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Fe-Re-S (Iron-Rhenium-Sulfur)

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Recently, four isothermal sections between 1200 and 900 °C were determined for this ternary system by [1999Kar].

Binary Systems

Only partial information has been gathered on the Fe-Re system [1993Oka]. Three compounds are known: $Fe_{20}Re_9$ (αMn type cubic), Fe_3Re_2 (σCrFe type tetragonal), and Fe_2Re_3 (βMn type cubic). Their homogeneity ranges or the formation temperatures are not known. There are two intermediate phases in the Fe-S system [1982Kub]. The monosulfide pyrrhotite $Fe_{1-x}S$ (hexagonal NiAs type) is stable at Fe-deficient (S-rich) compositions with a range of 50-55 at.% S. $Fe_{1-x}S$ at 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 orthorhombic FeS_2 (marcasite) at 425 °C. The phase relations below 350 °C in the pyrrhotite region are complex with the occurrence of several ordered forms. The Re-S phase diagram is not known. Rhenium disulfide ReS_2 is probably isotypic with the rhombohedral NbS_2 [Massalski2].

The Ternary Phase Equilibria

Using Re and Fe with 15 ppm of metallic impurities and S of 99.999% purity, [1999Kar] heated 96 alloy compositions in evacuated tubes, which were finally annealed between 1200 and 900 °C for 14-30 d and quenched in water. The phase equilibria were studied with optical microscopy and electron probe microanalyzer. The measured compositions of the coexisting phases were listed.

Along the Fe-Re side, [1999Kar] found that, in the temperature range of 1200-900 °C, only one intermediate phase σ with a homogeneity range is present. The other two intermediate phases were not found. It is not clear whether the presence of a very small amount of S (less than 0.1 at.%) in solution had any effect on the stability of these phases. The composition ranges determined by [1999Kar] for the face-centered cubic (fcc) γ, σ and (Re) [hexagonal close-packed (hcp)] along the Fe-Re side between 1200 and 900 °C is shown in Fig. 1.

Of the four isothermal sections constructed by [1999Kar] at 1200, 1100, 1000, and 900 °C, the sections at 1200, 1000, and 900 °C are redrawn in Fig. 2-4. At 1200 °C, the homogeneity ranges of γ, σ, and (Re) along the Fe-Re side are 0-21.6, 36.7-54.2, and 72.5-100 at.% Re. The Fe-rich part of the sulfide melt along the Fe-S side contains less than 0.15 at.% Re. The sulfide melt with 51-53.5 at.% S dissolves

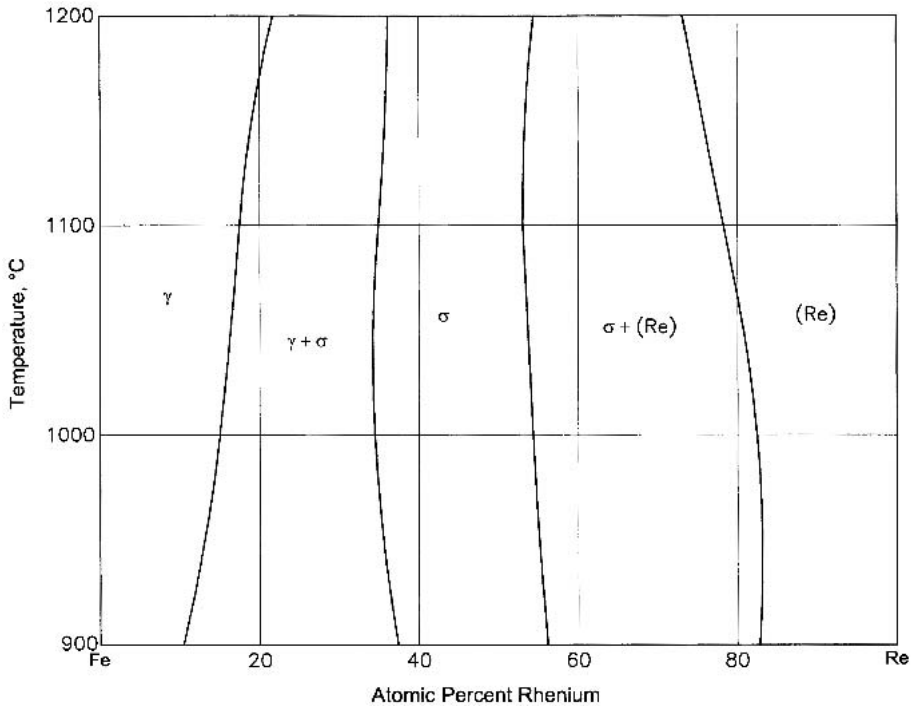

Fig. 1 Fe-Re phase diagram between 1200 and 900 °C [1999Kar]

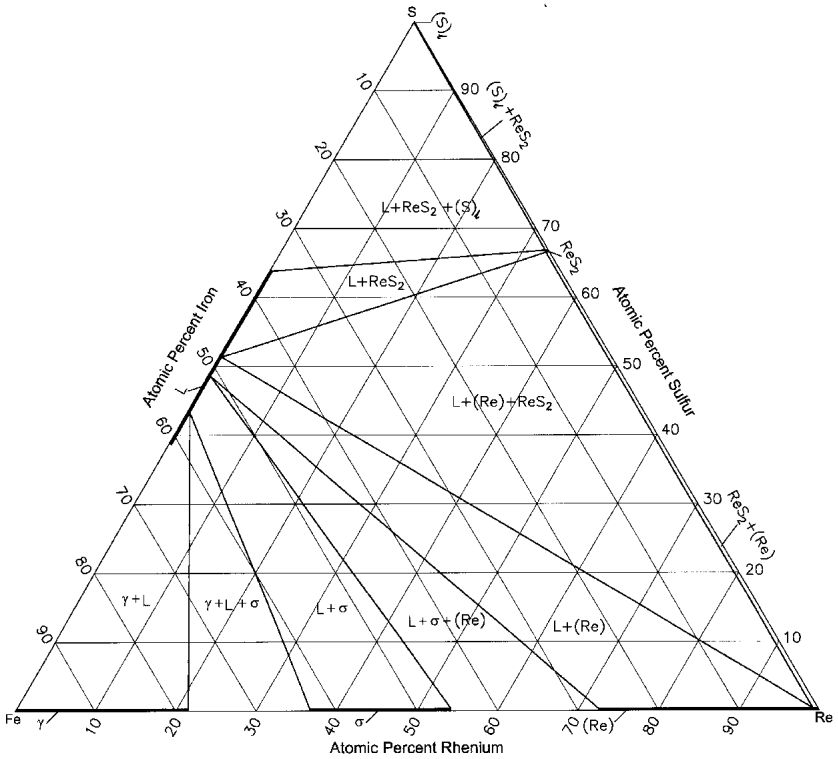

Fig. 2 Fe-Re-S isothermal section at 1200 °C [1999Kar]

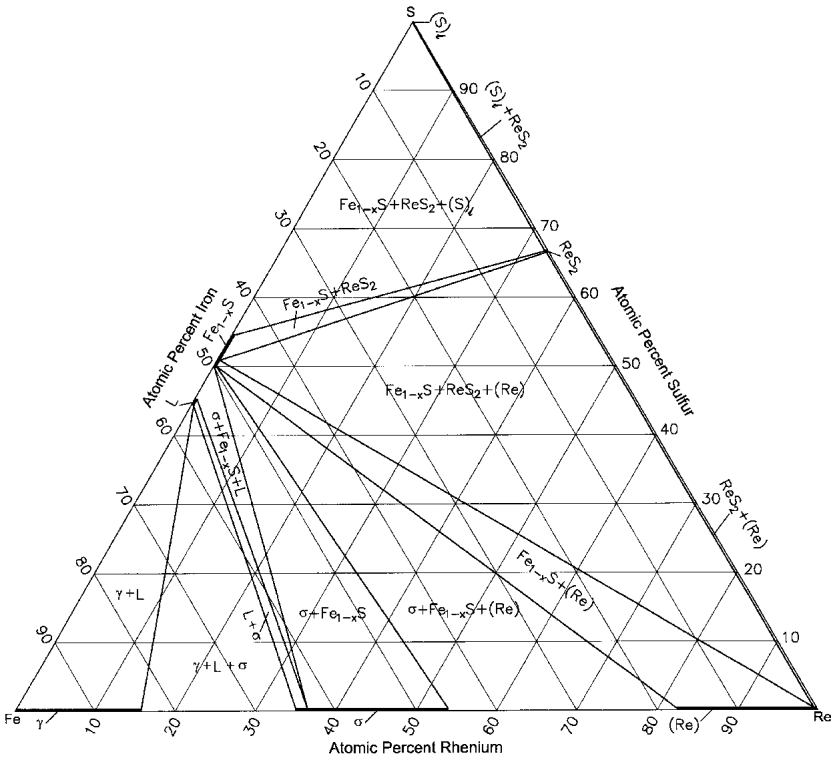

Fig. 3 Fe-Re-S isothermal section at 1000 °C [1999Kar]

0.3-0.4 at.% Re. ReS_2 dissolves 0.5 at.% Fe. At 1000 °C (Fig. 3), the homogeneity ranges of γ, σ, and (Re) along the Fe-Re side are 0-15.8, 35-54 and 82.5-100 at.% Re. Pyrrhotite in equilibrium with σ and (Re) contains 50.2 at.% S and 0.06 at.% Re. At higher S contents (51.1-53.4 at.%), pyrrhotite is in two-phase equilibrium with ReS_2 and con-

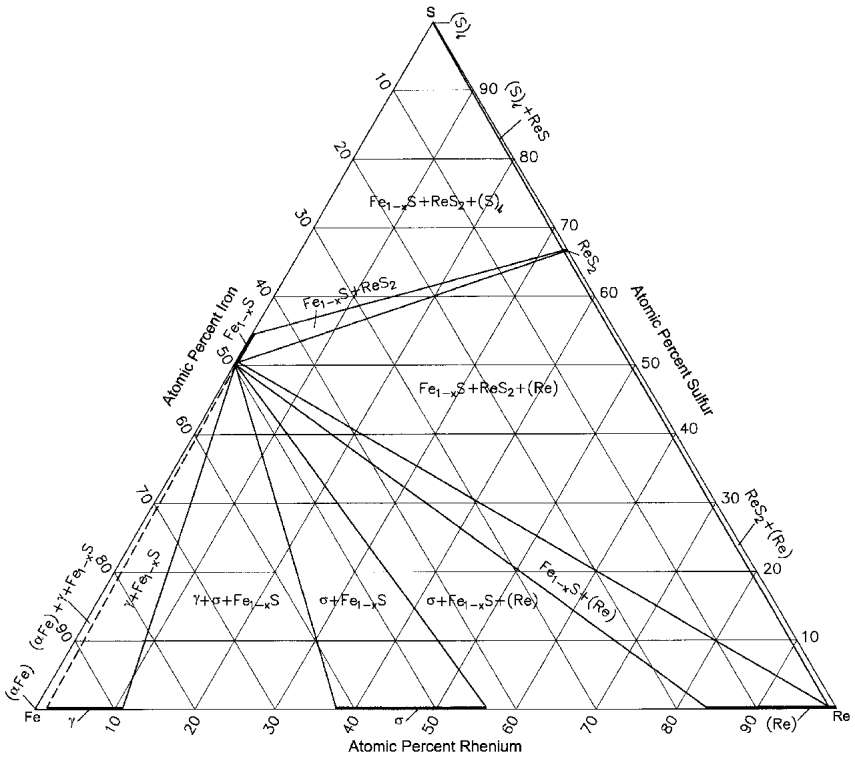

Fig. 4 Fe-Re-S isothermal section at 900 °C [1999Kar]

tains 0.10-0.15 at.% Re and ReS_2 contains 0.3-0.5 at.% Fe. At 900 °C (Fig. 4), the homogeneity ranges of γ, σ, and (Re) along the Fe-Re side are 0-11.1, 37.6-56.3, and 83.8-100 at.% Re. Pyrrhotite in equilibrium with σ and (Re) contains 50 at.% S and 0.03-0.05 at.% Re. Pyrrhotite in equilibrium with ReS_2 (~0.5 at.% Fe) and (Re) (1 at.% Fe) contains 50.65 at.% S and 0.1-0.2 at.% Re [1999Kar]. These results indicate that Re resides preferentially in the alloys along the Fe-Re side and in ReS_2, but very little in the sulfide melts and in solid pyrrhotite.

References

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