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Fe-S-Zn (Iron-Sulfur-Zinc)

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The previous review of this system [1988Rag] presented a schematic liquidus projection, a reaction scheme, and four isothermal sections from the studies of [1966Bar] at 850, 700, 600, and 400 °C. Recently, [1999Ito1, 1999Ito2] determined the activities of the components and the phase relations at 927 and 827 °C, with a view to throwing more light on a possible zinc production route by direct reduction of zinc sulfide with metallic Fe.

Binary Systems

There are two intermediate phases in the Fe-S system [1982Kub1]. The monosulfide pyrrhotite $Fe_{1-x}S$ (NiAs type hexagonal) is stable at Fe-deficient (S-rich) compositions with a range of 50-55 at.% S. $Fe_{1-x}S$ with 52 at.% S melts congruently at 1188 °C. In the Fe-FeS region, the solidification is through a eutectic reaction at 988 °C. In the FeS-S region, a monotectic reaction at 1082 °C yields $Fe_{1-x}S$ of 54.2 at.% S and a sulfur-rich liquid $(S)_l$. At 743 °C, cubic FeS_2 (pyrite) forms peritectically and undergoes a transition to the orthorhombic form (marcasite) at 425 °C. The phase relations below 350 °C in the pyrrhotite region are complex with the occurrence of several ordered forms. The Fe-Zn phase diagram exhibits a γ loop, extensive solubility of Zn in bcc Fe (α), and four intermediate phases: Γ, Γ_1, δ, and ζ [1982Kub2]. The Γ phase (Cu_5Zn_8 type cubic) forms peritectically at 782 °C. The Γ_1 phase (cubic) forms peritectoidally at 550 °C. The δ (hexagonal) and ζ ($CoZn_{13}$ type monoclinic) phases form through peritectic reactions at 672 and 530 °C, respectively. The final solidification at the Zn end through a eutectic reaction yields ζ + (Zn). The Zn-S phase diagram [1996Sha] exhibits a congruently melting compound ZnS, which exists in two allotropic forms. ZnS (wurtzite, *wz*) has the hexagonal *B*4 structure and sphalerite *sp* (also named zinc blende) has the cubic *B*3 form. The high temperature form is *wz*, which transforms at 1020 °C to *sp*.

Ternary Isothermal Sections

[1999Ito1,2] used 99.95% Fe, 99.999% Zn, and 99.5% ZnS to synthesize about 20 ternary compositions lying in the Fe-FeS-ZnS-Zn region. The final anneal was at 927 °C (1200 K) and 827 °C (1100 K) for 2 d, followed by water quenching. The phase equilibria were studied by x-ray powder diffraction and electron probe microanalysis. The measured compositions of the coexisting phases were listed. Activity measurements were made by the isopiestic method. There is no significant solubility of Zn in Fe sulfide. The solubility of S in Fe-Zn alloys is negligible. The isothermal section determined by [1999Ito1,2] for the Fe-FeS-ZnS-Zn region at 927 °C is redrawn in Fig. 1. Along the FeS-ZnS join, both *wz* and *sp* are stable at different composition ranges. The isothermal section at 827 °C [1999Ito1] (not shown here) is very similar to that at 850 °C reviewed by [1988Rag]. Only *sp* is stable at 850 and 827 °C.

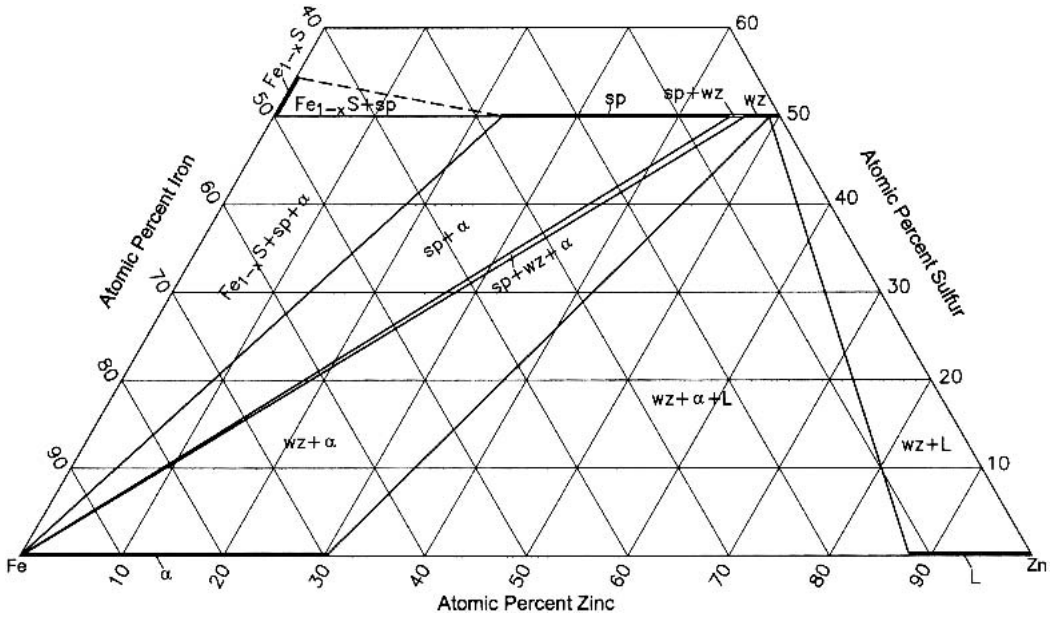

Fig. 1 Fe-S-Zn isothermal section at 927 °C [1999Ito1]. *sp* is sphalerite; *wz* is wurtzite

References

1966Bar: P.B. Barton Jr., and P. Toulmin: "Phase Relations Involving Sphalerite in the Fe-Zn-S System," *Econ. Geol.,* 1966, *61*(5), pp. 815-49.

1982Kub1: O. Kubaschewski: "Iron-Sulfur," *Iron—Binary Phase Diagrams,* Springer-Verlag, Berlin, 1982, pp. 125-28.

1982Kub2: O. Kubaschewski: "Iron-Zinc," *Iron—Binary Phase Diagrams,* Springer-Verlag, Berlin, 1982, pp. 172-75.

1988Rag: V. Raghavan: "The Fe-S-Zn (Iron-Sulfur-Zinc) System," *Phase Diagrams of Ternary Iron Alloys. Part 2,* Ind. Inst. Metals, Calcutta, 1988, pp. 335-49.

1996Sha: R.C. Sharma and Y.A. Chang: "The S-Zn (Sulfur-Zinc) System," *J. Phase Equilibria,* 1996, *17*(3), pp. 261-66.

1999Ito1: S. Itoh: "Phase Relations and Activities of Components in the Zn-Fe-S System att 1100 and 1200 K," *Mater. Trans. JIM,* 1999, *40*(7), pp. 618-26.

1999Ito2: S. Itoh, O. Inoue, M. Isshiki, T. Yamamura, and T. Azakami: "Phase Equilibria in Zn-Fe-S System at 1100 and 1200 K," *Nippon Kinzoku Gakkaishi,* 1999, *63*(2), pp. 215-20 (in Japanese).