**BRECCIAS AND GEOLOGICAL SETTING OF THE SANTA FE, NEW MEXICO USA IMPACT STRUCTURE.** E. L. Tegtmeier[1], H. E. Newsom[1], W. E. Elston[1], and T. H. McElvain[2], [1] Department of Earth and Planetary Sciences, University of New Mexico, MSC03- 2050 Albuquerque 87131, teggy@unm.edu, newsom@unm.edu, [2]111 Lovato Lane, Santa Fe, NM 87505.

**Introduction:** The discovery of shatter cones [1] in Proterozoic crystalline rocks in the western foothills of the southern Sangre De Cristo Mountains [2], a branch of the southern Rocky Mountains near Santa Fe New Mexico, USA, has prompted a study of widespread pervasive brecciation. Current reconnaisance is concentrated on a belt 6 km west of the shatter cones The emphasis is on field work and petrography. A search for additional impact criteria of impact is in progress.

Shatter cones crop out over a distance of 1.6 km along NM State Highway 475, beginning ~8 km east of the Santa Fe city limits (Fig. 1). Due to mountainous topography, their north-south extent has not yet been determined but is estimated to be < 1 km on either side of the road. The shatter cones locality is not brecciated significantly; pervasive brecciation increases towards the west. Breccias have been found 10 km ESE but their full extent in the intervening area not known. The problem of their distribution is complicated by multiple tectonic events before, after, and possibly coincident with the inferred impact event. The structure of the region is one of the most controversial topics in New Mexico geology: major Phanerozoic faults with lateral displacement > 100 km have been proposed [3]. One major fault terminates the shatter cone locality to the east.

**Geologic Setting:** The southern Sangre de Cristo range is a block of biotite schist and granite gneiss with metamorphic age 1.65 Ga, invaded by pegmatites and other granitoid rocks at 1.4 Ga. In the western foothills, Pennsylvanian (Upper Carboniferous) carbonates rest on Proterozoic rocks with depositional contact. Major disturbances associated with the 1.65 and 1.4 Ga Proterozoic episodes antedate shatter cone formation and pervasive brecciation. Later tectonic events include the rise of the Pennsylvanian to Permian Ancestral Rockies, Cretaceous to Paleocene Laramide orogeny and a sequence of late Cenozoic events culminating in vertical movement of several km (uplift of the present north-trending mountains and subsidence of the Rio Grande Rift to the west).

Shatter cones and pervasive brecciation occur in all types of Proterozoic rocks. Pennsylvanian and younger rocks are locally brecciated where cut by faults related to Phanerozoic tectonic events. The timing of inferred impact is probably constrained between emplacement of granitoids and Pennsylvanian deposition. However, within 2 m of the Pennsylvanian-Proterzoic contact, Pennsylvanian and Proterozoic clasts are locally intermingled. (Fig. 2) This probably reflects mass wasting during uplift of the Ancestral Rockies. However, impact during or after an early stage of Ancestral Rocky tectonism cannot be ruled out.

**Regional Brecciation:** West from the shatter cone outcrops, three major gradational transitions of brecciation intensity can be recognized:

Within 1 km, the crystalline rocks are broken by numerous faults with m-range displacements in random orientations. The rocks appear to be jostled without significant displacement. Type of brecciation depends on rock type. The granite gneiss breaks into blocks up to m size with varying degrees of fractal internal brecciation whereas biotite schists are broken into decimeter to meter size blocks. (Fig. 3 )

Within 2.5 km, the rocks are still jostled by numerous faults. The maximum size of angular granite gneiss clasts has decreased to ~ 10 cm set in a fractal matrix of similar material. In general, the fracturing appears to haved occured in-situ with little displacements of clasts. Biotite schist is internally fractured, sheared, and boudinaged along contacts with granite gneiss (Fig. 4). From this locality to the west internal brecciation decreases to the edge of the range.

**Pods of Granite Gneiss Breccia:** Numerous breccia pods, (horizontal dimensions ≤ 10x15 m, vertical exent unknown) form conspicuous walls aligned NNW. They are confined to the zone of most pervasive brecciation. Within the pods, granite gneisss clasts range from cm to m, supported by a fractal matrix of the same material heavily impregnated with hematite. Horizontal zoning suggests that the pods were emplaced by vertical movement. Within 1 m of breccia pod contacts with wall-rock, clasts tend to be subrounded, whereas internally they are angular. Where breccia pods were emplaced in biotite schist, clasts of schist ≤ 1 m occur within 1 m of the contact. They are enclosed by rinds, cm's wide, made up of accreted mm-cm size granite gneiss fragments (Fig. 5).

**Timing of Brecciation:** In Pennsylvanian rocks brecciation is confined to the vicinity of Phanerozoic structures. Complications arise because of possible reactivation of Proterozoic structures. However, brecciation is much more widespread in the Proterozoic rocks. The evidence suggests that brecciation occurred well before the onset of Pennsylvanian deposition.

**Interpretations:** Shatter cones are the only definitive evidence for impact. Because outcrops are limited to one mountain range of controversial structure, the geometry and erosion level of the inferred impact structure remain uncertain.

Speculatively, the zone of pervasive breccias suggests passage of an impact-induced shock wave which fractured rocks to the limit of microscopic resolution, but only caused m-scale displacements. The breccia pods may have been emplaced from above into zones of subcrater dilation, along pre-existing fractures.

**References:** [1] Fackelman, S.P. et al. (2006) *Geol. Soc. America Abstr. W. Programs,* v. 38, No. 7, p. 298. [2] Read, A. S. et al. (2003), *Open File Map GM 32*, N.M. Bur. Geology & Mineral Resources, 1:24,000 [3] Cather, S. M. et al. (2006) *Geol. Soc. America Geosphere* v. 2, p. 299-323.

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**Figures:** Distances are in km (miles), along NM State 475, from shatter cone outcrops.

Figure 1. Shatter cones in granite gneiss. 9 km (5.7 mi) from intersection of NM State 475 and NM state 590

Figure 2. Clast of Proterozoic granite gneiss in brecciated Pennsylvanian Limestone. Little Tesuque Canyon, 4 km west of location of figure 3.

Figure 3: Interlayered granite gneiss and biotite schist offset by randomly oriented m-scale faults. Granite gneiss is broken to decimeter to m size clasts. Biotite schist is sheared and broken to similar scale. Height of photo ~3 m. 2.5 km (1.5 mi).

Figure 4: Pennsylvanian limestone on blocks of intensely brecciated granite gneiss and biotite schist. Height is 3 m. 2.6 km (1.55mi).

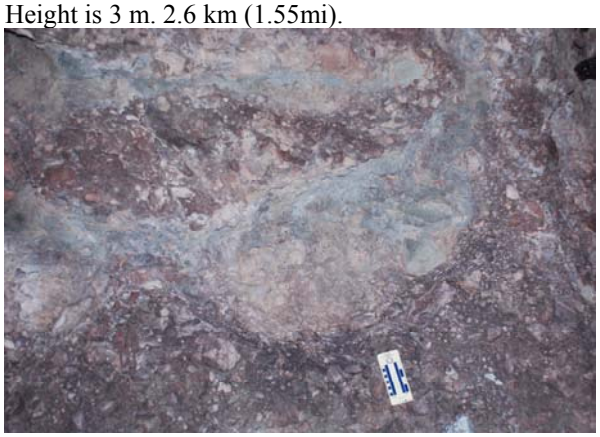

Figure 5: Clast of biotite schist with accretionary envelope near contact of breccia pod. 200 m from figure 3.