

Luogufengite: A new nano-mineral of Fe₂O₃ polymorph with giant coercive field

HUIFANG XU^{1,*}, SEUNGYEOL LEE¹, AND HONGWU XU²

¹NASA Astrobiology Institute, Department of Geoscience, University of Wisconsin-Madison, Madison, Wisconsin 53706, U.S.A.

²Earth and Environmental Sciences Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, U.S.A.

ABSTRACT

Luogufengite, Al-bearing ϵ -Fe₂O₃, is a new member of Fe₂O₃ polymorphs discovered in late Pleistocene basaltic scoria from the Menan Volcanic Complex nearby Rexburg, Idaho. It is an oxidation product of Fe-bearing basaltic glass at high temperature and is associated with maghemite and hematite. Luogufengite is an euhedral or semi-euhedral nano-mineral with its crystal size ranging from ~20 to ~120 nm. The mineral has a space group of *Pna*2₁; its unit-cell parameters refined from synchrotron X-ray powder diffraction pattern are $a = 5.0647(3)$, $b = 8.7131(6)$, $c = 9.3842(5)$ Å, and $Z = 4$ (calculated density = 4.905 g/cm³) with the doubled hexagonal (ABAC) packing of oxygen atoms. The eight strongest lines of the measured X-ray diffraction pattern [$d(\text{Å})/I(hkl)$] are: 3.197(27.3)(022); 2.945(29.1)(013); 2.708(100)(122); 2.437(35.8)(131); 1.716(24.4)(204); 1.507(40.7)(135); and 1.458(37.2)(330). The empirical formula is Fe_{1.71}Al_{0.24}Mg_{0.02}Ti_{0.03}O₃. The crystals display (110) twins with twin boundaries of (110), (100), and (130) due to their pseudo-hexagonal symmetry. Luogufengite is an important mineral that records paleomagnetism of volcanic rocks because of its large magnetic coercivity. This unique magnetic property of the mineral may explain the observed unusually high-remanent magnetization in some igneous and metamorphic rocks and even martian rocks with high-remanent magnetization. Some intergrowths of magnetite with ilmenite exsolution lamellae or hematite with magnetite lamellar precipitates have luogufengite-like 2D crystalline characteristics with the doubled hexagonal packing at the interface between cubic and rhombohedral structures. Luogufengite-like nano-domains at the magnetite/hematite interfaces might be responsible for the large coercive field of lodestones that are partially oxidized magnetite with hematite micro-precipitates.

Keywords: Luogufengite, hematite, maghemite, scoria, nano-mineral, remanent magnetization, coercive field, lodestone