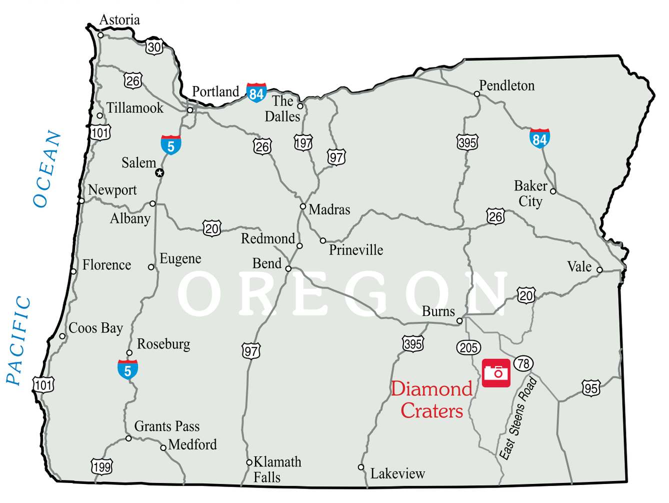
Text by Ellen M. Benedict, 1985

There is no other place in North America like Diamond Craters.

That's the opinion held by scores of scientists and educators who have visited and studied the area. It has the "best and most diverse basaltic volcanic features in the United States and all within a comparatively small and accessible area," one geologist summarized.

Yet visitors with little or no geologic training will probably see nothing more than acres of sagebrush and a few lava flows and craters.

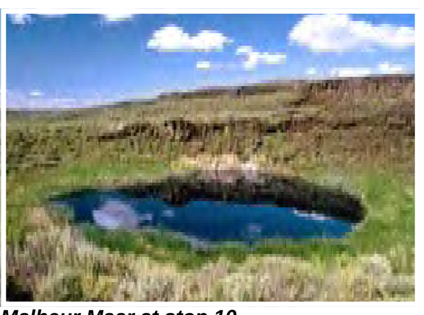
This guide will help you to locate and interpret some of the outstanding features of Diamond Craters that you might otherwise overlook. You won't be an accomplished geologist after finishing the tour, but you will have a greater appreciation for the area labeled by one scientist as "a museum of basaltic volcanism."



Travel And Hiking Hints

Diamond Craters is located in the high desert country about 55 miles southeast of Burns, Oregon. It's an isolated place and some precautions should be taken when traveling in the region.

Diamond Craters has no tourist facilities. The nearest place where gasoline is sold is at Frenchglen.


Malheur Maar at stop 10.

Keep your vehicle on hard-packed road surfaces and obvious parking areas. Certain roads and trails are closed for rehabilitation. Be careful or you might spend time stuck in loose cinder, volcanic ash, or clay.

If you go hiking, carry drinking water. Watch out for rattlesnakes. If you come upon one, stay calm and allow the snake to glide away.

It took thousands of years of volcanic activity to form Diamond Craters, but thoughtlessness or carelessness and forgetfulness to destroy its features. Help the BLM to protect and preserve Diamond Craters. Please do not destroy or collect plants, animals, or rocks.

How To Use This Guide

In the left margin are numbered paragraphs corresponding to the thirteen stops along the 40-mile auto tour between State Highway 205 at Diamond Junction to State Highway 78 at Princeton. The mileage below each number tells the distance from the last stop. Use your odometer and the map to help locate stops.

Features at stops correspond to points on a clock face. Imagine that you are standing in the middle of a clock face. Twelve o'clock is the road in front of you and 6 o'clock the road behind. If you always align the clock face with the road, you will be able to locate the features.

1 (0.0 miles) **Start Tour.** Mileage begins halfway between milepost 40 and 41 on State Highway 205 at the junction to Diamond. Turn left.

Diamond, Oregon, a small ranching community, was named in 1874 for Mace McCoy's Diamond brand. The nearby craters soon became known as Diamond Craters.

You'll cross the Central Patrol Road of the Malheur National Wildlife Refuge and the Blitzen River at 1.0 miles. The Blitzen River originates on Steens Mountain, the highest point in the southeastern skyline.

2 (2.5 miles) Park on the right edge of the road. On the left side of the road, north of the marshy area, is a panoramic view **of Diamond Craters**. Start at the west. Follow the edge (7 o'clock) of the lava flow east to **West Dome** (8 o'clock). **Central Dome** (8:30) looks like four or five humps along the skyline. **Graben Dome** (10:30) wears the crown of juniper trees. The two red cinder dish-shaped craters (9:30) midway below Graben Dome are part of **South Dome**.

As you can tell from the map, Diamond Craters resembles a thin, rocky pancake with a few bumps. There is only a 550 foot range from the lowest to highest point. Elevations are from 4,150 to 4,700 feet above sea level.

Have you noticed the *rimrock* on the buttes and the tablelands to the west, south, and east? The layer is the **Devine Canyon Ash-flow Tuff**. This weathered, reddish-brown layer may look solid, but it is actually composed of many thin layers of ash and rock all compacted together – something like caramel corn.

The rimrock came from a volcanic vent located under present-day Burns, Oregon. About 9.2 million years ago, a huge mass of hot gases, volcanic ashes, bits of pumice and other *pyroclastics* (fire-broken rock) violently erupted. The blast – greater than the May 18, 1980, eruption of Mt. St. Helens – deposited a layer of pyroclastics 30 to 130 feet thick over an area almost 7,000 square miles!

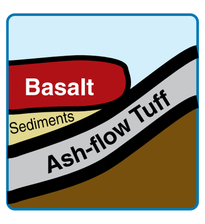

Twin Craters West dome at stops 8 and 9.

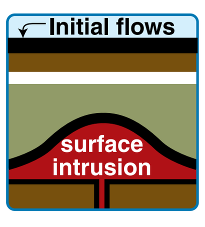
Pyroclastics are normal behavior for *magmas* (subsurface molten rocks) of *rhyolitic* (a volcanic material related to granite) composition. The *silica* (similar to Oregon beach sand) content is so high in the rhyolitic ash – 75 percent for the Devine Canyon Ash-flow Tuff – that the magma is very stiff and pasty. Great pressure builds within the volcano and eventually it explodes. When pressure doesn't build up, rhyolitic magma squeezes up, like toothpaste, building a bulbous, steep-sided *plug dome* over the vent.

If you want to look at Devine Canyon Ash-flow Tuff more closely, stop at the roadcut just before the junction (4.1 miles) where you turn left to Diamond Craters. The un-weathered rock is light gray.

3 (5.8 miles) Park on the rise at the right edge of the road, just past a junction coming from the east. You should be able to see the road to Diamond Craters disappearing in an S-shaped bend.

You are viewing the *contact* between the *Diamond Crater basalts* (dark lava flow, 10 o'clock) and the Devine Canyon Ash-flow Tuff (reddish-brown, 12 o'clock). If a hole were drilled through Diamond Craters basalts, it would probably hit lake sediments and Devine Canyon Ash-flow Tuff. Can you visualize the down-tilted layer extending under the lava flow?





How did Diamond Craters form? Sometime in the last 25,000 years (geologists are not sure just when), molten basalt spilled from deep cracks in the earth called *fissures*, then flooded in a thin layer over a relatively dry lake bed. Before the initial layer cooled completely, more basaltic magma injected underneath, creating six arching *structural domes.*

From here you can see two of the structural domes: **Graben Dome** (10:30 to 12 o'clock) and **South Dome** (9:30 to 10:30). Between here and the next stop, note the small bread-loaf shaped domes that are small-scale versions of the larger domes.

4 (1.2 miles) Park at the edge of the road where you can see lava flows to either side. You are looking at a scene of both quiet and explosive basaltic eruptions.

Lava flows, or streams of molten rock, at Diamond Craters contain an unusual diversity of features. Notice the wrinkled surface on the side of the *pressure ridges* (3 o'clock, close in). Imagine a runny, gaseous molten basalt flowing out in a thin layer, the crust chilling as the molten basalt remains red hot. The crust wrinkles – like the skin of a pudding – as the inside continues flowing. This is *pahoehoe lava*, noted for its smooth, wrinkled, ropy, or billowy surface.

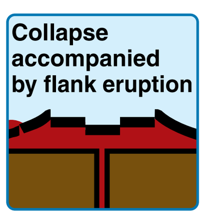
The **Lava Pit Crater**, (10 o'clock) is a shield volcano. The pahoehoe flows at Diamond Craters were highly fluid – the only flows fluid enough to develop *lava tubes, trenches, collapse craters* with and *without natural bridges, shield volcanoes, spatter cones and ramparts, kipukas, driblet spires* and many other features that you'll see later.

Lava flows are normal for the highly fluid (or thin and runny) basaltic magmas. The silica content is so low – it averages 49 percent for the Diamond Craters basalts – that the molten liquid floods all over the surface.

The game changes, however, when molten basalt and water mix. This happens either as the magma rises through water-soaked layers of earth or as the molten rock floods over the surface. The water changes to steam, powering the molten rock upwards with varying force – from quiet plops of spatter (small soft globs of molten basalt) to violent blasts of *tephra* (solid fragments ejected) thousands of feet high. All kinds of activity took place at Diamond Craters, creating an exceptional basaltic landscape.

More than two-thirds of Diamond Craters is blanketed under basaltic tephra blasted from vents within the six-mile wide "pancake." You can see tephra from here – it is the decomposing volcanic ash forming the soil under the sagebrush on South Dome (10 o'clock) and Graben Dome (12 o'clock). The tephra at Diamond Craters varies in size from volcanic ash to truck-sized blocks of rock.

Directly ahead against the sky is **Graben Dome** (10:30 to 2 o'clock). This may appear to be an ordinary hill but it really is a remarkable feature of Diamond Craters. As the initial basalt layer domed up, the rock stretched and fractured into long narrow blocks. The supporting magma erupted out to the sides of the dome through weak spots, forming flank flows. The summit blocks, without support, collapsed into a *graben*, a shoebox-shaped depression with open ends. This dome has a main graben, 100 feet deep, 7,000 feet long and 1,250 feet wide, and two smaller accessory grabens crossing the main graben at right angles. You can see the open end of an accessory graben (12:30) from here. At Stop Number 12, you will view a flank flow from Graben Dome.



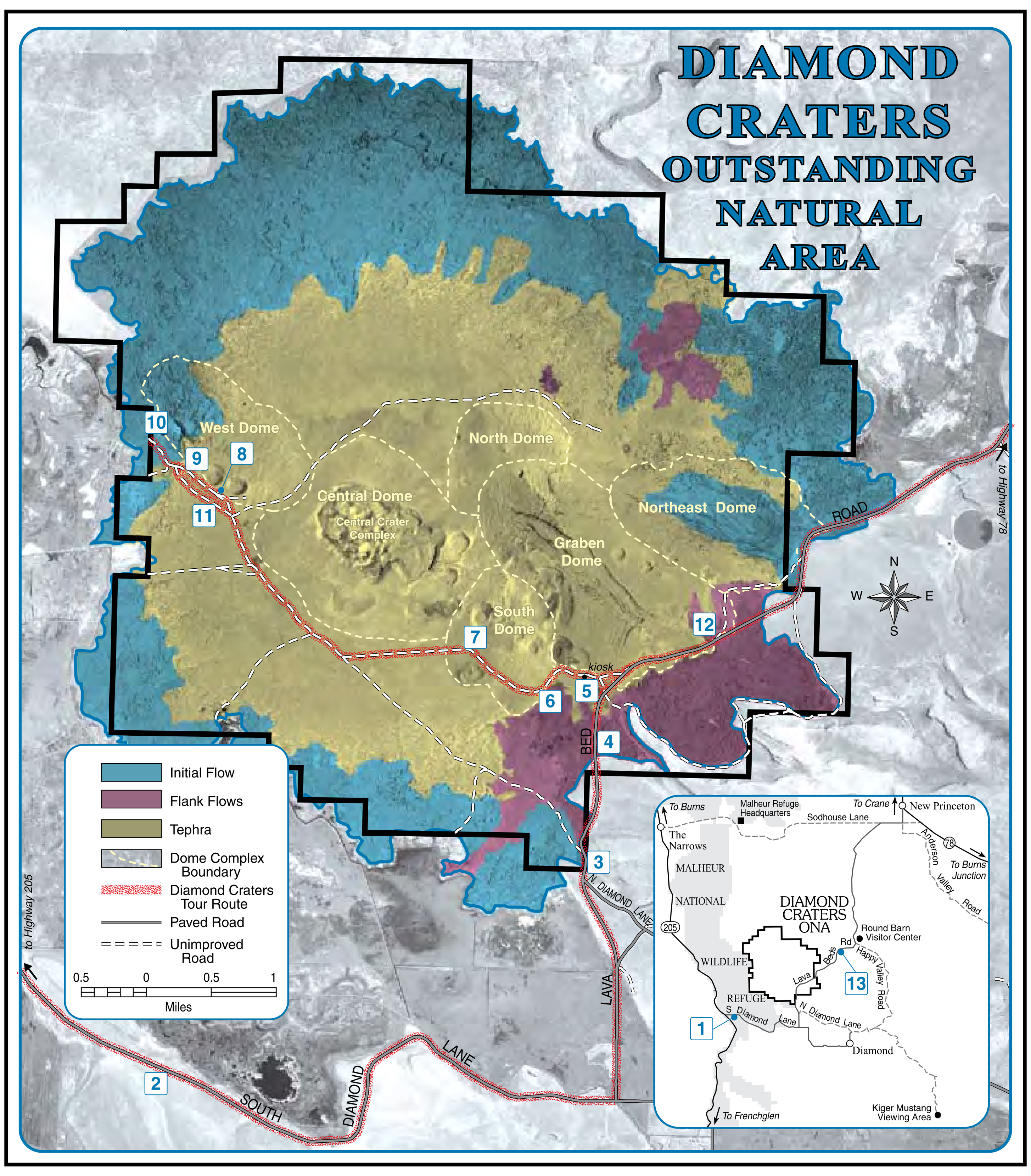
The weakened summit rock of South Dome (9 to 10:30) also collapsed, but irregularly as high pressure steam explosions blasted the supporting magma to the surface. From here, you can see three of the red cinder craters associated with South Dome: **Oval Crater** (10:30), partially visible at the skyline), **Keyhole Explosion Crater** (11 o'clock, base of domes) and **Big Bomb Crater** (12 o'clock, foreground). Red Bomb Crater, at Stop Number 7, is a fourth red cinder crater of South Dome.

As you travel to Big Bomb Crater (12 o'clock), you will cross a wall of Devine Canyon Ash-flow Tuff less than 0.1 miles from here. This wall is part of a kipuka, an island of older rock completely surrounded by younger lava flow. Continue on to the junction by Big Bomb Crater. Turn left.

5 (0.2 miles) Park immediately on the hard-packed cinder by **Big Bomb Crater**, a restored cinder pit. Here you can see *cored bombs*, which are marble-to-baseball-sized rocks. As the hot magma rises up through water-soaked layers, the water instantly changes to steam, causing magma to explode and hurl rock fragments in the air. The fragments fall back into the developing cinder cone and roll down into the vent. This is repeated several times as the fragments become coated with younger molten rock. Do you see any bombs with glassy cores? The glassy cores were analyzed and appeared to have re-melted 17,000 years ago, suggesting that this cinder cone is that old. Please do not break open or collect the bombs.

If you want to see the graben in Graben Dome, park here and hike up. Please, no vehicles. Even four-wheel drive vehicles will damage the area.

Continue westward. As you round Big Bomb Crater, at about 0.2 miles, you'll see the **Lava Pit Crater Flow** (10:30). Note that it resembles the rather flat shield of a Viking warrior.



6 (0.6 miles) Park in the small area by Lava Pit Crater at the top of the rise. Walk over to the crater. You are on a shield volcano. The word "volcano" refers both to the vent and to the hill, however low, formed around the vent.

Most first-time visitors to **Lava Pit Crater** assume that this crater was formed by a huge explosion. Not so! Instead, pit craters form as molten basalt repeatedly wells up at a vent and flows in channels and mini-lava tubes away from the vent and then subsides back into the layers. Still-molten lava at the vent subsides back into the vent leaving a pit. The lava may subside when it has degassed. The crater has enlarged as rocks have fallen away from the rim, burying the original floor under rock and dirt.

Stand on the high point of the western crater rim where you can see the lava flow with thick vegetation, just west of the Lava Pit Crater Flow. Now notice how barren the Lava Pit Crater Flow is. Which of the flows is older? It would be easy to assume the flow with the most plants is the oldest, but that is incorrect. The Lava Pit Crater Flow is older – it actually "lies under" the other flow. To prove this, walk down and follow the contact between the two flows to see which one is on top of the other. Be careful not to fall on the sharp lava. Please, no vehicles are allowed.

As you return to your vehicle, look closely at the dirt under the sagebrush and notice the weathering tephra. Between here and the next stop, Red Bomb Crater, you will be crossing South Dome, which is covered with tephra.

7 (0.5 miles) Red Bomb Crater. Pull into the short parking loop road. Avoid getting stuck by staying on the firmly packed surface. More than one vehicle has sunk to the hubs in this tephra.

While you stand on the crater rim and look toward the southern skyline, Steens mountain (7:30) rises nearly a mile above the Blitzen Valley. It is a west sloping fault block (6 to 9 o'clock) rising to an overall elevation of 9,773 feet above sea level.

Jackass Mountain (11 o'clock), reaching an elevation of 5,600 feet, is an east tilted fault block (9 to 11:30) of similar origin as Steens Mountain. About 16 million years ago, approximately 200 layers of *Steens Basalt* flooded out for miles from numerous vents. More recently, these layers fractured into elongated blocks that uplifted or down-dropped, forming basins and ranges. Deep under Diamond Craters there is probably Steens Basalt.

From here you get a good view of the stream-cut Devine Canyon Ash-flow Tuff that forms the uplands below the level of Steens Mountain. Closer in, you can see the southern parts of the Diamond Craters lava flows, mostly covered with tephra.

Red Bomb Crater, nearly 1,000 feet in diameter, formed as hot basaltic magma rose through the water-saturated layers beneath South Dome. The source of the water was run-off from Steens Mountain. The water changed to steam, generating a *confined steam explosion* (think of a hot water tank exploding). Magma and broken rock shot upward and rained down around the vent, forming the cinder, or more correctly, *scoria*, cone. Bombs and cinders stuck together forming the dark layers (11 o'clock). Volcanic activity resumed in a series of smaller explosive eruptions inside the big crater, forming the funnel-shaped craters. Which vent erupted last?

Now look at the bombs scattered along the parking loop road. You may see a *breadcrust bomb*. Cooling basaltic globs became airborne. The surface chilled as the inside gases, mostly steam, expanded. That caused the outside of the globs to crack, forming a breadcrust texture. Again, please leave the bombs in place.

Return to your vehicle and continue west. Along the skyline you can see **Ruptured Raven Ridge** (1 o'clock), part of the original domal arch of Central Dome.

Between Red Bomb Crater and East Twin Crater on West Dome, Stop Number 8, you will come upon several dead-end roads. Keep right on the main, well-traveled road until you come to three roads branching off at about 2.4 miles. **Take the middle branch**. You should be able to see two large craters in the side of West Dome. At about 2.6 miles, turn right on the short spur road to the first crater.

8 (2.7 miles) Park in the circular area just below the crater rim. This is **East Twin Crater**, an explosion crater of the *maar* type, literally a hole in the ground. A *maar* is a simple, circular depression surrounded by a low rim of ejected rock fragments. Imagine the large blocks of rock shooting through the air from this crater! Is there evidence that magma came to the surface in this explosion? Look at the dark red material at the eastern end of the rim – where did it come from and what is it? The original walls were steeper and the crater deeper. Gradually rocks broke loose, filling in the crater and enlarging its diameter.

9 (0.2 miles) Continue west, taking the first branch to the right. At 0.2 miles, you will see a short spur road going right to **West Twin Crater.** Looking at the crater, did magma surface in this explosion? Note the large blocks of rock in the sagebrush.

Again, as you travel toward Stop Number 10, you'll find a maze of dead-end roads branching off the main road. Stay on the main road until you come to a wide curve on a rise with a parking area on the north side of the road. The road ends about one-quarter of a mile farther at the boundary between Diamond Craters "Outstanding Natural Area" and the Malheur National Wildlife Refuge.

10 (0.5 miles) Park in the area on the rim of **Dry Maar**. This crater is a miniature "Hole in the Ground" similar to the gigantic one south of Bend, Oregon. Dry Maar may not seem too exciting until you realize that it and water-filled **Malheur Maar** (400 feet to the north) fit the original definition of a maar, which is "no magma surfacing during the explosion."

Here you get a good view of the exposed surface of West Dome. Unlike the other domes that you've seen, the summit of West Dome did not collapse or fracture. However, it is very interesting because six maar-type explosion craters did form. **Nolf Crater**, on the north of West Dome, is accessible only by hiking over the very rough terrain. **Multiple Explosion Crater** is about 600 feet north of here where you see the broken wall on West Dome.

Walk over to Malheur Maar and try to estimate how deep the water is. Thirty-two people took up the sediment—it was six feet. Under the spring-fed lake, there are about 50 feet of sediments which half fill the maar. The sediments have been studied and it was found that the Crater has contained water for 6,000 years. Pollen, plant debris, and layers of tephra accumulate rapidly in the lake, which is located at the boundary or *ecotone* between the sagebrush and the desert shrub communities. All of this makes Malheur Maar one of the most significant desert lakes between Mexico and Canada, especially for studies of past climates.

Turn around, and at 0.3 miles, take the right-hand road branch..

11 (0.7miles) Park at the edge of the road on the top of a rise where you can see the divide between Twin Craters at 9 o'clock. Here you get a good view of Central Dome (10 to 1 o'clock). Remember that Ruptured Raven Ridge (11 o'clock along the skyline) is part of the original domal arch.

You are looking into the **Central Crater Complex** (10:30 to 11:30) which is a *caldera*. A caldera is a depression similar to Crater Lake but without water. As the supporting magma under the Central Dome blasted out in explosive eruptions, the stretched summit rock collapsed into a caldera. The box-shaped depression with rounded ends is about one mile long, 3,500 feet wide and more than 200 feet deep. The Central Crater complex has more than 30 vents. In fact, the bumps you see are rims of funnel-shaped craters inside the caldera, similar to the craters at Red Bomb Crater. Near the end of the caldera is a moat inside the rim of the caldera.

Take a look at the dirt (tephra) under the sagebrush – it was blown out of the Central Crater Complex. Most of the tephra in Diamond Craters came from Central Dome. Even blocks of Devine Canyon Ash-flow Tuff surfaced from the bedrock beneath the Diamond Craters basalts. The sharp rocks in the road just before you arrive at South Dome are tephra from Central Dome.

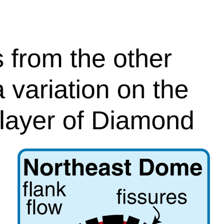
Continue east to Big Bomb crater (3.9 miles). Turn left, toward the French Round Barn. Note the eastern end of Graben Dome. The lava flows on the east side of the road are very complex – they are flank eruptions from Graben Dome. The geologists haven't even begun to figure out what exactly happened here.

12 (4.8 miles) Almost 1 mile north of Big Bomb Crater, turn into the first road to the left and park.

On either side of the road are flank flows from Graben Dome. Look at the shallow depression (8:30 to 10 o'clock), filled with spatter features. Observe the spatter ridge with the knob of spatter on top at 9 o'clock. Imagine a fire fountain powered by a very small amount of steam, showering spatter a few feet into the air. As the spatter falls back around the vent, it welds together into spatter *ramparts* or *walls* (around fissures) and spatter *rings* and *cones* (around circular vents).

Driblet spires, closely related to spatter features, sometimes form on pahoehoe flows as a gaseous spout develops, spitting thick globs of molten basalt a few feet into the air – like cream of wheat boiling – and plopping back down to stack up around the spout. On one flow or another, Diamond Craters contains almost every known variation of these features.

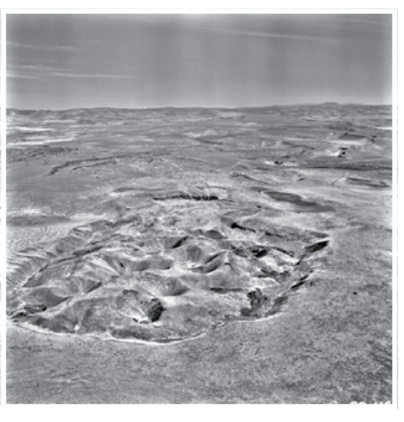
Northeast Dome (11 o'clock) differs from the other structural domes, even though it is a variation on the same theme. By the time the initial layer of Diamond Craters Basalt domed up, the layer was relatively cool and brittle. The summit rock fractured into numerous, nearly parallel, deep fissures – something like corn bread inflating and cracking as it bakes. Only a few of the fissures have been measured. One of them is 40 feet deep, eight feet wide, and nearly 250 feet long. As the supporting magma withdrew through flank eruptions on the northern and eastern sides, a small graben formed on the southeastern slope. You can see the far wall (11 to 12 O'clock) running parallel to the skyline.



Continue north on the country road and at 0.7 miles observe the spatter cones resulting from the flank eruptions. These features are on private property, so please don't cross the fence.

At 1.9 miles, you come to the edge or *toe* of the Diamond Craters flows. Devine Canyon Ash-flow Tuff can be seen on the hills to the right.

13 (3.8 miles) Pull off the road for a panoramic view of the northern half of Diamond Craters. Be safe and watch for traffic as this stop is on a hilltop.


Central Crater Complex at stop 11.

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For more information contact:

Bureau of Land Management
Burns District Office
28910 Highway 20 West
Hines, Oregon 97738
Phone: 541-573-4400
or visit us on the web:
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A Self-Guided Tour of:

Diamond Craters Oregon's Geologic Gem