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Iron isotope fractionation at high pressures: implication for core formation models

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Iron oxidation and reduction as well as phase and chemical transformations of iron bearing minerals are the primary chemical content of core formation processes. Iron stable isotope fractionation has much potentials for yielding information about temperatures, pressures and conditions of Earth's core formation. For this reason, careful studies and calibrations of iron stable isotope fractionations at high pressures may provide a deep insight into mechanisms of core segregation in the Earth and planetary body interiors. A method for determination of equilibrium iron isotope fractionation factors (beta-factors) at wide range of pressures (from ambient to ~ 150 GPa) was recently established [1 -3]. The method consists in obtaining ^{57}Fe partial vibration densities of states (PVDOS) at different pressures from synchrotron inelastic nuclear resonance x-ray scattering (INRXS) experiments followed by calculations of iron beta-factors from the ^{57}Fe PVDOS.
Using INRXS-derived ^{57}Fe PVDOS of Fe-metal [4], ferropericlase (FeP) [5], and postperovskite (PPV) [6], it was shown [3] that at high pressures FeP and PPV are enriched in heavy iron isotopes relative to Fe-metal contrary to low-pressure iron isotope fractionation regularity asserting that Fe-metal is enriched in heavy iron isotopes relative to ferrous compounds in equilibrium [7].
Along with iron, Earth's core may contain also Ni, Si, S, H, C, etc. according to modern models. We estimated effect of these elements on iron beta-factors using INRXS-derived ^{57}Fe PVDOS for $Fe_{0.92}Ni_{0.08}$and $Fe_{0.85}Si_{0.15}$[8], FeS [9], Fe_3S [10], FeHx [11], Fe_3C [12]. Additions of Ni and Si to Fe-metal do not affect the iron beta-factor. On the contrary, additions of S, H, and C reduce the iron beta-factors and aid in heavy iron isotope enrichment of silicate fraction during metal-silicate equilibrium differentiation.
Equilibrium iron isotope fractionation during Earth's core formation results in enrichment of silicate portion of the Earth in heavy iron isotopes. This may explain the observed enrichment (about 0.1 per mille for ^{57}Fe/^{54}Fe) of Earth's basalts in heavy isotopes with respect to those from Vesta and Mars [13 -15], in which cores were formed at relatively low pressures.
Presented results support the homogeneous equilibrium accretion model of Earth's core formation [16 -17]. According to this model, all incoming metal first equilibrates with mantle. The equilibration process occurs at pressures of more than 30GPa. Enrichment of lunar basalts in heavy iron isotope agrees with the equilibrium accretion model, since Earth's core was mainly segregated before the Moon-forming giant impact according this model.
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References.
1. V.B. Polyakov et al., Geochim. Cosmochim. Acta v. 69, 5531-5536, (2005)
2. V.B. Polyakov et al., Geochim. Cosmochim. Acta v. 71, 3833-3846, (2007)
3. V.B. Polyakov, Science v. 323, 912-914, (2009)
4. H.K. Mao et al., Science v. 292, 914-916, (2001)
5. J.-F. Lin, Geophys. Res. Lett.v. 33, L22304, (2006)
6. W.L. Mao, et al., Science v. 312, 564-565, (2006)

7. V.B. Polyakov, S.D.Mineev, Geochim. Cosmochim Acta v. 64, 849-865, (2000)
8. J.-F. Lin et al., Geophys. Res. Lett. v. 30, 2112, (2003)
9. H. Kobayashi et al., Phys. Rev. Lett., v. 93, 195503, (2004)
10. J.-F. Lin et al., Earth Planet. Sci. Lett., v. 226, 33-40, (2004)
11. W. L. Mao et al. Geophys. Res. Lett. v. 31, L15618, (2004)
12. L. Gao et al. Geophys. Res. Lett. v. 35, L17306, (2008)
13. F. Poitrasson et al., Earth Planet. Sci. Lett. v. 223, 253-266, (2004).
14. S. Weyer et al., Earth Planet. Sci. Lett. v. 240, 251-264 (2005)
15. R. Schoenberg, F. von Blanckenburg, Earth and Planet. Sci. Lett. v. 252, 342-359, (2006)
16. B.J. Wood, Philos. Trans. R. Soc. A v. 366, 4339, (2008)
17. A.N. Halliday, B.J. Wood, Science v. 325, 44-45, (2009)

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