GeoPRISMS
Draft Science Plan
1. Executive Summary

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The decade of MARGINS research unquestionably fostered major discovery in solid Earth sciences. The program succeeded because it recognized that progress on many outstanding questions required coordinated, multidisciplinary efforts spanning the shoreline across active continental margins, and integrating those with experimental and theoretical work. In so doing, the program built a large, interdisciplinary community well situated to carry out transformative shoreline-crossing studies in the future. The last decade also saw increased scientific excitement from several remarkable, unexpected observations of the behavior of active plate boundaries, and tremendous investment into the infrastructure needed to carry out their investigation. Overall, MARGINS was a success exceeding expectations, paving the way for new discoveries through a successor program as recommended by the 2009 Decadal Review Committee (DRC). This document introduces a draft plan for such a successor program, here termed GeoPRISMS (Geodynamic Processes at RIfting and Subducting MarginS). It outlines the scientific challenges that such a program will address, the program structure, and the approaches it will use to implement it. It follows the community consensus reached at the MARGINS Successor Planning Workshop (MSPW) in February, 2010.

GeoPRISMS will expand the dimensions of the original program in several fundamental ways, following DRC and MSPW guidance: (1) integration of scientific emphases, defining two Initiatives (SCD and RIE) rather than the four within MARGINS, (2) further integration through emphasis on overarching scientific themes that cross-cut tectonic categories, (3) explicit inclusion of surface processes and their feedbacks in the evolution of continental margins, (4) consideration of ancient and exhumed margins, (5) implementing science objectives through a hybrid of focus-site and thematic-based investigations, (6) increased attention to US margins and facilities such as EarthScope and the Cascadia Amphibious Array, (7) expanded emphasis on issues with direct societal impact, and (8) a vertically-integrated education and outreach program supporting development from K-12 to early career scientists. It will continue to emphasize multidisciplinary research and studies that cross the shoreline, recognizing that the shoreline is where much of continental evolution takes place, and is also where the dynamics of the solid Earth have the largest impact on human populations. MARGINS built this interdisciplinary, collaborative community, accounting for the scientific breakthroughs it has achieved; GeoPRISMS will sustain it.

The GeoPRISMS Science Program includes two broadly integrated initiatives, distinguished by tectonic setting:

- *Subduction Cycles and Deformation (SCD)* takes a holistic approach to the deformation processes and material cycles governed by subduction. It integrates and expands the former SEIZE and SubFac Initiatives, building on a growing recognition that the two systems are tightly linked and responding to many of the same forcing functions, although manifest in different ways. The SCD Initiative will focus on the coupled processes responsible for both long-term margin evolution and material transfer and short-term plate boundary deformation and volcanism. In particular, it studies the properties, mechanisms, and manifestations of strain build-up and release along the plate boundary, the transport and release of volatiles such as H_2O and CO_2 through the thrust zone and sub-arc mantle, and the ways in which these processes affect the long-term growth and evolution of continents. In so doing, SCD will provide fundamental scientific understanding of the processes that generate some of the largest natural hazards on the planet, including great earthquakes, tsunamis, and explosive volcanic eruptions.
- *Rift Initiation and Evolution (RIE)* provides a new and broad perspective on the processes by which continents break apart. It expands the former RCL Initiative to include the full

spectrum of stages of continental breakup, with increased emphasis on the interplay between surface processes, sedimentation, and continental evolution. It will include early-stage rifts but also the study of passive margins, which archive the entire history of rift zone construction and evolution. This approach provides direct relevance to understanding both mineral and petroleum resources. The RIE Initiative will seek to determine the parameters and physical properties that control the process of continental evolution, with particular emphasis on the initiation of continental rift zones, feedbacks between tectonics, magmatism, and surficial processes, and the resulting stratigraphic and tectonic architecture of rifted margins.

Both initiatives highlight the interconnectedness among surficial, shallow crustal, and deep Earth processes and their roles in plate boundary deformation, mantle rheology, magmatic processes, and volatile fluxes. Both will engage interdisciplinary teams carrying out observational, experimental, and modeling studies to address their fundamental questions. These investigations have practical applications for sustainability in the face of climate change and sea level variation, resource management and availability, and hazard mitigation. Furthermore, the proposed studies provide unique opportunities to build an appropriately educated workforce, the next generation of GeoPRISMS scientists, and will yield new knowledge about processes that fascinate the public.

Implementation of GeoPRISMS will follow a "hybrid" approach, in which focus-site studies will be complemented by thematic investigations. While major field efforts will occur in designated focus sites, as in MARGINS, studies that address programmatic themes but cannot be done in those sites will be supported elsewhere. Examples could include study of a process or system where best expressed, global comparisons to establish the significance of focused observations, or studies that sample different stages of a temporally evolving process. The sites themselves will be chosen at community workshops held in the program's first year. Finally, a suite of five Overarching Themes will serve as the basis for integrative studies and provide a framework for cross-initiative programs: (a) Origin and Evolution of Continental Crust; (b) Fluids, Magmas and Their Interactions; (c) Climate-Surface-Tectonic Feedbacks; (d) Geochemical Cycles; and (e) Plate Boundary Deformation and Geodynamics.

A broad array of tools and resources are now available to carry out GeoPRISMS scientific objectives, following a decade of infrastructure investment by NSF and other agencies. Observational facilities include new geophysical and geodetic facilities such as IODP, IRIS, UNAVCO, OBSIP, the *R/V Marcus Langseth*, and EarthScope. Computational infrastructure and software archives provided by CIG and CSDMS expand the numerical modeling potential within the new program. Strong international collaborations established during MARGINS will also transfer into the new program, as will new partnerships with domestic and foreign agencies.

The new directions outlined in this Science Plan will expand the broader impact of the program in several distinct ways. The explicit inclusion of sediment transport and deposition processes along both subducting and rifting margins will increase understanding of geologic hazards such as landslides and shoreline change, and provide natural links to the oil and gas industry. Continued emphasis on seismogenesis and a new focus on volcanic systems provides a springboard for study of hazards associated with megathrust earthquakes and volcanic eruptions, and potential linkages to mining and minerals. Furthermore, an emphasis on volatile exchanges, from weathering to the deep interior, will provide insight into the long-term evolution of the atmosphere and hydrosphere.

In concert with a new scientific agenda, a new and integrated educational program is envisioned, closely aligned with research priorities. The program is guided by the notion that GeoPRISMS science can impact education at all levels and in a diverse range of communities, starting with new partnership-

based outreach to K-12, continued development of the highly successful Undergraduate Mini-Lesson program, an extension of the Distinguished Lecture Program to bring top-level lecturers to a wide range of colleges, a new dedicated REU program to foster undergraduate research, a new series of short courses aimed at graduate students, and continuation of a Post-doctoral Fellowship program. Facilitated by an Education and Outreach director within the GeoPRISMS Office, this spectrum of activities will allow research results to rapidly enter the classroom, and will provide enhanced mechanisms for training the next generation of scientists. It is expected that some of these activities will be funded through proposals outside of the regular science panel.

In the near term, GeoPRISMS should pursue several important opportunities, without waiting for site selection workshops. These include but are not limited to (a) theoretical, experimental, or global comparisons that address GeoPRISMS science objectives without requiring major field efforts; (b) field efforts needed to complete work in existing MARGINS Focus Sites that address GeoPRISMS priorities; (c) integrated investigations that parallel the deployment of geophysical infrastructure taking place now, particularly those complementing the OCE/EAR MARGINS-EarthScope Cascadia Amphibious Array, and other amphibious surveys coordinated with EarthScope's Transportable Array as it makes its way across the continental US. Collaborative research efforts could begin along the US Gulf Coast, East Coast, Alaska and Cascadia, all of which have direct ties to GeoPRISMS science objectives.

In summary, the potential for new discovery within GeoPRISMS is even greater than that envisioned in the successful MARGINS science plan, and many new resources can be brought to bear that were not available a decade ago. By planning the entire program at once, a thoroughly integrated science agenda has been devised, centered on many of the major overarching themes that are central to modern inquiry in the solid Earth sciences. They also provide many opportunities for impacts through increasing our understanding of geohazards of primary economic resources, and by providing novel educational opportunities. By capitalizing on the new opportunities summarized here, and by harnessing the public's excitement in understanding US continental margins and their potential, GeoPRISMS will lead us toward transformative discoveries in the nature and evolution of continental margins worldwide.