Early differentiation of silicate reservoirs in the Earth

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If the Earth was molten at an early stage, as suggested by numerous models for terrestrial accretion, then its crystallization should have resulted in a chemical differentiation of the mantle. The latest largest impact which is likely to have produced a molten mantle is dated approximately at 50 Ma based on ^{182}Hf-^{182}W and Pb-Pb systematics. Thus, the age of mantle differentiation should be posterior to this event.
We have used ^{146}Sm-^{142}Nd systematics ($T_{1/2}$ = 103 Ma) can provide precise age constraints on the differentiation of the Hadean Earth. Remarkably, present-day terrestrial rocks do not show any anomalies in ^{142}Nd (with the precision allowing the detection of such anomalies), suggesting that the present-day mantle does not bear such chemical heterogeneities. In contrast, early archean rocks from Western Greenland show significant and resolvable ^{142}Nd anomalies, indicating that the mantle has been depleted around 4.46±0.11 Ga. Surprisingly, Lu-Hf systematics for the same samples show no evidence for fractionation. These combined observations can be reconciled by a model of crystallization of a magma ocean from bottom to top.
New mineral-melt partitioning data allow for the first time a rigorous test of such a model based on combined Sm-Nd and Lu-Hf systematics of early Archean rocks. Our calculations show that the data can be explained by the segregration of a 10 km thick crust during crystallization of the magma ocean. This hadean crust must have now been remixed in the mantle and the effect of this early differentiation on chemical heterogeneities in the present-day mantle will be discussed at the meeting.