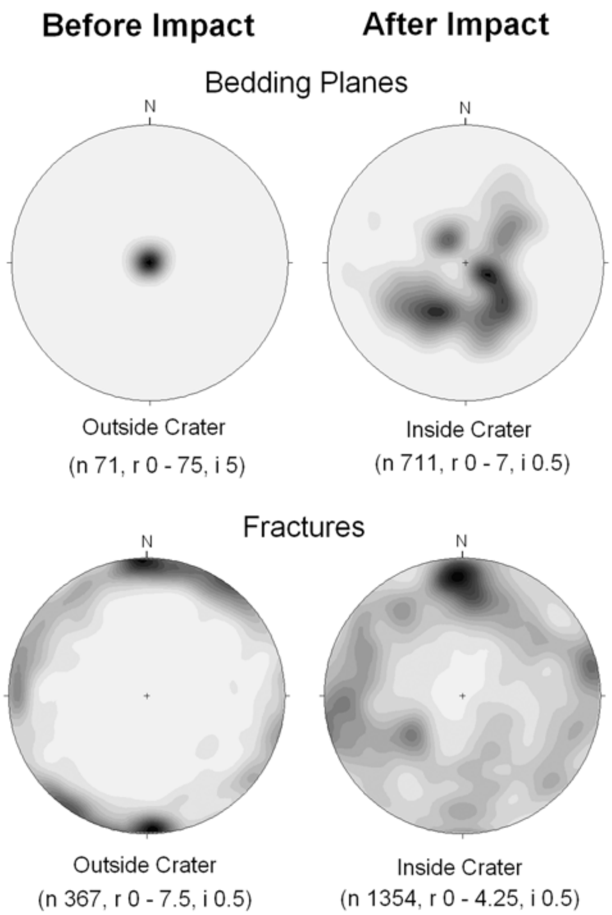

Figure 10. Equal-area plots of pole density contours displaying the geometry of bedding planes and fractures in the Moenkopi and Kaibab formations before the impact event (as measured outside the crater) and after the impact event (as measured inside the crater). Number of strike/dip measurements (n); pole density range in percent (r); and contour interval in percent (i).

sets of faults: (1) a few outward dipping reverse faults that are regularly distributed to a radial distance >700 m from the rim crest and (2) a few inward dipping thrust faults across the rim crest. Dips of the reverse faults are comparable to the conical fractures but are much steeper and therefore it is unlikely that the faults are genetically related to the fractures. In contrast, the geometry of the inward dipping thrust faults in the rim crest is similar to the concentric fractures exposed on the crater wall; however, it is unclear whether the concentric fractures have been involved in thrusting prior to crater wall slumping. A model of seismic refraction data [*Ackermann et al.*, 1975] suggests fracturing extends to a depth of 800 m beneath the crater rim, shallowing but extending out to radial distances >900 m. Gravity data [*Regan and Hinze*, 1975] and drilling studies [*Roddy et al.*, 1975] indicate fracturing beneath the true crater floor, but the actual extent of impact fractures is not yet fully understood. Therefore, it is uncertain whether the types of fracturing and the orientation of fracturing we observe in the upper crater walls are similar to those at depth. Potentially, some insights might be gleaned from studies of complex craters in sedimentary targets whose deeper levels are exposed because of erosion [e.g., *Kriens et al.*, 1999; *Scherler et al.*, 2006; *Okubo and Schultz*, 2007]. However, in those complex craters the type of fracture systems described at Meteor Crater will be modified by the flow of material to form a central peak and the extensive collapse of transient crater walls.

6. Comparing Simple Craters in Basalt and Sedimentary Rocks

[17] Lonar Crater is a simple, bowl-shaped impact crater that is similar in size (~1.8 km diameter, ~120 m deep) and age (~50 ka) to Meteor Crater [see *Fudali et al.*, 1980; *Kumar*, 2005]. In contrast, however, it was excavated from a layered sequence of basalt lava flows rather than sedimentary rocks. Significant differences exist in the nature of rim uplift and geometries and distribution of fractures and faults (Figure 13). Unlike Meteor Crater, it has a circular rather than square outline. Unlike Meteor Crater, it also has a circular distribution of impact deformation, instead of the preferred orientations seen at Meteor Crater. The target rocks for these two craters are different, which may partially explain these differences. The basalts of Lonar Crater have a much higher dynamic strength than the sedimentary rocks at Meteor Crater [*Ai and Ahrens*, 2004]. Also, preexisting tectonic fractures are less abundant at Lonar Crater than at Meteor Crater.

[18] A detailed view of the structural features in the upper crater wall at Lonar is illustrated by *Kumar* [2005]. The basalt sequence has been turned upward, producing a circular deformation pattern. Mean dips of lava flows vary from 5 to 35°, which are much lower than the dips of sedimentary rocks at Meteor Crater. Indeed, the rim of Lonar Crater is only 20 m higher than the surrounding plain [*Fredriksson et al.*, 1979]. If crater wall slumping during the modification stage is not greater than that at Meteor Crater and if erosion is similar, then there was less rim uplift at Lonar Crater than at Meteor Crater. This is particularly surprising because Lonar is slightly larger than Meteor Crater (~1.8 km versus ~1.2 km) and should, thus, have a correspondingly higher rim. The difference may be due to the target strength and impact parameters. Like Meteor Crater, three fracture systems (radial, concentric, and conical) are exposed on the inner crater wall. Interestingly, the radial fractures have spoke-like arrangement, unlike similar fractures at Meteor Crater that have preferred orientations. The concentric and conical fractures also show circularity in their strike pattern, unlike those at Meteor Crater where they have preferred orientations. Radial tear faults are apparently absent at Lonar Crater. Uplift and tilting of the basalt sequence and formation of the fractures inside the crater are clearly related to the impact event and are different from the preimpact structures such as cooling-related columnar joints and fractures of possible tectonic origin, which are observed outside the crater; however, the preimpact fractures are less abundant in the target basalts. These observations suggest that the shallower dips in the uplifted crater wall strata and