DEFORMATION FABRICS AND THEIR CROSS-CUTTING RELATIONSHIPS IN THE CENTRAL UPLIFTS OF LARGE IMPACT STRUCTURES. K. A. Milam, Department of Geological Sciences, Ohio University, 316 Clippinger Laboratories, Athens, OH, 45701, milamk@ohio.edu.

Introduction: Previous work on smaller complex craters less than 20 km in diameter [1-4] has uncovered a petrogenetic (deformation/modification) sequence expressed by cross-cutting relationships between deformation fabrics in target rocks. This sequence is most apparent in the uplifted rocks of crater floors (i.e. central peaks/uplifts). The deformation fabrics that have been studied include macro- and micro-indicators of shock metamorphism, such as shatter cones and planar deformation features. In addition, microfractures (mfrs), microfaults (mfs), major faults, and poly- and monomictic fault breccias have been observed and related to individual impact events [1-4]. These deformational fabrics consistently occur in specific cross-cutting relationships that correspond to the stages of an impact event.

This earlier work was limited to complex craters instead of simple craters because of the uplift component (which was found to produce added impact deformational fabrics, such as major faults) in the former type. The restriction to smaller (<20 km diameter) complex craters resulted from background research that indicated that other fabrics such as "pseudotachylites" (pts) or "pseudotachylitic breccias" (pbs) have been observed in craters larger than ~ 20 km [*Milam*, unpublished data] and that cross-cutting relationships between different "generations" of purported pts were complex and not clearly established [5-7].

New field and remote sensing observations demonstrate that deformational fabrics that occur in central uplifts of smaller complex craters are also common in larger terrestrial impact structures. Likewise, these deformational fabrics exhibit similar cross-cutting relationships that support the notion that the same petrogenetic sequence [8] occurs in larger diameter craters.

Methods: Preliminary field observations were made of the centers of the 54 km diameter Charlevoix impact structure in Quebec, Canada and ~300 km diameter Vredefort impact structure in South Africa during 2007-2008. Deformation fabrics were observed, characterized, and measured while in the field and in hand specimen.

Results: In addition to shatter cones (which have already been observed in both structures by other workers [9-10]), other deformational fabrics, identical to those observed in the central uplifts of smaller complex craters were observed. Mfrs and mfs have been observed in both the sedimentary and igneous target rocks of both Charlevoix and Vredefort. Similar to prior observations, mfs exhibit minimal (cm-scale) offsets and occur in parallel and sympathetic sets. As at smaller impact sites, most mfs are normal faults. Major faults have been inferred or observed by the author and others at each site. Fault breccias however, are not as well-exposed. At Vredefort, it is suspected that some of the pseudotachylitic breccias occur along major faults.

Cross-Cutting Relationships: Mfs and mfrs were observed cutting across pre-existing sedimentary features and igneous textures in target rocks (Figs. 1-4). At Charlevoix, shatter cone surfaces were observed offset by mf movement (Fig. 4). Both observations are consistent with the early stages of the petrogenetic sequence expressed in smaller craters [8]. They suggest that rock failure occurred following deposition/emplacement and with or after shock wave passage (post contact/compression). Mf offset of shatter cone surfaces further suggests activation of mfrs as target rock is compressed/decompressed and transported during the ejection/excavation stage of impact.

Figure 1. Mfr in the Kimberly Formation, Vredefort structure. Note the lack of offset in the quartz pebble conglomerate and the caribineer clip for scale

Figure 2. Normal microfaults in target rocks of the Vredefort impact structure, South Africa (5 Rand coin for scale)

Figure 3. Normal mfs in charnockitic gneiss of the central upift of the Charlevoix impact structure.

Temporal relationships between mfrs, mfs, major faults, fault breccias, and pseudotachylitic breccias are less clear due to a limited set of field observations. Initial observations of some wall rock exposures adjacent to a large pseudotachylites breccia in the Vredefort impact structure show that mfrs and mfs terminate against pts, suggesting that the latter was emplaced/injected following mfr formation and mf movement. This further indicates that pt formation is expressed in the latter stages of the petrogenetic sequence.

Initial Conclusions. All of these observations suggest that target rock deforms and is modified in a similar fashion during large impact events as compared to smaller collisions. With additional work, the same petrogenetic sequence (but modified by the incorporation of pts) may yet be observed in larger impact structures.

Figure 4. Mf offset of a shatter cone surface in the charnockitic gneiss of the central uplift of the Charlevoix impact structure. The fault surface is illuminated from the upper left of the image.

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