

DISCUSSION OF RESULTS

The initial slope of the acmite fusion curve, under conditions where oxygen fugacity is specified by hematite + magnetite, is about $20^\circ/\text{kb}$, one of the steepest of any silicate yet investigated. From the Clapeyron relation, $dT/dP = \Delta V/\Delta S$, it is clear that either ΔV is unusually large relative to ΔS , compared to other silicates, or ΔS is unusually small relative to ΔV . Since acmite melts incongruently to relatively dense solids (oxides) + liquid, ΔV could not be unusually large. It is probable, instead, that ΔS is unusually small relative to ΔV . This may be in part due to the low entropy of the oxides and also may indicate that coordination of the ions in the liquid is similar to that in acmite itself, contributing to the small change in entropy on melting.

In figure 3 the melting curves of diopside, jadeite, and acmite are compared. Substitution of Fe^{3+} for Al in jadeite to make acmite raises the melting temperature about 100°C at 30 kb and 50°C at 50 kb. However, acmite still melts about 250°C lower than diopside over most of the pressure range to 50 kb. Thus the presence of Na, Al, and Fe^{3+} in pyroxenes of possible mantle assemblages can have an appreciable effect on pyroxene stability. At first glance, the acmite and jadeite curves might be thought a model for the minimum temperatures of melting in the upper mantle. But two effects will work to lower these temperatures drastically, low relative values of oxygen fugacity and trace amounts of H_2O .

The continued incongruent melting of acmitic pyroxene over a wide range of oxygen fugacity and to high pressure indicates that in magmas

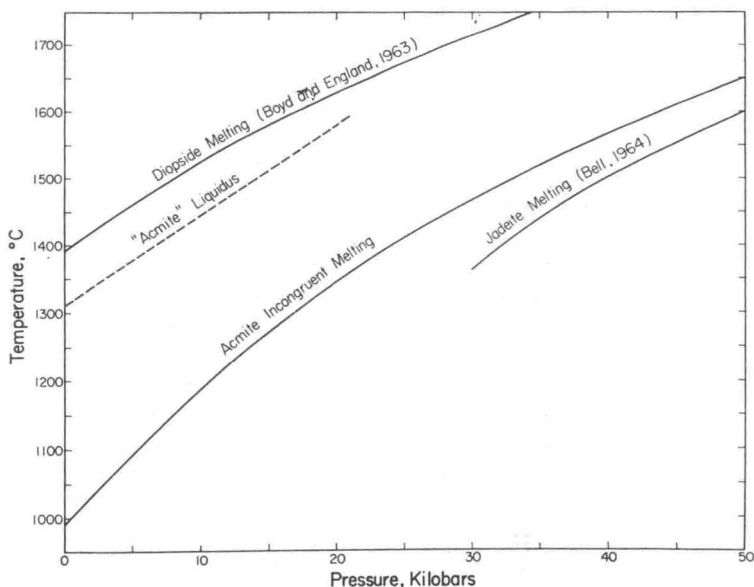


Fig. 3. Fusion curves of several related end-member clinopyroxenes.

with initial peralkaline tendencies, fractional crystallization due to separation of early-formed iron oxides or olivine could easily bring about a change in liquid composition toward a general enrichment of sodium and silica. Such a development of a peralkaline trend was postulated many years ago by Bowen, Schairer, and Willems (1930) and more recently by Bailey and Schairer (1966) on the basis of experimental work at 1 atm. The importance of this study is that pressures equivalent to depths of 120 to 140 km do not change the incongruent relationship discovered at 1 atm, which is basic to that theory. Indeed, partial melting of lower crust and upper mantle material, possibly involving several stages, would help generate the initial peralkaline trend. Mobile melts rich in Na and Si (also Al from jadeite "component"), compared to the crystalline residue, once formed, could work their way to the surface, leaving behind spinel-olivine assemblages. Spinel peridotite inclusions commonly found in association with alkali olivine basalts may partially reflect such a process.

Preliminary experiments on the join acmite-jadeite indicate that incongruent melting of pyroxene + hematite + liquid continues across to jadeite-rich compositions. In the 1-atm study of these compositions, although these jadeite-rich pyroxenes are not stable, hematite is stable at the liquidus to near jadeite composition (Bailey and Schairer, 1966). Yagi (1966) showed that, on the diopside-acmite join at 1 atm, pyroxenes from acmite₁₀₀ to acmite₄₀-diopside₆₀ (wt percent) also melt incongruently. Thus incongruent melting of soda-rich pyroxenes to oxides is a general phenomenon of some importance.

A "new melting law" of the form $T_M = T_M^\circ (1 + C \Delta V/V_0)$, for application at high pressures, has recently been proposed by Kraut and Kennedy (1966a). It was based on the observation that plots of melting temperature at pressure against isothermal (room-temperature) compression of the solid phase appeared to give a linear relation. These authors originally suggested that "this result seems to apply to all substances examined which melt with an increase in volume . . .". Shortly thereafter Kraut and Kennedy (1966b) indicated that some solidified gases did not obey this relationship. More recent work by Luedemann and Kennedy (1968) has shown that the linear relation also breaks down for the alkali metals as melting maxima are approached, and compression of the solid reaches 35 to 40 percent. The latter authors speculated that the results may indicate that, at equivalent compressions for silicates (in the deep mantle and core), fusion maxima would also be encountered. In the light of these arguments it seemed of interest to examine such a plot for acmite, which melts incongruently (fig. 4). Compressibility values are derived from ultrasonic measurements on a specimen of aegirite, which was not chemically analyzed (Birch 1966, tables 7-10 and 7-12; Alexandrov and Ryzhova, 1961).

It is clear that no linear relation between $\Delta V/V_0$ and melting temperature exists for acmite. In fact, the resulting curve is similar in form to the fusion curve itself. It was thought possible that deviation from