Geophysical Research Abstracts
Vol. 14, EGU2012-4826, 2012
EGU General Assembly 2012

Effect of fluid release on intermediate depth subduction processes: Insights from fully-coupled numerical modelling

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A wide range of geophysical/petrological data indicates that large amounts of water are released in subduction zones during the burial of oceanic lithosphere through metamorphism and associated dehydration reactions. Large volumes of aqueous fluids are expected and observed in the mantle wedge, just below the continental Moho. Recent estimates suggest that the mantle wedge is heterogeneously serpentinized (generally 20-30%). This serpentinization is believed to cause a significant weakening of the mantle wedge and therefore may critically control the depth of interplate seismogenic coupling. However, data constraining mechanisms driving deep (50-200km) fluid circulation are lacking and fluid-rock interaction processes remain weakly constrained at the km-scale. We herein propose a new fluid migration algorithm based on thermodynamic modelling (PerpleX) where fluids are free to migrate, driven by rock fluid concentration, non-lithostatic pressure gradients and deformation. Oceanic subduction is modelled using a forward visco-elasto-plastic thermomechanical code (FLAMAR algorithm) based on previous work by Yamato et al. (2007). After 15 Ma of convergence between the two plates, we show that deformation is accommodated along a low-strength shear zone in the wall of the subduction thrust interface, characterized by a weak (10-25% serp.) and relatively narrow (between 3-6km) serpentinized front/channel. Our results also show that dehydration associated with eclogitization of oceanic crust (60-75km) and serpentinite breakdown (110-130km) significantly weakens the mantle wedge at these depths, thereby favouring deep sedimentary accretion in the deep mantle wedge. We finally show that dehydration causes significant fluid overpressures in the downgoing oceanic lithosphere. These results bring new critical constraints on the location of intermediate-depth seismicity and dehydration-embrittlement processes reported by geophysical studies.