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Linear volcanic ridges due to small-scale convection driven by partial melting - a 3D-numerical study

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Intraplate volcanic chains unrelated to hotspots have yet been proposed to be caused by lithospheric stresses (Sandwell et al., 1995) or small-scale convective instabilities (SSC). In the Earth's uppermost mantle SSC is likely to develop due to instabilities of the thickened thermal boundary layer below the oceanic lithosphere. They are characterized by convective rolls aligning with plate motion, whose onset is earlier for higher Rayleigh numbers (e.g. hot or wet mantle), adjacent to fracture zones, or hotspot tracks. Beneath this younger and thinner lithosphere partial melt is potentially emerging in some of the upwellings (Raddick et al., 2002). Melting changes in particular the compositional buoyancy by melt retention and additional depletion of the residue, and therefore promotes upwelling and allows for further melting (Buoyant Decompression Melting).

Here we present the first results of a 3D thermo-chemical numerical mantle flow study on the interaction of SSC and BDM with a realistic, temperature-dependent rheology. We explore the crucial geologic features to trigger first melting and to initiate the above described process. We examine duration, amount and degree of melting of the BDM, and study the influence of BDM on the onset time and 3D-geometry of SSC. We vary parameters such as mode of melt extraction, plate speed, thermal and compositional Rayleigh number and initial conditions such as mantle temperatures and depletion distribution. Results suggest earlier onset for SSC, if it is powered by BDM, and reveal the conditions for this linked process. We furthermore show, that about 50 K smaller thermal anomalies are required to trigger SSC and BDM than to form partial melt statically below lithosphere.

This study thus puts additional constraints on the SSC hypothesis for intraplate vol-

canic chains.