ARE SHOCKED MINERALS UNIQUE TO IMPACT?

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Shocked quartz grains, taken as evidence of impact, are one of the primary criteria for the identification of impact craters and have also been taken as conclusive evidence for an impact causal relation for all K/T boundary phenomena. The tacit assumption that shocked minerals equals impact has precluded serious study of possible dynamically-induced microstructures from endogenous sources. Apart from observational work on diatremes from Canada (Sage, 1978), Montana, certain cryptoexplosion structures such as Vredefort (e.g., Reimold et al, 1988), and work currently underway at Dartmouth College and Texas A&M on rocks of kimberlitic affinity, there is little information on microstructures in rocks that may have been deformed dynamically by terrestrial processes. The presence of quartz shock lamellae at the Slate Islands diatreme Breccias, Lake Superior led Grieve and Robertson (1976) to conclude that these features were produced by impact while geologic evidence from the area (Sage, 1978) is indicative of dynamically emplaced diatremes of alkaline magmatic affinity.

The discovery of probable shock-induced microstructures at Toba and other explosive silicic volcanics (Carter et al., 1986; 1989) has led to the search for a signature that might distinguish between low-temperature ("impact") and high-temperature ("volcanic") shock. A series of 20 mm powder gun experiments were performed on Hospital Hill quartzite by F. Hörz of Johnson Space Center. Detailed petrographic analysis of samples shocked to 28 GPa, and at initial temperatures of 25°C and 440°C (Riemold, 1988; Carter et al.; 1989) indicates a strong dependence on temperature of the nature and development of microstructures (see figure): (a) whereas 91% of the grains from the low-temperature experiment contain lamellae, only 51% contain lamellae in the high-temperature run; (b) of the grains containing shock lamellae, 70% occur in multiple sets in the 25°C run as compared to only 20% at 440°C; (c) the form π dominates at 25°C whereas ω is more frequent at 440°C; (d) shock mosaicism is prevalent in both experiments, but shows significant recovery only in the 440°C run. Analyses of microstructures in quartz in K/T boundary sediments from Raton Pass, Gubbio (Carter et al., 1989), Walvis Ridge (Huffman, et al., 1988), and of materials unrelated to K/T from Toba Caldera (Carter et al., 1986; 1989) and the Slate Islands (Sage, 1978) show characteristics similar to those observed in the high-temperature experiment.

Because of the strong temperature dependence on the nature and development of quartz microstructures, it might also be expected that peak stress durations are of significance. Strain rates of hypervelocity impact experiments are near 10E7 (Duvall, 1968) whereas those associated with impacts and explosions are estimated to be from two to four orders of magnitude lower, respectively. Current technology does not permit dynamic experiments in the crucial gap 10E3-10E6 at the stresses and temperatures required and until this technology is developed, effects on microstructural development of peak stress durations associated with high vs. low temperature shock must remain conjectural.

A point of concern over shocked quartz observed at the K/T boundary is the absence of indications of intense shock deformation, including diaplectic glasses and high pressure polymorphs, coesite, stishovite common in known impact ejecta (McHone and Dietz, 1988). Although T. McHone (p.c., 1988) has found a suggestion of the presence of stishovite by X-ray diffraction studies of quartz separates from Raton Pass, the general lack of other indicators of intense shock may result from the limited area near the crater over which the most intensely deformed material is deposited (Melosh, 1988). Even the occurrence of coesite or stishovite (if confirmed) is problematic as these minerals can also form by terrestrial processes (e.g., Smith, 1984; Smyth and Halton, 1977).

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