# ARCHAEOLOGY SOUTHWEST *magazine*

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# In the Shadow of the Volcano: Recent Research at Sunset Crater

Mark D. Elson
Desert Archaeology, Inc.

Photograph of Paricutin Volcano, K. Segerstrom, USGS, 1946

*"At 4 p.m. . . . I noticed that a grotto which was situated on one of the knolls of my farm, had opened . . . and I saw that it was a kind of fissure that had a depth of only half a meter . . . I felt a thunder, the trees trembled . . . and it was then I saw how, in the hole, the ground swelled out and raised itself 2 or $2\frac{1}{2}$ meters high, and a kind of smoke or fine dust — gray like ashes — began to rise up in a portion of the crack . . . Immediately more smoke began to rise, with a hiss or whistle, loud and continuous, and there was a smell of sulfur. I then became greatly frightened." Dionisio Pulido, describing the birth of Parícutin Volcano in his cornfield on 20 February 1943 (from "Parícutin: The Volcano Born in a Mexican Cornfield," by James Luhr and Tom Simkin).*

IT BEGAN AS A SLIGHT SHIFTING of the ground, a small earth tremor noticeable enough to be felt, but not large enough to do any damage. This would be remembered later as the first sign that all was not right with the world.

The next two tremors were three weeks later, and these were larger, louder, more violent, each shaking the ground nonstop for almost a minute. Mothers clutched their babies, children cried, and men grabbed their weapons. Even the normally stoic dogs whimpered and ran to hide. It was noted later that the animals of the forest were unusually quiet, both before and after the tremor, and this became a sign to watch for. Still, the religious leaders told the people that even though this was not a good message from the gods, the proper rituals and behaviors would appease whomever was angry. It was close to corn harvest time in the Kana'a Valley, and there was much to be done to prepare for the coming winter.

The earth tremors began in earnest the following week. At least once or twice a day, and sometimes 10 or even 20 times, the ground shook, and loud cracking sounds came from deep underground. Although damage was minor and limited to a few collapsed walls and roofs, the people were scared. Their oral traditions recounted a time when the ground moved like this, but it was very long ago and not even the elders, nor their elders' grandparents and great-grandparents, had lived through such a time. Clearly, someone or something living deep inside the earth was very angry. Councils were held, the spiritual and moral transgressions of the people pointed out, and appropriate remedies prescribed. The religious leaders prayed and made offerings to the gods, in the hopes that the transgressions could be rectified, at least enough to stop the earth from shaking.

And then it happened. A crack in the ground, 100 feet long and two feet wide, appeared at the head of the valley, within sight of the ripening corn fields where the people were working. A strange whistling sound came out of the crack, and suddenly the ground

Issue Editors: Mark D. Elson and Michael H. Ort

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shook and the earth roared louder than the thunder of a summer rainstorm, which, until now, was the loudest sound anyone had ever heard. Most surprisingly, smoke, or what looked like smoke, began spewing from the crack, setting the nearby brush and trees on fire. This smoke was peculiar and fell back to the ground, forming a mound that was soon several feet high. The fissure quickly lengthened, producing a curtain of fire that leapt high into the sky. Those working in the fields hurried back to the village, with the roar of what was obviously a huge and very angry monster in their ears every step of the way. That night, the horizon glowed an unearthly red, and tongues of flame and lightning lit up the smoke-blackened sky, while the monster continued to bellow. The people began making plans to leave the village and move the five miles north to their lower-elevation winter settlement.

But early the next morning, the roar and smoke suddenly stopped, and several of the more brave villagers carefully crept to the base of the cone that was now over 150 feet high. The air smelled of burned earth and sulfur. A fine ashy powder covered the ground surface, along with larger black cinders and chunks of black rock, some of which were warm, or even hot, to the touch. Returning to the village, they consulted with the leaders, who told the people that the monster must be sleeping or had left. Groups were quickly assembled to harvest their fields, because without the corn harvest, the winter would be very difficult.

Almost everyone in the village who could walk returned to the fields and hastily began picking the nearly ripe ears, which were loaded into baskets and carried back to the village. They stared in awe and fear at the new 150-foot-high hill, wondering if, or when, the monster sleeping beneath it would awake. Their question was answered that afternoon, after only half the crop had been harvested, when, without warning, the monster began to roar again.

Peter Pilles, Jr.

*Sunset Crater Volcano and a portion of the Bonito lava flow. To the people living in northern Arizona, the eruption of Sunset Crater must have been an awe-inspiring sight.*

This time, the smoke shot up thousands of feet into the air, and black cinders and large basalt chunks rained down upon the people in the fields, who quickly grabbed their children and ran back to their homes. The base of the cone began to glow a fiery red, and lava started to ooze from it, moving directly toward the fields and the more distant village.

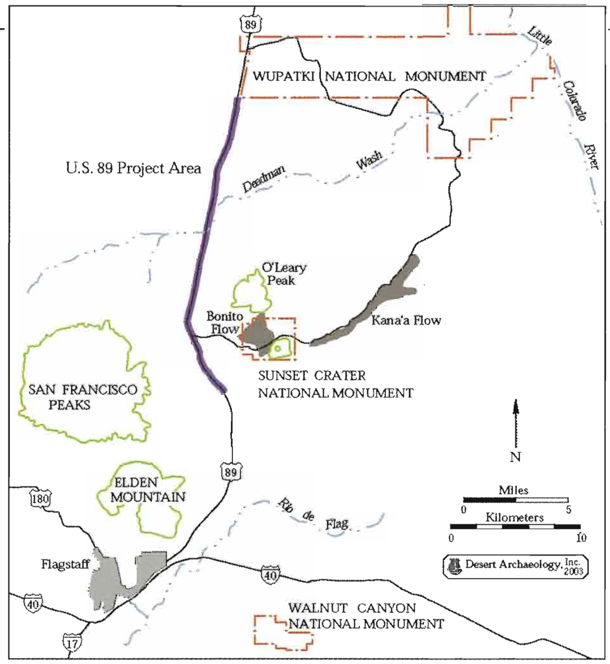
Gathering all the food they could carry, the people left the village within an hour, just as the lava pushed down the walls of the first house. The roar of the eruption had become even louder, almost deafening, and cinders, ash, and hot basalt continued to fall around the villagers. The forest was already on fire, and the smoke — mixed with the volcanic ash — made breathing difficult.

Still, luck was with the people, and they managed to get out with some food and only a few minor injuries. The food would not be enough to sustain them through the coming winter, but they could hunt and gather, and they could count on help from their more fortunate kin in other villages. But most importantly, the leaders needed to determine why this had happened and, once they did, undertake the proper rituals and prayers to ensure that it never happened again.

It must have worked, because to this day, some 900 years later, it hasn't.

The account told above about the eruption of Sunset Crater Volcano, while clearly fictional, could easily have occurred in the area just north of Flagstaff, Arizona, sometime between A.D. 1050 and 1150. Many of the details in this story are taken from accounts of the 1943–1952 eruption of a volcano in Michoacán, Mexico, called Parícutin. Parícutin is very similar to Sunset Crater and is perhaps the most well-studied cinder cone volcano in North America.

The significance of Sunset Crater was first realized in the summer of 1930, when archaeologists from the Museum of Northern Arizona (MNA) uncovered a prehistoric pit structure sealed beneath a thick layer of black volcanic cinders. The excavation of this structure provided the first definitive evidence that Sunset Crater erupted during the prehistoric occupation of the Flagstaff area. It would not be an exaggeration to say that this finding forever changed the nature of northern Arizona archaeology.



*Location of Sunset Crater Volcano.*

This issue of *Archaeology Southwest* explores Sunset Crater from several perspectives. Much of this research was undertaken through a highly productive collaboration between archaeologists from Desert Archaeology, Inc., and volcanologists and geomorphologists from Northern Arizona University. We were brought together by the Arizona Department of Transportation (ADOT), as part of the investigation of approximately 40 prehistoric sites along U.S. 89 just north of Flagstaff.

In this issue, volcanologist Michael Ort and I describe some of the results of our recent work at Sunset Crater. Much of this was funded by ADOT, though grants from the National Park Service and Western National Parks Association, and the assistance of the U.S. Geological Survey, have also aided our research. Archaeologist Chris Downum then presents the history of Sunset Crater dating, and particularly new information that is challenging what was once thought to be a well-established, if not sacred, A.D. 1064 date for the eruption. Geomorphologist Kirk Anderson discusses prehistoric agriculture in the Sunset Crater area, pointing out that theories derived in the 1930s by Dr. Harold S. Colton, the founder of MNA, are still very relevant today. Archaeologist Jeri DeYoung and Interpretative Specialist Carol Kruse examine the role of Sunset Crater in the National Park Service, discussing the history of the monument and outlining some of the research they have funded. Ort and I then describe our very recent research expedition to Parícutin Volcano. We hope this work will provide us with a chemical signature for that eruption, which we can then use to date the eruption of Sunset Crater. Although we do not yet have results from our work, the trip itself was highly illuminating and very exciting in terms of future research. Finally, Ort presents some new information on the Little Springs Volcano, an eruption on the north rim of the Grand Canyon that has only recently been found to have occurred at about the same time as Sunset Crater. The eruption of two volcanoes, located about 125 miles apart, would likely have had great meaning to the prehistoric inhabitants of the northern American Southwest.

There is no doubt that the eruption of Sunset Crater significantly affected the prehistoric people living in the Flagstaff area. The primary question we are asking is how these groups adapted to this catastrophic event, one that dramatically and permanently changed both the physical landscape and their ideological worldview. Previous research and our own archaeological investigations along U.S. 89 suggest that the small, relatively mobile groups living in the area at that time were in many ways pre-adapted to deal with the eruption, largely because they did not have a great deal of energy and resources invested in their habitation sites and agricultural field systems.

Our investigations indicate that a number of specific responses allowed a relatively quick adaptation to the eruption: (1) population movement; (2) use of new agricultural methods; (3) reliance on established kinship relationships; (4) changes in external exchange networks; and (5) initiation of volcano-related ritual behavior. While it is true that numerous villages and agricultural fields had to be abandoned, likely causing a fair amount of stress in the years immediately following the eruption, the eruption also had a beneficial side and opened up for settlement large areas of previously unfarmable land through the deposition of a "cinder mulch." The movement of people into these newly productive areas eventually resulted in the spectacular ruins seen today at Wupatki National Monument, which contain some of the largest and most complex sites in the Flagstaff area.

Volcano eruptions are one of the most powerful and destructive forces known in the natural realm. They are ripe with symbolism, dramatically altering the landscape by spewing molten rock from deep within the earth. They are fire-breathing, earth-shaking creatures, who, accompanied by lightning and thunder, have the power to turn the day into night and the night into day. It is little wonder that volcanoes both fascinate and terrify mankind, as much so today as in the prehistoric past.

# Collaborative Research at Sunset Crater Volcano

Mark D. Elson, Desert Archaeology, Inc.
Michael H. Ort, Northern Arizona University

THE ERUPTION OF SUNSET CRATER has long played an extremely important role in all models of Flagstaff prehistory. For example, to explain an increase in site density at the end of the eleventh century, Harold Colton first proposed that thin layers of deposited cinders acted as a water-retaining mulch, allowing previously unproductive areas to be farmed. In Colton's view, the opening up of new lands resulted in large-scale migrations (or a prehistoric "land rush," as Colton called it) that dramatically changed the nature of the groups living in the Flagstaff area. Colton's theory has been adopted, with some modifications, by more recent researchers, such as Christian Downum and Alan Sullivan, who proposed that the cinder mulch was an important factor in the initial settlement and subsequent population growth evident in Wupatki National Monument. Although a number of other researchers, such as Peter Pilles, have suggested that it was not so much the cinder mulch that allowed new lands to be farmed, but more favorable climatic conditions, all agree that the eruption of Sunset Crater had an enormous effect on the prehistoric inhabitants of the Flagstaff area, and probably the greater northern Southwest. Some 900 years later, Hopi accounts of the eruption are still passed from generation to generation as part of traditional history, strongly underscoring the significance of this event to those who witnessed it.


*Sunset Crater in the Sunset Crater Volcano National Monument, located about 15 miles northeast of Flagstaff, Arizona. Formed over 900 years ago by one of the region's most recent volcanic eruptions, the cinder cone rises a thousand feet above the surrounding ponderosa pine forest.*

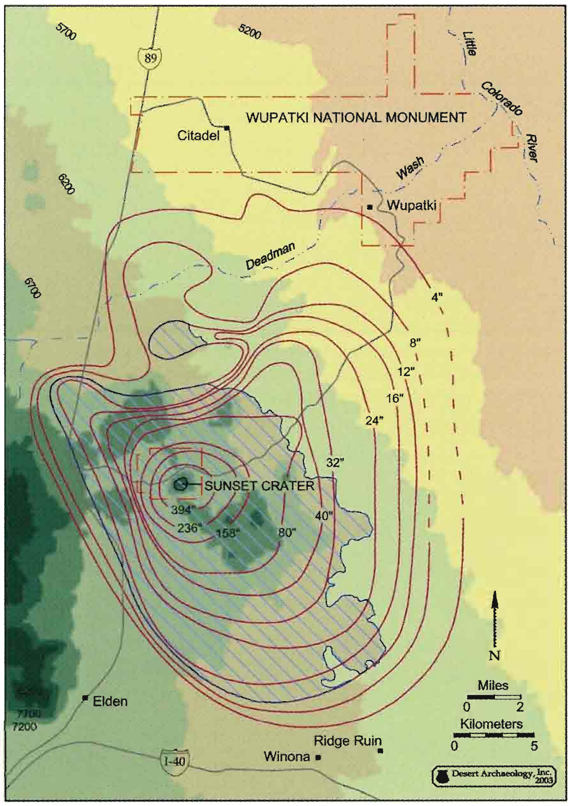
Sunset Crater was the largest volcanic eruption in the southwestern United States indisputably witnessed by surrounding prehistoric populations. Two smaller eruptions in the American Southwest are now dated to the period of human occupation: the McCartys flow near Grants, New Mexico, dated around 1200 B.C., and the Little Springs flow near the north rim of the Grand Canyon, recently dated to A.D. 1050–1200. We know that prehistoric groups were affected by the Little Springs eruption (see page 11). Whether prehistoric peoples also witnessed the McCartys flow is still unknown.

Sunset Crater is a cinder-cone volcano, a type that generally does not produce large explosions, unlike stratovolcanoes such as Mount St. Helens. Instead, they grow into cone-shaped features through fountaining lava that throws spatter, cinders, and ash hundreds to thousands of feet into the air. Slow-moving lava flows emanate from vents near the base of the cone. Evidence from modern cinder-cone volcanoes indicates that earthquakes occur for several weeks or months prior to the eruption, often increasing in frequency and magnitude. For example, at Paŕicutin Volcano in Michoacán, Mexico, a cinder cone very similar to Sunset Crater (see page 10), the first noticeable earthquake occurred 45 days prior to the eruption. A week later, daily earthquakes were occurring, increasing to 25 to 30 a day the week before the eruption. Finally, on the day before the eruption, 300 earth tremors were felt.

During an eruption, a cloud of ash and steam creates its own weather system, so that thunder claps and lightning around the volcano are common occurrences. At Paŕicutin, which was surrounded by several small villages of Puŕepecha (Tarascan) farmers, no one was killed by the lava or cinder fall itself, but three people and a number of cattle and horses were killed by lightning strikes. The fountaining lava also creates a tremendous noise, a loud roar with periodic explosions, that can be heard for hundreds of miles, along with whistling or hissing sounds. Additionally, the heavy ash and cinder fall, along with the smoke from accompanying forest fires, darkens the daytime sky, while at night the horizon glows a fiery red.

Such volcanoes can grow amazingly quickly: at Parícutin, the cinder cone grew to a height of 550 feet in six days. By the end of the first year, Parícutin had reached 1,100 feet, or 80 percent of its final height, suggesting that within a similar time frame, Sunset Crater may have been close to 1,000 feet high and 500 acres in area.

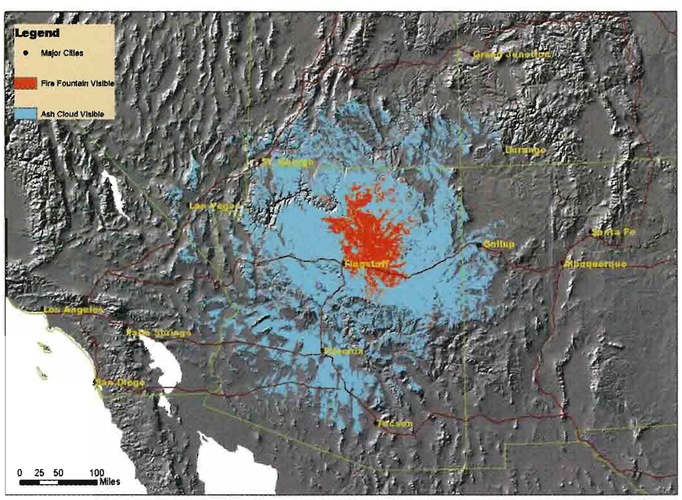
Sunset Crater lava flowed from two primary vents, covering an area of approximately three square miles to depths ranging between 5 and 100 feet. In addition, the eruption spewed ash and cinders over an area of about 900 square miles. Ash and cinder fall was heaviest closest to the volcano; deposits as thick as 16 inches were found in the fill of a pithouse at a site about four miles to the southwest, and deposits over 25 feet deep have been recorded closer to the cone. Significant accumulations occurred at distances as great as 15 miles, such as at Wupatki National Monument, where Sunset Crater cinder deposits between two and four inches have been recorded.




*Farming hazards and opportunities can be identified using this map of Sunset Crater ash and cinder thickness by Jason Hooten and Michael Ort. The cross-hatching indicates prime farm land where more than 12 inches of cinders and ash fell. Much of this large zone was abandoned when it became unproductive following the eruption. Areas with less than four inches of cinder mulch became the new prime farm land and saw populations increase.*

Four inches of ash is enough, particularly when wet, to collapse modern roofs. More significantly, as discussed by Kirk Anderson (see page 8), corn germination rates are significantly reduced with as little as six inches of cinder and ash cover, and corn seeds will not germinate in depths greater than 12 inches. A map of Sunset Crater ash and cinder thickness indicates that more than 12 inches of ash and cinder fell on a 150-square-mile (96,000-acre) area. It is almost certain that the inhabitants of these areas moved elsewhere following the eruption. Conversely, areas with cinder fall between one and four inches, which were previously too dry to farm, would have become available for settlement, because, as Colton first suggested, the cinders acted as a water-conserving mulch.

Based on the estimated minimum heights of the ash plume (5 miles in elevation) and lava fire fountain (850 feet in elevation), on a clear day the ash plume could have been seen from high points near Palm Springs, California; Las Vegas, Nevada; Durango, Colorado; west-central New Mexico; and close to the Arizona-Mexico border. The fire fountain, which would have been spectacular, particularly at night, was visible across a much smaller area, but still could have been seen from points in eastern, western, and central Arizona, and probably in southern Utah. Although it is not known how the eruption affected people living outside the immediate Flagstaff area, most groups living in the American Southwest during that time probably would have known that something very unusual was occurring.




*Viewshed of the Sunset Crater eruption computed through digital elevational modeling by Kyle Bohnenstiehl. Blue is the visibility of the minimum, 5-mile-high, ash cloud; red is the visibility of the minimum, 850-feet-high, fire fountain. Areas of significant prehistoric population, such as Chaco Canyon and the Phoenix Basin, were within sight of the ash plume.*

There can be little doubt that the eruption of Sunset Crater was one of the most significant events in the life of anyone living in the Flagstaff area in the mid- to late eleventh century. Throughout the world, most groups residing near active (and even inactive) volcanoes incorporate this feature into their belief systems. Eruptions are often seen as signs of spiritual transgressions, and offerings are commonly made in an attempt to avert the ongoing destruction. Hopi accounts of the Sunset Crater eruption cite various offenses, including gambling, immoral behavior, and the cuckolding of a katsina. At Parícutin, the native villagers blamed the eruption on the desecration of a shrine and "the wrath of God on a sinful people." The residents of Parícutin erected a row of six-foot-high wooden crosses in front of the moving flow to prevent it, unsuccessfully, from encroaching upon their village.

Studies of catastrophic events have shown that religious mechanisms for coping with a natural disaster are highly adaptive, enabling individuals and groups to more readily accept the event and begin the recovery process. At Sunset Crater, possible ritual behavior following the eruption is suggested by the recovery of over 50 pieces of Sunset Crater lava with impressions of prehistoric corn, or "corn rocks," from a site three miles from the flow.

The characteristics of the corn rocks, along with experimental data (see below), suggest that the rocks were made deliberately through placement of corn cobs as offerings around an hornito, or small spattercone. Corn is a sacred plant to all pueblo groups, and it is likely that it served a similar purpose in the prehistoric Flagstaff area. Why over 100 pounds of rocks with corn casts were then removed to a habitation site three miles distant is unknown. However, the corn rocks themselves may have been seen as a source of supernatural power or, given that one was found embedded in the wall of a masonry structure, as protection from the malevolent forces of the volcano.

## A Corn Rock Experiment

DURING A VISIT TO HAWAI'I in 1999, we had the opportunity to test several theories about how the corn rocks were formed. Our trip came about because Michael Ort, Nancy Riggs, and Wendell Duffield were taking a Northern Arizona University volcanology class on a field trip to Kilauea Volcano on the big island of Hawai'i, and they nicely let a couple of archaeologists tag along (and we need to say at the outset that the trip was paid for by the participants and not by the Arizona Department of Transportation).

Helga Teiwes

Mark Elson

*Top: Corn rock. Right: Volcanologist Wendell Duffield attempting to make corn rocks at Kilauea Volcano, Hawai'i. The smell of roasting corn filled the air as we undertook our experiments, and the other tourists found us amusing, as well as perplexing.*

We brought along a number of ears of dried Hopi corn, though we also went to a Safeway in Hawai'i and bought ears of frozen corn just in case. Luck was with us: Kilauea was active, and we were able to approach the lava flows just before they entered the ocean and exploded.

Our experiments were very fruitful. For instance, we learned that the lava at the very tip of a flow is already too cold and not fluid enough to cast corn, so the corn rocks could not have been made by lava accidentally overrunning a previously picked pile of corn in the field. We also learned that it is very difficult to make a corn rock and, in fact, we were not very successful. This suggested to us that the corn rocks were deliberately made and that spatter from an hornito might be the key.

Footage of our experiments is included in a documentary film about Desert Archaeology's U.S. 89 project, entitled *In the Shadow of the Volcano: Prehistoric Life in Northern Arizona* (see page 11).

# A Brief Account of the History of Sunset Crater Dating

Christian Downum
Northern Arizona University

*fact. n. the state of things as they are; reality; actuality; truth.* (Webster's New World Dictionary)

*I have yet to see any problem, however complicated, which, when you looked at it in the right way, did not become still more complicated.* (Poul Anderson)

*Members of the 1935 Museum of Northern Arizona archaeological expedition, designed to recover archaeological evidence to date the Sunset Crater eruption. Standing, left to right: Robert Lomadofkie, John McGregor (expedition leader), Walter Taylor, Fred Merkle, Larry Angel, Eddie Nequatewa. Seated, left to right: "Bud" Newman, George Dickey, Dick Wheller. Photograph taken at an archaeological camp near Black Falls, along the Little Colorado River. (Photograph courtesy of Chris Downum.)*

IT IS A FACT that Sunset Crater Volcano erupted between the fall of A.D. 1064 and the spring of 1065. Every visitor to Sunset Crater Volcano National Monument learns this, and countless students have absorbed this unassailable conclusion.

If only we could be sure it was true.

To understand where we are going in future studies of the Sunset Crater, it helps to see where we have been.

Sunset Crater was first recognized as an important force in the lives of local prehistoric peoples in the early 1930s during a series of remarkable archaeological expeditions by the Museum of Northern Arizona. By 1936, the eruption date was fixed with much precision, when John McGregor announced that the then-new science of dendrochronology (tree-ring analysis) showed that the volcano had erupted in A.D. 885, plus or minus 25 years. Harold Colton soon came to doubt this, and in 1945 he published a new estimate of the eruption date: A.D. 1046 to 1071. In 1958, dendrochronologist Terah Smiley further refined the date of Sunset Crater's eruption, fixing it in late A.D. 1064 or early 1065. In 1967, based on the excavation of a pithouse with cinders in the fill, David Breternitz proposed a second tree-ring-dated eruption event at around A.D. 1066. And finally, in the late 1970s, paleomagnetic dating of the Sunset lava flows suggested to geologists Eugene Shoemaker and Duane Champion that Sunset Crater might have been active for nearly 200 years after an initial eruption in the A.D. 1060s.

And here the story has stood, until now. Recent geological and archaeological data add new layers of complexity to the Sunset Crater story, and suggest that dating "an eruption" may be a vast oversimplification. Colton and his colleagues assumed that Sunset Crater was a single eruptive event, but it is now known that the eruption began along a several-mile-long fissure and then concentrated at Sunset Crater to produce at least three lava flows and eight cinder-and-ash deposits. The 200-year sequence of eruption events also now seems increasingly implausible, based on historical, geological, and archaeological evidence, as well as new paleomagnetic data.

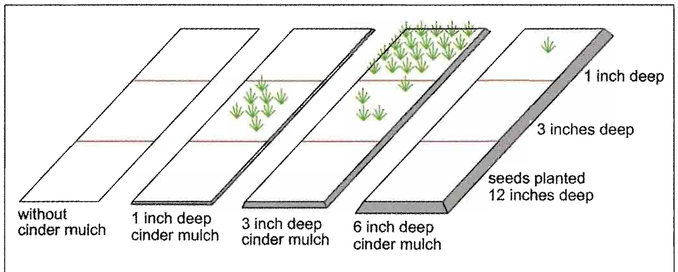
Even Smiley's A.D. 1064-1065 date, long sacred in archaeological circles, has recently been called into question, based on no clear association between his tree-ring specimens (from Wupatki Pueblo) and Sunset Crater (some 15 miles distant). In addition, the suppressed tree rings that Smiley saw following A.D. 1064 could have arisen from a number of different processes, with a volcanic eruption being only one possibility. Breternitz's A.D. 1066 date for a second eruption cannot be correct, because the tree-ring dates from his pithouse extend to at least A.D. 1068. In addition, it is unclear whether the cinder-and-ash deposits in this structure fell directly from the sky as a result of the eruption, or were deposited by wind or water at some point following the eruption.

So when did Sunset Crater erupt? Trying hard not to sound like a politician during a legal deposition, I would reply: It depends on what you mean by the terms "Sunset Crater" and "eruption." As the history of Flagstaff archaeology shows, facts can indeed change when one looks more closely. Stay tuned.

# Sunset Crater and Cinder Mulch Agriculture

*Kirk Anderson, Northern Arizona University*

THE BLACK CINDERS BLANKETING THE LANDSCAPE around Sunset Crater made it possible for prehistoric farmers to grow crops in previously marginal areas. In the 1930s, Harold Colton proposed that this "black sand" deposited by the Sunset Crater eruption acted as a moisture-retaining mulch, opening up new lands for settlement and serving as the catalyst for northern Arizona's first great land rush. Although dry farming was widespread long before the eruption of Sunset Crater, the newly deposited cinder mulch led to sufficient crop production at Wupatki and surrounding areas for large populations to thrive between about A.D. 1100 and 1250. But was the moisture-retaining capability of the cinders the only factor, or did climate also play a role?




*Experimental agricultural plot planted by botanist Gwendolyn Waring near Wupatki National Monument at an elevation of 5,700 ft. Note the absence of corn germination in areas without cinder cover and in areas with more than six inches.*

These questions have been addressed most recently during Desert Archaeology's excavations along U.S. 89 north of Flagstaff. Results of soil investigations by Northern Arizona University graduate student Joshua Edwards, experimental farm plots by botanist Gwendolyn Waring, and a paleoclimatic reconstruction by dendroclimatologist Matthew Salzer are providing a better understanding of the prehistoric agricultural record.

Kirk Anderson

*Prehistoric agricultural rock alignments within a cinder-covered field.*

Of the thousands of agricultural features in the area, the majority are linear rock alignments oriented perpendicular to the prevailing southwesterly winds. These features act as windbreaks to protect seedlings, reduce the drying effects of wind, and decrease sandblasting by fine cinders. Also, the rock alignments and cinder mulch reduce erosion, trapping sediment and organic matter to increase soil fertility. Waring's experimental farm plots show that at 5,700 feet in elevation, the optimum cinder depth for corn is one to three inches, while corn will not grow in cinder depths greater than six inches. Most importantly, this research strongly suggests that corn could not have been grown in the low-elevation Wupatki area without the cinder mulch, supporting earlier experimental work by Colton in the 1930s and Stuart Maule in the 1960s. To survive in this arid environment, Wupatki's farmers had to learn a new agricultural technique following the eruption — "cinder mulch agriculture."

But what was climate's influence during this time? Wet years during the early period (A.D. 1047-1066, 1068, 1077-1084) may have aided crop production as much as the cinder mulch. Dry years, particularly those toward the end of the occupation (A.D. 1215-1221, 1227, 1254, 1258, 1292-1300), when the population was large, may have hastened the abandonment of the area. Corn production was always marginal, and at times probably impossible, for the Wupatki inhabitants. Today, corn could not be grown in the Wupatki area without artificial irrigation, and there is no evidence for prehistoric canals or large-scale water reservoirs.

Therefore, it seems that both the "black sand" and climatic change hypotheses are valid. The inhabitants of the area around Wupatki were a relatively stable population living in a marginal environment, which flourished as a result of temporarily favorable climates, beneficial cinder-mulched soils, and technological and cultural innovations. These processes, combined with underlying social factors, led to dramatic population growth between the late eleventh and the early thirteenth centuries. However, negative climatic factors may have also led, ultimately, to the abandonment of the area sometime between A.D. 1250 and 1300.

# Sunset Crater and the National Park Service

*Jeri DeYoung and Carol Kruse*
*National Park Service, Flagstaff Area National Monuments*

FROM A DISTANCE THE RED CINDERS SEEM TO BE ON FIRE, John Wesley Powell wrote of Sunset Crater while on a U.S. Geological Survey expedition in 1885. He named the volcano Sunset Peak. To the Hopi, Sunset Crater is "Red Hill" or Polotsmo, home of the Kana'a katsinas. In 1928, the Famous Players — Lasky Moving Picture Corporation, filming Zane Grey's *Avalanche*, saw Sunset Crater's cinder slopes as the perfect setting for a shot-on-location landslide. This early "special effect" was to be created by blowing up the crater with dynamite. Fortunately, Harold Colton got wind of the movie company's plans and worked successfully with the United States Forest Service and local citizens to protect the volcano. On May 26, 1930, President Herbert Hoover established Sunset Crater National Monument, and in 1990, the name was changed to Sunset Crater Volcano National Monument to better describe its geologic origins.

In the early years, visitors to the monument were few; the primitive cinder road discouraged travel, as did rubber and gas rationing during the Second World War. In 1957, the National Park Service (NPS) undertook the Mission 66 Construction Program to improve the nation's parks for an increasingly mobile public. The Sunset Crater visitor center was constructed during this period. Today, over 190,000 people visit the monument each year: 25% are Arizona residents, and 20% come from overseas, especially Germany, France, and Great Britain. Many are en route to Grand Canyon National Park, but discover Sunset Crater as an unexpectedly spectacular side trip.

Research is revealing new information about the volcano, making the exhibits in the visitor center obsolete. The NPS is working with the Museum of Northern Arizona to design new exhibits in which the eruption will be interpreted as a dramatic geologic event that affected the landscape and all living things across a broad region. Interpretation of eruption-related cultural change will continue a few miles away at Wupatki National Monument, where new exhibits are planned as part of the same project. These exhibits, which will be funded with a portion of the entrance fees collected at each monument, should be in place by 2005.

An ongoing program of scientific research advances our understanding of the natural and cultural resources preserved within the monument. Current research sponsored by the NPS includes the Sunset Crater Dating Project; a project to assess the effects of off-trail trampling on nurse-plant ponderosa pine and soil retention; a project that examines deposits created by fumaroles (volcanic gas vents) from the volcano; and a project documenting traditional and historic uses of the land comprising the monument. In addition, the monument has been designated a pilot park to host instrumentation and interpret geophysical and geological findings of the multidisciplinary, multipartner National Earthscope Project.

*Seasonal Ranger Campbell and visitors at the entrance to the Ice Cave, Sunset Crater National Monument. (The photograph was taken by Zorro Bradley, National Park Service Archeologist and Sunset Crater National Monument Superintendent Cook, 10 May 1956. Photograph courtesy of Sunset Crater Volcano National Monument.)*

Sunset Crater has been many things to many people: a home, a scenic backdrop, a vacation highlight. Today, more than ever, it is also a window through which to view the history of our world and its inhabitants.

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For additional information on Sunset Crater Volcano National Monument, go to www.nps.gov/sucr.

# Paricutín Volcano Revisited

*Mark D. Elson, Desert Archaeology, Inc.*
*Michael H. Ort, Northern Arizona University*

Kirk Anderson

*The church at San Juan Parangaricutiro. The church and the village were partially buried by lava in 1944. Every year, a pilgrimage is made back to the church, retracing the walk the villagers made when the lava forced them from their homes 60 years ago.*

PARICUTIN VOLCANO ERUPTED in the late afternoon of February 20, 1943, arising from the cornfield of farmer Dionisio Pulido (see page 1). It was a catastrophe of major proportions for the native Purépecha (Tarascan) villagers who had lived in the area for generations, practicing subsistence farming augmented by hunting, gathering, animal husbandry, and the collection of pine sap from the nearby forests. Although the Purépecha had successfully fought off the Aztec, and had fiercely resisted the Spanish, they were helpless against the volcano. By the time the eruption ended in 1952, lava flows covered almost 10 square miles, while another 70 square miles were beneath more than 10 inches of ash and cinders — a depth from which agriculture was no longer possible. Five villages were partially or completely buried by the lava and ash fall, displacing thousands of people. No one was killed by the eruption itself. However, more than 100 people died; some, particularly the elderly, from sickness or from simply losing the will to live. Others died in land wars that broke out following the eruption, as those who were left homeless moved into new territories.

We visited Paricutin, located in Michoacán, Mexico — about a five-hour drive from Guadalajara — during the first week of January 2003. Our trip to Paricutin resulted from discussions with Paul Sheppard of the University of Arizona Laboratory of Tree-Ring Research. Paul specializes in extracting atmospheric nitrogen from tree rings, and he had heard about our work at Sunset Crater. Knowing that volcanoes emit large quantities of nitrogen when they erupt, he wondered whether elevated levels of nitrogen in tree rings could be used to date eruptions. Paul's idea sounded promising, so we applied for, and received, a small grant from the National Park Service to test this hypothesis. Because volcanoes also emit large amounts of strontium, we decided to look for chemical signatures for both elements in the pine forests surrounding Paricutin.

Wendell Duffield

*Michael Ort, with Mark Elson in the background, coring a tree in the forest around Paricutin Volcano. Tree rings dating to the eruptive period between 1943 and 1952 will be analyzed for elevated levels of nitrogen and strontium. Note the scar (and tin can) in the tree for sap collection.*

We hypothesized that "spikes" in nitrogen and strontium in tree rings between 1943 and 1952, as well as any physical alteration in the rings (such as ring suppression), would be indicative of the eruption, particularly when contrasted with tree rings from the pre-1942 and post-1953 periods. Because Paricutin is so well-studied, rings from years for which elevated levels occurred could then be correlated with the eruptive record. Using this method, we could then examine prehistoric tree rings from the Sunset Crater area between approximately A.D. 1000 and 1250, looking for similar spikes that would date each of the eruptive events and perhaps finally resolve the dating controversy described by Chris Downum (see page 7). The results of our research should be available by late summer or early fall.

We are happy to report that people in the Paricutin area are alive and well, if not thriving, showing both the resilience and the adaptability of the human spirit. Agriculture, animal husbandry, and pine sap collection are still economically important, although avocado cultivation and particularly forestry are now significant factors as well. The eruption is certainly not forgotten and has become embedded in both Christian and Purépecha rituals. Volcano tourism is rapidly becoming an important factor in the regional economy. Murals and dioramas of the eruption adorn churches and buildings in several towns, while photos and volcano souvenirs can be found in the markets. Although some of these opportunities were not available to the prehistoric inhabitants of the Sunset Crater area, they also learned to live with, and benefit from, their volcano.

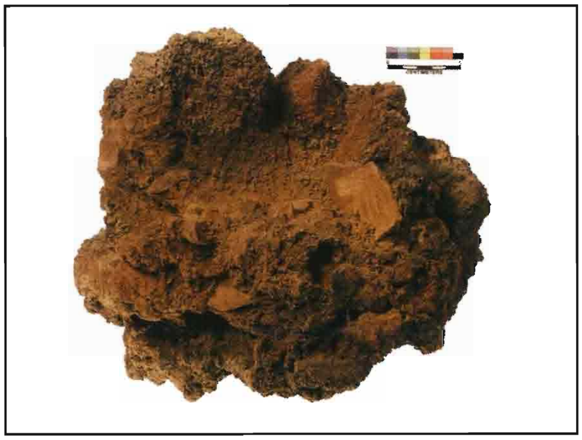
# Little Springs Volcano: A New Prehistoric Eruption

*Michael H. Ort, Northern Arizona University*

A 330-FOOT-TALL CONE OF SPATTER AND CINDERS, known as the Little Springs Volcano, lies approximately 15 miles north of the Grand Canyon, in the newly designated Grand Canyon-Parashant National Monument. Although Sunset Crater has long been considered the youngest, and perhaps only, volcanic eruption witnessed by prehistoric inhabitants of the American Southwest, new research by geologists George Billingsley of United States Geological Survey and Cassandra Fenton of the University of Utah suggests that the Little Springs eruption also occurred within the past 1,500 years.

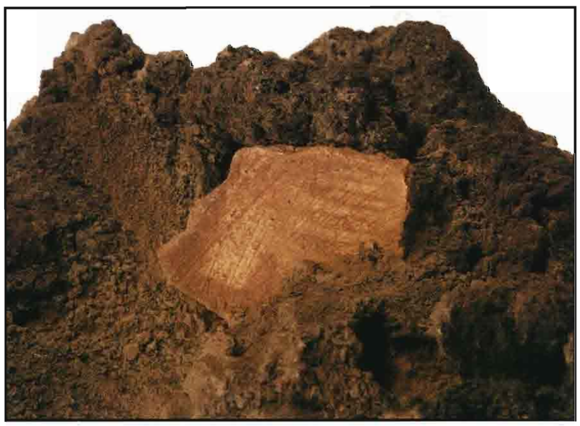
Most significantly, this dating was recently refined by the discovery of Hurricane Black-on-gray pottery — made between A.D. 1050 and 1200 — embedded in lava spatter apparently from the eruption. These sherds were found at a site about half a mile north of the Little Springs flow, and were brought to the attention of Mark Elson and me by John Herron, an archaeologist with the Bureau of Land Management. A few likely corn impressions were also observed in the lava, suggesting that corn may have been placed in pots near a source of spatter. Like the corn rocks from Sunset Crater, someone then picked up these "lava sherds" and moved them to a site away from the flow.

Mark Elson, Wendell Duffield, and I have recently received a grant from Western National Parks Association to begin a study of the volcano and the effect it may have had on the prehistoric inhabitants of this area. Planned research at Little Springs Volcano includes geological mapping, archaeological survey, chemical characterization studies, and paleomagnetic dating of the lava flow.



Robert Ciaccio

*Hurricane Black-on-gray (circa A.D. 1050-1200) ceramic embedded in lava from the Little Springs eruption. The lava flow from the eruption extended about a mile north and south of the volcano.*



Robert Ciaccio

**Sunset Crater Video — *In the Shadow of the Volcano: Prehistoric Life in Northern Arizona* is available at the Sunset Crater Volcano Visitor Center, or for $19.95, plus shipping, from the Center for Desert Archaeology (520.882.6846 or www.cdarc.org).**

## See the Center for Desert Archaeology website for more information: <http://www.cdarc.org>

THE CENTER FOR DESERT ARCHAEOLOGY, a private, nonprofit organization, promotes stewardship of archaeological and historical resources through active research, preservation, and public outreach. The Center is a 501(c)(3) organization and is supported through donations, memberships, and grants from individuals, foundations, and corporations. Center members receive an annual subscription to *Archaeology Southwest,* substantial discounts on other Center publications, opportunities to participate in archaeological projects, and invitations to special lectures and events. For more information or to join, contact Linda Pierce, Programs Manager, at 520.882.6946 or lpierce@cdarc.org.



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# Back Sight

VOLCANIC ACTIVITY, even on a relatively small scale, often makes the news. This issue of *Archaeology Southwest* conveys some of the newsworthy findings of a recent, contract-funded archaeological project. Sharing the latest research results from a diversity of sources is at the heart of the Center's mission.

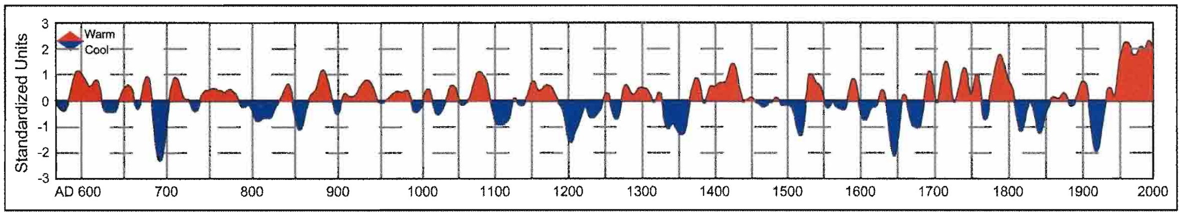
The U.S. 89 Archaeological Project brought together many scientific specialists to explore a rich archaeological zone that crosses a large volcanic field north of Flagstaff. The most recent eruption of Sunset Crater was only nine centuries ago, and the story of that volcano and its effect on the ancient residents of the Flagstaff area is the focus of this issue.

A related interdisciplinary study was also pursued on this project, with intriguing results. Matthew Salzer examined Flagstaff-area tree rings to reconstruct a record of past temperature variation. He went to the top of the San Francisco Peaks and sampled ancient bristlecone pines from the tree line, where their growth is strongly affected by temperature. He then conducted a rigorous analysis to develop a model of past temperature variation that, he argues, applies to the entire Colorado Plateau. In a recent article published in the journal *Kiva*, Salzer suggests that temperature was one of the factors that contributed to regional abandonments and migrations in the American Southwest during the A.D. 1200s.

**back sight (băk sīt)** n. **1.** a reading used by surveyors to check the accuracy of their work. **2.** an opportunity to reflect on and evaluate the Center for Desert Archaeology's mission.

Salzer's *Kiva* article also discusses how volcanism can lower temperatures on a global scale. Very large, explosive volcanoes can send enough ash into the atmosphere to reduce the solar energy reaching the earth and thereby depress temperatures. The global effects of a single volcanic eruption are usually on a time scale of several years, but if many large eruptions occur in succession, the effects can extend to a decade, or even more. The present discussion of Sunset Crater has shown that there were significant human consequences in the immediate Flagstaff area. However, Sunset Crater was too small to have had more than a regional impact.

A global effect that is apparent and is of interest can be seen in the graph of temperature variation for a period of more than 1,400 years. This graph shows deviations from the long-term mean. It indicates that there were substantial variations both above and below that mean over time. However, around 1950, an upward trend began that is greater than has been seen in the last 14 centuries. Such studies provide an important context for the issue of global warming. It is rare that archaeological studies have global implications, but increasing numbers of interdisciplinary teams are pursuing such broad issues.




*Variation in temperature over the past 1,425 years. Matthew Salzer sampled Flagstaff-area tree rings and reported the results in a recent University of Arizona doctoral dissertation. Note the warming trend initiated in the 1950s that continues today.*

Over the years, the Arizona Department of Transportation has funded archaeological research that has transformed our scientific understanding of the past in the American Southwest. This recent work continues that trend, with potential global implications.

William H. Doelle

*William H. Doelle, President & CEO*
*Center for Desert Archaeology*


Center for Desert Archaeology
*Archaeology Southwest*
300 E. University Blvd., Suite 230
Tucson, AZ 85705



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