Geophysical Research Abstracts, Vol. 9, 06458, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-06458

Intraplate volcanism due to small-scale convection - a 3D numerical study

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Some volcanic chains in the south pacific show fast and unsteady age progressions towards the East Pacific Rise (300 mm/yr) inconsistent with the plume hypothesis. They have yet been attributed to plate processes (cracking due to extension [Sandwell et al. 1995] or thermal contraction [Sandwell and Fialko 2004]) and dynamic mantle processes (return flow [Conder et al. 2002] or small-scale convective instabilities [Buck and Parmentier 1986]). The latter is supported by recent gravity studies [Harmon et al. 2006].

In the Earth's uppermost mantle small-scale convection (SSC) is likely to develop due to instabilities of the thickened thermal boundary layer below mature oceanic lithosphere (usually $\sim$70 Ma). They are characterized by convective rolls aligning with plate motion, whose onset is earlier for higher Rayleigh numbers (e.g. hot or wet mantle) and adjacent to lateral inhomogeneities, such as fracture zones or hotspot tracks. Beneath hence young ($<$ 40 Ma) and thin lithosphere partial melt is potentially emerging in the upwellings of SSC. Melting changes particularly the compositional buoyancy by melt retention and additional depletion of the residue, and therefore promotes upwelling and allows for further melting (buoyant decompression melting (BDM) [Raddick et al. 2002]). These processes allow only for a few percent of partial melting.

Here we present results of a fully thermo-chemical 3D-numerical mantle flow study on the interaction of SSC and BDM with a realistic, temperature-dependent rheology. We explore depth, duration, degree and amount of melting and melt extraction of the BDM, and study the 3D-geometry of SSC and melting. We vary parameters such as mantle temperature, plate speed, thermal and compositional Rayleigh numbers and melt extraction scheme. We compare patterns of SSC and melting with purely thermal

cases.
This study reveals, that 3D-patterns (and onset) of melting due to SSC are mainly controlled by thermal buoyancies. They are slightly modified by compositional buoyancies, latent heat of melt and melt extraction scheme. Moreover, we put constraints on the SSC hypothesis for intraplate volcanism. Positive thermal anomalies (> 100 K) would be required to trigger off-ridge melting in a static mantle (no SSC). However, we find, that a few percent of partial melt are emerging due to SSC for low mantle viscosities ($\sim 5 \times 10^{18}$ Pas) and ambient temperatures. We postulate small lateral thermal or compositional anomalies to obtain early onset of SSC locally yielding the observed patterns of volcanism (i.e. chains).

REFERENCES
Buck, W. R., and E. M. Parmentier (1986), Convection Beneath Young Oceanic Lithosphere: Implications for Thermal Structure and Gravity, J. Geophys. Res., 91(B2), 1961
Conder, J. A., D. W. Forsyth, and E. M. Parmentier (2002), Asthenospheric flow and asymmetry of the East Pacific Rise, MELT area, J. Geophys. Res., 107(B12), 2344
Harmon, N., D. W. Forsyth and D. S. Scheirer (2006), Analysis of topography and gravity in the GLIMPSE study region: compensation and uplift of the Sejourn and Hotu Matua ridge systems, J. Geophys. Res., 111(B11406)
Raddick, M. J., E. M. Parmentier, and D. S. Scheirer (2002), Buoyant decompression melting: A possible mechanism for intraplate volcanism, J. Geophys. Res., 107(B10), 2228
Sandwell, D. T., E. L. Winterer, J. Mammerickx, R. A. Duncan, M.A Lynch, D. A. Levitt, and C. L. Johnson (1995), Evidence for diffuse extension of the Pacific plate from Puka Puka and cross-grain gravity lineations, J. Geophys. Res., 100, 15078
Sandwell, D., and Y. Fialko (2004), Warping and cracking of the Pacific plate by thermal contraction, J. Geophys. Res., 109(B10411)