SOUTHERN HALF OF THE GREAT RIFT, IDAHO

James L. Papadakis
Manager, Crystal Ice Cave

(Editor's note: This multimedia presentation was not well adapted to adequate presentation in published proceedings such as this. For additional data and some alternate interpretations, the reader may wish to consult "Geologic Field Guide to the Quaternary Volcanics of the South-central Snake River Plains, Idaho," by Ronald Greeley and John S. King, Idaho Bureau of Mines and Geology Pamphlet no. 160, published in 1975.)

The Great Rift is located in southeastern Idaho on the 20,000 square mile Snake River Plain (Fig. 15-1). It consists of a zone of fissures from which volcanic products have erupted. Because of its uniqueness, it has been designated a national landmark. Its northern end is in the Pioneer Mountains, north of Craters of the Moon National Monument. It cuts across the monument from northwest to southeast, then curves southward and ends south of the Crystal Ice Cave area where its trend is about north 10° west. The rift zone is approximately 48 miles long. This presentation will be confined to the southern half of the rift, beginning at the point where it intersects the Craters of the Moon Lava Field (Fig. 15-2).

No lava flowed from the rift between the north end of the Crystal Ice Cave Field and the south edge of the Craters of the Moon Lava Field, a distance of 15 miles. In this section the rift appears as large earth cracks cutting through sagebrush-covered desert. The Crystal Ice Cave Field segment of the rift is about 3 1/2 miles long and covers an area of about 1 1/2 square mile. Just south of this is the Wapi Field which has an area of about 160 square miles (Fig. 15-3). Although not proven, it is suspected that the Great Rift was the source of lava for the Wapi Field. Apparently all of its lava came from Pillar Butte which is perforated with craters and small vents. The Wapi is relatively unkown but is a young volcano very similar to hundreds of somewhat older volcanoes on the Snake River Plain. Many lava channels and tubes radiate from Pillar Butte. Some can be followed for more than a mile. Away from Pillar Butte, most of the rest of the Wapi Field looks as if it was the product of a single eruption.

The series of volcanic events leading to the origin of caves within the Great Rift at the Crystal Ice Cave Lava Field (Fig.s 15-4 thru 15-6) is complex. The dominant structure here is a major fissure from which flowed two sequences of lava (the King's Bowl Rift). When this rift first opened, surface soils either cracked, forming two vertical faces, or caved off into the rift. Along an excavated trail, the soil zone is at least nine feet thick; caving into the rift occurred at this particular location. Ash blown by a west wind was deposited in stratified layers on the east side of the rift before the first eruption.

In the Hades area, at the north end of the field, the lava dike filling parts of this rift is exposed in Abyssal Pit (Fig. 15-7). Reddish soil is sandwiched between the older lava below and young rift flows above.

Lateral baking of the soil extends about 12 feet from the King's Bowl Rift. Vertical baking extends only about three inches below the lava. In unbaked soil, sagebrush roots have yielded a radiocarbon date of 2,130 plus or minus 130 B.P. This is comparable to one of the youngest dates obtained by Fred Bullard of the University of Texas at Craters of the Moon National Monument (2,085 plus or minus 85 B.P.).

Secondary fissures opened parallel to and about 1,500 feet distant from the main (King's Bowl) rift during the eruptions. These erupted no lava, and lava from the main rift flowed into them.

After initial flows, draining of lava occurred along the King's Bowl Rift to a point below the water table. Steam explosions resulted, followed by a spatter phase. A row of spatter cones called the Kilns formed at the extreme south end of the field (Fig. 15-3).

A second period of lava flows followed. Numerous minor vents became plugged and this rift began to develop specific centers of eruption. From north to south, these centers are: Hades area, Centicone area, King's Bowl area (the largest), and the South Grotto area. The South Grotto spatter cone is the largest on the Crystal Ice Cave Field. A natural bridge spans the rift inside the South Grotto. Here the rift has been explored to a depth of about 800 feet. Lava channels formed when lava drained back into the rift for the second time. Especially fine examples are located about 1,000 feet south of the King's Bowl. In other areas, the lava crust over the rift subsided as draining occurred.

Subsequently a major steam eruption occurred. In the Hades area, several large pits were blasted out. Tephra (explosion debris) was widely scattered in this area. In the King's Bowl area where vents were numerous, much of the lava capping was ripped off the previously capped

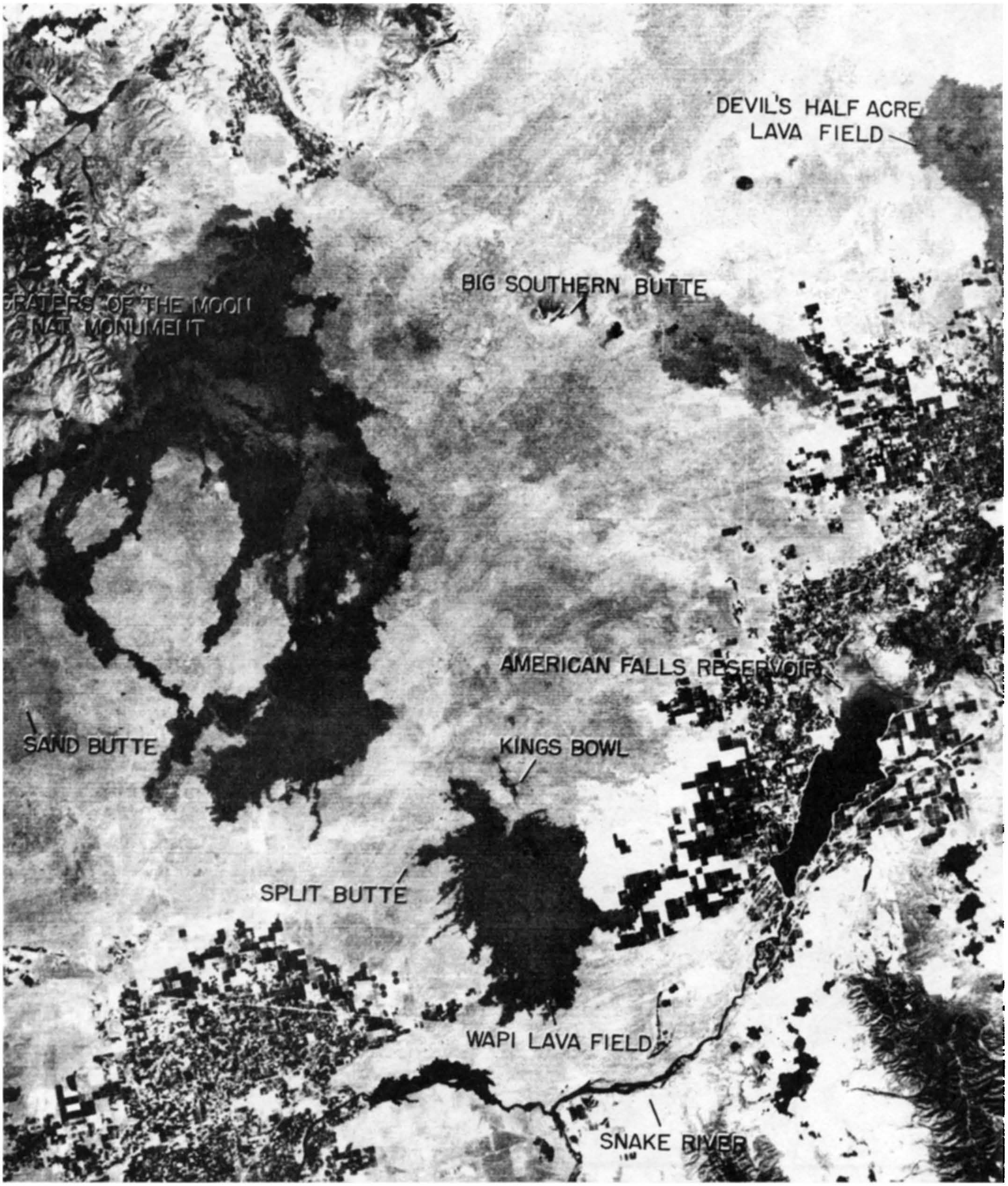

Figure 15-1: ERTS view of the Great Rift area, from Greeley and King, p.4.

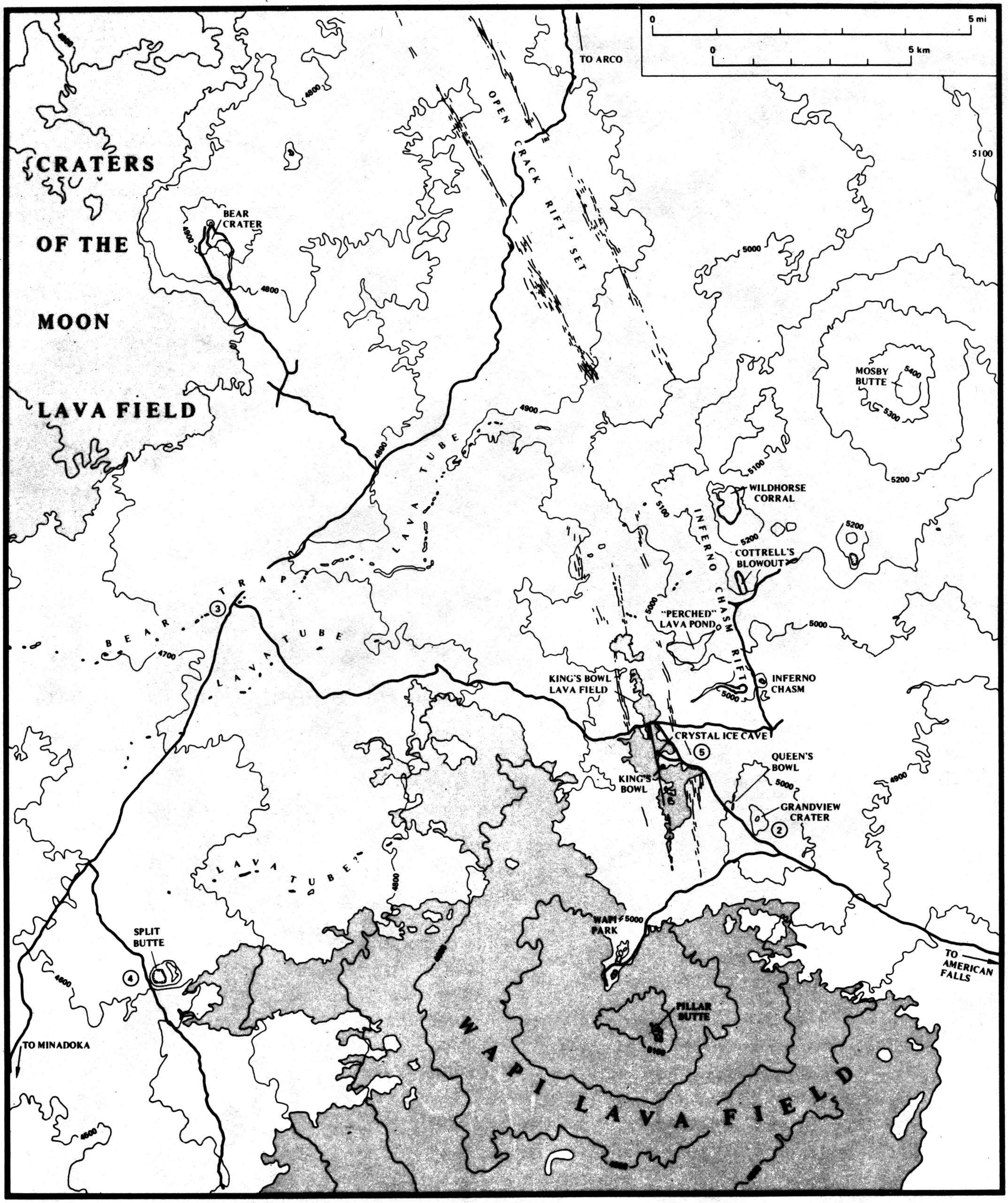

Figure 15-2: Map of southern half of the Great Rift, from Greeley and King, p.6.

Figures 4 & 5: Mosaic aerial view of Crystal Ice Caves Lava Field.

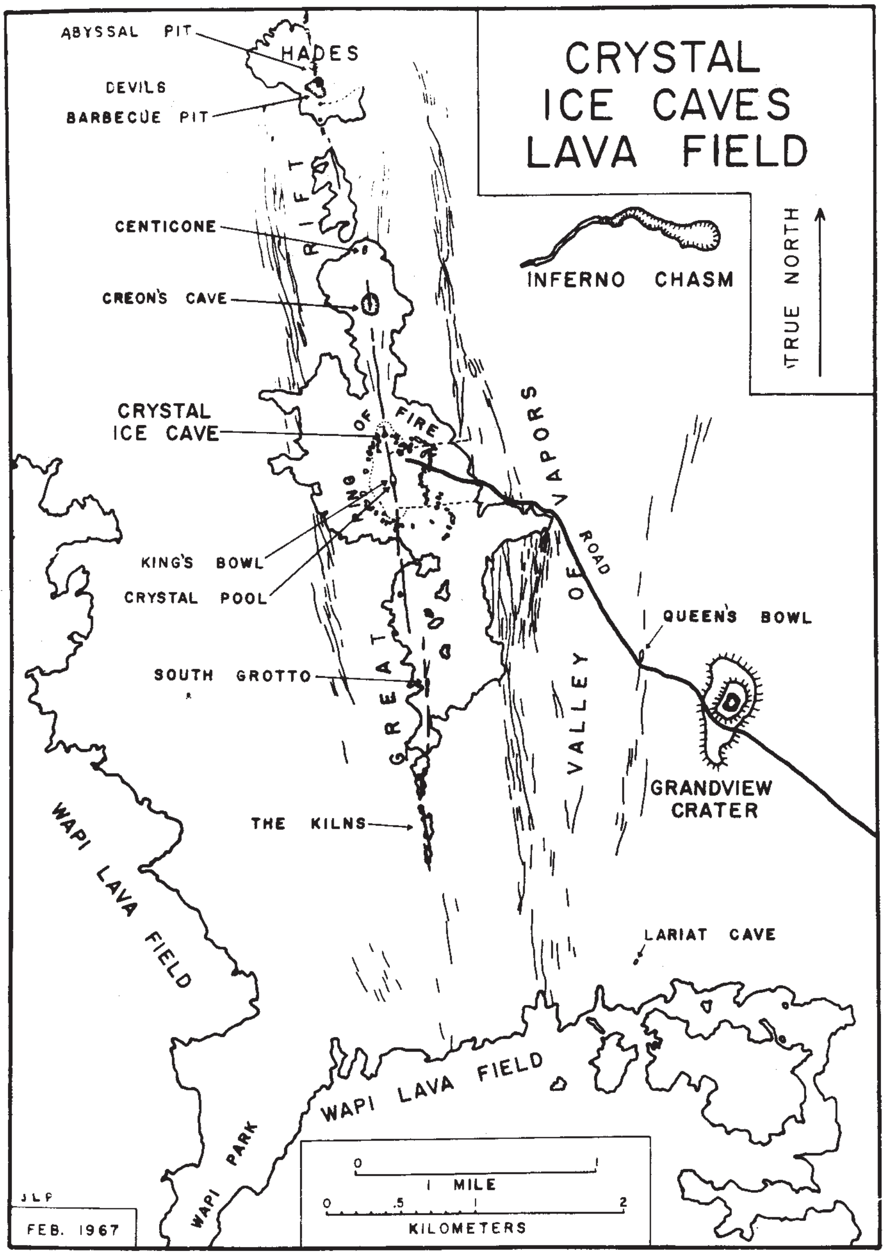

Figure 15-3: Map of Crystal Ice Caves Lava Field.

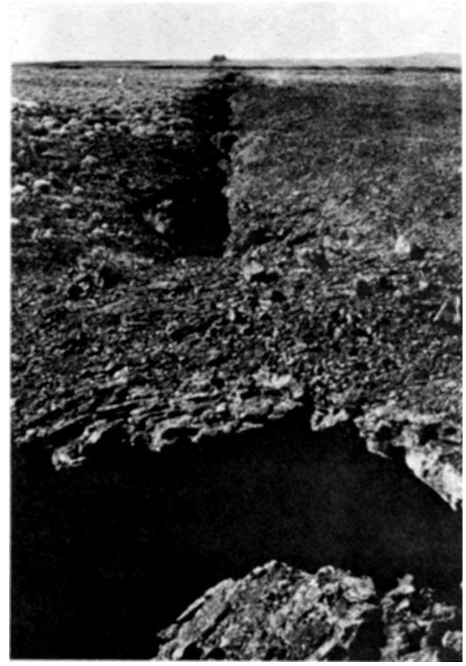

Figure 15-8: Ground level view looking toward South Grotto.

Figure 15-9; Soil horizon and dike in Abyssal Pit.

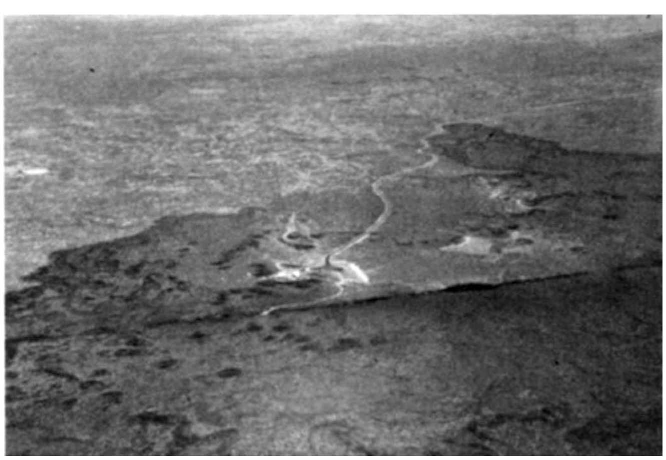

Figure 15-6: Oblique aerial view of King's Bowl area, showing ash drifted by west wind.

Figure 15-7: Low level view of Crystal Ice Cave section of the Great Rift.

Figure 15-10: King's Bowl and Great Rift, looking toward South Grotto.

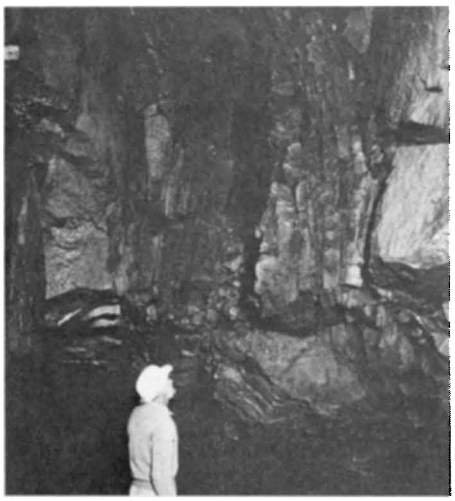

Figure 15-12: Selvages. Halliday photo.

Figure 15-14: Ice crystals and dripstone, Crystal Ice Cave.

Figure 15-11: Cavernous segment of the Great Rift. Halliday photo.

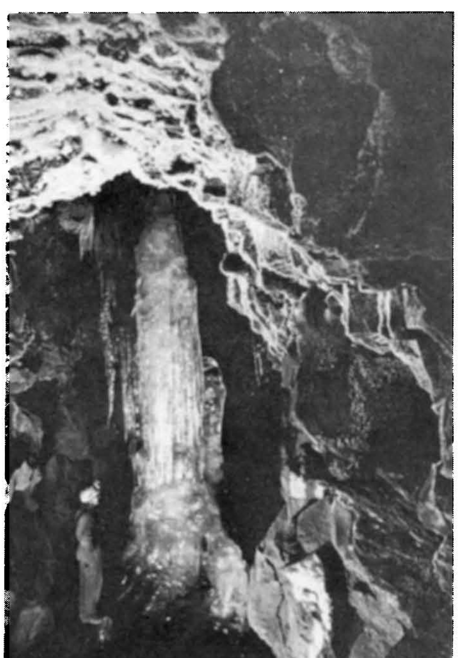

Figure 15-13: Giant ice column, Crystal Ice Cave.

portions of the rift. The King's Bowl explosion pit (Fig. 15-8) was the center of greatest violence. Lava drained to unknown depths below the water table, leaving the rift momentarily empty. Flooding ground water then resulted in steam explosions. A well recently drilled near the King's Bowl has encountered the present water table at a depth of 775 feet.

Fine ejecta was swept eastward by a west wind, obscuring the east edge of the lava field immediately down wind from the King's Bowl (Fig. 15-4). Nearby are small mounds which are believed to be rootless vents and erupted lava which flowed under the surface crust of flows from the King's Bowl vent. This surface originally was level with or higher than the tops of these rootless vents. Evidently much lava flowed out from these vents, enlarging the field, but great quantities must have drained back into the rift. The present surface slopes toward the rift and King's Bowl.

To view part of the King's Bowl Rift underground, visitors walk on a trail blasted out of solid rock (Fig. 15-10). Exposed on the walls of the rift are vertical layers, called selvages. These were coated on the walls of the rift by chilling of the molten lava. Each layer represents one eruption followed by a draining of lava. In the vicinity of the King's Bowl, the rift is about six feet wide.

Crystal Ice Cave is a commercialized segment of the rift. It has a continuous ice floor and is 370 feet long. The clearness of many of the ice speleothems is breathtaking (Fig. 15-11). In some areas, ice crystals grow on the cave walls at certain levels (Fig. 15-12). Another cave south of Crystal Ice Cave and north of the King's Bowl contains a room 500 feet long, 40 feet wide, and 70 feet high. I know of no other cavern chamber approaching such dimensions. Fissure caves of this sort are uncommon, and I would appreciate information on any others known or discovered throughout the world.

MATHEMATICAL ANALYSIS OF SOME LAVA TUBE MECHANICS

J. W. Harter, III
Southern California Grotto, National Speleological Society

PART I — BETA FORMULA

The simplest form of tube-bearing flow occurs when a mass of lava spreads from a small source, coolings as it advances. Consider a differential element of length dy, width dx, and height z. Heat radiation from the top surface is $\frac{dU}{dT} = E\sigma T^4 dx\,dy$. Change in heat content is $dU = \rho c z\,dx\,dy\,dT$. Combining: $E\sigma T^4 dx\,dy\,dT = \rho c z\,dx\,dy\,dT$. Or, taking $v = \frac{dy}{dt}$, which defines the coordinate system: $dx\,dy = z v\,dx \frac{\rho c}{E\sigma}\frac{dT}{T^4}$, and integrating: $\int\int dx\,dy = \int z v\,dx \int \frac{\rho c}{E\sigma}\frac{dT}{T^4}$, where the integrals on the right separate because T becomes independent of x in this coordinate system.

The double integral is surface area of the lava flow, while the first integral on the right is flow rate, Q. Defining beta as the temperature integral: 1) $A = \beta Q$, which is the desired result.

For a pahoehoe flow with constant, but not necessarily known, temperature profile, and neglecting heat of fusion: $\beta = \frac{\rho c}{E\sigma}\left(\frac{1}{T_1^3} - \frac{1}{T_0^3}\right)$. Using lack-of-movement freezing point for T_1 and eruption temperature for T_0, this describes a flow unit. Inserting Wentworth's temperature figures, beta is 5×10^3 sec/meter, which should be accurate to better than 30%.

Aa basalts have much lower surface temperatures than pahoehoes, so they should have significantly higher betas. Acidic lavas, on the other hand, have large T_1 and should have correspondingly small beta.

If flow rate is constant, equation (1) can be substituted into the volume equality $Ah = V = QT$, giving: (2) $\beta h = T$, which relates mean thickness of the flow unit to time of formation. For this relation it is convenient to use the reciprocal of beta, 70cm/hour.

It should be noted that a large number of fluid properties would intuitively be expected to affect size of a flow unit, but these properties all vanish with proper selection of coordinates and regions of integration. These properties affect shape, but not <u>size</u>.

It also should be noted that the T are surface temperatures, and that E can be eliminated by using pyrometer temperatures. This means that experimental error should be essentially the error in measuring Q. Equation (2) actually may be accurate enough that experimental beta could be used to obtain heat of fusion of the lava.