2D Numerical modelling of double subduction process

Yury Mishin, Taras Gerya, Jean-Pierre Burg
Department of Earth Sciences, ETH Zurich, Switzerland

Double subduction is a complex geodynamic process in which two plates following each other are synchronously subducted in the same direction. Double subduction episodes are characteristic for both modern and ancient plate tectonics and are, in particular, inferred in the history of the Himalayan collision zone. However, our knowledge about this process is limited by conceptual schemes and double subduction remains unexplained in terms of physical factors controlling its initiation, duration, dynamics as well as its relation to magmatic activity. We present first results on numerical simulation of double subduction process. Our current high-resolution 2D coupled geochemical-petrological-thermomechanical numerical model employs visco-plastic rheology of rocks and allows simultaneous treatment of heat, mass and water transport, metamorphic phase transformation, partial melting and melt extraction. We studied the influence of different physical factors on initiation, duration and dynamics of the process. In particular we explored the effect of varying convergence rate (0.0 – 7.0 cm/yr), age of the slab (10 – 100 Myrs), water propagation velocity (0-10 cm/yr) and dislocation creep activation volume (0.6 – 1.0 J/bar). Depending on these physical parameters (primarily on dimensionless ratio between convergence rate and water percolation velocity) numerical experiments show large variations in double subduction dynamics characterized by (i) different amount of shortening/extension in two simultaneously developing subduction zones, (ii) strong spatial and temporal oscillations of magmatic productivity (separated magmatic episodes) within two parallel volcanic arcs, and (iii) different modes of interaction of two subducting slabs (penetrating/non-penetrating) with the 660 km discontinuity. We compare numerical results with two geologically and geophysically investigated examples of double subduction: the past Karakoram and Kohistan Arcs and the active Izu-Bonin-Marianas and Ryukyu Arcs. Numerical predictions show important similarities with geological information and shed new light in interpreting the natural case stories. In particular, they allow deciphering magmatic and structural/kinematic interplays during double subduction tectonics.

Key Words: numerical modelling, double subduction, vage hydration, melt extraction