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Thermomechanical controls of island arc magmatism

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In order to understand physical controls of island arc magmatism we have created new generation of 2D and 3D coupled petrological-thermomechanical numerical models of subduction associated with magmatic arc development. The models include metamorphic phase transformations, spontaneous slab bending, subducted crust dehydration, aqueous fluid transport, mantle wedge melting, and melt extraction resulting in crustal growth. Numerical experiments exploring such models show many realistic features characteristic for natural arc settings: stable spontaneous one-sided subduction, mantle wedge hydration and melting, new magmatic crust formation atop the overriding plate, slab retreat associated with a backarc basin opening and new oceanic floor growth. Transitions between different tectonic regimes of subduction and associated island arc magmatism are strongly controlled by rheological weakening effects of (1) aqueous fluids propagating from the slab into the mantle wedge and (2) melts propagating from the mantle wedge toward the surface. The aqueous fluids mainly affect the forearc region controlling such processes as subduction erosion/accretion, intensity of mantle wedge hydration and partially molten plumes development. On the other hand, the extracted melts movement mainly affects the rheological properties of the lithosphere below the arc controlling necking of the overriding plate, arc extension, slab retreat and new oceanic floor development.

Composition and intensity of island arc magmatism strongly depend on the tectonic regime of subduction. Highest crustal growth rates are characteristic for retreating subduction settings which is mainly due to a large contribution from decompression melting of both hydrated and dry mantle. The rate of crustal growth also correlates positively with subduction rate and depends strongly on the slab age and intensity of melt extraction from the mantle wedge: the greatest volume of island arc crust is

formed with an intermediate melt extraction threshold (2-6 %) and medium subducted plate ages (70-100 Ma). Newly formed arc crust is predominantly composed of rocks produced by melting of hydrated and dry mantle. The contribution from melting of subducted crust is significant in cases of (1) strong subduction erosion of accreted sediments and related silicic plumes development (2) slowing/cessation of subduction associated with thermal relaxation and melting of the slab.