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Ca-Mg-Sr (Calcium-Magnesium-Strontium)

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This ternary system is one of the subsystems of the higher-order Al-Ca-Mg-Sr and Al-Ca-Mg-Mn-Sr systems, which are reviewed in this issue. A CALPHAD-type assessment of this system by extrapolating the binary edge systems was carried out by [2006Zho]. [2008Alj] reassessed the binaries using the modified quasichemical model and calculated liquidus projections, assuming different possibilities such as no solubility between Mg_2Ca and Mg_2Sr or complete solubility between them. Supported by new results from a limited number of key experiments, the thermodynamic assessment of this system was revised by [2009Jan].

Binary Systems

The Ca-Mg system [1995Aga] depicts one intermediate phase Mg_2Ca ($C14$, $MgZn_2$-type hexagonal). The Ca-Sr system [2003Zho] shows complete liquid and solid solubility. The isomorphous pairs βCa-βSr (bcc) and αCa-αSr (fcc) form continuous solid solutions. The Mg-Sr phase diagram [Massalski2] has four intermediate phases: $Mg_{17}Sr_2$ ($Ni_{17}Th_2$-type hexagonal), $Mg_{38}Sr_9$ (hexagonal, $P6_3/mmc$), $Mg_{23}Sr_6$ ($D8_a$, $Mn_{23}Th_6$-type cubic) and Mg_2Sr ($C14$, $MgZn_2$-type hexagonal).

Ternary Phase Equilibria

To identify key experiments, [2009Jan] used preliminary calculations based on binary extrapolations. With starting metals of 99.99% Ca, 99.98% Mg, and 99.99% Sr, two alloy samples with Mg content at 58 and 71 mass% were prepared and sealed in Ta capsules. Differential thermal analysis was performed at heating/cooling rates of 1 and 5 °C per min. The phases were identified with scanning electron microscopy and electron probe microanalysis.

In their thermodynamic calculations, [2009Jan] used the binary descriptions of [1995Aga] (Ca-Mg), [2003Zho] (Ca-Sr), and [2006Zho] (Mg-Sr). Liquid, fcc (αCa, αSr), bcc (βCa, βSr) and cph (Mg) phases were described by the substitutional solution model. No ternary interaction parameters were found necessary to describe these phases. The limited ternary solubility of Ca at constant Mg content in the

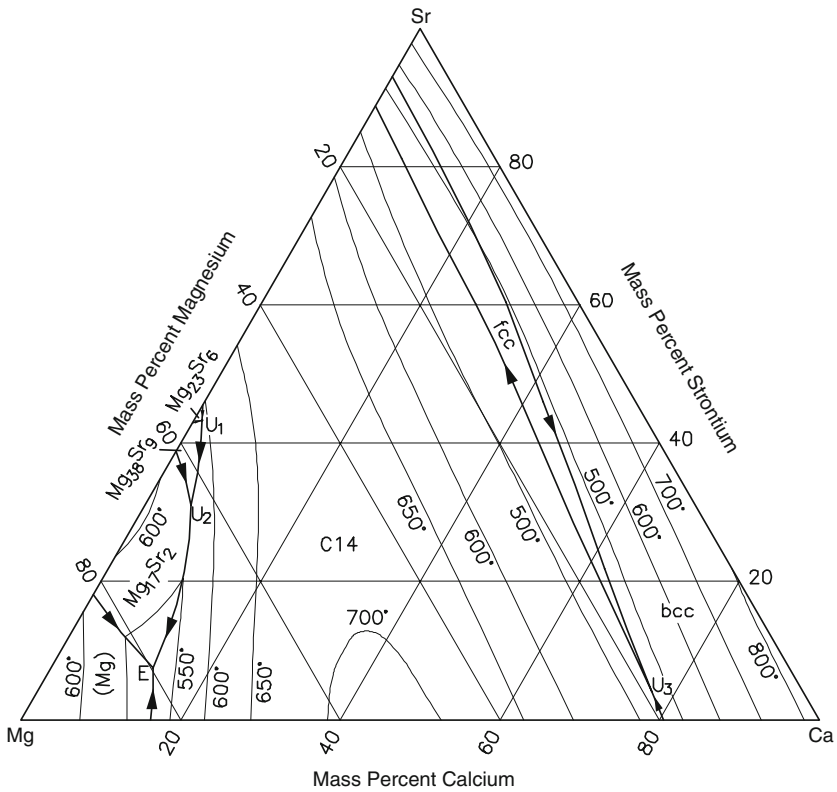

Fig. 1 Ca-Mg-Sr computed liquidus projection [2009Jan]

binary compounds $Mg_{17}Sr_2$ and $Mg_{38}Sr_9$ was taken into account in the sublattice model. The isostructural *C*14 compounds Mg_2Ca and Mg_2Sr exhibit complete solid solubility and were modeled as one phase. No excess energy term was found necessary, indicating an ideal nature of this solid solution.

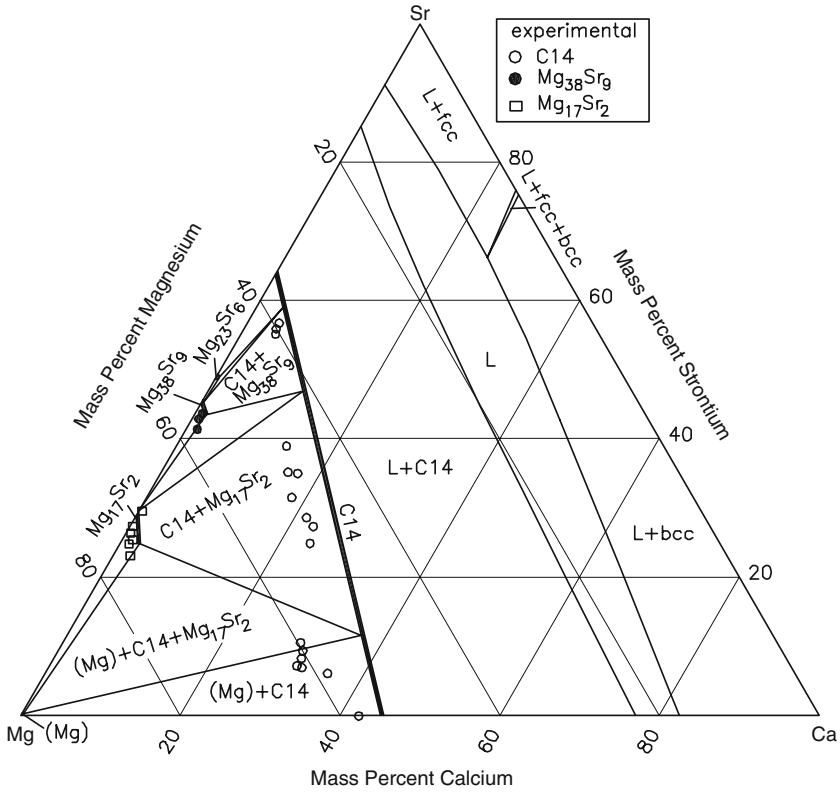

Fig. 2 Ca-Mg-Sr computed isothermal section at 500 °C [2009Jan]

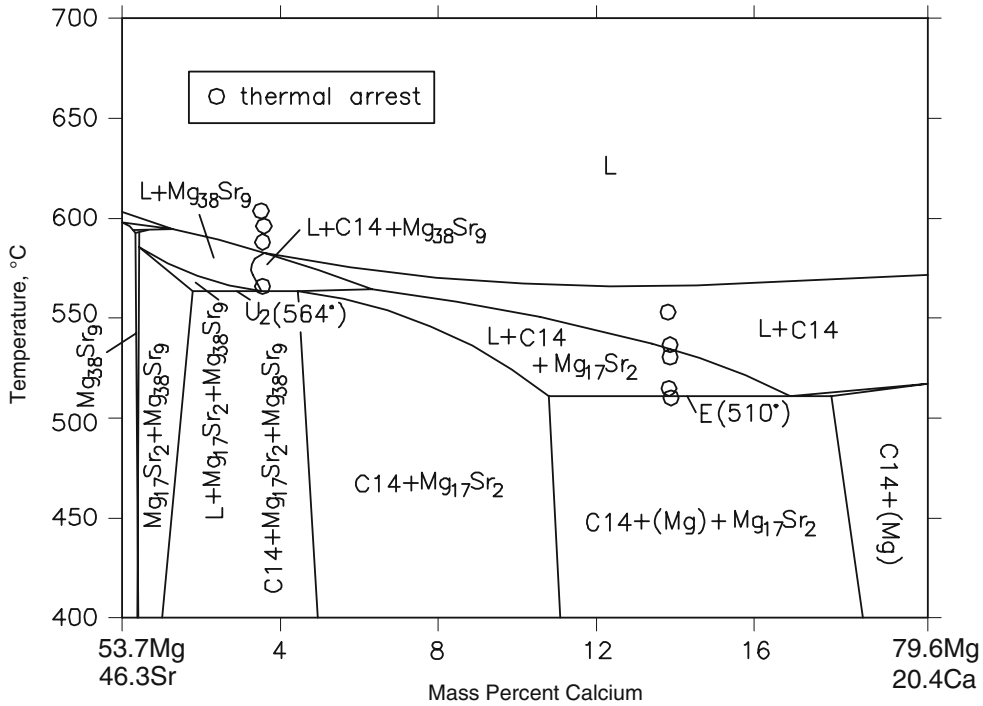

Fig. 3 Ca-Mg-Sr computed vertical section along the $Mg_{53.7}Sr_{46.3}$-$Mg_{79.6}Ca_{20.4}$ join [2009Jan]

The liquidus projection computed by [2009Jan] is shown in Fig. 1. No temperature maximum occurs in any of the univariant lines. Three U-type transition reactions were found: U_1 (594 °C), U_2 (564 °C), and U_3 (443 °C). The final solidification in the Mg-rich region is through the ternary eutectic reaction E (510 °C).

Figure 2 shows the computed isothermal section at 500 °C [2009Jan]. Mg_2Ca and Mg_2Sr form a continuous C14 solid solution. Experimental data on *C*14 plotted in Fig. 2 indicate that there is an extension of the $Mg_2(Ca,Sr)$ compound to the Mg-rich side [2009Jan]. Considering the stoichiometric nature of Mg_2Ca, this extension is unusual and probably needs further experimental confirmation. The liquid in the Mg-lean region extends from the Mg-Ca side to the Mg-Sr side.

Figure 3 shows a computed vertical section along the $Mg_{53.7}Sr_{46.3}$-$Mg_{79.6}Ca_{20.4}$ join, on which lies the composition of the two experimental alloys of [2009Jan]. The thermal arrests from the experimental alloys show reasonable agreement with the computed vertical section.

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