THE SUBDUCTION FACTORY: THE GLOBAL IMPACT OF MASS AND ENERGY TRANSFER AT CONVERGENT MARGINS

contributed by Julie Morris

Subduction of oceanic plates causes earthquakes, tsunamis and explosive volcanism. It also gives rise to beneficial products, such as ore deposits, geothermal energy and the ground we live on. The "subduction factory" recycles raw materials from the subducting seafloor and overlying mantle, and creates products on the upper plate in the form of melts, aqueous fluids and gases. Convergent margin processes have profound scientific and societal consequences, and a Subduction Factory Workshop was convened to develop plans to tackle the most important research.

The workshop—related to the MARGINS Initiative—was held from June 6 to 9, 1998 in La Jolla, CA. It was funded by JOI/USSSP, the National Science Foundation (Marine Geology and Geophysics), Washington University in St. Louis, and Scripps Institution. Approximately 65 scientists, representing the many disciplines required for integrated studies of the subduction factory, attended. The workshop mandate was to build and identify community consensus for scientifically and geographically focused interdisciplinary studies of the subduction factory.

The workshop participants recognized three themes as tractable and essential:

- The role of subduction parameters (e.g. slab and mantle temperature, convergence rate, subduction dynamics and mass transport to depth) as forcing functions in regulating chemical cycling and crustal growth.
- The volatile cycle through subduction zones and its impact on physical, chemical and biological processes from the trench to the back-arc.
- Mass balance and continental growth in the middle and lower arc lithosphere and as understood through experimental studies.

In a strong, but not unanimous, consensus the following actions were endorsed:

Selecting Nicaragua/Costa Rica as a site for focused interdisciplinary studies. Here: 1) variations in subduction dynamics and mass transport to depth are matched by sympathetic chemical gradients in the volcanic output, 2) abundant carbonate subduction exists for investigating the CO_2 cycle, and 3) the deeper plutonic section is exposed. The first reason links Subduction Factory and Seismogenic Zone goals into a scientifically integrated package. In addition, work in Central America will include studies of volcanic gases and their role in hazards, climate modification, and mass balance.

Determining a counterpoint site to Central America in a non-accretionary margin where old, cold slabs are subducting, and back-arc spreading is present. In the Marianas, Izu-Bonin and Tonga margins, key forcing functions are distinctly different from Central America. Because each margin is best suited for addressing specific themes, a workshop at the December 1998 American Geophysical Union meeting will be convened to set priorities.

Conducting selected studies of the subducting input and the volcanic and plutonic products of the Aleutians. Variations in subduction parameters alongstrike in the Aleutian arc present a great opportunity to examine forcing functions. A continental growth study from exposures of deeper arc crust and the hazards presented to U.S. residents and planes flying in U.S. airspace are additional reasons for working in the Aleutians. However, the relatively limited database is an issue.

The workshop attendees also recognized: 1) the need for Theoretical and Experimental Institutes to investigate the internal margin workings and to link observations across disciplines; 2) the role of InterMARGINS to coordinate international studies; 3) the importance of databases and uniform systems of sample curation and distribution; and 4) the need for well-defined studies in critical localities to ensure adequate sample sets, provide critical pieces of information or generate adequate data synthesis.

Scientific ocean drilling has been—and will continue to be—essential for studies of the subduction factory through 2003, and beyond. Much of what we know about the composition and alteration of the incoming ocean crust and the composition and mineralogy of its sedimentary veneer comes from ODP drilling. Recovery of the sedimentary section and deep penetration of the igneous basement outboard of the trench continues to be essential. Drilling, in combination with seismic imaging and geochemistry, is also essential for quantifying the fraction of sediment subducted to the depths of magma generation. In addition, scientific and technical progress has changed the way in which the ODP drillship, *JOIDES Resolution*, can be used. Casing techniques can provide better hole stability for deeper penetration and core recovery in the compressive re-

gime of the accretionary prism, to study sediment dynamics. Logging-While-Drilling techniques provide high-quality logs for density and porosity in fore-arc sites. Pore fluid sampling and analysis provide a very sensitive look at the diagenetic, hydrologic and chemical changes in the downgoing plate during the earliest stages of subduction. New capacity for microbiological study aboard the *JOIDES Resolution* will allow investigation of subduction trenches as important habitats in the biosphere. In any study of the subduction factory, it is essential that a reference site be drilled outboard of the deformation front.

Riser drilling will ultimately allow deeper penetration, improved hole stability, and better recovery under difficult drilling conditions typical of convergent margins. Drilling through the seismogenic zone will provide samples of aqueous fluids and of accreted and subducting sediments, necessary for understanding shallow subduction processes, and their effect on the slab delivered to depth. Riser drilling could improve access to deeper fore-arc serpentinites and associated pore-fluids. It may also provide a longer record of arc evolution through deep drilling in the arc edifice or in subsiding basins that receive volcanic sediments or ash.

Legacy boreholes are increasingly important for hydrological, geochemical, microbiological and seismic studies with long-term observatories. New developments are leading to a second generation CORK that will allow multiple levels in the borehole to be isolated from each other and from seawater, so that the hydrology, chemistry and microbiology can be investigated in several different horizons. Such observatories would be particularly useful in the fore-arc of margins selected for focused study, with isolation of intervals above and below the decollement and in the basement of the subducting plate. This information will be essential for understanding the volatile cycle in the shallow subduction factory, with obvious implications for the volatile budget. The same borehole can house a seismometer and strainmeter, leading to a better array for characterizing the seismicity and regional strain of convergent margins. Mini-CORKs are being developed to serve as shallow, inexpensive, easily deployed mini-observatories. These could be linked with borehole observatories as arrays for the investigation of the three-dimensional aspects of the subduction factory, such as hydrologic process, heat flow, seismicity, regional strain, geochemical variability, and biologic processes.

Details about the Subduction Factory Workshop and its report may be found on the web: epsc.wustl.edu/admin/people/morris/factory.html. The Subduction Factory Science Plan and the workshop report will be available at the MARGINS web site: www.soest.hawaii.edu/margins.

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