Cu-Fe-Mn (Copper-Iron-Manganese)

V. Raghavan

The review of this ternary system by [1988Ray] presented a liquidus surface and four isothermal sections at 1050, 950, 900, and 850 °C. The later updates by [1994Rag] and [2002Rag] added two computed isothermal sections at 1300 and 1150 °C from the work of [1981Nis] and an experimental section at 1200 °C based on the studies of [1997Oht]. The compilation of [1995Vil] included a liquidus projection and four isothermal sections assessed by [1988Ray], eight computed isothermal sections between 1300 and 600 °C from [1978Has], four vertical sections from [1913Par], and computed isothermal sections near the Fe corner by [1989Har] showing the face-centered cubic (fcc) – body-centered cubic (bcc) equilibrium between 850 and 550 °C. Miscibility gaps in the liquid and solid states were calculated by [2004Wan], who constructed a thermodynamic data base for Cu-Fe-X (X: Al, Co, Cr, Mn, Mo, Nb, Ni, V) ternary systems. [2003Mie] gave a thermodynamic description of the system near the Fe-Cu side. Recently, [2007Wan] carried out a thermodynamic assessment of this ternary system and computed nine isothermal sections, six vertical sections, and a liquidus projection. The computed diagrams were compared with the available experimental data.

Binary Systems

There are no intermediate phases in any of the three binary subsystems. A metastable liquid miscibility gap is known in the Cu-Fe and Cu-Mn systems. Computed phase diagrams of Cu-Fe, Cu-Mn, and Fe-Mn were given by [2007Wan]. Continuous face-centered cubic (fcc) solid solutions form between fcc Fe and γMn (denoted fcc_1) and between Cu and γMn (denoted fcc_2).

Ternary Thermodynamic Assessment

In their thermodynamic optimization of this ternary system, [2007Wan] used the available experimental results from the literature, including the reviewed data of [1988Ray] and [1995Vil]. No experimental measurements on the thermodynamic properties are known. The liquid, face-centered cubic (fcc), body-centered cubic (bcc), (αMn), and (βMn) phases were described by a subregular solution model. The magnetic contribution to the Gibbs energy was taken into account. The ternary interaction parameters derived by [2007Wan], along with the applicable binary parameters, were listed.

Nine isothermal sections between 1300 and 800 °C were computed by [2007Wan], these depicting the equilibrium between fcc_1 and fcc_2 or between fcc_1 and liquid. The sections at 1300, 1050, 950, and 850 °C are shown in Fig. 1-4. These are compared with experimental data from various sources, showing good agreement. Six vertical sections were computed by [2007Wan] at 10 or 20 mass % of Cu, Fe and Mn respectively. The computed
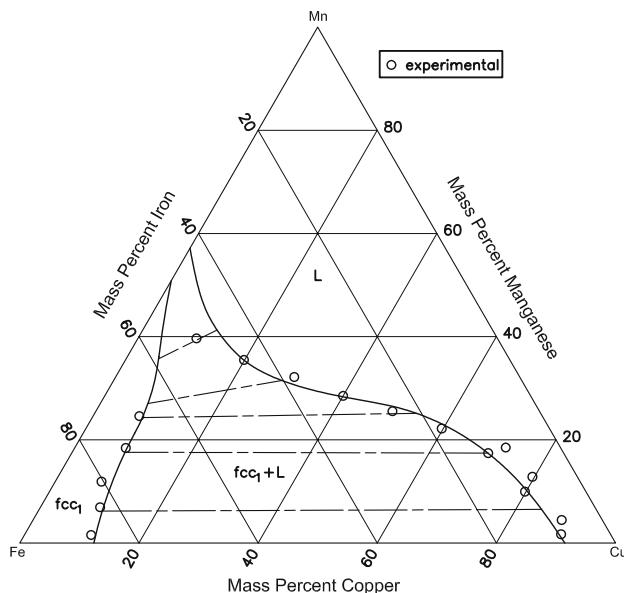

**Fig. 1** Cu-Fe-Mn computed isothermal section at 1300 °C [2007Wan]
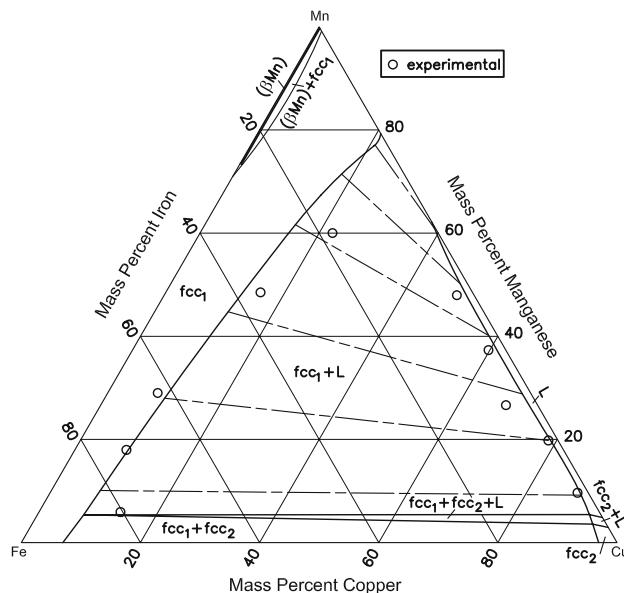
Fig. 2 Cu-Fe-Mn computed isothermal section at 1050 °C [2007Wan]
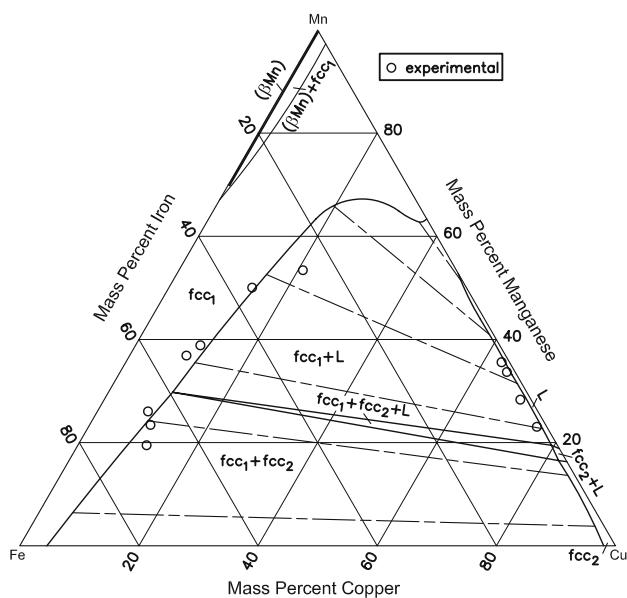
Fig. 3 Cu-Fe-Mn computed isothermal section at 950 °C [2007Wan]
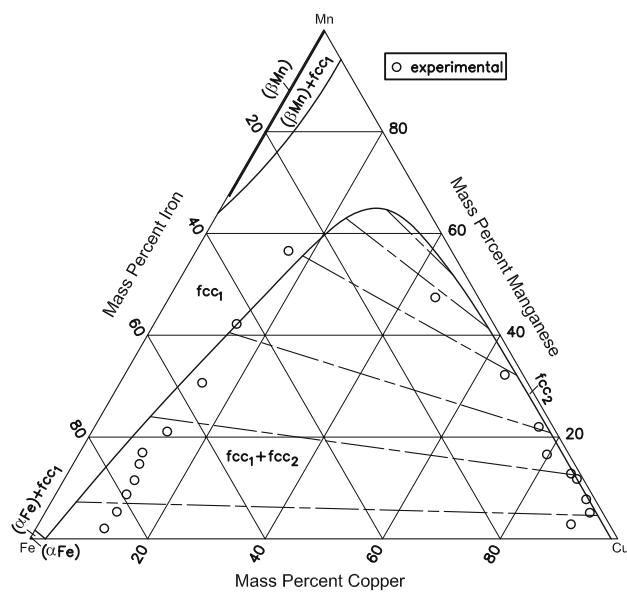
Fig. 4 Cu-Fe-Mn computed isothermal section at 850 °C [2007Wan]
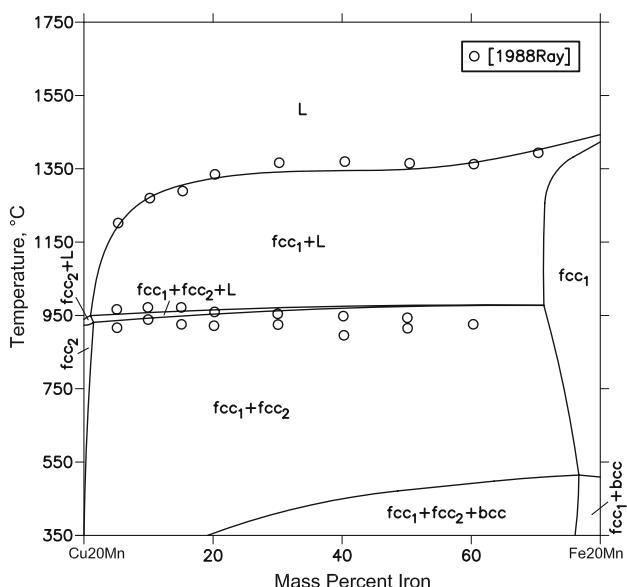
Fig. 5 Cu-Fe-Mn computed vertical section at 20 mass % Mn [2007Wan]
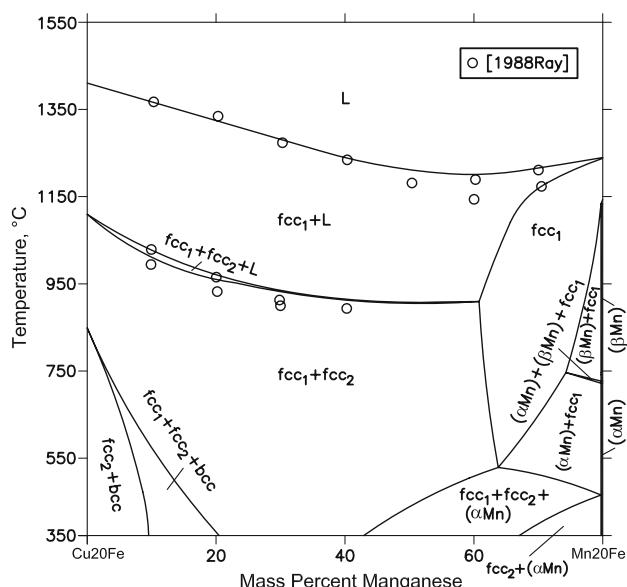
Fig. 6 Cu-Fe-Mn computed vertical section at 20 mass % Fe [2007Wan]

vertical sections were compared with the early experimental data of [1913Par], as reviewed by [1988Ray]. Figure 5-7 show three vertical sections at 20 mass % of Mn, Fe, and Cu respectively. Here again, the agreement with experimental data is good. In Fig. 7, the full details of the phase distribution near the Mn20Cu-end are not indicated.

Figure 8 shows the calculated liquidus projection and is compared with the constant-temperature contour lines evaluated by [1988Ray]. Two critical points C_1 and C_2

were obtained from the calculations. No critical points have been reported experimentally. C_1 (see Fig. 8) is at a temperature minimum (1441 °C) on the liquidus curve enclosing the bcc phase at the Fe corner and corresponds to the equilibrium: L + bcc ↔ fcc$_1$. C_2 is also at a minimum (896.5 °C) close to the Cu-Mn side and corresponds to the equilibrium: L + fcc$_1$ ↔ fcc$_2$. Another critical point labeled C′ in Fig. 8 (not indicated by [2007Wan]) is to be expected at the composition at which the miscibility gap in the fcc phase starts.
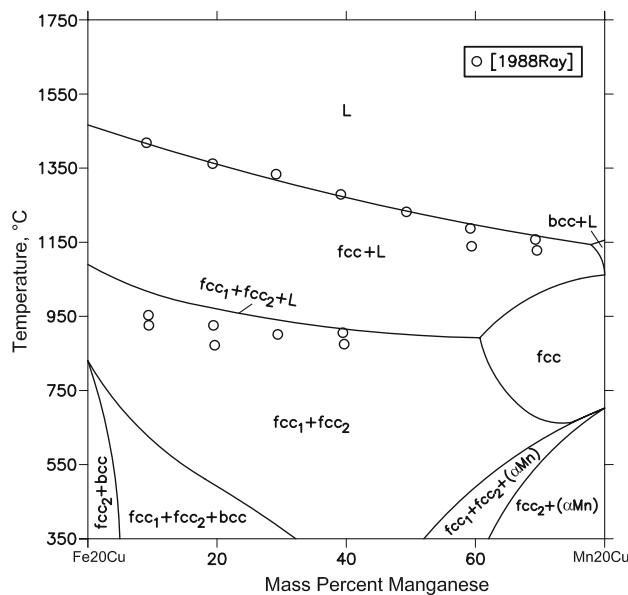
Fig. 7 Cu-Fe-Mn computed vertical section at 20 mass % Cu [2007Wan]
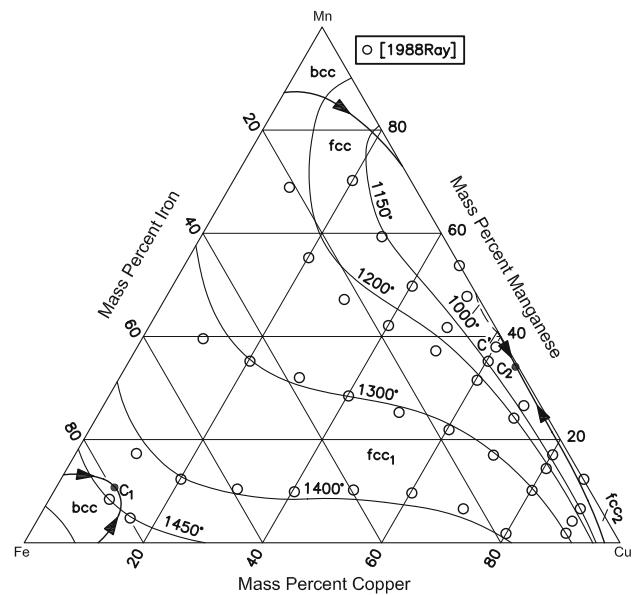
Fig. 8 Cu-Fe-Mn computed liquidus projection [2007Wan]

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