

11. Age of the Crater



As any visitor can see, the crater is exceptionally well-preserved. Although talus covers the lower slopes of the crater walls and finer-grained sediments cover the crater floor, the crater still has the sharp edges of a relatively unaltered structure. For that reason, a young age has always been assigned to it. Indeed, Barringer (1905) estimated the age to be 2,000 to 3,000 yrs, not much older than the 700 yr-old rim cedars (junipers). Likewise, Tilghman (1905) commented that the crater looked like it formed yesterday and that it must have an age less than 10,000 yrs and probably less than 5,000 yrs.

Measuring a precise age for the crater, however, was difficult. Even using modern techniques, the question of age was difficult to resolve. The impact did not produce huge volumes of impact melt that might be analyzed using the isotopic systems (*e.g.*, ^{39}Ar - ^{40}Ar) often applied to other igneous rocks, including impact melts. In addition, the crater is too young for many of those radiometric systems to be applied, because they involve half-lives that are too long. For that reason, many early attempts to determine the age of the crater relied on evaluations of erosion and sedimentation.

In a paper titled “The Age of Meteor Crater,” Blackwelder (1932) evaluated the thickness of lake sediments within the crater, the amount of alluvium and finer-grained debris on the crater slopes and crater floor, ravines cut into the crater deposits, and dissolution pitting of ejected limestone blocks. Based on those criteria, he estimated the crater was produced between 40,000 and 75,000 years ago. As described further below, this may be an incredibly accurate estimate.

At about the same time, Jakosky *et al.* (1932) conducted an electrical and magnetic survey of the crater. In the course of that investigation, they evaluated the thickness of lake beds on the crater floor, lag deposits of concretions on Coconino and Kaibab surfaces on the crater rim, and small basins filled with sediment from eroded ejecta. They argued that the “fresh looking cliffs” are not, in fact, fresh, but rather “the products of centuries of erosion.” They also pointed out that the thickness of Moenkopi buried beneath Kaibab and Coconino in the crater walls is much greater than the thickness of Moenkopi on the surrounding plains. They required sufficient time to erode up to 40 ft of Moenkopi on the plains. We now understand that this latter argument is flawed, because the Moenkopi is thickened by an overturned component in the crater walls and, thus, the discrepancy is not an erosional one. Nonetheless, based on all of these criteria, they concluded the crater formed tens of thousands of years ago and probably about 50,000 years ago.

Shoemaker (1960, 1974) compared the Pleistocene and Holocene alluvium that covers the ejecta blanket with deposits elsewhere on the Colorado Plateau. Drawing on those comparisons, he estimated (Shoemaker, 1974) the crater was produced “a few tens of thousands of years ago, as shown by the mid-Wisconsin age of the oldest sedimentary deposits on the rim and in the interior of the crater.” He quantified those words with estimates of 20,000 to 30,000 yrs and $25,000 \pm 5,000$ yrs (Shoemaker, 1983), which were numbers he used for over a decade. His estimate may have been influenced by the first radiometric age of material in the crater. Ives *et al.* (1964) obtained a radiocarbon age for shells from a dump around the crater’s main shaft. The measured age was $24,000 \pm 2,000$ yrs. The shells were believed to be from the basal portion of the lake sediments. Assuming the lake sediments were deposited immediately after the crater formed, the value indicated the age of the crater. However, if either the lake did not form immediately or the shells were from a higher level within the lake sediments, the date only represented a minimum age for the crater.

Those shells and other fossils deposited in lake sediments on the crater floor provide additional clues about the crater’s age through correlations with fossil assemblages in other localities and climatic events.

The results, however, are ambiguous (Reger and Batchelder, 1971; Forester, 1987) and will not be discussed in any detail here. In addition, a preliminary assessment of pollen from the base of the lake sediments (Davis and Kring, 2002) found an assemblage that is similar to those in 50 ka sediments in Walker Lake near Flagstaff. That, however, is more a measure of climatic conditions and not a diagnostic indicator of age.

Efforts to directly measure the age of the crater resumed in the mid-1980's, when Sutton (1985) measured thermoluminescence ages for shock metamorphosed rocks. He estimated an age of $49,000 \pm 3,000$ yrs for the crater. Similar ages were soon recovered using cosmogenic nuclides that measured the amount of time boulders on the rim of the crater had been exposed. In back-to-back papers, Phillips *et al.* (1991) and Nishiizumi *et al.* (1991) reported $49,700 \pm 850$ and $49,200 \pm 1,700$ yr ages, respectively. Based on the extraordinary agreement between these three independent studies, 49 or 50 ka is widely accepted to be the age of the crater.

The ages based on cosmogenic nuclides will be re-visited in the near future, because estimates of the production constants and scaling factors needed for the calculations have been improved. As I write this, a large project is underway to re-calibrate those systems, particularly for ^{36}Cl -based age determinations. Fred Phillips (of Phillips *et al.*, 1991) is leading this re-evaluation. It will be interesting to see if the re-calibrated system produces the same 49 to 50 ka age or a different age. Potentially, an improved set of production calculations may destroy the agreement that currently exists between ages determined using cosmogenic and thermoluminescence methods. At the moment, there are hints that the recalculated ^{36}Cl age will be older than 50 ka.

Plans for two other types of age determinations have been made. The first involves pack-rat middens that are scattered among the rocky clefts of the crater walls. Pack-rat middens have been excellent sources of both age and climate information elsewhere on the Colorado Plateau. Appropriate samples will be collected to determine an age for the deposits, which will provide an additional minimum age for the crater. In addition, the fossil sequence within the lake sediments will be resampled. This latter task, however, is delayed until the walls of Main Shaft and/or Shaft #2 in the crater floor can be stabilized. Efforts are underway to raise funds so that the shafts can be re-cribbed and converted into permanent research and educational facilities.