large number of end members. The area over which this sliding reaction will occur has not been determined experimentally and much longer run times (≈ 1 month) may be needed to establish this zone.

5. Interpretation

The present data suggest that eclogite will form at the expense of amphibolite when pressures are somewhere in the region of 10–30 kb at medium temperatures for basaltic rocks at high water pressures. This generally confirms LAMBERT and WYLLIE's (1968) experiments, but the difference between syntheses and reversals found here suggests that their synthesis experiments may be in error and should not be used for any specific argument as to magma generation in the upper mantle. Stability of one amphibole in a basaltic rock or under its own composition is no guide to the behavior of another amphibole in an ultramafic rock. Certainly their incoming of garnet at $P > 18$ kb (LAMBERT and WYLLIE, 1970) is open to doubt as no garnet nuclei were available in the starting mix. Tighter reversals are needed before evaluating the possibility that crustal eclogites form at high water pressures.

Garnet amphibolites lacking feldspar are expected to have higher densities (3.2–3.4 g/cm³) and higher estimated seismic velocities ($V_p = 7.6$–8.0 km/s) than previously thought possible for hydrated basic rocks, and may be important in the lower crust or upper mantle (<70 km), if water pressures are high. Garnet amphibolites lacking feldspar have been found in high-pressure crustal rocks (ESSENE, 1967) and may be widespread in the lower crust.

The apparent stability of biotite in the potassic alkali olivine basalt suggests that trioctahedral mica may be an important hydrous phase in the upper mantle. The decomposition of several amphiboles at high water pressures (fig. 3) apparently involves formation of another sheet silicate (talc) at high water pressures. SCLAR (1970) has synthesized a 10 Å micaceous phase in the system MgO–SiO_2–H_2O at $P > 30$ kb and $T < 500$ °C but has not yet shown whether this phase is stable by reversals nor reported its relation to other phases of ≈ 10 Å – as attapulgite. KUSHIRO et al. (1967) have examined phlogopite at high pressures and claim it is stable to at least 100 kb, but they have located a solidus in the system outside their stability field for phlogopite, whereas LUTH (1967) has shown that phlogopite breakdown

curve intersects the solidus at only 2 kb water pressure. This suggests that Kushiro et al. may have had $P_{H_2O} \ll P_T$ in their runs; they may have also had trouble with quench phlogopite. In a later series of experiments, YODER and KUSHIRO (1969) confirmed Luth's data and showed that phlogopite remains stable up to 1200 °C and 40 kb.

Appendix I

The thermodynamic calculations in fig. 3 were all based on experimental data, and extended to higher pressures and temperatures with the well-known relations

$$\left(\frac{\delta \Delta G}{\delta T}\right)_P = -\Delta S, \quad \left(\frac{\delta \Delta G}{\delta P}\right)_T = \Delta V.$$

The free energy data for water were taken from BURNHAM et al. (1968) below 10 kb, and above 10 kb from SHARP (1962). Measured high-temperature entropies ($S_T - S_{298}$) are not available for talc, tremolite or "hornblende" and were estimated by summing the high-temperature entropies of other silicates:

talc = 2 serpentine − 3 brucite*,
tremolite = talc + 2 diopside**,

and the entropy of "hornblende" was assumed equal to tremolite. From these estimates, the high-temperature entropies of talc and tremolite were fitted to the quadratic equation of the form

$$S_T - S_{298} = a \ln T + b10^{-3}T + c10^5 T^{-2} + d,$$

where the values of a, b, c, d are given in table 1.

TABLE 1

	a	b	c	d
Talc	+126.26	−5.06	+24.89	−745.82
Tremolite	+232.00	+10.02	+38.63	−1365.52

The molar volumes (V^0) of the silicates were taken from ROBIE et al. (1967) and the standard entropies (S_{298}^0) from ROBIE (1966); these data are not available for "hornblende" and were estimated: $V^0 = 270.5$ cm³. $S_{298}^0 = 131.6$ e.u. In making the calculations the com-

* Entropy data for serpentine and brucite are from KING et al. (1967).
** High-temperature entropy data for diopside are from KELLEY (1960).