either cause hydrous compounds to be formed[7] or it may act as a solvent to carry impurities into the sample container.[8]

A comparison of the room-temperature data on fired specimens (Fig. 4) and the elevated temperature data (Fig. 2) shows that the samples fired to 1000°C and over generally have higher ultimate compressive strengths. Samples fired to 1100°C were found to contain longitudinal cracks, which may explain why their strength was lower than that of the samples fired to 1000°C. No cracks were observed in those samples fired to 1300°C.

The microstructures of those samples showing the greatest variation in mechanical properties were examined with an electron microscope. The specimens were polished, etched with hydrofluoric acid, and replicated with a carbon–platinum mixture. The electron micrographs of specimen B taken with a magnification of 15 000 indicated that the specimen was composed of grains several microns in diameter, some of which contained a parallel arrangement of fibers while in others the most pronounced feature was parallel rows of etch pits. An electron micrograph of specimen C in Fig. 2 revealed two sets of fibers intersecting at 60° angles. Sample D was composed of grains with fewer etch pits and more heavily etched grain boundaries than in the other samples.

Although the mechanism responsible for the high-temperature strength is not known, it is apparently related to the bonding and interlocking of the fibers of protoenstatite. The general increase in strength obtained upon cooling of the cylinders is considered to be due to the solidification of a glassy siliceous phase, particularly in the case of specimens prefired at the higher temperatures. The silica is expelled from the talc structure as the reaction proceeds and gradually accumulates to form cristobalite as the temperature is increased. This accumulation of finely dispersed silica into cristobalite or a glassy siliceous phase may be responsible for the more heavily etched grain boundaries in the higher-temperature test specimens. This also
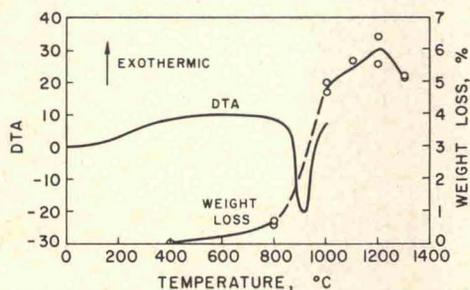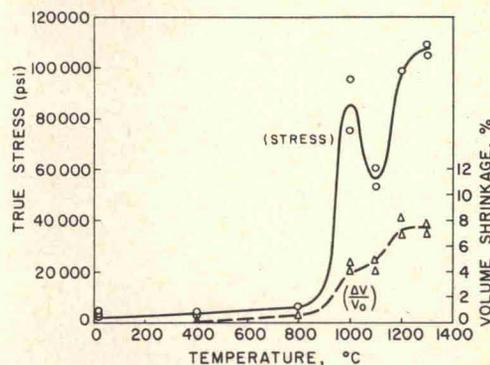
Fig. 4. Room-temperature compressive strengths and volume change in talc fired to the indicated temperatures.

suggests that at least part of the deformation may be due to grain boundary sliding.

The effect of firing time upon the high-temperature strength was not measured in this study. The probable effect of longer firing times would be to increase the strength at a given temperature, but it should not change the essential character of the ultimate strength curve in Fig. 2. No significant increase in the strength of talc could be expected below the transformation temperature, and the strength should still decrease at temperatures higher than 1100°C.

CONCLUDING REMARKS

The compressive strength of talc does not decrease with increasing temperature, but increases until it is as strong as sintered alumina at 1100°C. Above 1100°C, specimens of talc become weaker and can be deformed plastically. However, it should be noted that talc heated above 800° under conditions where a thermal gradient exists, such as in a high-pressure device, always would have a zone of strong, brittle material present. The effects of the increase in the bulk modulus of elasticity should also be emphasized. In an ideal high-pressure cell the pressure medium should deform easily to accommodate the volume changes due to compaction or phase changes. If the modulus increases, greater stress is necessary for the medium to adjust to these changes. The influence of temperature and stress upon deformation can be estimated from the curves in Fig. 1. The compressive tests in the present study were performed on unconfined cylinders, a situation in which fracture could occur by lateral movements of material. If the cylinders were confined, even higher stress levels could be expected.

It would be difficult to estimate the effect of this high-temperature strength upon the transmission of pressure in an actual high-pressure cell. In any event, the main effect would be expected at temperatures greater than 800°C, and any possible effect should become larger with increasing temperature and time. The pressure distribution, the effect of water vapor, and the temperature distribution in the cell are complicating factors which would need to be considered.

Fig. 3. Differential thermal analysis and weight loss after firing of talc.

[7] F. R. Boyd and J. L. England, J. Geophys. Res. 68, 315 (1963).
[8] E. J. Bradbury et al., Tech. Doc. Rept. No. ASD-TDR-62-73, Directorate of Materials and Processes, Wright-Patterson AFB (1962) (unpublished).