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Effect of iron content on spin transition pressure of ferropericlase

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The pressure-induced electronic spin transition of iron in ferropericlase, which is thought to be the second abundant mineral in the lower mantle, has been theoretically predicted. In fact, enormous evidence for spin paring transition of iron from high-spin (HS) to low-spin (LS) states in ferropericlase have been confirmed using various ways.Pressure at which the HS-LS transition occurs would depend on the iron content in ferropericlase. Fei et al. (2007) suggested that the spin transition pressure decreases with decreasing iron content in ferropericlase based on the P-V relation. When the iron content in ferropericlase is low, it becomes more difficult to detect the spin transition because of weak signal from the electronic state of iron. Lin et al. (2007a) and Ohta et al. (2007) measured electrical conductivity of the ferropericlase using diamond anvil cell (DAC) to pressures over 100 GPa. The electrical conductivity gradually increases by an order of magnitude up to 50 GPa but decreases by a factor of approximately three between 50 to 70 GPa. This decrease in the electrical conductivity has been interpreted by the isosymmetric HS to LS transition of iron in ferropericlase. The electronic spin transition of iron would result in a decrease in the mobility and/or density of the charge transfer carriers in the low-spin ferropericlase. Therefore, electrical conductivity measurement would be a powerful tool to detect the spin transition pressure of ferro-periclase as a function of iron content.
The starting materials were sintered aggregate of ferropericlase with a various amount of iron content ($x = 0.07, 0.10, 0.13, 0.17, 0.24$). Firstly the starting powder was synthesized from Mg and Fe metals by the sol-gel method. Then the ferropericlase was synthesized from the gel at 167 3 K for a few hours with a CO2 and H2 gas mixture to control just above the IW buffer. The powder was placed in Mo capsule and was sintered at 1 GPa and 1273 K for an hour in a piston cylinder apparatus.
The high pressures and high temperatures were generated using a Kawai-type multianvil apparatus with a DIA-type guide block system installed at the SPring-8 (SPEED mkII). We used sintered diamond cubes with an edge length of 14 mm as a second stage anvil. The anvil truncation was 1.5 mm. The generated pressures were calibrated by in situ X-ray diffraction with the Au pressure scale (Anderson et al., 1989). Electrical conductivity was measured by means of a 2-wire method with alternating current signal with an amplitude of 1V and a frequency range of 0. 1-1 Hz. The samples were once heated to 500 or 600 K and cooled to room temperature while measuring the conductivity.
The electrical conductivity of ferropericlase with various iron content at 500 K was measured as a function of pressure. At lower pressures, the electrical conductivity of all ferropericlase samples increases with increasing pressure. Both activation energy and activation volume of ferropericlase decrease with increasing iron content. For the ferropericlase with higher iron content ($x = 0.17$ and 0.24), the electrical conductivity monotonically increases with pressure up to 38 and 52 GPa, respectively. For the ferropericlase with lower iron content ($x = 0.07$ and 0.10), the electrical conductivity once slightly decreases or becomes constant with increasing pressure. Further increase in pressure lead to an increase of electrical conductivity. This trend is consistent with those of electrical conductivity of ferropericlase through the HS-LS transition measured at room temperature in the DAC (Ohta et al, 2007; Lin et al., 2007b). If these changes in the electrical

conductivity are attributed to the isosymmetric high to low spin transition of iron in ferropericlase, this conductivity change suggests that the spin transition pressure would decrease with decreasing iron content in ferropericlase.

Keywords: spin transition, ferro-periclase, electrical conductivity, pressure, iron