Special Seminar on Crustal Dynamics

Upper-mantle water stratification inferred from observations of the 2012 Indian Ocean earthquake

Speaker: Sylvain Barbot (Earth Observatory, Nanyang Tech. Univ., Singapore)
Date and Place: Jan. 12, 15:00~16:00, Room 513, Build. Dept. Earth Sci., Tohoku Univ.

Water, the most abundant volatile in Earth's interior, preserves the young surface of our planet by catalysing mantle convection, lubricating plate tectonics and feeding arc volcanism. Since planetary accretion, water has been exchanged between the hydrosphere and the geosphere, but its depth distribution in the mantle remains elusive. Water drastically reduces the strength of olivine and this effect can be exploited to estimate the water content of olivine from the mechanical response of the asthenosphere to stress perturbations such as the ones following large earthquakes. Here, we exploit the sensitivity to water of the strength of olivine, the weakest and most abundant mineral in the upper mantle, and observations of the exceptionally large (moment magnitude 8.6) 2012 Indian Ocean earthquake to constrain the stratification of water content in the upper mantle. Taking into account a wide range of temperature conditions and the transient creep of olivine, we explain the transient deformation in the aftermath of the earthquake that was recorded by continuous geodetic stations along Sumatra as the result of water- and stress-activated creep of olivine. This implies a minimum water content of about 0.01 per cent by weight—or 1,600 H atoms per million Si atoms—in the asthenosphere (the part of the upper mantle below the lithosphere). The earthquake ruptured conjugate faults down to great depths, compatible with dry olivine in the oceanic lithosphere. We attribute the steep rheological contrast to dehydration across the lithosphere–asthenosphere boundary, presumably by buoyant melt migration to form the oceanic crust.

From quiescence to unrest and back again: 150 years of geodetic measurements at Santorini volcano, Greece

Speaker: James D. P. Moore (Earth Observatory, Nanyang Tech. Univ., Singapore)
Date and Place: Jan. 12, 16:00~17:00, Room 513, Build. Dept. Earth Sci., Tohoku Univ.

Historical bathymetric charts are a potential resource for better understanding the dynamics of the seafloor and the role of active processes, such as submarine volcanism. The British Admiralty, for example, have been involved in lead line measurements of seafloor depth since the early 1790s. Here, we report on an analysis of historical charts in the region of Santorini volcano, Greece. Repeat lead line surveys in 1848, late 1866, and 1925–1928 as well as multibeam swath bathymetry surveys in 2001 and 2006 have been used to document changes in seafloor depth. These data reveal that the flanks of the Kameni Islands, a dacitic dome complex in the caldera center, have shallowed by up to 175 m and deepened by up to 80 m since 1848. The largest shallowing occurred between the late 1866 and 1925–1928 surveys and the largest deepening occurred during the 1925–1928 and 2001 and 2006 surveys. The shallowing is attributed to the emplacement of lavas during effusive eruptions in both 1866–1870 and 1925–1928 at rates of up to 0.18 and 0.05 km^3 a^{21}, respectively. The deepening is attributed to a load-induced viscoelastic stress relaxation following the 1866– 1870 and 1925–1928 lava eruptions. The elastic thickness and viscosity that best fits the observed deepening are 1.0 km and 10^{16} Pa s, respectively. This parameter pair, which is consistent with the predictions of a shal- low magma chamber thermal model, explains both the amplitude and wavelength of the historical bathymet- ric data and the present day rate of subsidence inferred from InSAR analysis.