Generation of Archean TTG rocks: Numerical simulations of thermo-compositional mantle convection

A.B. ROZEL[1], G.J. GOLABEK[2], T. GERYA[1], C. JAIN[1] AND P.J. TACKLEY[1]

[1]ETH Zürich, Sonneggstrasse 5, 8092 Zürich
[2]Bayerisches Geoinstitut, University of Bayreuth, D-95440 Bayreuth

We study the creation of primordial continental crust (TTG rocks) employing fully self-consistent numerical models of thermo-compositional convection on a global scale at the archean, after magma ocean crystallization. We solve the equations of compressible mantle convection, employing fully realistic rheological parameters [1] using the convection code StagYY [2] in 2D spherical annulus geometry for a one billion years period.

Starting from a pyrolytic bulk composition and an initially warm core, our simulations first generate mafic crust and depleted mantle in the upper mantle when the temperature exceeds the solidus temperature. In our model, the basaltic material can be both erupted (cold) and intruded (warm) at the base of the crust following a predefined partitioning. We track the PT conditions of the newly formed hydrated basalt and check if it matches the conditions necessary for the formation of TTG rocks [3]. We systematically test the influence of volcanism (eruption, also called “heat pipe”) and plutonism (intrusive magmatism) on the time-dependent geotherm in the lithosphere.

We show that the “heat-pipe” model (assuming 100% eruption and no intrusion) suggested to be the main heat loss mechanism during the Archean epoch [4] is not able to produce continental crust since it forms a too cold and thick lithosphere. We show that an intrusion fraction higher than 60% (in agreement with [5]) combined with a friction coefficient greater than 0.1 can product the expected amount of the three main petrological TTG compositions previously reported [3].

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