MAJOR LAVA CAVE SYSTEMS OF OREGON

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INTRODUCTION

In recent years there has been a significant increase in attention given to the genesis of lava tube caves and the features they contain. This has in part been due to NASA funding of projects designed to investigate lava caves as potential terrestrial analogs to certain lunar features (Greeley, 1971a). This report will look at the three major lava tube systems in Oregon and attempt to relate certain flow parameters to the overall character of these system.

The systems in question are the Arnold (Knutson, 1969, Greeley 1971b) and Horse (Greeley 1971b) Lava Tube Systems near Bend in Deschutes County, and the BLM (Ciesiel and Wagner, 1969, Knutson, 1970) Lava Tube System northwest of Burns Junction in Malheur County. In describing the Arnold and Horse Systems this report will rely heavily on the study by Ronald Greeley and for the BLM System the article by Ciesiel and Wagner will be utilized.

ARNOLD LAVA TUBE SYSTEM

The Arnold Lava Tube System is located about 12 miles Southeast of Bend, Oregon, in Deschutes County. It is traceable for a distance of about 7 km (4.5 miles) and consists of tube segments alternating with collapsed tube portions or collapsed lava ponds. The original limits of the system are not known. Beyond the upper and lower extremities, the Arnold flow is covered by younger basalts.

The character of the intact cavernous portions is that of unitary tubes of large diameter, up to 15 m high and 12 m wide. Roof sections are quite thick, up to 25 m and the deepest portion is some 40 m below the surface. This character is most evident in the long caves of the lower portion including Wind Cave (1170 m) and Pictograph Cave (about 500 m).

The upper portion of the system has several large collapse depressions, which can be interpreted as reflecting original tube sections as described for the lower portion of the system. Arnold Ice Cave is short but has a roof thickness of some 25 m.

In the middle portion are found the only shallow caves with relatively small diameter. Here the Arnold system flow was covered by a younger flow originating near Lava Top Butte. It can be presumed that this flow entered collapse-trench or tube portions of the Arnold system and created these shallower caves (Deg and Bat Caves). The latter is also the only cave in the system exhibiting 2 levels.

The lava ponds shown on the Arnold System map are interpreted as structures resulting from a halting in the flow of lava. Upon rupture of the downslope side, the pond drains (into a lava tube) lowering the thinly developed crust to the pond floor. The deepest part of the resulting depression is near the downslope end and the edges often dip in toward the center, reflecting deformation of the thin roof crust of the pond. It is possible that lava ponds result from irregularities in the pre-flow topography, where the lava flow is halted by a topographic rise.

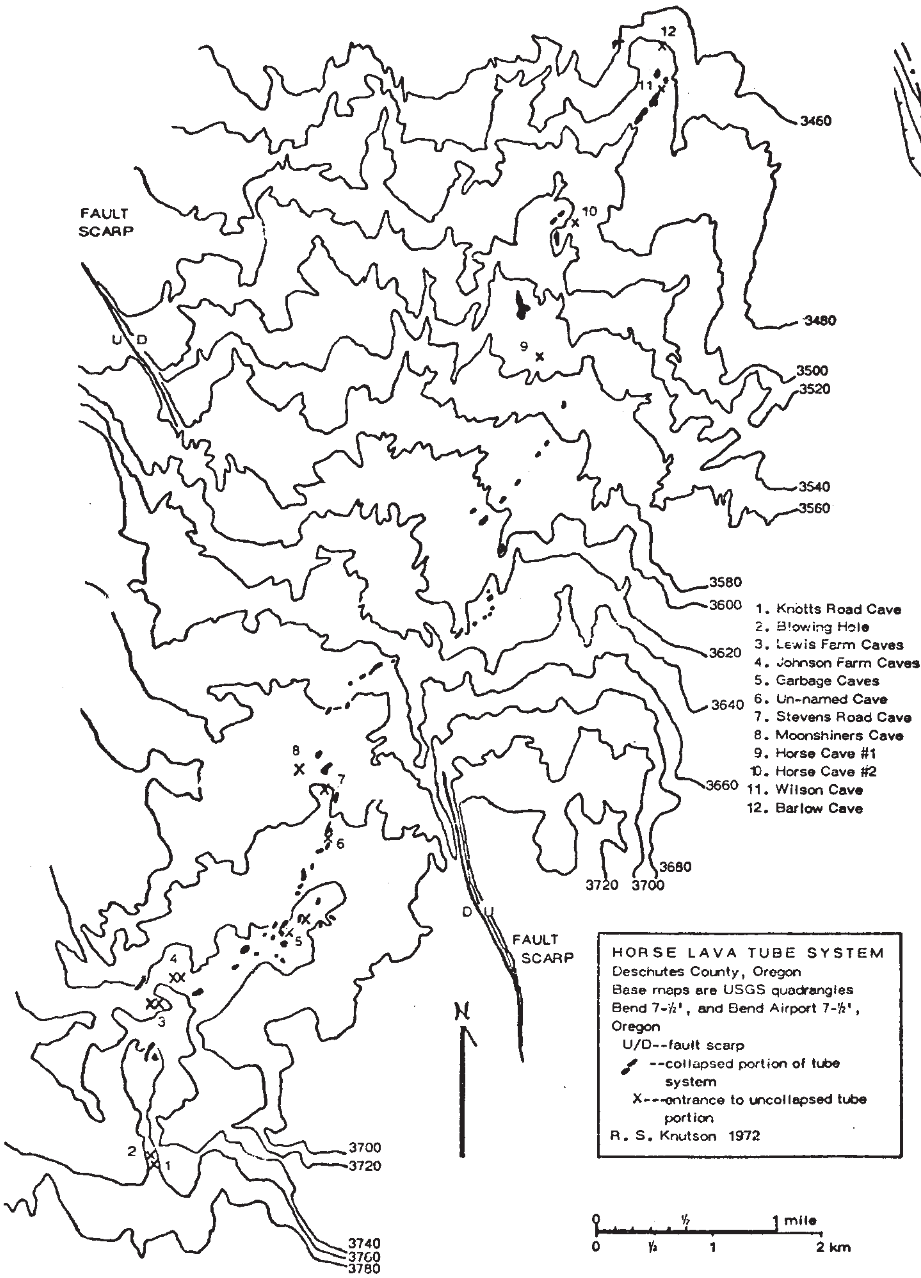
HORSE LAVA TUBE SYSTEM

The Horse Lava Tube System, about 2 miles east of Bend, is traceable for a distance of about 11 km (6.2 miles). As with the Arnold system, the source and terminus are covered by younger basalt flows. The character of the system, however, presents a marked contrast. Collapsed tube portions and short, intact cave segments represent a system of branching, braided, parallel, and sometimes disconnected lava tubes, all apparently combined as units in a single flow. No intact tube portion is deeper than 10 m below the surface and no collapse depression indicates a greater depth. Roof thickness varies from 3 to 8 meters. The longest intact tube portion is only about 150 m but this is not a good indication of tube length since intact segments often end in sand or dirt fill.

As with Arnold System, the Horse System appears to have generated a broad, low ridge along its axis.

BLM LAVA TUBE SYSTEM

The BLM Lava Tube System is situated in a lava flow south of Saddle Butte and northeast of Burns Junction, in Malheur County. The system has been traced for about 13.6 km (8.5 miles) and consists of tube segments and long, unroofed trench or collapsed tube portions. Two adjacent,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1. Knotts Road Cave
2. Blowing Hole
3. Lewis Farm Caves
4. Johnson Farm Caves
5. Garbage Caves
6. Un-named Cave
7. Stevens Road Cave
8. Moonshiners Cave
9. Horse Cave #1
10. Horse Cave #2
11. Wilson Cave
12. Barlow Cave
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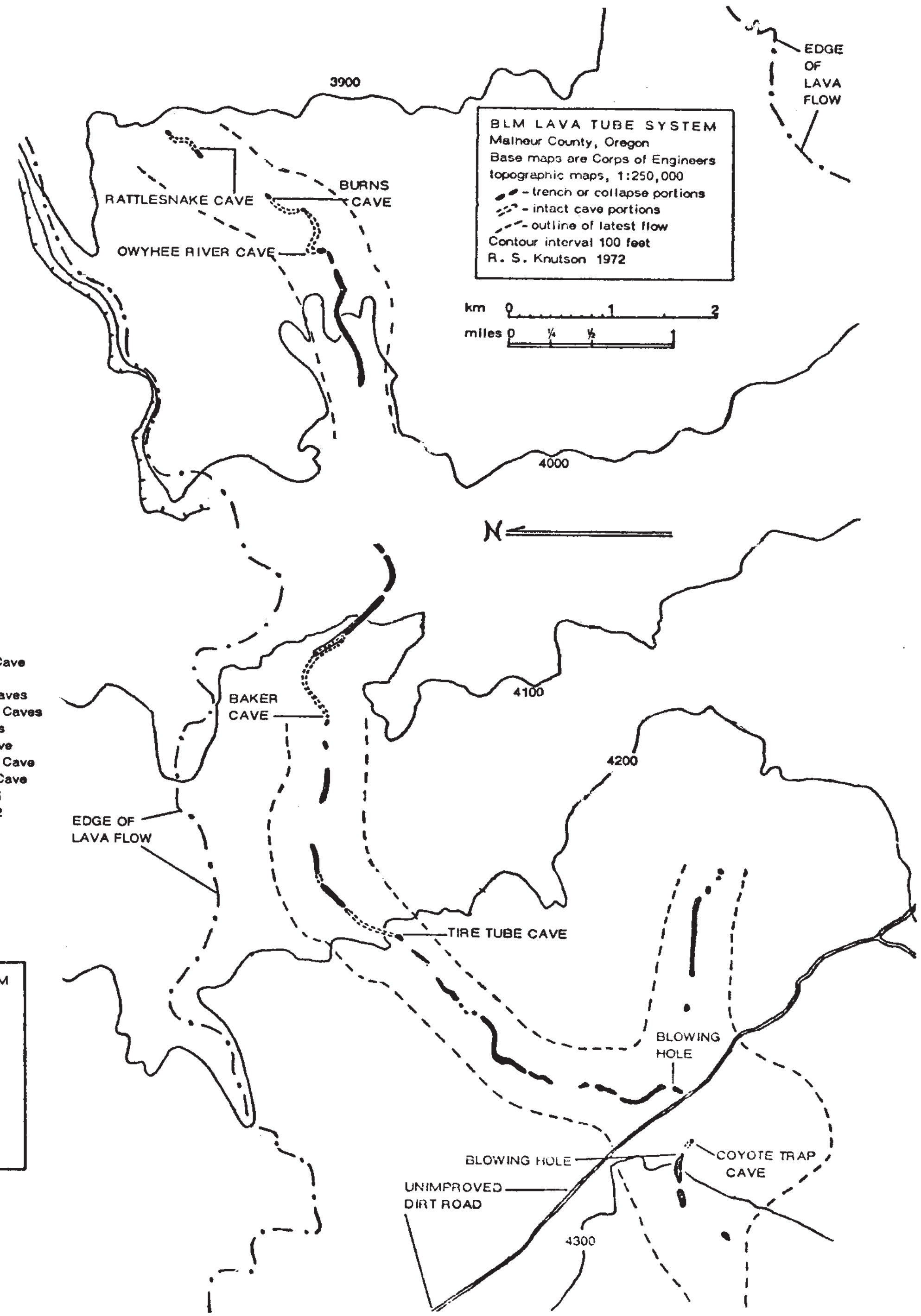
HORSE LAVA TUBE SYSTEM
Deschutes County, Oregon
Base maps are USGS quadrangles
Bend 7-½', and Bend Airport 7-½',
Oregon
U/D--fault scarp
--collapsed portion of tube system
X--entrance to uncollapsed tube portion
R. S. Knutson 1972
0 ½ 1 mile
0 ½ 1 2 km


EDGE OF LAVA FLOW
3900
BLM LAVA TUBE SYSTEM
Malheur County, Oregon
Base maps are Corps of Engineers
topographic maps, 1:250,000
- trench or collapse portions
- intact cave portions
- outline of latest flow
Contour interval 100 feet
R. S. Knutson 1972
km 0 1 2
miles 0 ¼ ½ 1
RATTLESNAKE CAVE
BURNS CAVE
OWYHEE RIVER CAVE
4000
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4100
BAKER CAVE
EDGE OF LAVA FLOW
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TIRE TUBE CAVE
BLOWING HOLE
BLOWING HOLE
COYOTE TRAP CAVE
UNIMPROVED DIRT ROAD
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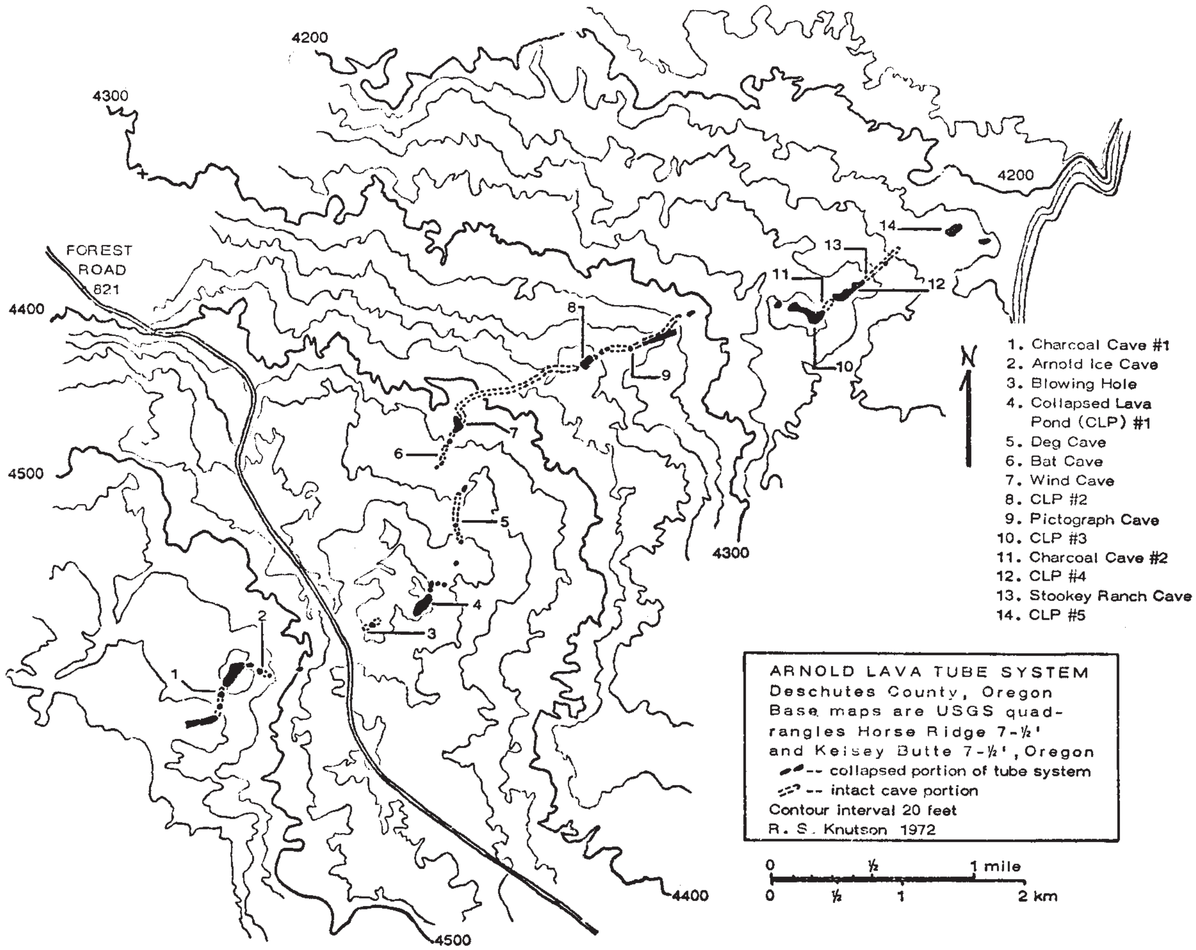
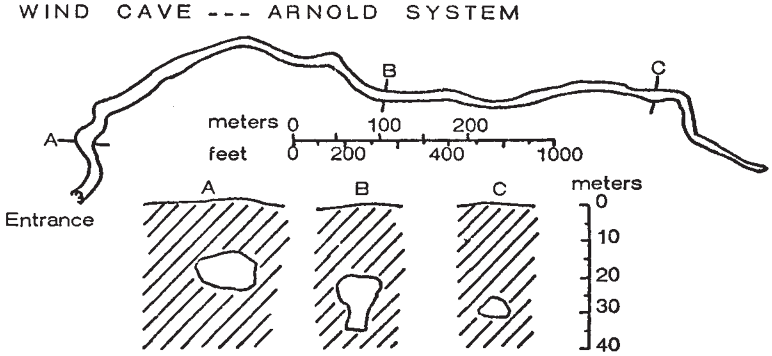
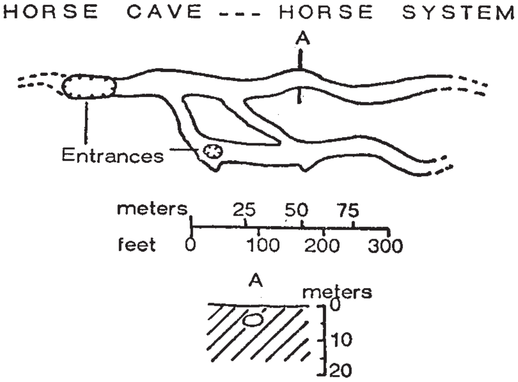


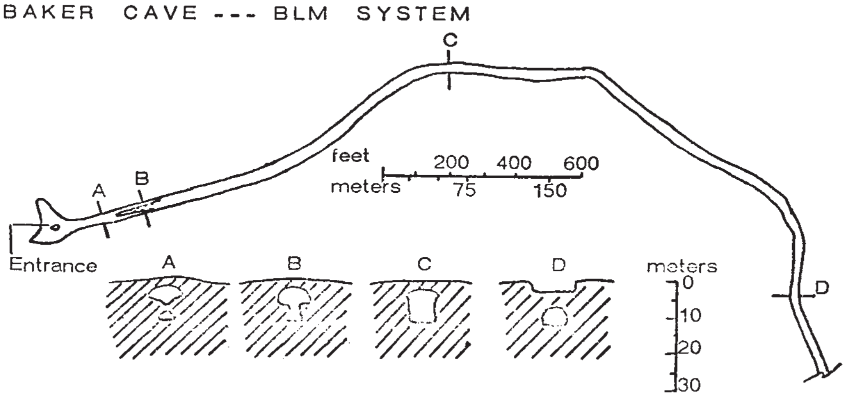
WIND CAVE --- ARNOLD SYSTEM



HORSE CAVE --- HORSE SYSTEM



BAKER CAVE --- BLM SYSTEM



SLOPE GRADIENTS FOR THE ARNOLD, HORSE AND BLM LAVA TUBE SYSTEMS

SYSTEM	TOTAL LENGTH	VERTICAL EXTENT	GRADIENT
Arnold	4.2 miles	320 feet	77 ft/mile
Horse	6.2 miles	260 feet	42 ft/mile
BLM	8.5 miles	370 feet*	43.5 ft/mile

*corrected for a steep section above the 4000 contour with a drop of 35 feet.

collapse depressions near the head of the system are of larger dimensions and may represent collapsed lava ponds or possibly the lava source, although short, uncollapsed cave portions are to be found about one-half mile upslope. These latter may not be part of the system. In general the trench portions are no deeper than 5 m, often have vertical walls, and there are long sections with a quite level dirt floor. It may be that these uniform trench sections represent unroofed channels. Such a trench is superimposed over the last 1000 feet of Baker Cave.

The tube segments are of medium to large dimensions. The longest is Baker Cave at about 1100 meters. This cave has sustained width and height of 15 m and 10 m, respectively. Owyhee River Cave achieves a cross-section of 20 m wide by 12 m high. At no point in the system is a cave floor more than 20 m below the surface. Only in Baker Cave is there separation into two levels, and there only in a short portion near the entrance. All known caves are unitary tubes.

Topographic indication of the tube system is minimal, but some trench and collapse structures represent local topographic highs. About 1-1/4 miles east (downslope) of Baker Cave the slope of the flow steepens for about 400 feet achieving a vertical drop of about 40 feet. It is assumed that this represents a steep portion in the pre-flow topography. A rim-rock scarp is adjacent to the flow at this point. No caves or collapse depressions are present in this steep section.

DISCUSSION

The three lava tube systems, from 7 to 14 km in length, are all situated on relatively flat lava plains, or relatively constant, gentle, gradient. It may be assumed that pre-flow topography was of similar nature--lava plains with no abrupt ridges or valley walls to channel the tube--containing flows.

Yet the three systems present a wide variance in size and nature. The ranking in depth of tube floors from the surface is: Arnold--40m, BLM--20m, and Horse--10m. The Horse System is apparently a braided network of channels while the Arnold and BLM Systems are unitary in nature.

It must be assumed that lava tube formation in terms of the size of tube formed in an unconfined flow will be determined by the viscosity of the flow and the gradient of the system.

The ranking in system gradient is as follows: Arnold--77, BLM--43.5, and Horse--42 ft/mile. This presents a rough correlation, especially if it is assumed that a braided system is shallower than the same flow operating through a unitary channel. That is, the Horse System may have been deeper if it had developed via a single flow channel.

Flow viscosity is a complex parameter and is dependent on several factors, including chemical composition, gaseous content and temperature of the lava. Since variance in only one of these factors is sufficient to control flow viscosity, determination of the eruptive viscosity of a flow is difficult.

The Arnold and Horse Systems are contained in the same basalt unit (Greeley, 1971b) presumably indicating a similar composition and gas content. Yet they are quite different, both in size (depth) and nature. The main factor here appears to be gradient, with the Arnold System on a much steeper slope. Yet it would seem that for lavas of similar viscosity, the flow on the steeper slope would be the thinner, not the thicker one. Perhaps the Arnold flow was lower in temperature, more viscous, and this resulted in a thicker flow.

The Horse and BLM Systems are of similar gradient but are in widely separated basalt flows. The difference in depth and character might, therefore, broadly be explained by a difference in flow viscosity. Indeed, the BLM flow lava appears to be much less vesicular and some cave breakdown blocks are composed of completely non-vesicular basalt. The lower gas content presumably resulted in a more viscous lava creating a thicker flow and a deeper cave. The low gradient and relatively higher fluidity of the Horse System lava presumably allowed for a broad, relatively thin flow resulting in more than one major channel.

The above analysis is probably over-simplified. For instance, the Arnold System may be formed in a narrow valley or rift which is now completely obscured. Detailed chemical analysis of the various lavas would be desirable.

CONCLUSIONS

The Arnold, Horse, and BLM lava tube systems present an interesting contrast in character, relative cross-section, size and depth. These systems are contained in flows of similar, non-channeled, situation. It is tentatively concluded that the differences are due to the controlling factors of lava viscosity and flow gradient.

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LAVA TUBES OF THE SOUTH MEDICINE LAKE HIGHLAND, CALIFORNIA

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ABSTRACT

The Medicine Lake Highland is an eastern extension of the Cascade volcanic province in northern California. Situated on the Modoc Plateau, the Highland is composed of a basaltic and andesitic shield volcano about 13 miles in diameter. It has a prominent summit caldera 6 miles long and 4 miles wide; postcaldera lavas include andesites, dacites and rhyolites. Holocene basalt flows, which erupted predominately from pit craters on the flanks of the shield volcano, contain numerous well-developed lava tubes in the northern region (Lava Beds National Monument) and in the southern region (Siskiyou County). In the southern region an unnamed series of basalts flowed south down a fault valley and merged with similar flows erupted from the Timbered Crater vent. Extensive lava tubes, many of which are partly collapsed, characterize the flows. One partly collapsed tube (possibly originating from Giant Crater) can be traced for about 14 miles. Some sections of the tube divide into four distinct levels that are stacked vertically for a total height exceeding 120 feet. Collapsed wall sections display preflow country rock and reveal the lower surface of the lava flow. Well-preserved sections of the lava tube linings, and subsequent flows along the floor. Details of these and other lava tube structures provide additional information on the mechanisms of lava tube formation and geomorphology.