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Evolution of P-wave velocities during antigorite dehydration at pressures up to 2.5GPa

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Antigorite dehydration is considered as one of the potential triggering mechanisms of intermediate depth earthquakes in subduction zones. Here, the evolution of p-wave velocities were measured during antigorite dehydration experiments at pressure and temperature conditions representative of the upper mantle (1 to 2.5 GPa) for the first time.

Experiments were realized on a natural antigorite serpentinite from Corsica (Gasc et al. 2011), using a 3rdgeneration Griggs-type apparatus equipped with p-wave velocity ultrasonic monitoring (Moarefvand et al. 2021).Velocities were measured maintaining constant hydrostatic pressure conditions at 1, 1.5, 2 and 2.5 GPa, and slowly heating the sample beyond dehydration temperatures. At each pressure conditions, two experiments were carried out at a maximum temperature of 650°C or 700°C respectively, in order to investigate reaction kinetics and equilibrium overstepping. Experiments were quenched once the dehydration was completed, in order to preserve the microstructure.

In all our experiments, P-wave velocity decreased dramatically at the onset of dehydration. This important drop in elastic properties is related to the fracturing and porous space generated by water release. At 700°C temperature, observed velocity drops were faster, and more pronounced compared to experiments performed at 650°C, indicating that the dehydration reaction progress was faster and more important. The velocity drop also got smaller with increasing pressure, but remained noticeable, even at 2.5GPa, a pressure at which the reaction volume change is negative. This indicates that even in the absence of fluid overpressures, the reaction is accompanied by an important amount of microcracking/softening. Recovered samples were then analyzed using scanning electron microscopy (SEM) and Electron backscatter diffraction (EBSD). With these microstructural data, the final reaction progress/advancement was estimated and we show that in situ measurements of p-wave velocity represent a good proxy for reaction progress and kinetics.

Our study opens up the door to a vast domain, where mineral reactions kinetics could be monitored in situ outside the synchrotron environment, via a direct access to elastic properties. It also reveals our need to apply state of the art effective medium theory modeling of porous and cracked aggregates when computing elastic properties of hydrating/dehydrating mineral assemblages. Finally, the elastic softening observed upon dehydration, even above 2GPa, tends to confirm the dehydration stress transfer model (Ferrand et al. 2017) for intermediate depth

earthquake triggering.

references:

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