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C-Cu-Fe-Sb (Carbon-Copper-Iron-Antimony)

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Recently, [2005Voi] determined the liquid miscibility gap and the distribution of Sb and C between the Fe-rich and the Cu-rich liquids at 1200 °C in C-saturated melts of this quaternary system.

Lower Order Systems

The mutual solubility between C and Cu is negligible. In the C-Fe system, the C content at saturation in Fe melts increases from 17.1 at.% at 1152 °C to ~21 at.% at 1600 °C. The C solubility in Sb melts increases from 0.33 at.% at 1055 °C to 0.94 at.% at 1327 °C. There are a number of intermediate phases in the Cu-rich part of the Cu-Sb system, none of which is stable at the temperature of interest here (1200 °C). There are no intermediate phases in the Cu-Fe system. A metastable liquid miscibility gap is known in this system. The Fe-Sb phase diagram has two intermediate phases: $FeSb_{1-x}$ (NiAs-type hexagonal) and $FeSb_2$ (marcasite-type orthorhombic). The known phase diagrams for the above systems were given by [Massalski2].

The update on the C-Cu-Fe system by [2002Rag] presented a liquidus projection for the Fe-rich region. The C-Cu-Sb system does not appear to have been investigated. A partial isothermal section at 1200 °C for the C-Fe-Sb system determined by [2005Voi] is shown in Fig. 1.

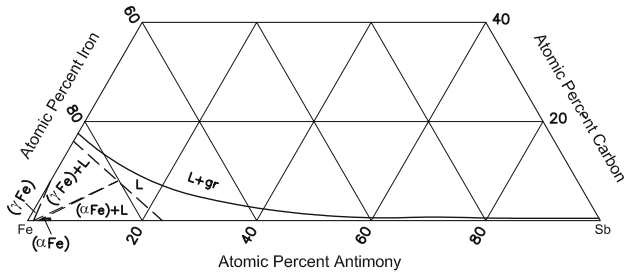

Fig. 1 C-Fe-Sb partial isothermal section at 1200 °C [2005Voi]

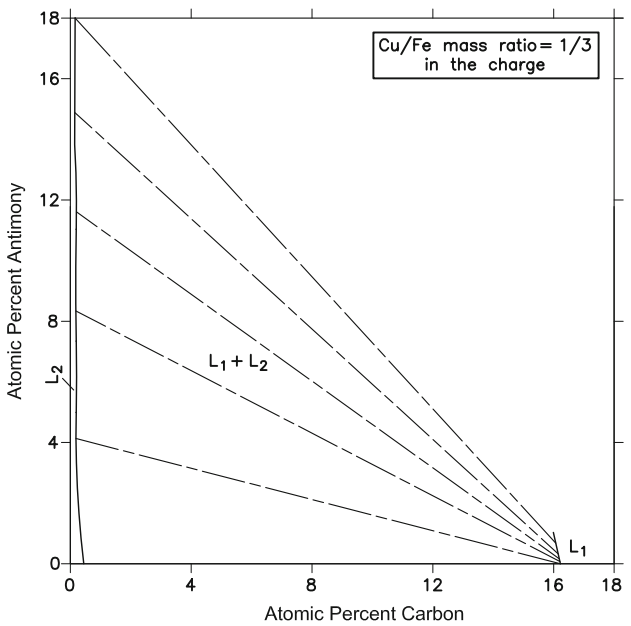

Fig. 2 C-Cu-Fe-Sb tie-lines between C-saturated Fe-rich liquid L_1 and Cu-rich liquid L_2 at 1200 °C [2005Voi]

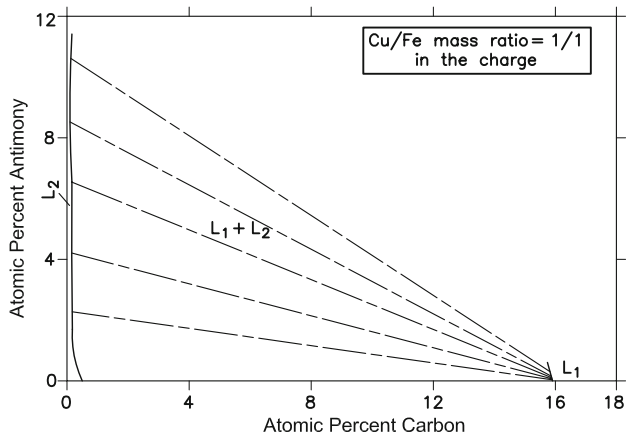

Fig. 3 C-Cu-Fe-Sb tie-lines between C-saturated Fe-rich liquid L_1 and Cu-rich liquid L_2 at 1200 °C [2005Voi]

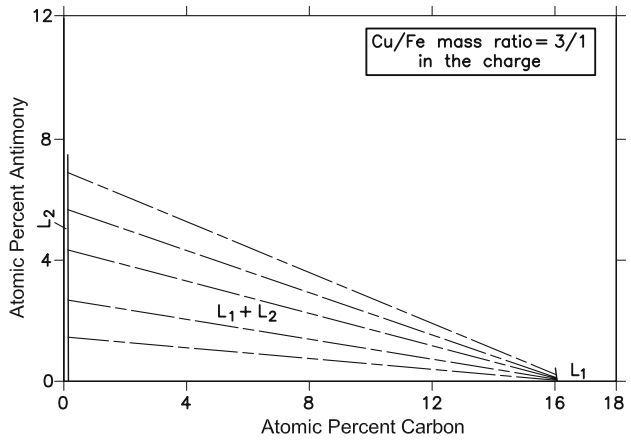

Fig. 4 C-Cu-Fe-Sb tie-lines between C-saturated Fe-rich liquid L_1 and Cu-rich liquid L_2 at 1200 °C [2005Voi]

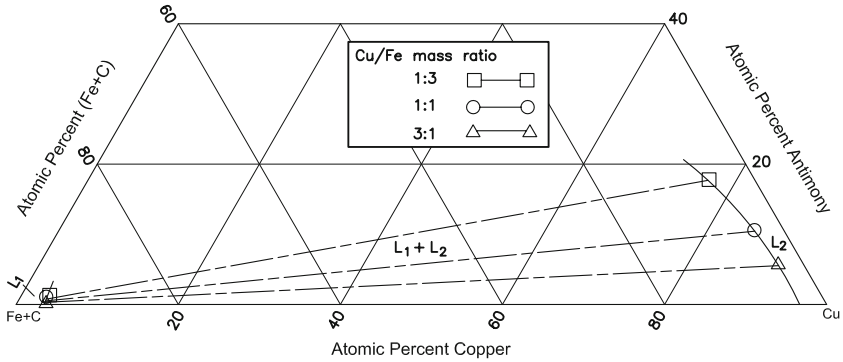

Fig. 5 C-Cu-Fe-Sb partial isothermal section at 1200 °C and at C saturation [2005Voi]

The data on the Cu-Fe-Sb system compiled by [1995Vil] from the early results of [1934Vog] show a miscibility gap between Fe-rich and Cu-rich liquids.

Quaternary Phase Equilibria

With starting materials of 99.99% purity, [2005Voi] prepared mixtures with a constant mass ratios of Cu/Fe = 1/3, 1/1, and 3/1, with a graphite rod for achieving C saturation and varying Sb content. The samples were sealed in quartz ampules, melted, and kept at 1200 °C for 12 h before quenching in water. The presence of two clearly-separated liquids was confirmed by metallography and electron probe microanalysis (EPMA). The composition was determined by combustion infrared spectrometry for carbon and by EPMA and inductively coupled plasma spectrometry (ICP) for the other elements. The measured compositions of the coexisting liquids were listed. The C, Fe, and Sb contents of the Cu-rich liquid were between 0.02-0.08, 3-4, and 2.8-29.8 mass%, respectively. The C, Cu, and Sb contents of the Fe-rich phase were between 3.9-4.0, 4-5, and 0.04-1.5 mass%, respectively. The observed variation in the C and Sb contents of the co-existing Fe-rich and Cu-rich liquids at 1200 °C is shown in Fig. 2-4 for Cu/Fe mass ratios of 1/3, 1/1, and 3/1, respectively in the charge [2005Voi]. Almost all Sb is dissolved in the Cu-rich phase, while C resides mostly in the Fe-rich phase. The liquid miscibility gap is plotted in Fig. 5 as a function of Cu, Sb, and (Fe + C).

The distribution of minor additions of Ag, Co, Ni, Pt, and S at 1200 °C between the Fe-rich and Cu-rich liquids was also studied by [2005Voi]. The distribution ratio $L^{Fe/Cu}$ (in mass%) for Co and Ni was more than 10 and 4, respectively, whereas it was less than 0.01 for Ag. Pt and S distributed more or less evenly between the liquids.

References

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