Geophysical Research Abstracts
Vol. 21, EGU2019-14647, 2019
EGU General Assembly 2019

Control of mantle potential temperature on plume-lid interaction and implications for the earliest continental crust.

Andrea Piccolo (1), Richard M. Palin (2), Boris J.P. Kaus (1), and Richard W. White (3)

(1) JGU Mainz, Institute of Geosciences, Department of Chemistry, Pharmacy & Geosciences, Mainz, Germany (piccolo@uni-mainz.de), (2) Department of Geology and Geological Engineering, Colorado School of Mines, (3) School of Earth and Environmental Sciences, University of St Andrews

It is usually assumed that the Archean upper mantle was hotter than the modern-day mantle ($\Delta T_P \sim 200^{\circ}C$). Estimate span from 1400– 1600 ˚C [1][2] and featured a high variability within the same age. These discrepancies have significant implications on the dynamics of the system and on continental crust forming processes, the bulk of which was produced during Archean. The earliest continental crust is mainly formed by Tonalite-Trondhjemite-Granodiorite suites (TTGs), which is widely accepted to be the product of hydrous meta-basalt partial melting. However, there is still no consensus on the geodynamic processes that created continental crust. TTGs melts required to be generated at high pressures. These conditions could be reached in an arc-related geodynamic setting or at the bottom of an evolving oceanic plateau. It is not clear if oceanic arcs were widespread during the Archean, while there is strong evidence that oceanic plateaus were more widespread than nowadays[3]. However, the effects of different T_P on the dynamics of plume-lid interactions and on continental crust production are not explored. Since the upper mantle T_P estimations vary, we here explore the effect of different upper mantle thermal states on plume-lid dynamics. We combine state-of-the-art thermodynamic models, with the 3D numerical code LaMEM. We performed systematic 2D and 3D simulations, assuming an initial small and short-lived mantle plume (T_p=1600˚C, r=150-200 km) and explore the effect of T_p, initial lithospheric thickness and melt extraction parameters. Our results suggest that at higher T_P (>1450 ˚C) even a short-lived mantle plume can potentially trigger a large-scale delamination of the whole lithosphere, inducing an enhanced production of continental crust. Meanwhile at lower T_P, the stability of the lithosphere is a function of its initial thickness, the amount of radiogenic heating and the convective Rayleigh number of the upper mantle. In the latter scenario, the amount of continental crust produced is limited, and is mainly concentrated around the rims of the plume. In most experiments, the oceanic plateau gravitationally collapses, while the old oceanic crust is over-thrusted at its rim. There are differences between 2D and 3D experiments, particularly with respect to the pressure at which melting occurs that produces continental crust. 3D experiments feature a consistent lower pressure, while in 2D models the conditions are more variable and shifted towards higher pressures. Both 2D and 3D experiments show a decrease of $T_P$as a result of dripping, which affects the final thickness of newly generated crust. Our results show that T_P exerts a strong control on the dynamics of the system and on TTGs formation.

[1] C. T. Herzberg, K. C. Condie, and J. Korenaga, “Thermal history of the Earth and its petrological expression,” *Earth Planet. Sci. Lett.*, vol. 292, no. 1–2, pp. 79–88, 2010.

[2] S. Aulbach and N. T. Arndt, “Eclogites as palaeodynamic archives: Evidence for warm (not hot) and depleted (but heterogeneous) Archaean ambient mantle,” *Earth Planet. Sci. Lett.*, vol. 505, pp. 162–172, 2019.

[3] B. S. Kamber, “Archean mafic–ultramafic volcanic landmasses and their effect on ocean–atmosphere chemistry,” *Chem. Geol.*, vol. 274, no. 1–2, pp. 19–28, 2010.