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The influence of mantle refertilisation on the formation of TTGs in a plume-lid tectonics setting

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Higher amounts of radiogenic elements and leftover primordial heat in the early Earth both contribute to the increased temperature in the Earth's interior and it is mainly this increased mantle potential temperature that controls the dynamics of the crust and upper mantle and the predominant style of tectonics in the Early Earth. The increased upper mantle temperature precludes the modern plate tectonics regime and stabilizes another type of global tectonics often called plume-lid tectonics [1] or "plutonic squishy lid" tectonics [2].

Plume-lid tectonics is dominated by intrusive mantle-derived magmatism which results in a thickening of the overlaying crust. The overthickened basaltic crust is transformed into eclogite and episodically recycled back into the mantle. Melt extraction from hydrated partially molten basaltic crust leads to the production of primordial tonalite–trondhjemite–granodiorite (TTG) continental crust. TTGs make up over half of the Archean crust and can be classified into low-, medium- and high-pressure types [3]. Field studies show that the three different types (low-, medium- and high-pressure) appear in a ratio of 20%, 60% and 20% [3]. Numerical models of plume-lid tectonics generally agree very well with these values but also show that the ratio between the three different TTG types varies greatly during the two different phases of the plume-lid tectonics cycle: growth phase and overturn phase [2].

Melt productivity of the mantle decreases rapidly after removal of the garnet and clinopyroxene components. Addition of new garnet and clinopyroxene-rich material into the harzburgitic residue should lead to a refertilised lherzolite which could potentially yield new melt [4]. Mixing of eclogite drips back into the mantle can lead to the geochemical refertilisation of already depleted mantle and allow for further extraction of melt [4].

We will explore this process of mantle refertilisation in our 3D petrological-magmatic-thermomechanical numerical modelling experiments and study its influence on the three types of TTGs during different phases of the plume-lid tectonics cycle.

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