Xenon constraints on the thermal history of the Earth

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There is still a controversy over the thermal evolution of the Earth and particularly about its early history. The evidence of a hotter mantle in the Archean comes mostly from the relative abundance of the magnesian lavas (komatiites) within the old cratons. But the thermodynamic conditions needed to generate them are disputed such that the proposed cooling since the Archean lies between 100 to 500K [1]. Furthermore first principle models of thermal history have difficulties avoiding unrealistically high cooling rates and thermal catastrophe [2,3], leading several authors to reconsider the sensitivity of heat flow parameterizations to mantle temperature [4]. As a consequence, further approaches are needed to better understand early Earth geodynamics and the onset of plate tectonics. In this study, we show how the isotopic Xenon signature of mantle rocks can constrain the thermal and degassing histories of the mantle. To account for the present day Xenon data, the mantle must have cooled very efficiently within the first 700m.y. before cooling at a slow modern rate through plate tectonics. We predict that the mantle has been partially melted about 8 times since its formation, 6 times during the Hadean alone when magmatic heat loss was dominant.

References

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