Developing US Beamline Infrastructure for In-situ Studies of Rock Deformation

*By In-Situ Rock Deformation (ISRD) Steering Committee**

The deformation of rocks encompasses a diverse set of physical processes that directly influence and control wide-ranging geological phenomena of societal and scientific importance. Experiments to characterize and quantify the response of rocks to deformation play a central role in understanding the dynamics of fluids in the critical zone, in tracking the global water budget, in mitigation and assessment of geohazards, in deciphering the physics of earthquakes, in predicting rates of topographic change, in determining the drivers of volcanism, and in revealing the factors that control plate tectonics. Laboratory-based studies of rock deformation are an essential component of addressing at least seven of the twelve priority science questions outlined by *Earth in Time*, the recent National Academy of Sciences decadal survey on the future of Earth Science research.

Experimental rock deformation faces the unrelenting challenge of measuring physical properties at extreme conditions and across many orders of magnitude in length scale and time scale. In addition, target processes are often dynamic, such that hypotheses can only be tested by tracking the evolution of material properties and microstructures during deformation. Synchrotron radiation has emerged as a major tool for overcoming these difficulties through collection of a wide spectrum of data *in situ* during deformation of geological materials. The most pressing targets that can be addressed with existing and new techniques include 1) the mechanical influence of fluids in the seismogenic zone, the critical zone, and the cryosphere, 2) the mechanical influence of material heterogeneities in sediments, rocks, and ice, and 3) the atomic-scale processes that control the short- and long-timescale dynamics of the lithosphere and asthenosphere.

The ISRD proposal highlights the capabilities and capacities of existing beamline infrastructure for significant future contributions, along with key avenues for infrastructure development at synchrotron beamlines that will lead to major breakthroughs in understanding the physics of rock deformation. In collaboration with scientists at several beamlines, we propose the following infrastructure development projects to support in-situ rock deformation research: 1) to implement support staff at ALS dedicated to development, upkeep and support of sample environments and apparatuses for studying near surface fluid-rock interactions; 2) to expand capacity and upgrade equipment at GSECARS, including integration of different techniques for studying dynamic processes in Earth's crust and upper mantle, and introduction of new sample environments for studying ice rheology and glacier dynamics; 3) to expand and improve operations of high-pressure equipment for studying ductile deformation at APS 6BM; 4) to install a new triaxial deformation apparatus for studying brittle deformation at NSLS-II. These projects are aspects of the overall operation and development proposed by each beamline to the new organization.