THE THERMAL DECOMPOSITION OF THAUMASITE FROM MOTHAE KIMBERLITE PIPE, LESOTHO, SOUTHERN AFRICA

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The endothermic decomposition of thaumasite from Mothae which has been investigated by DTA and TG shows a peak temperature of 138–203 °C, and reaction orders of 0.45–1.00, depending on the heating rate employed. The activation energy of the reaction was found to be about 19 kcal/mole; the enthalpy is 246 cal/g.

The decomposition seems to be divided into one reaction with \( n = 0.90 \), immediately followed by one with \( n = 1.59 \). The first reaction is attributed to the loss of \( \text{H}_2\text{O} \), the second one to the (partial) release of \( \text{OH} \) and \( \text{CO}_2 \).

Thaumasite, \([\text{Ca}_3\text{Si(OH)}_6 \cdot 12 \text{H}_2\text{O}]\text{(SO}_4\text{)} \text{(CO}_3\text{)}\), is one of the rare cases, where silica occurs in octahedral co-ordination \([1-3]\). Thaumasite is found in low-temperature and low-pressure parageneses \([4-7]\).

The thermal decomposition of thaumasite has previously been investigated by Badalov and Golovanov \([8]\), Zhabin \([9]\), Font-Altaba \([10]\), and Kirov and Poulieff \([11]\). The aim of the present contribution is a more detailed investigation of the decomposition reaction, with special emphasis on reaction kinetics.

Material and methods

The thaumasite used for this study is found as soft, white fibrous masses, forming veinlets within the “blue ground” kimberlite of Mothae pipe (Northern Lesotho). It most likely represents a very late-stage mineral, and occurs with zeolite minerals, apophyllite, vermiculite and saponite.

For the differential thermal analyses, Linseis (L-72) and Netzsch DTA equipment have been used, the latter for the curves given in Fig. 1. Analytical details are given in Figs 1–3 and Table 1 respectively. For thermogravimetry a Stanton thermobalance has been used.

Results and discussion

The general DTA curve of thaumasite is, according to Font-Altaba \([10]\), characterized by a large endothermic peak at 206 °C (loss of water and carbon dioxide), and a small exothermic effect at 709 °C (crystallization of larnite + anhydrite). Similar results have been obtained by Badalov and Golovanov \([8]\), Zhabin \([9]\),
and Ivanovna [12], who adds small endothermic effects at about 1030° and 1230° (reversible reaction) to the pattern. Federico [13] records endothermic reactions at 170°, 770°, 1260° and 1360°, and minor exothermic effects at 835° and 985°.

Our results (Fig. 1), measured in CO₂ flow, show the major endothermic effect at 168°, a minor peak at 675° and a larger effect at 1306°. The only exothermic peak appeared at 817°. On cooling, a small endothermic peak was found at 800°. The DTA pattern in air was similar to the above-mentioned curve. There is, however,

![Fig. 1. DTA curve of thaumasite. Heating rate: 10°/min; 15 l/h CO₂. Al₂O₃ crucibles; 50 mg sample, 138 mg alumina as reference material](image)

an endothermic reaction at 1085°, in agreement with the curve given by Ivanovna [12].

The main endothermic effect has been studied more closely. The peak temperature was found to increase with increasing heating rate: 1°/min — 138°, 5°/min — 153°, 10°/min — 166°, 20°/min — 173°, 50°/min — 203°. The value of 206.6 given by Font-Altaba [10] suggests that a heating rate of about 50°/min has been employed. This author also describes the decomposition of thaumasite to be a first-order reaction. Our investigations show that this is only true for heating rates of 20°/min; slower heating rates render lower reaction orders (Table 1).

The main endothermic effect is composite in its nature. In most of our runs, the peak might be approximated with a single reaction taking place. If heating rates of about 20°/min or more are employed, the composite nature of the reaction becomes evident (Fig. 2). If the reaction orders are evaluated according to Fig. 2, a value of 0.90 is obtained for the first, and 1.59 for the second reaction (Table 1).

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