

A new thermodynamic analysis of the intergrowth of hedenbergite and magnetite with Ca-Fe-rich olivine

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ABSTRACT

Some errors and metastable phase relations are found in a recently reported oxygen fugacity–silica activity [$\log f_{\text{O}_2}$ – $\log a(\text{SiO}_2)$] diagram of the fayalite-kirschsteinite-hedenbergite-magnetite-wollastonite (Fa-Kst-Hd-Mt-Wo) system at 400 °C and 1 kbar (Markl et al. 2001). Systematic thermodynamic analysis reveals that the composite exsolution lamellae of Mt and Hd in the olivine from the Ilimaussaq Intrusion, Greenland, should form when the reaction $3\text{Fa}+3\text{Kst}+\text{O}_2=3\text{Hd}+2\text{Mt}$ is overstepped on rapid cooling. This process is also accompanied by favorable f_{O_2} and $a(\text{SiO}_2)$ conditions. It is also found that the reaction mechanisms from Ca-Fe-rich olivine (Fa+Kst) to Mt+Hd are very different above and below the equilibrium temperature of the Mt-absent reaction $\text{Hd}+\text{Kst}=\text{Fa}+2\text{Wo}$. The mechanisms above the equilibrium temperature are obviously simpler than those below the equilibrium temperature. Despite this difference, the two types of mechanisms have many features in common: (1) Mt and Hd can form in Ca-Fe-rich olivine on continuous cooling; (2) If $a(\text{SiO}_2)$ is not buffered, an increase in f_{O_2} alone is enough to transform Ca-Fe-rich olivine into Mt and Hd; (3) At a fixed f_{O_2} or $a(\text{SiO}_2)$, the formation of Mt and/or Hd on cooling requires appropriate $a(\text{SiO}_2)$ or f_{O_2} ; and (4) The increase in $a(\text{SiO}_2)$ is favorable to the formation of Hd, but it is not essential for the intergrown exsolution of Mt and Hd. These common features are closely related to the fact that the process from Fa+Kst to Mt+Hd is an entropy decreasing oxidation reaction.

Keywords: Fayalite, kirschsteinite, hedenbergite, magnetite, exsolution, Schreinemakers analysis, oxygen fugacity, silica activity