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Stability of Epidote Minerals

A NUMBER of silicate minerals have proved difficult to synthesize by the commonly employed methods involving hydrothermal crystallization of glasses or reactive oxide mixes of suitable composition. Failure to synthesize a phase may be caused by the experimental conditions not being within the region where the phase is thermodynamically stable. But, in some cases, failure simply reflects a large nucleation barrier to the formation of the stable phase so that metastable phases which nucleate with ease form, and may persist indefinitely. Several workers¹⁻³ have considered this problem in relation to the epidote minerals, and the consistent failure of low-pressure synthesis could indicate that these phases may be stable only under relatively high-pressure conditions. Geological occurrence does not entirely support this proposition. The results presented here indicate that with these minerals nucleation is a sluggish process at low pressures, and if this step is by-passed, growth is readily achieved from the phases which normally form in synthesis. This sluggish nucleation is possibly related to the structure of the minerals.

Proof that the epidote minerals (zoisite, clinozoisite, epidote) are stable relative to the phases commonly formed in synthesis from their composition has been approached as follows. When zoisite is thermally decomposed at one atmosphere, reaction proceeds according to the reaction:



Similar reactions can be written for other members of the epidote family. When zoisite synthesis is attempted at low pressures and temperatures from a mix of appropriate composition, phases on the right of the above equation tend to be formed, or if leaching of silica occurs hydrogarnets may form. In the present experiments two starting materials were used; an iron-poor clinozoisite and an epidote which, judging from refractive index, contained around 13 per cent iron sesquioxide (Fe_2O_3). These phases were first thermally decomposed to form the high-temperature assemblages and then mixtures of the epidote mineral and high-temperature products

(that is, all the phases in the above equation) were sealed in small capsules with water and allowed to react for 30-80 days at 2,000 bars pressure and then examined by X-rays and microscope. With a mixture of epidote and decomposed epidote, it was found that epidote formed strongly at 505° and 630° C. while at 715° C. anorthite, garnet and magnetite were the dominant products. A mixture of clinozoisite and decomposed clinozoisite produced clinozoisite at 605° C. and anorthite and garnet (from refractive index and X-ray measurement close to grossularite) at 740° C. At 605° a few grains of garnet could be recognized, but growth of clinozoisite was spectacular. In two runs with epidote composition excess quartz was added and at 465° and 605° C. strong growth of epidote occurred.

These results indicate clearly that, relative to the normal products of synthesis, the epidote minerals are stable at moderate temperatures and water pressures. Thermodynamic consideration of entropy and changes in volume involved indicates that little pressure would be needed for their formation at low temperatures from suitable compositions. At temperatures around 300° C. and below, present results⁴ indicate that zeolites will become stable. Work on other reactions involving calcium aluminosilicates in progress also demonstrates that this method of mixtures may be of value in proving relative stability of phases whenever it is suspected that the slow step in the reaction kinetics is nucleation.

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