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Coupled dissolution and dehydration reactions of talc in subduction-zone fluids

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Talc, an extremely soft hydrous mineral formed during the hydration of ultramafic rocks, plays a critical role in subduction zones by facilitating water transport, reducing seismicity, and decoupling subducting slab from overlying mantle wedge [1–2]. While prior experimental studies have established talc's stability under water-poor conditions, this study investigates its behavior in water-rich environments. Experiments were conducted using a hydrothermal diamond anvil cell with synthetic talc and natural antigorite as the starting materials. Real-time Raman spectroscopic analyses were performed to monitor mineral and fluid changes.

Under dry conditions, talc typically decomposes via the reaction talc → enstatite + quartz + H_2O at ~800°C and ~10 kbar [3]. However, our results reveal that in the presence of abundant H_2O or 5 *m* H_2O-NaCl solution, talc undergoes coupled dissolution and dehydration, transforming into Mg-rich mineral forsterite and a silica-rich fluid between 650 and 700°C (Fig. 1). Similarly, antigorite decomposes into forsterite and a silica-rich fluid between 600 and 650°C in water-saturated conditions. These findings demonstrate that the coupled processes significantly lower talc's decomposition temperature by over 100°C compared to dry conditions. Higher pressures will increase dissolved silica and further enhance this effect.

Although abundant water may be scarce in subduction zones, sufficient localized water—such as from antigorite dehydration—can profoundly influence deep water cycling and subduction dynamics through the coupled reactions of talc.

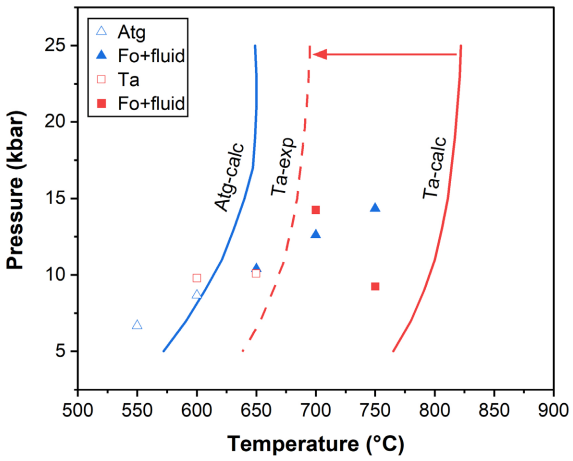

Figure 1 Pressure–temperature diagram comparing the calculated dehydration boundaries of antigorite (blue curve: antigorite → forsterite + talc/enstatite + H_2O) and talc (red curve: talc → enstatite + quartz + H_2O) [3] with our experimental results (bule triangle: antigorite → forsterite + silica-bearing fluid; red rectangle: talc → forsterite + silica-bearing fluid). The dashed curve represents an estimated experimental boundary of talc, assuming the same slope as the calculated one. Notably, only forsterite (Fo) was observed as a solid product during the decomposition of both antigorite (Atg) and talc (Ta), while dissolved silica was detected in the fluids.

[1] Pawley & Wood (1995), *Am. Mineral.* 80, 998-1003.

[2] Easthouse et al. (2025), *Geology*, in press.

[3] Holland & Powell (2011), *J. Metamorph. Geol.* 29, 333-383.