The 66th GRC & The 11th MEXT Shin-Gakujutsu "Core-Mantle Coevolution"

International Frontier Seminar

A laboratory-based framework for the interpretation of seismological models

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Date: 5.29.2017 (Mon.) 16:00 –18:00

Venue: Meeting Room #486, Science Research Bldg 1, Ehime Univ.

Seismic wave speeds have conventionally been measured in the laboratory with wave propagation techniques at MHz-GHz frequencies many orders of magnitude higher than those (mHz-100 Hz) of seismic exploration of the Earth's interior. However, at high temperatures and in the presence of fluids, wave speeds and attenuation are expected to be strongly frequency dependent – making direct application of such laboratory results questionable. In response to this imperative for laboratory measurements at seismic frequencies, instrumentation has been progressively developed over decades which is uniquely well suited to this task. The seismic-frequency forced oscillation tests are conducted under conditions of controlled temperature, confining pressure and pore-fluid pressure, in both torsion and flexure, at microstrain amplitudes typically within the linear stress-strain regime.

Pure fine-grained synthetic analogues for the olivine-rich rocks of the Earth's upper mantle were first tested to expose and understand the baseline behaviour of polycrystalline iron-bearing (Fo_{90}) olivine. Above ~900°C, the behaviour of such fine-grained polycrystals in torsional oscillation was found to depart strongly from the elastic ideal. Such viscoelastic behaviour involves both a shear modulus that decreases systematically with increasing oscillation period and associated strain-energy dissipation. Observed grain-size sensitivity of such behaviour has logically been attributed to stress-induced sliding on grain boundaries accommodated by elastic distortion of adjacent grains along with diffusional transport of matter along grain boundaries. In subsequent and ongoing work, the effects of partial melting and water on the high-temperature seismic properties are each being explored.

The stress-induced redistribution of intergranular fluid within crustal rocks is expected to result in similarly frequency-dependent elastic moduli or wave speeds and associated dissipation of strain energy. During the past few years such poroelastic relaxation has been explored in cracked crustal rocks, and synthetic analogues fabricated from dense glass rods and/or by sintering glass beads. Broadband study of such materials shows that ultrasonic measurements at ~1 MHz probe the saturated isolated regime in which there is insufficient time for stress-induced fluid flow, whereas forced-oscillation measurements at sub-Hz frequencies commonly yield substantially lower moduli and wave speeds in the saturated isobaric regime where stress-induced gradients in pore pressure are eliminated by fluid flow.

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