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STUDY BY SYNCHROTRON RADIATION OF THE SUPERSTRUCTURE OF TETRATAENITE FROM THE SAINT-SEVERIN METEORITE*

by

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Introduction

Tetrataenite is one of the FeNi minerals which is found in meteorite.The purpose of this work is to determine the ordering state of Fe/Ni atoms in tetrataenite, because it is closely connected with the thermal history of meteorite. Taenite is the high-temperature form, in which Fe/Ni atoms are disordered, and has the space-group symmetry of Fm3m. The crystal structure of taenite is simply described as f.c.c. structure, where all the atomic positions are occupied by Fe and Ni atoms with equal probability.

According to Clarke and Scott (1980), the structure of tetrataenite can be derived from f.c.c. structure of taenite by alternate ordering of Fe and Ni atoms.

Synthetic FeNi alloy is obtained only in the disordered phase, because the ordering process needs an extremely slow cooling rate of $1 \sim 100^{o}C/m.y.$

Experimental

A single crystal of taenite/tetrataenite of about 70μm in diameter could be separated from the Saint-Sĕverin meteorite, but is was not confirmed by the preliminary X-ray experiments with usual X-ray source whether it is taenite or tetrataenite. Lattice constants determined by the diffractometer are:
$a = 3.577(2)$, $b = 3.576(3)$, $c = 3.569(2)$, $\alpha = \beta = \gamma = 90^{o}$. The crystal was then mounted on a four-circle diffractometer of vertical type on BL-10a in Photon Factory, Laboratory for High-Energy Physics, Tsukuba, Japan.

The X-ray from the storage ring was monochromatized by Si(111) and the diffraction data were collected using the X-ray of $\lambda = 1.746$ Å. The correction parameters for anomalous scattering are:
for Fe : $\Delta f' = -6.299$, $\Delta f'' = 0.469$ for Ni : $\Delta f' = -1.740$, $\Delta f'' = 0.638$ (Sasaki, 1984).

The large difference in $\Delta f'$ and the small difference in $\Delta f'$ and the small difference in $\Delta f''$ are very adequate to determine the site occupancies in the structure. A total of 28 reflections was measured with $2\Theta<100^{o}$. The standard reflections measured at intervals of five reflections was used in the correction for decreasing intensity of the primary X-ray. The intensity distribution shows the clear tendency of tetragonal symmetry and all reflections which contradict the extinction rule of the face-centered lattice were observed.

Discussion

The crystal was confirmed to be tetrataenite because of the extinction rule. The determination of the site occupancies was carried out by a least-squares program and the results indicate perfect ordering of Fe and Ni atoms. The intensity distribution shows that atoms are no longer in the special position. Therefore the space group p4mm was assumed, because the tendency of $F_{hkl} \sim F_{khl} \neq F_{klh} \approx F_{lkh} \neq F_{lhk} \approx F_{hlk}$ was observed.

Further structure refinements are in process.

References

R.S. Clarke, Jr. & E.R.D. Scott (1980) Am. Min. 65, 624-630.

S.Sasaki (1984) KEK Rep. KEK 83-22.