Are intermediate-depth earthquakes in subducting slabs linked to dehydration?

Award: MARGINS-Related

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New thermal-petrologic models of subduction zones are used to test the hypothesis that intermediate-depth intraslab earthquakes are linked to metamorphic dehydration reactions in the subducting oceanic crust and mantle. We show that there is a correlation between the patterns of intermediate-depth seismicity and the locations of predicted hydrous minerals: Earthquakes occur in subducting slabs where dehydration is expected, and they are absent from parts of slabs predicted to be anhydrous. We propose that a subducting oceanic plate can consist of four petrologically and seismically distinct layers: (1) hydrated, fine-grained basaltic upper crust dehydrating under equilibrium conditions and producing earthquakes facilitated by dehydration embrittlement; (2) coarse-grained, locally hydrated gabbroic lower crust that produces some earthquakes during dehydration but transforms chiefly aseismically to eclogite at depths beyond equilibrium; (3) locally hydrated uppermost mantle dehydrating under equilibrium conditions and producing earthquakes; and (4) anhydrous mantle lithosphere transforming sluggishly and aseismically to denser minerals. Fluid generated through dehydration reactions can move via at least three distinct flow paths: percolation through local, transient, reaction-generated high-permeability zones; flow through mode I cracks produced by the local stress state; and postseismic flow through fault zones.

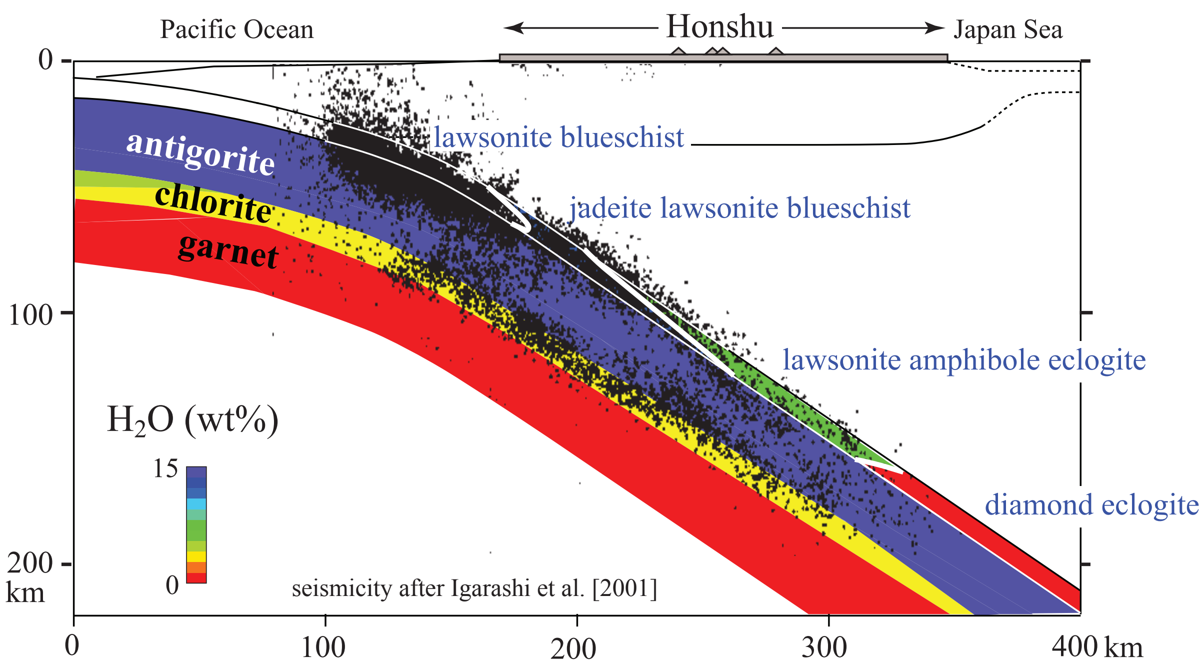

Figure: Correlation between seismicity and phase transformations in the Tohoku subduction zone. Metamorphic facies calculated following Hacker et al. [2002]. Seismicity above 200 km depth projected from 250 km north and south of the section [Igarashi et al., 2001] from 1975–1998, following a relocation with spatially variable station corrections. Information about hypocenter uncertainties is not given, but events shown have RMS residual in arrival time of < 0.3 seconds.

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Igarashi, T., T. Matsuzawa, N. Umino, and A. Hasegawa, Spatial distribution of focal mechanisms for interplate and intraplate earthquakes associated with the subducting Pacific plate beneath the northeastern Japan arc: A tripled-planed deep seismic zone, J. Geophys. Res., 106, 2177–2191, 2001.