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High form of pentlandite and its thermal stability

Asahiko Sugaki[1] **and Arashi Kitakaze**[2]

[1]4-30-503, Kadan, Aoba-ku, Sendai 980, Japan
[2]Institute of Mineralogy, Petrology and Economic Geology, Faculty of Science, Tohoku University, Sendai 980-77, Japan

Abstract

The high-temperature form of pentlandite ($Fe_{4.5}Ni_{4.5}S_8$) was found to be stable between 584 ± 3 and 865 ± 3 °C, breaking down into monosulfide solid solution and liquid at the later temperature. The phase is unquenchable and always displays the X-ray pattern of pentlandite (low form) at room temperature. High-temperature X-ray diffraction demonstrated that the high form has a primitive cubic cell with a = 5.189 Å (620 °C) corresponding to $a/2$ of pentlandite. The high-low inversion is reversible, accompanied by a large latent heat. It is thought to be order-disorder in character. The transition temperature falls with decreasing S content. The high form of pentlandite has a limited solid solution from $Fe_{5.07}Ni_{3.93}S_{7.85}$ to $Fe_{3.61}Ni_{5.39}S_{7.85}$ at 850 °C. However its solid solution extends rapidly toward $Ni_{3 \pm x}S_2$ in the Ni-S join with decreasing temperature. High-form pentlandite with Fe = Ni in atomic percent crystallizes first by a pseudoperitectic reaction between monosulfide solid solution and liquid. The high form (Fe = Ni) crystallized from the liquid always has the metal-rich (S-poor) composition in the solid solution at each temperature and coexists with taenite γ (Fe,Ni) below 746 ± 3 °C. This metal-rich high-form $Fe_{4.5}Ni_{4.5}S_{7.4}$ breaks down into pentlandite and γ (Fe,Ni) at 584 ± 3 °C (pseudoeutectoid).

These results suggest that in geological processes, such as the formation of Ni-Cu ore deposits, pentlandite can crystallize as the high form from liquid (sulfide magma) at the comparatively high temperatures around 800 °C.