Mantle dynamics in the Hadean : Earth and Mars

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The initial thermal state of the Earth differed from the present-day one, due to energy release from accretion and enhanced radioactive production. Extinct (^{146}Sm-^{142}Nd, $T_{1/2}$ = 103 Ma [1,2]) and extant (^{146}Sm-^{142}Nd, $T_{1/2}$ = 106 Ga; ^{176}Lu-^{176}Hf, $T_{1/2}$ = 37 Ga [3]) radioactive systems indicate major silicate differentiation within the first 200 Ma. Xenon isotopes have evolved by the decay of ^{129}I to ^{129}Xe ($T_{1/2}$ = 16 Ma) and by fission of ^{244}Pu ($T_{1/2}$ = 82 Ma) and ^{238}U ($T_{1/2}$ = 4.45 Ga) Ga to $^{131\text{-}136}Xe_f$. New data for mantle plume samples [4] together with litterature data for MORB [5] indicate that : (i) the fist 100 Ma were characterized by massive loss of gases from the mantle, consistent with large-scale magmatism during magma ocean episodes; (ii) whole mantle convection prevailed in the Hadean, so that isolation between a MORB-like mantle and a plume reservoir must have occurred later on, consistent with a recent model based on He isotopes [6]; (iii) atmospheric escape took place for about 200 Ma. During the Hadean, mantle convection was one order of magnitude more active than during the rest of the Earth's history. This activity might have slowed down abruptally by the end of this period. Mars, as sampled by Martian meteorites, contains also xenon from the decay of ^{129}I and from the fissions of ^{244}Pu and of ^{238}U [7]. After correction for the U contribution to fissiogenic Xe (refs. [4,5] for the Earth and and [7] for Mars), Mars and Earth have apparently comparable $^{129}I/^{244}Pu$ ratios that are both much lower than the chondritic value. This observation suggests that these two planets had comparable magmatic histories during the first 100 Ma, despite drastic differences in impact histories and sizes, and highlight the role of ocean magmas during this period of time. However, Mars retained much more fission Xe from ^{244}Pu than the Earth, thus Mars did not experience the intensive convection regime that characterized the Hadean Earth.

References

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