The influence of local cation-distribution on the magnetic properties in ilmenite-rich α-Fe_2O_3-$FeTiO_3$ systems

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The ilmenite-hematite ($xFeTiO_3$ – $(1\text{-}x)Fe_2O_3$) system has attracted significant attention because of its complex magnetic properties. Both ilmenite ($FeTiO_3$) and hematite (α-Fe_2O_3) are antiferromagnetic, but intermediate compositions can be strongly ferrimagnetic [1] and finely exsolved structures of hematite and ilmenite are found to have a magnetization larger than expected [2].The system is of significant interest as a source of natural remnant magnetism on the Earth, the Moon and Mars [2].

Here, we compile some recent Mössbauer studies of ilmenite-rich samples with different degree of local Fe^{3+}-ordering, ranging from a disordered cation distribution in a ball milled ilmenite [3], to Fe^{3+} in nanometer-sized hematite clusters in rapidly cooled ilmenite-rich samples [4], to nano- to micrometer-sized hematite lamellae exsolved in a slowly cooled natural sample of hemoilmenite [5]. We discuss the influence of the local cation ordering on the magnetic properties of the ($xFeTiO_3$ – $(1\text{-}x)Fe_2O_3$) system.

In the ball milled ilmenite-rich sample, the cations are disordered, and this has a large influence on the magnetic hyperfine interaction, but the Néel temperature is essentially not affected [3]. Nanometer-sized hematite clusters within an ilmenite-like matrix of rapidly-cooled samples show ferrimagnetic behaviour due to superexchange coupling with Fe^{2+} in ilmenite [4]. In the natural sample, high-field Mössbauer measurements indicate the presence of a minor ferrimagnetic hematite component [5].

[1]T. Nagate (1953), *Nature* **172**, 850. [2] P. Robinson, R.J. Harrison, S.A. McEnroe, and R.B. Hargraves (2002), *Nature* **418**, 517. [3] S. Mørup, H. K. Rasmussen, and C. Frandsen, in preparation.[4] C. Frandsen, B.P. Burton, H.K. Rasmussen, S.A. McEnroe, and S. Mørup (2010), *Phys. Rev. B* **81**, 224423. [5] C. Frandsen, S. Mørup, S.A. McEnroe, P. Robinson, and F. Langenhorst (2007), *Geophys. Res. Lett.* **34**, L07306.

Secular depletions in highly siderophile elements recorded in >3.6 Ga komatiites

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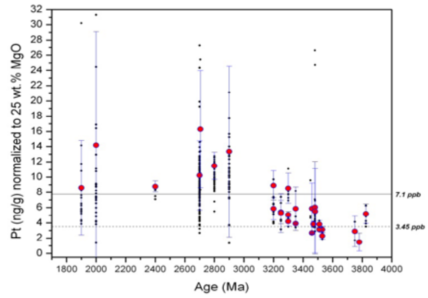
Plume-derived extrusive ultramafic rocks of peridotitic composition (komatiites) - and their metamorphic equivalents - can be used to probe changes in highly siderophile element (HSE) abundances for the komatiite source (mid- to lower mantle). These rocks appear to show a time-dependent depletion trend (see figure) in HSE abundances from Neoarchean to Paleoarchean samples [1]. In the figure, the solid line denotes the modern peridotite Pt concentration, while the dashed line shows the mean abundance for the oldest three analyzed komatiites.

HSEs should have strongly partitioned into the core during differentiation, but they show a higher than expected mantle abundances. This conundrum has led to the proposal that a "Late Veneer" (LV) delivered ~1% of Earth's mass after core closure [2], although this explanation is contested [3, cf. 4]. Recent modeling [5] shows that it is dynamically feasible for a ~2700-km diameter impactor to have delivered 1% of Earth's current mass as an LV after the Moon-forming impact. Assuming CI compositions, such an event is enough to explain the observed HSE enhancement. Some evidence also exists for LVs on the Moon and Mars in lunar basalts and SNC meteorites [6, 7]. While Mars' abundances are roughly equivalent to Earth's, the Moon is apparently ~1000× less enhanced for uncertain reasons.

We report new data from >3.6 Ga komatiitic rocks that exhibit a low HSE abundance. If Earth experienced an LV, it likely occurred between Moon formation and solidification of the first continental crust (pre-4.4. Ga). We postulate that the LV polluted the upper mantle with suspended platinoid elements that became progressively mixed. Additional samples in the data gap between 2.9 and 3.2 Ga will be measured for their HSE abundance to determine whether they too follow the postulated mixing trend.



[1] Maier *et al.* (2009) *Nature* **460**, 620-623. [2] Chou (1978) *Proc. Lunar Planet. Sci. Conf.* IX, 219–230. [3] Righter *et al.* (2008) *Nature Geoscience* **1**, 321-323. [4] Holzheid *et al.* (2000) *Nature* **406**, 396-399. [5] Bottke *et al.* (2010) *Science* **330**, 1527-1530. [6] Day *et al.* (2007) *Science* **315**, 217. [7] Jones *et al.* (2003) *Chem. Geol.* **196**, 21.