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CRUSTAL FORMATION AND RECYCLING IN AN OCEANIC ENVIRONMENT IN THE EARLY EARTH

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Several lines of evidence indicate higher mantle temperatures (by some hundreds of degrees) during the early history of the Earth. Due to the strong effect of temperature on viscosity as well as on the degree of melting, this enforces a geodynamic regime which is different from the present plate tectonics, and in which smaller scale processes play a more important role. Upwelling of a hotter mantle produces a thicker oceanic crust, of which the lower part may reside in the eclogite stability field. This facilitates delamination, making room for fresh mantle material which may partly melt and add new material to the crust (Vlaar et al., 1994).

We present results of numerical thermo-chemical convection models including a simple approximate melt segregation mechanism in which we investigate this alternative geodynamic regime, and its effect on the cooling history and chemical evolution of the mantle.

Our results show that the mechanism is capable of working on two scales. On a small scale, involving the lower boundary of the crust, delaminations and downward transport of eclogite into the upper mantle takes place. On a larger scale, involving the entire crustal column, (parts of) the crust may episodically sink into the mantle and be replaced by a fresh crust.

Both are capable of significantly and rapidly cooling a hot upper mantle by driving partial melting and thus the generation of new crust. After some hundreds of millions of years, as the temperature drops, the mechanism shuts itself off, and the cooling rate significantly decreases.

Vlaar, N.J., P.E. van Keken and A.P. van den Berg (1994), Cooling of the Earth in the Archaean: consequences of pressure-release melting in a hotter mantle, Earth and Planetary Science Letters, vol 121, pp. 1-18