This issue provides a preview of three upcoming meetings that will be critical to the further development and implementation of the MARGINS Program. The "Source to Sink" Workshop, scheduled for the last week of September 1999, will develop the MARGINS Science Plan for Sedimentology and Stratigraphy. In 2000, there will be two MARGINS Theoretical and Experimental Institutes. The first, on the "Rheology and Deformation of the Lithosphere", will occur in late January. The second, "Inside the Subduction Factory", will be held in August. Each will comprise a short course and a workshop. Following the successful RIDGE Program model, the short courses will foster stronger links between observationalists, experimentalists, and theoreticians, and give researchers and their students the required background to address complex, interdisciplinary problems. The workshops will focus on ways to implement these ideas; the first one will develop the "Rupturing Continental Lithosphere" Science Plan and the second will identify the next key Subduction Factory field/lab/model experiments.

The first MARGINS Newsletter (Spring 1998) gave a summary of (1) the MARGINS rationale, scientific problems, research strategies, and the four research initiatives, (2) the Seismogenic Zone Experiment (SEIZE) Workshop, and (3) planned ODP Leg 185 drilling of the input to the Izu-Bonin-Mariana Subduction Factory. The second Newsletter (Fall 1998) included articles on the planned (1) US-Japan 3-D seismic reflection, refraction and seismicity experiment in the central Nankai Trough, (2) microseismicity experiment to illuminate low-angle normal faulting in the active rift of the Woodlark Basin, and (3) ODP Leg 186 establishment of a long-term geophysical observatory at the Japan Trench, as well as (4) a summary of the Subduction Factory Workshop.

The field programs described in the first two Newsletters are being implemented this year. ODP Leg 185 has begun (18 April - 14 June) and Leg 186 will follow (20 June - 14 August). R/V Maurice Ewing will be used for the Nankai seismic experiment (18 June - 18 August), the Woodlark microseismicity experiment (30 August - 16 September), and a Woodlark heat flow experiment under the direction of Fernando Martinez (19 September - 22 October). Reports on these programs will appear in future issues of the MARGINS Newsletter. A report on ODP Leg 180 drilling in the western Woodlark Basin is provided in this issue, as is a description of the new SUBSCAN sidescan and sub-bottom imaging system (see page 12-14).

More than 50 people attended the MARGINS Subduction Factory meeting in San Francisco on 12/7/98 to discuss the relative merits of the Izu-Bonin-Mariana versus Tonga-Kermadec systems for a focused study area of intra-oceanic arcs. A vote taken at 7 pm after 1.5 hours of spirited debate was nearly unanimous in favoring the IBM system (35 for, 2 against, 8 abstentions of steering committee and non-US members). Therefore the community determined, MARGINS focused study field areas are: 1) for SEIZE: Nankai - Japan Trench; Costa Rica - Nicaragua (2) for SubFac: Costa Rica - Nicaragua; Izu-Bonin-Mariana. "In addition to the focus areas, allied studies at selected margins (the SubFac Science Plan specifically mentions the Aleutians and Cascadia) and paleo systems (such as exhumed subduction zones and arc basement) are necessary to make global comparisons to models that will emerge from the focus areas and to provide valuable further insight into these processes. In some cases these may occur after initial studies in the focus areas" (quoted from the Science Plans).

With the MARGINS Program announcement published by NSF last Fall, the first set of proposals were submitted to the January 15th MARGINS deadline. The joint EAR (CD) - OCE (MGG, ODP) MARGINS review panel met the first week of May and the results should be known soon. The steering committee and program managers are very excited by the potential of this joint ocean-and-earth science review process. Having removed a major stumbling block for MARGINS science that straddles the coastline, we are moving ahead on all fronts of program planning and execution.
**SOURCE TO SINK**

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**Towards a Sed/Strat Science Plan**

Margins are the principal locus of sediment accumulation on Earth. The pathways followed by sediments on their journey from source to a sink (e.g., hill-slope erosion, river transport, biological production, temporary storage, seabed burial) have major impacts on the lives and livelihoods of people worldwide, ranging from natural hazards, to pollutant transport, shoreline erosion, and resource preservation. The eventual sinks for sediments are in carbonate and/or siliciclastic depositional settings, where their fate is determined by diverse factors (e.g., sea level, tectonics, climate, sediment supply, ocean hydrodynamics) that control sediment deposition and burial. The resultant stratigraphy on margins is a tape recording of Earth history, but the fidelity with which the stratigraphy records processes occurring on Earth is variable. A rich, but complex signal is created. This signal needs much better understanding than presently available, in order to unravel the interrelationships of past processes and to predict impacts of future processes (including applied scientific considerations, such as: erosion and landslide mitigation, river flooding, dredge-spoils disposal, channel navigation, fishing activities).

NSF will fund a meeting at which the science plan for the MARGINS sedimentology and stratigraphy community will be created (JOI support also has been requested). This plan will suggest important directions for future research, recommend strategies for accomplishing this research and will consider candidate sites for detailed interdisciplinary studies. The science plan is expected to provide a blueprint for taking geomorphologic, sedimentary and stratigraphic processes to a substantially higher level of understanding. The research goal is to discern the relationships among processes relevant to sediment production, transport, accumulation, and preservation on margins at multiple temporal and space scales, from turbulence to tectonics and from sedimentary fabric to sequence stratigraphy and basin analysis.

**Coupled Land-Ocean Systems**

The meeting and the science proposed will use a systems approach to examine coupled land and ocean environments (from mountain tops across shorelines to abyssal plains). It will involve understanding of drainage-system development and evolution, examination of the interplay between the drainage basin and sediment input to marine environments, assessment of how whole dispersal systems respond to climatic and base/sea-level perturbations, and information about transfer functions from sediment dispersal to the stratigraphic record. The many processes producing sediment on land (e.g., weathering, hill-slope erosion, fluvial transport, landscape evolution) will be considered in concert with those processes that control sediment burial on carbonate, mixed and siliciclastic margins (e.g., sea-level fluctuations, ocean hydrodynamics, biological productivity). These diverse processes are linked as part of the continuum forming a sediment dispersal system. In addition, consideration will be given to other processes, which impact both sides of the shoreline by themselves (e.g., tectonic activity, climate changes, groundwater variations).

Emphasis will be placed on developing a significantly better understanding about the creation and interpretation of landscape evolution and the sedimentary record.

Understanding the linkages within entire sediment dispersal systems requires coordinated interdisciplinary investigations. Capturing this synergy will be important, and has the potential to foster much innovative research, as suggested below.

- **Landscape-evolution models** should be able to predict fluvial discharge of sediment, including hyperpycnal events that could transport sediment to deep portions of the margin.
- **Margin stratigraphy** can provide an independent check on terrestrial erosion rates from isotopic observations (e.g., ¹⁰Be, ²⁶Al) of land surfaces.
- **Models using precipitation forecasts** can predict hydrologic response in rivers, and can lead to stochastic models of sediment delivery to margins.
- **Events impacting land and sea** (e.g., river floods) can be investigated simultaneously through monitoring and rapid-response data collection.
- A fundamental question facing both geologic and oceanographic studies is how mass moves across isobaths on margins, especially across significant boundaries (e.g., shoreline, shelf break).
- **Fluvial environments and marine environments** can be investigated contiguously in a dispersal system, in order to elucidate linkages between them when base/sea-level fluctuations.
- **Many of the same fundamental physical mechanisms** operate for transport of sediment in fluvial and marine environments, and theoretical advances in one area should help the other.
- **Depositional environments** form a spectrum from carbonate to mixed siliciclastic, and should be studied as a depositional system in a process-oriented framework.
- **Melt-water pulses from terrestrial ice sheets** and catastrophic breaching of glacial lakes should be recorded in high-resolution sea-level curves and stable isotope (δ¹⁸O) data.
- **Integration of forward models**, inverse one-, two-, and three-dimensional models, margin sequence stratigraphic records, and global oxygen isotopic variations will provide a testable record of past eustatic change.
- **Reconstruction of sediment input**, eustatic, and tectonic variations will allow testing of models for sedimentation changes within sequences.
- **Reconstruction of erosion, transport and storage of sediment** in large river valleys can illuminate the linkages between tectonic and climatic events on land, and the magnitude, mineralogy, and timing of signals recorded in margin stratigraphy.
• Integration across scales and environments will require partnerships between modeling and observations.

**Experiment Design and Equipment**

Interdisciplinary field, lab, and modeling efforts, with a range of tools from computer and flume-tank simulations to airborne surveying and shallow ocean drilling, will be required to understand the dynamic components controlling erosion, sediment transport, and sediment dispersal from source to sink across the coupled land-ocean system. Although the potential study areas are not constrained prior to the creation of a science plan, a major contribution of the proposed meeting will be to identify several candidate areas best suited for future investigation. Scientific priorities and financial resources require a focused effort.

Certain field equipment is recognized as central to our quest for a quantum step in understanding landscape evolution, sedimentary processes and stratigraphy. High-resolution digital topography/bathymetry and other forms of remote sensing (such as side-looking sonar and radar, and hyperspectral imagery) will be essential, as will ground-penetrating radar/seismic systems and drilling at all elevations/depths (including shallow water 0-100 m). Multiple dating techniques (radiochemical, paleontological, cosmogenic radiochronology) will be important. Studies on land and sea are anticipated to provide time-series data regarding many important processes. Fiber-optic cables or telemetry systems would be ideal for these observations. Rapid response to events (e.g., floods, landslides, storms, earthquakes) also will be needed to maximize the information obtained for some processes, and this will require creative uses of ships, aircraft, and unmanned platforms (drones and AUVs).

Numerical modeling will be an important component to many studies, and the development of robust models may control the sequence of observations. In cases where models exist, they can help delineate the variables that must be measured. In cases where they don’t exist, experimental designs may have to wait. In other cases, observations will be needed before models can be formulated. Such evaluation of sequential timing for these and other considerations will occur at the meeting. In the context of a large, interdisciplinary effort, special attention shall be paid to designing tests and calibrations of mathematical models.

**Timetable, Funding and Applications**

The four-day meeting will be held at Lake Quinault, WA, on Sept 28-October 1, 1999. An organizing committee will help identify speakers, who will give educational presentations during the first two days. Prior to the meeting, participants will be asked to express thoughts about criteria for choosing topics and sites of investigation. These will be used to frame and focus the discussions on the final two days, when the science plan is written. Shortly after the meeting, a draft of the science plan and descriptions of 2-3 candidate study sites will be disseminated through the MARGINS web page and mailing list. Final consideration of these will occur during a community meeting at the December 13-17 AGU meeting. The goal is to build a consensus about topics and regions to study, and to prepare the community for submitting MARGINS proposals; i.e., to have a science plan for the Sedimentology and Stratigraphy portion of MARGINS in place by the end of 1999.

Approximately 50 participants are expected, and funds are available for travel support. Applications to attend the workshop should be submitted to the MARGINS Office. The MARGINS Steering Committee will be asked to evaluate candidates. To apply, send a one page (or less) e-mail message to margins@soest.hawaii.edu containing
(1) address and contact information, including web site,
(2) description of research interests,
(3) statement of potential contributions to the meeting.

**Organizing Committee**

C. Nittrouer* (U. Washington), convenor
N. Driscoll* (Woods Hole OI), convenor
J. Austin (UT Austin)
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**Rheology and Deformation**

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### Rheology and Deformation of the Lithosphere at Continental Margins

The primary goal of the MARGINS Program is "to understand the complex interplay of processes that govern continental margin evolution". The plan is to investigate active systems as a whole, viewing a margin not so much as a "geological" entity of divergent, translational or convergent type, but more in terms of a complex physical, chemical and biological system, subject to a variety of influences. One approach that has been adopted by MARGINS to promote progress toward this goal is the organization of Theoretical and Experimental Institutes. These Institutes are designed to foster stronger interaction between observationalists, experimentalists, and theoreticians, and to give researchers and their students the required background to address complex, interdisciplinary problems.

NSF has funded the first MARGINS Theoretical and Experimental Institute (TEI) in January of 2000 to investigate the "Rheology and Deformation of the Lithosphere at Continental Margins". Traditionally, such investigations have taken place at one scale in the laboratory and at entirely different scale in the field. Laboratory experiments are generally restricted to centimeter-size samples and day/year-length times, while geological processes occur over tens to hundreds of kilometers and millions of years. Application of laboratory results to geological systems necessitates extensive extrapolation in both time and spatial scales, as well as a detailed understanding of the dominant physical mechanisms. Development of an understanding of large-scale processes requires an integrated approach. Communication between experimentalists and theoreticians is essential in order to design experiments to address the implications raised by macroscopic field observations. One of the principal objectives of the MARGINS TEI will be to stimulate cross-disciplinary inquiry into the rheology and deformation of lithosphere, which will provide a better understanding of the varying margin architectures observed and a framework within which laboratory, field, and modeling experiments can be posed.

The R&D TEI will consist of a four-day Short Course followed by a two-day workshop. The first day of the Short Course will provide an overview of the setting and nature of deformation at extensional and compressional continental margins. Day 2 will concentrate on: a) observations supporting, and models explaining, strain partitioning within the crust and lithosphere and b) numerical and analogue modeling experiments that address the scaling problem of comparing physical experiments with natural systems. Day 3 will focus on laboratory observations related to frictional sliding and crack healing along fault surfaces. Day 4 will center on experimental studies of the rheology of crustal rocks. The Workshop will last two days and will be focused on the Rupturing Continental Lithosphere (RCL) initiative of the MARGINS Program: "a comprehensive investigation of faulting, strain partitioning, and magma emplacement at sites of active continental rifting where there is a transition to initial seafloor spreading". With the input from the Short Course, the Workshop is designed to flesh out the RCL science plan (fieldwork, modeling and experiments) and to select field areas for focused investigation (as has been done previously at workshops for two of the other MARGINS Initiatives: the Seismogenic Zone Experiment and the Subduction Factory).

### Timetable and Applications

The meeting will be held at Snowbird, Utah, January 23-30, 2000. One of the broad goals of MARGINS is to involve numerous researchers and students from a variety of fields in interdisciplinary research aimed at the complex interplay of processes that govern the formation and evolution of continental margins. Consequently, participation in the Short Course will be open to all researchers and students. Nevertheless, in an effort to maximize participation and effectiveness of communications, MARGINS supported attendance will be limited to 95 participants. For these participants, the MTEI will provide full travel and lodging costs for keynote speakers, convenors, students, and an additional 30 participants. Approximately 50% travel and lodging costs will be paid for an additional 20 participants. Registration fees will be reimbursed for keynote speakers, convenors, and students. High priority will be given to supporting students. Workshop participation will be limited to 30 people who will make the commitment to stay for the entire Workshop.

Applications to attend the TEI should be submitted to the MARGINS Office by 31 October. The MARGINS Steering Committee will evaluate these and make recommendations for the award of travel funds in November. To apply, send a one page e-mail message to margins@soest.hawaii.edu containing (1) address and contact information, including web site, (2) description of research interests, and (3) statement of potential contributions to the meeting. Inquiries may be addressed to either Garry Karner (garry@ldeo.columbia.edu) or Dave Kohlstedt (dlkohl@maroontc.umn.edu). For further information, see http://www.soest.hawaii.edu/margins/RheologyDeformation.html.

The MARGINS Steering committee is excited at the prospect of bringing together a number of research communities that traditionally have had little interaction. Prior to the meeting, participants will be asked to express thoughts about criteria for choosing topics and sites of investiga-
tion. These will be used to frame and focus the discussions during the two day workshop. Outlines of the short course lectures with key references and figures will be sent to all participants well in advance of the meeting. Following the meeting, we plan to publish the review papers derived from the lectures and associated participant research as a high-quality publication for broad distribution.

Rationale for the TEI
Rheology is the branch of Physics dealing with the deformation and flow of materials. Macroscopic observations of margins using remote sensing (e.g., seismics, gravity, magnetics) examine the style and wavelength of the deformation from which predictions are made concerning the "mode of deformation" (rheology) and how it varies throughout the deformational history. Laboratory experiments place constraints on the physical conditions required for materials to deform and illustrate how the deformational style varies as a function of temperature, strain rate, and material. Modeling efforts that incorporate and build on the results from laboratory experiments and make predictions of margin architecture that can be tested provide a potential vehicle to bridge the scaling problems of comparing physical experiments with natural systems.

The main goals of the four-day Short Course are to:
• educate researchers and students in rheology and deformation processes and to concentrate on aspects of theory that observations can test.
• enhance communication and interaction between modelers, experimentalists, and observationalists.
• bridge the scaling problems associated with comparing physical experiments with natural systems.
• foster interdisciplinary studies required to make substantial advances in understanding how the earth deforms at margins.

Rupturing Continental Lithosphere
With the input from the Short Course, the two-day Workshop is designed to flesh out the Rupturing Continental Lithosphere science plan (fieldwork, modeling and experiments) and to choose field areas for focused investigation. The Rupturing Continental Lithosphere initiative derived from two of the five science foci identified in the MARGINS Initial Science Plan, 1996: (1) The Low-Stress Paradox and (2) Strain Partitioning (see http://www.soest.hawaii.edu/margins/Science_Plan.html), and is briefly summarized here.

The mechanisms that allow continental lithosphere to be deformed by weak tectonic forces are not understood, nor is the manner in which strain is partitioned and magma distributed. These processes control the fundamental margin architecture and hence the location and magnitude of resources and geologic hazards. One way to solve these problems is to focus a comprehensive investigation on faulting, strain partitioning and magma emplacement at sites of active continental rifting where there is a lateral transition to initial seafloor spreading. The along strike variation will provide a spatial proxy for temporal variability. The effects of, and consequences for, hydrous fluids and sediments will be included in these integrated observational, laboratory and modeling experiments. The objectives of these experiments are to:

1. Determine the local and regional states of stress, the distribution and rate of strain, the pressures and temperatures, and the physical and chemical properties of rocks and fluids associated with a well-imaged and seismically active low-angle normal detachment (the extreme case of the weak fault paradox). Measurements of these in situ parameters made by drilling, instrumenting and long-term monitoring will be used to determine how such faults move at resolved shear stresses far smaller than those expected based on laboratory observations and Coulomb rheologies.

2. Determine the spatial and temporal distribution of strain by (i) mapping the geometry and offset of faults, (ii) inverting and modeling the stratigraphic and structural record to resolve the history of strain variation and its control on topography/erosion/deposition, (iii) using seismic, gravity/geoïd and geothermal methods to obtain an integrated sum of the deformation and a measure of the ductile thinning of the lower crust, and (iv) evaluating the heterogeneity of the continental lithosphere prior to rifting.

3. Determine the pattern of mantle flow, the extent of melt generation, and the style of melt migration and emplacement during continental rifting and the early stages of seafloor spreading by imaging with seismic and electromagnetic methods an active rift-spreading transition, by measuring the heat flow distribution, and by analyzing the chemistry of magmas emplaced in these regions.

Organizing Committee
G. Karner (Lamont-Doherty EO) convener
D. Kohlstedt (U. Minnesota) convener
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Inside the Subduction Factory

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Thematic Background

Subduction zones are locations of energy and mass transfer between the Earth’s lithosphere and interior, and therefore subduction zone processes influence the geodynamical and geochemical evolution of the mantle and crust. Current understanding suggests that many of the key elements to subduction zone processes take place at or near the top of the subducted slab at depths between 50 and 150 km. Here, mechanical coupling and heat-transfer between the subducting slab and the overlying mantle drive convection in the mantle and effect mass transfer from the slab to the wedge. Together, these processes result in partial melting that is ultimately expressed in arc and back arc volcanism and that is widely thought to control the long-term growth and chemical evolution of the continental crust. These processes also change the composition of both the portions of the slab that ultimately descend to depths greater than 150 km and the overlying wedge, thereby influencing the composition and structure of the mantle.

The importance of subduction zones was recognized early in the formulation of modern plate tectonic theory, but owing to their complexity—particularly in the intermediate depths (~50-150 km) where devolatilization, melting, and intermediate depth earthquakes occur—subduction zones are arguably the least-well understood portions of the shallow global tectonic framework. In contrast to what we know at mid ocean ridges, for example, we still do not know where melting occurs beneath arcs, whether it is driven by water fluxes and/or upwelling, how hot the mantle and slab are, and what their mineralogy is. After thirty years of study, some of the most basic questions are still with us.

In recent years, however, our understanding of subduction zones has increased as a result of improved geophysical, geochemical, experimental and geodynamical methods. Seismic velocity and attenuation models based on tomography and wave-form modeling permit inferences of temperature structure and partial melting within mantle wedges (e.g. Hasegawa et al., 1994; Zhao et al., 1994; Xu and Wiens, 1997; Zhao et al., 1997).

Geochemical tracers can now identify the separate contributions of subducted oceanic crust, sediments, and mantle wedge to arc volcanism (e.g., Tatsumi et al., 1986; Morris et al., 1990; Stolper and Newman, 1994; Hawkesworth et al., 1991; Plank and Langmuir, 1993; Elliott et al., 1997). Experimental petrology is now providing new data on melting and element partitioning in H2O-rich systems (e.g. Hirose and Kawamoto, 1995; Gaetani and Grove, 1998), traditionally very difficult processes to approach in the laboratory. And geodynamical models are beginning to incorporate dynamic slabs, melting, and chemical transport (Davies and Stevenson, 1992; Kincaid and Sacks, 1997; Iwamori, 1998).

Subduction Factory Initiative

Despite these recent advances, most studies and meetings are still done in isolation of other disciplines. Tomographic data could be combined with petrologic data to better constrain the locus of melting in subduction zones. Geochemical tracer studies of volcanic rocks need determination of partitioning and phase relations to identify the location of mineral reactions occurring in the slab and wedge. These mineral reactions, in turn, affect the seismic velocity structure of the slab, and perhaps even the location of earthquakes. Thus, self-consistent models of subduction zone structure are testable with both geophysical and geochemical observations. Quantum advancement in our understanding of the dynamic working of the subduction factory will only come from such multi-disciplinary studies. Such a multi-disciplinary approach to active systems is the underlying methodology of the MARGINS Program.

Formulating the essential problems, places and approaches to studying subduction processes was the main goal of the Subduction Factory Workshop, held in La Jolla in June 1998, and the resulting Subduction Factory Science Plan, published on the MARGINS web site (see http://www.soest.hawaii.edu/margins/SF_Sci_Plan.html). The Plan focuses on three main themes: (1) Subduction Parameters as Forcing Functions on Factory Output, (2) The Volatile Cycle through the Subduction Factory, and (3) Towards Mass Balance of Input and Output. In addition to the main science themes, the Subduction Factory initiative of the MARGINS Program centers around two multi-disciplinary field experiments; one in the Central American arc of Nicaragua and Costa Rica and the other in the Izu-Bonin-Marianas arc of the western Pacific. Combination of geologic, geochemical, geophysical, and oceanographic studies of well-chosen regions will lead to better understanding of the processes affecting mass transfer into and out of subduction zones on a regional (and ultimately global) scale. In addition to the focus areas, allied studies at selected margins (the SubFac Science Plan specifically mentions the Aleutians and Cascadia) and paleo systems (such as exhumed subduction zones and arc basement) are necessary to make global comparisons to models that will emerge from this work and provide valuable further insight into these processes. In some cases these may occur after initial studies in the focus areas. In parallel with such field experiments, theoretical and experimental studies of subduction zone processes are an intrinsic part of the Subduction Factory initiative.

Theoretical and Experimental Institute

In August 2000, the MARGINS Program will convene a Theoretical and Experimental Institute (TEI), funded by NSF, to address the Inside of the Subduction Factory. Many fundamental questions of the Subduction Factory Science Plan focus on the intermediate depth in the subduction zone, including: How do forcing functions such as conver-
gence rate, dip, slab temperature and slab output fluxes drive flow and melting of the mantle wedge? The devolatilization of the subducting slab is an essential component of the Earth’s water and CO₂ cycle. Where does the slab dehydrate, how do the fluids migrate out, and how do the fluids affect slab stresses? Mass balance across the subduction zone is critically dependent on the rate at which magmatic arcs grow, which in turn is dependent on the melting rate in the mantle. What factors control the volume and rate of melting in the mantle, and the mechanisms of melt aggregation and transport?

The TEI will be an important means to focus and energize allied experimental and theoretical studies, and to coordinate them with field based experiments. The Inside the Subduction Factory TEI will comprise a short course and associated workshop designed to further the understanding of mass and energy transfer in subduction zones and mantle wedges in the intermediate depth range (~50–~150 km)

The specific goals of the proposed TEI include:

- Education of the community of researchers, including graduate students, as to the methodologies, interpretations, limitations, and prospects of geochemical, geophysical, experimental and field studies of subduction zone/wedge processes.
- Identification of key field or experimental observations that must be collected or theory that must be developed (or key integration of data and theory) required to address significant unsolved problems related to subduction zone/wedge processes.
- Facilitation of discussion between experimentalists, modelers, and field practitioners involved in data collection at the SubFac localities (Central America, Izu-Bonin-Marianas).
- Incubation of a multi-disciplinary community that will continue to communicate as the Subduction Factory initiative proceeds

Meeting Format and Logistics
The meeting will take place in Eugene, on the campus of the University of Oregon, and will consist of a four day short course, followed by a one day workshop. In addition, there will be an optional 2-day field excursion to the Oregon High Cascades to see spectacular examples of modern arc volcanism, including Crater Lake and the Three Sisters region.

The Short course will be divided into three sections - Theoretical and Experimental Investigations of the Slab (1.5 days), and of the Mantle Wedge (1.5 days), and Observations from the Subduction Factory focused field experiment areas (1 Day). The first two sections will each include keynote speakers and discussions with perspectives from seismology, thermal evolution, geodynamics, rheology, petrology, and geochemistry. The workshop discussion will emphasize the relationship between the overall goals of the Subduction Factory focused field experiments and the needed laboratory and theoretical progress that must accompany those experiments.

Short Course participation will be limited to 100 individuals. Participant selection will be done by the conveners in consultation with the MARGINS Steering Committee and will be based on submitted abstracts and relevance of research interests. Twenty slots will be reserved for students. Workshop participation will be limited to 30 people, with selection based on a letter of interest outlining past, current, and likely future research activities.

Exact meeting dates and details of how to apply for the TEI will be published in the next MARGINS Newsletter and on the MARGINS web site.

Organizing committee
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Terry Plank (geochemist, Boston U.)
Geoff Abers (seismologist, Boston U.)
John Eiler (geochemist, Caltech)
Karen Fischer (seismologist, Brown U.)
Chris Kincaid (geodynamicist, U. Rhode Island)
Dana Johnston (host, U. Oregon).

References
Continental Rifting, Low-angle Normal Faulting and Deep Biosphere: Results of Leg 180 Drilling in the Woodlark Basin

by Brian Taylor, Philippe Huchon, Adam Klaus and the Leg 180 Scientific Party

Overview
What makes the largest faults, the ones that sustain most slip, much weaker than existing theories and experiments can explain? To answer this question, Leg 180 targeted drilling of an active fault at the western apex of the Woodlark Basin, where a seafloor spreading center is propagating into rifting Papuan continental crust. The crust there is being pulled apart at ~3 cm per year. The extension appears to be focused on a normal fault with shallow inclination (25-30° dip down to 9 km) that reaches the sea floor. This makes it ideal for study by vertical drilling but also particularly enigmatic: faults with low dip are locked by gravity and can only slip if unusually weak or well lubricated.

Leg 180 established a high-resolution syn-rift stratigraphy, vertical motion history, and basement petrology, of an actively rifting continental margin. The known extent of the deep-sea biosphere was deepened to 842 mbsf – partly as a result of the first use of techniques for uncontaminated sampling of moderately indurated, RCB cores. A bare rock spud-in penetrated the outcropping low-angle normal fault but characterization of the in situ fault properties at depth was thwarted by (a) the presence of trace hydrocarbons at primary Site 1108 and (b) metamorphic talus at alternate Sites 1110-13 closer to the 3 km high fault scarp. Subsequent review by PPSP has re-opened the possibility of deepening Site 1108.

Structure and Stratigraphy
During Leg 180 we drilled a transect of sites just ahead of the spreading tip: Sites 1109, 1115, and 1118 on the down-flexed northern margin; Sites 1108 and 1110-1113 into the rift basin sediments above the low-angle normal fault zone; and Sites 1114, 1116, and 1117 on the footwall fault block, Moresby Seamount -Site 1114 near the crest, 1116 on the southern flank, and 1117 into the upper fault face (Figs. 1-2).

The northern margin sites (1109, 1115, and 1118), cored to 802, 803, and 927 meters below seafloor (mbsf), respectively, penetrated the syn-rift cover sequence and into pre-rift sections: dolerites at Sites 1109 and 1118, and middle Miocene forearc clastics at Site 1115. A high resolution syn-rift stratigraphy, vertical motion history, and basement petrology was established. In accord with other land and well exposures, the presence of ophiolitic conglomerates deposited on the rift-onset unconformity at all three northern margin sites indicates the widespread occurrence of ophiolite forming the basement of the orogenically thickened Papuan Peninsula and Woodlark Rise. Syn-rift sedimentation was initially paralic to inner neritic, followed by successively deeper water Plio-Pleistocene hemipelagic and turbiditic deposits, with discrete inputs of volcanic ash and volcanioclastic turbidites. The detailed record of subsidence that began 6-8 Ma at/above sea level provides primary constraints on models of the continental extension. Seismic profiles and core observations evidence only minor normal faulting of the northern margin, which indicates a long wavelength (flexural) mechanism for the more than 2 km of subsidence observed.

At Site 1114, a south-southwest-facing normal fault offsets the basement by about 2 km near the crest of Moresby seamount (Fig. 2). A 6-m-thick tectonic breccia beneath the 286-m-thick Pliocene-Pleistocene sedimentary section occurs above a basement of metadolerite that was penetrated to 407 mbsf. Basement was not reached beneath the 159 m of coarse rift clastics at Site 1116. Sediments at these two sites document relatively proximal turbiditic and mass-flow deposition from an active arc source with additional metamorphic and ophiolitic components. There is also evidence for as much as 1 km of erosion, associated with uplift of the footwall following initial subsidence.

The most spectacular tectonic structure encountered during Leg 180 is the Moresby detachment fault, dipping at 27°+3° toward 015° (Fig. 3; Taylor et al., 1999). The apparent fault offset of the basement is 10 km horizontally and 5 km vertically (i.e., 11 km slip at 27° dip). At
Fig 1. Topography of the Papuan Peninsula and bathymetry of the western Woodlark Basin (500 m contour intervals) showing relocated epicenters (black circles) and earthquake focal mechanisms from Abers et al. (1997). The solid line is the landward boundary of oceanic crust and the thin double lines locate the spreading axes (Taylor et al., 1995). The straight line segment at 151°34.5˚E locates the Leg 180 drilling transect (see Fig. 2). Inset shows geographical location of the Woodlark Basin.

Fig 2. Nested meridional sections at 151°34.5˚E showing the (A) regional bathymetry and (B) local structures across the incipient conjugate margins. Leg 180 drill sites are depicted on the B section. T.G.= thermal gradient (°C/km). VE = vertical exaggeration.
Site 1117, where the fault plane crops out on the northern flank of Moresby Seamount, we drilled through the ~100 m-thick succession of deformed rocks into a gabbro basement. From bottom to top, the gabbro ranges from undeformed, to brecciated, to foliated cataclasite/mylonite. Epidote and quartz dominate the secondary minerals, indicating syntectonic greenschist facies conditions. Above this, an ultracataclasite fault gouge (5 m was recovered) crops out on the seafloor and represents the most advanced stage of deformation, with evidence for fluid-assisted alteration to produce serpentinite, chlorite, talc, calcite, ankerite, and fibrous amphibole.

A triple casing reentry hole was planned to intersect the low-angle normal fault at 900 mbsf where an estimated 9 km of the 11 km of basement-basement dip-slip offset have occurred. The presence of trace hydrocarbons at Hole 1108B (drilled to 485 mbsf), and the extent of talus proximal to Moresby Seamount where the fault is shallower (Sites 1110-1113, which penetrated 25-174 mbsf), precluded use of the available technology to meet our primary objective. Although the ~100-m-thick low-angle fault zone was cored through at Site 1117, the primary objective of Leg 180 was not met. To understand how an active low-angle normal fault zone slips we need to characterize the in situ properties - stress, permeability, temperature, pressure, physical properties, and fluid pressure - at depth. A return to Site 1108 has been proposed, with the goal of penetrating to/through the fault zone so that these parameters may be measured.

**Biosphere**

The longest profiles to date of the deep sub-seafloor biosphere were made at Sites 1115 and 1118 (Fig. 4). Bacteria were present in all samples analyzed at the three northern sites drilled to >800 mbsf. Both dividing and divided cells were present to 842 mbsf, although there is an indication that numbers are decreasing more rapidly than the model of Parkes et al. (1994) predicts, resulting in a sigmoidal depth distribution.

Because bacteria play a dominant role in the degradation of organic matter, and consequently drive chemical changes and diagenesis in sediments, their deep subsurface activity is evident in geochemical data from these sites (Fig. 4). Pore-water sulfate concentrations are depleted in the uppermost sediments, below which methane concentrations increase rapidly as methanogenic bacteria gain a competitive advantage over sulfate-reducing bacteria for common organic substrates. Biological decomposition of organic matter is also evident from the accumulation of ammo-

Fig 3. Stacked, migrated and depth converted multichannel seismic line through Site 1108 (modified from Taylor et al., 1999).
nia in the pore waters.

The persistence of microbial life into indurated sedimentary rock adds to a steadily growing body of evidence for a more extensive biosphere than previously imagined. That life is not merely a surface phenomenon has profound implications for the biodiversity of our planet, fossil fuel formation, the origins of life on Earth, and the potential for life on other planets. For a more complete summary of Leg 180 drilling results, see http://www-odp.tamu.edu/publications/prelim/180_prel/180toc.html.

Leg 180 Shipboard Scientific Party

References

Fig 4. Biogeochemical profiles at Leg 180 sites: A. Total bacterial populations. The solid curve represents a general regression line of bacterial numbers vs. depth in deep-sea sediments (Parkes et al., 1994), with 95% upper and lower prediction limits shown by dashed curves. B-D. Sulfate, ammonia, and methane depth profiles. Wavy line depicts unconformity. E. Methane/ethane ratios.
The littoral zone and inner continental shelf are gateways through which continentally-derived sediment must pass on their journey to the sea. However, our knowledge of sedimentary processes (i.e., transport, erosion, and deposition) and their spatial and temporal variability in these dynamic environments remains limited because of environmental stresses in near shore environments and inadequate shallow water sonar technology. Improved geophysical imaging of the preserved stratigraphy in shallow water regions is critical to determining the transfer functions between high-frequency sedimentary processes and the formation of the longer-term stratigraphic record. The dynamics linking physical processes operative on small spatial and temporal scales (“event” stratigraphy) to formation of the longer-term stratigraphic record must be understood in order to construct realistic quantitative stratigraphic and morphologic models for shallow water regions. Such understanding of littoral zone evolution also has practical applications for offshore cables, pipelines, geohazard assessment, erosion mitigation, disposal of dredge spoils, marine navigation channels, and Navy littoral operations.

In collaboration with Florida Atlantic University (S. Schock and L. Leblanc) and EdgeTech, we have developed a new state-of-the-art system (SUBSCAN) to improve acoustic imaging of the sedimentary record preserved in shallow water regions. Funding for the system was provided by the Office of Naval Research. SUBSCAN is a Chirp seismic reflection and sidescan sonar system that images both the seafloor and subbottom sedimentary layers (0.5 - 16 kHz subbottom; dual frequency 100 & 500 kHz sidescan). SUBSCAN is shown here in a piggy-back configuration with the Chirp system located in the nadir of the sidescan system. Funding for the system was provided by the Office of Naval Research.

**Fig 1.** SUBSCAN is a Chirp seismic reflection (bottom) and sidescan sonar system (top) that images both the seafloor and subbottom sedimentary layers (0.5 - 16 kHz subbottom; dual frequency 100 & 500 kHz sidescan). SUBSCAN is shown here in a piggy-back configuration with the Chirp system located in the nadir of the sidescan system. Funding for the system was provided by the Office of Naval Research.

along the Eel River shelf (offshore California) in an ONR funded program to image stratigraphic geometry and seafloor morphology along and across the littoral zone and inner continental shelf (Fig 2). The main objective of this ongoing project is to determine the relationship between the Eel and Mad riverine input, their subaqueous deltas, and the surrounding shallow water regions. This study combines investigation of how sediment input, tectonic deformation, eustasy, and physiography interact to form the stratigraphic record. In particular, we are examining the spatial and temporal links between rapid, short-term accumulations on the shelf (e.g., flood deposits) and longer-term accumulations, in order to understand the processes that govern sediment redistribution and preservation. In addition to ONR STRATAFORM research, we have used the new SUBSCAN system to determine the nature and origin of early Holocene channels in Vineyard and Nantucket Sounds (Fig 3).

The new system is easily mobilized for use on nearshore research vessels. Turn-key operations enable researchers to acquire high-resolution seismic images across shallow water environments with advanced user-friendly software for automated data analysis. The towing frame, winch, and deployment system are designed for small research vessels and operation in high energy environments. In order to overcome the operational obstacles of acquiring high resolution seismic data in the high energy surf zone, the system incorporates an innovative towed frame assembly that can be deployed from the beach. The tow frame is designed to be stable on the surface while being towed slowly across the surf zone out to mid-shelf water depths. Outside the surf zone the SUBSCAN vehicle is flown in a traditional configuration while maintaining a constant height above the seafloor. This
system will be operated as a community research tool.

For further information, contact Neal Driscoll (ndriscoll@whoi.edu).

**Subscan System Components:**
The system includes the following:

1) a DF1000 towfish and topside unit

2) a X-Star subbottom sonar including:

   a) a SB0512 tow fish with

      i) 2 planar receiving arrays

      ii) Woofer/tweeter transmitting pair covering the range of 0.5 -16 kHz

      iii) 31” pressure housing containing matching transformers, 2 channel power amp, 2 channel receiving amp, matching transformers, 2 channel DGA and A/D converters and associated DSP processors, Pentium 2 computer, ADSL telemetry transceiver, 300 VDC to 48/12/5 VDC power supplies

   iv) Pitch/Roll sensor

   b) A shipboard interface unit (SIU) that provides 300 VDC power to fish and the ADSL telemetry transceiver, hardware and software diagnostics, and an Ethernet output. There is a Pentium host.

   c) A topside Pentium processor with an ethernet input from the SIU. This performs the following

      i) Sub-bottom image display during acquisition and playback

      ii) Navigation interface

      iii) Seg-Y storage of subbottom and navigation data

Fig 2. A pronounced anticline is imaged by SUBSCAN between the Eel and Mad subaqueous deltas, offshore Northern California and appears to be the landward continuation of the Little Salmon Anticline observed offshore on the lower slope. The crest of the anticline is buried by approximately 3 meters of sand and in some areas a southward dipping fault appears to continue up into the overlying carapace. The style and nature of the anticline changes dramatically along strike; the anticline is obscured by gas farther offshore, to being a text-book example here in shallow water. Preliminary analysis suggests that this fault/fold structure continues onshore and crosses Samoa Beach and northern Humboldt Bay and appears to extend under the City of Eureka, CA.
Fig 3. (Upper left) Using a prototype of our new SUBSCAN system, high resolution sonar data were collected across the seaward extent of the linear Cape Cod valleys which for the first time clearly imaged the internal structure of the channel fill and overlying stratigraphy. The system was able to penetrate ~20 m beneath the Holocene to Present sands and gravels. (Lower right) Given that the system is broad band (e.g., 0.5 - 16 kHz), different frequency bands can be examined to generate both deep penetration and high resolution images of the subsurface geology. An example of the high resolution data from the Chesapeake Bay is shown. (Lower left) 100 kHz sidescan record that was collected with the subbottom data. (Upper right) 500 kHz sidescan data that was also collected and permits examination of backscatter variation with frequency.
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Meetings

Non-Volcanic Rifting of Continental Margins: A Comparison of Evidence from Land and Sea

U.S. Marine Seismic Reflection Acquisition Needs For the Next Decade
La Jolla, California, USA, October 17-19, 1999

The Non-Steady State of the Inner Shelf and Shoreline Coastal Change on the Time Scale of Decades to Millennia in the Late Quaternary
University of Hawaii, Honolulu, Hawaii, USA, November 9-12, 1999

The Nature and Tectonic Significance of Fault Zone Weakening

Penrose Conference on Volcanic Rifted Margins

Structural Architecture of Rifted Continental Margins

For more information on these announcements visit our web site:
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