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Involvement of Serpentinites in Intermediate Depth Seismicity Assessed from Deformation Experiments

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Tremendous progress was recently made in understanding the mechanics of intermediate and deep earthquakes, notably thanks to the combination of high pressure deformation experiments and in-situ synchrotron techniques. Intermediate earthquakes, which are much weaker than their deep and shallow counterparts are particularly difficult to reproduce in the laboratory.

However, in recent studies, we were able to evidence brittle behavior of antigorite-rich samples at high PT conditions (1-5 GPa and 300-800°C), where acoustic emissions (i.e. labquakes) were associated to faulting. Pure antigorite samples show a brittle temperature window centered around 500°C that seems to correlate with the very onset of the mineral's breakdown, and is therefore not associated with the release of water. Similarly, brittle faulting of partly hydrated samples (containing a mixture of olivine and antigorite) can occur with minor amounts of antigorite, due to stress percolation upon antigorite breakdown. Unlike low-pressure faulting related to dehydration (i.e. dehydration embrittlement), faulting is here enabled by the metastability of the solid phase rather than by a fluid overpressure. In this case, dynamic fault propagation could occur concomitantly with the appearance of melt and/or dehydration products along the fault plane, as shown by microstructural observations.

These results present major similarities with the now-classic concept of transformational faulting, as defined by Green and co-authors in the case of olivine transformations for deep earthquakes. In fact, it is likely that many other minerals display the same behavior when deforming as they undergo a phase transformation. Here, we provide evidence that antigorite-rich rocks are involved in intermediate earthquakes in such a way, i.e. by faulting of a destabilizing mineral at high pressure and temperature conditions.