Geophysical Research Abstracts
Vol. 13, EGU2011-6298, 2011
EGU General Assembly 2011

Slab break-off and applications to Tethys subduction

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The closure of most of the western Tethys has involved a complex history of subduction, continental collision and back-arc spreading events since the Eocene. Despite sophisticated reconstructions and high-resolution tomographic results, considerable uncertainty remains about the timing of continental collision at Italy, North-Africa, and Turkey-Iran, and the possible occurrence and dynamics of slab detachment in these areas. Here, we present 3-D, fully dynamical numerical models of oceanic subduction and continental collision, and use model results to put new, important constraints on the geodynamical evolution of this area.

Seismic tomography clearly shows stagnation of fully developed subducting slabs under most of the Mediterranean, which indicates that those slabs are largely supported by the mantle phase transition and viscosity increase across 660 km. Freely hanging slabs that are unsupported by the base of the upper mantle experience large tensile stresses, and the break-off of those slabs has been demonstrated before with numerical models. Here, we show that, even for Mediterranean slabs, for which reduced tensile stress is expected, because they rest on the base of the upper mantle, slab break-off is expected to occur. This supports slab detachment scenarios as inferred from post-collisional magmatism and tomographic studies.

Due to uncertainties in plate reconstructions and limited tomographic resolution, significant uncertainty exists on the timing of continental collision along the North-African and Turkey-Iran margins, and the possible occurrence of slab detachment in these regions. Our numerical models provide new constraints. Results indicate that slab age and strength plays a crucial role in the timing of slab break-off and the speed of a propagating slab tear. A strong, old subducting oceanic slab leads to slab break-off at 20-25 Myr after the first onset of continental collision, and subsequently a slab tear migrates more or less horizontally through the slab with a propagation speed of 100-150 mm/yr. In contrast, young or weak slabs show first break-off already 10 Myr after continental collision, and can experience tear migration rates up to 800 mm/yr. Given the old age of the subducted Neo-Tethys ocean, these results put tighter constraints on collision and break-off timing.