INTENSE FRACTURING OF QUARTZ AT THE ROCK ELM (WISCONSIN) "CRYPTOEXPLOSION" STRUCTURE: EVIDENCE FOR METEORITE IMPACT. B. M. French[1] and W.S. Cordua[2], [1]Dept. of Mineral Sciences, MRC 119, Smithsonian Institution, Washington, DC 20560, mnhms053@sivm.si.edu, [2]Dept. of Plant and Earth Science, Univ. of Wisconsin-River Falls, 410 South Third St., River Falls, WI 54022, (william.s.cordua@uwrf.edu).

The Rock Elm Structure (Lat. 44°43'N, Long. 92°14'W) is a circular disturbed area about 6 km in diameter, located in otherwise undisturbed flat-lying Paleozoic sandstones and limestones about 300 m thick, which overlie Precambrian metasediments and felsic volcanics. The structure shows many geological features suggestive of "cryptoexplosion" structures produced by meteorite impact **[1,2]:** (1) a generally circular outline; (2) a ring boundary fault with $\geq$50 m displacement; (3) a "central dome" of possible Cambrian (Mount Simon?) sandstones with $\geq$250 m of structural uplift; (4) a 5-mgal negative gravity anomaly; (5) an annular deposit of post-structure shales and sandstones around the central dome. An unusual breccia containing basement rock fragments occurs as float in the central area. Previous studies **[1,2]** have found no shock-metamorphic effects.

We report here the presence of two types of unusual planar microdeformation structures in quartzite pebbles and larger ($\geq$0.5-1 mm) single quartz grains from the (Mount Simon?) sandstone exposed in the uplifted central dome. P1 features typically occur as 2-3 sets of sharp, straight to slightly curved, and generally parallel planes per grain. Individual planes are typically 0.5-5 mm long, 3-10 µm thick, and 0.1-0.5 mm apart **[FIGS. 1, 2].** They appear to be open fractures (cleavage) in the quartz. P2 features occur as multiple, closely spaced, parallel to slightly curved sets of planes generally 25-250 µm long, 1-3 µm thick, and spaced $\leq$5 µm apart. They do not cross the larger P1 features, and they often radiate from them to form a distinctive "feather" texture **[FIG. 2].** P2 features appear composed of arrays of small fluid inclusions, and they resemble shock-produced decorated Planar Deformation Features (PDFs) **[3,4],** except for their short length and their presence only in restricted areas of the host grains.

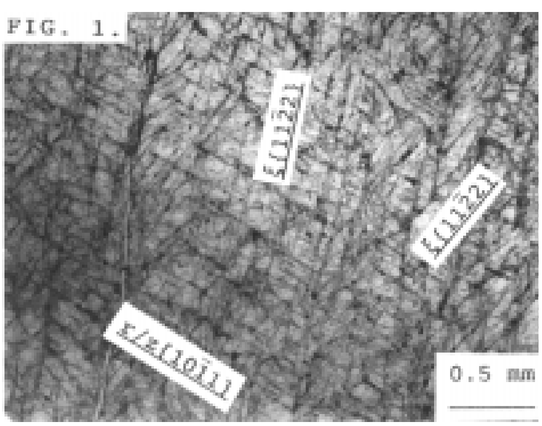
Petrofabric measurements of the orientations of both P1 and P2 features were made using standard Universal Stage techniques **[3,4].** Data are presented as histograms of the angle between the pole to the plane and the quartz c-axis ($\perp \wedge c$) **[FIG. 3].** The assignment of {hkl} values was verified for selected grains by rotation of the stereonet plot **[3,4].** Extinction in quartz grains is highly undulose (typically 5-15°); angular measurements are probably not accurate to better than $\pm$5°. P1 features, interpreted as fractures (cleavage) in the quartz, show maxima at c(0001) (0°), r/z $\{10\bar{1}1\}$ (52°), and $\xi\{11\bar{2}1\}$ (48°), identical to fracture fabrics observed in shocked sandstones from established impact structures **[5-8].** P2 features, tentatively interpreted as incipient PDFs, show concentrations at angles >40°, with maxima at $\xi\{11\bar{2}2\}$ (48°), r/z$\{10\bar{1}1\}$ (52°), and s$\{11\bar{2}1\}$ (66°). No concentrations parallel to $\omega\{10\bar{1}3\}$ (23°) and $\pi\{10\bar{1}2\}$ (32°) are observed. These orientations are similar to those of better-developed PDFs in shocked sandstones from established impact structures **[9,10].** An additional concentration at c(0001) (0°) may represent shock-produced basal lamellae **[7]**, or basal Brazil twins **[11,12]**.

The similarity of microdeformation features in quartz from Rock Elm samples to those from established impact structures provides strong evidence that Rock Elm is also an impact structure. In particular, the development of intense fracturing in quartz indicates the presence of shock pressures $\geq$5 GPa **[13],** and this feature may be used as independent evidence for impact, even in the absence of well-developed PDFs **[5,6].** Presently unanswered questions include: (1) the actual amount of structural uplift of the central region, for which approximately 600 m would be expected for a 6-km-diameter structure **[14,15];** (2) the origin of the basement-rock breccia and its relation to the rest of the structure. Further study is hampered by the poor exposure, and core drilling is needed to establish precisely the pre-impact stratigraphy, the crater structure, and the origin of the basement rock breccia. The poorly-known crater age (post-Ordovician; pre-Pleistocene) needs to be better constrained by determining the age of the apparent crater-fill sediments surrounding the central dome.

REFERENCES: [1] W.S. Cordua (1985), Geology 13, 372-374; **[2]** W.S. Cordua (1987), pp. 123-152 in Minn. Geol. Survey Guidebook Series, No. 15, N. Balaban, ed. **[3]** W.v. Engelhardt and W. Bertsch (1969), Contrib. Mineral. Petrol. 20, 203-234; **[4]** D. Stöffler and F. Langenhorst (1994), Meteoritics Planet. Sci. 29, 155-181; **[5]** T.E. Bunch and A.J. Cohen (1964), Geol. Soc. Amer. Bull. 75, 1263-1266; **[6]** T.E. Bunch (1968), pp. 413-432 in Shock metamorphism of natural materials, B.M. French and N.M. Short, eds., Baltimore, MD, Mono Book Corp.; **[7]** N.L. Carter (1968), pp. 453-474, in ibid.; **[8]** B.M. French et al., (1974), Geol. Soc. Amer. Bull. 85, 1245-1248; **[9]** R.A.F. Grieve et al. (1996), Meteoritics Planet. Sci. 31, 6-35; **[10]** V.A. Gostin and A.M. Therriault (1997), Meteoritics Planet. Sci. 32, 593-599; **[11]** H. Leroux et al. (1994), Tectonophys. 230, 223-239; **[12]** P. Joreau et al.(1996), Earth Planet. Sci. Lett. 138, 137-143; **[13]** F. Hörz (1968), pp. 243-253 in Shock metamorphism of natural materials, B.M. French and N.M. Short, eds., Baltimore, MD, Mono Book Corp.; **[14]** M. Pilkington and R.A.F. Grieve (1992), Rev. Geophys. 30, 161-181;

[15] R.A.F. Grieve and M. Pilkington (1996), AGSO Jour. Austral. Geol. Geophys. 16, 399-420.

FIGURES: **[1]** Multiple, closely-spaced P1 features (fractures) in a coarse-grained quartzite pebble from the Rock Elm Structure. Sample WRF-98-15B. **[2]** Combined P1 (fractures) and P2 features (incipient PDFs?), forming an unusual "feather" structure in a quartzite pebble from the Rock Elm Structure. Sample WRF-98-15C. **[3]** Composite histogram of angles (⊥∧c) between poles to planes and quartz c-axis for three quartzite pebbles (samples WRF-98-15A, -15B, -15C) from Rock Elm structure: P1 features (fractures), upper; P2 features (incipient PDFs?), lower. {hkl} values at top indicate angles corresponding to specific planes in the quartz crystal lattice.



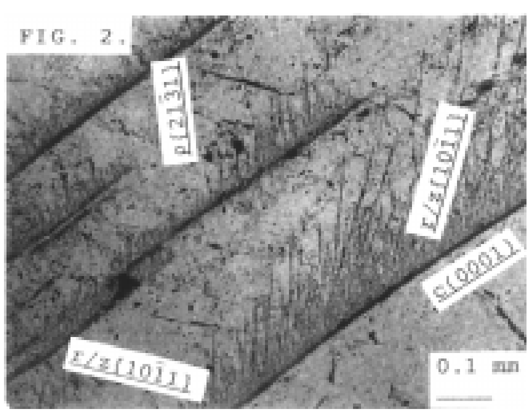


FIG. 3.