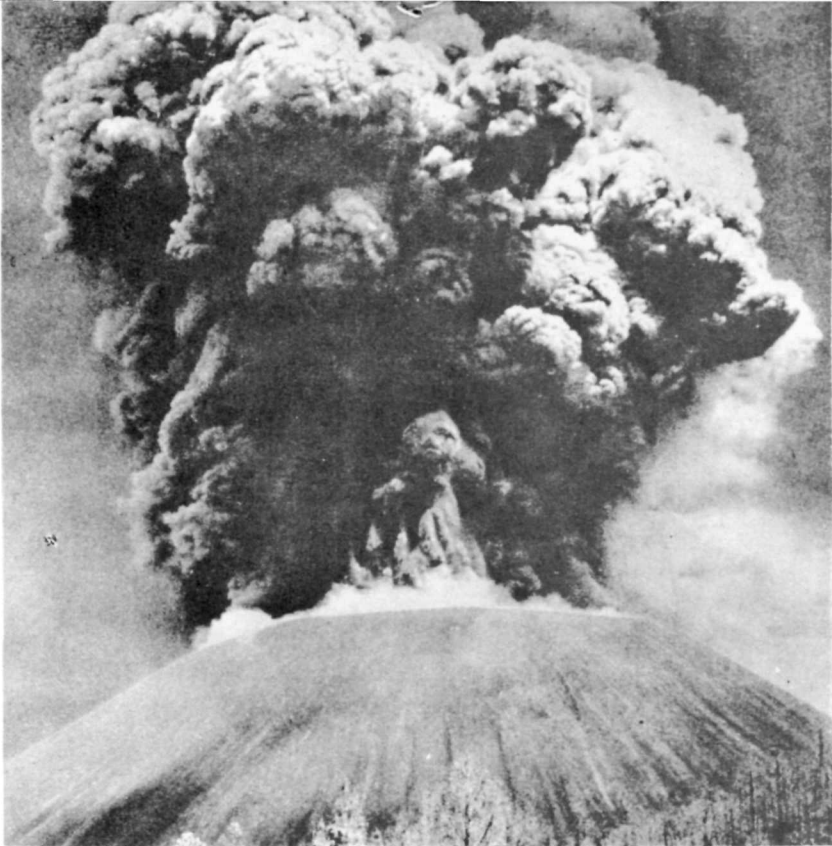




*Lava Flow*  
**NATURE TRAIL**

SUNSET CRATER NATIONAL MONUMENT  
ARIZONA

15 CENTS IF YOU TAKE THIS BOOKLET HOME



*Paracutin Volcano in Mexico. Sunset Crater may have looked like this when it erupted about 900 years ago.*

### **NATIONAL PARKS AND MONUMENTS**

Sunset Crater National Monument is one of more than 280 areas administered by the National Park Service, U. S. Department of the Interior. These include such areas as Grand Canyon and Yosemite National Parks and other Parks and Monuments set aside for their scenic, scientific and historic values. Sunset Crater was established as a National Monument on May 26, 1930, by proclamation of President Herbert Hoover.

To preserve the Parks and Monuments for the enjoyment and inspiration of future generations it has been necessary to prohibit hunting, grazing, mining, woodcutting, and other activities which would destroy the handiwork of nature. We hope you will join with us in protecting Sunset Crater National Monument by taking only pictures and inspiration and leaving only footprints and goodwill.

**HELP KEEP AMERICA BEAUTIFUL**

## INTRODUCTION

The 1,000-foot high Sunset Crater erupted sometime between the fall of 1064 and the spring of A.D. 1065 and was the last eruption in this volcanic field. Its ash fall forced local Indians to flee their homes, but at the same time built up a beneficial moisture-retaining layer of cinders which made dry farming possible. This change in soil moisture conditions caused a prehistoric land rush that drew an estimated 8,000 people into a region of 800 square miles.

As a purely geological attraction, Sunset Crater exhibits an extremely wide range of volcanic phenomena, with several kinds of lava and a large variety of spatter cones and fissures, as well as squeeze-ups. The latter are relatively rare.

The trail begins just to the west of the Ranger Station, and is about a half mile long. It will take you to some of the more interesting features of Sunset Crater National Monument. It is a loop trail and in about 45 minutes of easy walking you return to the parking area.

The numbered markers along the trail correspond to numbered paragraphs in this booklet.

*If you plan to enter the ice cave at Stop No. 3 a flashlight is necessary.*

**Stop No. 1.** *Fumarole or "spatter cone."* Fumaroles can be thought of as miniature volcanoes. They are formed by the violent escape of gases from solution within the lava. The bottom of this spatter cone has been oxidized by these gases, forming the red color, which is mostly iron oxide.

**Stop No. 2.** *Line of fumaroles.* Along the trail are several fumaroles which erupted along a crack or fissure in the lava flow. Such fissures are common sites for fumaroles to form in; they also form along the edges of the flow.

**Stop No. 3.** *Cave in a collapsed lava tube.* Even after a thick crust formed on the cooled surface of the lava, the molten mass underneath continued to flow. Here, the mass drained away and left a tube extending approximately 225

feet under the lava flow. Later, contraction caused by further cooling caused portions of the cave to collapse as well as the surface cracks above it that you see today.

Ice can be found in the cave year round. It forms as water from the surface percolates into the cave and freezes. This ice is preserved during the summer because the overlying lava acts as an excellent layer of insulation. *Please do not break or remove any of the ice, so that those who follow you can also see its beauty.* If you enter the cave, a flashlight is necessary.

The small white-barked trees which you see growing near the cave entrance are quaking aspen (*Populus tremuloides*). They may be concentrated here because this area is relatively low, and more surface water may be available during periods of runoff.

**Stop No. 4.** *Ponderosa pine, or "western yellow pine,"* (*Pinus ponderosa*). In the Sunset Crater area ponderosas are sparse and widely spaced. Because of this they have well developed lower branches, forming stunted, bushy trees. They are often twisted and deformed. In other parts of Arizona, however, these trees form the largest, finest

*View from top of Sunset Crater looking east.*



ponderosa forests to be found in the United States. The odd growth of the trees in this area is due not only to their sparseness, but also probably due to the strong prevailing southwest winds, inadequate moisture and perhaps to mineral deficiency or excess in the local volcanic soil.

Young ponderosa pines do not have the characteristic orange-yellow bark of the mature trees. Instead their bark is rough and black, and they are sometimes called "black-jack" pine.

**Stop No. 5.** *Small fumarole or lava bubble.* This feature is at the end of the short side path. Walk over and examine it. About 50 feet south of this fumarole, notice a similar but slightly smaller lava bubble with the top still intact.

**Stop No. 6.** *Apache-plume (Fallugia paradoxa).* This shrub derives its name from the plumelike seed clusters which appear in the summer and fall of the year. It provides browse for deer and sheep, and is used by the Hopi (HOH-pee) Indians for arrowshafts and, with duck grease, as hair dressing.

**Stop No. 7.** *Pinyon pine (Pinus edulis).* The small tree on the rock above you is a pinyon, a common small pine of the Upper Sonoran Life Zone that extends from the Sonoran plains of Mexico, after which the zone is named, northward into Colorado and Utah. The pinyon nuts you see in the local stores are the seeds of the pinyon and are quite delicious, raw or roasted. These nuts have recently become commercially important and provide a source of income to many Indians in northern Arizona.

To the West in the distance you see the San Francisco Peaks, which culminate in Mt. Humphrey, elevation 12,670 feet, the highest point in Arizona. On the cool moist slopes of the peaks which incidentally are the remnants of an extinct volcano, are found dense forests of pine, quaking aspen, spruce, and fir. The higher areas of the peaks are above timberline and the small plants growing there are similar to the vegetation of the Arctic regions.

Thus in the very few miles from Sunset Crater to the top of the San Francisco Peaks you can go from the Upper Sonoran Life Zone with its pinyon through the ponderosa forest of the Transition Zone, the quaking aspen of the Canadian Zone, the Hudsonian Zone with its spruce and fir forests and finally the Arctic-Alpine Zone where the climate is too severe for trees to grow at all. To do this at sea level it would be necessary for you to travel from Mexico to the Arctic.

**Stop No. 8.** *Wax currant (Ribes cereum)*. The berries of wild currants are an important food for wildlife and sometimes used for making jelly. A preparation of the wax currant has been used by the Hopi Indians as medicine.

Currants and gooseberries harbor one stage of the white pine blister rust and are being killed out where commercially important stands of white pine occur. Control of these shrubs has not been found necessary in Arizona.

**Stop No. 9.** *Storm damage*. The fallen trees which you see in this vicinity and in other places on the Monument are caused by windstorms. High winds often topple trees in the cinder area because their root systems are shallow. These trees are sometimes referred to as "blow-downs" or "wind-falls." This shallow root system for ponderosa is unusual, because they develop deep roots in better soil. It is believed that in this area any water which passes through the first few feet of the soil sinks so deep into the loose cinders underneath that the tree roots cannot reach it. Hence the roots are found near the surface and take up the moisture absorbed by the decayed needles and soil on or very near the surface of the ground.

You will note that some of these trees have been burned. This was probably caused by lightning, which often strikes trees in this area. You will see further evidence of lightning damage at Stop No. 15.

**Stop No. 10.** *Plant succession*. Along this trail you are seeing the story of the plant world unfold as it has been doing



*Sunset Crater, Cinder Hill and Bonita Lava Flow*

for eons. This story is a systematic process known as plant succession, which proceeds in this arid climate from bare rock to the beautiful ponderosa pine forest of the region.

Before you on the bare rocks of the lava flow you will notice splotches of gray and green. These splotches are in reality tiny plants, known as lichens. Lichens consist of two simple plants, an alga and a fungus, which depend upon one another for their existence. Due to a very specialized life system they can exist upon the bare rock, obtaining food from the air and rain water, and from the rock itself. Slowly they wear away the rock with their tiny roots, and with weak acids which they produce, until some soil is formed.

As soon as some small amount of soil is formed, mosses move in and crowd out the lichens just as dandelions move into your lawn at home. The mosses being even more powerful, break down more rock to form more soil and are in turn driven out by grasses and annual flowers.

These annuals, in turn, break down the rocks further with their roots until shrubs such as the skunkbush sumac and Apache-plume can survive, and, finally enough soil collects to support a tree. This is an extremely slow process

taking thousands of years to complete under these climatic conditions.

In this particular area most of the soil which supports the vegetation has been carried in by the wind. However, the lichens before you are slowly breaking down the solid rock to form new soil, which will in turn nourish the mosses and so on through the full cycle of plant succession.

**Stop No. 11.** *A'A'* (pronounced *ah ah*) lava flow. This is a Hawaiian term describing the rough jagged surface. The black lava rock itself is called basalt. Rough texture of the flow is an original feature caused by breaking up of surface crust which formed by cooling as the lava flowed slowly along. The lava looks as fresh as if it flowed yesterday because the cool dry climate of this area has slowed down biochemical weathering and change. It is very recent, geologically, for Sunset Crater's eruption can be dated accurately by archeological and tree-ring methods as occurring between the fall of A.D. 1064 and spring of A.D. 1065.

At this point the trail is on the upper surface of the lava flow which you have been walking along since the last stop.

There are two major lava flows in this area. The one on which you are standing is the younger, or Secondary flow. The trail which you will follow to the next stop leads up to the surface of the older, or Primary flow.

**Stop No. 12.** *Gas vesicles and xenoliths.* Gases play a major role in the eruption of a volcano. They constitute more erupted material by weight and volume than do the lava and cinders. When lava emerges on the earth's surface, it has moved from a region of high pressure to one of low pressure. The contained gases expand rapidly and are forced out of the lava, much like carbonated gas fizzes out of the beverage in a pop bottle when the cap is removed. This escaping gas forms the holes or vesicles which you see here.

Also visible from here (indicated by the white arrow) are rocks surrounded by lava called xenoliths. These foreign rocks are actually fragments of sedimentary rock

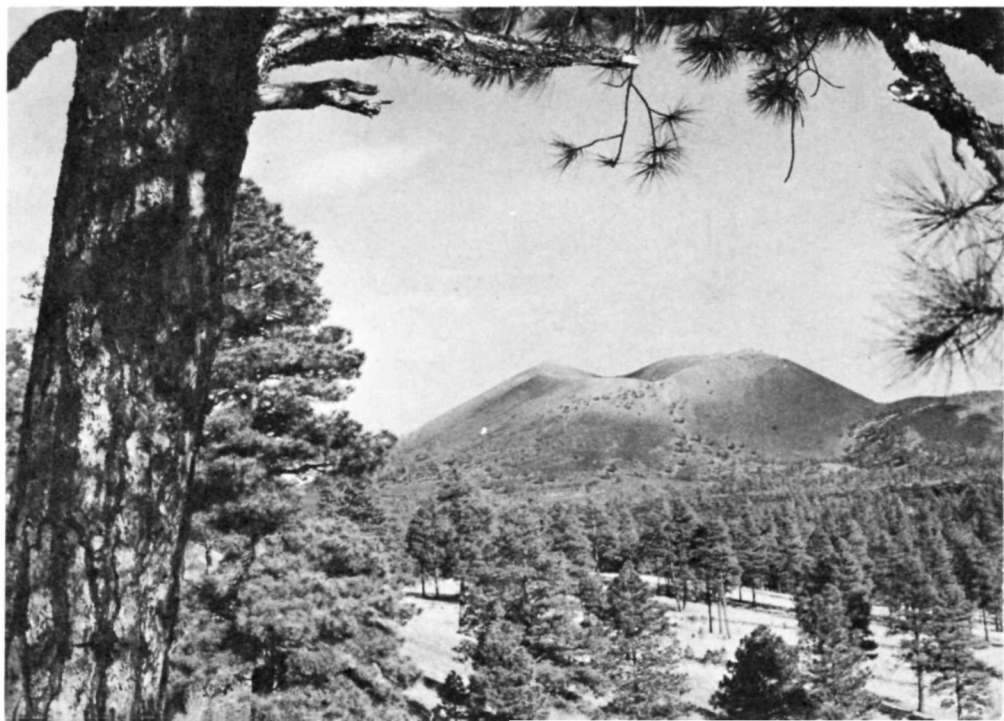


brought up from a great depth when the lava was forced up through the bedrock. Pieces of bedrock are broken off, fused into the molten lava, and carried to the surface. Here at this stop the xenolith is the yellowish-white Kaibab limestone.

**Stop No. 13.** *Pressure crack and ridge.* The large crack or fissure which you see here was caused by pressures which can develop within lava flows in several ways. One way is for younger lava to be intruded or squeezed under and up through the older lava, arching it up and breaking it. This is the case here. Note the lava in layers or flow units about 5 feet thick, exposed on the inside wall of the crack.

**Stop No. 14.** *Squeeze-ups.* The standing section of lava ahead of you, marked by the white arrow, is a squeeze-up. As the younger lava described above forced its way up through the crack it cooled to the consistency of modeling clay. This congealed lava was molded into wedge-shaped masses or squeeze-ups, which often bent under their own weight as they rose in the crack. (See photo, page 8). They show grooves or striations where they pushed and scraped

*Distant view of Sunset Crater through ponderosa pines.*





*Squeeze-ups at northwestern base of Sunset Crater's cone described at Stop No. 14*

against the walls of the fissure. Squeeze-ups are common at Sunset Crater, but are more rare in other lava fields.

**Stop No. 15.** *Ponderosa pine adaptation.* The ponderosa pines in the Sunset Crater area exemplify several adjustments which trees make to live under adverse conditions. The roots which you see exposed here are one such adaptation—to loose, porous soil. This has been discussed at Stop No. 9. Another adaptation is the tree's ability to survive injurious lightning strikes. The spiral groove which you see in the bark of this tree was caused by lightning. Fifty feet down the trail in the direction from which you have just come, on the north side of the trail, you will see a tree which was badly split by lightning but which still lives.

**Stop No. 16.** *One-seed juniper (Juniperus monosperma).* This tree is commonly miscalled cedar due to the aromatic wood. There are no true cedars (*Cedrus*) native to the New World. In association with pinyon, juniper makes up the scrub (or pygmy) forests of the Southwest. Locally it is extensively used for fence posts and firewood. Indians have many uses for the tree and its berries in preparation of medicine. Perhaps because of the clean aromatic fragrance, extracts of berries and twigs are widely used in "cleansing" ceremonies, or purification rits of certain tribes.

Between here and the next stop, look for examples of small lava bubbles or blisters.

**Stop No. 17.** *Lava bubble or blister.* Bubbles such as this (indicated by the white arrow) were formed by the escape of gas when the lava had almost congealed. Some of the bubbles in this area are intact, others have burst. Their formation can be visualized by imagining a pan of fudge boiling on a stove. Other blisters can be seen nearby.

**Stop No. 18.** *Sunset Crater.* From this point you have an excellent view of the Cinder Cone. Of the more than 300 extinct cinder cones comprising the San Francisco Peaks

Volcanic Field, Sunset Crater is the youngest, or most recent, and the only prehistoric eruption which has been accurately dated. It was first given the name Sunset Peak by Major John Wesley Powell, famous geologist and explorer, in 1879. He was naturally impressed by the red and yellow hues formed in the oxidized cinders on the rim of the crater, which gives the impression of perpetual sunset upon the cone. The name was later changed to Sunset Crater.

Cinder cones are one of three principal types of volcanoes found around the world. The other two are shield and composite volcanoes. The cinder cone is the only one which commonly erupts lava from its base. Bonita Lava Flow, over which you have been walking, issued from the base of Sunset Crater near the Ranger Station. Only cinders and ashes were erupted through the crater at the top of the cone.

**We hope you have enjoyed this trail. Please return this booklet before you leave, or you may purchase it by dropping 15 cents in the coin slot in this box or at the register desk.**

### **CRATER RIM TRAIL**

If you want to see more of Sunset Crater, and have an hour or so to spend, climb to the crater's rim. The trail starts at the same point as the Lava Flow Trail, and is indicated by a sign. The climb is steep and strenuous.

Be sure to wear old shoes; high topped boots are best. The first part of the trail is the steepest and may seem discouraging, but after a bit it becomes easier. Once on the crater's rim, walk to the highest point for a wonderful view eastward towards the Painted Desert and the Navajo and Hopi Reservations.

**P L E A S E  
TAKE NOTHING BUT PICTURES  
LEAVE NOTHING BUT FOOTPRINTS**



### **CONSERVATION — YOU CAN HELP**

If you are interested in the work of the National Park Service and in the cause of conservation in general, you can give active expression of this interest, and lend support by alining yourself with one of the numerous conservation organizations, which act as spokesmen for those who wish our scenic heritage to be kept unimpaired for the enjoyment of future generations.

Names and addresses of conservation organizations may be obtained from a ranger.

### **ADDITIONAL POINTS OF INTEREST**

This region is one of the most interesting scenic and archeological localities in the United States. Wupatki National Monument, 18 miles north, and Walnut Canyon National Monument, 21 miles south, were both areas in which hundreds of prehistoric Indian farmers found their destinies intertwined with the black volcanic cinder mulch which covered so much of their lands.

Farther south in the Verde Valley, noted as Great Drought refugee areas, are Tuzigoot and Montezuma Castle National Monuments (the latter including Montezuma Well).

**This booklet is published in cooperation with the National Park Service  
by the  
SOUTHWEST PARKS AND MONUMENTS ASSOCIATION**

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activities of the National Park Service*  
We recommend the following items for  
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