Dehydration-driven stress transfer: from the lab to the field

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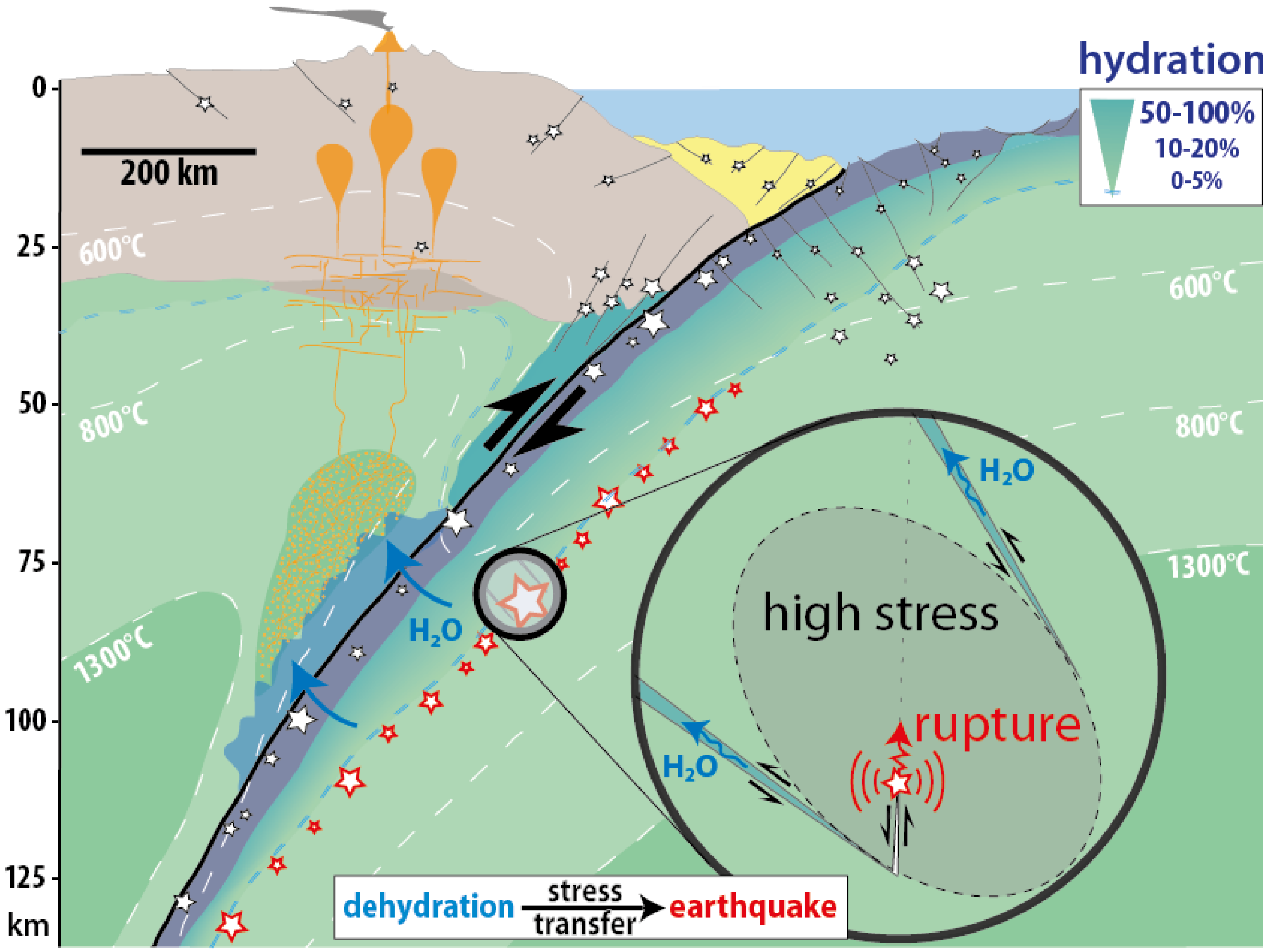
Earthquakes are dynamic ruptures occurring in elastically deformed rocks. The question of their triggering mechanism has triggered any number of articles. We need simple observations. Earth's crust has variable compositions and complex geometries, making earthquakes mechanics difficult to unravel. Compared to the crust, the mantle has quite simple composition and geometry: peridotite, locally hydrated along deep faults. Here we decipher the mechanism of mantle earthquakes of the lower Wadati-Benioff plane by performing deformation experiments on dehydrating serpentinized peridotites (olivine+antigorite) at upper mantle conditions. At 1.1 and 3.5 GPa, the dehydration of deforming samples containing only 5 vol% of antigorite suffices to trigger laboratory quakes. Experimentally produced faults are sealed by fluid-bearing micro-pseudotachylytes, demonstrating that antigorite dehydration triggered dynamic shear failure of the olivine load-bearing network. These laboratory analogues of intermediate-depth earthquakes demonstrate that, for realistic elastic strain, little dehydration is required to trigger embrittlement. We propose an alternative model to dehydration-embrittlement in which "Dehydration-Driven Stress Transfer" (DDST; Ferrand et al., 2017), rather than fluid overpressure, causes embrittlement. Comparing experimental and natural Gutenberg-Richter laws, the DDST model has recently been tested for seismological data from the Pacific slab beneath Tohoku and Hokkaido and confirmed as the most accurate to explain lower Wadati-Benioff events (Kita & Ferrand, submitted).

Keywords: DDST, Dehydration-Driven Stress Transfer, Earthquakes, Serpentine, Peridotite, Wadati-Benioff


hydration
50-100%
10-20%
0-5%
200 km
0
25
50
75
100
125
km
600°C
800°C
1300°C
H2O
high stress
rupture
dehydration
stress
transfer
earthquake