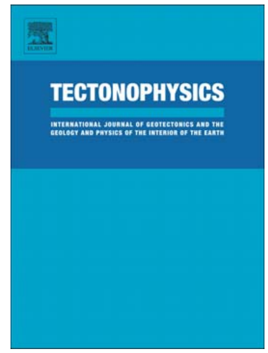

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Coupled petrological-geodynamical modeling of a compositionally heterogeneous mantle plume

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Self-consistent geodynamic modeling that includes melting is challenging as the chemistry of the source rocks continuously changes as a result of melt extraction. Here, we describe a new method to study the interaction between physical and chemical processes in an uprising heterogeneous mantle plume by combining a geodynamic code with a thermodynamic modeling approach for magma generation and evolution. We pre-computed hundreds of phase diagrams, each of them for a different chemical system. After melt is extracted, the phase diagram with the closest bulk rock chemistry to the depleted source rock is updated locally. The petrological evolution of rocks is tracked via evolving chemical compositions of source rocks and extracted melts using twelve oxide compositional parameters. As a result, a wide variety of newly generated magmatic rocks can in principle be produced from mantle rocks with different degrees of depletion. The results show that a variable geothermal gradient, the amount of extracted melt and plume excess temperature affect the magma production and chemistry by influencing decompression melting and the depletion of rocks. Decompression melting is facilitated by a shallower lithosphere-asthenosphere boundary and an increase in the amount of extracted magma is induced by a lower critical melt fraction for melt extraction and/or higher plume temperatures. Increasing critical melt fractions activates the extraction of melts triggered by decompression at a later stage and slows down the depletion process from the