DEFORMATION/MODIFICATION SEQUENCE IN TARGET ROCKS OF COMPLEX CRATERS < 20 KM DIAMETER: IMPLICATIONS FOR IMPACT CRATER IDENTIFICATION. K. A. Milam[1] and B. Deane[2], [1]Department of Geological Sciences, Ohio University, 316 Clippinger Laboratories, Athens, OH, 45701 (milamk@ohio.edu), [2]Department of Earth and Planetary Sciences, University of Tennessee, 1412 Circle Drive, Knoxville, TN 37996-1410.

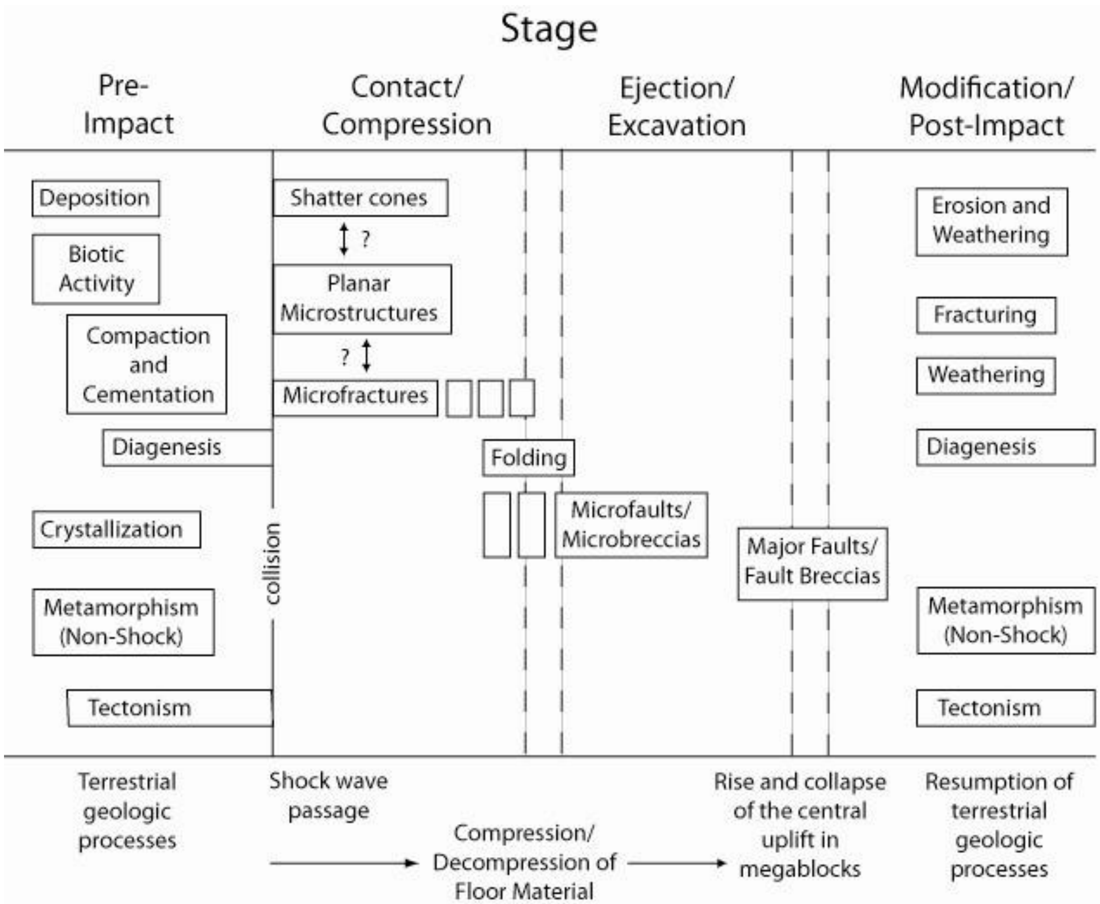

Figure 1. Petrogenetic sequence depicting target rock deformation in central uplifts. This sequence is primarily based on field and petrographic observations of terrestrial complex craters < 20 km diameter.

Previous field work and petrographic observations of central uplift rocks in complex craters [1-4] have led to the identification of fabrics related to deformation of target rocks during impact events. Any of these fabrics may occur as a result non-impact tectonic, mass-wasting, or other processes. However, these features have been associated with known terrestrial impact craters in geologic settings where they are otherwise absent from nearby target rocks. Deformation fabrics increase in density with proximity to the crater center and are most common in areas where unequivocal shock features (shocked phases, high-pressure polymorphs, and shatter cones) have been observed. More importantly, these fabrics occur in a discernible and predictable sequence reflective of the various stages of an impact event (Fig.1).

Regardless of target rock type, primary textures in central uplift rocks are cut by curvilinear shatter cone fractures and parallel sets of microfractures (mfrs) when such deformation fabrics are present. Both shatter cones and mfrs form early during contact/compression and are representative of target rock failure. Their relative order of formation from cross-cutting relationships however, remains inconclusive. Both however, form prior to ejection/excavation as evidenced by their in clasts of crater ejecta/resurge [5, this work]. Rock fracturing begins at relatively low minimum pressures (<2 GPa) and shatter cone formation at higher pressures (~2-30 GPa) when target rock yield strength has been exceeded [6]. This implies that mfr generation may precede shatter cone development, but field verification has so far proven impossible.

Differences in minimum pressures of deformation and fracture style also imply that both fracture types form by differing mechanisms of rock failure.

During compression and the early stages of uplift, rocks are sometimes folded, especially where a lateral transport component is present. This is evidenced by folded layers containing shatter cones and dilated fractures in some central uplifts. Mfrs then develop into microfaults (mfs) as some movement along mfr surfaces occurs. Most mfrs develop into normal mfs, although rare instances (<10%) of reverse mfs do occur. Displacements along individual mfs are minor (typically < 2 cm) and when summed, do not account for the much larger (hundreds of meters) total displacement observed in central uplifts. Concentrations of normal or reverse mfs in various megablocks comprising central uplifts suggest that mf movements are likely during both compression and uplift.

Uplift of the crater center is thought to be accomplished by acoustic fluidization [7] of target rocks. This uplift is accommodated along major faults that bound large (m^3 and km^3 in volume) megablocks of shocked- metamorphosed target rock. Unlike mfs, displacements (tens to hundreds of meters) along major faults can account for the uplift observed in complex craters. Movement along major faults can also generate fault breccias and drag folds, but many major faults superficially resemble and are oriented in a manner similar to that nearby mfs. This suggests that some major faults may develop along pre-existing mfrs and mfs. Some major faults however, do not utilize mfr/mf surfaces, but instead are generated along bedding planes.

There are two primary types of breccias that occur along major fault planes: monomict and polymict. Clasts in monomict breccias are most commonly reflective of adjacent host rock, suggesting local derivation during fault movement. Polymict breccias represent larger displacements along major faults, incorporating a wider variety of lithologies during megablock movement. Some polymict breccias seem to also represent injection of multiple clast and matrix types along fault (and sometimes bedding) planes. Temporal relationships between the two breccia types are still under investigation, but previous investigations [8] have suggested that polymict breccias are first to form.

Recognition of these deformation fabrics and determination that they were formed in the same sequence listed above may prove a useful tool in the initial confirmation of complex craters on Earth and other planets. There are numerous suspected impact structures that have yet to be confirmed because of the lack of definitive or easily identifiable shock features. This may relate to the lack of minerals in target rock that commonly show signs of shock metamorphism (i.e. planar microstructures) or their replacement during diagenesis. Similarly, coarser-grained (i.e. sandstones or plutonic rocks) or highly-weathered rocks may expose only crudely-developed or questionable shatter cone surfaces. Likewise, drill cores from completely buried suspect craters may inadequately sample shocked rocks, making confirmation challenging at best.

The presence of shock deformation fabrics (such as mfrs and mfs) are less dependent on target lithology, are not as affected by post-impact diagenesis, and occur at scales larger than typical shock-metamorphic features (such as PDFs and shatter cones). Thus the identification of these fabrics along with determination of cross-cutting relationships, make this sequence useful for identifying complex craters in the field or under a petrographic microscope. And while these observations primarily apply to smaller (<20 km) complex craters, initial studies [8-9, this work] have suggested that the cross-cutting relationships between some of these fabrics (or their larger-scale equivalents) may apply to larger complex craters as well (such as the 54 km diameter Charlevoix structure). High-resolution visible imagery has likewise suggested that the same fabrics and petrogenetic sequence may apply to central uplifts on Mars [10].

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