



Figure 1. Capulin Volcano National Monument in northeastern New Mexico preserves this classic cinder cone volcano, now thought to be much older than before.

CAPULIN VOLCANO IS APPROXIMATELY 59,100 YEARS OLD

Cosmogenic helium aging technique key to clearing up age old question

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CAPULIN VOLCANO NATIONAL MONUMENT (fig. 1), located in northeastern New Mexico, preserves a small portion of the Raton-Clayton Volcanic Field. This field contains a surprisingly wide variety of volcanic rock types (Gust 1990). It is the easternmost Cenozoic volcanic field in North America, and is located near the intersection of the Rio Grande Rift and the Jemez Lineament, two zones of crustal weakness. These characteristics make Capulin Volcano an interesting subject for geologic research. Under a cooperative agreement between the park, the NPS Southwest Region, and the College of Santa Fe, we began a geologic research project two years ago. Park staff have been closely involved with the project and Mr. John Morrow and his family have provided access to their ranchlands for mapping lava flows. This report focuses on one facet of the research: the age of the volcano.

Volcanism in the Raton-Clayton Volcanic Field began about 8.2 million years ago and continued until Capulin Volcano erupted (Stormer 1972), the time of interest in our study. Previous attempts at determining the age of Capulin Volcano have focused on its relationship with the nearby Folsom Man site.

AGE OF THE FOLSOM MAN SITE

Archeologists excavated The Folsom Man site, located about 10 mi (16.1 km) from Capulin Volcano, in 1926. It is famous because the excavators found projectile points in direct association with the remains of an extinct bison (*Bison antiquus taylori*), indicating that humans were in this region much earlier than had been previously thought (National Park Service 1994). The find is in stream deposits (or alluvia) laid down by the Dry Cimarron River and its tributaries. Haynes et al. (1992) dated a composite sample of five discrete lumps of charcoal from this horizon (the sedimentary layer corresponding to human occupation) using accelerator mass spectrometry, and reported an age of $10,890 \pm 50$ years before present (B.P.). An earlier carbon 14 (^{14}C) determination on other charcoal yielded a date of 10,000 years B.P. (Muehlberger 1955), and the bison bones revealed a ^{14}C date of 10,260 years B.P. (Anderson and Haynes 1978).

Bryan (1937) was the first to study the geology of the Folsom site, and he identified two alluvial sequences, the lower of which is the Folsom occupation horizon. Charcoal from the upper one, also alluvial in origin, has a ^{14}C date of 4,350 years B.P. (Muehlberger 1955).

Nine miles down the Dry Cimarron from the Folsom site, Muehlberger (1955) identified Capulin Volcano basalt flows sand-

wiched between what he interpreted as Bryan's two alluvial deposits. Hence, the Capulin eruption was assigned an age range of between 10,000 and 4,350 years B.P. Such correlation of stream deposits is very difficult, however, due to discontinuous outcrops, and the date has never been considered definitive.

Subsequent work showed that this is indeed the

case. Anderson and Haynes (1978) identified several distinct alluvial deposits at the Folsom Man site, and they concluded that the basalt flow in the Dry Cimarron Valley overlies an alluvial sequence older than the Folsom occupation horizon. They also made a ^{14}C age determination that confirms this; the age of a baked organic soil from this older unit yields a date of $22,360 \pm 1,160$ years B.P. That was a minimum age; the actual age could have been older due to contamination of the sample by modern plant materials.

Altogether, these studies indicated that the eruption of Capulin Volcano took place before 22,000 years B.P., and Folsom hunters probably did not observe the eruption. However, these previous studies did not date Capulin Volcano directly.

NEW AGE DETERMINATION

In the most recent study, we determined the age of a sample of Capulin basalt using the cosmogenic helium technique. Cosmogenic helium dates provide information on how long a particular rock sample has been within about 1 m (3.2 ft) of earth's surface (Cerling 1990). Cosmic rays produced by the sun and other stars enter earth's atmosphere and travel through it. Some of the rays are slowed and stopped due to interaction with the atmosphere, but most make it to earth surface. These cosmic rays spall heavier atoms in the rock, splitting them into smaller atoms, especially helium 3 (^3He). The cosmic ray flux is relatively constant, and its small variations have been documented in detail. Therefore, the production of ^3He , normally a very scarce isotope, occurs at a steady, known rate at earth surface. The $^3\text{He}:^4\text{He}$ ratio, which compares the amount of cosmogenic helium (^3He formed by cosmic ray bombardment) with normal helium (^4He , common

in the atmosphere and rocks), is then used to determine the amount of time a rock surface has been exposed to the atmosphere. A correction is made for altitude and latitude to account for the effects of the atmosphere on cosmic rays.

Careful sampling is required to date an eruption age. Researchers must first find a lava sample that has been at the surface in its present orientation since cooling. At Capulin Volcano, we sampled a lava flow feature near the volcano's boca, or mouth (fig. 2), that formed when lava was squeezed upward through a crack, creating a thin spine. This feature has remained in this form, with scrape marks on its side, since

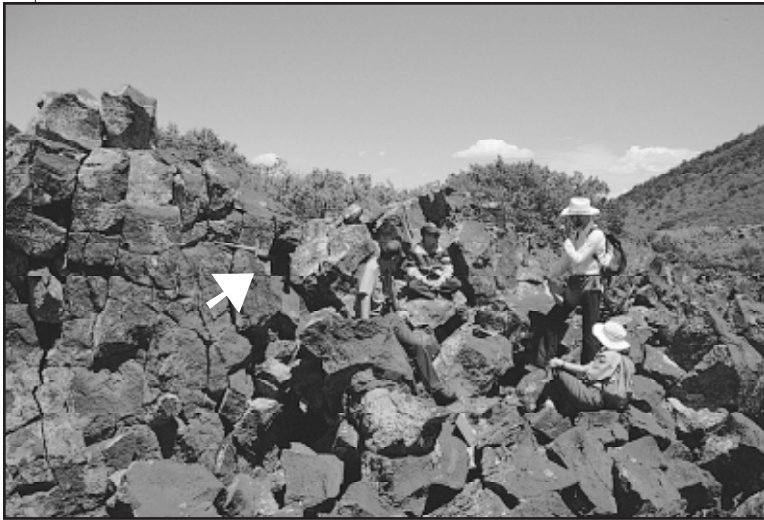


Figure 2. Long ago, during eruption, cinders on Capulin Volcano gave way to lava that opened a vent near its base. Researchers collected a lava sample (below the rock hammer) at this vent or boca for cosmogenic helium dating.

the lava flow cooled. It also has a large field of lava rubble around it, with no trees or vegetation to shield it from cosmic rays, and it is not in a position for deep snow build up. These circumstances lead us to interpret the cosmogenic helium date as the age of the lava flow sample.

Our results indicate that Capulin Volcano is 59,100 years old \pm 6,000 years. Helium dates can be younger than the true age of a volcano. As already mentioned, cosmogenic helium in the rocks results from the amount of time the rocks are exposed to cosmic rays. Any rock shading by vegetation, overlying soils, snow, etc., would reduce the cosmogenic helium level in the rocks and would result in a younger age. However, we carefully chose a sample site that we believe has been exposed to the atmosphere since Capulin erupted. We therefore suggest that Capulin Volcano is late Pleistocene rather than Holocene in age.

GEOMORPHIC ANALYSIS

The geomorphology, or shape, of Capulin volcano also indicates that it is not particularly young. Cinder beds at the outer edge of the rim of the volcano dip inwards toward the crater. If a volcano is young and little affected by erosion, we would expect outward dipping layers. As a volcano ages, outward dipping cinder beds on its rim are likely to be removed by erosion, leaving only the inward dipping portions.

A prominent 30-foot-thick spatter flow is located on the southeastern edge of the rim. A spatter flow resembles a normal basalt flow; however, it is formed by the agglomeration of small amounts of lava

(spatter) thrown out of a vent and extends for only a short distance. The rim spatter flow is partially unsupported by cinder and juts out approximately 30 ft from the side of the volcano. If the volcano were young, we would expect the flow to be completely surrounded by cinder. In an older volcano, we would expect erosion to carry away some of the cinder, leaving the spatter flow exposed. Similarly, loose cinders form an apron around the volcano, indicating that they have had time to erode from the main cone, even though erosion is slow in this dry climate.

FURTHER STUDIES

The geomorphic observations and new age determination are compelling; however, we need to conduct further analyses to confirm that the volcano is older than previously understood. We plan to make an additional cosmogenic age determination (using aluminum instead of helium)

and another researcher will make an argon-argon age determination. We have already carried out paleomagnetic sampling of the basalts, and will study these data. We plan to submit a final report of this project, including the additional age determinations and a discussion of the other elements of the project, for future publication in *Park Science*.



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