# Seismic properties of hydrous and partially molten synthetic dunites

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The influence of hydrous, but water-undersaturated conditions and aspects of the role of partial melting of upper-mantle materials, remain to be clarified through ongoing experimental work.
Water-undersaturated conditions have been realised in the laboratory in the relatively oxidizing environment within Pt capsules/sleeves. Specimens of synthetic Ti-doped olivine have been hot-pressed within Pt capsules with a range of Ti concentrations from 176 to 802 atom ppm Ti/Si. At sufficiently oxidizing conditions, a stable extended defect is formed involving Ti/Mg substitution charge balanced by double protonation of a neighbouring Si vacancy (Berry et al., *Geology*, 2005)., The concentrations of chemically bound H range between 330 to 1150 atom ppm H/Si (Berry et al., *Geology*, 2005). Torsional forced-oscillation tests were conducted at seismic periods of 1 –1000 s and 200 MPa confining pressure during slow staged cooling from 1200 to 25°C. Each Ti-doped specimen showed mechanical behaviour of the high-temperature background type involving monotonically increasing dissipation and decreasing shear modulus with increasing oscillation period and increasing temperature. The modulus dispersion and dissipation measured under these water-undersaturated conditions are markedly stronger than for a similarly prepared specimen tested dry within an Ni-Fe sleeve under more reducing conditions. However, the data for the hydrous specimens display only limited sensitivity of the seismic properties to variation of the concentration of the Ti-hydroxyl defect. The lower shear moduli and higher dissipation measured under water-undersaturated conditions are clearly attributable to the different chemical environment. Presumably, the contrasting chemical compositions (and hence effective viscosities) of grain-boundary regions and/or differing populations of lattice defects are responsible. Clarification of the relative roles of grain-boundary sliding and any additional intragranular relaxation under increased $f_{H2O}$ and $f_{O2}$ thus offers the prospect of an improved understanding of the seismological signature of more oxidized/hydrous portions of the Earth's upper mantle, such as subduction zone environments (Cline et al., *Nature Geoscience*, submitted). Concerning the seismic properties of partially molten lherzolite, bulk modulus relaxation caused by stress-induced change in the proportions of coexisting crystalline and melt phases has recently been proposed (Li and Weidner, *PEPI*, 2013). In order to further assess this possibility, a forced oscillation experiment has been conducted at seismic frequencies on a newly prepared synthetic dunite specimen (sol-gel olivine + 2.6% added basaltic melt glass) utilizing an enhanced capacity of the ANU apparatus to operate in both torsional and flexural oscillation modes. Shear modulus and dissipation data are consistent with those for melt-bearing olivine specimens previously tested in torsion, with a pronounced dissipation peak superimposed on high-temperature background. Flexural data exhibit a monotonic decrease in the complex Young's modulus with increasing temperature under trans-solidus temperatures. The observed variation of Young's modulus, closely comparable with that measured by Li and Weidner, is well described by the approximation 1/E ~ 1/3G, which holds when G/3K << 1. At high homologous temperatures, when the shear modulus is low, extensional and flexural oscillation measurements thus offer little resolution of bulk modulus –leaving the possibility of its partial relaxation unresolved. Planned experiments involving the measurement of volume changes caused by oscillating confining pressure may provide the answer (Cline and Jackson, *GRL*, 2016).

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