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Quantifying the influence of redox conditions on the seismic properties of olivine

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A series of eight olivine specimens were fabricated by hot-pressing at 1200˚C and 300 MPa. Each hot-pressed specimen was then wrapped in Pt, Ni or NiFe foil to vary oxygen fugacity ($f\mathrm{O}_2$), and interrogated via forced torsional oscillation. Mechanical testing was conducted at 10 oscillation periods between 1 and 1000 s, at a confining pressure of 200 MPa, during a slow staged-cooling from a maximum temperature of 1200˚C to room temperature. After mechanical testing, each specimen was axially sectioned and EBSD was used for the determination of the representative grain size, and grain size distribution of each sample. In addition, each longitudinal section was mapped via FTIR to determine the spatial distribution and concentrations of chemically bound and molecular water. Amongst these specimens, chemically bound 'water' contents were observed to vary between 0 and 1150 atom ppm H/Si, and molecular water concentrations varied between 0 and 245 atom ppm H/Si. Our forced-oscillation results demonstrate that the measured magnitude of anelastic relaxation within the experimental 'window' of oscillation periods is unrelated to the water content. Rather, a relationship was observed between the magnitude of anelastic relaxation and the prevailing redox conditions, which is influenced by the choice of metal sleeving used during the mechanical test. Further, regardless of water content or metal sleeving, each specimen exhibits coupled variations in shear modulus and dissipation within the observational window, indicative of 'high-temperature background' behavior, that can be described by a Burgers-type model. During initial fitting of the Burgers models, the unrelaxed shear modulus at a reference temperature of 900˚C (G_{UR}) and the temperature derivative of the unrelaxed shear modulus (dG_U/dT), were treated as adjustable parameters. For all Fe-bearing olivine samples (but not a hydrous and oxidized Fe-free sample) we observe deficits of G_{UR},and increased values of dG_U/dT, relative to the expected elastic (anharmonic) behavior of Fo_{90} olivine. This behavior is indicative of anelastic relaxation occurring at shorter periods than observable within the 'window' of oscillation periods used in the mechanical test. Moving towards a comprehensive seismologically applicable Burgers model, which includes this newly observed effect of redox conditions on anelastic relaxation, we will present our progress in reconciling truly anharmonic and elastic behavior of Fo_{90} olivine with our observed forced-oscillation data.