more joint systems in the Moenkopi Formation: NNW-SSE and ENE-WSW oriented subvertical joints. All these joint systems are well preserved in the exposures of Moenkopi and Kaibab formations, and are thought to have been formed as a result of tectonic deformation affecting the Colorado Plateau well before the impact event [e.g., *Kelley and Clinton*, 1960]. These joint systems also control the regional fluvial drainage development of the plateau [*Shoemaker*, 1963]. In addition to these fracture systems, faults subparallel to the NNW-SSE to NW-SE oriented fracture systems occur in the area and extend for more than a kilometer. However, according to *Roddy* [1978], none of these faults occurred at the point of impact and they were at least 5 km from the point of impact (Figure 1).

[10] Although preimpact fracture systems have been reported previously [*Shoemaker*, 1960; *Roddy*, 1978], the data are sparse and no longer available for analysis. Also, many of the previous data were collected from stereophotographic measurements [see *Roddy*, 1978]. Therefore, we have collected a new set of data containing the strike/dip measurements of the Moenkopi and Kaibab bedding planes and the fractures present in them. The data are presented in Figure 3. Our measurements illustrate that the bedding planes of sedimentary rocks are nearly horizontal (mean dip: $4° \pm 1°$) (Figure 3), confirming the earlier drilling results and outcrop measurements. The new measurements also reveal a few additional details. We find that the majority of the fractures in the Kaibab Formation are oriented in ENE-WSW direction with subvertical dips. As previously suggested by *Shoemaker* [1963], these fractures probably control the regional drainage patterns around the crater. Interestingly, this dominant fracture set is also approximately parallel to the ENE-WSW crater walls (Figure 3). Therefore, the data indicate the preexisting fractures do not strictly bisect the crater corners, and most of them are, indeed, parallel to the crater long walls.

4. Impact-Generated Structures

[11] Impact deformational structures include folds, faults, fractures, and rim uplift that changes the attitude of the rock formations in and around the crater. Unlike preimpact tectonic structures, these are formed within a few seconds or less. The best place to observe these impact structures in a simple crater are in the bedrocks exposed on the inner crater walls [e.g., *Kumar*, 2005] and along a cross section of the crater rim [e.g., *Brandt and Reimold*, 1995]. Although the morphology of Meteor Crater has been said to be influenced by the preimpact joint systems [*Shoemaker*, 1963], there has been no detailed study that relates how the preimpact fractures affected the impact deformational features exposed on the crater wall. The previous studies apparently lack documentation of impact related joint or fracture systems along the entire crater inner wall. Therefore, we have conducted a structural analysis of the Moqui and Wupatki members of the Moenkopi Formation and the Alpha Member of the Kaibab Formation; these rock formations are more or less continuously exposed below the ejecta, whereas the underlying rock formations are only intermittently exposed on steep slopes where they are largely covered by talus and alluvium near the present-day crater floor. Hence, structural mapping was restricted to the upper crater wall. It involved documentation of the geometry of bedding planes, various fracture systems, faults and slump units. The inner crater wall can be divided into twelve angular zones or tectonic blocks (Figure 2) that are bounded by prominent faults with near-vertical, scissors-like faults [e.g., *Shoemaker*, 1960; *Kring*, 2007]. Technically, however, they may be better described as high-angle, dip-slip faults. The largest fault occurring in the southeast corner has generated ~45 m of displacement [*Shoemaker and Kieffer*, 1974]. Structural measurements within the blocks were collected and then compared with adjacent blocks.

[12] These measurements reveal radial, concentric, and conical sets of fractures, which are illustrated in outcrop view (Figure 4) and schematically (Figure 5). Figures 6, 7, and 8 show the measured geometries of these radial, concentric, and conical fracture systems in the upper crater wall, respectively. The radial fractures have subvertical dips and strike approximately perpendicular to the bedding

Figure 2. (a) A simplified geologic map of Meteor Crater based on a map originally prepared by E. M. Shoemaker in 1957–1958 and reproduced by *Shoemaker and Kieffer* [1974]. The crater wall exposes four formations: Moenkopi Formation (MF) that consists of Moqui and Wupatki members (mainly sandstones and siltstones); Kaibab Formation (KF) that consists of Alpha, Beta, and Gamma members (mainly dolomitic limestones); Coconino Formation (CF) (mainly sandstones) overlain by a thin bed of Toroweap Formation containing sandstones. A thin sandstone (SS) marker bed occurs within the Alpha Member. The ejecta blanket of this crater is very well preserved up to a radial distance of >1 km from the crater rim. The lower crater wall exposes the following breccia units: allogenic breccia or impact-related breccia with shock-metamorphosed sandstone, labeled IB; authigenic breccia or fault breccia, labeled FB; and mixed breccia or fallback breccia, labeled MB. Along the lower crater walls, talus and fine debris cover the allogenic breccia, reducing the steepness of the crater wall. A ~30-m-thick lens of lake sediments covers the allogenic breccia in the crater center, and, along their periphery, the lake sediments are interfingered with alluvium that is derived from the crater wall. The crater rim is divided into 12 tectonic blocks (labeled with a number from 1 to 12); they are bounded by prominent dip-slip faults (one of which is labeled fault). There are minor faults that do occur within a block, and one of which is labeled F. Thrust faults also occur on the northern and western crater walls, and one of which is labeled T. Four corners of the crater are cut by major faults (for example, see the one that is labeled as major fault in the southeast crater corner), which are often called tear faults in the literature. (b) A panoramic view of the crater wall looking from the ENE to the SSE; an apparent squarish outline of the crater can be seen. The upper walls have an average slope of ~40°–50° but at places are near vertical. Structural geological studies were conducted on the upper wall, where the Moenkopi and Kaibab formations are exposed.