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Is a deep subduction channel detectable by seismic observations?

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Fluid-dynamic simulations have shown that a deep subduction channel is a feasible concept to explain the rapid exhumation of ultra-high-pressure rocks. However, it is unknown whether a subduction channel is generally developped, or only in certain areas or only during a certain period of the subduction history. To gain insight into this important geodynamic problem, information from active subduction zones would be a great step forward. The question is whether an active subduction channel can be identified by geophysical, in particular, seismological methods.

To answer this question, we have set up a 2D velocity model of the Hellenic Subduction Zone (HSZ) for which detailed structural information is available from previous work. The model represents a vertical cross section through the HSZ that strikes parallel to the subduction direction and reaches from the accretionary ridge south of Crete to the Cyclades and beyond. The model honours geometrical properties of the slab such as bending and overlying crustal structure, physical properties such as temperature and pressure and, finally, petrological properties of the rocks such as mineral composition and phase relations.

We performed numerical simulations of seismic wave propagation through this model using a 2D SPECFEM code. As source, we assume an intermediate-depth earthquake situated in the subducted oceanic crust. To study the effect of a subdution channel, a thin, wedge-shaped layer is added on top of the oceanic crust extending from 50 km to 150 km depth and consisting of eclogite blocks sitting in a serpentinite matrix. Seismic velocities of this assemblage are generally lower than those of the surrounding mantle but depend on the size spectrum and amount of the eclogite blocks. Seismic waves are generated in a frequency range from 2 to 6 Hz. Remarkably, the seismic wavefield at the surface is significantly modified by the thin channel. In particular, a new, stable, large amplitude phase appears in the forearc which is not present in the model without channel. It might be an indicator of the existence of a subduction channel which could be recorded by a dense seismic profile crossing the subduction zone.