distortion, the crystal-size broadening will be correspondingly less and the estimated crystal size will be larger. At present, 4×10^{-6} cm must be taken as a lower limit to the crystal size. However, the fact that there is no noticeable diminution of the broadening within the time-temperature limits of the experiments suggests that the distortional contribution to the broadening may be small so that the crystal size may indeed be as small as 10^{-5} cm. This result implies that the diffusion processes that occur in these topotactic reactions take place over quite short distances and this is compatible with the relatively low temperatures at which the reactions proceed to completion as compared with the higher temperatures required when forsterite is formed from mixed powders of MgO and SiO_2.

Discussion

Chemical equations for formation of forsterite. From the MgO–SiO_2 equilibrium diagram, forsterite and enstatite would be expected as reaction products from the recrystallization of dehydroxylated serpentine. The equation can be written:

$$(3MgO.2SiO_2) \rightarrow (2MgO.SiO_2) + (MgO.SiO_2)$$

serpentine anhydride	forsterite	enstatite
	58·3 %	41·7 %

The intimate mixing of the 'oxides' in the serpentine after dehydroxylation would be expected to favour the attainment of equilibrium and any residual 'water' might assist the reaction since water often provides a catalytic effect. The non-appearance of crystalline enstatite until higher temperatures (> 1000° C) are reached raises doubts as to the validity of this equation, but it is not conclusive evidence because if enstatite is slow in crystallizing an amorphous phase of enstatite composition may be formed.

The fact that the amount of forsterite found experimentally, 75 to 80 %, is much greater than the amount predicted by this equation indicates that the reaction is probably not proceeding directly towards the ultimate equilibrium.

A second equation can be written on the supposition that all the MgO in the serpentine composition goes into forsterite, leaving a residue of amorphous silica:

$$(3MgO.2SiO_2) \rightarrow 1{\cdot}5(2MgO.SiO_2) + 0{\cdot}5(SiO_2)$$

forsterite	silica
87·5 %	12·5 %

This equation gives the maximum amount of forsterite, 87·5 %, which is not greatly in excess of the measured amount. That the observed amount, about 75 to 80 %, is somewhat less is not surprising since a small proportion of MgO might well be retained in the amorphous silica phase. What seems most important is that the measurements point much more strongly towards the second equation than towards the first. The criticism of Ball and Taylor (1963, p. 474) that in previous work silica was introduced 'merely to balance the chemical equations' was a valid criticism, but the present results seem now to provide at least a partial justification.

Consideration of the inhomogeneous mechanism proposed by Ball and Taylor (1963)

They considered that the dehydroxylation and recrystallization of serpentine in air may proceed in four stages as follows:

Dehydroxylation: Protons migrate to reaction zones where water molecules are liberated. Mg and Si ions counter-migrate keeping the Mg:Si ratio more or less unchanged at 3:2, while the oxygen framework remains largely unchanged. This means that after the loss of water from regions that become pores, the remaining oxygens accommodate all the Mg and Si ions. The anhydride product is a partly disordered material giving an essentially 'amorphous' X-ray powder diagram.

Cation reorganization. A partial separation into Mg-rich and Si-rich regions begins, which requires Mg and Si ions now to move in opposite directions.

Forsterite crystallization. An ordering of cations and a change in oxygen ion packing in the Mg-rich regions leads to formation of forsterite.

Enstatite formation. The Si-rich regions change to enstatite but this stage occurs less readily than the others for reasons that are not at all clear.

The present experiments confirm the first stage, namely dehydroxylation and formation of an 'X-ray amorphous' phase. The degree of disorder in this phase must not be over-exaggerated since topotaxial relations between serpentine and forsterite require persistence of some degree of order. It has been shown that as recrystallization proceeds, forsterite (but no enstatite) appears in fine-grained form, increasing in amount with time and temperature until about 75 to 80 % of the product is forsterite, which requires that practically all the MgO of the serpentine composition goes to form forsterite. This does not support the second and third stages described by Ball and Taylor, in which Mg-rich

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