Iron Oxides in a Soil Developed from Basalt

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Abstract: A dusky red Oxisol forming on a tholeiitic basalt is found to contain varying proportion of aluminous hematite (Hm) and titanoaluminous maghemite (Mh) in the different size fractions. Maghemite is the main iron oxide in the sand and silt fractions whereas Hm is dominant in the clay fraction, together with gibbsite (Gb), kaolinite (Ka), rutile (Rt) (and probably anatase, An) and Mh. Maghemite is also the major oxide mineral in the magnetic separates of soil fractions (sand, about 65% of the relative Mössbauer spectral area; silt, 60%). Hematite (sand, 30%; silt, 15%) and ilmenite (Im) (sand, 5%; silt, 16%) are also significantly present in the magnetic extract. Accessory minerals are Rt and An. No magnetite (Mt) was detected in any soil fraction. Sand- and silt-size Mh have similar nature (a_0 = 0.8319 ± 0.0005 nm; about 8 mol% of Al substitution; saturation magnetization of 49 J T^{-1} kg^{-1}), and certainly a common origin. Lattice parameters of clay-Mh are more difficult to deduce, as magnetic separation was ineffective in removing nonmagnetic phases. Al content in Hm varies from 14 mol% (clay and silt) to 20 mol% (sand). The proposed cation distribution on the spinel sites of the sand-size Mh is: $[Fe_{0.92}Al_{0.08}]\{Fe_{1.43}Ti_{0.18}\square_{0.39}\}O_4$ ($\square$ = vacancy, [ ] = tetrahedral sites and { } = octahedral sites), with a corresponding molar mass of 208.8 g mol^{-1}. The predicted magnetization based on this formula is $\sigma \cong 68$ J T^{-1} kg^{-1}, assuming collinear spin arrangement. The large discrepancy with the experimentally determined magnetization is discussed.

Key Words: Hematite • Ilmenite • Maghemite • Magnetic Fraction • Mössbauer • Spinel

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