PETROGRAPHY OF SHOCKED-QUARTZ SAND IN POLYMICT LITHIC BRECCIA, BUCK RIDGE ROAD, CENTRAL WETUMPKA CRATER, ALABAMA

J. R. Morrow[1] and D. T. King, Jr.[2]

[1]Dept. of Geological Sciences, San Diego State University , San Diego, CA 92182-1020, USA; [2]Geology Office, Auburn University, Auburn, AL 36849-5305, USA

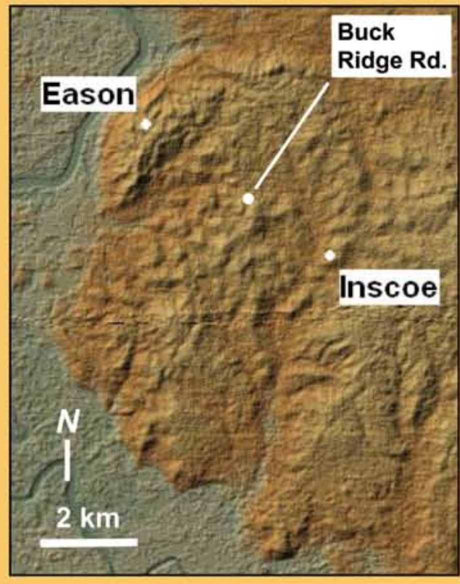


Figure 1 – False-color DEM image of Wetumpka impact structure, Alabama. Eason and Inscoe well locations and Buck Ridge Road locality are indicated.

Figure 2 – Buck Ridge Road outcrop in 2005, showing weathered polymict lithic breccia with light-colored, quartz sand-rich matrix (circled) that was sampled for petrographic analyses.

Introduction: Along Buck Ridge Road, central Wetumpka crater (**Fig. 1**), polymict megabreccia and breccia composed of a chaotic mix of crystalline metamorphic slabs and blocks, comminuted metamorphic- and sedimentary-clast lithic gravel, sand grains, and argillaceous matrix are exposed (**Fig. 2**). This polymict unit represents crater-filling slumpback of proximal ejecta [1]. Poorly consolidated, medium- to coarse-grained (250–1000 μm) quartz sand from the polymict breccia matrix was examined in grain-mount thin sections using universal stage and standard petrographic microscopes to identify and describe possible evidence of shock metamorphism.

Shock-metamorphic effects: Point-count analysis of 750 quartz grains within the thin sections showed that the population is composed of 69 vol. % monocrystalline quartz, 12 vol. % polycrystalline quartz, 5 vol. % quartz with sweeping, undulose extinction, and 14 vol. % quartz with planar microstructures (PMs) and mosaic extinction. Of the total quartz population, about 90 vol. % showed some rounding at the grain margins, indicating that these grains were probably sourced from the upper, sedimentary part of the target. The PMs and mosaic extinction pattern are interpreted to be the result of shock metamorphism.

The common PMs within the quartz grains are very similar to those documented from other proven impact structures, including Barringer, Gardnos, and, especially, Rock Elm [2,3,4]. The PMs occur as multiple sets of planar elements within grains; overall, an average of 3 sets per grain is present. In the Buck Ridge Road sample, PMs occur in two primary forms, following the terminology of French et al. [4] (**Figs. 3-4**):

(1) P1 type. P1 elements closely resemble planar fractures (PFs) or cleavage in quartz, which occur in multiple sets of open, parallel, flat to curviplanar planes aligned with distinct crystallographic orientations (**Figs. 5-6**). The P1 planes, which commonly show 2–4 sets per grain, are usually about 3–5 μm wide, are spaced 10–50 μm or more apart, comprise 76 freq. % of the PMs, and often cross most or all of the grain. The P1 sets most commonly occur with planes equivalent to c(0001), r/z, ξ, and *m/a* crystallographic orientations. Notably, planes parallel to ω and π are absent and rare, respectively (**Figs. 3-4**).

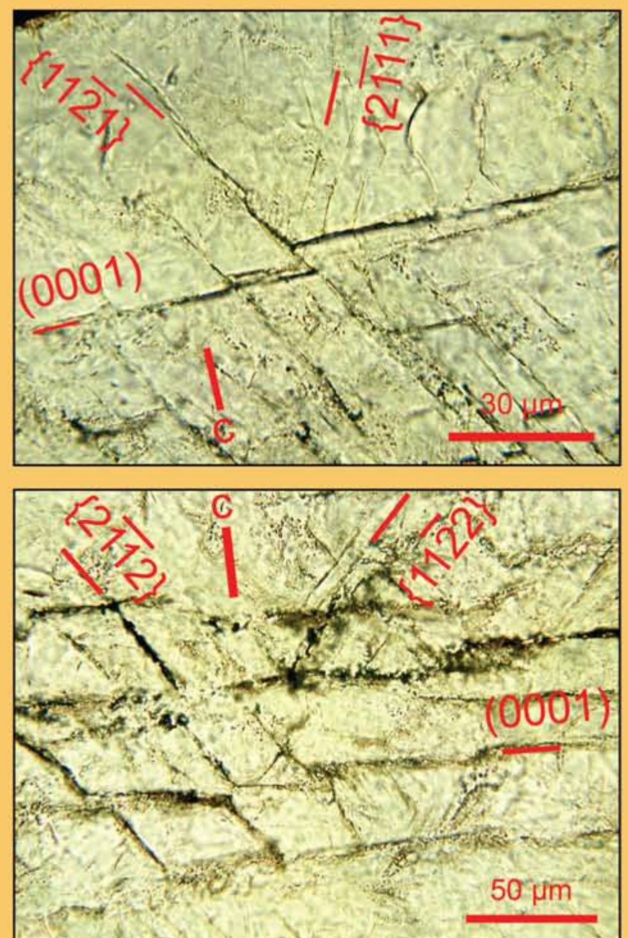
(2) P2 type. P2 elements are much shorter, much thinner, and more closely spaced than P1 planes, and strongly resemble closed, partly decorated to non-decorated planar deformation features (PDFs) (**Fig. 7**). The P2 planes, comprising 24 freq. % of the PMs, are usually about 1–3 μm wide and spaced <10 μm apart. The P2 sets are often developed off of or cross-cut by through-going P1 planes, forming "feather" or "ladder" structures (**Figs. 5-6**; cf. [4]). In some grains, P1 and P2 sets with the same crystallographic orientation occur. As in P1 elements, c(0001), *r/z*, and ξ planes are most common, although ω and π sets constitute 21 freq. % of the P2 forms.

Virtually all quartz grains that contain PMs also display a mosaic extinction pattern characterized by patchy, blocky, and sharply divided crystal sub-domains (**Figs. 8-9**). This pattern is distinguished from the broad, sweeping, undulose extinction noted in some non-PM bearing grains, which is interpreted as the result of normal burial metamorphism. Such other common shock-metamorphic indicators as markedly reduced birefringence, diaplectic glass, or melt were not noted.

Discussion: As noted for other sedimentary target impacts [3,5], the poorly consolidated, saturated, and porous upper target layers at Wetumpka played a critical role in the resulting greater abundance of P1 sets relative to P2 sets, as well as in the crystallographic orientations of these sets. The quartz PM development and the presence of both low- and high-index sets give further evidence of the predicted heterogeneous distribution and impedance of shock energy through the target. Further, these target properties may have also hindered development of such other expected shock products as diaplectic glass and melt.

Acknowledgements: JRM received partial funding from the University of Northern Colorado Earth Sciences Department. DTK was supported by the Wetumpka Impact Crater Fund at Auburn University.

References: [1] King D. T., Jr. et al. (2006) *Meteoritics & Planetary Sci.*, *41*, 1625–1631. [2] French B. M. et al. (1997) *Geochim. Cosmochim. Acta, 61(4)*, 873–904. [3] French B. M. (1998) *LPI Contribution 954*, 120 p. [4] French B. M. et al. (2004) *GSA Bull.*, *116(1/2)*, 200–218. [5] Grieve R. A. F. et al. (1996) *Meteoritics & Planetary Sci.*, *31*, 6–35.



Figures 5-6 – Plane-light photomicrographs showing multiple sets of PMs in quartz, Buck Ridge Road sample. Crystallographic orientations are indicated. Includes P1 type sets and smaller sets transitional to P2 type. Note "feather" structures formed of P2 sets developed off of larger P1 sets. In upper image, also note offset of c(0001) planes by second P1 set.

Indexed PM orientations; absolute frequency (%)[a]
Total of 124 sets in 40 grains; 3 sets/grain

	P1 (PFs)	P2 (PDFs)	P1+P2
Number of planes:	94	30	124
Form:			
c(0001)	30	20	27
$\omega\ \{10\bar{1}3\}$	n.d.	7	2
$\pi\ \{10\bar{1}2\}$	2	14	5
$r/z\ \{10\bar{1}1\}$	19	20	19
$m\ \{10\bar{1}0\}\ /\ a\ \{11\bar{2}0\}$	11	3	9
$\xi\ \{11\bar{2}2\}$	15	17	15
$s\ \{11\bar{2}1\}$	5	3	5
$x\ \{51\bar{6}1\}$	7	13	9
$\rho\ \{2\bar{1}31\}$	2	3	2
Unindexed	9	n.d.	7
	100	100	100

Figure 3 – Summary of PM planes and crystallographic orientations in quartz, Buck Ridge Road locality. [a] = indexing and plotting method after [5]; n.d. = none detected.

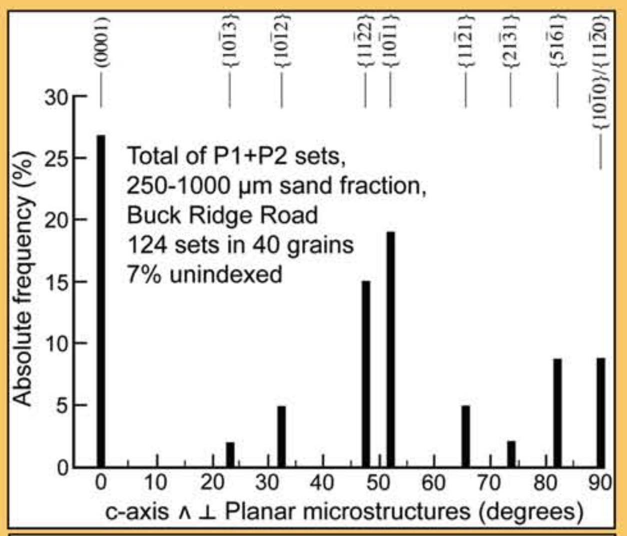
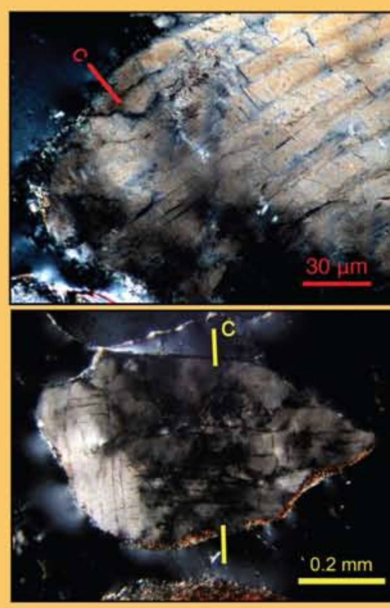


Figure 4 – Plot of absolute frequency percent of indexed PMs, composed of combined P1 and P2 sets, in quartz from Buck Ridge Road polymict breccia. P1 and P2 sets are similar to those in [4]; indexing and plotting after [5].



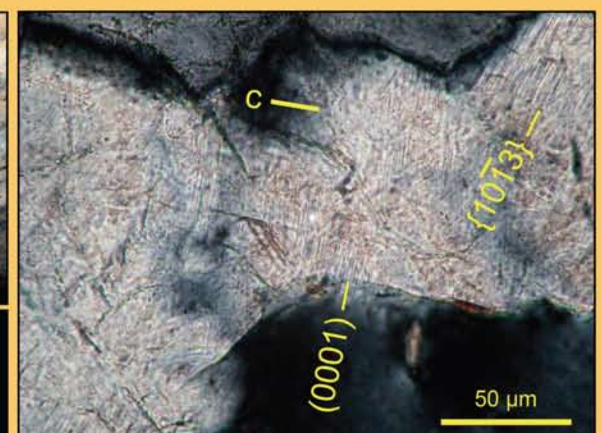


Figure 7 (above) – Polarized-light photomicrograph showing multiple sets of unusually well-developed, variably decorated PDFs (P2 planes) within polycrystalline quartz grain, Buck Ridge Road sample.

Figures 8-9 (left) – Polarized-light photomicrographs showing characteristic PMs and patchy mosaic extinction pattern within shocked-quartz grains, Buck Ridge Road sample.