Fig. 5. Effect of water pressure on melting of silica, SiO_2, and granite, with water entering the liquids. The melting behavior of SiO_2 under inert pressure is shown for comparison.

water is one of the commonest in experience. For many decades it had intrigued geologists to consider what influence water or other volatile materials would have on the melting behavior of rocks. Naturally, to carry out such an experiment the entire assembly of rock and volatile addition would have to be confined under pressure at or near the melting points of the rocks which are of the order of 1000–1500°C. In Fig. 5 two examples are shown of the influence of water pressure on common rocks and minerals. The lowering of the melting point of SiO_2 from 1730 to 1250°C under only 1000 atm of water pressure is quite dramatic. The water in this case dissolves in the siliceous liquid. Also shown for comparison is the influence of inert or dry pressure on the melting point of silica. In this case the gas or solid transmitting the pressure does not dissolve in either the liquid or solid silica. The similar dry-pressure curve is also shown later for the important mineral diopside, to illustrate the fact that in general the melting point is raised slowly with pressure. The distinction between melting in an inert atmosphere and one in which the volatile phase under pressure dissolves in the liquid should be borne in mind. In deeply buried rocks it can be assumed that much of the water is effectively sealed in the system and may enter the liquid phase. The results of the study of melting the assemblage of minerals which form granite are also shown in Fig. 5. The fact that a granite can be melted as low as 660°C at a pressure of 4000 atm (corresponding to a burial of about 10 miles) with only a few per cent of water in the liquid is one of the most important clues on the origin of many of the commonest igneous rocks in the earth.

Applications in petrology. While the synthesis of new or important compounds has a spectacular aspect, much of the recent effort of physical chemists working with high pressures is concerned only incidentally with synthesis. Instead, the main drive is toward the obtaining of new data on the pressure, temperature, and composition conditions under which certain mineral assemblages are stable. Nature provides several typical assemblages of minerals as characteristic of certain rock types or families. As the conditions under which each particular assemblage is stable are determined, a partial reconstruction can be provided of the conditions which must have existed at any particular place on the earth.

Two different types of reactions may be studied in this connection. The first type involves reactions such as decarbonation or dehydration. Two simple reactions of this type are used in the pressure-temperature diagram of Fig. 6, to illustrate the principle of the application of such data. The general form of such curves is seen to be convex toward the high-temperature and low-pressure side, with very steep slopes at pressures above a few thousand atmospheres, with an asymptotic approach to the temperature axis at very low pressures. On the low-temperature side of such curves, the hydrates such as mica, or carbonates such as magnesite, are stable. Thus, if the pressure from the depth of burial can be estimated by studying the minerals present, it is possible to determine whether or not the rock has been heated to temperatures above the curve. Thus it is possible to explain why the dark micas occur in some high-temperature extrusive rocks (lavas) while the white or muscovite micas do not. The dehydration-decomposition curve for the latter, not shown in Fig. 6, lies some 350°C lower than the dark-mica curve shown, while the temperatures of these rocks are intermediate.

In Fig. 7 is shown a compilation on one diagram of several p-t curves for assorted yet common compositions. Each curve represents a transformation reaction, where the composition of the condensed phases on either side of the p-t curve is the same. It may be noted that these curves are quite different from those of Fig. 6. They are all essentially straight lines in the pressure range shown. The
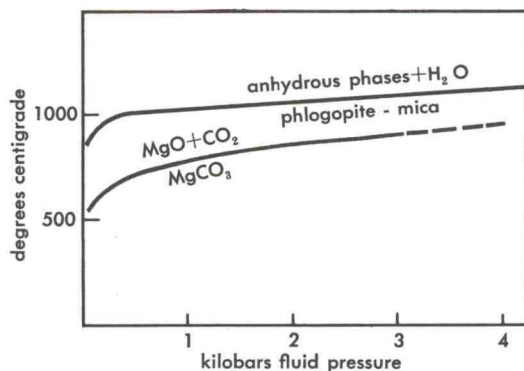

Fig. 6. Typical stability curves for minerals which lose CO_2 or H_2O on heating.
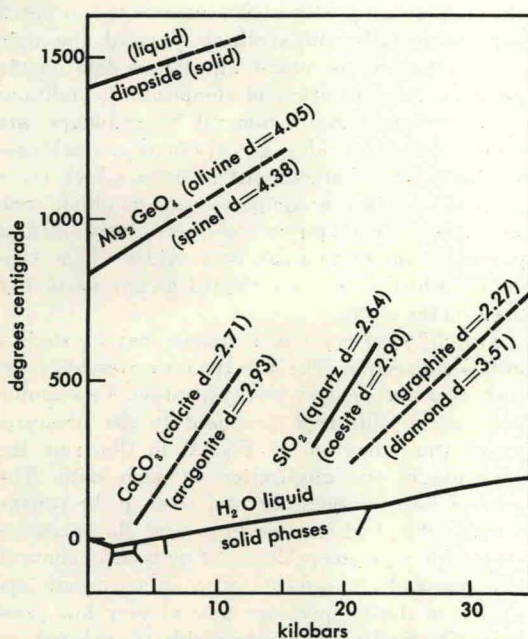
Fig. 7. Curves showing pressure-temperature dependence of typical solid-solid and solid-liquid transformations for single substances.

dense form is favored by high pressure. The pressure theoretically required to make diamonds is actually quite modest. Transformations that require twice the pressure to give the dense forms have been studied quantitatively.

In general, Fig. 7 illustrates how solid-liquid transformations such as the melting of ice do not differ basically from solid-solid transitions. These curves may of course be used in a manner similar to that described for Fig. 6 to suggest whether or not a particular rock was exposed to a certain set of *p-t* conditions. In practice, curves of both types are used to refine as far as possible the petrologic predictions which can be made.

Application to geophysical problems. From the same studies on the changes in phase (from less dense to more dense forms) in those minerals which geologists believe make up most of the mantle of the earth, it is possible to explain some of the variations in the velocities of seismic pulses at different depths in the earth. The present results do in fact suggest the possibility that the layering in the earth may not reflect changes in composition at all. Indeed, refined and sophisticated measurements of color changes in important minerals such as olivine at pressures up to 150,000 atm indicate that such a mineral may become metallic at pressures of less than 1,000,000 atm. In such phases the neutron and proton cores may eventually be stripped of their extra nuclear electrons to become a sort of metallic plasma. This may well represent the real conditions at the core of the earth. *See* EARTH INTERIOR.   [F.DA.; R.R.]

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