SHATTER CONE EXPOSURES INDICATE A NEW BOLIDE IMPACT STRUCTURE NEAR SANTA FE, NEW MEXICO. S. P. Fackelman[1], T. H. McElvain[2], J. R. Morrow[3], and C. Koeberl[4], [1]Earth Sciences, University of Northern Colorado, Greeley, CO 80639 (sfackelman@yahoo.com), [2]111 Lovato Lane, Santa Fe, NM 87505, [3]Department of Geological Sciences, San Diego State University, San Diego, CA 92182, [4]Department of Geological Sciences, University of Vienna, A-1090 Vienna, Austria.

Summary: The discovery of *bona fide* shatter cones in an area at least 3 km^2 in extent near Santa Fe, New Mexico, USA, indicates the presence of a so-far unknown, deeply eroded impact structure that is between ~320 Ma and ~1 Ga in age.

Introduction: The shatter cones are observed ~12 km northeast of Santa Fe, along Hyde Memorial Park Road [1]. These exposures extend laterally ~2 km along the road and ~1 km north of the road. Outcrops were found in road cuts, allowing easy access, as well as in natural exposures, indicating these features are not the result of rock blasting during road construction. The shatter cones appear as a series of nested, subconical, planar to slightly curved multiply-striated fracture surfaces within crystalline, Paleo- to Mesoproterozoic crustal and supracrustal rocks. Most of the shatter cones occur within a potassium feldspar-rich, equigranular, medium-grained granite (Fig. 1), although several exposures within biotite schist and quartzite are noted. Mapping located the shatter cones only within Proterozoic rocks, despite an extensive search in unconformably overlying upper Paleozoic sedimentary rocks. Shatter cones were studied for extent and orientation, as well as for petrographic evidence of shock metamorphism. Also, a locally exposed monomict breccia overlying the Proterozoic rocks may provide additional evidence for the new impact structure.

Field evidence: Mapping of 110 individual shatter cones revealed an area of at least 3 km^2 covered by these features. Individual shatter cones were observed to be up to ~1 m long. Measuring the apical surfaces of the cones revealed that the maximum width of the shatter cones was a reflection of lithology, rather than of location. Where shatter cone-bearing granite and schist are in contact, the maximum shatter cone width in granite is ~0.5 m, while the cones developed in the adjacent schist reach only ~0.3 m across. Because shatter cone orientation has been suggested to indicate the point of origin of the impact shock wave (references in [2]), orientations of the shatter cone axes were carefully measured, binned into 10° increments, and plotted on equal-area stereonets (Figs. 2–3). Shatter cone axes along Hyde Park Road are oriented N to NNE (Figs. 2–3), while orientations north of the road are shifted significantly to the E (Fig. 4). The changing axis orientations are interpreted to reflect an impact site towards the northeast of the shatter cone outcrops, although the exact position remains unverified.

Petrographic evidence: Thin sections were prepared both parallel and perpendicular to shatter cone surfaces. Perpendicularly cut thin sections contain possible evidence indicative of low levels of shock metamorphism. Several quartz grains have been identified containing poorly developed planar microstructures. Even though no evidence of planar deformation features in quartz has yet been found, shatter cones are formed at such low levels of shock (i.e., <10 GPa) that the environment may not have been suitable for the development of such higher-level shock features [2]. In addition to the planar microstructures, irregular subplanar and curviplanar fractures were noted in the quartz grains, furthering the potential evidence for low levels of shock metamorphism within the shatter cones. To date, no glassy patches or veneers (see, e.g., [3]) have been found along the shatter cone surfaces.

Discussion: The shatter cone outcrops, together with possible petrographic evidence of low shock-metamorphic levels, are strong evidence for a deeply eroded bolide impact structure. Furthermore, the overlying monomict breccia, which is pre-Upper Carboniferous and contains Proterozoic crystalline clasts in a sandy matrix with planar microstructure-bearing quartz grains, has been suggested as a possible ejecta blanket from the impact [4]. Cross-cutting relationships demonstrate that shatter cone formation must have postdated the Mesoproterozoic (i.e., <1 Ga, the approximate minimum age of the crystalline target rocks) and, if the observed overlying breccia is linked positively to the event, the age of the probable impact event could be as young as Early Carboniferous (i.e., >320 Ma). Unlike the steeply dipping orientations of poles perpendicular to relict bedding-plane surfaces in the Proterozoic supracrustal rocks, the shatter cone axes are relatively tightly clustered and oriented largely subvertical (Figs. 1–4), suggesting that the cone formation post-dated significantly regional Mesoproterozoic tectonism. By the late Neoproterozoic, the crystalline target rocks were probably exhumed to a sufficiently shallow structural depth to allow formation of shatter cones by an impact event. The identification of the remnant of a new meteorite impact structure of so-far unknown diameter has significant implications to both impact studies and regional tectonic models.

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References: [1] Fackelman S. P. et al. (2006) *GSA Abstracts with Prog.* 38(7), 298. [2] French B. M. (1998) *LPI Contribution 954*, 120 p. [3] Nicolaysen L. and Reimold W. U. (1999) *J. Geophys. Res.* 104(B3), 4911–4930. [4] McElvain T. H. et al. (2006) *GSA Abstracts with Prog.* 38(7), 298.

Figure 1. Shatter cone outcrop within Proterozoic granite, along Hyde Memorial Park Road. Cone axes are oriented sub-vertically, with cone apices directed upward towards top of exposure. Yellow notebook is 15 cm long.

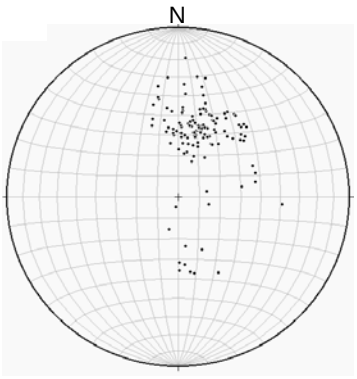

Figure 2. Equal-area stereonet plot (lower hemisphere) of axis orientations for all measured shatter cone outcrops.

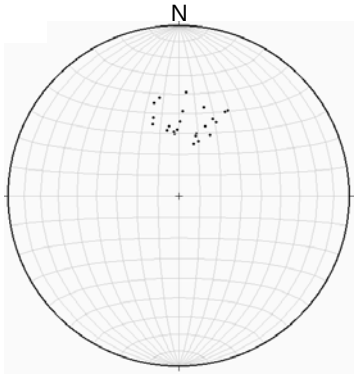

Figure 3. Equal-area stereonet plot (lower hemisphere) of axis orientations of a shatter cone outcrop located along the Hyde Memorial Park Road.

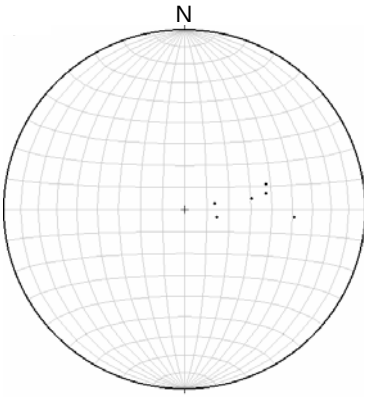

Figure 4. Equal-area stereonet plot (lower hemisphere) of axis orientations of shatter cone outcrops located along the Chamisa Trail, ~1 km north of Hyde Park Road.