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Geoid from convection models with thermochemical piles (LLSVPs) and a thermodynamically consistent melting model for ULVZs

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We present geoids computed both from Cartesian and axisymmetric-spherical FEM convection models with dense thermochemical piles (Large Low Shear Velocity Provinces) in the lower mantle. We used a Rayleigh number of $5 \cdot 10^7$ and buoyancy ratio B_r of thermochemical piles of 0.8 with a temperature- and composition-dependent viscosity and a 50-fold viscosity increase in the lower mantle which was found to give LLSVPs with characteristic shape [1]. The spontaneously arising, prominent thermochemical piles exhibit a marked excess density-related positive geoid contribution.
In the future, we plan to additionally include partially molten ULVZs near the CMB into our models. To this end, we developed a thermodynamically consistent melting model for the lowermost mantle. Taking realistic density excess of high pressure mantle melt over solid mantle at lowermost mantle pressures as observed in experiments [2] and values for entropy of melting [3], the P-T-dependent melting curve of the reaction exhibits a marked negative Clapeyron slope in the lowermost mantle. For melting, we use a hypothetical eutectic melting model [4] with a maximum melt fraction of 30 % at CMB temperature consistent with seismic observations on ULVZs [5].
Using this thermodynamically consistent melting model, we investigated the formation of a dense, partially molten layer at the base of the mantle in dynamic thermal convection models. The models include latent heat related to the melt reaction, adiabatic heating/ cooling and viscous shear heating. In a parameter study, we found that whereas the maximum vertical extent of the partially molten ULVZs depends on several parameters like Rayleigh number, excess density of the partially molten ULVZ, eutectic melting temperature and entropy of melting, it is most severely restricted by the strong negative slope of the melting curve for a given excess density of the melt.

References

[1] A.K. McNamara, E.J. Garnero, S. Rost, Tracking deep mantle reservoirs with ultra-low velocity zones, Earth and Planetary Science Letters 299(2010) 1-9.
[2] J.L. Mosenfelder, P.D. Asimow, T.J. Ahrens, Thermodynamic properties of Mg2SiO4 liquid at ultra-high pressures from shock measurements to 200 GPa on forsterite and wadsleyite, Journal of Geophysical Research-Solid Earth 112(2007) -.
[3] L. Stixrude, B. Karki, Structure and freezing of MgSiO3 liquid in Earth's lower mantle, Science 310(2005) 297-299.
[4] R. Boehler, High-pressure experiments and the phase diagram of lower mantle and core materials, Reviews of Geophysics 38(2000) 221-245.
[5] Q. Williams, E.J. Garnero, Seismic evidence for partial melt at the base of Earth's mantle, Science 273(1996) 1528-1530.