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Elasticity data along the forsterite – fayalite solid solution

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Four natural samples of olivine along the forsterite – fayalite join having the following compositions Fo92Fa8, Fo80Fa20, Fo71Fa29 and Fo62Fa38 were studied by means of single-crystal X-ray diffraction at high pressure in situ using a diamond-anvil cell up to about 8 GPa in order to evaluate how important physical properties like the isothermal bulk modulus (and its first pressure derivative, K0 and K‘) changes as a function of iron along one of the most studied solid solution in earth sciences. Due to the abundance of olivine in the upper mantle (up to 60%) several works have been performed in order to define its physical properties: in particular, considering all previous works performed at high pressure it appears evident that a significant degree of scatter is present with K0 values determined for pure forsterite ranging between 123 and 132 GPa and for fayalite ranging between 113 and 136 GPa. Intermediate compositions resulted to be not much investigated and the bulk modulus data also show marked differences ranging between 123 and 131 GPa. Among all the literature data it must be noted that unfortunately the first pressure derivative, K‘, has been too often fixed to 4 and when determined it showed in general values close to 4 (in only one study the K‘ is higher than 5). The aim of this work is to definitively clarify the effect of one of the most common cation substitution in mineralogy, as the Mg/Fe one, on the elastic properties of Mg-rich olivines.

Our results definitively show that the bulk modulus and its first pressure derivative do not show any variation along the compositional range investigated and plotting the V/V0 ratio against the pressure for each composition we obtained a unique indistinguishable curve corresponding to a third-order Birch-Murnaghan equation of state having the following coefficients K0 = 124.7(9) GPa and K‘ = 5.3(3). Our bulk modulus is slightly lower than those published so far. The low scatter in our data gave us the opportunity to refine simultaneously the unit-cell volume, V0, the bulk modulus, K0, and its first pressure derivative, K‘, ensuring in this way a strong reliability for our results.