

Geologic Points of Interest in the Echo Crater Area

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1 Coyote Butte shallow crater vents

The two peaks of Coyote Butte are separated by two craters that represents the eruptive vents of formation. The linear trend formed by those two craters is continued by a previously unmapped series of more shallow craters south of Coyote Butte in the direction of Echo Crater. The shallow crater vents follow a trend roughly parallel to the Great Rift.



2 Trench Mortar Flat crater vents

A well defined system of crater vents lies between the two Trench Mortar Flat (TMF) cinder mounds, Southwest of Crescent Butte. There are six craters of similar size that line along the Great Rift. The average crater length and width is 65 and 40 meters respectively. The craters span approximately 0.5 km along the Great Rift. Walls of agglutinated spatter outline the depressions. Large boulders of failed spatter wall lie inside most of the craters.

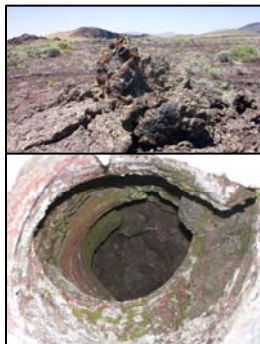


3 Tree Molds

Cylindrical molds formed by lava that cooled and hardened around a tree. A hollow space remains after the tree rots and erodes. Both molds described below are vertical.

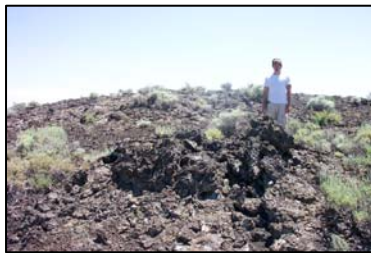
3a

TMF cinder mound: This Tree Mold is the deepest recorded in the park as of 2006. It is 4.44 meters deep and 0.38 meters wide. Layers of spatter surround the feature and give it several feet of relief, which makes it easy to spot from a distance. The mold is in pristine condition and appears to have a number of intact limb molds.



3b

TMF near waterholes: Located between Bearsden and Little Prairie waterholes, this mold is surrounded by spiny pahoehoe. It measures 2.9 meters deep and 0.45 meters wide. It is in pristine condition and 3 limbs have been recorded. A distinctive mold of charred wood is preserved here. This mold also has a couple feet of positive relief.



4 Waterholes

The waterholes along the Trench Mortar Flats in this region are perched water tables over ice, trapped by impermeable, ice-saturated basalt below.

4a

Yellowjacket Waterhole: This waterhole is found at the bottom of the second large crater vent south of the Trench Mortar Flat cinder mounds. A roughly defined deer trail leads to the bottom of the crater. The hole is approximately 1.5 m across, and the water level is 0.5 m below the surface level. As the name suggests, this waterhole is frequently teeming with yellowjackets, and the water surface is covered by a floating layer of dead insects.



4b

Bearsden Waterhole: This waterhole is a small cave formed at the bottom of a crater vent along the Trench Mortar Flat rifts. Water and unmelted snow are found a short distance in from the cave entrance. The crater is marked by large rock cairns.



4c

Little Prairie Waterhole: This waterhole can be found inside one of the deep, narrow rift cracks along Trench Mortar Flats. It is marked by two logs lain across the rift; also in the immediate vicinity is an old sheep trough that remains from early ranching in the area. The water level is approximately 8 m below ground level; a bucket is necessary to reach the water.



5 Southern Crescent Butte area

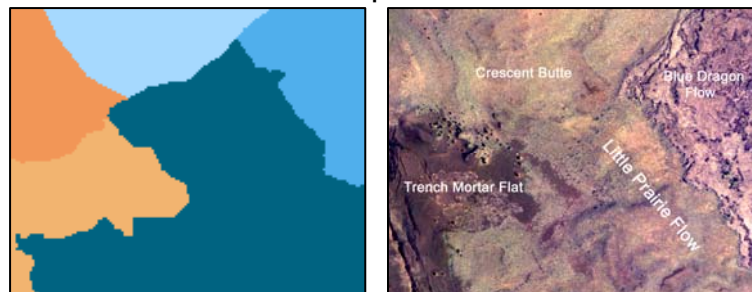
The researchers present an interpretation of the geology immediately southeast of the Crescent Butte cinder cone significantly different from that previously presented by Kuntz et al. (1989a,b). The area of discrepancy is a shallow rectangular saddle about 500 m long NE-SW and 300 m across NW-SE. The previous map had identified this saddle as Trench Mortar Flat pahoehoe, forming a boot-shaped extension of the Trench Mortar Flat flow separating Crescent Butte from the Little Prairie flow. A low ridge about 2 m high along the southeastern edge of the saddle was identified as the Little Prairie-Trench Mortar Flat contact.

Old Interpretation



We found several problems with this interpretation. First, this valley is very heavily vegetated with sagebrush and grasses, far more so than any other location on the Trench Mortar Flat flow. It seems improbable that so much vegetation could develop on such a young flow (2,205 y), and that so much more vegetation would develop in this saddle than in neighboring areas in the same unit. Second, there are no continuous flow fronts of fresh Trench Mortar Flat lava preserved in the saddle; lava outcrops in the saddle are sparse, weathered, and covered by ash and vegetation. Third, if the 2 m ridge did represent a contact, one would expect to find onlap and deflation features as the Trench Mortar Flat flow rolled up onto the older Little Prairie. There are no such contact features along that ridge. We conclude that the saddle region is Little Prairie flow. The ridge previously identified as a contact is another flow front of Little Prairie. The Trench Mortar Flat flow ends at a shallow escarpment roughly corresponding with the end of the bare cinder soils.

New Interpretation



6 Slump blocks in interior of Echo Crater

The floor of the central part of Echo Crater is covered with huge, monolithic spatter formations. These range from 5-8 m in height, and are composed of flat-lying spatter layers with occasional tachylytic material. The spatter blocks are similar in appearance and composition to the crater walls. These monoliths are likely blocks of the crater wall that failed and slumped down into the crater.



7 Xenolith in Echo Crater

A white, granulitic xenolith is embedded in the south wall of Echo Crater. The xenolith is about 1 m long by 0.5 m wide, and is embedded in basaltic lava. Several other xenoliths of similar appearance and composition, ranging in size from 15-40 cm, are embedded nearby in the same wall. Granulite is likely a component of the basement rock underlying the rhyolite and basalt.



8 Extended rift system on Echo Crater flank

Numerous large spatter blocks can be found on the southeast flank of Echo Crater. These blocks are up to 125 m long and range from 3-6 m in height, and are composed of flat-lying or gently tilting spatter layers. They form linear trends following an azimuth of approximately 340, nearly parallel with the Great Rift direction. Together, they represent a continuation of the rift system south of Echo Crater. Multiple spatter rampart sets are evident, corresponding to different eruption events. The oldest ramparts are at least 300 m apart, indicating a huge rift system. The marked point of interest is a small upwelling with parallel spatter layers in the middle of the rift, representing one of the last eruptive events in this system.



9 The “C” spatter rampart

A spatter rampart in the South Echo Flow region, about 160 m straight-line distance from one end to the other. The rampart has a circular shape similar to the letter C. The rampart is asymmetrically shaped; the northeast, outer part of the C forms spatter cliffs up to 4 m tall, but the southwest, inner part of the C has no large spatter outcroppings. The circular shape of the rampart suggests a vent within the C; one of several small spatter outcrops in the center of the rampart could represent remnants of the vent. Sharp vertical grooves are found along 25 m of the northeast spatter wall and extend as far as 2 m up the side of the wall. These striations have considerable relief, rising up to 2 cm above the wall surface. These represent slump scars along a gravity fault, where part of the spatter rampart failed and slid down. The sharp relief of the grooves suggests that the spatter was still hot and malleable when it failed. The failed block is not present or visible; it has likely been buried by cinder soils.



12 Watchman flank vents

The Watchman is a cinder cone associated with the Trench Mortar Flat volcanic event. It was also the site of two flank lava eruptions. The north slope of Watchman produced a pahoehoe flow, and the south slope produced a slabby pahoehoe (slab-lava) flow. The uppermost point of each flow features a shallow valley or rift with small spatter ramparts on each side, representing vents or eruptive fissures associated with the Trench Mortar Flat event. The south vent spatter ramparts are partially composed of tachylytic material.



13 Flat spatter layers - Watchman

Agglutinated spatter layers outcrop on the northwest side of the Watchman Cinder Cone. The layers are very well defined with beds of spatter ranging from several centimeters to 0.5 meters thick. The outcrop is approximately 30 m long and ranges from 3-6 m in height. The layers are gently dipping at approximately 5 degrees. The source of the spatter is believed to be the nearby vent on the Watchman's north flank.



10 The “Spire” rafted block

A large upright spatter spire, approximately 8 m tall and 4 m wide. The spire is composed of welded spatter layers and agglutinated cinders, tilting in parts of the feature up to 75°. The north side of the spire features a smooth throat lining approximately 10 cm thick, similar to the lining seen in spatter cones in the developed part of the park. This is probably a rafted block from the Sentinel eruptive fissure.



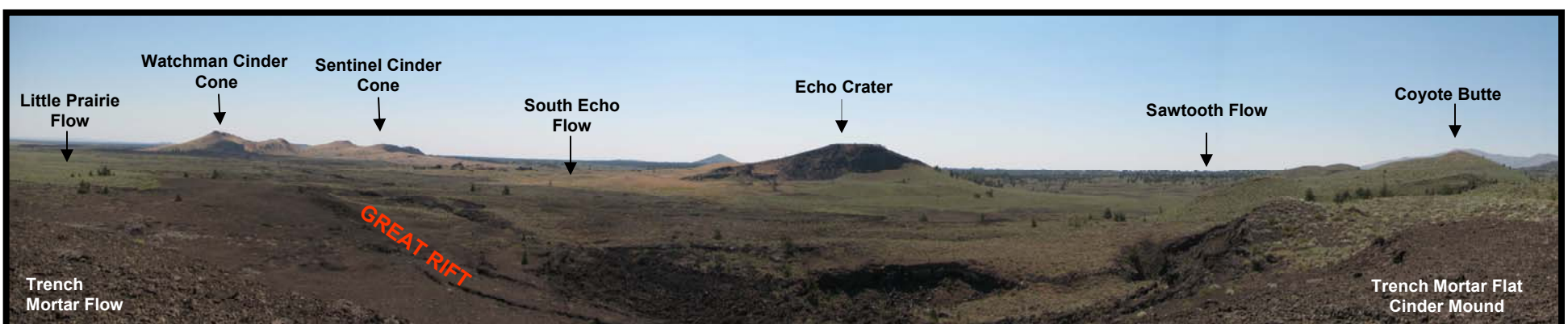
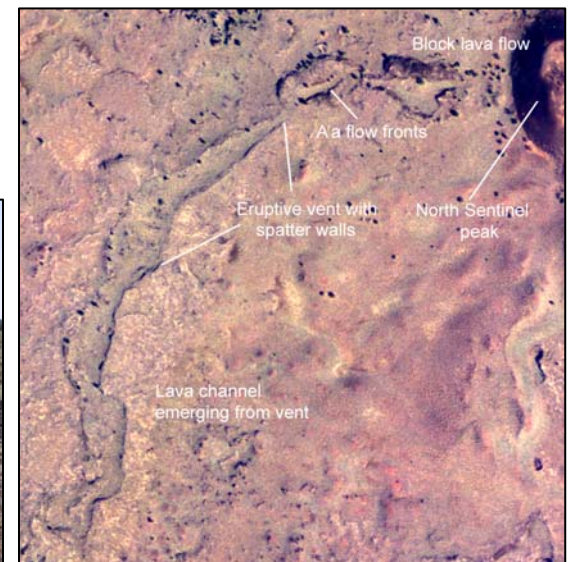
14 Cave – South of Sentinel

This small cave south of Sentinel extends back approximately 10 m, with ceilings as high as 3 m. The ceiling is approximately 2 m thick. The entrance to the cave is littered with large rubble from previous collapse episodes. The cave walls and floors are covered in lichens and mosses. A rock cairn marking the cave is visible from the top of the Sentinel.



11 Vent system southwest of Sentinel

An elongated, channelized trough begins along the southwest flank of the Sentinel cinder cone and continues for 1.7 km towards the Sawtooth flow contact. Near the Sentinel, a flank vent with block lava flows on either side runs at an azimuth of roughly 240. Approximately 120 m further southwest of this vent, two prominent a'a flow fronts have been preserved. These flow fronts have shallow southern slopes and steep northern slopes, indicating flow to the north. Beyond these flow fronts, the lava type of the trough walls changes to agglutinated spatter (below left). The trough here is an elongated vent varying in width from 50 to 90 m and running north-south about 380 m before closing in the shape of a circular vent. Beyond the circular vent, the channel continues and curves towards the southeast as it approaches the Sawtooth flow. This feature was previously mapped as a lava channel; this interpretation is supported by its curving shape. However, the observation that many of the channel's walls are spatter ramparts, rather than lava levees, is inconsistent with this interpretation. The researchers believe that this feature starts as an elongated vent and transitions to a lava channel beyond the circular vent. The varying widths of the vent correspond to different eruptive events over the vent's lifetime. The a'a may have flowed over and obscured part of the vent near the end of its period of activity.



Panoramic picture taken from TMF cinder mounds at N 4808525 E 297146

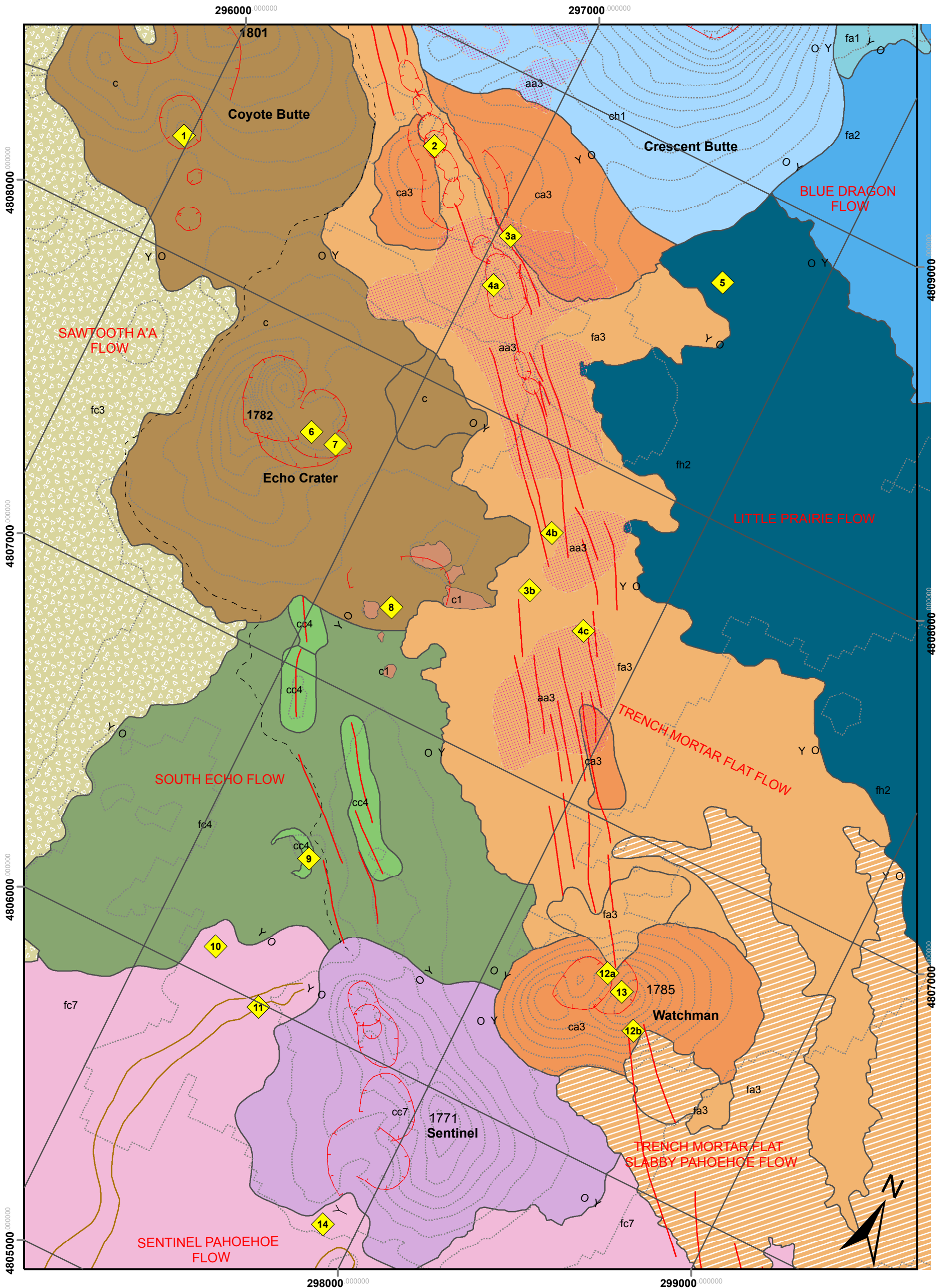
REFERENCES CITED

The Echo Crater area was first mapped by M. A. Kuntz et al. (1989) through a series of publications by the USGS. The USGS published four separate 1:24,000 geologic maps that covered the northern portion of the Craters of the Moon lava field. These four quadrangles (GQ-1632, 1633, 1634, 1635) spanned to cover the boundaries of Craters of the Moon National Monument. Detailed mapping of the Echo Crater area was undertaken by Steven Chemtob and Benjamin Brulet during the summer of 2006 as a continuation of the detailed Great Rift mapping that took place the previous two summers. The 1:12,000 map of the Echo Crater area will provide a more refined understanding of the volcanic history of the region. In addition, two pages regarding points of geologic interest in the mapping area were published in the summer of 2006. The detailed descriptions with photos will allow visitors to conveniently locate and visit unique geologic features.

- Kuntz, M.A., Lefebvre, R.H., Champion, D.E., Skipp, B.A., 1989a, Geologic Map of the Inferno Cone Quadrangle, Butte County, ID: U.S. Geological Survey Quadrangle Map GQ-1632, scale 1:24,000.
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- Champion, D.E., Kuntz, M.A., Lefebvre, R.H., 1989c, Geologic Map of the North Laidlaw Butte Quadrangle, Blaine and Butte Counties, ID: U.S. Geological Survey Quadrangle Map GQ-1634, scale 1:24,000.
- Kuntz, M.A., Champion, D.E., Lefebvre, R.H., 1990, Geologic Map of the Fissure Butte Quadrangle, Blaine and Butte Counties, ID: U.S. Geological Survey Quadrangle Map GQ-1635, scale 1:24,000.
- Wetherell, K. A., Clennon, R. P., Truitt, K. E., and Hansen, N., 2005, Geologic Map of the Broken Top Area: scale 1:12,000.
www.nps.gov/applications/parks/crmo/ppMaps/new_map2.pdf
- Field Photos: Steven Chemtob, Benjamin Brulet, and Douglass Owen

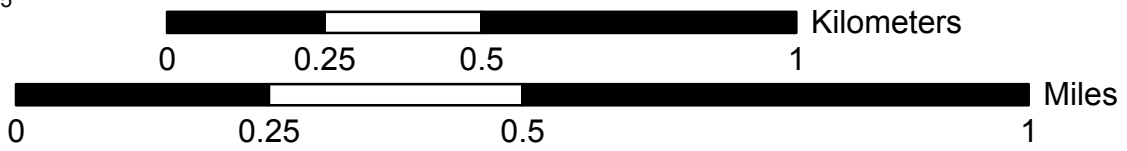
Geologic Map of Echo Crater Area Craters of the Moon National Monument and Preserve

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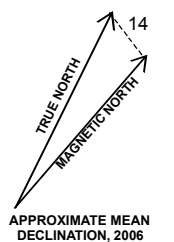


Source: ESRI Data & Maps
Geologic Quadrangles - 1632, 1633, 1634, 1635
Projection: North American Datum 1983
1000 m Universal Transverse Mercator grid,
zone 12
Created in ArcGIS 9 using ArcMap
for Craters of the Moon National
Monument and Preserve

SCALE 1:12,000











CONTOUR INTERVAL 10 METERS




Description of Map Units

Lava flows of the Echo Crater area, Craters of the Moon lava field;
Units arranged by age; youngest unit is located in the top left
hand column and become progressively older down to the right

MAP SYMBOLS

-  **Cave** – lava tubes formed by the withdrawal of molten lava after the formation of a surface crust
-  **Hiking Trail**
-  **Contour Line**
-  **Scarp** – Gravity fault: vertical lines point to areas of lower elevation
-  **Eruptive and Non-eruptive fissures**
-  **Contact** – relative ages of flows indicated by Y: younger, O: older
-  **Lava Channel**
-  **Geologic Points of Interest**

GEOLOGIC UNITS

<div style="background-color: #ADD8E6; padding: 5px; display: inline-block; margin-bottom: 10px;">fa1</div> <p>Broken Top pahoehoe basalt flow (nd, ~2000) Surface-fed flow from vents, fissures, cracks, and a few small spatter vents on east and southeast flanks of Broken Top cinder cone (ca1; see Wetherell et al., 2005). Only distal flanks of flow appear in the Echo Crater area. Here, the flow is characterized by hummocky, light-colored lava with significant vegetation and very fluid, glassy breakout flows.</p>		<div style="background-color: #90EE90; padding: 5px; display: inline-block; margin-bottom: 10px;">fc4</div> <p>South Echo flow and related deposits (nd)</p> <p>Pahoehoe basalt flow Thin, surface-fed flow erupted from fissures running between Echo Crater and the Sentinel cinder cone. Almost entirely covered by cinders, fine lapilli, and vegetation.</p>	
<div style="background-color: #6495ED; padding: 5px; display: inline-block; margin-bottom: 10px;">fa2</div> <p>Blue Dragon pahoehoe basalt-hawaiite flow (2,076±45) Surface- and tube-fed flow originating from vents at the Spatter Cones (ca2) and Big Craters cinder cone (ca5) in the Inferno Cone quadrangle (Kuntz et al., 1989a). Characterized by spiny pahoehoe flows with glassy, vesicular surfaces and iridescent light and dark blue glassy coatings. Common features: pressure ridges, inflation pits, and drained tumuli.</p>		<div style="background-color: #FFB6C1; padding: 5px; display: inline-block; margin-bottom: 10px;">fc7</div> <p>The Sentinel flow (nd) and related deposits</p> <p>Pahoehoe basalt flow Surface-fed flow erupted from craters and flank vents of the Sentinel cinder cone. The flow is almost entirely covered by cinders and thick sagebrush, but there are periodic linear outcroppings of rough pahoehoe lava 1-2 m high, possibly corresponding to old pressure ridges.</p>	
<p>Trench Mortar Flat flow (2,205±25) and related deposits</p> <div style="background-color: #FFDAB9; padding: 5px; display: inline-block; margin-bottom: 5px;">fa3</div> <p>Pahoehoe basalt-hawaiite flow with volcanic ash deposits Surface-fed, thin, shelly flows erupted from southern set of fissures northwest of the Watchman cinder cone (ca3). Also comprises breakout flows from the slabby pahoehoe (slab-lava) flow that erupted from southeast Watchman flank vent. Partially obscured by deposits of ash and fine lapilli also associated with the Trench Mortar Flat event, mainly <1 m thick.</p>		<div style="background-color: #DDA0DD; padding: 5px; display: inline-block; margin-bottom: 10px;">cc7</div> <p>The Sentinel cinder cone Cinder cone consisting of two peaks and at least five craters, indicating a complex eruptive history. The cone features agglutinated cinder layers tilting away from the crater vents forming cliffs up to 3 m high. The craters form linear trends roughly corresponding to the direction of Great Rift. The cinder cone is approximately 110 m high and 900 m across.</p>	
<div style="background-color: #FFDAB9; padding: 5px; display: inline-block; margin-bottom: 10px;">fa3</div> <p>Slabby pahoehoe flow Degassed, highly viscous lava with slabby surface too rough to be obscured by ash. Northeast of the Watchman cinder cone (ca3), slabby pahoehoe (slab-lava) formed where the Trench Mortar Flat pahoehoe flow continued to flow after its crust had congealed. Slabby pahoehoe also formed from degassed lava erupted directly from the southeast Watchman flank vent.</p>		<div style="background-color: #ADD8E6; padding: 5px; display: inline-block; margin-bottom: 10px;">ch1</div> <p>Crescent Butte cinder cone (nd, ~15000) Source for the Crescent Butte pahoehoe flow (fh1) (Wetherell et al., 2005). Cone is composed of cinders and features agglutinated spatter layers surrounding the large crater and numerous volcanic bombs. Western part of cone is mantled with ash from the Trench Mortar Flat volcanic event.</p>	
<div style="background-color: #FFDAB9; padding: 5px; display: inline-block; margin-bottom: 10px;">ca3</div> <p>The Watchman cinder cone and other cinder mounds Cinder mounds form on either side of the fissure sets associated with the Great Rift along the Trench Mortar Flats. These mounds consist of cinder soils, agglutinated spatter deposits, and occasional volcanic bombs. The Watchman cinder cone, the largest of these deposits, is approximately 140 m high and 750 m in diameter.</p>		<div style="background-color: #008080; padding: 5px; display: inline-block; margin-bottom: 10px;">fh2</div> <p>Little Prairie pahoehoe basalt flow (nd, ~15000) Surface- and tube-fed pahoehoe flow covered by sagebrush and grasses. Characterized by occasional low outcroppings of weathered pahoehoe basalt and ridges that preserve old flow fronts, significantly in the area just southeast of Crescent Butte. The source vent is unknown.</p>	
<div style="background-color: #90EE90; padding: 5px; display: inline-block; margin-bottom: 10px;">fc3</div> <p>Sawtooth a'a trachyandesite flow (6,020±160) Long flow erupted from vent on southern flank of Big Cinder Butte cinder cone (cc3) (Wetherell et al., 2005). Characterized by numerous steep-fronted lobes partially buried by large ash units. Edge of flow features occasional pahoehoe squeeze-out flows. Flow is heavily vegetated by sagebrush, limber pine, and various grasses.</p>		<div style="background-color: #D2B48C; padding: 5px; display: inline-block; margin-bottom: 5px;">c</div> <div style="background-color: #FF8C00; padding: 5px; display: inline-block; margin-bottom: 10px;">c1</div> <p>Cinder cones (Holocene and latest Pleistocene) with spatter ramparts A series of cinder cones having no known associated lava flows; thus, no exact ages can be assigned. Echo Crater is approximately 80 m high and 850 m across, and features huge cliffs surrounding the central crater composed of spatter and lava, as well as spatter ramparts surrounding the rift system southeast of the central crater (c1). Coyote Butte is approximately 55 m high and 700 m across; two prominent crater vents separate its two peaks.</p>	