THE VETLESEN PRIZE

LECTURES

Achievement in the Earth Sciences

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Present-day Sea Level Rise: the Role of Space Observations

Sea level rise is one of the best indicators of current climate change. For 30 years, sea level rise is routinely measured by a series of high-precision altimeter satellites. Their observations have shown that the global mean sea aaccelerated ice mass loss from the Greenland and Antarctica ice sheets. Other space-based and in situ observing systems (GRACE space gravimetry and Argo automatic floats) have allowed us to quantify the contributions of land ice loss and ocean warming to sea level rise, hence assessing the closure of the sea level budget. Satellite altimetry has revealed strong regional variability in the rates of sea level change, a result of the redistribution of heat and freshwater by the ocean circulation, mostly driven by internal climate variability. New observational challenges are now emerging, among these, accurate monitoring of sea level changes along the world coastlines. How much sea level is rising at the coast remains poorly known because satellite altimetry has been optimized to study the open ocean, and many coastlines in the world are under-sampled by tide gauges. Besides, small-scale coastal processes superimposed to the global mean rise and the regional trends may cause sea level rise at the coast to significantly deviate from offshore. However, dedicated reprocessing of past altimetry missions and new altimetry technology now provide novel information on coastal sea level change, of high value for improving climate models used for projections and for implementing adaptation strategies to future climate change.

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Living with Pressure: Adventures with Olivine and Beyond

A background in solid-state physics, together with materials science and interests in earth, and planetary sciences provided the skills to study the physical and chemical properties of minerals and rocks at high pressures and temperatures, with particular emphasis on strength. Experiments quantify the behavior of geological materials – primarily olivine – under extreme conditions as the basis for understanding and modeling the dynamical behavior and chemical evolution of deep interiors of terrestrial planets. Over time, research in my lab on fluid-rock interactions demonstrated that a small amount of water in the form of hydrogen dissolved in olivine produces a dramatic reduction in strength. Such water weakening has important consequences for convection in Earth's mantle by enabling plate tectonics, a phenomenon that is absent on Venus, a relatively dry planet often considered Earth's twin. A small amount of melt also significantly affects the strength of otherwise crystalline rocks. Not only is the strength of a partially molten rock sensitive to melt distribution, but also melt distribution is profoundly influenced by deformation. This coupling between deformation and melt distribution results in self-organization of melt into melt-enriched shear zones that not only localize deformation but also provide high permeability paths for rapid transport of melt from depth to Earth's surface. Recent studies designed to understand the formation of long-lived ductile shear zones at tectonic plate boundaries involve high-strain torsion experiments on rocks composed of olivine plus pyroxene. This research now explores mechanisms of mixing and grain-size reduction of both minerals during deformation, leading to weak fine-grained rocks capable of facilitating strain localization.

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