Supplemental road log 1: From Grants to eastern margin of El Malpais, Sandstone Bluffs Overlook, and McCartys lava flow

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SUPPLEMENTAL ROAD LOG 1: FROM GRANTS TO EASTERN MARGIN OF EL MALPAIS, SANDSTONE BLUFFS OVERLOOK, AND MCCARTYS LAVA FLOW

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Assembly Point: Best Western Inn and Suites, 1501 East Santa Fe Avenue, Grants
Distance: 37.8 miles to last stop; 75.6 miles (round trip).
Stops: 2

SUMMARY

This road log visits some of the landscapes associated with El Malpais National Monument and regional volcanism in the Grants area. The road log takes us from Grants eastward to NM Highway 117, and southward along NM 117 to two stops along the eastern margins of El Malpais. Although the area has been visited during previous New Mexico Geological Society Field Conferences, this trip will focus on the physical characteristics of the lava flows.

Stop 1 will be at the Sandstone Bluffs Overlook of El Malpais National Monument for a regional overview, including the Zuni Mountains and Mount Taylor, and discussion of general physical volcanology, natural history, and historical characteristics of the lava flows of El Malpais. **Stop 2** will be an examination of the youngest lava flow, the McCartys lava flow. Discussions will center on the overall physical volcanological characteristics of the flow, with an emphasis on evidence of modes of lava flow emplacement, and an additional discussion of recent dating results.

0.0 Begin in parking lot of Best Western located on the south side of Santa Fe Avenue at the east end of Grants. Turn right to leave the lot and proceed towards Interstate 40 onramp. The view east as you leave the lot is directed toward Horace Mesa, a high basalt-capped mesa that marks the southwestern edge of the Mount Taylor volcanic field. **0.6**

0.6 Turn left (east) onto I-40 on ramp. **0.6**

1.2 9:00 to 11:00, Horace Mesa, the southwest end of the Mount Taylor volcanic field. The slopes of the mesa reveal the eastward-dipping Cretaceous strata of the Grants monocline bounding the Zuni uplift.

For the next 3.2 miles, I-40 crosses the distal northern end of lava flows erupted from El Calderon (Fig. S1.1), a scoria cone near (east of) Bandera Crater. These flows have been dated at 54 ka (Laughlin and WoldeGabriel, 1997; Cascadden et al., 1997). The preservation of the surface of the flow is generally consistent with the surfaces on flows of this age throughout the Southwest. In some literature the lava flow along I-40 in this area is referred to as the "Laguna flow," but "El Calderon flow" is more descriptive and avoids confusion with the lava flow located near Laguna much farther east along I-40. **3.4**

4.6 **Leave I-40 via exit to Highway 117.** Immediately to the right along the exit ramp is a section through the narrowest part of the McCartys lava flow. This is the youngest lava flow in New Mexico and has been dated at 3.2-3.6 ka (Dunbar and Phillips, 1994), with a range in determined ages that indicate a minimum age of between 1.4 ka and maximum age of 5.1 ka before the present (Laughlin et al, 1993). The road cut was formerly well-exposed (Fig. S1.2), but the Highway Department banked local dirt up against the outcrop along the exit ramp, thus destroying an unusually revealing cross section of a lava flow. Note that the cross-sectional shape

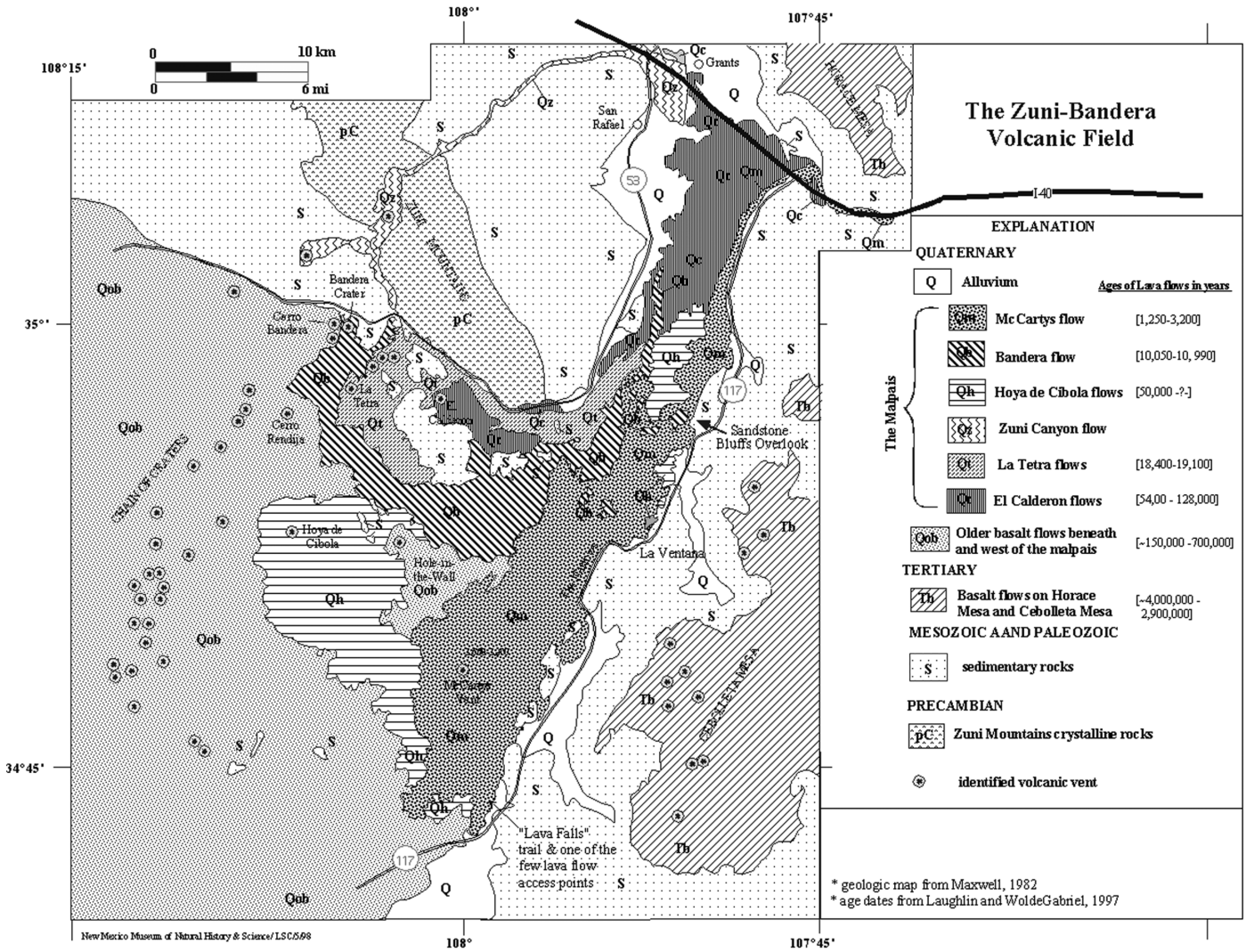

FIGURE S 1.1. Geologic map of the Zuni-Bandera volcanic field including the area of El Malpais. Map redrafted from Maxwell (1982, 1986).

of the flow is elliptical, typical of single lava flow units. Also note that here the McCartys lava flow follows a topographic drainage etched along the eastern side of the older El Calderon flows. **0.3**

4.9 **Turn right** (south) on NM-117. **0.1**

5.0 The outcrops in the hill on the right consist of Jurassic Morrison Formation, which contains fragmentary dinosaur (sauropod) bones here. Numerous exposures of small displacement faults in the outcrops here imply Laramide dextral strike-slip motion (Maxwell et al., 1989).

Beyond, in the valley floor at the immediate base of the hill, is one of the more interesting portions of the McCartys lava flow from the standpoint of lava emplacement mechanics (Fig. S1.3). The general morphology of the flow surface in this area was also briefly discussed in a previous field conference guidebook (see Maxwell et al., 1989, p. 21, fig. 1-85.6c), but is expanded in the following.

The lava flow was constricted here to a width of about 200 meters. Yet the flow surface records very little deformation, channelization, or interior structure, in seeming contradiction to the fact that a large volume of lava moved through this constriction. The flow interior, examined prior to the unfortunate covering of the cut through the flow at I-40, revealed an other-

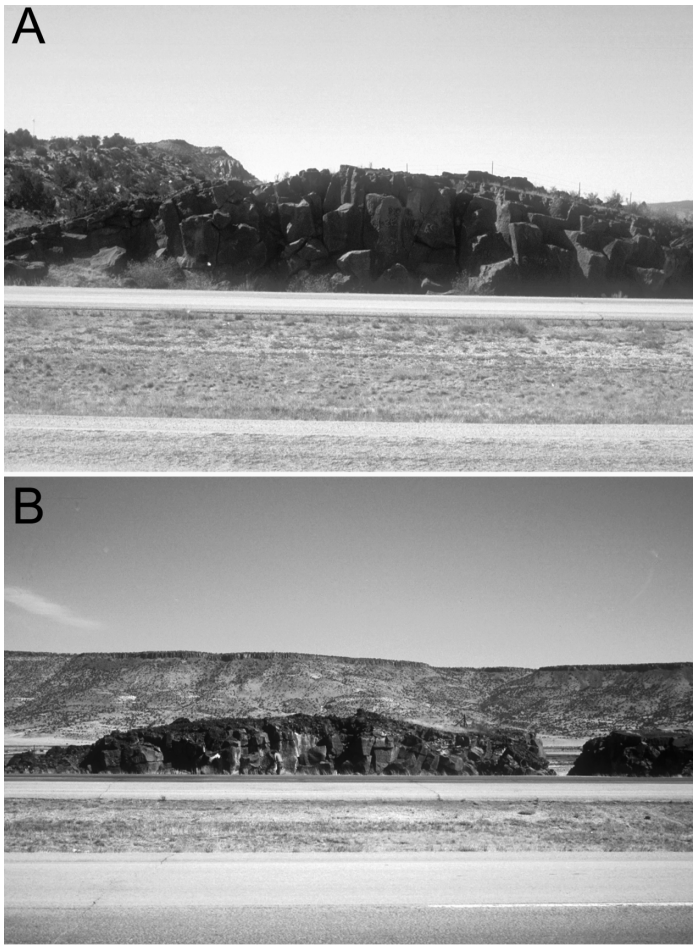

FIGURE S 1.2. Cross section through the McCartys lava flow where it narrows before entering the valley of the Rio San Jose. A. Section on the south side of I-40 before it was covered by the Highway Department. B. Section on the north side of I-40. This section shows the elliptical sectional profile that is predicted for elongate lobes of sub-tabular viscous flow.

FIGURE S 1.3. Vertical air photo of the McCartys lava flow where it narrows to less than 200 meters width. The lava flow retained the theoretically-predicted shape of a single slightly-confined flow unit. The preserved surface is also relatively devoid of deformation associated with through-going flow.

wise characteristic basaltic flow cross section: broadly elliptical section shape, marginal vesicular zones, and relatively unvesiculated interior. Structures characteristic of channelized flow or lava tube flow are not strongly expressed (Fig. S1.2). This implies that the flow volume in this constriction was completely replaced during emplacement of the flow farther north and east, and that the flow surface and internal features here record the last stages prior to cessation of flow. This is further supported by the absence of strong deformation in the surface: Aside from longitudinal stretch lineation in the pahoehoe crust and late parallel longitudinal cracks along the crest of the flow, no significant evidence for channelization exists. Continued movement of the flow from upstream resulted in buckling and crushing of pahoehoe plates, many of which were thrust out and onto the surface (Fig. S1.4). This interpretation would imply that the cracks are the result of expansion over a plug-like interior injected during the terminal phases of flow cooling and emplacement and that the disturbed pahoehoe plates represent crushing of the solidified crust upstream of the constriction because of continued incremental movement in the main volume of the flow. Had the flow not been in the terminal phases, it is likely that a new channel would have budded and either overtopped the neck or flowed around it. **0.7**

5.7 Crossbedded sandstone on left. On the right is the margin of the McCartys lava flow. A disrupted shelly pahoehoe surface here imparts the appearance of aa. Examination of the flow here suggests that local jams in the stream resulted in shearing dislocation of the solidified crust. **1.2**

6.9 Summit of the Zuni Mountains is at 2:00 (Mount Sedgwick). **1.7**

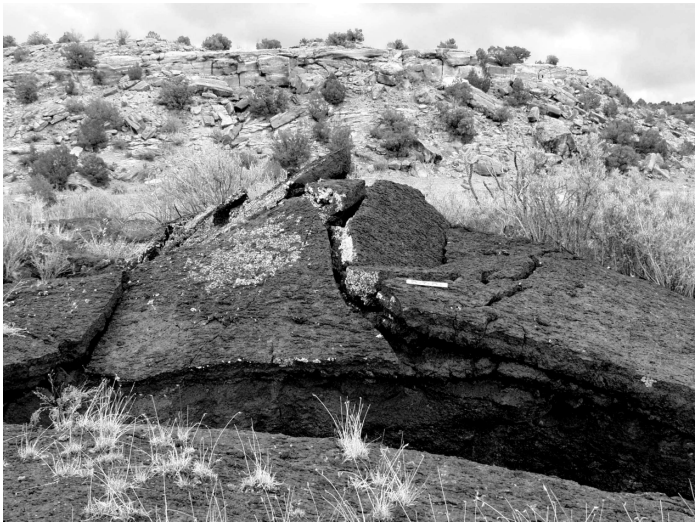

FIGURE S 1.4. Local buckling of crustal plates along the narrowest part of the McCartys lava flow due to jamming of the solidified crust. Buckling of this type likely occurs when the interior of the flow continues to move downstream resulting in a net shear across the upper solidified crust and from the pressure of crustal plates upstream. View is directed east from the center of the lava flow.

8.6 Ahead in the distance are cliffs of Jurassic Zuni Sandstone that form the eastern boundary of the El Malpais. **2.6**

11.2 Sign says "Entering El Malpais National Monument." **2.2**

13.4 Entrance to the El Malpais visitors center on the left. This center focuses largely on the cultural and biological aspects of the Monument. **0.8**

14.2 Turn right to follow graded road to the Sandstone Bluffs Overlook (actually the El Malpais overlook from a sandstone bluff!). **1.0**

15.2 Old house here is a homestead from the 1930s built using blocks from a nearby Anasazi ruin. **0.6**

15.8 Road divides, continue right to overlook parking area. **0.2**

16.0 **STOP 1.** Sandstone Bluffs overlook. The view from this stop includes a sweeping panorama of the valley (Fig. S1.5A) floored by several young lava flows. This view is frequently featured in photographic collections and paintings of New Mexico scenic places (A recent example of the latter is the painting by Doug West, "From Higher Ground, 1995"). The panorama at this stop includes, from left to right, the cliffs of Jurassic Zuni Sandstone along the eastern margin of El Malpais, the cones of the Zuni-Bandera volcanic field, the Zuni Mountains, Grants Ridge, Horace Mesa, and Mount Taylor. From this angle the view of Mount Taylor is at its most dramatic. The profile is essentially that of a truncated conical composite volcano (Fig. S1.5B). Drill cores and seismic data indicate that the valley between the cliffs here and the distant flanks of the Zuni Mountains is a deep structural graben filled to a depth of between 600 and 900 ft with basalts and various late Cenozoic sediments (Hawley and Love, 1991).

Several flow units of a wide range in age are encompassed within the field of view immediately to the west (Fig. S1.5C), including flows with sources at Hoya de Cibola, Bandera, Twin Craters, and El Calderon. The darker flow nearest to the base of the sandstone cliffs here is the McCartys lava flow, 38 km long from the source vent to the eastern-most tip along I-40. This is one of the largest young lava flows in the world and consists of 3 km^3 of tholeiitic (Carden and Laughin, 1974) lava. The source area (Fig. S1.6), on the south end, is characterized by a small scoria cone approximately 2 miles from the eastern edge of the lava flow. The source vent served as a target for aerial bombing practice during WWII. **After stop, return to Highway 117. 2.3**

18.3 Turn right (south) on Highway 117. **1.3**

19.6 Sign: Acoma Reservation Boundary. Lava flows here abut the cliffs of Zuni Sandstone on the right dipping eastward away from the Zuni Mountains. **1.3**

20.9 A large reentrant along the edge of the McCartys flow is here underlain by an older flow, the Hoya de Cibola flow. **0.6**

21.5 Steep cliffs of massive Zuni Sandstone adjacent to the road illustrate the process of undermining and back-wasting through which these cliffs may retreat over time.

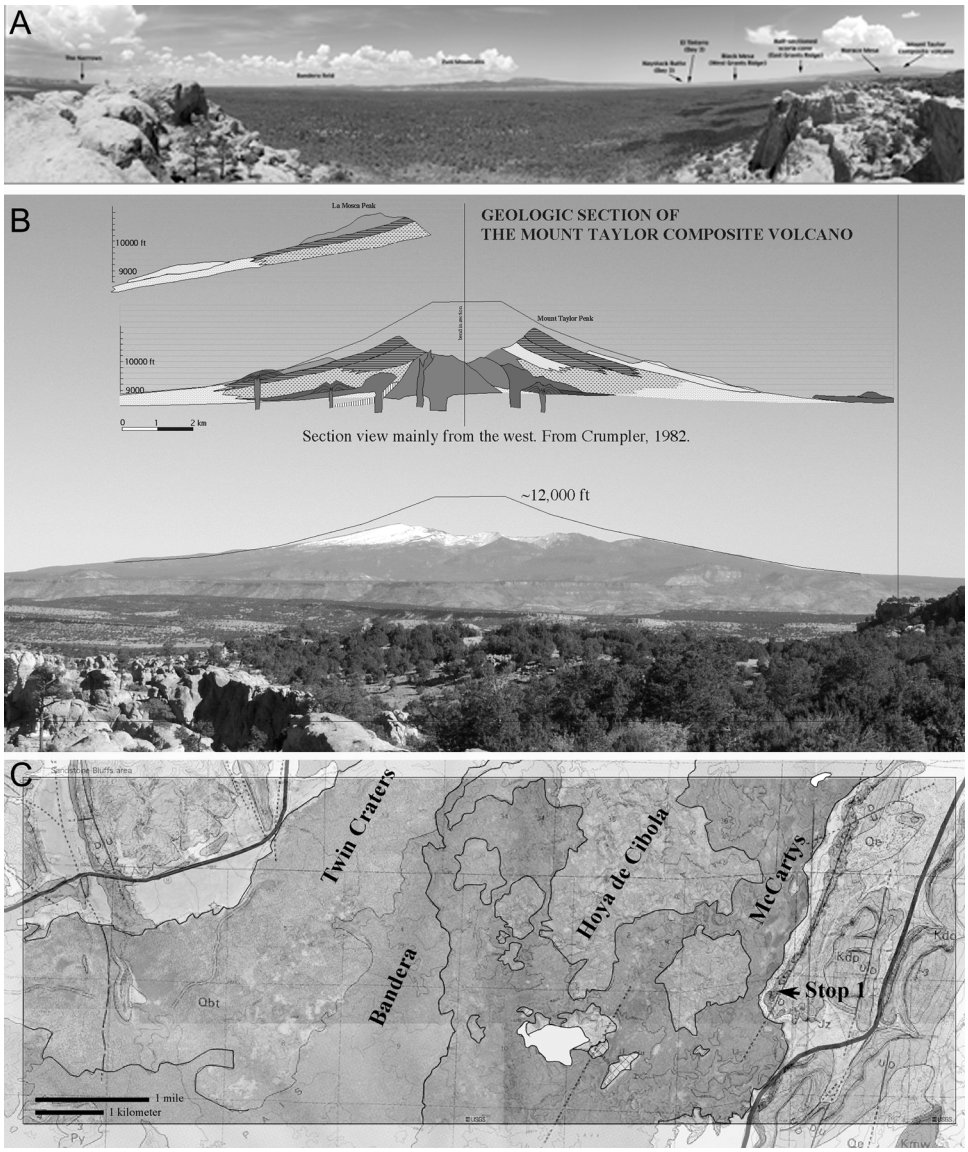

FIGURE S 1.5. A. Panorama from the Sandstone Bluffs overlook, El Malpais National Monument. From this point one sees a broad valley flanked on the west by the Zuni Mountains and on the north by basalt-capped mesas of the Mount Taylor volcanic field. The youngest (McCartys) lava flow visible in the valley floor is adjacent to the bluffs and is actually very narrow. Most of the valley floor valley directly in a line between the overlook and the Zuni Mountains consists of the Hoya de Cibola, Bandera, and El Calderon lava flows. Other features visible from here include the distal cones of the Zuni-Bandera field. On a clear day Haystack Mountain and El Tintero (last stop, Day 3) may be seen in the distant horizon. B. Mount Taylor volcano as seen from the Sandstone Bluffs overlook. The view from this angle (south flank of Mount Taylor volcano) is that of a classic composite volcano with sweeping flanks, and a truncated summit. The cross section is based on a composite of sections from the western and northern quadrants of the volcano, and therefore is an approximation of the section as viewed from the Sandstone Bluffs Overlook. C. Distribution of several flow units directly west of Stop 2 located on an air photo.

Undercutting of the sandstone cliffs here may be occurring where spring seepage disintegrates the sandstone near the cliff base. This is followed by massive vertical spalls and slumps. An example of such a slump may be seen adjacent to the highway where a large "sliver" of the face has dropped down in recent times. **0.8**

22.3 The flows visible next to the road on the right are not the McCartys lava flow, but are older flows (Hoya de Cibola flow). Because most of the flows underlying the McCartys lava flow at this point originated in the Bandera Crater region near the southern end of the Zuni Mountains farther west, the distance of these flows from their source

FIGURE S 1.6. Small scoria cone at the source of the McCartys lava flow. Surface view of the vent area. The lumpy appearance of the cone and the disturbed basaltic plate-like fragments near its base are the results of aerial bombing practice during WWII.

vents at this point is greater than that of the McCartys flow from its source vent. **0.9**

23.2 Zuni-Acoma trailhead. The trail crosses several flow units of the El Malpais series and connects the east and west sides of the valley. **0.3**

23.5 La Vieja ("the old woman") on the right is a Zuni Sandstone erosional remnant. The Zuni Sandstone near the base of La Vieja is characterized by thin variegated complex lineation typical of so-called "picture sandstone." Note hoodoos (pedestals with overhanging tops) in Zuni Sandstone on the left. **1.7**

25.2 In this vicinity the horizontal line of sight along the margins of the lava flow enables one to see that the lava surface actually consists of several levels, platforms, or terraces. The origin of this tendency of lava flows to develop distinct surface levels is unclear. Because hydrostatic overpressures may be an important control on the thickness attained by lava flows, one interpretation is that they may represent the influence on lava inflation by successive stages in the "upstream" lava supply rates. **0.4**

25.6 Sign: Leaving Acoma Reservation. **0.3**

25.9 La Ventana parking area on the left. The road curves around cliffs of Zuni Sandstone. Note the view of Mount Taylor in the distance across the surface of the young McCartys lava flow. **0.7**

26.6 The Narrows. The McCartys lava flow abuts cliffs of Zuni Sandstone. **2.1**

28.7 The surface of the lava flow adjacent to the road in this area illustrates the variable relief that occurs throughout the lava flow. The term "pressure ridge" is frequently used to describe these swells with longitudinal cracks. Some pressure ridges are related to lateral deformation at the edges of the flow, whereas others may be related to vertical deformation due to inflation and deflation of the lava flow during emplacement. **1.3**

30.0 Leaving The Narrows. **1.9**

31.9 Note that here the McCartys lava flow has encircled the low ridge of sandstone on the right at 1:00-3:00. **1.8**

33.7 Lava flows near road have flowed through a gap in the ridge on the right. **1.0**

34.7 Note that the flow margins are characterized by short "toes" or lobes extending from the general margins of the flow throughout this area. These are particularly common in this area where the lava flow has moved through the gap in the ridge to the west and may represent breakouts during late deflation of the local flows. **2.8**

37.5 **Turn right** onto access road to Lava Falls Trailhead. **0.3**

37.8 Parking area for the Lava Falls Trail, **Stop 2** (Fig. S1.7). The main purpose of this stop is to examine some classical lava flow surface details and their implications for lava flow emplacement. The McCartys lava flow is the type area for many of the detailed surface characteristics of pahoehoe lava flows (Fig. S1.7) (Nichols, 1936, 1938, 1946) due to its youthful age and preservation of a myriad of small scale features resulting from plastic deformation of a fluid, hot silicate melt. The lava flow surface here at the Lava Falls area differs from that in much of the flow, particularly the lesser preservation in this area of glassy and dark surfaces, however, access here is relatively simple. We will follow the trail cairns and walk

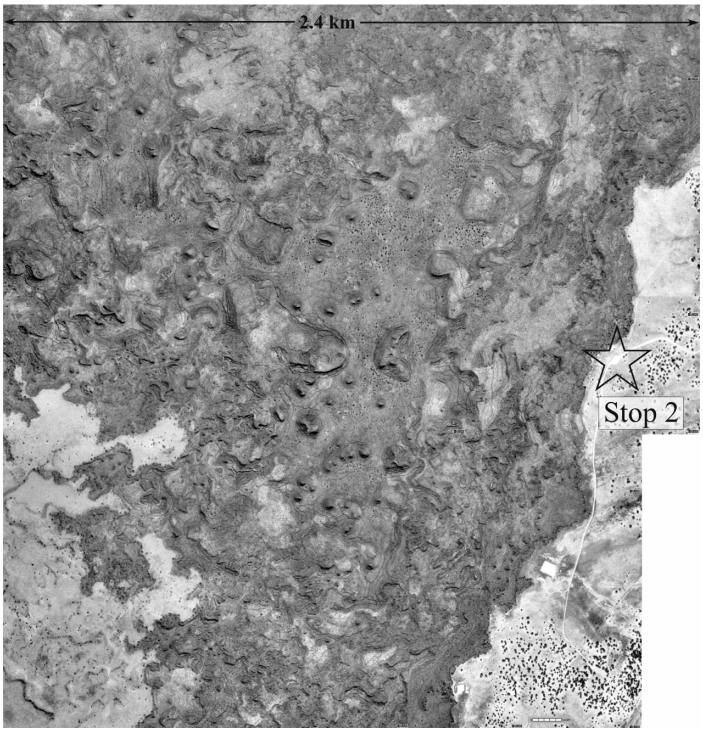

FIGURE S 1.7. Air photo of the surface of the McCartys lava flow in the vicinity of the Lava Falls trail. Note the abundance and distribution of collapse depressions.

on the flow in order to observe pahoehoe texture, collapse depressions, squeeze-ups, shark's-tooth projections, lava blisters, grooved lava, lava driplets, lateral deformation and tension cracks.

After stop return to vehicles and return to Grants.

End of Supplemental Road Log 1.