

Geodynamic models of the Hellenic slab: implications for seismicity and stress

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The Hellenic subduction zone is characterized by slow convergence (~ 2 cm/yr), trench rollback ($\sim 1\text{--}3$ cm/yr), and a slab that extends into the lower mantle to depths of ~ 1200 km, while seismicity is confined to the upper ~ 200 km. Seismic source analysis further indicates that the stress orientation in the slab transitions from trench-parallel compression at shallow depths to down-dip compression near ~ 100 km. The aim of this work is to explain such seismicity pattern and stress distribution in the slab in terms of a long-term geodynamic evolution of the Hellenic subduction.

It has been suggested that the cessation of seismicity at ~ 200 km depth may be attributed to the presence of dry continental material within the subducting slab below this depth. To investigate this, we used 2-D geodynamic models designed in StagYY, where the incoming African plate consists of alternating oceanic and continental stripes proposed by geological reconstructions for Early Cretaceous. Intermediate-depth seismicity is typically linked to dehydration embrittlement. Therefore, only the oceanic crustal and sub-crustal material can host intermediate depth seismicity. Our model slabs show a completely dry slab below ~ 200 km, precluding dehydration related seismicity at these depths in agreement with the observed cutoff in seismicity.

While 2D models can provide a first order estimate of slab hydration and related seismicity with depth, 3D models are necessary to provide insight into the inherently 3D distribution of stress. We therefore extended our analysis to 3D regional spherical models in StagYY to explore the effects of sphericity, slab heterogeneity and differential rollback due to the presence of a weak zone in the overriding plate. The models show that the trench curvature is largely controlled by spherical geometry and along-strike variations in slab rollback, where the latter is mostly responsible for the transition from along-trench compression at shallow depths to down-dip compression below ~ 100 km, as indicated by the seismic source models.