Life, Earth and Environmental Sciences (LESC)

ACTIVITY
Workshops on Marine Research Drilling
(MAGELLAN WORKSHOP SERIES)

Workshop

IODP Drilling of the "Shackleton sites" on the Iberian Margin:
In Search of a Plio-Pleistocene Marine Reference Section

Lisbon, 9-10 November 2009

FINAL REPORT

Co-sponsored by

1. Summary

Few marine sediment cores have played such a pivotal role in paleoclimate research as those from the Iberian margin (the "Shackleton sites"). These cores have become *de facto* marine type sections of millennial variability for the last several glacial cycles.

The main objective of the workshop was to assemble researchers who have worked on the Portuguese Margin, and especially the "Shackleton sites" , to discuss the development of an IODP proposal to extend these remarkable records into the Plio-Pleistocene by drilling using the JOIDES *Resolution*. The workshop provided a forum for invitees to summarize past work and present new data, identify key unanswered questions, and discuss the best drilling strategy for reaching the overall goals.

We originally envisioned that the workshop would be solely focused on paleoceanography, but during the organization of this workshop we were approached by Portuguese and Italian colleagues from the tectonics community. This group is interested to establish a borehole observatory (i.e., "CORK" and instrumented hole) in the region of the fault believed to have caused the devastating Lisbon earthquake and tsunami in 1755. Given the societal relevance and importance of this geohazard objective, we invited 7 scientists with tectonic interests to join the workshop.

All participants presented their interests to the group (see work program below). Following open discussion and independent meetings by the two groups, we agreed the best approach for achieving both scientific objectives would be to submit parallel proposals with paleoceanographic and tectonic themes for the deadline of 1st April. Because the tectonic objectives and planning are complicated and have not advanced as far as the paleoceanographic aspects, a pre-proposal is planned oriented to understanding several tectonic questions as well as recovering the Miocene to pre-Miocene geology and stratigraphy for the region, with submission in either April or October 2010. Submission of a full proposal addressing the paleoceanographic objectives at the "Shackleton sites" will move forward as originally planned.

2. Description of the scientific content and of the discussion at the event (max 4 pages)

The list of presentations is provided in the attached work plan.

The meeting opened with the presentation of the motivation behind the proposal submitted for the organization of the meeting and the "white paper" submitted to the IODP INVEST meeting (Bremen, September 2009). David Hodell, who gave the presentation, reviewed the goal of recovering cores on the Portuguese margin that contain a continuous time series of millennial-scale climate variability to address questions such as:

1. What was the nature of millennial-scale variability in older glacial periods of the Pleistocene? How does it compare to variability of the last glaciation? Did D-O oscillations occur during previous glacial periods? If so, how did their structure and pacing compare to the last glaciation?
2. How did the character of millennial-scale variability change as orbital and glacial boundary conditions changed during the Pleistocene? How do millennial and orbital bands of climate variability interact? What role do millennial-scale events play in

triggering glacial terminations (Wolff et al., 2009)? Did millennial-scale climate variability change in frequency or amplitude across the mid-Pleistocene transition (~920 and 640 ka) when the average climate state evolved toward generally colder conditions with larger ice sheets, and the spectral character of climate variability shifted from dominantly 41 to 100 kyrs?

Furthermore the stratigraphic approach used by Shackleton et al (2000, 2004) to reconstruct the phasing of millennial climate variability during the last glaciation was introduced thereby circumventing many of the problem associated with developing age models on millennial timescales. A similar strategy can be applied to older glacial periods of the Plio-Pleistocene to address questions such as: Has the bipolar seesaw been a persistent feature of the climate system during the Pleistocene? Hodell also reviewed IODP proposal submission procedures and possible timetables to drill the Shackleton sites before the end of the current phase of IODP.

Gabriella Carrara followed with an explanation of the importance of having an instrumented site (i.e., a CORKed hole) in the Cadiz Gulf to establish a borehole observatory . She presented the region's tectonic setting relative to the complex Europe-Africa plate boundary and the resulting seismic activity, making the case for the need for better monitoring of seismic activity in the area. The geohazard potential of this region is high as witnessed by the Lisbon earthquake in 1755.

Fátima Abrantes reviewed the location of DSDP, ODP and IMAGES sites on the Portuguese Margin (Fig. 1) as well as the existing seismic data (Fig. 2) and introduced the possibility of expanding the recovery beyond the Pleistocene by drilling 5 site locations that would allow the recovery of thick Pliocene and Miocene sequences that are well defined on seismic profiles (Fig. 3).

Francisco Sierro advanced the idea of drilling the continental slope to establish the phase relationship between millennial-scale climate changes and global sea level variations during the last climatic cycles. The strategy is similar to that applied to the Gulf of Lions (Sierro et al., 2009).

Susana Lebreiro proposed drilling on the Tore Seamount, which is a region of lower sedimentation rate than the "Shackleton sites". Because the site is elevated above the sea floor, it is free from many of the influence of downslope transport. As such, the site could be used as a reference site to identify possible disturbances in deeper sites along the margin. Furthermore, Lebreiro proposed an "exploration site" located in the Tore "crater", a 120-m wide basin that has acted as a sediment trap since its formation. The origin and age of the basin in yet unknown.

All other participants emphasized the superior quality of the data obtained from the Portuguese Margin and underscored their interest and support in seeing the "Shackleton sites" by IODP.

Chronis Tzedakis highlighted the fact that these sites represent an ideal location not only because they provide a rare opportunity to link terrestrial and marine records, but also because they offer the possibility of correlating them to the polar ice-cores.

Jaume Frigola offered the possibility of using a Spanish ship to obtain TOPAS data for the area(s) of interest.

After the paleoceanographic discussion, the tectonics group presented their objectives with two main talks by Laura Beranzoli and Miguel Miranda. The high-magnitude seismicity of the Gulf of Cadiz (SW Iberian margin), which is the result of the tectonic activity along the complex Europe-Africa plate boundary, has generated intense scientific research in the last 20 years by numerous international teams, including several EC and national-funded projects. These initiatives produced a large amount of geological and geophysical data (bathymetry, MCS profiles, backscatter, refraction and OBS seismic data, core data...). However, most of the projects were dedicated to the characterization of the seismogenic and tsunamigenic sources in the region. More recently, a phase of geohazard and tsunami warning monitoring started within the European Project NEAREST. Nevertheless, many questions still remain unanswered and, consequently, the geohazard group met separately on Day 2 to discuss scientific objectives to be investigated with drilling and the establishment of a long-term borehole observatory in the area.

Statements of interest were read submitted by colleagues who could not attend the meeting but are very much interested in participating in the drilling project.

Following oral presentations, discussion ensued considering two possible drilling proposal strategies. One approach is to submit a single proposal that includes both the Shackleton sites and a borehole observatory site. The second option is to submit separate but parallel proposals. The consensus was that the latter option is preferable because of the different "drilling readiness" of the two objectives. All necessary site survey data is available to propose the Shackleton sites, whereas there are a host of unresolved issues with the borehole observatory site that will require additional time to resolve. Day 1 ended with the decision for the paleoceanographic and tectonic groups to meet separately throughout the next day for planning a drilling strategy to meet the scientific objectives.

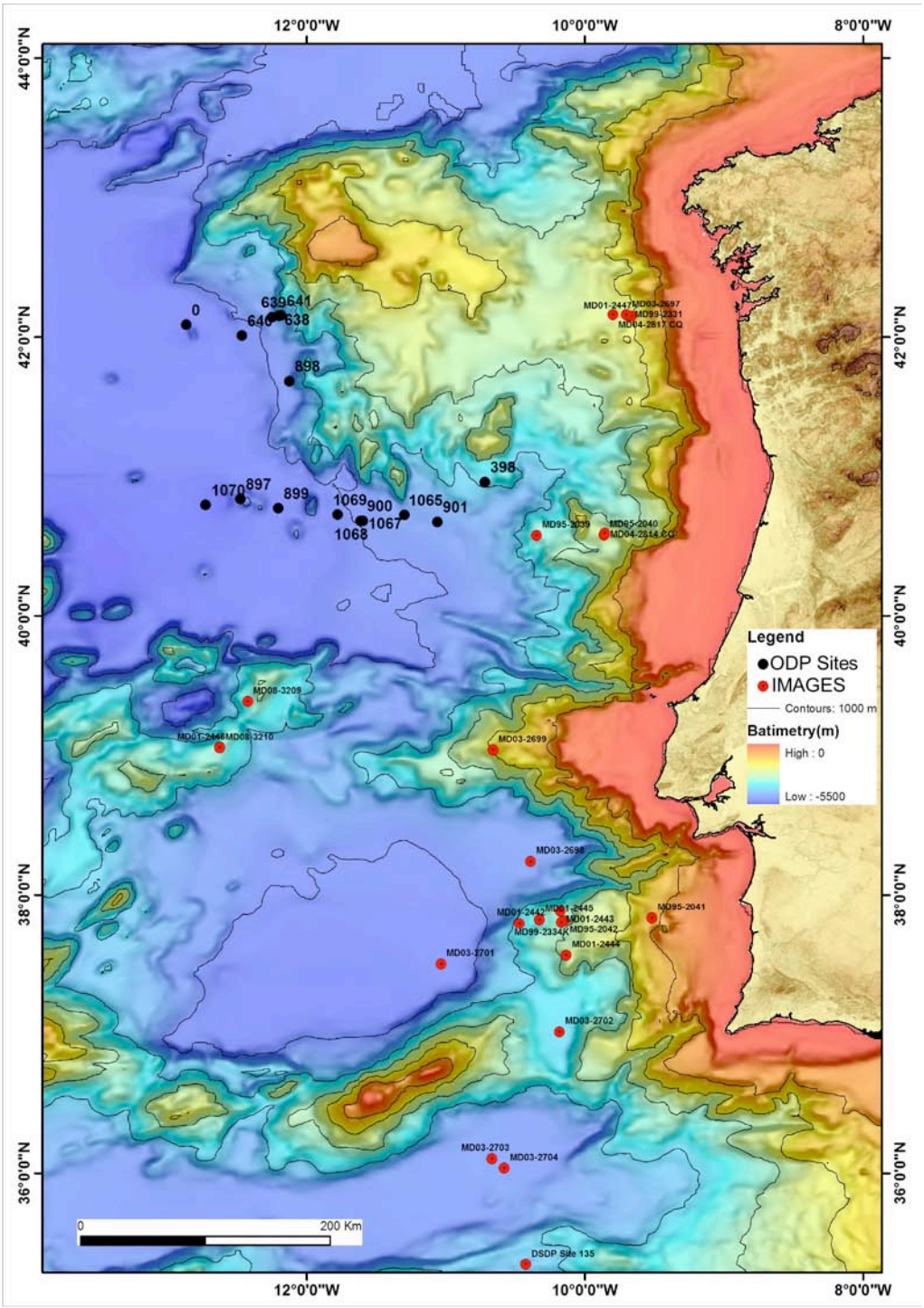

Figure 1. Location of existing drilled (DSDP Legs 14 and 103; ODP Legs 149 and 173) and long piston cores (IMAGES MD95, MD03 and MD04; POP MD99 and MD01; AMOCINT MD09) on the Portuguese Margin morphology map. Figure prepared by L. Batista.

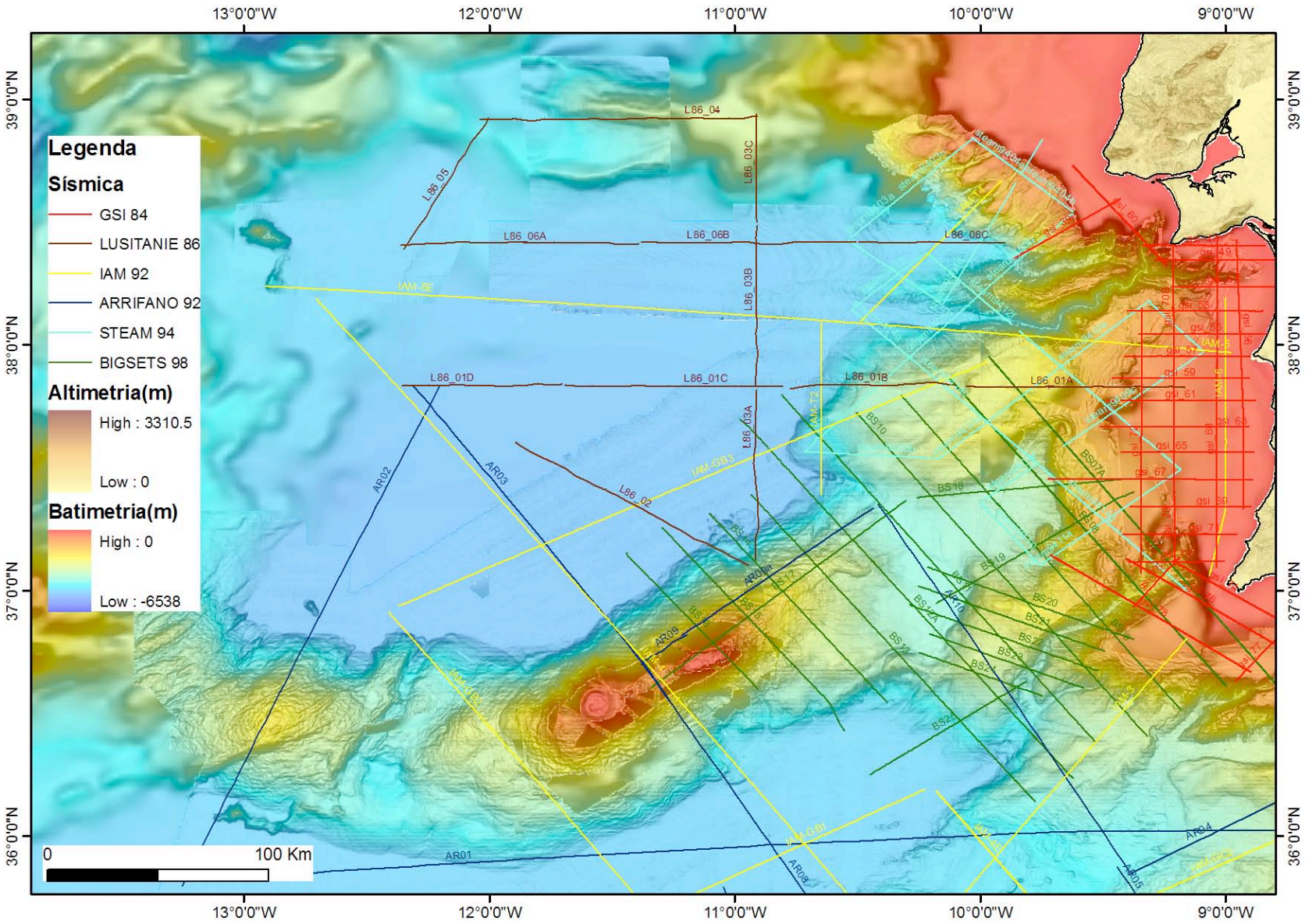

Figure 2 – Existing Seismic Lines in the selected area of the Portuguese Margin.

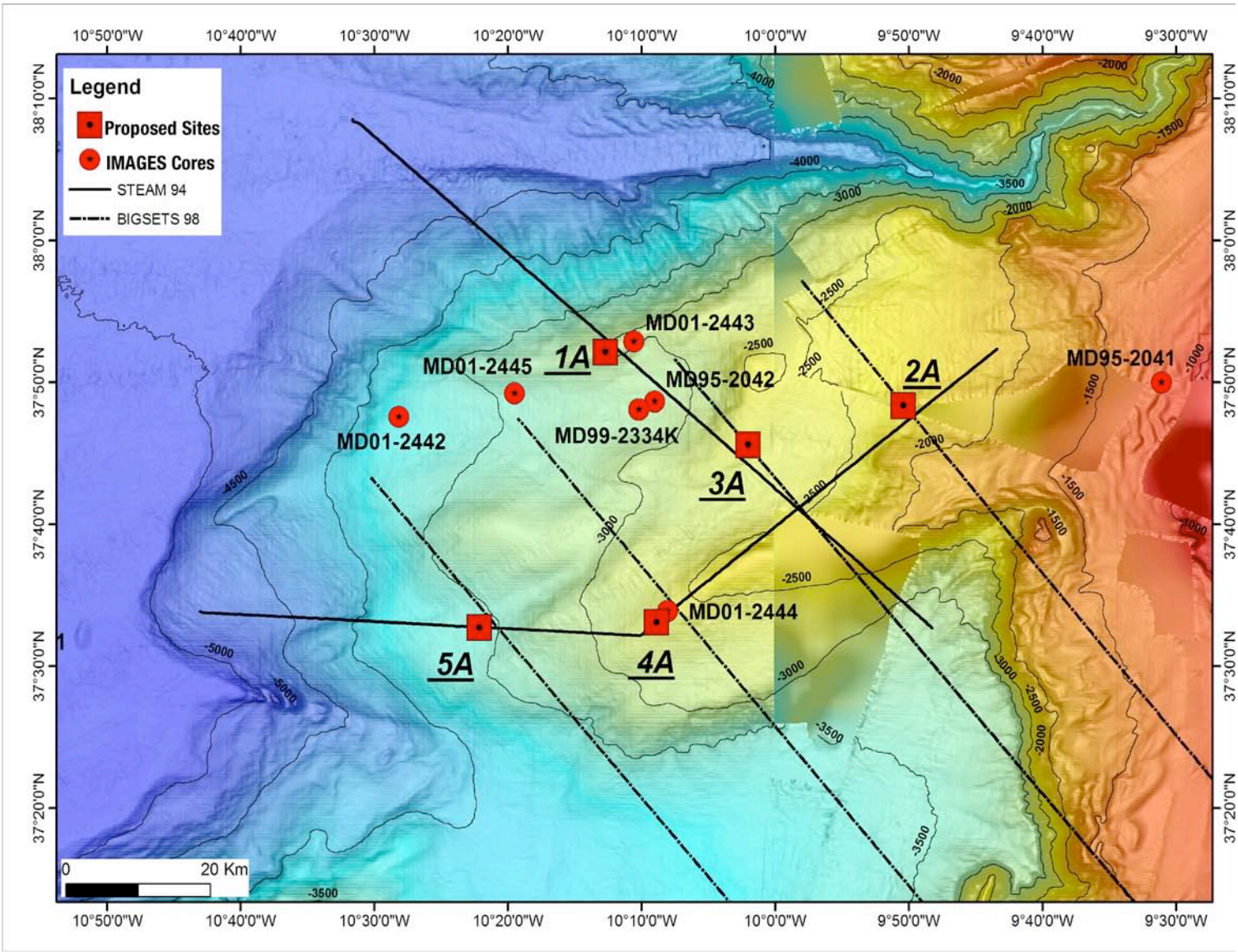

Figure 3. Location of the proposed sites 1A to 5A.

3. Assessment of the results and impact of the event on the future direction of the field (max 2 pages)

The paleoceanographic working group spent most of Day 2 reviewing seismic lines and discussing options for site locations. Five potential sites were identified (Figure 3) and drilling time estimates were calculated using the IODP Coring Estimator spreadsheet. Site selection was preceded by a discussion whether to extend the stratigraphic range of the proposed drill sites to include the thick pre-Pliocene sequence of sediment on the Portuguese Margin. The consensus was that the primary objective of the proposal should be focused on obtaining the Plio-Pleistocene sequence at multiple sites in multiple holes. Core quality and diagenesis are also important factors and the pre-Pliocene sequence is deeply buried and likely beyond the range of the hydraulic piston corer.

We discussed the role of the "Shackleton sites" as marine reference sections, including the suggestion by *Alley (2003) that paleoceanographers should consider following the ice core community's lead and organize a research effort to "generate a few internationally coordinated, multiply replicated, multiparameter, high time resolution-type sections of oceanic change*." The Shackleton sites could serve as a proof of concept for adopting a new strategy for sampling and analyzing IODP cores that emphasizes a truly muti-proxy approach with attention to resolution, replication and time control." In anticipation of the high sample demand for these reference sections, many holes per site (upwards to six) would be needed to produce multiple composite sections. This may be an appropriate time for IODP to consider a new model for the sampling and analysis of sediment cores for paleoceanographic purposes. Discussion included the possibility of assembling teams of investigators with a coordinated sampling plan for generating true multi-proxy records. The group may require a memorandum of understanding (MOU) that outlines obligations of investigators for sharing samples and producing results.

During the discussions of the tectonic group, outstanding questions were identified and sites were identified that could address the relevant problems. The most important questions include: 1) what is the recurrence interval of potential destructive earthquakes and tsunami? 2) what is the rheology of the area? 3) what are the interactions between fluid pressure variation and fault kinematics?

All the participants in the tectonics group were supportive of writing an IODP pre-proposal to establish a borehole observatory in the Gulf of Cadiz. In addition the group decided to organize another meeting at the end of Jan 2010 in order to better define the current state of knowledge, data availability, scientific and technological partnership and the development of a work plan. The future meeting will be open to all the parties (including those present and absent from this workshop) interested in the topic.

In summary, the most important outomes of the workshop will be the preparation of two proposals for submission in 2010: one proposal to be submitted April 1 to drill the "Shackleton sites" and a second pre-proposal addressing the tectonic objectives to be in either April or October.

Magellan Workshop

IODP Drilling of the "Shackleton sites" on the Iberian Margin: In Search of a Plio-Pleistocene Marine Reference Section

9 – 10 November, Lisbon

The workshop will take place at LNEG, VIP room. Transportation to LNEG leaves daily from the location point marked on the map and that is located 350 m from the Hotel. In the evenings transportation back to the city center will be arranged according to needs.

The primary purpose of the workshop is to organize and plan the submission of one or more IODP drilling proposals for the April 1, 2010 deadline. This will entail prioritizing the scientific objectives of the drilling program, formulating a drilling strategy, and identifying the best site locations to drill.

Participants should be prepared to present a 10-15 min ppt on scientific interests for this proposal as well as on existing background data. Although some discussion of prior results is encouraged, please also consider the following questions when preparing your presentations:

1. Which of the important scientific themes that form the IODP Initial Science Plan will drilling the Portuguese Margin address?
2. Why is it necessary that scientific ocean drilling be used to explore the problem?
3. What are the key unanswered questions to be addressed by scientific drilling of the Portuguese Margin?
4. What new aspect(s) of the problem will the proposed drilling address?
5. What new results are expected from the proposed drilling?
6. What new insights into the problem can only be gained by the proposed drilling?
7. What is the societal relevance of drilling the Portuguese Margin?
8. What are the specific hypotheses and/or models to be tested through drilling?
9. What are the best strategies for reaching the overall goals?

Work Plan

Monday 9

9:30 – 9:35 **Fátima Abrantes** - Welcome, Presentation of the WS plan & Information
9:35 –9:50 **David Hodell** "Drilling the "Shackleton sites" on the Portuguese Margin as a Quaternary Marine Reference Section"
9:50 – 10:10 **Gabriella Carrara** "Geo-hazards in the Gulf of Cadiz Some good reasons to drill for a long term observatory here".
10:10 – 10:25 **Fátima Abrantes** "Interests from the UGM/LNEG and possible sites with Paleoceanographic potential"
10:25 – 11:45 Coffee-Break
11:45 – 12:00 **Francisco Sierro** "Drilling on the Portuguese continental slope to track millennial sea level changes".
12:00 – 12:15 **Susana Martin Lebreiro** "Iberian sites (*Shakleton´s & more*) for a IODP paleoceanographic-hazards pre-proposal"
12:15 – 12:30 **Chronis Tzedakis**

12:30 – 12:45 **Joan O. Grimalt, Belen Martrat and others** "Research interests on the search for a Plio-Pleistocene marine reference section in the Shackleton sites"
12:45 – 13:00 **Francesca Sangiorgi** and Henk Brinkhuis "Expression of interest in future drilling on the Portuguese Margin"
14:00 – 14:15 **Jaume Frigola** "The Interests of the University of Barcelona"
14:15 – 14:30 **Filomena Ornella Amore** "The evolution of calcareous nannofossil assemblages and their relationship with climate variability during the MPT and Middle Bruhnes Event".
14:30 – 14:45 **Alexandre Incarbona "Primary productivity variability on the Atlantic Iberian Margin over the last 70,000 years: evidence from coccolithophores and fossil organic compounds"**
14:45 – 15:00 **Paulo Legoinha** and João Pais "IODP Drilling of the "Shackleton sites" on the Iberian Margin: In Search of a Plio-Pleistocene Marine Reference Section".
15:00 – 15:20 **Antje Voelker** "Review of the GUCADRILL proposal"
15:20 – 15:35 **Laura Beranzoli and Angelo de Santis** "The Iberian Margin Drilling proposal - The added value from long-term multidisciplinary sub-seafloor, seafloor and water column monitoring".
15:35 – 15:50 **Miguel Miranda** "Drilling the Gulf of Cadiz: The importance for understanding the seismogenic sources"
15:50 – 16:30 *Coffee-Break*
16:30 – 18:30 Open discussion on existing proposal options
(One combined proposal, Paleo + 1 hazards hole, *vs* a paleo and a NH proposal)
Overview of received statements of interest from **Tiago Alves, Angelo Camerlangi, Maria Fernanda Goñi**

Tuesday 10
9:30 – 9:45 Plenary discussion of major science objectives and strategy
9:45 – 10:00 Definition of groups and attribution of responsibilities
10:00 – 13:00 WG Paleo (VIP) + WG Hazards (room 2023)
13:00 – 14:00 Lunch
14: 00 – 16:00 WG Paleo (VIP) + WG Hazards (room 2023)
16:00 – 16:30 Coffee Break
16:30 – 17:30 WG Paleo (VIP) + WG Hazards (room 2023)
17:30 – 17:45 Final decisions, attribution of different responsibilities, deadline definitions
17:45 – 18:00 Presentation WG Paleo
18:00 – 19:00 Presentation WG Hazards

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Invited scientists who could not attend but showed interest and requested to be kept on the list for further information

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- Francesca Sangiorgi, Institute of Environmental Biology, U. Utrecht, Netherlands.
- Henk Brinkhuis, Institute of Environmental Biology, U. Utrecht, Netherlands.
- Isabel Cacho Lascorz, ICREA, Istitució Catalana de Recerca i Estudis Avançats, Departament d'Estratigrafia, Paleontologia i Geociències Marines, Barcelona, Spain.
- Jacqueline Flueckiger,ETH Environmental Physics, Institute of Biogeochemistry and Pollutant Dynamics, Zurich, Switzerland
- Javier Hernández,Facultad de Ciencias del Mar, Dpto. Geociencias Marinas,. U. Vigo, Spain
- Joachim Schoenfeld, GEOMAR, Germany
- Luis Menezes Pinheiro, Depto Geociencias, U. Aveiro, Portugal
- Luke Skinner, Dpt. Earth Sciences, U. Cambridge, UK.
- Maria Fernanda Sanchez-Goni, EPOC, U. Bordeaux, France
- Nevio Zitellini, Instituto di Geologia Marina, CNR, Bologna, Italy
- Nicolas Thouveny, CEREGE, U. d-Aixe-Marseille, France
- Paolo Favali, INGV-Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy.
- Stephanie Desprat, EPOC, U. Bordeaux, France
- Tiago Alves, Sch. of Earth and Ocean Sciences, U. Cardiff, UK.
- Till Hanebuth, Marum - Zentrum für Marine Umweltwissenschaften, U. Bremen, Germany
- Tim Freudenthal, Marum - Zentrum für Marine Umweltwissenschaften, U. Bremen, Germany
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