ELECTRON PETROGRAPHY OF SHOCK-INDUCED CRYSTALLOGRAPHICALLY CONTROLLED PLANAR FEATURES IN QUARTZ. Charles B. Sclar and Jon F. Bauer, Department of Geological Sciences, Lehigh University, Bethlehem, PA 18015.

Planar features or planar elements are close-spaced (<10 μm spacing) parallel sets of crystallographically controlled planar deformation structures each less than 2 μm in width. They commonly occur in multiple sets in individual single-crystal grains. These features are produced in quartz at high strain rates induced by shock loading and have been extensively studied in natural samples and in experimentally shocked samples by petrographic methods using universal-stage methods (e.g. 1, 2, 3) and interference microscopy (4). Several hypotheses regarding the mechanism by which planar features are formed have been proposed, viz., (a) They are either lattice-controlled fractures (openings) produced in tension during rapid unloading or lattice-controlled fractures produced during rapid unloading which are coincident with pre-existing slip systems activated under high compressive stress (5); (b) They are due to plastic deformation (gliding on slip systems) above the Hugoniot elastic limit; and (c) They are formed by nucleation of high-pressure polymorph(s) on slip planes during compression followed by partial to complete transformation of these crystalline phase(s) to glass on relaxation (6). Some planar features in natural shocked quartz consist of a short-range-order phase characterized by a lower index of refraction than the still crystalline host (4, 7). The occurrence of parallel sets of submicroscopic lamellae of glass in crystalline quartz in experimentally shocked and naturally shocked quartz has been observed by transmission electron microscopy (8, 9). Stishovite aggregates in planar elements have been observed petrographically (2, 10).

We have examined by optical and electron optical methods samples of quartz sand shock loaded in the range 100-300 kilobars. Thin sections reveal the presence of well-developed planar features. Thin foils prepared by ion bombardment reveal by transmission electron microscopy the presence of multiple sets of glass lamellae (based on selected-area electron diffraction) in a highly damaged but still crystalline matrix. No high-pressure polymorphs of silica were found in the glass. These results are in accord with those reported earlier (8, 9) and support the hypothesis that the planar features are plastic deformation structures produced by crystallographically controlled slip. In view of the relatively low shock-pressure range represented by these samples, it seems unlikely that the glass which constitutes the planar features could have been produced solely by reversion of high-pressure polymorphs on pressure release. Instead, it seems probable that the silica glass produced as a result of slip constitutes the medium in which the high-pressure polymorphs of silica may nucleate. This supports the view based on the petrography of natural shocked samples (11) that the silica glass which constitutes the planar features may be the precursor of coesite and stishovite in shocked quartz.

ELECTRON PETROGRAPHY OF QUARTZ

Sclar, C. B.

(1) Hörz F. (1968) In Shock Metamorphism of Natural Materials. French B. M. and Short N. M., Eds., Mono. p. 243-253.

(2) v. Engelhardt W. and Bertsch W. (1969) Contr. Mineral. Petrol. 20, p. 203-234.

(3) Müller W. F. and Défourneaux M. (1968) Zeitschr. Geophys. 34, p. 483-504.

(4) Chao E. C. T. (1967) Science 156, p. 192-202.

(5) Sclar C. B., Short N. M. and Cocks G. C. (1968) In Shock Metamorphism of Natural Materials. French B. M. and Short N. M., Eds., Mono., p. 483-493.

(6) Stöffler D. (1972) Fortschr. Miner. 49, p. 50-113.

(7) Stöffler D. (1967) Contr. Mineral. Petrol. 16, p. 51-83.

(8) Müller W. F. (1969) Naturwiss. 56, p. 279-280.

(9) Christie J. M. and Ardell A. J. (1976) In Electron Microscopy in Mineralogy. Wenk H. R., Ed., Springer. p. 374-403.

(10) Stöffler D. (1971) J. Geophys. Res. 76, p. 5474-5488.

(11) Chao E. C. T. (1968) In Shock Metamorphism of Natural Materials, French B. M. and Short N. M., Eds., Mono., p. 135-158.

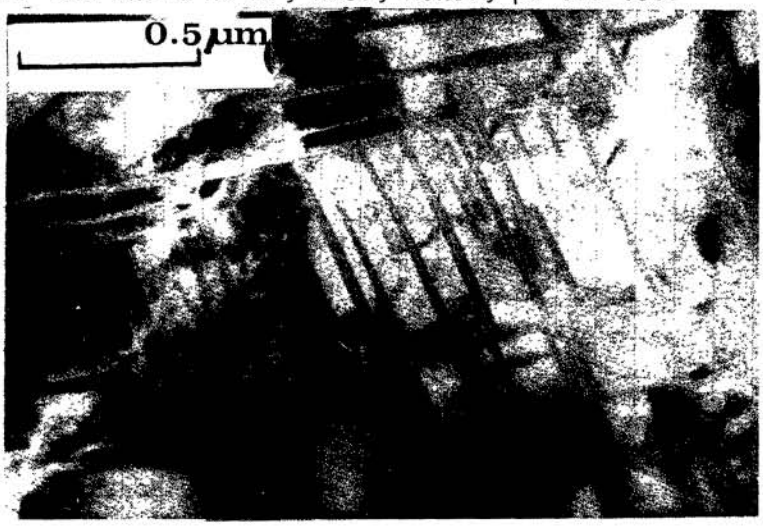

Fig. 1. Electron micrograph of experimentally shocked quartz which shows two intersecting sets of glass lamellae correlative with planar features observed optically.