JEODI
Joint European Ocean Drilling Initiative

EUROPEAN SCIENCE FOUNDATION E·S F

APLACON

An International Conference aimed at integrating Alternate Platforms (Mission Specific Platforms) as part of the Integrated Ocean Drilling Program

Organized by : JEODI, ESF and ESCOD

APLACON CONFERENCE - ALTERNATE PLATFORMS AS PART OF THE INTEGRATED OCEAN DRILLING PROGRAM (IODP)

May 10-12, 2001, Lisbon, Portugal

The APLACON meeting is the logical continuation of the CONCORD (Japanese Deep Ocean Riser Vessel) and the COMPLEX meetings and will address science themes which require technologies other than those provided by the Japanese vessel and the JOIDES Resolution replacement proposed as part of IODP. The objective is to define the science programme that will require a third core capability of "Mission Specific Platforms in IODP". An important aim of this meeting will be to incorporate projects involving these Mission Specific Platforms in scientific programmes requiring a multiple-platform drilling approach in the IODP.

This meeting has been sponsored by the following organisations:

The European Science Foundation
The EC-project Joint European Ocean Drilling Initiative (JEODI)
The IGM-Departamento de Geologia Marinha, Portugal

THE INTEGRATED OCEAN DRILLING PROGRAM (IODP)

From 1968 and the verification of the Plate Tectonic hypothesis, the Deep Sea Drilling Project (DSDP) and, later, from 1985, the Ocean Drilling Program (ODP) have undertaken an unprecedented programme of international research in earth sciences. This research was organised around the activity of a single deep-ocean drilling ship. From October 2003, international scientific ocean drilling will enter a new era of sampling the ocean floor with the development of a multiple platform program. This new programme, *The Integrated Ocean Drilling Programme (IODP),* will provide a powerful and unique data base which will be fundamental in understanding the way the Earth functions. These data will help solve important societal issues such as, the rates of, and reasons for, climate change, exploration for new energy sources and mitigation of major catastrophes (earthquakes, submarine slides etc..). Furthermore, the recent discovery of a biosphere hidden in the deep ocean-floor has implications for the understanding of the origin of life on Earth and our adjacent planets, which we have barely began to uncover.

In addition to scientific advances, IODP will provide a window for the development of technology related to drilling and the exploration of the Earth. In a rapidly evolving planet, the fundamental, social and economical knowledge to be gained by scientific ocean drilling are immense. IODP will further provide a means of building an outreach programme to students and the general public by the creation of virtual environments, involving drilling to understand climate change, bio-diversity, risks related to earthquakes, etc., and the dissemination of this information to teachers.

"IODP" : A NEW, MULTI-PLATFORM, SCIENTIFIC OCEAN DRILLING APPROACH

In order to investigate previously unexplored domains, oceanic drilling now requires a multiple platform approach.

The USA and Japan have recognised this need and proposed a new program (IODP) involving two ocean-going vessels: a very deep-drilling vessel that the Japanese have started to construct and shall operate, and a second multi-tasking vessel which the USA will equip and operate, with similar capabilities to the Joides Resolution (http://www.oceandrilling.org) used in the current programme (ODP).

- The Japanese vessel will be able to drill deeper than any vessel has drilled in the oceans, potentially as much as 8km below sea floor and in 4000 m deep oceans. One of the main scientific objectives of the Japanese initiative is to drill into seismically active regions in order to understand the processes that cause earthquakes. The Japanese vessel will also allow Earth scientists to achieve some of the major objectives of the past 50 years, such as: drill through an entire section of ocean crust and reach the Earth's mantle; drill into hydrocarbon bearing horizons and explore the deepest parts of continental margins to evaluate, in particular, processes related to the formation and maturation of petroleum and gas.

- The US vessel will continue to explore the oceans providing fundamental data on climate change and the dynamics of the Earth, which are essential for any future efforts in climate modelling, and can only be obtained by obtaining complete drill cores from different time-scales and different paleo-geographic latitudes on Earth. These cores are essential complements to those obtained in glaciers and inland lakes, as they provide information on ocean currents and related climatic systems (for example El Nino events) which can only be observed at sea. Also, dramatic events which may have had a major influence on the evolution of life on Earth such as meteorite impacts, or even in historical times widespread droughts in Africa can only be recorded in dust carried into the oceans and preserved in sediments.

These two vessels alone are unable to achieve several of the objectives of the IODP science plan (http://www.iodp.org/pdf/IODP_Init_Sci_Plan.final.pdf). In particular, they will not be able to core in ice covered regions and shallow water environments (less than about 200m of water). The Arctic is the thermostat that controls the Earth's ocean currents and its deep sea-floor remains totally unknown. The sediments deposited in the shallow seas and continental margins control the carbon cycle on Earth and, for example, provide our hydrocarbon resources. These sequences are best sampled with Alternate Platforms, now termed "Mission Specific Platforms (MSP)" by IODP. The MSP will be implemented on a "fit to mission" basis and will comprise a fleet of different geo-technical drilling vessels, barges, remote drilling systems, etc.. The APLACON conference has as its objective the justification of the scientific rational for the use of Mission Specific Platforms (MSP). The projects defined in this volume will provide the basis for a series of IODP proposals for MSP use in IODP and, where appropriate, their integration in Multi-Platform drilling programmes, spanning several years of research, and involving two or more of the vessels available to IODP.

TURBIDITE SYSTEMS IN THE WESTERN MEDITERRANEAN SEA: CONTRIBUTION OF SEDIMENTARY FACIES TO UNDERSTAND TURBIDITE SYSTEM GROWTH AND TO EVALUATE TURBIDITE SYSTEM MODELS

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The Ebro Turbidite System and the Guadalfeo Turbidite System are located respectively in the NW and the SW Mediterranean Sea. The Ebro Turbidite System has developed during the Upper Pliocene and Quaternary, has about 600 ms (twtt) of maximum thickness and covers an area of 3000 km^2. Its main architectural elements includes: multiple short canyons, slides and mass flow deposits, channel-levee complexes (erosive-depositional and depositional), interchannel areas, and base-of-slope aprons. The Guadalfeo Turbidite System has developed during the Pliocene and the Quaternary, has about 800 ms (twtt) of maximum thickness, and covers an area of 1000 km^2. It is composed mainly by 10 fanlobes (channel-levee complexes and channelized lobes). The drilling on these turbidite systems has a wide scientific relevance because they offer a good opportunity to understand the growth processes of small, mixed turbidite systems and to improve the existing sedimentary models of turbidite systems located in a semi-enclosed basins.

SHALLOW WATER DRILLING IN THE DOGGER BANK: SUBMERSION HISTORY AND PORE-WATER CHEMISTRY AS A KEY TO UNDERSTAND SEA-LEVEL MOVEMENTS, PALEO LAND DISTRIBUTION AND DEGLACIATION OF NORTH WESTERN EUROPE

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The North Sea is an area of foremost scientific interest for research on relative sea-level change and land surface evolution, especially in the context of climatic and tectonic change. Recent geophysical modeling has greatly advanced understanding of the important role of solid earth processes of glacio- and hydro-isostasy in controlling the complex spatial and temporal evolution of the area, in particular spatial differences in sea-level change (Fig. 1). The purpose of the proposed study is (1) to improve the above models of relative sea-level change and paleogeographic development by expanding the sea-level database with data from the marine realm, focusing on presently missing early Holocene and Pleistocene data (2) to improve understanding of the interactions among solid earth, hydrosphere and atmosphere by extraction of hydrogeological (Fig. 2) and climate data from the marine cores. The hydrogeological component implies a novel linkage of the study of surface environmental change (sea-level, climate) with that of the subsurface environment ('subsea ocean'). The significance of the data to be gathered and models to be developed would extend well beyond the borders of the North Sea.

The Dogger Bank area in the North Sea is proposed as the main target area for a combined sedimentological, geochemical and hydrological study because of its central location within the North Sea and its unique topographic, sedimentary and hydrological features. The alternative platform program to be deployed within the upcoming Integrated Ocean Drilling Program after 2003 (COMPLEX Meeting, ODP Euroforum) and as outlined in the existing ODP Long Range Plan, provides an excellent vehicle to obtain the required data.

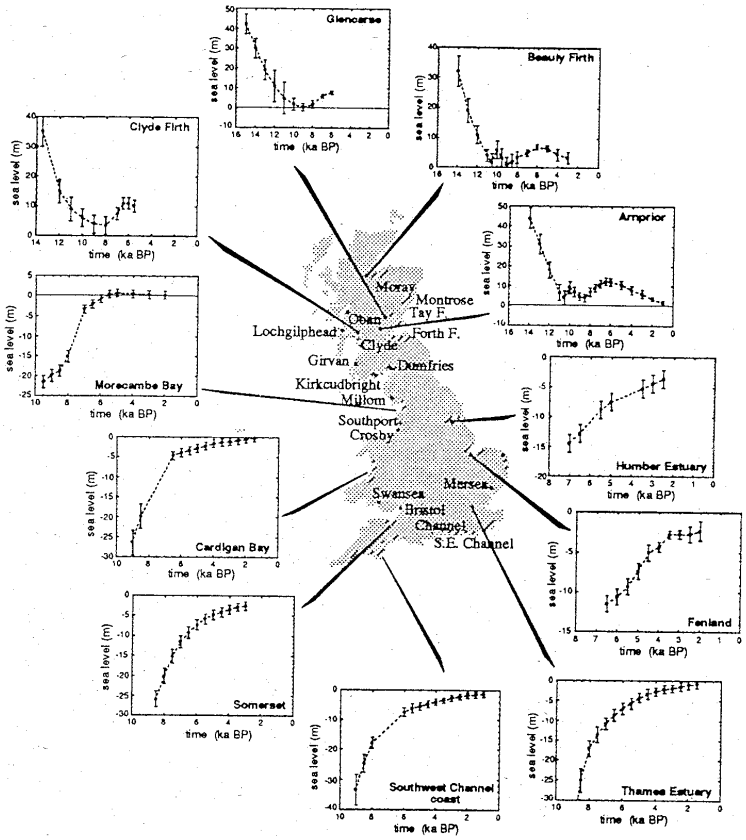

Fig. 1 Spatially variable Holocene sea-level history around the British Isles

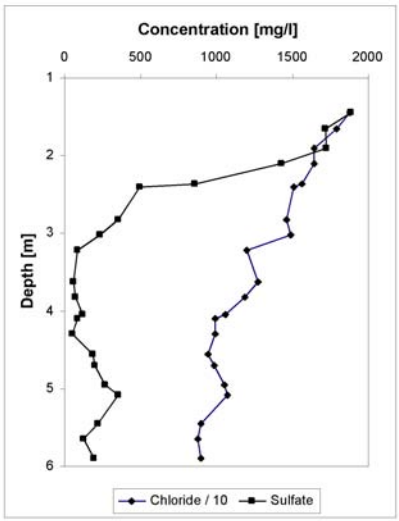

Fig. 2 Strongly reduced chloride concentrations at shallow depths in the North Sea

THE DEVELOPMENT OF ODP PROPOSAL 533: PALEOCEANOGRAPHIC AND TECTONIC HISTORY OF THE CENTRAL ARCTIC OCEAN

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Summary
Seismic reflection profiles were acquired from the Lomonosov Ridge in the central Arctic Ocean during expeditions in 1991, 1996, and 1998. A scientific drilling proposal submitted to ODP in 1998 used these seismic profiles to identify drilling targets suitable for both paleoceanographic and tectonic objectives. The data collected in 1991 contains the two key seismic profiles. ODP proposal 533 was ranked no. 1 by the JOIDES Science Committee (SCICOM) during its meeting in August, 2000. Drilling this proposal requires the use of a drilling platform supported by two icebreakers, that is, the use of alternate platforms. The ODP Long Range Plan (1996) emphazises the importance of drilling Arctic Ocean deep-sea sediments and the ODP will also consider expanding operations by using alternate platforms. An Arctic DPG was formed by SCICOM in December 2000. Its goal is to develop a project management plan encompassing the logistical, technical, and budgetary requirements for scientific drilling on Lomonosov Ridge. Results from its preliminary report indicate that Proposal 533 can be drilled towards the end of ODP in 2003, at the cost of a standard ODP leg. The highly succcessful programs thus far carried out by ODP in the world's temperate oceans can now come true in one of the last frontier's, the Arctic Ocean, using drilling and alternate platforms - as ODP's crowning achievement in 2003.

Background
The scientific exploration of the central Arctic Ocean made huge progress during the 1990's, as a result of several successful icebreaker expeditions: 1991 *(Oden* and *Polarstern* - surface ships no 4 and 5 to reach the geographic North Pole); 1994 *(Louis St. Laurent* and *Polar Star)*; 1996 *(Oden* and *Polarstern);* and 1998 *(Arktika* and *Polarstern)*. These expeditions had broad scientific mandates and covered sampling and data acquisition of all natural systems from the atmosphere to sea-floor. Geological coring and seismic reflection programs hence were key components of all these expeditions; the longest piston core that has been retrieved is 17 m long. Acquisition of geophysical data sets and sea-floor mapping were greatly enhanced through a series of yearly expeditions using US navy nuclear submarines, e.g., the 1999 *Hawkbill* cruise, collecting sidescan, swath bathymetry and chirp sonar data. All these efforts created a wealth of new data and provided a scientific basis for a much more accurate representation of Arctic processes in, for example, global climate models.
We have learned that the Arctic Ocean indeed plays a fundamental role in the global ocean/climate system: the dense cold bottom waters of most of the world's oceans partly originates in the Arctic Ocean; the permanent Arctic sea-ice cover has a tremendous influence on the Earth's albedo and the distribution of fresh water, and its variation both seasonally and over longer time periods. Thus, the ocean has a direct influence on global heat distribution and climate. Despite this, the logistical difficulties associated with the work in this remote and harsh region have prevented us from gathering the critical data needed to document the role of this key region in the

development and maintenance of the global climate system.

Several hundred short cores of Pleistocene age have been retrieved from the Arctic Ocean, but little information is available about its pre-Pleistocene paleoenvironments. Four cores have been retrieved from a small sector of the Alpha Ridge (85°N-86°N/98°W-129°W) that are of Late Cretaceous (3) and Eocene (1) ages. None of these four cores exceed 4 m in length. Temperate marine conditions existed during the Late Cretaceous (Campanian-Maastrichtian) based on evidence provided by silicoflagellates and diatoms from the three short T-3 and CESAR cores (Clark et al., 1980; Bukry, 1981; Thiede et al., 1990). A recent finding of crocodile-like vertebrates from Ellesmere Island is also compatible with temperate conditions in the Arctic during the Late Cretaceous (Tarduno et al., 1998). One very short T-3 core containing an assemblage of cool temperate silicoflagellates of middle or late Eocene age provides the sole evidence for early Cenozoic marine conditions in the Arctic (Bukry, 1984). Thus, existing core material, at best, represents a few percent of the Cenozoic history of the Arctic Ocean.

In a series of visionary reports, paleoceanographers have emphasized the importance of sampling the Arctic's deep-sea sediment archive, without which it appears difficult to fully appreciate and model global environmental change (e.g., COSOD I and II, ODP Long Range Plan, FUMAGES, COMPLEX). Another pamphlet focussing on the the central Arctic Ocean is Thiede's (1992) "The Arctic Ocean Record: Key to Global Change (Initial Science Plan)", in which a series of potential Arctic deep-sea drilling sites were suggested, based on, in most cases, lower-quality seismic records collected before the late 1980'ies.

The Lomonosov Ridge breakthrough during the 1990's

The Lomonosov Ridge was discovered in 1948 by the Soviet "High Latitude Air Expeditions", but the presence of a deep bathymetric barrier across the Arctic Ocean was inferred from earlier tidal measurements in 1904 and 1936, and also later from deep water temperature differences in 1953. This transpolar feature rises over 3 km above the adjacent abyssal plains. Aeromagnetic surveys of the Eurasian Basin reveal a remarkably clear pattern of magnetic lineations which can be interpreted in terms of seafloor spreading along the Gakkel Ridge since Chron 24 (~55 Ma). If we compensate for that motion, the Lomonosov Ridge is brought into juxtaposition with the Barents/Kara Sea margin in the early Cenozoic.

Two seismic profiles were acquired across the Lomonosov Ridge in about 8/10 ice during the Arctic Ocean '91 expedition (Jokat et al., 1992). At 88°N in 1 km of water, the ridge is 80 km wide with a 450 to 500 m thick section of acoustically stratified sediments that cap the ridge above an unconformity (Figure 1). Below this unconformity, sediments are present in down-faulted asymmetric half-grabens. Seismic velocities from refraction experiments are typical for hemipelagic sediments above the unconformity (1.8-2.2 km/s) and are > 4 km/s below. Other regions of the Lomonosov Ridge have been explored, also containing potential drilling targets. For example, during the Arctic Ocean '96 expedition, a third seismic profile was acquired across the ridge at 85°N, in shallower water, but with a thinner sediment cover (Kristoffersen, 1997). Subsequently, Jokat (1999) collected additional seismic reflection data from the crest of the Lomonosov Ridge between about 85°N and 80°N.

The Lomonosov Ridge is interpreted to be a continental sliver that separated from the Eurasian plate during the Paleocene and moved into its current position with seafloor spreading along the

Gakkel Ridge, the Arctic extension of the mid-Atlantic ridge system (Wilson, 1963; Vogt et al., 1979; Kristoffersen, 1990). As the Lomonosov Ridge moved away from the Eurasian plate and subsided, sedimentation on top of this continental sliver began and continued to the present, providing what may be a continuous stratigraphic sequence. The elevation of the ridge above the surrounding abyssal plains, indicates that sediments on top of the ridge have been isolated from turbidites and are likely of purely pelagic origin.

The upper 450-500 m section of stratified sediments on the Lomonosov Ridge is considered to represent a stratigraphic record spanning approximately the last 50 million years, yielding an average sedimentation rate of ~1 cm /1000 years if assuming continuous deposition. One may thus conclude that the 450-500 m thick hemipelagic sediment sequence draping the crest of the Lomonosov Ridge between 87°N and 88°N, at about 1 km water-depth, contains a unique archive of climatic and paleoceanographic information, which is the key to unravelling the Cenozoic environmental history of the central Arctic Ocean.

JOIDES encouragement to develop a mature ODP drilling proposal for the Arctic

The obvious target for scientific drilling on the Lomonosov Ridge was recognized in 1991, from the moment the key reflection seismic profiles were collected. Seven years later, in 1998, a small group of scientists decided to submit a preliminary proposal to ODP. Encouraged by the wording in the ODP Long Range Plan about the importance of both Arctic Ocean drilling and alternate platform drilling, the proponents thus challenged the ODP community with the opportunity of capturing a beautiful climate record from the Lomonosov Ridge sequence. The preliminary proposal was well received, and the JOIDES ESSEP review urged the proponents to submit a full proposal.

In order to add expertise, the proponent group was enlarged from five to eleven persons, and the full proposal (533-Full) was submitted in March 1999. The proposal was revised later during 1999, and an addendum was written in early 2000. Proposal 533 was thereafter sent for external review. The reviews were entirely consistent in that they strongly supported the science presented, that the choice of drilling site locations was excellent for solving the proposed scientific problems, that the drilling strategy offers a good solution for fulfilling stated goals, and, finally, that the suggested platform strategy, involving two icebreakers and a drilling platform, is highly appropriate for this proposal.

No. 1 ranking by JOIDES SCICOM of Proposal 533 and establishment of the Arctic DPG

"The JOIDES Science Committee considered 33 drilling proposals at its August meeting in Halifax and assigned a global ranking to 30 of those proposals. This was the most competetive ranking and scheduling meeting ever, with nearly all of the proposals judged to have merits as drilling projects. Your proposal ranked 1st out of 30..." Letter from the SCICOM Chair, 23 August, 2000.

At the August 2000 meeting, SCICOM also decided to establish an Arctic Detailed Planning Group, with the purpose to find out "how to do it" with respect to Proposal 533. The membership of the Arctic DPG was established in December 2000, and the kick-off meeting was held in January 2001. The preliminary DPG report presents three alternatives consisting of different drilling platform and support icebreaker configurations. The preferred platform scenario

draws a cost of about 6.3 million (long) dollars, if Sweden's contribution, the icebreaker *Oden*, is taken into account. Scientific ocean drilling on the Lomonosov Ridge thus can be achieved at a cost which is virtually that of a standard ODP leg.

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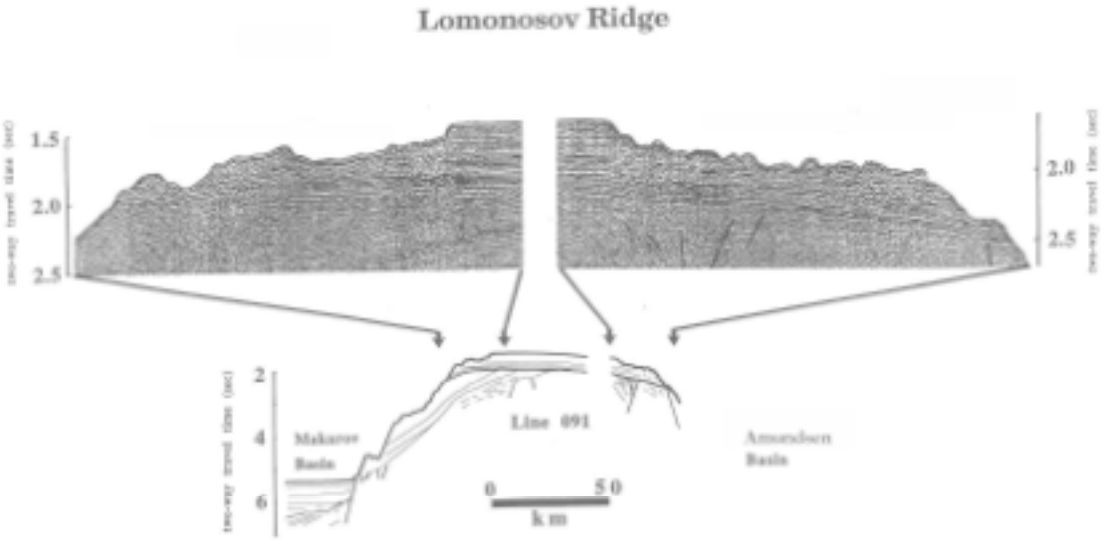

Figure 1. : Seismic profile AWI-91091, transecting the Lomonosov Ridge at ca 87°40'N. The key paleoceanographic sites (LORI-01, -09) will be located on the shallow, flat crest.

ANTARCTIC MARGIN DRILLING: AN IODP CHALLENGE

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A. Background. In 1996 a suite of proposals from ANTOSTRAT[1] Regional WGs and others to drill the Antarctic margin was refined and prioritised by an ODP Antarctic DPG. ANTOSTRATís aim was to determine Antarctic glacial history directly from glacially-transported sediments, and assess its effect on sea-level change. The background was unsatisfactory - ice sheet evolution was deduced only from low-latitude proxy measurements, of which the two principal (oxygen isotopes and sea-level) disagreed, and were ambiguous. In these proposals, drilling at several sectors of the margin would be combined by numerical models of ice sheet development, and in each sector two sedimentary environments were available (diamict on the continental shelf and slope, and derived fine-grained hemipelagics on upper continental rise drifts). The aim lay clearly within the ODP Long Range Plan.

Two of the four proposals have been drilled (Leg 178 to the Antarctic Peninsula, Leg 188 to Prydz Bay), and ice-sheet modelling has developed, but the basic problem remains: ice sheet history is still uncertain. Proxy measurements (particularly oxygen isotopes) provide more detail, but the ambiguity and disagreement are still there. Leg 178 showed Antarctic margin drilling is viable, while identifying its limitations, and Leg 188 (without an ice support ship) has resolved early glacial history very clearly. The proposals not yet attempted (Wilkes Land and the Eastern Ross Sea) are to examine the crucial intermediate stages of ice sheet evolution - how big was the Oligocene ice sheet, and across the Middle Miocene transition?Through this time, was the ice sheet sensitive to orbital insolation changes? When did the West Antarctic ice sheet develop? These key questions (and others) can be addressed only by drilling margin sediments.

B. Science. We make two other general points.

First, the role of the high latitudes within the global climate system (over a long or a short time scale, with or without an ice sheet) is crucial. Being remote from solar heat input, they will usually contain a record of climate change more sensitive to earth processes, that must be examined in order to assess the size of any effect.

Second, the high latitudes contain possibly even more than their share of potential causes of climate change, because of the power of snow and ice within feedback loops.

The new IODP initial Science Plan (iSP) is more focussed than its predecessor, but its text reflects these truths in many places. We wish to note the following, in the specific context of the iSP foci and ìInitiativesî:

1. The overdeepened inner Antarctic continental shelf preserves in places an expanded (decadal to century scale) Holocene sedimentary climate record that as yet is only sampled in one place (Palmer Deep, Antarctic Peninsula: Leg 178). The present global coverage of Holocene sites is

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[1]ANTOSTRAT, originally the Antarctic Offshore Acoustic Stratigraphy initiative, exists within SCAR, the Scientific Committee for Antarctic Research, an ICSU Committee. It is much broader than the Antarctic marine seismic reflection community, and recently dropped the ìOffshoreî. Its focus is now more towards sampling, and embraces climate history back to 130 Ma. An ANTOSTRAT plenary in Italy in September will reconsider its scope and priorities.

very sparse, and other sediment records are needed to check the validity of both these few and the continental ice core records with which they are usually compared. The Antarctic margin is a prime environment.

2. The warm extreme climate events of the Cretaceous and Paleocene-Eocene did involve high-latitude warming (as the iSP notes), and detailed records are needed from high latitude margins in particular, to determine the amplitude of warming.

3. The origin of Neogene cold extreme climatic events (eg. the early Miocene Mi1 and Mi1a) is in many ways more intriguing than that of the better-known warm events. It seems most likely that the high latitudes were involved, presaging their later function as isolated reservoirs or as sites of powerful feedback mechanisms that amplified cooling. To determine unambiguously the role of the Antarctic ice sheet, it is necessary to examine Antarctic margin sediments.

4. As effective as ìeventsî, as a focus for understanding global climate (perhaps even more effective), are ìswitchesî, when a sharp change in climate is not returned quickly to something like the earlier state. Within the Cenozoic these have tended to involve Antarctica - there are switches at the Eocene-Oligocene boundary and in the middle Miocene, when major changes in ice sheet volume are known or suggested. Again, whether the ice sheet is an active player or a passive recorder in these changes, the Antarctic margin record is important.

C. Techniques. Drilling on the Antarctic margin to date has identified and worked within several technical limitations, which a more capable future program should be able to overcome:

1. Recovery. ODP recovery of diamict on the continental shelf was poor, probably for two reasons. First, large clasts within unconsolidated diamict were not supported by the matrix during drilling, so they shifted and, often, jammed in the drill bit, greatly reducing recovery. Second, ocean swell at times prevented drilling entirely (for safety reasons) and at other times degraded recovery. It is important that techniques that elsewhere have overcome such difficulties (active heave compensation, diamond drilling etc) should be made available.

2. Access. The problem of access is not so dramatic for the Antarctic as for the Arctic ocean basin, but consider the following:

Past Antarctic margin drilling was confined to a narrow ice window each year: it never overcame this problem, so Antarctic excursions were always limited in time extent and logistically inefficient, with large passage time premiums, weighting the scales against us.

Some environments (eg. continental rise sediment drifts off the Ross Sea) are always pack-ice-covered, making them inaccessible to old-style drilling.

ODP could never dampen the adverse effects of ocean swell by drilling deep within the expanded sea-ice cover in winter.

In summary, the proposals submitted to ODP were viable, but had been limited (by ANTOSTRAT) in science scope, to take into account the technical limitations.

D. Conclusions. Antarctic glacial history remains unknown. Antarctic margin drilling can contribute to this major study **and** to the more focussed IODP, but requires emphasis on an ice-going vessel with diamond drilling capability.

PROMESS: PROFILES ACROSS MEDITERRANEAN SEDIMENTARY SYSTEMS

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«PROMESS» is a group of scientific proposals requiring three different coring and drilling platforms, each best suited for specific penetrations, recovery and water depths (ranging from 50 to 2500m). Its general objective is to obtain comprehensive transects across Mediterranean Sedimentary Systems in areas with high sedimentation rates, good sequence preservation and contrasted local/regional settings. The major scientific objectives include :

Stratigraphic response to glacio-eustatic and climatic cycles during the last 400ky,

Study of the variability and impact of continental slope stability,

Processes of formation and architecture of sand bodies, including shelf, slope and deep-sea environments,

High-resolution analysis of sediment fluxes and climate changes in areas of high sedimentation rates (ca 1 m/ky).

PROMESS 1 is devoted to the continous drilling/coring of «shallow water» (50-300m water depth) sections with a geotechnical vessel (from the industry). This operation will complement corings performed with the Marion Dufresne (PROMESS 2) and deep-water drilling proposed with the JOIDES Resolution or her replacement (ODP proposal 467) (Promess 3). It is carried out within the OMARC cluster of European projects. Furthermore, it is a contribution to a new, joint Europe-US initiative for studying Strata Formation along two Mediterranean Continental Margins (EUROSTRATAFORM). **The two selected targets,** the Gulf of Lions and the Central Adriatic, are some of the best-studied areas in Southern Europe. High and very high-resolution seismic investigations have demonstrated that major scientific issues with important societal impact are recorded in depositional sequences very well preserved on the continental shelf and slope. Despite a long time geophysical investigation of these continental margins, no «ground-truthing» has been performed so far, thus preventing any detailed understanding of the time-scales of preserved sequences and physical processes at the origin of major sediment bodies.

Specific objectives of PROMESS 1 are :

1- To provide a chronostratigraphic framework (over the last 400,000 years) for 2 deltaic margins where seismic and sequence stratigraphic interpretations are already in progress, and where conceptual, analog and digital stratigraphic models will be applied.
1- To tie stacking patterns and discontinuities on the shelf to global (glacio-eustatic), regional (paleoceanographic, paleoclimatologic), and local (tectonic *s.l.)* changes
1- To ground-truth seismic facies (including sandy clinoforms) in order to improve the predictive capability of seismic tools.

1- To measure physical properties of sediment in areas prone to failure (steep slope, very high sedimentation rate, seismic hazards…) in order to calculate slope stability hazards.

The two study areas represent a counterpart to glaciated continental margins studied by STRATAGEM. They are situated sufficiently far from the former margins of the major ice sheets for sea level to follow, in a first approximation, the eustatic changes.
The central portion of the Gulf of Lions is a particularly stable margin, whereas the Central Adriatic is subject to frequent earthquakes and significant uplifting. The combined study of the two study areas will permit to decipher global glacio-eustatism from local tectonic effects, especially by the means of stratigraphic modelling.

Three types of targets have been selected in both areas :

The shelf-edge area.
In the two study areas, seismic data on the outer continental shelf display prograding regressive units bounded by major erosional discontinuities. On the upper slope, below the depth of the lowest sea-level lowstand, sedimentation is continuous and the unconformities become correlative conformities that can be traced along long distances. Coring this shelf-edge area will allow for dating the periods of sediment transport due to continental and shelf erosion, determining the time-scale (100 or 40 ky) of sequence development, and gaining access to an expanded record (about 1m/ky) of climate changes. This will permit more precise numerical stratigraphic simulations . Conversely, an accurate dating of erosion phases will permit to better constrain sea-level changes during poorly known phases such as the transition between isotopic stages 3 and 2. The mechanical properties of the sediments of these zones prone to failure will be measured in order to determine geohazards.

Facies analysis of shelf sediment bodies
The outer continental shelf is characterized in both areas by prograding units with clinoforms which have never been successfully sampled. In the Gulf of Lions, it is known that the upper portion of these sediment bodies (2 .5m) consists of sand. Recovery of similar facies present on many continental shelves around the world has always been difficult (i.e. ODP leg 174A on the New Jersey Margin, 1997). The use of well adapted (geotechnical) technology is expected to permit better recovery. It will allow for: (a) the interpretation of the origin of these major shelf facies (in terms of physical processes and sedimentary environments), (b) deterrmination of the stage of the sea-level change they formed and (3) lastly, the significance (minor sea-level changes, shifting of depocenters) of internal discontinuities.
Synthetic seismograms will help identify the physical properties responsible for creation of seismic reflections.

Transgressive and highstand record of the last deglacial phase
Both areas have large deltaic systems that provide an expanded record of the rapidly changing conditions of climate, hydrodynamism, sea-level, and sediment fluxes during the last ca 15,000y. The objective is to have access to this well preserved record, in order to link the changes observed

in the marine record to what is already known from the drainage basins (melting of the Alps glaciers) and from historical changes of the deltaic systems. Shallow cores (10-15m long) have already been obtained in both areas from relatively distal sections where the deglacial deposits are thinner, demonstrating the feasibility of the use of such sediment for the characterisation of short term events. Only a long geotechnical drilling, however, would provide an expanded and continous record of the entire deglacial phase allowing high resolution approach

SEA LEVEL, CLIMATE, AND NEOTECTONICS: THE PLEISTOCENE ARCHIVE IN NERITIC CARBONATES OF THE MEDITERRANEAN SEA

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Rationale. The Mediterranean Sea is a world-class natural laboratory which allows to analyze aspects related to sedimentary depositional systems, tectonic control on basin evolution, or the temporal paleoceanographic changes in a semi-enclosed sea. It has been visited by a number of DSDP and ODP legs, and questions such as the Messinian Salinity Crisis, sapropel formation, or structural evolution of the Alboran and Eastern Mediterranean Sea were addressed. This proposal aims to analyze deposits which until now were not accessible using conventional ODP techniques: the nearshore (neritic) sediments. Within this broad area it is intended to focus especially on (1) the benthic carbonate associations, that is the non-tropical carbonate factories; (2) the spatial and temporal sedimentary and palaeoecological dynamics of these ecosystems as a response to past sea level and climate fluctuations; and (3) the tectonic and neotectonic control on deposition. Methods to be used are: coring as well as seismic profiling.

(1) Non-tropical carbonates. Carbonates of the Mediterranean Sea belong to the warm-temperate realm and can be assigned to the bryomol and rhodalgal associations. These carbonate-producing biocoenoses were extensively analyzed during the last decades. Much less is known, however, about the thickness as well as the temporal and the spatial evolution of the systems. Our understanding of the facies, the facies dynamics and the mode of accumulation of temperate carbonates mainly results from extensive studies which have been performed along the South Australian Shelf (e.g. ODP Leg 182). This area, however, has the peculiarity of a deep-lying storm abrasion base inducing no or only minor sedimentation on the shelf above a water depth of 90 m. In the Mediterranean Sea, wave and storm abrasion base is much shallower, in general permitting a net sedimentation up to sea level. Adopting a combined approach of high resolution seismic grids and coring along selected transects should allow to develop models of these deposits which can be used to better understand similar past carbonate depositional systems in the geological record. Here, it is especially referred to mid-latitude carbonates, but also to neritic carbonates which formed during "doubthouse" intervals. It shall also be tested if the unusually high contents of H_2S, CH_4, and CO_2 encountered in the south Australian non-tropical carbonates (ODP Leg 182) are a peculiarity related to this specific depositional system, or if such high gas contents are inherent to non-tropical carbonates. This could e.g. explain the peculiar diagenetic paths of such carbonates. Indications of high gas contents in Mediterranean nearshore deposits have been shown in a number of seismic lines.

(2) Sea level changes and paleoceanography. Results obtained during several DSDP and ODP Legs (e.g. 160, 161) provide a solid reference to understand the Pleistocene palaeoceanographic evolution of the Mediterranean Sea.

Through analysis of oxygen isotope variations of planktonic foraminifers, a reconstruction of the oxygen record back to approx. 1.7 Ma was achieved. This record shows the imprint of orbital forcing on water mass changes, but is also demonstrates that sub-Milankovitch signals occur. As Pleistocene-Holocene sea level changes are climatically controlled, relevant shoreline migrations should result from these fluctuations. Response of the Mediterranean shelf sedimentary systems (siliciclastics and carbonates) to the youngest sea level cycle follows the model of sediment volumetric partitioning known from sequence stratigraphy. The lowstand deposits formed as shelf margin systems tracts located at the shelfbreaks in water depths of around 110 to 120 m. The transgressive and highstand systems tract, which forms the presently evolving "coastal prism", are detached from the lowstand systems tract due to the backstepping of the depocenters. This model is largely derived from sedimentary geometries as imaged in shallow seismic data, and needs a detailed testing and a comprobation with sedimentological data (cores). The high-resolution seismic lines also show that the youngest depositional sequence which currently develops on the shelf is subdivided into different packages. These packages may bear the sedimentary record of the previously discussed isotopically derived sub-Milankovitch cyclicity and may allow a precise reconstruction of sea level and water mass changes. Data from the Mediterranean ODP legs have also shown that the "classical" youngest global climatic and palaeoceanographical changes can be recognized in the pelagic Mediterranean deposits. The effects of these fluctuations on the neritic carbonate-producing benthic communities, however, is largely unknown. Although neritic benthic carbonate production in mid-latitude settings is generally lower than it is in low latitudes, a quantification is needed for such mid-latitudinal settings. Such a quantification must include the so far unknown carbonate-production rates during the past temperature conditions and the sea level lowstand. The tracing of these responses would also provide an important base for the better understanding of the vulnerability of the present-state biocoenoses to future changes. A particular aspect of this part of the proposal would be a longitudinal transect of sites encompassing the Western and Eastern Mediterranean basins in order to trace water mass changes and to reconstruct variations in supply of Atlantic Water into the sea.

(3) Tectonic and neotectonic control on deposition. In a number of cases, preservation but also exhumation of Neogene and Quaternary sediments as well as volcanic rocks in the perimediterranean area are linked to the structural framework. Recent earthquake dates, as well as the record of the past 600 a, show that moderate to strong earthquakes occur frequently within the dextral Afro-European Convergence Zone. Earthquake foci are aligned along faults. As such, the seismic-sedimentary data should be analyzed with respect to structural elements which have been active during the last 10-20 ka. A main focus of this part of the proposal is to characterize the relationship between morphology of the sea floor and tectonic structures in actively deforming areas. Fault- and earthquake related indices have to be searched in order to determine consequences for the depositional system, but also to analyze potential seismogenic risks (e.g. slope instabilities) for nearby coastal areas.

Scientific Drilling on the Canadian Beaufort Shelf Using Fit-to-Mission Platforms and Technologies

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In 1988 a bottom founded drilling platform was used to complete a 500 m deep borehole in 32 m of water on the central Canadian Beaufort Shelf. The Beaufort Shelf is a sea-ice dominated margin, located north of 69° in the Arctic Ocean. The borehole site was near the depocentre of the post-Neogene Beaufort-Mackenzie basin that has accumulated approximately 3500 m of sediment over the past 5 million years. The Quaternary sediment wedge at this depocentre is estimated to be about 1 kilometre thick (Blasco et al., 1990). The upper 700 metres of this wedge consists of a sequence of frozen ice-bearing and non-ice-bearing sediments.

The borehole was completed using conventional drilling techniques and unconventional chilled drilling muds to maintain in-situ negative temperatures to minimize sample disturbance. Sediment units were sampled discontinuously downhole. Recovered core samples were maintained at near in-situ negative temperatures in specialized freezers and were logged and analyzed for sedimentology, biostratigraphy, porewater geochemistry (salinity, oxygen and hydrogen isotopes), ice content and ice fabric.

Based on the interpretation of field logs and borehole sample analyses, 8 sediment cycles were identified. Each cycle is comprised of a retrograding sand unit and overlying transgressive mud unit with an associated contact unconformity. Sand units showed primary fluvial sedimentary structures (trough cross bedding), low salinities, fluvial sourced-porewaters, freshwater pollen assemblages, terrestrial macrofossils at base and significant ice content (as pore ice, lenses, layers, and vein ice). The mud units exhibited both uniform and interbedded fine sand/silt/clay lithologies, higher salinities, estuarine to shallow marine palynomorphs and microfossil assemblages and low to high ice content (as pore ice, lenses, layers, and vein ice). Isotope geochemistry indicated a marine source for porewaters in the mud units. Ice fabric analyses of both the sand and mud units suggested near-surface formation processes for the segregated ice (similar to growth processes observed in modern Mackenzie delta sediments). In addition, the ice fabric indicated rapid formation with no subsequent deformation.

The stratigraphy is interpreted to be the cyclic deposition of retrograding glaciofluvial outwash sand deposits unconformably overlain by transgressive interbeds and marine muds. The biostratigraphy was dominated by a repeated sequence of palynomorph assemblages indicating cyclic paleo environments ranging from tundra to boreal conditions. Chronological control is weak as the paleomagnetic stratigraphy was not included in the drilling program, but foraminiferal assemblages suggest an inferred age of 1.4 Ma at the base of borehole. If the interpreted stratigraphy and inferred chronology are correct, the central Canadian Beaufort Shelf holds a paleoclimatic record for 8 glacial/interglacial cycles over the past 1.4 Ma.

The deep borehole was primarily drilled for engineering design purposes. Borehole samples were provided to the Geological Survey of Canada to establish a geologic framework for understanding the evolution of thick ice-bearing permafrost to depths beyond 500 m on the central shelf. Based on the interpreted stratigraphy, permafrost aggrades through the glaciofluvial outwash sands as they accumulate on the exposed shelf during glacial periods of low sea level. During interglacial periods and high sea levels negative bottom water temperatures protect the shelf and permafrost is preserved. Ice-bearing sediments accumulated on the shelf over time with successive glaciations and continued basin subsidence (Blasco, 1995, 2001)

Around the Arctic margin, in areas of high sedimentation rates, such as in the Beaufort and Laptev Seas, thick continuous sediment sequences occur that preserve unique high resolution Arctic paleoclimate records. Fit-to-mission drilling platforms and technologies, like the ones used here, can be used to successfully recover these climate records, necessary to extend the global network of sites into the Arctic Ocean. Results from these Arctic borehole sites would be used to understand the roles of Arctic Ocean paleoceanography and arctic processes [formation of permafrost and hydrate] in Earth 's past climate.

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THE EOCENE-OLIGOCENE BOUNDARY IN THE ROSS-SEA (ANTARCTICA) BASED ON DOWNHOLE MEASUREMENTS OF THE CAPE ROBERTS PROJECT

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Drillhole CRP-3 of the Cape Roberts Project in the northern McMurdo Sound (Ross Sea, Antarctica) targeted the western margin of the Victoria Land Basin to investigate Neogene to Palaeogene climatic and tectonic history by obtaining continuous core and downhole logs. Well logging of CRP-3 has provided a complete and comprehensive dataset of in situ geophysical measurements down to the bottom of the hole (920 meters below sea floor). Evaluation and interpretation of the downhole logging data was performed using the multivariate statistical methods of factor and cluster analysis. The factor logs are mirroring the basic geological controls (i.e., grain size, porosity, clay mineralogy) behind the measured geophysical properties, thereby making them easier to interpret geologically. Cluster analysis of the logs groups similar downhole geophysical properties into one cluster, delineating individual logging or sedimentological units. These objectively and independently defined units, are helpful in differentiating lithological and sedimentological characterisations (e.g. grain size, sediment provenance, glacial influence). For CRP-3, the three factor logs derived from the downhole measurements are describing the grain size (lithology), the diamict/conglomerate occurrence (glacial influence), and the sediment fingerprint (provenance). By cluster analysis of the three factor logs, it was possible to divide the borehole into three main sections. The upper section down to about 230 mbsf is dominated by mudstone with clearly different physical properties from the mudstones occurring below this depth. Beneath 230 mbsf sandstones are dominating the lithology. Two types of sandstones could be characterised with the lower sandstone being dominant below 630 mbsf down to 790 mbsf. These two types of sandstones, which are differentiated mainly by their magnetic properties, can be correlated to the detrital mode provenance analysis (see column »provenance"). The boundary marks the Eocene/Oligocene boundary.

Comparison of these results with the seismic stratigraphy shows that the major change in sediment source from Victoria to Taylor Group is not seen by seismic sequence analysis. This finding will have consequences for the entire Ross Sea seismic stratigraphy.

THE LAST DEGLACIAL SEA LEVEL RISE IN THE SOUTH PACIFIC : OFFSHORE DRILLING IN TAHITI (FRENCH POLYNESIA) AND ON THE AUSTRALIAN GREAT BARRIER REEF – O.D.P. PROPOSAL # 519

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The history of sea-level and sea surface temperature variation associated with the last deglaciation is of prime interest to understand the dynamics of large ice sheets and their effects on Earth's isostasy. So far, the only sea-level record that encompasses the whole deglaciation is based on offshore drilling of Barbados coral reefs (Fairbanks, 1989) which overlie an active subduction zone, implying that the apparent sea-level record may be biased by tectonic movements.

The O.D.P. proposal #519 (Camoin, G., Bard, E., Hamelin, B., Pezard, Ph., Davies, P.J., and Dullo, W.-Chr.) seeks to establish the course and effects of the last deglaciation in two reef settings developed in tectonically inactive areas at sites located far away from glaciated regions : in Tahiti and on the Australian Great Barrier Reef. At each site, it is proposed to realize a transect of several offshore drill holes in combination with very high resolution seismic data and downhole measurements. The water depths for the proposed sites in the two areas, Tahiti and the Great Barrier Reef, range from 50-300 m and are not accessible to the JOIDES Resolution. The drilling operations can never be achieved with this ship and a fit-to-mission drilling platform is required. This proposal, as the whole shallow water program rests on the successful development of an alternative drilling platform.

The Proposal #519-Full2 proposed to use an alternate drilling equipment, the Portable Remotely Operated Drill (PROD), which has the capacity to drill 100m holes and can be operated and deployed from a 30m ship; it also has the capacity to switch repeatedly from drilling to coring, re-enter the hole, and log the hole. This drilling system is still under development and needs to be tested in reef environments after the tests carried out in Australia, in the Timor Sea and in the US Pacific Northwest.

An alternative to the drilling operations in Tahiti and the Great Barrier Reef has been proposed in 2001 to ODP (Addendum to proposal #519 ; Camoin, G., Bard, E. and Hamelin, B) and consists of the use of the geotechnical marine vessel M/V Mariner based in Singapore and owned by Fugro-McClelland Marine Geosciences. In order to achieve successful core recovery (minimum : 90%), the following systems are proposed : top drive, hydraulic rig with motion compensated power swivel and piggy back coring set up. The field operations are expected to last between 18 and 30 days in Tahiti (18 boreholes for a total penetration of 1320 m) and between 11 and 18 days on the Great Barrier Reef (11 boreholes for a total penetration of 730 m) with an emphasis on optimum recovery

Our proposal has three major objectives :

A - To reconstruct the general pattern of sea-level rise during the last deglaciation events in order : 1) to establish the amplitude of the maximum lowstand during the Last Glacial Maximum

(LGM) ; 2) to assess the validity, the timing and amplitude of meltwater pulses (so-called MWP-1A and MWP-1B events; c. 13,800 and 11,300 cal. yr BP ; Fairbanks, 1989 ; Bard et al., 1990) which are thought to have induced reef-drowning events (Blanchon & Shaw, 1995) and to have disturbed the general thermohaline oceanic circulation and, hence, global climate ; 3) to test predictions based on different ice and rheological models. The reconstruction of sea level curves will rely on the absolute dating of *in situ* corals provided by radiometric methods ($^{230}Th/^{234}U$-TIMS, ^{14}C-AMS) and paleobathymetric informations deduced from reef communities which live in a sufficiently narrow or specific depth range to be useful as absolute sea level indicators.

B - To identify and to establish patterns of short-term paleoclimatic changes that are thought to have punctuated the transitional period between present-day climatic conditions following the LGM in order to get a better knowledge of: 1) the regional variation of SSTs in the south Pacific; 2) the climatic variability and the identification of specific phenomena such as El Nino-Southern Oscillation (ENSO); 3) the global variation and relative timing of post glacial climate change in the southern and northern hemisphere. It is proposed to quantify the variations of sea surface temperatures based on high-resolution isotopic and trace element analyses on massive coral colonies.

C - To analyse the impact of sea-level changes on reef growth, geometry and biological makeup, emphasizing: 1) the impact of glacial meltwater phases (identification of reef drowning events); 2) the morphological and sedimentological evolution of the foreslopes (highstand vs lowstand processes); 3) the modeling of reef building; 4) environmental changes during reef development.

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LARGE IGNEOUS PROVINCES AND SHALLOW WATER DRILLING: AN EXAMPLE OF THE ONTONG JAVA PLATEAU:

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Significant portions of oceanic large igneous provinces (LIPs), which include oceanic plateaus, volcanic passive margins, submarine ridges, ocean basin flood basalts, and seamount groups, lie in relatively shallow water. Such regions are accessible by mission-specific vessels, and inaccessible to the riser and non-riser platforms envisioned for the Integrated Ocean Drilling Program (IODP). Therefore, to fully investigate the causes, processes, and consequences associated with LIP formation, we must utilize the full triad of IODP drilling platforms.

One outstanding success of scientific ocean drilling has been to establish that oceanic LIPs represent voluminous, episodic magmatic events. Nevertheless, we still know far less about oceanic LIPs than about any other type of volcanism on Earth. Significant progress in understanding oceanic LIPs almost entirely depends on drilling because most oceanic LIPs are covered by thick sediment. Future scientific drilling of LIPs will investigate mass and energy fluxes from the mantle to the crust and their relationship to LIP genesis, including the nature and relative role of mantle reservoirs and extruded melts, the affect of different dynamic setting on melting, the magmatic and tectonic processes associated with emplacement and post-emplacement, and the impact on the hydrosphere, atmosphere, and biosphere. Two objectives of drilling LIPs are of particular interest to a broad scientific community: (1) to understand mantle behavior during these massive, episodic magmatic events, and (2) to determine potential causal relationships and feedback mechanisms between LIP emplacement and environmental change.

The Ontong Java Plateau, in the equatorial western Pacific Ocean (Figure 1), is the most voluminous oceanic plateau. Ten major island groups, atolls, and reefs surmount the plateau. No volcanic rock is known to crop out on any of these features, but all are presumably underlain by volcanic material at as yet undetermined depths. With appropriate geophysical surveying, the lagoons and other shallow waters, together with the subaerial portions of the Ontong Java Plateau, offer highly prospective and scientifically rewarding mission-specific drilling targets for the IODP. Other oceanic LIPs offer similar opportunities.

CHALLENGES FOR DRILLING IN THE WESTERN MEDITERRANEAN: POTENTIAL TARGETS IN ALBORAN AND SOUTH BALEARIC BASINS

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Late Cretaceous-to-Paleogene continental collision between the Eurasian and African plates and post-collisional tectonics in the westernmost Mediterranean has resulted in complex lithosphere deformation. Miocene basins, often described as Mediterranean «back-arc basins», originated in this region by late extension on the sites of the former Cretaceous-to-Paleogene orogens. Significant debate and controversial hypotheses on the genesis and tectonic evolution of these basins focus on the processes that caused the Alboran and South Balearic basins, behind the Gibraltar Arc, and its genetic link with the Betic-Rif-Tell Cordilleras and the formation of the Arc. This region is considered a «case study» in which drilling is essential to conduct investigations for solving thematic problems on lithosphere stretching and lithosphere deformation mechanisms occurring in «back-arc settings» under convergence geodynamic contexts.

Despite significant results provided by ODP Leg 161 (*Comas et al.*, 1999) on Neogene extensional processes in the westernmost Mediterranean, the origin of the Alboran Basin, and particularly its present relationship with the adjacent oceanic South Balearic Basin has not yet been completely addressed. The processes that produced the rapid evolution of a collisional zone into a locus of extreme crustal stretching and adjacent contraction, the exhumation of deep crustal rocks, and the westward Gibraltar Arc migration need to be adequately explained. Furthermore, the magma and oceanic-crust generation in this geodynamic context should be investigated in order to constrain the competing hypothesis for the origin of these basins. Therefore, thematic tectonically-oriented drilling targets have only been partially accomplished in the westernmost Mediterranean, and fundamental scientific questions of the dynamics of Earth's interior in this region deserve more extensive exploration by ocean drilling.

W-E transects of drill sites from the West Alboran Basin to the South Balearic Basin, are envisaged as potential targets for a possible multi-leg, multi-platform proposal in the westernmost Mediterranean. Scientific objectives of potential drilling targets are:

5- The timing of lithosphere stretching and complete –tectonic and thermal- subsidence history of the thinned continental crust from a more complete sampling of the early Miocene ?-to-Recent sediment cover in both basins.

- The nature and origin of the large-scale mud diapirs and mud-volcanoes in the Miocene to Recent sequence from the West Alboran Basin, and the field of fluid flow and venting (fluid composition, flux rates, microbial geology) carry from depth to the seafloor.
- The deep metamorphic rocks in the basement (to complete Site 976 results) to provide data on exhumed rates from deep crustal levels, and on fluid chemistry and thermal and strain histories of the orogenic terrane through the extension.
- The post-collisional processes, and major tectonic events, that initiate and end the extremely high magma production rates in the Alboran-South Balearic transition and the continental

break-up and oceanic basement growth overcoming the continental suture in the South Balearic basin.

- The complex magmatic history (e.g.: ages, thermal and material exchanges, mass fluxes and depletion fluids, crustal metasomatism and melting) that may have resulted from removal of the continental lithosphere mantle beneath the former Alpine orogen and its interaction with astenosphere upwelling.
- The recent and active tectonics at continental margin / oceanic crust major boundaries (seismogenic wrench-fault systems) to explain present day lithosphere behave.

Furthermore, direct long-term observations at drill-sites near active major crustal-fault systems (e.g., near Mazarron and Palomares faults in the Iberian margin, and Habibas fault in the Argelian margin) will allow measurements of contemporary convergence rates, and will constrain strain and crustal deformation in response to active present-day convergence. Besides, monitoring drill-sites in these seismogenic zones can help to evaluate seismic hazard in the westernmost Mediterranean by studying the earthquake cycle, and its nucleation and distribution-depth within the convergent plate boundary.

Drilling at this region should also improve land-sea integration and may increase the interest from interdisciplinary shore-based scientists in ocean drilling challenges. Positive co-operations between on-going research projects in progress is providing a prominent geological and geophysical field and analytical data-set to fulfill strategic purposes, and site survey requirements, to support a drilling proposal in the westernmost Mediterranean basins toward the «Integrated Ocean Drilling Program»- IODP.

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LATEST PLEISTOCENE DROWNED CORALGAL BANKS & MOUNDS ALONG THE EDGE OF THE SOUTH TEXAS AND MISSISSIPPI-ALABAMA SHELVES: (ODP PROPOSAL 581-FULL): A FEASIBILITY TEST USING AN ANCHORED DRILLING VESSEL AS AN ALTERNATE PLATFORM TO THE D/V JOIDES RESOLUTION.

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Southern and Baker Banks are currently drowned coralgal reefs about 40 to 50 m-thick on the edge of the South Texas Shelf 55 km offshore Corpus Christi. They are interpreted to have grown during the first half of last sea level transgression on top of topographic highs occurring along a Last Glacial Maximum lowstand siliciclastic paleo coastline. Contemporaneous and similar coral reef establishment, growth, and demise have been reported along the Mississippi-Alabama shelf margin. We are proposing to drill and analyze nine 60 to 100 m - deep boreholes along the edge of the South Texas and Mississippi-Alabama continental shelves. The detailed description of the different lithologies and depositional environments, the borehole logs, the geochemical analyses, and U/Th and ^{14}C AMS dating of these nine cored sedimentary sequences will allow us to develop the following objectives:

(a) The drilled material will shed some new light on the enigmatic findings that coralgal edifices flourished on the edge of the South Texas and Mississippi-Alabama shelves during the first part of last deglaciation, an interval of time when conditions of sea surface temperature were possibly warmer and sea surface salinity were lower in the northern Gulf of Mexico, and rates of eustatic sea-level rise much faster than they are today;

(b) The drilled material will improve the resolution of the last deglacial sea-level history from late Glacial to the Younger Dryas, including the interval of the melt-water pulse 1A, from a passive margin environment less influenced by discontinuous tectonic activity as in the offshore Barbados,

(c) The drilled material will help us to better understand the sedimentary and biological processes involved with the origin (initial establishment), growth, and demise of carbonate reef tracts along the edge of siliciclastic shelves

(d) The latest Pleistocene transgressive coralgal reefs on the edge of the South Texas Shelf can be studied as recent analogs for oil and gas reefal reservoirs buried in siliciclastic shelves.

Although this proposal, focused on the drilling a series of seven boreholes across Southern and Baker Banks, in addition to a two boreholes-transect across the Mississippi-Alabama shelf edge, is submitted based upon its sole scientific merit, this drilling program could be also considered as an exemplary scientific drilling activity in shallow water conditions to promote alternate drilling platform as being a full part of IODP. This drilling program could also be used as a feasibility test in using the highly maneuverable, 190-ft-long R/V Seaprobe I of Fugro-McClelland as an alternate drilling platform to drill coralgal edifices in water depths shallower than 120 m. The intent is to mobilize the R/V Seaprobe I from Port Aransas (about 50 km from Southern Bank) and reduces dramatically the costs of mobilization/demobilization for such an operation. The field operations are expected to last between ten to fifteen days and will consist of drilling 7 boreholes about 80 – 100 m deep and with an emphasis on optimum recovery (80-90 %) of the coralgal Unit III. The first costs for drilling the seven boreholes on Southern and Baker Banks and the two boreholes MA-1 and MA-2 along the edge of the Mississippi-Alabama shelf have been estimated at about US $ 500,000.

YOUTHFULL BELIZE BARRIER REEF; MODEL FOR MODERN BARRIER REEF ESTABLISMENT DURING THE MID-BRUNHES

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Fossil and active barrier reefs contain some of the best-preserved records of global sea-level fluctuations, climatic changes, and variations of oceanic circulation and physical/chemical conditions. Fossil barrier reefs are also well-known to serve as large oil and gas reservoirs. Because modern barrier reefs along mixed siliciclastic carbonate margins are very significant sedimentary deposits in terms of their geographical extent and overall volume of stored carbonate, they were thought to represent long-lived (several million of years) and well established sedimentary bodies. Contrary to those intuitive thoughts, results of several recent research programs have pointed out that modern barrier reefs such as the Australian Great Barrier Reef, the Florida Keys, the Belize Barrier Reef, and some reefs in Southeast Asia, correspond in reality only to late Pleistocene thin coralgal deposits covering lowstand siliciclastic paleo coastal sediments and are probably younger than 500,000 years. Their apparent synchronous establishment and remarkably identical evolution would point toward a global and common cause to explain their sudden establishment along the edges of low latitude siliciclastic continental shelves. Unique late Pleistocene modification of the overall Pliocene-Pleistocene eustatic fluctuations could have triggered the most recent establishment of modern barrier reefs.

We have developed this model based upon the interpretation of a series of Shell/Pecten MCS dip lines across the lagoon and the barrier/back barrier reef complex and the high resolution seismic grids that we collected in the Southern Lagoon and offshore basins, the modern Belize barrier reef consists of thin late Quaternary carbonate blankets overlying a late Pliocene to early Pleistocene paleo coastal siliciclastic prograding complex. This complex was deposited during an interval characterized by a continuously falling sea level relative to an early Pliocene unusually high sea level interval. We have proposed that the Belize barrier reef and the other modern barrier reefs were first established on a worldwide scale during the unusually high 130 to 150 m amplitude sea level transgression at the oxygen isotope stage 12/11glacial/interglacial transition. This dramatic sea level transgression completely flooded the late Pliocene-early Pleistocene siliciclastic paleo coastlines, earlier established as a response to a gradual and overall significant downward shift of the general base level since the onset of the Northern Hemisphere glaciations about 3.3 Ma. During stage 11 when sea level transgressed and submerged for the first time the former fluvial plains, as it happened during the last sea level transgression, barrier reefs establish themselves on the edge of siliciclastic continental shelves, usually on topographic highs of drowned lowstand siliciclastic paleo shorelines. Because longshore currents usually trap the siliciclastic sediments and fresh water input from river discharge along the newly established coastal zones during a sea level highstand, the new shelf edge becomes favorable to coral growth. If those favorable conditions to coral growth persist, the barrier reefs continue to flourish during most of the sea level highstand interval and possibly extend laterally as long as the accommodation space remains available. During the interglacial (highstand) stages subsequent to stage 11, such as stages 9, 7(?), 5 and 1, barrier reefs reestablished themselves on the karstified surface of the previous interglacial barrier reefs and on top of siliciclastic beach ridges and barrier reefs deposited during the previous glacial lowstand in front of the exposed barrier reef. The reefal material deposited during the initial (stage 11) establishment of the reef is, therefore, usually entombed under a series of stacked transgressive and highstand coralgal packages (stages 9, 7(?), 5, and 1).

We will propose to drill a transect of boreholes across the Belize mixed carbonate siliciclastic shelf margin from the shelf lagoon lowstand incised valleys, back reef, barrier reef, reef slope, lowstand delta and deep sea fan. To achieve the drilling objectives, we will propose to use several types of alternate platforms, such as a land based diamond drill rig, anchored drilling vessel such as R/V *Seaprobe* of Fugro-McClelland, and giant piston coring using the R/V *Marion Dufresne*.

LOW LATITUDE CARBONATE DRILLING AND CORING IN THE WESTERN INDIAN OCEAN

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This proposal aims to study rapid climate changes and sea level fluctuations using high-recovery cores (Images) of carbonates for analyses of paleotemperatures, rapid climate change and paleoceanographic transects for water mass history.

The understanding of anthropogenic modifications affecting the present-day environment supposes a knowledge of natural variability of climate and sea level over the recent centuries and millennia. Among climatic variations, the coupled tropical ocean-atmosphere system remains poorly known. During the last decade, international scientific programs such as TOGA, WOCE and IMAGES contributed or are contributing to a better knowledge of the system, particularly concerning the active role of the ocean.

Within reef frameworks there is a record of large-scale phenomena such as sea level changes. Due to their growth within a narrow depth window (i.e. within 30m), coral reefs represent excellent gross sea level indicators. The precise meaning of any environmental signature within the reefs must therefore be understood within the context of sea level change. Apart of the formation of uplifted onshore or drowned offshore terraces, carbonate platforms and reefs directly report sea level changes into the basin by shedding shallow water material. During highstands of sea level, huge quantities of sediment is being exported, while during low stands only little amounts enter the basin due to subaerial exposure of shallow water carbonate productions sites.

The basic objective of the present proposal concerns the reconstruction of paleoclimatic, sea level and environmental changes in the Western Indian Ocean during the last two glacial interglacial periods, with special emphasis on getting high resolution Holocene time series.

There are several reasons why the Western Indian Ocean (the Mozambique Channel) has been selected as a target:

1. It provides a good latitudinal gradient, offering sites close to the Equator (the Seychelles at about 4°S), via Mayotte (14°S) to the present southern limits of reef growth (Tuléar, Madagascar at 24°S). The same sites also provide evidence from a range of tectonic settings, from isolated volcanic islands (e.g. Réunion Island, Mauritius and the Comoro Islands) to the granitic Seychelles and the microcontinent of Madagascar. Such a variety of tectonic settings is required for deciphering regional tectonic factors and isostatic rebound from global eustatic sea level changes.

2. Information on sea level changes during the last glacial cycle in this part of the Earth is scarce. They are based on reef growth curves established in Réunion, Mauritius and preliminarily in Mayotte. Morphological mapping and sampling along the Comoro Islands reef slopes has provided valuable indications of changing sea levels during the last glacial cycle. Submerged terraces exist in several different water depths among which those presently at -60m and -90m are the most prominent. They are covered by shallow-water coral communities which were drowned during late Pleistocene-Early Holocene meltwater pulses.
3. The Western Indian Ocean represents a transitional zone between subpolar and tropical influences. The latitudinal distribution of sites allow the record of a glacial effect of Intertropical Convergence Zone (ITCZ) shift during the time.

Major topics are:

- Carbonate production and highstand shedding. Do the existing models we have from the Caribbean provide the model to understand ancient systems?
- How are the terminations known as meltwater pulses and documented in drowned reefs recorded in the periplatform sediments? (A short lag in aragonite accumulation?)
- Is there a significant shedding pattern with respect to continental margins and oceanic islands (e.g. Mozambique versus Mayotte)?
- Is the different subsidence history of continental margins and oceanic islands reflected in different sediment and facies pattern?
- To core for ultra high resolution Holocene sequences in order to built bridges with existing reef drillings on the Seychelles, Mayotte and Madagascar.

DEEP- TO SHALLOW-WATER DRILLING IN SOUTHEAST ASIA

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Summary
We recommend that JOIDES consider conducting a major drilling program in the tropical seas of Southeast Asia and northern Australia. Within this area, the full spectrum of drilling opportunities exists from the deep ocean to the shallow cratonic seas of submerged lands of Southeast Asia and Australia. The sediments within this area have been deposited under similar fluctuations in sea level, tectonics, and paleoclimate as were Phanerozoic sedimentary rocks of the world's continents. The region spans climate belts from the ever-wet tropics to savannas of the dry tropics and fills a vital information gap between the dry-lake coring in Australia (30^{O}S) and the Quaternary studies conducted in China (in cooperation with Australia) and Lake Baikal (54^{O}N). The combination of interlayered marine, continental (paleosols), and probably lacustrine environments in shallow tropical seas, deep-ocean, and ocean margins presents a unique opportunity to address questions of the relation among a virtually complete range of depositional sites under a variety of tectonic, climatic, and sea-level conditions. The shallow-water environment will be particularly valuable in evaluating epicontinental sedimentation and stratigraphy, in the context of tectonics and changes in climate (including local mountain glaciation) and sea level on land currently beneath the seas and associated islands. We stress the strong marine/continental connections in this program and recommend that the marine part be combined with a major component of adjacent onshore geology. The two components should be related in a series of reports and maps leading to a major summary volume upon completion of the program.

Overview

Southeast Asia and northern Australia comprise the world's only major tropical epicontinental system comparable to the epicontinental systems of the Paleozoic and Mesozoic. The broad flat surfaces are interrupted by actively building mountains and volcanoes. The region spans from equatorial ever-wet to the dry tropical climate belts; much of it is subject to monsoons. Glaciers are melting on the mountains in New Guinea, and with evidence of more extensive glaciation in the past. Coral reefs lie off the southwest coast of Sulawesi and Australia. The entire region fills an information gap between the dry-lake coring in Australia and the Quaternary studies conducted in China and Lake Baikal.

In this region, Miocene was a time of extensive carbonate deposition - coral reefs and platform carbonates. Subsequently, siliciclastics generated by tectonic activity and climatic changes have replaced much of the carbonate-producing environment. This transition is well documented in the Coral Sea, Gulf of Carpentaria, New Guinea, and the Gulf of Thailand/Kalimantan area. Limited studies of sedimentation in the equatorial region suggest that there are elements of sedimentation in the tropics that are not well documented in the literature. To understand the entire epicontinental system, it is imperative that a study of the region includes a strong onshore component.

Active and passive margins are found in the region, offering opportunities for drilling in distinctly different tectonic settings, yet within the context of one geologic province. Open-ocean environments and plate subduction are characteristic of the southern and southwestern part of Indonesia and enclosed passive basins lie to the

northwest (South China Sea). Obducted ocean crust has been described along the northern part of New Guinea, a trend of active tectonism that extends to Timor and westward to the subduction zone of Java and Sumatra.

Ocean circulation and its role in heat transfer among the islands of Southeast Asia has been the subject of considerable research, particularly in the last decade. Transgressions and regressions change the role of the islands and the cratonic crust in control of the passage of water through the region.

Climate and Sea level

It is commonly accepted that the climate change record is more obvious at higher latitudes than it is in the equatorial region. There is also the perception that late Cenozoic climate change had little effect in the equatorial region; however, a growing body of evidence suggests that this is not the case. Because of near-equatorial glacial record and the shallowness and flatness of the sea floor, it is possible to evaluate latitudinal paleoclimate gradients and cycles from the equatorial regions to interior Australia and to Thailand and how these changed from glacial to interglacial times. The entire region was emergent during low stands of sea level. Climatically sensitive paleosols, vegetation patterns, a sediment record of a lake that formed during the last glacial period in the Gulf of Carpentaria, and pulses of sediment flux to marine and lake records all provide an excellent opportunity to systematically document late Cenozoic, low-latitude and Southern-Hemisphere global change. Transgressions over these very flat surfaces were rapid and were characterized by enormous areas of very shallow water, where only very low-energy conditions could prevail. Under such low-energy conditions, paleoclimate records and sensitive records of sea-level changes have a good probability of survival during transgressions. Gravity cores taken from the Gulf of Carpentaria contain preserved paleosols.

Modern analogue

Models describing the distribution of various limestone, shale, and sandstone deposited in shallow epicontinental seas are based on the present shelf/slope models, where sediments are deposited on a sloping sea floor and the nature of the sediments deposited is dependent on water depth and ocean currents. These models may not be applicable to situations where the sea floor is flat, as appears to be the case in ancient epicontinental seas. The sea floor in this region is flat and may be an excellent modern analogue for sedimentary processes in ancient epicontinental systems.

Key Objectives:

* publish a series of coordinated and coherent products based on a comprehensive understanding of the relations among the various geologic processes in a single epicontinental system,

* determine the magnitude of low-latitude climate change during glacial cycles; this information is of great relevance to Global Climate Models for which data on the tropics are limited,

* evaluate the relations between climate change and sea-level change where a range of climatic parameters extends from the tropical wet to the tropical dry zone within one large sedimentary system and has changed through time,

* study the effects of tectonics, climate and climatic variability, and sea-level change on sediment supply and stratigraphy in a cratonic sea for application to studies in ancient epicontinental basins of the world, and

* evaluate seismic and sequence stratigraphy in a modern epicontinental sea for comparison with models already developed for continental margins.

ODP DRILLING OFFSHORE NEWFOUNDLAND: SAMPLING AN ATLANTIC ARGIN FROM CONTINENTAL SHELF TO RISE

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This paper introduce a Ocean Drilling Program (ODP)-Oil Industry, Canadian initiative that includes scientific drilling and related geoscience on the Canadian Atlantic Margin.

The study of rift basins is one of the perennial ODP investigative themes while the topic of extensional basin formation and evolution is of utmost interest for the oil and gas industry. The Grand Banks of Newfoundland is an Atlantic type passive margin that contains rift and epeiric basins formed in the context of Pangea break-up. The Grand Banks area consists of an intricate network of interconnected rift basins separated by basement cored, sedimentary ridges. There is a dynamic industry presence in the area with activity including extensive 3-D seismic surveys, field exploration, site survey works, delineation drilling and production of hydrocarbons. A lot has been learned about the area's geology after 30 years of scientific and commercial investigations. However, many fundamental questions on the tectonic, structural, stratigraphic, fluid flow, climate and deep biosphere remain unanswered in this region. An ODP (or IODP) drilling leg is proposed to drill a suit of holes located on the shelf and slopes of Grand Banks of Newfoundland to address some of these questions:

- There is a lack of cores in the Tertiary and Late Cretaceous sections, and the Base Tertiary unconformity has rarely been sampled. So is the case with the break-up unconformity on the slope and rise, in front of the Grand Banks where divergent margin type basins are located. The tectonic significance of these unconformities is still debated. If it occurred, exhumation of the basins at the end of Cretaceous should be recorded in the rock interval at and above the regional U and Base Tertiary erosional unconformities.
- The role of deep-seated detachment faults in the formation of half-graben type basins and intervening ridges.
- The detailed stratigraphy and sea level change during the Late Cretaceous and Cenozoic time may answer questions related to northern ocean opening, water circulation, organic productivity and glacial cycles.
- The presence of Late Jurassic beds including the prolific Kimmeridgian source rocks in the sedimentary cuvettes and basins located on the slope and rise.
- Salt tectonics and its influence on coarse clastics depositional patterns.
- Fluid flow patterns, a possible two-phase hydrocarbon generation, distribution of heavy oil, and sealing properties of faults and roof strata.
- Correlation between seismic and geological markers and the predictive value seismo-stratigraphy curves. Proper dating of unconformities and their association to rifting events.
- Questionable nature of basement in the Salar or East Flemish Cap Basins, in front of and at the presently inferred continent-ocean boundary.
- The nature of the sediments and basins situated westward of Murre Fault and the role of Bonavista Platform as rift shoulder.

- Accumulation of turbidite sand mounds on the slope and rise of the Grand Banks and their interior architecture.
- The role of compaction and overpressure in trap formation and preservation and migration of hydrocarbons
- The role of gas hydrate and water filled sandstone lenses in slope stability and hazard prediction

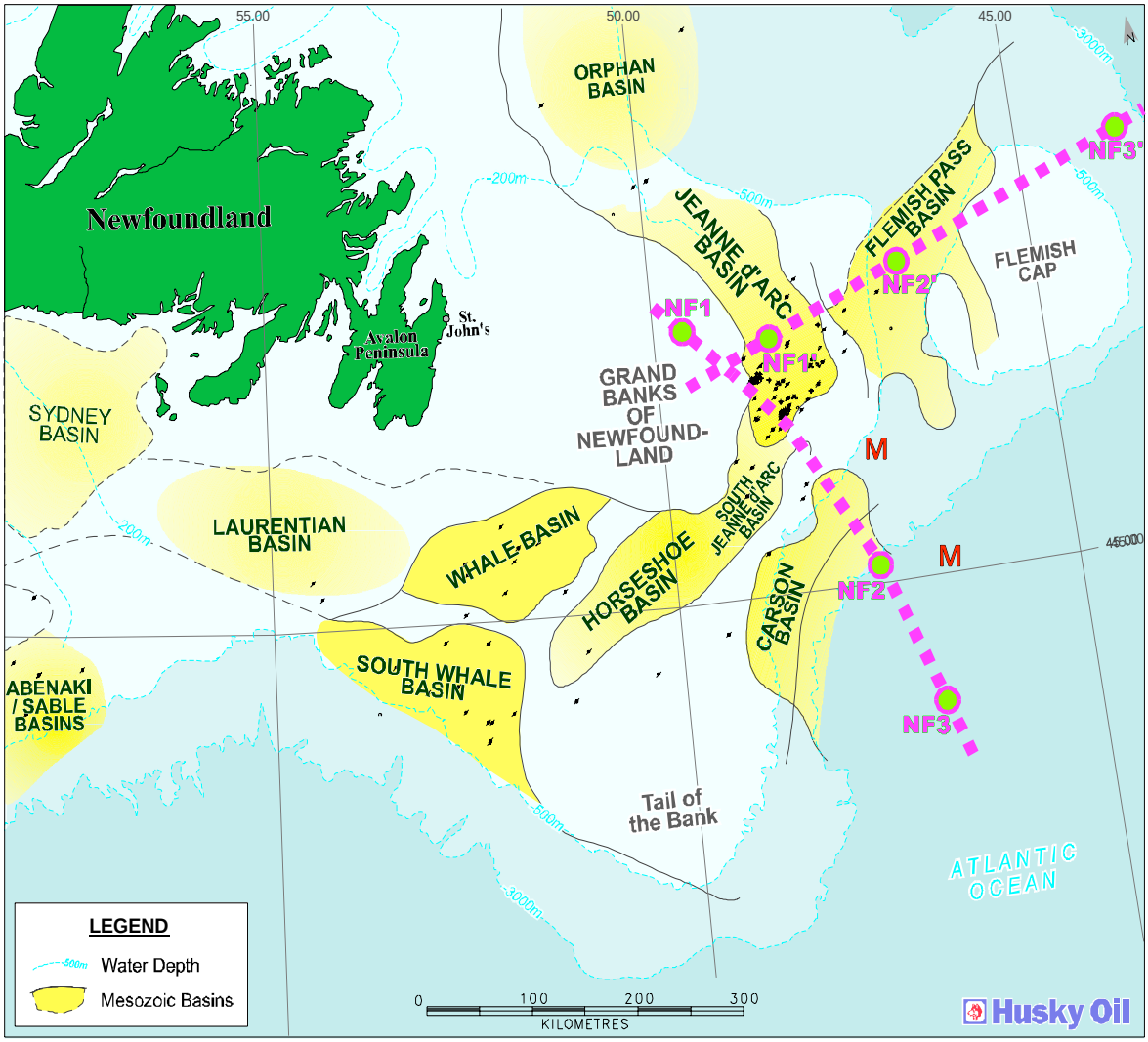

Figure 1. *Atlantic Canada and tentative location of ODP-INDUSTRY drilling transects. M denotes recent MARIPROBE geophysical data acquisition.*

Use of Multiple Platforms and Special Technologies. Diverse ODP and offshore industry drilling and sampling platforms are required to accomplish investigation and groundtruthing of the listed objectives. From shallow coring to deep penetrating holes, these platforms must be used within an integrated geoscience program anchored by ODP (IODP) and partially supported/sponsored by the industry. An invaluable program of 2 to 4 km of continuos coring is envisaged for the deep penetration sites. Joides Resolution without or with BOP could be used

on the shelf, slope and upper rise (water depth between 50 and 5000m), pending on site survey specifics. Industry dynamically positioned rigs for extra-coring in non-potential reservoir intervals may also be used. Recent shallow sediments may be investigated with dredging units. ODP advanced logging tools or industry standard logging suite at the time of drilling and together with fluid flow measurement tools and hydrate preservation assemblage will be required.

The Grand Banks of Newfoundland represents an excellent testing ground for passive margins, rift basins, global change, geo-hazards and petroleum basin related topics. It may also be an area where the academia, research institutes, geological surveys, government agencies, oil companies and ODP can reach collaboration on both financial and scientific plane.

"FROM PORCUPINE ABYSSAL PLAIN TO ENGLISH CHALK" - A EUROPEAN MULTIPLATFORM PROPOSAL TO DRILL A CRETACEOUS TO NEOGENE PALEOCEANOGRAPHIC DEPTH TRANSECT IN THE EASTERN ATLANTIC

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The eastern Atlantic margin offers a unique paleoceanographic archive documenting the opening history of the central and northern Atlantic and the history of the establishment of modern oceanic circulation. We suggest drilling a paleoceanographic depth-transect along a profile ranging from the present Porcupine Abyssal Plain over Goban Spur and the Celtic Sea, to land outcrops on the south coast of England. Such a multi-platform enterprise would involve JOIDES Resolution-type drilling in the abyssal plain and along the continental margin as well as gear suitable for drilling on shallow water siliclastic shelves.

This proposal aims at better understanding the following objectives, which are ultimately linked to one another :

1) the paleoceanographic evolution of the eastern Atlantic and its sea-ways in Cretaceous to Neogene times,
2) periods of extreme global warming and their impact on both bio- and atmosphere.

For the Cretaceous, the region to be covered by the proposed transect represents a key area for the understanding of marine sea-ways between the Boreal Realm and the Tethys. This also includes connections between the central Atlantic and Arctic Ocean via the Norwegian Seaway (Gradstein et al. 1999).

Deep Sea Drilling Project Leg 80 drilled a number of early Cretaceous to Neogene sections along Goban Spur with Cretaceous black shales which correlate to global Oceanic Anoxic Events (e.g. OAE 2, Bonarelli Event, Cenomanian-Turonian boundary). Due to moderate sedimentation rates and burial along Goban Spur, calcareous microfossils are well preserved even in the Cretaceous sediments and show an ideal potential for recording paleoeceanographic informations.

Along with the Late Paleocene Thermal Maximum (LPTM) mid-Cretaceous OAEs represent spectacular examples for transient periods of extreme warmths which most likely were forced by elevated concentrations of greenhouse gases. The ODP Program Planning Group on Extreme Climates defined these intervals as being crucial for a better understanding of a greenhouse world (Kroon et al., 2000). Study of the sedimentary record of periods of extreme warmth along an ocean-land depth transect is one of our major proposed research avenues. The objective is to correlate oceanic sections with well-studied land profiles on England´s south coast (e.g. Jenkyns

et al., 1994). A key question concerns the exact timing of warming events. For the Cenomanian-Turonian thermal maximum the isotopic data indicate exact correlation with the OAE in England In Italy and in the southern hemisphere (Exmouth Plateau) δ18O values suggest maximum temperatures after the OAE in the early Turonian.

Our proposal also addresses paleoceanographic aspects of the Paleogene and Neogene. Expanded Paleocene and Eocene sections along Goban Spur and the presence of the LPTM again offer potential for an ocean-land correlation of these intervals with sections on the Isle of Wight or Paleogene sediments in Belgium.

The establishment of the global conveyor belt in the Neogene, the history of which can also be studied along the proposed depth transect, is yet another milestone in the evolution of the eastern Atlantic.

A gateway issue for these younger periods in earth history are the role of the Island-Faroe-Ridge and Denmark Strait during the Neogene.

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RELEVANCE OF ANTARCTIC MARGIN DRILLING IN IODP

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One of the main objectives of the IODP initial science plan is to understand the history of the Earth system in an attempt to predict its future. Ice sheets are an important component of the Earth system. In particular, the Antarctic Ice Sheet has influenced cyclic global sea level, paleoceanographic and paleoenvironmental change since its formation around 34 Ma ago. To decipher the long-term history of multiple growth and collapse of the Antarctic ice-sheet, and related sea level, paleoceanographic and paleoenvironmental changes is one of the main goals of the SCAR-ANTOSTRAT Program. Two regions (the Antarctic Peninsula and Prydz Bay), out of five proposed around the Antarctic margin, were drilled by ODP. In each of these regions, the ice sheet has a different sensitivity and response to climatic forcing due to differences in size and geographic/geologic settings (Huybrechts, 1993; Barker et al., 1998). The main objective for drilling all of the regions is to estimate the evolution of the Cenozoic Antarctic ice from both, the continental-based East Antarctic Ice Sheet (EAIS) (eastern Weddell Sea, Prydz Bay, and Wilkes Land), and the marine-based (WAIS) (Antarctic Peninsula and eastern Ross Sea) (Barker at al., 1998). Proposed deep drilling in the Wilkes Land margin, which is thought to be one of the Antarctic margins most sensitive to future temperature changes, has been forwarded to IODP.

Some of the Antarctic glacial history records that are critical for understanding Cenozoic environmental change on a global scale are for example: 1) the extreme climate events of the Paleocene-Eocene, 2) the mid-Miocene transition to cold Neogene, and 3) Holocene paleoenvironemnatl change at decadal to century scales. These records can be obtained by shallow drilling in at least two depositional environments: deep inner shelf basins and continental shelf progradational wedge. Deep (>1000 m) inner-shelf basins surveyed around Antarctica contain a decadal to century scale record of Holocene paleoproductivity similar to the one obtained from the Palmer Deep Basin during ODP Leg 178. These records can be directly compared to the records from ice cores in order to extract the climate/paleoenvironmental signal. Several regions of the Antarctic continental shelf (e.g., Wilkes Land margin) have foresets of the progradational wedge that nearly outcrop at the seafloor. A thin layer of hemipelagic sediments and diamict separates the most recent Pleistocene record from the older pre-glacial and glacial strata. These strata could be cored with a rotary drilling system that could operate in water depths of < 1000 m and could achieve penetrations of 50-150 m. The chronostratigraphy and environmental proxies from drilling these Antarctic margin sections, is essential to provide age and paleoceanic boundary conditions for models of ice sheet and climate behavior (with or without large ice sheets). Average planetary temperature is expected to rise by between 1°-3°C in the next 100 years and twice this by the end of the following century (IPCC, 1996). Looking back in time, such temperatures were last experienced on the planet between 35 and 40 million years ago respectively, before formation of the northern polar ice-sheets.

The use of a shallow-water, shallow penetration rotary drilling system in the Antarctic margin would not only benefit the scientific goals of ANTOSTRAT but would also significantly contribute to scientific problems of other existing Antarctic programs and initiatives (e.g., WAIS, ANTIME, CRP, GLOCHANT, etc).

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PROPOSAL FROM THE EC 5TH FRAMEWORK STRATAGEM PROJECT

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The STRATAGEM project is a EU-funded 5th Framework project that is investigating the late Cenozoic development of the glaciated European margin; it forms part of the OMARC (Ocean Margin Research Consortium) cluster. The project also has substantial support from the oil industry in the form of co-operation agreements with four Joint Industry Projects active in the area. STRATAGEM is a three-year project that started in March 2000, and aims firstly to generate a stratigraphic framework for the late Cenozoic of the European glaciated margin, as well as a model for the evolution of the area. This form of project will enable the STRATAGEM partners to be in an excellent position, in due course, to identify the optimum drilling sites for any investigation involving the Upper Cenozoic section, and for advising more-specialist projects on the regional geological context of their work.

As implied by the STRATAGEM logo, a particularly important feature of the glaciated European margin is the common occurrence of prograding wedges or of trough mouth fans, and are good examples of a world-wide phenomenon. Detailed understanding of the wedges and their causes will not be possible until drilled sections can be obtained in order to carry out a wide range of analyses. This would entail drilling in water depths ranging from 150 to 1800 m, with targets at a sub-seabed depth from 100 m to over 1800m., and it is envisaged that the primary studies to be carried out on the recovered cores would include the following:

- Identification of the lithological makeup of the wedges and of changes with time; relate to source areas and their history, and to climatic changes.
- Detailed sedimentological studies of the cores.
- Dating of the sediments by all possible means to accurately define the history of sedimentation and relate this to source area erosion, un-roofing and uplift.
- Identification of gas hydrates or diagenetic fronts within the successions.
- Geotechnical studies related to instability; detailed analysis of possible weak layers.

From these studies and ongoing work on STRATAGEM and other projects, it will be possible to more-accurately answer a series of very significant scientific questions that are additionally of considerable importance to the oil industry and others who require knowledge of the ocean margin:

- The reasons for a change in the pattern of margin sedimentation in the late Neogene, and when precisely did it happen? Were there latitudinal variations in timing? How do these relate to other prograding wedges worldwide?
- Was this pattern related to uplift, and if so can we contribute to an understanding of the cause of the uplift that appears to be a feature of North Atlantic significance?
- The detailed history of glaciation on the margins, the timing of the first shelfwide glaciations and the frequency and intensity of subsequent events and the latitudinal variations. Relate these to studies of the source areas.
- The historical pattern of major instability on the margin; can this be related to climatic, tectonic or oceanographic events in an attempt to better predict future slides?
- Contribute to detailed studies of the sedimentology and internal architecture of clastic prograding wedges.
- Gain an improved knowledge of the geotechnical characteristics of the margin sediments in order to improve future operational safety.
- Assess the extent of gas hydrates in sediments in relation to theoretical models.
- From the sedimentological studies allied to seismic interpretation, examine the temporal and spatial relationships between alongslope, downslope and vertical flux in the development of a margin.

SHALLOW WATER FLUID FLOW, DIAGENESIS, PALEOCLIMATE, AND SEA-LEVEL OBJECTIVES IN THE GREAT AUSTRALIAN BIGHT

An opportunity exists on the vast continental shelf off southern Australia to address important diagenesis, fluid flow, paleoclimate, and sea-level scientific objectives. Achieving these objectives will require deployment of a shallow water drilling platform, as Leg 182 *JOIDES Resolution* drilling confirmed the absolute necessity of decoupling the drill bit from the pervasive heave in order to obtain adequate recovery. The drilling of Leg 182 provided exciting results in some areas, but in others only offered tantalizing insights into processes controlling deposition and post-depositional alteration of a dominantly cool-water carbonate platform. The shallow-water parts of this depositional system, underlying the present continental shelf, remain as the critical unexplored component needed to link shelf-edge and deeper sequences with the onshore record.

The Great Australian Bight, south of central Australia, encompasses a vast, tectonically-stable shelf that extends for some 300 km offshore, reaching a depth of 200 m at the shelf edge. Because of water depth constraints, the Leg 182 drilling transect (Fig. 1) extended from the upper continental rise to the shelf edge. This proposal advocates the drilling of a complementary transect from the shelf-edge to the innermost shelf, in water depths from 35 to 188 m.

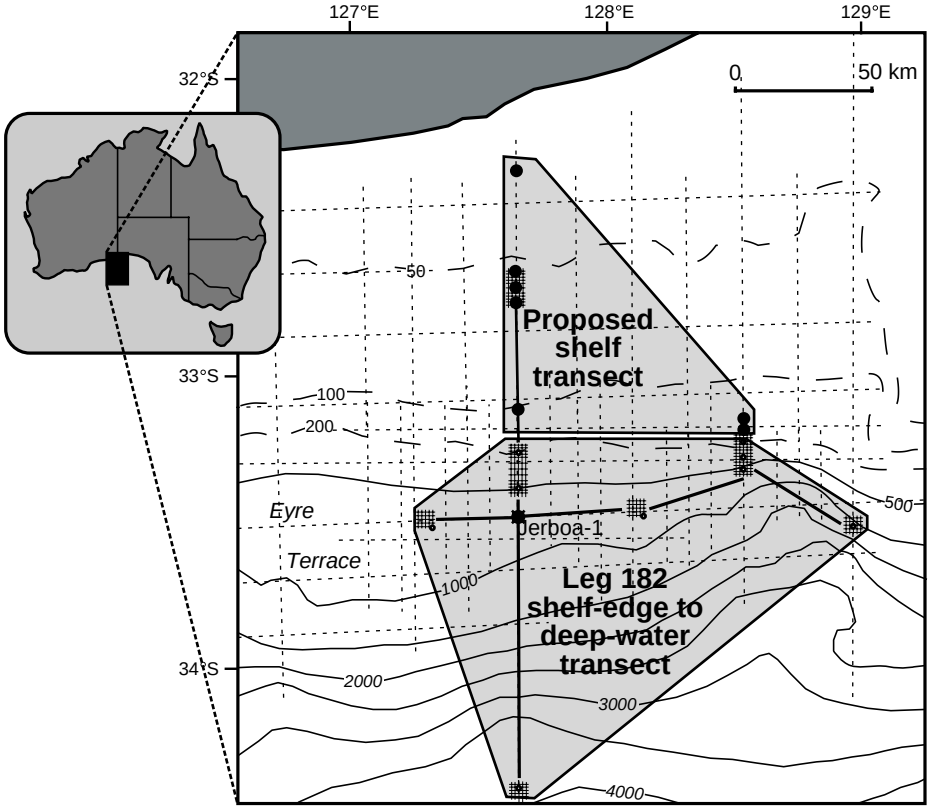

Fig. 1 Location of proposed shallow water drilling transect in the central Great Australian Bight, landward of the Leg 182 upper slope to continental rise transect.

FLUID FLOW AND DIAGENESIS OBJECTIVES

One of the most unexpected results of Leg 182 drilling was the discovery of a high salinity brine in pore waters at seven sites. The salinity reached values as high as 106, and it appears that there is a common depth of the salinity maxima below sea-level at all sites. Pore fluids in the Pleistocene portion of some of the sites also possessed a Na+/Cl- ratio in excess of seawater, suggesting that the fluids in these sediments had been involved in the dissolution of NaCl.

The most likely source for such high salinity fluids is from evaporative systems episodically fed by seawater, and we speculate that during successive low sea-level periods the vast Eucla Shelf may have contained shallow saline lakes that produced multiple episodes of brine infiltration into the substrate underlying the present-day continental shelf. The modern shelf surface consists of broad areas of older Cenozoic limestone with interspersed coarse-grained bioclastic ridges, oriented approximately normal to the prevailing energy direction. These ridges may have constituted semi-permeable barriers between open ocean salinity waters and evaporative, high-salinity lakes, with sufficient permeability to allow episodic recharge of the shallow lakes.

We suggest that a combination of fluids derived from the continental landmass, with greater hydrostatic head, together with these intra-shelf infiltrated brines, produced a 'tongue' of high salinity fluid that now extends out to the upper slope within the uppermost few hundred meters of sediment. It is likely that hydrostatic variability resulting from both sea-level fluctuations and ocean swell contributed to brine circulation by hydrostatic 'pumping' (Fig. 2). Confirmation of the source and geochemistry of these brines, together with an analysis of fluid circulation controls, requires pore-water analysis along a transect of drill sites across the modern shelf. The compilation of geochemical data trends from these sites offers an opportunity to make a major contribution towards an understanding of the relationship between hydrogeological driving forces and sea-level oscillations. An important component of the proposed drilling will be to deploy geochemical 'CORK's at one or more of the sites, to determine fluid composition and circulation rates. The shallow water depths of the proposed sites should minimize the technical difficulties associated with revisiting and servicing CORK(s).

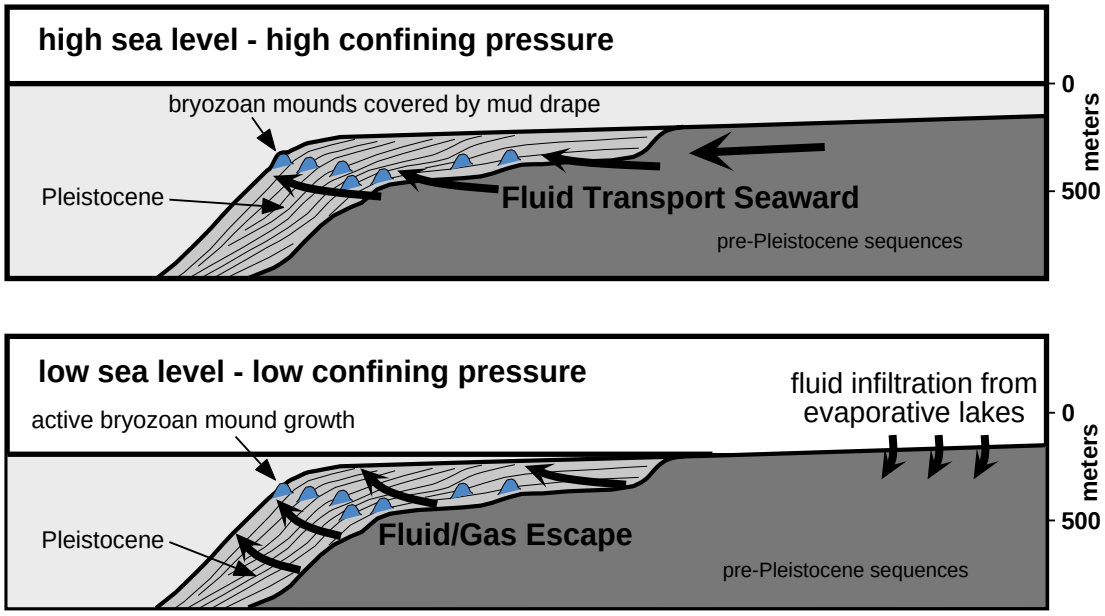

Fig. 2 Schematic diagram showing speculative fluid transport paths under different sea-level conditions, contributing to hydrostatic pumping action.

Leg 182 drilling showed the importance of the interaction between the abundant organic material derived from biogenic activity on the shelf with the high salinity brines. Under normal conditions, the organic material would be oxidized first by oxygen and then by sulfate utilizing bacteria, thereby creating alkalinity and hydrogen sulfide. The high salinity brines underlying and within the Pleistocene succession provide up to three times the normal sulfate concentrations and therefore, with sufficient organic material, significantly higher amounts of hydrogen sulfide can be formed. This significantly accelerated the normal diagenetic alteration of metastable aragonite and high-Mg calcite to the more stable low-Mg calcite and dolomite. The high alkalinity environment created a thermodynamic regime favorable for the formation of dolomite. These effects were least apparent towards the distal margin of the high salinity brines at deeper sites on the slope, and increased to reach a maximum of ~20% dolomite at the shallowest site drilled at the shelf edge. A full understanding of the components and interactions within this complex system requires analysis of the more landward sequences underlying the modern shelf.

PALEOCLIMATE OBJECTIVES

Seismic imagery shows that Cenozoic sequences on the Eucla Shelf preserve a spectacular record of climate change, with sequence geometry indicating that the cool-water depositional conditions prevalent throughout the Cenozoic were interrupted by an episode of warm subtropical or cool tropical reef growth to form a rimmed "Little Barrier Reef" (Fig. 3) platform edge underlying the central Eucla Shelf. A series of sites across this feature offers the opportunity to derive a detailed record of climatic oscillations during the early stages of Southern Ocean development. These sites would permit:

• evaluation of paleotemperature control on carbonate facies that form a rimmed carbonate platform edge, deposited under presumed warm subtropical or tropical conditions, compared with ramp platform morphology deposited under warm temperate or cool subtropical conditions elsewhere on the margin;

• a comparison of the faunal composition and community structure of the reefs forming the rimmed margin with the characteristics of the bryozoan mounds representing cooler water deposition.

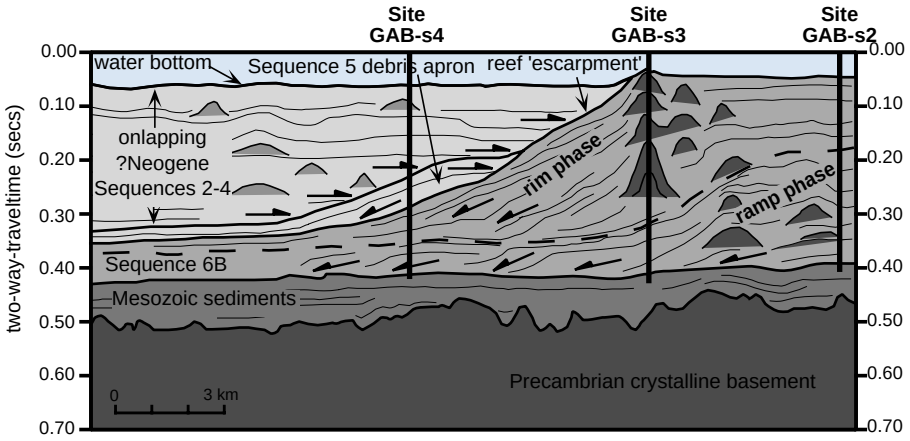

Fig. 3 The "Little Barrier Reef" is spectacularly visible on seismic data, occurring in the middle of the broad Eucla Shelf. The top of the reef escarpment occurs in 50 m water depth.

SEA-LEVEL OBJECTIVES

An understanding of the effects of sea-level on sediment deposition and post-depositional processes are common to the fluid circulation, diagenesis, and paleoclimate objectives. In addition, the direct effect of sea-level fluctuations on sediment facies can also be targeted by the proposed drilling program. Leg 182 recovered excellent, high resolution Pleistocene shelf-edge and upper slope successions (>450 m of Pleistocene sediment at two sites). However, the absence of a record from the shallow, uppermost parts of the clinoforms imposes critical restrictions on the extent to which we can describe facies. variations within cool-water carbonate depositional systems resulting from sea-level movements. The combination of excellent high resolution seismic reflection data and full down-hole logging enables high resolution site-to-site correlation that will permit a detailed understanding of the role of the relative contributions of shelf-edge bryozoan build-ups and off-shelf sediment transport to form the clinoforms. We propose that shallow-water sites to sample the upper 'limbs' of the clinoforms underlying the outer shelf (Fig. 4) will enable the full architecture and process/response reaction of this system to sea-level fluctuations to be determined.

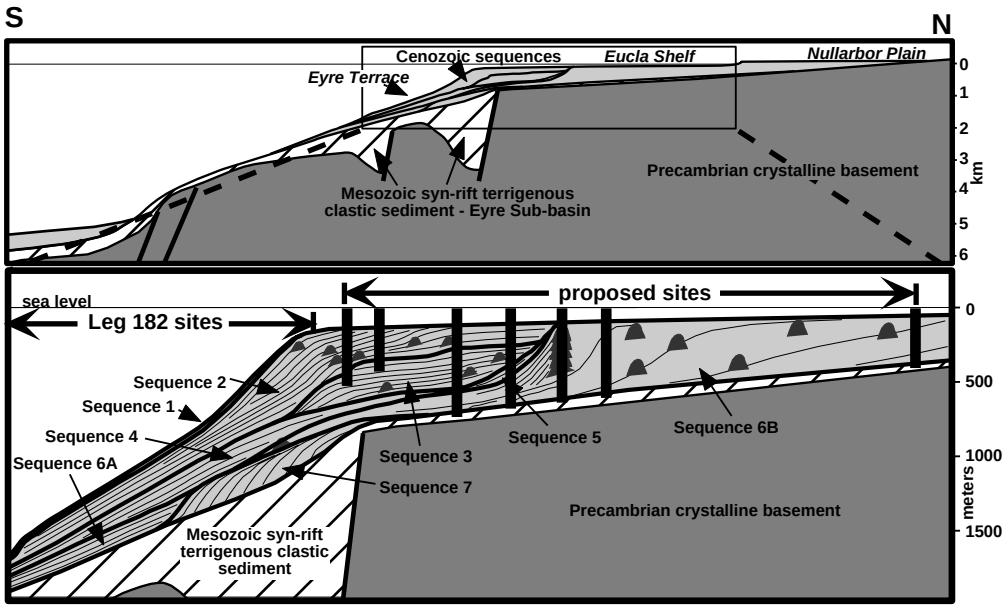

Fig. 4 Schematic diagram showing the distribution of seismic sequence across the Eucla margin. The transect of proposed sites (heavy bars) occur in water depths from 35-188 m.

Much of the above is derived from "Effects of Climate, Sea-level, and Fluid Flow on development of the Eucla Cool-water Carbonate Platform: An ODP Proposal for the Great Australian Bight shelf", by D.A.Feary, N.P. James, A.C. Hine, P.K. Swart, M.J. Malone, and A.R. Isern.

DISCOVERING THE HIDDEN HISTORY OF THE LUCKY STRIKE HYDROTHERMAL FIELD - UNDERSTANDING THE RELATIONSHIP BETWEEN HYDROTHERMAL ACTIVITY, MAGMATIC EVOLUTION AND VOLCANIC STYLE

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Introduction and geological setting

The Lucky Strike hydrothermal field occurs in the summit basin of a large prominent seamount that forms the shallow center (1700 m depth) of a ridge segment centred on 37º17,5'N and 32º16,5'W, located South of the Azores Islands on the slow-spreading Mid-Atlantic Ridge (MAR). This second order ridge segment is characterised by an unusually large central volcanic complex, which comprises a plateau that rises from a mean basal depth of 2200m, with a history of explosive eruption and hydrothermal activity. This plateau is 5 km wide (east to west) and 6 km long (north to south). The volcanic plateau comprises up to seven constructional terraces with three conical edifices at its highest point in the centre, representing the maximum height of the volcano. At its deepest ends, the segment is about 3200 m deep.

Hydrothermal constructions and activity occur within the three central cones, on their flanks and mostly around a circular flat area of draped lavas, pillars etc, described as a recently active lava lake (Fouquet et al, 1995), and the vents are dispersed over an area of about 1 km^2. The Lucky Strike field is considered as one of the most important sulphide deposits in the oceans (Fouquet, 1999). Large subdomains of the Lucky Strike fields are covered by hydrothermally cemented breccias (named slabs; Costa et al, 1995; Fouquet et al, 1996, 1998).

The MAR close to the Azores has large variations in axial depth, crustal thickness and basalt composition, due to the influence of a mantle hot spot on the ridge, providing the potential for investigating effects, other than spreading rate, on hydrothermal systems (Langmuir et al, 1997). Furthermore, it also provides a unique opportunity to study the effects of explosive volcanic activity, in a deep marine environment, and its relationship to hydrothermal activity, alteration and sulphide deposition.

Previous work

Since the discovery of the Lucky Strike hydrothermal field - in 1992, during the FAZAR survey cruises, this area has been extensively surveyed: five cruises under the FARA program, four cruises under the AMORES and MAST-MARFLUX programs and the LUSTRE and TTR-10 cruises. Bathymetric and sonar data were obtained and water column studies were made. Images of the sea floor were obtained during several dives and using remote control imaging

instruments. Hydrothermal fluids, biological and various lithologic types were sampled - sediments, sulphides, volcanic and hydrothermal rocks, were collected by dredges, TV-grabs, submersibles and remote control vehicles. Only superficial sediment and rock coring - core tips - recovering the very first millimetres from the seafloor, obtaining only a few grams of material - were made. Unfortunately, like for most of the other more than 200 hydrothermal sites, already identified, we do not have any third dimension data. Actually, to date only three sites have been drilled by ODP - Middle valley (Juan de Fuca Ridge), TAG (Mid Atlantic Ridge) and Pacmanus (Manus Back-Arc). Studies made using data collected in the Lucky Strike field enhance the following characteristics: the site appears to have had and extensive history; the hydrothermal biological community is very specific; the variations in fluid composition are geographically dependent and the hydrothermal deposits are distinctive for the Atlantic due to the abundance of barite (Langmuir et al, 1997; Fouquet et al, 1999)

Technical and scientific objectives

The main objectives of this project will include the drilling and coring of the Lucky Strike hydrothermal field in the area inside the three volcanic cones and also the different types of lithological units - taking into account the detail mapping features obtained by TOBI - that make up the central volcanic complex. Since the area has a depth less than 2000 m it will be possible to use any of the portable seafloor drilling and coring systems (PROD or BGS) that can be used from ships of opportunity; alternatively, areas bellow 2000 m could be sampled using BMS system. All of these alternative drilling platforms could be co-ordinated with other possible projects to be held by Joides Resolution in the Lucky Strike area.

This will allow confirming the existence of sulphides bellow the bottom surface, indicated by the low permeability nature of the slabs, sealed by previous hydrothermal activity, as well as the types and spatial mineralisation distribution around the lava lake and the relations between sub-surface mineralisation and fluids expelled by the vents. The nature and extent of hydrothermal alteration related to the Lucky Strike field can only be assessed by deep drilling. Finally, a door will also be open to understanding the types and relations of microbiological communities in hydrothermal areas (deep biosphere and its relation with hydrotermal processes).

The sampling of fresh rocks, including basalts/glasses, is a fundamental requirement to model and understand the magmatic and volcanic evolution. This will permit: a)the study of the relationship between magma chemistry, eruptive style and the depth and position on the volcanic complex; b) to know the distribution, variation and concentration of volatiles (both pre and post-eruptive); c) to understand the relationship between volcanic evolution and hydrothermal activity - distribution and origin of permeability in explosive volcanic products, and the consequences for alteration and mineralisation of permeable volcanic materials.

All of these approaches will contribute significantly to derive a model for volcanic, magmatic and hydrothermal evolution of central volcanoes on Mid-Ocean Ridges.

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LAND-SEA LINK TO THE HIMALAYAN REGION AND TECTONIC-CLIMATIC-OCEANIC FORCING IN THE BAY OF BENGAL

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Nearshore and continental margin settings are the most complex depositional environments, where land transport processes interact with ocean currents, and atmospheric forcing is acting in parallel to tectonics or sea level changes on the distribution patterns of particle transport. Although signals of climatic changes are difficult to decipher there, they carry the most valuable information about the Earth's system due to the proximity to land and high accumulation rates with high temporal resolution.

As an example for the most prominent late Neogene event, we propose to investigate the Bengal fan which records the tectonic and erosion history of the Himalaya. Because of the intensity of the land-sea fluxes, the erosion of the Himalaya influences significantly the chemistry of the ocean and participates to a possible tectonic control of the global climate. The objective is to quantify these fluxes across the coast and the associated built-up of the world's largest sediment fan in the Bay of Bengal by drilling deep and shallow holes in the Bengal Fan, upper slope, into transport channels and canyons and in the shelf region.

A multiplatform approach is required to adapt to the technical and scientific challenges as drilling into deposits of India-Asia collision sediments in more than 2 km depth, drilling a latitudinal transect across the Bay of Bengal, studying subsidence history near the shelf break as a major control of living conditions in the Bangladesh coastal zone, following the particle transport from river input through coast-parallel sediment transport towards the generation of frequent turbiditic and slope failure events in the Swatch of No Ground. Subsequent sediment transport is restricted to narrow bands in the vicinity of deep sea channels, representing depositional environments of high and continuous sediment accumulation over short periods of time. In order to use this archive for the reconstruction of short term and long term geologic and climatic history, we suggest to carry out several drilling campaigns.

• A deep drill hole placed in the center of the Bengal Fan at moderate water depth would provide a unique opportunity to study the Paleogene depositional history including the early onset of fan deposition related to the continental collision of India and Asia and to the initiation of the Himalayan uplift. Locations close to the collision front are rare, and sites in the Indus Fan as the only alternative are affected by massive slope failures. Moderate slope angles and high sediment accumulation make the Bengal Fan most suitable for a drilling campaign with the new riser drillship, which may become available for IODP within the next decade.
• A transect of three drill holes to study Mio-Pliocene sedimentation was previously proposed

for a 'conventional' ODP proposal (Prop. ODP 552) covering an age interval from recent to appx. 10-15 Ma. Since fan sedimentation is restricted to relatively narrow bands in the vicinity of the active transport channel, a sufficient lateral coverage is required to test the regional significance of the major sedimentation changes recorded in the distal Fan (Leg 116). This will achieve a complete record of climatic, monsoonal and sedimentary history derived from the Himalayan mountain range through the Ganges-Brahmaputra river system. It is important to understand the monsoon evolution in relation with the Himalayan and Tibet uplift, environmental changes such as the expansion of C4 plants in the subcontinent and to quantify the effect of this erosion on the global carbon cycle. The drilling proposal was based on a seismic survey carried out through R/V Sonne Cruise SO 125, which was targeted to channel sedimentation and the overall sediment distribution in the fan.

• A series of dedicated shallow drill holes in the Channel-levee systems developed in deep sea fans in the vicinity of focused pathways of turbidites. They reveal a typical sedimentologic sequence changing through the construction of levee side walls guiding. During their limited lifetime, systems in the Bengal Fan reveal a pronounced and unique lateral segmentation, probably caused by frequent channel jumps. A series of holes (50 to 150 m) will allow to understand the lateral variability and the typical lifetime of the systems which is an essential structural calibration of deeper drill holes. They also represent high-resolution paleoclimatic archives and important sedimentologic structures as potential reservoir of hydrocarbon and as fluid sources during dewatering and sediment compaction.

• Drilling on 'alternate platforms' in the Swatch of no Ground, on the outer Bangladesh shelf, near recent foreset beds and inland within the river plains shall enlighten fluxes and budget of particles and ground water controlled by the river, coastal current, turbidites and suspension load. The sedimentary budget of the complex 'river plain - shallow marine deposits - canyon and shelf - proximal fan - distal fan' is most relevant for the sensitive balance between sediment-load-driven and tectonic-driven subsidence and accumulation and for the living conditions of more than 100 million people.

- Drilling in the Swatch of No Ground (200-800 m water depth; several sites of 50-100 m penetration) shall reveal the mechanisms, by which particles are mobilized by storms on the shelf, trapped in the canyon, and re-mobilized through different slope failure processes, providing the dominant sediment input to the active channel. Annual to decennial resolution can be achieved including the reconstruction of tropical storms, the strength of coast-parallel current and variations in river transport.
- Subsidence is affected by the sediment accumulation over longer time scales and by large scale tectonic processes related to plate tectonics. Recent seismic data have revealed several phases of low-sea-level sedimentary deposits, which can be used along the shelf break to separate the subsidence rate from sea level changes. This important information can be derived by a combination of a dedicated high-resolution seismic survey and drill holes of 50 to 200 m penetration in critical locations along the shelf break, and is of highest relevance to coastal engineering and future concepts for land utilization.
- The foreset beds are rapidly migrating seawards, but age control is limited due to the availability of short sediment cores. Drilling in shallow water may help to complete the quantification of sediment input and transport through the river delta, and several coast-

parallel drill sites of 50-150 m penetration are proposed in the vicinity of the foreset beds in water depths of 20 to 120 meters.

- In addition to the reconstruction of particle transport, an important question is related to the flow of fluids, in particular where fresh water is moving underground to the ocean, contributing a significant proportion of the total water flow. To clarify this contribution, dedicated drilling is planned for geochemical and hydrologic studies both on land, in shallow water and near potential outflow zones near the foreset.

In summary, the connected systems between mountain denudation, intermediate sedimentary deposits in river plains, and sediment deposition in shallow and deep marine deposits, shall be studied in detail, using different drilling tools and technologies, which are needed to acquire high temporal and structural resolution. Close links to detailed seismic investigations are essential to optimize such data sets for regional predictions of budgets and fluxes.

QUATERNARY DEVELOPMENT OF THE BELIZE BARRIER REEF, CENTRAL AMERICA

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Information on the response of reefs to rate of sea level changes is notably lacking in spite of the common use of phrases such as »catch-up, keep-up, and give-up" (1, 2). The importance of antecedent topography in controlling the distribution of barrier reefs and atolls is also a subject of speculation. The 250 km long Belize Barrier Reef offers an unusual opportunity of providing some answers to these problems. The antecedent surface beneath the barrier reef deepens appreciably along depositional strike from north to south from a few meters to more than 30 meters (3, 4). Consequently boreholes through the Holocene barrier reef should provide meaningful data on reef colonization with respect to the rate of rise of Holocene sea level. Moreover the information on the Belize shelf and atolls indicates that underlying Pleistocene limestone consistently dates at around 130,000 years BP (isotope stage 5e) regardless of current depth below sea level (5). Therefore dating of the underlying Pleistocene surface should contribute knowledge on the rate of subsidence and/or karst erosion of the antecedent topography from north to south. The depositional facies represented by the underlying antecedent topography is also of interest in that there should be an obvious facies difference between the Pleistocene limestone deposited in a few meters water depth in the north versus the 30 meters plus water depth in the south. Additionally, the drilling goal would be to drill through the Pleistocene to document unambiguously when reefal conditions began with respect to the possible role of antecedent topography in localizing barrier reef development.

One of the problems in pursuing these ends is the need for delineating the geometry of the several antecedent surfaces, beneath the Holocene and within the Pleistocene. The barrier reef itself poses severe restrictions on obtaining this information by seismic acquisition as seismic ships simply cannot get across the reef because of its extremely shallow depth. What we propose to do to compensate for this is to drill a series of closely spaced boreholes normal to the reef front to provide the necessary geometry as well as the lithologic information. At this preliminary stage we envision 4 west to east transects across the reef spaced more or less equidistantly from north to south. Each transect would consist of 5 closely spaced drilling localities to give us the necessary geometry of the underlying Pleistocene geometry. We firmly believe that this information would go a long way not only in providing answers to the evolution of the Belize Barrier Reef, the longest continuous reef in the Atlantic Ocean, but also would contribute to an understanding of reef development elsewhere.

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THE CRETACEOUS GATEWAY BETWEEN THE ARCTIC AND ATLANTIC OCEANS
PROPOSAL FOR THE OCEAN DRILLING PROJECT
IN COOPERATION WITH INDUSTRY
(ODP # 588 – FULL)

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Abstract. The Vøring Basin, offshore mid-Norway combines unique scientific targets with industrial interests, and provides a special opportunity to forge and extend links between the ocean drilling project and petroleum industry. Both interests groups focus on better understanding of the complex tectono-magmatic-, thermal-, stratigraphic-, and sedimentary-geochemical history of the Cretaceous basins that formed the narrow seaway between Greenland and Norway. There is an abundance of high resolution reflection seismic profiles, and few wells.

We propose 3 drill sites, with 4 alternate ones, safe for open hole drilling, that will recover targets in microfossil rich open marine mudstones, at shallow burial depths. Sediments to be cored are postulated to range from Aptian through Eocene age, and will detail phases of pre-rift extension in the middle Cretaceous, and syn-rift phases in early Campanian - early Maastrichtian, and mid Maastrichtian - Paleocene, prior to post-rift subsidence during the opening phase of the Norwegian Sea, starting with anomaly 24b. Detailed biota, age and stable isotope correlations to coeval sites in the deep Atlantic Ocean will help to determine the role of the Norway - Greenland gateway in Cretaceous and Paleogene watermass exchanges.

Specifically, we propose to test the hypotheses that: (1) A deep marine gateway of Cretaceous age existed between Norway and Greenland, that connected to the Atlantic realm, and possibly linked the Atlantic to the Arctic; (2) This Nordic seaway played a role in the formation of Cretaceous Atlantic deep waters; (3) Cretaceous organic events extended from the Atlantic in the boreal gateway, suggesting periodic deeper watermass restrictions in phase with global events of a climatic/tectonic nature; (4) Major subsidence and local uplift occurred prior to and during Campanian - Paleocene rifting and break-up of the gateway, the magnitude and timing of which are poorly known.

Continuous coring will shed light on a particularly complex phase in the geodynamic history of the Norwegian/Greenland margins, during the pre- and synrift phases.

DSDP Leg 38, and ODP Legs 104, 151 and 162 focussed on the latest syn- and post- rift history of the northeastern North Atlantic, with sites between Norway and Greenland drilling Eocene through Plio/Pleistocene strata that record post-rift, pre-glacial and glacial/interglacial history. No sites have been drilled in the deep marine sediments laid down during Cretaceous - Paleocene, in a boreal setting, at a time of warm climates.

The proposed coreholes will recover the northernmost Paleocene and Cretaceous sediments in the Atlantic realm.

Preface. This Ocean Drilling Project (ODP) proposal grew out of detailed discussions during the workshop 'Cooperation in Scientific Ocean Drilling: Forging Industry-Academic Partnerships, held in October 1999 in Houston, TX, USA (Armentrout & Gradstein, 2000). The workshop was attended by over 50 participants, over half from industry.

In a preliminary form, this proposal was evaluated in May and June 2000 by ESSEP and ISSEP of ODP. Following evaluation, the authors were encouraged to proceed to full proposal with details on sites and paleoceanographic and tectonic objectives. During the fall of 2000, the full proposal was evaluated by the ODP panels, leading to the request for minor updates. Targets are syn-rift Paleocene and pre-rift Cretaceous deep marine sediments that are the northernmost to be cored by the Ocean Drilling Project in the Atlantic realm. The Møre and Faroes basins to the south are off-limit for ODP.

The authors of this proposal have been encouraged by shallow core hole drilling (1007 m in length) in 1990 and 1991 on structural highs like Naglfar and southern Lofoten margin (fig. 2), with an open hole, slim-line drilling rig, that safely recovered Cretaceous and older marine sediments. The slim-line cores are of poor quality, and few data has been released (see e.g. Brekke, 2000). Other highs drilled commercially, like Vema Dome, Gjallar Ridge, and Utgard High (fig. 2) were dry-holes (see section on Hazards).

Extensive academic and commercial interests exist in better understanding the complex tectonic-, heatflow-, stratigraphic-, and sedimentary-geochemical history of the Cretaceous - Paleocene basins, offshore mid-Norway. The 'Nansen Arctic Drilling Initiative' to study the Arctic Ocean, will be greatly served by ODP data from this critical gateway region, in the doorstep of the Arctic Ocean. The Cretaceous gateway record will be crucial for interpreting any Arctic record, where the influence of any Atlantic waters will be even less.

Vøring Basin combines unique scientific targets with ongoing industrial activity, and provides a special opportunity to forge and extend links between JOIDES and Industry. Both Statoil, TGS-NOPEC, VBPR, the Norwegian Petroleum Directorate (NPD) and other petroleum companies and institutions will cooperate in pursuing ODP drilling. There is an abundance of high resolution multi-channel seismic (MCS) data, and shallow buried Cretaceous-Paleogene, open hole prospects.

Objectives for ODP Drilling: The following general hypotheses are to be tested in the Vøring Basin (Table 1):

(1) A deep marine gateway of Cretaceous age existed between Norway and Greenland, that connected to the Atlantic realm, and possibly linked the Atlantic to the Arctic;

(2) This Nordic seaway played a role in the formation of Cretaceous Atlantic deep

waters;

(3) Cretaceous organic events extended from the Atlantic in the boreal gateway, suggesting periodic deeper watermass restrictions in phase with global events of a climatic/tectonic nature;

(4) Major subsidence and local uplift occurred prior to and during Campanian - Paleocene rifting and break-up of the gateway, the magnitude and timing of which are poorly known.

Continuous coring and well-logging will shed light on a particularly complex phase in the geodynamic history of the Norwegian/Greenland margins, during pre- and synrift phases.

The geochemical, sedimentary, and stratigraphic-tectonic implications of the new data are of great interest to petroleum industry active in this deep water frontier.

Proposed ODP Sites. Potential ODP sites were selected (a) as far south along the continental margin as feasible, with the Møre, north Viking, and Faroes Basins to the S and SW of Vøring being politically off- limit, and hazardous without riser system, (b) as shallowly buried as possible to enhance carbonate recovery, (c) to recover the deepest and most open marine Cretaceous through Paleogene sediments. We know from industry wells that diverse plankton faunas and floras are present in the region.

The three primary sites are, in order of scientific priority (table 1) :

Site Vor-1A (fig. 1)**,** flank uplifted transform margin high, NE of Jan Mayen Fracture Zone, southern Vøring Basin: Late Cretaceous through Paleocene and early Eocene (incl. K/T boundary), open marine mudstone and marl, with a rich calcareous fauna anticipated.

Site Vor-2A (fig. 1), synclinal feature on Naglfar Dome (Hel Graben, NW Vøring Basin): Post-rift Eocene hemipelagic ooze, late syn-rift marine Paleocene mudstone, early syn-rift open marine Campanian - Maastrichtian mudstone.

Site Vor-3A (fig. 1), northern Någrind Syncline, southern Lofoten Platform, near Bivrost Lineament: Paleocene syn-rift marine mudstone, Cenomanian - Albian open marine mud- and siltstone.

Alternate sites with additional and overlapping objectives are (table 1):

Alternate Site Vor-4A (fig. 1), northern Någrind Syncline, southern Lofoten Platform, adjacent to Bivrost Lineament: Aptian/Albian open marine mud- and siltstone.

Alternate Site Vor-2B (fig.1) synclinal feature on Naglfar Dome (Hel Graben, NW Vøring Basin): post-rift Eocene hemipelagic ooze, late syn-rift marine Paleocene mudstone, and early syn-rift Campanian – Maastrichtian deep marine mudstone

Alternate Site Vor-5A (fig. 1), Vema Dome, NW Vøring Basin: Deep marine, early syn-rift Campanian-Maastrichtian mudstone.

Alternate Site Vor-6A, SE flank of Hel Graben, northern Vøring Basin: Marine syn-rift Paleocene mudstone and tuf, abruptly overlying Campanian silt/sandstone

The Coring Time Estimator of ODP caculated a total of 54.5 days on site for prime sites Vor-1A through Vor-3A; local transit time between sites is very small; the drilling weather window is April-September.

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A MARINE RECORD OF HOLOCENE CLIMATE EVENTS IN TROPICAL SOUTH AMERICA

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Metal concentration data (Ti, Fe) from the anoxic Cariaco Basin off the Venezuelan coast record with subdecadal resolution variations in the hydrological cycle over tropical South America during the last 14 ka. Following a dry Younger Dryas, a period of increased precipitation and riverine discharge occurred during the Holocene 'thermal maximum'. Since ~5.4 ka, a trend towards drier conditions is evident from the data, withhigh amplitude fluctuations and precipitation minima during the time interval 3.8 to 2.8 ka and during the 'Little Ice Age'. These regional changes in precipitation are best explained by shifts in the mean latitude of the Atlantic Intertropical Convergence Zone (ITCZ), potentially driven by Pacific-based climate variability. The variations recorded in Cariaco Basin sediments coincide with events in societal evolution that have been suggested previously to be motivated by environmental change. Regionally, the Cariaco record supports the notion that the collapse of this civilization coincided with an extended period of drier conditions, implying that the rapid growth of Mayan culture from 600 to 800 AD may have resulted in a population operating at the fringes of the environment's carrying capacity. The Cariaco Basin record also hints at tropical climate events similar in timing to high latitude changes in the North Atlantic often invoked as pivotal in the settlement history of the Vikings in Greenland and to societal developments in Europe.

PRODUCTIVITY OR VENTILATION? THE IMPORTANCE OF MULTIPROXY RESULTS FROM A CALIFORNIAN UPWELLING CELL (ODP HOLE 1017E, SAN LUCIA SLOPE).

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During the last glacial interval the oxygen content of sediments at intermediate water depths along the California Margin fluctuated in concert with rapid climate change. ODP Hole 893A high resolution benthic records show large shifts in both bottom water oxygen concentration and temperature, suggesting intermediate waters bathing the site shifted from an oxygen-rich, cool to an oxygen-poor, warm source. It has remained a debate, however, whether these shifts in oxygen concentration were purely the result of variations in North Pacific Intermediate Water (NPIW) ventilation or were produced by local productivity-driven organic matter decay. Lying beneath an upwelling cell, ~50 km north of Santa Barbara Basin, ODP Hole 1017E provides a unique opportunity to test the productivity versus ventilation hypothesis. If decoupling between productivity indicators and proxies for sediment oxygen concentration can be demonstrated, then importation of the oxygen signal to the site by NPIW is implied.

ODP Hole 1017E was dedicated to the production of high resolution multiproxy records. The core was sampled continuously every 3 cm eliminating sample depth errors between proxies. The resulting records ($\delta^{15}N$, planktonic foraminiferal $\delta^{13}C$, planktonic foraminiferal fauna, % carbonate, % organic carbon, Ag/Cd ratio, Mo, Re, I/Br, and other trace elements) suggest productivity increased during warm intervals (interstadials and the Holocene), while sediment oxygen concentration decreased. A strong productivity pulse, possibly driven by intense upwelling occurred during the Bølling when the sediments became strongly sulphate reducing. The Ållerød and Younger Dryas remained relatively unproductive, however only the Younger Dryas contained well oxygenated sediments. The close correlation between clay content (Fe/Al, Mg/Al, Ni/Ti, Cu/Ti and Zn/Ti), % organic carbon and interstadials suggest the production of nepheloid layers associated with either enhanced California Undercurrent flow or large scale eddies connected with upwelling. Proxies for sediment oxygen content are therefore not only influenced by the imported intermediate water oxygen content and surface productivity, but grain size as well.

Variability in upwelling and consequently productivity occurred alongside interstadial sea surface temperature shifts at the site during the last glacial, suggesting the upwelling cell off Point Conception existed intermittently and was intimately linked with climate change. Molybdenum precipitation during the most significant interstadials occurred as the pore water oxygen concentration was driven down by synchronous importation of oxygen depleted NPIW and episodes of enhanced organic matter deposition. During the coolest stadials high NPIW oxygen content and low productivity combined to preserve Iodine. A difference in the oxygen content of sediment pore water is apparent between the Ållerød and the Younger Dryas, despite no evidence for productivity or grain size shifts. Thus the bottom water oxygen signal must have been imported at this time by intermediate waters bathing the site, demonstrating both the ventilation history of NPIW, as well as productivity off California played a role in the sedimentary redox history of ODP Hole 1017E.

These multi-proxy records demonstrate the complexity of modern paleoceanographic studies and signify the possible movement of the field toward data-intensive, multi-variable analysis. To obtain information on such a wide range of climatic variables requires the availability of significant amounts of sediment for analysis. In this case it was possible through the dedication of an entire ODP core. Future opportunities to produce this type of study could also involve giant piston cores capable of coring 30 to 80 m of sediment at a time such as are presently available on the Marion Dufrense, and have been utilized by the IMAGES project. Such drilling would easily and efficiently allow the collection of sufficient sedimentary material for future high resolution, late Quaternary, multi-proxy paleoclimatic studies.

MAGMATIC-HYDROTHERMAL SYSTEMS AT CONICAL, EDISON, AND TUBAF SEAMOUNTS (NEW IRELAND FORE-ARC), PAPUA NEW GUINEA

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We propose to explore for the first time the subsurface nature of seafloor magmatic-hydrothermal systems by drilling at Conical, Edison, and TUBAF seamounts in the New Ireland Fore-Arc of Papua New Guinea. To date, only seawater-dominated hydrothermal systems have been drilled by the Ocean Drilling Program (Leg 139: Middle Valley, Leg 158: TAG, Leg 169: Middle Valley/Escanaba Trough, Leg 193: Manus Basin). Drilling of epithermal systems, for which a contribution of reactive magmatic fluids and gases has been documented, is the logical continuation of the ODP efforts to understand fluid circulation and magmatic processes in the oceanic crust.

All three seamounts are alkaline volcanoes in a rifted fore-arc setting of the New Ireland Basin. They are located in a zone of recent seismic and volcanic activity and elevated heat flow only 10 km south of Lihir Island, which is host to the giant (40 million ounces) Ladolam epithermal gold deposit (Moyle et al., 1990). The island of Lihir is part of the Tabar-Lihir-Tanga-Feni island chain, situated in a fore-arc basin behind the presently inactive Manus-Kilinailau trench northeast of Papua New Guinea (Fig. 1).

The Conical, Edison, and TUBAF seamounts are volcanic cones rising up to 600 m above the surrounding seafloor just south of Lihir Island (Herzig et al., 1994, 1998). The summit plateau of Conical seamount is characterized by intense hydrothermal alteration and mineralization consisting of a clay-adular-silica assemblage as well as gold-rich polymetallic vein sulfides (up to 230 ppm Au) and associated pyrite stockworks (Herzig et al., 1999; Petersen et al., 2001). The style of alteration and mineralization, including the extremely high concentrations of gold, indicates a similarity to subduction-related epithermal systems and gold deposits on land (e.g., the Ladolam deposit on Lihir Island) rather than to conventional black smoker-type seawater circulation systems. TUBAF seamount appears to be a pyroclastic cone composed of volcanic ejecta (Herzig et al., 1998; Franz & Wirth, 2000). Abundant volcanic bombs contain a wide range of ultramafic, mafic, and sedimentary nodules representing a cross-section of the oceanic lithosphere and fore-arc crust sampled by the trachybasalt during its ascent through deeply penetrating fractures. Drilling this site would give the first opportunity to understand the contribution of a modified mantle wedge to gold-enriched magmas of this area. Edison seamount is characterized by an intense biological activity (some dm-thick layers of living mussels and snails were found in its crater; Herzig et al., 1994) which is sustained by methane and/or H_2S either of hydrothermal or gas hydrate origin.

Technological problems at the proposed sites will arise from drilling fractured basaltic rocks which are altered and mineralized to different degrees and from small-scale changes in rock composition resulting in different resistance to drilling. During ODP Leg 193 at the Pacmanus site only poor core recovery of less than 10% was achieved which indicates that the current ODP technology has to be improved with respect to drilling in highly fractured and mineralized rocks (e.g., with respect to control the weight on bit).

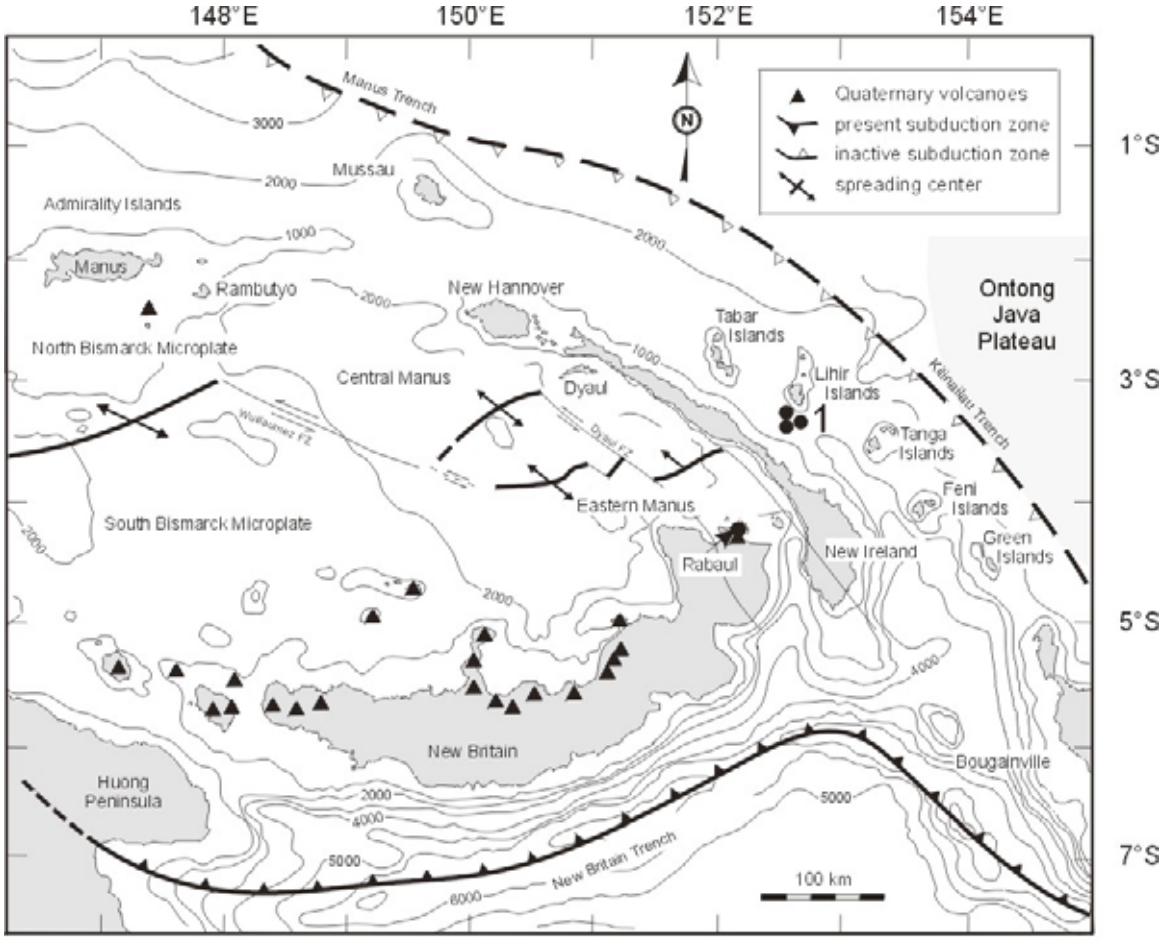

Figure 1

Fig. 1: Simplified regional geological map showing the location of the major tectonic elements in the New Ireland/Bismarck Sea region and the proposed drill sites south of Lihir Island (1) situated in a fore-arc position relative to the Manus-Kilinailau subduction zone.

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SHALLOW WATER DRILLING FOR INSTALLATION OF A SLOPE STABILITY OBSERVATORY, FRASER DELTA FORESLOPE, WESTERN CANADA

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Submarine slope stability is an important safety issue on many continental margins and submarine slides are a major mechanism for transfer of sediment from the continent to the ocean basin[1]. Our understanding of the processes that lead to slope failure in the marine environment is very limited due to the lack of in situ measurements of the critical geotechnical parameters. It is particularly important to understand the role of excess pore pressure and its evolution under different loading conditions. This proposal presents a candidate site for in situ studies of these parameters on a slope that is known to be unstable and where transmission of electrical power and data to and from land will be available through the Victoria Experimental Network UnderSea (VENUS), a Canadian initiative linked to NEPTUNE (North East Pacific Time-series Undersea Networked Experiments).

The Fraser River delta is a Holocene sediment body deposited in the Strait of Georgia, a Cretaceous and Cenozoic forearc basin of the Cascadia subduction zone. The modern morphologic elements of the Fraser River delta include an extensive delta plain, active distributary channels constrained by dikes and jetties, and a 200 km^2 delta slope incised by channels, gullies and sea valleys exhibiting sediment mass-failure features. The main channel of the Fraser River delta has been stabilized since the early part of the twentieth century, resulting in deposition being concentrated in the Sand Heads region of the slope. Slope failures have been documented in this region, the most recent having occurred in 1985 when more than 10^6 m^3 of sediment was displaced[2,3]. There is also evidence from adjacent parts of the delta slope of geologically recent slope failures.

Previous research shows that several factors combine to cause slope failure at Sand Heads: (1) high rates of deposition that create low bulk densities; (2) high static shear stresses resulting from rapid slope steepening; (3) cyclic loading at the tidal time scale resulting in cyclic variations in excess pore pressure and strain softening of the sediments; and (4) delay of pore pressure response by the presence of free methane gas in the sediments and resultant build-up of excess pore pressure[3,4]. To date, only short term monitoring of some of these parameters has been possible. Trigger mechanisms that affect seafloor stability over long time scales have not been studied in situ (seismic liquefaction, storm wave loading and groundwater flow). A broad range of scenarios can be proposed in which failure would occur both at Sand Heads and on the adjacent, more statically stable slope, underscoring the need to better understand the role of these factors.

The proposed borehole observatories would provide a means to monitor the natural variation of forcing functions, pore pressures and sediment deformations over long time periods. This would allow for a wide range of loading conditions and sediment responses to be documented, starting with cyclic changes related to tides but including a range of events such as storm waves and earthquakes of various magnitudes. It is our principal aim to observe the in situ conditions up to and possibly during the early stages of slope failure.

A second scientific objective to monitor the groundwater flow from delta sediments to the water column is also proposed. Modelling studies have shown that submarine groundwater seepage at the delta front is likely[5]. The seeping groundwater originates from the delta plain and adjacent uplands. This seepage could increase pore pressures below impermeable layers and contribute to slope instability. Also, given the intense agricultural land use of the delta plain, seepage represents a potential source of nutrients and contaminants to the marine environment.

A preliminary list of instrumentation for the slope stability observatories includes the following: (1) pore pressure arrays; (2) tiltmeters for detecting downslope creep and incipient failure; (3) hydrophones and accelerometers for detecting seismic waves generated by earthquakes and by controlled sources to determine shear wave velocity structure and gas content; (4) in situ pore fluid sampling for gas detection and contaminant analysis; (5) in situ analysis of conductivity, pH, Eh and nutrient ions in pore water.

While this proposal is still at a preliminary stage, two possible configurations for the observatories are suggested for consideration: (1) CORK-ed boreholes with perforated casing for formation-testing sensors, downhole instrument arrays and water sampling systems[6]; (2) pushed-in systems based on seismic piezocone penetrometers for piezometric and seismic measurements. Electrical power and data transmission would be provided by the proposed VENUS network, allowing real-time monitoring and shore-based logging of all basic parameters as well as experiment-specific control of sensors. Given the risk of slope failure inherent to the program, it is proposed that a permanent network of observatories be established on the relatively stable part of the slope to provide long-term monitoring of sediment response to the various loading conditions, while a sacrificial observatory be established at Sand Heads in the region of incipient liquefaction in order to follow the evolution of conditions up to the point of slope failure.

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MINERAL REACTIONS OF THE SLOW-SPREADING GAKKEL RIDGE, ARCTIC OCEAN, AS A SOURCE OF ABIOTIC ORGANIC MATTER

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In oceanic lithosphere a classic chemical reaction called the 'Fischer-Tropsch Type' (FTT) synthesis is probably a significant process. In the commercial Fischer-Tropsch synthesis reaction organic compounds, especially alkanes, alcohols and carboxylic acids, are formed at high temperature from CO and H_2 in the presence of a metal or mineral catalyst. On Earth, the mantle is degassed with respect to CO and CO_2. Percolation of water leading to serpentinization of Fe(II)-rich minerals, primarily olivine, is efficient in peridotite rock of the seafloor. Peridotite is an ultramafic rock, i.e. a rock with low silica content, that originates from the Earth's upper mantle. Molecular hydrogen formed from water is an important reaction product when the Fe(II) minerals are oxidized to magnetite during the serpentinization process. The hydrogen then reacts with CO and CO_2 that is degassed from the mantle (or that may originate from other sources) and forms organic compounds. The classes of organic compounds that are predicted to form in relatively high quantities in these environments are, first of all, methane, but also larger organic compounds like linear hydrocarbons and carboxylic acids.

The exposure of ultramafic rocks in mid-oceanic ridges is consistent with low magma budget, relatively thin crust and irregular faulting patterns. Therefore, slow-spreading (fractured) ridges like the Mid-Atlantic Ridge (MAR), the SW Indian Ridge (SWIR) and, in particular, the Gakkel Ridge of the Arctic Ocean are more likely to reveal abiotic production of organic compounds than fast-spreading ones because of better penetration of water. Drilling in the spreading centre of the Arctic Ocean may thus shed light on a process that may be potentially important for the global carbon budget and for the nurturing of a subsurface biosphere but that has thus far been difficult to address scientifically.

SHALLOW WATER TO DEEP-WATER TRANSECT DRILLINGS FOR SEA-LEVEL CHANGES AND LAND-OCEAN LINKAGE

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BACKGROUND

ODP has conducted so far several Legs in order to construct a sea-level curve independently of the hypotheses by Vail et al. (1977) and Haq et al. (1987). The main objective of Legs 133 and 166 was to determine the timing of sea-level movements from Oligocene to Pleistocene, so called icehouse age, within carbonate sequence stratigraphic framework. Legs 143 and 144, on the other hand, were adopted to acquire sea-level information in the Cretaceous as greenhouse age. Furthermore, Leg 150 in 1993 and Leg 174A in 1997, which are drilled on both continental shelf and slope, discussed paleoenvironmental changes and sea-level fluctuations from Eocene to Pleistocene.

IPOD and ODP drilled several deep-sea fans, such as Mississippi Fan (Leg 96), Bengal Fan (Leg 116) and Amazon Fan (Leg 159). One of the objectives of these submarine-fan targeted Legs was to determine the relationship between the development of fan deposits, sea-level change, and climatic and possibly tectonic changes. They provided important information about the climate and erosional history of source areas.

Many Legs has been carried out in order to study paleooceanography. Some of them drilled ocean margin and got some land-ocean linkage data. Leg 159 drilled on continental slope off shore Ghana Africa. One goal of Leg 159 was to obtain a continuous upper Miocene to Pleistocene succession of pelagic sediments to document paleoclimatic and paleooceangraphic change. Leg 56/57 and Leg 191 drilled several sites on shelf and slope of the Japan Arc-Trench System. They got important information from a continuous succession of Paleogene to Pleistocene sediments. Furthermore, Leg 184 drilled several sites on South China Sea at water depths >1000 m. One goal of Leg 184 was to identify and better understand the links between tectonic uplift, erosion and weathering, hemipelagic sediments, and climate change, including the co-evolution of the Asian monsoon and Neogene global cooling.

OBJECTIVES

A large amount of significant information had been acquired in the previous sites of the above mentioned Legs, and they have contributed for the recent paleooceanographic and sedimentological researches. Leg 174A drilled two sites (Sites 1071and 1072) on the New Jersey shelf at water depths <100 m. We examine the relationship between sequence architectures and sea-level change. We got important information form siliciclastic shelf sediments from Leg 174A. But we are still difficult to discus relationship between sea-level change and global climate change for the lack of land-ocean linkage data. Therefore, I propose to drill on shelves where landside of previous drilled deep-sea sites. They will relate sea-level changes to global climatic changes from the land-ocean linkage point of view.

POTENTIAL AREAS

1. Forearc basins in Offshore Japan (landside shelf of Legs 56/57 and 191)

In Offshore Japan, which is located in the middle latitude area, high resolution biostratigraphic framework is available in Offshore Japan. Because surface geology is detailedly studied in the Japanese Islands, correlation to the onshore stratigraphy may provide us detailed discussion with high accuracy. The Northwestern Pacific margin is one of the most appropriate sites for discussion of sea-level changes and land-ocean linkages, because high rate of deposition provides us significant data with quite high-resolution. Land-ocean transect drilling will provide us important information about structure of ocean currents (Kuroshio current). Tectonic factors, such as subsidence in forearc basins, can be reduced on the basis of geophysical interpretation, and of inter-basinal correlation of acquired information.

2. South China Sea (landside shelf of Leg 184)

It is expected that a new station in this area can provide information about Asian Monsoon and ocean currents.

3. Western side of African continent off shore Ghana and Congo (landside shelf of Leg 159)

4. Northern and Eastern parts of Offshore Australia

New stations in those areas, which are located in the middle latitude of the southern hemisphere, provide significant reference information for the data from the Northern Pacific, Atlantic and other areas.

CONCLUSION

Land-ocean transect drillings are useful for the studies of environmental changes of the Earth. It is worthwhile to drill with three deferent types of platform, such as juke-up rigs, Riserless Vessel, and Riser-Equipped Vessel.

NATURE, STRUCTURE, AND PHYSICAL PROPERTIES OF THE OCEANIC LITHOSPHERE: REQUIREMENTS FOR SERIES OF SHALLOW AND ORIENTED CORES IN HARD ROCKS

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Along the course of DSDP/ODP projects, only a few successful holes were drilled in hard-rocks close to mid-ocean ridges. Most of them penetrate basalt sections (e.g., Site 504, CostaRica Rift; Site 395, MAR), and a few in gabbros (e.g., Site 735, SWIR) or in peridotites (e.g., Site 895, Hess Deep). In most cases, these are single holes, offering no insights into the lateral extension of the observed lithologies, compositions, structures and physical properties. The only noticeable exception is the Atlantis Bank (SWIR), where Hole 735B (Legs 118 & 176) is complemented by Hole 1105A (Leg 179) about 1.2 km away and a series of shallow cores [1], allowing some attempts of lateral correlation in gabbroic rocks [2-3].

The purpose of this abstract is to underline the importance of shallow sampling along the mid-ocean ridge, hence the need in IODP for the deployment of platforms/tools allowing short (in the range 10/100m) coring, to sample time/space series. Our understanding of mid-ocean ridge processes would gain a lot from being able to study such series of samples, which do not necessarily require deep holes, and therefore do not necessarily require large/heavy platforms such as the Joides Resolution or OD21. One may envisage several applications for this type of sampling, including that of :

Low-angle, normal faults

Drilling an array of orientated cores on low-angle detachment surfaces (megamullions) is essential to provide constraints on the development of such surfaces, such as the distribution of deformation fabrics, the distribution of magnetic inclinations (allowing reconstruction of the rotation history, the mapping of the different lithologies (basalts, peridotites, …) and their contacts, the distribution of high-temperature structures and microstructures (deformation fabrics, melt channels, dikes, …) in the upper-mantle peridotites, etc… Such approach was used at the Atlantis bank (SWIR), using portable wireline rock drills [1](BGS rock drill/5m, and BRIDGE rock drill/1.1 m, oriented).

Along- and across-axis geochemical and hydrological variations of the basaltic crust

Dense networks of cored samples (glass and fresh basalts) are needed to address questions about geochemical variations related, for instance, to variations in magma production/delivery at slow-spreading ridges, or to the unsteady-state influence of hotspots. The evolution with age or along-axis (provided that zero-age crust can be drilled and cored with some success) of the transport properties of the basaltic crust can be inferred from the variations of physical properties (acoustic, electrical, …), as measured in-situ in boreholes and on time/scale series of oriented laboratory samples.

Compared physical properties of oceanic lithosphere rocks

One of the remaining challenges for marine geophysicists is to recognise the geological nature of major seismic discontinuities such as the Moho in the oceanic lithosphere. In order to be able to distinguish serpentinised peridotites and gabbros, one needs to be able to measure in-situ the characteristic petrophysical signatures (seismic anisotropy, density, electrical properties, …) of these rock types [4-5]. This requires increased resolution of sea-bottom experiments, and also a better knowledge of the in-situ petrophysical properties and of the lateral variations of the fabrics in the various rock types, which can be measured in-situ in boreholes and on time/scale series of oriented laboratory samples.

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RESPONSES OF HIGH LATITUDE CORAL REEFS TO QUATERNARY CLIMATIC CHANGES IN NORTH WESTERN PACIFIC

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Coral reefs are tropical coastal ecosystems comprising highly various organisms. Reef deposits include various skeletal organisms by which paleoenvironments and depositional ages can be determined precisely. Thus, the deposits provide important information on past tropical shallow water environment. In order to clarify relationships between reef formations and climatic changes, especially to global warmings/cooloings, it is necessary to investigate the reef deposits at relatively higher latitudes within reef provinces, because such reefs were considered to be more sensitive to the environmental changes than those in proximal areas of the provinces. In this context, the Ryukyu Islands are one of the best fields.

We propose scientific drillings_into the Quaternary carbonates in reef to shelf to trough/trench areas around the Ryukyus to resolve following problems.

1. Changes in coral communities in time and space

It was clearly shown that the compositions of coral communities are highly varied within a Pleistocene pile (Sagawa *et al*., in press), which reflects not only the Quaternary sea-level changes but also ecologic succession of the coral communities during the deposition. Consequently it can be expected that the drillings around the Ryukyus would allow to reconstruct the long-term succession of coral communities and their spatial distributions.

2. Differences in stratal architectures

The Ryukyu Islands are located at the boundary between the coral reef and non-coral reef regions in the present western Pacific. Thick reef carbonates accumulated in the Quaternary in the southwestern part of the islands, but little in the northeast. Thus, there exists a Darwin Point within the Ryukyu Islands at which the sedimentation rate is in equilibrium with the erosion rate. It is inferred that the point may have migrated northward during a transgression at interglacial stages/stadials. The nature of migration of the Darwin Point is of great importance to clarify the climatic/oceanographic factors controlling the reef formations. The drillings into insular shelf sediments covering the Northern and Southern Ryukyus will provide us the boundary conditions of reef growths (latitudes, SSTs, etc).

3. Role of coral reefs in global carbon cycle

Reef biotas have played an important role in a carbon cycle by fixing carbon as carbonates through the Phanerozoic. The Quaternary coral reefs may have also contributed to abrupt climatic changes through a positive feedback mechanism. Carbonate production rates of reefs may

have been accelerated during a transgression, because the atmospheric CO_2 concentration increased due to the carbonate precipitation in the sea, resulting in a rise in atmospheric temperature. The Quaternary carbonate accumulation rates of the reefs are considered to good examples to testify this hypothesis.

4. Early carbonate diagenesis in subtropical to warm temperate regions

The mineralogy, water temperature, and fluid chemistry of tropical carbonates are highly different from those of temperate ones, which result in different diagenetic products. As the shallow water carbonates in the Ryukyus were subject to repeated, episodic, subaeraial exposures due to the Quaternary sea-level changes, the temporal and spatial distribution of diagenetic products would record the latitudinal migrations of diagenetic regimes and the magnitude of sea-level changes.

5. Initiation of "Coral Sea"

The Pliocene strata consist chiefly of siliciclastics contrasting to the carbonate-dominant Pleistocene to Holocene deposits in the Ryukyus. This implies that the marine environments dramatically changed from “Siliciclastic Sea” to “Coral Sea” in the earliest Pleistocene. The initiation of "Coral Sea" is thought to have caused by the opening of the Okinawa Trough. The Ryukyu Islands were separated from the Eurasian Continent by the trough. At that time, the Kuroshio Current (North Pacific Current) changed its path; it flowed into the East China Sea through the Taiwan Strait and passed northeastward along the Islands. These decreased the sedimentation of siliciclastics and allowed corals to flourished in the Ryukyu Islands. However, this scenario has not been testified based on the precise data.

To resolve the problems described above, the multiple drillings through the Ryukyu Arc (from Okinawa Trough to Ryukyu Trench) should be conducted on 3 to 5 transects which covers wide latitudes of the Ryukyus.

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ARCTIC DRILLING FOR DECIPHERING ITS TECTONIC AND CLIMATE HISTORY

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The Arctic Ocean is an area of extreme environmental conditions compared with the world's oceans because of its perennial ice cover. In the recent discussions on global warming the north and south polar regions play an important role as it is believed that they are the most sensitive to any changes of climatological factors.

Critical for a scientifically sound prediction of the present day climatic situation is a sufficient knowledge on how the Earth's system behaved in the past. This information is partly hidden in the present day ice shields but also in the terrestrial and marine sediments. Research on ice cores recovered from Greenland and Antarctica reveal the climate variations for the last 15,000 to 300,000 years. To look further back in time sediment cores from submarine ridges, seamounts and shelf areas have to be analysed. Studies of such cores suggest that the frequency and/or duration of glacial ice influx into the Arctic Ocean have increased during the past several million years. Furthermore, geological data suggest that the Arctic Ocean was not continuously ice covered during the last 100 Myr (Cretaceous times). What has caused the formation of the sea ice cover and of the continental ice caps? The transition from an ice-free Earth of the warmer Cretaceous to the present bipolar ice condition is explained in the context of palaeogeography and Earth orbital forcing. The distribution and size of continents and ocean basins influence ocean and atmospheric circulation. Particularly, the crustal plate motions towards their present positions changed the ocean circulation system by opening and closing seaways.

For a better understanding of the long term environmental changes, high quality core information from the Central Arctic is needed. Several hundred sediment cores taken from ice island and recent icebreaker experiments contain information on the Quaternary of the Arctic Ocean but less than 10 cores provide information on the older geological history. Especially an enhanced model for the climate of the Arctic during the last 80 Myr (transition from a 'hot' to a 'cold' house) can only be achieved by high quality core information from locations, where deposits of different geological epochs can be reached. Such a data set will provide the first

reliable information on the geodynamic history of the pre-Quaternary Arctic, which is critical for any plate and environmental reconstructions. Critical information on the palaeogeography, the geodynamic history and the environment of the Arctic Ocean during different intervals can then be used as boundary conditions for a more sophisticated long term global climate modelling. Important areas for such a scientific challenge will be:

MESOZOIC AND CENOZOIC SITES

Location	Sed. Thickness	Age of oldest sediments
Chukchi Plateau	~500 m	80-100 Myr
Mendeleev Ridge	~1000 m	80-100 Myr
Alpha Ridge	>1000 m	80-100 Myr
Lomonosov Ridge	500 –1000 m	0-70 Myr
Yermak Plateau	500 m	0-30 Myr
Fram Strait	~2000 m	0-20 Myr

Siberian, Norwegian, Greenlandic, Canadian and American shelves at various locations. Across the shelves the strategy will be a) to recover old sediments from eroded platforms by offset drilling and b) to recover ultra high-resolution cores for the younger geological history.

For addressing scientific drilling the high Arctic and its surrounding shelves alternate platforms are necessary. For deciphering critical information from the regions mentioned above an effort lasting well over a decade is necessary. The drill ship must be an icebreaker with sufficient engine power to keep position even in difficult ice conditions. For targets in the central Arctic icebreaker support still be necessary to keep position in 3-5 m thick sea ice.

THE LONG-TERM HISTORY OF ICE-SHEETS AND PERMAFROST IN THE SIBERIAN ARCTIC: SHALLOW-WATER DRILLING IN THE LAPTEV SEA

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The Arctic comprises some of the most sensitive elements of the global environment, which are considered to respond rapidly to climate change. In this context the Laptev Sea and its Siberian hinterland are of particular interest. River discharge into the Laptev Sea constitutes a key source for the Arctic halocline's freshwater budget and the shallow Laptev Sea shelf is a major ice production area, linking the Siberian shelves to the Arctic Ocean and the Nordic seas.

During the past years Russian and German scientists systematically investigated the extreme environmental system of the Laptev Sea in the Siberian Arctic to decipher the mechanisms which controlled past climate variations as well as ongoing environmental changes. However, our knowledge of the processes which drove the system in the past is still very limited because only a few short sediment cores have been obtained so far. For instance, the TRANSDRIFT VIII expedition in 2000, the first scientific drilling leg to the Siberian Shelf seas, recovered sediment sections in the Cenozoic-age rift system of the eastern Laptev Sea to study Arctic climate changes on time scales beyond the Holocene. Because of the shallow water depth of the Laptev Sea shelf, one major objective of the expedition was to investigate whether past sea-level lowstands caused the development of permafrost also on the shelf. For this purpose, the TRANSDRIFT VIII shipboard party cored 5 holes at 3 sites in the northeastern Laptev Sea onboard the Russian drilling vessel NIS KIMBERLIT. During this short pilot leg (only five days), a total length of 40 m of sediments were recovered. The sediments show that submarine permafrost exists at two sites already at about 9 m below sea floor. Shipboard results indicate the occurrence of different types of permafrost-affected sediments. At all instances, however, ice-bearing and ice-bonded sediments were discovered, verifying for the first time the existence of submarine permafrost in the Siberian Arctic.

Based on this successful pilot phase it is planned to continue drilling in the Laptev Sea along a transect from the continental slope to the Siberian hinterland during the next five years. The proposed drill sites are in the seasonal ice covered eastern part of the shallow shelf, where already a detailed site survey has been carried out, as well as in the region of the Lena Delta. The primary goal of drilling is to recover long sediment cores (up to 120 m below sea floor) in order to study Arctic climate changes since Pliocene times. This will include the following specific objectives:

- centennial - to millennial-scale paleoclimate changes during past glacial/interglacial cycles;
- long-term history of ice-sheets and permafrost, land/ocean-sediment flux, river discharge, and Arctic biota;
- sea-level cycles and their environmental effects;
- sources and sinks of greenhouse gases.

Drilling in the Laptev Sea will be carried out by Russian research vessels, such as KIMBERLIT, and/or by mobile platforms from the fast ice. Offshore and onshore drilling is considered to open up new perspectives to interpret the longer-term climatic history of the Laptev Sea region and, thus, of the Siberian Arctic.

THE DYNAMICS OF GIANT SUBMARINE LANDSLIDES - AN ALTERNATE PLATFORM APPROACH

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Giant, catastrophic landslides are among the most powerful natural hazards on Earth. On land they may reach volumes and travel distances of 10-10^2 km^3 and 100 km; below the sea, they may reach 10^3-10^4 km^3 and 200 km or more. The travel distances are extraordinarily large and suggest that parts of a landslide must advance as a granular flow. However, the dynamic regimes of emplacement are poorly constrained, because giant landslides are rarely seen in operation and because, apart from surface layers, only limited data are available about the nature of their deposits. A programme of drilling through the complete thicknesses of submarine landslides would yield new and essential constraints on quantitative models of giant landslide dynamics.

Catastrophic, giant collapses are recorded about 3 or 4 times a decade on land. The frequency of giant submarine events is less-well constrained, but may approach a similar order of magnitude. In addition to threatening communication lines across the sea floor, giant submarine landslides severely disrupt sea-bed habitats and can trigger regional tsunami. Their lengths increase with volume along a trend overlapping that for subaerial landslides, while their size and gross surface morphology, as determined by sonar, provide the closest analogy for giant landslides identified on the terrestrial planets. Understanding the dynamics of giant submarine landslides is thus important not only for reducing marine hazards, but also for investigating the behaviour of subaerial and extraterrestrial analogues.

Current models of subaerial landslides favour a granular-flow mechanism to account for the long runout of giant collapses [1]. Energy loss is thus attributed to fragments colliding, sliding and rolling past each other, as well as to any viscous deformation of an interstitial medium, such as mud, water, or a well-packed powder matrix [2,3]. Although collisional losses are often assumed to be dominant, friction in the interstitial medium may be equally important. Also unresolved is whether rates of energy loss are controlled by deformation in a basal boundary layer or by fragment interactions throughout a landslide.

Improved contraints on dynamic regime can be expected from structural and textural analyses of landslide deposits. Crucial is the ability to sample the whole thickness of a landslide at different locations along its length. For example, the granulometry of a deposit will help to evaluate the relative importance of collisional and interstitial energy losses, while granulometric variations can be used to identify horizons of concentrated deformation.

Ocean islands are ideally suited for investigating giant landslides. Volcanic islands, in particular, are commonly steep sided and prone to major collapse several times during their growth. Among archipelagos, moreover, several deposits are normally available for sampling within a restricted area. The Canary Islands are among the most promising sampling locations in the Atlantic Ocean. All seven islands in the archipelago show evidence of submarine failure [4] and a number of the landslide deposits have been scanned by sonar [5]. Sampling would require drilling through ~10^2 m of deposit at sea depths of some 3 km. Ideally, at least three locations would be sampled along the length of a landslide, representing proximal, medial and distal facies. Suitable deposits for study include the Güimar, Orotava and Cañadas landslides around Tenerife, and the El Golfo and El Julan landslides from El Hierro. Sample cores will be used to investigate structural and textural variations within a deposit. The data will be incorporated as boundary constraints into first-order scaling models, to quantify limits on emplacement regime. Additional constraints will be applied from data already available from subaerial landslides [1]. The results will be used to define a dynamic regime map for giant submarine landslides, providing a foundation for future quantitative hazard analyses.

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DRILLING ARCTIC OCEAN MARGINAL PLATEAUS : KEY TO THE COMPLEMENTARY HISTORIES OF ARCTIC PLATE KINEMATICS, THE EVOLVING POLAR WATERMASS AND GATEWAY CONNECTIONS TO LOWER LATITUDES.

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Summary
The Arctic Ocean is roughly four times the size of the Mediterranean, and one third of this area comprises shallow seas. An icegoing drilling platform would provide access to geologic records from several marginal plateaus (w.d. < 2000 m) which hold the key to the main stages in evolution of the deep basins of the Arctic Ocean and the timing of their deep tele-connections to the global water masses. Condensed sections of fine-grained sediment on marginal plateau depocenters and sampling of sediment drifts along some of their slopes would be invaluable in reconstructing the Cenozoic paleoceanographic and paleoclimatic history of the Arctic.

Evolution of the polar environment
Geological data from the circumpolar polar continents and limited coring of marginal plateaus in the Arctic Ocean, together with geophysical data, indicate that the present deep basins of the Arctic Ocean formed in at least two stages. From its creation in the early Early Cretaceous, until opening of Fram Strait connected it to the Atlantic in the late Paleocene, the Arctic Basin was landlocked except for shallow, epicontinental connections to the Atlantic via the Western Interior Seaway in North America and to Tethys via the Turgai Strait in western Siberia.
The first stage of opening created the Canada Basin of the Arctic Ocean during the early Early Cretaceous by rifting of Arctic Alaska and Chukotka away from the Canadian craton triggered by tensional stresses associated with the SiberianTraps/Iceland Hotspot in conjunction with distal effects of subduction at the North Pacific Rim. Short cores from Alpha Ridge with abundant diatoms and silico-flagellates indicate a warm Late Mesozoic ocean with upwelling conditions. The second stage of opening created the Eurasia Basin by the extension of North Atlantic sea floor spreading into the Arctic region between Svalbard and Greenland.

The first indication of an Arctic-Atlantic seaway is suggested by occurrences in northern Alaska and Ellesmere Land of late Paleocene mollusks and ostracodes previously known only in northern Europe. In the Alaska/Chukota sector of the Arctic Ocean marine invertebrate biota were dominated by Atlantic taxa until opening of the Bering Strait from 5.5 to 4.8 Ma., after which Pacific taxa dominated. Opening and closing of the Pacific gateway had a major control on terrestrial faunal exchange between Asia and North America. Opening of the Fram Strait gateway has been linked to intensification of bottom water formation. However, direct geologic control on the evolution of the Fram Strait gateway is non-existant, except that sediments from Site 909 in the deep central part of the Fram Strait suggest no dramatic changes in bottom water activity during early Miocene to Pliocene. These sediments most likely postdate gateway opening. Other sites drilled on sediment drifts on the northwestern Svalbard margin did not penetrate the Pliocene section.

How can the geological record from the marginal plateaus contribute to constrain the evolution of a polar watermass and tele-connections to the global ocean?
Piston coring on the Alpha, Lomonosov and Northwind Ridges of the Arctic Basin has yielded information on their stratigraphy and plate kinematics, contributed age constraints on the Canada Basin, and provided information on latest Cretaceous, early Paleogene, late Neogene and Quaternary paleoceanography and paleoclimate of the central Arctic Basin. They have also revealed a history of Paleogene alkalic volcanism on Alpha Ridge that may have important tectonic and paleoclimatic implications. It would appear assured, therefore, that sampling of the condensed Cretaceous, Tertiary and Quaternary sedimentary sections that have been identified on the Arctic marginal plateaus as well as a major sediment drift along the northern flank of Yermak Plateau will provide a means for assessing the paleoceanography and paleoclimate of the Arctic Ocean from the Cretaceous through the Holocene. Drilling of depth transects will enable definition of water mass characteristics through time. This together with more precise geologic control on gateway evolution will provide a more rigorous reference for assessments of the impact of an Arctic tele-connection on the global thermohaline circulation through the Cenozoic.

State of readiness for scientific drilling
A number of good targets have already been identified by reconnaissance seismic reflection surveys on Northwind Ridge/Chukchi- and Yermak plateaus. Limited seismic data are also available from Morris Jesup Rise. Also high resolution chirp sonar data and swath bathymetry exists from parts of Northwind Ridge/Chukchi- and Yermak plateaus. Seismic reflection surveys of additonal potential sites would optimize the chances of achieving important scientific results.

Technology required
All marginal plateaus are covered by sea ice during the summer. An icegoing drilling platform with capabilities for at least 2000 m drill string is required for a minimum of 3 seasons.

SHALLOW OFFSET DRILLING ON THE EAST GREENLAND VOLCANIC RIFTED MARGIN

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A significant proportion of the early Tertiary North Atlantic large igneous province is preserved below sea level along the continental shelf of East Greenland. This magmatic record provides a unique opportunity to characterize the influence of the Iceland plume in space and time during the development of this volcanic rifted margin. A high-resolution record of early Tertiary magmatism closest to the plume track is preserved on-shore in the Blosseville Coast region (68^{o} N). A complementary record distal to the Iceland plume track (63^{o} N) was recovered during ODP Legs 152 and 163, and suggests that a decoupling of the thermal and compositional nature of the plume takes place between 63^{o} N and 68^{o} N. However, little is known about contemporaneous magmatism between these two regions 600 km apart. Recent reflection seismic data indicate bare-rock exposure of breakup related seaward-dipping (10-20^{o}) volcanics on the inner Southeast Greenland shelf between 65-66^{o} N. These volcanics should be accessible for stratigraphically controlled sampling through shallow offset drilling. This has been confirmed using the British Geological Survey Seabed Rockdrill from the Finnish Research Vessel ARANDA. Conditions varied from excellent bare-rock (< 0.5 m of glaciomarine overburden) with good recovery of basement lithologies to difficult or impossible conditions with more than 2 m of clast-loaded overburden. Extensive work along a transect at 65^{o} N recovered core from more than 20 sites representing a minimum of 5 km of lava stratigraphy, including metamorphosed olivine-rich lavas of a pre-breakup series and more pristine plagioclase phyric basaltic lavas of an oceanic series. The samples obtained through this shallow drilling fill in important gaps in regional coverage by the deep ODP drilling and provide jointly with onshore studies a good example of integrated land studies, shallow marine coring and deep marine drilling.

CLIMATE HISTORY OF THE MEDITERRANEAN OUTFLOW CONTOUR CURRENTS OR CONTOURITES OF THE FARO DRIFT AND GULF CADIZ AS A RESULT OF THE MEDITERRANEAN OUTFLOW

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OBJECTIVES

1. Drifts offer the advantage of high sedimentation rates with potential high resolution paleoceanographic and paleoclimatic records preserved, and thus a unique opportunity to study high frequency climate variability of flows during the last glacial/interglacial marine cycles. Our proposal focus on the Faro Drift and the Gulf of Cadiz as optimal sites to monitor the MOW short and long-term scale temporal variations in current velocities and intensities.

2. The Gibraltar Straits acts as a gateway from the semienclosed Mediterranean Sea to the Atlantic Ocean – high-resolution sedimentary records back in time million years give insights into the Plio-Pleistocene evolution of the cooling hydrographic conditions since the Mediterranean Messinian salinity crisis (6Ma). Seismic profiles indicate a 600 m thick Faro Drift aged 4-5 m.y. (Faugères et al., 1985).

3. Gas Hydrates (ver ODP 172 vol, pag9)

The Faro Drift is located in an area with frequent and active downslope processes, given the presence of various small submarine canyons, and slope unstability related to the presence of gas hydrates ? ? ? ?

PREVIOUS WORKS

Previous studies in the Faro Drift and G. Cadiz have been limited by poor geophysical data and core recovery (Faugères et al., 1985, Faugères et al., 1986, Nelson et al., 1993).
New generations of seismic profilers, high resolution swath bathymetry (Discovery 244, Kenyon et al., XXXX ; USA-GardnerXXX ; TTR9, XXX; and Discovery 249, Weaver et al., 2000) and coring devices made recently available six giant piston cores 20 m long corresponding to about 40 ky in time scale (Images V, MD114, Leg5, Thouveny et al., 1999).

In sinthesis, the main objectives of the up to present works focus on: the activity of the contourite system related to the MOW; sediment deposition under different current flow regimes; long and short term climate control of sediment transport and erosion; understanding of recent deepsea sedimentary processes; effects of the interaction of across slope processes with alongslope currents; and estimation of rate and scale of sedimentary bodies change.

Other drifts in the Atlantic Ocean have been subject of paleoclimatic study during DSDP Leg 94 (Feni and Gardar Drift), ODP Leg 162 (Feni, Gardar and Bjorn Drifts) and ODP Leg 172 (Blake-Bahama Outer Ridge)

SCIENTIFIC QUESTIONS

Many are the questions for which we would like to find answers with this proposal: Has the strengh of the Mediterranean outflow been intensified during glacial-interglacial cycles, with loweringrising of sea level? Which was the magnitude of the change? Will we be able to compare various glacial and interglacial cycles? What kind of imprint had the slope and bottom currents left in the contourite sediments? Is the sedimentation rate on the Faro Drift high enough to record short-term climate and oceanographic events? How significant was the long-term paleoceanographic variability during those cycles? To which extent do slope processes (turbidity currents) interfere in the alongslope processes (contour currents)? How important is the bottom morphology in the geometry of the drift? How is the Plio-Pleistocene oceanic cooling reflected in the Drift hemipelagic sediments? How is the Messinian salinity event registered?

STRATEGY

To fulfil the objectives, two transects across the Faro Drift (600 to 1200 m) and along the outflow in the G.Cadiz (600-2000m) are proposed.

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TAGUS ABYSSAL PLAIN: SEDIMENT TRANSPORT THROUGH SUBMARINE CANYONS

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OBJECTIVES

To calculate the budget and identify the sources of sediments transported from the shelf, through the Cascais and Lisbon-Setubal canyons, to the Tagus Abyssal Plain (TAP).

PREVIOUS WORK

Only two works (Lebreiro, 1995; Duplaix et al., 1965) have focused on the sedimentary history of the Tagus Abyssal Plain. In her Ph.D. thesis, Lebreiro (1995) studied the last 70 ky of the sedimentary infill of the plain, based on piston cores 9 m long, collected onboard the British RV Discovery (Weaver et al., 1989). The reconstruction of the TAP geological history, in terms of sediment provenance, canyon source, proximal fans and temporal scale (Pinheiro et al., 2000, Lebreiro et al., in prep.) was very limited by the cores size and equipment capacity to drill coarse sand spots. Our proposal relies on the new sampling of the conducts to identify the sources of sediments and to track paths as well as to calculate the volumes transported to the TAP, and longer records through the basin area to expand the TAP infilling.

In 1999 on board the Prof. Logachev-TTR9 cruise, the Portuguese margin slope and the TAP proximal area, including the source canyons, were covered by Okean side scan sonar imagery (Kenyon et al., 1999) indicating present-day activity in the Setubal-Lisbon system, but not in the Cascais canyon mouth.

Other abyssal plains have been targeted in ODP Leg 123 (Argo AP), ODP Leg 149 (Iberia AP) and ODP Leg 157 (Madeira AP).

SCIENTIFIC QUESTIONS

The following are some of the questions our proposal aim to answer:

1. How much volume of sediment was transported from the shelf to the Tagus Abyssal Plain along time?

2. Do canyons function as traps for sediments or a pass-by via? In the first case, is the sediment retained mainly in the head, the canyon or the fan domain?

3. Which characteristics and behavior have the depositional flows?

4. Is there a preferential source of sediments? A switch between canyons ?

5. Which factors controlled the emplacement of detritic flows to the Tagus Abyssal Plain ? Is the canyon activity enhanced during high/low sea levels or transitions between glacial/interglacials? How much do tectonics and seismicity contribute ?

STRATEGY

Along the canyons, we propose,

- to drill 4 sites along the Cascais Canyon (on the head at aprox. 200 m, in the canyon at 2500 m and 4800 m, and on the deep fan at 5100 m); and 4 sites along the Lisbon-Setubal Canyon

(at 50 m and 80 m on both heads, at 2500m in the canyon after the two individual canyons joint, and at 5100 m on the deep fan).

On the plain itself, we propose,

♣ two sites, one in the deepest part of the plain to collect the longest sedimentary record, and the second closer to the northern border of the Gorring Bank to check a potential additional source of sediments.

NEED FOR ALTERNATIVE PLATFORMS

To fulfil the drilling objectives, the following alternative platforms are needed:

- shallow water plus rotary system to recover sediments in the canyon heads
- deep water combined with rotary system to be able to recover sands at the deep fans in the canyon mouths.

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WHY A DRILLING PROPOSAL IN THE ENGLISH CHANNEL FOR 2003 INTEGRATED OCEAN DRILLING PROGRAMME ?

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The "Channel system", *système Manche*, stretches out from the shallow water of the south of the North Sea to the deep sea fans in the gulf of Biscay. It includes the English Channel, the Western Approaches and the Continental Slope of the Celtic Margin. The "Channel system" is linked upstream with the drainage basins of rivers such as Seine, Somme, Solent and, probably during some lowstands, with other streams such as Rhine and Thames when the North Sea was overridden by the ice and when they were diverted southward to the English Channel (Figure 1).

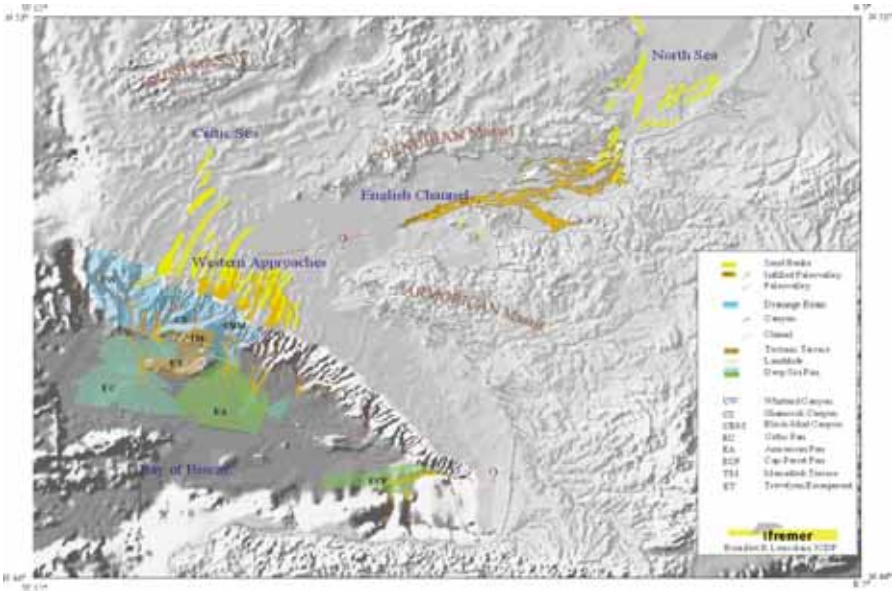

Figure 1 : The Manche paleoriver system (Bourillet and Lericolais, 2001)

Major tectonic events structured the margin as extensive phase (opening of the Atlantic during the Cretaceous) or as compressive phase (Pyrenean orogenesis during Mid-Tertiary) responsible for the Hurd Deep graben. Then the prograding prism builded up during Neogene (Jones and Cockburn formations) was remoulded during the glacio-eustatic period of the Plio-Quaternary with the setting up of the giant sand banks close to the shelf break.

Through the last 3 Ma, the "Manche" paleoriver settled down on the NE-SW post-carboniferous syncline between the Cornubian and the Armorican ridges. The system is characterized in the Eastern English Channel by a paleovalleys network ending up in the Hurd Deep. Some on-land rivers were or are directly linked to this network. Infilled or dry paleovalleys incise the cretaceous chalk during the very lowstands. In contrast, the Western part of the English Channel does not present any paleovalley. They reappear in the Western Approaches cutting the Cockburn formation and in places the top of the Jones formation. Some of these paleovalleys reach the shelf break and join to the upper canyon network of the slope. The canyon network

presents an organization similar to on-land drainage basins. The Western Approaches continental slope is divided into two basins. The eastern one leads to the Armorican deep sea fan. The western basin is one of the two tributaries of the Celtic deep sea fan.

The infills of either the Eastern English Channel paleovalleys, the Hurd Deep or the Western Approaches paleovalleys are made up several nappes. Seismic profiles do not show any continuity of either those nappes from one sector to an other or between the layers of the upper slope and those of the deep sea fans. The only means to study their relationship, the stratigraphy and the paleoenvironments lie in the absolute dating and the mineralogical signatures which could be obtained from analysis of drillholes. The main questions regarding the Channel system are as follow : the ages of the four layers in the Hurd Deep, when and where do the Rhine sediments arrive ?, what is the age of the paleovalleys incision ? What is the age of the sand banks ? are they only tidal features or erosional features ? do the sediments trapped within the Neogen prism contribute to the budget of the deep sea fan ? is the English Channel sediment signature different from this of the St Georges Channel?

Drillholes already exist. The UK sector and to a lesser extend the French sector of the syncline was intensively studied for hydrocarbon goals. The DSDP programme carried out two campaigns on the continental rise and slope for the study of the deep structure of the margin. However in both cases, the wells were not selected for a sedimentological purpose and the soft layers were not or poorly recovered. Based on recent works conducted within the MAST 1 Resecused project, the MAST 2 Starfish and Enam 1 projects or on current works conducted within the MAST 3 Enam II project, the French Sedimanche programme and the "Channel group" network, we propose three sites along a transect trought the area.

Our first priority is the Hurd Deep. It records sediments depositions from small amplitude low sea-levels which could be correlated with the known on-shore sea-levels.

The seond priority is the shelf break including the youngest layer of the Neogen prism, the Little Sole formation over the Cockburn and Jones formations.

The third priority is the outer shelf with the paleovalleys network incising the Jones formation and the overlaying sand banks.

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THE LAURENTIAN CHANNEL: LATE AND MIDDLE QUATERNARY RECORD OF SEA/ICE SHEET INTERACTIONS IN THE NORTHWEST ATLANTIC.

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Background / Rationale: During the last deglaciation, a deep reentrant of the eastern Laurentide Ice Sheet (LIS) formed in less than a thousand years in the gulf and estuary of the St. Lawrence River, mainly as a result of the rapid collapse of a coupled ice shelf/ice stream system [1,2,3]. Our proposed drilling sites will provide a high resolution record of sea/ice shelf/ ice stream interactions in a region where shelf collapse occurred less than 600 km from a major outflow center of the LIS, a situation which is perhaps the best analog to the West Antarctic ice shelves[4] in the current context of rising sea level.

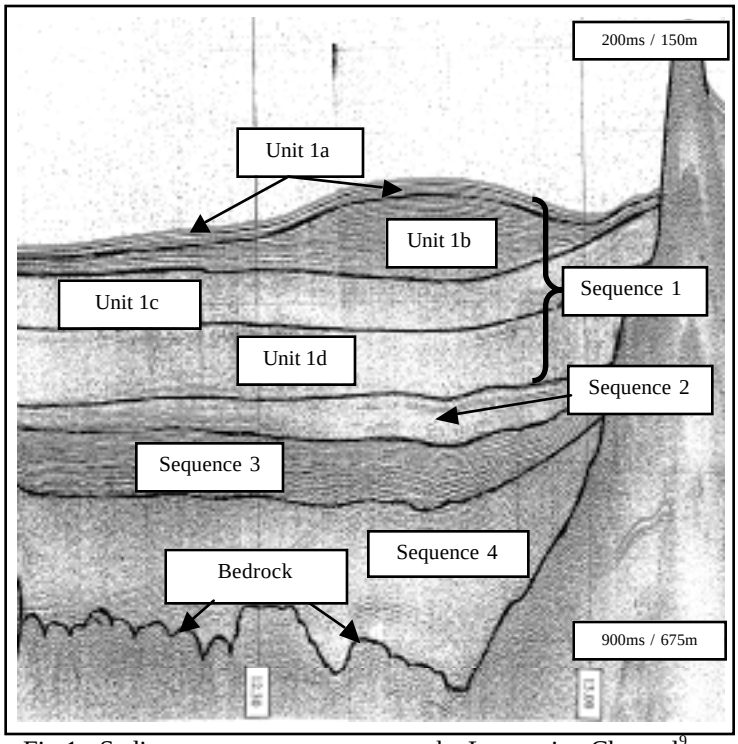

Fig.1: Sedimentary sequences across the Laurentian Channel[9]

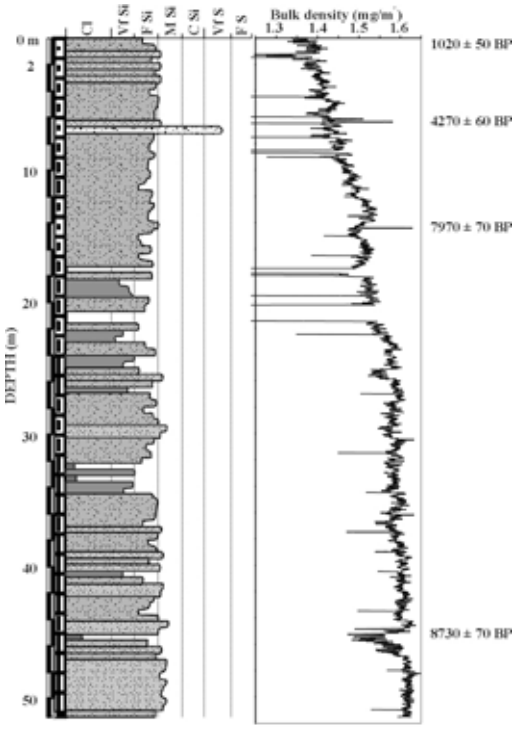

Fig. 2: Core MD99-2220 (units 1a,b,c)

Impact/Objectives: The two projected boreholes will have multiple impacts, most importantly providing a high resolution record of ice stream/ice shelf/ocean interactions during the 14000-10000 years BP interval, a period of rapid environmental change and rising sea level, including a proximal marine record of the Younger Dryas. This record is particularly timely in view of concerns about the stability of West Antarctic ice shelves. The St. Lawrence Estuary boreholes will also provide the first

>long= record (4 stacked sequences), possibly spanning the Late and Middle Pleistocene, and will establish relationships between this proximal marine record and LIS dynamics and chronology.

Location/description: The Estuary and Gulf of St. Lawrence are the site of a major submarine trough, 300 to 400 m in depth and 60 to 80 km in width, extending over a distance of 1200 km to the edge of the Scotian Shelf. This trough (Laurentian Channel) served as one of two major outlets for the eastern Laurentide Ice Sheet. The southeastern outlet was fed by the St. Lawrence Ice Stream (SLIS), which controlled deglaciation patterns and events in all regions adjacent to and upstream of the channel during the last deglacial cycle[2,3] and presumably during earlier ones. The provenance of ice-rafted detritus in North Atlantic Heinrich layers[5, 6, 7, 8, 9] indicates that the two main LIS outlets, the SLIS and the Hudson Strait Ice Stream, differed significantly in timing and response. At ~ 14 000 y BP, the Laurentian Channel formed a major, shelf-covered reentrant within the LIS and is thus expected to yield a high resolution record of the ensuing period of global deglaciation and rapidly rising sea level. Recent seismic profiling (1996-1999) with 1 and 4 kJ sparkers in the lower estuary site has revealed 4 megasequences of marine and glaciomarine sediments[9] filling a deeply entrenched channel (Fig. 1). The upper sequence, which unconformably overlies the last glacial-interglacial transition (125 ky), is about 250 m thick; piston coring during the MD-99 IMAGES cruise has confirmed an Holocene age for the upper 51 metres (Fig. 2). Below the unconformity, three additional stacked sequences, partly eroded in their upper part, fill an underlying rugged topography that may be Tertiary in age. At site 2, in the shallower middle estuary, near Iles-aux-Coudres, seismic surveys also provide a record of several stacked sequences below the last glacial-interglacial transition, which was sampled by a land-based borehole in the early nineties[10, 11] .

Planned work: The first campaign (2002) will be a general site survey aimed at assessing the nature of the seafloor at the lower and middle estuary sites. At each of the two sites, this will include SEAMAP swath scan bathymetry and a standard site survey with 1 and 4 kJ sparkers. The second phase (2003) consists of drilling at the two sites: (1) The lower estuary borehole (site 1: Laurentian Channel) at ~300 m water depth, (2) the middle estuary borehole (site 2: Iles-aux-Coudres channel) at 10-30 m water depth (drilling platform). Drilling will be followed by a multidisciplinary (stratigraphy, sedimentology, lithology, paleontology, geochemistry and geochronology) assessment of the cores. This project could be a component of the larger LISO (Laurentide Ice Sheet Outlets) proposal.

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GEOCHEMICAL APPROACHES AND DRILLING PERSPECTIVES FOR PALEOENVIRONMENTAL RECONSTRUCTION IN THE WESTERN MEDITERRANEAN

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The western Mediterranean is considered an excellent natural laboratory for monitoring global and regional climate changes. High sedimentation rates together with a continuos sedimentation in this region provide optimal conditions for ultra-high-resolution analyses ($< 10^3$ years) focused on palaeoenvironmental reconstructions. Geochemical proxies have been used to assess the sensitivity of the eastern Mediterranean to past climate changes, such proxies have not been applied as extensively to monitor climate changes in the western Mediterranean. Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP) results as well as field studies in uplifted marine sections of the eastern Mediterranean provide a detailed geochemical record of sapropel deposition. ODP Leg 161 has demonstrated the deposition of organic rich layers (ORLs) in the western Mediterranean (Comas, Zahn, Klaus et al., 1996). Western Mediterranean ORLs are however not well documented mainly because of the small number of samples available compared to eastern Mediterranean locations, and also because the sapropel/ORLs identification in the westernmost Mediterraneanis not so straightforward.

In the eastern Mediterranean, geochemical evidence, essentially based on biogenic barite concentration, support enhanced productivity as the main cause for the most recent sapropel deposition.The barite-enriched horizons record the original sapropel thickness prior to partial oxidation. Detrital element concentration in the sapropel layers reveal lower eolian inputs, which support increased precipitation/runoff likely responsible for the higher nutrient supply leading to increased productivity. This geochemical record in most of the eastern Mediterranean locations where S1 interval was analyzed is relatively similar. At ODP Site 976, in the Alboran Sea Basin, color and organic carbon content are not indicative of S1sapropel deposition. The very high sedimentation rate at this site, results in organic carbon content of less than 1%. Furthermore, anoxic diagenesis in this site has led to very poor barite preservation. Ba enrichment is not recognized in the S1 sapropel interval, while extensive pyrite development took place. Post depositional processes may have caused a significant alteration of the original geochemical record, thus compromising interpretation. These conditions are most likely restricted to the Alboran Sea basin while further East, in the southeastern part of the South Balearic basin, an excellent sediment interval containing a sapropel layer was recovered during the Basacalb cruise (TTR-1999). At this location, high sedimentation rates allow a very high resolution analysis of the sapropel interval. Here color, thus organic carbon content, is clearly indicatative of the sapropel layer. Moreover, Barite in this core seems to be very well preserved and a similar geochemical record to the eastern sapropel layer is recognized. This suggests that mechanisms responsible for sapropel deposition occurred throughout the Mediterranean which has important implications to

global climate change. A more detailed record of sapropel deposition in this region requires future drilling in selected sites targeted to reconstruct ocean dynamics (circulation changes and water masses characterization), atmospheric input (eolian fluxes), the lithosphere imprints (sedimentary regime) and the biosphere characteristics (biological productivity), and their response to past climate changes. Furthermore, ultra-high-resolution analyses in the western Mediterranean will allow documenting water mass exchanges and assessing the regional influence of the Mediterranean on the Atlantic ocean. The western Mediterranean and the connecting Atlantic regions should therefore be considered as appropriate candidates for future drilling aimed at paleoenviromental reconstructions. Such drilling objectives should be included in combined-platform proposals.

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Global Sea Level and the Architecture of Passive Margin Sediments: Shallow-Water Drilling of the New Jersey Continental Shelf

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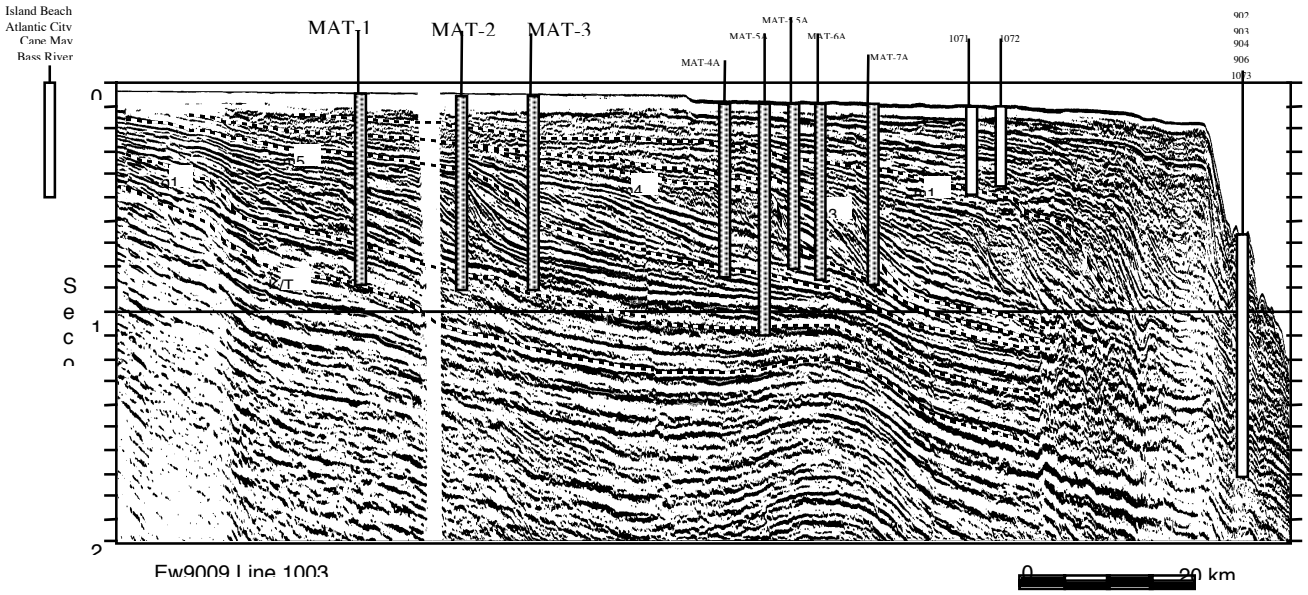
We propose to drill three sites on the inner continental shelf of New Jersey (Figure 1) to estimate amplitudes and rates of Cenozoic global sea-level (eustatic) change and to evaluate the response of passive continental margin sedimentation to eustatic change in general. These sites will provide continuous recovery of siliciclastic sequences on a modern continental margin at locations chosen to provide definitive measures of sea-level amplitudes and to evaluate models of sedimentation and facies distribution. This will be the culmination of many years of effort in implementing "The New Jersey/Mid-Atlantic Sea-Level Transect" (MAT) strategy developed and endorsed by several advisory and review bodies. Prior MAT drilling has focused on the New Jersey slope (ODP Legs 150, 174A), outer shelf (ODP Leg 174A), and onshore (ODP Legs 150X, 174AX). Collectively these efforts have been successful in providing ages of sequence boundaries and tying each to the $\delta^{18}O$ proxy of glacioeustasy, yet have fallen short of the ultimate objectives because facies that register the most sensitive record of sea-level change, the paleo inner shelf, have not been continuously sampled. Consequently, a critical gap remains in the MAT concerning our knowledge of global sea-level change and its imprint on the stratigraphic record. We propose to obtain continuous cores and downhole logging measurements within crucial paleo inner shelf facies using a commercial jack-up drilling rig. The sites we propose, MAT 1-3, represent the most sensitive and financially accessible locations for deciphering amplitudes and testing facies models. By integrating our results with those derived from other sections in both shallow water and the deep sea, we anticipate that drilling MAT1-3 will allow us to: 1) provide estimates of eustatic amplitudes and generate a testable record of eustatic variations; 2) evaluate the effects of eustasy, tectonics, and sediment supply on the stratigraphic record; and 3) test models that predict the nature and distribution of sedimentary facies in passive margin strata.



PHOSPHATE AND ASSOCIATED SEDIMENTS ON THE WESTERN IBERIAN MARGIN: A RECORD OF OCEAN CHANGES

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The continental margin extends from the coastal environments, including estuaries and shorelines across the continental shelf and slope to the base of the continental rise or trench system. Sedimentary deposits of the continental margins are land derived clastic sediments and biochemical and chemical sediments resulting from oceanic processes. The interplay of these sediment types is a direct or indirect consequence of tectonic, environmental and biological changes. Therefore, the continental margin deposits potentialy preserve a record of changing global conditions

An understanding of the past changes in the North Atlantic Ocean can potentially be obtained through the study of the environmental records preserved in the authigenic mineral suites of the W Iberian Margin. There, a complex, though poorly understood, sequence of chemical and biochemical sediments is known to exist, both in Tertiary sedimentary rocks and in modern surficial sediments.

Background

Phosphatic sediments (phosphorites) and associated sedimentary assemblages have been extensively studied in recent years, particularly with the International Geological Correlation Program Project 156 and 325. That research has shown that phosphorites have formed at particular times in earth history and at preferred locations. Using the known spacial and temporal distribution it has been possible to develop broad-scale models wich relate phosphogenesis to changes in ocean chemistry and ocean circulation patterns and to relative sea-level change (Cook & Shergold, 1986; Notholt & Jarvis, 1990; Burnett & Riggs, 1990, Follmi 1994, Glenn et al. 2000). For the most part, these models have been developed for onshore Phanerozoic phosphate deposits ranging in age from Cambrian to Tertiary. Moreover in order to better understand the processes involved, attention is increasingly turning to the phosphate deposits which presently exist on, or immediately beneath, the continental margins in a number of areas, most notably eastern Australia, Chile-Peru and the southeastern United States. What has emerged from these studies is a new understanding of the role of marine processes such as sea-level change and upwelling, and of chemical or biochemical processes such as iron-phosphate cycling and apatite precipitation through cyanobacterial activity on phosphogenesis.

If we can "unscramble" the complex and interdependent processes of authigenesis and biogenesis on some of the more critical continental margins such as the Western Iberian margin, and the Moroccan margin, then we can unlock the history of upwelling in the northeastern Atlantic at time scales ranging from thousands to millions of years. If this is then linked to parallel studies proposed by other research groups for the southwest African and Peru-Chile margins then there is the potential to provide the "ground truth" for some of the current global circulation models and establish a history of global ocean change.

Scientific And Technical Description

The project proposed here is concerned with the critically important Iberian margin because of the known occurrences there of phosphatic and glauconitic sediments and because of the upwelling that occurs on this margin. As part of this study, the phosphatic/authigenic sediments will be put on a framework of high resolution stratigraphy based on biochronology and geochronology. In addition, cryptocrystalline carbonate fluorapatite (approximating to $Ca_5 (PO_4)_3 F, CO_3$) has the potential to provide a remarkable isotopic record comprising $\delta^{13}C$ (carbonate), $\delta^{18}O$ (carbonate) and $\delta^{18}O$ (phosphate) from the lattice, together with $\delta^{13}C$ (organic matter) and $\delta^{34}S$ (sulphides), and to related with genesis of phosphorites like $^{87}Sr/^{86}Sr$ and $^{234}U/^{238}U$. This combination of high resolution stratigraphy and a multi-faceted isotopic record is quite unique in terms of its potential for providing a record of ocean change that has not been adequately exploited. This study aims to correct this omission.

Authigenic sediments generally appear to have formed in the past in thinn transition zones between thicker and more uniform sequences of carbonate and siliciclastic or volcaniclastic sediments in continental margin environments. Some of these transition zone sediments occur in concert with major global changes, including changes in global tectonics, paleogeography, and paleoclimates that dramatically affected paleoceanographic environments. Thus, the presence and distribution of this authigenic sedimentary suite within the sedimentary column may record important global paleoceanographic and paleoclimatic changes, as well as concentrations of important mineral resources. But whilst we now have a general understanding of the empirical relationships, there are many fundamental questions to be answered.

Field operations

1.Surveying

The Iberian margin survey will complement existing data and will comprise up to 4 transects in each study area (Fig.1) from the coast to approximately 2000 meters water depth on the slope,

with appropriate cross tie lines and interline tracks in areas of particular interest. A suite of seismic equipment will be operated simultaneously to provide detailed information on the seabed and high resolution profiles of the subsurface

2. Sampling

Seabed samples and relativelly shallow cores will be collected at selected sites along the geophysical traverse lines at up to 150 stations. The equipment used will include: Giant Piston Corer; Tvgrab, Vibrocorer and Boxcorer.

3.Drilling

Up to 4 continuously cored boreholes will be drilled to several hundred meters depth, with at least one in each transect. This will require a drilling ship chartered for a total of up to 40 days.

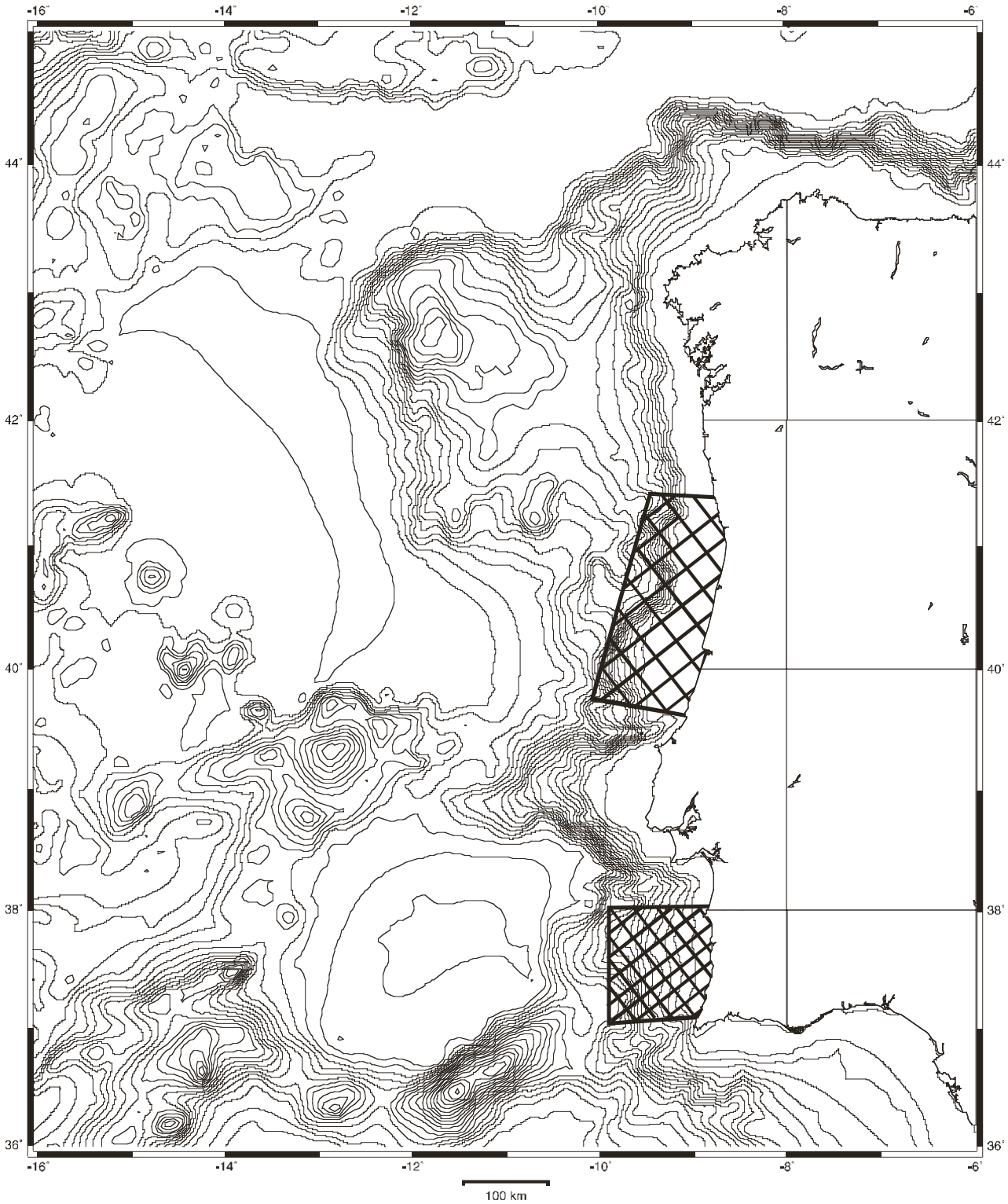

Fig. 1: The two areas of the Portuguese margin to be surveyed, sampled and drilled.

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Arctic Ocean Scientific Drilling: Fit-For-Purpose Strategies

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Introduction

Scientific drilling in the Arctic Ocean includes a wide range of targets over an even broader range of physiographic regions. The Nansen Arctic Drilling Program defined high priority earth science research in the areas of paleoceanography, tectonic evolution, sediment flux and continental margin evolution, and the lithosphere. These same research topics were recently reviewed and highlighted as important areas for study by the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES) Arctic Program Planning Group (APPG). The range of physiographic regions includes deep water basins, continental ridges, spreading ridges, shallow water continental margins, and large submarine fan systems. In comparison with scientific drilling in other oceans where variable water depths and sediment/rock types drive the selected drilling system and platform, the Arctic adds another dimension: varying sea ice conditions. This continuously moving, thick, and dense sea ice cover is the major consideration in the selection of fit-for-purpose drilling systems. In this context, a variety of drilling systems and platforms are described that are fit for the purpose of meeting scientific objectives in the range of sea ice conditions that occur in the Arctic Ocean.

Ice Conditions

In general, the sea ice conditions are quite different when comparing the central ocean basin with the marginal seas. During winter, the entire Arctic Ocean, including the marginal seas, are characterized by a continuous sea ice cover. However, in summer, the marginal seas have a highly variable sea ice cover and can be ice free for long periods of time. In contrast, the central ocean basin is usually ice covered all year with 97% coverage in winter (Fig. 1) and variable coverage during summer (85-95%).

Figure 1 Arctic sea ice imaged with Radarsat

The central ocean has two major surface water/ice circulation systems, the Beaufort Gyre and the Transpolar Drift. The Transpolar Drift moves ice and water from the Laptev Sea and East Siberian margin across the ocean to exit at the Fram Strait. This circulation system is characterized by younger, thinner ice. In contrast, the Beaufort Gyre circulates older, thicker sea ice anticyclonically in the western part of the ocean basin.

Fit-for-purpose Options

Due to the variability of sea ice conditions by region across the Arctic Ocean and seasonally, drilling systems will vary by location and by season. The types of systems that are needed to meet this wide range of needs for the Arctic Ocean can be described in four types:

(1) floating platforms in open, ice free water,
(2) platforms fixed to land-fast ice,
(3) platforms fixed to the seafloor, and
(4) icebreaking vessels in sea ice covered waters.

All of these systems have seen drilling success in the Arctic Ocean. Many of these successes come from activities in the Beaufort Sea where a significant amount of hydrocarbon exploration has occurred over the past 25 years. Another fit-for-purpose system is one currently in the planning stages within the Ocean Drilling Program (ODP) This is a fit-for-purpose suite of vessels for drilling and sampling a highly-ranked scientific target: the paleoceanographic sediment sequence on Lomonosov Ridge. Details of these examples and their applications in ocean drilling will be presented at the conference.

Summary

There is a growing awareness that we lack even the most fundamental understanding of the Arctic's climate and tectonic history, leaving large gaps in the global earth system. These gaps are beginning to be filled, as evidenced by the recently compiled bathymetry map (Fig. 2), the first accurate picture of this ocean floor for scientific research. These gaps must also be filled by the results from scientific drilling. There are significant physical challenges; but service industries at the 1st JEODI workshop agreed that technology exists to meet these challenges for successful Arctic scientific drilling. The strategies described here are examples of the expeditions that have used or soon will use these technologies. The experience is young, however, and should be viewed as a solid base for improving future Arctic operations. For example, the ODP Lomonosov program will be completed in 2003 at a location in the Transpolar Drift where ice conditions are less severe than the Beaufort Gyre. This experience is important for planning and conducting future programs in more severe sea ice locations.

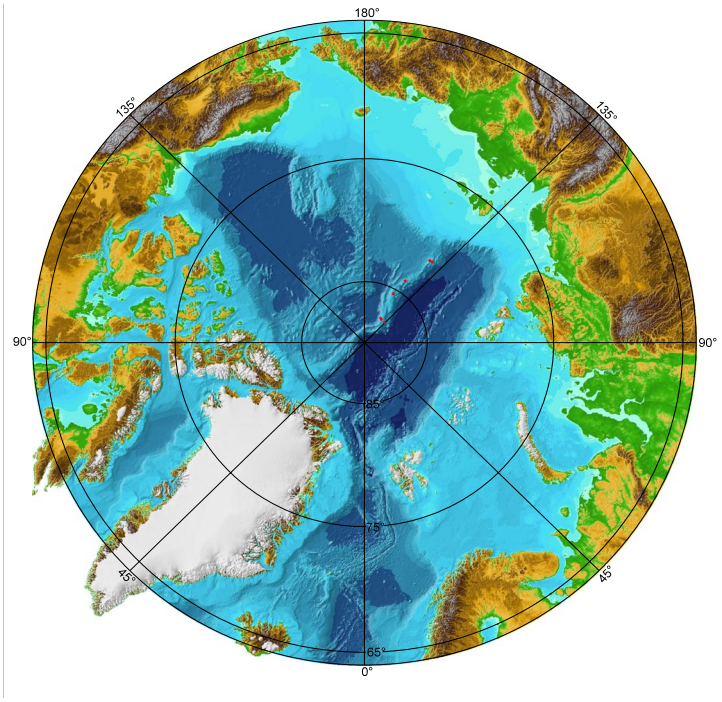

Figure 2 Arctic Ocean bathymetry (Jakobsson et al. 2000)

THE CORINTH RIFT LABORATORY

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Introduction :

In their guest to understand the hydraulic behavior of faults and fractures and their changes with stress variation, the geoscientists are still poorly armed. On one hand, data indicate that the rheology of the faulted strata plays a major role: shale may create clay smearing (Lehner & Pilaar, 1997) whereas, at temperatures over 80/100°C, pressure solution processes quickly seal fractures in sandstones after rupture (Moretti et al., 2000; Labaume & Moretti, 2001). The hydraulic behavior of discontinuities also appears to be stress dependent and may therefore change during the depletion of hydrocarbon fields. We are still unable to quantify these changes and to precise eventual thresholds. On the other hand, fluid pressure influences the friction on the fault plane and therefore changes the rate of displacement. A large number of seismologists consider that the low average friction coefficient in the large fault zones is due to high fluid pressure (Evans, 1993 and many others). Permanent and instantaneous hydraulic behavior of the faults and fractures under stress/strain excitation is obviously different due to diagenitic processes but the rate of these fluid/rock interactions, which could be related to the buildup of high pressures in the faults, is still the subject of debate.

To clarify these issue, a complete set of data is necessary, and European academic and private laboratories, as well as oil companies, have decided to pool their efforts to collect such a data set by creating the CORINTH RIFT LABORATORY (CRL) with the help of the EEC. The goal is to investigate fault mechanics and their relation to fluid flow and earthquakes by continuous monitoring of strain, seismicity, fluid pressure and geochemistry at the surface and at various depths in boreholes intersecting active faults.

This natural laboratory is centred on the south shore of the Corinth rift, near the city of Aigion (Fig 1). This rift is the most seismically active zone of the EU and the fastest area of continental break-up with 1.5 cm/yr of North-south extension and more than 1 cm/yr of uplift of the southern shore (Tselentis & Makropoulos, 1986). This high rate of displacement leads to the outcrop of very recent fault planes with large offsets and excellent exposure. The studied faults affect Cretaceous carbonate rocks similar to the ones that constitute the reservoirs of many hydrocarbon fields, in southern Italy as well as in the Middle East. The seismogenic zone starts at around 5.5 km depth and the project is to drill it in about 4 years time.

Up to now, the funding obtained to create the CRL (4 accepted EC projects: CORSEIS, DG-LAB, 3F-CORINTH, and AEGIS, plus a couple of national efforts) covers:

- Surface arrays of accelerometers, GPS, seismic stations over an area of 30 by 30 km,
- Several shallow wells for strain, stress and fluid flow monitoring

- 4 wells, 500 to 1200 meters deep, on active faults
- Permanent geochemical stations
- Data transfer and storage, including data base management
- Cross-training of geophysicists and IT specialists.

A total of 23 European groups are involved in the consortium.

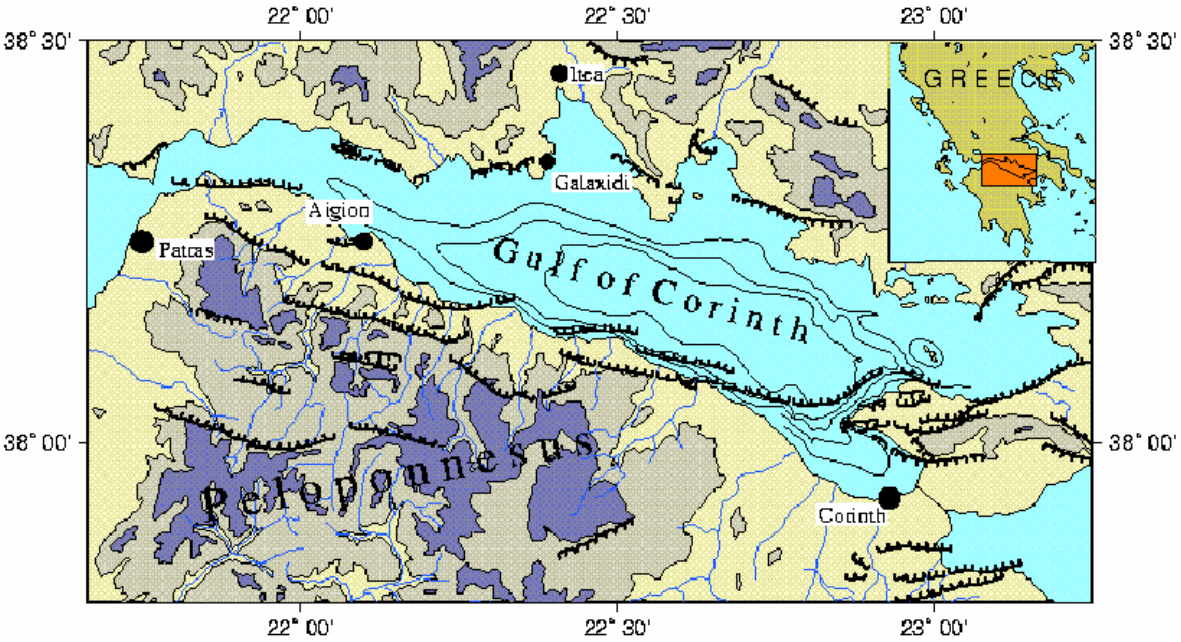

Fig 1: Structural map of the Gulf of Corinth area, modified from Rigo et al. (1996). The fault which will be monitored outcrops at the Aigion City.

Our goal is to obtain:

- A complete record of stress, strain and fluid flow versus time in, above, and around an active fault plane
- Recent and present strain through paleoseismology and GPS
- Seismic and aseismic transients and earthquake precursors
- No-linear effects of soft soils on strong motion
- Seismic hazard assessment methodology
- A precise description of the geometrical complexity and of the resulting anisotropy of the carbonate around the fault plane
- 200 meters of core and a large set of logging + borehole imaging data (DSI, FMI, BHTV…)
- A complete knowledge of the chemical composition of the current fluid above, below and around the fault zone, before (Fig 2), during and after an earthquake. These analyses will be carried out by a newly-developed permanent geochemical monitoring system (GMS II, Quattrocchi et al., 2000).

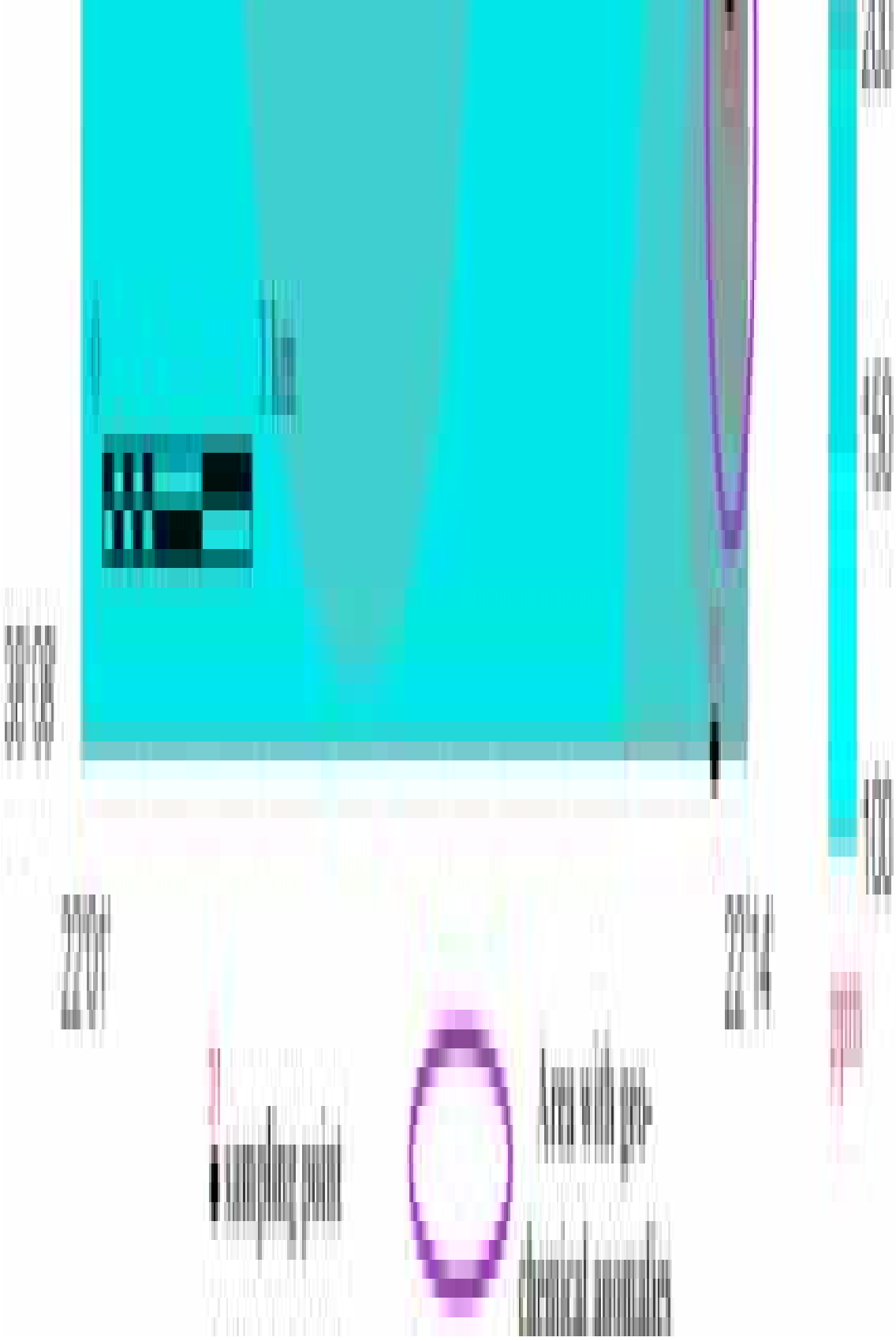

Fig 2 : CO2 concentration anomalies in relation with the structural position (measured by ING)

All the data will be integrated through description of the fracture network, modelling of fault behaviour, modelling of fluid/rock interactions, and modelling of micro-seismicity in terms of stress changes and fluid pulses.

Schedule :

The wells will be drilled during autumn 2001, after a seismic survey has been performed to define their optimum location; installation of permanent surface arrays already started in April 2000, and geological fieldwork started in June 2000.Geochemical monitoring started in September 2000.

Next steps:

The second step of the project will be the monitoring of the seismogenic zone located below the Gulf of Corinth between 5 and 12 km depth as shown on Fig 3. Various technical options are possible for the well: a deviated onshore well from the northern or southern shore or an offshore well. Our main goal is, as described previously, the monitoring of the fault and the search for earthquake related fluid flow variations. We therefore need to have a permanent access to the well for a couple of years

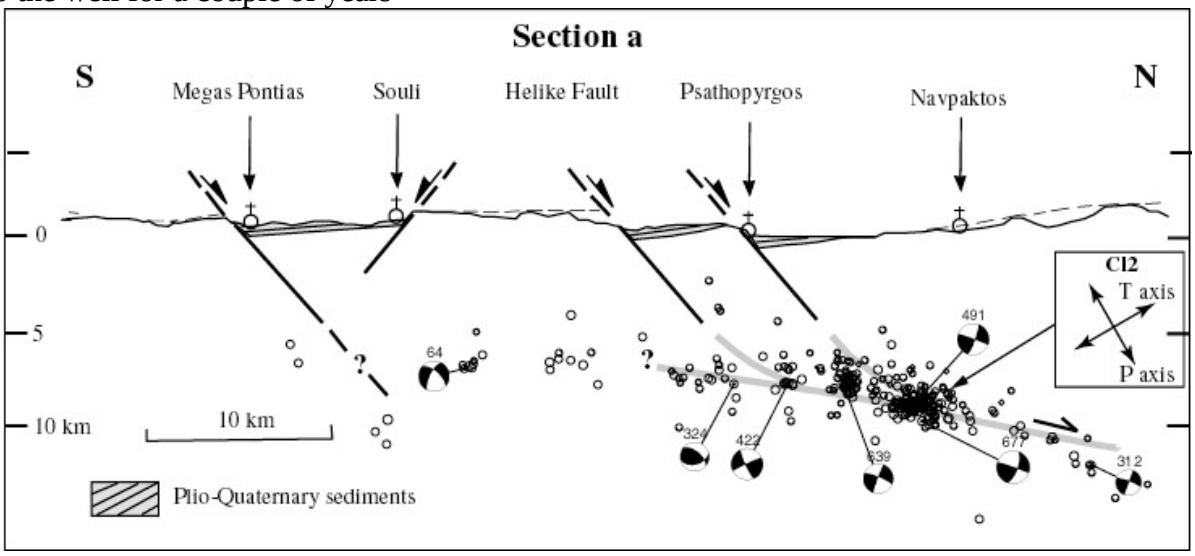

Fig 3: Seismicity in the studied area. The Gulf is no more than 10km width, northward from Psathopyrgos.

In addition to these measurements at depth, we will continue the monitoring of the faults at the surface. Fluids and gas escape have been described from the fault scarp in the Gulf and we hope to have the logistic facilities to monitor them, in particular the gases, which are very difficult to monitor in air. In terms of technology we will be interested by a permanent submarine station to follow fault activity (displacement, fluids and gas escape), as we are currently doing onshore (cf Fig 2 for fluid monitoring).

Acknowledgement:

The CRL is funded by the European Community, M yero Yanni, G Ollier and J. Garnish being the scientific advisers, the CNRS-INSU and the private companies which are partners. The various partners, in addition of the co-authors IFP, IPGP and Schlumberger, are Enterprise Oil, IPSN (France), GFZ (Germany), the National Observatory of Athens, the Universities of Athens (NTUA & NKUA), of Patras and Thessaloniki in Greece, of Brunel and Edinburgh in UK, of Paris and Nice-Sophia Antipolis in France, of Lieges in Belgium, of Catania in Italy, and of Barcelona (Spain) as well as the laboratories of ING (Rome), CERMES, Armines and ENS (Paris), CNRS (Gif sur Yvette and Montpellier).

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CHICXULUB: DRILLING THE K-T IMPACT CRATER

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The Chicxulub structure in Mexico is now generally accepted as the site of the K-T impact, that was, at least in part, responsible for the global mass extinction approximately 65 million years ago. Chicxulub is potentially the most significant event to occur on Earth in the last 100 million years – the extinction of all large land animals over ~25 kg provided the opportunity for the rapid evolution and diversification of the mammals, leading eventually to the evolution of man. The impact energy was equivalent to one Hiroshima-size bomb occurring on every square kilometre of the Earth's surface, and caused the rapid release of large volumes of polluting dust and volatiles into the Earth's atmosphere. However, the kill mechanism is not entirely clear. The arguments for further investigation of Chicxulub are compelling. If we wish to understand this event fully, we must quantify the associated environmental devastation. This can only be done by direct sampling of the target rocks at and close to the impact site. Our objectives for drilling at Chicxulub are: (1) to identify the correct lithological and structural form of Chicxulub, (2) to improve our understanding of large-scale impact cratering, and (3) to use these to constrain the environmental effects of this impact.

The crater is now buried beneath several hundred meters of post-impact sediments, with the Yucatan coast line passing approximately through the crater centre. Recently-acquired marine seismic data have allowed the definition of the structure of the offshore portion of the crater, clearly imaging the pre-impact Mesozoic rocks and the post-impact basin (Fig. 1). These data have provided us with an opportunity to identify specific drilling targets. The ODP sites have been selected to complement the proposed onshore drilling, and target scientific objectives that either cannot, or cannot easily, be achieved onshore. We propose two drill sites. CHICX-01A is a 4.3-km-deep hole just outside the crater, that penetrates through Tertiary rocks, impact ejecta, the entire Mesozoic section, and bottoms in Palaeozoic basement. The primary objectives of this hole are: (1) to identify the thickness, composition and character of the pre-impact target rocks, (2) to characterize the target rock lithologies within the ejecta, and (3) to improve our understanding of excavation and ejecta emplacement at large impacts. CHICX-02A is a 3-km-deep hole that penetrates the peak ring within the impact basin. The primary objectives of this hole are: (1) to determine the lithological and structural character of the peak ring, testing competing models of peak-ring formation, (2) to constrain the mechanics of transient-cavity collapse hence improving estimates of crater size, and (3) to characterize the impactites, both in order to identify the composition of the target rocks and meteoritic component, and to investigate clast- and melt-mixing relationships. Secondary objectives include understanding the creation and evolution of the Yucatan peninsula, studying climatic and sea-level changes throughout the Mesozoic and Cenozoic, investigating impact-related hydrothermal fluid flow and searching for

associated microbial life, investigating Chicxulub as a potential economic resource, confirming the age of impact, and studying the local hydrogeology.

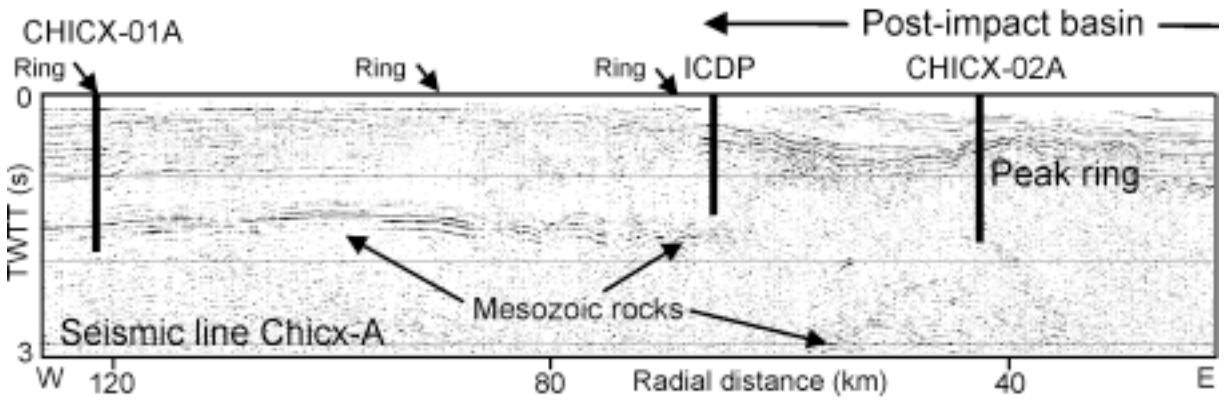

Fig. 1 Location of ODP holes. ICDP is the proposed site of the onshore drilling (start date Sept. 2001), projected on to the offshore seismic profile.

Why drill offshore?

Half of the crater lies offshore. At present our direct knowledge of the target at Chicxulub is based on a few drill samples, located onshore, to the south and south east of the crater centre. The Mesozoic section appears to be significantly thicker offshore than onshore, and it is likely that there are systematic variations in lithology, especially in the environmentally-important proportion of sulphate in the target. Drilling both on and offshore is the only means available for the correct identification and quantification of the impact target. Both the ODP drill sites have been positioned precisely, ~ ±2 km, using marine seismic reflection data; mislocation would compromise their intent. Additional, soon-to-be-acquired, 3D seismic data offshore will provide a detailed structural context for the boreholes. The potential for extensive, high quality reflection profiling onshore is extremely limited by population density, karstification, high cost, and environmental considerations, and the combination of seismic and drillhole data is much more powerful than are either alone. This can only be achieved offshore.

FRASER RIVER SOURCE TO SINK STUDY

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The source-to-sink concept has been developed by the U.S. supported "Margins" initiative[1]. Briefly, the concept is to adopt a systems approach to the study of coupled drainage basin and depositional basin systems. It involves the understanding of landscape evolution, sediment supply to the ocean, how the system responds to climatic and base-level or sea-level perturbations, and how sediment supply and dispersal relates to the stratigraphic record. The pathways followed by sediment in transport from source to sink (slope erosion, river transport and seabed deposition) have major impacts on human populations. Furthermore, continental margins, which receive sediment from fluvial systems, contain a record of changes within the drainage basin which would allow for paleoclimatic and paleohydrologic reconstruction.

The Fraser River and delta system provides an ideal situation in which to explore the source-to-sink concept. The system is young (completely Holocene) and dynamic, yet "closed" with source and sink in relative close proximity. Source sediment comes from the Coast Range mountains east and north of Vancouver, and the Strait of Georgia provides an enclosed basin that has captured sediment through the Holocene. The natural history of the system has likely responded to climatic changes since the last glaciation, while human intervention over the last 200 years, such as logging, placer mining, flood control and dredging, is known to have had a significant impact on several parts of the system including the Fraser Delta. Many of the elements related to landscape evolution, source sediment generation and stratigraphy have already received attention from researchers in various disciplines. The proposal here is to develop an umbrella project that integrates these studies and provides a mechanism for the acquisition of data to fill critical gaps in knowledge, in an attempt to reconstruct the Holocene evolution of the Fraser sedimentary system.

A key element in this study would be the drilling by IODP of a set of offshore boreholes, ranging in water depths from 50 to 350 m on the delta foreslope and pro-delta environments within the Strait of Georgia with the objective of obtaining a complete Holocene record. These boreholes would provide for detailed reconstruction of sediment dispersal in the Georgia Basin and correlation with events recorded in the onshore record, where substantial geotechnical and geological drilling has taken place. Some specific scientific issues that would be addressed by this project include:

1. System evolution and sediment pathways

The objective would be to establish as complete a record of the Holocene as possible. Because of delta progradation, the IODP boreholes would recover a high resolution record of the late Holocene but decreasing resolution with depth. Complementary boreholes from the delta plain would add to the resolution of the older Holocene record. Mineralogic provenance studies would be used to trace the evolution of the drainage basin and to identify major changes and

events within the record. Specific tracers such as organic carbon and detrital vegetal matter (for forestry impacts) and heavy metals (as tracers of industrial activity and, in the case of mercury, used in placer gold mining[2]) could be evaluated for the late Holocene interval.

2. Neotectonics and seismicity

The Fraser River delta and Strait of Georgia lie in a region of high seismogenic risk due to build up of lithospheric stress caused by subduction of the Juan de Fuca plate beneath the North American plate (the Cascadia subduction zone). The Strait of Georgia is a Cretaceous and Cenozoic forearc basin of the subduction margin and remains in the arc-trench gap of the Cascadia subduction zone. Tectonics, therefore, plays a critical role in the architecture of the basin. The region has sustained substantive earthquakes within the historical record and throughout the Holocene, as evidenced by landslide and liquefaction features within delta deposits[3]. Sediment mass failures caused by earthquakes, as well as by other means (e.g. tsunamis, static failure), likely serve as important mechanisms of sediment delivery to the basins. Earthquakes may also cause elevation re-adjustments, which affect sediment delivery pathways. A complete stratigraphic record will assist in a greater understanding of the tectonic history of the region and the role tectonics has had in the development of the delta, in addition to assisting in seismic risk assessment.

3. Paleoclimatology, paleoceanography

Complete stratigraphic sequences are critical to paleoclimatological and paleoceanographic studies. A distribution of boreholes will provide the material necessary for studying climate change through the late glacial and Holocene periods in southwestern BC. At the geological time scale, the deglaciation and sea level history of southwestern British Columbia is in much dispute. Deglaciation had a large impact on both water and sediment supply, and therefore influenced the construction of the delta greatly in the early post-glacial phase. Extreme changes in relative sea level elevations within very short periods of time are suggested for the region. Relative sea level position is critical to the development of the delta, changes of which will be reflected in transgressive and regressive system tracts. Data from the IODP boreholes will help to understand mechanisms of climate change and to delineate the timing of glacial recession for isostatic rebound modeling. At shorter time scales, the oceanography of the Strait of Georgia changed significantly through the Holocene, as sea level fell and rose and as Fraser River outflow volumes and directions changed. The oceanography of the basin is critical to the transport and deposition of delta sediments. Micropaleontologic and palynologic analysis of offshore boreholes will allow the reconstruction of the Strait's surface and bottom temperature and salinity, while mineralogic studies will reconstruct fine sediment dispersal conditions and paleocirculation.

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CARBONATES FROM THE GULF OF CALIFORNIA, MEXICO: A CALIBRATION OF CARBONATE FACIES TO MARGIN PALEOCEANOGRAPHY

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Models of carbonate system evolution have traditionally focused on relative sea level and regional tectonics as the controlling forces that determine platform geometries and facies associations. It is becoming increasingly evident that changes in the global climate and ocean environment have also had major impacts on the evolution of carbonate systems, but our understanding of causes and effects remains poor. Climate and ocean circulation, which affect both temperature and nutrient availability determine the boundary conditions for the biota that form carbonate platforms. In turn the biota affect platform geometry, character of the sediments, and facies dynamic as well as determine the overall rate of growth.

The characteristics of tropical ('photozoan assemblage', *sensu* James, 1997 - zooxanthellate corals, ooids, and green algae) and cooler water settings, usually <18°C ('heterozoan assemblage', *sensu* James, 1997 - bryozoans, molluscs, small benthic foraminifers and coralline algae with accessory echinoderm, brachiopods and azooxanthellate corals) are well defined, whereas the characters of transitional carbonates (between 18°C and 25°C) are an hybrid between the two ('heterozoan assemblage with additional scattered zooxanthellate corals and large foraminifers). Additionally, it has been shown that tropical biotic communities can change to communities resembling those of cool and temperate waters as a response to increasing availability of trophic resources without significant temperature lowering (Hallock, 1988). Therefore, establishing reliable criteria to differentiate between carbonates formed under cold water from those formed under high nutrient supply is a critical issue in the study of carbonate systems, and is particularly critical if one wants to fully understand the relationships between carbonate systems and climate change.

Longer-term trends in the alternation of Photozoan and Heterozoan carbonates through geological time may reflect evolutionary and cyclic changes in the environments in which carbonate formed. Less obvious is how can these be interpreted in terms of climate and oceanography and how much can we extrapolate present-day oceanographic relationships to the geological past. A calibration is needed with modern environments and with the recent variations related to Pleistocene glacial/interglacial cycles. The Gulf of California (Mexico), because it comprises a range of carbonate facies spanning over 1000 km across latitudinal boundaries, provides a unique opportunity to calibrate these boundaries to combined temperature/nutrient distribution and to extend these throughout glacial/interglacial boundaries.

HEAVE COMPENSATED GLAD800 CORING SYSTEM

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The GLAD800 coring system was developed as a joint venture between the International Scientific Drilling Program and DOSECC to collect long, high-resolution cores in modern lakes. The scientific objective of these samples is the determination of high-resolution climatic records. The drilling system consists of a barge that supports a diamond coring rig. The barge has a 4-point anchor system to maintain position, although efforts to fund a dynamic positioning system are underway. The system is staffed by three drillers and three scientists per shift with a drilling supervisor serving as the barge captain.

The collection of core from modern lakes presents technical challenges that have been solved with the GLAD800 including:

- A drilling system that can continuously sample sediments of different composition and stiffness.
- A barge that can anchor in water depths up to 200 meters and safely support drilling operations and scientific crews.
- A modular design that allows for inexpensive operation worldwide.
- A cost structure that takes into consideration long times of mobilization with relatively short drilling campaigns.

The drill rig has a total depth capability of 800 m (water + sediment) using HWT drill rods. Core is collected in standard ODP-size plastic liners. This size was selected for compatibility with analytical and archiving facilities. The use of a smaller HQ drill string will result in a total depth capability of 1200 m.

The GLAD800 is a complete drilling system that includes a drill rig, drill rods and riser pipe, down-hole tools, inventory and machine shop, and facilities for preliminary core description and storage. The system can be transported as twelve 20-foot containers.

The drill rig has both multiple platform capability and can also be used as a land-based diamond coring rig. In fact the first two projects drilled by the GLAD800 rig were on land. This flexibility is an important consideration for the variety of drilling projects visualized for the system.

A variety of different drilling tools are required to collect the different types of sediment encountered in recent lakes. The GLAD800 includes six standard tools that we have collectively named the DOSECC Lake Coring System (DLS). They are in order of increasing stiffness of sediment:

- Shelby “push” tube
- Hydraulic Poston Core (HPC)
- Extended Shoe, non-rotating
- Extended Core Bit, rotating (The Alien)
- Diamond Core Bit (mining)
- Non-sampling assembly (rotary).

The DLS cores a 139.7 mm diameter hole. Most of the tools are designed to collect core within an ODP-size plastic liner that has an inner diameter of 62 mm. The exception to this is the Extended Core Bit that collects core 61 mm in diameter.

The GLAD800 was tested in the summer of 2000 on the Great Salt Lake and Bear Lakes, both located in Utah. This initial test recovered approximately 650 m of core with a recovery of 93%. Single holes of up to 120 m in depth below lake floor were collected in water up to 52 m deep. At the time of this conference, the system is in use on Lake Titicaca in Bolivia.

The installation of the heave compensation system will allow the drill rig to be used in the shallow marine environment as well as the deep, large lakes of the East African Rift. In particular, the AHC-GLAD800 rig is intended for use on the STRATFORM Program. The objective is to collect cores of 200 m in water up to 100 m deep. For this application, the AHC-GLAD800 will be deployed from the *R/V Knorr*. Sea trials of the system are planned for the fall of 2001 with a drilling campaign scheduled for summer 2002.

EVALUATION OF TECTONIC DEFORMATION IN THE OCEANIC CRUST FROM REPEATED LOGGING OPERATIONS

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The need to study mechanisms and processes rather than solely structures, which is emphasized in IODP science plan, calls for the development of in situ monitoring in the domain of solid earth cycles.. Until now in ODP, such monitoring has been mostly concerned with the emplacement of permanent instruments such as CORKs with pressure or temperature sensors. However, this long-term monitoring strategy is limited by the access capability in the case of a unique drilling platform, several years being often necessary before returning to a given drillsite. This shortcoming is somewhat alleviated in the case of CORKs where a submarine diving to the sea floor re-entry funnel can download months to a few years of data. Unfortunatly, only a handfull of parameters can be presently accessed from this technology. This abstract discusses the possibility of monitoring a whole range of parameters by repeated logging operations deployed from a light drillship in the context of a multi-platform operation. The example of upper oceanic crust deformation analyses is presented here with the case of DSDP/ODP Hole 504B.

With 2111 meters below sea floor (mbsf) and 1836 meters into basaltic basement, DSDP/ODP Hole 504B remains today the deepest hole ever drilled in the context of scientific ocean drilling. It is located 200 km south of the Costa Rica Rift in 5.9 Ma old ocean crust. As such, it constitutes the reference section for the structure upper oceanic crust created at medium spreading rate, as well as for analyses of dynamic processes under which the basaltic ocean floor evolves. Eight DSDP and ODP drilling legs have been necessary to reach this depth in a hole which was not initially designed to penetrate this deep into the crust. These consecutive operations in the same borehole provide an example of how repeated logging might be used to monitor crustal processes. For example, repeated temperature profiles obtained at each re-entry into the hole, have helped constrain the hydraulic regime of the upper crust. An underpressurized 20 meter thick aquifer located under a massive unit at about 50 m into the crust was found to draw water from the ocean. The water flow into basement was shown to decrease gradually over more than 10 years, until hydrostatic equilibrium was reached. Similar repeated logging could be conducted in the future to record the evolution of a number of dynamic parameters. The example of crustal deformation is discussed below.

During the last re-entry into the hole (ODP Leg 148), a dual-caliper measurement of hole size was obtained over the entire hole from the deployment of the FMS imaging sensor. The two profiles revealed several locations where the hole diameter was surprizingly smaller than the drill bit size which initially cut the hole (Pezard et al., 1996). This apparent discrepancy was explained from the re-appraisal of BHTV acoustic scans (Figure 1) recorded in the lower part of the hole during ODP Leg 140. The cross-sections constructed from acoustic scanning of the

borehole wall revealed the shearing of the hole along a tectonically active fault plane. Such shearing has been described in several industrial and scientific hole in the past (Maury and Zurdo, 1994; Cornet et al., 1997; de Larouzière et al., 1999; Célérier et al., 2000), explaining drilling accidents and revealing the presence of tectonically active fault at depth in the subsurface. At 1583 mbsf into Hole 504B, the strike-slip deformation mode is coherent with stress analyses (Moos and Zoback, 1990; Pezard, 2000). The presence of hole sections smaller than bit size demonstrate that borehole deformation continues after the drill pipe has been taken out of the hole. The evolution of such deformations, which is presently unknown, could help constrain the deformation rate of the upper crust, which directly relates to fluid circulation along such discontinuities and the associated crustal alteration. A detailed evaluation of deformation mechanisms and associated fluid circulation over a period of about 10 years would be the basis to identify active hence permeable horizons, thus evaluate fluid flux in basaltic basement and contribute to mass balance computations for the long-term evolution of the oceanic crust due to hydrothermal circulation.

As part of IODP, a constraint on the deformation rate of the oceanic crust could be provided by multiple re-entries in the same hole and repeated BHTV acoustic scanning. Several logging sensors could be deployed during these consecutive re-entries in order to monitor a series of parameters such as, for example, temperature, pressure, electrical potential and hole deformation. In the case of Hole 504B, a platform capable of deploying 3500 m of pipe would be required to convey the logging tools to the sea floor. Such a deployment would be possible from a platform much smaller, hence more easily available, than the JOIDES Resolution if an aluminium drill pipe were used. This is due to the smaller density (about 1/3) of aluminium with respect to a steel. This "light vessel/multiple re-entry/repeated logging" strategy could also be applied to the monitoring of other environnements in the ocean.

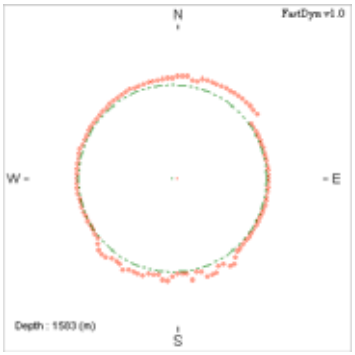

Fig. 1. Cross section of DSDP/ODP Hole 504B obtained at 1583 mbsf from BHTV transit-time data. A NE-SW trending fault plane active during drilling is shearing the hole in a right-lateral fashion. After shearing, the NW quadrant of the hole has been reamed by thedrill bit on the way out of the hole of the drill pipe.

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DRILLING WINNER AND LOOSER REEFS TO OPTIMIZE PREDICTIONS OF THE CONSEQUENCES OF GLOBAL CLIMATIC CHANGE

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Several near-catastrophic mortality events in recent coral systems over the last two decades have led much of the scientific community to question the continuous functioning and future of Holocene coral reefs. Pessimistic scenarios predict drowning of most reefs due to loss of biological function (loss of ecological integrity due to bleaching induced by temperature increases, decreased calcification due to changed atmospheric CO_2 levels) within the next few hundred years.

However, even if many of he world's reefs are predicted to be doomed, refuge areas appear to exist. These seem to be concentrated in areas of medium depth (frequently characterized by coral biostromes), upwelling areas, and certain high-latitude areas.

In order to obtain information about the future of the world's coral reefs, it is necessary to integrate studies of the demise of ancient reefs with studies of the functioning of predicted refuge reefs.

By drilling terminated reefs, it will be possible to determine the causes for reef termination. The magnitude of environmental variability leading to the termination of these ancient reefs will then be compared to the magnitude of predicted environmental variability. A better understanding of past terminations and catastrophic events will then allow to fine-tune predictions of future changes.

By drilling reefs and coral biostromes in possible refuge areas, it will be possible to better understand the structural evolution of these systems which can then serve as a key to understanding the environmental tolerances of the system. Based on these tolerances, models can be developed that predict survivability of refuge coral systems and will, for the first time, not only provide a body-count of what will be lost, but provide realistic estimates of how much will remain.

With the aid of the Austrian Science Foundation, University of Graz (UG) is the home of the "Reef Drilling Project" and has invested heavily into shallow submerged reef drilling to recover cores of up to 12m length and 60mm diameter. International collaboration partner is the National Coral Reef Institute at Nova Southeastern University in Florida.

(A) Drilling looser reefs (terminated reefs)

At UG, a multi-year project has studied reef termination in the geological record and the recent. Termination-sequences in Miocene coral frameworks were studied in outcrop in Austria (PALAIOS 15: 399-413) and in recent reef frameworks in the Caribbean and

Indonesia (CORAL REEFS, in press). Methods utilized were excavations through frameworks to reveal initiation and termination sequences.

In Florida, using a hydraulic underwater drilling system anchored to the seafloor at 8-10 m depth, a Pleistocene reef system off Broward County is being systematically drilled. Recovered core lengths vary between 1 and 10m. It is the aim to produce a complete transect of 10-m-long cores along a land-sea and a lateral transect. Thus the ecological structure and lateral dynamics of the reefs can be investigated by integration between the cores along the transect and termination sequences can be detected. The 10-m-length of the cores was determined by preliminary investigations into the thickness of the framework.

We suggest to drill deep drowned reef systems off the Florida coast, such as the third Pleistocene reef tract off Broward County, the Pleistocene outlier reefs off Florida and the early Holocene drowned reef terrace off Grand Cayman. Our own drilling initiative presently reaches 10m water depth. Using alternative platforms, it will be possible to drill more, and deeper, outcrops and to integrate these findings.

(B) Drilling winner reefs (potential refuges)

Since 15 years, UG has been investigating high-latitude reefs (Red Sea, Arabian Gulf and Caribbean) and reefs in upwelling areas (Bahamas, Cayman, South Africa, United Arab Emirates) that could serve as refuge reefs in times of a possible predicted global reef crisis. Studies of the lateral distribution of reefs and reef-associated coral frameworks provided a new coral framework concept, that of the coral carpet=biostrome (BEITR. PALÄONT. 15: 103, GEOL. SOC. SPEC. PUB. 178: 71-88). Coral biostromes and non-reef frameworks cover up 20 times more space than reefs and are therefore an important battery for biodiversity and the carbonate factory -147, FACIES 36: 141-162, CORAL REEFS 18: 241-253). Investigations into the framework and ecological dynamics of these systems (MAR ECOL 15: 213-231, CORAL REEFS 18: 63-73) support hypotheses that these framework types are good candidates for "winner reefs", i.e. such that will survive, even if worst-case scenarios of global change are true.

We suggest to drill biostromal coral frameworks (up to 11m thick) and reefs in the northern Red Sea (Egypt). Detailed maps are available for northern Safaga Bay and preliminary maps for Foul Bay. Cores obtained from these areas would supplement data from almost two decades of field work.

Reefs in upwelling areas off Cat Island showed less mortality during the 1998 bleaching event than comparable reefs in nearby Eleuthera. Reefs in Cat Island and Eleuthera should be drilled in order to assess differences in upwelling-influneced framebuilding, which will help to reveal whether these reefs really are good candidates for “winner reefs”.

University of Graz Reef Drilling Project,
8m depth on Pleistocene Reef off Ft. Lauderdale, Florida

AN INVESTIGATION INTO THE CAUSE OF DROWNED CARBONATE BANKS

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The Problem: - Since the publication of Schlager's paper in 1981 (1), drowning has been cited with ever increasing frequency as a cause of the cessation of carbonate deposition. Commonly an accelerated rate of sea level rise has been cited either explicitly or implicitly as the cause for the failure of carbonate deposition to keep pace with the rate of rise of sea level. To a lesser extent nutrient supply has also been cited as a possible cause for the demise of reef carbonate deposition. Not withstanding the frequent citations of drowning in the literature, there is virtually no evidence on the specific cause of drowning, only speculation. The Maldives offer an unusual opportunity to provide data on the cause of drowning.

Background: - The greater part of the Maldives consists of a double row of atolls separated by an Inner Sea with water depths of 250 to 450 m (Fig. 1). Two exploration wells have been drilled in the area and document the occurrence of some 2000 m of carbonate above subaerially weathered basalt. These results along with interpretations of the accompanying seismic have been reported by Aubert and Droxler (2), Purdy and Bertram (3), Aubert and Droxler (4), and Belopolosky (5). All the seismic lines demonstrate partial filling of the Inner Sea by prograding Miocene carbonates.

Drowning Relationships: -The Inner Sea side (eastern side) of Ari Atoll lies generally above the edge of the underlying prograding platform but in the northern part of this same atoll there is apparent backstepping from this position to the defining edge of the modern atoll, leaving a drowned platform as testimony to its former position. The drowned platform expands laterally northward where first Rasdu Atoll occurs as a small reef remnant on its surface and then is succeeded farther northward by the large, entirely drowned surface of Fuad Bank (Fig. 1). Still farther north there is a return to reef colonisation of the underlying substrate in the form of Horsburgh and South Malosmadulu atolls (Fig. 1). The problem to be solved is what causes the difference between drowning and reef colonisation of the underlying platform.
It is difficult to believe how environmental control, such as temperature, salinity, nutrient supply or currents, could vary in such a complex way in the middle of the Indian Ocean. Depth of antecedent topography seems more plausible, but the resolution of existing industry seismic is insufficient to demonstrate whether this is or is not the case. The drowning problem extends to the deep east-west channels that separate the atolls from each other because continuity of progradation extends across them from atoll to atoll. This suggests that former carbonate mega-banks have somehow been dismembered to form the modern distribution of atolls. The formation of these channels provided the blueprint for the present-day distribution of atolls. Their origin and that of the drowned banks pre-date the Pleistocene because their present-day depth is generally significantly greater than that of the last glacial low stand of sea level.

Data Required: - What is necessary to resolve the problem, or at least constrain it, is high resolution shallow seismic data to provide the depth and geometry of underlying antecedent surfaces and bore holes to provide ground truth in reefal versus drowned bank areas. Water

depths for drilling would vary between a few meters in the modern reef areas to a maximum of 250 meters over the drowned banks. Seismic acquisition and interpretation are necessary to provide drilling sites that will maximise information.

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THE SCIENCE, IMAGING AND TECHNICAL CHALLENGES OF SUBMERGED CORAL REEF DRILLING

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Thirty-nine scientists and engineers from 8 countries participated in the International Workshop on Submerged Coral Drilling, which was co-sponsored by the National Science Foundation and JOI/USSAC and held in St. Pete Beach, Florida from September 27-30, 2000. The workshop was organized and convened by Terry Quinn and Sandy Tudhope, with the assistance of Larry Edwards, Rick Fairbanks, Michael Gagan, and Fred Taylor. The principal objective of the workshop was to have the coral-based-scientific, imaging and geotechnical communities identify how the capabilities of each community could be better integrated to solve the pressing scientific issues that can uniquely be addressed via submerged coral drilling.

Annually banded massive corals and their associated reefal deposits have some unique attributes that make them exceptional archives of environmental change in the tropics through the Late Quaternary. These include the ability to directly date corals by high-precision, U-series techniques, the proven ability of large corals to yield high-resolution (e.g., ~monthly) multidecadal-to-multicentury long records of past climate variability in the Late Quaternary, and the utility of corals and associated deposits as recorders of past sealevels. Participants in the International Submerged Coral Workshop identified four overarching scientific issues that can be ideally addressed by the drilling of submerged coral reefs:

1. What is the nature and magnitude of tropical climate change on millennial to interglacial timescales. For example, are there major changes in the tropical hydrological cycle from glacial to interglacial conditions; are there changes in the dynamics of the tropical climate system on millennial timescales, and if so what is their relationship to the Heinrich event variability documented from high and mid-latitudes?
2. How do the dominant modes of tropical climate variability respond to changing climatic boundary conditions? For example, what are the sensitivities of El Niño Southern Oscillation (ENSO), monsoonal, and interdecadal coupled ocean-atmosphere dynamics to changes in orbital forcing, global and regional temperatures, and sealevels over century to glacial-interglacial timescales?
3. What is the timing and magnitude of sealevel variations during the Late Quaternary? To what extent does sealevel respond to millennial-scale climate variability?
4. What is the nature of the radiocarbon timescale between 12 Ka BP to 40 Ka BP, a time when the abundance of fossil trees are insufficient to produce a radiocarbon calibration based on tree rings?

These four scientific questions, along with other compelling questions concerning fluid flow in reefs and reef ecology, require that submerged coral reefs be successfully cored. To achieve the objectives, coring in shallow water depths (0-200 m) is required. The required depth of penetration of the cores would generally be tens of meters, to a few hundred meters maximum. A lively discussion amongst the workshop participants focused on the issue of core recovery in the reefal environment. Complete core recovery is a laudable objective and clearly maximizes the potential scientific return on the drilling. However, it is important to note that a drilling program

that focused on recovering only *in situ* coral heads would still permit most scientific objectives related to climate, sealevel and radiocarbon calibration to be met. Clearly, there needs to be a cost/benefit analysis performed relative to the merits of the vastly different approaches to core recovery in the reefal environment.

The first traditional challenge of ocean drilling is the identification of the drilling target, although this challenge may not be as critical in submerged coral drilling as is often assumed. A suite of remote-sensing technologies is available at a reasonable cost to the academic community, ranging from multibeam sonar, side-scan sonar, to very high-resolution (i.e., meter-scale horizontal resolution and sub-meter scale vertical resolution), seismic-reflection profiling. A newer technology called chirp sonar is now being used extensively in siliciclastic environments, where it provides maximum horizontal resolution of 25 cm while providing ~30 m of penetration in unconsolidated shelf siliciclastics. It would be highly desirable to see if the chirp system could be viable tool in submerged coral drilling site surveys.

Submerged coral drilling may involve a completely different approach to pre-drilling target identification and real-time core acquisition compared to the more traditional drilling of ocean sediments and rocks. Land-based drilling on uplifted carbonate islands has unequivocally demonstrated that buried coral heads can be efficiently recovered by using the principles of coral-reef geomorphology even in the absence of geoacoustical surveys. Furthermore, such land-based drilling programs have often used a drilling strategy that emphasized multiple cores, in preference to single (or a few) deeper cores. The scientific rewards for recovering *in situ* coral heads are so large that a few "dry holes" (i.e., those devoid of coral heads) do not necessarily have a significant negative impact on many of the science objectives. Submerged coral drilling will not likely be a process in which a single, deep borehole is made while the ship maintains station for days to weeks at a time. Instead, a much more likely scenario is one in which multiple sites are drilled in close proximity. Any marine-based drilling program for coral reefs must be flexible enough to be able to make numerous station changes as quickly and efficiently as possible. Thus, submerged coral science truly requires a dedicated "fit-to-mission" philosophy to ocean drilling.

The second, and perhaps more daunting, challenge facing a successful coring campaign of submerged coral reefs is the deployment of the "proper tool for the job". Maintaining station, maintaining proper weight on the drill bit, and negating the effects of heave pose significant challenges to drilling in shallow water (< 200 m). Workshop participants identified 17 potential platforms for conducting geotechnical sampling/coring operations ranging from barges, seabed frames, jack-up rigs, vessels and drillships. Barges, vessels and drillships maintain station in shallow-water by anchoring (4-point or taught-wire) or by dynamic positioning (DP), although anchoring is more likely in water depths < 75 m. Seabed frames and jack-up platforms minimize problems associated with maintaining station, weight on bit and heave, although there are limitations with some of these platforms in terms of drilling multiple holes in close proximity. A "mining- or mineral-type" drill rig may be best suited for use in a submerged coral drilling program because of the coral-reef lithologies and the science objectives of drilling and recovery of coral heads. This type of drill rig commonly uses a diamond coring system with thin kerf bits, small cores and wireline sampling. For diamond coring with core size HQ (~60 mm) or larger, the diamond core barrel can be interchanged with piston, push, punch or percussion samplers without pulling the drill string. Diamond coring is especially sensitive to any changes in weight on bit, therefore proper heave compensation is critical to successful coring. When drilling is performed from a platform positioned at the sea surface, a riser is likely needed

to provide both lateral support to the smaller diameter mining drill rods and to make it possible to re-entry the holes during the drilling operations. Versatility and portability are critical attributes of any drilling platform used for submerged coral drilling.

In summary, DSDP and ODP have been, and IDOP will be, the preeminent program(s) for the drilling and recovery of ocean sediments and rocks. DSDP and ODP have not traditionally been involved in shallow-water science and especially submerged coral reef drilling largely because of technical limitations of a single-ship program, despite the significant scientific returns that such drilling would provide. A new era in ocean drilling is upon us — IODP — and this program needs to embrace a "fit-to-mission" approach so that drilling proposals having high scientific merit will not be denied funding based on perceived technical limitations. Workshop participants endorsed the notion that submerged coral reef drilling could fall under the purview of IODP because decades of previous ocean drilling have resulted in a system that is well equipped to manage science proposals, funding, sample handling and storage, travel and logistics, etc. However, workshop participants also recognized that drilling platforms separate from a "JR-type" drillship are required for a successful submerged coral drilling program. The challenge in front of IODP is to be flexible enough to drill the scientific proposals that are highest ranked, regardless of the platform that is required to accomplish the highest priority scientific objectives, as long as they are reasonable from an economic perspective. Workshop participants strongly endorsed the concept of a tripartite drilling approach for the IODP consisting of a non-riser drillship, riser drillship and a suite of mission-specific platforms.

SHALLOW-WATER DRILLING OF CARBONATE PLATFORM EDGES AND UPPER SLOPE REGIONS: THE HUNT FOR LOWSTAND REEFS

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Carbonate platforms are able to produce large quantities of sediments during sea-level highstands when the production areas on the platforms are flooded. These usually muddy aragonite-rich sediments can be transported over long distances into the surrounding basins. During lowstands in sea level the main production areas on the platform are exposed, thus preventing significant export of aragonite-rich sediments. However, analysing the periplatform sediments near carbonate platforms like Great Bahama Bank showed that still relative large quantities of aragonite-rich sediments are produced and deposited in the basinal areas. While the slopes of Great Bahama Bank are rather steep the question arises where these aragonite-rich sediments are produced. In other words, what are the main producers of these type of sediments that were shedded into the basin and where were the production areas situated? To address these questions at least two regions are proposed as possible targets for further studies:

Caribbean: 1. Great Bahama Bank (In co-operation with Gregor Eberli and Robert Ginsburg, Miami; Flavio Anselmetti, Zürich; Christian Betzler, Hamburg/Cambridge)

The geology of this large carbonate platform system is well known. The export patterns through time are well documented (e.g. ODP Leg 166; Eberli et al., 1997; Swart et al., 2000, and related papers). The questions that need to be addressed are (1) what happened to the reefs and sediment production sites during sea-level lowstands, and (2) to verify the sequence stratigraphic stacking pattern along the carbonate platform margin.

2. Pedro Bank (In co-operation with André Droxler, Houston; Nils Andresen, Kiel).

This slightly inclined carbonate platform shows a difference of approx. 60m waterdepth between the yet productive areas in the south and the northern deeply submerged platform top (Glaser, 1991; Glaser & Droxler, 1993; Andresen, 2000). By drilling the sequences on the top of the northern and southern platform margin more information can be obtained on the sedimentation processes during the flooding this platform i.e. the duration of time gaps between flooding of the platform margin and the start of reef growth and sediment export.

3. Belize (See also the proposal by Eberhard Gischler, Frankfurt; Edward Purdy, London)

The sedimentation model for the Belize Reef proposed by James and Ginsburg (1979), which in later stage was tested by modelling studies of Bosscher (1992), showed a detailed stacking pattern of reef sequences in response to sea-level variations. This stepping up and down of the reef system would allow us to test the true amplitudes of sea level and the response of a carbonate system to these changes. It will allow us to understand facies stacking patterns in time, which can be verified by high resolution dating of the sediments recovered in analogue to studies by Gischler et al. (2000).

Indian Ocean: 4. Mayotte (In co-operation with Christian Dullo and Jens Zinke, Kiel; Gilbert Camoin, Aix-en Provence/Numea; Bernard Thomassin, Marseille)

Numerous authors have studied the atoll of Mayotte (e.g. Dullo et al., 1998; Zinke, 2000; Zinke et al. in press). Knowing the precise sequence of events that characterise the sea-level curve

during flooding of the platform it will be interesting to drill the upper slope to reefal areas and determine the events affecting the various production areas during fluctuations in sea level. These observations also will allow us to quantify the precise amplitudes of these sea-level variations. In this research area the expertise of several European research projects can be combined.

Summary

Shallow-water drilling of reefs on platform margins offers a wide range of study areas in which the response to sea-level fluctuations can be tested in sedimentological and paleontological sense. Other important topics that can be addressed are the analysis of reef-stacking patterns in relation to glacial-interglacial sea-level variations, the sequence boundary paths and, last but not least, the quantification of rates of sea-level fluctuations.

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DRILLING THROUGH AN ACTIVE CALDERA, OFFSHORE THE PHLEGREAN FIELDS, ITALY

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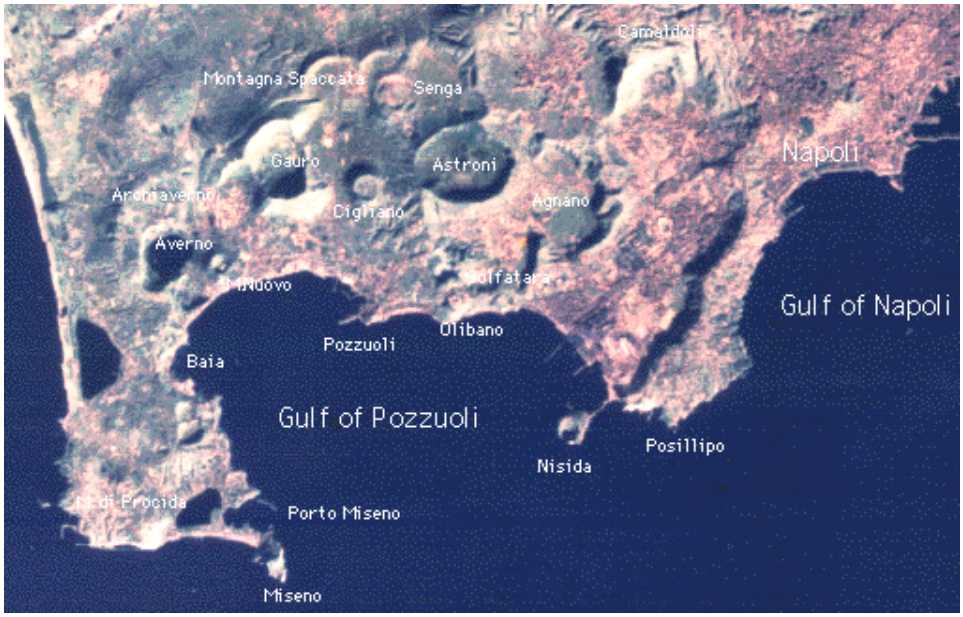

DRILLING SITE

CONTINENTAL SHELF OFFSHORE THE PHLEGREAN FIELDS CALDERA, SOUTH ITALY

Location: Latitude 40.8°N; Longitude 14.1°E
Water depth range (50-300)
Summit elevation of the caldera onland: 458 m

FRAMEWORK OF DRILLING PROGRAMME

IODP shallow water drilling on a continental margin by Mission Specific Platform (MSP)

OBJECTIVES OF THE PROPOSED IODP LEG

Short-term objectives

Short-term objectives of the programme include:

1) The study of the deep structure of the submerged caldera offshore the Phlegrean Fields by the acquisition of a broad spectrum of reflection seismic profiles (high-resolution/shallow penetration to low resolution/deep penetration data sets);

2) The reconstruction of unrest volcanic evolution of the caldera and the assessment of potential risk in a densely populated area;
3) The integrated study of the sedimentary record of the continental shelf in the Bay of Naples (high-resolution physical stratigraphy, paleoclimatic reconstruction, sterile cores analysis for biological studies, single-crystal, laser-fusion $^{40}Ar/^{39}Ar$ age dating of marine tephra for chronostratigraphic calibration etc.)
4) Study of the bacterial content of the Upper Quaternary sedimentary strata and the transition zones between thermophilous and hyper-thermophilous bacterial associations at depth;

Long-term objectives

The proposal will be aimed at:

1) Integrating MSP coring operations offshore the Phlegrean Fields caldera into a long-term multi-platform drilling programme involving two or more drilling platforms and including land-to-sea geophysical and geological transects across the Campania Volcanic district and the Upper Pleistocene deposits of the Bay of Naples, Eastern Tyrrhenian Margin;
2) Building up the Phlegrean Fields caldera IODP programme as a "case study" or "natural observatory" of worldwide interest in which the full potential of IODP can be demonstrated as essential in solving major problems in earth, environmental and biological sciences.

LINKS WITH NATIONAL AND INTERNATIONAL PROJECTS

The proposed programme carries opportunity to include integration or develop joint targets with ongoing national or international projects like **SERAPIS** (Tomography of the Phlegrean Fields), **Euro STRATAFORM** (drilling of Quaternary expanded sections on the European continental margin for paleoenvironmental purposes), **CARG** (1:50.000 scale geologic mapping of the Italian continental shelf).

MAJOR CALDERAS OF THE WORLD

Onland calderas

- Ilopango caldera, El Salvador
- Long Valley Caldera and Mono-Inyo Craters, California, USA
- Newberry Caldera, Oregon, USA
- Ngorongoro Caldera, Tanzania
- Yellowstone Caldera, Wyoming, USA

Onland-offshore calderas

- Phlegrean Fields, Italy
- Rabaul Caldera, Papua New Guinea

RATIONALE

The Phlegrean Fields (also called Campi Flegrei - "the burning plain") is an active caldera with two historic eruptions and signs of unrest in recent years. Volcanism has occurred in the Campi Flegrei area during the past 50 ka, including two extremely violent explosive eruptions, the one that erupted the Campanian Ignimbrite (35 ka ago) and another one only 12 ka ago which produced the Neapolitan Yellow Tuff.

Between 8050 BC and 1700 BC there were thirteen dated prehistoric eruptions and most were moderate-large to large in size (VEI=3-4). Eight of the prehistoric eruptions produced pyroclastic flows. One of the prehistoric eruptions was phreatic and another produced a dome. The Phlegrean Fields caldera formed about 35,000 years ago with the eruption of 80 cubic km of ash (the Campanian Tuff). The caldera is about 13 km in diameter and includes numerous cones and craters. The caldera is about 25 km west of Vesuvius and 5 km west-southwest of Naples.

Millions of people live on the Phlegrean Fields caldera and in nearby the town of Naples, a major urbanized area on the eastern Tyrrhenian Sea. It has been calculated that a week at least will be required to evacuate all the people living nearby or within the Phlegrean Fields caldera.

Recent evolution the a long-lived, unrest volcanic history of the caldera

Two historic eruptions occurred in 1198 and 1538. The 1198 eruption was at Solfatara and relatively small. The 1538 eruption at Monte Nuovo lasted about a week but included several types of activity. This was the first record of a new cone forming on a volcano. The eruption was explosive and generated pyroclastic flows. It also produced a lava lake and lava flows. Near the end of the eruption, while people were climbing on the cone, there was a phreatic explosion. Twenty-four people were killed; some by falling and sliding down the cone. At distances of 5 km, trees were knocked down by the phreatic eruption. About 12 m of uplift preceded the eruption. This observation is based on the presence of borings, made by marine organisms, in marble pillars at the temple of Serapis. The columns were about 11 m below sea level before 1000 AD. Shortly before the eruption started the area near Pozzuoli was uplifted 4 m.

Volcanogenic earthquakes in 1970 caused some houses to collapse.. The most recent episode of unrest began in 1982. Over a two-year period, the area near Pozzuoli was uplifted by 1.8 meters and the number and size of earthquakes increased. By mid-1984, the rate of uplift and number of earthquakes declined.

Importance of the selected site and research topics

The Phlegrean Fields probably represent the most interesting example in the world of an active caldera that develops across a densely populated continental margin. As it partially develops beneath the sea water, extending over the inner continental shelf of South Italy, the Phlegrean Fields area is a best site to test the potential of IODP shallow water drilling on a continental margin by Mission Specific Platform (MSP) as well as long-term multi-platform drilling programmes that include land-sea transects. Moreover, historical or archeological evidences that document the occurrence of seismic and volcanic activity and sea-level changes in this area date back at least 2.000 years B.P., thus allowing long-lived, direct observation of geologic processes on the human scale.

The proposed shallow water MSP drilling operation of the Phlegrean Fields offshore south Italy, is likely to be a “case study” or “natural observatory” of worldwide interest in which the full potential of IODP can be demonstrated as essential in a better understanding of major problems like the geologic evolution of large calderas, the interplay between climatic, eustatic and

volcano-tectonic forcing, the dynamics of the heat and fluid flow systems and the response of the biotic component to extreme environmental conditions.

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EXPLORING THE ORIGIN AND GLOBAL TELECONNECTIONS OF DECADAL-TO-MILLENNIAL-SCALE CLIMATE VARIATIONS IN THE PLEISTOCENE

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Over the last years Dansgaard-Oeschger (DO) climate cycles, first found in ice cores from Greenland and later in marine and terrestrial sediment records from the last glacial cycle 80,000-10,000 yr ago, have become increasingly established as global climatic oscillation lasting approx. 1500 or 3000 years. The actual origin and forcing of these climate periodicities, which are discontinuous and much shorter in length (900-950 yr?) during the Holocene, but most important for climate prediction, may either lie in low or high latitudes. On the one hand, the equatorial Pacific was proposed by some climate models showing Milankovitch related ENSO-style oscillations of atmospheric convection and in the advection of water vapor to northern high latitudes. The other potential source area lies in a tiny region of the northwestern North Atlantic, where surge-driven meltwater pulses coming from East Greenland may have controlled abrupt changes in the formation of North Atlantic Deepwater at times of lowered sea level. To test these models concerning different source areas and potentially different trigger and transfer mechanisms in the ocean and/or the atmosphere from high to low latitudes and amongst the various ocean basins during glacial and interglacial times will require a systematic CALYPSO-style coring of 60-100 m long deep-sea sediment records. This will allow mapping of the temporal and spatial distribution patterns of DO climate signals and unravelling their phase relationships ("teleconnections") on a global scale from pole to pole and across various glacial and interglacial stages over the last 500,000 yr. Moreover, shorter lasting and obviously discontinuous decadal-to-centennial-scale climate cyclicities such as the North Atlantic Oscillation and various periodicities of solar insolation gain an ever increasing relevance for climate prediction and thus also need to be recorded on a global scale. Major target regions to be proposed for coring transects of ultrahigh-resolution sediment records will in particular comprise the western and eastern margins of northern and central Africa, the western margin of the Americas and Australia-Indonesia, the Southern Ocean, the eastern margin of New Zealand, the continental margins around India, and the Bering Sea. In total these efforts will sum up to at least some eight to twelve coring legs over the next few years.

COMPARISON BETWEEN RECENT AND OLD CONTINENTAL MARGINS

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A number of projects are directed to continental margin areas of the North Atlantic realm where plate margins have been active at different times of the Earth history. Investigations include seismic data collection, geochemistry, single-grain geochronology and of course field work. Listed below are some projects directed to the evolution at old relict plate margins now located in the interior of continents and where the principal investigators seek cooperation with research groups working in modern analogues.

§1 Evolution of the early Earth in Greenland with Precambrian plate margins, coordinated by Martin Whitehouse at the NORDSIM laboratory, Swedish Museum of Natural History (email martin.whitehouse@nrm.se).

§ 2 1900 Ma evolution at a continental margin in Northern Sweden with extensions to Finland, including developments in the Skellefte ore district, coordinated by Pär Weihed at CTMG and Luleå University (email par.weihed@sb.luth.se). Compare with Babel seismic profile and the Archaean – Proterozoic Boundary Zone at Luleå-Jokkmokk from isotopic Sm-Nd and zircon data.

§3 Early Mesoproterozoic evolution (c. 1600 Ma) of the western margin of the Baltic Shield – tectonics, sedimentation and magmatism. Coordinator: Sven Åke Larson at Gothenburg University (email sal@geo.gu.se).

§4 Grenvillian evolution in the Baltic Shield, tectonics, sedimentation and magmatism during the Sveconorwegian tectonic cycle and Rodinia assembly, Sven Åke Larson and others.

CLIMATE AND TECTONICS MODULATING PALEOGENE, NEOGENE AND POTENTIAL FUTURE ENVIRONMENTAL EVOLUTION: HIGH RESOLUTION KEY–SITES FROM THE EURAMERICAN GATEWAY (CLIMTEC)

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The Neogene, with its rapid climatic and tectonic changes is a key time and the North Atlantic a key area for the study of the Geosystem as a whole and the interaction of Lithosphere, Ocean and Atmospheres especially for the impact of Greenhouse conditions on Europe in particular.

The conditions of ice–house climates, including the orbital factors *modulating* the ice–ages are known quite well. However little is known about (a) the Neogene greenhouse conditions themselves (see Smolka 2000) and the factors that *enabled* the global environmental change from greenhouse conditions to conditions with large ice–sheets in the Northern Hemisphere (including the ice–coverage of the Arctic Ocean).

One factor enabling northward energy transport was the closing of the Isthmus of Panama (including its impact on the deep circulation) around 4 m.y. The formation of *massive* ice–sheets needs however energy and moisture in the Norwegian Sea / the Arctic Ocean. Thus the *other key–factor* modulating the change of Neogene greenhouse conditions is the *massive* the inflow of energy and moisture into the already cold Norwegian Sea. While old analyses regard the *first* establishment of deep–water exchange between Norwegian Sea and North Atlantic in Oligocene times as the *final* onset of deep water exchange, new analyses of DSDP/ODP sites (including faunal analyses) as well as comprehensive seismic mapping show that sedimentation and volcanic activity inhibited *effective* deep–water exchange between Norwegian Sea and North Atlantic in Miocene and Early Pliocene times. Reestablishment of deep–water exchange occurred at about 2.6 m.y. A final solution of this question is however only possible through drillsites in the Denmark Straits (between Iceland and Greenland), on the Iceland–Faeroe Ridge (redrills of old rotary–cored sites 336 and 352 of Leg 38) and sites in the Faeroe–Shetland Channel.

Any successful interpretation of future data in the Arctic Ocean needs in addition to be backed by knowledge about the transfer of energy further southward through the Denmark Straits, Iceland–Foeroe Ridge and (northward flow) Faeroe–Shetland Channel. These areas, which are of key interest to the climate of Europe are however the last white parts on the map of ODP as they are either not drilled yet (Denmark Straits, Faeroe–Shetland Channel) or only drilled with spot-cored rotary cores (large coring–gaps) of the pioneer days of DSDP (Leg 38, Sites 336 and 352).

Thus the ClimTec Leg (563/Pre) addresses the following questions:

1) Comprehensive paleoenvironmental reconstructions. These are not only isotope–based. Efficient biota–based transfer–algorithms that range well back into the Miocene permit

quantitative paleotemperature assessments for Neogene greenhouse climates. The respective curves and maps will show very detailed both the climate variability within Neogene greenhouse times (data to be coupled with an atmospheric general circulation model) and during the transition (timescales, preceding fluctuations, magnitudes) toward glacial times (examples in Smolka 2000).

2) Quantitative analyses of the watermasses, not only geochemical proxies but also faunal/floral communities will document the history of watermasses both within the Norwegian Greenland Sea and across the ClimTec area (Denmark Straits, Iceland Faeroe Ridge and Faeroe Shetland Channel).
3) The synthesis of well–data with seismics will finally (and in some areas for the first time(!)) establish boundary conditions (such as but not limited to) paleobathymetry and paleoproductivity. These data will be needed both for quantitative paleooceanographic models and for better assessment of areas of deep petroleum formation.
4) The more knowledge about the Norwegian Sea, the Barents Sea and the Arctic Ocean (mainly seismics) becomes available the more complex the questions about the tectonic history becomes (timing and magnitude of subsidence, stressfields). Thus a detailed assessment of the subsidence history large heterogeneous crustal sections provides quantitative background data which, together with data from other Legs will be of crucial importance to (4a) quantitative paleostressfield analyses and (4b) in the long range also quantitative plate tectonic models integrating (the still) simplifying planetological models with recent advances in finite–element based tectonic models.
5) The future of Europe depends on the quantitative assessment of greenhouse climates. (how they look like, temperature– and moisture distributions). These data are provided for already realized Greenhouse Climates by Neogene time–series, espcially those provided by ClimTec. Furthermore data–based stability–analyses and insight into the boundary conditions that enabled the change to ice-house conditions are measurable deliverables of ClimTec.

Two of the proposed sites are redrills of old DSDP sites. This means that the whole suite of necessary analyses was already carried out and they are already mature for drilling. The other sites of ClimTec are located in areas that are characterized by a wealth of seismic data. This means that it is possible to do the necessary preparative work for ODP 563/ClimTec in more than eight months. This means also that it is factually a "must" to drill ODP 563/ClimTec in the forthcoming months as the Joides Resolution is in the Atlantic and possible future Arctic sites need respective backing.

As the relevant Legs (with the exception of the pioneer Leg 38) simply spudded their sites well away from the ClimTec area (Fig. 1), the indirect deduction of the subsidence history of the Greenland Scotland Ridge is still only a compromise, especially as key sections have not been drilled (sites DKS–1 to DKS–4, IFR–1 and IFR–2 and FSC–1 and FSC–2, see Fig. 1). Because future Arctic drilling needs to be backed by hard data if syntheses shall go beyond description, both history of watermasses (including that at various depth levels), subsidence history of relevant sections (Denmark Straits, Faeroe Shetland Channel, Iceland Faeroe Ridge) and individual blocks need to be assessed carefully.

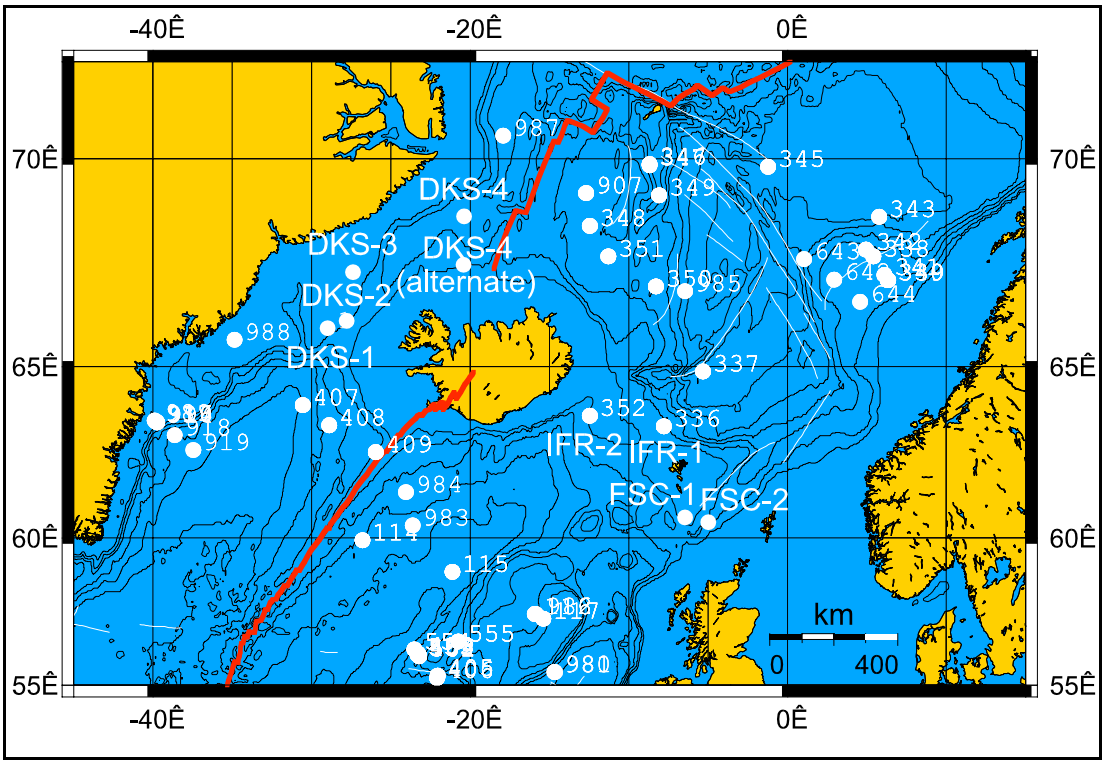

Fig. 1: Existing DSDP/ODP sites show that many drillsites are well off the Greenland Scotland Ridge. **ClimTec Sites** are labeled **DKS-1 to DKS-4** (between Iceland and Greenland), **IFR-1 and IFR-2** (on the Iceland Faeroe Ridge) and **FSC-1 and FSC-2** in the Faeroe Shetland Channel (basemap from www.geomar.de).

The deliverables of this transect are

(1) hard knowledge about the subsidence history of the Denmark Straits, the Iceland–Faeroe Ridge and the Faeroe–Shetland Channel.

(2) hard data on the Neogene (greenhouse/coolhouse) paleotemperature history of both the surface water and various water bodies

(3) Syntheses (together with modeling) of already realized Neogene greenhouse climates including (coupling the results with an atmospheric general circulation model, Smolka 2000) the assessment of the impact of already realized greenhouse ocean on the environments of Europe.

Paleoenvironmentally these sites contribute, in connection with existing data to Neogene (greenhouse) environmental syntheses, maps (currents, temperatures, water bodies) that, beyond the benefits for society ("how may greenhouse–environments look like"), back also future syntheses of sites spudded in the Arctic Ocean.

Thus it is suggested to realize ClimTec (ODP563/Pre) as joint initiatives of various institutes in Europe, coordinated by the institute of the proponent.

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MORPHOLOGY OF PASSIVE MARGIN CONTINENTAL SHELVES

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Passive margin continental shelves differ in form from region to region, some having a very gentle gradient from the shore to the shelf break, others a steep gradient, and others having one or more breaks in slope between the shore and edge of the main continental slope. The underlying cause of these different shapes is not known, but is suspected to be related to long-term tectonic subsidence, isostatic adjustment following the last glacial episode, rate of sediment supply, currents, and wave activity. Ideally, continental shelves should be "at grade," reflecting the balance between these processes. However, except near a few major rivers, the sediment supply during interglacial times is inadequate to fill the accommodation space created by erosion during low stands of sea level during glacial times. Hence most modern shelf profiles reflect the shape of the shelf during the sea level lowstands, subsequently adjusted isostatically by the load of water of the sea level highstand.

Although long-term tectonic subsidence is ultimately responsible for creating the accommodation space in which sediments can accumulate, it is now a minor factor affecting the shelves bordering the Atlantic. The isostatic depression of the shelves due to the water loading of the last sea level rise is about 1/3 the water depth, so that reconstruction of the shelf profiles before that sea level rise is a straightforward matter; the differences in profiles have been accentuated by the isostatic adjustment, but must be due to another cause. Sediment supply is important in controlling shelf morphology near major rivers such as the Amazon, Orinoco and Mississippi, but in many areas the fluvial sediment supply has been too small to fill the coastal estuaries since the last sea level rise, much less modify the shelf profile. Currents on the shelf are important in distributing sediment that rivers deliver to the shelf, but again this effect is largely limited to the areas near major sediment-laden rivers. Waves can resuspend sediment so that it can be transported by currents. The waves that affect the greatest depths are those with a long wavelength, particularly storm surge in regions frequented by hurricanes, and the long swell originating in the Southern Ocean. We suspect that wave activity may be the most likely cause of the differences of shelf profiles. If this is true, shelves exposed to long swell are most likely to have a deeper shelf break and a generally steeper gradient.

We propose a program of transects of shallow holes (200-300m) across shelves having markedly different profiles to develop an understanding of the processes controlling the shapes of continental shelves. The Atlantic offers a number of excellent prospects, in areas where the rates of tectonic subsidence and sediment supply are well known. The information required from cores is sedimentology, geotechnical properties, fossil content, and age of the shelf sediments. High resolution shallow seismics should provide a framework for placing the core information into a larger context. It would be important to do transects in areas where there is a possibility of obtaining deeper 3-D seismics in order to relate information from the study proposed here to the seismic stratigraphic concepts utilized in industry.

1. SEA LEVEL CHANGE - SHALLOW SHELF SEAS AND SHELF TO ABYSSAL PLAIN TRANSECTS

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Area of interest is the SW Approaches of the English Channel.
Objectives to sample a Neogene to Quaternary sequence of unconsolidated sand and mud to provide control on the neotectonic/sea level change evolution of the area.
The Neogene to Holocene evolution of sediment transport patterns on the Western Approaches shelf and margin (extending up into the English Channel) is poorly understood. Neogene to Holocene sediments are mainly confined to the shelf margin, with Quaternary sediments confined to palaeochannels in the inner parts of the English Channel. One of the most intriguing deposits is located within the Hurd Deep. Another comprises a series of linear sand banks on the shelf edge.
The identification and mapping of these deposits is based almost entirely upon seismic data, but there is as yet little sampling to allow the discrimination of age and facies. The available evidence suggests that the Quaternary to Recent shelf sediment transport processes are strongly influenced by sea level changes related to continental ice volumes. These climate-related events have succeeded Neogene neotectonic deformation. A catastrophic origin has been proposed for the extensive channel systems that characterise the sub-seabed in the inner channel region up to the Dover Straits, although it is more likely that the channels have formed mainly through fluvial processes. Recent work in the Hurd Deep suggests that the formation of this feature may be structurally controlled.
Whatever the recent evolution of the Channel and its Approaches, discrimination between the different theories can only be advanced by sampling the sequences that lie immediately beneath the seabed; to determine their sedimentary character and age. To this end a drilling campaign has been devised with the objective of sampling a representative series of geographically separate sedimentary units; that are distributed from the middle shelf (Hurd Deep), to the shelf edge and Abyssal Plain. Drilling technology is required to ensure the maximum recovery of the unconsolidated sediments necessary to the high-resolution nature of the investigation.
Water depths are within shelf ranges down the Abyssal Plain. The samples so acquired will be used for comparison with the extensive Quaternary sequences sampled in the southern North Sea and at the IPOD sites on the Goban Spur and Meriadzek Terrace in the deeper waters of the continental slope.

2. SHALLOW WATER CARBONATES, GAS HYDRATES
SUBSESSION ON GAS HYDRATES AND SLOPE STABILITY

Areas of interest the NW European and Papua New Guinea margins

Objectives are to core and sample an offshore sediment slump that caused the PNG tsunami of 17th July 1998 when 2,200 people died, and to compare the deformation with similar sized structures off the NW European Shelf (such as the Afen slide). The PNG slump is a maximum of 740 metres thick and an internal BSR, assumed to be a hydrate layer, was dislocated during deformation. The slump is rotational and in cohesive sediments that were displaced after an earthquake. A combination of sediment type, structure and the fluid composition are factors critical to the slumping event. However, only 6 metre long piston cores are available to provide control. A cored section of the slump is required to provide data on the overall sediment type(s) as well as sediment geotechnical and fluid properties and data on the basal detachment. Coring the hydrate layer will provide data on the morphology and chemical properties of this feature.

PROPOSAL FOR A NEW DEDICATED EUROPEAN ARCTIC RESEARCH ICE BREAKER (WITH A DEEP OCEAN DRILLING CAPABILITY): AURORA BOREALIS (DRAFT NAME)

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Scientific and Economic Objectives

The high latitude oceans are subject to rapid changes with vital environmental consequences and also with economical opportunities. The latest example is provided by the news about the shrinking of the Arctic sea ice cover, which could lead potentially to an opening for the sea traffic through the sea routes to the north of North America and Eurasia. Year-around marine research in the Arctic is therefore urgently needed.

The central Arctic Ocean has not been visited by a deep-drilling research vessel (DSDP/ODP) and therefore its long-term environmental history as well as the tectonic structure are poorly known. A European contribution to IODP could consist of drilling targets in the permanently ice-covered Arctic Ocean.

A new dedicated European research ice breaker with a deep ocean drilling capability would provide the opportunity to conduct international, interdisciplinary expeditions during all seasons of the year and to penetrate into permanently ice-covered basins of the central Arctic Ocean.

Dimensions (draft design) and Capabilities of the New Ice Breaker

Length LPP 132.00 m; displacement 23,000 t.

Ability to serve the needs of the polar science disciplines: meteorology, glaciology, oceanography, biology, geology and geophysics as well as marine technology. Capacity of laboratories and electronic areas is 2300 m^2.

Ability to endure winter and spring expeditions to the permanently ice-covered central Arctic Ocean. Ice breaking performance of more than 2 m and dynamic positioning in ice.

Deep drilling and coring capability in up to 4 km water depths penetrating into the sea floor up to 1 km.

The European Aspect

Promotion of the continuity for European polar research programmes and of the internationally successful competition about the leadership in Arctic research.

The new research ice breaker is thought of as an alternate platform in the European contribution to the successor of the Ocean Drilling Program, the Integrate Ocean Drilling Program (IODP).

The formation of an European Consortium of interested institutes/countries is required to share the responsibility for the planning and construction of the Arctic ice breaker and to coordinate the scientific programmes.

TESTING CLIMATE MODELS WITH ALTERNATE DRILLING PLATFORMS

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Even the most advanced fully dynamic coupled ocean atmosphere models show discrepancies between observed and predicted climate parameters, e.g. surface temperatures, over large areas and in key-regions for palaeoclimate reconstructions. One critical area is the North Atlantic from the Last Glacial Maximum (LGM) to present.

Based on the first high resolution model simulation of the LGM (latest Hadley Centre Model) surface temperature predictions for parts of the modern northern North Atlantic lead to considerably higher temperatures than actually observed. This is due to the enhancement of the wind-driven gyre, caused by strong katabatic flow of the Laurentide icesheet. Drilling and coring with alternate platforms would allow to study LGM sedimentary records along a depth-transect intersecting with onshore sections hence allowing to test whether there is any evidence in the sedimentary record of strong and continuous katabatic flow of the Laurentide Ice Shield. Other temperature anomalies where alternate platform drilling could provide a problem solution are observed along Antarctica, off-shore East Africa and western North America.

DRILLING & CORING OFFSHORE MARINE SUCCESSIONS FROM SEA ICE PLATFORMS: CAPE ROBERTS PROJECT (1997-2000), ANTARCTICA

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Three holes were drilled from ~2m thick sea ice platforms into an upper Paleogene-lower Neogene succession on the margins of the Victoria Land Basin in the Austral summers of 1997-2000. The Cape Roberts Project (CRP) comprised a six-nation scientific and technical consortium from Australia, Germany, Italy, New Zealand, United Kingdom and the United States. Sites were located ~12km offshore in water depths between 150 and 295m. Initial Reports and Science Results are published in *Terra Antartica* (Siena, Italy). Technical operation details for each drillhole are also provided in the Initial Reports volumes. A Longyear 44HD drill rig was used. A 125mm diameter riser system was run from the surface and embedded in the seafloor. The drill string consisted of Q series pipe (HQ:OD 96mm/ID 61m and NQ:OD 76mm/ID 45mm). Rigid flotation collars and air bags provided buoyancy for the riser-drill string assembly and minimized the weight of the drill rig, other equipment and structures on the ~2m annual sea ice platform. Drilling fluid control of density, viscosity, hole conditioning, fluid loss, and cementing was controlled by mixtures of sea water, potassium chloride, Guar gum, XCD polymer, Pac-R, mica, and calcium chloride. Core recovery rates ranged between 86 to 98 percent in the more than 1700m of strata penetrated during 91 days of drilling. Drilling, coring and logging activities produced an average downhole progress of approximately 19m/day. The drilling assembly developed for CRP proved particularly suitable for operations in relatively shallow water polar sedimentary basin margins characterized by a variety of clastic lithologies, abrupt lithofacies changes, and an abundance of unconformities. Without the very high rates of core recovery obtained it would have proved impossible to decipher a detailed record of basin margin cyclostratigraphy. The core record obtained provided a virtually continuous sedimentary succession through the western margin of the Victoria Land Basin, dating from 17 to 34 million years ago; and penetration of 100 m into the Devonian Beacon Supergroup below the basin floor. Paleobotanical evidence (*Nothofagidites*, podocarps, palms) from the oldest Cenozoic sediments cored show that the Ross Sea coast of East Antarctica had a cool temperate climate from 34 to 25 million years ago; and the presence of occasional boulders and striated clasts indicate glacial activity and rafting at this time. The period from 25 to 17 million years ago, records a low-growing, sparse tundra vegetation on adjacent mountains, and evidence for ice sheet and glacier extension offshore and over the drillsites. A prominent feature of CRP drillhole Oligocene-Miocene stratigraphy is the occurrence of more than 50 unconformity-bounded stratigraphic sequences or sedimentary cycles comprising ordered alternations of diamictitite, sandstone and mudstone. One sequence is 64 m in thickness but many are significantly thinner. Chronostratigraphy is constrained by a combination of radiogenic dating of tephra and volcanic clasts, biostratigraphy and magnetostratigraphy. A comprehensive study of three sequences straddling the Oligocene-Miocene boundary points to deposition in less than 400,000 years and perhaps as little as 120,000 years. The occurrence, stratigraphic distribution and relationships between the wide variety of benthic and planktic marine fossil groups and their relationships to lithofacies within each sequence points to the existence of dynamic basin margin environments which were responding to changes of the terrestrial ice margin, sea ice cover, sea level and water mass characteristics. Further, it is suggested that the total sedimentary and biological environment was responding to orbitally induced fluctuations of the East Antarctic Ice Sheet margin, possibly at 40,000 year frequencies.

BRAZIL-FALKLAND (MALVINAS) CONFERENCE: PALEOCEANOGRAPHY OF A MIXING REGION

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In 1999 we submitted a proposal to ODP (556-Pre) to drill a number of transects on the Atlantic margin of South America, at the edge of the Argentine basin (between the Falkland Islands and the Rio Grande Rise). The target is late Neogene paleoceanography. We are especially interested in the reconstruction of the history of the mixing of tropical and subantarctic water masses in this region, which represents the general site of the confluence between the Brazil Current and the Falkland (Malvinas) Current. The dynamics of this region are important in several contexts: for the heat budget of the South Atlantic, for the production of intermediate water, and for the level of regional productivity.

We proposed to drill several transects across the continental margin bounding the Argentine Basin to the west, and several sites in the mudwave area. The proposed transects and their sites are oriented east-west, to optimize detection of the motions of the Brazil- Falkland (Malvinas) Current confluence and mixing center. Shallow sites, on the upper continental margin, should help to reconstruct the properties of overlying waters, where the mixing takes place.

The environmental panel of ODP supported the proposed work and requested a full proposal. The program is viewed as a natural extension of recent Leg 175 (Benguela Current) drilling efforts. ODP recognizes that the Argentine Basin research has the potential to significantly further our understanding of the South Atlantic's role in climate change. Of particular interest is the potential for one or more depth transects for reconstructing intermediate and deep-water circulation.

Preliminary site selection is based on work we have done on Pleistocene sediments in the region, using RV METEOR, in 1993, 1994 and 1999. An especially valuable feature of these

expeditions, in the present context, are detailed surveys of bottom morphology using HYDROSWEEP technology. METEOR's PARASOUND equipment records the structure of the uppermost about 100 m of the sediment. Also, we have in hand a suite of box cores and oversize gravity cores up to 20 m long. Further site survey data are available from METEOR-Cruise M49/2 and /3 (January – March 2001) using high resolution reflection seismics.

SOUTHERN IBERIA ABYSSAL PLAIN: A DEEP TEST OF TIME AND MODELS ON A COLD RIFTED MARGIN

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Post-2003 deep drill site. Proposed 24 September, 1998
Water depth: ca. 5300m Sediment thickness: ca. 2200m Basement penetration: ca. 100m

Background and objectives:

Despite having drilled an east-west transect of ten sites across ocean-continent transition of West Iberia our knowledge of the last stages of rifting of margin is constrained by the fact that all sites necessarily sampled only basement highs and the sediments above them. Therefore, we now propose a generic deep site situated towards the oceanward edge of the thinned continental crust under the southern Iberia Abyssal Plain (a precise location has yet to be chosen). Because the site will be located in a basement low between a pair of tilted fault blocks the hole will be able to address significant geological problems that so far have not been addressed because previously it was be located so as to enable the hole to also penetrate an intrabasement sub-horizontal reflector that represents a significant syn-rift detachment fault but this objective will require a major additional basement penetration of several hundred meters.

Detailed objectives (in order of ease of attainment):

1. sample the post-rift (post-earliest Cretaceous) section that remains uncored (so far only the Paleocene to Recent section has been cored continuously) to document about the first 65Ma of the post-rift history of margin (about one thermal time-constant in length),
2. sample the earliest post-rift and the syn-rift sections to document the timing and duration of rifting (to confirm or refute the hypothesis, based on seismostratigraphic studies, that rifting lasted only a few million years (from Late Berriasian to Early Valanginian)) and the break-up of continental crust (onset of mantle exhumation?).
   These sections will also reveal the thermal subsidence and the sediment facies associated with this important stage of margin development at a point close to where continental crust eventually ‘broke’.
3. to determine the nature of the sediment-basement contact i.e. is it the result of syn-rift onlap or post-rift draping? Is the basement surface (which so far in 5 out of 6 Leg 149/173 holes that penetrated igneous or metamorphic rocks on basement highs has been covered by breccia) a fault plane that is part of a major detachment system?
4. To discover whether the extrusive melt products, that that are predicted to exist by numerical models, but which so far have barely been in drill cores (or other samples) from this margin, have accumulated in the depressions between the basement highs,
5. To seek further evidence of the existence of lower continental crust at the oceanward edge of rifted continental crust, that dredging, submersible sampling and drilling have so far rarely located, and to deduce the syn-rift and late pre-rift deformation history of such crust,
6. To penetrate an intrabasement sub-horizontal reflector that appears to represent a significant syn-rift detachment fault and hence to determine the role and history of such faults in the extensional process.

DETAILED STUDIES OF A TSUMAMIGENIC STRUCTURE OFFSHORE SW IBERIA, THE MARQUES DE POMBAL FAULT: THE CHANCE OFFERED BY THE TECTONIC SOURCE OF THE 1755 LISBON EARTHQUAKE.

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Episodically tsunamis affect the coastlines of several countries, causing hundreds casualties and compelling civil authorities and scientific community to devise effective strategies for mitigating human losses and damages.

In SW Iberia, offshore Cabo de S. Vincente, a single, 60 km long, active thrust structure with total dip-slip displacements up to 1100 m and decollement surface recognizable down to 10 sec TWT (about 12-15 km depth) has been discovered. This tectonic structure is located on a present day active seismic area and is inferred to be the most probable location of the large “1755 Lisbon Earthquake” epicentre. The precise localization of a tsunamigenic source in a narrow area could offer straightforward opportunity in the study of tsunami generating mechanisms, propagation and warning. This structure is presently under intense geophysical and geological investigation sponsored by the EC through the project BIGSETS (Big Sources of Earthquake and Tsunami in SW Iberia). The OPD sites here proposed will be a crucial step to acquire some of the key parameters needed for the understanding and the modelling of the tsunami generation mechanism. To achieve these targets we suggest one borehole across the fault plane to measure the physical properties of the rocks, the "in situ" stress field and the frictional resistance to slip; a second stratigraphic one to obtain a rough evaluation of the number of relevant up-lift events of the structure, of their age and amplitude and moreover to gain a good statistical evaluation of its seismic risk potential.

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