liberated, with a converse migration of other cations, Mg^{++} and Ni^{++}, to maintain electrical neutrality.

Ball and Taylor (1963) have given a detailed description of the heterogeneous processes by which the dehydroxylation and recrystallization of serpentine (both chrysotile and platy forms) may take place. They considered the formation of forsterite and also, at higher temperatures, of enstatite, and, under hydrothermal conditions, of talc.

Although the crystallographic relations provide strong pointers of how these 'ordered' reactions may occur, they scarcely give quantitative information. Since the reactions probably occur on a fine scale, possibly within domains of the order of 10^{-6} cm in size, it is not easy to obtain any direct information on the ionic (mainly cationic) migrations by which they are considered to take place. The present writers have sought further information by making quantitative measurements on the development of forsterite and, as will be shown here, the results suggest a somewhat different sequence of events than those postulated by Ball and Taylor.

Experimental

A massive serpentine from Quebec Province, of fine grain size and pale buff colour, was used. No mineral impurities were detected by X-ray diffraction. The mineral appears to be a layered structure with considerable stacking disorder. Powders with particle sizes in the range < 60, > 100-mesh screen size were heated in air in uncompacted form on a thermobalance at 570° C for periods of about 20 hours. From the loss of weight compared with the maximum loss at higher temperatures, it was determined that the mineral was about 90 % dehydroxylated by this treatment. X-ray diffraction data showed no residual reflections from unreacted serpentine and no detectable forsterite. Subsequent heat-treatments were carried out in air in temperature-controlled furnaces at temperatures ranging from 650° to 800° C for periods up to 100 hours. A few experiments were carried out at higher temperatures up to 1400° C to study the formation of enstatite.

Forsterite was determined quantitatively by integrated X-ray diffraction measurements using boehmite as an internal standard. Four forsterite reflections and two boehmite reflections were measured with a scanning speed of $\frac{1}{4}$° 2θ/min.

The results are shown in fig. 1 where the amount of forsterite formed is expressed as a percentage of the weight of the final fired material, i.e., as a percentage of completely anhydrous material. The maximum

amount of forsterite developed is about 90 % of the weight of the fully anhydrous material and is obtained after heating at 800° C for periods of 20 hours or longer. The internal standard, boehmite, was calibrated with respect to a nearly pure, well-crystallised, 'fused-cast' forsterite. The latter contained just detectable amounts of MgO and clino-enstatite, estimated at 5 to 7 % total impurity. Determinations made without allowance for these impurities may be over-estimated by a few percent,

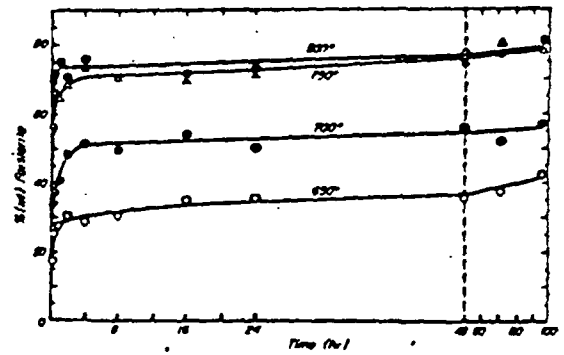

FIG. 1. Weight percent of forsterite formed from powdered serpentine in periods up to 100 hours when heated isothermally at temperatures shown in °C.

so that the value of 80 % forsterite may need to be reduced to about 75 to 76 %.

It was observed that the reflections from the forsterite derived from serpentine were broadened with respect to those from the high-temperature-produced forsterite. The broadening was approximately the same irrespective of the time (1 to 96 hours) or temperature (650 to 800° C) of the heat-treatment. If this broadening is attributed to small crystal size, and if a correction for instrumental broadening is based on the reflections from the high-temperature-produced forsterite, then a value of the order of 4×10^{-6} cm is obtained for the crystal size of the forsterite obtained from serpentine.[1] If the broadening arises partly from lattice

[1] The correction used for instrumental broadening is:

$$B^2_{observed} = B^2_{crystal\ size} + B^2_{instrumental}$$

The crystal size is calculated from the Scherrer formula: $t = \lambda / B_{crystal\ size} \cos\theta$.