Geodynamic regimes of crustal growth at active margins: numerical modeling

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The dynamics of crustal growth under active continental margins were analyzed by using a coupled 2D petrological-thermomechanical numerical model of an oceanic-continental subduction process. This model includes spontaneous slab retreat and bending, dehydration of subducted crust, aqueous fluid transport, partial melting, melt extraction and melt emplacement in form of both extrusive volcanics and intrusive plutons. Depending on variable model parameters such as plate velocities and degree of rheological weakening induced by fluids and melts, the following three geodynamic regimes of crustal growth were identified: (i) stable subduction without plume development (ii) subduction assosiated with plume emplacement and (iii) subduction accomplished by lithosphere extension and back arc spreading. Crustal growth in a stable subduction setting results in the emplacement of flattened intrusions within the lower crust of mainly basaltic to andesitic composition. At first melts extracted from partially molten rocks located atop the slab (i.e. hydrated mantle, sediments and basalts) intrude into the lower crust followed by mantle-derived (wet peridotite) basaltic melts from the mantle wedge. Thus, extending plutons form associated with low crustal growth rates (15 km^3/km/Myrs) and a successively increasing mantle component. In a plume-present regime, crustal growth is accomplished by the formation and emplacement of silicic plumes. In the course of subduction localization and partial melting of basalts and sediments along the slab induces Rayleigh Taylor instabilities. Hence, buoyant silicic plumes are formed, composed of partially molten sediments, basalts (oceanic crust) and serpentinite. Subsequently, these plumes ascend, crosscutting the lithosphere before they finally crystallize within the upper crust in form of silicic batholiths. Additionally, basaltic intrusions within the lower crust are formed derived by partial melting of rocks

located atop the slab and inside the plume. Crustal growth rates increase with time before reaching a steady state (60km^3/km/Myrs). The mantle component of the newly produced crust decreases with time. Subduction in an extensional arc setting results in decompression melting of dry peridotite. The backward motion of the subduction zone relative to the motion of the plate leads to thinning of the overriding plate. Thus, hot and dry asthenosphere rises into the neck as the slab retreats, triggering decompression melting of dry peridotite. As a result crustal growth rates increase to values of about 100km^3/km/Myrs.