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3D dynamics of hydrous thermal-chemical plumes in subduction zones

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Mantle wedges are identified as sites of intense thermal convection and thermal-chemical Rayleigh-Taylor instabilities ("cold plumes") controlling distribution and intensity of magmatic activity in subduction zones. To investigate 3D hydrous partially molten cold plumes forming in the mantle wedge in response to slab dehydration, we perform 3D petrological-thermomechanical numerical simulations of the intraoceanic one-sided subduction with spontaneously bending retreating slab characterized by weak hydrated upper interface. I3ELVIS code is used which is developed based on multigrid approach combined with marker-in-cell method with conservative finite-difference schemes. We investigated regional 800 km wide and 200 km deep 3D subduction models with variable 200 to 800 km lateral dimension along the trench using uniform numerical staggered grid with 405x101x101 nodal points and up to 50 million markers. Our results show three patterns (roll(sheet)-, zig-zag- and finger-like) of Rayleigh-Taylor instabilities can develop above the subducting slab, which are controlled by effective viscosity of partially molten rocks. Spatial and temporal periodicity of plumes correlate well with that of volcanic activity in natural intraoceanic arcs such as Japan. High laterally variable surface heat flow predicted in the arc region in response to thermal-chemical plumes activity is also consistent with natural observations.