American Mineralogist, Volume 83, pages 786–793, 1998

The influence of iron substitution on the magnetic properties of hausmannite, $Mn^{2+}(Fe,Mn)_2^{3+}O_4$

V. Baron,[1,*] J. Gutzmer,[2] H. Rundlöf,[3] and R. Tellgren[3]

[1]The Studsvik Neutron Research Laboratory, S-611 82 Nyköping, Sweden
[2]Department of Geology, Rand Afrikaans University, P.O. Box 524, Auckland Park 2006, Johannesburg, South Africa
[3]Inorganic Chemistry, Ångström Laboratory, Uppsala University, Box 538, S-751 21 Uppsala, Sweden

Abstract

The occurrence of hausmannite with an apparent Curie temperature close to 750 K, instead of 41.8 K was recently described from hydrothermally altered manganese ore from the Kalahari manganese field, South Africa. The unusual magnetic properties were related to the substitution of Fe^{3+} for Mn in the hausmannite structure. Because of the large differences in the scattering lengths of Fe and Mn, $b_{Fe} = 9.94$ and $b_{Mn} = -3.73$ fm, respectively, we performed neutron powder diffraction experiments at 295 and 10 K on natural mineral separates and synthetic compounds to determine the influence of the Fe substitution on the crystal structure and the magnetic properties of the hausmannite. Rietveld refinements of synthetic Fe-rich hausmannite neutron powder diffraction patterns at 295, 60, and 10 K indicate some significant and interesting changes of magnetic properties and crystal structure of hausmannite, which are directly linked to an increasing amount of iron substituting for manganese. The unit-cell parameters of $Mn_{3-x}Fe_xO_4$, in particular, illustrate decreasing Jahn-Teller distortion with increasing Fe content, whereas the Curie temperature was found to increase significantly with increasing Fe content. Nevertheless, this study indicates that the presence of Fe-rich hausmannite causes the unusual high-temperature ferrimagnetic behavior in the Kalahari manganese field.