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Fe-O-Si-Zn (Iron-Oxygen-Silicon-Zinc)

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In this quaternary system, the isothermal equilibria at 827 °C in the FeO-SiO_2-ZnO subsystem coexisting with Fe were first determined by [1993Ito]. Subsequently, [2001Jak] investigated the liquid-solid equilibria and computed liquidus projections.

Ternary Subsystems

The Fe-O-Si system was reviewed by [1989Rag]. This review presented a liquidus projection in the FeO-Fe_2O_3-SiO_2 region, three isothermal sections at 1600, 1200 and 900 °C and a reaction sequence. The Fe-O-Zn system is updated in this issue. The ZnO-SiO_2 pseudo-binary system was investigated by [1997Jak]. The calculated phase diagram (Fig. 1) showed satisfactory agreement with the experimental data. The ternary compound Zn_2SiO_4 forms congruently at 1513 °C. On either side of this compound, a simple eutectic type of solidification occurs with no terminal solubility. The activities of ZnO in the ZnO-SiO_2 system between 800 and 700 °C were determined by [1989Ito] from emf measurements. The Fe-Si-Zn system was reviewed by [1992Rag] and updated subsequently.

Quaternary Phase Equilibria

Starting with high purity powders of Fe, Zn, FeO, ZnO and prior-made compounds of Zn_2SiO_4 and Fe_2SiO_4, [1993Ito] prepared briquettes, which were sealed in evacuated quartz tubes, annealed at 827 °C for 60 h and quenched in water. The phases were identified with x-ray powder diffraction and the phase compositions were measured with electron probe microanalyzer (EPMA). Using stabilized zirconia solid electrolyte, [1993Ito] measured the partial pressures of oxygen by the emf method. Figure 2 shows the isothermal equilibria projected on the FeO-SiO_2-ZnO plane. As the experiments were done at iron saturation, all phase fields contain additionally (Fe). The activities of FeO and ZnO in the four-phase equilibrium of FeO + Fe_2SiO_4 + Zn_2SiO_4 + (Fe) were found to be 0.93 and 0.53 respectively. The corresponding values for the equilibrium of FeO + Zn_2SiO_4 + ZnO + (Fe) were 0.87 and 0.80.

More recently, [2001Jak] pelletized powder mixtures of Fe_2O_3, SiO_2 and ZnO (99.5+% purity), annealed them in air between 1450 and 1200 °C, followed by quenching in iced water. The microstructures were examined with optical and scanning electron microscopy. The phase compositions were measured with EPMA and listed. Earlier, with the same starting materials and experimental techniques, [2000Jak] determined the liquid-solid equilibria in this quaternary system at metallic iron saturation.

In their thermodynamic description, [2001Jak] used the quasi-chemical model for the liquid slag phase. The compound energy formalism was used to describe the ternary compounds fayalite (Fe_2SiO_4) and willemite (Zn_2SiO_4), providing for mutual solid solubility. Using the results of [2001Jak] and [2000Jak], along with selected data from the literature, the thermodynamic interaction parameters were optimized.

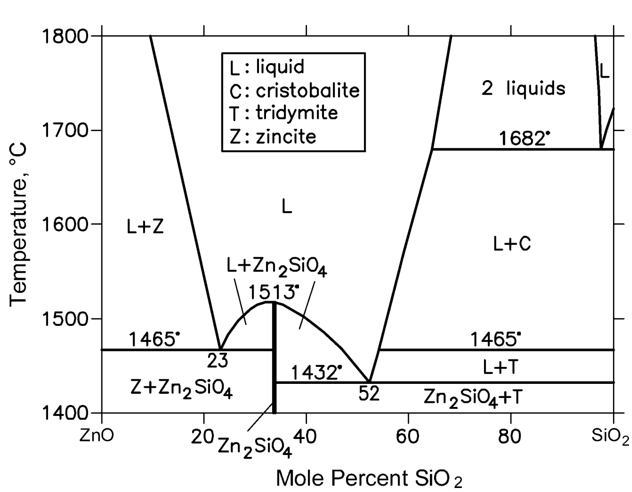

Fig. 1 ZnO-SiO_2 computed pseudo-binary section [1997Jak]

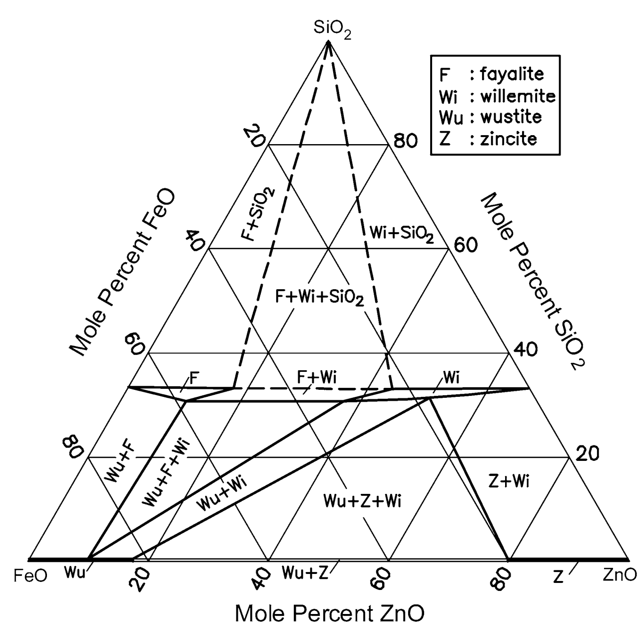

Fig. 2 Fe-O-Si-Zn isothermal equilibria at 827 °C on the FeO-SiO_2-ZnO plane at iron saturation [1993Ito]

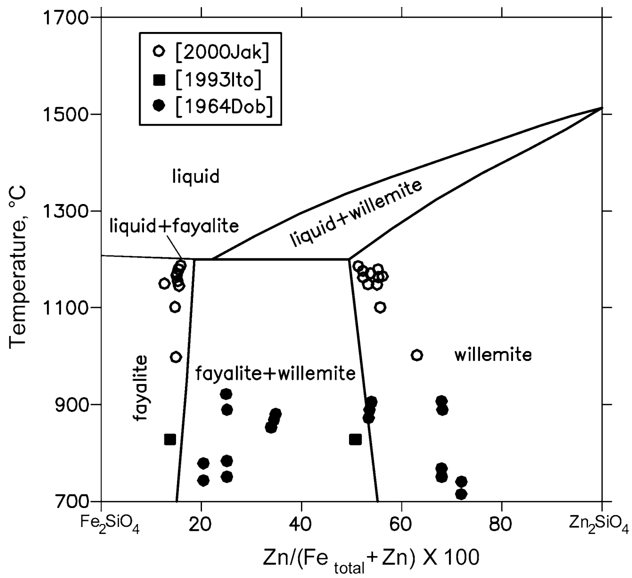

Fig. 3 Fe-O-Si-Zn computed vertical section along the Fe_2SiO_4-Zn_2SiO_4 join at iron saturation [2001Jak]

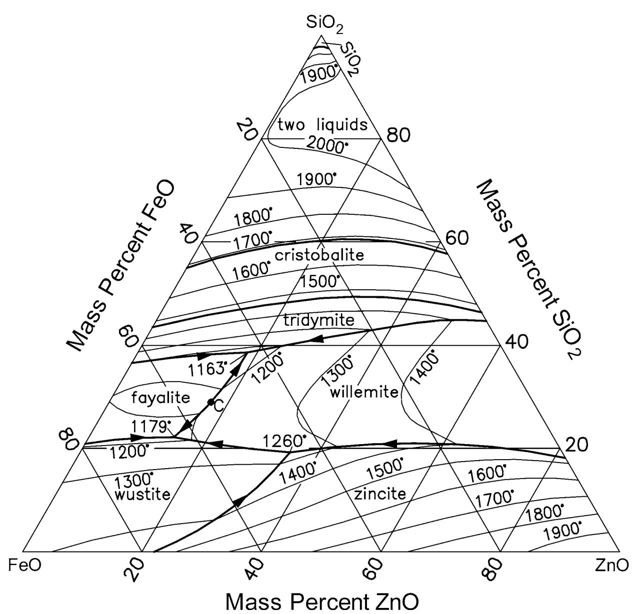

Fig. 4 Fe-O-Si-Zn computed liquidus projection on the FeO-SiO_2-ZnO plane at iron saturation [2001Jak]

The pseudo-binary section computed along the Fe_2SiO_4-Zn_2SiO_4 join at iron saturation is shown in Fig. 3. The mutual solid solubility between fayalite (Fe_2SiO_4) and willemite (Zn_2SiO_4) is extensive. The experimental points from [1964Dob], [1993Ito] and [2000Jak] show a wide scatter. The computed liquidus projection on the FeO-SiO_2-ZnO plane at metallic iron saturation is shown in Fig. 4. The marked 'primary' fields contain in addition metallic (Fe). The arrows indicating the direction of decreasing temperature are as given by [2001Jak]. Not all arrows are marked by [2001Jak]. A temperature maximum C at ~1205 °C corresponding to the congruent melting of fayalite is expected on the indicated liquidus line in Fig. 4. Three five-phase invariant points were computed: (i) L + (Fe) + Wu + Wi + Z at 1260 °C, (ii) L + (Fe) + Wu + Wi + F at 1179 °C and (iii) L + (Fe) + T + Wi + F at 1163 °C. In the above, Wu = wustite, Wi = willemite, F = fayalite, T = tridymite, and Z = zincite. [2001Jak] also computed a liquidus projection in 'air'.

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