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Three-Dimensional Numerical Modeling of Crustal Growth at Active Continental Margins

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Active margins are important sites of new continental crust formation by magmatic processes related to subduction of oceanic plates. We investigate these phenomena by using three-dimensional coupled petrological-geochemical-thermomechanical numerical model, which combines a finite-difference flow solver with a non-diffusive marker-in-cell technique for advection (I3ELVIS code, Gerya and Yuen, 2007). The model includes mantle flow associated with the subducting plate, water release from the slab, fluid propagation that triggers partial melting at the slab surface, melt extraction and resulting volcanic crust growth on the surface. The model also accounts for variations in physical properties (mainly density and viscosity) of both fluids and rocks as a function of local conditions in temperature, pressure, deformation, nature of the rocks, and chemical exchanges. Our results show different patterns of crustal growth and topography at the surface during subduction at active continental margin comparable to nature. Often two trench-parallel lines of magmatic activity are formed on the surface which reflects two maxima of melt production atop the slab. The intensity of melt extraction influences thermal-chemical plumes forming atop the slab and thus notably modifies the crustal growth rate. We demonstrate potential applicability of our model to clustering of magmatic and seismic activity in Southern Alaska subduction zone.