Meeting Summary:
Towards Integration and Synthesis of MARGINS S2S Research in PNG and NZ Focus Areas,
5-9 April 2009, Gisborne, New Zealand

Steven Kuehl¹, Nicola Litchfield² and Alan Orpin³

¹Virginia Institute of Marine Science, Gloucester Pt., VA, USA; ²Geological and Nuclear Sciences, Lower Hutt, NZ; ³National Institute of Water & Atmospheric Research, Wellington, NZ

Introduction

Erosion sculpts the landscape, and redistribution of the resultant sediment creates the alluvial plains, coasts, deltas, and continental shelves upon which most of the world’s population lives and from which it derives much of its energy and water. This transfer of sediment and solute mass from source to sink plays a key role in the cycling of elements such as carbon, in ecosystem change caused by global change and sea-level rise, and in resource management of soils, wetlands, groundwater, and hydrocarbons. Although the source to sink system has been studied in its isolated component parts for more than 100 years, significant advances in our predictive capability require physical and numerical modeling of fluxes and feedbacks based on data from integrated field studies. The Source-to-Sink Initiative is an attempt to quantify the mass fluxes of sediments and solutes across the Earth’s continental margins by answering the following questions:

1. How do tectonics, climate, sea-level fluctuations, and other forcing parameters regulate the production, transfer, and storage of sediments and solutes from their sources to their sinks?

2. What processes initiate erosion and transfer, and how are these processes linked through feedbacks?

3. How do variations in sedimentary processes and fluxes and longer-term variations such as tectonics and sea level build the stratigraphic record to create a history of global change?

Research during the 6 years of MARGINS Source-to-Sink (S2S) studies in the Gulf of Papua and New Zealand focus sites has provided many new insights and serves as a foundation for comparative studies. A workshop was held in Gisborne, 5-9 April 2009 (Figure 1), involving many of the PI’s, international partners and interested parties from the two focus sites as a logical first step towards integration and synthesis of results from the focus areas, which is central to...
the concept and ultimate success of the MARGINS S2S program. The intention of this workshop was to encourage robust scientific discussion that builds on our most-recent knowledge gleaned from the MARGINS Source-to-Sink focus sites, the New Zealand and Gulf of Papua systems, and to look toward the future seeking an understanding of global processes and responses.

The workshop was designed to achieve five distinct goals:

1. Delineate the key results from the two S2S focus sites.
2. Identify the outstanding scientific gaps to fulfill the program goals.
3. Demonstrate the wider potential of our results to the understanding of source-to-sink systems globally.
4. Document the societal relevance of our results.
5. Identify future research goals and opportunities.

The workshop structure encouraged robust scientific discussion that builds on our most-recent knowledge gleaned from the focus sites, and looked toward the future seeking an understanding of global processes and responses. The first day featured introductory keynotes and a series of overview talks, which ensured a common reference point and a stepping stone to build later group discussions. The overview speakers were charged with identifying the remaining scientific gaps or research needs for the future. A student poster session featured some of the ongoing work in the focus areas and related S2S studies.

A “Compare and Contrast” thematic session followed during day two and part of day three. Teams of three individuals led short and provocative thematic presentations, designed to explore contrasts between the PNG and NZ focus areas, and invited comment and discussion from the floor. An important goal for each “Compare and Contrast” group was to identify key similarities or differences between the systems, and capture overarching findings that may apply to source-to-sink systems globally (i.e., to extend our results beyond individual focus areas). The subsequent invitation by participants was a critical ingredient, building robust lines of scientific inquiry and isolating exciting science, engaging the diverse community attending the workshop. This encompassed conceptual and numerical modeling efforts, and a sub focus of this session was to highlight challenges and opportunities for the observational and modeling communities in exploring S2S systems.

A mid-workshop field trip allowed participants not familiar with the New Zealand focus site a chance to get an overview of parts of the terrestrial sector; and also gave participants an opportunity to interact and discuss their science away from the formal structure of the workshop. The dramatic Gisborne landscape served as a stimulus and a practical demonstration of the wider implications of S2S.

Breakout discussion groups were held during the last part of the workshop intended to identify and refine future opportunities and goals for the source-to-sink community. The last day was used to finalize a road map for the future through large and small group discussions. The scientific communities conducting S2S-type research have benefited from a variety of funding sources associated with a number of agencies and countries over the past decade. Support for the S2S concept has been widely embraced and the approach has much scientific and societal relevance, providing a springboard towards the future.

**Meeting highlights**

Presentations by meeting participants and following discussions provided a wealth of information and insight to the focus areas, a comprehensive summary of which is beyond the scope of this report. A complete synthesis of workshop presentations can be found in the extended summary at: [http://www.nsf-margins.org/S2S/2009/](http://www.nsf-margins.org/S2S/2009/). Selected workshop highlights are reported below.

Keynote talks by Chuck Nittrouer, Basil Gomez and James Syvitski highlighted some of the key comparisons between the two S2S focus areas (Table 1), demonstrated the importance of source studies to understanding interbasin signal correlations, and detailed the role of surface dynamics modeling for S2S studies, respectively.

An overarching theme for S2S research is to determine how event signals are propagated through the system. Generally, low frequency, high magnitude events show the greatest fidelity and event signatures (volcanic eruption, earthquake, large storm, land-use change events) can be correlated between cores in the middle and lower floodplain, and shelf. Major periods of differing late Holocene sedimentation rates can be simulated by numerical modeling (coupled Hydrotrend and Sedflux models). Erosion is driven by anthropogenic activity (land-use changes) and climate (ENSO, SAM). Modelling suggests future climate change may reduce the

<table>
<thead>
<tr>
<th>Comparison of dispersal systems</th>
<th>Fly</th>
<th>Waipaoa</th>
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<tbody>
<tr>
<td>Climatic setting</td>
<td>wet tropical</td>
<td>temperate</td>
</tr>
<tr>
<td>Basin size</td>
<td>75,000 km²</td>
<td>2,200 km²</td>
</tr>
<tr>
<td>Sediment Discharge</td>
<td>large (10⁶ t/y)</td>
<td>moderate (10⁶ t/y)</td>
</tr>
<tr>
<td>Manipulation</td>
<td>small (+35%)</td>
<td>large (+550%)</td>
</tr>
<tr>
<td>Lowland floodplain</td>
<td>long tidal reach</td>
<td>trivial tidal reach</td>
</tr>
<tr>
<td>River mouth</td>
<td>delta, mangroves</td>
<td>strand plain</td>
</tr>
<tr>
<td>Discharge events</td>
<td>unrelated to ocean</td>
<td>correlated to ocean</td>
</tr>
<tr>
<td>Gravity flows</td>
<td>saltwater (fluid mud)</td>
<td>also freshwater (hyperpynical flows)</td>
</tr>
<tr>
<td>Shelf sedimentation</td>
<td>clinoform prograde</td>
<td>basin infill</td>
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<tr>
<td>Tectonic setting</td>
<td>foreland basin</td>
<td>fore-arc basin</td>
</tr>
<tr>
<td>Offshore loss</td>
<td>~3%</td>
<td>~15%</td>
</tr>
<tr>
<td>Offshore sediments</td>
<td>mostly carbonate</td>
<td>mostly siliciclastic</td>
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</tbody>
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*Table 1. Key contrasting attributes of the Fly and Waipaoa sedimentary systems.*
mean flow, which will also influence the mean annual suspended sediment load and bedload (depending on the climate change scenario). Climate drivers influence ocean circulation, big events, and sediment flux, with local evidence of correlation to high-frequency global climate proxies.

Future S2S studies will benefit from an integrated community of experts to promote the quantitative modeling of earth-surface processes (CSDMS; see http://csdms.colorado.edu). A key component of CSDMS is cyber-infrastructure to distribute model, data and educational repositories. Currently there are >100 models, 32 model initialization or boundary condition global databases, and >100 ppt presentations, lecture materials and movie simulations. CSDMS also provides middleware to couple and nest numerical models. Modular modeling helps to quantify Geoscience knowledge in terms of uncertainty, variability, error, precision, accuracy, and confidence.

Some selected examples of overview presentations provide a sampling of the rich diversity of S2S research. For example, applications to long term (since late Miocene) stratigraphic evolution of the mixed carbonate-siliciclastic such as GoP sedimentary system are now possible. Some key results based on a well established last sea level cycle (last 150 ky) are:

- Shallow carbonate hightstand shedding, already established in pure carbonate systems (e.g. Bahamas), also observed (even better) in Gulf of Papua mixed siliciclastic-carbonate system.
- Timing of mud transfer from inner shelf to slope and basin linked to early sea level fall and not maximum lowstand.
- Timing of sand transfer into adjacent basins and final accumulation linked to maximum sea-level lowstand - modulation at millennial time scale.
- Early transgressive carbonate establishment and growth occurs on top of LGM lowstand siliciclastic coastal deposits (Figure 2).

The synergy identified between carbon and sedimentary cycles, carried out within the S2S framework, received considerable attention at the workshop. For the New Zealand focus area, suspended sediment and floodplain POC is composed of rock (fossil) C, modern OC and an aged component that may be from old soils. POC changes in composition across the shelf; nearshore winnowing of terrestrial OC enriches shallow water sediments in kerogen, and addition of modern marine OC is seen on the inner and middle shelf. The appearance of aged material on outer shelf and upper slope may indicate along-shore transport. In the Gulf of Papua, a regular pattern of inshore - offshore facies associated with distinct biogeochemical compositional gradients and relative dominance of physical / biological processes is observed (Figure 3). An energetic, oxygenated topset (70% area) has central role as processing region: net terrestrial C incineration (~65 - 70%) is seen with distinctive suboxic authigenic mineral suites. Interactive material exchange occurs between inshore – offshore areas (export, import). Export of refractory C from mobile mud topset to foreset follows topset burn off. Seasonality related to Monsoon and Trade wind periods is also evident in seabed reworking, water column productivity, and remineralization patterns.

Another focal point for the workshop was discussion of the development of numerical models, data, acquisition and feedbacks. A key challenge here concerns bridging timescales: how do we upscale from events to millennia (and beyond)? Some of the upscaling obstacles include: computationally intensive to simulate millennia with 1 min timesteps; constraints on boundary conditions degrade sharply in detail on longer timescales; and model sensitivity to initial-boundary conditions. Model input from observations requires careful measurement strategies. The likelihood of capturing important events during limited instrument deployments is low. However, we can use coarser but plentiful observations of forcing to run models over wide range of events, which may allow us to extract key “characteristic

![Figure 2. Model of mixed carbonate-clastic sedimentation in Pandora Trough (Gulf of Papua). Neritic carbonate export to the basin was linked to an acceleration of sea level rise at the end of the Younger Dryas which triggered the general re-flooding of adjacent shallow carbonate bank tops, re-initiating neritic carbonate production on previously exposed and karstified banks. Sandy and muddy clastic turbidites commonly occurring during LGM and carbonate bank tops, re-initiating neritic carbonate production on previously exposed and karstified banks.](image-url)
events” which drive system evolution. One successful example of model development for the New Zealand focus area was as simulation of Holocene shoreline progradation (Figure 4). The results showed a deceleration with time as a consequence of steady subsidence and increased bypassing to the shelf. The balance between terrestrial and marine energy is shown to influence sediment size partitioning, but much more for mud than for coarse sediments.

What can the S2S community achieve within the lifetime of the current S2S program?

The workshop participants identified several concrete steps that should be taken to bring a rational closure to the current S2S program, including:

- Hold a planning workshop with the ultimate goal to produce a text/volume that provides a holistic overview of S2S concept. This would identify key chapters and research leaders to take ownership of the various subsections. The thematic approach taken at this meeting could be transposed as the basis for a textbook, and encourage comparison and contrasts to system outside of the current focus sites.
- Produce a critical review of the S2S concept; its historical successes, weaknesses, which outcomes have led to paradigm shifts.
- Encourage small working group meetings for more focused integration, and compare and contrast between focus sites.
- Promote integration with the CSDMS community and the writing of joint CSDMS proposals.
- Generate more proposal pressure from the S2S community, particularly integrative proposals.
- Hold a workshop to integrate results from the New Zealand MD cores, including sedimentology, carbon, and paleoearthquake studies.
- Finish work in the terrestrial portion (especially the lower reaches of the floodplain) of the Gulf of Papua. The terrestrial, marine, carbon, and modeling workers all highlighted this as a significant gap in our knowledge.

Developing a robust science beyond the current program

Workshop participants were asked to address future lines of inquiry for S2S research, resulting in a number of suggestions for future research directions, including:

- The community recognized the benefit of process-related lines of inquiry with sediment studies and the potential benefit of exploring a closer relationship with the carbon community. There are avenues that might allow this relationship to be heightened and expanded in the new MARGINS program, but this collaboration might also prosper under other program directions.
- A budget approach to sediment systems is challenging because of the time and space variations in sources and sinks, and discussion throughout the workshop highlighted a number of issues at all points along the S2S system. Budgets for both sources and sinks need to be defined and uncertainties quantified. There was recognition among workshop participants that for both S2S focus areas, identifying and quantifying sediment sources would be prerequisite to formulating a comprehensive budget.
- The importance of tectonics in the production of sediment and accommodation space, across a range of timescales, raises the question of the appropriateness of timescales when working in areas with high tectonic activity. Punctuated tectonic and high-frequency sediment responses are an avenue for future work. Tectonics research also provides potential linkages with the other MARGINS objectives.
- Understanding the propagation of event signals through sedimentary systems remains a fundamental question. This theme was revisited in numerous discussions and reinforces an opportunity and need to have synchronous terrestrial and marine field programs in an effort to understand and predict how event signals are recorded.

Summary Remarks

For the first time nearly all the S2S researchers assembled to talk exclusively about their work at the two focus sites.
To that end, the 84 workshop participants (representing 8 countries) indicated a high level of interest in integrated studies and the value-adding that a holistic approach brings to their science. This was also evidenced by the numerous informal small group discussions occurring throughout and immediately following the workshop. Student numbers were high (22) and a dedicated student poster session (21 posters) was well received, highlighting the important role student participation has in S2S research. One of the exciting outcomes of the meeting was the synergy identified between carbon and sedimentary cycles, carried out within the S2S framework. Carbon can be used as a tool to understand sedimentary processes, and offers potentially important insights to the wider sedimentary community. Similarly, an understanding of sedimentary processes is required to predict carbon cycling. The carbon researchers highlighted some potential areas of immediate integration, but another focused workshop could develop a long-term plan within a new program to envelop the carbon science committee at large.

Investigation of mass transfer of materials between successive segments of sediment dispersal systems is a unique aspect of S2S science. Because the S2S approach is very young (less than a decade), there has not yet been a critical appraisal of how the diverse new discoveries feed into our larger understanding of sedimentary systems. Enthusiastic acceptance of S2S concepts makes this an ideal time to embrace the broad community of scientists undertaking S2S research and to document and test the new ideas that have been generated.

![Figure 4. Left Panel - Bulk sediment storage in Holocene from an inverse model. A) Terrestrial storage. B) Tectonic storage Right Panel - Poverty Bay progradation (A) showing decelerating progradation rate (B) (from M. Wolinsky).](image)

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**MARGINS Townhall and Community Forum**

**AGU Fall Meeting 2009**

With Comments on the MARGINS Program status from NSF and MARGINS Chair


MARGINS will host a Townhall meeting and community forum at the AGU Fall Meeting on the evening of Tuesday December 15 at 6 PM in the Westin Market Street Hotel, Metropolitan Room 3. The event is open to all with an interest in the MARGINS program. The MARGINS Chair and NSF Program Manager will discuss aspects of the upcoming MARGINS Successor Program Workshop.

Student entrants of the MARGINS Student Prize for Outstanding Presentation are invited to display their AGU posters and discuss their research with the scientific community. This will be a great opportunity for them to further share their results and interact with a wide spectrum of MARGINS scientists. There will be time to mingle, and refreshments will be available.
Meeting Summary
Rupturing Continental Lithosphere: Integration, Synthesis, and Forward Vision
April 30-May 2, 2009. Charleston, North Carolina

Erin Beutel¹, Cindy Ebinger², Joann Stock³, Mark Behn⁴, Ramon Arrowsmith⁵

¹College of Charleston; ²Rochester University; ³California Institute of Technology; ⁴Woods Hole Oceanographic Institution; ⁵Arizona State University

Introduction

The MARGINS program has contributed to the fundamental understanding of the plate tectonic processes that provide the unifying theory for Earth system science. During the past decade, the multidisciplinary research community fostered by the Rupturing Continental Lithosphere initiative has examined the rifting and rupture process in the Gulf of California and Red Sea focus sites. Previous research had focused on lithospheric stretching; our community has made new discoveries by probing ‘outside the lithospheric box’. Through an integrative approach, RCL researchers and collaborators examined driving processes on the surface and base of the plate, as well as internal forces, such as lateral density and strength variations accompanying faulting, stretching, and magma intrusion. Sedimentation and erosion, as well as magmatism and mantle composition, exert strong controls on rift architecture, and new theory demonstrates important feedbacks between sediment loading and magmatism. These collaborative theoretical, seismological, structural, thermochronological, sedimentological, geochemical, and experimental studies firmly establish the strong signal in the along-axis segmentation of a rift from initiation to breakup, and implications of segmentation for sediment pathways and orographic relief.

Observations from the Gulf of California and Red Sea RCL focus sites, as well as from active rift zones worldwide, confirm that the spatial distribution of magmatism, extension, and erosion/transport/deposition varies in space and in time as initially thick continental lithosphere is thinned, heated, and eventually ruptured. The faulting process has a characteristic length scale largely controlled by the plate rheology, and dike intrusion from crustal magma reservoirs introduces additional scaling factors. Comparisons of space-based geodetic, structural, and seismic studies reveal major discrepancies between time-averaged and instantaneous rates; the mismatch provokes new theory and experiments with a fully 4 dimensional approach to explain the time scales of the rifting process.

The passive margin setting of gracious Charleston, South Carolina served as the backdrop to the April 30-May 2 MARGINS Rupturing Continental Lithosphere conference. Charleston is located near the initial rupture of Pangaea, and on continental flood basalts interbedded with clastic sedimentary sequences. As the EarthScope and other initiatives move into the Charleston area these important aspects of an ancient continental rupture will be imaged for comparison with RCL results. Eighty-nine participants from the US, Mexico, UK, Canada, New Zealand, Germany, Czech Republic, Korea contributed to 4 days of presentations and discussion. Numerous students and young scientists attended. The workshop was sponsored by the National Science Foundation through the MARGINS program. Workshop organizers Erin Beutel (College of Charleston), Cindy Ebinger (University of Rochester) and Joann Stock (Caltech) gratefully acknowledge the skillful assistance of Geoff Abers and the MARGINS office staff of Niva Ranjeet, Kristen Woodford, and Andrew Goodwillie in the planning and execution of the workshop.
Workshop Aims

The Charleston RCL meeting capped nearly 8 years of onshore and offshore research in the Gulf of California and Red Sea-Gulf of Suez focus sites by teams of US, Mexican and European scientists. A mid-stage meeting on the Gulf of California focus site was held in 2006, but the last comprehensive RCL workshop was held in 2000.

The RCL workshop was organized in three parts: 1) synthesis of new findings from the Gulf of California and Red Sea focus sites as well as theoretical and laboratory studies; 2) integration of these results with global studies of rifting processes with emphasis on magmatism, surface processes and uplift, and strain patterns in space and time; and 3) identification of key questions for the next decade of research. Each of the five major sessions was introduced by 1-2 keynote speaker(s), followed by a few short presentations chosen to stimulate general discussion sessions, and to link to the many posters displayed throughout the meeting. The five sessions and discussions were co-convened by early career scientists who helped maintain lively and balanced debates. Scientists from the College of Charleston led walking tours of historic Charleston, which was devastated by the 1886 earthquake.

In response to the positive reviews of the Decadal Review committee (http://www.nsf-margins.org/Review2009/1_DRCrep09.pdf), all participants were invited to an additional day of planning to focus future science objectives for a successor program, embrace the sediment flux community into the evolving ‘Rifting, Sedimentation and Fluids’ initiative, and debate the merits of thematic and focus site approaches. Mark Behn (WHOI) coordinated breakout groups and discussions on Sunday, May 3. Early career scientists led breakout sessions on science themes and program implementation strategies. Broad consensus was achieved across the RCL community, and across the broad range of disciplines. In this report, we summarize these insightful and far-reaching discussions below, and more fully as a white paper for online discussion on the MARGINS web page.

RCL Achievements, Synthesis, and Integration

New 4 dimensional observations from the Gulf of California and Red Sea focus sites have motivated fundamental laboratory and numerical modeling experiments to isolate the competing effects of magmatism, sedimentation and rheology. These models show that 1) sedimentation plays a key role in the distribution of strain and magmatism from rift inception to breakup; 2) the presence of melt facilitates or drives rift initiation and leads to strain partitioning during all stages of rifting. In both the Red Sea and Gulf of California, geodetic observations, paleo-seismicity studies, and plate reconstructions confirm that strain has localized to new plate boundaries after breakup, with only minor amounts of internal deformation to the trailing plates.

Gulf of California

Large differences are seen in structural and magmatic rift characteristics in different segments of the Gulf of California rift [Lizarralde et al. 2007]. Both the availability of melt (mantle fertility) and the timing and distribution of sediments strongly influence the localization of strain and magmatism. These studies clearly established a feedback between crustal melt distribution and extensional strain.

Mantle dynamics play a fundamental role in the localization of melt production zones along the length of the Gulf of California. Shear velocity anomaly patterns at 60 km subsurface show 3 centers of particularly low velocity 200-250 km apart. These are laterally displaced from rifting centers but appear to correlate with pre-rift zones of high-Mg andesites, suggesting the strong influence of earlier subduction on the present-day mantle structure. Alternatively, dynamic component of upwelling may keep the melt production centered beneath the original location of rifting even as the plate boundary migrates to the east [Wang et al., submitted, 2009].

Research in the northern Gulf of California marries industry and academic data sets as well as field mapping and marine seismic studies to evaluate strain localization in space and time [e.g., Aragon-Arreola and Martin-Barajas, 2005]. Marine flooding occurred synchronously within multiple rift segments, signaling the localization of strain to narrow, incipient spreading zones [Contreras et al., 2007].

Nearly all of the submarine region of the N Gulf basins may be new crustal area, but the relatively low crustal seismic velocities of this broad zone suggest unusually felsic crust [Gonzalez-Fernandez et al., 2005]. The timing of formation of the “new” crust agrees well with the plate motions but not with some microfossil stratigraphy. Thermal insulation by thick sedimentary cover may permit extreme crustal extension, delaying the onset of sea-floor spreading in northern rift basins [Bialas et al., 2009].

Basins in the south central Gulf show a major reorganization at 2.5 Ma. [Umhoefer et al., 2007a], synchronous with the beginning of robust spreading at the Alarcón rise [Sutherland, 2006; Umhoefer et al., 2007b]. A few hundred km northward, in the Central Gulf, strain localized into a central rift zone several million years earlier, in the Late Miocene [Oskin et al., 2003]. In both cases, however, transform faults and accommodation zones are parallel to BAJA/North America relative motion. Receiver functions indicate thinner crust beneath the high topography of the eastern Peninsular Ranges Batholith in the northern gulf [Persaud et al., 2007], suggesting a role for ductile behavior of the lower crust, which may have flowed into the rift or delaminated, falling into the mantle.

The past decade has seen the documentation of aseismic slip with or without seismic tremor accompanying the rise of magma through the plate in extensional settings [e.g., Lohman and McGuire,
2007]. Similar patterns are seen in the magma-rich southern Red Sea and East African rift systems [e.g., Wright et al., 2006; Keir et al., 2009].

Red Sea

Although rifting has been basically amagmatic, punctuated episodes of magmatism at rift inception and breakup controlled rift architecture. The <4 My spreading segments of the Red Sea illuminate the initial stages of seafloor spreading, and continental rupture processes. Magma generated within segments is focused to a central location where it ascends along faults, producing paired volcanoes flanking the rift axis. Melt is soon able to ascend vertically at axis to form axial volcanoes within deeps. In three-dimensions, axial volcanoes grow and coalesce to form a contiguous rift axis [e.g., Cochran and Karner, 2007].

Upper mantle tomography from the Red Sea rift also shows fundamental along-axis variations correlating directly with the surface expression of magmatism [Park et al., 2007]. Tomographic models reveal a low-velocity region along the western side of the ~1000 m-high, magmatically active, Arabian Shield, but little evidence for low velocities beneath the largely amagmatic northern Red Sea. The magnitude and large horizontal dimensions of the mantle low velocity zone suggests that mantle upwelling supports plateau uplift.

Geodetic observations indicate that modern Arabia plate motion is the same as the average velocity during the past ~23-30 Ma when Arabia separated from Nubia, and imply that spreading in the Red Sea is primarily confined to the central rift zone [Reilinger et al., 2008]. Complementary integrated structural and thermo-chronometric studies along the Saudi Arabian margin of the Red Sea supports this hypothesis by documenting the onset of major continental rifting at ~23-25 Ma [Stockli et al., 2006]. This work, however, also shows a marked rift reconfiguration in terms of both kinematics, spatial strain accommodation, and basaltic magmatism at ~15 Ma in response to inception of the Gulf of Aqaba transform fault and collisional tectonics along the northern margin of the Arabian plate.

Integration with Current Rift Studies

Major advances in theoretical, laboratory, and non-focus sites worldwide offer further insights to RCL aims, and serve as springboards to the next decade of ‘Rifting’ research. Models of the rift process complement and expand the scope of the science questions being asked at focus sites and integrate multiple stages and types of rifting as well as multiple approaches to rifting processes. Presentations at the RCL workshop highlighted the multidimensional nature of rifting and included foci on the role of magmatism and volatiles in the rifting process; the role of pre-existing structures (both crustal and mantle); the evolution of strain and segmentation of rifting through time; and the possible role of sediments in the evolution of the rift system.

Role of Magmatism and Volatiles in the Rifting Process

New theoretical, laboratory, and observational analysis indicate that the presence of melt in and below the lithosphere has a strong effect on the strength of the lithosphere and therefore how it rifts. Dike intrusions in the form of dikes have been shown to facilitate initially strong, thick continental and possibly cratonic lithosphere [Buck, 2004]. Magmatic intrusions have also been shown to control aspects of rifting and rift evolution through metasomatism and three-dimensional mechanical and density variations (caused by both the presence of hot melt and cooled mafic intrusions). Variations in density and mechanical response affect stress distribution, strain partitioning, magmatic segmentation, rift scaling and evolution. Field observations strengthen the links between magmatism, strain in rift zones, and rifting. Clifton and Kat-tenhorn [2008] document an oscillatory strain field in the period between magma intrusion episodes of period ~1000 years, with fault slip occurring during magmatic and intermagmatic periods. Space-based geodetic and seismicity data from Afar document as much as 8 m of opening during a 2-week time period, with a significant fraction of magma sourced from the ~60 km-long segment center [Wright et al., 2005; Keir et al., 2009].

Pre-existing and Evolving Structures

In addition to evolving magmatic conditions in rifts, pre-existing, and evolving, conditions within the mantle and lithosphere can affect rift strength, stress and strain distribution, magmatic scaling and evolution. Holtzman and Kendall [in press] calculated elastic and viscous properties of multi-scale distributions of melt to quantify the physics of partially molten regions beneath rift zones. Even 1% melt, if aligned and segregated, can cause an order of magnitude reduction in effective viscosity. It was also noted that the distribution of existing volatiles in the Black Sea appeared to affect the distribution of magmatism and the variation in rifting styles seen along strike [Shilling-ton et al., 2009]. Small melt fractions in the mantle lithosphere may, therefore, lead to strain localization, with significant consequences for the dynamics of rifting. In an earlier rifting episode a synthesis of petrological and geophysical constraints from the successfully rifted N Atlantic passive margins suggests crustal anatexis as a source of felsic melts and the complete removal of mantle lithosphere prior to continental break-up as a pre-existing condition [Meyer et al., 2009]. While new models of observations from the Rio Grande rift zone demonstrated the role of pre-existing lithospheric heterogeneities on strain localization and thermal perturbations in the Rio Grande rift zone, and predicted consequent changes in mantle lithospheric structure [van Wijk et al., 2008].

Evolution of Strain and Segmentation

Strain evolution and segmentation were shown to vary through time and in
response to the above variables. Gulf of Corinth studies revealed that the strain localization occurred within 3 million years of formation \cite{Bell et al., 2009}, while localization may have taken much longer along the length of the cratonic East African Rift \cite[e.g., Wynn et al., 2008; Keir et al., 2009].

**Sedimentation and Climate**

Advances in our understanding of the processes occurring at the transition from continental rifting to seafloor spreading stem from new perspectives on the role of sedimentary strata deposited in rift zones. Accumulation of sediment has long been recognized as a mechanism of crustal formation in deep continental rifts. Known and suggested effects of sedimentation in rift zones include: (a) rapid transformation of sediments to metasedimentary rock, providing a possible explanation for “transitional” crust at many rifted margins; (b) suppression of eruptive volcanism, with low-density silicic melts rising through sediment to the seafloor while mafic melts remain intrusive; (c) thermal blanketing and suppression of hydrothermal circulation, which leads to enhanced extraction of mantle melt and early transition to narrow rifting \cite{Lizarralde et al., 2007}; (d) reduction of differences in buoyancy forces that arise from extension, also favoring an early transition to narrow rifts \cite{Bialas and Buck, 2009}; and (e) broad diffuse deformation after the transition to narrow rift mode \cite{Persaud et al., 2003}. While these studies point to the likely influence of sediment input on lithospheric processes in evolving rifts, many aspects of this mechanism remain controversial and poorly understood.

Integrated studies of geomorphology, thermochronology, and mechanical modeling in continental examine the effects of climate and erosion in rift settings, with the recognition that even modest topographic elevation on rift flanks can have substantial impact on atmospheric circulation. A study of low-T thermochronology suggested that uplift on the flanks of the east African rift led to Neogene aridification in Africa and intensification of monsoonal circulation in Asia \cite{Spiegel et al., 2007}. Chapin \cite{2008} proposed that initial opening of the Gulf of California led to enhanced monsoonal flow, which triggered integration of the Colorado River and resulting flux of sediment into the Salton Trough and Gulf of California. Mack et al. \cite{2009} showed that footwall incision and basin filling in the Megara Gulf, Greece, were driven by increased catchment runoff related to Pleistocene climate change. These studies point to the important but little-studied feedbacks among rift-related deformation, atmospheric circulation, climate change, erosion, and transfer of sediment from eroding highlands to subsiding rift basins.

**Shaping the Future of RCL**

New and fundamental scientific questions have arisen regarding the development and evolution of continental margins. Many of these questions have stemmed from the advances made during the first phase of the MARGINS program. The systems-science approach required to answer these questions requires interdisciplinary crossing the shoreline.
proposals evaluated by interdisciplinary oceans and earth sciences panels (tectonic/atmospheric/hydrological/ecological/societal). The MARGINS initiative fostered an international community; its successor program facilitates the practical application of invaluable international collaborations that would otherwise be unlikely to crystallize. Many original questions were shaped by early career scientists who have become productive contributors to the scientific community. Early career scientists have been, and will be integral to the continued success of MARGINS.

Articulating our emerging goal

Breakout group and general discussions converged on the overarching goal of a successor program: ‘To understand the forces, responses, and feedbacks between continental rifting, mantle melting, and sedimentation. Below we identify several specific questions that were posed, which require integration of short-term and long-term observations and theory to fully understand processes.

1. What are the mechanisms and feedbacks that cause lithospheric weakening and thinning leading to continental rifting, with an emphasis on the role of magmatic and aqueous fluids in initial lithospheric strength reduction, and the feedbacks between sedimentation, climate and strain distribution in space and time?

2. What are the mechanisms and feedbacks controlling the along-axis segmentation of continental rifts from initiation to breakup, with an emphasis on the generation and focusing of magmas, and the timescales and rates of processes?

3. What are the implications of these processes in terms of societally-relevant issues such as earthquake and volcanic hazards, and the storage and release of hydrocarbons and greenhouse gases?

4. What are the rates, processes and timescales of delta transport across shelves into deep basins? How do these processes vary with climatic and tectonic forcing in continental rifts, and how are the signals of these variations expressed in the stratigraphic record?

5. What are the dynamic feedbacks among crustal deformation, erosion, climate, and sedimentation in and adjacent to continental rifts?

What infrastructure and approaches are needed to achieve goals?

Sequestered funds within a future MARGINS program will allow the development and use of large-scale infrastructure investments to study scientific problems that would not arise from a core NSF program. This will catalyze the development of future large projects and international collaborations that would benefit from this infrastructure. The current MARGINS program promotes informed collaboration rather than competition thus leveraging infrastructure to benefit scientific advance. The active involvement of scientists in different disciplines who communicate and address fundamental questions synergistically would be impossible without an umbrella program like MARGINS. Some of the timescales of problems in the continental margins problems require a rapid response that is best orchestrated through a program such as MARGINS. Examples include the recent boninite eruption at the Tonga trench, funded through a partnership between MARGINS and Ridge 2000 (p. 12-15).

As with the current MARGINS program, a successor program seeks to "cross-the-shoreline" with joint observations based on marine seismic (and other geophysical datasets), sampling, drilling (onland and offshore), terrestrial field observations, satellite based studies, geochemical analyses, new geochronologic methods, experimental approaches, and numerical models. We wish to take advantage of new technologies (SAR satellite data or other space-based technologies that can see through vegetation; quantify displacements, deformation, or fluxes) or advances in established techniques. MARGINS is well positioned to take advantage of a wide breadth of new technologies. The rapid growth and success of the CIG initiative, for example, facilitates the general use of coupled models and computational abilities for rheological, mechanical, and coupled surface evolution problems (deformation, fluid flow, etc.) relevant to continental margins problems. The successor program aims to leverage existing computational infrastructure developed by NSF funding for geodynamics and landscape evolution. In addition, we aim to take advantage of geoinformatics and encourage open-access databases for new data collected under the MARGINS program. An outcome of the current and future program is fully developed proposals to IODP; OOI; Earthscope; and evolving partnerships with industry to provide a substantial element of subsurface characterization. MARGINS will allow the development and use of large-scale infrastructure investments to study scientific problems that would not arise from a core NSF program. Finally, annual and required meetings of ‘Rifting’ researchers will maximize scientific productivity and synergy.

Program Structure: Focus Sites vs Themes

Meeting participants debated the pros and cons of focus sites, thematic programs, and hybrid theme and focus site options. Answers to the fundamental rifting questions above necessarily require new observations from and new models of multiple locations globally spanning the evolution of rifts from inception to breakup. There was a clear consensus that 1) a future Rifting, Sedimentation, and Fluids program should include studies at active margins where processes can be examined as they are happening, as well as successfully rifted margins with experiments that span the ocean-continent divide and 2) that focus sites should enable characterization of 4D strain processes. The merit of a coupled active-ancient program stems from new technologies to probe ancient margins in 3D, and to develop strong IODP proposals and links with industry. The final choice of sites builds on existing major experiments & infrastructure, allowing
us to apply RCL experience to future sites. Specific experiments revisiting previously sampled sites will enhance the cost-to-benefit ratio of past projects (e.g., drill sites).

Concluding Remarks

The Charleston RCL meeting achieved consensus on core themes for the MARGINS successor program. These scientific aims, and programs to achieve these aims will be honed and structured at an open meeting in San Antonio in February, 2010. A White Paper expanding these points will be posted on the MARGINS web page in November, 2009 (www.nsf-margins.org/Planning_and_review).

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Eruptions in the NE Lau Basin

Joseph A. Resing, Robert W. Embley, and Kenneth H. Rubin

1 National Oceanic and Atmospheric Administration; 2 School of Ocean and Earth Science and Technology, University of Hawaii

An active boninitic eruption was observed at West Mata (Figure 1) submarine volcano in the NE Lau basin in May 2009. West Mata volcano is the largest of a series of en echelon volcanoes lying between the magmatic arc front and the NE Lau spreading center. The eruption was witnessed as a part of an eruption-response cruise to examine the sites of two eruptions in the NE Lau Basin that were discovered in November 2008 during a NOAA-Pacific Marine Environmental Laboratory expedition on R/V T. G. Thompson. The second of the two eruptions was along the NE Lau Spreading Center (NELSC) and was not actively erupting during the response cruise. During the response cruise five ROV dives were conducted at West Mata Volcano and two at the NELSC to characterize the volcanic deposits and associated phenomena. These observations provide fundamental new insights on eruptive phenomena in the deep sea. The eruption at the NE Lau spreading center is the first ever observation of a very recent eruption along a back arc spreading center, while the eruption at West Mata was the first ever observation of an active boninitic eruption. Zero-age samples of boninite (a rare, water-rich magma type believed to form from slab-derived fluid fluxing of shallow refractory mantle) were collected for petrological and geochemical studies.

Background and Rationale

West Mata

The eruption at West Mata was detected by an intense plume rising ~175 m above its summit with some of the highest values of turbidity, \( H_2 (> 9000 \text{ nM}) \), \(^3\text{He}\), oxidation-reduction potential anomaly, and pH anomaly ever measured in a hydrothermal plume. The plume had abundant large glass and mineral shards (10-70 \( \mu \text{M} \)), which, when combined with the elevated \( H_2 \) values, provides convincing evidence for the interaction between molten rock and seawater. High acoustic backscatter derived from the R/V Thompson's EM300 multibeam sonar system was consistent with very young and
perhaps persistent volcanic activity. This was a very exciting result, because West Mata would represent only the second site on the planet where we could study an erupting submarine volcano. Studies of a long-term eruption at 540m depth at NW Rota-1 volcano in the Mariana arc have provided dramatic first insights on the physical volcanology, chemistry, and biology of a submarine eruption [Embey et al., 2006; Chadwick et al., 2008; Resing et al., 2007; Walker et al., 2008; Limen et al., 2006]. The West Mata site is 500m deeper than NW Rota, thus providing a better understanding of the constraints of pressure on an active deep sea eruption. The SW-NE striking trend of West and East Mata and several ridges to the northwest suggest that volcanic activity in the area is concentrated along tear faults possibly induced by disruption (rift) of the crust at the northern termination of the Tonga subduction zone. This area is also the locus of Quaternary boninite volcanism, as shown by a handful of both backarc and fore-arc samples that have been dredged in the region, including the proto-rift zone northwest of West Mata [Falcon et al., 2007]. This evidence provided further impetus to visit the suspected West Mata eruption site, and was key in engaging the MARGINS community in this effort. Boninites after all provide an unparalleled opportunity to investigate the composition of slab derived fluids and their effects on the subduction zone mantle melting regime. It was reasoned that fresh, known age boninite samples from West Mata would provide a high fidelity record of these processes, including the measurement of the all-important U-series decay-chain nuclides, which provide information on the timing, conditions, and magnitude of fluid addition to the magmatic source.

NELSC

The eruption on the NELSC was detected from hydrothermal plumes found in the water column 800-1000 m above the southern segment. These plumes also contained high concentrations of volcanic glass shards and H₂ (≥3μM), providing evidence for molten-rock sweater interactions. Near-bottom temperature anomalies >0.5°C over a small region of the neovolcanic ridge indicated the likely location of the eruption. The NELSC event posed the first opportunity to compare the geologic style of back-arc volcanic accretion and environmental impacts to ones documented over the past two decades on other ridges (Juan de Fuca, Gorda, EPR) and seamounts (Loihi, NW Rota). Responses to volcanic events on the Juan de Fuca Ridge and East Pacific Rise spreading centers during the past two decades have resulted in new insights on chemical, biological, and geological processes, including: (1) volumes and extent of eruptions with major insights on how the ridge is constructed through time [Chadwick and Embey, 1994; Embey et al., 2000; Formani et al., 1998]; (2) eruption durations, mechanisms, and compositions of their volcanic products constrain the conditions, timing, and processes of magmatism at those sites [Rubin et al., 1994; Perfit and Chadwick, 1998; Rubin et al., 2001; Rubin et al., 2005]; (3) the biological response to eruptions [Cowen et al., 2004; Huber et al., 2003; Shank et al., 1998; Tunnicliffe et al., 1997], (4) the chemical evolution following magmatic perturbations [Resing et al., 1999; Butterfield et al., 1997; Lilly et al., 2003; Von Damm et al., 1995]; and (5) the discovery and sampling of the subsurface biosphere beneath the mid-ocean ridge [Cowen et al., 2004; Delaney et al., 1998; Huber et al., 2003; Summit and Baross, 1998]. In addition to these fundamental questions there is also the overarching question of how submarine volcanism and hydrothermalism works at a variety of geologic settings, depths, and magma compositions.

For all of these reasons, it was deemed critical to revisit both of these sites to observe and map the sea floor and to collect volcanic and hydrothermal products at the eruption sites as soon as possible. These observations would provide context to on-going studies at other arc and back-arc sites of interest to the Margins and Ridge 2000 programs (such as the Marianas SubFac focus site and the Eastern Lau Integrated Studies Site, respectively). The rapid response to these eruptions was funded jointly by the Marine Geology and Geophysics program at NSF (via Ridge 2000, MARGINS, and core funds) and the National Oceanic and Atmospheric Administration (Ocean Exploration and Research and the Eastern Pacific Marine Environmental Laboratory VENTS program). Coordination provided by Ridge 2000, MARGINS, and the VENTS programs resulted in the receipt of 37 letters of interest to participate in the study at sea and/or through land-based studies.

Discovery and Achievements

The NE Lau Response cruise departed Apia Samoa on May 5 and returned on May 13th. Seven dives of the Jason-2 vehicle from the Woods Hole Oceanographic Institution (WHOI) were conducted. Within a little more than an hour of reaching the bottom at West Mata on the first dive (J2-413) we

Figure 2. Magma bubbles observed on Dive 420 (bubble diameter is ~1m).
came across an active eruption at 1205 m near the summit of West Mata volcano, at a site we named Hades vent. The eruption was characterized by glowing molten lava, explosions, the creation of large amounts of volcanioclastic materials, and the active formation of pillow lavas. This was the first ever observation of active lava flows in the deep ocean, thus, this is the first documentation of one of the most fundamental processes forming the Earth’s surface. The eruptive activity was present during each of the five dives at West Mata and these dives revealed much about current and past volcanic activity there.

Many large magma bubbles (Figure 2) were observed on several dives. They were presumably formed mostly by vapor water expanding within the molten lava. In addition to the water (both magmatic and interstitial), the bubbles also contained other magmatic gasses (SO$_2$, CO$_2$, and H$_2$), created during the interaction between the molten lava and the water vapor. Samples were collected of rocks, sands, microbes, fluids, and macrofauna and the Autonomous Underwater Vehicle D. Allan B. from the Monterey Bay Aquarium Research Institute made high resolution maps of the volcano. Two small hydrophones were also deployed by Jason-2 within 20-40 m of the eruption site. These data will be used to compare the short-term magmatic degassing cycles at West Mata with those recently quantified at the NW Rota-1 site [Chadwick et al., 2008]. In addition CTD tows and casts over the eruption sites were reoccupied to provide a time series of the water-column anomalies and a hydrophone mooring, deployed in January 2009 as a response to the discoveries of the eruptions, was recovered.

Perhaps of greatest interest to the MARGINS community are the types and compositions of lavas and volcanioclastic sediments collected on the expedition. Both sites are dominated by gas-rich magmas (vesicularities of 25 to 40%). West Mata is currently erupting orthopyroxene, clino-pyroxene plus olivine porphyritic boninite [Peter Michael, unpublished] with equally crystal-rich older rocks also present at this site. NELSC has been erupting nearly aphyric, compositionally heterogeneous basalt with chemically enriched compositions (e.g., Th = 3.3 ppm, Th/U > 3.8). Rocks from both sites are being studied for a large suite of geochemical characteristics to define magma compositions, petrogenetic conditions, and magmatic timescales. Rocks are also being dated by $^{210}$Pb-$^{210}$Pb and $^{206}$Pb-$^{238}$Ra chronology, which will provide temporal information ca 1 month and decadal timescales, respectively, useful for both the petrologic and the ecologic aspects of the investigations at both sites.

The eruptive activity at the NELSC was examined using two Jason-2 ROV dives and one AUV dive. The first ROV dive landed in the middle of a glassy, unseminated lava flow devoid of biological colonization, suggesting that we had located, in part, the site of the recent eruptive activity. We named this eruption deposit the Puipui lava flow. However, aside from the fresh lava flows and volcanenic debris, there was no evidence of new and/or enhanced hydrothermal activity along the ridge. A previously known site [P. Crowhurst, Nautilus Minerals Inc., pers. comm.] of weak hydrothermal activity was relocated on older lava flows to the north, and was sampled for fluids, micro-, and macro-biology. The MBARI AUV surveyed the neovolcanic ridge and a CTD-tow-yo was conducted along the same path over the eruption area as the tow-yo in November 2008 (that showed temperature anomalies as high as 0.5°C). The tow-yo revealed no major hydrothermal plumes in the area and no near-bottom temperature anomalies over the eruption site. The absence of an extant hydrothermal system along this part of the ridge indicates that the lava flow was quite small, was cooled quickly, and/or was supplied by a relatively small dike. In any case, the apparent absence of a recent or recently reset hydrothermal system precluded the study of the chemico logical colonization, suggesting that we had located, in part, the site of the recent eruptive activity. We named this eruption deposit the Puipui lava flow. However, aside from the fresh lava flows and volcanenic debris, there was no evidence of new and/or enhanced hydrothermal activity along the ridge. A previously known site [P. Crowhurst, Nautilus Minerals Inc., pers. comm.] of weak hydrothermal activity was relocated on older lava flows to the north, and was sampled for fluids, micro-, and macro-biology. The MBARI AUV surveyed the neovolcanic ridge and a CTD-tow-yo was conducted along the same path over the eruption area as the tow-yo in November 2008 (that showed temperature anomalies as high as 0.5°C). The tow-yo revealed no major hydrothermal plumes in the area and no near-bottom temperature anomalies over the eruption site. The absence of an extant hydrothermal system along this part of the ridge indicates that the lava flow was quite small, was cooled quickly, and/or was supplied by a relatively small dike. In any case, the apparent absence of a recent or recently reset hydrothermal system precluded the study of the chemico biological evolution following an eruption and greatly reduces its potential use as a comparison site for the R2k ELSC ISS. Dive 416 was used to identify both the lateral extent and the southern terminus of the lava flows from the recent eruption. Once the southern terminus of the lava flows was documented, the dive was moved south along the NELSC to Maka Volcano where a high-temperature hydrothermal system was located previously by Nautilus Minerals Inc. The hydrothermal vents at Maka were black smokers located on a large mound of sulfides. The site was sampled for rocks, biology, fluids, and sulfides; thus it provides a relevant comparison to the East Lau Spreading center ISS.

Conclusions

This expedition was a success on multiple fronts. We collected 22 biological, 69 fluid, 15 gas, and 68 rock and/or clastic samples from two sites of ongoing or recent submarine volcanic activity. The rocks included rare boninite lavas. The NELSC and West Mata eruptions will provide insight on the long-term history of a back-arc rift zone, with the West Mata site representing a proto-backarc system (young rifted crust) and the NELSC site the established backarc spreading system. Geochemical and petrological investigations of the lavas will improve our understanding of material and energy fluxes through subduction zones and their role in the volcanism there. A chemical study of the magmatic/hydrothermal fluids from a West Mata eruption combined with those in the rock will aid and improve our understanding of the flux of volatiles through the subduction zone. Analysis of video and acoustic data will enhance our understanding of deep-sea eruption processes. Results from this expedition are part of a special session at the Fall 2009 AGU entitled “Submarine Volcanic Eruptions: Studies of Geologic Chemical and Biological Processes.” Although many studies are currently underway, letters of interest outlining new avenues of pursuit are welcomed.

NE Lau Response Team: E. Baker, J. Lupton, M Lilley, T. Shank, R. Dziak, T. Collinsius (Jason 2 Expedition Leader),

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A great many people from the funding agencies (NSF and NOAA-Ocean Exploration) and MARGINS and Ridge 2000 communities put in a heroic effort to help make this expedition happen. In particular, D. Fornari, G. Abers, and J. Gill provided critical insight and coordination on behalf of this effort. The interaction between MARGINS and Ridge 2000 scientists has been very rewarding.

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MARGINS Database
• Visit www.marine-geo.org/ports/margins
• Search and download data for 70 MARGINS-funded field programs
• Download GeoMapApp and Virtual Ocean
• Visit the MARGINS-MGDS exhibit booth (#307) at Fall AGU
Introduction

A key function of the MARGINS Education & Outreach effort is to transform MARGINS findings and data for use in the classroom. One step toward this end is the development of hands-on educational modules called “mini-lessons” which feature MARGINS concepts and data conveniently packaged for use by faculty in introductory or upper level college geoscience courses. More than 30 MARGINS related mini-lessons are currently available, hosted by the Science Education Resource Center (SERC) at Carleton College (http://serc.carleton.edu/margins/collection.html).

Much of the work to complete the mini-lesson collection was accomplished at a recent workshop, held May 28-29, 2009 at the Lamont-Doherty Earth Observatory (LDEO), Fig. 1, as the combined effort of MARGINS researchers and geoscience faculty from around the country. The objectives of the Mini-lessons workshop were two-fold: to use newly collected in-class assessments of mini-lessons to improve and polish an initial suite developed following a workshop in May 2007 (see report in MARGINS Newsletter # 19), and to design and complete a new suite of mini-lessons, filling some content gaps that had been identified. Workshop participants were asked in advance to evaluate an existing mini-lesson, or to propose a new one. On the first day of the workshop, evaluators were paired with the authors of both old and new mini-lessons for a session of small group critiques and brainstorming, followed by an afternoon of lesson construction and revision. Specialists from SERC, Cathy Manduca and John McDaris, and MARGINS senior coordinator and Marine Geoscience Data System expert Andrew Goodwillie, circulated to facilitate the process. Database specialists Karin Block (PetDB) and Annika Johansson (SedDB) gave brief outlines of their databases and also helped build mini-lessons. On the second morning, new evaluators were assigned to groups of mini-lesson developers, for a second round of critiques and revision. Common design problems, useful approaches to engage students and ways to make the lessons easy to use by faculty were drawn from the group and summarized by SERC Director, Cathy Manduca.

Mini-lesson builders and evaluators at the workshop were: Karen Bemis (Rutgers), Maggie Benoit (College of New Jersey), Susan Bilek (New Mexico Tech), Mike Carr (Rutgers); James Conder (Southern Illinois); Stacia Gordon (UC Santa Barbara); Stephen Hurst (Illinois); Lonnie Leithold (North Carolina State); Laura Mallard (Appalachian State University); Cecelia McHugh (Queens College); Elisabeth Nadin (Brown); Andy Newman (Georgia Tech); Cindy Palinkas (U of Maryland); Leslie Sautter (College of Charleston); Gerry Simila (Cal State Northridge); Glenn Spinelli (New Mexico Tech); Susanne Straub (LDEO); Sandra Swenson (CUNY); Laura Wetzel (Eckerd College) together with MARGINS Education convenors Andy Goodliffe (U of Alabama); Rosemary Hickey-Vargas (Florida International University); Jeff Ryan (University of South Florida) and Geoff Abers (LDEO).

The resulting collection of mini-lessons includes themes from all four MARGINS initiatives, and features new titles such as: “A Geologic Safari of the East African Rift and the Newark Basin: Why These Areas are More Alike than you Know”, “Sediment Production and Distribution Across Margins”, “A Tour of the Mariana Subduction System”, “From Ocean Topography to Flexural...”
Rigidity”, and “News Flash: MARGINS Discovery Student Presentations”. Mini-lessons each have a summary page listing a statement of learning goals, context for use, and a description of the lesson with links to needed materials, which could be downloadable assignments, PowerPoint presentations, online computer applications and databases. The front page also lists teaching tips and ways to assess the outcome of the lesson in the classroom.


One exciting aspect of the workshop was broad recognition of GeoMapApp as an invaluable tool for teaching geoscience concepts. In the summary session it was noted that more in-depth instruction was needed for faculty to become fully familiar with all the capabilities of this application. As a result, a GeoMapApp Webinar was held in July, and is now available on the MARGINS webpage. A GeoMapApp User Guide and cookbook has also been created (http://www.geomapapp.org/GMA/newHelp/GMA-Help_2.html).

The MARGINS mini-lesson effort is supported by a grant from NSF’s Course, Curriculum, and Laboratory Improvement (CCLI) program to MARGINS education group members.

Now it’s your turn to help! The mini-lessons are ready for use. Please include them in your undergraduate courses and let us have feedback. Each mini-lesson has a link to an evaluation form. Your feedback will help to further improve the lessons.

The MARGINS Education team anticipates that the MARGINS mini-lesson collection will be a valuable tool for disseminating the results of the MARGINS program and for rapidly moving MARGINS breakthrough science into the undergraduate geoscience classroom.

The MARGINS Distinguished Lecture Program: Success in Outreach

Andrew Goodwillie, MARGINS Office

Following the mid-term review of the MARGINS program, the MARGINS Distinguished Lecture Program (DLP) was started in 2005 as a means of widely expanding awareness across the earth sciences community of MARGINS science. Due to overwhelming demand, the number of speakers was doubled in 2007.

The program has been a tremendous success, with high-profile MARGINS scientists presenting technical and public lectures on subjects related to each of the MARGINS initiatives.

Four completed DLP lecture series have so far taken place, and the current one for the 2009-2010 academic year is about to get started. The program has been broadly advertised through listserv announcements, newsletter articles, advertisements in Eos and GSA Today, and through mailing MARGINS DLP brochures to almost 900 degree-granting colleges and universities. Such wide coverage has ensured that schools with geoscience departments of all sizes are included in the announcements.

Since program inception, applications to host a DLP speaker have been received from 330 unique institutions across the country, with DLP speakers dispatched to 75 of these. For the upcoming series, seven DLP speakers will visit a further 23 schools.

One measure of success of the program is the diversity of institutions that have applied to host a speaker. For example, of the 66 applicant institutions for the current 2009-2010 series, 55% were classed as specifically catering to under-represented student bodies, and four are undergraduate-only schools.

The program allows the speakers to mix with students and faculty at the host institutions and, in some cases, new research opportunities have been created. The effectiveness of the DLP program is

Figure 1. Donna Shillington (front row, center), DLP speaker for the RCL initiative during her April 2009 visit to Kutztown University.
best gauged not only by the range of host institutions visited but also by the tremendous response from host institutions.

Examples of feedback:

- I think the MARGINS Distinguished Lecture Program is an excellent program that allows small departments like ours to bring in renowned speakers at the top of their fields. This helps not only the students in the department, but also the faculty.

- The speaker gave an outstanding lecture at our general audience series. The Geology undergrads were captivated by his capacity to weave interesting science with “tales of adventure” from the field. I thank him for being so generous with his time and MARGINS for making this program available to institutions such as ours whose lecture series are perpetually lacking funds to bring in top-notch speakers such as this.

- Thank you so much for running this program. It’s a great opportunity to promote interdisciplinary science to our students as well as bring a scientist with expertise outside our small department to campus!

- I continued to cite examples from the speaker’s presentations in my course lectures for several weeks afterwards, and his presentations also provoked some independent research by our graduate students. Hence I would consider this one of the most successful “knowledge transfer” exercises in our departmental speaker series this past year.

- It is an incredible resource for a small program such as ours. MARGINS made it possible for us to expose our students to cutting edge state-of-the-art research.

MARGINS has organized an excellent seminar series. It helps in a great way to a small department like us. We appreciate it a lot.

Over the past four years, the MARGINS DLP program has brought groundbreaking MARGINS science to a diverse range of research and teaching universities, enabling faculty, staff and students at dozens of institutions across the country to interact with cutting-edge MARGINS geoscientists. As the first decade of MARGINS draws to a close, the DLP program continues to enhance the impact of MARGINS science upon the earth sciences community.

View a full list of speakers online: www.nsf-margins.org/DLPProgram/09-10/index.html
Since 2003, the MARGINS program has funded a number of postdoctoral fellows, both within the special MARGINS Post-doctoral Fellowship and within the regular NSF-MARGINS programs. These biographies profile postdoctoral fellows Christie Rowe and Ikuko Wada.

**Ikuko Wada**

**NSF Award**
0840800

Woods Hole Oceanographic Institution

**MARGINS FELLOWSHIP:** A Synthesis of the Physical State of the Mantle Wedge in Costa Rica-Nicaragua and Izu-Bonin-Mariana

Temperature is a primary factor that controls many important geophysical processes in subduction zones, including earthquakes and arc volcanism. The subduction zone thermal structure is strongly influenced by solid-state mantle wedge flow, which is driven largely by viscous coupling between the slab and the overriding mantle. Geophysical observations, such as surface heat flow, indicate that this flow is absent in the most seaward part of the forearc and therefore that the slab and mantle are decoupled. During my doctoral research with Kelin Wang at the University of Victoria and the Pacific Geoscience Centre, Geological Survey of Canada, British Columbia, Canada, I investigated the effect of slab-mantle decoupling on the wedge flow and thermal structure through numerical modeling. The model results revealed that a weakened interface relative to the strength of the overriding mantle always leads to complete stagnation of the mantle due to the strong sensitivity of the mantle strength to temperature and that the mantle either does not flow at all or flows at full speed. This bimodal flow behavior results in a strong thermal contrast between the stagnant and flowing parts of the mantle wedge. Using heat flow data and other geological and geophysical constraints, I found that the maximum depth of slab-mantle decoupling is 70-80 km for most, if not all, subduction zones. The recognition of the importance of the maximum depth of decoupling provides important implications to the study of subduction zone geodynamics. As a MARGINS postdoctoral fellow, I will start the next stage of my research at Woods Hole Oceanographic Institution with my mentors Mark Behn and Alison Shaw in November 2009. My research will focus on the physical state of the mantle wedge, which is controlled not only by mantle flow, but also by other processes such as hydration, melting, and the evolution of mineral grain size. I will investigate how these processes take place in the mantle wedge using numerical models and a wide range of geophysical and geochemical observations made in the two MARGINS SubFac Integrated Study Sites, the Izu-Bonin-Mariana and Costa Rica-Nicaragua margins. I am excited to have this opportunity to pursue my research in subduction zone geodynamics.

**Christie Rowe**

**NSF Award**
0840977

University of California, Santa Cruz

**MARGINS FELLOWSHIP:** Fluidization of Very Thick Granular Layers in Ancient Thrust Faults

Greetings MARGINS Community!

I am going to spend the next two years studying transient fluidization of granular fault rocks in Alaska and Namibia, working with Emily Brodsky at UC Santa Cruz to investigate rheology and behavior of such rocks, and the implications for co-seismic weakening in shallow crustal faults. Thank you NSF/MARGINS! I am a field geologist and love messy and complex systems. Working with Emily, I am learning how to simplify and quantify my field observations to extend my ability to use outcrops of old exhumed faults to understand how modern faults slip - and how evidence of ancient seismic slip can be detected in the rock record.

My undergraduate research at Smith College was on blueschists and eclogites from the Franciscan Complex in California. Some of my samples came from some mélangé terranes, where I remember thinking I would never work again because the rocks are so “ugly”. After a couple years in the leaky petroleum tank removal business, I went to UC Santa Cruz to study with J. Casey Moore. Casey and I went looking for preserved strands of the plate boundary faults in the subduction complex on Kodiak Island, Alaska. We looked at the low-temperature evolution of subducting sediments at the top of the seismic zone which dominate the décollement surface at shallow depths in many plate boundaries, looking for the key reaction which causes the aseismic to seismic transition when the décollement is at about 100-150°C.

Talk about “ugly” rocks! Kodiak is a pile of sheared, low-grade turbidite mélanges - mostly dark grey rocks with dark grey shear zones and blackish faults, which are hard to study when it’s raining all the time. It wasn’t until my second field season on Kodiak that the sun came out for a few days. This was pretty lucky because when the outcrops dried we realized there were some very strange black fault rocks exposed
there. With (then post-doc) Francesca Meneghini, I spent the next few years working on these rocks and discovered that they are thick layers of very finely banded pseudotachylytes and microcataclasites that we think formed during earthquake slip. They formed when rupture propagated through granular cataclasites and mélanges, not through intact rock. Akito Tsutsumi (U. Kyoto) has had some success in experimentally producing friction-induced melting in these soft rocks, implying that sufficient frictional heating can occur even when the rocks are assumed to be relatively weak. The seismic fault rocks are recycled during slower, distributed slip into clasts within the thicker fault zone fabrics, preserving repeated cycling of slow, distributed creep and fast, localized slip - a snapshot of the earthquake cycle from an early Paleocene plate margin.

When I was finishing my PhD, I met Emily Brodsky who was then moving to UCSC. She recognized that my field observations of fault rocks could be used to quantitatively constrain aspects of fault rock flow. Working together to investigate the rheology of the fault rocks during seismic slip was really exciting and opened up a whole new area of research for me.

I moved to University of Cape Town in a tenure-track position to teach structural geology, mapping and tectonics. Exposure to the incredible geology of southern Africa exploded my research interests into several new areas, including soft sediment deformation, nappe emplacement and continental orogeny. My collaborator Jodie Miller introduced me to the Naukluft Nappe Complex in central Namibia, where sparse vegetation and incised topography (coupled with extreme heat) can sometimes make it feel as if one is mapping inside a 3D seismic volume. I was excited to discover that the sole thrust of this 500Ma nappe complex displayed some similar textures to those I had seen in other faults, which have not yet been studied in adequate detail.

When I decided to move back to the US, Emily and I proposed this MARGINS Fellowship to study the fault rocks in Pasagshak (Alaska) and Naukluft (Namibia). Both these thrusts are low angle faults which were active at shallow depths and low temperatures which show textural evidence of very thick (meters to 10m) granular layers which were transiently fluidized. If this fluidization occurred during seismic slip it could dramatically weaken the fault zone. The very similar textures found in the subduction thrust (Pasagshak) and continental nappe sole thrust (Naukluft) suggest that this phenomenon can occur in diverse tectonic settings.

With fourth-year students from UCT, I am mapping and documenting deformation structures in the Naukluft cataclasites. I look forward to field work in Namibia as a chance to maintain my connections to the students and faculty in South Africa and Namibia. If you have graduate opportunities for some bright and hard-working international students, please contact me.

NEW MARGINS Staff:
Karen Benedetto, Administrator

The MARGINS Office has gained a new staff member, Karen Benedetto, to serve as the Administrator.

Karen has worked at Lamont since 2004 in various positions. She has processed rocks for sampling for Peter Kelemen, done extensive laboratory work for Joerg Schaefer, processed and submitted grants for several scientists in the Geochemistry division and field work for Wade McGillis.

After many years in corporate America as a Supply Chain professional, Lamont is a breath of fresh air!

Find out more about the MARGINS Office online at:
http://www.nsf-margins.org/MARGINS_Office/MARGINSoffice.html

Have an idea for a newsletter article?

We are now accepting contributions from the community for the Spring 2010 MARGINS newsletter.

If you have an article or other newsworthy item – no matter how large or small – that you think may be of interest to the broader MARGINS community, please send it to the MARGINS Office for consideration.

The deadline for newsletter submissions is February 15, 2010.

For more information please contact the MARGINS Office at margins@nsf-margins.org.
Cascadia Amphibious Facility Planning Group Meeting

June 30-July 1 2009

G.A. Abers, MARGINS Steering Committee Chair
G. Ekström, EarthScope Steering Committee Chair

On June 30 and July 1, a mix of 31 scientists and NSF officials met at Lamont-Doherty Earth Observatory with a brief six weeks forewarning to discuss the Cascadia Facility Enhancement Initiative. The meeting was co-sponsored by EarthScope and MARGINS. The resulting report has been released at www.nsf-margins.org/Cascadia/09meeting. This article is excerpted from that report.

Brief description of Initiative formulation

As part of the 2009 Stimulus or ARRA (American Recovery and Reinvestment Act) spending, NSF’s Earth Sciences (EAR) and Ocean Sciences (OCE) divisions are each receiving $5M in facility-related investment. The funds are targeted toward Facility-related investments to support EarthScope and MARGINS science objectives, with an initial emphasis on onshore/offshore studies of the Cascadia margin. Under current plans, the EAR portion will be spent to enhance data collection from the EarthScope PBO geodetic facility in Cascadia, and to deploy additional USArray Transportable Array seismic equipment in the region, not necessarily only re-occupying previous stations. The OCE portion will go toward a pool of Ocean Bottom Seismographs (OBS’s), ultimately part of the OBS Instrument Pool (OBSIP), to be deployed off Cascadia. OBS deployments will be supported by other funds. NSF currently envisions an initial deployment of at least 3 years, with a review to determine future use of this equipment. All of these instruments are to be “open” community facilities providing data to any interested investigator as quickly as possible, in the manner of most current EarthScope stations.

Planning Group Meeting

Upon request from the National Science Foundation, the chairs of the EarthScope and MARGINS Steering Committees convened a 24-person Planning Group to provide guidance on the use and implementation of the facility. The Planning Group was given two charges: (a) to describe the primary scientific opportunities and critical objectives that the new Facility could address, and (b) to devise an initial implementation plan for the Facility. Participants were invited immediately upon announcement of NSF’s ARRA opportunities, and were selected from both EarthScope and MARGINS communities, and from a range of institutions. At the same time, the initial description of the Facility was distributed broadly to the MARGINS and EarthScope bulk email lists, and an open web-based Forum was established to allow for community-wide input to this planning. The Planning Group was joined, during portions of the meeting, by seven representatives of NSF and the major facility support groups involved (IRIS/USArray; UNA VCO/PBO; OBSIP Instrument Centers). The resulting Report, drafted immediately after the meeting, summarizes discussion first about scientific opportunities and then about implementation.

Science Objectives

Scientific objectives for this facility include the following primary targets, detailed in the report:
- ETS – Episodic Tremor and Slip
- Interplate seismicity
- Repeating and slow earthquakes
- Crustal seismicity
- Earthquakes within the subducting plate
- Water transport in a young subduction zone
- Melt production and the plumbing system of volcanoes
- Seismic anisotropy and mantle flow patterns
- Subduction zone segmentation

In many cases, Cascadia forms an excellent setting to study these fundamental aspects of subduction, and the facility is seen as a potentially transformative opportunity to enhance our understanding.

Implementation Recommendations

The planning group based its discussion of the implementation on guidance from the NSF as well as on documents provided by the PBO/UNAVCO, USArray/IRIS and OBSIP facilities, and on presentations given by representatives from these facilities. The planning group recognized that immediate open access to onshore and offshore data from both seismic and geodetic instrumentation will facilitate integrated research by many members of the community. The group further recognized that the proposed new facility will meet only a subset of identified instrumentation needs, and that additional facilities and experiments are required to address several of the scientific objectives discussed at the meeting.

With regard to the onshore portion of the new facility (PBO and USArray), the planning group recommended that the initial instrument deployment in Cascadia take place essentially in the form proposed by the facility groups (PBO/UNAVCO and USArray/IRIS), consisting of a uniform distribution of GPS and broadband seismic stations that extend along the length of Cascadia from the Ca-
MARGINS Successor: Call for White Papers

Submission Deadline: January 1, 2010

The MARGINS Successor Planning Workshop will be held in San Antonio, TX on February 15-18, 2010

www.nsf-margins.org/SuccessorProgram

All members of the scientific community interested in future science on plate margins are invited to submit one or more White Paper(s) to the MARGINS Office in advance of the MARGINS Successor Planning Workshop. The planning process is open, and these White Papers provide a means for all members of the broader scientific community to contribute cogent and well-argued ideas for future directions of the program. White papers will be used in developing the workshop program, and will be publicly available.

White Papers should be clear and succinct, and limited in length to 2 pages of text plus 1 page of figures and references. The paper may address any topic of relevance to the workshop. We particularly seek white papers that outline broad, high-priority, and novel science questions and objectives for future research relating to the formation, evolution, and/or processes active along subduction or rifting margins. Recommendations for technological developments, instruments, facilities, and observatories necessary to address these questions are also welcome, as well as papers advancing educational and outreach objectives and topics of broader societal relevance. White papers should be of general interest, rather than advocacy statements for specific studies, locations, or focus sites. Additional guidelines for submitting White Papers can be found here: http://www.nsf-margins.org/SuccessorProgram/whitepapers.html
The Future of MARGINS:
A Planning Workshop for a MARGINS Successor Program

February 15-18, 2010, San Antonio, TX
Applications Closed

Workshop Planning Committee Members:

Julia Morgan (morganj@rice.edu) - Chair, Ramon Arrowsmith (ramon.arrowsmith@asu.edu),
Mark Behn (mbehn@whoi.edu), Sue Bilek (sbilek@nmt.edu), Cindy Ebinger (ebinger@earth.rochester.edu),
Marc Hirschmann (hirsc022@umn.edu), Demian Saffer (dms45@psu.edu), Doug Wiens (doug@kermadec.wustl.edu),
Andrew Goodliffe (amg@ua.edu) - Education Liaison, Tom Gardner (tgardner@trinity.edu) - Local Liaison

MARGINS Steering Committee Chair: Geoff Abers (abers@ldeo.columbia.edu)

In its first decade, the MARGINS program has yielded fundamental insights into the
processes that shape the evolution of active continental margins. NSF authorization of a MARGINS
Successor Program now depends on community development of a clear and focused Science Plan that
identifies and elucidates fundamental, multidisciplinary scientific objectives with high potential for
transformative discoveries in the evolution and geodynamics of subduction and rifted margins. The Sci-
ence Plan must also map out the structure of the program. Key decisions will be made at this workshop
to lay the groundwork for the new Science Plan, including:

- Define high-priority Research Questions
- Outline the Initiative Structure and Scientific Goals
- Identify Focus Sites or Thematic Topics to meet the goals
- Define new MARGINS educational / outreach programs
- Provide guidance to the Science Plan Writing Team

A MARGINS successor program will build upon the impressive accomplishments of past MARGINS
inter-disciplinary research, however, it must also anticipate exciting new and emerging opportunities
in margin evolution and geodynamics. As a framework, the MARGINS Steering Committee envisions a
successor program that will:

- Investigate the geodynamic, surficial, and climatic processes that build and modify subduction zones
  and rifts over a wide range of timescales (from s to My).
- Address complex coupled systems along plate margins through an integrated approach,
  combining field research in structure and tectonics, geophysics, geomorphology, geochemistry,
  sedimentology and stratigraphy, with experimental, analytical and numerical modeling studies.
- Involve large amphibious and land-based field programs, as well as smaller focused field and
  lab-based studies.
- Contribute fundamental knowledge relevant to understanding economic resources, geologic
  hazards, climate change, and environmental management.

Submission of topical White Papers is invited from all interested parties. White Papers can be con-
tributed on-line before January 1st 2010 at the following website: http://www.nsf-margins.org/Suc-
cessorProgram/whitepapers.html, and will be made available to all attendees prior to the workshop.

Please send any questions to the MARGINS Office: margins@ NSF-MARGINS.org

More information is available online at:
www.nsf-margins.org/Successor Program
Present and Future

As I enter my final, “lame duck” year as Chair, it is exciting to see so much energy and enthusiasm in the MARGINS community. We have just finished a series of Workshops and TEI’s (Theoretical and Experimental Institute’s) synthesizing most aspects of MARGINS: the Volatiles TEI in September 2009; the RCL Synthesis Workshop in May 2009; the S2S Integration and Synthesis workshop in April 2009; the SEIZE Next Decade Workshop in September 2008, and the IBM and Central America Focus Site workshops in 2007. These have been exciting meetings that demonstrate how MARGINS has succeeded in building a diverse, interdisciplinary community of scientists working on big problems. Each workshop had 75-145 participants adding up to over 500 individual scientists, many more than the 130-140 PI’s funded by the program. Nearly one third have hailed from other countries, a comparable fraction are students or post-doc’s, and participants span virtually all disciplines that have contributed to MARGINS over the last decade.

These meetings parallel last year’s Decadal Review and next year’s efforts to build a successor to MARGINS, as discussed in some detail in the last Newsletter. As a consequence, much time at all of these meetings has been devoted to discussions about future scientific opportunities and the motivation for a successor program, engaging as many of the 500 participants as possible. In addition, we continue to deliver newsletters and announcements to over 1500 addresses, manage web-based open forums, host large AGU receptions (this year: see p. 5), host small working groups, and through the Steering Committee (MSC) interact with many other organizations as the need arises. Still, there are always valuable perspectives that are not reaching the MSC, and we must continue to find ways to expand the community.

The biggest opportunity for community participation in the planning process will be the MARGINS Successor Planning Workshop (MSPW) in San Antonio this February, and the related White Paper call (p. 22).

Discussions at these workshops share some common themes. First, MARGINS has been most successful when truly interdisciplinary, and that interdisciplinarity should be a cornerstone of any successor. Second, exciting problems are continuing to emerge in both rifts and subduction zone settings, and we are both making great progress and understanding the scientific problems with far greater sophistication than a decade ago. For example, the Volatiles TEI highlighted major advances in our understanding of thermal structure and the water output at volcanic arcs, leading to clearer questions about the origins of arc volcanism. A third common theme has been several new problems that cross current initiative boundaries, primarily to stay focused on the most interesting science, but also to entrain groups of researchers not currently part of MARGINS. Two examples: the discovery of silent slip transients and tremors at the transition between SEIZE and SubFac regimes, and recent major advances in our understanding of the interplay between erosion, sedimentation and rifting. Fourth, new technologies and infrastructure bring new opportunities, from new seafloor observatories to continent-scale geophysical arrays to state-of-the-art computing. While specific directions remain to be resolved in San Antonio, there is clearly a good start.

New Events

This year has been more than planning. This spring saw a major rapid response, a joint MARGINS-Ridge 2000 cruise to the northern end of the Tonga-Lau system to investigate possible active submarine eruptions (see p. 12). When the R/V Thompson arrived at West Mata volcano, just behind the northernmost Tonga arc, the science party caught a spectacular eruption in progress, something rarely seen under water. It was particularly exciting because the region is one of the few on the planet where young boninite lavas have been found, a composition associated with the early stages of oceanic subduction. We all eagerly await their first reports at this Fall’s AGU meeting.

Also, thanks to the Reinvestment and Recovery Act, NSF is making a substantial investment in geophysical instrumentation across the Cascadia margin, with MARGINS and EarthScope partnering to develop scientific guidance (see p. 21). The facility itself, and the open data set it will generate, has great potential to significantly advance our understanding of subduction. This is a real opportunity to establish strong ties between marine and terrestrial programs at NSF and among scientists. With community support, this facility could lead to both a broader science program in Cascadia and a long-term movable facility for amphibious observation.

MSPW

Since the last newsletter, the MARGINS Successor Planning Workshop has moved from a vague idea to a scheduled event with plans rapidly falling into place. Thanks for the tremendous effort on part of the MSPW conveners (see p. 23) and in particular Juli Morgan who leads them. This is a major undertaking; it is the first all-MARGINS workshop in decades and the first time that we try to produce a single draft Science Plan for all aspects of the program.

The biggest challenge will be to identify new, exciting science that is both tractable in a decade of research, and requires focused funding in the MARGINS style. The most-asked question by NSF (and others) is “why not core?”; in other words why the science being proposed cannot be done through normal NSF core...
programs. Looking back at the successes of the last decade there are some obvious answers, including the reality of making interdisciplinary research work and the directing of large field experiments, but we will need to come up with very compelling, clear answers to this question if we want to justify continuing with a separate program. I encourage you to prepare for the meeting ahead of time, write White Papers by Jan. 1 (see p. 22), and participate in the meeting as much as possible. On your calendars: San Antonio, Feb. 15-18, 2010.

People

Since I last wrote, several changes have taken place on the MARGINS Steering Committee. First, I am happy to welcome Rosemary Hickey-Vargas from Florida International University to the MSC and MARGINS Education Advisory Committee. Rosemary assumes the role of liaison to the education community and also brings substantial expertise and experience in arc geochemistry and petrology. Second, Ramon Arrowsmith from Arizona State is joining the MSC. He brings critical expertise at the interface between surface processes and tectonics, in the Gulf of California and many other non-MARGINS sites, and brings experience from the GEON data effort. Lastly, Andrew Goodliffe from University of Alabama is joining the Education Advisory Committee, and is serving as the Education liaison to the February planning meeting. As well as an educator, Andy is a marine geophysicist who has contributed greatly to our understanding of active rifts. Welcome Rosemary, Ramon and Andy.

With all additions come departures, and we must say farewell to Jeff Ryan, John Swenson, and Tom Dunne, all of whom left the MSC in winter-spring 2009. Their contributions have been substantial, particularly through the Decadal Review, and they will be missed.

Within the MARGINS Office I am delighted to welcome Karen Benedetto as the new MARGINS Administrator, who comes to us with several valuable years experience with the Lamont administration. She replaces Kristen Woodford, who has been an incredibly effective Administrator but for some reason would rather accept a law school scholarship, which she started this September. We will miss Kristen’s humor and ability a great deal, but Karen has ramped up very quickly and has made the transition completely painless.

As you probably noticed, one thing that did not change this year is the Chair. Although nominally a three-year rotation, NSF has asked me to extend my tenure by one year (353 days as of this writing, but who’s counting), to ensure continuity of Office operations through the transition. Thanks to all for your patience through this transition.

MARGINS Steering Committee Highlights

19th-20th March 2009, NSF Headquarters, Arlington, VA

Compiled by Andrew Goodwillie

Much of this steering committee meeting was devoted to discussing the results of the MARGINS decadal review and to planning for a possible successor program. A tentative timetable for successor program planning was drawn up.

1) Geoff Abers, MARGINS chairman, welcomed new committee member Rosemary Hickey-Vargas and thanked all committee members for their efforts on the MARGINS Decadal Review. He summarised recent activities of the MARGINS Office. Much effort had gone into preparing and compiling documentation for the MARGINS review. The Office arranged various activities at Fall AGU 2008. The chairman also noted the rapid growth in publications over recent years as MARGINS-funded projects have been reaching fruition.

2) Bilal Haq, NSF Program Director, presented an NSF update.

- The MARGINS panel received roughly 40 proposals with initial funding going to a dozen of these, primarily for synthesis and integration activities. Stimulus money may allow additional projects to be funded.
- The steering committee was congratulated for undergoing a successful decadal review of the MARGINS program. The review report highlighted MARGINS’ success in building a large multi-disciplinary community that has led to transformative breakthroughs and impressive scientific results. The review documentation and report are here: www.nsf-margins.org/Review2009/index.html
- To plan for a successor program, NSF encourages involvement of the broader geoscience community. A draft science plan would be needed by mid-2010 to ensure a continuous proposal cycle should a successor program be approved. A community-wide planning workshop will take place in February 2010 (see MSPW box on page 23; www.nsf-margins.org/SuccessorProgram).

3) Upcoming Meetings

- Steve Kuehl updated the committee on the April 2009 S2S Synthesis workshop in New Zealand, with more than 75 people from 8 countries planning to attend (see S2S report on page 1).
- Cindy Ebinger summarised the April 2009 RCL Synthesis and Integration workshop, to be held in Charleston, South Carolina, with almost 90 participants (see RCL report on page 6).
- A MARGINS Education Mini-Lessons Workshop planned for May 2009 will create a new suite of undergraduate-level classroom-ready teaching modules (see Mini-Lessons workshop report on page 16).
- The Volatiles Theoretical and Experimental Institute planned for September...
2009, with almost 100 participants, aims to broaden the scope of volcanoes studies to shallower regions and to volatiles in rifts. It will also include a future-looking component (www.nsf-margins.org/SF/2009/).

4) Northeast Lau Spreading Centre (NELSC) – Rapid Response

Jim Gill summarised evidence from a Nov 2008 NOAA VENTS cruise for an underwater eruption at the NELSC and the subsequent request by a group of researchers for rapid response funding (Joe Resing/Bob Embley, PIs). Data from the successful May 2009 cruise is now available at www.marine-geo.org/tools/search/entry.php?id=TN234 and a special session at AGU on Submarine Volcanic Eruptions is planned (see Lau rapid response report on page 12).

5) MARGINS publications

The committee encouraged the use by convenors of MARGINS-sponsored meetings of on-line publications such as G-Cubed special themes and journal special issues as a means to capture publications related to the meeting content.

6) MARGINS impact at AGU

The chairman illustrated the impact of MARGINS science by the number of MARGINS-related AGU talks and sessions at each Fall meeting – about 30 special sessions each year fall in this category (see AGU sessions on page 28). Additionally, Abers noted that winners of the MARGINS Student Prize have taken up post-doctoral positions and proposal writing.

7) Large-scale field programs

• Sue Bilek outlined progress in the NanTroSEIZE project. Stage 1 drilling is complete. Stage 2 – preparation for observatories and riser drilling – takes place this summer. A G-Cubed Theme will focus on NanTroSEIZE.

• Joann Stock summarised a project to seismically image the Salton Trough transitional crust, a collaboration with Mexican colleagues, and funded jointly by MARGINS, EarthScope and USGS. About 3000 seismometers deployments will be made with seismic profiling due to start over the summer.

8) Database and data compliance

Andrew Goodwillie updated the committee on the status of the MARGINS database (see database report on page 27). New-look, faster web pages were released, along with GeoMapApp version 2. There was a discussion of data policy compliance.

9) Education and Outreach

• Geoff Abers highlighted the popular Distinguished Lecture Program (see DLP impact article on page 17).


• Andy Goodliffe (University of Alabama) has joined the MARGINS Education Advisory Committee to help with education planning efforts for a MARGINS successor program.

• It was noted that an NSF supplement of $10-15k allows a PI to add an educator to a project: www.nsf.gov/publications/pub_summ.jsp?WT.z_pims_id=5736&ods_key=nsf05047

10) Facilities presentations

• Computational Infrastructure for Geodynamics (CIG): Mike Gurnis summarised the NSF-supported CIG program, a partnership between Earth Sciences, Mathematics and Computational Sciences aiming to deploy the latest computer infrastructure tools and benchmark testing. The CIG Science Steering Committee produces a rolling five-year strategic plan based upon community input. CIG is in a transitional period as it works towards its own successor program that will likely focus upon developing integrated global models that include a range of physical parameters. The potential for more collaboration between CIG and SubFac-SEIZE projects was emphasised.

• EarthScope: Bob Woodward, Director of USArray, presented an overview of EarthScope activities which is now in its second five-year funding block. Around 150 researchers make use of the EarthScope facilities: SAFOD, PBO, USArray (FlexArray). A transportable array of 400 seismometers is moving across the country occupying 2000 stations with adoption by local groups of some sites as permanent stations. All Earthscope data are openly available. A May 2009 EarthScope Onshore-Offshore mini-workshop aims to address how to better design experiments that cross the shoreline. Issues over the timing of equipment availability and the proposal funding cycle were discussed.

• Drilling Program: NSF program manager Rodey Batiza updated the committee on drilling program activities. With retrofitting complete, JOIDES Resolution is drilling again. Along with Japan’s Chikyu drill ship and the Mission-Specific Platform, IODP is now fully operational. NSF aims to renew funding for the IODP drilling program beyond 2013 and new science planning aimed at addressing exciting scientific questions will be done. The status of the proposed academic-industry-government drilling consortium designed to overcome a serious funding shortfall will become known over the summer.

11) Planning for a MARGINS Successor program

The bulk of the steering committee meeting was spent in discussion of the planning schedule and possible approaches to a MARGINS successor program. For example, issues over whether to encourage a thematic-based program instead of one centred upon a focus site model were considered at length, as was the size, scope and intended outcomes of a community-wide planning meeting. The chairman thanked all members for their thoughtful involvement (see MSPW box on page 23; www.nsf-margins.org/SucessorProgram).
Status Report on the MARGINS Data Portal
November 2009

Andrew Goodwillie and the MARGINS Database Team
Lamont-Doherty Earth Observatory, Columbia University

The MARGINS database group (www.marine-geo.org/portals/margins) would like to thank the following investigators for contributing information and data since the last newsletter report for a number of MARGINS-funded field programs.

In the PNG area, ADCP and BLISP data can be downloaded for the 2003 Western Venturer Fly River field program of Chuck Nittrouer, Andrea Ogston and Miguel Goni. From that same year, basic cruise information for Dietrich and Parker’s shallow coring work on the Strickland River floodplain is also now available. For his 2004 Melville cruises studying clinoform sequence stratigraphy, Neal Driscoll contributed hull-mounted and towed CHIRP data. And, Irena Overeem donated information and scanned images for her Fly River coring work.

In the IBM focus site, updated links were added to IRIS for seismic data collected by Doug Wiens’ group with their 2003-2004 and 2006-2008 land seismometer multi-scale seismic imaging projects. Processed swath bathymetry grids from 24 JAMSTEC cruises aboard Kairei have been added to the GeoMapApp multi-resolution bathymetry DTM: a number of these lie in the IBM region.

The Central America focus site also saw updates. Toby Fischer contributed information on his 2001-2003 volcanic gas field sampling expeditions. For the Holbrook-van Avendonk-Lizarralde-Cheadle TICO-CA V A program, XCTD and XBT data files were added along with details of OBS operations and links to the land-based seismic refraction work. Links to seismic data at IRIS were also made for the CRSEIZE and Nicoya/Osa field programs (Susan Schwartz and Tim Dixon, PIs) and TUCAN project (Geoff Abers and Karen Fischer).

For the southern end of the Gulf of California focus site, the full suite of field CHIRP and sidescan data files and shot point files was provided by Graham Kent, Neal Driscoll and Paul Umhoefer. Links were also made to the IRIS repository for data collected by Jim Gaherty and John Colins from their SCOoba OBS array.

Details of the Nankai Kumano Basin 3-D multi-channel cruise undertaken on commercial seismic vessel Nordic Explorer in 2006 were received from Greg Moore and Nathan Bangs, with data sets tied to publications.

MARGINS and Ridge 2000 co-sponsored an exciting rapid response cruise to the Northern Lau/Tonga region in May 2009, with Joe Resing and Bob Embley as chief scientists. A site of a potential

MARGINS Prize for Outstanding Student Presentation

The MARGINS Office and Steering Committee are offering $500 prizes for two Outstanding Student Presentations on MARGINS-related science at the AGU Fall Meeting, December 14-18, 2009 in San Francisco. The two prizes, one for a poster presentation and one for an oral presentation, will be awarded to highlight the important role of student research in accomplishing MARGINS-related science goals, and to encourage cross-disciplinary input. Any student who is first author and is working on science themes related to the objectives of the MARGINS program is eligible to participate. Students do not have to be working on a MARGINS-funded project in order to enter the competition. Students from the international community as well as those from the U.S. are encouraged to apply.

Posters and talks will be judged throughout the AGU meeting. Students have an additional opportunity to display their posters during the MARGINS Townhall and Community Forum at 6pm, Tuesday, December 15th in the Westin Market Street Hotel Metropolitan-3 Room. The MARGINS Student Prize winners and any honorable mentions will be notified after the AGU Fall Meeting, and will be highlighted in the MARGINS newsletter and website, including notification to the host schools of their achievement.

Application deadline: Friday, November 20, 2009

Visit the MARGINS website for further information: http://www.nsf-margins.org/AGU2009/
boninite eruption, data files for this cruise are publically available: multibeam swath bathymetry, XBT, and CTD files, and raw and processed ADCP data.

Web page updates

MARGINS portal web pages (www.marine-geo.org/portals/margins/) include an updated and faster Search For Data page. In addition to providing key word searches on scientist name, data and device type, field program ID, Focus Site, date ranges and geographical bounds, users can search for data associated with specific publications and MARGINS NSF awards. A Google Maps™-based interactive map shows ship survey tracks, stations and samples from MARGINS-funded expeditions within each of the focus sites. Clicking on a track or station invokes a link to the associated data sets and field program information. Statistics on data file downloads are compiled annually and sent to the contributing scientists.

Education and Outreach

In May 2009, a workshop attended by more than two dozen members of the MARGINS community resulted in a new range of MARGINS mini-lessons for undergraduate teaching (see workshop article on page 16). Many of the 30 ready-to-use mini-lessons use MARGINS data and database resources, with GeoMapApp featuring prominently. The mini-lessons cover a wide-range of MARGINS science and are listed here: http://serc.carleton.edu/margins/collection.html An on-line webinar (http://serc.carleton.edu/margins/webinar_s09/) was run over the summer to highlight MARGINS mini-lessons and GeoMapApp. In addition, a special session (ED) at the 2009 Fall AGU meeting will focus on the MARGINS mini-lessons project and database tools along with similar education initiatives from other large programs.

MediaBank (http://media.marine-geo.org), a recently-added database resource, provides ready access in a gallery format to MARGINS-related images which include photos of IBM volcanoes from Dave Hilton, focus site maps, and images from a number of MARGINS decadal review nuggets. We welcome more contributions.

GeoMapApp and Virtual Ocean

The free map-based data exploration and visualisation tool, GeoMapApp (www.geomapapp.org), saw a major new version (2.0) released over the summer. With enhanced functionality, many new data sets and greater ease-of-use, the release was accompanied by a new GeoMapApp User Guide which incorporates a cookbook. Through an ongoing international collaboration with JAMSTEC, more grids of processed multibeam bathymetry in waters around Japan and the western Pacific have been added. Multimedia tutorials for GeoMapApp are available on the GeoMapApp web page.

Virtual Ocean (www.virtualocean.org), offers GeoMapApp capabilities in 3-D and continues to draw new users. A wide range of built-in data sets is available. Data tables can be imported and manipulated, custom maps can be generated.

The Global Multi-Resolution Topography synthesis (GMRT) which is the base map for GeoMapApp and Virtual Ocean has been updated with multibeam data at regular intervals.

We welcome new contributions of data and information from your MARGINS-funded work: please contact us at www.marine-geo.org/about/contact.php.

MARGINS at AGU
Fall Meeting 2009

This year’s Fall AGU meeting, 14-18 December 2009, in San Francisco, features a number of MARGINS-sponsored and MARGINS-related events.

• Science sessions relevant to MARGINS are listed on pages 29-31.
• Other sessions of interest are on page 31-32.
• MARGINS Townhall and Community Reception: Tuesday 15th December, 6-8pm (see information box on page 5).
• MARGINS Student Prizes for Outstanding Presentations – see box on page 27.
• MARGINS database exhibit – live demos of GeoMapApp, Virtual Ocean, and more! Visit Exhibit Hall booth 307. Free goodies!

www.nsf-margins.org/AGU2009/
www.agu.org/meetings/fm09/
Sessions relevant to MARGINS Science at AGU Fall Meeting 2009

The extensive list of sessions in AGU's Fall Meeting program can be daunting, so each year the MARGINS Office assembles a list of sessions that we think may be of special interest to the MARGINS community. Other relevant sessions were captured from the AGU website (http://www.agu.org/fm09) or listed by request of the corresponding session’s convenors.

**AGU Code Key:** Capital letters assigns session's theme. First number indicates the day of the week (1=Mondat, 2=Tuesday, etc.). Second number indicates session time (1X: 8:00; 2X: 10:20; 3X 13:40; 4X 16:00). E.g., OS23A = Ocean Sciences, Tuesday, Session 3A. Please refer to the AGU meeting program to verify session times and locations.

**Education and Human Resources**

**ED: Using Digital Information Resources and Findings from Major Research Initiatives to Transform Undergraduate Instruction**
Convenors: Jeffrey Ryan, Don Reed, Andrew Goodwillie, Cathy Manduca

The development of geo-information databases with global reach and spanning multiple disciplines, and digital visualization/interpretive tools to manipulate these large datasets has dramatically facilitated the creative repurposing of results from major geoscience research programs for use in geoscience courses and curricula at the college level, and to facilitate undergraduate research. This session seeks to highlight exemplary classroom applications of the fruits of major research efforts (ex.: the NSF-MARGINS Program, IODP, EarthScope, Ridge 2000, GEON, AMS/NOAA initiatives, NASA exploration programs, etc.) toward identifying the best educational practices for the use of these new tools. ED13D, ED24A.

**Study of Earth’s Deep Interior**

**DI: Linking Earth’s Deep Interior to the Surface Environment**
Convenors: Peter Clift, Clinton Conrad, Husson Laurent, Alison Shaw

Plate tectonics provides an interface across which Earth’s deep interior communicates with its outer shells: atmosphere, hydrosphere, sediments and crust. Earth’s interior dynamics may exert controls on the climatological, biological, cryospheric, hydrologic, and tectonic systems acting at the surface by affecting continental motions, surface deformation, and volcanism. Conversely, surface processes may affect deep interior dynamics by changing the spatial and temporal distribution of heat flow, temperature, hydrology, geochemistry, and rheology of the lithospheric interface. Likewise, volatile exchange between the mantle and its exospheric reservoirs, particularly at subduction zones, affects rates and styles of mantle flow, volcanism, and tectonics by influencing mantle composition, melting, and rheology. This interdisciplinary session explores links between the Earth’s surface and interior dynamics by incorporating observations and modeling studies looking either upwards or downwards within the whole-Earth system. Studies examining deep interior links between sea level, climate, sediments, geochemistry, petrology, tectonics, and other variables are welcome. DI32A, DI33B, DI41A.

**DI: Seismic Anisotropy and Geodynamics**
Convenors: Eduoard Kaminski, Greg Hirth, Karen Fischer

Seismic anisotropy has become a major tool to infer deformation and related convective flow in the solid Earth. A growing body of laboratory experiments, naturally deformed rock samples, seismological observations and geodynamical models are now available to solve old geodynamical problems and to allow new ones to emerge. However, these studies have also revealed the complexity in lattice preferred orientation (LPO) development and in seismic wave interactions with anisotropic media. Multidisciplinary efforts are therefore required to understand anisotropy itself, and to fully realize its potential for constraining mantle dynamics. This session will emphasize (1) cutting-edge disciplinary findings including new seismological approaches to measuring anisotropy, experiments on LPO in Earth-like conditions (e.g. volatiles, melt, stress and pressure effects), and theoretical modeling of LPO development and of anisotropic rheology; and (2) multidisciplinary studies that link geodynamics and seismic anisotropy, from the lower crust to the core. DI41B, DI51A, DI52A.

**DI: Subducting Slabs: Integrating Seismic Properties from Laboratory Data and Field Observations**
Convenors: Peter Ulmer, Luigi Burlini, Jay Bass, Carmen Sanchez-Valle

The current generation of seismic results and high-resolution images of subducting slabs suggest several characteristic features, including low velocity anomalies and high degrees of velocity anisotropy. Interpreting these features in terms of changing slab petrology at depth, associated to deformation, is a challenge that requires interdisciplinary approaches. The aim of this session is to bring together experimentalists, computational mineral physicists, petrologists, seismologists, and geochemists to present and discuss recent results and future research directions regarding the structure, mineralogy, and ultimate fate of subducted slabs, including implications for mantle dynamics and geochemical recycling in the Earth. Topics include theoretical and laboratory constrains on seismic velocities, anisotropy; deformation and rheology of subducted rocks, the role and recycling of volatiles, advances in the theory and modeling of anelasticity, as well as inverse modeling that provides constrains on the thermal structure and mineralogy of subducted slabs. DI14A, DI21A.

**Tectonophysics**

**T: The Many Faces of Slow Slip, Tremor, and Earthquakes**
Convenors: Joan Gomberg, Roland Burghmann, Paul Bodin
Great interest has recently focused on observations and implications of deformational processes that give rise to slow fault slip, tremor and earthquakes in plate boundary settings. This session posits that revealing the key processes and conditions that control the generation of these coupled phenomena requires investigating them in widely diverse environments and with a diversity of interdisciplinary approaches. In this session we will examine this diversity, with presentations of studies of the coupled phenomena of slow slip, tremor, and earthquakes not only in plate-boundary environments, but also in the laboratory, computer models, landslides, glaciers, and other natural systems. The session solicits abstracts that address these topics using a variety of approaches within specific environments or that compare and contrast the phenomena observed in different settings. T11C, T13D, T21F, T22B, T23E.

T: Earthquakes at the Edge: Observing and Understanding Transitions of Seismogenic Properties and Processes Along Subduction Zones
Convenors: Elizabeth Screaton, Saneatsu Saito, Andrew Newman, Robert Harris.

The world’s largest earthquakes occur in subduction zones; with the ultimate magnitude controlled by the updip, downdip and lateral extent of rupture. Additionally, the updip and lateral extent contribute greatly to tsunami generation. Barriers to rupture propagation may be controlled by prior seismic and aseismic slip, material behavior, subducted topography, fluid pressure, temperature and overburden that affect interface effective stress, strength, and friction. However, precise determinations of the defining parameters remain elusive. Because transitions mark critical changes in environmental parameters that result in earthquake rupture propagation or cessation, multidisciplinary studies that explore these transitions can greatly improve our understanding of earthquake and tsunami occurrence and potential. We invite contributions that address present challenges or offer new insights or synthesis studies aimed at understanding the nature and extent of seismogenic updip, downdip, and lateral transitions along the subduction interface. Studies may focus on short and/or long-term character of the seismogenic system. T11D, T12A, T13E, T14A, T21C, T23B.

T: Arc Systems, Ophiolites, and Continental Crust Formation
Convenors: Yoshiyuki Tatsumi, Terry Plank, Douglas Wiens, Shuichi Kodaira, Robert Stern, Jonathan Snow, Yasuhiko Ohara

Continental crust is unique to the Earth in our solar system, and understanding its genesis and recycling requires collaboration between geophysicists, geologists, petrologists, and geochemists. The balance of crustal growth and loss at subduction zones is not well understood, nor are the tectonic drivers that set rates. Magmas in subduction zones build continental crust from dynamic melting processes in the mantle wedge, but also may assimilate earlier arc crust, remobilize crustal protoliths, and founder back into the mantle. This session will highlight disciplinary and multi-disciplinary studies of the rates and processes of generating and recycling continental crust at subduction zones, and especially hypotheses that can be tested by ocean drilling, or MARGINS and EarthScope data. Recent studies of forearc and backarc crust suggest dramatic differences between the two. Forearcs are built on highly deplet ed mantle with high-Mg andesitic lavas, and backarcs show more affinity to MORB both in the chemical composition of the lavas and the lower degree of depletion of the mantle section. At the same time, many or most ophiolites are thought to originate in a broadly “Supra Subduction Zone” setting. Given the new observations, it ought to be possible to make the distinction between forearc and backarc ophiolite setting more precisely. This session invites contributions from those studying present-day forearc and backarc regions, as well as those studying ophiolites, to bring a multidisciplinary approach to understanding the genesis of SSZ crust in the ocean basins. T21A, T23A, T31D, T32A, T33D.

T: Gulf of California-Salton Trough Rift Margin: Recent Findings and Remaining Questions
Convenors: Scott Bennett, Daniel Brothers, Jared Kluessner

Continental rifting and formation of ocean basins is a fundamental component of plate tectonics. The Gulf of California-Salton Trough represents an active oblique-divergent plate boundary that provides a superb natural laboratory to study processes driving continental rifting and the spatial and temporal evolution of a young rifted margin. The Gulf of California-Salton Trough has been a focus site for the NSF-MARGINS ‘Rupturing Continental Lithosphere’ (RCL) initiative for nearly a decade, resulting in transformative research and discoveries from a focused community of earth scientists. Although much has been discovered about this young rift during the past decade, many fundamental questions remain in the following areas: (1) understanding early continental break-up and extension, (2) the role of magmatism and fluids, (3) 4-D distribution of lithospheric strain, (4) the interplay of sedimentation and climate and their influences on rift architecture, (5) timing of marine incursion, and (6) the nature of the continent-ocean lithospheric boundary. As Margins RCL reaches its 10th year, this session serves to highlight recent and ongoing research in the Gulf of California-Salton Trough, and to summarize remaining questions regarding processes that rupture continental lithosphere. We invite all abstracts pertaining to the physical development of this rift system. T31A, T33E.

T: Tectonic, Sedimentary, Magmatic, and Thermal Evolution of Lithospheric Extension Leading to Continental Breakup and Seafloor Spreading
Convenors: E. Burov, Cynthia Ebinger, Sylvie Leroy, Paul Umhoefer, Gianreto Manatschal, Cecile Robin, Erin Beutel, Jolante van Wijk

The mechanisms controlling lithospheric thinning and rupture leading to seafloor spreading are at present not well understood. Particularly controversial is how the crust can thin to less than 10 km without showing apparent brittle faulting, how extreme crustal thinning and breakup are documented in the stratigraphic record, the role and timing of emplacement of magma and the related thermal structure during and after continental breakup. During the last 20 years a variety of models have been proposed to describe the processes...
of continental extension and rifted-margin formation, however, the observational evidence to support any of the models remains equivocal and there is no consensus on the generality of these models. Therefore it is essential to compare model predictions with observations from extensional basins and rifted margins which can provide critical information on the thermal structure and composition of the crust and lithospheric mantle, timing and spatial distribution of magmatism, and the stratigraphic and subsidence history during and after rifting. This session will be a forum for discussion of mechanisms associated with lithospheric extension, ranging from little extended intracontinental rift basins to mature rifted margins where break-up occurred. In particular, we encourage the presentation of observational data and numerical models that give insights into the spatial and temporal evolution of the processes leading to continental breakup.

T: Seismotectonics of the Arabian Plate and its Boundaries
Convenors: Francisco Gomez, Robert Reilinger, Eric Sandvol
Over the past 10 – 15 years, our understanding of Arabian Plate tectonics has yielded new insight into fundamental processes of continental collision, rifting, and transform faulting, as well as a valuable opportunity to evaluate the role of driving/resisting forces involved in plate motion. This session aims to bring together, as oral and poster presentations, results of recent neotectonic, seismological, geophysical, and geodetic studies of the Arabian plate and the tectonic development of its adjacent plate boundaries, including the Bitlis-Zagros collisional belt, the Red Sea / Gulf of Aden continental rifting and mid-ocean ridge spreading, and the Dead Sea transform system. Our goal is to assemble a comprehensive view of the state-of-knowledge of the tectonic and geodynamic framework of the Arabian plate and surrounding regions. T51C, T53G, T54C.

Volcanology, Geochemistry and Petrology

V: Geochemically Complex, Multicomponent Fluids and Geologic Processes
Convenors: Jim Webster, Craig Manning.
Volatile components in hydrothermal fluids exert fundamental controls on processes of metamorphism, magmatism, alteration and mineralization, and volcanic eruption. Natural hydrothermal fluids contain complex mixtures of the volatile components H2O, CO2, CH4, H2S/SO2, Cl, F, ± B. Our understanding of complex multicomponent fluids is currently limited, however, because experimental research typically involves only two, or more rarely, three of these volatile components. Furthermore, the limited nature of the experimental database has constrained the development of geologically accurate thermodynamic models that demonstrate how such fluids control processes of metamorphism, magmatism, alteration and mineralization, and volcanic eruption. We invite contributions from all avenues of study on geochemically complex fluids: thermodynamic, experimental, fluid/melt-inclusion, and hydrous-mineral geochemical studies. In particular, we encourage submission of contributions that focus on the interactions and interface between metamorphic/hydrothermal fluids and magmatic fluids.

U: The EarthScope Initiative: From North America Geodynamics to New Frontiers in Science
Convenors: Kristine Larson, Michael Hedlin, Christine Puskas, Lucy Flesch
U51D, U52A, U53A, U53B.

EP: Dynamics and Processes of Deltas, Fans, and their Distributary Channels
Convenors: Doug Edmonds, Doug Jerolmack, Ben Sheets, David Mohrig
EP41A, EP43F

G: Volcano Geodesy: Monitoring and Modeling
Convenors: Tim Masterlark, Andrew Newman, Maurizio Battaglia, Mike Lisowski
G41A, G43C, G44A

G: The Earthquake Cycle in the Middle East
Convenors: Sigurjon Jonsson, Andrea Wальpersdorf
G33D

MR: Rock Deformation from Grain Boundaries to Plate Boundaries
Convenors: Phil Skeme, Daniel King
MR24A, MR41A, MR44A

NH: Drilling and Monitoring for Earthquake Disaster Mitigation
Convenors: Reiji Kobayashi, Casey Moore, Yuzuru Yamamoto
NH31A, NH34A

PP: Changing Terrestrial Fluxes to the Oceans: Investigating Controls on Weathering and Sediment Fluxes Through Time Using Geochemical Proxies
Convenors: Julie Pett-Ridge, Chris Siebert, Kevin Burton
PP21C, PP23A

DI: Structure and Dynamics of the Earth’s Upper Mantle and Transition Zone: The Role of Water
This is a continued list of the funded MARGINS Proposals for the fiscal year 2009. Because of the late budget resolution, NSF spending for FY09 was not finalized for the printing of the Spring Newsletter. If additional awards are announced, they will be listed in the next Newsletter and added to the MARGINS Awards web page.

MARGINS-NSF Awards 2009

**NSF Awards 0841079 and 0841075**

**Collaborative Research: Advanced models of magma migration at convergent MARGINS**

Marc Spiegelman\(^1\), Peter van Keken\(^2\)

\(^1\)Columbia University; \(^2\)University of Michigan Ann Arbor

The work proposed is to develop quantitative tools to model fluid flow and magmatism at subduction zones. The focus of the work will be on the top of the downgoing slab where fluids are released by metamorphic dehydration reactions, and the mantle wedge where fluids interact with high temperature solids to form magma. The work will start with 2-D models and extend to more challenging 3-D models.

**NSF Awards 0840981, 0840794, 0840574, and 0840448**

**Collaborative Research: Synthesis and Integration of Magmagenetic Controls for Subduction Factory Focus Sites**

Robert Stern\(^1\), James Gill\(^2\), Mark Feiengenson\(^3\), Michael Carr\(^2\), Peter van Keken\(^4\)

\(^1\)University of Texas at Dallas; \(^2\)University of California-Santa Cruz; \(^3\)Rutgers University New Brunswick; \(^4\)University of Michigan Ann Arbor

This is a 3-year collaborative project (between 5 US and 2 Japanese scientists) to use the Earthchem database to assemble high-quality geochemical and isotopic data for fresh, young igneous rocks from Izu-Bonin-Mariana and Central America arcs into a Subduction Factory Geochemical Reference Library. These data will then be used to generate forward models (using the Arc Basalt Simulator, or ABS; Kimura et al. 2009). ABS is an Excel spreadsheet-based program that is designed to be flexible and accessible. Models will be site-specific, using appropriate plate age and convergence rates to generate thermal structure models appropriate for each subduction zones. Best estimates for the compositions of subducted sediments and oceanic crust at each focus site will be used in tandem with thermodynamic models of prograde metamorphism to model mineral reactions and fluid/melt generation within the subduction zone. We will train users of the Library and ABS at two free workshops at national scientific meetings. We will also develop lesson plans that explore controls on subduction zone magma genesis using ABS and the Subduction Factory Geochemical Reference Library.


**NSF Award 0840862**

**Mariana Forearc Geology and Early Arc Volcanism**

Mark Reagan\(^1\), William McClelland\(^1\), David Peate\(^1\)

\(^1\)University of Iowa

We are exploring the origin of early subduction-related volcanic rocks from the Izu-Bonin-Mariana (IBM) fore-arc. The goal of the project is to develop a comprehensive understanding of the evolution of the southern portion of this arc during its infancy. Most of the samples analyzed for this study were collected during diving with the Japanese submersible Shinkai 6500 in 2006 and 2008 southeast of Guam. Other samples were collected from the fore-arc islands. We are presently analyzing whole rocks and pillow glasses for major element, trace element, volatile element, and Sr-Nd-Pb-Hf isotope compositions. Major, trace, and volatile element concentrations of olivine-hosted glass inclusions in olivine also are being determined. Eruption ages are being constrained by \(^{40}\)Ar/\(^{39}\)Ar and...
U-Pb geochronology. Preliminary findings are that the oldest lavas in this system resemble mid-ocean ridge basalts, but have minor geochemical differences suggesting that they are subduction-related. These forearc basalts (FAB) are overlain in turn by low- to high-Ca boninite, and normal arc lavas. Thus, we postulate that the FAB were the first volcanic rocks to erupt after subduction began. Their genesis largely involved decompression melting of upwelling mantle as it ascended to fill space left by the catastrophic initial sinking of the slab. Continued melting of this now-shallow mantle residue in the presence of a robust flux of water-rich slab-derived fluid resulted in the genesis of the boninites. Normal arc volcanism began after the changeover from infant-arc mantle upwelling to normal mantle counterflow.

**NSF Award 0840983**

**Central American Magmatic Volatile Histories as Recorded by Apatite Phenoocrysts**

Jeremy Boyce¹, Craig Manning¹

¹University of California-Los Angeles

Apatite is a valuable recorder of magmatic processes affecting major, trace, and volatile elements because it offers temporal information via core-to-rim relationships, diffusion profiling, and isotope geochronology. It is proposed to extend the work of Boyce and Hervig (2009) by collecting and characterizing apatite-bearing volcanic rocks from four volcanoes in CAVA. A series of piston-cylinder experiments will be conducted to equilibrate volatile solubility in apatite and representative melts and to develop an empirical functional relationship describing the relation between apatite and melt compositions. Measurements of H, C, F, S, and Cl in apatite will be made by secondary ion mass spectrometry (SIMS) with a spatial resolution at the micron-scale.

**NSF Awards 0841092, 0841049, and 0840887**

**Collaborative Research: Formation, Reworking and Accumulation of Sedimentary Deposits, Waipaoa River Shelf, New Zealand**

John Walsh¹, David Corbett¹, Courtney. Harris², Andrea Ogston³

¹East Carolina University; ²College of William & Mary Virginia Institute of Marine Science; ³University of Washington

Funds are provided to the PIs to collect data on the Waipaoa continental shelf to build on results of prior work in the area. The objective of the study is to use bottom tripods to record data relevant to sediment processes along an apparent transport route, and to collect cores and, at some sites, measure critical shear-stress. The study will consider locations where cores were collected during a prior study, and one major focus of the study is the comparison of cores collected in different years to determine if additional layers have been deposited. Radiochemical studies will also be undertaken at these sites to help quantify the deposition of sediments. The bottom tripods will be placed along a line on the shelf, near the shelf break and on the upper rise in areas that appear to be transport pathways or sites of deposition. The tripods would be deployed for a year. The third component of the study is the creation and use of a model with the objective hindcast sedimentation events in the area.

The study includes student involvement and training and will lead to an understanding of the relationship of shelfal processes to resultant stratigraphic architecture which is an important challenge in stratigraphy and has the potential to aid exploration for resources in the future.

**NSF Award 0841111**

**Sediment production via landsliding in the Waipaoa: Temporal and spatial variability using InSAR, LiDAR, air photos, and Be-10**

Joshua Roering¹, David Schmidt¹

¹University of Oregon Eugene

Funds are provided to quantify spatial and temporal variations in landslide sediment production in the Waipaoa River Basin, New Zealand using a variety of remote sensing techniques (InSAR, airborne LiDAR, historic air photos) in combination with cosmogenic radionuclides (¹⁰Be). The Waipaoa Basin is one of the MARGINS Source-to-Sink study sites, and this work will contribute to an overall understanding of sediment generation and mobilization in landslide-prone areas. The PIs will: 1) estimate the spatial distribution of slope failure on seasonal timescales since the early ‘90’s, 2) track downslope movement of natural and anthropogenic features and generate maps, 3) document case studies of landslide-prone hillslopes and their coupling to channel networks, and 4) study the difference in landslide activity upstream and downstream of knickpoints, and the relation to long-term climate evolution and land use change.

**NSF Awards 0841114 and 0840894**

**Collaborative Research: SERPENT: Serpentinite, Extension and Regional Porosity Experiment across the Nicaragua Trench**

Steven Constable¹, Kerry Key¹, Rob Evans²

¹University of California-San Diego Scripps Inst of Oceanography; ²Woods Hole Oceanographic Institution

The thin, rocky shell of the Earth, the lithosphere, is broken into a mosaic of thin plates that are inconstant motion. Along some boundaries between plates, one slides beneath the other and is consumed in a process known as subduction. Most of great earthquakes and violent volcanic eruptions occur at subduction zones. Both
of these processes are significantly affected by the amount of water that is carried into the interior with the downgoing plate, but these processes remain poorly understood because the amount of water entering the subduction system remains poorly constrained. A major carrier of water is the mineral serpentine, and one of the major uncertainties is the volume of water that is being carried into the subduction system by serpentinized upper mantle. Electromagnetic geophysical methods are sensitive to the presence and concentration of water at depth in the Earth. This project consists of a large-scale electromagnetic experiment along a 300 km profile off Nicaragua in a region that shows evidence for substantial fault related fluid circulation in the crust and possibly in the upper mantle, and high Ba/La ratios and water contents in adjacent onshore volcanics suggesting a strong slab fluid input into the arc-melting. This survey will combine controlled-source electromagnetics (CSEM) with broadband and long period magnetotellurics (MT) to provide a comprehensive picture of the conductivity structure from the seafloor to the upper mantle, representing the entire input into this part of the Central American subduction zone. In addition to the societal relevance of improving our understanding of processes that produce earthquakes and volcanic eruptions, this project will promote international scientific cooperation and support two Ph.D. students.

NSF Awards 0842137 and 0842338

Collaborative Research: Acquisition of GPS and seismic equipment for Phase 2 of a Plate Boundary Observatory, Nicoya Peninsula, Costa Rica

Timothy Dixon¹, Susan Schwartz²

¹University of Miami; ²University of California, Santa Cruz

Episodic tremor and/or slow slip events are now well described in the subduction zones of Cascadia, Japan, and Mexico, and are providing insights into the frictional properties of the plate interface in these seismogenic zones. Both Cascadia and Japan are well instrumented with seismometers and high precision GPS systems; Cascadia observations have been greatly augmented by NSF’s Plate Boundary Observatory (PBO). Episodic tremor and slow slip likely occurs in most subduction zones, but lack of network instrumentation makes rigorous comparison difficult. The northern Costa Rica plate boundary zone provides an ideal locale for such a network. Convergence rates are up to a factor of two higher compared to the other well studied regions, and the Nicoya Peninsula extends close to the trench, allowing optimum location of instruments. With initial funding from NSF beginning in 2005, we installed a sparse network of GPS and seismic instrumentation to study slow slip events and seismic tremor in this region. One episode of slow slip and tremor was observed in May–2007 when the network was partially complete. In this new project, we will augment and upgrade the existing network to PBO standards, operate it for three years, and analyze and interpret any new events that are recorded. Preliminary results suggest slow slip events in both 2008 and 2009, with seismic tremor recorded during the 2008 event.

NSF Award 0927446

Marine Seismic Reflection and Refraction Study of the Salton Trough

Neal Driscoll¹, Alistair Harding¹, Graham Kent¹

¹University of California-San Diego Scripps Inst of Oceanography

The U.S. west coast is subject to significant risk of very large earthquakes, and heavily populated Southern California is particularly vulnerable owing to its proximity to the San Andreas Fault. The linkage of this fault system through the Salton Sea region is poorly understood, in part because the structure beneath the Salton Sea has not been defined. The project, conducted in conjunction with a deployment of on-land seismic stations, will address that problem by deploying an array of ocean bottom seismometers (OBS) on the floor of the Salton Sea, and conducting a complementary multi channel seismic survey aimed at imaging the structure beneath the Salton Trough. Improved understanding of the Earthquake hazard in this region has direct societal benefit. The project will also contribute to science education in California, and support the Ph.D. research of a young female graduate student at UCLA.

MARGINS Bibliography

The MARGINS Office has compiled a list of publications related to MARGINS science. Currently more than 250 MARGINS-funded publications are included, as well as over 200 related articles.

Visit www.nsf-margins.org/Bibliography/

- Download the versatile MARGINS EndNote™ library. Search or sort by Initiative, Focus Site, award number, and more
- View publications lists for the RCL, S2S, SEIZE and SubFac initiatives
- Search for MARGINS special volumes and books

Wait - my paper is not listed! What should I do? Contact the MARGINS Office (margins@nsf-margins.org) and we’ll update the list.
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MARGINS Steering Committee

Geoffrey Abers*, Chair
Lamont-Doherty Earth Observatory of Columbia University
P.O. Box 1000
Palisades, NY 10964
Tel: (845) 365-8711, Fax: (845) 365-8150, E-mail: margins@nsf-margins.org, Website: www.nsf-margins.org

Ramon Arrowsmith
School of Earth and Space Exploration
Arizona State University
PO Box 871404
Tempe, AZ 85287-1404
Tel: (480) 965-5081
ramon.arrowsmith@asu.edu

Nathan Bangs
Institute for Geophysics
University of Texas at Austin
4412 Spicewood Springs Rd, Bldg. 600
Austin, TX 78759-8500
Tel: (512) 471-0424
nathan@utig.ig.utexas.edu

Mark Behn
Woods Hole Oceanographic Institution
Mailstop 22
Clark 260B
Woods Hole, MA 02543
Tel: (508) 289-3637
mbehn@whoi.edu

Susan Bilek
Dept of Earth & Environmental Science
MSEC 354
New Mexico Tech
Socorro, NM 87801
Tel: (575) 835-6510
sbilek@nmt.edu

Cynthia Ebinger
Department of Earth and Environmental Sciences
University of Rochester
227 Hutchinson Hall
Rochester, NY 14627
Tel: (585) 276-3364
ebinger@earth.rochester.edu

James Gill
Earth Sciences Department
University of California-Santa Cruz
1156 High Street, 137 Applied Sciences
Santa Cruz, CA 95064
Tel: (831)-459-3842
jgill@es.ucsc.edu

Mike Gurnis
Division of Geological and Planetary Sciences
California Institute of Technology
351 South Mudd Laboratory, MS 252-21
Pasadena, California 91125
Tel: (626)-395-6979
gurnis@gps.caltech.edu

Rosemary Hickey-Vargas*
Department of Earth Sciences
Florida International University
University Park 11200 SW Park Street, PC 315B
Miami, FL 33199
Tel: (305) 348-3471
hickey@fiu.edu

W. Steven Holbrook
Department of Geology and Geophysics
University of Wyoming
Earth Sciences Building 3016
Laramie, WY 82071-3006
Tel: (307) 766-2724
steveh@uwyo.edu

Steve Kuehl
Virginia Institute of Marine Science
College of William and Mary
Holben House Room 201
Gloucester Point, VA 23062
Tel: (804) 684-7118
kuehl@vims.edu

Demian Saffer
Department of Geosciences
Pennsylvania State University
310 Deike Building
University Park, PA 16802
Tel: (814) 865-7965
dsaffer@geosc.psu.edu

Education Advisory Committee

Members above marked * plus:

Cathy Manduca, Carleton College
cmanduca@carleton.edu

Don Reed, San Jose State University
dreed@geosun.sjsu.edu

Andy Goodliffe, University of Alabama
amg@ua.edu

Jeff Ryan, University of South Florida
ryan@chuma.cas.usf.edu

Ex-Officio:

Andrew Goodwillie
Lamont-Doherty Earth Observatory
andrewg@ldeo.columbia.edu

This information is also posted on the MARGINS website, where it is continuously updated.

MARGINS Office
Lamont-Doherty Earth Observatory, P.O. Box 1000, 61 Route 9W, Palisades, NY 10964
Tel: (845) 365-8711, Fax: (845) 365-8150, E-mail: margins@nsf-margins.org, Website: www.nsf-margins.org

Chair: Geoff Abers (abers@ldeo.columbia.edu), Coordinator: Niva Ranjeet (ranjeet@ldeo.columbia.edu) Senior Science & Education Coordinator: Andrew Goodwillie (andrewg@ldeo.columbia.edu) & Administrator: Karen Benedetto (karenb@ldeo.columbia.edu)

NSF Program Directors
National Science Foundation, 4201 Wilson Boulevard, Arlington, Virginia 22230

Bilal Haq
Marine Geology and Geophysics Program
Division of Ocean Sciences
Tel: (703) 292-8582
Fax: (703) 292-9085
bhaq@nsf.gov

Deborah Smith
Ocean Drilling Program
Division of Ocean Sciences
Tel: (703) 292-7484
Fax: (703) 292-9085
dksmith@nsf.gov

William Leeman
Petrology and Geochemistry Program
Division of Earth Sciences
Tel: (703) 292-7411
Fax: (703) 292-9025
wleeman@nsf.gov
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