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Research Advances

Status of Silicon in Magnetite

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Objective

Magnetite occurs widely from hydrothermal to magmatic rocks, which has inverse spinel structure. As known for long time, it carries some foreign matters, such as Al and Ti, even silicon. Silicon and iron are quite different, either from the ionic radii or electronic obtain ability. However, both electron microprobe data and wet chemical methods analysis show that magnetite contains certain amount of silicon. Whether the silicon is similar to Al, Mg and Ti, entering into the magnetite lattice, is not clear. In addition, isomorphism would occur in both tetrahedron and octahedron in magnetite, replacing the Fe^{3+} and Fe^{2+}. For example, previous study show the Ti^{4+} mostly replaces Fe^{3+} in octahedron. We do not know whether silicon has a similar behavior with titanium because Si^{4+} ion radius is much smaller than Ti^{4+}. Some studies have shown that the silicon content in magnetite may relate to diagenetic environment. In a hydrothermal environment, silicon content in magnetite may up to 6.19wt%, whereas in magmatic ones, it seems that silicon content mostly under detection limit of mirocprobe. The aim of this study is to identify the status of silicon in magnetite and decipher the relations between silicon content and diagenetic environments.

Methods

The Yamansu iron deposit in Xinjiang Province was chosen as the study target, where massive garnet layer and late stage skarn minerals developed extensively. This work conducted detail study on the Yamansu skarn-type magnetite by electron microprobe, scanning electron microscope, transmission electron microscope, X-ray diffraction, Raman spectra and Mossbauer spectrum techniques. Artificial synthetic magnetite in hydrothermal circumstances was also involved. It is noteworthy that a few other hydrothermal iron deposits were also studied in

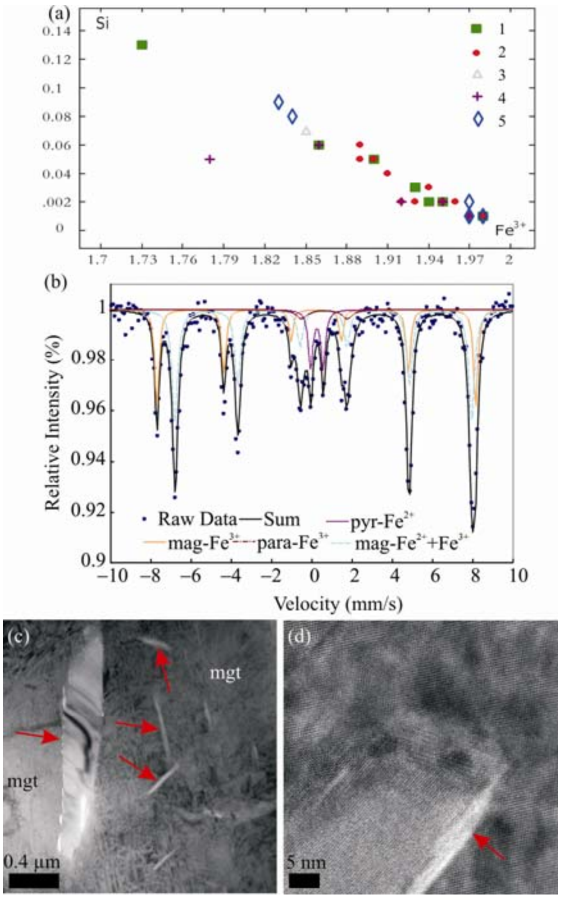

Fig. 1. (a), The content relation diagram between Fe^{3+} and Si in the magnetite from Yanmansu skarn type deposit from Hami Xinjiang. In the diagram 1-5 represent massive magnetite, magnetite in garnet skarn, retrograde-stage skarn, basaltic wall rock and magnetite grains in garnet crystals. In the diagram horizontal ordinate are based on the results of the eight oxygen atoms formula calculation:Fe^{2+}=Fe(total)–Fe^{3+}; Fe^{3+}=8-Si^{4+}-Fe^{2+}(total)-Ca^{2+}- Al^{3+}-Mn^{2+}-Ti^{4+}-Mg^{2+}; (b), Representative Mossbauer spectrum of magnetite from Yamansu deposit; (c), Silicates/high silicon phase (indicated by red arrow) occurred in magnetite. Mgt, magnetite; (d), Si solid solution in high crystallinity magnetite (indicated by red arrow).

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order to make comparisons.

Results

Our present study shows that: (1) Magnetite from Yamansu deposit developed massively, and most magnetite crystals show subhedral to euhedral in shape. Magnetite is inhomogenous in scale of micrometer and silicon content in magnetite from the Yanmansu skarn-type deposit is relatively high (up to about 2wt%), which is significantly higher than the magnetite from magma types. (2) The content of Si and Fe^{3+} has an obvious negative linear relationship which indicates Si may enter the lattice of magnetite structure (Fig. 1a). However, it is noteworthy that this linear relationship probably caused by artificial during structural formulae calculation; (3) Transmission electron microscope display clearly silicates do exist in magnetite (Fig. 1c). These silicates are mostly prolate, ranging from a few to dozens microns; (4) Silicon solid solution was found in magnetite with a = 8.37Å (Fig. 1d); and (5) Mossbauer spectrum results also indicate silicon-bearing magnetite have nearly symmetrical six-line absorption peak, and Si replaces the position of Fe^{3+} in the tetrahedron, and the value of quadruple splitting in the octahedral higher, the more extensive of isomorphous substitution (Fig. 1b).

Conclusions

Previously, very few textbooks or research papers talked about the silicon isomorphism in magnetite due to lacking related analytical means mostly. This research primary concludes that Si would occur in the tetrahedral sites of magnetite in the skarn circumstances via multidisciplinary study. However, this study in this domain will not end. The prospecting in the next step would be distinguishing features of this silicon-bearing magnetite.

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