Seismic evidence for fluid-related embrittlement at intermediate depths

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Genesis of intermediate-depth earthquakes is an enigma, because high lithostatic pressures render ordinary dry frictional failure unlikely. Earthquakes in a subducting crust can be linked to the dehydration of lawsonite (Okazaki and Hirth, 2016), but earthquakes in a mantle have been discussed in terms of dehydration of hydrous minerals (e.g., Yamasaki and Seno, 1996; Peacock, 2001) or thermal instability (e.g., Kelemen and Hirth, 2007; Prieto et al., 2014). Here I show waveform analyses of two small seismic clusters in the subducting crust and mantle, providing lines of evidence for fluid and phase-transformation related embrittlement in both the crust and mantle. For the cluster in the crust, I reveal that tensional earthquakes are located 1 km above compressional earthquakes, suggesting that the shear strength of faults is too weak to response to different stress regime over a short distance. In addition, earthquakes with highly similar waveforms lie on well-defined planes with complementary rupture areas, suggestive of progressive ruptures along pre-existing fossil faults. The tensional stress is interpreted as a dimensional mismatch between crust transformed to eclogite and underlying untransformed crust. I observe a marked migration of a seismic sequence in the mantle that started with an M 4.1 event at the deepest part of the cluster. The seismic sequence continued for 6 month with upward seismicity migration by 6 km. An upward migration of overpressurized fluids reduces effective normal stress and weakens the strength of the faults sufficiently to bring the system into the brittle regime under the deviatoric stress. The permeability of the mantle is estimated to be 10^{-15}–10^{-19} m^2.

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