(*in* Sosman, 1927), Goranson (1949), and Griggs, Turner, and Heard (1960) show a high degree of consistency, but values obtained at confining pressures between one atmosphere and 20 kb are quite variable.

The only previous data available on the strengths at room temperature for other orientations are determinations for compression perpendicular to the *c*-axis at atmospheric pressure (Berndt, in Sosman, 1927) and compression normal to *r* at 5 kb confining pressure (Griggs, Turner, and Heard, 1960). These are represented, with the data from the present study, in figure 9b.

The abnormally high values of strength at high confining pressures obtained by Griggs and Bell (1938), Bridgman (1940), and Goranson (1949) may have been due to high friction at piston-cylinder contacts in their apparatus or to high strength of the confining media employed (Griggs, Turner, and Heard, 1960). Errors due to such effects could not be corrected in the data of these investigators, but should be compensated for in our data as a result of the method of reduction (comparison with a calibration sample of very low shear strength). The values obtained in the present study may be slightly low since no correction was made for the low but finite strength of the indium in the calibration sample.

The origin of the fractures.—The prominent set of planar fractures normal to the cylinder axis is present in samples of all orientations. These fractures are planes of zero shear stress during the experiment; they are also normal to the axis of maximum principal stress during the loading of the sample and obviously could not have developed as extension fractures during loading. The simplest explanation of these features is that they are extension cracks which formed during the unloading of the sample. The fractures appear to be due to stress set up between the copper jacket and the quartz during unloading, for in experiments conducted under similar conditions with soft material, such as silver chloride around the quartz, cracks of this type are not formed.

Similar doubts exist as to the exact time that the other planar and curved fractures (excluding feather-fractures) were produced. It is unlikely that such extension fractures would form at the high pressures that existed in the sample during most of the experiment. They probably formed at the end of the unloading of the sample or even during preparation of the thin sections. It should be noted that they show a rather weak tendency to parallelism with the unit rhombohedra, similar to that demonstrated by Bloss (1957) for fractures produced by grinding at room temperature and pressure, and by Borg and others (1960) for fractures produced in deformation experiments on sand at moderate confining pressures.

The feather-fractures, on the other hand, probably originated along with, or immediately after, the failure of the specimens along the faults. They appear to be extension fractures related to the faults. The fact that these fractures are not quite parallel to the cylinder axis, which is the axis of maximum principal stress in the samples until failure, may reflect the influence of the anisotropy of the crystals, since they show some tendency to be parallel to the unit rhombohedra; but it is equally likely that this reflects the inhomogeneity of the stress after failure, and the feather-fractures may have formed normal to the axis of least principal stress after failure in the vicinity of the faults where they occur.

The nature and origin of the faults.—The nature of the faults is of particular interest because of (a) their parallelism with crystallographic planes and (b) their inclination, in some instances, at angles greater than 45° to the axis of maximum principal stress. There are few data in the literature on the crystallographic orientation of fractures in brittle materials deformed in compression. There are cases reported in which fractures in quartz (Griggs and Bell, 1938) and dolomite (Higgs and Handin, 1959) are non-crystallographic, but in others, such as the quartz crystal illustrated by Griggs and Handin (1960) the fractures are crystallographically controlled. There appears to be no consistency.

The development of faults at angles greater than 45° to the compression axis implies either (1) that if the faults are due entirely to fracture the planes have markedly lower shear strengths than others in the quartz, or (2) that the faulting is due to slip on the planes, since slip is independent of the normal stress on the slip-plane and may therefore occur on planes inclined at angles greater than 45° to the axis of maximum principal stress. The question arises whether the faulting is purely a fracture phenomenon or is initiated by plastic deformation (slip).

That the visible faults are predominantly fracture phenomana is demonstrated by the following features:

(a) There is considerable fracturing on a fine scale in the vicinity of the faults.

(b) The layer of isotropic material along many of the faults forms a discontinuity in the crystal, and the continuity of a crystal is not impaired by slip.

(c) It was not possible to determine the direction of displacement on faults accurately, but in all cases it appeared to be parallel to the direction of maximum resolved shear stress in the fault. For rhombohedral faults, this means that the shear was not parallel to a unique crystal direction, as is generally true of slip.

(d) The sudden shock accompanying failure is characteristic of fracture. It is possible, however, that failure was preceded by slip parallel to the planes of the faults.

It is possible to determine the relative ease with which faulting takes place parallel to different crystal planes (c, r, z, m, a) by comparing (1) the stresses on all possible fault planes in cylinders of a single orientation, at the time of failure (and noting which is the main fault); and (2) the rupture strengths of cylinders of different orientations, in which different crystal planes are expressed as the main faults. Thus in cylinders compressed perpendicular to r_1 and z_1, the shear stress is greater on the other unit rhombohedra (z_2, z_3 and r_2, r_3 respectively) than on the base (c), which is invariably the main fault. It follows that faulting takes place more easily, that is, at lower shear stress, on the base than on the unit rhombohedra. This conclusion is supported by the strength measurements, for cylinders $\perp r$ and $\perp z$, which fault on the base, are consistently weaker than cylinders $\| c$, which fault on the unit rhombohedra,