PRELIMINARY SHOCKED-QUARTZ PETROGRAPHY, UPPER WEAUBLEAU BRECCIA, MISSOURI, USA

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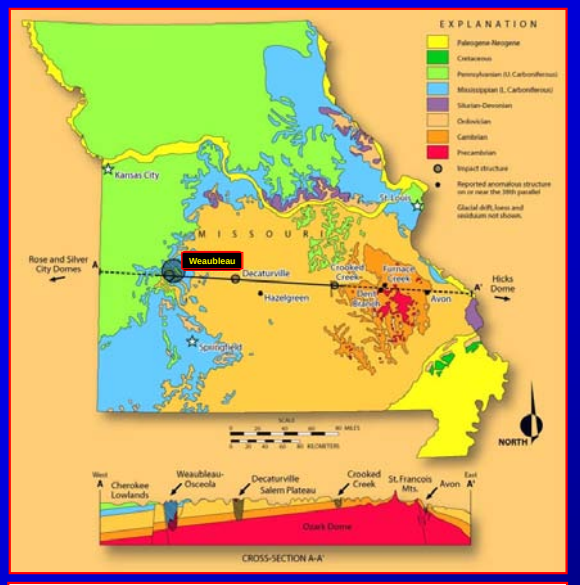

Figure 1 – Generalized geologic locality map and cross section of Missouri, showing west-east alignment of Weaubleau structure and other 38th parallel structures.

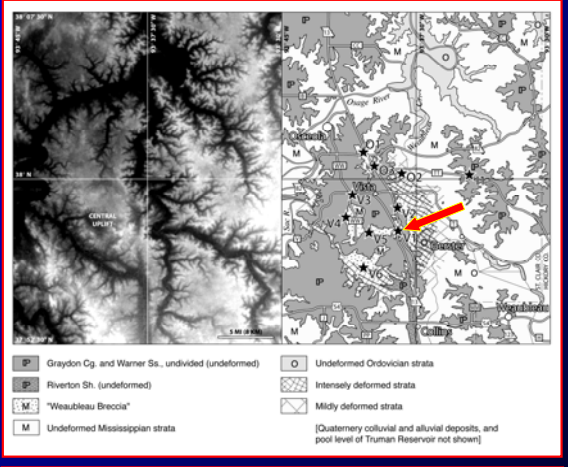

Figure 2 – Satellite image and geologic map overlay of Weaubleau structure, including central uplift. Sample site in upper Weaubleau Breccia along Missouri Highway 13 is indicated by arrow.

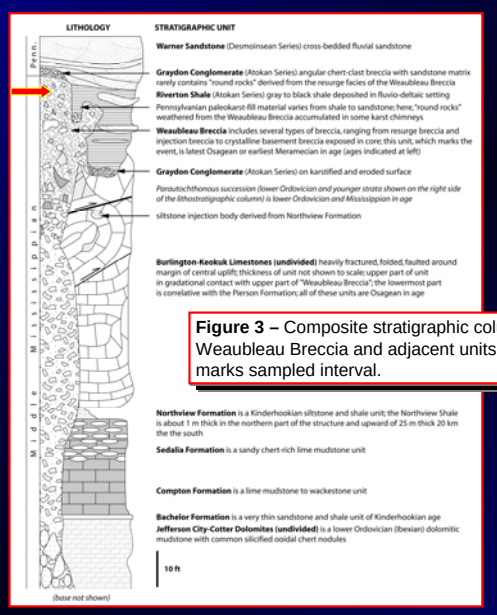

Figure 3 – Composite stratigraphic column of Weaubleau Breccia and adjacent units. Arrow marks sampled interval.

Introduction: The Weaubleau structure, an ~18-km-diameter circular anomaly in southwestern Missouri, is among the most well preserved of the 38th parallel structures spanning the North American Midcontinent (**Fig. 1**) [1,2]. Recent and ongoing work provides strong structural, stratigraphic, petrographic, and biostratigraphic evidence that the Weaubleau structure resulted from a marine bolide impact event during the late Osagean to early Meramecian (mid-Mississippian) interval [1–4]. In the ~9-km-diameter central portion of the structure, a distinct polymict unit forms the upper part of the informal "Weaubleau Breccia", which includes a variety of breccia types across the structure (**Figs. 2–3**). The upper polymict unit, interpreted to be an impact crater-filling resurge breccia, contains lithic clasts, fossils, and shocked grains sourced from pre-event Lower Mississippian, Lower Ordovician, and Precambrian crystalline target units (**Figs. 4–5**) [1–4].

Quartz Occurrence: Insoluble residues of formic and hydrochloric acid-dissolved bulk samples from resurge breccia outcrops along Missouri Highway 13, which runs through the east-central part of the structure, yielded abundant loose siliciclastic sand and gravel grains. A petrographic microscope point-count of 1400 grains in the 100–500 µm fraction identified 55 vol. % monocrystalline quartz, 23 vol. % chert and polycrystalline quartz, 12 vol. % radial-fibrous quartz of probable diagenetic origin (**Fig. 6**), 1 vol. % feldspar, and 9 vol. % quartz with pervasive mosaic extinction and common planar microstructures (PMs) (**Figs. 7–10**).

Evidence of Shock Metamorphism: The PMs in quartz include (1) about 60 freq. % planar fractures (PFs) or cleavage occurring in multiple sets of open, parallel, flat to curviplanar forms aligned with distinct orientations; and (2) about 40 freq. % short, closed, and partly decorated multiple sets of parallel planes that closely match previously documented shock-induced planar deformation features (PDFs) in quartz from other proven impact craters [5]. The PDFs are ~1–3 µm wide, are spaced ~1.5–5 µm apart, are characterized by discrete crystallographic orientations, and occur in multiple sets with up to 5 sets per grain. About 10 vol. % of the PM-bearing quartz grains show reduced birefringence, based on qualitative comparison with the highest order interference colors present in the same sample. Universal stage microscope indexing of the PMs show that c(0001) and {11$\bar{2}$2} crystallographic orientations are most frequent, although, in decreasing abundance, {10$\bar{1}$1}, {10$\bar{1}$3}, {10$\bar{1}$2}, and other higher index planes are present (**Fig. 11**). The abundance of altered quartz containing well-preserved PMs, which strongly resemble shock-induced PFs and PDFs, provides further robust evidence that the Weaubleau structure resulted from a major bolide impact event.

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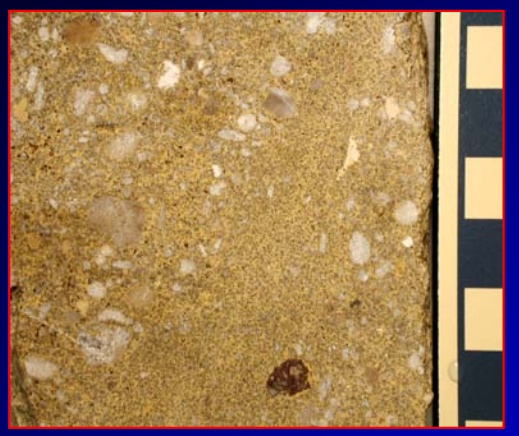
References: [1] Evans K. R. et al. 2003. Assoc. Missouri Geol., Field Trip Guidebook:1–31. [2] Evans K. R. et al. 2003. Abstract #4111. *LPI Contribution* 1167. [3] Evans K. R. et al. 2005. *Meteoritics & Planetary Science* 40, Supplement:A45. [4] Miller J. F. et al. 2006. *Geol. Soc. America Abstr. with Prog.* 38(7):184. [5] French B. M. 1998. *LPI Contribution* 954. 120 p. [6] Engelhardt W. v. and Bertsch W. 1969. *Contrib. Mineral. and Petrol.* 20:203–234. [7] Stöffler D. and Langenhorst F. 1994. *Meteoritics* 29:155–181. [8] Grieve R. A. F. et al. 1996. *Meteoritics & Planetary Science* 31:6–35. [9] Langenhorst F. 2002. *Bull. Czech Geol. Survey* 77:265–282.

Figures 4–5 – (Above) Photograph of road cut exposure of upper Weaubleau resurge breccia exposed along Missouri Highway 13; exposure is ~3 m high. (Below) Photograph of cut slab of polymict upper Weaubleau Breccia from outcrop in Fig. 4, showing heterolithic mix of lithic clasts, fossil fragments, and grains; scale is in cm. This locality was the source of quartz grains analyzed in the study.



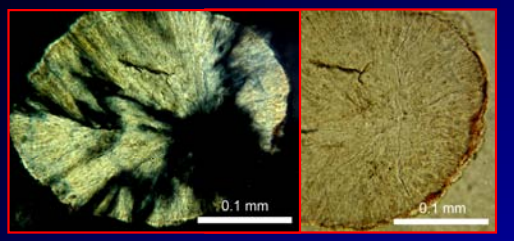


Figure 6 – Plane- (right) and polarized-light (left) photomicrographs of common sand-size, diagenetic radial-fibrous quartz grains. Fibrous texture shows pseudo-planar structures that are different from true planar features distinguishing the shocked-quartz grains.

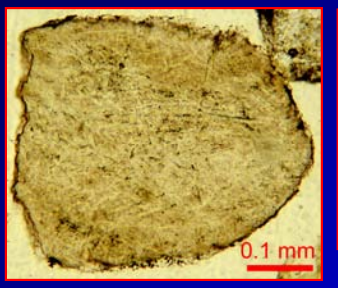


Figure 7 – (Left) Plane- (left) and polarized-light (lower left) photomicrographs of shocked-quartz grain showing cloudy, patchy grain toasting and well-developed grain mosaicism.

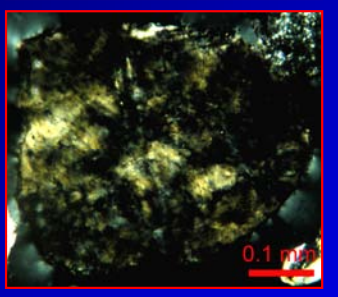
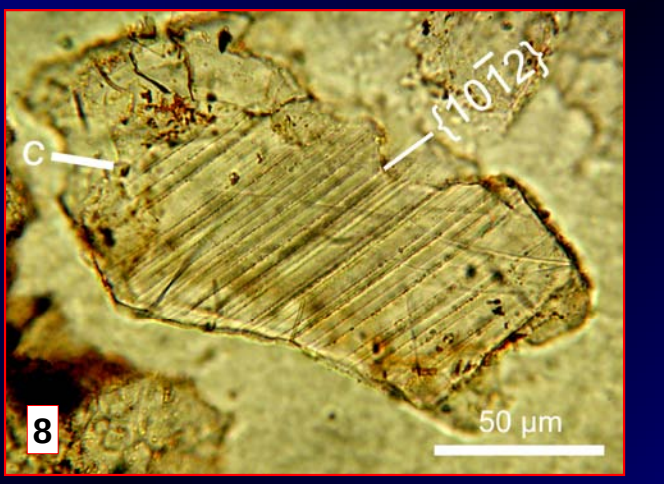
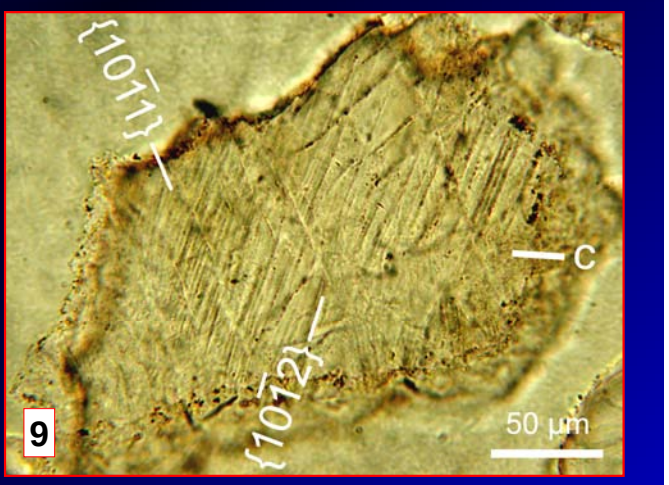
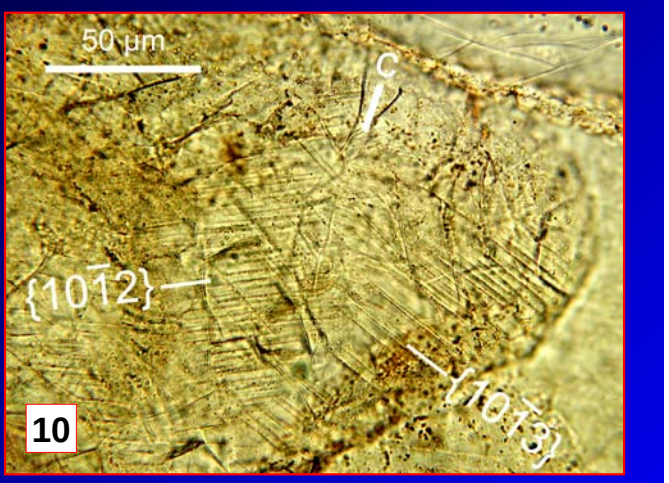


Figure 11 – (Right) Plot of absolute frequency percent of indexed PMs, composed of ~60% PMs and ~40% PDFs, in quartz from the upper Weaubleau Breccia. Indexing and plotting method after [6–9].







Figures 8–10 – Plane-light, flat-stage photomicrographs showing multiple sets of PDFs and PFs in quartz, upper Weaubleau Breccia sample. Selected crystallographic orientations are labeled.