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EXPERIMENTAL DEFORMATION OF QUARTZ SINGLE CRYSTALS AT 27 TO 30 KILOBARS CONFINING PRESSURE AND 24°C*

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ABSTRACT. Oriented cylindrical samples cored from clear untwinned quartz crystals were deformed in compression in a piston and cylinder device, using bismuth as the pressure medium. Manv samples were deformed to failure in the BiII⇄BiIII transition at 27 kb and the ultimate strengths of these samples are recorded; the values show a high degree of consistency. Strengths of samples compressed parallel to the *c*-axis are significantly higher than those of crystals compressed in other directions.

The samples failed by rupture along "faults" in planes of high shear stress. These are crystallographically controlled: they are commonly parallel to the basal plane *c* and the unit rhombohedra *r* and *z*, and rarely to the prisms *m* and *a*. The main faults are generally inclined at less than 45° to the axis of compression but in crystals of two orientations they are inclined at angles greater than 45° to the compression axis. The faulting is apparently a fracture phenomenon. Thin zones of isotropic material, with lower refractive index than quartz, are present along many faults; some of these zones contain minute amounts of crystalline material, with higher indices and lower birefringence than quartz, probably coesite. The origin of these new phases is discussed.

Faulting takes place at lower shear stress on the base than on the unit rhombohedra, and on the unit rhombohedra than on the prism planes. Shear strengths along different planes are unrelated either to the bond density across these planes, the shear moduli, or the theoretical strengths. Other workers have shown that at higher temperatures quartz deforms by slip on the base and other planes including rhombohedral planes and possibly prism planes; the critical shear stresses for slip on the different planes, insofar as they are known, appear to vary in the same way as those for faulting. It is suggested that faulting is initiated by small amounts of slip on the planes; this gives rise to submicroscopic cracks which become large enough to propagate as brittle fractures.

INTRODUCTION

At the time when this study was begun, there was no unequivocal evidence that plastic deformation of quartz had been produced experimentally in the laboratory. It has been shown by many workers that high confining pressure tends to inhibit the fracture of materials and thus enhances the possibility of plastic flow taking place. In view of this, the present series of experiments was undertaken to determine if quartz would yield by plastic deformation at confining pressures in the region of 25 to 30 kilobars (kb) at room temperature, and, if so, to identify the mechanisms of deformation.

The experiments were carried out in a piston and cylinder apparatus, designed by G. C. Kennedy (Kennedy and LaMori, 1961). Cylinders cored from single crystals of quartz were deformed in compression, using bismuth as the pressure medium. The dimensions of the sample and the assembly were arranged so that the quartz would be deformed as the bismuth underwent a polymorphic transition at 27 kb, thus fixing the confining pressure.

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