EXTENSIONAL FAULTING OF THE OVERTURNED COCONINO EJECTA LAYER AND EMPLACEMENT OF FALLBACK BRECCIA AT BARRINGER METEORITE CRATER (a k a METEOR CRATER).

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Introduction: The target sequence at Barringer Meteorite Crater (a k a Meteor Crater) is composed of (from bottom to top) the gray Coconino Sandstone, buff Kaibab (dolomite) Formation, and red Moenkopi (shale and siltstone) Formation. When those units were excavated and ejected, they produced an overturned flap [1–3], with Coconino deposited on top, that was extended beyond the crater rim to distances of at least two crater radii. Coconino ejecta is absent from most of the west, north, and east sides of the crater [1], possibly due to erosion [2,4], but forms a continuous deposit on the south side of the crater. The details of its emplacement and internal structure have received very little study, although it is generally viewed as a relatively coherent unit of rubble. Reverse faults have been documented in the underlying, uplifted bedrock [5], but until recently [6], extensional deformation of that overturned flap during emplacement was unknown. In the current study, we continue to explore that type of deformation and also show that normal faulting facilitated the preservation of previously unrecognized deposits of fallback breccia beyond the crater rim.

Measured Sections: We measured cross-sections of ejecta exposed in quarries on the south side of the crater. The quarries are dominated by a monomict breccia of Coconino-derived ejecta. Rotated clasts of sandstone are variably shocked; some clasts are gray-colored and appear to be unaffected by the impact, while the bulk of the unit is less coherent, bright white, and microscopically deformed. The quarries expose ~5½ to 7½ m of the monomict Coconino breccia (ejecta) layer. The bottom of the measured sections is the quarry floor, so these are minimum thicknesses for that unit. Three boreholes drilled ~20 m east-southeast of the quarry [7] indicate the total thickness of the monomict Coconino breccia is 9 to 13 m.

That unit is sometimes covered with a polymict breccia containing a chaotic assemblage (in order of abundance) of Kaibab, Moenkopi, and Coconino debris. No lechatelierite, impact melt, or meteoritic fragments have been found in the quarry sections. Shoemaker [1] mapped this unit as the older of two alluvium units, although we argue below that it is primary fallback breccia. This unit has also been equated [1] with alluvium southeast of the crater that contains lechatelierite, other highly shocked varieties of Coconino, and meteorites. In four locations in the quarries, this polymict breccia forms the down-dropped hanging walls of normal faults (Fig. 1). Strikes of the fault planes range from 80 to 105º (i.e., generally E-W) and dips are to the south. Three faults have standard dips (52 to 59º) for normal faults, while one is shallower (34º). The vertical displacement along two of the faults is at least 140 to 180 cm. The polymict breccia can be traced beyond the quarry walls in two elongate exposures that lie between outcrops of Coconino ejecta. These exposures imply the faults seen in the quarry walls extend east ~150 m parallel to the crater rim.

Elsewhere along the quarry walls the monomict Coconino breccia is covered with an ~½ m thick unit that is more clearly alluvium. The base of the unit has a series of rounded Kaibab cobbles that are covered by an assortment of small clasts of all three target lithologies. The clasts are aligned and imbricated. This unit cross-cuts one of the faults that juxtaposes the polymict breccia with the monomict breccia, indicating the deposition of the polymict breccia and faulting preceded the deposition of this unit.

Modern sand, derived from ejected Coconino, blankets portions of the area. The surface has also been disturbed by mining and other activities.

Discussion: We are evaluating two hypotheses for the polymict breccia on the hanging walls of the faults. (i) Structural deformation occurred at the time of ejecta emplacement in a series of normal faults like those recently mapped in Kaibab ejecta [6], or very shortly after emplacement during settling of the ejecta blanket. In this case, the polymict breccia is a primary deposit of ejected fallback debris. (ii) Alternatively, the breccia represents fallback ejecta that was transported a short distance (only ~100 m from the crater rim) between the time of impact and ~11 ka (when there was a dramatic climate change), was lithified into an alluvium deposit, and then faulted. We cannot think of any mechanism to cause alluvium to fault that late after the impact, because no other process has caused structural deformation in the area during the past ~50 ka. Thus, we favor the first hypothesis.

If the polymict breccia exposed in the quarry walls is primary fallback ejecta rather than alluvium, this does not preclude alluvium from being present elsewhere on the ejecta blanket. The data above only suggest that the unusual, circumferential alluvium deposits adjacent to the quarry are fallback breccia deposits that are preserved because they were faulted downward into the Coconino ejecta blanket.

We note, however, that several other polymict breccia deposits south of the crater rim are on topographic highs. If they are alluvium, then the alluvium either flowed uphill to where it now resides, or 5 to 7 m of post-depositional erosion of the ejecta blanket occurred between those deposits and the crater rim (i.e., not via radial erosion, but by circumferential erosion). Neither of those scenarios seems likely, which suggests the origin of other deposits of polymict breccia, currently mapped as alluvium, should also be re-evaluated.

Acknowledgements: We thank the Barringer Crater Company and Meteor Crater Enterprises for hosting the Field Training and Research Program at Meteor Crater and gratefully acknowledge the financial support provided by NASA's Lunar Science Institute through the LPI-JSC Center for Lunar Science and Exploration.

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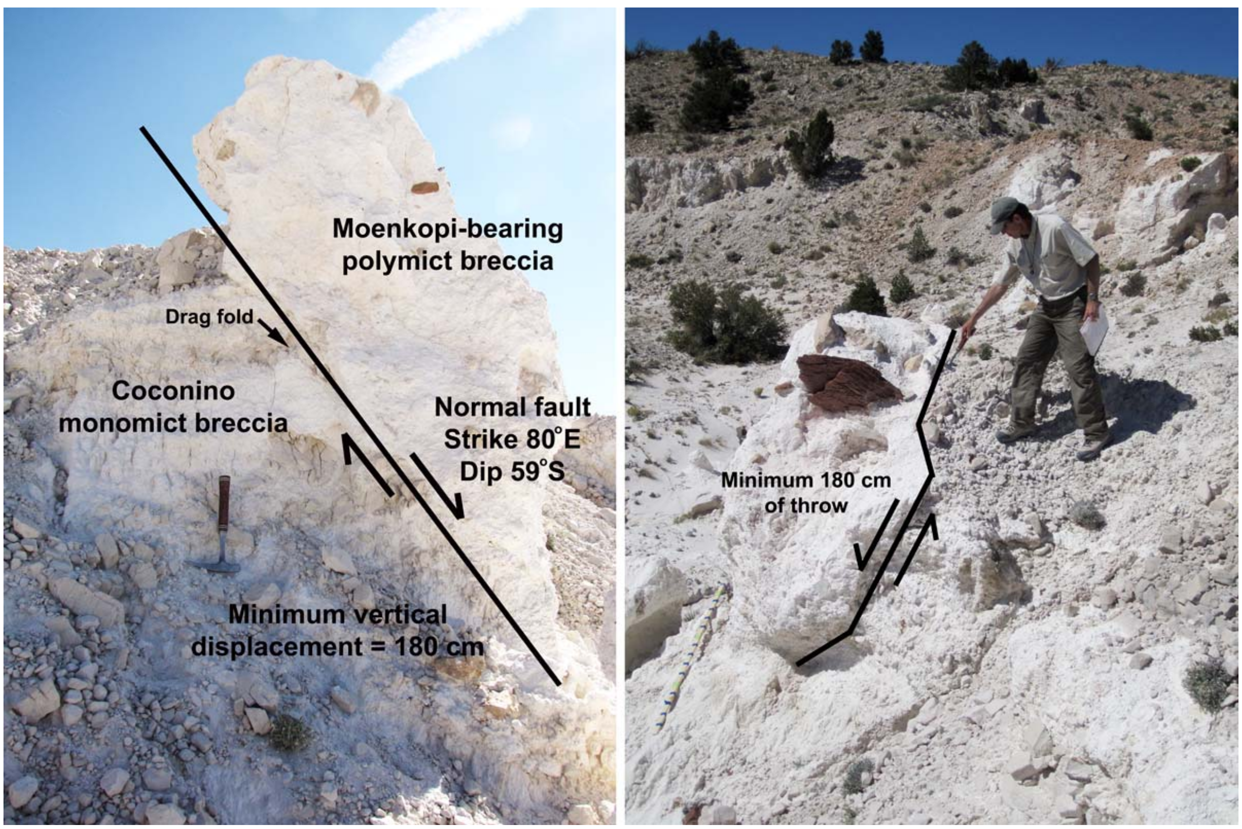

Fig. 1. One of four normal faults. (left) View of normal fault from the quarry floor, looking east-southeast. A red Moenkopi-bearing polymict breccia was faulted down into the overturned Coconino monomict breccia. A hammer provides scale. (right) View of the same fault from the eroded surface of the ejecta blanket, looking west-northwest. The same hammer provides scale.