Elastic properties of dolomite-ankerite solid solutions

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Dolomite, $CaMg(CO_3)_2$, is one of the most abundant carbonates in the Earth's crust. Ankerite, $CaFe(CO_3)_2$, is the Fe-rich double carbonate isostructural to dolomite. End member ankerite does not exist in nature, however dolomite-ankerite solid solutions have been observed up to 70 mol% in the ankerite component [1]. Single crystal studies on dolomite and dolomite-ankerite solid solutions have shown that the substitution of Mg with Fe leads to changes in the bond lengths and angles but do not lead to significant changes in compressibility [2]. The systematic study of the elastic properties of carbonates as a function of their structure and chemical composition at ambient conditions is fundamental to understand the compositional behavior of carbonates and to set a benchmark for ab initio studies. The elastic tensor coefficients of pure dolomite at ambient conditions have been reported in several studies [3,4]. However, no studies on the complete elastic tensor of dolomite-ankerite solid solutions have been reported so far.
Here, we used Brillouin spectroscopy to determine the sound velocities and elasticity of dolomite-ankerite solid solutions along the $CaFe_xMg_{1-x}(CO_3)_2$ join (x = 0.05, 0.63) at ambient conditions to evaluate the effect of Fe on the elastic properties. Our results show that the presence of Fe has an effect on the individual elastic tensor coefficients leading to a linear decrease of C_{11}, C_{33} and C_{44} (-17% for C_{11} and C_{33} and -13% for C_{44} compared to dolomite) and a linear increase of the C_{12} and C_{15} (+9% and +20% respectively) coefficients. C_{13} and C_{14} do not appear to be sensitive to compositional changes. The linear dependence of the elastic tensor coefficients of dolomite-ankerite solid solutions on composition is consistent with what has been observed in Mg,Fe single carbonate minerals, $Mg_{1-x}Fe_xCO_3$[5, 6]. The presence of 63 mol% of the $CaFe(CO_3)_2$ component in dolomite-ankerite solid solutions, leads to a lowering of the acoustic velocities (-8% for v_p and -13% for v_s), bulk modulus K (-10%), and shear modulus G (-13%), compared to pure dolomite.

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