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Strength and Dilatancy of Partially Serpentinized Peridotites: A Little bit of Serpentinite can go a Long way

J. Escartín [1], G. Hirth [2], B. Evans [3]

[1] Lab. Petrologie, CNRS/Paris 6, Case 110, 4 Place Jussieu, Paris, 75252, France
[2] Dep. Geology and Geophysics, WHOI, McLean Bldg, Woods Hole, MA 02543, USA
[3] EAPS, MIT, 77 Mass. Av., Cambridge, MA 02139, USA

Deformation experiments show that slightly serpentininized peridotites (<15%) are as weak as pure serpentinite, and exhibit a similar mode of non-dilatant deformation. We deformed intact cores of Balsam Gam (North Carolina) and Kukes (Albania) dunites in a gas apparatus, at Pc<400 MPa and room T. Volume changes during deformation were monitored with electrical strain gauges. Peridotites with a degree of serpentinization β<5-15% (inferred from the density) have the same strength and pressure dependence of strength (i.e., coefficient of internal friction μ=0.35) as pure serpentinite [Escartin et al., 1997]. At β<15% the strength of peridotite increases abruptly to that of pure dunite, more than a factor of two higher than that of serpentinite. The pressure of the transition from localized to distributed deformation shows a similar non-linear dependence on density/ β, increasing from 150-350 to >1000 MPa, also at β<15. The volumetric strain data document a non-dilatant mode of brittle deformation comparable to that observed in pure serpentinites, with very small amounts of dilation or compaction ($<$0.2%), even at pressures <100 MPa. These data indicate that serpentinite, despite being a minor component, accommodates most of the deformation in the rock, while olivine, which has a dilatant deformation mode [Shimada et al., 1983], is not deformed significantly. The variation of strength and mode of deformation occurs on a critical range of β=5-15%. Using a linear density-compressional velocity Vp relationship (calculated from published velocity data at P=200 MPa), the transition from 'weak' serpentinite to 'strong' dunite rheology occurs at Vp 7.5-7.9 km/s. These results have important implications for the rheology and tectonic evolution of the oceanic crust. The presence of small amounts of serpentinite (15% or less) throughout the oceanic lithosphere can considerably reduce its strength by >50%. The weakness of partially serpentinized peridotites and the suppression of mechanisms such as dilatancy strengthening early during the serpentinization process can promote the localization of deformation at depth (e.g., formation of detachments), even within slightly altered mantle.