

Experimental comparison of abiotic and microbial Fe-mineral transformations to identify pathways of magnetic nanoparticle production during pedogenesis

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We present results from an on-going interdisciplinary experimental study of possible pathways for producing Fe-oxide nanoparticles during pedogenesis of loess-derived soils. The phenomenon of magnetic enhancement in many soil types has been recognized for several years, but the question of whether the enhancement process is primarily driven by microbial activity or abiotic processes is still unresolved. Bioreduction experiments were carried out using the dissimilatory Fe-reducing bacteria *Shewanella putrefaciens* with synthetic nanoparticle preparations of Fe-oxides and oxyhydroxides including goethite, lepidocrocite, ferrihydrite and maghemite. The products of bioreduction are compared with abiotic alteration experiments to examine heating-induced dehydration and redox reactions. Bacterially-mediated re-mineralization of precursor phases produces characteristic high-purity, highly-crystalline euhedral Fe-oxides. Heating-induced dehydration of nanogoethite and lepidocrocite produces topotactic reactions which form pseudo-morphed hematite and maghemite respectively, with distinctive nanostructures containing high concentrations of crystalline defects. However, reduction-heating of dehydrated nanogoethite produces Fe-oxide with non-unique magnetic signatures and morphology that obscure the inorganic origin of the mineral product. The magnetic properties, microstructure, and morphology of the reaction products were characterized with a combination of low-temperature magnetic remanence and susceptibility, high-resolution TEM microscopy, and x-ray diffraction. This study is working toward the identification of magnetic and non-magnetic biosignatures in Fe-oxides that may help elucidate the origins of magnetic minerals in a number of environments, including soils and terrestrial sediments in addition to other planetary settings.

The nature of pyroxenite xenoliths of mantle wedge beneath the Avacha volcano (Kamchatka, Russia)

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Bulk-rock composition determined by XRF for peridotite xenoliths of Avacha volcano shows variations in petrogenic components (in wt.%): SiO₂ (40.5-47), TiO₂ (0.01-0.07), Cr₂O₃ (0.25-1.9), Al₂O₃ (0.3-1.8), MgO (42-48.2), FeO (7.6-10.4), MnO (0.11-0.15), NiO (0.25-0.33), CaO (0.35-1.4), Na₂O (0.1-0.15), K₂O (0.02-0.06). Pyroxenite xenoliths are divided into two groups: orthopyroxenites and clinopyroxenites. In comparison with the harzburgite xenoliths clinopyroxenites are characterized by lower of MgO (17-20.3), NiO (~0.02), Cr₂O₃ (0.12-0.3) contents and by higher SiO₂ (48.6-51), TiO₂ (0.2-0.45), Al₂O₃ (2.6-4.9), CaO (17.3-19) and Na₂O (0.4-0.85) (in wt.%). The bulk-rock composition of orthopyroxenite xenoliths (in wt.) is: SiO₂ (49-54.8), Cr₂O₃ (0.3-1.2), TiO₂ (0.03-0.12), Al₂O₃ (1.2-2.8), MgO (26.6-34.5), FeO (4.7-10) and CaO (1.4-8.5), NiO (0.08-0.15), Na₂O (0.1-0.4). The chemical compositions of peridotitic and pyroxenitic minerals and their primary melt and syngenetic fluid inclusions were described in [1-2].

According to ICP-MS data primary peridotite xenoliths are extremely depleted. Metasomatized peridotite xenoliths, which contain newly formed clinopyroxene, amphibole and sometimes interstitial silicate glasses, differ from primary harzburgites by higher REE contents. Orthopyroxenites have smooth patterns with depletion in LREE ([La/Yb]_n – 0.3-0.7). Clinopyroxenites are the most enriched in trace elements compared to other ultramafic xenoliths ([REE/C₁]_n – 2-5). Their patterns are characterized by high MREE/HREE ([Sm/Yb]_n – 1.5-2.1).

Orthopyroxenites can be considered as derivatives of the metasomatized harzburgites due to their similar bulk-rock composition and features of changes in the mineral composition. Clinopyroxenite xenoliths were formed probably as a result of metasomatic transformation and melting of mantle lherzolites, but not of harzburgites of mantle wedge beneath Avacha volcano.

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[1] Timina *et al.* (2012) *Dokl Earth Sci* **442**, 115-119. [2] Timina *et al.* (2012) *TBG-XV Abst Volume*, 141-142.