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Modelling the thermal evolution of the mantle post-supercontinent formation: insulation effects and timescales

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Continental insulation during the Mesozoic may offer an explanation as to why the mantle below the African plate, a former site of continental aggregation, is hotter than normal. Numerical modelling studies have shown that the formation of a supercontinent over a mantle downwelling can initiate a reorganization of mantle convection planform, resulting in subcontinental upwellings. We examine the evolution of mantle dynamics after supercontinent accretion along a convergent plate boundary for a variety of mechanical and thermal boundary conditions to isolate the dominant aspect of continental aggregation on mantle evolution. The models feature high Rayleigh numbers, stratified viscosities and oceanic plates. Continental insulation is modelled by both varying thermal diffusivity throughout the plates (prescribing a continental region with lower conductivity than an oceanic region), and explicitly limiting continental surface heat flux relative to the heat flux through the isothermal surface of the oceanic plates. In a suite of calculations we compare the implications of modelling continental insulation using different methods. We also analyse the timescales on which plume driven supercontinental dispersal might occur for the different scenarios examined. Results from 2D and 3D numerical convection studies are presented, and show that the mechanical nature of isolating the sub-supercontinental mantle from cold downwellings is sufficient to cause a reversal in mantle flow below a supercontinent.