

CRATERS OF THE MOON NATIONAL MONUMENT
Arco, Idaho

ARCO TUNNEL - ADDITIONAL OBSERVATIONS

July 11, 1960

Since September 20, 1959 additional observations pertinent to Arco Tunnel have been made. Information regarding the mineralogy, climate, biology and geology are herein reported. A check survey was also made to determine the accuracy of the map prepared in 1958.

MINERALOGY

The white, easily fusible mineral found on the floor of Arco Tunnel has been identified as thenardite possessing water of crystallization approaching that of mirabilite. On March 17, 1960 a sample of the mineral was examined under a petrographic microscope in the laboratory of the Department of Mineralogy at the University of Utah. By using index oils, fragments were examined under an incandescent lamp provided with a daylight filter. The range of refractive indices lies between 1.42 and 1.45. The mineral was kept in a sealed vial and under refrigeration from the time the mineral was collected in Arco Tunnel early in January, 1960 until brought into the laboratory. Even while transferring fragments from the container to a glass slide efflorescence proceeded rapidly. The mineral, after the water of crystallization is lost, appears to show a slight increase in refractive indices. No optical determinations were attempted on the altered material. The fresh fragments showed a large 2V angle, somewhat pitted surfaces and a possibility of one direction of cleavage. The optic sign is biaxial+. Hardness (Mohs scale) was estimated to be about 2.

Because the optical properties and the rapid loss of water of crystallization approached no single mineral closely it was decided to have the specimen identified by the X ray diffraction method. A portion of the specimen was run and the pattern

checked by Miss Barbara Anderson, a researcher at the University of Utah. Several runs showed sodium sulfate ($\text{Na}_2\text{SO}_4 \cdot 7-10\text{H}_2\text{O}$) and rapid alteration to thenardite (Na_2SO_4). Because of the rapid loss of water, difficulties were also encountered during the X ray determination. For this reason the exact proportion of water could not be established.

Before the optical determination a few preliminary tests were made. Solubility of the hydrous mineral is very high. No means for quantitative observations were available but it can readily be seen that the mineral dissolves rapidly in a very small quantity of water. No effervescence occurs in cold or warm dilute (10%) hydrochloric acid. In the Bunsen flame, the strong yellow sodium color is visible.

Because no comprehensive reference work on mineralogy appears in the monument library, the following description of thenardite and mirabilite which the hydrated form resembles, chemically at least, is included for the reader's convenience. *

THENARDITE. Na_2SO_4 . In orthorhombic crystals, pyramidal, short prismatic or tabular; also as twins (Fig. 406, p. 180). Basal cleavage. H. = 2.7. G. = 2.68. Easily fusible. Soluble in water. White to brownish. Optically +. Ax. pl. parallel (001). $Z = a$ axis. $a = 1.471$, $B = 1.477$, $y = 1.484$. $2V = 83^\circ$. Changes on heating at 235°C . to a negative uniaxial form, metathenardite. Often observed in connection with salt lakes, as on the shores of Lake Balkash in Semipalatinsk, Siberia, and at Shermakha northwest of Baku in Azerbaijan, Caucasus Mts. It occurs in Spain in the Provinces of Madrid and Toledo, especially at Espartinas near Aranjuez. Found in Chile near Tarapaca northeast of Iquique, Province of Tarapaca, and at Caracoles in Antofagasta; from near Aguas Blancas near Copiapo in Atacama, etc. In the United States in extensive beds on the Rio Verde in central Arizona. In California, at Borax Lake, San Bernardino Co. In Nevada at Rhodes Marsh, Mineral Co.

*Ford, William E., Dana's Textbook of Mineralogy, 4th ed., 1932, New York, John Wiley & Sons, Inc.

MIRABILITE. Glauber Salt. Monoclinic. Crystals like Pyroxine in habit and angle. Usually in efflorescent crusts. Cleavage: $a(100)$, perfect; $c(001)$, $b(010)$ in traces. $H=1.5-2$. $G=1.481$. Luster vitreous. Color white. Transparent to opaque. Taste cool, then feebly saline and bitter. Optically negative. Ax. $pl.\perp(010)$. $Z \wedge c$ axis $=+26^{\circ}$ to 31° . $B = 1.437$. (On recrystallized material $B = 1.395$.)

Comp. - Hydrous sodium sulphate, $Na_2SO_4 \cdot 10H_2O =$ Sulphur Trioxide 24.8, soda 19.3, water 55.9 = 100.

Pry., etc. - In the closed tube much water; gives an intense yellow color to the flame. Very soluble in water. Loses its water on exposure to dry air and falls to powder.

Obs. - Deposited from Saline waters and occurs associated with halite and gypsum. Occurs in the salt deposits of Austria at Ischl, Hallein, and Hallstadt in Salzburg, and at Aussee in Styria. Abundantly in the hot springs at Karlsbad (Karl Vary) and at Sedlitz, south of Brdx in Bohemia of Czechoslovakia. In northern Spain from the district of La Rioja. From Kirby Thore, Westmorland. Large quantities of this sulphate are obtained from the Great Salt Lake in Utah.

CLIMATE AND WATER

To date no regular study of the tube's climate has been undertaken. However, on the evening of June 8, 1960 a sling psychrometer was brought into the cave. Three readings were taken. The first was an atmospheric observation taken in the sink outside of the entrance. The second and third readings were taken in the tube at station 11, just beyond the low crawlway, and in the vicinity of the "Forum", respectively. Readings are tabulated below:

Reading	Air Temperature	Relative Humidity
1.	50 oF.	64 %
2.	34.5	100
3.	38	92

On June 8 and 14, 1960 deposits of ice were abundant but were melting rapidly. Some parts of the floor were almost completely covered with ice. Ice stalactites were common about the joint cracks in the ceiling and walls, except in areas of the cave where the roof rock is quite thin. Ice was also noted on the ceiling between stations 11 and 12. The ice here had a feathery form with hexagonal outlines. Rather than deposition from water percolating into the cave through the joints, this form of ice appears to be the product of deposition by condensation of vapor-

laden air. Air currents are generally quite strong in this portion of the tube during all seasons of the year.

The ice stalactites and sheet deposits of ice on the floors commonly show a polygonal pattern of growth "sutures" apparently delineating the boundaries of many crystallization nuclei. In many of the stalactites and in some of the stalagmites the "sutures" extend completely through the ice in a plane perpendicular to the long axis of the stalactite or stalagmite. Parting occurs along these planes more readily than elsewhere. Many of the broken stalactites may be found on the floor in the spring of the year having forms like thick discs due to breakage along these parting sutures.

BIOLOGY

While in the cave on June 8, 1960 a myotis bat was seen in flight.

On June 14, 1960 several spiders were seen. Since no preserving fluids were available, a specimen was not collected. Near point 9C2 of region "D" (see map) a spider was examined. The specimen examined is typical of others seen previously. The tan body was about 7 mm. long. The second pair of legs were longer than the others and appeared to be used also as feelers. These dual purpose legs were about 28 mm. in length. The mandibles were conspicuously large and formidable. Nearby was a small white creature about 2 mm. in length, probably an insect.

From cracks in the ceiling of the east upper level of the "Forum" (shaded red on map) plant roots were noted on June 21, 1960. Undoubtedly, the roots belong to small perennials which are commonly found in crevices in the lava flows. Surface expressions should show an interesting comparison between plants which have roots immersed in the humid air of lava tubes and those which depend solely upon rainfall and seepage of meteoric water. Here is an area of study for a trained botanist.

SURVEY AND MAP

As mentioned in Exploration of Arco Tunnel, Sanchez, September 20, 1959, p. 9 a check on the underground survey and map was planned. Early in June 1960 the opening near point 36 was marked by a stiff wire with an attached flag.

On June 25, 1960 a transit survey (stadia) was run from the T. 1 N.-T. 2 N. line to the flagged opening and thence to the cairn at the Arco Tunnel entrance. The transit was set on the east-west line by sighting in the N. $\frac{1}{4}$ corner and the NE corner of section 6, T. 1 N., R. 25 E. David C. Ochsner, Chief Park Naturalist assisted in surveying. Both the bearing of a line and its distance from station 1 at the Arco Tunnel entrance to the opening near station 36 agree with those calculated from survey notes.

Sta. 1 to Flag near Sta. 36			
	Bearing		Distance
From map	N 17° 30' E (true)		1150 ft.
From survey	N 20° 22' E "		1167 ft.

Because the discrepancy is not too great and the scale of the map is small, no attempt has been made to revise the map.

GEOLOGY

Whenever time permits, the writer plans to continue studies of Arco Tunnel and other lava tubes within the Monument. Since the check on the map accuracy has been completed, correlation of surface features with the system of passages is planned. It is believed that surface expressions of the "Forum" and other areas, especially the upper levels (shaded in red on map) exist.

Though thin flow units obscure much of the lava flow's pattern, some surface portions undoubtedly will correlate with the passage below. It is hoped that time will be available to survey the surface by using map and compass, recording observations, and comparing them with the log of passages. Any surface expressions of the distributary pattern especially will be sought.

PHOTOGRAPHS

Photographs were taken by Mr. Ochsner and the writer on June 14, 1960. Both 35 mm. slides and 4 x 5 black and white photographs repose in the monument files. Since only a small number of the cave's features have been photographed, additional photo trips will be made.

Peter G. Sanchez
Ranger-Naturalist

TEMPERATURE AND HUMIDITY READINGS
OF
ARCO TUNNEL

August 14, 1960

On a photographic trip to Arco Tunnel a sling psychrometer was again taken into the cave and the following readings were taken:

Location	Time	Temperature	Relative Humidity
Headquarters	9:00 p.m.	66° F.	44%
Inside roadway	10:00 p.m.	60°	92%
The Forum	11:00 p.m.	42°	100%
Inside roadway	11:30 p.m.	38°	100%
Rim of sink at entrance	11:45 p.m.	63°	56%

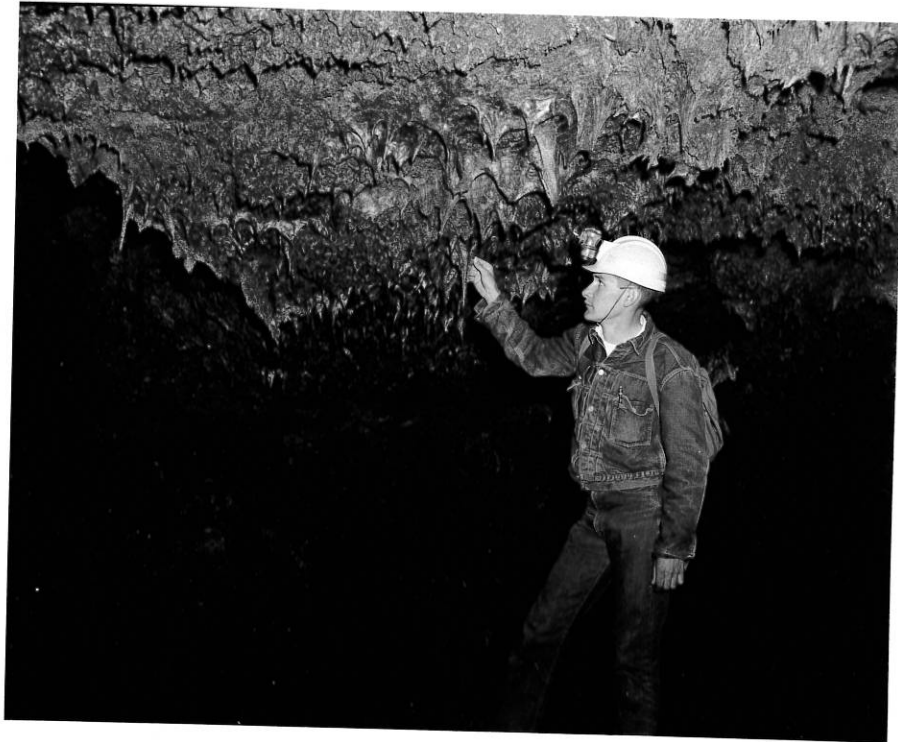
While in the tube several myotis bats were seen. Occasionally a small white insect was seen.

Between the entrance and the roadway a trail of gum wrappers was found. Also the broken bases of two large stalactites between stations 4 and 5 of the main passage were noted. None of the stalactites were seen in the cave and it is believed that they were removed by visitors to the cave.

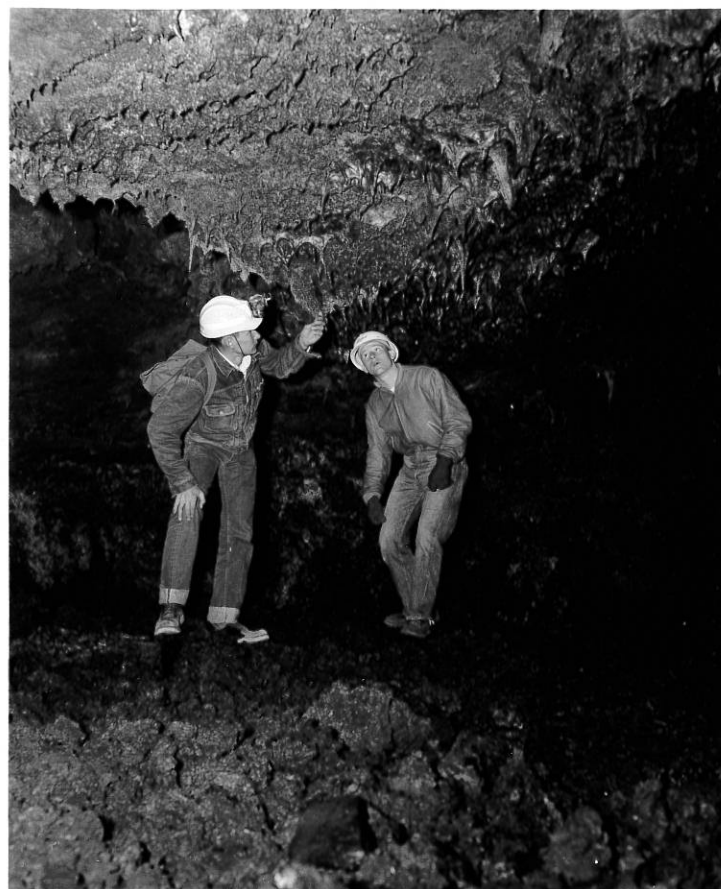
Members of the party were David C. Schaefer, Seasonal Park Ranger William Babcock and Peter G. Sanchez.

Peter G. Sanchez
Ranger-Naturalist

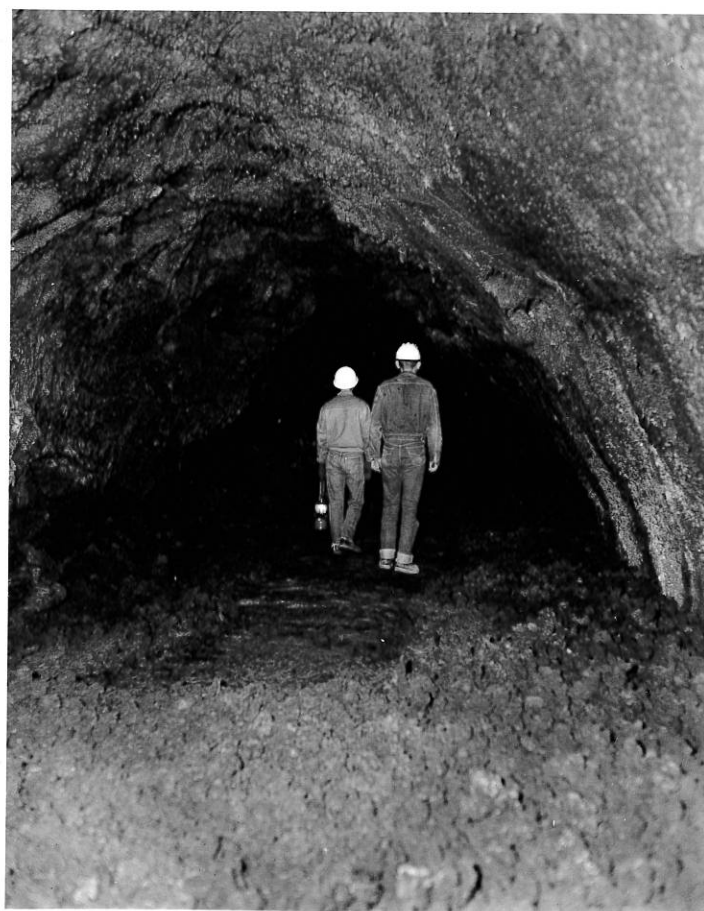
August 15, 1960



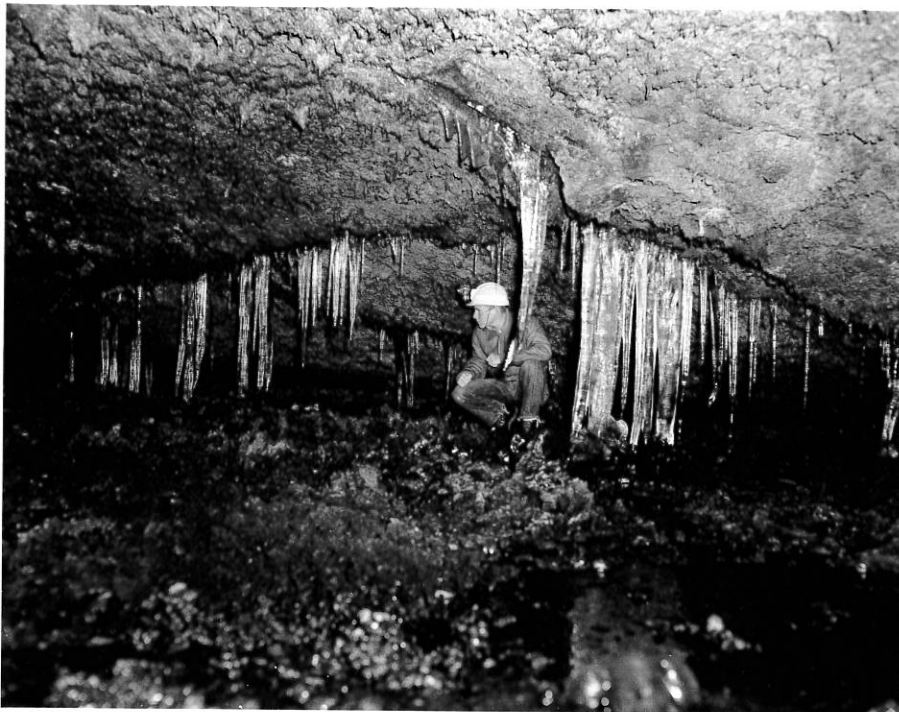
Large lava stalactites at Station 36. The author
lends scale. Negative No. 384



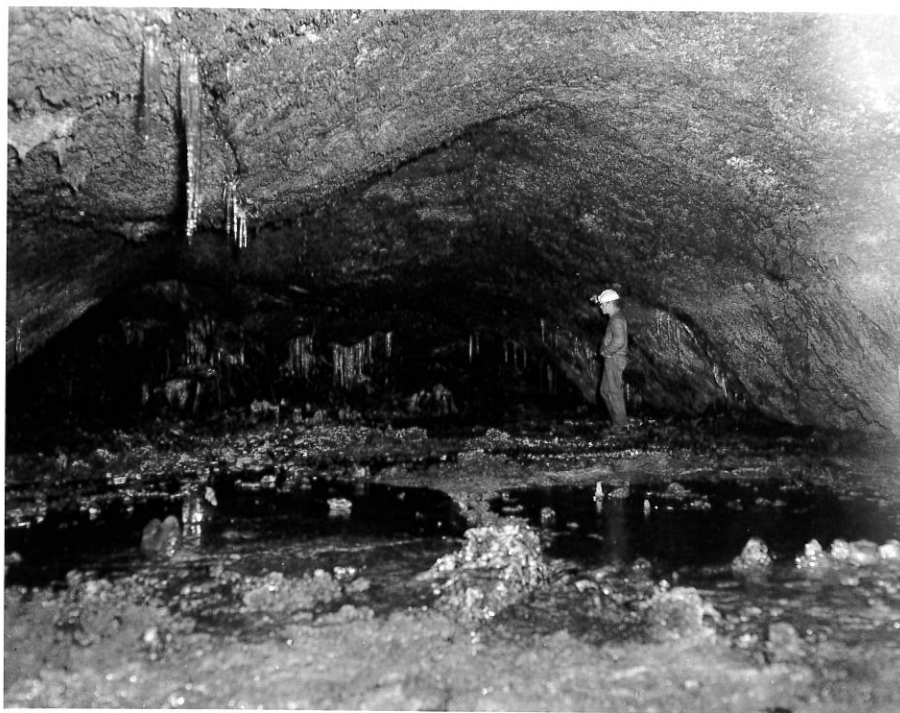
Lava stalactites at Station 36 examined by
the author, left, and P.K. Henderson.
Negative No. 383



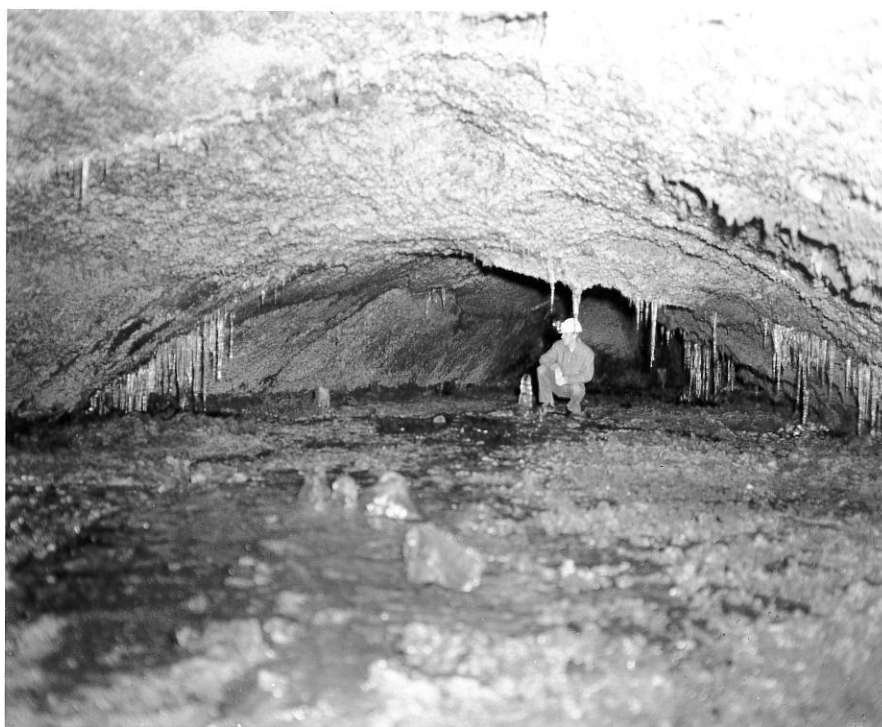
Passage near Station 19 showing sharp boundary between pahoehoe and aa scum surfaces of floor. P.K. Henderson and the author, right, walking on pahoehoe. Negative No. 382



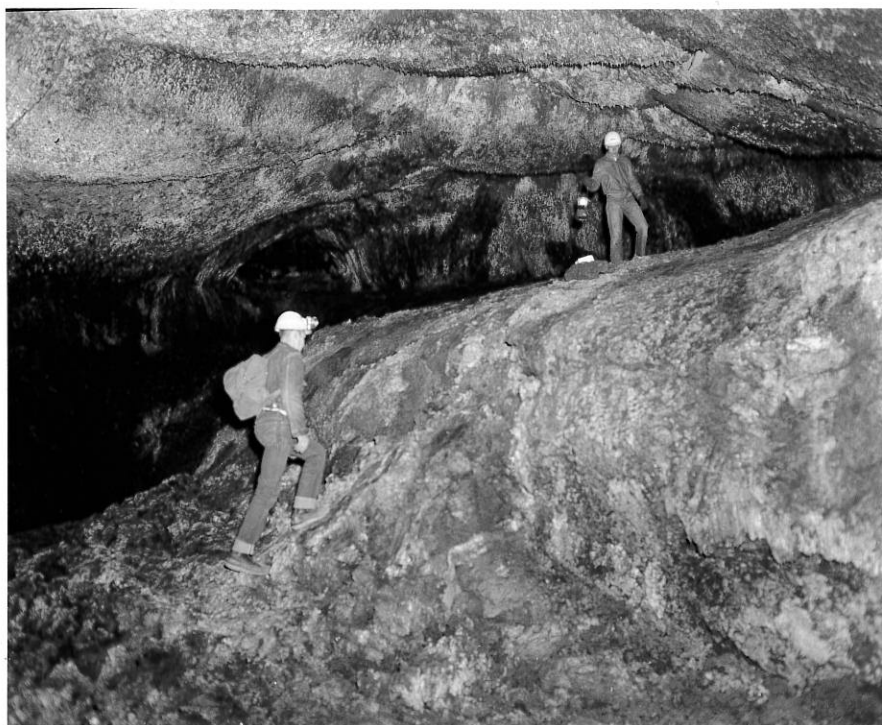
Ice stalactites and columns near Station 12 examined by
Porter K. Henderson. Negative No. 381



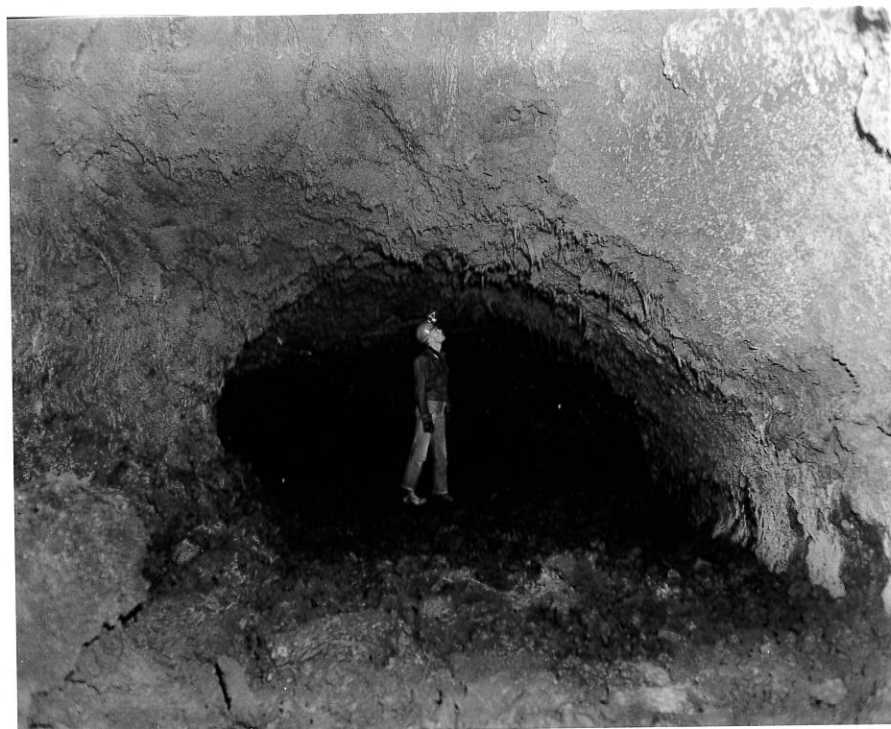
Ice-floored portion near Station 8. Note ice stalactites
fed by water seepage through joint cracks. Negative No. 379



Ice stalactites and large stalagmite (near P.K. Henderson).
Between Stations 11 and 12. Negative No. 380



A portion of the "Forum" showing east bench and upper
level. Negative No. 385



Passage, Region E, between Points 22 and 23.
Negative No. 480



Bulbous stalactites, Region E, near Station 2h.
Negative No. 452



Group of bent stalactites which fell from ceiling when
hot. Negative No. 479



Crackway from Station 11. Negative No. 484



Crackway from Station 10. Negative No. 501



The Forum from east bench. Negative No. 482



East bench of the Forum from Point 30. Negative No. 483