Magnetic transition in (Mg,Fe)O

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It is believed that (Mg,Fe)O with B1 (rock salt) structure is the second major constituent in the Earth‘s lower mantle. While periclase has no phase transition experimentally studied so far, wustite distorts to a rhombohedral structure above 16 GPa at 300K (Zou et al., 1980), probably because of antiferromagnetic (AFM) ordering (Smart and Greenwald, 1951). The relationship between magnetic and structural change is important to understand fundamental behavior of iron-bearing mineral. In this study, we have investigated the compositional dependence of the Neel temperature at room pressure to study the origin of the rhombohedral distortion at high pressure.

The (Mg_{1-X},Fe_X)O with variable Fe contents were synthesized from oxide mixtures of Fe_2O_3 and MgO in a gas furnace at 1473 K for 12 hours under the controlled oxygen fugacity. The sintered samples were identified using SEM-EDS and also powder X-ray diffraction method. Each sample was confirmed to be a single phase with a B1 structure and chemically homogenous with the initial composition within the error. The powdered samples were encapsulated in nonmagnetic nongelatin capsule.

We measured magnetization at every 5 K in the temperature range between 5 and 300 K, using Superconducting Quantum Interference Device (SQUID) (Quantum design, MPMSR-7) at constant magnetic field of 1000 G.

The Neel temperature in each composition was determined as the maximum value of magnetization in the obtained M-T relation. The Neel temperature increases with increasing Fe content. The magnetic phase boundary has a clear cusp at around X=0.5 at 55 K, which was different interpretation from the previous study (80 K) by Moessbauer, in which a linear relation was suggested (Speziale at al., 2005). The cusp may imply the magnetic structural should change around X=0.5.

If the pressure of the magnetic transition coincides with the structural transition, the structural phase boundary of (Mg_{1-X},Fe_X)O shifts to higher pressure with Mg content compared to pure wustite. Considering all results, (Mg,Fe)O is expected to be paramagnetic state with B1 structure in the lower mantle condition.

However, ($Mg_{0.2}$,$Fe_{0.8}$)O transforms to rhombohedral structure in the same pressure as FeO at room temperature (Kondo et al.,2004). On the other hand, ($Mg_{0.4}$,$Fe_{0.6}$)O reported to be stable in the B1 structure up to 98 GPa and 300 K (Jung-Fu Lin et al.,2002). Therefore, the gradient of the structural phase boundary looks to be dT/dP=2.2(1) at a maximum, which is extremely smaller than that of FeO (dT/dP=14.3) (Fei and Mao, 1994).