Low-frequency seismic properties of olivine-orthopyroxene mixtures

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Although the seismic properties of polycrystalline olivine have been the subject of systematic and comprehensive study at seismic frequencies, the role of orthopyroxene as the major secondary phase in the shallow parts of the Earth's upper mantle has so far received little attention. Accordingly, we have newly prepared synthetic melt-free polycrystalline specimens containing different proportions of olivine (Ol, Fo\textsubscript{90}) and orthopyroxene (Opx, En\textsubscript{90}) by the solution-gelation method. The resulting specimens, ranging in composition between Ol\textsubscript{95}Opx\textsubscript{5} and Ol\textsubscript{5}Opx\textsubscript{95} composition, were mechanically tested by torsional forced oscillation at temperatures of 1200 °C to 400 °C accessed during staged cooling under a confining pressure of 200 MPa. The microstructures of tested specimens were evaluated by BSE, EBSD and TEM. The forced-oscillation data, i.e. shear modulus and associated strain-energy dissipation at 1-1000 s period, were closely fitted by a model based on an extended Burgers-type creep function. This model was also required to fit data from previous ultrasonic and Brillouin spectroscopic measurements at ns-µs periods. Within the observational window (1-1000 s), the shear modulus and dissipation vary monotonically with period and temperature for each of the tested specimens, which is broadly comparable with that previously reported for olivine-only samples. There is no evidence of the superimposed dissipation peak reported by Sundberg and Cooper (2010) for an Ol\textsubscript{60}Opx\textsubscript{40} specimen prepared from natural precursor materials and containing a melt fraction of 1.5%. The higher orthopyroxene concentrations are associated with systematically somewhat lower levels of dissipation and corresponding weaker modulus dispersion. The new findings suggest that the olivine-based model for high-temperature viscoelasticity in upper-mantle olivine requires only modest modification to accommodate the role of orthopyroxene, including appropriate compositional dependence of the unrelaxed modulus and its temperature derivative.