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Assessment of carbonate detectability in the lower mantle based on elastic wave velocity measurements of iron-bearing carbonates using nuclear inelastic scattering

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One of the most important parameters in quantifying the deep Earth carbon cycle is how much carbon is subducted into the Earth's interior. The solubility of carbon in dominant mantle phases is relatively low; hence carbon is primarily stored in accessory phases. At low pressures in subduction zones where conditions are relatively oxidised, the predominant carbon-bearing phase is carbonate, where its composition depends on the prevailing pressure, temperature and bulk composition. Knowledge of carbonate phase equilibria constitutes an important step in quantification of the carbon cycle; however knowing how much carbon is involved in the subduction process is also crucial. The degree to which carbon can be detected in subducting slabs using geophysical methods depends on its abundance as well as the contrast in properties between carbonated and non-carbonated lithologies. Elastic wave velocity data reported in the literature for carbonate at ambient conditions indicates that density and velocity contrasts for carbonated versus non-carbonated assemblages are close to the resolution of seismic data for current models of carbonate abundance in subducted slabs, suggesting that it is unlikely that the presence of carbonate could be detected using wave velocities alone. However a high-spin to low-spin transition in ferrous iron causes a large volume decrease in iron-bearing carbonates, and while the spin transition is not relevant to upper mantle assemblages, it could be a factor for deeper assemblages. Up to now, however, there are no elastic wave velocity measurements for carbonates at high pressures and high temperatures. We have therefore undertaken such a study, starting with high-pressure measurements of $FeCO_3$ elastic wave velocities through the spin transition. Velocities were derived from nuclear inelastic scattering data collected at beamline ID18 at the European Synchrotron Radiation Source. Preliminary results show a substantial increase in shear wave velocity through the spin transition, which can be used to assess the detectability of carbonated assemblages in the lower mantle.