GeoPRISMS
Draft Science Plan

10. Other Impacts of the GeoPRISMS Program

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10.1. Interdisciplinary Science and Community Building

One of the extraordinary accomplishments of the MARGINS Program was the development of a large, interdisciplinary community over a decade's time. A major vehicle for this achievement was sponsorship of workshops. The GeoPRISMS Program will continue in this role, building on the successful model of MARGINS. Four workshop classes will be sustained:

- *Initiative Planning Workshops*, which will take place in the first year of GeoPRISMS to clarify the scientific objectives of the new initiatives, define the specific themes and primary sites for initiative studies, to direct the science, and to complete the detailed GeoPRISMS Science Plan.
- *Theoretical and Experimental Institutes (TEIs)*, which provide broad education across the disciplines, and are designed to cross-educate diverse groups of scientists about controversies, approaches, techniques, and problems in a spectrum of disciplines relevant to the problem at hand. TEIs lead to new collaborations and multidisciplinary proposals, entrain new scientists from outside of the GeoPRISMS community, and train a generation of young scientists to approach problems in an interdisciplinary manner.
- *Thematic Workshops*, which will address specific problems of interest to a number of GeoPRISMS investigators, guided by the Overarching Themes detailed in Section 3.
- *Primary Site Workshops*, which will be used to delineate new research objectives and outline approaches at Initiative Primary Sites, and subsequently, to exchange knowledge, guide new ventures, and synthesize the work done at these sites.

Workshop participation will be open to the broader U.S. community (not just GeoPRISMS PIs), including researchers within national agencies, as well as members of the international community with continuing interests in GeoPRISMS activities. This will ensure that GeoPRISMS continues to build the strong national and international partnerships necessary to carry out global science, thereby broadening the pool of ideas within the community, and leveraging resources and knowledge to strengthen it. Workshops outcomes will include new research collaborations to carry out the science objectives, along with special volumes of research papers and special sessions at scientific meetings, to disseminate results. In addition, the GeoPRISMS Steering & Oversight Committee will be proactive in organizing large special sessions at major national meetings (AGU, etc.), following a very successful MARGINS practice, to enhance rapid communication of new discoveries.

10.2. Understanding Geohazards

Much of the world's population lives along coastlines, and many of the natural hazards that affect society occur at this critical interface between the oceans and continents (Figure 10.1). Recent events, such as great earthquakes, tsunamis, explosive volcanism, marine and terrestrial mass wasting events, great storms such as Hurricane Katrina, and floods and sediment-transport that accompany them, all demonstrate the importance of understanding the solid Earth at continental margins. What GeoPRISMS can contribute are the fundamental scientific underpinnings of any educated approach to these and other critical societal concerns. GeoPRISMS is poised to make major contributions to our scientific understanding of such hazardous phenomena, their causes, and their consequences. Highlighting these connections will be a significant new program element, as recommended by the DRC.

Seismogenic zone studies within the SCD Initiative, focused on the properties and processes that govern the planet's largest earthquakes, define an obvious connection, highlighted by the devastating 2004 Sumatra earthquake and tsunami and the more

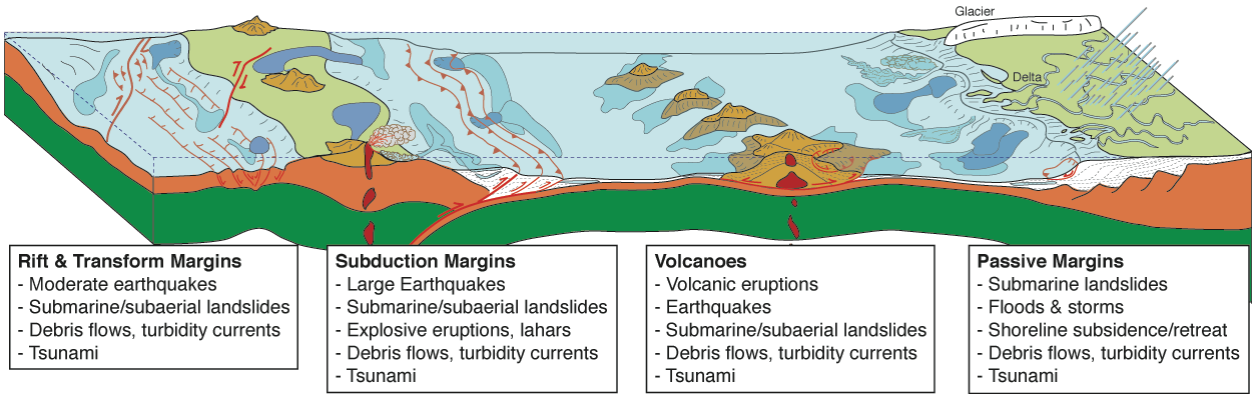

Figure 10.1: Representative geohazards that can originate along continental and volcanic margins. (Figure modified from Morgan et al. [2009]).

recent 2010 Haiti and Chile earthquakes. Seismic surveys carried out over continental margins subject to earthquakes, direct sampling and instrumentation of active fault zones, and both onshore and offshore paleoseismology can provide critical observations. Further research should also allow better evaluation of proposed triggering of large earthquakes by slow slip events. Such data could eventually assist operational agencies worldwide in improving earthquake hazard assessment.

GeoPRISMS investigations will also provide new insights into arc volcanism, in a setting that includes most of the planet's most deadly explosive volcanoes. These events are devastating locally and can have regional or even global impacts on the earth's atmosphere, affecting phenomena from short-term climate to global air travel (e.g., Iceland, April 2010). GeoPRISMS studies will provide valuable data to define the eruptive histories of volcanoes, and constrain the geochemical evolution that might influence eruptive behavior. Ash layers that accumulate in ocean trenches are often the key to dating turbidite records used to reconstruct subduction zone earthquake histories, as well as explosive eruptions. New information and interpretations generated by GeoPRISMS can be expected to assist the U.S. Geological Survey in its responsibility to advise the public of earthquake and volcanic hazards, through integrative and focused studies of both seismogenic faults and active magmatic systems.

The GeoPRISMS program addresses geohazards at rift margins. Studies of active coastal and slope processes provide emphasis on the erosion, transport, and transfer of sediments across the shoreline, and their storage in the marine setting (Section 5). These studies will take into account the role of both long-term and short-term sediment transfer and depositional processes that contribute to the architecture along passive margins controlled by coastal subsidence and climate-induced changes. Slope instability and consequent landsliding on all types of margins can be initiated by floods, storms, earthquakes, and eruptions, and GeoPRISMS provides the means to study the mechanisms of mobilization and transport, and potentially, precursory phenomena indicative of failure. Beyond sedimentary processes, measurements of deformation and fault activity will clarify earthquake hazards that affect populations living along active rifting margins.

In both Initiatives, the systems approach of GeoPRISMS provides vital constraints on the complex interplay and feedbacks between tectonics, sediment generation and transport, and global climate change. For example, compressional and extensional tectonics can lead to broad plateau uplift that deflects continental scale drainage networks, and that serves as a topographic barrier to atmospheric circulation, with feedbacks to the ocean circulation pattern. Continental rupture culminates in the formation of new ocean basins that fundamentally

change ocean circulation, with clear atmospheric feedbacks and climate change. Because of their mix of organic rich muds, narrow oceans, and moderate to rapid sediment rates, rifts in their early stages are the ideal setting for formation of large gas hydrates which later may be destabilized. In addition, thermal uplift may disrupt the connection between seaways, thereby further altering ocean circulation and climate (Section 5). Over time scales of years, some of the most profound effects on the climate come from explosive volcanic eruptions that eject aerosols high into the atmospheres. While most of these effects diminish after a few years, the largest historic eruptions have had profound consequences for humanity. New gas and volatile measurements from arc volcanoes are helping to quantify these processes better, and better understand such effects.

10.3. Economic Resources

The impacts of an improved understanding of continental margins upon our economic resources cannot be understated. An extraordinary fraction of the world's population lives along continental margins and depends on the resources of these margins, including water and food. They are directly affected by both onshore and offshore habitat loss, due to changing coastal conditions and riverine influx, and the hazards described above. At the same time, these margins are undergoing major changes in real time (e.g., Section 5.2-5.4). The GeoPRISMS program can make substantial contributions to understanding the processes that affect these settings and how their change through time will impact economic resources of many types.

A quantitative, process-based, understanding of margin evolution is also proving fundamental to discovery and exploitation of energy and minerals. The petroleum industry has now moved into frontier settings such as deepwater basins, forearc basins, poorly explored deeply buried parts of mature basins, and unconventional resources such as gas hydrates and shale-gas environments. In the deepwater environment, a single exploration well can cost $200,000,000 and a production facility can cost an order of magnitude more. Any increase in our understanding of margin processes that can incrementally impact risk in this environment can have enormous impact. Successful and cost-effective exploration strategies in these frontier areas are enhanced through understanding of the tectonic, stratigraphic, and fluid flow processes operating during formation and evolution of margin basins.

Submarine active margins are also sites where large precious and base metal deposits formed in the past, and are even forming today. Active submarine hydrothermal venting has been discovered throughout western Pacific arcs, in part through MARGINS. Almost half of current global mineral exploration is for gold and the largest new deposits are in subduction environments, such as the caldera of Lihir volcano and at 1500 mbsl in the northeast Manus Basin, both in Papua New Guinea. The metals in these deposits are mostly derived from subduction zone magmas and volcanic rocks, and are transported in saline fluids similar to those responsible for metasomatizing arc magma sources and for the explosive eruption of arc volcanoes. Consequently, understanding the origin and setting of the metal deposits is directly related to the origin and evolution of mantle, crust, and fluids in subduction zones at many scales, goals that figure prominently in GeoPRISMS.

For these reasons, the new program will feature strong links to energy and resource issues, as recommended by the DRC. While direct linkages depend upon the ultimate form that agreements and partnerships take (see Section 8.3), increased emphasis on relevance will be a high priority.

10.4. Data Management in GeoPRISMS

The first decade of MARGINS has involved marine and terrestrial field programs across a wide range of scales, from small-scale fieldwork by individual PIs to complex multinational experiments. At the initiation of the MARGINS program, facilities existed to accommodate some types of data, but

in many cases data sets resided primarily with individual scientists. To ensure long-term data preservation and to provide broad data access and distribution, the MARGINS data management system (*www.marine-geo.org/MARGINS*) was initiated in Fall 2003 at Lamont-Doherty Earth Observatory. It includes a central, searchable metadata catalog with links to download data files, hosted locally or in remote archives including UNAVCO, IRIS and EarthChem. Data system tools include the visualization and analysis applications GeoMapApp and Virtual Ocean. The data system has become well integrated with the MARGINS program, forms the basis of significant outreach activities (Section 9), and provides field data and documentation for all MARGINS expeditions.

It is expected that the range of field programs and data collected in GeoPRISMS will broadly resemble that in MARGINS, but opportunities exist to provide greater support for integration and education through added facilities. Data management discussions at the MSPW suggested several possible areas of high priority growth potential, described below. Some of these opportunities can be easily managed, while others will require community discussion and vetting. It is expected that a small Data Management Task Force will be convened early in GeoPRISMS to evaluate and prioritize these opportunities.

Existing infrastructure and an expanded GeoPRISMS data system: Considerable data infrastructure currently exists to facilitate GeoPRISMS program science and should be built upon. New capabilities to support multi-PI collaborations could be developed, such as common work space for data analysis, where PIs working in a similar region or on a common process could easily share a wide variety of observations. A central data system could also serve as a hub for distributing more integrative data products and analysis tools. Some of this capability exists in CIG and CSDMS, and partnerships with these programs could advance this goal. Currently, there is no infrastructure for the archiving of experimental data such as lab-based rheological studies and sediment flux models, but possibly such data could be archived under an expanded data system. GeoPRISMS will also continue forging strong ties to the EarthScope facility, and expanding the underlying existing data management links to IRIS and UNAVCO for seismic and geodetic data, respectively.

Data policy compliance: NSF requires the long-term preservation of and broad access to digital data and physical samples acquired with NSF funding. While compliance with the MARGINS data policy was successfully achieved for field data sets, challenges remain for data types with no obvious home archive. Also, the existing MARGINS data policy (dating from 2005) should be reviewed to ensure that it adequately addresses the requirements of GeoPRISMS and current NSF practices.

Incorporating secondary data: Derived and analytic data can be of broadest use for the multi-disciplinary and integrative studies that are likely under the GeoPRISMS program, but are not routinely archived. However, easy access to such secondary data has potential to revolutionize the synthesis of multidisciplinary observations. Many of these data do not have standard repositories or homes, therefore a goal for the community will be to establish a suitable framework in which such data could be more widely distributed.

Data Citation: Creating citations for field data will allow scientists to refer to it soon after acquisition in a consistent and long-lasting manner. The database group is developing capacity to publish data sets with digital object identifiers (DOIs) within the international STD-DOI system. IRIS is currently pursuing another model of data set citation through Seismological Research Letters. These data citation and tracking systems need to be evaluated and should be pursued in the data management plan for GeoPRISMS.

Physical samples: At present there is no formal structure for the routine archiving of physical samples (rocks, fluids) collected under most NSF awards, with samples historically housed at PI host institutions. The curation of physical samples needs to be addressed at the NSF agency level, perhaps

through partnerships with national museums such as the Smithsonian and American Museum of Natural History.

Numerical models: The CIG and CSDMS computational facilities provide infrastructure for the archiving and dissemination of certain types of modeling source code (See Section 8.1.7). GeoPRISMS PIs will be encouraged to submit relevant software.

Industry data: Availability of industry-collected 3-D seismic and downhole data sets could greatly benefit future GeoPRISMS science. Gaining access for broad use and publication within the research community is likely to present challenges and may require development of formal industry-academic partnerships. GeoPRISMS should also work with industry partners to find solutions for preservation of industry data sets that are no longer viewed as commercially valuable, for example within the data management system.

Primary Site/Thematic Data Compilation: As primary sites are identified for the GeoPRISMS program, early priority should be given to identify and assemble key existing data sets for the region. Compiling these data sets and making them available to the community through an expanded MARGINS-GeoPRISMS data portal would help with field work planning, for example. Compilation of the existing data may not be trivial, particularly for terrestrial data sets and geochemical data, and dedicated support may be needed for this initial task.

By these many different means, the GeoPRISMS program will be able to contribute to the much broader scientific community in a timely manner, allowing other researchers invested in related studies to access the data for their investigations. This approach is compatible with an increasing emphasis on open (or rapid) data access through many other organizations, initiatives and facilities, including EarthScope and potentially R/V Marcus Langseth acquired seismic data.