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Crustal growth in subduction zones

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There is a broad interest in understanding the physical principles leading to arc magmatisim at active continental margins and different mechanisms have been proposed to account for the composition and evolution of the continental crust. It is widely accepted that water released from the subducting plate lowers the melting temperature of the overlying mantle allowing for "flux melting" of the hydrated mantle. However, relamination of subducted crustal material to the base of the continental crust has been recently suggested to account for the growth and composition of the continental crust.

We use petrological-thermo-mechanical models of active subduction zones to demonstrate that subduction of crustal material to sublithospheric depth may result in the formation of a tectonic rock mélange composed of basalt, sediment and hydrated /serpentinized mantle. This rock mélange may evolve into a partially molten diapir at asthenospheric depth and rise through the mantle because of its intrinsic buoyancy prior to emplacement at crustal levels (relamination). This process can be episodic and long-lived, forming successive diapirs that represent multiple magma pulses. Recent laboratory experiments of Castro et al. (2013) have demonstrated that reactions between these crustal components (i.e. basalt and sediment) produce andesitic melt typical for rocks of the continental crust. However, melt derived from a composite diapir will inherit the geochemical characteristics of its source and show distinct temporal variations of radiogenic isotopes based on the proportions of basalt and sediment in the source (Vogt et al., 2013). Hence, partial melting of a composite diapir is expected to produce melt with a constant major element composition, but substantial changes in terms of radiogenic isotopes.

However, crustal growth at active continental margins may also involve accretionary processes by which new material is added to the continental crust. Oceanic plateaus and other crustal units may collide with continental margins to form collisional orogens and accreted terranes in places where oceanic lithosphere is recycled back into the mantle. We use thermomechanical-petrological models of an oceanic-continental subduction zone to analyse the dynamics of terrane accretion and its implications to arc magmatisim. It is shown that terrane accretion may result in the rapid growth of continental crust, which is in accordance with geological data on some major segments of the continental crust. Direct consequences of terrane accretion may include slab break off, subduction zone transference, structural reworking, formation of high-pressure terranes and partial melting (Vogt and Gerya., 2014), forming complex suture zones of accreted and partially molten units.

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