E. Gràcia and A. Vizcaino to INETI, Lisbon (Portugal) in Nov. 2004 (1 week) to sample a sediment core from the Tagus Abyssal Plain.

Attending the 2nd EuroMargins Conference and meeting in Barcelona 11-13 Nov. 2004 (funded by the ESF). E. Gràcia, J.J Dañobeitia, P. Santanach, A. Vizcaino attended.

Participating in the SWIM swath bathymetric cruise of the Coral Patch area on board the RV Explora. S. Diez participated.

**WP 3, PI: Luis Manuel Matias**, Centro de Geofísica da Universidade de Lisboa, Portugal

Despite the fact that the SWIM project has not received any funds from the Portuguese funding agency, the Portuguese group pursued the contacts with partners, in order to follow the SWIM scientific objectives.

Luis Matias visited M.A. Gutscher at Brest, during one week in July 2005.

Maria Ana Baptista, Miguel Miranda and Luis Matias received the visit of researchers from the University of Brest and Morocco regarding the study of tsunami generation and propagation.

**WP 4, PI: Marc-Andre Gutscher**, IUEM, CNRS, Brest

2 visits by M.-A Gutscher and J. Roger to Univ. of Lisbon to perform tsunami modelling, Feb. 2005 (5 days)

Participation by Italian, Spanish, Portugese, English, German and French scientists at the 3 day IMPACTS Workshop 16-18 March 2005, Brest, France (funded by the ESF)

Attending the Mediatic Meeting Barcelona (Nov. 2004) funded by the ESF, M.-A. Gutscher and E. Thiebot attended.

Attending the EGU Meeting Vienna (Apr. 2005). M.-A. Gutscher and E. Thiebot attended. E Thiebot’s trip was funded by the ESF.

**b) Congress Presentations:**

Babonneau, N., Gutscher, M.-A., Gonthier, E., Mulder, Th., 2006. Turbidite sequences in the deep basins offshore SW Iberia as possible paleoseismological markers. Proc. EGU Meeting, Vienna, Apr. 2006, Geophysical Research Abstracts, v. 8, CD-ROM.

BARTOLOMÉ, R., GRÀCIA, E., RUBIO, E., DAÑOBEITIA, J.J., TERRINHA, P., AND SWIM-2006 CRUISE PARTY, (2006). New multichannel seismic data imaging of the western part of Gulf of Cádiz (SW Iberian Margin): The SWIM-

- 2006 cruise. *Third EUROMARGINS Conference*, Bologna (Italia), 4-7 October (Poster).
- BARTOLOMÉ, R., GRÀCIA, E., SWIM & IMPULS WORKING GROUPS (2005). High resolution mapping and seismic imaging in seismogenic zones: Application in SW Iberia and Almeria margin. *Martech Workshop*, Vilanova i la Geltru (Spain), 17-18 November 2005 (Oral).
- BLONDEL, PH., GÓMEZ-SICHI O., GRÀCIA, E., DAÑOBEITIA, J.J. (2004). High-resolution sonar mapping of tsunamigenic areas and quantitative analyses – Applications to the Southwest Iberian Margin. *7th Conference on Underwater Acoustics*, Delft (Netherlands), (5-8 July).
- CAMURRI, F., GRÀCIA, E., GUTSCHER M.A, MATIAS M., ROVERE M., SAHABI M., TORELLI L., WEAVER P., N.ZITELLINI, 2004. Deformazione tettonica lungo il limite di placca Eurasia-Africa ad Ovest dello Stretto di Gibilterra: risultati di una ricerca coordinata in ambito europeo. Gruppo nazionale della geofisica della terra solida, *GNCTS - 23 Convegno Nazionale*, Roma 14-16 Dicembre.
- Carrara G., Torelli L., Sartori R., Zitellini N. (2002) - Rifting and crustal structure across the SW Tyrrhenian basin. *GNCTS, 21° Convegno Nazionale*, Roma 19-21 Novembre 2002, Riassunti Estesi, 64-65.
- Carrilho, F. and Luis Matias, “Relação Entre a Sismicidade e as Fontes Sismogénicas na Zona SW de Portugal Continental”, *AMPG2007-5º Simpósio de Meteorologia e Geofísica da APMG*, 5-8 Fevereiro, Peniche, 2007.
- DIEZ, S., GRÀCIA, E., GUTSCHER, M.A., MATIAS, L., MULDER, T., TERRINHA, P., SOMOZA, L., ZITELLINI, N., DE ALTERIIS, G., HENRIET, J.P., DAÑOBEITIA, J.J. (2005). Bathymetric map of the Gulf of Cadiz, NE Atlantic Ocean: The SWIM multibeam compilation. *250<sup>th</sup> Anniversary of the 1755 Lisbon Earthquake*, Lisbon (Portugal), 1-4 November.
- Diez, S.; Gràcia, E.; Gutscher, M. A.; Matias, L.; Mulder, T.; Terrinha, P.; Somoza, L.; Zitellini, N.; Alteris, G.; Henriet, J. P. and Dañobeitia, J. J. (2006) The Swim Bathymetric Compilation of the Gulf of Cadiz. *5º Simpósio sobre a Margem Ibérica Atlântica*. Aveiro. pp. 55-56.
- Duarte, J.C., F. Rosas, L.M. Pinheiro, L.M. Matias, A.M. Carvalho, P. Terrinha, M. Ivanov, 2005. Interpretation of recent sedimentary and tectonic structures off SW Iberia from multibeam bathymetry, seismic reflection and experimental modelling, *Geophysical Research Abstracts*, Vol. 7, 07867, EGS-AGU-EUG Joint Assembly, Vienna, 2005.
- Ferreira, J.M., Luis Matias, Filipe Rosas, Rui Fernandes, “Modelação Tectónica da Fronteira de Placas a SW da Península Ibérica”, *AMPG2007-5º Simpósio de Meteorologia e Geofísica da APMG*, 5-8 Fevereiro, Peniche, 2007.
- GAFEIRA, J., GRÀCIA, E., TERRINHA, P., VIZCAINO, A., DANOBETIA, J.J. (2005). Morphostructural Mapping of the Marques de Pombal Fault Area (SW Portuguese Margin). *European Geosciences Union (EGU)-05*, Vienna (Austria), 24-29 April.
- GÓMEZ SICHÍ, O., PH. BLONDEL, PH., GRÀCIA, E., VIZCAINO, A., DAÑOBEITIA, J.J. (2004). High-Resolution Sonar Imagery of Tsunamigenic Areas – Acoustic Textures and Seafloor Segmentation in the SW Iberian Margin. *Characterisation in-situ des fonds marins. Sea-Tech Week*, Brest (Francia), (21-22 Octobre).
- GRÀCIA, E., VIZCAINO, A., ESCUTIA, C., GARCÍA-ORELLANA, J., ASIOLI, A., LEBREIRO, S., DIEZ, S., BARTOLOMÉ, R., DAÑOBEITIA, J.J. (2005). Paleoseismic record of the SW Iberian Margin earthquakes based on correlation and dating offshore turbidite events. *Iberian Margin Paleoseimology, Active Tectonics and Sedimentology (IMPACTS). Workshop sponsored by ESF-EuroMargins*, Brest (France), 16-18 March.
- GRÀCIA, E., LARRASOÑA, J.C., ESCUTIA, C., LEBREIRO, S., GARCÍA-ORELLANA, J., VIZCAÍNO, A. (2003). Paleoseismic record of the SW Iberian Margin earthquake events: First results of the “PRIME” cruise. *Deep Water Processes in Modern and Ancient Environments*, Barcelona and Ainsa (Spain), (15-19 September 2003).
- GRÀCIA, E., VIZCAINO, A., PALLÀS, R., GARCÍA, J., GAFEIRA, J., TERRINHA, P., ESCUTIA, C., DIEZ, S., WILLMOTT, V., CASAS, D., DAÑOBEITIA, J.J., (2005). Submarine landslides associated to the active Marques de Pombal Fault, offshore Portugal (SW Iberian Margin): Paleoseismic Implications. *2nd Int. Conf. Submarine Mass Movements and their Consequences*, Oslo (Norway), 5-7 September.
- GRÀCIA, E., VIZCAINO, A., ESCUTIA, C., GARCÍA, J., DIEZ, S., PALLÀS, R., SANTANACH, P., ASIOLI, A., LEBREIRO, S., TERRINHA, P., BARTOLOMÉ, R., DAÑOBEITIA, J.J., CASAS, D., WILLMOTT, V., VERGES, J., FERNÁNDEZ, M., VILLASEÑOR, A., (2005). Submarine Landslides Associated to Active Faulting Offshore Portugal (SW Iberian Margin): Paleoseismic Implications. *PICASSO workshop*, Mecina Fondales, Granada, (27-28 June).
- GRÀCIA, E., VIZCAINO, A., PALLÀS, R., GARCÍA, J., ASIOLI, A., DIEZ, S., ESCUTIA, C., LEBREIRO, S., WILLMOTT, V., CASAS, D., DAÑOBEITIA, J.J., (2005). How often events such as the 1755 Lisbon Earthquake occur? Holocene marine paleoseismic record revealed by deep water turbidites and debris flow deposits from the SW Iberian Margin. *250<sup>th</sup> Anniversary of the 1755 Lisbon Earthquake*, Lisbon (Portugal), 1-4 November.
- GRÀCIA, E., BARTOLOMÉ, R., TERRINHA, R., DAÑOBEITIA, J., ASTBURY, R., BIROUK, A., CARCELEN, J., CASAL, R., DIEZ,



- S., FARRAN, M., GUIDO, F., LO IACONO, C., MORENO, X., PIÑERO, E., POZO, J.L., PRADES, J., READ, S., ROMÁN, M.J., RUANO, P., RUBIO, E., VALADARES, V., VIZCAINO, A., ZAHINOS, A., 2006. Active tectonics of the western Gulf of Cádiz (SW Iberian Margin) based on new multichannel seismic data from the SWIM-2006 cruise. *5th Symposium on the Iberian Atlantic Margin*, Aveiro (Portugal), 2-4 November.
- GRÀCIA, E., VIZCAÍNO, A., BARTOLOMÉ, R., ESCUTIA, C., TERRINHA, P., ASIOLI, A., GARCÍA-ORELLANA, J., DIEZ, S., DAÑOBEITIA, J., SWIM-06 CRUISE PARTY. Active faulting and paleoseismic signature at the external part of the Gulf of Cadiz: Implications for Earthquake and Tsunami Hazard assessment in the Southwest Iberian Margin. *Congreso Nacional de Ingeniería Sísmica, Girona, 8-11 Mayo 2007*.
- GÓMEZ SICHÍ, O., BLONDEL, P., GRÀCIA, E., (2005). Acoustic textures and seafloor characterisation of submarine landslides: An example from the SW Iberian Margin. *Underwater Acoustics Measurements: technologies and results. FORTH, Crete (Greece), (28 June-1 July)*.
- GÓMEZ SICHÍ, O., BLONDEL, P., GRÀCIA, E., (2005). Acoustic Textures and seafloor characterisation of submarine landslides: An example from the SW Iberian Margin. *Boundary influences in high frequency, shallow water acoustics. Bath (UK), (5-9 September)*.
- Gutscher, M.-A., Leroy P., Graindorge, D., Babonneau, N., Maad, N., and Ait-Brahim, L., 2007. Active deformation and paleoseismology of northern Morocco: onshore and offshore faults and the source of the great 1755 earthquake and tsunami. MAPG Meeting, Marrakech, Oct. 2007.
- Gutscher, M.-A., Dominguez, S., Westbrook, G., Gente, P., Babonneau, N., Mulder, T., Gonthier, E., Bartolome, R., Luis, J., Rosas, F., 2007. The Gulf of Cadiz accretionary prism: the active offshore link between the Rif and Betic mountain belts. MAPG Meeting, Marrakech, Oct. 2007.
- Gutscher, M.-A., P. LeRoy, D. Graindorge, N. Babonneau, N. Maad, Dominguez, S., Westbrook, Fernandes, R., Miranda, J.M., 2007. Active subduction as the driving force behind recent deformation and long-term seismicity in the Gibraltar - Gulf of Cadiz region. MAPG Meeting, Marrakech, Oct. 2007.
- Gutscher, M.-A., and Westbrook, G., 2007. Great earthquakes in slow subduction zones. IODP Geo-hazards Workshop, Portland, Oregon, Aug. 2007.
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## Personnel directly funded by the EUROCORES Programme

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

Alexis Vizcaino, PhD Student, 1<sup>st</sup> January 2004-30<sup>th</sup> December 2005, PhD date: January 2009

Alexis was funded 2 years by ESF EuroMargins SWIM. The remaining years he has been funded from national and EU projects. He is on his 5<sup>th</sup> year now finishing the articles to include on his manuscript and will present his doctoral thesis by January 2009

# Links between sequence stratigraphy and the mineralogical, geochemical and reservoir quality evolution of deep-marine clastic sediments

## Abstract

Studies of the influence of changes in relative sea level and rate of sediment supply, which make the basis for sequence stratigraphy, have so far been most successfully applied to transitional and shallow-marine environments. In such environments, there are also potential links between sequence stratigraphy and the mineralogical and geochemical modifications, which hence allow a considerably improve ability to predict the reservoir quality of these sediment packages. Conversely, both sequence stratigraphy and its relationship to the mineralogical, geochemical composition and reservoir quality of deep-sea sediments are still poorly constrained in the literature. The fundamental hypothesis that we thus seek to test is that changes in the relative sea level are probably accompanied by predictable changes in the primary sand composition and texture as well as the diagenetic modifications of deep-marine clastic sequences in passive continental margins. The present proposal brings together a large spectrum of approaches to develop our understanding of the geometry and the prediction of reservoir quality in this tectonic setting. A detailed assessment of the mineral content and texture of these reservoirs is, for the first time, tentatively integrated with facies analysis in a sequence stratigraphy context, exploring the interest of bulk rock geochemistry in scaling upwards the mineralogical information. The expected achievement is a conceptual model predicting primary sand composition and, when combined with modeling of the thermal history and the fluid-induced changes in mineralogy and porosity-permeability, an integrated tool for the evaluation of reservoir quality in deep-marine clastic deposits. The sequences selected to test our basic hypothesis and the complementarities of the proposed approaches are taken from offshore New Jersey as well as from the 4 Faeroe/Shetland and the Vøring Basin, at the British and the Mid-Norwegian continental shelves, respectively.

## Partners

(VR, CNRS, NFR, MCyT, FWO, CNR)

### **Dr Sadoon Morad (project leader)**

Uppsala Universitet, Uppsala, Sweden

### **Pr Alessandro Amorosi**

Università di Bologna, Bologna, Italy

### **Dr Daniel Garcia**

Ecole Nationale Supérieure des Mines de Saint-Etienne, Saint-Etienne, France

### **Dr Rafaela Marfil**

Universidad Complutense de Madrid, Madrid, Spain

### **Pr Petter Nystuen**

Universitetet i Oslo, Oslo, Norway

### **Pr Rudy Alin Swennen**

Katholieke Universiteit Leuven, Heverlee, Belgium

<b>Collaborative Research Project (CRP)</b>
<b>1. General information</b>
<p><u>Project Reference Number</u> : 01-LEC-EMA10F  <u>Acronym / Short Title</u>: -  <u>Full Title</u>: <b>Links between sequence stratigraphy and the mineralogical, geochemical and reservoir quality evolution of deep-marine clastic sediments</b>  <u>Project Leader name</u>: <i>Dr Sadoon Morad</i>  <u>Project Leader affiliation</u>: <i>Department of Earth Sciences, Uppsala University, Sweden</i>  <u>Institutional home page (URL)</u>: <a href="http://www.geo.uu.se/">http://www.geo.uu.se/</a>  <u>Project-related home page (URL)</u>: -  <u>Reporting period</u>: 01/10/2004 to 30/09/2007</p>
<b>2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)</b>
<b>IP 1</b>
<b>Dr Sadoon Morad</b> , Uppsala Universitet, Uppsala, Sweden
Total Funding amount of the IP: EUR 140 000
<b>IP2</b>
<b>Pr Alessandro Amorosi</b> , Università di Bologna, Bologna, Italy
Total Funding amount of the IP: EUR 50 000
<b>IP3</b>
<b>Dr Daniel Garcia</b> , Ecole Nationale Supérieure des Mines de Saint-Etienne, Saint-Etienne, France
Total Funding amount of the IP: EUR 10 000
<b>IP4</b>
<b>Dr Rafaela Marfil</b> , Universidad Complutense de Madrid, Madrid, Spain
Total Funding amount of the IP: EUR 43 000
<b>IP5</b>
<b>Pr Petter Nystuen</b> , Universitetet i Oslo, Oslo, Norway
Total Funding amount of the IP: EUR 110 000
<b>IP6</b>
<b>Pr Rudy Alin Swennen</b> , Katholieke Universiteit Leuven, Heverlee, Belgium
Total Funding amount of the IP: no funding

### 3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

In the present project, we have studied the provenance and diagenesis of marine turbiditic arenites in relation to sequence stratigraphy and depositional facies in four basins. The ultimate goal would be to unravel and predict the evolution pathways of reservoir quality during progressive burial of the turbiditic arenites. Initially we aimed at accomplishing the research collaborative work on turbiditic arenites from passive margin settings (Faroe-Shetlands Basin on the British continental shelf and the Voring Basin in offshore Norway). However, we discovered that our work would gain even greater value if a comparative study is made on marine turbidites from active margin settings. For this purpose, the foreland Ainsa Basin in the Spanish Pyrenees was selected for study.

Linking the diagenetic evolution pathways to sequence stratigraphy in marine turbiditic sediments raised two important challenges:

(i) There is little consensus among sedimentologists for a “standard” sequence stratigraphic frame in marine turbidites owing to only indirect potential impact of changes in the relative sea level on the architecture of marine turbidites, the scarcity of good outcropping analogues for passive margin settings, and to the strong impact of tectonics for active settings;

(ii) Diagenetic and reservoir-quality evolution pathways of arenites are influenced by complex array of parameters, which are influenced not only by the changes in the relative sea level and rates of sediment supply, but also by the depositional mineralogy of the sand, which depends, in turn, on provenance and changes in the relative sea level.

In the course of this collaborative research work, part of the work was devoted to update the stratigraphic framework, which was of crucial importance for achievements of our goals. However, much effort was focused on unraveling and predicting the systematic relationships between depositional facies, petrology (provenance and diagenetic alterations) and geochemical variability of marine turbiditic sands from passive versus active basin settings. Using the integrated approach of linking the petrological and geochemical parameters to sequence stratigraphy and depositional facies in a comparative study of marine turbidites from passive versus active margin settings is considered to be a major contribution to this field of research. The latter is particularly true when turbidites are becoming the most attractive targets for hydrocarbon exploration worldwide.

The achievements of this project would probably not have been reached without involvement of the CRP. New research directions have merged through the course of the accomplishment of the original research proposal, such as comparing the marine turbidites from the passive margin to those from the active margin settings. The group has decided to meet in the next spring to discuss further development and collaboration within the overall framework of the research direction. For some specific details, please see point 5A below.

### 4. What did you not achieve in the CRP and why? (max 1 p.)

Please use the original proposal as reference and explain any deviations from the work plan

Finding an accepted and ready to use sequence stratigraphic and depositional facies models was difficult, mainly because these aspects of marine turbidites have been and still are controversial. Thus, linking the diagenetic alterations, reservoir-quality evolution pathways, provenance, and geochemistry was not straightforward and required additional, yet useful and instructive efforts. It also appeared that obtaining set of samples that suit all participants and at various stages of the work was riddled with some uncertainties. Nevertheless, we have had tremendously useful lessons from these problems and shortcomings, which will help us achieving better results and



in more efficient ways during our future collaboration.

**5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)**

**5. A.** Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

The present program raised a proposal to stand an EGU 2008 session on :

**“Integrating mineralogical/geochemical/sedimentological data in sandy turbiditic reservoirs”,**

co-convened by three project participants.

Our first perspective is phenomenological: how much variable (and predictable) is the mineralogy of sandy reservoirs? This issue is of interest for reservoir assessment, notably where chemical reactions are expected (for instance CO<sub>2</sub> storage). The purpose is to improve reservoir models and their stochastic representation (from sedimentology & geostatistics) by adding mineralogical information (from petrology & geochemistry). Our second perspective is methodological : how a sedimentological facies (or sequence) translates into the language of petrology (point counting, provenance) and/or geochemistry ? What is the potential of these quantitative techniques to improve sedimentological models ?

**5. B.** Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

\* Development of predictive models for the preservation of deeply buried (greater than 4 km) turbiditic sandstone reservoirs

\* Conditions of formation and parameters controlling the distribution patterns of glaucony to aid the sequence stratigraphic analysis of marine turbidites

**6. Your feedback on the EUROCORES Programme (max 1 p.)**

**6.A.** What, in your view, is the added value of being part of a EUROCORES Programme

(i) To work in close collaboration and have fruitful discussions with scientists from related fields from several countries on topic related to the impact of diagenetic alterations on reservoir characteristics of marine turbiditic arenites.

(ii) Have access to analytical facilities.

(iii) Involvement of young Ph.D. students and post-doctoral fellows.

**6.B.** Give any critical and constructive comments on the EUROCORES Programme and its procedures

Research councils from the various countries involved showed variable degrees of commitment to the approved proposal and had different routines to deal with providing grants to the scientists involved. This resulted in difficulties in bringing all the scientists involved into a similar phase of project evolution. EUROCORES should perhaps make sure that the different councils will seriously support and show commitment to the proposed European project before seriously evaluating them.

## Appendix 1. List of Products of the CRP

### 1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more CRPs** (if any)

- (1) Mansurbeg, H., Morad, S., Amorosi, A., Garcia, D., Marfil, R., Nystuen, J.P., 2005. The impact of meteoric-water flux on diagenetic alterations in Palaeocene deep-water, marine sandstones, the Shetland-faroes basin, the British continental shelf. EGU, Vienna, Austria. *Geophysical Research Abstracts*, Vol. 7, 04781, 2 pp.
- (2) Mansurbeg, H., Morad, S., Marfil, R., El-ghali, M.A.K., Caja, M.A., Amorosi, A., Sherwani, G., Nystuen, J.P., Garcia, D., 2006. Diagenesis and reservoir quality evolution of palaeocene deepwater, marine sandstones, the Shetland-faroes basin, the british continental shelf. EGU Vienna, Austria. *Geophysical Research Abstracts*, Vol. 8, 10268, 2 pp.
- (3) Mansurbeg, H., Morad, S., Marfil, R., El-ghali, M.A.K., Nystuen, J.P., Caja, M.A., Amorosi, A., Sherwani, G., Garcia, D., La Iglesia, A. Diagenesis and reservoir quality evolution of Palaeocene deepwater, marine sandstones, the Shetland-Faroes Basin, the British continental shelf. *Marine and Petroleum Geology*. (accepted).
- (4) Caja, M.A.; Marfil, R.; Garcia, D.; Mansurbeg, H.; Remacha, E., 2006. Diagenesis, carbonate cementation and reservoir quality evolution of Eocene deep-water marine turbidite sandstones of the Hecho Group, South-Central Pyrenees. *Geotemas*, 9, 49-52.
- (5) Caja, M.A.; Marfil, R.; Garcia, D.; Mansurbeg, H.; Amorosi, A.; Morad, S., 2006. Diagenesis, carbonate cementation and reservoir quality evolution of Eocene deep-water marine turbidite sandstones of the Hecho Group, South-Central Pyrenees. 3rd Euromargins Conference Bolonia (Italia), Abstract book, pp. 14.
- (6) Caja, M.A., Permanyer, A., Marfil, R., Al-Aasm, I.S., Martin-Crespo, T., (2005) Fluid flow record from fracture-fill calcite in the Eocene limestones from the South-Pyrenean Basin (NE Spain) and its relationship to oil shows. *Journal of Geochemical Exploration*, 89, 27-32.
- (7) Caja, M.A., Marfil, R., Garcia, D., Remacha, E., Gual, G., 2005. Dolomitisation processes affecting the yellow marker beds in the turbidite systems of the Hecho Group, South Central Pyrenean basin, Spain. EGU, Vienna, Austria. *Geophysical Research Abstracts*, Vol. 7, 09493, 3 pp.
- (8) Caja, M.A., Marfil, R., Garcia, D., Remacha, E., Morad, S., Mansurbeg, H., Amorosi, A., 2006. Petrography and geochemistry of dolomite-rich condensed sections: fluid characterisation and evolution (Hecho Group, South Central Pyrenean Basin, Spain). EGU, Vienna. *Geophysical Research Abstracts*, Vol. 8, 09002, 3 pp.
- (9) Marfil, R., Mansurbeg, H., Garcia, D., Caja, M.A., Remacha, E., Morad, S., Amorosi, A.; 2007. Dolomite-rich condensed sections in the overbank of turbidite channels, Eocene Hecho Group (South-central Pyrenees, Spain). In: *Linking diagenesis to sequence stratigraphy*. Eds. S. Morad and M. Ketzer Special Publication International Association of Sedimentologists (IAS). (accepted).
- (10) Caja, M.A.; Marfil, R.; Garcia, D.; Remacha, E.; Pérez Fortes, P., 2006. Variabilidad en la composición y procedencia de las areniscas turbidíticas del Grupo Hecho (Pirineo Sur-Central). *Geotemas*, 9, 53-56.
- (11) Caja, M.A.; Marfil, R.; Garcia, D.; Remacha, E.; Mansurbeg, H.; Morad, S.; Amorosi, A., 2007. Provenance and reservoir quality of carbonate-rich turbiditic arenites from the Hecho Group, South Central Pyrenees, Spain. (EGU, Vienna, Austria. *Geophysical Research Abstracts*. (accepted).
- (12) Caja, M.A.; Marfil, R.; Garcia, D.; Remacha, E.; Mansurbeg, H.; Morad, S.; Amorosi, A., 2007. Provenance evolution of carbonate-rich turbiditic arenites from the Hecho Group (south-central Pyrenees, Spain): implications for active tectonic settings. (submitted to *Basin Research*).
- (13) Garcia, D., Swennen, R., Nystuen, J.P., Amorosi, A., Marfil, R., Morad, S., 2004. Whole rock geochemical systematics in siliciclastics. EUROMARGINS Conference, 11-13 November 2004, Barcelona, Spain.
- (14) Garcia, D.; Caja, M.A.; Marfil, R.; Remacha, E.; Mansurbeg, H.; Morad, S.; Amorosi, A., 2007. K-feldspar albitization in the Hecho Group turbidites (south-central Pyrenean Basin, Spain) and fluid-rock exchange models. EGU, Vienna, Austria. *Geophysical Research Abstracts*.
- (15) Garcia, D., Marfil, R., Morad, S., et al., 2006. Dynamics of chemical change in deep diagenesis: a comparative modelling approach. 3rd EUROMARGINS Conference, Abstract book, pp 34. Bolonia (Italia).

## 1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

Amorosi A., Sammartino I. & Tateo F., 2007. Evolution patterns of glaucony maturity: A mineralogical and geochemical approach. In: C.R. Glenn & G.M. Filippelli (Eds.) Authigenic Mineral Formation in the Marine Environment: Pathways, Processes and Products. Deep Sea Research Part II, 54, 1364-1374.

Amorosi A., in press. The occurrence of glaucony in the stratigraphic record: Distribution patterns and sequence-stratigraphic significance. In: Ketzer M. & Morad S. (Eds.) IAS Special Publication.

Amorosi A., submitted. New perspectives on the sequence stratigraphy of glaucony-bearing deposits as revealed by the Cenomanian glaucony of Normandy (Northern France). In: Jarvis I. (Ed.) IAS Special Publication.

## 1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

## 1 D. Patents and industry collaborations

## 1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

## 1 F. Participation in other conferences

Please list only the most relevant

Amorosi A., Ferrari V., Sammartino I. & Tateo F., 2004. Distribution patterns of glaucony from Lower Cenomanian deposits of Northern France. AGU, San Francisco. AGU Fall Meeting, San Francisco, 13-17 December 2004, 1007.

Amorosi A., 2005. Glaucony and sequence stratigraphy: new insights from the Cenomanian deposits of Normandy (Northern France). Geoitalia 2005, Spoleto, 21-23 settembre 2005, 220.

Amorosi A., 2006. The occurrence of glaucony in the stratigraphic record: Distribution patterns and sequence-stratigraphic significance. General Assembly of the European Geosciences Union (EGU), Vienna, Austria. Geophysical Research Abstracts, 8, 08572. Invited key lecture.

## Appendix 2. Scientific & technical personnel involved in the CRP

## Personnel directly funded by the EUROCORES Programme

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

Mr Howri Mansurbeg, Ph.D. funding from Uppsala University for four years (defended his thesis 2007)

Mr Mohamed El-ghali, Ph.D. funding from the Libyan government (defended his thesis 2006)

Dr. Irene Sammartino, post-doc, contract 01 March 2006- 30 June 2005

Dr. Irene Sammartino, post-doc, contract 01 December 2006- 28 February 2007

Dr. Miguel Ángel Caja, pre-doc, funding from the Spanish Ministry, 01-01-2004 to 31-12-2004 and collaboration in the Euromargin project from 2005 to 2007.

# European carbonate margins as recorders of past global change: cretaceous *greenhouse* versus carboniferous *coldhouse* examples

## Abstract

Fossil continent - ocean boundaries represent unique archives of regional and global change. Changes in climate, drainage patterns, sediment production and transport, palaeo-sea surface temperatures and seawater geochemistry are recorded in fossil carbonate margins. We propose an in-depth study and comparison of two selected margins (Northern Spain and Greece), which represent significantly different episodes of Earth history in terms of global climate, atmospheric pCO<sub>2</sub>, seawater composition and carbonate producing biota. The mid-Carboniferous margin (Spain) represents a 'coldhouse' example and the Late Cretaceous margin (Greece) provides an example of the 'greenhouse' mode of Earth's system. First, we intend to concentrate on the sedimentologic and sequence stratigraphic framework of both margins. A special focus will be on the quantitative determination of the carbonate production potential, and the role of inorganic versus biologically induced and biologically controlled production. Sedimentological studies will lead to a semi-quantitative reconstruction of middle Carboniferous and Late Cretaceous sea-level changes. Coeval sections across platform-to-basin transects allow for a determination of amplitudes of relative sea-level fluctuations. Compared to the Late Cretaceous these are expected to be different during the middle Carboniferous when glacial eustasy was important. Second, we will apply  $\delta^{13}\text{C}$ ,  $\delta^{18}\text{O}$ , Sr-isotopes and trace element ratios to different carbonate materials in order to reveal spatial and temporal variability of sea-surface temperatures and specifically of the palaeo-thermocline recorded in the geochemistry of fossil carbonate margins in Spain. Chemostratigraphy ( $\delta^{13}\text{C}$ ,  $^{87}\text{Sr}/^{86}\text{Sr}$ ) will be important for the correlation of Upper Cretaceous carbonate margins. A particularly novel aspect of this study will be the testing and application of Ca isotopes ( $\delta^{44}\text{Ca}$ ) to the sedimentary geochemistry of Carboniferous and Cretaceous carbonates from well constrained depositional settings. These results will be compared to core material from modern tropical carbonates with the expectation to gain new insight in the exogenic calcium cycle.

## Partners

(NWO, DFG)

### **Dr Adrian Immenhauser (project leader)**

Vrije Universiteit, Amsterdam, The Netherlands

### **Dr Thomas Steuber and Jörg Mutterlose**

Ruhr-Universität Bochum, Bochum, Germany

<b>Collaborative Research Project (CRP)</b>
<b>1. General information</b>
<p><u>Project Reference Number</u> : 01-LEC-EMA11F</p> <p><u>Acronym / Short Title</u>: -</p> <p><u>Full Title</u>: <b>European carbonate margins as recorders of past global change: cretaceous <i>greenhouse</i> versus carboniferous <i>coldhouse</i> examples</b></p> <p><u>Project Leader name</u>: <i>Dr Adrian Immenhauser</i></p> <p><u>Project Leader affiliation</u>: <i>Vrije Universiteit of Amsterdam, NL (now Ruhr-University Bochum, Germany)</i></p> <p><u>Institutional home page</u> (URL): <a href="http://www.falw.vu.nl">www.falw.vu.nl</a> (now <a href="http://www.ruhr-uni-bochum.de/sediment/">http://www.ruhr-uni-bochum.de/sediment/</a>)</p> <p><u>Project-related home page</u> (URL): now <a href="http://www.ruhr-uni-bochum.de/sediment/">http://www.ruhr-uni-bochum.de/sediment/</a></p> <p><u>Reporting period</u>: 01/10/2004 to 30/09/2007</p>
<b>2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)</b>
<b>IP 1</b>
<b>Dr Adrian Immenhauser</b> , <i>Vrije Universiteit, Amsterdam, The Netherlands (now Ruhr-University Bochum, Germany)</i>
Total Funding amount of the IP: EUR 164 800
<b>IP2</b>
<b>Dr Thomas Steuber &amp; Jörg Mutterlose</b> , <i>Ruhr-Universität Bochum, Bochum, Germany</i>
Total Funding amount of the IP: EUR 151 000



### 3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

#### General remarks

Given to the different funding periods of the German (PhD 3 years) and the Dutch science foundations (PhD 4 years) the two projects were a bit out-of-phase in this last stage of the projects. Nevertheless, both PhD students were closely embedded in this study and supported by a number of BSc and MSc students from both universities. Now that both projects are terminated, we draw the following conclusions:

#### Carboniferous

Bram vd Kooij, the Amsterdam PhD student has compiled three manuscripts focussing on different aspects of the sedimentology, geochemistry and paleoceanography of the steep Carboniferous margins in Asturias, Northern Spain. One of the three papers is in press for late 2007, the second submitted and the third is nearly completed. See also Appendix 1A and B. Below the three papers are summarized in a succinct manner:

vd. der Kooij et al. (in press 2007; Journal of Sedimentary Research). This paper deals with conspicuous **red-stained carbonate facies** exposed in the slope facies of the Sierra de Cuera in Northern Spain. Red-stained carbonate facies is known from many localities and time slices worldwide (e.g. Ammonitico Rosso etc.) but only a limited number of detailed studies has focussed on the overall controlling mechanisms of red-staining of marine carbonates. Here, we describe the different facies types in detail and place them in their sedimentological, sequence stratigraphic and palaeoceanographic context. A key outcome is the direct bathymetric control available at the Sierra de Cuera allowing for predictive conclusions for other red-stained facies in segmented outcrops elsewhere. In addition, an overall review of red stained facies as described in the literature is provided and discussed in the context of our findings.

vd. der Kooij et al. (submitted; Sedimentology). This second paper deals with important volumes of early marine carbonate cements along the Carboniferous slopes investigated. Previous work dealing with early marine seafloor cementation has mainly dealt with either cementation in the shallow, wave agitated upper water column or with hemi-pelagic cementation at greater depths. The intermediate level, **deep carbonate slope cementation**, has largely been neglected so far. Here, we describe and discuss marine fibrous cements from the Carboniferous slopes in Spain and place them in context with similar slope precipitates from the Permian Capitan Reef in New Mexico and Texas the Miocene to Holocene Mururoa Atoll in the equatorial Pacific. Several chapters discuss the different hydrodynamic, geochemical and biological factors controlling deep slope cementation. A key learning point from this compilation is the fact that the interaction of physical, chemical and biological factors is exceedingly complex. This paper is not really offering solutions but it represents an excellent documentation of the problem.

vd. der Kooij et al. (in prep for Geology). The third, nearly completed, paper discusses the outcome of **bathymetric sedimentary geochemistry** ( $\delta^{18}\text{O}$ ,  $\delta^{13}\text{C}$ , trace elements) transects across several of the Carboniferous slopes in Northern Spain. In contrast to the conventional approach, we do not investigate the stratigraphic but rather the spatial and bathymetric variability of micrite-based isotope data from carbonate margins. The main observation is that isotopes shift considerably across a mid-slope facies change from upper slope microbial boundstones to lower slope breccia deposits and again towards the slope to basin transition. According to a conventional interpretation one would conclude that the isotope shifts are controlled by differential diagenesis of the two contrasting facies types. Based on a second data set on marine fibrous cements obtained along these transects, we are able to document that facies or diagenesis certainly has affected matrix micrites but is a poor explanation for the observed  $\delta^{18}\text{O}$  shifts in fibrous cements. A tentative interpretation suggests that the observed facies change is not coincidental but controlled by a layered Carboniferous ocean in these marginal basins. Layered marginal oceanic basins are common in the present world but have, to our knowledge, never been documented from rocks as old as the Carboniferous.

## Cretaceous

M. Hagmaier, the PhD in the Bochum project has terminated his work about a year ago. During the second phase of the project, the evolution of depositional environments in Cretaceous carbonate margins of the Ionian Islands, Greece was evaluated in more detail. The Cenomanian/Turonian transition, a critical episode in the evolution of carbonate platforms worldwide, is recorded in the sampled deposits and its precise position was determined by carbon-isotope stratigraphy. This research is the focus of a paper presently in preparation by M. Hagmaier.

Latest Maastrichtian rudist-bearing limestones have been correlated with **strontium-isotope stratigraphy** (Steuber et al., 2007). In the Mediterranean region, this is the first record of species-rich rudist associations close to the Cretaceous/Tertiary boundary, and argues for a catastrophic extinction of these major carbonate producers on Cretaceous platforms. The sampled material of rudist shells contributed to the reconstruction of paleo-climatic changes during the mid-Cretaceous (Steuber et al., 2005). These results are based on seasonal temperature variations that are recorded in cyclic changes of  $\delta^{18}\text{O}$  values in the shells of the bivalves.

Our research initiative on the **calcium isotopic composition** of marine carbonates has been completed (Immenhauser et al., 2005; Steuber & Buhl, 2006). The application of Ca isotopes in geosciences is a relatively novel approach. We were able to elaborate the first comprehensive dataset on marine carbonates that compares the chemical composition with Ca-isotope values. The calcium isotope composition was analyzed in modern, Cretaceous and Carboniferous marine skeletal carbonates, and in components and diagenetic cements of Cretaceous and Carboniferous limestones. In order to gain insight in the fractionation mechanisms of Ca isotopes in marine carbonates, splits of samples were analyzed for Sr, Mg, Fe and Mn concentrations, and for their oxygen and carbon isotopic composition. Biological carbonates generally have lower  $\delta^{44/42}\text{Ca}$  values than inorganic marine cements, and there appears to be no fractionation between seawater and marine inorganic calcite. No significant temperature dependence of Ca-isotope fractionation was found in shells of rudist bivalves that have recorded large seasonal temperature variations as derived from  $\delta^{18}\text{O}$  values and Mg concentrations. The reconstruction of secular variations in the  $\delta^{44/42}\text{Ca}$  value of seawater from well preserved skeletal calcite is compromised by a broad range of variation found in both, modern and Cretaceous biological carbonates, independent of chemical composition or mineralogy. First results of Ca-isotope analyses have shown that large variations in the  $^{44}\text{Ca}/^{42}\text{Ca}$  ratio occur among components of limestone samples. Biological carbonates generally have lower  $\delta^{44/42}\text{Ca}$  values than inorganic marine cements, and there appears to be no fractionation between seawater and marine inorganic calcite. A kinetic isotope effect related to precipitation rate is considered to control the discrimination against  $^{44}\text{Ca}$  in biological carbonates. This is supported by a well-defined correlation of the  $\delta^{44/42}\text{Ca}$  values with Sr concentrations in Cretaceous limestones that contain biological carbonates at various stages of marine diagenetic alteration. Despite variations that may be due to still unidentified biological fractionation mechanisms, the  $\delta^{44/42}\text{Ca}$  values of Cretaceous skeletal calcite indicates that the  $\delta^{44/42}\text{Ca}$  value of Cretaceous seawater was by 0.3–0.4‰ lower than that of the modern ocean. This is in accordance with previous considerations about the oceanic Ca budget and high Ca concentrations of Cretaceous seawater. Please not that a subsequent ESF project (EUROCLIMATE, CASIOPEIA) follows this research line and more research is under way.

In conclusion, the now completed CRP has followed the lines described in the original proposal submitted to ESF. We have compiled what might be presently one of the most detailed data frameworks of a steep Carboniferous carbonate slope in terms of sedimentology, geochemistry and paleoceanography. Carbonate margins are intriguingly complex archives of climate change as they link oceans and continents. Much work has been performed at the Cretaceous margins in Greece but there the outcome is less straightforward. This is partly due to the less extensive outcrops making lateral correlations depending on time-consuming dating first. A total of eight publications (including a Nature publication) have come out from this CRP linking only two research groups. Another aspect of this CRP was the application of the non-conventional calcium-isotope system to paleoceanographic research question. Two published manuscripts document our success. More publications are in progress.

In conclusion, the project is considered to be successful despite the limited number of researchers involved. The support by the national funding agencies and ESF is greatly appreciated. It seems obvious to us that a similar result could not have been achieved without this CRP.

#### 4. What did you not achieve in the CRP and why? (max 1 p.)

Please use the original proposal as reference and explain any deviations from the work plan

According to the original proposal submitted to ESF, the CRP was subdivide in two phases: Phase I – Compilation of data on two contrasting carbonate margin settings (Cretaceous and Carboniferous) and Phase II – Comparison of these data sets in review-style papers. The second goal must be considered too ambitious for the time framework of 3-4 years in retrospect. Clearly, the PhD students needed all the time allocated to their projects (3 years in Bochum and 4 years in Amsterdam) in order to complete their work and hence Phase I. It is only AFTER the PhD students have assembled the data of Phase I, that the PI's are in the position to summarize these data in a contrast comparison. A first attempt is made in vd. Kooij et al. (under review). Here the deep slope cementation of regionally different carbonate margins from different time slices is compared and discussed. The last papers of the PhD students are under review or in the final phase of compilation. The contrast comparison of the two data sets will be the responsibility of the PI's.

#### 5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

##### 5. A.

Two follow up projects based directly on the present CRP of one of the PI's (Immenhauser) are summarized here. Please note that the second PI (Steuber) has accepted a position in the Middle East and has no direct access to European research activities.

- A project supported by the Spanish founding agency for four years (PI's: Federico Olóriz Sáez (Granada) and Immenhauser (Bochum); "Señales bióticas y abióticas en la interpretación de dinámicas paleoambientales y paleobiológicas en su contexto estratigráfico: aproximación a las interpretaciones ecostratigráficas". [Biotic and abiotic signals for interpretations of palaeoenvironmental and palaeobiological dynamics in their stratigraphic context: approaching eco-stratigraphical interpretations]) dealing with the spatial geochemical record of Jurassic onshore-offshore transects in Southern Spain. The PhD student (Rute Coimbra) has commenced her work and is presently here in Bochum on a work visit.
- A one year project (Geochemical Reconstruction of Lateral Changes in Cenomanian Epicontinental Shelf Water Masses, Northern Germany; IM 44/3-1) supported by the German founding agency (DFG) dealing with geochemical and paleontological evidence for Cenomanian spatial organization of water masses in Northern Germany. The PI's are Immenhauser (Bochum) and M. Wilmsen (Würzburg).

##### 5. B. Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

From the viewpoint of my own research direction I would like to propose the following:

In the past decades climate research has been driven by mainly marine research (with the exception of for example the GIPS and GRISP ice cores and similar initiatives). More recently, speleothem-based continental climate research has been particularly successful because of the very high time resolution based on U-Th dating. I might be wrong, but my impression is that the link between oceans and continents has not been sufficiently explored and that the seagoing and the land-based climate research communities represent two basically separated populations. I propose that ESF could have a leading role in linking continental and oceanic climate archives in Europe. Obviously, margins hold a leading position in this ocean to land game. More specifically, I refer to several ongoing research activities in Morocco, Spain, France, Turkey and Israel all focussing independently on land-based speleothem records of the last say 5 to 200 kyrs. In addition, a rich archive of Holocene and Pleistocene climate data from the Mediterranean basin exists and more research is under progress. With this present situation in mind, one might consider a Mediterranean-wide climate research initiative linking both domains, the continental and the marine one. I am pretty sure this or a similar initiative will soon be discussed but it would indeed be wishful to see ESF taking a leading position here.

## 6. Your feedback on the EUROCORES Programme (max 1 p.)

### 6.A. What, in your view, is the added value of being part of a EUROCORES Programme

I answer to this question with a number of keywords: Networking; access to European top-level research in other disciplines; interdisciplinarity; inspiring new ideas; competitive research clusters; being up-to-date on “what is going on”; visibility; influence.

### 6.B. Give any critical and constructive comments on the EUROCORES Programme and its procedures

**Critical comments:** I criticize two aspects: (1) the concept of “bigger is better” and (2) the “over”-interdisciplinarity of EUROCORES projects.

(1) From my experience any scientific collaboration has a sub-critical mass, a critical mass, and a supra-critical mass. Two three research associates in one CRP might be at the lower limit, more than 6 or 7 at the upper limit and research initiatives with about 20 groups involved are in my view counter-productive. The energy consumed due to simple coordination exceeds the benefit of the larger population by far. (2) Interdisciplinarity is a strength and a weakness of EUROCORES. The strength of interdisciplinarity is obvious and requires no further discussion. The weakness becomes obvious in for example “geochemistry” sessions I witnessed during EUROMARGINS meetings. The range of topics covered was from REE chemistry of intraplate volcanism, via glauconite diagenesis to Palaeozoic oceanography. Exposed to such a tremendous range of topics, even experienced and motivated colleagues “shut down”.

**A (hopefully) constructive comment:** I am intrigued by the potential of open access publications particularly when provided by European Science Organisations such as EGU. I propose that ESF should aim at booking a specific amount of money for each research initiative specifically for page charges of European open access publications (ESF offers a wide range of high level outlets). As such ESF activities would become directly available to a much wider audience for no costs. I am not in favour of financing Elsevier or Springer or any other commercial publisher with European tax money.

## Appendix 1. List of Products of the CRP

### 1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more CRPs** (if any)

As indicated in previous reports, our research initiative was the only one dealing with fossil land based margins (as opposed to recent seagoing research). As such our attempts to link with other CRP's failed despite all attempts. As a consequence we regret that we have no inter-CRP publications.

### 1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

Papers in international, peer-reviewed journals (note, abstracts are listed under 1F)

IMMENHAUSER, A., NÄGLER, T.F., STEUBER, T. & HIPPLER, D. (2004): A critical assessment of mollusk  $^{18}\text{O}/^{18}\text{O}$ , Mg/Ca, and  $^{44}\text{Ca}/^{40}\text{Ca}$  ratios as proxies for Cretaceous seawater temperature seasonality. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **215**, 221-237.

MASSE, J.-P., and STEUBER, T. (2007): Strontium isotope stratigraphy of Lower Cretaceous rudist bivalves.- *SEPM Special Publication*, **87**.

STEUBER, T., and BUHL, D. (2006): Calcium-isotope fractionation in modern and ancient marine carbonates. *Geochimica et Cosmochimica Acta*, **70**, 5507-5521.

STEUBER, T., PARENTE, M., HAGMAIER, M., IMMENHAUSER, A. VAN DER KOOIJ, B., and FRIJA, G. (2007): Latest Maastrichtian species-rich rudist associations of the Apulian margin of Salento (S Italy) and the Ionian Islands (Greece). *SEPM, Special Publication*, **87**.

STEUBER, T., RAUCH, M., MASSE, J.-P., GRAAF, J., and MALKOČ, M. (2005): Low-latitude seasonality of Cretaceous temperatures in warm and cold episodes.- *Nature*, **437**, 1341-1344.

VAN DER KOOIJ, B., IMMENHAUSER, A., STEUBER, T., HAGMAIER, M., BAHAMONDE, J.R., SAMANKASSOU, E., and MERINO TOMÉ, O. (in press for end 2007): Marine red staining of a Pennsylvanian carbonate slope: environmental and oceanographic significance. *Journal of Sedimentary Research*.

VAN DER KOOIJ, B., IMMENHAUSER, A., STEUBER, T., BAHAMONDE, J.R. and MERINO TOMÉ, O. (submitted): Origin and precipitation mechanisms of volumetrically important marine cement on deep submarine slopes. *Sedimentology*.

VAN DER KOOIJ, B., IMMENHAUSER, A., STEUBER, T., BAHAMONDE, J.R. and MERINO TOMÉ, O. (in prep for Geology): Geochemical and stratigraphical evidence for a layered Carboniferous ocean.

### 1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

[http://www.scinexx.de/index.php?cmd=geotech\\_imfocus&id=411](http://www.scinexx.de/index.php?cmd=geotech_imfocus&id=411)

<http://www.pm.ruhr-uni-bochum.de/pm2005/msg00332.htm>

Several interviews in the local and national radio, TV and newspaper articles.

### 1 D. Patents and industry collaborations

Not applicable

## 1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

As indicated previously, our networking potential was very limited due to no overlap with other CRP's. Nevertheless, please note that two follow up projects have resulted from the EUROMARGINS initiative nonetheless.

## 1 F. Participation in other conferences

Please list only the most relevant

### Conference abstracts

#### 2004

HAGMAIER, M., STEUBER, T., IMMENHAUSER, A., VAN DER KOOIJ, B., VAN DER LAND, C., and SHARIF, L. (2004): Megabreccias in the Upper Cretaceous of the Apulian Margin (Ionian Islands, Greece).- 32nd International Geological Congress; Florence. (Poster)

HAGMAIER, M., STEUBER, T., IMMENHAUSER, A., VAN DER KOOIJ, B. (2004): Megabreccias in the Cenomanian of the Apulian Margin.- 2nd Euromargins Conference; Barcelona. (Poster)

VAN DER KOOIJ, B., IMMENHAUSER, A., STEUBER, T., BAHAMONDE, J., HAGMAIER, M., and SAMANKASSOU, E. (2004): Palaeoceanographic record of Carboniferous coldhouse margins in Northern Spain (Cantabrian Mts.).- 32nd International Geological Congress; Florence. (Poster)

VAN DER KOOIJ, B., IMMENHAUSER, A., STEUBER, T., BAHAMONDE, J., HAGMAIER, M., SAMANKASSOU, E. and MERINO TOMÉ, O. (2004): Palaeoceanographic record of Carboniferous coldhouse margins in Northern Spain (Cantabrian Mts.).- 2nd Euromargins Conference; Barcelona. (Poster)

VAN DER LAND, C., IMMENHAUSER, A., STEUBER, T., HAGMAIER, M., and VAN DER KOOIJ, B. (2004): Environmental and palaeoceanographic significance of a Cenomanian ooidal facies from Kefalonia Island (Greece).- 32nd International Geological Congress; Florence. (Poster)

STEUBER, T. (2004): Seawater composition and the evolution of carbonate margins.- 2nd Euromargins Conference; Barcelona

STEUBER, T., and RAUCH, M. (2004, invited lecture): The strontium/calcium budget of Cretaceous seawater.- 32nd International Geological Congress; Florence.

#### 2005

HAGMAIER, M., STEUBER, T., IMMENHAUSER, A., VAN DER KOOIJ, B., VAN DER LAND, C., SHARIF, L. (2005): Mid-Cretaceous (Late Albian - Turonian) evolution of the Apulian margin (Ionian Islands, Greece).- Seventh International Congress on Rudists; Austin, Texas. (Poster)

HAGMAIER, M., STEUBER, T., IMMENHAUSER, A., VAN DER KOOIJ, B., VAN DER LAND, C., SHARIF, L., and ONNEKEN, J. (2005): Evolution of depositional environments of the Apulian margin (Kefalonia Island, Greece) during the mid-Cretaceous (Albian-Turonian).- EGU General Assembly; Vienna. (Poster)

VAN DER KOOIJ, B., IMMENHAUSER, A., STEUBER, T., SAMANKASSOU, E., BAHAMONDE, J., HAGMAIER, M., and MERINO TOMÉ, O. (2005): Paleo-oceanographic significance of red-stained sedimentary intervals in a Pennsylvanian high-rising carbonate platform.- 13th SwissSed Meeting; Fribourg.

VAN DER KOOIJ, B., IMMENHAUSER, A., STEUBER, T., SAMANKASSOU, E., BAHAMONDE, J.R., HAGMAIER, M., and MERINO TOMÉ, O. (2005): Paleoceanographic significance of red-stained sedimentary intervals in a Pennsylvanian high-rising carbonate platform.- EGU General Assembly; Vienna.

MASSE, J.-P., and STEUBER, T. (2005): Strontium-isotope stratigraphy of Lower Cretaceous rudist bivalves.- Seventh International Congress on Rudists; Austin, Texas. (Poster)

SKELTON, P., MASSE, J.-P., STEUBER, T., and IMMENHAUSER, A. (2005): A new rudist from the Upper Qishn Formation (Lower Aptian) of the Haushi-Huqf area, southern Oman.- Seventh International Congress on Rudists;



Austin, Texas.

- SARI, B., STEUBER, T., and ÖZER, S. (2005a): The Cenomanian-Turonian boundary positive  $\delta^{13}\text{C}$  excursion (OAE-2) recorded in peritidal limestones from the Bey Dağları carbonate platform, western Taurides, Turkey.- Seventh International Congress on Rudists; Austin, Texas.
- SARI, B., STEUBER, T., and ÖZER, S. (2005b): The Cenomanian-Turonian boundary positive  $\delta^{13}\text{C}$  excursion (OAE-2) recorded in peritidal limestones from the Bey Dağları carbonate platform, western Taurides, Turkey.- 7th International Symposium on the Cretaceous; Neuchâtel.
- STEUBER, T. (2005): Late Cretaceous history of Tethyan rudist formations and carbonate platforms: Timing of events and correlation based on strontium-isotope stratigraphy.- 7th International Symposium on the Cretaceous; Neuchâtel.
- STEUBER, T., and BUHL, D. (2005): The calcium - isotope system: a new tool in carbonate sedimentology.- Trends and Developments in Carbonate Sedimentology and Stratigraphy; Erlangen.
- STEUBER, T., PARENTE, M., KORBAR, T., HAGMAIER, M., VAN DER KOOIJ, B., FRIJIA, G. (2005): Latest Maastrichtian rudist associations of Apulia (Italy, Croatia, Greece): Implications for the extinction of the Hippuritoidea.- Seventh International Congress on Rudists; Austin, Texas. (Poster)

## 2006

- IMMENHAUSER, A., V.D. LAND, C., STEUBER, T., GRAAF, J., SIMONE, L., V.D. KOOIJ, B., and HAGMAIER, M. (2006): Primary low-Mg calcite ooids from the Cretaceous of Greece and Italy – Implications for ooid genesis and Cretaceous seawater chemistry.- 17<sup>th</sup> International Sedimentological Congress; Fukuoka.
- VAN DER KOOIJ, B., IMMENHAUSER, A., STEUBER, T., HAGMAIER, M., and BAHAMONDE, J. (2006): Origin and driving mechanisms of volumetrically important radiaxial fibrous calcite precipitation on deep submarine slopes.- 17<sup>th</sup> International Sedimentological Congress; Fukuoka.
- VAN DER KOOIJ, B., IMMENHAUSER, A., STEUBER, T., HAGMAIER, M., and BAHAMONDE, J. (2006): Origin and driving mechanisms of volumetrically important radiaxial fibrous calcite precipitation on deep submarine slopes.- Carboniferous Conference Cologne; Cologne. (Poster)
- VAN DER KOOIJ, B., IMMENHAUSER, A., STEUBER, T., SAMMANKASSOU, E., BAHAMONDE, J., HAGMAIER, M., and MERINO TOMÉ, O. (2006): Paleooceanographic significance of red-stained sedimentary intervals in a Pennsylvanian high-rising carbonate platform.- Third Euromargins Conference, Bologna. (Poster)
- VAN DER KOOIJ, B., IMMENHAUSER, A., STEUBER, T., CSOMA, A., HAGMAIER, M., and BAHAMONDE, J. (2006): Origin and driving mechanisms of volumetrically important radiaxial fibrous calcite precipitation on deep submarine slopes.- Third Euromargins Conference, Bologna.
- STEUBER, T. (2006): Late Cretaceous rudist bivalves and carbonate platforms: rates of evolution and timing of events correlated by strontium-isotope stratigraphy.- Geological Society of America, Annual Meeting; Philadelphia.
- STEUBER, T. (2006, invited keynote lecture): Sea-surface temperature seasonality during cool and warm episodes of the Cretaceous: Implications from isotopic and chemical intra-shell variations in mollusk calcite.- Third Euromargins Conference, Bologna.

Please note, 2007 was mainly focused on the compilation of papers and no conference communications of our CRP projects have been made. In addition the German research component has ended in 2006.

## **Appendix 2. Scientific & technical personnel involved in the CRP**

### **Personnel directly funded by the EUROCORES Programme**

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

Amsterdam (PI Immenhauser): PhD student Bram vd Kooij, presently compiling the last publication of his thesis. PhD defence planned for January or February 2008. Contract started 2004 ended 2007.

Bochum (PI Steuber): PhD student Mischa Hagmaier, still writing up his ms whilst working in another position. PhD defence planned for 2008 (unspecified). Contract started 2004 ended 2006.

# The role of mantle-crust interaction in the early phases of passive margin development: the case of the Vøring plateau, NE Atlantic

## Abstract

It is proposed to resample and reinvestigate the drill cores from Hole 642E, Ocean Drilling Program Leg 104, Outer Vøring Plateau, NE Atlantic. These cores keep a record of magmatic events dating back to the early rifting phases of the NE Atlantic ocean. The bottom section of the hole is made up of a 'Lower Series' consisting of basic dykes and flows of basaltic andesites, peraluminous cordierite-bearing dacites, rhyolitic ignimbrites, and interbedded volcanoclastic units. This Lower Series underlies a thick 'Upper Series' of transitional-type mid-ocean ridge tholeiites. The Lower Series assemblage is clearly indicative of interaction of mantle melts with crustal material and/or of significant crustal melting by underplating. The section is particularly suited to study contamination of mantle magmas with crust, because the chemical and isotopic character of the crustal component can be unambiguously defined. The research devoted thus far to the Hole 642E volcanics has been rather limited. Moreover, since the original studies, there have been several new developments in petrogenetic concepts and in analytical facilities for isotopic (e.g., high precision Hf- and Pb- isotopic analyses) and trace element analysis (solution and laser ablation ICP-MS). The new studies aim to better define the eruption modes and depositional environment of these subaerially erupted volcanics, in order to shed light on eruption and magma dynamics. A substantial amount of new samples will be studied for trace element composition by ICP-MS and Sr,Nd,Hf,Pb- isotopic composition by TIMS and multicollector ICP-MS with a view to establish the extent and processes of mantle-crust interaction. This will in turn allow to better constrain the intrinsic geochemical heterogeneity –in space and time– of the mantle melts produced in the (proto-) Iceland mantle plume.

## Partners

(FWO, DFG, NFR)

### Pr Jan Hertogen (project leader)

Katholieke Universiteit Leuven, Leuven, Belgium

### Dr Rolf-Birger Pedersen

Universitetet i Bergen, Bergen, Norway

### Pr Lothar Viereck-Götte

Friedrich-Schiller-Universität Jena, Jena, Germany

**NO REPORT RECEIVED FOR THIS PROJECT**

# Slope stability on Europe's passive continental margins (SPACOMA)

## Abstract

Improved knowledge of the past and better understanding of the present seabed stability are essential for an understanding of the sediment dynamics of the European continental margins as a whole. Submarine slides are common and very effective mechanisms of sediment transfer from shelf and upper slope to deep-sea basins. During one single event enormous sediment volumes can be transported on very gentle slopes over distances exceeding hundreds of kilometres. Typically such events can last from less than an hour to days as documented by the 1992 Grand Banks submarine slide event that also created a tsunami, which caused devastation on adjacent coastal lowlands. In this project we focus on systematic advancement in our understanding of sediment dynamics of submarine slides in the context of global change. We prioritise the research objectives (1) slide headwall development on upper continental slopes, (2) slope stability of river-fed and carbonate margins, (3) slope stability of glacier-fed siliciclastic margins, (4) geo-mechanical controls on the formation and trigger mechanisms of submarine slides, (5) numerical modelling of sediment break up, mobility and run out, and (6) slide frequencies in regions of long-term instability in relation to sea-level change.

## Partners

(NFR, MCyT, NERC, DFG)

### **Pr Jürgen Mienert (project leader)**

Universitetet i Tromsø, Tromsø, Norway

### **Dr Miquel Canals**

Universitat de Barcelona, Barcelona, Spain

### **Pr Julian Dowdeswell**

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Universitetet i Bergen, Bergen, Norway

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### **Carl Bonnevie Harbitz**

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Norges Geotekniske Institutt, Oslo, Norway

### **Dr Rüdiger Stein**

Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, Germany

<b>Collaborative Research Project (CRP)</b>
<b>1. General information</b>
Project Reference Number : 01-LEC-EMA14F Acronym / Short Title: <i>SPACOMA</i> Full Title: <b>Slope stability on Europe's passive continental margins</b> Project Leader name: <i>Pr Jürgen Mienert</i> Project Leader affiliation: <i>University of Tromsø, NO</i> Institutional home page (URL): <a href="http://uit.no/geologi">http://uit.no/geologi</a> Project-related home page (URL): <a href="http://www.ig.uit.no/euromargins/index.htm">http://www.ig.uit.no/euromargins/index.htm</a> Reporting period: 01/10/2004 to 30/09/2007
<b>2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)</b>
<b>IP 1</b>
<b>Pr Jürgen Mienert</b> , Universitetet i Tromsø, Tromsø, Norway
Total Funding amount of the IP: EUR 446 000,- ( <i>3569000 NOK</i> )
<b>IP2</b>
<b>Pr Miquel Canals</b> , Universitat de Barcelona, Barcelona, Spain
Total Funding amount of the IP: EUR 75 000,-
<b>IP3</b>
<b>Pr Julian Dowdeswell</b> , University of Cambridge, Cambridge, United Kingdom
Total Funding amount of the IP: EUR 360 000.- ( <i>125.209,52 BPounds</i> )
<b>IP4</b>
<b>Pr Hafliði Hafliðason</b> , Universitetet i Bergen, Bergen, Norway
Total Funding amount of the IP: EUR 375 570,- ( <i>3006000 NOK</i> )
<b>IP5</b>
<b>Carl Bonnevie Harbitz</b> , Norges Geotekniske Institutt, Oslo, Norway
Total Funding amount of the IP5+6 : EUR 565 500,- ( <i>4524000 NOK</i> )
<b>IP6</b>
<b>Dr Carl Fredrik Forsberg</b> , Norges Geotekniske Institutt, Oslo, Norway
<b>IP7</b>
<b>Dr Rüdiger Stein</b> , Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, Germany
Total Funding amount of the IP: EUR 146 000,-

**Note: The funding amounts given do not include the costs for ship time and other large scale facilities!**

### 3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

The SPACOMA project has focussed on a systematic advancement in our understanding of sediment dynamics of submarine slides in the context of global climate change. We have prioritized the research objectives (1) slide headwall development on upper continental slopes, (2) slope stability of river-fed and carbonate margins, (3) slope stability of glacier-fed siliciclastic margins, (4) geo-mechanical controls on the formation and trigger mechanisms of submarine slides, (5) numerical modelling of sediment break up, mobility and run out, and (6) slide frequencies in regions of long-term instability in relation to sea-level change.

The SPACOMA project brought together a team of experts in sediment slides, gas hydrates, geotechnical seabed investigations, modeling of sediment dynamics, and continental margin research enabling a skilled use of front-line technologies in co-operation with the Norwegian hydrocarbon industry. Detailed images of seafloor failures provided by swath mapping, side-scan sonar and 3-D seismic imaging enable us to understand the complex processes and resulting impacts. We have used designated seafloor regions where submarine slide observations can best be made (Figure 1). Also, we assessed the specific conditions in each of the river-fed and glacier-fed margin regions from the Mediterranean to the Arctic. The SPACOMA work can be seen in context with our launched UNESCO IGCP 511 project activities that started in 2005 on "submarine slides and their consequences". Three conferences have been successfully carried out, the 3<sup>rd</sup> with more than 100 participants on Santorini, Greece. The 4th Conference on Submarine Mass Movements is to be held in the U.S. (Austin) during the fall of 2009, and it will be co-chaired by colleagues from Shell. The Director and Associate Directors of the BEG, as well as the senior researchers are very enthusiastic about this plan, where the largest geoscience school in the US with a large student body to provide support to the meeting.

There is a high demand for detailed knowledge of actual seabed conditions and seabed processes on both sides of the Atlantic and in other areas of the world ocean to improve our understanding of sediment dynamics under global change. The interactions of the Euromargin\_SPACOMA and international UNESCO supported research groups improved internationalization of European science, it will lead to an exchange of ideas in areas of common interest, and it will provide much better opportunities for our young scientists to do research with experts at various research institutions.

The SPACOMA investigations allowed combining field investigations of submarine slides including their headwalls and glide planes (e.g. Vanneste et al., 2007, Nygård et al., 2007, Hjelstuen et al., 2007) with laboratory studies to investigate the characteristics of glide planes (e.g. Yang et al., 2007), and the effect of high sedimentation rates (e.g. Leynaud et al., 2007), gas hydrate dissociation versus dissolution (Mienert, in press) and potential triggers as an example for an Arctic slide (Winkelmann and Stein, 2007) or the W-Mediterranean (Urgeles et al., 2006).

We propose new scenarios explaining retrogressive slope failures. We plan to summarize our findings in one or two joint publications after the end of the project, i.e. 2008. Until now, we have published more than twenty peer reviewed articles and have contributed with more than 20 oral presentations and more than 20 Posters to national and international conferences. The CRP activities on the European margin include several successful research cruises as well as the presentation of our results during EUROMARGINS sessions at EUG and IGCP 511 conferences. Finally, the invitation of our post doctoral scientists to conferences in the United States, and the interest by the hydrocarbon industry to host the IGCP 511 conference in Austin clearly demonstrates a high level of recognition and international attention of the slope stability project and EUROMARGINS.



### **Slope stability of river fed NW Mediterranean margins**

The causes that brought portions of a submarine slope to fail at the NW Mediterranean margin, and whether this slope may fail again or not are important issues. However, it is not simple to answer because of the inaccessibility of the subseabed and lack of borehole information. The question why a relatively large area (2200 km<sup>2</sup>, 26 km<sup>3</sup>) at 11 ka failed off the Ebro Margin, NW Mediterranean was studied by means of geophysical (multibeam bathymetry, seismic reflection profiles and side-scan sonar data), sedimentological and geotechnical data. Backanalysis of the slide and interpretation of the geophysical data sets determine that undrained failure occurred in the form of small rotational retrogressive slides. The measured strength profile is compared to that obtained from backanalysis and found to be in substantial agreement if relatively small earthquake ground motions are considered (~0.05g). Pre-conditioning factors promoting instability of the slope included oversteepening, reduction of shear strength along the failure plane and overloading due to differential compaction and faulting associated to a deep-rooted inactive volcanic dome, and recent avulsion and deposition of sediments from a channel-levee complex. Seismic activity associated with these faults is considered as the most likely triggering mechanism since regional earthquakes do not appear to induce accelerations large enough. The slope resulting from the slide appears to be presently safe both under static drained and undrained conditions. An earthquake that is able to induce accelerations of ~0.1g is needed to produce permanent deformations of the slope, which could finally induce failure (Urgeles et al., 2006).

### **Slope stability of glacier-fed siliciclastic margins**

Seismic hazards offshore Fennoscandia could have been underestimated considering the very likely increase in seismicity following the isostatic rebound from 10 ka to the present. An earthquake –induced excess pore pressure generation can lead to the liquefaction of coarse-grained cohesion-less soils. Therefore, one question relates to the location, magnitude and frequency of earthquakes on these margins, which can be measured for the present time but can only be inferred for past times from historical records or modelling scenarios. According to Siebert and Dowdeswell (2004) and Dowdeswell et al. (in press), the Eurasian ice sheet reached its maximum volume of appr. 5 500 000 km<sup>3</sup> at 16 ka. After the deglaciation, isostatic uplift has been estimated in the Barents Sea around 100 m/kyr at 9 ka and for East Scandinavia around 300 m/kyr between 11 ka and 9 ka (Bungum et al., 2005). They proposed a fast uplift between 10 and 8 ka followed by a slower uplift between 7 and 2 ka. They also mentioned that while glacial isostatic adjustment and seismicity are related, the relationship is ambiguous. However, an intensified high seismicity is documented (occurrence of a number of M 7+ earthquakes) around 10 ka. Dating of fault activity in Lapland (northern Fennoscandia) provide 8200 ± 250 a for the Parve fault (estimated moment magnitude= 8.1; single event) and 9300 a for the Masi fault (estimated moment magnitude=7.7; single event). Their observations point towards higher frequency of seismic hazards in this area during the early Holocene! In addition, we have calculated very high sedimentation rates (several metres per thousand yrs) and extreme sediment delivery from marine ice streams during glacial times (Nygard et al, 2007), which in turn caused a build up of pore pressure in underlying contouritic sediments. Pore pressure dissipation occurs downslope (Leynaud et al., 2007) since shelf areas are highly compacted and do not allow for pore pressure dissipation towards the shelf. Such a development may help to explain why the mega-slope failures on glaciated margins started at the base of the slope leading to retrogressive slope failures.

#### **4. What did you not achieve in the CRP and why? (max 1 p.)**

Please use the original proposal as reference and explain any deviations from the work plan

We did not achieve all the age datings necessary to evaluate much better the frequency of submarine slides of the W-Mediterranean. This data base – if achieved - would enable one to evaluate slide processes in context with global climate change or/and tectonic activity. Submarine slides of the Mediterranean occur in a complex sedimentary environment driven by tectonic events, seismicity and climate driven sediment discharge and sealevel change.

The Arctic margins are evenly important, where we established the age control for one mega-slide at one location. Here, we are just at the beginning to determine the slope failure processes in space and time.

Age dating of submarine slide events requests not only a detailed surface and subsurface mapping followed by a designated sediment coring operation (Haflidason, et al., 2005); also needed is a very careful dating of strata

immediately above the termination of a slide event. This strategy is very time consuming and newly mapped submarine slide events may not be dated within the time period of a project due to a variety of reasons: (1) not enough carbonate material for dating (problem in the Arctic basins), (2) disturbed material due to thin layers and bioturbation, (3) material > 50 kyrs does not allow for AMS <sup>14</sup>C method application and other appropriate dating methods are to be chosen.

In contrast to the given limitations, the SPACOMA project achieved major advancements in our understanding of sediment dynamics of submarine slides in the context of global climate change. Extreme sediment (~ 1,1GT of sediment per year) and ice discharge from marine-based ice streams during ice ages played a major role in recurrent Pleistocene mega failures of the northern hemisphere, which we investigated in detail. The frequency of the investigated slides was documented for the northern margins. Working areas on the Norwegian Margin include the Arctic N-Svalbard, the SW Barents Sea and the Mid-Norwegian margin mega slides. Detailed images of seafloor failures provided by swath mapping, side-scan sonar and 3-D seismic imaging enable us to understand the complex processes and resulting impacts on the seabed for the Nordic as well as submarine slides in the western Mediterranean margins. We have assessed the specific conditions in each of the river-fed and glacier-fed margin investigated regions from the Mediterranean to the Arctic, where the slide dynamics and tsunami potential has been documented for the first time, but in-situ geotechnical measurements as for example pore pressure are needed for assessing the present day conditions for a slope to fail.

#### **5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)**

**5. A.** Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

New research activities as a result of the CRP are planned in cooperation with colleagues from the US and Canada. The activities relate to the IODP-Geohazard workshop and planning activity for drilling potential sites of slope failures and gas hydrates in the light of global warming. During the workshop the intention of a joint proposal to be led by J. Mienert, S. Holbrook, D. Mosher, CF Forsberg and H. Haflidason has been put forward, which is to be prepared in the next 2 years, before the drilling vessel returns to the Atlantic Ocean (2010/11).

**5. B.** Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

Future studies of geohazards (specifically submarine slope failures) should develop a joint program that provides a focussed bridge between observations on one hand and models on the other end. We need carefully carried out tectonic/earthquake assessments, fluid flow and excess pore pressure assessments, gravity modelling combined with what we describe based on seismic imaging. A sophisticated modelling group for very complex slope failure dynamics (not only debris flows) is needed, and individual European researchers may establish a research team of excellence without being bound to one place. This may come from a bottom-up initiative driven by recognized scientific needs via workshops but also from the readiness of funding agencies to support new initiatives in EUROMARGIN research. It enhances flexibility and creativity for young researches and could lead to a flexible top international research community in a needed and applied research field.

#### **6. Your feedback on the EUROCORES Programme (max 1 p.)**

**6.A.** What, in your view, is the added value of being part of a EUROCORES Programme

Each of the participants has access to research vessels and various technologies, and a pooling allows increasing the quality of research, i.e. sharing ideas, knowledge, and technologies. The cooperation between academia and industry may be established in one or two but not in all of the participating countries, thus a programme such as EUROCORES is opening previously closed doors enhancing cooperation. It allows improving knowledge and technology transfer across nations in a timely manner, where hopefully all participating parties will gain.

Young researchers are more exposed to job opportunities due to various research collaborations, and they do not depend any more on local and sometimes manifested research structures, those who drive for excellence are easily absorbed by opportunities in a large research community.

**6.B.** Give any critical and constructive comments on the EUROCORES Programme and its procedures

All funding agencies should envision a commitment to a budget they may agree upon, otherwise we may risk the success of individual projects. I speak here as a chairman of EUROMARGINS, where several projects had severe problems due to unforeseen funding scenarios (mainly southern European partners experienced a budget cut!).

The objectives and responsibilities of the scientific committee and its chairman, and the ESF scientific officer should be clear right from the beginning of a programme.

Brochures, websites including all necessary informations should be available by ESF soon after the project starts.

ESF may consider helping to inform the public through concerted TV or Journal activities. I suggest approaching the publishers of airplane journals, if exciting science should surface from ESF or other programmes here is the place to distribute it for public outreach. In the airplane we will have a broad audience, and they have the time to read!

## Appendix 1. List of Products of the CRP

### 1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more CRPs** (if any)

- Vanneste, M., C. B. Harbitz, F. V. De Blasio, S. Glimsdal, J. Mienert and A. Elverhøi (in press). Mass-transport deposits from the Hinlopen slide, Arctic Ocean – Their geomorphology, slide dynamics and tsunami potential. Submitted to Society of Sedimentary Geology – Special Publication.
- The importance of mass-transport deposits in deepwater settings. Lastras, G., Canals, M., Amblas, D., Ivanov, M., Dennielou, B., Droz, L. and Akhmetzhanov, A., the TTR-14 Leg 3 Cruise Scientific Party, submitted. Eivissa slides, western Mediterranean Sea: morphology and processes. *Geo-Marine Letters*.
- Lastras, G., De Blasio, F.V., Elverhoi, A. and Canals, M., 2005. Conceptual and numerical modeling of the BIG'95 debris flow, Western Mediterranean Sea. *Journal of Sedimentary Research*, 75: 784-797. doi: 10.2110/jsr.2005.063.
- Lastras, G., Canals, M., Urgeles, R., Hughes-Clarke, J.E. and Acosta, J., 2004. Shallow slides and pockmark swarms in the Eivissa Channel, Western Mediterranean Sea. *Sedimentology*, 51: 837-850. doi: 10.1111/j.1365-3091.2004.00654.x.
- Vanneste, M., Berndt, Chr., Laberg, J.S.; Mienert, J. 2007. On the origin of large shelf embayments on glaciated margins—effects of lateral ice flux variations and glacio-dynamics west of Svalbard. *Quaternary Science Reviews*.
- Nygård, A., Sejrup, HP., Hafliðason, H., Lekens, W., Clark, CD., Bigg, GR., 2007. Extreme sediment and ice delivery from marine ice streams; new evidence from the North Sea. *Geology*, v.35, no.5, 395-398.
- Dowdeswell, J.A., Ottesen, D. and Rise, L., 2006. Flow-switching and large-scale deposition by ice streams draining former ice sheets. *Geology*, v. 34, p. 313-316.
- Dowdeswell, J.A., Ottesen, D., Rise, L. and Craig, J., 2007. Identification and preservation of landforms diagnostic of past ice-sheet activity on continental shelves from three-dimensional seismic evidence. *Geology*, v. 35, p. 359-362.
- Ottesen, D. and Dowdeswell, J.A., 2006. Assemblages of submarine landforms produced by tidewater glaciers in Svalbard. *Journal of Geophysical Research*, v. 111, F01016, doi:10.1029/2005JF000330.
- Ottesen, D., Dowdeswell, J.A., Landvik, J.Y. and Mienert, J., 2007. Dynamics of the Late Weichselian ice sheet on Svalbard inferred from high-resolution sea-floor morphology. *Boreas*, v. 36, p. 286-306.
- [Leynaud, D.](#); [Sultan, N.](#), and [Mienert, J.](#), 2007. [The role of sedimentation rate and permeability in the slope stability of the formerly glaciated Norwegian continental margin: the Storegga slide model](#). *Landslides*. DOI 10.1007/s10346-007-0086-z
- Muñoz, A., Lastras, G., Ballesteros, M., Canals, M., Acosta, J. and Uchupi, E. 2005. Sea floor morphology of the Ebro Shelf in the region of the Columbretes Islands, Western Mediterranean; *Geomorphology*, 72 (1-4): 1-18.
- Amblas, D., Canals, M., Urgeles, R., Lastras, G. and Hughes-Clarke, J.E., in press. Morphogenetic mesoscale analysis of the northeastern Iberian margin, NW Mediterranean Basin. *Marine Geology*.
- Sultan, N., Gaudin, M., Berne, S., Baztán, J., Canals, M., Urgeles, R. and Lafuerza, S., in press. Analysis of slope failures in canyon heads: Example from the Gulf of Lions; *J. Geoph. Res.*
- Urgeles, R., Leynaud, D., Lastras, G., Canals, M., Mienert, J., 2006. Back-analysis and failure mechanisms of a large submarine slide on the Ebro slope, NW Mediterranean. *Marine Geology*, doi: 10.1016/j.margeo.2005.10.04
- Urgeles, R., De Mol, B., Liqueste, C., Canals, M., Hughes-Clarke, J.E., and the Arraix Shipboard Party, in press. Sediment undulations off Barcelona's new port: Signs of early slope instability or bottom current sediment waves? *Journal of Geophysical Research*.

## 1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

- Mienert, J., in press. Methane hydrates and submarine slides, Encyclopedia of Ocean Sciences, Elsevier-Oxford, UK.
- Vanneste M, Mienert, J., Bünz, S. (2006). The Hinlopen Slide: A giant, submarine slope failure on the northern Svalbard margin, Arctic Ocean. *Earth and Planetary Science Letters*, Vol.245, p. 373-378.
- Winkelmann, D., Jokat W., Niessen, F., Stein, R., Winkler, A., 2006. Age and extent of the Yermak Slide north of Spitsbergen, Arctic Ocean. *Geochem. Geophys. Geosyst.*, 7, Q06007, doi:10.1029/2005GC001130.
- Winkelmann, D. and Stein, R. 2007. Triggering of the Hinlopen/Yermak Megaslide in relation to paleoceanography and climate history of the continental margin north of Spitsbergen. Q06018, doi:10.1029/2006GC001485.
- F. V. De Blasio, A. Elverhoi, L. E. Engvik, D. Issler, P. Gauer, and C. Harbitz, 2006. Understanding the high mobility of subaqueous debris flows. *Norwegian Journal of Geology* 86 (3):275-284.
- P. Gauer, A. Elverhoi, D. Issler, and F. V. De Blasio, 2006. On numerical simulations of subaqueous slides: Back-calculations of laboratory experiments of clay-rich slides. *Norwegian Journal of Geology* 86 (3):295-300.
- S. L. Yang, A. Solheim, T. J. Kvalstad, C. F. Forsberg, and M. Schnellmann, 2006. Behaviour of the sediments in the Storegga Slide interpreted by the steady state concept. *Norwegian Journal of Geology* 86 (3):243-253.
- S. Yang, C. F. Forsberg, A. Solheim, and T. Kvalstad, 2006. Statistical Analysis of Well Logs Compared with the Geotechnical Data in Storegga Slide Area. *Marine Georesources and Geotechnology* 24:237-250.
- S. Yang, T. Kvalstad, A. Solheim, and C. Forsberg, 2006. Parameter studies of sediments in the Storegga Slide region. *Geo-Marine Letters* 26 (4):213-224.
- S. L. Yang, S. Lacasse, and R. F. Sandven, 2006. Determination of the transitional fines content of mixtures of sand and non-plastic fines. *Geotechnical Testing Journal* 29 (2):102-107.
- S.L Yang, R. Sandven and L. Grande, Steady state line of sand-silt mixture. *Canadian Geotechnical Journal*, 43: 1213-1219, 2006.
- Proceedings:
- Shaoli Yang T.Kvalstad A.Solheim and C.F.Forsberg. Slope Stability at Northern Flank of Storegga slide. Proceedings of 17<sup>th</sup> International offshore and polar engineering conference, vol3, 1524-1529, Lisbon, July1-6, 2007.
- Shaoli Yang, F.Nadim and C,F,Forsberg. Probability study on submarine slope stability. Published in Advances in natural and technological hazards research, the third international symposium on Submarine mass movement and their consequences, Santorini, Greece, 161-170, 2007.
- Shaoli Yang, Suzanne Lacasse, Carl Fredrik Forsberg. Application of packing models for binary mixtures, International Conference on Soil Mechanics and Geotechnical Engineering, Japan, 2005.
- Shaoli Yang, Zenon Medina-Cetina and Farrokh Nadim. Uncertainty analysis on remoulded undrained shear strength of marine clay. Accepted by the first international symposium on geotechnical safety and risk, Shanghai, 2007.
- In preparation:
- F.V. De Blasio, A. Elverhøi, C.F. Forsberg, P. Gauer, S. Glimsdal, H. Hafliðason, C.B. Harbitz, D. Issler, T.J. Kvalstad, A. Moen, A. Nygård, A. Solheim, M. Vanneste (in alphabetical order, in prep) The North Sea Fan: An integrated Geohazard Study.

- D. Issler.(in prep)Curvature effects in depth-averaged flow models on arbitrary topography. Planned for Computers and Geosciences
- D. Issler, P. Gauer, A. Moe, and F. Irgens. (in prep a) Flow-Regime Transitions in Granular Gravity Mass Flows – An Extension of the Norem–Irgens–Schieldrop Model. Suggested journals: JGR, JFM, Physics of Fluids, European Physical Journal.
- D. Issler, A. Moe, X. Cui and N. Gray (in prep. B). *D2FRAM* – A general non-oscillatory central difference (NOC) scheme for gravity-driven mass flows. Numerical simulation with the multi-regime, density-dependent, extended NIS rheology
- T.J. Kvalstad, S.L.Yang, S.L. Lee and Å Høisæter, .(in prep). Effect of hydrate dissociation on clay behaviour. Suggested journal: Canadian Geotechnical Journal.
- T.J. Kvalstad, .(in prep). Weak layers in submarine slide events? Comparison of smectites and siliceous oozes with illite dominated marine clays. Suggested Journal: Canadian Geotechnical Journal
- S.L.Yang, A.Solheim, C.F.Forsberg, T.Kvalstad, X.L.Feng, A.L.Li, R.Urgeles .(in prep). Properties of river-fed sediments compared with glacier-fed sediments. Being prepared for EUROMARGIN special Marine Geology issue.

## 1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

### national / international Newspaper articles

- Anonymous. Premiat el mapa del relleu submarí de Catalunya. Barcelona Verda (Ajuntament de Barcelona, monthly magazine), 101 (01.08.05), p. 27.
- Anonymous. El mapa de sota el mar. Presència (Girona), (02.09.05, p.22-23 (weekly magazine).
- Anonymous. El relieve submarino de Catalunya, La Vanguardia (newspaper), 28.07.05, p. 25.
- Canals, M., Casamor, J.L., 2004. Mediterraneo Noroccidental – Relieve submarino; Investigaciony ciencia, (Num. Monografico), p. 27-31, Barcelona, Spain.
- Picó, M.J. and Canals, M., 2006. Valls submarines al descobert; Nat, 13: 24-27.
- Canals, M., 2006. Catàstrofes submarines: una altra cara del conflicte home -natura; VI Trobada de Professors de Ciències de la Terra i del Medi Ambient de Batxillerat, ICE UB - Cosmocaixa, Barcelona 27.01.06.
- Canals, M., 2004. Per les mars del món; 50 años IES Balaguer, Balaguer, Lleida. ESF-EUROMARGINS – 17/03/2006 13 / 31
- Canals, M., 2004. El fons marí com a font d'informació: metodologies aplicades a la reconstrucció del clima, cicles geoquímics i processos marins (with I. Cacho); Seminaris Multidisciplinars del Parc Científic de Barcelona, Barcelona, Spain.
- Canals, M., 2005. 20.000 llegües de viatge submarí. De la ficció a la realitat. El relleu submarí de Catalunya; Ciclo de Conferencias “Els matins del Museu”, Cosmocaixa, Barcelona, Spain.
- Dowdeswell, J.A., 2005. Ice and Environmental Change. Presentation at Backwell School, North Somerset, UK,
- Dowdeswell, J.A., 2006. Ice and our changing climate. Presentation at Bath Festival.
- Pearce, J., 2007. The last Generation: How Nature Will Take Her Revenge for Climate Change. Amazon.co.uk. Interview with EUROMARGIN scientist are published in this book.

## 1 D. Patents and industry collaborations

We (UiTromsø) were partner in the development of a new high-resolution 3D seismic system, which received a Norwegian patent.

Industry collaboration with the hydrocarbon industry of Norway, France and lately the US:

Norsk Hydro and the Seabed Consortium, Statoil, Shell.

## 1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

EUROMARGINS conference, Palau de les Heures, Barcelona, November 2004, organised and hosted by UB, with a large participation and many high-quality contributions which resulted in a successful and profitable meeting for the research teams involved in all 14 Euromargins CRPs.

Edvard Suess session - EUROMARGINS, EGU2005, 28-29 April 2005, Vienna, Austria. 2-day session with both oral and poster presentation covering the 14 EUROMARGINS CRPs, including special attention for Young Scientist presentations. Convened by: J.-Pierre Henriet

EUROMARGINS session European Geophysical Union conference in Vienna, April 2006. Convened by: J. Mienert et al.

EURODOM-EUROMARGINS Slope Stability Course, 29 March – 2 April 2004, Barcelona.

EURODOM-EUROMARGINS Training Course *Processes related to slope stability and fluids in continental margins*. 30-31 May 2005, Tromsø.

EUROMARGINS-SPACOMA workshop, March 2, 2006. NGI, Oslo. Internal evaluation and report preparation where participants presented achievements and future working plans. Publication, networking and data integration were key topics addressed during this workshop.

EUROSTRATAFORM/PROMESS1 annual meeting. 24-27 October, Salamanca, Spain. Visit of young researcher S. Yang (NGI) to UB, for integrating geotechnical parameters of the Mediterranean landslides into the overall slide database at NGI.

NETWORKING between OGS and UB: synergy action with the purpose to organize a 10-day scientific survey (SBAL-DEEP) on the southern Balearic margin within EUROMARGINS-SPACOMA framework as well as HERMES (EU-FP6) and EURODOM (EU-FP5).

UNESCO supported IGCP 511 project established in 2005 including a part time secretary office at the NGI in Oslo. International collaboration and networking is guaranteed through the close collaboration between the EUROMARGINS-SPACOMA researchers and the UNESCO International Geoscience Programme (IGCP), through project N. 511 Submarine Mass Movements and Their Consequences, by J. Locat, J. Mienert, and R. Urgeles, providing multinational platforms for earth scientists to exchange knowledge and methodology on a multitude of geological issues of global importance.

2nd International Conference on Submarine Mass Movements and Their Consequences, September 2005, Oslo, within the IGCP Project N. 511 and EUROMARGINS-SPACOMA..

NETWORKING activity with the Integrated Ocean Drilling Program (IODP) through the European Consortium for Scientific Ocean Drilling (ECORD). A proposal has been submitted both to ECORD and the Spanish Ministry of Research for the organisation within the ESF Magellan Workshop Series for a workshop on *Scientific Ocean Drilling behind the assessment of geo-hazard from submarine slides* scheduled for Summer/Fall 2006. The workshop will be an official activity of the IGCP Project N. 511 (Submarine Mass Movements and Their Consequences).

NETWORKING activity with UiT, Ui Oxford and AWI to enhance the collaboration and prepare the Cruises for the Arctic i(R/V Polarstern, R/V Jan Mayen, R/V James Clark surveys off northern Svalbard).

ESF Magellan Workshop Series. Workshop Scientific Ocean Drilling behind the assessment of geohazard from submarine slides, Barcelona, 2006.

ESF EUROMARGINS session at EGU 2007, Vienna

ESF EUROMARGINS session at Bologna, Italia



IODP-Geohazard workshop with EUROMARGIN-SPACOMA participation (invited), Portland, USA, 2007.

3rd International Conference on Submarine Mass Movements and Their Consequences, September 2007, Santorini, within the IGCP Project N. 511 and EUROMARGINS-SPACOMA.

## 1 F. Participation in other conferences

Please list only the most relevant

Ambblas, D., Canals, M., Urgeles, R., Lastras, G., Hughes-Clarke, J.E., 2004. Seascape of the north-eastern Iberian Margin. EUROMARGINS Conference, 11-13 November 2004, Barcelona, Spain.

Ambblas, D., Urgeles, R., Canals, M., Lastras, G. and Hughes-Clarke, J.E., 2004. The sediment drainage pattern of the Catalan Margin, NW Mediterranean Sea: a view from multibeam and high resolution seismic reflection data. 37th CIESM Conference, 7-11 June 2004, Barcelona, Spain. 37th CIESM Congress Proceedings, vol. 37, p. 4.

Canals, M. and Lastras, G., 2004. Slope instabilities of Western Mediterranean margins; EUROMARGINS Conference; Barcelona, Spain (keynote talk).

Canals, M., Lastras, G., Ambblas, D., Urgeles, R., Acosta, J. and Casamor, J.L., 2005. Slope instabilities on the northeastern Iberian and Balearic continental margins: An overview. Second International Symposium on Submarine Mass Movements and Their Consequences, ICG-NGF Joint Meeting, 4-7 September, Oslo, Norway, Abstracts and Proceedings of the Geological Society of Norway, 2: 23-24.

Lastras, G. and Canals, M., 2004. Slides and related fluid escape features in the Eivissa Channel, Western Mediterranean. 37th CIESM Conference, 7-11 June 2004, Barcelona, Spain, 37th CIESM Congress Proceedings, vol. 37, p. 43.

Lastras, G., Canals, M., Dennielou, B., Droz, L., Ivanov, M., Ambblas, D. and the TTR-14 Leg 3 Shipboard Scientific Party, 2005. The Eivissa slides in the Western Mediterranean Sea: morphology, internal structure and their relation with fluid escape features. International Research Conference on Geosphere -Biosphere Coupling Processes: the TTR approach towards studies of the European and N. African margins, TTR-14 post-cruise conference, 2-5 February, Marrakesh, Morocco. Intergovernmental Oceanographic Commission, Workshop Report n. 197, p. 49-50.

Lastras, G., Canals, M., Ambblas, D., Ivanov, M. and the TTR-14 Leg 3 Shipboard Scientific Party, 2005. The Eivissa slides in the Western Mediterranean Sea: morphology, internal structure and their relation with fluid escape features. EGU General Assembly, 24-29 April, Vienna, Austria. Geophysical Research Abstracts, vol. 7, 02583.

Mienert, J., Vanneste, M., Bünz, S. *Arctic continental margins north of Svalbard show evidence for submarine megasliding and possible gas hydrates*. 19th Winter Conference, 9-12 January 2005, Røros, Norway.

Mienert, J., Vanneste, M., Bünz, S. (invited) *What did we learn from giant submarine slides and their gas hydrate systems offshore the mid-Norwegian margin and the Arctic ?* GEOITALIA 2005, Spoleto, 21-23 September 2005, Italy.

Mienert, J. (keynote) *Slope instability and their consequences*, EGU General Assembly, 24-29 April 2005, Vienna, Austria. Geophysical Research Abstracts. Vol. 7.

Nygård, A.; Sejrup, H.P.; Lekens, W.; Hafliðason, H.; Iversen, H. 2005. High output rates of subglacial till at the outlet of a paleo-ice stream draining the southwestern Fennoscandian Ice Sheet. EGU General Assembly, Wien. Geophysical Research Abstracts. Vol. 7.

Urgeles, R., Lastras, G., Canals, M., Leynaud, D. and Sultan, N., 2004. Triggering mechanisms of a major debris flow off the Ebro margin, NW Mediterranean: the BIG'95. 37th CIESM Conference, 7-11 June 2004, Barcelona, Spain, 37th CIESM Congress Proceedings, vol. 37, p.71.

Urgeles, R., Canals, M., Locat, J., Lastras, G., Hughes-Clarke, J.E. and Ambblas, D., 2004. Multibeam surveys for sedimentary, environmental and hazard assessment, 32nd International Geological Congress, Florence (Italy), 20-28 August/04. Abstracts CD-ROM, Edition.

- Urgeles, R., Amblas, D., Lastras, G., Canals, M., Loubrieu, B. and Hughes-Clarke, J.E., 2005. Submarine erosion insights from the NE Iberian margin. EGU General Assembly, 24-29 April, Vienna, Austria. Geophysical Research Abstracts, vol. 7, 01540.
- Urgeles, R., Leynaud, D., Lastras, G., Canals, M. and Mienert, J., 2005. Back-analysis and failure mechanisms of a large submarine slide on the Ebro slope, NW Mediterranean. Second International Symposium on Submarine Mass Movements and Their Consequences, ICG-NGF Joint Meeting, 4-7 September, Oslo, Norway, NGF Abstracts and Proceedings of the Geological Society of Norway, 2: 88.
- Vanneste, M., Bünz, S., Mienert, J. *Multi-phase Submarine Mega-sliding on the Arctic Continental Margin north of Svalbard: Characteristics, Morphology and Volume Estimates*. International Symposium on Submarine Mass Movement and Their Consequences, 4-8 September 2005, Oslo, Norway. Abstracts and Proceedings of the Geological Society of Norway, 2
- Vanneste, M., Bünz, S., Mienert, J. *Multi-phase submarine mega-slide development on the Arctic continental margin north of Svalbard*. Edvard Suess session - EUROMARGINS, EGU2005, 24-29 April, Vienna, Austria. Geophysical Research Abstracts. Vol. 7.
- Vanneste, M., Mienert, J. *Gas hydrates and slope stability: Examples from the Norwegian- Svalbard margin*. 2nd EUROMARGINS conference, 11-13 November 2004, Barcelona, Spain .
- Winkelmann, D., Jokat, W., Niessen, F., Stein, R., Winkler, A.. The Yermak Slide – New Constraints on Extent and Age, 22nd International Polar Meeting German Society of Polar Research 18 - 24 September 2005 in Jena, Germany.
- Amblas, D, Urgeles, R., Canals, M. and Lastras, G., 2005. Morphogenetic mesoscale analysis of the northeastern Iberian continental margin. EGU General Assembly, 24-29 April, Vienna, Austria. Geophysical Research Abstracts, vol. 7, 06413.
- Hafliðason, H., Sejrup, H. P., Nygaard, A., Gram, I. H. and Bryn, P., 2004. The Holocene (7.250 14C yrs BP) Storegga Slide, Mid-Norwegian Margin: The Modern Analogue To Paleo High Latitude Mega Slides. AGU Fall Meeting, San Francisco.
- Hafliðason, H., Sejrup, H.P., Nygård, A. and Lekens, W., 2005. The age of the Storegga-North Sea Fan mega slides and their timing in relation to sea-level stand. EGU Meeting Vienna, April 2005. Geophysical Research Abstracts. Vol. 7.
- Hafliðason, H., Sejrup, H.P., Nygård, A., 2005. Holocene submarine Mass Movements on the mid-Norwegian Margin and Their Associated Deepwater Turbidite Systems in the Norway and the Lofoten Basin. Amer. Geophys. Union Fall Meeting, San Fransisco .
- Lastras, G., De Blasio, F.V., Canals, M., Elverhoi, A. and Urgeles, R., 2005. Conceptual and numerical modeling of the BIG'95 debris flow, Western Mediterranean Sea. Second International Symposium on Submarine Mass Movements and Their Consequences, ICG-NGF Joint Meeting, 4- 7 September, Oslo, Norway, Abstracts and Proceedings of the Geological Society of Norway, 2: 52-53.
- Ottesen, D., Dowdeswell, J.A., 2005. Submarine landforms and glacier surging in Svalbard, AGU Fall meeting, San Francisco.
- Planke, S., Berndt, C., Eriksen, F.N., Eidem, T.R., Mienert, J., Åsheim, S. *The PCable: Intelligent and versatile acquisition of low-fold, high-resolution 3D seismic data*. Norway. International Symposium on Submarine Mass Movement and Their Consequences, 4-8 September 2005, Oslo, Norway.
- Planke, S., Eriksen, F.N., Eidem, T.R., Berndt, C., Mienert, J., Åsheim, S. *The PCable: Intelligent and versatile acquisition of low-fold, high-resolution 3D seismic data*. 19th Winter Conference, 9- 12 January 2005, Røros, Norway.
- Urgeles, R., De Mol, B., Liqueste, C., De Batist, M., Canals, M. and Hughes-Clarke, J.E., 2005. Sediment undulations off Barcelona's new port: Signs of early slope instability or bottom current sediment waves?, 2nd International Conference on Submarine Mass Movements and their Consequences, 5-7 September/05, Oslo (Norway), NGF Abstracts and Proceedings of the Geological Society of Norway, 2: 90.
- Urgeles, R., Canals, M., Masson, D.G. and Carracedo, J.C., 2005. Evolution of the western Canary Islands and adjacent basin from major flank collapses, 2nd International Conference on Submarine Mass Movements and their Consequences, 5-7 September/05, Oslo (Norway), NGF Abstracts and Proceedings of the Geological Society of Norway, 2: 89.

Vanneste, M., Berndt, C., Mienert, J. *3D seismic imaging of submarine slide development on the Western Svalbard margin*. Edvard Suess session - EUROMARGINS, EGU2005, 24-29 April, Vienna, Austria. Geophysical Research Abstracts. Vol. 7.

Vanneste, M., Bünz, S., Mienert, J. *Multi-phase submarine mega-slide development on the Arctic continental margin off North Svalbard*. 2nd EUROMARGINS conference, 11-13 November 2004, Barcelona, Spain.

Vanneste, M., Mienert, J., Berndt, C. *3D seismic imaging of submarine slide development on the Western Svalbard margin*. 2nd EUROMARGINS conference, 11-13 November 2004, Barcelona, Spain.

Winkelmann, D., Jokat, W., Niessen, F., Stein, R., Winkler, A. (2005). New constraints on slide extent, structure and timing of the Yermak Megaslide north of Spitsbergen, Arctic Ocean, 2<sup>nd</sup> International Alfred Wegener Symposium, 30 Oct - 2 Nov, Bremerhaven, Germany.

Winkelmann, D., Stein, R., Niessen, F. The Yermak Slide north of Svalbard (Arctic Ocean) - Preliminary Results, 2nd EUROMARGINS conference, 11-13 November 2004, Barcelona, Spain.

Yang, S., Kvalstad, T.J., Solheim, A., Forsberg, C.F. Parameter studies of sediments in the Storegga Slide area. EGU, April 2005.

Hogan, K.A., Dowdeswell, J.A., Evans, J., Mugford, R., Noormets, R., and Ó Cofaigh, C., 2006. Past ice-sheet and slide activity on the north and east Svalbard margin. Third EUROMARGINS Conference, CNR Bologna, 4th-7th October 2006.

Hogan, K.A., Dowdeswell, J.A., and Mienert, J, 2006. High-resolution side-scan sonar data from large-scale slope failures on the northern Svalbard and western Norwegian margins (Poster). Third EUROMARGINS Conference, CNR Bologna, 4th-7th October 2006.

Hogan, K.A., Dowdeswell, J.A., Evans, J., Mugford, R., Noormets, R., and Ó Cofaigh, C., 2006. Ice sheet dynamics and large-scale slope failures on the north and east Svalbard margin (Poster). Ocean Margins LINK Programme Science Meeting, Geological Society, London, 15th-16th November, 2006.

Hogan, K.A., and Dowdeswell, J.A., 2007. Erosion, transport and deposition of sediment on the formerly glaciated north and east Svalbard continental margin. European Geosciences Union, Vienna, 16th-20th April, 2007.

*In addition more than 10 in 2006 and 2007!*

Mienert, J., Hafliðason, H., Perez-Garcia, C., Bünz, S., Vanneste, M., 2007, oral. Norwegian margin outer shelf cracking north of Storegga slide, UNESCO IGCP-511 conference: Submarine mass movements and their consequences, 1-3.10., Santorini, Hellas

Mienert, J., 2007, oral invited. Submarine slides on glaciated versus nonglaciated passive margins, IODP – Geohazard workshop, 26-30.08., Portland, USA

Mienert, J., 2007, oral invited. ESF Euromargins – Large scale dynamics and micro-scale processes affecting margins, EGU conference, 15-19.04., Vienna, Austria

## Appendix 2. Scientific & technical personnel involved in the CRP

### Personnel directly funded by the EUROCORES Programme

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

Lastras, G., 2004. Young submarine landslides in the Ebro margin and the Eivissa Channel, Western Mediterranean. PhD thesis, University of Barcelona.

Acosta, J., 2005. The Balearic Promontory: seafloor morphology and sediment cover. PhD thesis, University of Barcelona.

Hogan, Kelly, in prep. PhD thesis started 1,5 years after EUROMARGIN-SPACOMA.

Winkelmann, Daniel, in prep. PhD thesis, finished in 2008

Vanneste, M., 2006. Received a researcher position at ICG- International Centre Geohazard Research, Oslo, Norway.

Nygård, Atle.2006. Received a research position at the University of Bergen

# Swath-seismic mapping of European continental margins (SWATHSEIS)

## Abstract

We propose the development of "swath-seismics" using 9 parallel 9-channel streamers as an antenna to map out sub-surface geology at continental margins. As the width of each swath is approximately twice the water depth, the method can cover areas, several orders of magnitude more quickly than conventional mapping with grids of 2-D seismic lines or multistreamer near-vertical seismics (e.g. 3-D). Targets include tilted fault blocks, serpentinite ridges, the tops of lava flows, the top of the giant Gibraltar Olistostrome and the Bottom Simulating Reflector (BSR). The BSR is associated gas, which occurs at the base of gas hydrates. The method should also be able to image and map fields of diapirs and mud volcanoes. The versatility of the method gives it widespread and diverse application to European continental margins and their conjugates. Mapping of basement structure (faults blocks and lava flows) is particularly relevant for studies of rifting processes at both non-volcanic and volcanic continental margins. Mapping of BSRs and of mud volcanoes and other seeps and vents are essential for studying the fluid flow regime of the margin, and its linkages with the thermal regime, slope stability, neotectonics and gas hydrates. The proposal, thus, has relevance for all three main themes of the EUROMARGINS call for proposals.

## Partners

(DFG, FCT, NFR, NERC)

### **Pr Tim Reston (project leader)**

Christian-Albrechts University, Kiel, Germany

### **Pr Rolf Mjelde**

Universitetet i Bergen, Bergen, Norway

### **Dr Luis Pinheiro**

Universidade de Aveiro, Aveiro, Portugal

### **Pr Graham Westbrook**

University of Birmingham, Birmingham, UK

## Collaborative Research Project (CRP)

(to be completed with information from the ESF database)

### 1. General information

Project Reference Number : 01-LEC-EMA15F

Acronym / Short Title: SWATHSEIS

Full Title: **Swath-seismic mapping of European continental margins**

Project Leader name: Pr Tim Reston

Project Leader affiliation: Christian-Albrechts University, Kiel, DE

Institutional home page (URL): www.ifm-geomar.de

Project-related home page (URL): www.ifm-geomar.de/index.php?id=swathseis

Reporting period: 01/10/2004 to 30/09/2007

### 2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)

#### IP 1

**Pr Tim Reston**, Christian-Albrechts University, Kiel, Germany

Total Funding amount of the IP: EUR 119 400

#### IP2

**Pr Rolf Mjelde**, Universitetet i Bergen, Bergen, Norway

Total Funding amount of the IP: EUR 100.00 for Phase 2, not used (see below)

#### IP3

**Dr Luis Pinheiro**, Universidade de Aveiro, Aveiro, Portugal

Total Funding amount of the IP: EUR 00.00

#### IP4

**Pr Graham Westbrook**, University of Birmingham, Birmingham, UK

Total Funding amount of the IP: EUR 00.00

### 3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

The SWATHSEIS project successfully completed a pilot study indicating the feasibility of using swath-seismics for mapping out the structure of the European continental margin. Swath-seismic is a new idea based on using an array of receivers (hydrophones) to image in all directions and not just directly beneath the sail-line, thus providing a quick (and hence cheap) alternative to traditional 3D seismic. The project showed that the method would work and addressed a number of questions raised by the initial reviewers, thus fulfilling the criteria for further funding during a second phase. For more information please refer to previous documents.

### 4. What did you not achieve in the CRP and why? (max 1 p.)

Please use the original proposal as reference and explain any deviations from the work plan

SWATHSEIS was unable to construct the system designed in the pilot phase because of delays in securing support from the funding agencies for the second phase of the project. Although some funding agencies (e.g. Norway) did reserve funds for the second phase, there was no across the board agreement on how the second phase should be approved. The upshot was that when the pilot phase was completed, the lack of a clear directive from ESF on how to obtain funds for the second phase meant that time ran out for the project before a second phase could begin.

These problems arose from the approval of a pilot phase without specifying a mechanism for assessing the success of the pilot phase and without a procedure for subsequent allocation of financial support to the second phase. The resulting inevitable delays in securing such funding and the imposition of a rigid timetable for the end of the Euromargins programme, meant that the system could not be built within the framework of the project.

### 5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

**5. A.** Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

There are plans within IFM-GEOMAR to construct the SWATHSEIS system and future collaborations with Bergen and Birmingham have been discussed but not within the framework of the ESF or FP7.

**5. B.** Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

Eurocores programmes are in principle an excellent idea. However they can only work if the ESF has clear procedures in place for various contingencies. In our case these would include procedures on how to judge the success of pilot studies and how to guarantee the rapid approval of the necessary funding of successful projects. SWATHSEIS was approved as a pilot phase but no guarantee of continued funding after the completion of the pilot phase existed nor any clear mechanism on how to apply for such funding, with the result that the much of the work of the successful pilot phase could have gone to waste.

### 6. Your feedback on the EUROCORES Programme (max 1 p.)

**6.A.** What, in your view, is the added value of being part of a EUROCORES Programme

**Very little.** The entire pilot project was funded by the DFG and the other partners were not awarded any funds



during this phase. Bergen and Birmingham were involved peripherally but without funds could do little more than offer advice which they would have done outside of the Euromargins programme. They had or could seek funds for the second phase, but the Euromargins timetable and procedural uncertainty prevented this happening as described above.

**6.B.** Give any critical and constructive comments on the EUROCORES Programme and its procedures

The main problem was the lack of clear procedures for the assessment of a pilot study and for a decision on how a second phase could be approved. Such procedures need to be agreed in future Eurocores programmes.

## Appendix 1. List of Products of the CRP

### 1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more** CRPs (if any)

None, as only IFM-GEOMAR took part in the pilot study.

### 1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

Publications on the theory of swath-seismics are in production. However, with plans to build the system at an advanced stage, future papers are to be expected.

### 1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

### 1 D. Patents and industry collaborations

Collaboration with Veritas-DGC, who provided some data for testing the method.

### 1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

### 1 F. Participation in other conferences

Please list only the most relevant

Poster presentation at EGU meeting in Vienna in 2005

Presentations at German Geophysical Society meetings in 2004 and 2005

## Appendix 2. Scientific & technical personnel involved in the CRP

### Personnel directly funded by the EUROCORES Programme

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

Dr Gerald Klein, post-doctoral research assistant (scientific employee) from September 2003 to August 2005.

# Litospheric memory and tectonic (re)activation of volcanic rifted margins and their borderlands: quantitative modelling of North-Western European margin system dynamics (NEMSDYN)

## Abstract

The prime scientific objectives of this EUROMARGINS proposal are to advance understanding of: 1) processes and events during the formation of a volcanic margin, i.e. from onset of rifting to onset of "normal" sea floor spreading; 2) the processes controlling post-breakup history of a volcanic margin. To this aim we have selected the NW European volcanic margin as a natural laboratory. In particular the Mid-Norway Margin offers a comprehensive, high-quality database for an integrated study by a multidisciplinary team of researchers working on constraints for crustal architecture and margin topography and research groups with recognized modelling expertise on lithosphere- and surface-processes in rifted margin systems. This study holds also considerable potential for a close feedback with related complementary EUROMARGINS studies focussing on the collection of new geophysical datasets on deep-crustal architecture offshore Mid-Norway and East -Greenland. At present a unique opportunity exists for EUROMARGINS researchers to make a breakthrough by connecting better understanding of breakup tectonics at volcanic rifted margins to new concepts on tectono-thermal and geomorphological development in volcanic margin borderlands. The natural laboratory of the NW European volcanic margin is extremely well suited for well-constrained numerical and analogue modelling.

## Partners

(DFG, NFR, NWO, CNRS)

### **Pr Paul Andriessen (project leader)**

Vrije Universiteit, Amsterdam, The Netherlands

### **Dr Jean-Pierre Brun**

Université de Rennes 1, Rennes, France

### **Pr Jan Inge Faleide**

Universitetet i Oslo, Oslo, Norway

### **Dr Brian Horsfield and Magdalena Scheck-Wenderoth**

GeoForschungsZentrum Potsdam, Potsdam, Germany

<b>Collaborative Research Project (CRP)</b>
<b>1. General information</b>
<p><u>Project Reference Number</u> : 01-LEC-EMA16F  <u>Acronym / Short Title</u>: NEMSDYN  <u>Full Title</u>: <b>Litospheric memory and tectonic (re)activation of volcanic rifted margins and their borderlands: quantitative modelling of North-Western European margin system dynamics</b>  <u>Project Leader name</u>: Pr Paul Andriessen  <u>Project Leader affiliation</u>: VU University Amsterdam, NL  <u>Institutional home page</u> (URL): www.geo.vu.nl/users/tecroot  <u>Project-related home page</u> (URL): -  <u>Reporting period</u>: 01/10/2004 to 30/09/2007</p>
<b>2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)</b>
<b>IP 1</b>
<b>Pr Paul Andriessen</b> , Vrije Universiteit, Amsterdam, The Netherlands
Total Funding amount of the IP: EUR 348 464
<b>IP2</b>
<b>Dr Jean-Pierre Brun</b> , Université de Rennes 1, Rennes, France
Total Funding amount of the IP: According to my information <u>no funding</u> has been provided for this part of the program
<b>IP3</b>
<b>Pr Jan Inge Faleide</b> , Universitetet i Oslo, Oslo, Norway
Total Funding amount of the IP: EUR 490 000
<b>IP4</b>
<b>Dr Brian Horsfield &amp; Magdalena Scheck-Wenderoth</b> , GeoForschungsZentrum Potsdam, Potsdam, Germany
Total Funding amount of the IP: EUR 176 616 over 36 months

### 3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

**IP1: Integrated modelling on post-breakup margin inversion (post-doc project, Dr C. Pascal, VU Amsterdam).** The focus of this post-doc project at the Free University of Amsterdam is to explore quantitatively (i.e. by means of thermo-mechanical numerical modelling) the geological factors controlling the post-breakup dynamics of the mid-Norwegian margin.

The post-doc, Dr. C. Pascal, left the Free University for a permanent position at NGU Trondheim, Norway in March 2005. Certainly his involvement in the EUROMARGINS program played a decisive role in getting this position. However, the result of this position change was that only part of the research could be accomplished.

The approach taken in this IP1 project is to develop new numerical tools for quantifying gravitational body force, due to topography and density heterogeneities in the deeper lithosphere, and their impact on margins. In order to do so he used seismic data-sets from the literature and those delivered from IP4 of this program and FP1. The outcome of IP1 contribution is a computed lithosphere thickness in the area of the mid-Norway margin and the northern North Sea.

The computed results are compared to the results of seismic tomography studies of the area in order to validate the model. The result is very important for the lithospheric architecture, needed in IP3 and IP4. Within this project the gravitational potential energy was computed in order to establish a comparison with the lithospheric thickness in four profiles running from onshore southern Norway to the North Sea. The obtained results suggest that contrasting lithospheric architecture existing between Norway onshore and the North Sea induced compression by 14 to 20 MPa in the North Sea Basin. This is an important indication for the flexure and basin infill history (IP3 and IP4). At the same time this consideration is valuable for the onshore-offshore erosion-tectonic-sedimentation connection (IP2). In fact the post-doc has continued his research in his new position and collaborated with several researchers from the others IP's.

**IP1 was continued in July 2006 (post-doc project, Dr Th. Mauduit, VU Amsterdam).** The focus of his research is the role of pre-existing lithospheric weak zones in extensional domains in both 2D and in 3D. The approach taken is analogue modelling that allows the laboratory simulation of both 2D and 3D configurations of crust and lithospheric extension. ). In this context it is important to note that the work relationship with the University of Rennes, France, as originally foreseen in the program, is materialised through the IP1 continuation in the direction of analogue experiments and runs.

Despite the very restricted time period, experiments and runs of a set up of a new analogue technique have shown that heterogeneities in the lithosphere control segmentation of the margin and that plume constituting weak zones in the mantle localize the rifting and dramatically change the deformation pattern. The outcome of the experiments has been compared to the observations made in the study region of the Northern Atlantic margin.

The second part addressed the issue of basin migration and thus the locus of sedimentation through time. The approach is a combined analogue and numerical modelling effort, varying the strain rate. Low strain rate resulted in the development of a basin and range type of crustal deformation; high strain rates lead to a much more diffused deformation in the crust, without deep basin to develop. At very high strain rates the experiments show that deformation is localized in the centre of the initial rifts and that sediments should principally be deposited in this region. This finding does not correspond to earlier outcomes of numerical modelling. The experiments are very interesting to IP2, IP3 and IP4. At the same time the results of IP2, IP3 and IP4 have been used to set up the optimal conditions for the analogue experiments. This shows the importance of integrating all the work packages and also shows that a stand alone project would never have achieved the results obtained in the CRP

A possible very important outcome of the experiments is the suggestion that asymmetry of the Greenland-Norway conjugate margins may have been controlled by the inherited lithospheric structure. However due to the restricted time available particularly aspects have to be worked out in more detail in the future and therefore collaboration has been seek for with for example Dr. J van Wijk of the Los Alamos National Centre, new Mexico, USA.

**IP2: Uplift and denudation dynamics of the margin system (PhD project, Mrs drs A Biarc VU Amsterdam).** The focus of IP2 is on constraining timing and quantification of uplift and denudation records onshore, using low temperature geochronometry such as fission track analyses and (U-Th)/He. The aim is to unravel and constrain

vertical motions and their relation to tectonic and surface processes, with special emphasis of the Neogene uplift in southern Norway connected to climate and to compare uplift histories on both sides of the margin.

To constrain the Neogene vertical motion (uplift and denudation) history of southern Norway, apatite grains from apatite separates used for fission track thermochronology were selected and analysed for (U-Th)/He. Unfortunately the (U-Th)/He age results of the apatite were older than the corresponding fission track dates, whereas the reverse trend is expected. It was impossible to extract the Neogene signal with the chosen approach. It was therefore decided to start with the second objective, the low thermal geochronologic constraints on the Greenland margin, in order to compare the uplift and denudation history. The study area in Greenland is the Jameson Land Basin. For that purpose fieldwork and sampling was performed with an international group of geologists, another way of networking. The fieldtrip was very successful and many samples were collected. Vertical and longitudinal profiles have been sampled and analysed by both methods. FT analyses show Upper Triassic- Lower Jurassic cooling, in several cases confirmed by (U-Th)/He apatite dating. However younger (up to Oligocene) signals are also picked up by the (U-Th)/He method. More analyses are needed before final conclusions can be drawn.

Although the focus of the PhD in this program was redirected, the FT study of the Norwegian margin was not abandoned, to the contrary. More analyses were performed at the VU, in London and Trondheim, Norway. This effort of mainly the last decades resulted in an overview article with all available data of Norway, Sweden and Finland, published in 2007. The overview at large and detailed FT studies indicate that crustal scale structures have had a significant influence on topographic development and denudation, therefore giving crucial clues for understanding the evolution and development of the margin and underlining the importance of inherited structures. The obtained information is crucial to understand the development and evolution of the continental margin of Norway.

The CRP was one of the driving forces to complete this achievement, bringing together the contacts and detailed knowledge of the various parts of the Scandinavia and therefore making clear that such an overview is needed for all research groups working in Scandinavia.

**IP3: Structural modelling and modelling of subsidence history in order to reconstruct and quantify the tectono-sedimentary evolution and the generation, migration and alteration of hydrocarbons offshore Norway (PhD project ,A. Cavanagh, and post-doc Y. Maystrenko at GFZ-Potsdam)** The focus of IP3 is to reconstruct the tectono-sedimentary evolution offshore Norway and consequences on the generation, migration and alteration of hydrocarbons.

The main objectives of IP3 are to get in depth understanding of the deformation processes at the Norwegian continental margin and the influence on petroleum systems through time. To achieve this goal a crustal scale 3D structural model of the Vøring and Møre basins, including the continental part and the oceanic part close to the continent transition has been constructed and used as a base for structural analysis. The study areas are the SW Barents Sea and the Vøring Margin. Structural analysis showed that changing patterns of deformation are relevant to understand the opening of the North Atlantic Ocean, but also the fate of petroleum systems in the area. Regional structural analysis and first subsidence analysis showed that the location of depo centres as well as paleo-depth changed repeatedly with time and that subsidence is largely load-induced. The implication of this study is that large quantities of sediments were supplied by fast erosion of the source area, making the link to IP1 and IP2. Modelling of a number of regional 2D lines in the south-western Barents sea established the sensitivity of a petroleum system on the Arctic borderlands of the margin to uplift and erosion for three scenarios belonging to the Cenozoic era. These are Paleocene and Oligocene-Miocene inversions related to North Atlantic Rifting, and a Late Pliocene-Pleistocene inversion related to glacial cycles. Structural reconstruction has been used to quantify the brittle extension that has affected the margin since the beginning of the Cretaceous. The outcome of this part of the study indicates that crustal stretching was differential for the upper and lower crust (decoupled system) and that the largest part of the post-Jurassic subsidence at the Norwegian margin was not related to brittle deformation, but to deeper seated processes. This outcome clearly shows how well IP3 and IP1 and IP2 are interconnected and that integrating these study within the CRP made it possible to obtain the results.

The integral view on the processes controlling the evolution of passive volcanic margins had simply been impossible to attain in another way than within the CRP. The assessment of the structural relationships of different lithospheric levels is unique at the achieved spatial resolution and was only possible due to the joint expertise in geophysical and geological methods with regional expertise and data. Special highlights were (1) that the lithospheric mantle is less dense beneath the ocean than beneath the continent and (2) that model integrating the detailed knowledge of the crust as well as gravity and temperature data put strong constraints on the geometric and thermal configuration of the lithosphere-asthenosphere boundary. A third main result was the quantification of uplift-related changes in

pressure temperature condition and related phase changes in petroleum systems, in particular concerning the impact of glacial (un)loading.

**IP4 Deep structure and vertical movements of the mid-Norwegian margin – onshore -offshore links (2 PhD projects of University of Oslo, University of Bergen)** The activity of the Norwegian IP is subdivided into three interconnected modules, which together focus to advance processes and events during the formation and evolution of the volcanic margin of mid-Norway. This program is closely linked and integrated with the EUROMARGINS program 01-LEC-EMA FP01. Module N1 has as main objective the vertical movement on the mid-Norwegian continental margin, N2 aims at the coast-parallel fault-systems and related differential vertical motions, and N3 module uses the integrated results of the 2 other modules for a quantitative modelling. IP4 is closely linked to IP3, IP2 and IP1 as is shown also by the joint publications.

**N1: Offshore studies – Norwegian continental margin** Off mid-Norway, a series of regional 2D crustal transects across the margin have been constructed based on an integrated analysis of deep wide-angle seismic data (OBS and ESP), deep and standard multichannel seismic (MCS) reflection profiles, potential field data, heat flow, and scientific and commercial boreholes. The regional crustal-scale profiles have been distributed to groups, both within EMA16 and others, that have use them as constraints in their quantitative modelling to enhance understanding of key processes in volcanic margin formation and evolution (see N3 below).

**N2: Onshore studies – Coastal regions of central Norway** The onshore activities built on recent year's advances in understanding the tectonic evolution of Central Norway and the Mid-Norwegian Shelf. These results include the position and importance of major Late Caledonian extensional detachment zones, which can be traced offshore, where they appear to affect the later structuring of the shelf. Recent work onshore has unraveled several events of mainly brittle reactivation within the detachment zones; events which differs both in transport direction and the character of deformation. Apatite Fission Track (AFT) studies have resolved differential uplift of structural blocks in the Mesozoic of the coastal Trøndelag region. Field work has been carried out in selected regions, both above and below the major detachment zones. We have also studied the intersection between the west-coast N-S structural grain and the NE-SW trending Møre-Trøndelag Fault Complex. These two structural trends also represent the main grain of the Mid-Norwegian Shelf.

**N3: Modelling** Both 2D and 3D quantitative modeling has been carried out by GFZ Potsdam. UiO and IRIS have established the geohistory by backstripping and restoration of the EUROMARGINS transects, while IFE has focused on tectonomagmatic processes in their forward modelling. All modeling initiatives have addressed the vertical motion and temperature histories of the continental margin, and any impact of the break-up related magmatism. We have also initiated collaboration with PGP (Physics of Geological Processes – a Centre of Excellence at University of Oslo) on 3D modeling of stress to enhance understanding of relations between deep and surface processes. The Norwegian modelling efforts will continue as part of the NFR Petromaks project and through collaboration with other institutions.

The CRP has resulted in interdisciplinary work linking together important data and results from both offshore and onshore studies. Through quantitative modeling we have improved the understanding of important processes in the formation and evolution of volcanic margins. The CRP has contributed to closer collaboration between the Norwegian modeling groups and established links to relevant groups abroad. The various modeling groups have applied different modeling approaches/strategies and tools on the same set of constraints. These make possible a very interesting comparison of the modeling results/predictions.

In summary it can be said that this ESF CRP was very successful and gained a lot of new and complementary outcome and therefore improving our understanding of the processes operating and being active at and during continental margin development and evolution, the main purpose of this program.

*We did not present any figures, because of the urgent request of the ESF office to be restrictive in space. Figures of all important outcomes of this successful CRP are of course available.*



#### 4. What did you not achieve in the CRP and why? (max 1 p.)

Please use the original proposal as reference and explain any deviations from the work plan

We have covered most of the planned activities, but some of the results are delayed or not completely finished as foreseen. The main reason is one post-doc (Dr C. Pascal, VU Amsterdam) left for a permanent position (Trondheim Norway) and 2 PhD students (Oslo University and University of Bergen) left for jobs in the industry. One PhD position (University Bergen) was replaced and the thesis will be completed in August 2008. The PhD at VU Amsterdam had a delay of 8 months because of a serious illness and the thesis will be completed at the end of 2008.

(U-Th)/He apatite analysis of samples from southern Norway turned out to yield odd results, a feature that is encountered at various other sites in Scandinavia and other old cratons all over the world. So It was impossible to detect the Neogene (climate?) signal with this approach. However, although not very clear yet, detailed FT analyses indicate that crustal scale structures have had a significant influence on topographic development and denudation. Many joint papers and abstracts were produced within and through the CRP, dealing with important subparts and collaborations between the PI's, showing the success of the EUROMARGIN program. It has also been possible to link up with another EUROMARGIN program, but mainly due to overlapping in personnel. The overall integration turned out to be much more difficult, despite mutual workshops in Oslo and Potsdam, mutual visits and networking. The main reason has been that not all projects have started at the same time and because of the turnover of the temporary researchers during the course of the program. Nevertheless the program has been very successful and almost all planned activities described in the proposal have been covered.

#### 5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

**5. A.** Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

The PI's of the IP's have been very active in being again PI's in new research programs and projects:

- The modelling activities in EMA16 have been followed up in the party overlapping NFR Petromaks project (VOTEC) and through collaboration with University of Liverpool in their industry funded MM2 project (prof. dr. Jan-Inge Faleide and his team).
- Results from EMA16 have also formed the basis for new proposals submitted to the ESF EUROCORES TOPO-EUROPE program and the NFR Petromaks program (prof. dr. Jan-Inge Faleide and his team).
- Several new projects have been developed and submitted within ESF TOPO-EUROPE (Topo-WIBA, LITHMEM): (Dr. M Scheck-Wenderoth and her team).
- NorMar: a joint program of the universities of Delft, Utrecht and Vu Amsterdam within the Top research school ISES in the Netherlands (prof. dr P. Andriessen and his team)
- A new CRP and several new projects submitted within the ESF TOPO-EUROPE initiative (TOPO Source/Sink, TOPOCaucasus, ThermoTopo, TOPO-WIBA) (prof. dr P. Andriessen and his team).
- Collaboration between University of Oslo (Physics of geological Processes, VU Amsterdam, Cambridge University and California State University: Exhumation history of the Scorebysund and Kong Oscars Fjord region, East Greenland (prof. dr P. Andriessen and his team).

**5. B.** Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

The success of the follow-up EUROCORES TOPO-EUROPE initiative shows to my opinion one very important aspect. The bottom up procedure of researchers designing and developing a major research program involving almost all countries in Europe is a need. Too many programs within Europe are top-down, making them partially political. So the priority for ESF is to support and facilitate such bottom-up initiatives coming from researchers within the discipline. More and more the researchers feel the need that they should be supported in this aspect. Cross bridging programs like the ESF EUROCORES should however also include funding for workshops and long term visits between the research sites, enabling sharing facilities and transferring know-how between the young researchers. At the

same time funding for costly investments should be made possible through these programs.

## **6. Your feedback on the EUROCORES Programme (max 1 p.)**

### **6.A.** What, in your view, is the added value of being part of a EUROCORES Programme

The main advantage participating in EUROCORES is the networking with other (sub) disciplines across institutional and political boundaries. Sharing data and know-how triggers new developments in approach, methods and complementarities. New projects and collaboration have been developed and established, for instance within the ESF EUROCORES TOPO-EUROPE programs with partners in formerly separate CRP's.

For the young researchers employed through these ESF programs the added value is working within a bigger program, meeting and discussing with experts in several fields, sharing know-how and data. It also gives them the opportunity to make use of data and results from other partners and thus put their own data and findings in a larger perspective and context. This enables them to publish in better journals and together with international well known experts from outside their own institution. For young researchers the ESF programs are ideal for networking, yielding great opportunities for their future career. However, the disadvantage is that they are offered jobs elsewhere or by the industry, before finishing their part in the program as happened in our ESF EUROMARGINS Program.

### **6.B.** Give any critical and constructive comments on the EUROCORES Programme and its procedures

One critical remark concerns the development of new initiatives as experienced during the EUROMARGIN program and TOPO-EUROPE. In both cases partners from different countries are very enthusiastic and seek ways to join. The partners are not arbitrary; no they form the core of the initiative. However for several countries the problem arises about funding support from their national research agencies. In some countries there is no problem, but this is unfortunately not the case for all countries. For program leaders an uncertain situation occurs and may jeopardise in the worst case scenario the initiative and therewith the effort of all other countries involved. This aspect makes the ESF program rather vulnerable and it is recommended to find ways to solve this issue.

Another point to be made is the following. Program leaders are supposed to put quite some time in running these research program. In the case of big programs, with many countries involved, running and managing the program may take substantial time to do it properly. The problem that occurs related to this issue is that it is impossible to request for managerial money. ESF should consider this point and try to solve this.

## Appendix 1. List of Products of the CRP

### 1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more** CRPs (if any)

Joint publication between EMA16 and EMA01:

Scheck-Wenderoth, M., Raum, T., Faleide, J.I., Mjelde, R. and Horsfield, B. (2007) The transition from the continent to the ocean - a deeper view on the Norwegian Margin. *Journal of the Geological Society*, 164, 4, 855-868.

### 1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

**In bold are given the joint publication within the CRP**

Cavanagh, A. J.; Di Primio, R.; Scheck-Wenderoth, M.; Horsfield, B., 2006: Severity and timing of Cenozoic exhumation in the southwestern Barents Sea. *Journal of the Geological Society*, London, 163, 1-14.

Cloetingh, S., Ziegler P.Z., Beekman, F., Andriessen, P.A.M., Matenco, L., Bada, G., Garcia-Castellanos, D., Hardebol, N, Dezes, P. and Sokoutis, D. (2005). Lithospheric memory, state of stress and rheology: neotectonic controls on Europe's intraplate continental topography. *Earth Science Reviews* (24) 241-304.

Cloetingh, S.A.P.L, Ziegler, P.A., Beekman, F., Andriessen, P.A.M. , Hardebol, N, & Dezes, P (2006). Thermo-mechanical controls on Alpine deformation of NW Europe. In: Gee, D.G. & R. A. Stephenson, R.A. (eds) *European Lithosphere Dynamics*. Geological Society, London, *Memoirs*, 32, 113-127.

Cloetingh, S.A.P.L. , Ziegler, P.A., Bogaard, P.J.F., Andriessen, P.A.M., Artemieva, I.M., Bada, G., Balen, R.T. van, Beekman, F., BenAvraham, Z., Brun, J.P., Bunge, H.P., Burov, E.B., Carbonell, R., Facenna, C., Friedrich, A., Gallart, J, Green, A.G., Heidbach, O., Jones, A.G., Matenco, L.C., Mosar, J, Oncken, O., Pascal, C., Peters, G., Sliupa, S., Soesoo, A., Spakman, W., Stephenson, R.A., Thybo, H., Torsvik, T.H., De Vicente, G., Wenzel, F. & Wortel, M.J.R. (2007) The geoscience of coupled deep Earth-surface processes. *Global and Planetary Change*, 58(1-4), 1-119.

**Gabrielsen, R.H., Braathen, A., Olesen, O., Faleide, J.I., Kyrkjebø, R. & Redfield, T. (2005) Vertical movements in south-western Fennoscandia, regions and processes: a review from the Present to the Devonian. *Norwegian Petroleum Society Special Publication 12, 1-28.***

Hendriks, B. W. H. & Redfield, T. F. (2005) Apatite fission track and (U-Th)/He data from Fennoscandia: An example of underestimation of fission track annealing in apatite, *Earth and Planetary Science Letters* 236, 443- 458.

**Hendriks, B., Andriessen, P., Huigen, Y., Leighton, C., Redfield, T. Murrell, G., Gallagher, K. & Nielsen, S.B. (2007) A fission track data compilation for Fennoscandia. *Norwegian Journal of Geology*, vol 87, 143-155.**

Henriksen, H., & Braathen, A. (2005) Effects of fracture-lineaments and in situ rock stresses on groundwater flow in hard rocks: A case study from Sunnfjord, Western Norway. *Hydrogeology Journal*. ISSN: 1431-2174 (Paper) 1435-0157 (Online).

Lindanger, M., Gabrielsen, R.H., & Braathen, A., in press: On scaling relationships of fault core lenses. *Norwegian Journal of Geology*.

Mjelde, R., Raum, T., Breivik, A., Shimamura, H., Murai, Y., Takanami, T., Brekke, H. & Faleide, J.I., 2005. Crustal structure of the Vøring Margin, NE Atlantic derived from OBS-data: geological implications. In: Doré, A.G. & Vining, B. (eds) *Petroleum Geology: North West Europe and Global Perspectives - Proceedings of the 6th Petroleum*

Geology Conference. Geological Society, London, p. 803-813.

Olsen, Å.E.V., Gabrielsen, R.H., Braathen, A. & Redfield, T.F. Fault systems marginal to the Møre-Trøndelag Fault Complex, Central Norway. Norwegian Journal of Geology.

Osmundsen, P.T., Braathen, A., Sommaruga, A., Eide, E., Skilbrei, J.R., Olesen, O., Nordgulen, Ø. Roberts, D., Andersen, T.B. & Mosar, J., 2005: Metamorphic core complexes and gneiss-cored culminations along the Mid-Norwegian margin: an overview and some current ideas. Norwegian Petroleum Society Special Publication 12, 29-42.

Osmundsen, P.T., Eide, E., Haabesland, N.E, Roberts, D., Andersen, T.B., Kendrick, M., Bingen, B., Braathen, A., & Redfield, T.F., 2006: Kinematics of the Høybakken detachment zone and the Møre-Trøndelag fault complex, Central Norway. Journal of the Geological Society, London 163, 303-318.

**Pascal, C. Roberts, D & Gabrielsen, R. H., (2005). Quantification of neotectonic stress orientations and magnitudes from field observations in Finnmark, northern Norway. Journal of Structural geology 27, 859-870.**

Pascal, C., Ebbing, J. & Skilbrei J.R. 2007 Interplay between the Scandes and the trans-Scandinavian Igneous belt: Integrated thermo-rheological and potential field modelling of the central Scandes profile. Norwegian Journal of Geology, vol 87, 3-12.

**Redfield, T. F., Braathen, A., Gabrielsen, R.H., Torsvik, T.H. & Andriessen, P. A. M. (2005) Late Mesozoic to Early Cenozoic components of vertical separation across the Møre-Trøndelag Fault Complex, Norway. Tectonophysics 395, 233-249.**

Redfield, T. F., Osmundsen, P. T. & Hendriks, B. W. H. (2005) The role of fault reactivation and growth in the uplift of western Fennoscandia. Journal of the Geological Society, London, Vol. 162, 2005, pp. 1013-10.

Tsikalas, F., Faleide, J.I., Eldholm, O. and Wilson, J. (2005) Late Mesozoic-Cenozoic structural and stratigraphic correlations between the conjugate mid-Norway and NE Greenland continental margins. In: Doré, A.G. & Vining, B. (eds) Petroleum Geology: North West Europe and Global Perspectives - Proceedings of the 6<sup>th</sup> Petroleum Geology Conference. Geological Society, London, p. 785-801.

### 1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

Not applicable

### 1 D. Patents and industry collaborations

On the Norwegian margin we have established a long-term and close collaboration with the petroleum industry. Our CRP has further strengthened the links between academia and industry.

### 1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

Networking workshop in Oslo: 15-17 April 2004, Euromargins workshop of EMA16/EMA01/EMA17 members, Oslo

Networking workshop in Oslo: 23 -24-January 2006, workshop of EMA16/EMA01 members from GFZ-Potsdam and University Oslo in Oslo

Networking workshop at GFZ Potsdam: Synthesis of projects at the North Atlantic margin, 19-20 February 2007, together with CRPs Magmatic evolution (FP13) and Conjugate margins (FP01)

### 1 F. Participation in other conferences

2004

Faleide, J.I., Tsikalas, F. & Eldholm, O.: "Lofoten-SW Barents Sea and NE Greenland margins in the NE Atlantic: evolution of conjugate continental margins in a regional rift-shear tectonic setting". European Geosciences Union (EGU) 1<sup>st</sup> General Assembly, April 25-30, 2004, Nice, France.

Faleide, J.I., Tsikalas, F. & Eldholm, O.: "Evolution of conjugate continental margins in a regional rift-shear tectonic setting: the Lofoten-SW Barents Sea and NE Greenland margins in the NE Atlantic". "Arctic Geology, Hydrocarbon Resources and Environmental Challenges" Conference, May 24-26, 2004, Tromsø, Norway.

Tsikalas, F., Kuszniir, N.J. & Faleide, J.I.: "Crustal architecture and depth-dependent lithosphere stretching of the northern Vøring and Lofoten segments of the Norwegian margin: along strike variation across the Bivrost Transfer System". GeoMod 2004 "From Mountains to Sedimentary Basins: Modelling and Testing Geological Processes", June 9-11, 2004, Emmetten, Lake Lucerne, Switzerland.

Hendriks, B.W.H., Andriessen, P.A.M., Huigen, Y.D., Murrell, G.R.M. & Redfield, T.F. (2004) An Apatite Fission Track data compilation for Fennoscandia. 10th International conference on Fission Track Dating and Thermochronology, August 8-13 2004, Amsterdam, the Netherlands.

Faleide, J.I., Tsikalas, F., Breivik, A.J., Engen, Ø, Wilson, J., Eldholm, O. & Ren, S.: "NE Atlantic Late Mesozoic-Cenozoic evolution and links to the Arctic". 32<sup>nd</sup> International Geological Congress (IGC), August 20-28, 2004, Florence, Italy.

Tsikalas, F., Faleide, J.I. & Eldholm, O.: "Cenozoic development of the conjugate margins off NE Greenland and Norway". 32<sup>nd</sup> International Geological Congress (IGC), August 20-28, 2004, Florence, Italy.

2005

A.I. Biarc, P.A.M. Andriessen, J. Juez-Larré, E.H. Hartz, C. Pascal: Timing of the vertical movements of the Northern European margin system. European Geosciences Union, Vienna, Austria, 24-29 April 2005

Cavanagh A. J., Di Primio R., Horsfield B.: Thermal history, ice loading and inversion of the southwestern Barents Sea as revealed by basin modelling. European Geosciences Union, Vienna, Austria, 24-29 April 2005.

Cavanagh A. J., Di Primio R., Horsfield B.: Thermal history, ice loading and inversion of the southwestern Barents Sea as revealed by basin modelling. EUCOP II European Conference on Permafrost, Potsdam, 12-16 June 2005.

Cavanagh A. J., Di Primio R., Scheck-Wenderoth M., Horsfield B.: Basin Modelling of Exhumation in the Petroleum Systems of the South-Western Barents Sea. AAPG Paris, 11 -14 September, 2005.

Faleide, J.I., Mjelde, R., Tsikalas, F., Breivik, A.J., Raum, T., Wilson, J. & Eldholm, O.: "EUROMARGINS research on the Norwegian continental margin – towards a regional 3D model of the crustal architecture and evolution". Norwegian Geological Society 19<sup>th</sup> Congress, January 9-12, 2005, Røros, Norway.

Faleide, J.I., Andriessen, P.A.M., Jokat, W., Scheck-Wenderoth, M., Geoffroy, L., Hertogen, J., Mjelde, R., Tsikalas, F. & the NE Atlantic EUROMARGINS Team: "Dynamics of conjugate volcanic margins". European Geosciences Union (EGU) General Assembly, April 24-29, 2005, Vienna, Austria (Keynote oral presentation).

Redfield, T.F., Osmundsen, P.T. & Hendriks, B.W.H. (2005) Fault reactivation and the Cenozoic uplift of western Norway. European Geosciences Union (EGU) General Assembly 2005, April 24-29, 2005, Vienna, Austria.

Scheck-Wenderoth, M., Eue, E., Faleide, J.I., Mjelde, R., Di Primio, R. & Horsfield, B.: "Deformation at the Norwegian Continental Margin". European Geosciences Union (EGU) General Assembly, April 24-29, 2005, Vienna, Austria.

- Solheim, M., Eliassen, H., Braathen, A., & Venvik, G., 2005. Mesozoic to recent (?) faulting in coastal Mid-Norway; examples from Frøya and adjacent areas. Norwegian Geological Society 19<sup>th</sup> Congress, January 9-12, 2005, Røros, Norway. Abstracts and Proceedings of the Geological Society of Norway 1-2005, p. 111.
- Tsikalas, F., Faleide, J.I., Eldholm, O. & Wilson, J.: "Conjugate mid-Norway and NE Greenland continental margins: Late Mesozoic-Cenozoic tectono-stratigraphic correlations and margin evolution". EGU General Assembly 2005, April 24-29, 2005, Vienna, Austria.
- Scheck-Wenderoth, M., Eue, D., Faleide, J.I., Mjelde, R., di Primio, P. & Horsfield, B. (2005) Deformation at the Norwegian Continental Margin. AAPG Annual Convention, June 20-24, 2005, Calgary, Canada.
- Hendriks, B.W.H. & Redfield, T.F. (2005) Evidence for underestimation of long-term FT annealing in apatite from natural FT and (U-Th)/He data. Goldschmidt meeting, Moscow Idaho.
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## Appendix 2. Scientific & technical personnel involved in the CRP

### Personnel directly funded by the EUROCORES Programme

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

#### IP1:

Dr. C. Pascal	Post-doc	VU Amsterdam	01.10.2003 – 01.03.2006
Dr. T. Mauduit	Post-doc	VU Amsterdam	15.07.2006 – 01.02.2007
Mrs. Drs A. Biarc	PhD	VU Amsterdam	01.06.2004 – 31.05.2008

#### IP3: (only had personnel co-funded by EUROMARGINS)

Jonas Wilson	PhD	Univ. Oslo	01.01.2004 – 30.06.2005
Morten Solheim	PhD	Univ. Bergen	01.06.2004 – 01.03.2005
Eivind Bastesen	PhD	Univ. Bergen	01.12.2005 – 15.08.2008

Wilson and Solheim left for industry positions before completing their PhD degree.

Bastesen replaced Solheim and will complete his PhD study in August 2008.

#### IP4:

Dr. Andrew Cavanagh	Post-doc	GFZ, Potsdam	15.11.2003 – 01.03.2006
Dr. Yuryi Maystrenko	Post-doc	GFZ, Potsdam	2006 – 2007
Mrs Dorothea Eue	student	Freie Universitaet/GFZ Potsdam	01.04.2005 – 01.08.2005

# Sedimentation processes on the Portuguese margin: the role of continental climate, ocean circulation, sea level and neotectonics (SEDPORT)

## Abstract

The collaborative project SEDPORT aims to investigate the impact of strong climatic oscillations that have occurred in the North Atlantic and over adjacent continents on sedimentary processes and depositional features on the Portuguese shelf and upper slope. Major goals are to better determine the influence of biological productivity, subaerial and submarine sediment transport mechanisms on the composition and properties of margin sediment cover during the last glacial-interglacial transition in comparison to modern mean environmental conditions. Hereby special emphasis is given to the question of how these sedimentation processes may have changed under varying climate conditions that affected ocean circulation, sea-level, and continental weathering, vegetation and precipitation since the last Ice Age into the Late Holocene. Land-ocean linkages and source to sink relationships for terrigenous material are of particular interest. A synoptic palaeoenvironmental reconstruction of a passive margin including the coastal zone, shelf and slope, taking into account the significant influence of transport and sedimentation processes under varying climates in the hinterland and the ocean, is anticipated as the final product of SEDPORT. For this purpose, comprehensive data sets of sedimentological and compositional parameters from shelf and slope surface sediments and sediment cores will be compiled from existing archives, newly generated data and studied in detail considering palaeoclimatic/environmental mechanisms. This all will be put in context with studies of satellite images and documentation of particle transport through the water column with sediment trap deployments, camera systems, and a underwater remotely operated vehicle (ROV) as well as with an estuarine sediment record from the Tagus valley.

## Partners

(CNRS, FCT, NWO)

### **Pr Ralph Schneider (project leader)**

Institut für Geowissenschaften der Universität Kiel, Kiel, Germany

### **Dr Fatima Abrantes**

Instituto Nacional de Engenharia, Tecnologia e Inovação, Alfragide, Portugal

### **Pr Dick Kroon**

Vrije Universiteit, Amsterdam, The Netherlands

## Collaborative Research Project (CRP)

### 1. General information

Project Reference Number : 01-LEC-EMA17F

Acronym / Short Title: *SEDPORT*

Full Title: **Sedimentation processes on the Portuguese margin: the role of continental climate, ocean circulation, sea level and neotectonics**

Project Leader name: *Pr Ralph Schneider*

Project Leader affiliation: *Institut für Geowissenschaften der Universität Kiel, DE*

Institutional home page (URL): [www.gpi.uni-kiel.de](http://www.gpi.uni-kiel.de)

Project-related home page (URL): -

Reporting period: 01/10/2004 to 30/09/2007

### 2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)

#### IP 1

**Pr Ralph Schneider**, Institut für Geowissenschaften der Universität Kiel, Kiel, Germany

Total Funding amount of the IP: EUR 329 000

#### IP2

**Dr Fatima Abrantes**, Instituto Nacional de Engenharia, Tecnologia e Inovação, Alfragide, Portugal

Total Funding amount of the IP: EUR 90 000

#### IP3

**Pr Dick Kroon**, Vrije Universiteit, Amsterdam, The Netherlands

Total Funding amount of the IP: EUR 477 100

### 3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

The SEDPORT project aimed to investigate the impact of strong climatic oscillations that have occurred in the North Atlantic on sedimentary processes and depositional features on the Portuguese shelf and upper slope. The influence of biological productivity, fluvial and submarine sediment transport mechanisms on the composition and properties of margin sediments should be determined, covering the last glacial-interglacial transition to unravel how these sedimentation processes may have changed under varying climate conditions that affected ocean circulation, sea-level, and continental weathering, vegetation and precipitation since the last Ice Age into the Late Holocene. The CRP SEDPORT established a multi-proxy analysis of two high sedimentation shallow water sedimentary sequences recovered off Lisbon (Portugal) which allow a view of continental climate, oceanic conditions and biological response over the last 100 years. Sea Surface Temperature (SST) is derived from alkenones, upwelling strength indicated by diatom abundance, river input and indirectly precipitation, are indicated by Fe concentration and Sea Surface Salinity (SSS) derived from planktonic foraminiferal isotopes. The comparison of these proxy records to historical instrumental time series of marine and atmospheric parameters (SST, Sea Level Pressure, Precipitation, River Flow and Upwelling Intensity) provide important information relative to the validity of those proxies. Besides, calibration of the available proxies is being attempted by multiple regression with the objective of defining the statistical relation between the different proxy records, the river flow, and upwelling intensity, making available transfer equations to quantitatively reconstruct those processes back in time. Subsequently, paleoenvironmental reconstructions provided evidence for changes in past temperatures, marine biological productivity, continental weathering, and for sediment transport mechanisms on Holocene fluvial sediment accumulation in the vicinity of the Tagus river, including the coastal zone, shelf and slope.

Surface samples from four different regions along the western Portuguese shelf were analysed in terms of the provenance of their organic matter. In the North, off the Douro River mouth, river discharged, continental input is combined with marine produced material. Surface sediments inside the Tagus Estuary show a clear imprint of continental organic material. The decrease of continental organic contributions on the Tagus mud belt is visible by an increasingly marine source signature in the organic matter off the Tagus Estuary mouth. The southern sampling region off Cape Sines is characterised by exclusively marine input, due to the absence of major rivers. Camera and hydroacoustic investigation with a remotely operated vehicle (ROV) and with a parametric echosounder system along the coast revealed a highly variable sediment texture with sharp boundaries between different sediment textures. An evaluation of changing sediment properties during the past 3 000 years was obtained by a multi-proxy analysis of gravity cores from the Tagus Prodelta. The proxy data show only weak changes in the marine climate conditions and in the quantity of organic matter contribution from land. In contrast, physical sediment properties such as magnetic susceptibility and grain-size indicate changes in sediment supply and transport mechanisms around 2 000 and 600 years BP. Grain-size analysis yielded three lithogenic modal size distributions (end-members), which are clearly related to organic and inorganic sediment properties. The magnetic susceptibility signal is carried by the finest end-member, organic carbon is related to an intermediate end-member and the calcium carbonate correlates with the coarsest sediment component. Variance in the different components shows a correlation with the North Atlantic Oscillation.

On the shelf, magnetic susceptibility, grain-size and XRF Fe data as well as <sup>210</sup>Pb and AMS <sup>14</sup>C dating of sedimentary sequences have allowed the identification of an "instantaneous deposit" at about 20 cm in the box-cores. Downcore we could establish a hiatus corresponding to 355 years of sedimentation at both sites: a 39 cm "instantaneous deposit" of coarse material including carbonate broken shells on the SSW site; and a 1.5 m "instantaneous deposit" of fine material on the W site. Both hiatus and instantaneous deposits are considered to originate from a tsunami event. The box-cores deposit has an estimated age of 1969 AD and it is attributed to the 1969 earthquake caused tsunami. The hiatus and deposits found downcore are believed, due to the age limits encountered, to represent the 1755 Lisbon major earthquake related tsunami. These data further indicate a sediment deposit similar in type and thickness on both SSW and W sites in 1969, while the 1755 AD record indicates a higher energy backwash along the SSW and a preferential deposition of fine suspended matter towards the W.

In the deep realm, changes in thermohaline circulation play a major role, particularly during the Deglaciation. Changes in sea level affect both settings by quantitatively changing the supply of terrigenous sediment to the deep sea and by changing the volume of sediment accommodation space on the shelf. The frequency of turbidites has been timed in a deep-sea core based on a chronostratigraphy utilizing  $^{21}\text{C}$  ages, oxygen stable isotopes and paleomagnetic key global anomalies. Higher frequency of turbidites, recorded in a levee located between the Tagus and the Sado submarine canyons at a water depth of 4602 m, occurs at lowering sea levels controlled by Northern Hemisphere rapid temperature fluctuations, such as cold Heinrich-events and Dansgaard-Oeschger stadials. Slope instability on the Portuguese Margin is induced by 15-30 metres sea level variations caused by millennial scale abrupt climate oscillations during Marine Isotope Stage (MIS) 3. As widely known in the geological record, a pronounced large sea level changes on orbital (interglacial-glacial) scales have also generated higher turbidity frequency during the last glacial MIS 2 than during the Holocene. Additionally, the postglacial sea level rise leads to a relocation of the upwelling cells from the shelf edge onto the shelf, which becomes evident by nutrient proxies.

The long CALYPSO deep-sea sediment cores also provided insights into the climate variability during MIS 9 to 17 revealing centennial-scale SST and stable isotope variability for surface and deep water dwelling foraminifera. During MIS 9 and MIS 11 SST were warmer than during the current interglacial (MIS 1) and warm SST prevailed for 30 ka during MIS 11.3. The glacial inception from MIS 11.3 to 10 and glacial stages MIS 12 and 10 experienced millennial-scale temperature oscillations, similar to the variations observed during the last 80 ka. Changes in the bottom water are related to a deepening of the North Atlantic Deep Water (NADW) and Mediterranean Outflow (MOW) interface. While interglacial periods recorded the presence of NADW (like today), periods of climate deterioration were associated with an increasing influence of a deeper flowing MOW with MOW then being the dominating water mass during full glacial periods. Based on the benthic stable isotope data the presence of MOW was only assumed, so that trace element ratios in benthic foraminifera shells were measured to obtain information on the bottom water temperatures (new research topic performed within the framework of the FCT funded project PORTO). In addition, the first results from core MD03-2699 are in part the basis for a proposal on trace element studies during interglacials submitted to FCT in 2006.

The land-sea correlation of sediment properties and climate proxy records is still an open task and has to await the final data from-land drilled cores performed by the Dutch partner of SEDPORT. However, from the existing sediment core and echosounder data it was possible to calculate a rough budget for sediment transport from Tagus valley to the Tagus mud belt on the shelf. The estimate proposes that in about 12.000 years 11.5 Km<sup>3</sup> of fine sediment deposited in the lower Tagus valley, which implies a sedimentation rate in the order of 0.2 cm/yr. On the other hand, the prodelta volume on the shelf estimated from seismics and morphology reveal a deposit of  $\pm 9.800$  Km<sup>3</sup> of fine sediment for the same time interval, that is, a sedimentation rate of 0.3 cm/yr. A rough estimation of the volume of sediment deposited in the prodelta during the last 13.5 kyr, and the values estimated from the mean annual river suspended load, make it apparent that only 4% of the load transported into the ocean was deposited in this shallow water body, that is, most of the suspended sediment transported by the river is likely to escape to the deep basins through the canyons.

The work so far accomplished on the land reconstructions include fieldwork for data gathering comprising 16 weeks core drilling in 2004 and 2005 on 6 transects on the Tagus floodplain by means of 124 manual coring operations. Transects were evenly distributed from north to south over the Lower-Tagus floodplain, perpendicular to the valley axis. 4 mechanical deep cores to a maximum depth of 51 m were evenly distributed from north to south over the Lower Tagus floodplain and 15 geo-electrical measurements were done in the Lower Tagus Valley. Additional geological and geotechnical data from boreholes in the Lower Tagus Valley were gathered from INETI and other Portuguese companies and institutions. For comparison with the marine records samples from marine core for grain-size and pollen studies were performed at very high temporal resolution. From these core data, together with a total of 50 radiocarbon dates from terrestrial cores, lithological cross sections were constructed based on the 6 cored transects and data from geotechnical studies for the construction of bridges in the Lower Tagus Valley, which finally led to the construction of 5 palaeogeographic maps using ArcGIS software.

The major results from the land-based study comprise identification of 9 major facies units (fluvial terraces, lowstand fluvial, tidal and intertidal marsh and mudflat, marine prodelta, distributary mouth bar, fluvial floodbasin, fluvial levee, fluvial channel and aeolian dunes) within the Tagus valley-fill and construction of a sequence stratigraphic model. This has led to the establishment of a valley-fill history of the Lower Tagus Valley since the LGM

including a 3D valley-fill reconstruction taking into account the Weichselian incision and lowstand until the LGM, sea-level rise induced fluvial aggradation within the incised valley until the early Holocene, sea-level rise forced rapid drowning (transgression) of the valley and creation of marshes and an inland marine basin until ~7000 BP, as well as the formation of a regressive system and a tide-dominated delta within the Lower Tagus Valley together with progressive southward infilling of the valley and start of off-shore marine delta build-up until present. Also, for the first time human influence since about 1000 BP such as deforestation and agriculture could be detected both on land and off-shore by increased sedimentation rates, increased magnetic susceptibility signals and a grain-size increase in the floodplain and a grain-size decrease off-shore, as well as the end of peat formation in fluvial swamps and rejuvenation of the Tagus channel belt. Outstanding results are the construction of first data-based sea-level curve for Portugal and the Atlantic Iberian Peninsula, the first reconstruction of lowland-setting fluvial flooding history of Portugal and the Atlantic Iberian Peninsula for the period since about 7000 BP, including climatic and vegetation interpretation of a distal organic fluvial marsh, sediment budgets and fluxes for the Holocene valley-fill of the Lower Tagus Valley and their relationship with sediment input changes from the hinterland due to climatic and human influences.

The final work still planned is the calculation of sediment budgets for Holocene Tagus valley-fill on land using Petrel © Reservoir Engineering Software, Tagus catchment large scale analysis of soil types for estimation of Holocene erosion, and iron oxide-type determination of terrestrial samples with high Magnetic Susceptibility signal.

#### **4. What did you not achieve in the CRP and why? (max 1 p.)**

Please use the original proposal as reference and explain any deviations from the work plan

1) At the begin in 2003, SEDPORT had a very encouraging start of the project, with lab visits of the German and Dutch PhD students at the Lisbon Marine Geosciences Department and the execution of two cruises with RV POSEIDON and RV MARION DUFRESNE, allowing retrieval of new sediment cores from the shelf mud belt and from the flanks of the Tagus Canyon, as well as echosounder and ROV camera profiling of shelf deposits, plus the installation of 2 sediment trap moorings. However, after the first year the overall SEDPORT CRP went into significant reorganisation and shortage in the list of individual scientific goals of the partners. The reason was that expected funding for proposed PhD students or post-doc salaries in case of the Portuguese and Dutch partners was not approved. Moreover, a significant drawback for the entire CRP was the fact that, due to a badly organised funding process by ESF EUROCORES EUROMARGINS funding partners, the originally intended comparison of German PhD students to the results obtained by the Dutch and Portuguese CRP partners, particularly the comparison of sediment cores from the shelf and the estuary, was not possible and has still to be done. This will be accomplished in thesis work of the Dutch student Geert-Jan Vis and may result in further joint CRP publications. The main reason for this delay in one of most important objectives of SEDPORT was the different time line of the PhD work programs (German thesis 3 years, start 2003, finished 2006, and Dutch thesis 4 years, start 2004, finished by mid of 2008). Together with the loss of sediment traps (see below), for the German partner this caused a significant delay in accomplishment of one PhD thesis. The second German PhD thesis was shifted towards the investigation of camera surveys for marine snow, sediment trap material from moorings offshore North Africa and to surface sediment samples available in the Bremen core repository from previous Bremen cruises that covered the NW African and Iberian Margins.

2) Due to the loss of the 2 sediment trap moorings by the end of 2004, which could not be recovered after one year of deployment with a small Portuguese Navy vessel, large parts of the proposed investigation of the modern shelf to slope sedimentation processes using grain-size and inorganic chemical composition had to be cancelled. Fortunately, one of the traps was caught in 2006 by a fish trawler, however, as Portuguese funding was low and secondary payment came in late, work on samples of that sediment trap for modern upwelling conditions is still pending but will commence in December 2007.

3) Study of the plankton net samples and stable isotope measurements in the water samples – both taken during SEDPORT cruise PO304 in 2003 – were also delayed but can potentially be done by the Portuguese CRP in 2008.

3) Land sections in the Tagus valley cover the time period of the late glacial to the Holocene. The strategy of the complementary “marine research” was to establish robust proxy records with a focus on the time period covered in the land section in order to allow for a detailed correlation between land and ocean time series. Accordingly,



deeper (older) sections in the marine records were studied less intensely.

4) Difficulties with the visualization of the image data recovered during the PO304 cruise and reduction in funding for PhD student salaries made the neotectonics study initially planned impossible.

**5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)**

**5. A.** Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

1) In order to better understand the processes of river mud deposition on the shelf and slope echosounder profiles and photographs of the sea floor were taken during the PO 304 cruise in 2003 which show the thickness and extent of the Holocene mud belt and the effect of bottom currents and waves on the sediment surface, e.g., ripples and overall sorting, respectively. For the echosounder surveys a portable hydroacoustic system designed for shallow water environments at the University of Rostock (Nonlinear Sediment Echo Sounder System SES-2000, Prof. G. Wendt) was mounted on RV Poseidon. However, most of the survey data obtained in the Tagus pro-delta and on the adjacent Portuguese slope has to still to be synthesized for publications. This can be done under the auspices of the MARUM-RCOM Bremen, as part of a research project called "Sediment-Partitioning and -Transformation on the shelf" which is actually working on the redistribution processes of the Holocene mud belt patches on the Portuguese shelf to the north of our working area.

2) The Portuguese partner has submitted a couple of new project proposals to the Portuguese Science Foundation, which main objectives are follow ups of questions generated during this study.

3) For the Dutch partner scientific collaboration with the Friedrich-Schiller University Jena (Germany) has evolved.

**5. B.** Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

Research for climate proxies in very high resolution sequences covering the last 100 to 1000 years are fundamental to develop proxy records of the more recent past ocean and land climate conditions which can be directly related to historical instrumental climate records. Herefore, fast accumulating Holocene mud belts can provide marine archives for, both, the land and ocean climate change. However, given the highly dynamic sedimentation behaviour of, e.g., the Tagus river and its effect on offshore sedimentation patterns, more research aiming at a better understanding of the underlying controls for land-ocean and shelf-slope sediment transport processes are crucial. In particular the increasing human influence on riverine sediment budgets worldwide and the effects of deforestation require a detailed knowledge of the processes involved in order to improve predictions of the long-term consequences for future generations. In case, of the Tagus mud belt we also had to recognise the effects of tsunami deposits. Therefore, further large scale sediment and biochemical source-to-sink processes and their relationship to natural climate conditions as well as under human influence, e.g., damming, deforestation, agricultural soil erosion, will be needed.

## 6. Your feedback on the EUROCORES Programme (max 1 p.)

### 6.A. What, in your view, is the added value of being part of a EUROCORES Programme

The added value is in the cooperation with other European research groups and the possible mobility of young and well-established researchers through net-working programmes within the respective EUROCORES programme and by regular scientific programme meetings. For this CRP SEDPORT EUROMARGINS stimulated an intense collaboration between the different partner institutes. Based on the EUROCORES platform joint international seagoing and land based sampling campaigns were carried out. Regular e-mail correspondence, joint workshops and meetings at international conferences facilitated vivid discussions and exchange of scientific ideas. In that sense the EUROCORES initiative funnelled international scientific expertise in order to better understand the coupled land-ocean-climate evolution in/off the Tagus region.

### 6.B. Give any critical and constructive comments on the EUROCORES Programme and its procedures

Scientific management of the project was sometimes hampered by unclear (or weakly defined) project responsibilities between ESF and the national funding agencies. Similarly, individually reporting to both ESF and the national funding agencies in our view represents a reporting overkill. On the other hand, the lack of confidence in national funding for the individual CRP partners after scientific evaluation and project approval through the ESF makes it unlikely to put efforts in new proposals under the EUROCORES programme if this problem cannot be resolved.

In addition, to the national funds, ESF is providing a significant financial contribution for networking, workshops, and travels in such a EUROCORES programme, however, often the expensive payment of the seagoing and land-based coring and sampling platforms is lacking, because national funding agencies are reluctant in sponsoring programme-oriented multi-national use of such infrastructure. Therefore, it should be considered to install more programme-oriented large infrastructure projects, e.g., ESF EUROCORES EUROMARC, however, with firm commitment of financial contributions from national funding agencies at the beginning.

## Appendix 1. List of Products of the CRP

### 1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more CRPs** (if any)

#### Manuscripts published or in press:

Alt-Epping, U., Mil-Homens, M., Hebbeln, D., Abrantes, F., & Schneider, R.R., 2007a. Provenance of organic matter and nutrient conditions on a river- and upwelling influenced shelf: A case study from the Portuguese Margin. *Marine Geology*, 243, 169-179.

Abrantes, F., Alt-Epping, U., Lebreiro, S., Voelker, A., & Schneider, R.R., 2008. Tsunamis Sedimentological Record on Shallow Shelf areas: The case of the AD1969 and AD1755 on the Portuguese Shelf off Lisbon. *Marine Geology*, in press.

Gil, I.M., Abrantes, F., Hebbeln, D., 08. Diatoms as upwelling and river discharge indicators along the Portuguese margin: instrumental data linked to proxy information. *The Holocene*, in press.

#### Manuscripts submitted or in preparation:

Alt-Epping, U., Stuu, J.-B., Hebbeln, D., Abrantes, F., & Schneider, R.R., 2007b. Variations in sediment provenance during the past 3 000 years off the Tagus River, Portugal. *Marine Geology*, submitted.

Alt-Epping, U., Hebbeln, D., Schneider, R.R., & Lebreiro, S., 2008. Holocene changes in environmental conditions on the Portuguese margin. In prep.

Lebreiro, S.M., Voelker, A., Vizcaíno, A., Abrantes, F., Jung, S., Alt-Epping, U., Gràcia, E., Thouveny N. 2008. How instable becomes the Iberian continental slope under abrupt climate changes? In prep.

#### Reports:

Segl, M., Alt-Epping, U., de Abreu, L., Dimmler, W., Franke, P., Hüttich, D., Jung, S., Langer, J., Rathmeyer, V., Rodrigues, T., Wunderlich, J. (2004). Report and preliminary results of Poseidon cruise 304, Galway–Lisbon; 5.-22.Oct. 2003. *Berichte aus dem Fachbereich Geowissenschaften der Universität Bremen*, No. 230, 27 p.

#### Extended abstract:

Lebreiro, S., Voelker, A., Alt-Epping, U., Vizcaíno, A., Jung, S., Abrantes, F., Gràcia, E., Abrupt climatic “Heinrich” and “Dansgaard-Oeschger”-type events generate slope instability on the Portuguese margin. Laboratorios asociados meeting at Calouste Gulbenkian Foundation, Lisbon, March 2007.

#### Conference presentations:

Alt-Epping, U., P, Franke, Schneider, V. Rathmeyer, M. Segl, and R. Schneider, (2004): Sediment patterns on the South Portuguese Atlantic Margin: Direct observations with a Remotely Operated Vehicle. 1st EGU General Assembly, Nice – France (25-30 April 2004).

Alt-Epping, U., Schneider, R., Jouanneau, J.-M., Mil-Homens, M., Voelker, A., (2004): Organic matter composition off the Tagus River: evaluation of terrestrial versus marine sedimentation as a tool for climate reconstruction in the hinterland. EUROMARGINS conference, Barcelona, Spain, 11.-13. November 2004.

Schneider, R.R. and CRP partners, (2004): Climate-related changes of terrigenous and marine sedimentation off the Tagus. ESF EUROMARGINS Conference, Palau de les Heures, Barcelona, Spain, 11-14 November 2004.

Alt-Epping, U., Schneider, R., Lebreiro, S., Abrantes F. (2005): Organic matter composition in marine sediments off the Tagus River. EGU 2nd General Assembly, Vienna, Austria, 24.-29. April 2005.

Abrantes, F., Rodrigues, T., Vis, G.-J., Alt-Epping, U., Voelker, A., Gil, I., Lebreiro, S., Schneider, R., Kasse, C., Jung, S.J.A., Kroon, D., Prick, A., Prins, M., Sedimentation Processes on the Tagus River System (Portuguese Margin) during the Holocene – SEDPORT Main Results. *Geophysical Research Abstracts*, Vol. 8, 10665, 2006, SRef-ID: 1607-7962/gra/EGU06-A-10665 (invited talk)

Schneider, R.R. and CRP partners, (2006): Quaternary sedimentation off the Tagus river, the land-ocean connection, ESF EUROMARGINS Conference, Bologna, Italy, 4-7 October 2006.

Lebreiro, S. M., A. Asioli, A. Piva, F. Abrantes, G. Vis, A. Voelker, U. Alt-Epping, E. Gràcia, R. Bartolomé, P. Terrinha, A. Vizcaino, J.J. Dañobeitia, C. Escutia, J. García-Orellana, V. Willmott, D. Casas, N. Zitellini, S. Diez, R. Pallàs, A. Villaseñor, I. Cacho, Climate and slope instabilities (land-ocean sediment transport). Talk presented at the IMAGES-PAGES workshop on Circum-Iberia Paleoceanography and Paleoclimate in Peniche (Portugal), 15th to 18th January, 2007.

Lebreiro, S., Voelker, A., Alt-Epping, U., Vizcaíno, A., Jung, S., Abrantes, F., Gràcia, E., Higher frequency of turbidites during abrupt climatic "Heinrich" and "Dansgaard-Oeschger"-type events – evidence for slope instability on the Portuguese margin. Poster presented at the ESF Research conference on "Ocean controls in abrupt Climate Change" in Obergurgl (Austria), 19th to 24th May, 2007.

Abrantes, F., Rodrigues, T., Vis, G.-J., Alt-Epping, U., Voelker, A., Gil, I., Lebreiro, S., Schneider, Sedimentation and Climatic Processes on the Tagus River System (Portuguese Margin) – Talk given during the 17th INQUA Congress in Cairns (Australia), 28th July to 3rd August, 2007; abstract (#0677) published in: Quaternary International, vol. 167-168, Suppl. 1, p. 4.

Lebreiro, S., Voelker, A., Alt-Epping, U., Vizcaíno, A., Jung, S., Abrantes, F., Gràcia, E., Higher frequency of turbidites during abrupt climatic "Heinrich" and "Dansgaard-Oeschger"-type events – evidence for slope instability on the Portuguese margin. Poster presentation (P1–65) at the 9th International Conference on Paleoceanography (ICP) in Shanghai (China), 3rd to 7th September, 2007; ICP9 abstract volume, p. 66-67.

## 1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

### PhD Theses:

PhD thesis of Geert-Jan Vis consisting of 4 peer-reviewed papers (all in prep.):

1. The Lower Tagus since the LGM: estuarine and tide-dominated delta facies (to be submitted December 2007);
2. The Lower Tagus Valley: Palaeogeographic development since the LGM (to be submitted January 2008);
3. Holocene flooding history and human impact of the Lower Tagus River (to be submitted March 2008);
4. Holocene sediment flux changes and land-sea correlation of the Lower Tagus (to be submitted May 2008).
5. Decadal-scale Holocene climate variations in the N-Atlantic (to be submitted early 2008).

PhD Thesis of Alt-Epping, U., (2007): Late Quaternary Sedimentation Processes and Sediment Accumulation Changes off Portugal. Dissertation, Berichte, Fachbereich 5 Geowissenschaften, Universität Bremen. Submitted.

### Technical reports:

De Abreu, L. and T. Rodrigues (2003). Cruise report of the Portuguese participants on the PO304-SEDPORT scientific cruise on board the "POSEIDON", Lisbon-Las Palmas, 15th -25th October. Departamento de Geologia Marinha, Relatório Técnico, INGMARDEP n.26/2003, 23 p.

Segl, M., Alt-Epping, U., deAbreu, L., Dimmler, W., Franke, P., Hüttich, D., Jung, S., Langer, J., Ratmeyer, V., Rodrigues, T., Wunderlich, J., Report and preliminary results of RV Poseidon cruise 304, Galway – Lisbon, 5.-22. October 2003. Berichte, Fachbereich Geowissenschaften, Universität Bremen, No. 230, 27 pages, Bremen 2004.

Gil, I. M., 2005. SEDPORT cruise on board the Andrómeda. Lisbon - Lisbon 25.10 - 26.10.2005. INETI, Departamento de Geologia Marinha, Relatório Técnico INGMARDEP/10/2004-11/112004.

### Conference presentations:

Gil, I., Abrantes, F., Hebbeln, D. - High resolution diatom records reveal upwelling and the Tagus River input (Lisbon latitude, Portugal) for the last century. EGU 2005 Meeting, 24-29 April 2005, Vienna, Austria.

Rodrigues, T., Flores, J.-A., Abrantes, F. & Grimalt, J. - Coccolithosphere record in the Tagus Prodelta for the last 13.5 Kyr: A Comparison with the biomarker signal. 10th. Conference of the Internacional Nannoplankton Association (INA), 28th August to 4th September, 2004, Departamento de Geologia, Universidade de Lisboa,

Portugal.

- Rodrigues, T., Abrantes, F., Grimalt, J., Lebreiro, S. - Climate and productivity interpretation for the last 100yr on Portuguese Margin - Biomarkers evidence. EGU 2005 Meeting, 24-29 April 2005, Vienna, Austria.
- Voelker, A.H.L., Rodrigues, T., Lebreiro, S.M., Abrantes, F.F.G., deAbreu, L., Grimalt, J.O., Climatic Change during Marine Isotope Stages 11–19: First Results from Portuguese Margin Site MD03-2699. EGU 2005 Meeting, 24-29 April 2005, Vienna, Austria.
- Voelker, A. H., de Abreu, L., Lebreiro, S. M., Abrantes, F. G., North Atlantic Deep Water Variability During MIS 11-15: Evidence from the Portuguese Margin. *Eos Trans. AGU*, 86(52), Fall Meet. Suppl., Abstract PP54B-01, 2005.
- Voelker, A. H. L., McManus, J., Lebreiro, S., Abrantes, F., Deep Water Variability at the mid-depth Portuguese Margin during Marine Isotope Stages 10 to 16. *Geophysical Research Abstracts*, Vol. 8, 06395, 2006, SRef-ID: 1607-7962/gra/EGU06-A-06395 (poster presentation)
- Rodrigues, T., Abrantes, F., Grimalt, J. O., Voelker, A., Lebreiro, S., Surface water temperature and productivity changes during MIS 9 to 19 off Portugal, *Geophysical Research Abstracts*, Vol. 8, 06392, 2006, SRef-ID: 1607-7962/gra/EGU06-A-06392 (poster presentation)
- T. Rodrigues, F. Abrantes, J.O. Grimalt, J.A. Flores and S. Lebreiro; Paleoclimate changes in the Tagus Prodelta during the last 14 kyr: Biomarker and coccolith evidences, T1-058, HOLIVAR2006 Open Science Meeting Natural Climate Variability and Global Warming, London 12-15 June 2006
- Abrantes F.; Rodrigues T.; Gi, I.; Jonsdottir H.; Lebreiro S.; Harris I.; Witt I.; Grimalt J.; Proxy calibration to instrumental dataset: implications for Paleoceanographic Reconstructions, 3rd Euromargin Conference, Processes at the Passive Continental Margins, Bologna, 4-7 October 2006
- T. Rodrigues, F. Abrantes, J. Grimalt, A. Voelker; Marine Isotope Stage 11 (MIS 11): analogies with the Holocene on the Portuguese Margin First MedCLIVAR Workshop on Reconstruction of Past Mediterranean Climate, Carmona, Spain, 9-11 Nov 2006 (oral presentation)
- T. Rodrigues, F. Abrantes, J. O. Grimalt, A. Voelker, Marine Isotope Stage 11 (MIS 11): analogies to the Holocene on the Portuguese Margin, 3rd Euromargin Conference, Processes at the Passive Continental Margins, Bologna, 4-7 October 2006
- Voelker, A. H., Rodrigues, T., Abrantes, F., Grimalt, J. O., Upper Water Column Variability During Marine Isotope Stages (MIS) 10 to 17 on the Western Iberian Margin. Poster presented at the AGU Fall Meeting, San Francisco (USA), 11th to 15th December, 2006; abstract published in: *Eos Transactions AGU*, 87(52), Fall Meeting Supplement, Abstract PP23C-1778.
- Rodrigues, T., Abrantes, F. F., Grimalt, J. O., Voelker, A. H., Climate variability during Marine Isotope Stage 11 and the Holocene on the Portuguese Margin. Poster presented at the AGU Fall Meeting, San Francisco (USA), 11th to 15th December, 2006; abstract published in: *Eos Transactions AGU*, 87(52), Fall Meeting Supplement, Abstract PP23C-1785.
- Voelker, A., Rodrigues, T., Lebreiro, S., Abrantes, F., Grimalt, J., Surface and Deep Water Changes at site MD03-2699 on the Mid-depth Portuguese Margin During MIS 10 to 12. Poster presented at the INQUA-Morss workshop on MIS 11 on the 29th January, 2007 in Woods Hole (USA).
- Abrantes, F. F., Rodrigues, T., Lopes, C., Gil, I., Jonsdottir, H., Harris, I., Witt, L., Grimalt, J., Proxy Calibration to Instrumental Dataset: Implications for Paleoceanographic Reconstructions. Talk given during the 17th INQUA Congress in Cairns (Australia), 28th July to 3rd August, 2007; abstract (# 0686) published in: *Quaternary International*, vol. 167-168, Suppl. 1, p. 4.
- Voelker, A., Martin, P., Lebreiro, L., Abrantes, F., Millennial-scale Deep/ Intermediate Water Changes at the Mid-depth Portuguese Margin During Marine Isotope Stage (MIS) 11. Talk given during the 17th INQUA Congress in Cairns (Australia), 28th July to 3rd August, 2007; abstract (# 0983) published in: *Quaternary International*, vol. 167-168, Suppl. 1, p. 436.
- Voelker, A., de Abreu, L., Abrantes, F., Winter mixed layer conditions in the mid-latitude North Atlantic during MIS 11. Poster presentation at the 17th INQUA Congress in Cairns (Australia), 28th July to 3rd August, 2007; abstract (# 1359) published in: *Quaternary International*, vol. 167-168, Suppl. 1, p. 436.

Rodrigues, T., Voelker, A., Abrantes, F., Grimalt, J. O., Mid-Pleistocene Sea Surface Temperature Variation off Portugal. Poster presentation (P1–107) at the 9th International Conference on Paleoceanography (ICP) in Shanghai (China), 3rd to 7th September, 2007; ICP9 abstract volume, p. 89.

Abrantes F; Rodrigues, T; Gil, I; Jonsdottir, H; Lopes, C; I. Harris, Witt I., Grimalt, J. Proxy Calibration to Instrumental Dataset: Implications for Paleoceanographic Reconstructions. 1st MedCLIVAR Workshop Reconstruction of past Mediterranean climate: Unexplored sources of high resolution data in historic time. Carmona / Espanha, 9-11 Novembro 2006

Rodrigues, T., Abrantes, F., Grimalt, J., Flores, J-A, Lebreiro, S. Climate and Productivity Interpretation for the last 10,000 years on the Portuguese Margin – Biomarkers Evidence. 1st MedCLIVAR Workshop Reconstruction of past Mediterranean climate: Unexplored sources of high resolution data in historic time. Carmona / Espanha, 9-11 Novembro 2006.

### **1 C. General outreach**

Radio interviews, TV coverage, Newspaper articles etc.

- Two lectures by Geert-Jan Vis in 2007 for Dutch amateur geologists association “GEA”
- Geert-Jan Vis is in touch with the national Portuguese newspaper “Diario de Noticias” for an article in a weekend magazine.

### **1 D. Patents and industry collaborations**

Geert-Jan Vis has shared information on sand-distribution in the Lower Tagus Valley with APSOR Areias e Seixos de Portugal, S.A. in exchange for logistical support.

### **1 E. Networking within the CRP**

Networking with other CRPs is in Part 3 (completed by ESF)

Project coordination was executed through SEDPORT meetings at INETI (IP 3), regular email exchange about the project status amongst the PI's, Postdocs, and new PhD students involved, through joint visits and presentations at conferences. The most important activities for ensuring CRP collaboration dissemination of results as well as training and support of PhD students are listed below.

- Project Planning Meeting of the project PIs: Ralph Schneider, Dick Kroon, Fátima Abrantes, with participation of other project researchers Luis Gaspar, Simon Jung, Susana Lebreiro, Pedro Terrinha, Jef Vandenberghe, and Antje Voelker. The meeting organized by the INETI group, took place in Alfragide / INETI (former IGM) on the 16th and 17th June 2003.
- Visit of Ulrich Alt-Epping, Ph.D. contracted by Bremen University: literature compilation and samples collection for  $\delta^{13}\text{C}_{\text{org}}$  and  $\delta^{15}\text{N}$ , 15-18th June 2003.
- Participation of Antje Voelker, Susana Lebreiro, Pedro Terrinha and Ulrich Alt-Epping (as Portuguese team member) on leg 1 of PICABIA cruise on RV Marion Dufresne 14-26th July, 2003.
- Participation of D. Kroon, R. Schneider, and A. Voelker at 1st ESF EUROMARGINS Science Forum, Amsterdam, The Netherlands, 19-22 November 2003.
- Participation of Teresa Rodrigues in the PO304 cruise onboard the RV Poseidon, from Lisbon to Las Palmas, 15th – 25th October 2003. Deployment of 3 sediment traps in two moorings, 4 gravity cores, 14 water stations, 24 stations with plankton and multinet samples, and ROV dives, were done along transects across the Portuguese shelf in two areas of upwelling plumes. Cruise financed by the German counterpart.
- 24th- 28th October, 2004: Participation by Philip Franke, Jana Koesters, Dirk Moorhoff and Isabelle Gil in the Portuguese RV Andromeda cruise to retrieve the 2 moorings placed from the Portuguese margin. Afterwards sampling of core PO287-1-3G for carbon and nitrogen isotopic analyses in Bremen, 24th- 28th October, 2004.

- In December 2004 members from all involved institutions came to Lisbon for a sampling party of core MD03-2698 from the Tagus canyon levee. Samples for pollen abundance test study were taken from cores MD03-2698 and MD03-2700G. The PhD students Ulrich Alt-Epping and Geert-Jan Vis stayed for a one week sampling party of MD03-2698 and D13882.

- Geert-Jan Vis and Sjoerd Boehncke from the VU Amsterdam (IP3) have also visited INETI in several occasions, both to compile literature and access restricted reports from the INETI library, as well as for the recovery of several cores along Tagus valley.

- A 2nd period of field work in early October to mid November, 2004 by Geert-Jan Vis and accompanying students in Tagus valley, including two short visits to INETI during one of which he discussed the results from the previous visit and future plans with Dr Fatima Abrantes; drilling of 2 long cores in the Tagus valley performed by the drilling department of INETI (Mr Silva-Lopes).

- SEDPORT meeting 14th October, 2005 for exchange of actual information and new data, as well as the definition of possible joint publications. Participants Ulrich Alt-Epping (IP1), Geert-Jan Vis (IP3) and Lisbon (IP2) colleagues; Ulrich Alt-Epping spent the full week, mainly discussing and comparing his data with the data acquired at DGM/INETI.

- Presentation of achieved CRP results at the ESF EUROCORES Euromargins Conference in Bologna, Italy, October 2006. Final discussion of joint publications, missing data, and of upcoming achievements from land-based drilling by the Dutch partner in 2007.

#### **Research and coordination visits with other projects or partners important to SEDPORT:**

- 25th-29th October, 2004: participation of Susana Lebreiro in the sampling party of Euromargins project SWIM in Barcelona, during which the available data of core MD03-2698 were compared with those of the 4 cores of the SWIM project from the southwestern Portuguese margin.

- Isabelle Gil stayed at Bremen University in February, May, November and December 2005.

- Teresa Rodrigues stayed at Institute of Chemical and Environmental Research, CSIC, Barcelona, Spain in July, August, October, November of 2004, March, July, October and November of 2005.

- Meeting of Fatima Abrantes, Ulrich Alt-Epping and Antje Voelker at RCOM, Bremen university, on June 29th, 2006 to discuss Ulrich's PhD work and manuscripts.

## **1 F. Participation in other conferences**

Please list only the most relevant

2004: EGU

2005: EGU, AGU Fall meeting

2006: EGU, 1st MedClivar workshop, AGU Fall meeting, VII Congresso Nacional de Geologia Évora (Portugal)

2007: INQUA, ICP9

2004 & 2006: Fluvial Archives Group (FLAG) meetings in Siena (Italy) and Izmir (Turkey)

International conference on Fluvial Sedimentology 4-yearly meeting in Delft (NL)



## Appendix 2. Scientific & technical personnel involved in the CRP

### Personnel directly funded by the EUROCORES Programme

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

#### IP 1:

Ulrich Alt-Epping, PhD student, 01/04/2003 – 31/03/2006

Philip Franke, PhD student, 01/05/2003 – 30/04/2006

#### IP 2:

Teresa Rodrigues, fellowship for Master degree, 08/09/2003 – 31/05/2004; Master degree obtained in Feb. 2004

Dr Antje Voelker, postdoctoral fellow, 01/08/2004 – 31/07/2005

Isabel Gil, doctoral fellow, 01/08/2004 – 31/12/2004; DSc received 30th June, 2006

Maria José Custódio, lab technician, 01/07/2004 – 30/06/2005

João Paulo Ferreira, lab technician, 01/12/2004 – 31/08/2005

Andreia Rebotim, student fellow, 02/05/2007 – 31/12/2007

Célia Santos, student fellow, 14/05/2007 – 31/12/2007

#### IP 3:

Geert-Jan Vis, PhD student, 15/01/2004 – 14/01/2008

Dr. Pallavi Annand, post-doc researcher, 01/06/2005 – 31/01/2006

# Transition from a continental to an oceanic rift: geology and biogeochemistry of the northern Red sea

## Abstract

The collaborative project SEDPORT aims to investigate the impact of strong climatic oscillations that have occurred in the North Atlantic and over adjacent continents on sedimentary processes and depositional features on the Portuguese shelf and upper slope. Major goals are to better determine the influence of biological productivity, subaerial and submarine sediment transport mechanisms on the composition and properties of margin sediment cover during the last glacial-interglacial transition in comparison to modern mean environmental conditions. Hereby special emphasis is given to the question of how these sedimentation processes may have changed under varying climate conditions that affected ocean circulation, sea-level, and continental weathering, vegetation and precipitation since the last Ice Age into the Late Holocene. Land-ocean linkages and source to sink relationships for terrigenous material are of particular interest. A synoptic palaeoenvironmental reconstruction of a passive margin including the coastal zone, shelf and slope, taking into account the significant influence of transport and sedimentation processes under varying climates in the hinterland and the ocean, is anticipated as the final product of SEDPORT. For this purpose, comprehensive data sets of sedimentological and compositional parameters from shelf and slope surface sediments and sediment cores will be compiled from existing archives, newly generated data and studied in detail considering palaeoclimatic/environmental mechanisms. This all will be put in context with studies of satellite images and documentation of particle transport through the water column with sediment trap deployments, camera systems, and a underwater remotely operated vehicle (ROV) as well as with an estuarine sediment record from the Tagus valley.

## Partners

(CNR, CNRS, NERC, DFG)

### **Pr Enrico Bonatti (project leader)**

Consiglio Nazionale delle Ricerche, Bologna, Italy

### **Pr Carlo Doglioni**

Università La Sapienza, Roma, Italy

### **Dr Marco Ligi**

Università di Bologna, Bologna, Italy

### **Dr Neil Mitchell**

Cardiff University, Cardiff, United Kingdom

### **Dr Monique Seyler**

Institut de Physique du Globe, Paris, France

### **Dr Bertrand Sichler**

IFREMER, Plouzané, France

### **Pr Peter Stoffers**

Institut für Geowissenschaften der Christian-Albrechts-Universität, Kiel, Germany

## Collaborative Research Project (CRP)

### 1. General information

Project Reference Number : 01-LEC-EMA21F

Acronym / Short Title: -

Full Title: **Transition from a continental to an oceanic rift: geology and biogeochemistry of the northern Red sea**

Project Leader name: *Pr Enrico Bonatti*

Project Leader affiliation: *Consiglio Nazionale delle Ricerche, ISMAR, Bologna, IT*

Institutional home page (URL): <http://www.ismar.cnr.it>

Project-related home page (URL):[http://doc.bo.ismar.cnr.it/CRUISE\\_REPORTS/RS05\\_REP/index.html](http://doc.bo.ismar.cnr.it/CRUISE_REPORTS/RS05_REP/index.html)

Reporting period: 01/10/2004 to 30/09/2007

### 2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)

#### IP 1

**Pr Enrico Bonatti**, Consiglio Nazionale delle Ricerche, Bologna, Italy

Total Funding amount of the IP: **EUR 286,000.00**

#### IP2

**Pr Carlo Doglioni**, Università La Sapienza, Roma, Italy

Total Funding amount of the IP: **EUR 0 (included in IP1)**

#### IP3

**Dr Marco Ligi**, Consiglio Nazionale delle Ricerche, ISMAR Bologna, Italy

Total Funding amount of the IP: **EUR 0 (included in IP1)**

#### IP4

**Dr Neil Mitchell**, Cardiff University, Cardiff, United Kingdom

Total Funding amount of the IP: **EUR 500.00**

#### IP5

**Dr Monique Seyler**, Institut de Physique du Globe, Paris, France

Total Funding amount of the IP: **EUR 4,000.00 in 2004**

#### IP6

**Dr Bertrand Sichler**, IFREMER, Plouzané, France

Total Funding amount of the IP: **EUR 0.00**

#### IP7

**Pr Peter Stoffers**, Institut für Geowissenschaften der Christian-Albrechts-Universität, Kiel, Germany

Total Funding amount of the IP: **EUR 97,646.00**

### 3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

The Project addressed an important open problem in the Earth Sciences, namely, by what processes is the transition from a continental to an oceanic rift achieved. This problem has a bearing on a number of first-order questions, such as the origin of oceans that form due to continental drift (i.e., the Atlantic), and the formation of passive margins. We addressed these themes in the Red Sea. The Red Sea, together with the Gulf of Aden and the East African Rift, is part of a rift system that since late Oligocene-Miocene has been fragmenting the Arabian-Nubian shield. This rift system provides the closest modern analog of the rifting and rupturing of the continental lithosphere that formed the passive margins of the Atlantic, Indian and Arctic Oceans: it is an ideal setting to investigate tectonic and petrological aspects of the transition from a continental to an oceanic rift, and the formation of passive margins and of "initial" transform faults.

The project focused in the central/northern Red Sea, where the region of discrete nuclei of axial emplacement of oceanic lithosphere gives way to the northern region where the Red Sea appears to be carpeted by stretched and thinned continental crust. Building on previous work, we carried out in Jan-Feb 2005 a field expedition with the R.V. Urania of the Italian National Research Council. The work focused on the two northernmost nuclei of oceanic lithosphere emplacement (Tethis Deep and Nereus Deep); on the transition zone between the two; and on the Zabargad Fracture Zone, a prominent structure that intersects the sea from coast to coast, and that may represent the precursor to a major oceanic transform fault.

#### ***Geology and Petrology (IP1, IP2 and IP3)***

We carried out multibeam bathymetry subbottom acoustic profiling (chirp) magnetics, seismic reflection profiling and rock, sediment and water sampling. Our surveys revealed that Tethis Deep is the result of the axial merging of three "subdeeps". It consists of a complex rift valley bound by 1 km thick steep walls affected by several normal faults. It is carpeted by an echelon volcanic ridges, similar to the "neovolcanic zones" found in the axial rift valley of slow-spreading mid ocean ridges. The floor of the valley is punctuated by numerous small (few hundreds meters high) volcanic cones, in a setting similar to that observed in the Afar Rift in the Southern Red Sea region. The topography of the steep walls of the valley is smoothed in some areas by what appear to be "salt glaciers", where evaporite bodies deform and move downslope. Tectonic features were observed to lie frequently parallel or perpendicular to the sea-floor gradient, suggesting that gravity is an important factor in their origin. The southern termination of the Tethis rift valley system is marked by basement topographic highs; particularly prominent is a semicircular large (10 km diameter at the base) body. The lack of internal acoustic reflections suggests it is an igneous body. The morphostructural imagery of the Thetis multi-deep system is consistent with our working model whereby the initial emplacement of oceanic crust occurs in discrete cells that propagate axially.

To the north of Tethis, Nereus Deep, is a well developed rift valley axial segment, structurally simpler than Tethis, with a single well developed "neovolcanic zone". The transfer zone between Tethis and Nereus (and between Tethis and Hadarba Deep to the south) lack an axial rift valley; they are covered by a sediment pile that includes Miocene evaporites (ubiquitous in the Red Sea) dismembered by numerous extensional faults. It appears that no oceanic crust has been emplaced yet in these transfer zones. The transfer zones between Deeps, exemplified by the Thetis/Nereus transfer zone, constitute "locked zones" against which axial propagation of the oceanic segments impacts and slows down.

Dredging of the Tethis and Nereus neovolcanic zones recovered fresh glassy basalts, that from preliminary analyses have MORB composition. Analytical work is in progress in basalt and basaltic glass samples collected from the three Thetis sub-basins. Preliminary data indicate that the Thetis basalt differ in chemistry from those of Nereus and other axial deeps, suggesting that each Deep constitutes an independent thermal/melting upper mantle system.

Lack of time prevented us from doing geophysical surveying and rock sampling along the Zabargad Fracture Zone, except for a few multibeam/magnetometric profiles.

#### ***Earth surface processes (IP4)***

Surface morphologic data (bathymetry) collected with the multibeam echo-sounder on R/V Urania revealed a

remarkable series of flow structures around the margins of Thetis Deep. We interpret these as salt glaciers formed by mobilisation of the Red Sea evaporites caused by lateral unloading of the margins of the Deep as the Deep itself has been excavated by dissolution of evaporites and deepened tectonically. These features are unique - we know of only coarse scale examples of sub-surface autochthonous salt tongues imaged with industry 3D seismic and some subaerial salt glaciers in very dry environments (e.g., Iran) that are comparable to these features. Such a result would not have been produced without the cruise on Urania as the few existing multibeam datasets in the Red Sea were collected with lower-resolution, narrower swath classic SeaBeam systems and published in only contour form that obscures the flow structures.

New research prompted by these data has involved Professor Ernie Rutter, an experimental petrologist in Manchester, in addressing the mechanical behaviour of halite with varied applied stress and interstitial water. This further work aims to address: (1) why the flows, from morphology, appear to be relatively shallow structures compared with the evaporite's multi-km thickness suggested by seismic refraction data and (2) the stress-strain rate behaviour of the evaporites based on likely deformation mechanisms. Simple geomorphological modelling suggests that the flows should erode where they are expected to accelerate on the steepening gradients around the Deep's margins. However, our new data show that they do not erode, probably because the flows run out and thin on the steeper gradients (as corroborated by seismic reflection data) or other effects compensate for faster movements on steep gradients.

#### ***Hydrothermal fluids (IP7)***

The funding through DFG (STO 110-39-1), the European Science Foundation, our international research partners, and national and international governmental support made it possible to finish our studies of brine biogeochemistry and of sediments carpeting brine-filled Red Sea deeps. Geochemical tracers are being studied in the brines collected from Nereus, Oceanographer and Conrad Deep. The strictly hydrothermal input is limited in these northern Red Sea brines, that owe their composition to seafloor reactions of seawater with Miocene evaporites, with superimposed biogeochemical processes.

The CRP helped us to complete our recent research activities where we followed the promising multidisciplinary approach we started in our research in the 90<sup>th</sup>. We think we could solve basic questions addressing problems in brine biogeochemistry and shed light on topics for future research activity correlating geophysical data and geochemistry of evaporite/fluid interaction in the Red Sea.

#### **4. What did you not achieve in the CRP and why? (max 1 p.)**

Please use the original proposal as reference and explain any deviations from the work plan

The political situation in the Red Sea region made it very laborious to obtain permits from the circum-Red Sea countries to work in their territorial and economic zones. As result the expedition with the RV Urania was delayed by nearly two years, causing a series of difficulties.

#### ***Geology and Petrology (IP1, IP2 and IP3)***

Due to a delay in the arrival of Egyptian officials at Suez we had to cut the field work by almost one week. Consequently we were forced to reduce the proposed work along the Zabargad Fracture Zone. We ran a few multibeam lines across the Zabargad fracture zone, but we were unable to carry out a complete multibeam/seismic reflection survey and rock sampling program.

#### ***Earth surface processes (IP4)***

We originally proposed to attempt to balance the turbidite infill within the Deep with the amount of erosion around the margins of the Deep. Unfortunately, only a few erosive channels were found in the new data and the infill turned out difficult to characterise because of the complexity of volcanic structures over-printing the sediments. Due to time limitations, we were able to collect only limited seismic. Nevertheless, the salt glacier structures described in *section 3* are spectacular and more than compensate for the lack of success in this area.

#### ***Petrology and Geochemistry (IP5) and Magnetism (IP6)***

The French research teams (Dr. M. Seyler of the University of Lille and Dr. B. Sichel of IFREMER Brest) did not receive any funds from the French financing agencies. This has limited the extent of their activities.

### **Hydrothermal fluids (IP7)**

Unfortunately we could not revisit Atlantis II Deep with RV Urania during RS05. The Atlantis-II Deep is the endmember example for hydrothermally controlled brine composition in the Red Sea. The planned revisit in 2005 should have given us missing data of biogeochemical, organic and inorganic signatures of the endmember brine.

### **5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)**

**5. A.** Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

A number of scientific papers are being prepared with the results of the Project.

We plan to go back to the northern Red Sea in 2008 with the R/V Urania to complete the field work along the Zarbargad Fracture Zone and to extend the geophysical surveys south of Tethis Deep.

Our German colleague Axel Erhardt (BGR, Hannover) will perform geophysical investigations between 27°N and 23°N in the Red Sea with RV Meteor in 2009. Strategy of seismic measurements profiles are partly based on results of this project. Recent deep seismic information will then be available for additional brine-filled Red Sea deeps. Brine geochemistry/fluid-rock interaction investigated during this project will be correlated to seismic information about sediment stratigraphy (e.g. evaporite sequences, basalt intrusions) and fluid migration pathways (e.g. main fractures).

Mitchell convened a special session at EGU on submarine geomorphology with John Hillier and are proposing another this coming 2008 (with John Hillier and Thierry Mulder as co-convenors). These are based in part on science of Euromargins and we have sought involvement of Euromargins PIs.

**5. B.** Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

Within the submarine Earth Surfaces Processes field, there has been a tendency for researchers in Marine Geology and Petroleum-related Stratigraphic Modelling to work independently. The ESF could have a good role in bringing together these communities, with potential benefits to academic Marine Geology of the large datasets being acquired by the petroleum and associated industries.

### **6. Your feedback on the EUROCORES Programme (max 1 p.)**

**6.A.** What, in your view, is the added value of being part of a EUROCORES Programme

**6.B.** Give any critical and constructive comments on the EUROCORES Programme and its procedures

## Appendix 1. List of Products of the CRP

### 1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more CRPs** (if any)

### 1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

#### - Peer reviewed articles in journals (*published, in press or accepted*)

Botz, R., Schmidt, M., Wehner, H., Hufnagel, H., and Stoffers, P., Organic-rich sediments in brine-filled Shaban- and Kebrit Deeps, Northern Red Sea. *Chemical Geology* **244**, 520-553, 2007.

Dekov V.M., Scholten J.C., Botz R., Garbe-Schönberg C.-D., Stoffers P., Fe–Mn-(hydr)oxide-carbonate crusts from the Kebrit Deep, Red Sea: Precipitation at the seawater/brine redoxcline. *Marine Geology*, **236**, 95–119, 2007.

Ligi M., E. Bonatti, A. Cipriani and L. Ottolini, Water-rich basalts at mid-ocean-ridge cold spots. *Nature*, **434**, 66-69, 2005.

Taviani M., M. Lopez Correa, H. Zibrowius, P. Montagna, M. McCulloch and M. Ligi, Last glacial deep-water corals from the Red Sea. *Bull. Mar. Sci.*, **81**(3), 2007.

#### - Peer reviewed articles in journals (*submitted or in preparation*)

Aeschbach-Hertig W., Kipfer R., Schmidt M., Botz R., Winckler G., Noble gases in the Shaban Deep, Red Sea, in preparation.

Antunes A., Schmidt M., Taborda M., Nobre M.F., Huber R., Precipitation of high Mg-calcite by *Idiomarina* sp. strain SD-14A, and possible impact on the geology and geochemistry of the Shaban Deep, Red Sea, *Applied and Environmental Microbiology*, submitted.

Botz R., Schmidt M., Wehner H., Stoffers P., Sedimentation Rates in the Shaban Deep (southern basin), Red Sea., *Geochem. Geophys. Geosyst.*, submitted.

Botz R., Schmidt M., Ostertag-Henning C., Kus J., Olgun N., Garbe-Schönberg C.-D., Thermal imprint on Red Sea surface sediment, in preparation.

Ligi M., F. Chierici, M. Cuffaro and A. Calafato, Three-Dimensional mantle passive flow beneath mid-ocean ridge: an analytical approach. *Geophys. J. Int.*, submitted.

Mitchell, N.C., Ligi, M., Redini, F., Bonatti, E., and Rutter, E., Submarine salt glaciers in the central Red Sea, *Basin Research*, in preparation.

Redini F., Bonatti E., Bortoluzzi G., Calafato A., Cipriani A., Ferrante V., Ligi M., Lopez Correa M., Carminati E., Mitchell N., Sichler B., Rasul N., Al Nomani S., Bahareth F., Khalil and Schmidt M, Initial emplacement of oceanic crust in the northern Red Sea: Thetis and Nereus Axial Throughs. *Tectonophysics*, in preparation.

Schmidt M., Botz R., Ehrhardt A., Ligi M., Garbe-Schönberg C.-D., Stoffers P., Bonatti E., Origin of Red Sea brine between 23 and 27°N – constrains from geochemical tracer studies, in preparation.

#### - Other

Bonatti E., Bortoluzzi G., Calafato A., Cipriani A., Ferrante V., Ligi M., Lopez Correa M., Redini F., Barabino G., Carminati E., Mitchell N., Sichler B., Schmidt M., Schmitt, Rasul N., Al Nomani S., Bahareth F., Khalil S.,



Farawati R., Gitto D. and Raspagliosi M, Geophysical, geological and oceanographic surveys in the Northern Red Sea. Report on the morphobathymetric, magnetometric, oceanographic, coring and dredging investigations during cruise RS05 aboard R/V Urania, *ISMAR Bologna Technical Report*, **94**, pp 40, 2005.

## 1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

### - *national / international Newspaper articles*

EXPLORA – La TV delle Scienze, 31-JAN-2005, Il mar Rosso potrebbe diventare il quarto oceano, [http://www.explora.rai.it/online/doc\\_news.asp?news\\_id=384](http://www.explora.rai.it/online/doc_news.asp?news_id=384)

NEWTON – Uno scienziato per amico, 31-JAN-2005, , Il mar Rosso potrebbe diventare il quarto oceano, [http://newton.corriere.it/PrimoPiano/News/2005/01\\_Gennaio/31/marrosso.shtml](http://newton.corriere.it/PrimoPiano/News/2005/01_Gennaio/31/marrosso.shtml)

ECPLANET quotidiano tecnologico e scientifico, Il quarto oceano, <http://www.ecplanet.com/canale/ecologia-6/ricerche-143/0/0/16225/it/ecplanet.rxd>

CITTA' DELLA SCIENZA, Il CNR studia il prossimo "quarto oceano", [http://www.cittadellascienza.it/news\\_dal\\_mondo/index.cfm?sw=1&id\\_cat=4&ID\\_LANCI=2820](http://www.cittadellascienza.it/news_dal_mondo/index.cfm?sw=1&id_cat=4&ID_LANCI=2820)

NONO CIELO, 14-FEB-2005, Il quarto oceano, <http://nonocielo.splinder.com/archive/2005-02>

## 1 D. Patents and industry collaborations

## 1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

Mitchell attended the Bologna ESF conference and used the opportunity for a network meeting between the other participants to the project.

## 1 F. Participation in other conferences

Please list only the most relevant

### Presentations in Scientific Meetings

#### - *Oral presentations*

Bonatti E., Transition from a continental to an oceanic rift in the Northern Red Sea, Third ESF EUROMARGINS Programme-wide Conference, 4-7 October 2006, Bologna, Italy, 2006.

Botz, R.; Wehner, H.; Schmidt, M.; Stoffers, P., Organic-rich sediments in brine-filled deeps, Red Sea. EGU General Assembly 2006, Vienna. Geophys. Res. Abstr., 8, EGU06-A-0557, 2006.

Botz, R., Wehner, H., Schmidt, M., Stoffers, P., Organic-rich sediments in brine-filled deeps, Red Sea. Third ESF EUROMARGINS Programme-wide Conference, 4-7 October 2006, Bologna, Italy, 2006.

Bonatti E. and the RS05 Team, Initial Emplacement of oceanic lithosphere in the Northern Red Sea, EGU06-A-10288; SSP17/TS2.4-1WE10-006, *European Geosciences Union General Assembly 2006*, 2-7 April, Vienna, 2006 (solicited).

Ligi M., E. Bonatti, G. Bortoluzzi, D. Brunelli, E. Carminati, A. Cipriani, V. Ferrante, F. Redini, G. Barbino, Initial Emplacement of Oceanic Lithosphere in the Northern Red Sea, *AGU Fall Meeting*, San Francisco, California, December 11-15, 2006.

Schmidt, M., Botz, R., Aeschbach-Hertig, W., Bayer, R., Schmitt, M., Boettcher, M., Stoffers, P., Bonatti, E., Biogeochemistry of brines in the Northern Red Sea. EGU General Assembly 2006, Vienna. Geophys. Res. Abstr., 8, EGU06-A-04400, 2006

Schmidt, M., Botz, R., Aeschbach-Hertig W., Bayer, R., Schmitt, M., Böttcher, M., Stoffers, P., Bonatti, E., Biogeochemistry of brines in the Northern Red Sea. Third ESF EUROMARGINS Programme-wide Conference, 4-7 October 2006, Bologna, Italy, 2006.

**- Posters**

Taviani, M., M. Lopez Correa, H. Zibrowius, M. McCulloch, P. Montagna, M. Ligi, (2005): Last glacial deep water corals from the Red Sea.- Poster, 3rd International Congress on Deep-Sea corals, December 2005, Miami, Florida, 2005.

Bonatti E., G. Bortoluzzi, Brunelli D., V. Ferrante, M. Ligi, M. Lopez Correa, F. Redini, A. Cipriani, G. Barabino, E. Carminati, A. Calafato, N.C. Mitchell, B. Sichler, M. Schmidt, M. Schmitt, N. Rasul, S.N. Al-Nomani, F. Bahreth, R.K. Farawati, S.M. Samir, A. Shawky, Y.M. Al-Hazmi, Transition from a continental to an oceanic rift in the Northern Red Sea, Polar Ridges Meeting and Workshop 2006, Sestri Levante, September 19-22, *Ofioliti*, 31, 227-249, 2006.

## Appendix 2. Scientific & technical personnel involved in the CRP

### Personnel directly funded by the EUROCORES Programme

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

Dr. Redini Francesco, PhD achieved within the project (2002-2005): thesis title "Evoluzione geologica delle zone di frattura oceaniche: indagini geologico-geofisiche lungo la zona di frattura Zabargad (Mar Rosso) e analisi comparative con le grandi trasformi oceaniche", Department of Earth Science, University of Bologna, pp. 89, 2005.

18 month post-doc fellow (February 16<sup>th</sup>, 2006 to August 15<sup>th</sup>, 2007)

Dr. Marco Cuffaro, 20 month post-doc fellow (May 1<sup>st</sup>, 2007 to December 31<sup>st</sup>, 2008)

Dr. Valentina Ferrante, 12 month post-doc fellow (July 13<sup>th</sup>, 2007 to July 12, 2008)

Portaro Rosana, 5 month post-degree fellow (July 11, 2004 to September 10<sup>th</sup>, 2004; May 25<sup>th</sup>, 2006 to July 3<sup>rd</sup>, 2006; May 23<sup>rd</sup> 2007 to July 3<sup>rd</sup>, 2007).

Stefano Carluccio, hardware and software support, 4 month contract (June 21<sup>st</sup>, 2005 to October 20<sup>th</sup>, 2005).

Dr. Tim Worthington, 9 month post-doc fellow at Kiel University.

Nazli Olgun, MSc achieved within the project: thesis title "Heat affected foraminiferal alteration in the Shaban Deep, Northern Red Sea", Inst. of Geosciences, Kiel, pp. 87, 2007.

# Imaging the western Mediterranean margins : a key target to understand the interaction between deep and shallow processes (WESTMED)

## Abstract

This is a process-oriented multidisciplinary project that integrates geological and geophysical studies to investigate the structure and evolution of the continental margins surrounding the Western Mediterranean. The coverage of available data differs noticeably from the Alboran margins (good coverage) to the South Balearic and North Algerian margins and deep basin (almost no data). Several collaborative marine and onland surveys are proposed in the frame of this project. A combined wide-angle and multichannel seismic survey, with onland data acquisition in the northern margins, is planned to unravel the structure of the crust and the uppermost mantle along selected profiles. Marine surveys based on high-resolution seismics and acoustic data acquisition will be undertaken in selected parts of the Algerian and the SE Iberian margin to investigate the sediment dynamics (turbiditic currents, depositional systems, slope instability and active tectonics) in along-strike and conjugate margins. Experimental analyses on collected offshore and onshore rock samples (from sediments to xenoliths) to determine their petrophysical and geochemical characteristics will allow for further constraints on evolutionary models. Numerical and analogue models will be developed at different scales to decipher the structure of the lithosphere and sublithospheric mantle, as well as, to reproduce the first-order driving mechanisms responsible for the present-day configuration of the region. The interaction between deep and shallow processes will be studied by integrated models relating tectonics, magmatism, vertical movements, and surface mass transport. To this end, portions of the Western Mediterranean margins will be selected as natural laboratories. Some of the proposed experiments will be done in combination with already submitted or approved projects by National Funding Agencies (MARSIBAL-Spain), (SISAL-France), and (MARADJA-France). Ship facilities and human resources will be shared within the present Collaborative Research Project.

## Partners

(MCyT, CNR, NWO, CNRS, DFG)

### **Dr Manuel Fernandez Ortiga (project leader)**

Consejo Superior de Investigaciones Científicas, Barcelona, Spain

### **Dr Miquel Canals**

Universitat de Barcelona, Barcelona, Spain

### **Dr Bernardo Cesare**

Università di Padova, Padova, Italy

### **Pr Jacques Déverchère**

Univ. de Bretagne Occidentale, Plouzané, France

### **Dr Massimo Mattei**

Università Roma Tre, Roma, Italy

### **Dr Alain Mauffret**

Université Pierre-et-Marie-Curie/Paris 6, Paris, France

### **Dr Menchu Comas Minondo**

Universidad de Granada, Granada, Spain

**Dr Tim Reston**

Christian-Albrechts University, Kiel, Germany

**Dr Randell A. Stephenson**

Vrije Universiteit, Amsterdam, The Netherlands

**Pr Rinus Wortel**

Universiteit Utrecht, Utrecht, The Netherlands

<b>Collaborative Research Project (CRP)</b>
<b>1. General information</b>
<p>Project Reference Number : 01-LEC-EMA22F  Acronym / Short Title: <i>WESTMED</i>  Full Title: <b>Imaging the western Mediterranean margins : a key target to understand the interaction between deep and shallow processes</b>  Project Leader name: <i>Dr Manuel Fernandez Ortiga</i>  Project Leader affiliation: <i>Consejo Superior de Investigaciones Cientificas, Barcelona, ES</i>  Institutional home page (URL): -  Project-related home page (URL): -  Reporting period: 01/10/2004 to 30/09/2007</p>
<b>2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)</b>
<b>IP 1</b>
<b>Dr Manuel Fernandez Ortiga</b> , Consejo Superior de Investigaciones Cientificas, Barcelona, Spain
Total Funding amount of the IP: EUR 140 000
<b>IP2</b>
<b>Dr Miquel Canals</b> , Universitat de Barcelona, Barcelona, Spain
Total Funding amount of the IP: EUR 47 000
<b>IP3</b>
<b>Dr Bernardo Cesare</b> , Università di Padova, Padova, Italy
Total Funding amount of the IP: EUR 135 000
<b>IP4</b>
<b>Pr Jacques Déverchère</b> , Université de Bretagne Occidentale, Plouzané, France
Total Funding amount of the IP: EUR 18 500 ( <i>through GDR Marges, INSU-CNRS, France</i> ) and 54 days of cruise (MARADJA2, October 25 - December 12, 2005)
<b>IP5</b>
<b>Dr Massimo Mattei</b> , Università Roma Tre, Roma, Italy
Total Funding amount of the IP: EUR 120 000
<b>IP6</b>
<b>Dr Alain Mauffret</b> , Université Pierre-et-Marie-Curie/Paris 6, Paris, France
Total Funding amount of the IP: 0 EUR
<b>IP7</b>
<b>Dr Menchu Comas Minondo</b> , Universidad de Granada, Granada, Spain
Total Funding amount of the IP: EUR 110 000
<b>IP8</b>
<b>Dr Timothy Reston</b> , Christian-Albrechts University, GEOMAR Research Centre for Marine Geosciences, Kiel, Germany
Total Funding amount of the IP: EUR 90 450
<b>IP9</b>
<b>Dr Randell A. Stephenson</b> , Vrije Universiteit, Amsterdam, The Netherlands
Total Funding amount of the IP: EUR 192 265
<b>IP10</b>

<b>Pr Rinus Wortel</b> , Universiteit Utrecht, Utrecht, The Netherlands
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Total Funding amount of the IP: EUR 374 442
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### 3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

The scientific objectives of the CRP are related to the following major EUROMARGINS topics:

- Sediment dynamics
- Rifting processes
- Numerical and analog modelling

Within each of these major topics, the major achievements are:

**Sediment dynamics.**- The main areas where studies related to sediment dynamics are performed are the Almeria margin and the Carboneras fault onshore (IP-1), the Cartagena-Mazarron margin (IP-2), the southern margins of the Balearic Promontory -Emile Baudot Escarpment- (IP-3), and the Algerian margin (IP-4). Major contributions are:

- a) the mapping of structures related to Quaternary-Recent tectonic activity and their topographic relieve expression along the mentioned margins
- b) the evidence that active tectonics controls mass wasting processes and turbiditic systems
- c) Better understanding of the evolution and controlling factors of the tributary valley system in the Almeria margin and establishing the predominance of down-slope processes vs. along-slope processes.
- d) determining the chronostratigraphy of turbidite events in the Alboran basin, and the role of sea level changes and local factors (sediment source, oceanography, neotectonics, physiography, etc.) on the spatial and vertical distribution of the turbidite events
- e) detailed morphology of the abyssal plain of the South Balear-Algerian basin showing active faulting and folding, mud-volcanos, diapiric deformation, and large recent debris flow deposits
- f) continuation of the offshore structures mapped out in the Algerian margin to onshore regions and improvement of the seismic hazard assessment
- g) evidence that sediment transport and salt tectonics are both dependent on the active tectonics and identification of channelling of turbidites and their erosional/depositional pattern along the Algeria margin
- h) Almost complete high resolution bathymetry map of the westernmost Mediterranean

Clearly, without the involvement in the CRP only partial knowledge on the sedimentary processes occurring in the Alboran and Algerian basins and their respective margins would have been developed instead of the general and diverse view that we have obtained.

**Rifting processes.**- The overlapping of the study regions of each Individual Project results in a high and interesting superposition of ideas and results. Topical studies were developed in/by: *Structural Geology* in the Alboran basin, Betics-Gibraltar-Rif system, Algerian margin, and the linking region between Betics and Iberian Chain (IP-1, IP-2, IP-4, IP-7). *Rheology-seismicity-magmatism* in the Eastern Betics and the Almeria-Cartagena margin (IP-1, IP-2, IP-10). *Paleomagnetism* in the Neogene basins of the Betics and Rif (IP-2, IP-9). *Petrology, petrophysics and geochemistry* of magma and lower crust rocks of the Almeria-Cartagena margin (IP-2, IP-10). *Crustal and lithospheric structure* of the whole region (IP-1, IP-2). *Wide-angle seismics* in the Alboran basin and south-Balear/Algerian basin (IP-1, IP-2, IP-8).

Major contributions are:

- a) Structural studies show that deep crustal structure exerts a strong control on the post-rift evolution of the south-Iberia margin resulting in basin inversion, differential vertical movements and laterally variable folding.
- b) Sedimentary budget for the Neogene and Quaternary basins (Alboran, Gulf of Cadiz, Guadalquivir, Rharrb and intramontane basins of Betics and Rif) allows us for first estimates of regional erosion/sedimentation rates through time
- c) A synthesis of the major structural units linking the Betics and Rif through the Gulf of Cadiz region
- d) Predominance in the Algerian margin of back thrusts inverting the previously passive margin and implying underthrusting of the Neogene oceanic crust



- e) Field work in the Barsella area (linking zone between Betics, Iberian Chain, and Valencia Trough) shows extensional structures oriented NNW-SSE and NE-SW clearly post-date the compressional structures related to the Pre-Betic fold and thrust belt
- f) Paleomagnetic results show clock-wise and counter-clock-wise rotations in the Betics and Rif, respectively, during and after Late Miocene indicating that bending of the Gibraltar Arc system were not complete at that time
- g) P-T paths of the Alboran crustal domain indicating synorogenic and postorogenic exhumation of deep crustal levels related to crustal stretching
- h) Timing, composition and melting of magmas, which indicate crustal anatexia induced by lithospheric thinning and/or emplacement of magma at the base of crust
- i) 2D and pseudo-3D crustal and lithospheric models of the whole region show prominent lithospheric thinning beneath the High and Middle Atlas and limited lithospheric thickening in the Gibraltar Arc system.

**Numerical and analog modelling.**- These studies include 3D modelling of crustal and lithospheric structure (IP-1); 2D numerical modelling of initiation of subduction and slab break-off (IP-1); Subduction Transform Edge Propagator –STEP– model (IP-6); 3D analog modelling of subduction and slab roll-back (IP-9). Major contributions are:

- a) Incorporation of temperature dependent mantle density in the 1D joint inversion algorithm of geoid and elevation data to map crustal and lithospheric thicknesses, as well as, petrophysical properties of mantle to make compatible thermal and tomography models and to derive dynamic topography contribution.
- b) Assemblage of a 3D numerical code to integrate gravity, geoid, elevation and temperature distribution calculations to model crustal and lithospheric structure with a variable number of bodies/layers.
- c) Design and assemblage of a 2D numerical code using level-sets and enriched finite elements to model initiation of subduction and slab break-off effects
- d) Identification of Mediterranean regions where trench migration occurs and where the application of STEP fault model is particularly suitable. Application of the STEP model to the Calabrian arc region.
- e) Analog modelling of slab roll-back shows that poloidal and toroidal flows are both active since the beginning of subduction, mantle circulation is episodic, and plate width influences mantle circulation.

**New ideas and directions.**- The results obtained in this multidisciplinary and process oriented Collaborative Research Project have permitted us to reformulate some topical aspects concerning the evolution of the Western Mediterranean: a) retreating of subducting slab and further tectonic shortening on a highly segmented Tethyan ocean as the main process responsible for the present morphology of the western Mediterranean sea; b) present conditions for a possible subduction initiation in the Algerian margin; and c) incorporating the High and Middle Atlas and the NW Moroccan margin as a key player in the evolution of the westernmost Mediterranean.

#### 4. What did you not achieve in the CRP and why? (max 1 p.)

Please use the original proposal as reference and explain any deviations from the work plan

Main deviations from the initial work plan are:

- a) No MCS profiles covering the East Alboran and the Algerian basins were acquired. The reason for that was the lack of funding to the IP-6. Nevertheless, the Principal Investigator, Prof. Alain Mauffret has been actively involved in the CRP and has produced a number of relevant papers.
- b) The studies related to the dynamics of the Eastern Betics margin and the connection between the opening of the Valencia Trough and the Algerian basin could not be completed due to the premature leaving of the contracted Post Doctoral position in IP-9, which is still not covered.

## 5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

**5. A.** Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

The collaboration within the CRP has resulted in some common short-term strategies to promote:

- a) a new CRP proposal in the framework of the TOPOEUROPE programme 'Plate reorganization in the western Mediterranean: lithospheric causes and topographic consequences (TopoMed)', in which the emphasis is focused on (1) to determine the recent tectonic and morphological changes (including vertical and horizontal motions) related to the final stages of the slab roll-back phase and the onset of compressional inversion in the coastal regions surrounding the western Mediterranean (last 5-10 Ma at least), and (2) to unravel links between surface/shallow processes and deep lithospheric/mantle structures and dynamics.
- b) The PICASSO (Program to Investigate Convective Alboran Sea System Overturn) initiative, which in addition to the US project proposal must agglutinate European and North African research teams to develop a multidisciplinary and international investigation on the structure and geodynamic evolution of the Betics-Gibraltar-Rif system using passive seismology, magnetotellurics, geochemistry/petrology/ structural geology, and geodynamic modelling. Within this initiative there are several ongoing national projects and some submitted proposals.

**5. B.** Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

According to the state of the art of the area, future developments and research priorities should be in:

- Improving the imaging resolution of the present-day structure of the crust and upper mantle, which includes new developments on the data acquisition systems and the deployment of multi-experimental platforms (seismology, magnetotellurics, GPS, etc.).
- New generation of large-scale geodynamic modelling tools linking surface and deep seated processes and incorporating full 3D calculation and views, highly non-linear equations, and discontinuous mechanics.
- Linking thermophysical properties of mantle minerals to pressure, temperature and composition in the Earth. This will determine our understanding on how densities evolve within the Earth, on the coupling between thermo-mechanical and thermo-chemical processes, and what seismic velocities, electrical conductivity and thermal properties of mantle minerals are over the full range of plausible pressures, temperatures and compositions to better image the Earth's interior.

## 6. Your feedback on the EUROCORES Programme (max 1 p.)

**6.A.** What, in your view, is the added value of being part of a EUROCORES Programme

Unfortunately, the programmes at European level that allows for collaboration among different countries are very scarce. Therefore, there are several aspects that have supposed an added value:

- a) at the scale of the Collaborative Research Project, the EUROCORES Programme allowed the different teams to interact and to exchange experiences in diverse topical fields. This has been possible because multidisciplinary was

a condition of the Programme.

b) active exchange of PhD-students and Post-Docs with the associated improvement in the know-how at individual and team levels.

c) Use of large-scale facilities (e.g. research ships, laboratories, equipments, etc.)

d) The interaction between the different CRP's has also allowed exchanging knowledge and experiences in a variety of regions and setting.

e) perhaps the most important has been to cohere international research groups with a critical mass to propose and tackle new research problems in the Solid Earth field.

**6.B.** Give any critical and constructive comments on the EUROCORES Programme and its procedures

The main criticism to the EUROCORES Programme refers to the funding organization of the Programme. The fact that each Individual Project depends on its own national funding agency and, in some cases, on the national topical programme produces important distortions. This is the case, for instance, of ship-time allocation which in our case has delayed the cruises due to the national schedules. Also, some countries may decide to not fund a particular IP because of national evaluation committees. The high discrepancy in the salary of PhD students and PostDoc among the different European countries put additional problems to find good candidates to be contracted. In summary, a centralized European funding agency would be much more efficient to develop European research scale projects.

## Appendix 1. List of Products of the CRP

### 1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more** CRPs (if any)

### 1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

- Acosta, J., Ancochea, E., Canals, M., Huertas, M.J. and E. Uchupi. Early Pleistocene volcanism in the Emile Baudot Seamount, Balearic Promontory (Western Mediterranean Sea), *Marine Geology*, 207 (1-4), 247-257, 2004.
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## 1 C. General outreach

## 1 D. Patents and industry collaborations

## 1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

## 1 F. Participation in other conferences

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## Appendix 2. Scientific & technical personnel involved in the CRP

### Personnel directly funded by the EUROCORES Programme

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD



# An integrated study of seepage through the seabed of the Nile deep-sea fan (MEDIFLUX)

## Abstract

At continental margins fluid and gases are emitted into the ocean via the seafloor. The forms of emissions extend from diffusive flow through the seafloor, to focussed flow through seeps and vents, and can be highly variable in time and space. Fluid seeps are highly dynamic sites where geosphere, biosphere, hydrosphere and atmosphere are linked. Seep fluids (liquids and gases) include hydrocarbons, carbon dioxide, nitrogen and hydrogen sulfide, in addition to water. These energy sources support distinct biological communities and chemosynthetic organisms. Currently, the global inventory of fluid seeps at passive continental margins is growing rapidly, but geological, chemical and biological processes operating at those fluid seeps remain little known. In this regard, important research tasks are deriving methane fluxes in their relevance to climatic changes, evaluation of fluid-triggered instabilities on continental slopes, and hydrocarbon geochemical prospecting in the deep offshore. MEDIFLUX proposes a comprehensive, transdisciplinary investigation of fluid seepage at a site exemplarily rich in a large variety of fluid escape structures on a passive continental margin, the Nile deep-sea fan. Objectives are (1) to describe the geographical distribution, types, geological formation and activity of fluid seeps of the Nile deep-sea fan, (2) to determine the composition of emitted fluids and use this information to infer fluid properties and fluid processes at depth, (3) to understand the controls and mechanisms of chemical element transport and breakdown by seep biota, and to obtain a well constrained budget of element cycling and export at fluid

## Partners

(CNRS, DFG, NWO)

### **Dr Jean-Paul Foucher (project leader)**

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### **Dr Catherine Pierre**

LOCEAN, Paris, France

### **Pr Jaap Sinninghe Damsté**

Koninklijk Nederlands Instituut voor Onderzoek der Zee, Texel, The Netherlands



<b>Collaborative Research Project (CRP)</b>
<b>1. General information</b>
Project Reference Number : 01-LEC-EMA23F Acronym / Short Title: <i>MEDIFLUX</i> Full Title: <b>An integrated study of seepage through the seabed of the Nile deep-sea fan</b> Project Leader name: <i>Dr Jean-Paul Foucher</i> Project Leader affiliation: <i>IFREMER, Plouzané, FR</i> Institutional home page (URL): <a href="http://www.ifremer.fr">www.ifremer.fr</a> Project-related home page (URL): - Reporting period: 01/10/2004 to 30/09/2007
<b>2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)</b>
<b>IP 1</b>
<b>Dr Jean-Paul Foucher</b> , IFREMER, Plouzané, France
Total Funding amount of the IP: EUR 44 000 in 2003-2004 + ATALANTE expedition NAUTINIL
<b>IP2</b>
<b>Dr Antje Boetius</b> , MPI/AWI, Bremen, Germany
Total Funding amount of the IP: EUR 126 000 + METEOR expedition BIONIL
<b>IP3</b>
<b>Pr Gert de Lange</b> , Universiteit Utrecht, Utrecht, The Netherlands
Total Funding amount of the IP: EUR 400 000
<b>IP4</b>
<b>Dr Jean Mascle</b> , Observatoire Océanologique, Villefranche-sur-Mer, France
Total Funding amount of the IP: EUR ?
<b>IP5</b>
<b>Dr Alain Prinzhofer</b> , Institut Français du Pétrole, Rueil-Malmaison, France
Total Funding amount of the IP: EUR ? <i>(to be corrected by the PI)</i>
<b>IP6</b>
<b>Dr Myriam Sibuet &amp; Dr Karine Olu–Le Roy</b> , IFREMER, Plouzané, France
Total Funding amount of the IP: EUR ? <i>(to be corrected by the PI)</i>
<b>IP7</b>
<b>Dr John M. Woodside</b> , Vrije Universiteit, Amsterdam, The Netherlands
Total Funding amount of the IP: EUR 149 477 + shiptime? <i>(to be corrected by the PI)</i>
<b>IP8</b>
<b>Dr Catherine Pierre</b> , LOCEAN, Paris, France
Total Funding amount of the IP: EUR ? <i>(to be corrected by the PI)</i>
<b>IP9</b>
<b>Pr Jaap Sinninghe Damsté</b> , Koninklijk Nederlands Instituut voor Onderzoek der Zee, Texel, The Netherlands
Total Funding amount of the IP: EUR ? <i>(to be corrected by the PI)</i>

### 3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

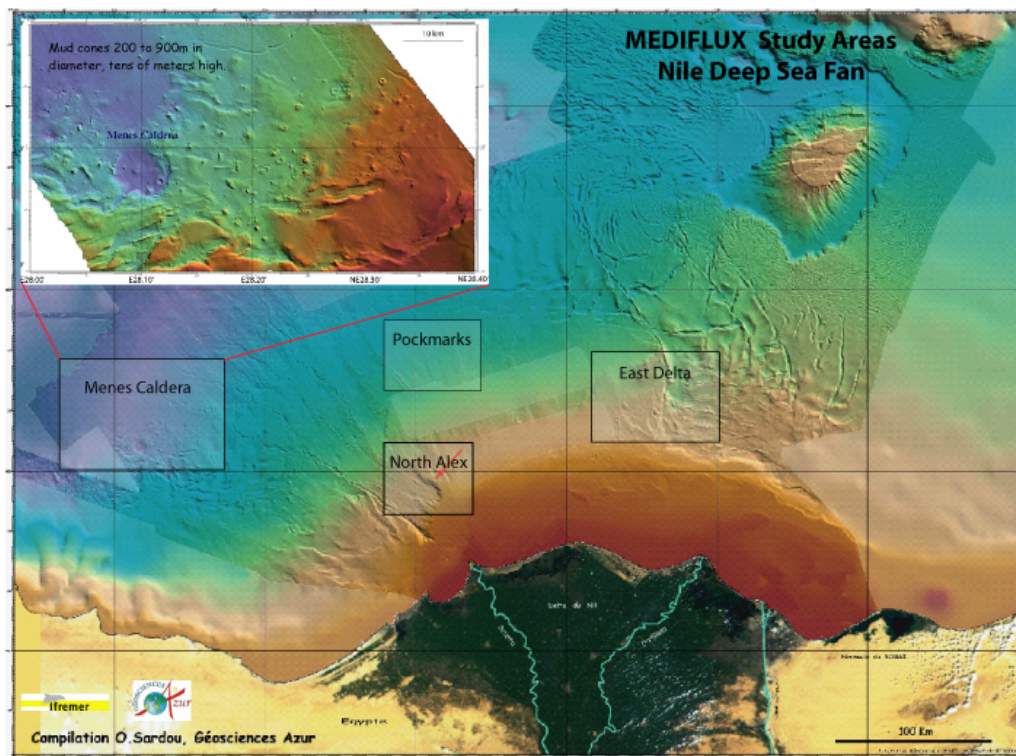
#### Objectives (reminder):

MEDIFLUX is a comprehensive, trans-disciplinary investigation of fluid seepage at an exemplary site rich in a large variety of fluid escape structures on a passive continental margin, the Nile deep-sea fan. Objectives are (1) to describe the geographic distribution, types, geological formation and activity of fluid seeps of the Nile deep sea-fan, (2) to determine the composition of emitted fluids and use this information to infer fluid properties and fluid processes at depth, (3) to understand the controls and mechanisms of chemical element transport and breakdown by seep biota, and (4) to obtain a well constrained budget of element cycling and export at fluid seeps.

#### Most important achievements:

**A coordinated programme at sea with three major cruises** successively led by France (Nautinil on RV L'Atalante, 2003, chief scientist JP Foucher), the Netherlands (Mimes on RV Pelagia, 2004, chief scientist J Woodside) and Germany (BioNil on RV Meteor, 2006, chief scientist A Boetius) **allowed for a detailed description of the geographic distribution, types, geological formation and activity of fluid seeps of the Nile deep-sea fan to be made.** Also, **MEDIFLUX was the first project to study the microbiology and biogeochemistry of methane seeps on the passive margin of the E Mediterranean. It discovered an enormous diversity of deep-water habitats related to hydrocarbon and brine emission.** Target sites included active mud volcanoes emitting gas, showing high temperature gradients indicating a high activity of mud eruption or warm fluid flow. Some of the mud volcanoes contain vast and deep brine pools representing unknown ecosystems. Other areas show vast cementation by authigenic carbonates overlying highly gassy and reduced sediments. **A high diversity of methanotrophic and thiotrophic microorganisms and symbiotic invertebrates** was found associated with these active seep systems, however, with very low biomasses. This comprehensive, trans-disciplinary investigation, mobilizing a network of research groups amongst the most qualified and experienced ones in Europe, and over a time span of only 4 years, **would not have been possible without the structuring frame of the MEDIFLUX Cooperative Research Project (CRP) in EUROMARGINS.**

1. **Processing and integration of the various, multi-scale geological and geophysical data and dive observations** that were collected during the three expeditions **document the various processes and styles of fluid emissions through the seafloor and attest to the discovery of an exceptional high level of natural brine, pore water, and hydrocarbon seepage through various mud volcanoes and gas chimneys of the Nile Deep Sea Fan (NDSF).** Three types of emissions were found to be active and were thus explored in more detail. One of the sites, a zone in the western sector of the Nile deep sea fan known as the Menes caldera, at a depth of 3000 metres, discharges brines at a temperature of around 57°C. These brines form pools and lakes on the seafloor with dimensions reaching a brine layer thickness of 250 m in the crater of the 'Chefren' mud mound situated in the interior of the Menes caldera. 'Cheops', another mud mound in the Menes caldera, has a much shallower pool (perhaps 7-15 m deep) with lower temperature brine (25°-42°C depending on location) suggesting less vigorous activity than at 'Chefren'. Intense microbial activity is observed around the brine lakes. Corresponding to a second type of emission, the mud volcanoes named 'Isis', 'Osiris', and 'Amon', in the eastern sector of the Nile fan at depths around 1000 metres, are characterized by elevated temperatures in the upper muddy sediments (more than 40°C at 9 metres below the seafloor in the centres of Isis and Amon) and intense degassing. Mud volcano North Alex, situated at a depth of 550 metres, was the focus of an exploratory dive during which intense degassing was observed in the form of bubbles of gas issuing from the seafloor within a radius of about 50 metres from the centre. The third type of fluid emissions is from a field of 'pockmarks' (shallow bowl-shaped depressions in the seafloor with diameters of the order of tens of metres and depths of a few metres) in the central part of the Nile fan at depths around 2000 metres. These results have been published or are in the process of being published in synthesis papers (Dupré et al, 2007; Bayon et al., submitted; Huguen et al, submitted).



2. **Nature of the emitted fluids.** Hydrocarbon gases at high concentrations have been collected in the sediment and the water column, reflecting a high venting activity in several zones of the NDSF. Methane concentrations in the water column reach 40  $\mu\text{mol/L}$  at 'Chefren' and 18  $\mu\text{mol/L}$  at 'Cheops', up to 40 000 times the background value of the Mediterranean. Carbon and hydrogen isotopic analyses suggest mixing between thermogenic and biogenic methane at 'Cheops' but a strong thermogenic imprint at 'Chefren'. **Thermogenic gases, generated from deep petroleum systems**, without post-genetic fractionation, were sampled at 'Isis', 'Osiris' and 'North Alex'. Noble gas isotopic patterns indicate a long residence time at 'Chefren' and 'North Alex'.
3. **'Isis' mud volcano as a pilot study site** (Mastalerz et al., 2007; Feseker et al., submitted to Special Issue EUROMARGINS). 'Isis', because of its simple, axisymmetrical 'mud-pie' geological structure, its high mud temperature, up to 43°C at 11 m below the seafloor, and its high venting activity shown by the occurrence of a large methane plume (1550nmol/L) in the bottom sea water, has been selected as a pilot study site to investigate fluid flow instabilities at a submarine mud volcano. Repeated observations of the temperature and chlorinity gradients in the upper meters of sediment revealed an **unexpected regime of decreasing temperatures that has been tentatively explained by slow percolation of seawater** through the seafloor on the summit of the mud volcano.
4. **Authigenic carbonates.** All authigenic carbonate samples studied are carbonate-cemented mudstones. Carbonates are rich in aragonite. **U-Th dating of cold seep carbonates offers a promising tool to bring new insights into biogeochemical processes at cold seeps and to assess the timing and duration of fluid venting.** This innovative method was applied to a 5.5-cm thick crust sampled in a pockmark area of active fluid venting. Results provide evidence for continuous downward carbonate precipitation at the studied location over the last  $\sim 5000$  years (Bayon et al., in press). Lipid biomarker record reveal that AOM is the major process that induced the formation of carbonate. Relatively steady  $\delta^{13}\text{C}$  values of AOM-derived biomarkers are indicative of insignificant alterations in AOM communities and hence suggest **rather uniform local seepage environment** during the formation of the carbonate crust. In contrast, one bivalve shell from the pockmark province recorded a strong sharp  $\delta^{13}\text{C}$  decrease that was interpreted as linked to a **major methane release event extending over a few months** (Liétard and Pierre, submitted).
5. **Animal communities associated with cold seeps.** Megafauna are more frequently observed in the central pockmark fields. They are dominated by vestimentifera tube worms (Siboglinidae) anchored to carbonate crusts by a thin root. Other fauna include Idas mussels, Lucinoma aff.kazani clams, anemones, galatheid

crabs, gastropods and polychetes. Up to six types of bacteria co-occur in the gills of the Idas mussels. Work regarding this unexpected diversity of symbiotic bacteria is currently being completed by host characterization.

6. **Microbial processes.** . We identified the occurrence of specific archaeal and bacterial lipids in the sediments and methane-related carbonates collected from venting sites which differ in the chemicals emitted (methane, wet gas, oil, sulfide, brines, etc.). Our results show the presence of anaerobic methanotrophs (ANME) at all studied mud volcanoes (MVs). The study of different fluid venting environments revealed different intensities and duration of AOM, most likely forced by intensity of local seepage activity, pathways, and migrated products. Based on the biomarker concentrations, the highest methane-derived biomass signal was detected in the methane-related carbonates and surrounding sediments from the North Alex MV, the site where spontaneous free-gas emanations have been observed. The distributions of specific <sup>13</sup>C-depleted archaeal biomarkers (isoprenoidal dialkyl glycerol diethers, glycerol dialkyl glycerol tetraethers, pentamethylcosane, crocetane) indicate a variability of the archaeal populations in the sediments with depth whereas carbonates show more stable composition, which, based on the lipid composition, could relate to both ANME-1 and ANME-2 archaeal groups. A novel association of archaeal lipids was found in the Chefred MV, where a new type of ecosystem with “iron” and “sulfur” precipitates and microbial mats was discovered. The capacities of methanotrophic microorganisms to control methane emission was lower in most E. Med habitats than in other ocean regions, despite the high availability of oxygen and sulfate. Potentially other components of the brines or interstitial porewaters repress methanotrophic activities. This needs further investigation.

#### 4. What did you not achieve in the CRP and why? (max 1 p.)

Please use the original proposal as reference and explain any deviations from the work plan

The project has been successful probably beyond our hopes. Main objectives have all been achieved.

A main advantage was the very early scheduling of the exploratory expedition NAUTINIL ( the first of the three expeditions in MEDIFLUX) which provided all partners with samples. Unfortunately, the third major MEDIFLUX expedition (METEOR expedition BioNil M70/2 ) providing biological samples was scheduled fairly late in November 2006 with respect to the overall MEDIFLUX schedule. The submission of data to the public databases is delayed for this reason.

#### 5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

**5. A.** Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

Several of the target sites of the MEDIFLUX project were successfully proposed as targets of the new ESF EuroCores EuroDeep Project CHEMECO.

Several partners and members of the Euromargin community have also continued work in the Eastern Mediterranean in the framework of the FP6 project HERMES. A major European research expedition has been organized, the MEDECO expedition of the RV Pourquoi pas? in October 2007 with several MEDIFLUX target sites in the Nile fan also selected as HERMES MEDECO study sites, and the same community will propose work together in the FP7 Program on the Environment (ENV.2008.2.2.1.2 Deep sea ecosystems).

**5. B.** Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

The EuroMargins community has provided input to the writing of the Deep Sea Frontier Brochure which summarizes recommendations for the next 5-10 years in the field of ocean margin and deep sea research.

**6. Your feedback on the EUROCORES Programme (max 1 p.)**

**6.A.** What, in your view, is the added value of being part of a EUROCORES Programme

Connecting leading laboratories in Europe.

Facilitating shared access to relevant infrastructure in Europe (e.g. submersible Nautinil, ROV Quest, AUV Aster<sup>x</sup>, ...).

Participation in EuroMargin workshops for European networking and education of PhD students.

**6.B.** Give any critical and constructive comments on the EUROCORES Programme and its procedures

Interaction with funding agencies/institutions has appeared to be poor for several countries.

Funding and scheduling the field work (ship time, mobilization of survey and dive tools), after a project has been well ranked by ESF, remain highly uncertain in many cases. The three-year duration of a project is too short for projects dealing with deep water processes and field work organization.



## Appendix 1. List of Products of the CRP

### 1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more CRPs** (if any)

- Organization (J Woodside) and Participation in the ESF EUROMARGINS SEACAM Workshop, Rimini, Italy, 9-12 September 2007. SEACAM report.

### 1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP** (both joint and individual)

#### Peer-reviewed papers

Bayon G., Henderson G.M. & Bohn M.. U-Th stratigraphy of a cold seep carbonate crust. *Chemical Geology* (in press)

Bayon, G., Loncke, L., Dupré, S., Caprais, J.-C., Ducassou, E., Duperron, S., Etoubleau, J., Foucher, J.-P., Fouquet, Y., Gontharet, S., Henderson, G.M., Huguen, C., Klaucke, I., Mascle, A., Migeon, S., Olu-Le Roy, K., Ondréas, H., Pierre, C., Sibuet, M., Stadnitskaia, A. and Woodside, J., M., 2007. Fluid seepage on an unstable margin: The case of the Centre Nile fan. *Marine Geology* (submitted to EUROMARGINS special issue)

Dupré, S., Woodside, J., Foucher, J.-P., de Lange, G., Mascle, J., Boetius, A., Mastalerz, V., Stadnitskaia, A., Ondréas, H., Huguen, C., Harmégnies, F., Gontharet, S., Loncke, L., Deville, E., Niemann, H., Omoregie, E., Olu-Le Roy, K., Fiala-Medionil, A., Dählmann, A., Caprais, J.-C., Prinzhofer, A., Sibuet, M., Pierreh, C., Sinninghe Damsté, J., and the NAUTINIL Scientific Party, 2007. Seafloor geological studies above active gas chimneys off Egypt (Central Nile Deep Sea Fan). *Deep Sea Research Part I: Oceanographic Research Papers* 54, 1146-1172.

Feseker, T., Dählmann, A., Foucher, J.-P., Harmégnies, F., In-situ sediment temperature measurements and geochemical porewater data suggest highly dynamic fluid flow at Isis mud volcano, eastern Mediterranean sea. *Marine Geology* (submitted to EUROMARGINS special issue).

Gontharet S., Pierre C., Blanc-Valleron M.-M., Rouchy J.-M., Fouquet Y., Bayon G., Foucher J.-P., Woodside J.,

Mascle J. and the Nautinil Scientific Party, 2006. Origin of the diagenetic carbonate crusts and concretions from the mud volcanoes and pockmarks of the Nile deep-sea fan. *Deep Sea Research I* (in press)

Gontharet, S., Stadnitskaia, A., Bouloubassi, I., Pierre, C., Sinninghe Damsté, J.S. 2007. Palaeo methane-seepage history traced by biomarker patterns in a carbonate crust, Nile deep-sea fan (Eastern Mediterranean Sea). *Marine Geology* (submitted to EUROMARGINS Special Issue).

Huguen C., Mascle J., Woodside J., Zitter T., Foucher J.P., 2005. Mud volcanoes and mud domes of the central Mediterranean ridge: near-bottom and in situ observations. *Deep Sea Research*, 52, 1911-1931

Huguen, C., Foucher, J.-P., Mascle, J., Ondréas, H., Thouement, M., Gontharet, S., Stadnitskaia, A., Pierre, C., Bayon, G., Loncke, L., Boetius, A., Bouloubassi, I., De Lange, G., Fouquet, Y., Woodside J. M. and the NAUTINIL Scientific

Party, 2007. The Western Nile Margin Fluid seepage features: "in situ" observations of the Menes caldera (NAUTINIL Expedition, 2003). *Marine Geology* (submitted to EUROMARGINS special issue).

Liétard C. & Pierre C. High resolution isotopic records ( $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$ ) and cathodoluminescence of lucinid shells from methane seeps of the Eastern Mediterranean. *Geo-Marine Letters* (submitted).

Mastalerz, V., de Lange, G., Dählmann, A., Feseker, T., 2007. Active venting at the Isis mud volcano, offshore Egypt: Origin and migration of hydrocarbons. *Chemical Geology*, 246, 87-106.

Omoregie, E.O., Mastalerz, V., de Lange, G., Straub, K.L., Kappler, A., Røy, H., Stadnitskaia, A., Foucher, J.-P., Boetius, A. 2007. Biogeochemistry and community composition of iron- and sulfur-precipitating microbial mats at the Chefren mud volcano (Nile Deep Sea Fan, Eastern Mediterranean). *Applied and Environmental Microbiology* (in press).

Omoregie, E.O., Niemann, H., Mastalerz, V., de Lange, G., Stadnitskaia, A., Mascle, J., Foucher, J.-P., Boetius, A. 2007. Microbial methane oxidation and sulfate reduction at cold seeps of the Nile Deep Sea Fan (Eastern Mediterranean Sea). *Marine Geology* (submitted to EUROMARGINS Special Issue).

Stadnitskaia A., Bouloubassi, I., Elvert, M., Hinrichs K.-U., Sinninghe Damsté, J.S. 2007. Extended hydroxy archaeol, a novel lipid biomarker for anaerobic methanotrophy in cold seepage habitats. *Organic Geochemistry* (submitted).

## 1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

Several interviews with journalists have resulted in newspaper articles and radio exposure for the research in France, Germany and the Netherlands (e.g. in the Netherlands: *Volkskrant* 20-03-04, *Nederlands Wereld Omroep* in April 2004, and a public lecture at Museum in The Hague the 17 December 2004, in Germany: interviews of A Boetius for *Science New*; Finnish Television, on Microbial Diversity in the Deep Sea ).

ESOF Euroscience open forum, 15-19 July Munich.

Lecture by A. Boetius "Achieving results in European science collaborations: Bio-diversity at ocean margins" in the ESF Special Session "Can the European Dimension in the Research Agenda be Delivered?"

## 1 D. Patents and industry collaborations

## 1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

Several cooperative initiatives were successful including:

NIOZ work was carried out in close partnership with MEDIFLUX co-workers from the MPI (Bremen, Germany; PI is Prof. A. Boetius) and the Université Pierre et Marie Curie (Paris, France; PI is Prof. C. Pierre). Under the umbrella of the MEDIFLUX project, two collaborative visits (20.03.05 – 02.04.05 and 25.09.05 – 09.10.05) of a PhD student S. Gontharet (promoter Prof. C. Pierre; Université Pierre et Marie Curie, Paris, France) were carried out to the laboratory of Marine Biogeochemistry and Toxicology (Royal NIOZ). During these visits, the main aim for

S.Gontharet was to learn molecular biomarker techniques of value to her research while carrying out certain laboratory work on her samples, and to work jointly with Prof. Dr. J.S.Sinninghe Damsté and A. Stadnitskaia on publications in which their results are integrated. Regarding the formation of the authigenic methane-related carbonates, studies are all integral to the MEDIFLUX research. Thus it was important for both groups to work together for a broader interpretation of the material.

In July 2005, A.Stadnitskaia was invited to visit MPI (Prof. A. Boetius, E.Omerighe; Bremen, Germany). The visit was devoted to compare of obtained lipid (NIOZ) and molecular biological (MPI) data and to discuss/outline preliminary plan of joint publications.

## 1 F. Participation in other conferences

Please list only the most relevant

Numerous presentations were made at national and international conferences (AAPG, AGU/EGU,...) including:

- **AGU/EGU 2004 General Assembly**, Nice, France, BG Session "Methane fluxes", Convenor A. Boetius, co-convenor S Joye, with key contributions by MEDIFLUX partners.
- **EGU 2005 General Assembly**, Vienna, Austria, Session BG3.02 "Methane fluxes at continental margins: budgets and controlling factors (co-sponsored by OS & CL)", Convenor A Boetius, co-convenor S Joye, with key contributions by MEDIFLUX partners.
- **EGU 2007 General Assembly**, Vienna, Austria, Session BG6.04 "Methane fluxes at continental margins: ecosystems, drivers and controls" (co-listed in CL), Convenor A Boetius, Co-Convenor JP Foucher, with key contributions by MEDIFLUX partners.
- **Goldschmidt Conference**, August 2007, Cologne Session "Theme 12 "Oceans and Atmospheres": Symposium 4: Biogeochemistry in Extreme Marine Environments" Convenor A Boetius, P Linke, K Wallmann, with key contributions by MEDIFLUX partners.
- **Participation in the Research Workshop entitled "Fluid seepages and mud volcanoes in the Mediterranean and adjacent domains " organized by the CIESM in Bologna, Italy, 19-22 October 2005.** The Workshop was a great opportunity to exchange knowledge and share experiences with other groups working in thematically similar research. MEDIFLUX participants: J. Mascle, T. Feseker, S. Dupré, G. de Lange, G. Bayon, S. Gontharet.

## Appendix 2. Scientific & technical personnel involved in the CRP

### Personnel directly funded by the EUROCORES Programme

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

See PI statements in Interim Reports.

#### Involvement of young scientists

**6 PhD students involved (all PhDs defended):** Laurent Camera (Geosciences Azur), Vincent Mastalerz (Univ Utrecht), Swanne Gontharet (UPMC Paris), Cécile Liétard (UPMC, Paris), Sébastien Duperron (Ifremer), Enoma Omoregie (MPI)

**4 Post-doc involved:** Stéphanie Dupré (Free Univ Amsterdam), Tom Feseker (Ifremer), Helge Niemann (AWI/MPI), Alina Stadnitskaia (NIOZ).

# Tectonic control, deep crustal structure and fluid escape pathways in the gulf of Cadiz mud volcanic field (MVSEIS)

## Abstract

This project investigates the deep crustal structure, the sedimentary section and sediment dynamics, the tectonic control and the detailed geometry of the fluid escape pathways in an area of active mud volcanism in the Gulf of Cadiz, from where gas hydrates have been recovered. It joins the efforts of a multidisciplinary and multi-national team of scientists conducting active research in the Gulf of Cadiz, with expertise in various complementary research fields relevant to this investigation. An innovative multiscale approach to the imaging of the mud volcanic edifices, fluid conduits and largescale tectonic control on gas escape features will be applied, acquiring both deep seismic profiles, and high resolution, closely spaced, 2-D seismic surveys (pseudo-3D, using for the first time in this area two recently developed high-resolution deep-tow seismic systems: DTAGS and the new RCMG's deep-tow system). The deep crustal structure of the area will be investigated with seismic reflection profiles and new refraction and wideangle data, acquired along existing deep multichannel seismic lines. Particular attention will be put into unravelling the links between the deep faulting in the accretionary complex/olistostrome and the mud volcanism. Active faults in the Gulf of Cadiz and off SW Portugal will be targets of further investigation and sedimentary coring, in order to determine the age of their most recent activity, which will allow constraining the recent stress field in the study area and to unravel its relationship with the mud volcanism. The transition between focused flow and diffuse flow patterns in shallow horizons, the intrinsic facies of diffuse flow pathways and the role of stratigraphic controls on flow deflection and shallow migration pathways will also be investigated. One other topic that will be investigated is the possible methane-related origin of some carbonate mound build-ups and chimneys, focussing on any potential relationship with subtle underlying structural deformations such as polygonal faulting. Also, the relative role of climate-controlled oceanographic variability versus tectonics in the episodic formation and activity of fluid venting structures will be investigated. Particular emphasis will be put into unravelling the effect of the periodic variability of the Mediterranean Outflow Water (MOW) on the dissociation of gas hydrates, particularly in the northern sector of the Gulf of Cadiz, and the contribution of the release of the methane stored in the oceanic sediments to the formation of carbonate crusts and chimneys and to the greenhouse gas effect. Using heat-flow data and high resolution bathymetry, attempts will be made to estimate the volume of gas hydrates and methane Gulf of Cadiz. Finally this project will contribute to the understanding of the role of methanotrophic and sulphide-reducing bacteria (SRB) in the building up of chemosynthetic ecosystems and "reefs" and the biomineralisation processes related to biochemical transfer between methane and organisms in the Gulf of Cadiz.

## Partners

(MCyT, FWO, FCT, CNRS)

### **Dr Luis Pinheiro (project leader)**

Universidade de Aveiro, Aveiro, Portugal

### **Dr Joan Gardner**

Naval Research Laboratory, Washington DC, United States

### **Dr Marc-André Gutscher**

Université de Bretagne Occidentale, Plouzané, France

### **Pr Jean-Pierre Henriët and Pr Pieter Van Rensbergen**

Universiteit Gent, Gent, Belgium

### **Dr Luis Somoza**



<b>Collaborative Research Project (CRP)</b>
<b>1. General information</b>
<p><u>Project Reference Number</u> : 01-LEC-EMA24F  <u>Acronym / Short Title</u>: <i>MVSEIS</i>  <u>Full Title</u>: <b>Tectonic control, deep crustal structure and fluid escape pathways in the Gulf of Cadiz mud volcanic field</b>  <u>Project Leader name</u>: <i>Dr Luis M. Pinheiro</i>  <u>Project Leader affiliation</u>: <i>Universidade de Aveiro, PT</i>  <u>Institutional home page</u> (URL): <a href="http://www.cesam.ua.pt/">http://www.cesam.ua.pt/</a> <a href="http://www.ua.pt/geo">www.ua.pt/geo</a>  <u>Project-related home page</u> (URL): <a href="http://www2.geo.ua.pt/mvseis/">http://www2.geo.ua.pt/mvseis/</a>  <u>Reporting period</u>: 01/10/2004 to 30/09/2007</p>
<b>2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)</b>
<b>IP 1</b>
<b>Pr Luis M. Pinheiro</b> , Universidade de Aveiro, Aveiro, Portugal
Total Funding amount of the IP: EUR ? 105 000 ( <i>200.000 Euros more for 2008 to carry out the final MVSEIS cruise wait confirmation from FCT</i> ).
<b>IP2</b>
<b>Pr Marc-André Gutscher</b> , Université de Bretagne Occidentale, Plouzané, France
Total Funding amount of the IP: EUR 460 000 ( <i>including grants and allocated ship time</i> )
<b>IP3</b>
<b>Pr Jean-Pierre Henriët, Dr Pieter Van Rensbergen, Dr. Davy Depreiter</b> Universiteit Gent, Gent, Belgium
Total Funding amount of the IP: EUR 0 ( <i>Funding only obtained for RCMG's EUROMARGINS Moundforce project participation, with authorization to participate in MVSEIS without any additional funding</i> )
<b>IP4</b>
<b>Dr Luis Somoza</b> , Instituto Geológico y Minero de España, Madrid, Spain
Total Funding amount of the IP: EUR 50 000
<b>AP1</b>
<b>Dr Joan Gardner</b> , Naval Research Laboratory, Washington DC, United States
Total Funding amount of the IP: EUR 0



### 3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

- 1. Discovery of new mud volcanoes and fluid escape structures:** Until present 41 mud volcanoes (MVs), and 2 mud cones were discovered and confirmed by coring in this area. 38 of these were discovered on cruises coordinated by MVSEIS PI's. MVSEIS cruises alone discovered and confirmed by coring 13 MVs. Other fluid escape structures identified on side-scan sonar images and seismic profiles wait confirmation by coring hopefully during the final MVSEIS cruise next summer (this cruise should have taken place last summer but was postponed to 2008 due to ship's problems; funding confirmation is needed).
- 2. Scientific cruises in the scope of MVSEIS and related projects where PI's are involved: 12:** CADIPOR (MVSEIS, 2002, WP4); GAP (Kopf, 2003; participation of MVSEIS PI's and students); TTR-14 (MVSEIS, 2004, WP1 and WP-4); CADISAR-2 (2004, WP3); MATESPRO (2004, WP1); DELILA (MVSEIS, 2004, WP3); SWIM-04 (2004; participation of MVSEIS partners); DELSIS (2005, WP3); CADIPOR- 2 (2005, WP3); TTR-15 (MVSEIS, 2005, WP1, WP4); SWIM-05 (SWIM, 2005, participation of MVSEIS partners); TTR-16 (MVSEIS, 2006, WP1; WP4).
- 3. Contribution to the completion of a high resolution multibeam bathymetry map for the Gulf of Cadiz and mapping of the area of active deformation.** MVSEIS contributed to this compilation coordinated by the SWIM Euromargins Project (where MVSEIS partners participate), through the DELILA, DELILA-2, CADISAR-2 cruises, the Portuguese MATESPRO cruise (coordinated by Portuguese MVSEIS partners) and collaboration with the German GAP cruise (A. Kopf).
- 4. Processing, interpretation (structural and detailed seismo-stratigraphic) and calibration of the seismic reflection profiles acquired with well data (where available).** This was carried out for most of the available and more representative seismic profiles.
- 5. Structural control of the mud volcanism and fluid escape structures, active structures, seismicity and neotectonics.** The new seismic, side-scan sonar and high-resolution bathymetry provide a much better constrained picture of the structural control of the fluid escape structures in the area. Mud volcanism appears to be controlled by major fault systems and to be restricted to the accretionary wedge now mapped in detail, where active deformation is taking place. Major fault systems related to the Africa-Eurasia plate boundary were imaged and a continuous, active deformation front all along the NW, W, SW and S limits of the accretionary wedge was mapped, raising the question of the possible existence of an active subduction in the area. New images of the subduction zone beneath Gibraltar were also obtained. The deep crustal faulting appears to control the location of the fluid escape manifestations at the surface (MVs, mud diapirs, pockmarks, carbonate mounds and fault-controlled diapiric ridges). This was confirmed by the geochemical signature of the fluids, which indicates intensive mixing of deep and superficial fluids. The concentration of the mud volcanoes and the geochemical evidence of active dewatering processes is common in convergent margin settings and supports continued deformation in the accretionary wedge, which could be linked to a narrow subduction system beneath Gibraltar.
- 6. High resolution images of mud volcanoes and fluid conduits.** High resolution seismic profiles combined with deep-towed side-scan sonar and high resolution MB bathymetry reveal the detailed internal and external structure of the MVs and allow imaging of some of the major fluid conduits. A detailed study of the El Arraiche Mud Volcano Field was carried out (WP-4), combining high resolution sea floor and subsurface mapping, allowing a detailed description of the mud volcano activity in relation to the structural setting, a description of the morphology of the sediment extrusion and intrusion, the characterization of the faunal distribution at shallow to deep water mud volcanoes in the Gulf of Cadiz, the temporal and spatial variations of mud volcanic eruptions in relation to recent structural evolution of the study area (with details of the history of activity of the MVs), and the correlation of the eruption activity between mud volcanoes in a seismic stratigraphic framework. A morphological comparison with onshore mud volcanoes and magma volcanoes confirmed the occurrence of

different morphological end-members in relation to the type of extrusion.

- 7. Gas Hydrates, Bottom Simulating Reflectors (BSR) and shallow gas hydrate accumulations:** Gas hydrates were recovered from 4 MVs in the Gulf of Cadiz (Ginsburg, Bonjardim, Captain Arutyunov and Porto), but it is likely that they also exist in other MV's. They were analysed at the Univ. Bristol (collaboration with E. Hornibrook), and at the Univ. Aveiro (collaboration with J. Coutinho), complementing previous studies carried out in St. Petersburg (Mazurenko et al., 2002; 2003). The presence of significant percentages of C<sub>2+</sub> homologues indicates a thermogenic origin for the gas, suggesting the existence of petroleum in sediments at depth. A BSR was identified on the Mercator MV (WP 4), on high resolution seismic profiles. Thermal modelling demonstrated that thermogenic gas hydrates with a composition similar to that observed by Mazurenko et al. (2003) can indeed be stable at such shallow depths; this is one of the shallowest reports of hydrate accumulations.
- 8. Direct observation of active gas bubbling in the Gulf of Cadiz and methane release to the hydrosphere/atmosphere.** Active fluid seepage was first observed on the Mercator Mud Volcano (Cadipor-2 cruise; Van Rooij, 2005). During the TTR-15, cruise clear gas bubbles escaping to the water column were also observed and recorded. As concerns the escape of methane to the hydrosphere/atmosphere and its potential contribution to global climate change, pore water analyses and methane oxidation measurements in sediment cores from several MVs showed that the hydrocarbons are completely consumed in subsurface sediments. Anaerobic oxidation of methane (AOM) and sulphate reduction rates (SRR) show maxima in distinct subsurface sediment horizons at the methane-sulphate transition zone (SMT), ranging with depths from 20 to 200 cm below sea floor. Corresponding lipid biomarker and 16S rDNA clone library analysis show that AOM is mediated by a mixed community of previously described anaerobic methanotrophic archaea and associated sulphate reducing bacteria (SRB). These results indicate that, at their present state of activity, the contribution of methane to the hydrosphere and potentially to the atmosphere from the mud volcanoes in this area is not significant, but this may not be the case during eruptions.
- 9. Mineralogical, petrological and geochemical and geomicrobiological characterization of sediments and mud breccia clasts.** Carried out in collaboration with ETH, Geomar and the Univ. Bristol. It included: mineralogical and petrographical description of the mud-breccia clasts and samples, which provide a window to the deep sedimentary units of the basin; bulk and clay fraction mineralogy of sediments and clasts by XRD; biomarker analysis on sediment samples to investigate the microbial consortia and processes involved in anaerobic methane oxidation (AOM) which prevent the release of methane to the hydrosphere/atmosphere
- 10. Mineralogical, petrological, geochemical and geomicrobiological characterization of methane-related authigenic carbonates (MDAC).** Extensive abundance of MDAC in the Gulf of Cadiz reveal areas of intense fluid seepage in the past. Studies included 87Sr/86Sr analyses, SEM coupled with elemental analysis, the determination of total Organic C, Total C, N and O, XRD mineralogy, Stable C and O isotopes; microscopy cathodoluminescence on thin sections, and U/Th isotopic analyses for age determination (at ETH and Geomar, in collaboration with A. Eisenhower and J. Mckenzie).
- 11. Gas composition, microbial methanogenesis and geochemical characterization of the mud volcano gases and interstitial fluids.** Molecular and isotopic analyses of the composition of the hydrocarbon gases from pore fluids and clathrates was carried out and integrated with geological and geophysical data to provide constraints on the depth of methanogenesis and the processes involved in the generation, migration and mixing of the gases vented at mud volcanoes. Hydrocarbon gases are essentially thermogenic in origin, indicating the presence of petroleum at depth. This was directly confirmed by the analysis of petroleum in lipids extracted from mud breccia sediments at several MVs. The bulk of the fluids generating seepage are released from deeply buried sediments (~ 3.5-4 km) during clay mineral transformations at temperatures ~ 60°C to 150°C (smectite-illite transformation). These fluids are mixed with hydrothermal fluids formed at temperatures > 150°C at greater depth, and their chemical composition becomes modified due to leaching of evaporites during transport in the sediments at some of the sites (e.g., Ginsburg MV). This work was carried out in collaboration with E. Hornibrook, R. Pancost and M. Nuzzo (Univ. Bristol), C. Hensen (Geomar), R. J. Parkes (Univ. of Wales at Cardiff) and João Coutinho (Univ. Aveiro). It comprised: (1) Analysis of pore water H<sub>2</sub> in the sediments; (2) Analysis of pore water Volatile Fatty Acids by ion chromatography (at the Univ. Wales, UK); (3) Determination of the rate of microbial methane production in the sediments using radio-labelled (14C) substrates; (4) estimation of microbial biomass in sediments by epifluorescence microscopy; (5) GC-FID analysis of the molecular composition of light hydrocarbons (C<sub>1</sub>-C<sub>5</sub>); (6)

Analysis of the stable carbon isotope composition of C<sub>1</sub>-C<sub>5</sub> by GC-IR-MS; (7) Analysis of the stable hydrogen isotope composition of methane by GC-pyrolysis-MS (at Isotech Laboratories, USA); (8) Analysis of lipid biomarkers extracted from mud breccia sediments by GC-MS (Collaboration with R. Pancost from Univ. Bristol). Studies on the chemistry of interstitial fluids were carried out by C. Hensen and colleagues at Geomar (Collaboration), and were also carried out at the Univ. Aveiro on samples from TTR-14 and TTR-15. Sediments were characterized for water and carbon content and the percentage of the fine fraction (less than 63 µm). Sediments and interstitial waters were analysed by ICP-MS, for determination of total concentrations of Br, Li, Rb, Na, K, Ca, Sr, Ba, Fe, Mn, Cu, Zn, Ni, B, Cd and Pb. Gases and sediments from Meknés, Semenovich, Porto and Bomjardim MVs were analysed by GC to determine the concentration in hydrocarbons. Methane stable carbon ( $\delta^{13}\text{C}$ ) and stable hydrogen ( $\delta\text{D}$ ) isotopic composition were determined by GC-IRMS.

**12. Heat flow transects.** Acquired by WP-2, WP-3 and WP-5, showing active underthrusting pattern (collaboration with I. Grevemeyer, IFM-Geomar).

**13. Tsunami waveform modelling.** Performed by WP-3, in collaboration with M.-A. Baptista and J.M. Miranda (University of Lisbon), with participation WP-1 partners, to better understand the source of the 1755 Lisbon earthquake and seismicity of the area.

**14. Characterization of the faunal distribution at shallow to deep water mud volcanoes in the Gulf of Cadiz.** In collaboration with M. Cunha (Biology Dep., Univ. Aveiro).

**15. Modelling the effect of seafloor current driven subsurface fluid pumping.** WP-4 has come forward with alternative hypotheses for driving subsurface fluid flow in shallow sediments. Numerical modeling indicates that the flow of a seafloor current over an obstacle, as well as tidal oscillation, is capable of effectively altering the thermal and geochemical field in shallow sediments. This is of great importance for geochemical processes, e.g. in relation to anaerobic methane oxidation and the formation of hydrocarbon-derived carbonates. For the thermal field, changes in local thermal gradients or effective temperature, the stability field of gas hydrates can be influenced.

**Final remark.** Most of the initial CRP objectives were achieved, as well as new complementary scientific objectives, not included in the initial plan, which arose as the project developed, thanks to the collaboration of new partners and intense CRP and cross-CRP collaboration, largely promoted by the several Euromargins funded cross-CRP Workshops and participation in project meetings at major conferences. This would not have been easily achievable under another project scheme. Collaboration between geologists, geophysicists, geochemists, biologists, and microbiologists increased since the start of the project and those who made significant contributions became associated to the project, participated in MVSEIS cruises and are working on data collected in the scope of the MVSEIS project. The results obtained are extremely encouraging and exciting and contribute significantly to a better understanding to the processes and products in areas of hydrocarbon-rich fluid seepage, which is one of the key objectives in the Euromargins scientific programme.

#### 4. What did you not achieve in the CRP and why? (max 1 p.)

Please use the original proposal as reference and explain any deviations from the work plan

It was not possible yet to acquire some of the data that was initially planned, due to two unforeseen circumstances, such as ship availability and the fact that, in particular, a considerable amount of funding for shiptime initially planned by WP-1 and WP2 was not allocated to the project. Nevertheless, the MVSEIS partners, as shown in this report and the Interim report, were able to find alternative solutions to minimize this impact, by joining efforts in joint cruises and by seeking external funding and collaboration with other projects. The missing data includes multichannel seismics (MCS), refraction and wide-angle seismic reflection profiles, high resolution DTAG deep towed profiles and heat-flow data – basically 2 cruises which could not take place. The reasons for this were: (1) a technical problem with the RV Hesperides and the tight ship schedule which has not yet allowed the cruise planned in the Spanish Work package to take place; this cruise should investigate in more detail particularly the the Tasyo field and the northeastern part of the Gulf of Cadiz; (2) A technical problem with the RV Explora, which did not allow the initial WP-1 seismic refraction cruise to take place, although OBS's were available as planned, since the

plan was to use the opportunity of the passage of this ship in the area to act as a shooting ship and enable the acquisition of the deep seismic data; (3) the reduced funding attributed to the Portuguese work package did not allow the initially planned 1 month cruise with acquisition of heat-flow measurements and deep-towed high resolution seismic profiles (using the WP-5 DTAG system). However, if funding is confirmed by the Portuguese Science Foundation, the final MVSEIS cruise planned by WP1 which should have taken place in the summer of 2007 will take place in the summer of 2008 and a significant amount of new data will be acquired to complement that already available. This lack of funding also did not allow one of the student scholarships to be opened (essential to help with some of the detailed processing of the deep seismic reflection profiles), but it may be opened in 2008 if funding permits. Nevertheless, alternative solutions were sought and good project results were obtained, including the discovery several new mud volcanoes and the development of new lines of research, often based on other sources of funding. Unplanned detailed studies of the methane-related authigenic carbonates, were carried out, including dating of the crusts and chimneys, determining the role of AOM and the development of geomicrobiological studies, in collaboration with new research groups (such as the Univ. Bristol, ETH, Chemistry Dep., Univ. Aveiro) and networking activities with other Euromargins partners externally funded.

#### **5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)**

**5. A.** Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

New follow-up activities include:

The IODP Pre-proposal 689 "Mud Volcanoes as a Window into the Deep Biosphere " (Depreiter, D. et al.; [http://www.iodp.org/index.php?option=com\\_docman&task=doc\\_download&gid=819](http://www.iodp.org/index.php?option=com_docman&task=doc_download&gid=819) for proposal summary), submitted to IODP in 2006 aims to drill the Mercator mud volcano on the Moroccan margin for studying geomicrobiological, geochemical, thermal and physical aspects of a mud volcano. The drilling would allow testing of the BSR hypothesis, and give insight in the internal plumbing system and growth history of mud volcanoes. The proposal benefits from MVSEIS results, and several partners from the CRP were involved in developing the proposal. The proposal is developing towards a Full proposal in 2008.

Several MVSEIS PI's, together with other Euromargins CRP's are involved in the HERMES Project and new possibilities are being analysed for the continuation within HERMES 2.

Several MVSEIS PI's, based on this experience of working together recently applied jointly to the TOPOEUROPE Programme and new joint ventures are envisaged for the projects approved.

Several bi-lateral collaboration schemes (e.g. Portugal-Germany; Portugal-Morocco, etc.) have arisen as a result of this project and have allowed scientists to apply for national funding for joint actions as spin-offs of this project to jointly investigate questions that have arisen and develop new lines of joint research.

**5. B.** Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

Cold seeps and areas of extensive fluid seepage are of major scientific importance since they deal with fundamental scientific questions like the contribution of these systems to global climate change, life adaptation to extreme habitats and associated ecosystem characterization, geosphere/biosphere coupling processes, possible alternative energy resources for the 21<sup>st</sup> century (e.g. gas hydrates) and biotechnology developments, the role of the deep biosphere and natural hazards connected to gas hydrate de-stabilization and/or to active tectonics that generally characterize areas of extensive fluid seepage. Europe, given its vast richness in this type of habitats and natural laboratories, can have a world leading role in research in this area. That clearly demands a multi-national and multidisciplinary approach and the joining of efforts and sharing of large scale facilities and expertise between different European countries, for which ESF can play a most important role. The results from the fluid flow Euromargins projects have already levered other large multi-national research projects, such as Hermes. Also, new initiatives some of which are already taking place involving deep-sea drilling (IODP) to test the new ideas proposed is fundamental. In particular joint studies involving continental drilling and deep-sea drilling on these systems is a must. Fostering the involvement of industry in such projects, for sharing of data and technological developments would be a very good move forward.

## 6. Your feedback on the EUROCORES Programme (max 1 p.)

### 6.A. What, in your view, is the added value of being part of a EUROCORES Programme

Being part of an Eurocores program has had several added values. First, thanks to this scheme, several transnational teams of scientists dealing with a fairly large variety of topics in Earth Sciences could apply for funding and carry out joint collaborative research on key multidisciplinary topics. The fact that several projects in complementary areas, ranging from fluid flow to other aspects of continental margins were taking place at the same time under the same programme and that cross-CRP communication was strongly encouraged, facilitated and promoted, for instance by the allocation of funds for joint Workshops and CRP meetings for presentation and discussion of results at large international conferences, allowed many new ideas, often not included in the original work plans to be put into action, thus opening new fields for international collaboration, as has happened during the execution of this project.

### 6.B. Give any critical and constructive comments on the EUROCORES Programme and its procedures

As concerns the functioning of future Eurocores programmes, this has shown to be an excellent mechanism to foster this type of fairly large trans-national multidisciplinary projects. The communications channels established and the funding that has been allocated for joint workshops and meetings where ideas and data can be shared between the different CRP's, together with the support for student's and young researchers participation in these meetings, has proven to be of the utmost importance for the scientists involved and for achieving the aimed results. The bureaucracy of the system and reporting procedure has been lightened to the minimum, which is very important for the scientists involved to be able to concentrate on the research.

The main concern in such a scheme, from our experience, is that it of the utmost importance that the national funding agencies make a firm commitment of the funding allocated to the projects and that this funding is allocated timely to the scientists, so that the project objectives can be achieved. As far as we know this has already been improved in the most recent versions of this funding scheme.



## Appendix 1. List of Products of the CRP

### 1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more CRPs** (if any)

Since several MVSEIS PI's and partners are involved in 3 Euromargins Projects, namely MVSEIS, MOUNDFORCE and SWIM, and these three projects deal with very complementary problems, many of the papers published involve close collaboration between at least 2 of these CRP's. In fact two of these projects deal with fluid flow and its expressions (MVSEIS and MOUNDFORCE). In areas like the Gulf of Cadiz, mud volcanoes and carbonate mounds are strongly linked. As concerns the SWIM project, it deals with the active tectonics of the Africa-Eurasia plate boundary, which strongly controls the fluid escape structures in this area.

#### **2008, in prep.**

Nuzzo M., Hornibrook, E. R. C., Hensen C., Schneider, von Deimling J., Parkes, R. J., Rinna, J., Sommer, S., Magalhães, V. H., Reitz, A., Brückmann, W., and Pinheiro, L. M. Shallow microbial recycling of deep-sourced carbon in Gulf of Cadiz mud volcanoes. (to be submitted to *Geomicrobiology Journal*, end of January).

Nuzzo M., Pancost R. D., Hornibrook E. R. C., Hensen C., Gill F., Magalhães V. H., Haeckel M., Reitz A., Scholz F., Brückmann W., and Pinheiro L. M. Origin of light volatile hydrocarbon gases in mud volcano fluids, Gulf of Cadiz – Indications for hydrothermal methane vents (To be submitted to *Geochimica et Cosmochimica Acta*).

#### **2008, submitted or in press**

Gonzalez, F. J., L. Somoza, R. Lunar, J. Martinez-Frias, J. A. Martin Rubi, T. Torres, J. E. Ortiz, V. Diaz del Rio, L. M. Pinheiro, and V. H. Magalhaes. Hydrocarbon-derived ferromanganese nodules in carbonate-mud mounds from the Gulf of Cadiz: mud-breccia sediments and clasts as nucleation sites. (*Submitted to EUROMARGINS special issue of Marine Geology*).

Magalhaes, V. H., L. M. Pinheiro, C. Vasconcelos, J. A. Mc Kenzie, S. M., Bernasconi, A. Kopf, M. K. Ivanov, V. Diaz-del-Rio, and L. Somoza. Morphological, mineralogical and geochemical characterization of methane-derived authigenic carbonates from the Gulf of Cadiz: a formation model. (*Submitted to EUROMARGINS special issue of Marine Geology*).

Medialdea, T., L. Somoza, L. Pinheiro, M. C. Fernandez-Puga, J. T. Vazquez, R. Leon, M. K. Ivanov, V. Magalhaes, V. Diaz-del-Rio, R. Vegas, and A. Maestro. Fluid escape pathways and tectonics in the Gulf of Cadiz. (*Submitted to EUROMARGINS special issue of Marine Geology*).

Terrinha, P., Matias, L., Vicente, J., Duarte, J., Luis, J., Pinheiro, L., Lourenço, N., Diez, S., Rosas, F., Magalhães, V., Valadares, V., Zitellini, N., Mendes Víctor, L. and MATESPRO Team. Sea floor morphology and active tectonics of the Gulf of Cadiz Africa-Iberia transpressive boundary: new evidence from multibeam bathymetry and seismic reflection data. (*Submitted to EUROMARGINS special issue of Marine Geology*).

#### **2007**

González, F. J., Somoza, L., Pinheiro, L.M., Ivanov, M., Lunar, R., Martínez-Frías, J., Martín Rubí, J. A., Leon, R. Díaz del Río, V. (2007). Biomineralizaciones de pirita-carbonatos mediadas por microorganismos extremófilos en el Golfo de Cádiz. En: II Semana de Jóvenes Investigadores. Publicaciones del Instituto Geológico y Minero de España pp. 71-81. IGME Madrid. ISBN: 978-84-7840-719-4.

Gutscher, M.-A., Dominguez, S., Westbrook, G., Gente, P., Babonneau, N., Mulder, T., Gonthier, E., Bartolome, R., Luis, J, Rosas, F., Terrinha, P., and the Delila and DelSis Scientific Teams. (in press). Tectonic shortening and gravitational spreading in the Gulf of Cadiz accretionary wedge: observations from multi-beam bathymetry and seismic profiling. *Journal of Marine and Petroleum Geology*, Sp. Vol. on Submarine instabilities (in press).

Hensen, C., Nuzzo, M., Hornibrook, E., Pinheiro, L.M., Bock, B., Magalhães, V.H. and Brückmann, W. 2007. Sources of mud volcano fluids in the Gulf of Cadiz - indications for hydrothermally altered fluids. *Geochimica et Cosmochimica Acta*, 71: 1232-1248.

#### **2006**

Hernández-Molina, F. J.; Llave, E.; Stow, D.A.V.; García, M.; Somoza, L.; Vázquez, J.T; Lobo, F.; Maestro, A.; Díaz del Río, V.; León, R.; Medialdea, T. Gardner, J. (2006). The Contourite Depositional System of the Gulf of Cadiz: a sedimentary model related to the bottom current activity of the Mediterranean Outflow Water and the

continental margin characteristics. *Deep-Sea Research II*, 53: 1420-1463.

Llave, E., Schonfeld, J., Hernandez-Molina, F.J., Mulder, T., Somoza, L., Diaz del Rio, V. and Sanchez-Almazo, I. 2006. High-resolution stratigraphy of the Mediterranean outflow contourite system in the Gulf of Cadiz during the late Pleistocene: The impact of Heinrich events. *Marine Geology*, 227: 241-262.

Niemann, H., Duarte, J., Hensen, C., Omoregie, E., Magalhães, V.H., Elvert, M., Pinheiro, L.M., Kopf, A. and Boetius, A. 2006. Microbial methane turnover at mud volcanoes of the Gulf of Cadiz. *Geochimica et Cosmochimica Acta*, 70: 5336-5355 doi:10.1016/j.gca.2006.08.010.

### **2005**

Van Rensbergen, P., Depreiter, D., Pannemans, B., Moerkerke, G., Van Rooij, D., Marsset, B., Akhmanov, G., Blinova, V., Ivanov, M., Rachidi, M., Magalhães, V., Pinheiro, L., Cunha, M. & Henriot, J.P., 2005. The El Arraiche mud volcano field at the Moroccan Atlantic slope, Gulf of Cadiz. *Marine Geology*, 219(1), 1-17.

### **2004**

Medialdea, T., Vegas, R., Somoza, L., Vázquez, J.T., Maldonado, A., Díaz-del-Río, V., Maestro, A., Córdoba, D and M. C. Fernández-Puga (2004). Structure and evolution of the Olistostrome complex of the Gibraltar Arc in the Gulf of Cádiz (E Central Atlantic): evidence from two long seismic cross-sections. *Marine Geology* 209, 1-4 , 173-198.

### **2003**

Díaz-del-Río, V., Somoza, L., Martínez-Frias, J. , Mata, M.P., Delgado, A., Hernandez-Molina, F.J., Lunar, R., Martín-Rubí, J.A., Maestro, A., Fernández-Puga, M.C., León, R., Llave, E., Medialdea, T., Vázquez, J.T. (2003). Vast fields of hydrocarbon-derived carbonate chimneys related to the accretionary wedge/olistostrome of the Gulf of Cádiz. *Marine Geology* 195, 1-4, 177-200.

Maestro, A., Somoza, L., Medialdea, T., Talbot, C.J., Lowrie, A., Vázquez, J.T. y Díaz del Río, V. (2003). Large-scale slope failure involving Triassic and Middle Miocene salt and shale in the Gulf of Cadiz (Atlantic Iberian Margin). *Terra Nova*, 15, 6: 1-12.

Pinheiro, L.M., Ivanov, M., Sautkin, Akhmanov, G., Magalhães, V.H., Volkonskaya, A., Monteiro, J.H., Somoza, L., Gardner, J., Hamouni, N, Cunha, M. and the TTR10 Cruise party (2003). Mud volcanism in the Gulf of Cadiz: results from the TTR-10 cruise. *Marine Geology*, 195, 131-151.

Somoza, L., Diaz-del-Rio, V., León, R., Ivanov, M., Fernandez-Puga, M., Gardner, J., Hernandez-Molina, J., Pinheiro, L.M., Rodero, J., Lobato, A., Maestro, A., Vasquez, J., Medialdea, T. & Fernández-Salas, L. (2003). Seabed morphology and hydrocarbon seepage in the Gulf of Cadiz mud volcano area: acoustic imagery, multibeam and ultra-high resolution seismic data. *Marine Geology*, 195, 153-176.

Terrinha, P., Pinheiro, L., Henriot, J., Matias, L., Ivanov, M., Monteiro, J., Akhmetzanov, A., Volkonskaya, A., Cunha, T. Shashkin, P., Rovere, M, TTR10 Cruise party (2003). Tsunamigenic-seismogenic structure, neotectonics, sedimentary processes and slope instability on the SW Portuguese margin. *Marine Geology*, 195, 55-73.

## **1 B. Publications and products of individual projects**

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

### **2008, in prep.**

Berndt, C., Gutscher, M.-A., and Akhmetzhanov, A., (in prep.). Deep-rooted mud volcanism in the Gulf of Cadiz supports a subduction plane origin for the 1755 Lisbon earthquake. *Geology*, (to be submitted spring 2008).

Nuzzo M., Hornibrook E. R. C., Hensen C., Schneider von Deimling J., Parkes R. J., Rinna J., Sommer S., Magalhães V. H. , Reitz A., Brückmann W., and Pinheiro L. M. Shallow microbial recycling of deep-sourced carbon in Gulf of Cadiz mud volcanoes. (to be submitted to *Geomicrobiology Journal*)

Nuzzo M., Pancost R. D., Hornibrook E. R. C., Hensen C., Gill F., Magalhães V. H., Haeckel M., Reitz A., Scholz F., Brückmann W., and Pinheiro L. M. Origin of light volatile hydrocarbon gases in mud volcano fluids, Gulf of Cadiz – Indications for hydrothermal methane vents (To be submitted to *Geochimica et Cosmochimica Acta*)

### **2008, submitted or in press (6 submitted to SCI journals)**

Gonzalez, F. J., L. Somoza, R. Lunar, J. Martinez-Frias, J. A. Martin Rubi, T. Torres, J. E. Ortiz, V. Diaz del Rio, L. M. Pinheiro, and V. H. Magalhaes. Hydrocarbon-derived ferromanganese nodules in carbonate-mud mounds from



the Gulf of Cadiz: mud-breccia sediments and clasts as nucleation sites. (*Submitted to EUROMARGINS special issue of Marine Geology*).

Magalhaes, V. H., L. M. Pinheiro, C. Vasconcelos, J. A. Mc Kenzie, S. M., Bernasconi, A. Kopf, M. K. Ivanov, V. Diaz-del-Rio, and L. Somoza. Morphological, mineralogical and geochemical characterization of methane-derived authigenic carbonates from the Gulf of Cadiz: a formation model. (*Submitted to EUROMARGINS special issue of Marine Geology*).

Medialdea, T., L. Somoza, L. Pinheiro, M. C. Fernandez-Puga, J. T. Vazquez, R. Leon, M. K. Ivanov, V. Magalhaes, V. Diaz-del-Rio, R. Vegas, and A. Maestro. Fluid escape pathways and tectonics in the Gulf of Cadiz. (*Submitted to EUROMARGINS special issue of Marine Geology*).

Rosas, F.M., Duarte, J.C., Terrinha P., Valadares V., Matias L. (submitted) - Morphotectonic characterization of major bathymetric lineaments in NW Gulf of Cadiz (Africa-Iberia plate boundary): insights from analogue modelling experiments. *Accepted with minor corrections to EUROMARGINS special issue of Marine Geology*.

Somoza, L., J. Gardner, K. Loudon, R. Leon, V. Diaz del Rio, W. Jung, F. J. Hernandez-Molina, T. Medialdea, and F. J. Gonzalez. Anomalous heat flows at mud volcanoes and pockmarks in the Gulf of Cadiz: focused fluid venting, gas hydrates and Mediterranean undercurrent. (*Submitted to EUROMARGINS special issue of Marine Geology*).

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### **1 C. General outreach**

Radio interviews, TV coverage, Newspaper articles etc.

#### **TV appearance**

Gutscher, M.-A. French Television station M6, 29/Nov/2005 23:00 (interview in Lisbon). Tsunami en France, sommes-nous menacés? (show produced and narrated by Mac Lesggy).

Pinheiro, L. M.: Portuguese Television station –Channel 2, 17 Jan. 2006 – Program 3810. The MVSEIS Project (show produced by TV Program 3810).

#### **Radio appearance**

Gutscher, M.-A.: Tsunami hazard in Morocco. Radio Maroc, Casablanca, 4 Octobre 2007 (interview par telephone). Réseau d’alerte au tsunami au Maroc et le projet Européen Nearest.

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#### **National / international Newspaper articles (presenting the CRP or part of the CRP results)**

##### **2007**

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##### **2005**

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**Süddeutsche Zeitung**, Munich Allemagne, 27 July 2005, p. 9 Überall Atlantis. M.-A. Gutscher. <http://www.sueddeutsche.de/wissen/artikel/496/57439/>

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##### **2004**

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**National Geographic News Online**. 30 August, 2004 (interview by telephone). Great Portugal earthquake may have a sequel, study says. [http://news.nationalgeographic.com/news/2004/08/0830\\_040830\\_portugal\\_quake.html](http://news.nationalgeographic.com/news/2004/08/0830_040830_portugal_quake.html)

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**National Geographic** News Online 30 August, 2004. M.-A. Gutscher. [http://news.nationalgeographic.com/news/2004/08/0830\\_040830\\_portugal\\_quake.html](http://news.nationalgeographic.com/news/2004/08/0830_040830_portugal_quake.html)

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**The Scotsman** 27 August, 2004. Europe warned to expect massive earthquake as anniversary nears. <http://news.scotsman.com/scitech.cfm?id=1003432004>

#### Conferences for the general public:

Séisme et tsunami du 26 déc. 2004 en Sud-Est Asie: l'Europe est-elle aussi menacée?, 8 Fév. 2005 Conférence IUEM, Plouzané. M.-A. Gutscher.

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Les tsunamis : regards croisés d'un écrivain et d'un scientifique, 18 Mai 2005 Discussion, Librairie Dialogues, Rue de Siam, Brest. M.-A. Gutscher.

## 1 D. Patents and industry collaborations

As concerns the crustal structure and tectonics of the Gulf of Cadiz, access to some multichannel seismic lines acquired in 2000-2001 by TGS-NOPEC (Norway) in this area was granted to WP1, for planning of the cruises and data acquisition. Also, WP4 studies on the Morocco margin have benefitted from contacts and information exchanges with ONHYM and REPSOL.

## 1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

There was quite an intense networking within the CRP, mainly thanks to the workshop facilities provided by ESF, as well as travelling grants mainly for students and young researchers. Many of the MVSEIS cruises were planned and carried out jointly between more than one national workpackage. This was complemented by meetings organized with national or bi-lateral funding. As a result, most papers involve collaboration between members from different WPs. In all the ESF-funded Workshops organized, as well as in large international conferences and scientific meetings, a period was always devoted to internal CRP discussions, presentation/discussion of the results and planning of new data acquisition, discussion of data processing parameters and joint interpretation of data. This

provided a unique opportunity for the members of the CRP coming from different countries to meet together. Intense email exchange took place for joint preparation of joint papers.

#### **2007**

SEECAM WORKSHOP, Rimini (Italy) 10.09.07 - 13.09.07 SEECAM workshop. GEOLOGICAL, CHEMICAL AND BIOLOGICAL INTERACTIONS AT COLD SEEPS AND CARBONATE MOUNDS – A SYNTHESIS. GEOITALIA 2007, Rimini, September 10-13, 2007. Organized jointly by the MVSEIS, MOUNDFORCE and MEDIFLUX CRP's. Internal CRP meetings were carried out.

#### **2006**

WP-4 participated in a HERMES cruise by NOC with R/V Charles Darwin in 2006 during which high-resolution 3D seismics have been acquired over Mercator mud volcano on the Moroccan margin.

In the scope of the CRUP/DAAD joint action from 2005 (2 year duration), several WP1 students and scientists were able to meet together and continue the geomicrobiology research work at the Max Planck Institute and the University of Aveiro

#### **2005**

5 months stay of **Joana Duarte** (MSc student), at the Max Planck Institute (MPI) for Marine Microbiology, Bremen. This was possible thanks to a collaboration with another Principal Investigator from the MEDIFLUX Euromargins project, Antje Boetius (MPI, Bremen Germany), which was started thanks to the scientific interchange that was possible through the workshops organized with the ESF/Euromargins support, which allowed intensive interchange of results and ideas among the various Fluid Flow Projects in Euromargins. Extra funding was obtained for this action, through a Joint Portuguese-German Action, financed by CRUP (Board of Rectors of the Portuguese Universities) and DAAD (German Academic Exchange Service). The title of this joint action was: Geosphere/Biosphere Coupling Processes in the Gulf of Cadiz, and it was coordinated by A. Boetius (MEDIFLUX) and L.M. Pinheiro (MVSEIS).

2 visits by M.-A Gutscher and **J. Roger** to Univ. of Lisbon to perform tsunami modelling. Feb. 2005 (5 days).

Participation of Italian, Spanish, Portuguese, English, German and French scientists and **students** at the 3 day IMPACTS Workshop 16-18 March 2005, Brest, France (funded by the ESF).

EGU Meeting Vienna (Apr. 2005). Most CRP PI's and students from the different countries involved in the project attended the meeting and internal CRP meetings to discuss joint results and plan new actions were carried out. **E. Thiebot** and **V. Magalhães** participations were funded by the ESF. The same has happened in most EGU meetings, for which ESF has organized meetings and sponsored student participation.

Interaction with the Euromargins SWIM Project. Participation of several members of the MVSEIS team, including **students**, in the compilation of the new high resolution bathymetric chart for the Gulf of Cadiz, which includes multibeam data acquired during the TASYO, MATEPRO, DELILA, CADISAR and GAP cruises.

#### **2004**

Organization of the meeting MARGIN GEOFLUIDS: THE AVEIRO FORUM, 1-3 April 2004, Aveiro, Portugal. This meeting, funded by ESF, was brought together 36 researchers and **young researchers** from 3 Euromargins projects (MVSEIS, MEDIFLUX and MOUNDFORCE) and representatives from other 2 (SWIM and WESTMED). Key research issues were discussed between the various projects dealing with fluids in continental margins, together with a large exchange of experience and data interpretation. New joint lines of action were coordinated (including launching of bilateral actions to support researchers and student interchange). Well known scientists in this field were invited for keynote talks. Representatives from the Intersectorial Oceanographic Commission and from the Portuguese Science Foundation were also present. Internal CRP's meetings were carried out in one of the days of the meeting.

MEDIATIC Meeting, in Barcelona, November 2004, funded by ESF, organized by the WESTMED Euromargins Project, and which joined together 3 Euromargins projects: WESTMED, SWIM and MVSEIS. This was also an excellent

opportunity for the researchers and **young researchers** of these 3 projects to meet, discuss, share data and experience, and prepare joint activities. This meeting was highly complementary to the Aveiro Forum because it concentrated on the tectonic aspects of MVSEIS, including the deep crustal structure in the Gulf of Cadiz and the nature and location of the Africa-Eurasia Plate Boundary in this region. A summary of scheduled cruises was listed so that every participant was aware of any opportunities for joint collaboration and sharing shiptime. Internal CRP's meetings were carried out in one of the days of the meeting.

2 visits by M.-A Gutscher to Univ. of Lisbon to perform tsunami modelling. Nov. 2003 (3 days), March. 2004 (2 days).

2 week visit by L. Matias to Univ. Brest (July 2004) (seismic processing).

Participation by 1 Italian, 1 Spanish, 4 Portuguese and 3 French scientists on DELILA cruise R/V D. Carlos 27 Sept. – 8 Oct. 2004.

Participation of elements and **young researchers** from MVSEIS and SWIM Euromargins projects in the MATESPRO cruise, June-July 2004, which acquired multibeam data made available for MVSEIS.

Involvement of 2 new researchers (chemists) in the Portuguese team: J. Coutinho, specialist in gas hydrates with experience in the oil industry, and E. Pereira, specialist on geochemistry of sediments and pore-water samples.

Visit of **Vitor Magalhães** to ETH Zentrum, Geologisches Institut, Zurich, to perform analytical work and to discuss with C. Vasconcelos and J. McKenzie the preliminary interpretation of the analytic results on authigenic carbonate samples collected in the Gulf of Cadiz during the TTR11, TTR12, ANASTASIA2000, ANASTASIA 2001 and GAP cruises. The analytic work carried out at ETH included XRD analyses, stable carbon and oxygen isotopes, microscopic cathodoluminescence observations, and U/Th isotope analyses.

Approval and start of a bilateral Portuguese-German Action between the Portuguese team and the Max Planck Institute, Bremen, Germany, to perform biomarker analysis on sediment samples from both MVSEIS and GAP cruises. One MSc student (**Joana Duarte**) spent 3 months at MPI working on biomarkers together with Antje Boetius' research group. This is a networking activity within the CRP and between CRP's.

Collaboration with E. Hornibrook, R. Pancost and M. Nuzzo, from the University of Bristol, R. J. Parkes from the University of Wales at Cardiff, and with C. Hensen and W. Bruckmann (IFM-Geomar) on methanogenesis and mud volcano fluids origin and composition. **M. Nuzzo** has participated in the GAP, the TTR-14 and TTR-16 cruises, and has analyzed samples collected by C. Hensen for gas geochemistry during the Merian 1 cruise and she has completed her PhD in April on sediment and gas samples from all these cruises. She has also spent some time at the Univ. Aveiro in 2005 learning microbiological techniques. Marianne Nuzzo was associated to the MVSEIS team.

Participation of M.-A. Gutscher and **E. Thiebot** in the Mediatic Meeting Barcelona (Nov. 2004), funded by the ESF. Internal CRP meetings were carried out during their meeting.

Participation on a meeting of the Portuguese and Spanish MVSEIS teams in the University of Cadiz. L. M. Pinheiro, **V. Magalhães, C. Roque, M.C. Fernandez-Puga**.

Participation of **D. Depreiter** and P. Van Rensbergen on a Training course on "Continuum modelling of non-linear equations using the finite element method", Oslo (NOR), 10.05.2004 - 05.06.2004

Participation of **D. Depreiter** on the Agououn/USC International Geobiology Course 2004, Catalina Island (USA), 10.06.2004 - 24.08.2004

### **2003**

Marie Curie Training, by **C. Middag**, Kiel (GER), 22.09.2003 - 03.10.2003



## 1 F. Participation in other conferences

Please list only the most relevant

### *Invited/keynote talks*

**2007**

**SEECAM-Geitalia workshop "GEOLOGICAL, CHEMICAL AND BIOLOGICAL INTERACTIONS AT COLD SEEPS AND CARBONATE MOUNDS – A SYNTHESIS". Rimini, September 10-13**

Magalhães V. H., Pinheiro L. M., Ivanov M. K., Vasconcelos C., McKenzie J. A., Bernasconi S. M., Kopf A. J., Díaz-del-Río V., González F. J. and Somoza L., 2007. Authigenic carbonates from the Gulf of Cadiz.

Nuzzo M., Gill F., Hensen C., Hornibrook E. R. C., Pancost R. D., Magalhães V. H., Haeckel M., and Pinheiro L. M. The origin of light volatile hydrocarbon gases in mud volcano fluids, Gulf of Cadiz.

***Magellan Workshop on "Exploring escarpment mud mound systems and mud volcanoes with new European strategies for sustainable mid-depth coring, Murten (Switzerland) 26.04.2007-29.04.2007***

Depreiter, D. (2007) Mud volcanoes as a window into the deep biosphere.

***2nd International Workshop on Gas Hydrates for the Future Energy and Environment. Kitami Institute of Technology***

Poort, J., Kaulio, V., Depreiter, D. & Soloviev, V., 2007. The thermal signals in gas hydrate seeps and mud volcanoes: an overview. In: Proceedings 2nd Int. Workshop Gas Hydrates for the Future Energy and Environment. Kitami Institute of Technology. pp. 11-16.

**2005**

***AGU 2005 Fall Meeting***, San Francisco (USA) 05.12.2005 - 09.12.2005

Depreiter, D., Van Rensbergen, P., Poort, J., De Boever, E., Swennen, R. & Henriët, J.P. (2005). Integrated geophysical and petrological characterization of mud volcanoes at the Moroccan Atlantic margin – linking morphology to fluid flow".

Tytgat, N., Depreiter, D., Kervyn, M., Van Rensbergen, P., Henriët, J.P. & Ernst, G. (2005). Comparing the morphology of mud versus magmatic volcanoes.-

***250<sup>th</sup> anniversary colloquium of the 1755 Lisbon earthquake***, Lisbon, 1.11.2005 – 4.11.2005

Diez, S., Gracia, E., Th., Gutscher, M.-A., Matias, L., Mulder, T., Terrinha, P., Somoza, L., Zitellini, N., de Alteris, G., Henriët, J.-P., and Danobeitia, J.J. (2005). Bathymetric map of the Gulf of Cadiz, NE Atlantic Ocean: The SWIM multibeam compilation.

Gutscher, M.-A. (2005). Whodunnit in 1755? New clues from Sumatra, from the seafloor off SW Iberia and from GPS. (invited talk).

***2<sup>nd</sup> International Workshop on "Gas hydrate studies and other related topics – for future energy and environment considerations***. Kitami (JAP), 21.10.2005 – 23.10.2005

Poort, J., Kaulio, V. & Depreiter, D. (2005). The Thermal Signals in Gas Hydrate Seeps and Mud Volcanoes: An Overview.

***CIESM Workshop: Fluid seepages/mud volcanoes in the Mediterranean and adjacent domains***, Bologna (ITA) 19.10.2005 - 22.10.2005

Henriët, J.P., Hamoumi, N., Pinheiro, L., Ivanov, M., Van Rensbergen, P., Depreiter, D. (2005). The mud volcano province on the Atlantic Moroccan margin: towards a natural laboratory for joint European-Maghreb research.

Pinheiro, L.M., Magalhães, V., Somoza, L., Gardner, J., Ivanov, M., Kopf. (2005). Structural control of mud volcanism and hydrocarbon-rich fluid seepage in the Gulf of Cadiz: Recent results from the TTR-15 Cruise.

***Association des Sédimentologues Français Meeting***, Giens, France, 10.2005

Gutscher, M.-A., Babonneau, N., Gonthier, E., Mulder, Th. (2005). Enregistrement sédimentaire de la paléosismicité dans le Golfe de Cadix.

***GV Annual Meeting on "System Earth-Biosphere coupling"***. Erlangen (GER), 24.09.2005 – 29.09.2005

Henriët, J.P., Foubert, A., Maignien, L., "Atlantic Carbonate Mound drilling: challenges ahead, from Porcupine to the Morocco margin" –THE PROPOSALS '573-LIGHT' AND '673-PRE' TEAMS & EXPEDITION 307 SCHIPBOARD PARTY.

Depreiter, D. & Henriët, J.P. (2005). Gas hydrate stability and focussed fluid seepage in mud volcano settings: IODP 673Pre proposal.

Foubert, A., Maignien, L., De Boever, E., Beck, T., Hebbeln, D., Blamart, D. & Henriët, J.P. (2005). Carbonate mounds in a seep province on the Moroccan margin: a prime target for ocean drilling (IODP 673-pre proposal).

***AAPG Annual Convention***, Calgary (CAN), 19.06.2005 – 22.06.2005 2005

- Depreiter, D., Van Rensbergen, P., Poort, J., De Boever, E., Swennen, R. & Henriët, J.P. (2005). Integrated geophysical and petrological characterization of mud volcanoes at the Moroccan Atlantic Margin – Linking morphology to fluid flow.
- EGU General Assembly 2005**, Vienna (AUT), 24.04.2005 - 29.04.2005
- Depreiter, D. (2005). Mud volcanism and mounds on the Moroccan margin: origin and growth.
- Van Rensbergen, P., Depreiter, D., Pannemans, B. & Henriët, J.P. (2005). Sea floor expression of sediment extrusion and intrusion at the El Arraiche mud volcano field, Gulf of Cadiz.
- Pinheiro, L.M., Comas, M., Magalhães, V., Carvalho, A., Moedas, J., Aguado, B., Somoza, L., Gardner, J. And Ivanov, M. (2005). Structural control on hydrocarbon-rich fluid venting in the Gulf of Cadiz: new insights from the TTR-14 and MATESPRO cruises.
- Gutscher, M.-A., and the DELILA Shipboard Party (2005). Active deformation in the Gulf of Cadiz: New cruise results and the possible link to the source of the 1755 Lisbon earthquake and tsunami.
- Thiebot, E., Camurri, F., Gutscher M.-A., Klingelhöfer, F., Perrot, J. (2005). Deep structure of the Gulf of Cadiz from reflection/refraction seismic data.
- IMPACTS Workshop: Iberia Margin Paleoseismology, Active Tectonics and Sedimentology**, Plouzané, France. 16.03.2005 – 18.03.2005
- Hensen, C., Nuzzo, M., Hornibrook, E.R.C., Brüeckmann, W., Magalhães, V.H., Parkes, R.J. And Pinheiro, L.M. (2005). The origin of mud volcano fluids in the Gulf of Cadiz.
- 4th Symposium of Meteorology and Geophysics of the APMG (in Portuguese)**, 14.02.2005 – 17.02.2005
- Matias, L., Terrinha, P., Mendes-Victor, L. E Grupo Matespro-Mb. (2005). O Levantamento Multifeixe Matespro Revela Novas Estruturas Tectónicas na Margem SW Ibérica.
- Geosphere-Biosphere Coupling Processes: the TTR interdisciplinary approach towards studies of the European and N. African margins. TTR14 Post-cruise meeting and International Conference**. 02.02.2005 – 05.02.2005
- Magalhães, V.H., Birguel, D., Peckmann, J., Srisawang, B., Pinheiro, L.M., Vasconcelos, C., Mckenzie, J.A. And Ivanov, M.K. (2005). Authigenic carbonate chimneys and crusts from the Gulf of Cadiz: Biomarker evidence of archaea mediating anaerobic oxidation of methane.
- VIII International Conference on Gas in Marine Sediments**, Vigo, Spain. 05.09.2005 – 10.09.2005
- Niemann, H., Duarte, J., Hensen, C., Omeregíe, E., Elvert, M., Magalhães, V.H., Boëtius, A. And Pinheiro, L.M. (2005). Complete Reduction of Methane Efflux from Mud Volcano Sediments in the Gulf of Cadiz.
- The Atlantis Hypothesis Conference**, Milos, Greece. 11.06.2005 – 13.06.2005
- Gutscher, M.-A. (2005). The destruction of Atlantis by a great earthquake and tsunami? a geological analysis of the Spartel Bank hypothesis.
- PANGEA-05**, Univ. Évora, Março, 2005.
- Pinheiro, L. M. (2005). Processos de acoplamento Geosfera/Biosfera em sistemas associados a escape de fluidos ricos em hidrocarbonetos. (Invited talk)**
- 2004**
- EuroMargins MEDIATIC Meeting**, Barcelona 11.11.2004 – 13.11.2004
- Gutscher, M.-A. (2004). The search for the source of the Great Lisbon earthquake.
- Gutscher, M.-A. and Delila Team, Cadisar 1 And Cadisar 2 Teams (T. Mulder *et al.*), and Gap Team (A. Kopf *et al.*) (2004). Gulf of Cadiz: New cruise data provide impetus for deep sea drilling.
- Pinheiro, L.M., Somoza, L., Henriët, J.-P., Van Rensbergen, P., Gutscher, M.A., Gardner, J. and Mvseis Research Team (2004). Gas seepage and mud volcanism in the Gulf of Cadiz: new results from the EUROMARGINS MVSEIS project.
- 23rd International Association of Sedimentologists Meeting**, Coimbra, Portugal.
- Pinheiro, L.M. (2004). Hydrocarbon-rich fluid seepage, gas hydrates and mud volcanism in the Gulf of Cadiz. (Invited Keynote Talk).
- Pinheiro, L.M., Magalhães, V.H. and Monteiro, J.H., (2004). Vulcanismo de lama, hidratos de metano e potenciais ocorrências de hidrocarbonetos na Margem Sul Portuguesa profunda (in Portuguese). Academia de Marinha. (Invited Talk).
- 2003**
- 1st International Workshop on Continental Margin Tectonics and Gas Hydrates, Beijing, China (16-18/11/04)**.
- Pinheiro, L.M. (2003). Gas hydrates and mud volcanism in the Gulf of Cadiz. First International Workshop on Continental Margin Tectonics and Gas Hydrates Conference Proceedings, Beijing, Nov, 2003; 17. (Invited Talk).

## Oral Presentations/posters

### 2007

- Berndt, C., Haeckel, M., Hensen, C., Heeschen, K., Klaeschen, D., Masson, D., Depreiter, D., Planke, S. & Akhmetzhanov, A (2007). Halokinesis-controlled mud volcanism in the Gulf of Cadiz, Hermes Annual Meeting, Algarve (PT) 26.03.2007-30.03.2007.
- Depreiter, D., Naudts, L., Foubert, A. & Henriët, J.P. (2007). Externally driven subsurface fluid pumping and consequences. Geoph. Res. Abstracts, 9, 06128. EGU General Assembly, Vienna (AT) 13.04.2007-18.03/.2007
- Duarte, J.C., Rosas, F., Terrinha, P., Valadares, V., Matias, L., Roque, C., Magalhães, V., Henriët, J.P., Taborde, R. and Pinheiro, L. 2007. Deep Submarine Giant Scours in northern Gulf of Cadiz offshore SW Iberia): a singular case of sedimentary and tectonic coupling? In: EGU General Assembly 2007 (Ed EGU), 9, pp. SRef-ID: 1607-7962/gra/EGU2007-A-03940. Geophysical Research Abstracts, Vol. 9, 03940.
- González, F.J., Somoza, L., Pinheiro, L.M., Magalhães, V.H., Ivanov, M., Lunar, R., Martínez-Frías, J., Martín Rubí, J.A., León, R. and Díaz del Río, V. 2007. Authigenic pyrite mediated by extremophile microorganisms related with active methane-seeps in the Gulf of Cadiz: evidences from textural, geochemical and underwater observations. In: EGU General Assembly 2007 (Ed EGU), 9, pp. SRef-ID: 1607-7962/gra/EGU2007-A-06963. European Geosciences Union, Vienna, Austria.
- Gutscher, M.-A., Leroy P., Graindorge, D., Babonneau, N., Maad, N., and Ait-Brahim, L., 2007. Active deformation and paleoseismology of northern Morocco: onshore and offshore faults and the source of the great 1755 earthquake and tsunami. MAPG Meeting, Marrakech, Oct. 2007.
- Gutscher, M.-A., Dominguez, S., Westbrook, G., Gente, P., Babonneau, N., Mulder, T., Gonthier, E., Bartolome, R., Luis, J, Rosas, F., 2007. The Gulf of Cadiz accretionary prism: the active offshore link between the Rif and Betic mountain belts. MAPG Meeting, Marrakech, Oct. 2007.
- Gutscher, M.-A., P. LeRoy, D. Graindorge, N. Babonneau, N. Maad, Dominguez, S., Westbrook, Fernandes, R., Miranda, J.M., 2007. Active subduction as the driving force behind recent deformation and long-term seismicity in the Gibraltar - Gulf of Cadiz region. MAPG Meeting, Marrakech, Oct. 2007
- Gutscher, M.-A., and Westbrook, G., 2007. Great earthquakes in slow subduction zones. IODP Geo-hazards Workshop, Portland, Oregon, Aug. 2007.
- Gutscher, M.-A., and Westbrook, G., 2007. Slow subduction, low-taper margins : mechanics and possible impact on mega-thrust earthquake generation. Subduction conference, Montpellier, June 2007.
- Gutscher, M.-A., Dominguez, S., Westbrook, G., Gente, P., Babonneau, N., Mulder, T., Gonthier, E., Bartolome, R., Luis, J, Rosas, F., and the Delila and DelSis Scientific Teams, 2007. The Gibraltar- Cadiz subduction zone: new marine geophysical data and the link to the Great 1755 "Lisbon" earthquake and tsunami. Subduction conference, Montpellier, June 2007.
- Gutscher, M.-A., Dominguez, S., Westbrook, G., Gente, P., Babonneau, N., Mulder, T., Gonthier, E., Bartolome, R., Luis, J, Rosas, F., and the Delila and DelSis Scientific Teams, 2007. Tectonic shortening and gravitational spreading in the Gulf of Cadiz accretionary wedge: results from bathymetric swathmapping and seismic surveys. Proc. EGU Meeting, Vienna, Apr. 2007, Geophysical Research Abstracts, v. 9, CD-ROM.
- Westbrook, G., and Gutscher, M.-A., 2007. Tectonic and gravitationally induced deformation in the accretionary wedge of the Gulf of Cadiz. TTR (Training Through Research) Workshop, Bremen, Jan. 2007.
- Magalhães, V. H., B. Buffett, D. Archer, L.M. Pinheiro. Stability of Gas Hydrates at Mud Volcanoes and Methane Seepage Sites in the Gulf of Cadiz: Correlation with Past Oceanographic Changes. AGU Fall Meeting, San Francisco 10-14 December 2007.
- Magalhães V. H., Pinheiro L. M., Ivanov M. K., Vasconcelos C., McKenzie J. A., Bernasconi S. M., Kopf A. J., Díaz-del-Río V., González F. J. and Somoza L., 2007. Authigenic carbonates from the Gulf of Cadiz. SEECAM workshop. GEOLOGICAL, CHEMICAL AND BIOLOGICAL INTERACTIONS AT COLD SEEPS AND CARBONATE MOUNDS – A SYNTHESIS. GEOITALIA 2007, Rimini, September 10-13, 2007
- Magalhães, V.H., Pinheiro, L.M., Birgel, D., Peckmann, J., Niemann, H., Santos, L., Vasconcelos, C., McKenzie, J.A. and Ivanov, M.K. 2007. Microbially-mediated formation of methane-derived carbonates from the Gulf of Cadiz. In: Geo-marine Research along European Continental Margin - 16th post-cruise conference of the TTR programme (Eds G. Bohrman and M. Ivanov), Bremen, Germany.
- Maignien, L., Depreiter, D., Foubert, A., Boon, N., Verstraete, W. & Henriët, J.P. (2007). Biogeochemistry of carbonate mounds from the Pen Duick Escarpment in the Gulf of Cadiz. Geoph. Res. Abstracts, 9, 08287. EGU General Assembly, Vienna (AT) 13.04.2007-18.03/.2007.
- Nuzzo M., Gill F., Hensen C., Hornibrook E.R.C., Pancost R. D., Magalhães V. H., Haeckel M., and Pinheiro L. M.

- (2007). The origins of light volatile hydrocarbon gases from mud volcano fluids, Gulf of Cadiz. SEECAM workshop. GEOLOGICAL, CHEMICAL AND BIOLOGICAL INTERACTIONS AT COLD SEEPS AND CARBONATE MOUNDS – A SYNTHESIS. GEOITALIA 2007, Rimini, September 10-13, 2007.
- Pinheiro, L. M. (2007) Main results from the MVSEIS Euromargins Project investigating deep tectonic controls on cold seeps of the Gulf of Cadiz, SW Iberia. SEECAM workshop. GEOLOGICAL, CHEMICAL AND BIOLOGICAL INTERACTIONS AT COLD SEEPS AND CARBONATE MOUNDS – A SYNTHESIS. GEOITALIA 2007, Rimini, September 10-13, 2007.
- Pinheiro, L. M. (2007). Summary of research activities carried out in the framework of the MVSEIS project. Main achievements. EuroMargins MEDIATIC II Workshop, Barcelona, Feb, 2007.
- Rosas F.M., Duarte J.C., Terrinha P., Vicente J., Matias L., Valadares V., Duarte H. and Roque A.C. (2007) - Strain partitioning and westwards migration of deformation in NW Gulf of Cadiz (Africa-Iberia plate boundary). Geophysical Research Abstracts, Vol. 9, 06742.
- Santos, L., Almeida, A., Boetius, A., Cunha, A., Niemann, H., Magalhães, V.H. and Pinheiro, L.M. 2007. Microbial communities involved in anaerobic methane oxidation in mud volcanoes from the Gulf of Cadiz. In: Geo-marine Research along European Continental Margin - 16th post-cruise conference of the TTR programme (Eds G. Bohrmann and M. Ivanov), Bremen, Germany.
- Somoza, L., Pinheiro, L., Rio, V.D.d., Medialdea, T., V.Magalhaes, Gonzalez, F.J. and Leon, R. 2007. Volcanes de fango, chimeneas y gases hidratados: manantiales de hidrocarburos naturales en el golfo de cádiz. In: XII Reunión Nacional de Cuaternario, Resúmenes XII Reunión Nacional de Cuaternario, Ávila (2007), pp. 2, Ávila.
- 2006**
- Babonneau, N., Gutscher, M.-A., Gonthier, E., Mulder, Th., 2006. Turbidite sequences in the deep basins offshore SW Iberia as possible paleoseismological markers. Proc. EGU Meeting, Vienna, Apr. 2006, Geophysical Research Abstracts, v. 8, CD-ROM.
- González, F.J., Pinheiro, L.M., Magalhães, V.H., Ivanov, M., Somoza, L. and Merinero, R. 2006. Pyrite nucleation induced by sulphate-reducing bacteria in carbonate chimneys from the Vernadsky Ridge, Moroccan Margin (Gulf of Cadiz). In: European Geosciences Union 2006 (Ed E.G. Union), Geophysical Research Abstracts, 8, pp. EGU06-A-03759. European Geosciences Union, Vienna.
- González, F.J., Pinheiro, L.M., Magalhães, V.H., Ivanov, M., Somoza, L. and Merinero, R. 2006. Sulphate-reducing bacteria as nucleation sites for pyrite in carbonate chimneys from the Vernadsky Ridge, Moroccan Margin of the Gulf Of Cadiz. In: Geological Processes on Deep-Water European Margins. International Conference and 15th Anniversary TTR Post-Cruise Meeting (Ed G.G. Akhmanov), pp. 31-34, Moscow /Zvenigorod, Russia.
- Gutscher, M.-A., Dominguez, S., Westbrook, G., Gente, P., Babonneau, N., Mulder, T., Gonthier, E., Bartolome, R., Luis, J, Rosas, F., 2006. Upslope spreading and tectonic shortening in the Gulf of Cadiz accretionary wedge: observations from multi-beam bathymetry and seismic profiling. Proc. AGU, San Francisco, 2006, EOS, v. 87.
- Gutscher, M.-A., Dominguez, S., Fernandes, R.M., and Miranda, J.M., 2006. Seafloor deformation in the Gulf of Cadiz and GPS data indicate active WSW motion of the Gibraltar arc. Proc. EGU Meeting, Vienna, Apr. 2006, Geophysical Research Abstracts, v. 8, CD-ROM.
- Magalhães, V., Vasconcelos, C., Gaspar, L., Pinheiro, L. and Ivanov, M. 2006. Carbonatos autigénicos do Golfo de Cadiz: caracterização e modelo de formação. In: VII Congresso Nacional de Geologia, Evora, Portugal.
- Magalhães, V.H. 2006. Authigenic carbonates from the Gulf of Cadiz: Records of fluid flow episodes. In: Processes at the Passive Continental Margins (EUROMARGINS CONFERENCE), Bologna, Italy.
- Magalhães, V.H., Birguel, D., Peckmann, J., Pinheiro, L.M., Vasconcelos, C., McKenzie, J.A. and Ivanov, M.K. 2006. Biomarker and SEM evidences of microbial mediation in the formation of methane-derived authigenic carbonates from the Gulf of Cadiz. In: 5º SIMPOSIO sobre a MARGEM IBÉRICA ATLÂNTICA / 5º SIMPOSIO sobre el MARGEN IBÉRICO ATLÁNTICO / 5th SYMPOSIUM on the IBERIAN ATLANTIC MARGIN, Aveiro, Portugal.
- Magalhães, V.H., Pinheiro, L.M., Gaspar, L., Vasconcelos, C. and Ivanov, M.K. 2006. Origin and paleo-temperature reconstruction of fluids that originate MDAC from the Gulf of Cadiz, using differentiation of the calcite and high Mg-calcite from dolomite for stable isotopes measurements. In: European Geosciences Union 2006 (Ed E.G. Union), Geophysical Research Abstracts, 8, pp. EGU06-A-07510. European Geosciences Union, Vienna, Austria.
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## Appendix 2. Scientific & technical personnel involved in the CRP

### Personnel directly funded by the EUROCORES Programme

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

#### PhD thesis concluded, based on MVSEIS data and/or MVSEIS related

- 2007. Vitor Magalhães.** Member of the Portuguese team. Scholarship from the Portuguese Science Foundation (FCT). All data acquisition, participation in cruises/meetings funded by MVSEIS. Thesis fully based on MVSEIS data. *Authigenic carbonates and fluid escape structures in the Gulf of Cadiz*. Universidade de Aveiro, 421 pp. Supervisors: L.M. Pinheiro (MVSEIS) and M. Ivanov. (PhD awarded, March 2007).
- 2007. Marianne Nuzzo.** Member of the Portuguese MVSEIS team. Scholarship from the Portuguese Science Foundation. Participation in cruises/meetings funded by MVSEIS. Thesis based largely on MVSEIS data. *The origin of light hydrocarbon gases in mud volcano fluids, Gulf of Cadiz*. University of Bristol, UK, 323 pp. Supervisors: E.R.C. Hornibrook and L.M. Pinheiro (MVSEIS). (PhD awarded, May 2007).
- 2007. Cristina Roque.** Member of the Portuguese MVSEIS team. Scholarship from the Portuguese Science Foundation. Participation in cruises/meetings funded by MVSEIS. Thesis used MVSEIS data. *Cenozoic Tectonostratigraphy of the South and Southeast Portuguese margins: a model of stratigraphic correlation*. University of Lisbon, 310 pp. Supervisor: P. Terrinha (MVSEIS). (PhD awarded, November 2007).
- 2005. Emmanuelle Thiebot.** *Structure profonde et remobilisation de la marge nordouest-Marocaine*. Thesis completed Dec. 2005, UBO Brest. PhD advisor M-A Gutscher.

#### PhD thesis underway:

- 2008. David Depreiter.** *Drivers, modes and products of subsurface fluid flow*. PhD thesis, in prep.

#### MSc theses concluded, based on MVSEIS data

- 2006. Joana Duarte.** Member of the Portuguese team. Funded jointly by MVSEIS and MPI (Max Planck Institute) through cross-CRP collaboration (supervisors: Luis Pinheiro and Antje Boetius) to work on MVSEIS and GAP data. *Geosphere/Biosphere Coupling processes in marine sediments from the Gulf of Cadiz*, 119 pp + appendices. (MSc awarded, December 2005).
- 2007. João Casal Duarte.** Member associated with the Portuguese team. Participated on several MVSEIS cruises and used MVSEIS data. *Large crescent-shaped structures in the deep waters of the Gulf of Cadiz* (MSc awarded, Sept, 2007). Supervisor: P. Terrinha (MVSEIS). (in Portuguese).
- 2004. Bertrand de Saint-Jean.** *Prisme d'accrétion de Gibraltar: structure profonde et évolution tectonique*. (research project, completed June 2004, Univ. Brest). Supervisor : M.-A. Gutscher.

# Networking activities of the programme

EUROCORES Programmes comprise a networking and dissemination component which primarily aims at strengthening internal programme coherence and external programme visibility. Networking with the aim of programme coherence would seek to develop synergies between the funded projects, and can address programme aspects that the highly competitive selection process has left uncovered. This may include forging links with other promising research networks. Activities with the aim of programme visibility promote the contributions of the field to wider areas of participating disciplines or to spread it beyond core countries. The benefits of interdisciplinary and international collaborative research would become visible in such activities. The EUROCORES networking and dissemination components can include workshops, conferences, summer schools, strategy and infrastructure meetings, mutual research visits, and dissemination support (e.g.: conference attendance, joint publications). Considering that EUROCORES programmes privilege the funding of innovative, emerging and/or as yet under-connected research, the overall objective of these activities is to strengthen the field in question (capacity building) and to discover new research horizons (perspective creation).

## Conferences

### **First EUROMARGINS annual conference**

Amsterdam, 20-22 November 2003, 55 participants

### **Second EUROMARGINS annual conference**

Barcelona, 11-13 November 2004, 130 participants

### **European Geophysical Union (EGU) General Assembly 2005**

Session US4: EUROMARGINS Dynamic processes

Session SSP11: EUROMARGINS The Edvard Suess Session on Processes shaping Margin Systems

Vienna, 24-29 April 2005, 44 participants

### **European Geophysical Union (EGU) General Assembly 2006**

Session SSP17: Processes of rifting, sediment transport, fluid flow and biogenic activity

Vienna, 2-7 April 2006, 32 participants.

### **Third EUROMARGINS annual conference**

Bologna, 4-7 October 2006, 89 participants

### **European Geophysical Union (EGU) General Assembly 2007**

Session SSP24: Processes of rifting, sediment transport, fluid flow and biogenic activity

Vienna, 16-20 April 2007, 30 participants

### **European Geophysical Union (EGU) General Assembly 2008**

Session GM6.2: Seafloor expression of tectonic and geomorphic processes

Vienna, 14-18 April 2008

## Topical workshops

### Workshop MEDIATIC

Barcelona, Spain, 25-27 March 2004, 37 participants

Organizer: Dr Manel Fernandez Ortiga

CRPs involved: SWIM, WESTMED, MVSEIS

The MEDIATIC Workshop took place from 25th to 27th of March in Barcelona hosted by the 'Centre Mediterrani d'Investigacions Marines i Ambientals' (CMIMA) pertaining to the *Consejo Superior de Investigaciones Cientificas* (CSIC). The main objective of the Workshop was to promote the discussion and the exchange of information among the different groups participating in any of the EuroMARGINS projects dealing with 'Rifting Processes' and/or 'Sediment Dynamics' as main topics of their research, and having as study areas the Western Mediterranean and/or the adjacent Atlantic margin. Therefore, the MEDIATIC Workshop call was addressed to scientists from WestMed, SWIM and MVSEIS projects with the aim of exchanging data, knowledge, and experience, as well as, coordinating future surveys and activities. The Workshop focussed on those aspects related to crustal and lithospheric scale processes including tectonics, structural geology, volcanism, present-day crustal and lithospheric structure, large-scale sedimentary transport, neotectonics, seismicity and paleoseismicity. We avoided to tackle fluid related processes provided that this topic was planned to be covered in a further specific workshop held in Aveiro. The MEDIATIC workshop was very successful in reaching the planned objectives. It was attended by a total of 37 assistants with a remarkable participation of young scientist. All the involved national work-packages dealing with *Rifting Processes* and/or *Sediment Dynamics* sent at least one representative except for the case of GEOMAR who apologized for not being able to attend the workshop. Interactions among the different CRP's were identified and future collaborations were established on the base of common topics and/or surveys. A number of actions were identified as main objectives in future projects. These included:

- To decipher the character (continental vs oceanic) of the crust flooring the Gulf of Cadiz.
- A complete cartography of high resolution bathymetry in the Gulf of Cadiz and Western Mediterranean
- To increase the number of heat flow measurements in the Gulf of Cadiz and South Balearic – Algerian basins.
- To increase the resolution in estimating hypocentre determinations in the Gulf of Cadiz region. The active mobility (short and mid-term stays) of PhD students and Post-Doc was considered fundamental though no specific funds for that are available.

### Workshop Margins Geofluids

Aveiro, Portugal, 1-3 April 2004, 35 participants

Organizer: Dr Luis Pinheiro

CRPs involved: MEDIFLUX, MVSEIS, MOUNFORCE, WESTMED

The ESF-sponsored Networking Activity and workshop - *Margin Geofluids: the Aveiro Forum* - involved 3 EUROMARGINS Collaborative Research projects (CRP's): **MVSEIS** (*Tectonic control, deep crustal structure and fluid escape pathways in the Gulf of Cadiz mud volcanic field* - FP24), **MOUNFORCE** (*Forcing of carbonate mounds and deep water coral reefs along the NW European Continental Margin* - FP06) and **MEDIFLUX** (*An integrated study of seepage through the seabed of the Nile Deep-Sea fan* - FP23). It was hosted by the University of Aveiro, Portugal, and it took place between the 1<sup>st</sup> and the 3<sup>rd</sup> of April, 2004. The main objectives of this Workshop were to promote the discussion, interchange of information, identification of key scientific problems and common objectives, and to strengthen the collaboration and coordination between the various scientific groups participating in the 3 EUROMARGINS projects dealing with *Fluid Flow Processes at continental margins*. The workshop addressed thematic scientific topics common to the 3 CRP's, such as mud volcanoes, mud diapirs and other fluid-escape structures, gas composition and origin, the formation and occurrence of authigenic carbonate crusts and chimneys, and cold-seeps associated ecosystems, aiming at a coordination of actions and joining of efforts between the different scientific groups, in particular as regards sharing laboratory



facilities, cruise data, opportunities, and expertise. Representatives from two other EUROMARGINS projects dealing with deep crustal structure in neighbouring areas - **SWIM** (*Earthquake and tsunami hazards of active faults at the South Iberian margin: deep structure, high-resolution imaging and paleoseismic signature* - FP09) and **WESTMED** (*Imaging the Western Mediterranean margins: a key target to understand the interaction between deep and shallow processes* - FP22) – were also invited to participate in this meeting, since the objectives and results of those projects are relevant to a better understanding of fluid flow processes, in particular for the Cadiz and Mediterranean region. This meeting followed the *MEDIATIC* ESF-sponsored *Workshop* organized in Barcelona in March 2004, which involved the WESTMED, SWIM and MVSEIS CRP's. By consensus between the organizers, this forum was organized as a two and a half days meeting. The workshop consisted mainly of plenary sessions, to promote cross-CRP interaction. The presentation/discussion sessions were organized by thematic topics common to all CRP's. Some time was also allocated for internal CRP and cross-CRP meetings. It is considered that this was a very successful meeting and that the main objectives were attained. There was a good attendance and participation from all CRP's, with a large number of presentations by students and young researchers. The invitation of representatives from two other EUROMARGINS projects was highly beneficial and allowed a broader perspective, in particular as concerns the influence of deep crustal structure on fluid flow problems. There has been a good discussion of the various topics throughout the meeting and the thematic cross-CRP sessions allowed an integrated view of common key problems in the three main geographical areas under study, and the discussion on the best way to try to solve them. Key scientific problems and lines of action were analysed in the framework of 3 main integrating topics: (1) *Mud volcanoes, gas hydrates, seismicity and tectonics*; (2) *Carbonate crusts and chimneys, and geomicrobiology*; and (3) *Biodiversity and ecosystems in cold seeps*. Collaborations between the different groups were promoted, including mobility of students and researchers between groups and the launching of joint actions. The clear need for a multidisciplinary approach to the study of cold seeps was highlighted and stressed, joining together the efforts of geologists, geophysicists, biologists, microbiologists and geochemists. A strong participation in the next EGU meeting in Nice was encouraged, as well as the contribution from the group to an EUROMARGINS publication in EOS. Finally, opportunities in the scope of ESONET, the 6<sup>th</sup> Framework Program and IODP were analysed, including coordinated actions aiming at future deep sea drilling in mud volcanoes and carbonate mounds in the study areas.

### **Workshop on EUROMARGINS research in NE Atlantic**

Oslo, Norway, 15-17 April 2004, 43 participants

Organizer: Prof. Jan Inge Faleide

CRPs involved: 5

A EUROMARGINS workshop was organized in Oslo on April 15 to 17 2004. In this informal workshop we gathered scientists from several EUROMARGINS projects focusing on the structure and evolution of the rifted volcanic margins in the NE Atlantic. In addition we invited some key people (from both academia and industry) working with similar/relevant research topics onshore/offshore East Greenland and mid-Norway. We brought together modelers that presented their quantitative approach (what processes are modeled and what data input is needed) and geologists/geophysicists presenting their best up-to-date constraints based on integrated/interdisciplinary studies from both offshore and onshore areas of the conjugate Norwegian-Greenland margins.

*Onshore Norway* The field work carried out in Central Norway as part of EUROMARGINS is coordinated by University of Bergen and the Geological Survey of Norway (NGU). Central Norway is an excellent study area of near-shore, shelf-related events because of several fault-bounded Jurassic basins in the coastal region, which put constraints on both the timing and style of faulting. This link is further supported by recent Ar-Ar and Apatite Fission Track (AFT) studies, which spans the frame between Late Caledonian extensional events of Devonian age, and Mesozoic faulting activity. Vrije Univ. Amsterdam also has long experience with studies of the uplift of southern Norway in particular based on AFT data.

*Offshore Norway*



Univ. Oslo has a long term experience with integrated basin and margins studies at the Norwegian continental margin (mainly carried out within their Passive Margin Research Group – supported by Statoil). They will provide the structural and stratigraphic framework needed for many of the other studies. Univ. Bergen has through close collaboration with industry and international partners established a comprehensive deep seismic refraction data base covering large parts of the mid-Norwegian continental margin. These data give important information about the deep basin configuration and crustal structure of the continental margin. The UiO and UiB results will be closely integrated and made available to all research groups that need input to their studies.

#### *Offshore Greenland*

AWI has acquired a key data set for studies of the NE Greenland continental margin. Their results should be closely integrated with results obtained by GEUS and Univ. Oslo in previous studies and linked to the onshore geology.

#### *Onshore Greenland*

Field studies onshore Greenland are equally important as on the Norwegian side. At the workshop contacts were established between GEUS, PGP and VU. These will be developed into collaboration on the structure and uplift of East Greenland relevant to EUROMARGINS studies.

#### *North Atlantic Volcanic Province*

Several workshop participants (e.g. from Univ. Leuven, Univ. Jena, Univ. Oslo and VBPR – Volcanic Basin Petroleum Research) have a special interest and knowledge of the igneous activity associated with the early Tertiary continental breakup and initial opening by sea floor spreading of the Norwegian-Greenland Sea.

#### *Modelling*

Modelling is carried out by several institutions within FP16 of EUROMARGINS (Vrije Univ. Amsterdam, GFZ Potsdam, Univ. Rennes). Several Norwegian institutions (Rogaland Research, Institute for Energy Research, SINTEF Petroleum, Univ. Bergen and Univ. Oslo) are involved in a tectonic modeling project focusing on the Vøring margin offshore mid-Norway funded by the Research Council of Norway, Statoil and Shell under the PETROMAKS programme. PGP (Physics of Geological Processes), a centre of excellence at the University of Oslo, also has a strong modelling group that has shown interest in the same area.

At the workshop we agreed that all modeling groups should receive the same set of modeling constraints – a set of regional crustal-scale profiles across the Norwegian margin will be distributed to all groups that will use them as constraints in their quantitative modeling to enhance understanding of key processes in volcanic margin formation and evolution. The groups should collaborate closely and meet for discussions and comparison of results.

#### *Conclusions*

The workshop was very informative to all participants with respect to status and plans for ongoing research projects within the NE Atlantic region. Particularly important and successful were the close links we established between the modelers and the people carrying out geological and geophysical mapping (both onshore and offshore) as well as industry people doing petroleum exploration within the main area of interest. Close links have been established between the research groups and they will further develop collaboration where and when needed. When the main results from each group are available, they should meet again for integration and comparison of results with special emphasis on structure and evolution of the conjugate margins in the NE Atlantic.

#### **Workshop InterMARGINS**

Pontresina, Switzerland, 10-16 July 2004, 46 participants  
Organizer: Prof. Robert Withmarsh

The first InterMARGINS Workshop took place from 10-16 July 2004 in Pontresina in the Swiss Alps. It was convened by Garry Karner, Gianreto Manatschal and Luis Pinheiro and was attended by 46 invited scientists from 13 countries (Australia, Brazil, Canada, Egypt, France, Germany, India, Ireland, Norway, Portugal, Switzerland, UK, and USA). The aim of the workshop was to bring together, and improve interactions between, observationalists and numerical modellers working on rifted continental margins. In addition two field trips during the workshop to view the exposed rifted margins of the Tethyan ocean in the Alps were led by Gianreto Manatschal. The Workshop was an enormous success and was greatly enjoyed by the participants for its open and positive discussions and for the dramatic outcrops viewed in the field. During the week of July 11–16, 2004, in the Swiss Alps, interspersed with brilliant sunshine and snow, 46 researchers working on extensional systems met in Pontresina, Switzerland (Fig. 1). And so commenced the first workshop to be organized by InterMARGINS. The aim of the workshop was to bring together, and improve interactions between, observationalists and numerical modelers working on rifted continental margins. The workshop was an enormous success and the participants were appreciative for its open, frank, and positive discussions and for the dramatic outcrops viewed in the field. The admittedly intensive workshop had as its ambitious objectives: 1) summarize the latest developments in extensional basin and lithospheric deformation concepts, key results (both observational and modeling), and modeling codes developed over the last few years. 2) Benchmark basin and lithospheric codes in terms of temperature structure, strain rates, and subsidence/uplift patterns in space and time. 3) Identify and generate a set of fundamental lithospheric extension observations (geological, onshore and marine geophysical, petrophysical, and petrological data) for constraining and testing theoretical and conceptual models. The workshop was convened by Garry Karner (Lamont-Doherty Earth Observatory, USA), Gianreto Manatschal, (University of Strasbourg, France), and Luis Pinheiro (University of Aveiro, Portugal). The workshop attracted participants from Australia, Brazil, Canada, Egypt, France, Germany, India, Ireland, Norway, Portugal, Switzerland, UK, and USA - a truly international affair (Fig. 2). The workshop was made possible with funding from the European Science Foundation, the UK National Environment Research Council, InterMARGINS, and the US National Science Foundation. Workshop logistics were the responsibility of the US MARGINS Office and the University of Strasbourg. Attendees were invited following response to an EOS advertisement – the workshop organizers and an international selection committee made a preliminary selection list, with final approval of the list being made by the InterMARGINS Steering Committee.

## **Workshop IMPACTS**

Plouzané, France, 16-18 March 2005, 23 participants

Organizer: Dr Marc-André Grutscher

CRPs involved: 5

The Southern Iberia region (Gulf of Cadiz and Alboran Sea) is a region of complex tectonic and sedimentological interaction between the Atlantic and Mediterranean domains. The plate boundary here between Africa and Eurasia is not well defined, yet has produced strong historical seismicity including the Great Lisbon earthquake (M8.7) in 1755, the Cape St. Vincent earthquake (M7.9) in 1969, and the Al Hoceima earthquake (M6.3) in Feb. 2004. The uppermost turbidite in the abyssal plains to the west of the Gulf of Cadiz records the 1755 earthquake, and older deposits offer a unique opportunity to conduct paleoseismological studies of past great earthquakes. The contourite deposits formed by the Mediterranean Outflow Waters record variations in paleoclimate. The recent discovery and sampling of mud volcanoes has also drawn attention to the region, because of the link to fluid transport processes, to gas hydrates, to deep chemosynthetic biological communities and because of the tectonic implications. Current interest in the region has stimulated 3 EUROMARGINS Collaborative Research Projects, as well as numerous marine geophysical and geological cruises planned for summer / autumn 2004. Two main purposes of the Brest Workshop are; 1) to allow researchers to present the preliminary results of these cruises and 2) to coordinate further research efforts (in particular future cruises) in the region to avoid duplication of results and thus ensure the optimum utilization of European Research Facilities. Another expression of the intense research activity in the region is the submission in Spring 2004 of three preliminary IODP proposals to drill the seafloor in the Gulf of Cadiz region. The stated objectives are tectonics/paleoseismology, paleoclimate and sedimentology. The third major purpose of this workshop is 3) to coordinate these preliminary drilling proposals, seeking common drill sites which can fulfil complementary

objectives and to work towards drafting a joint drilling proposal. The expected outputs of this workshop are thus: coordination of future cruises and drafting a common drilling proposal.

### **Workshop MEDIATIC II**

Barcelone, Spain, 14-16 February 2007, 29 participants

Organizer: Dr Manel Fernandez Ortiga

CRPs involved: WESTMED, MVSEIS, SWIM

The MEDIATIC-II Workshop took place from 14<sup>th</sup> to 16<sup>th</sup> February 2007 in Barcelona hosted by the 'Centre Mediterrani d'Investigacions Marines i Ambientals' (CMIMA) pertaining to the Consejo Superior de Investigaciones Científicas (CSIC). The MEDIATIC-II Workshop call was addressed to the Principal Investigators and one more scientist from each Individual Project. A total of 30 participants attended the meeting including most of the Individual Projects of the three involved Collaborative Research Projects. 1. To make a joint assessment of the development of the three CRP's and to establish general concluding remarks on the corresponding scientific topics. 2. To explore from individual projects, future collaborations and joint actions (presentations, publications, research initiatives, etc.). 3. To explore the possibility to participate in one or more future Collaborative Research Projects within the framework of the new TOPO-EUROPE EUROCORES programme and or other ongoing initiatives in the region (PICASSO, Topo-Iberia, etc.).

### **Workshop on the North Atlantic Margin**

Potsdam, Germany, 19-20 February 2007, 13 participants

Organizer: Dr Magdalena Scheck-Wenderoth

CRPs involved: 3

The workshop took place at GeoForschungsZentrum Potsdam and followed the programme listed in appendix 1. The list of participants (Appendix2) includes project partners from three different EUROMARGINS projects: Imaging the present crustal structure with geophysical methods; (FP01); Magmatic evolution (FP13) and Integrated basin modelling (FP16). It was the primary goal of this workshop to integrate the outcomes of these three projects. According to the programme, Bernard Avril, EUROCORES Programme Coordinator for Geosciences, gave an overview presentation on the current state of funding opportunities within ESF. After this update the main results obtained in the three EUROMAGIN projects have first been summarized and subsequently discussed. The group unanimously was of the opinion, the outcomes of the EUROMARGINS projects are exciting and that, besides some new conclusions, a lot of new questions have emerged. These questions should be addressed in future projects and one frame for such collaboration is offered by the open call of EUROCORES TOPOEUROPE. The evolution of onshore-offshore connections across the conjugate margins of the North Atlantic will be of major value for the understanding of topographic evolution. The different models resulting from the work in EUROMARGINS have different implications and could be tested by future work. New analogue experiments are envisaged to evaluate the mechanical role in the lithosphere necking process, of i) crust and mantle heterogeneities, inherited from Caledonian orogeny, ii) high velocity bodies in the lithosphere, and iii) the interactions of deformation with massive volcanism. Geophysical experiments were proposed especially for the Greenland side, furthermore, AFTA-studies and petrological studies envisaged. In addition, the GPS-community could be involved. The results from different passive seismologic experiments will provide further constraints on the present day snapshot of the lithosphere. The group collectively decided that the dataset of this conjugate margin system is unique concerning quality, quantity and interdisciplinarity, and agreed to continue collaboration and keep momentum.

### **Workshop SEECAM**

Rimini, Italy, 10-14 September 2007, 25 participants

Organizer: Dr John Woodside

CRPs involved: MEDIFLUX, MOUNDFORCE, MVSEIS

The goal is to bring together biologists, geochemists, geophysicists, and geologists who are studying cold seep environments and the carbonate mounds that sometimes form there, and in the format of a workshop with excursions to fossil cold seep areas to discuss the characteristics and origins of cold seeps both in active present day environments and in the geological record. Scientists studying modern seeps focus on complete systems and their processes whereas scientists studying seeps in the geological record often see incomplete seeps that no longer function. Because both groups can learn from each other, we decided to have a joint workshop with researchers from both communities. Furthermore, because cold seeps are not yet often recognised in the geological record nor are their potential associations or relationships with other phenomena such as coral reefs, their environment and controls should be examined in present day seeps and the results used in better interpreting the geological record. Three Euromargins projects examining a variety of seeps and mounds in often different ways will integrate their results to address key questions that are difficult for the individual projects to answer independently, thus simultaneously creating a synthesis of results. The networking activity will also benefit from interaction with non-Euromargins projects studying similar phenomena because the workshop will be held jointly during an international meeting where these topics are discussed; and costs can be reduced by having excursions together.

## Short-term visits and dissemination travel grants

### **Shaoli YANG**

Presentation: Submarine Mass Movements and their Consequences

3<sup>rd</sup> International Symposium

Santorini, Greece, 30 September – 03 October 2007

**Affiliation:** International Center for Geohazards (ICG), Norwegian Geotechnical Institute, Oslo, Norway

**Project 14F:** Slope Stability on Europe's Passive Continental Margins

### **Teresa RODRIGUES**

Presentations: Mid-Pleistocene Sea Surface Temperature Variation off Portugal

Seasonal Thermocline Conditions in the Mid-Latitude North Atlantic During Marine Isotope Stages 10 to 14

9<sup>th</sup> International Conference on Palaeoceanography – The Future Ocean: Perspectives from the Past

Shanghai, China, 02 – 07 September 2007

**Affiliation:** INETI- National Institute for Engineering Technology and Innovation, Department of Marine Geology, Alfragide, Portugal

**Project 17F:** Sedimentation Processes on the Portuguese Margin: The Role of Continental Climate, Ocean Circulation, Sea Level, and Neotectonics

### **Isabelle MARTINS GIL**

Presentation: Diatom record of surface circulation variability in the North Atlantic (Laurentian fan) during the last 11000 years

9<sup>th</sup> International Conference on Palaeoceanography – The Future Ocean: Perspectives from the Past

Shanghai, China, 02 – 07 September 2007

**Affiliation:** Technology and Innovation (INETI), Marine Geology Department, National Institute of Engineering, Alfragide, Portugal

**Project:** working with Dr Fatima Abrantes on Project 17F Sedimentation Processes on the Portuguese Margin: The Role of Continental Climate, Ocean Circulation, Sea Level, and Neotectonics

# Publications

## 2003

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Belgium

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Germany

**Consiglio Nazionale delle Ricerche (CNR)**

Italy

**Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO)**

The Netherlands

**The Research Council of Norway (NFR)**

Norway

**Fundação para a Ciência e a Tecnologia (FCT)**

Portugal

**Comision Interministerial de Ciencia y Tecnologica (CICYT)**

Spain

**The Swedish Research Council**

Sweden

**Natural Environment Research Council (NERC)**

United Kingdom

# PART 2

## Final Report Assessment

# Synthesis

*Note to Jean-Pierre: Please check the text below since I wrote this myself based on the individual assessments. You may want to change, add or remove parts since it has to be written by the RP and not by ESF .... Thank you.*

Overall, the review panel emphasizes the success and the very good level of scientific achievement of the various EUROMARGINS projects and of the programme as a whole. It is recognized that the programme has gathered a lot of new scientific data, helped to coordinate ship cruises and has set the ground for future projects at the European level. The EUROCORES umbrella has been very useful to bring together small and efficient groups of scientists with few partners and well identified goals and helped the community to reach a critical mass and find their place at the European level. The review panel notes also the difficulty encountered by several groups related mainly to the lack of commitment of several funding agencies during the course of the projects. The review panel also stressed the importance of networking, training and dissemination for the overall success of the programme and underlined their efficiency and the benefit-to-cost ratio of these activities.

EUROMARGINS was composed of 14 Collaborative Research Projects. The review panel has prepared the following consensus report during their last Review Panel meeting on 19<sup>th</sup> February 2008 for each individual project based on the final reports and on the presentations provided by the project leaders during the final Scientific Committee meeting on 18<sup>th</sup> February 2008.

## **01-LEC-EMA01F: Crustal architecture and evolution of the conjugate volcanic margins off mid-Norway and East Greenland in a total rift context**

*Project leader: Jan Inge Faleide*

Crustal architecture and evolution of the conjugate volcanic margins off mid-Norway and East Greenland in a total rift context. An overall successful project, notwithstanding a few weaker points, e.g. at the level of the French and German participation/funding. Successful integration. Good publication record.

## **01-LEC-EMA06F: Forcing of carbonate mounds and deep water coral reefs along the NW European continental margin (MOUNDFORCE)**

*Project leader: Tjeerd van Weering*

Successful, very productive and well integrated project. Lots of good new observations, although there is still a lot to do to understand initiation of mound growth and too few details in report on Gulf of Cadix findings. In the future integration of a paleo-oceanographic component could be productive. Helped put together aspects of the HERMES.

## **01-LEC-EMA09F: Earthquake and tsunami hazards of active faults at the south Iberian margin: deep structure, high-resolution imaging and paleoseismic signature (SWIM)**

*Project leader: Nevio Zitellini*

Good results. Large set of seismic data. Very good publication record. Most objectives achieved. The bathymetric data compilation is an important outcome. Made a major contribution to MVSeis. SWIM resulted in an EC STREP project on tsunami prediction.

## **01-LEC-EMA10F: Links between sequence stratigraphy and the mineralogical, geochemical and reservoir quality evolution of deep-marine clastic sediments**

*Project leader: Sadoon Morad*

Links between sequence stratigraphy and the mineralogical, geochemical and reservoir quality evolution of deep-marine clastic sediments. The results from this project, of a recognized complexity, are not evident from the report. It is not clear to what extent the major objectives have been met, and the reasons are not evident. The publication record is questionable.

**01-LEC-EMA11F: European carbonate margins as recorders of past global change: cretaceous *greenhouse* versus carboniferous *coldhouse* examples**

***Project leader: Adrian Immenhauser***

European carbonate margins as recorders of past global change: Cretaceous greenhouse versus Carboniferous coldhouse examples. A good project, though the level of integration of the two components is still subject to improvement. This is expected in future work and publications. Good publication record. Output useful for teaching purposes.

**01-LEC-EMA13F: The role of mantle-crust interaction in the early phases of passive margin development: the case of the Vøring plateau, NE Atlantic**

***Project leader: Jan Hertogen***

The role of mantle-crust interaction in the early phases of passive margin development: the case of the Voering plateau, NE Atlantic. No report available for this project. No reported workshop activity within the programme.

**01-LEC-EMA14F: Slope stability on Europe's passive continental margins (SPACOMA)**

***Project leader: Jürgen Mienert***

Slope stability on Europe's passive continental margins. A very successful project. A good analysis on the mechanisms of slope failure. Dating and palaeoclimate impact are issues which will be addressed in the future. An excellent publication record and networking effort. The level of involvement of young researchers is appreciated.

**01-LEC-EMA15F: Swath-seismic mapping of European continental margins (SWATHSEIS)**

***Project leader: Tim Reston***

The pilot study is considered as successful, which motivates further efforts towards funding of the prototype development.

**01-LEC-EMA16F: Litospheric memory and tectonic (re)activation of volcanic rifted margins and their borderlands: quantitative modelling of North-Western European margin system dynamics (NEMSDYN)**

***Project leader: Paul Andriessen***

An overall successful project with significant achievements, but structurally it might have benefitted of a larger extent of integration. The perspective of comparative modeling exercises is attractive. An appreciated number of PhD's.

**01-LEC-EMA17F: Sedimentation processes on the Portuguese margin: the role of continental climate, ocean circulation, sea level and neotectonics (SEDPORT)**

***Project leader: Ralph Schneider***

A successful programme, despite funding problems and the loss of moorings. A sound level of publication. An excellent participation in the ESF networking activities. Results are expected to have a significant impact.

**01-LEC-EMA21F: Transition from a continental to an oceanic rift: geology and biogeochemistry of the northern Red sea**

***Project leader: Enrico Bonatti***

Transition from a continental to an oceanic rift: geology and biogeochemistry of the northern Red Sea. An endeavour in a difficult area, with little evidence of new results. A moderate level of networking.

**01-LEC-EMA22F: Imaging the western Mediterranean margins : a key target to understand the interaction between deep and shallow processes (WESTMED)**

***Project leader: Manuel Fernandez Ortiga***

A very successful project, with significant achievements. A good integration with other projects, and an active involvement in ESF networking. A very good publications output.

**01-LEC-EMA23F : An integrated study of seepage through the seabed of the Nile deep-sea fan (MEDIFLUX)**



***Project leader: Jean-Paul Foucher***

A balanced multinational participation with strong scientific teams. Most of the objectives have been achieved. The output is strongly confined to surface and subsurface processes and fluxes. A follow-up involving the link with geodynamics will be attractive. The participation to workshops and networking was high. The involvement of PhD students was significant.

**01-LEC-EMA24F: Tectonic control, deep crustal structure and fluid escape pathways in the gulf of Cadiz mud volcanic field (MVSEIS)**

***Project leader: Luis M. Pinheiro***

One of the most successful projects in spite of limited funding. Resourcefull use of shiptime. Excellent coordination of teams and students. Linked to 4 other Euromargin projects (close links with SWIM). Large amount of new data, important results, well integrated with a view to processes. Good publication record.

## Recommendations

We miss about one half to one page recommendations for future activities from the Review panel based on the individual evaluations.

# Individual Evaluations

Each review panel member has been invited to provide an assessment of the programme as a whole. The purpose of the Final Evaluation is to make up the overall picture and present the key results of the programme. It was stressed to the review panel members that the evaluation concerns the overall achievements of the programme and as such complements the reporting of individual projects conducted by the national funding agencies. The main evaluation criteria and guidelines have been proposed. The evaluations received are provided in the next pages.

## **1. Evaluation of the programme on the basis of its scientific achievements**

Provide an objective assessment of the EUROMARGINS programme on the basis of the scientific achievements highlighted by the Project Leaders in their report and presentation.

Comment on the level of scientific cooperation, the degree of integration across disciplines and the European added value of the collaborations within the EUROMARGINS programme.

Based on your scientific assessment, would you say that the EUROMARGINS Programme set new directions in its field of research and broke new grounds?

## **2. Evaluation of the programme on the basis of networking, training and dissemination**

Provide an objective assessment of the merits of the EUROMARGINS programme based on the networking, training and dissemination activities developed during the project duration.

Comment on the usefulness and impact of these activities on the EUROMARGINS programme and the relevant field of research.

## **3. Recommendations to ESF and funding agencies**

Based on the evaluation of the EUROMARGINS program, provide suggestions for the future developments of the EUROCORES Programme, in particular regarding sub-area that was not covered within EUROMARGINS or new directions which have emerged.

Recommendations for the future of the scientific field as a whole (mid to long term vision to develop research agendas and for ESF priorities for future programmes).

Your feedback on the EUROCORES programme and type of activities proposed within the programme.

## Review panel member 1

### 1. Evaluation of the programme on the basis of its scientific achievements

The overall achievements of the pioneering EUROCORES programme Euromargins are outstanding, despite one or two partial or total drop-outs.

For the European margin teams which focus on environmental issues and Geosphere-Biosphere coupling processes, this programme came **timely**, and helped to bridge the gap between FP5 and FP6, or to some extent FP7.

It furthermore provided the **proper scale of cooperation**, which had been a factor of success in FP5 and got lost in FP6 (“the IP era”): an average of 4 to 6 teams joining forces provides the optimal dimension for producing leading edge science at the best benefit-to-cost ratio.

To a certain extent, the comparison between the “**user-friendly**” ESF-steered science programmes and the EC-steered programmes is not appropriate. Again, the benefit-to-cost ratio of ESF programmes is unrivalled. Still, it is fair to underline that (1) the successful Euromargins programme largely built upon the prior shaping of the margins community under the successive EC “MAST” programmes, and (2) the EC programmes have brought to their “clients” some degree of managerial professionalism, on which they could build in the ESF programmes.

The **hybrid regimes of funding** (different level, timing, rules, reliability) from the national agencies is a recurrent source of irritation to frustration in many teams, and it has significantly impacted on the scientific output of some projects: “collateral damage”. The problem could to some extent be solved by a central fund.

For the European margin teams with focus on lithospheric processes, the level of success (or should we say of exclusivity) possibly had not met the initial expectations, as they probably had not anticipated to be in competition with the already largely organized “environmental” community (shaped through MAST). Still, they are correctly represented, as a fair balance has been achieved at the level of the selections, and this “entry level” participation has contributed to the success of this community in a next EUROCORES, Topo-Europe. In a way, Euromargins has indirectly contributed to **allow the “lithospheric” teams to catch up with the “environmental” ones** and to forge an excellent, multidisciplinary and integrated European task force in the research on ocean margins, from Lithosphere to Biosphere, which does set new directions and break new grounds.

*Please, rate the EUROMARGINS programme as appropriate:*

0: cannot evaluate

1: weak

2: average

3: good

X 4: excellent

## 2. Evaluation of the programme on the basis of networking, training and dissemination

The programme has benefitted from a generous grant of the EC to EUROCORES to promote networking, training and dissemination, and ESF overall made a very good use of it. Though largely advertised among the PI's, these opportunities might have been under-solicited. Still, various workshops brought individual Euromargins projects closer to each other, in average 3 projects per workshop. As a participant and user of a couple of these workshops, I wish to underline their efficiency and again their benefit-to-cost ratio, compared with the output of participation to mega-events like AGU, EUG, etc.

***Please, rate the EUROMARGINS programme as appropriate:***

0: can not evaluate            1: weak            2: average  
3: good                            x 4: excellent

## 3. Recommendations to ESF and funding agencies

The ESF EUROCORES "two is out" rule, which moved into practice as EUROCORES proceeded, has little ground: the Euromargins programme gives ample evidence of projects with two or more deficient financing sources – whatever the cause and legitimacy – which still generated good science.

The centralizing and advance commitment of funding might help solve the recurrent problem of a posteriori drop-out of funding of successful projects.

## Review panel member 2

### 1. Evaluation of the programme on the basis of its scientific achievements

Overall : Very good program, particularly considering the complexities of funding. A great number of exciting results, a lot of new data. Did promote interactions between countries and set the ground for new cooperative projects that are now being funded at European level.

Assessment of individual projects:

01F-Crustal Architecture. Very good. Successful integration of existing seismic data on the norwegian margin and new german cruise on conjugate Greenland margin. French participation largely disconnected, seismic cruise not funded. German participation somewhat underfunded. Futire directions : continue processing of german cruise, continue modeling, IODP proposal. Good publication record .

06F-Moundforce. Very good. Successful, very productive and well integrated project. Lots of good new observations, although there is still a lot to do to understand initiation of mount growth and too few details in report on Gulf of Cadix findings. In the future integration of a paleo-oceanographic component could be productive. Helped put together aspects of the HERMES.

09F-SWIM. Very good. Successful integration of bathymetry and seismic imaging in the Gulf of Cadix. Main results : construction of accretionary prism has ceased since (late miocene ?) time, leaving way to NNW-directed compression. Documented recent active WNW-trending strike-slip faults. Good link with MVSeis. Other good points of project are the signature of a data sharing agreement between participants, and the publication of a bathymetric compilation. Set the ground for funded NEAREST Strep.

10F- Clastic sediments. Weak. Not clear what has been achieved. Publication record not so strong.

11F-Carbonate margins. Very good. Small project, two partners and 2 PhDs. Successful in terms of data acquisition and promising results of fundamental importance for paleo-oceanographic work. Results from the two study areas (and 2 thesis) now need to be integrated. Vey good publication record.

13F- Mantle-crust. Weak. No report. No interim report. This project appears to have fell through.

14F- Slope stability. Very good. Large and successful project. Many PhDs and post-docs. Important results on characteristics of giant slides in arctic regions and smaller slope failures in western Med. Good approaches of causing processes. Asessment of tsunami hazard. Good publication record. There is matter for more work on dating and the link with paleo-climate. IODP proposal is being put together.

15F- SWATH-mapping. Successful pilot study. Actual construction of the seismic acquisition system should be encouraged.

16F- Lithospheric memory. Good. Main achievements : numerical modeling of Norwegian margin in link with 01F, and fission track dating compilation on fenno-scandia which documented recent uplift of margin (unrelated to rifting). The publication record is good but the report is a bit complex.... probably because the two aspects of the project (modeling and fission track-dating) do not concern the same geodynamic processes.

17F- SEDPORT. Very good. Successfull study, from shore to continental slope. Good coordination of teams. Important results, with significant potential impact in terms of paleoclimate studies. Some setbacks in funding probably account for a relatively small number of publications.

21F- Red Sea. Weak. Political and logistical problems have disrupted the cruise program. Little integration. Few publications.

22F- WestMed. Good to very good. Successful project in spite of difficulties in coordinating seismic cruises. Good multidisciplinary integration (from petrology to geodynamic modeling). Planning for cruises may not have been sufficiently effective. The large OBS experiment was carried out late in the project so that these data are still being processed. In addition, the cruise plan apparently separated OBS data acquisition from reflection experiment so that, due to the

seismic reflection cruise not being funded, seismic lines now available do not have reflection info. The publication record is good.

23F-Mediflux. Very good. Very successful and balanced cooperation between 3 countries. Large amount of new data. Multidisciplinarity (geosciences o microbiology). The geoscience part of the work appears more descriptive than process oriented.. although the link with salt tectonics is nicely illustrated. Links with HERMES and EURODEEP.

24F- MVSeis. Very good. One of the most successful projects in spite of limited funding. Resourcefull use of shiptime. Excellent coordination of teams and students. Linked to 4 other Euomargin projects (close links with SWIM). Large amount of new data, important results, well integrated with a view to processes. Good publication record.

**Please, rate the EUROMARGINS programme as appropriate:**

0: cannot evaluate	1: weak	2: average
3: good	4: excellent	

**2. Evaluation of the programme on the basis of networking, training and dissemination**

The Euomargins program has gather a lot of new data, helped coordinate cruises, and set the ground for successful EC proposals.

Possibly its main value is to have supported relativcly small projects, with few partners and well identified goals, in addition to larger, multi partners and multi cruises projects. Such relatively small projects do not find their place at EC level, yet are clearly the appropriate scale to address many science questions. They are usually confined to national level and the Euomargins program has allowed for european cooperation.

Its main weaknesses have been, as foreseen, in the coordination of widely different funding systems. I'll make 2 suggestions about this in §3.

**Please, rate the EUROMARGINS programme as appropriate:**

0: can not evaluate	1: weak	2: average
3: good	4: excellent	

**3. Recommendations to ESF and funding agencies**

Formally identify support available from each country prior to proposal evaluation and mandate ESF to distribute these resources based on ranking. Avoid providing the list of well ranked projects to national funding agencies for them to pick their choice regardless of absolute ranking.

Add a standard "cruise proposal" form to projects which require cruises to be funded, either separately at national level, or through resources made available to ESF for the program. This will allow the Eurocore reviewers to have a better grasp of the quality of all the component of the project. Cruises are largely technical operations and, although the science objectives may look good, the cruise itself may not be practical (not the right tools, not the right team, unrealistic timing of operations etc..).

Putting together and assessing this form will also, very pragmatically, help progress toward a future European-based management of seagoing facilities.



## Review panel member 3

### 1. Evaluation of the programme on the basis of its scientific achievements

The final reports of the various projects and the oral presentations of these reports at the wrap-up meeting in Brussels, February 2008, indicate that overall the Euromargins Program was a very successful program. It promoted interactions and cooperation between scientists from various countries and also between scientists in the same country from different universities and research centers that otherwise probably would not cooperate. The program also promoted sharing resources such as ship-time. Most of the proposals were multidisciplinary and important scientific advances were achieved. It was particularly beneficial for young scientists, for Ph.D. and Master students and for Post Doctorate Fellows, and helped some of them to acquire jobs. The resulting numerous joint and individual publications attest to the success of the program.

*Please, rate the EUROMARGINS programme as appropriate:*

0: cannot evaluate            1: weak                    2: average  
3: good                         X4: excellent

### 2. Evaluation of the programme on the basis of networking, training and dissemination

Evaluation included in comments on point 1.

*Please, rate the EUROMARGINS programme as appropriate:*

0: can not evaluate            1: weak                    2: average  
3: good                         X 4: excellent

### 3. Recommendations to ESF and funding agencies

1. Many of the projects encountered funding problems from one or more of the participating agencies. This impacted some of the programs, others were successful in securing funds from new resources. In the future in programs like the Euromargins, funding commitments by participating agencies must be secured for the highest ranked projects.

2. Although realizing that this recommendation may not be easy to implement it is recommended that as much as possible the needed ship-time should also be better coordinated and secured for projects that require it.

3. At the beginning of each highly ranked and funded project a statement of clear responsibilities by the main participants should be established.

4. In several of the final reports the main emphasis was on what was done instead of on the main scientific results that were not documented in enough details.

5. It seems to me that the amount of networking required is excessive. Many of the participants have attended too many meetings and workshops which cut into the time available for research. Networking and exposing young scientists are important, but if excessive could impact their scientific output.

## Review panel member 4

### 1. Evaluation of the programme on the basis of its scientific achievements

Based on the documentation presented in the EUROMARGINS final reports, as well as my personal knowledge of some of the research carried out in the individual programs plus attendance at specific EUROMARGINS related sessions held at international meetings, I consider the EUROMARGINS Programme to be an outstanding success. Marine research is complex and technologically challenging. It requires the interaction and contribution of various research groups in a well-coordinated fashion necessitated by the scheduling of ships and the placement of shipboard equipment. Bringing the cruises to actuality fosters interactions among research groups and promotes networking for future actions. Thus, in this sense, much has been achieved as many of the research groups are involved now in the subsequent EUROCORES programmes, such as EURODIVERSITY and EUORMARC. The level of scientific achievements is represented by the large number of research papers and doctoral theses evolving from the programme, as well as the new scientific ideas that have been germinated from the research. In my opinion, the EUROMARGINS Programme has firmly established a strong platform for developing future research initiatives in marine sciences on a European scale.

Specific scientific accomplishments can be better gleaned from the presentations.

***Please, rate the EUROMARGINS programme as appropriate:***

0: cannot evaluate            1: weak            2: average  
3: good                        X 4: excellent

### 2. Evaluation of the programme on the basis of networking, training and dissemination

See statement under point 1.

***Please, rate the EUROMARGINS programme as appropriate:***

0: can not evaluate            1: weak            2: average  
3: good                        x 4: excellent

### 3. Recommendations to ESF and funding agencies

For the success of future EUROCORE programmes, the commitment of funding from the participating funding agencies must be ensured for proposals, which have been evaluated and approved. It is usually essential that all partners in a proposal are able to participate in the research in order to achieve the overall goals. If not fully funded, the scientific input from missing partners must be accommodated by the other funded research groups, which can often create a difficult situation and lead to failure in the completion of objectives. Recognizing that marine science research is expensive due to logistical considerations, perhaps, per-proposals could be reviewed by the individual funding agencies to determine if the budgets are acceptable or not. If not, then the lead proponent for a proposal would have the opportunity to solicit other partners, who could ultimately be funded. With the full range of required expertise being involved in projects, the successful outcome of the research will be guaranteed.

## Review panel member 5

### 1. Evaluation of the programme on the basis of its scientific achievements

Based on the concise and informative presentations and the final reports highlighting the major results I got a very good overview of the spectrum of topics tackled in the Euromargins programme. More than 80 % of the projects concentrated in three areas N Atlantic Gulf of Cadiz and W Mediterranean for which a tremendous amount of new exciting data and process understanding could be achieved. The remaining projects contributed important aspects, which could not be addressed in the key areas. The programme benefited very much from the close and regular networking among the groups, which reached in the course of this international initiative a very high scientific standard.

The research questions were timely and raised the interest of commercial companies and intensified contacts with the industry exploring georesources. This opened in several cases the young scientists new professional opportunities either in business or other research institutions. Management of cruises with complex technology were to some extent challenging. However this often encouraged innovation and resulted in intensified collaboration with scientists working in similar fields outside of the EUROMARGINS programme. These joint activities have strengthened at a very large European scale the go-together in marine science. Overall the EUROMARGINS programme was very successful. The excellent results created in the frame of the different programmes open perspectives for future innovative, competitive international programmes in marine science.

***Please, rate the EUROMARGINS programme as appropriate:***

0: cannot evaluate

1: weak

2: average

3: good

x 4: excellent

### 2. Evaluation of the programme on the basis of networking, training and dissemination

Networking at different levels of the EUROMAGINS consortium was excellent. For the graduate students and post-docs, this initiative was an excellent training experience as they could develop scientific skills and receive stimulations in the interdisciplinary context of most of the programmes. During the numerous meetings they got a chance to enter and make part of a friendly, but competitive science community standing for the same vision to understand physical, chemical and biological processes in passive continental margin setting. The number of PhD thesis and publications show the very good outreach and prove an excellent dissemination of the achieved knowledge.

***Please, rate the EUROMARGINS programme as appropriate:***

0: can not evaluate

1: weak

2: average

3: good

x 4: excellent

### 3. Recommendations to ESF and funding agencies

Modifications in the procedure:

1) Binding confirmation for financing ship cruises or any other expensive infrastructural access should be available when national funding organisation negotiate and appoint the finally funded proposals.

2) If selected proposal will not get funding for some of the minor but relevant component for the proposal, the leading groups should either be allowed (without any further reviewers evaluation)

1) getting financial support from their principal partners funding agencies to cover for the failed components and work will be done by a partners from the PI countries.

2) „advertising“ the missing tasks internationally to find a partner with financial resources, which could fill the gap.

A future science perspective:

EUROCORE could take the lead to set up a programme for a deep understanding of « Mediterranean/Near/Middle East/Central Asia human cultural evolution and environmental changes » bringing together earth scientists (tackling past, present and future environmental change problematic in this densely populated area) with archaeologists, historians, eventually sociologists?

Relevance of EUROCORE:

EUROCORE is an absolutely necessary vehicle for 2 reasons, (i) an objective, independent, international scientific evaluation and (ii) the national funding agencies, scientifically interested to fund competitive projects, decide on “goes”. The projects focusing at the level of European clusters on specific science themes are given the opportunity to get them started based on national scientific interests or priorities. This makes decision less bureaucratic and more science oriented.

## Review panel member 6

### 1. Evaluation of the programme on the basis of its scientific achievements

The level of scientific achievements is represented by a large number of research papers and doctoral theses evolving from the programme. As well as the new scientific ideas that has been germinated from the research.

The documentation presented in the EUROMARGINS final reports shows that EUROMARGINS has been an important Programme to for the interaction and contribution of various groups in a well-coordinated fashion , in spite of the difficulties that often appears due to the scheduling of ships.

From my point of view, the scientific level of the projects are in general very good; presentations of the results showed that most of them has achieved most of the main objectives, nevertheless some of them fail in aspects concerning to networking , particularly numbers 21F 16F, 11F, and 10F.

In my opinion, the EUROMARGIN Programme, has established a strong platform for developing future research initiatives in marine sciences.

***Please, rate the EUROMARGINS programme as appropriate:***

0: cannot evaluate            1: weak            2: average  
3: good                            x 4: excellent

### 2. Evaluation of the programme on the basis of networking, training and dissemination

In spite of that integration has failed in some individual projects (see point 1), networking has been carried out in attendance at specific EUROMARGINS sessions at international meetings.

Training and dissemination of results of the individual projects are considered as a good level, only very few of them have partially failed in these aspects.

***Please, rate the EUROMARGINS programme as appropriate:***

0: can not evaluate            1: weak            2: average  
3: good                            x 4: excellent

### 3. Recommendations to ESF and funding agencies

Founding from the participating agencies must be ensured for proposals, which have been evaluated and approved. It is essential that all partners in a proposal are able to participate in order to achieve the main goals.

It should be also very interesting, for the success of the programme, that participating agencies establishes the availability of ships for the marine campaigns, to avoid the problems that frequently appears at the moment to start schedule of work.

# EUROMARGINS Review Panel

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