

with double superscripts in Fig. 6, and the projected field boundaries around them were sketched from Fig. 5(b) and the known ternary relationships. Figure 6 is thus a projection of the vapor-saturated liquidus surface onto the plane  $\text{Ca}_2\text{SiO}_4\text{-Ca(OH)}_2\text{-MgO}$  along the  $\text{H}_2\text{O}$ -liquid tie-lines. Figure 3 indicates that the part of the vapor-saturated liquidus surface within the area  $\text{AW}_1\text{W}_2\text{YX}$  (compare Figs. 3 and 6) is situated just a short distance on the  $\text{H}_2\text{O}$  side of this triangle. The arrangement of quaternary field boundaries shown in Fig. 6 is thus a more accurate representation than Fig. 5(b) of the phase relationships on the vapor-saturated liquidus surface within the tetrahedron  $\text{CaO-Ca}_2\text{SiO}_4\text{-MgO-H}_2\text{O}$ . This projection has the added advantage that all of the crystalline phases encountered at this pressure have compositions lying on the plane. Figure 6, summarizing the results obtained in this study, has been combined with other known and inferred data to provide Fig. 7.

The compositions of the projected liquids are:

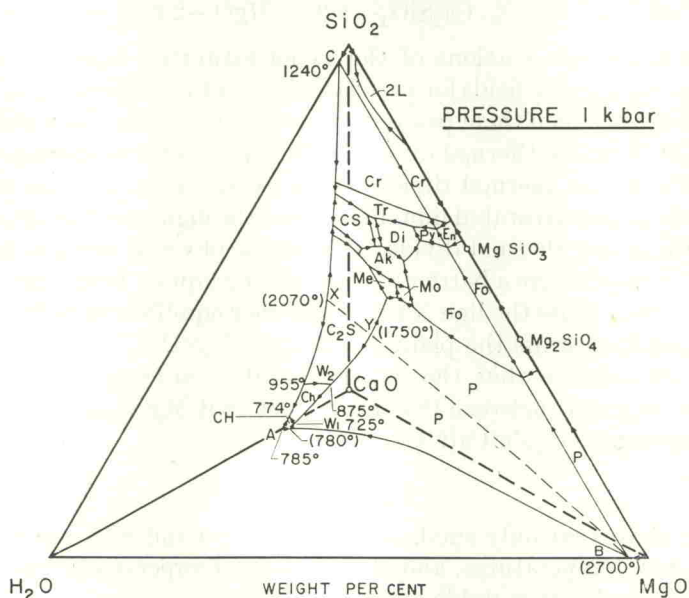
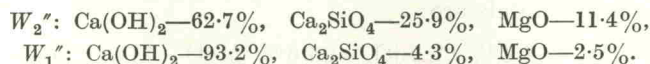
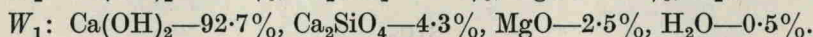
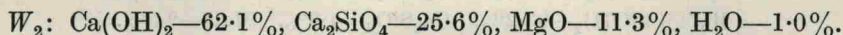


Fig. 7. The system  $\text{CaO-MgO-SiO}_2\text{-H}_2\text{O}$  at 1 kilobar pressure: schematic diagram based on Figs. 2, 3 and 6. The phase relationships for the system  $\text{MgO-SiO}_2\text{-H}_2\text{O}$  are shown, see Fig. 2; En—enstatite. ABC is the vapor-saturated liquidus surface transferred from Fig. 3, and the dashed line XYB is a thermal maximum on this surface. The phase relationships above XYB are based on the system  $\text{CaO-MgO-SiO}_2$  (see Fig. 2), and those below XYB are based on the experimental results shown in Fig. 6. Temperatures in parentheses are estimated. For abbreviations see text or legends for Figs. 1 and 2.

It is convenient to consider the vapor-saturated liquidus surface in two portions, above and below the thermal divide XB shown in Figs. 3 and 7. The phase relationships above the line XYB in Fig. 7 are assumed to be similar to those of the anhydrous system (Fig. 2), with temperatures somewhat lowered as a result of the small percentage of  $\text{H}_2\text{O}$  dissolved in the liquids, and with the two-liquid volume being closed before the liquids become saturated with  $\text{H}_2\text{O}$ . This part of the vapor-saturated

liquidus surface remains very close to the anhydrous base, and the distribution of isotherms on the anhydrous liquidus surface permits a confident statement that primary fields for dicalcium silicate and for periclase are the only ones extending across XYB on the vapor-saturated liquidus surface, through a wide pressure range. The phase relationships below the line XYB in Fig. 7 are more complex than in the anhydrous system, because of the formation of hydrous compounds with stability fields on the liquidus. The surface here extends somewhat towards the H<sub>2</sub>O corner of the quaternary tetrahedron. The liquid compositions  $W_2$  and  $W_1$  are believed to contain a little more H<sub>2</sub>O than the projected liquids  $W_2''$  and  $W_1''$  in Fig. 6, and making adjustments to allow for this, the estimated compositions of the quaternary peritectic and eutectic liquids are:



The upper and lower portions of the vapor-saturated liquidus surface have in common the primary phase fields for periclase (P) and for dicalcium silicate (C<sub>2</sub>S), and the field boundary between them passes through a pronounced maximum in temperature at the point Y on the thermal divide XYB. All available evidence suggests that the portion XY of the thermal divide would persist as a significant temperature maximum on the vapor-saturated liquidus surface through a very wide pressure range. The portion YB of the thermal divide, although a physical temperature maximum only near to Y, is as effective a barrier to crystallizing liquids as the thermal maximum XY. Liquids cannot cross the line XYB with either equilibrium or fractional crystallization; nor can they cross the plane XYB.MgO.Ca<sub>2</sub>SiO<sub>4</sub>.

These results indicate that the vapor-saturated eutectic liquid in the system CaO–MgO–H<sub>2</sub>O contains between 0.5 and 3.5 per cent MgO, and probably less than 1% H<sub>2</sub>O in excess of the join Ca(OH)<sub>2</sub>–MgO.

#### DISCUSSION

The results show that only small amounts of MgO and SiO<sub>2</sub> are soluble in fused portlandite at low temperatures, and that liquidus temperatures rise sharply when periclase or silicates become stable on the liquidus.

The existence of the thermal divide XYB on the vapor-saturated liquidus surface shows that, with fractional crystallization at this pressure, the high temperature silicate liquids with compositions richer in SiO<sub>2</sub> than XYB are unable to yield a low temperature residual melt that is capable of precipitating the hydrated phases. Crystallization of these minerals yields only silicates and a separate vapor phase. Any liquid with composition poorer in SiO<sub>2</sub> than XYB, however, will yield a hydrated low temperature residual liquid with fractional crystallization, and this liquid will precipitate hydrated phases. A similar thermal divide was encountered in the system CaO–SiO<sub>2</sub>–CO<sub>2</sub>–H<sub>2</sub>O (WYLLIE and HAAS, 1965). Increasing pressure is not likely to cause any significant changes in the position or stability of the thermal divide until different mineral assemblages are produced at very high pressures, perhaps in the 15 to 30 kb range.

Figure 7 can be used as a model for the system CaO–MgO–SiO<sub>2</sub>–CO<sub>2</sub>. From what is known of the system CaO–SiO<sub>2</sub>–CO<sub>2</sub>–H<sub>2</sub>O (WYLLIE and HAAS, 1965), it is to be