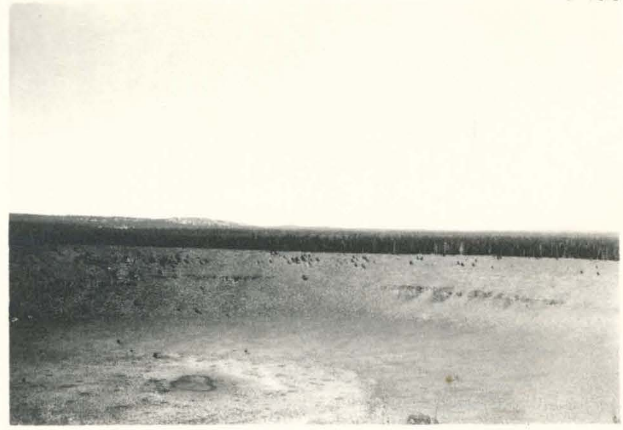
HOLE-IN-THE-GROUND

Lake County, Oregon



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* *

HOLE-IN-THE-GROUND, CENTRAL OREGON
Meteorite Crater or Volcanic Explosion?

by

Norman V. Peterson* and Edward A. Groh**

Lewis McArthur, in Oregon Geographic Names, has described Hole-in-the-Ground as follows: "Hole-in-the-Ground, Lake County. This very remarkable place is well described by its name. It covers an area of about a quarter of a square mile, and its floor is over 300 feet below the surrounding land level. It is about eight miles northwest of Fort Rock."

Hole-in-the-Ground is a large, almost circular, bowl-shaped crater in the northwest corner of Lake County. It has a slightly elevated rim and looks very much like the famous Meteorite Crater in north-central Arizona. This remarkable resemblance and the lack of an explanation of the origin in the published literature was brought to the attention of the department by Groh and is the basis for the present study.

The original plans for the study included only Hole-in-the-Ground and the nearby larger, shallower crater, Big Hole, but very soon after arriving in the area the writers noticed other interesting volcanic features of explosion origin. These features, shown on the index map (figure 1), include Fort Rock, Moffit Butte,

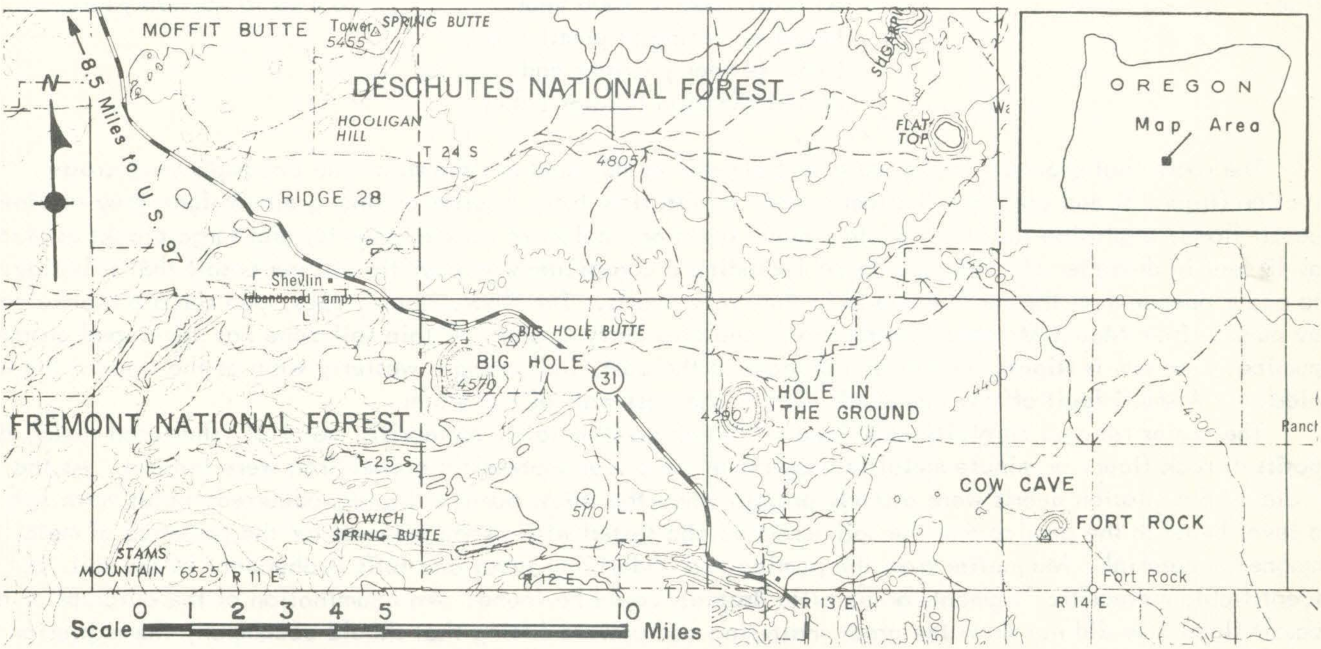

Figure 1. Index map of the Hole-in-the-Ground area, central Oregon.

- -

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Flat Top, and several unnamed landforms north and west of Hole-in-the-Ground. All were examined and are described briefly in later paragraphs.

After a reconnaissance of the geology of the whole area was made, two days were spent studying the rocks in the walls and rim of the Hole-in-the-Ground crater and searching for evidences of meteoritic material.

Hole-in-the-Ground

Hole-in-the-Ground (figure 2) is in sec. 13, T. 25 S., R. 13 E., in the extreme northwestern corner of Lake County. It can be reached by turning east from Oregon Highway 31 on a well-marked Forest Service road 25 miles southeast of the junction with U.S. Highway 97 near Lapine, Oregon.

The depression or crater has many of the characteristics of a meteorite crater. It is almost circular with steep walls sloping to a flat floor that is about 425 feet below a raised rim. The highest point on the rim is at an elevation of 4800 feet, about 500 feet above the floor of the crater.

The resemblance between Hole-in-the-Ground and the Arizona meteorite crater is shown by the following comparison:

	"Hole-in-the-Ground"	"Meteorite Crater"
Diameter	5000'	4000'
Depth (crest of rim to crater floor)	425'	613'
Height of rim above surrounding plain	100' to 200'	148' to 223'
Rim slope to plain	about 5°	3° - 5° ($\frac{1}{2}$ mile)
Rock in walls	Basalt, ash flow, tuff, and explosion debris	Limestone and sandstone
Age	At least 2000 to 9000 years, based on dating of pumice falls from Newberry Crater and Mount Mazama (Crater Lake).	20,000 to 75,000 years.

The rocks that crop out in the walls of Hole-in-the-Ground are shown on the accompanying cross-section (figure 3) and are, from bottom to top, an ash flow tuff, a series of fine-grained light-gray olivine basalt flows, explosion tuffs that contain many types and colors of rock fragments, and large blocks as much as 10 feet in diameter of explosion debris including a conspicuous porphyritic olivine basalt that is believed to occur deeper than the rocks exposed in the crater walls. The floor, steep slopes, and rim are blanketed by pumice from Mount Mazama (Crater Lake) and Newberry Crater. A thin soil zone has developed on the pumice. The rim is slightly higher and broader to the east, indicating a westerly wind at the time of the explosion. A small fault offsets the basalt flow in the east wall of the crater.

The crater rim was carefully examined to determine if metallic meteoritic material, shattered rocks, deposits of rock flour, or minute metallic droplets of vaporized meteoritic nickel-iron were present. As the crater and explosion debris were already present when the latest pumice showers occurred, holes were dug to a level beneath the pumice and the soil screened and tested with strong magnets for the presence of metallic magnetic material. Magnetite from the pumice and underlying lavas and tuffs is abundant in the soil, but no identifiable meteoritic fragments or metallic droplets could be found. An examination of the outcrops of the basalt flows also did not show the great shattering and upward tilting that should accompany the explosion of a large meteorite.

It is almost certain that, if this crater were the result of a meteoritic impact explosion, fragments of nickel-iron and metallic droplets or their oxidized products would be present in abundance on and around the rim, as is the case at the Arizona Meteorite Crater. This should be true even for a stony meteorite, because they generally contain several percent of nickel-iron in metallic form. It is very doubtful if a large stony meteorite could survive passage through the atmosphere to produce a crater of this size; rather, the sudden

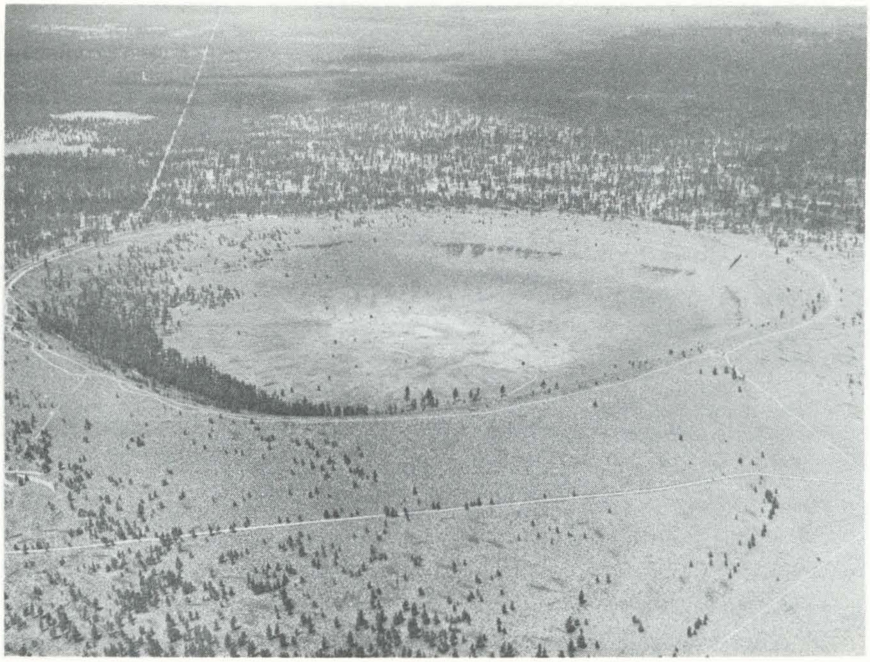

Figure 2. Aerial view of the Hole-in-the-Ground looking to the northwest. Road in foreground leads from Oregon Highway 31 to east rim viewpoint. Basalt flow visible in far wall of crater. White spot is small playa at bottom of crater. East rim viewpoint is about 500 feet vertically above this playa.

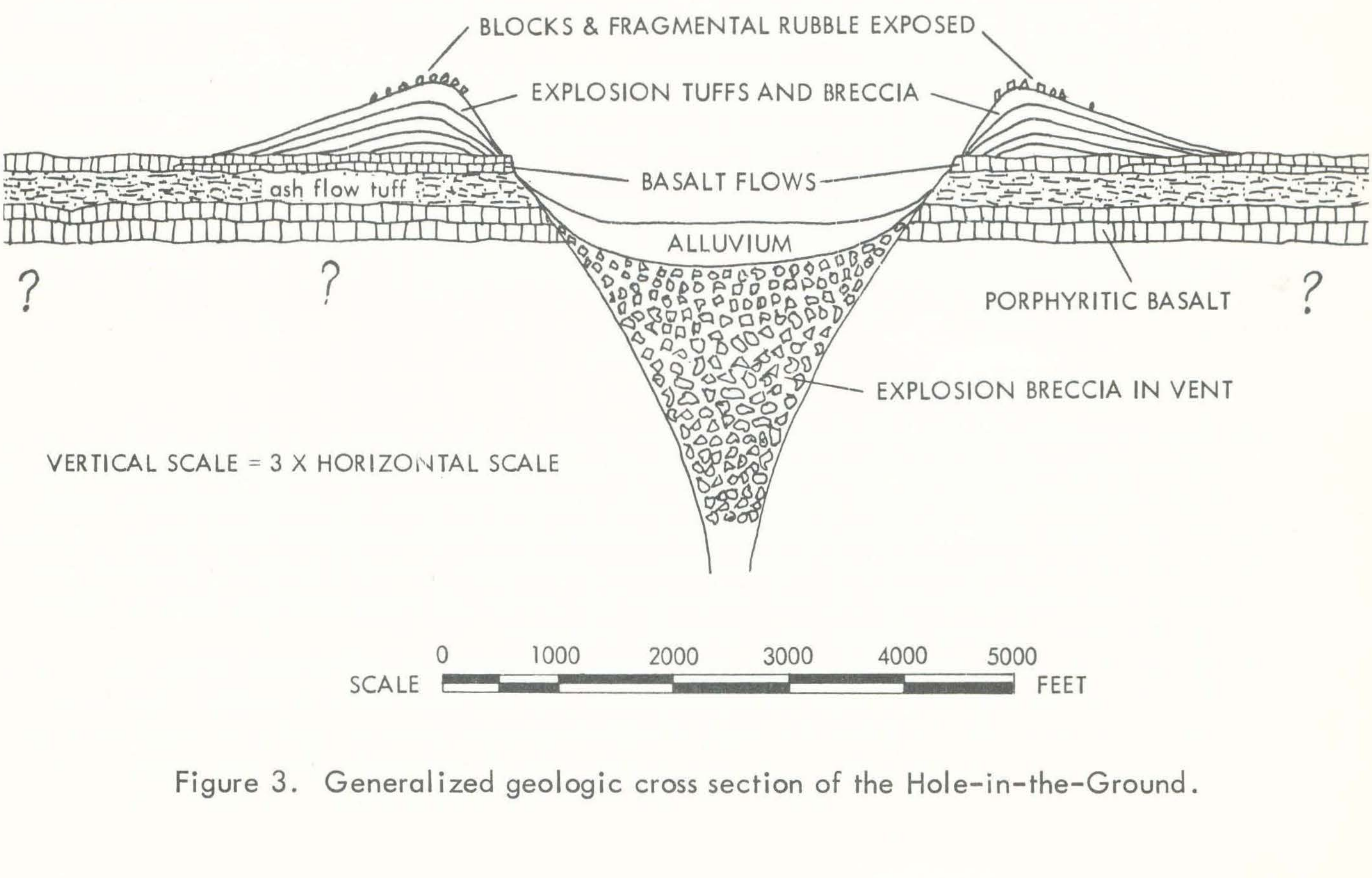

Figure 3. Generalized geologic cross section of the Hole-in-the-Ground.

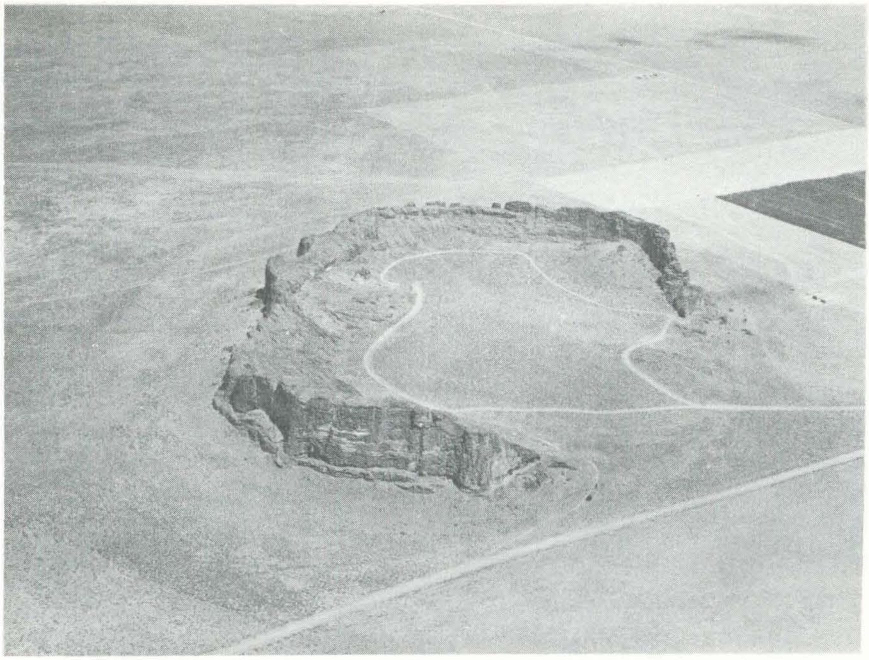

Figure 4. Aerial view of Fort Rock looking to the northeast. Differential weathering has accentuated bedding in nearest wall. This wall is a sheer cliff about 200 feet high and more than 300 feet above the plain. Pleistocene lake terraces have been cut into both ends of "horseshoe".

heat and pressure evolved upon encountering the denser air mass would cause the meteorite to break into many fragments. Only small craters or pits would result when these struck the earth.

In the absence of any positive evidence for its formation by meteorite impact, the location of the crater in an area of known recent volcanic activity and the many associated volcanic features point to an abrupt volcanic explosive origin for the Hole-in-the-Ground.

It is believed that Hole-in-the-Ground resulted from a single or a very brief series of violent explosions caused when rising magma suddenly came in contact with water-saturated rock. The source of the water could have been the extensive lake that once existed in Fort Rock Valley. The explosion blew out large quantities of older rocks, together with pyroclastic material, and formed an embryonic tuff ring. Apparently the magma withdrew after this brief activity and did not continue or return to eject additional pyroclastic material in the quantity for the formation of a large tuff ring. A detailed description of this process is given in the discussion of Big Hole, a similar but more fully developed feature.

Big Hole

This large depression, as shown on the index map, is in secs. 5, 6, 7, and 8, T. 25 S., R. 12 E. It is a broad shallow crater with walls and rim made up of dark-gray and brown lapilli explosion tuffs and breccias. These rocks dip outward from the center of the crater. The rims are not quite as well defined as at Hole-in-the-Ground and a heavy stand of timber within and around the crater makes detail difficult to see. Big Hole, however, is a much better developed tuff ring than Hole-in-the-Ground in that a greater volume of pyroclastic debris has accumulated around the rim. Although both craters are young geologic features, Big Hole appears to be the older. In other respects the two craters are alike.

The Big Hole tuff ring is very similar to the well-known Diamond Head tuff ring on Oahu, one of the Hawaiian Islands. A tuff ring or tuff cone is a broad-floored ring-enclosed volcanic crater. Such features typically have steep inner walls that show the edges of both inward and outward dipping layers of explosion tuffs and breccias. The ejected fragments have been dropped directly into place after being hurled high into the air. (The tuffs and breccias are composed of consolidated heterogeneous mixtures of vitric material from the parent magma and fragments of previously formed rocks.) Good —

There is a very definite association of tuff rings with water, and they are believed to occur where intrusive magmas have come into contact with water-saturated rocks at shallow depths. Tuff rings are thought to be formed in a very short period of time (a few days to a few months) by a rapid series of explosions that eject fine ash and rock fragments high into the air. Each explosion is followed by slumping of the crater walls and rock falling directly back into the crater to form a plug; then water rushing into the crater furnishes the steam for another explosion. Crude gravity sorting of the particles that are dropped directly into place accounts for the distinct layered structure of the tuff rings.

Big Hole, Hole-in-the-Ground, and the other tuff ring features in the area may have been formed as far back as Pliocene time, but more likely during the Pleistocene or even Recent epochs when large pluvial lakes occupied valleys formed by block faulting. At the time these lakes existed there was sufficient ground water in the area to affect the intruding magma in the manner that has been described.

Eroded Remnants of Other Tuff Rings

Fort Rock

In Oregon Geographic Names, Lewis McArthur described Fort Rock as follows: "The rock is an isolated mass, imperfectly crescent shaped, nearly one-third of a mile across and its highest point is about 325 feet above the floor of the plain on which it stands. It has perpendicular cliffs 200 feet high in places."

A brief inspection of this striking, well-known landmark (figure 4) in the broad Fort Rock Valley shows that it is an isolated erosional remnant of what was once a much larger tuff ring. The yellowish and brown tuffs with a variety of dark to light colored volcanic fragments are similar to the explosion tuffs at Big Hole.

A detailed study of the attitudes of the tuff layers would probably show whether or not the eroded central part of Fort Rock is actually the crater from which the tuff has been ejected. In general, the thin layers of airborne tuffs dip to the southeast and this would seem to put the center of volcanism to the northwest outside the present confines of Fort Rock. Similar layered explosion tuffs are known to occur beneath the soil zone a mile to the north.

The unusual shape of Fort Rock does not seem to be the direct result of its original volcanic form; rather it is more likely the result of later erosion by wave action in a large pluvial lake, as shown by terraces cut into the southern end of the horseshoe-shaped walls. Hole-in-the-Ground and Big Hole, on the other hand, were unaffected by wave erosion as they lay at an elevation above the level of the lake.

Moffit Butte

Moffit Butte is a bold erosional feature just to the north of State Highway 31 in sec. 7, T. 24 S., R. 11 E., about 10 miles southeast of Lapine. The steep cliffs and badlands type of erosional landforms can be seen from the highway.

The cluster of ridges and hills that makes up the butte appears to be composed of the remnants of one or more tuff rings. Thin to thick layers of yellowish to brown lithic explosion tuffs and tuff breccias occur in a roughly circular to elliptical pattern with the dips of the beds or layers toward the center. There is enough variation in the attitudes at different places so that this may be a cluster of tuff rings superimposed on one another.

Near the highway at the southern edge of the butte there is a small area capped by a thin, cindery, reddish-black basalt flow. A narrow dike or pipe-like mass that is probably the source of the flow cuts the tuffs nearby.

Ridge 28

This unnamed northeast-trending, low ridge in sec. 28, T. 24 S., R. 11 E., is also made up of yellow-brown lithic explosion tuffs that dip to the northwest, south, and southeast. This landform is also believed to be only an erosional remnant of a once larger tuff ring.

Flat Top

The eroded edges of the layered explosion tuffs are present as far north as Flat Top in secs. 13 and 14, T. 24 S., R. 14 E. Here again the lithic explosion tuffs have variable attitudes. Unlike most of the other features described, this one is capped by a thin flow of basalt. This basalt probably filled a shallow broad crater soon after the explosive phase that was responsible for the layered tuffs and overflowed to the northwest. This basalt and the eroded tuffs are surrounded by Recent younger vesicular basalt flows in which original flow features like pressure ridges, lava tubes, and ropy crusts can still be seen.

Niggers Heel and Toe Butte (Cow Cave, Fort Rock Cave)

This small butte about 1½ miles west of Fort Rock is famous as the cave where some of the oldest Indian artifacts from Oregon were found. Sandals woven from shredded sagebrush bark were discovered beneath a layer of pumice that had exploded from Newberry Crater. Dating by the carbon-14 method shows that the sandals were made at least 9000 years ago.

The butte is made up of a variety of pyroclastic and flow rocks. The western part in which the cave (known locally as the Cow Cave) occurs is made up of reddish scoria fragments that are rather loosely cemented. The eastern part of the butte is capped by a thick reddish to black basalt flow that forms a steep cliff with large blocks at its base.

The waves from the large lake that once occupied Fort Rock Valley eroded the cave in the loosely cemented scoriaceous material of this butte, at the same time cutting the terraces at Fort Rock.

Summary

Hole-in-the-Ground remains a unique topographic feature of Oregon for its marked similarity to a meteorite crater, though its origin is volcanic. The meteorite crater of Arizona was produced by the explosion of an iron meteorite, estimated to have weighed between 20,000 and 60,000 tons, upon impact with the earth. The release of the colossal kinetic energy of a body this size, travelling at an estimated speed of around 10 miles per second at impact, blasted out the crater. For Hole-in-the-Ground the energy came from hot magma making contact with water or water-bearing rock, forming suddenly enormous steam and gas pressure which punched its way through the overlying rock to the surface in one or two bursts. The explosive energy needed to produce a crater this size with a buried nuclear charge would be over 5,000,000 tons, TNT equivalent, on the basis of a similar estimate for the Arizona meteorite crater. Thus can be realized the tremendous energy contained in volcanic forces that produced the Hole-in-the-Ground and the other volcanic explosion features described previously.

The volcanism producing the landforms described in this article was but a small part of the activity going on in the region to the north at Newberry Crater and to the west in the High Cascades during the Pleistocene and Recent epochs. Much of this volcanism was the relatively quiet outpouring of fluid lavas, yet at the same time explosive activity ejected gigantic amounts of pyroclastics. The pumice falls of Mt. Mazama (Crater Lake) and Newberry Crater bear witness of this as two examples in Recent time alone.

Further study of this area will probably reveal more of these tuff cones or their eroded remnants. Doubtless others remain hidden, having been covered by later volcanic flows and lake sediments.

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* * * * *

~~Fenner Hudson~~

Description of Fort Rock tuffs by Waring – USGS WSP 220

"Fort Rock --- an isolated mass in the northwestern part of the Christmas Lake Valley, is the most prominent of these remnants. It is imperfectly crescent-shaped, nearly 1/3 mile across, and rises ~~ts~~ in its highest part 325 feet above the valley floor, with perpendicular cliffs 200 feet above its talus slopes. The tuff of which it is composed is a tawney, rather firmly cemented material, consisting of fragments of effusive rocks and volcanic cinder. This material is largely used in the western part of the county for building purposes being soft when first quarried and easily cut into blocks that harden on exposure, and as it is used especially for chimneys it is locally known as "chimney rock."

"Volcanoes have many habits not subject to mathematical analysis" Stearns, Vasvik.

Hollis M Dole, Director

Hack in his study of the ~~Hopi~~ Buttes Diatremes states that the structure of diatreme fillings indicate that subsidence occurred after eruption.

Volcanic action was violently explosive and extrusion of lava was limited to small mushroom shaped domes around the numerous diatremes.

At Hopi Buttes (Crazy Water Spring) 5 diatremes exposed. some overlap and truncate each other

Serrated — saw

glassy ash & lapilli

Leadership

Features in the Pinacate Volcanic field of Sonora, Mexico are called calderas by Johns. He also describes one as a diatreme.
Northwest to west trending arc about 20 mile long

Johns called similar features in the Pinacates miniature calderas, and he attributes the foundering of these tuff ~~cone~~ -breccia cones to the elimination of magmatic support at depth.

Johns interpreted the sequence of events leading to the Pinicate Craters to be :—

Development of a diatreme through explosive drilling of a vent in the rocks overlying a chamber of partly crystallized magma. With reduction in confining pressure the magma began to vesiculate briskly, to rise in the vent, and to "flash off" its dissolved volatile constituents with increasing violence as it rose. At the surface a cone grew rapidly in response to repeated contributions of juvenile crystals, pellet of ~~~~ lava, and abundant basaltic froth, along with numerous fragments of older rocks torn from the walls of the conduit. This ultra-vesiculation of basaltic magma was truly catastrophic, and marked the end of positive volcanic action at each locality. Rapid evacuation of the magma reservoirs effectively removed support from beneath the cones and the platforms on which they were built, and subsequent foundering was inevitable.

Johns also suggests ~~implies~~ that abundant groundwater may have been responsible for the initial steam explosions

Age - upper Pleistocene

William Howell

GSA Bull. vol. 71 - Shoemaker + Chas. - Origin of the Rio Basin,

Generalized - Hypothesis of diatreme evolution - Shoemaker - Hopi Buttes.

Initial phase of nearly all volcanic activity in the Navajo-Hopi Buttes region was probably the explosive drilling of a vent. These vents were ~~[illegible]~~ limited width and may have merged laterally or downward with dikes or may have been entirely unassociated with dikes. In general they were filled with a quiet upwelling of lava, which in some vents reached the surface and poured out in considerable volume. If the volcanic process ended here

gradual and progressive subsidence — continuous over a long period of time demonstrated by a complex sedimentary history. depression created at surface filled with sediments - funnel shaped orifice enlarged by inward collapse of the vent - Sediments sucked downward and compressed in the narrowing orifice - large blocks derived from collapsing walls incorporated in the diatreme filling.

Composition of rocks at Hopi Buttes -

Alkalic basalts — monchiquite and minette
high concentrations of water titania, and phosphate

$86,000 Tons

It is believed that Hole-in-the-Ground resulted from a single or a very brief series of violent explosions caused when rising magma suddenly came into contact with water-saturated rocks. The explosion ejected large quantities of older rocks together with pyroclastic material, and formed ~~an embryonic maar tuff~~ a maar or dry maar ring. Apparently the magma withdrew after this brief activity and did not continue ~~or~~ return to eject additional pyroclastic material ~~in the quantity for the formation of a large tuff ring.~~ or to come ~~into the crater to form~~ up and fill the crater with lava. ~~A detailed description of this process is given in the discussion of Big Hole, a similar but more fully developed feature.~~

E.M. Shoemaker describe another ~~mett~~ way that maars are probably formed where the eruptive magma is an alkali basalt that is characteristically rich in water and other volatiles.

The magma ascends along preexisting fractures or new fractures propagated by the intruding magma. Exsolution or boiling begins at a level where rock pressure equal partial vapor pressure of magma.

Fracture opens gases begin to move at appreciable velocity, decompression allows boiling at lower level in magma column, materials are accelerated upward, spalling of walls increases with rock fragments entrained in rising gases. Spalling at depth will be sudden & violent but near the surface slumping gentler occurs. ~~The vent is~~

By this rather simplified explanation the vent is cored.) The magma column would boil periodically as it reached a critical level and act much the same as a geyser. This would result in crude bedding from gravity sorting as the ejected rock fragments fall into place from high in the air.

ABSTRACT

Peterson, Norman V., Department of Geology and Mineral Industries, Grants Pass, Oregon, and Groh, Edward A., Portland, Oregon: Hole-in-the-Ground and associated tuff rings or maars in Central Oregon.

Meteorite impact craters and maar type volcanic craters look so much alike that they are very often confused with one another. Hole-in-the-Ground, a conspicuous, almost undissected crater, in northwest Lake County, Oregon, strikingly resembles the famous Meteor Crater in north-central Arizona. A careful examination of Hole-in-the-Ground showed no evidence of meteoritic material or shattered and upturned wallrocks, but did show typical features of a maar type volcanic crater. Nearby Big Hole is larger, shallower, and has a greater volume of ejecta in its rim. It is very similar to the Diamond Head tuff ring on Oahu in the Hawaiian Islands.

During a reconnaissance of the area surrounding Hole-in-the-Ground many partly to almost completely dissected tuff ring features including Fort Rock were found, indicating that violent short lived volcanic activity has been widespread in Central Oregon.

STATE DEPARTMENT OF GEOLOGY
AND MINERAL INDUSTRIES

1069 STATE OFFICE BUILDING
PORTLAND 1, OREGON

June 15, 1961

Sample submitted by Ed Groh (DOGAMI)

Analysis by: 7 Oh

Sample received on

Analysis requested

Lab. No.	Sample Marked	Results of Analysis	Remarks
P-26544	#1	Nickel - .01%, cobalt - nil	Sample #S-3, #S-5, and #S-6 were ruined during analysis, so the results are missing. Sorry - 7 Oh
P-26545	#2	Nickel - Trace, cobalt - nil	
P-26546	#3	Nickel - Trace	
P-26547	#4	Nickel - Trace	
P-26548	#5	Nickel - Trace	
P-26549	#S-1	Nickel - .01%, cobalt - nil	
P-26552	#S-4	Nickel - .01%, cobalt - nil	

#1 - Soil sample from rim - Twelve Mile Cr. crater - 1/4 mi from center

#2 - Same - 1/2 mi. from center of crater

#3 - " - 5/8 mi. " " " "

#4 - " - 1 mi. " " " "

#5 - " - 1 3/4 mi. " " " "

#S-1 - Anthill on S. rim - magnetics

#S-4 - Anthill on E. rim - magnetics

The Department did not participate in the taking of this sample and assumes responsibility only for the analytical results.

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DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1069 STATE OFFICE BUILDING
PORTLAND 1

Date June 15, 1961

Field Laboratory Number S-2

Name DOGAMI

General Laboratory Number P-26550

Address

Spectrographic Laboratory Number

City

QUALITATIVE SPECTROGRAPHIC ANALYSIS
(Quantities estimated to nearest power of ten)

Ed Groh

S-2

Iron fragments from road on S. rim of Hole-in-the-Ground (Bull-dozerite)

1. Elements present in concentrations over 10%

Iron

2. Elements present in concentrations 10% to 1%

Silicon

3. Elements present in concentrations 1% to 0.1%

Aluminum, manganese

4. Elements present in concentrations 0.1% to .01%

Sodium, tin, chromium, nickel

5. Elements present in concentrations .01% to .001%

Magnesium, calcium, titanium, vanadium, copper, cobalt

6. Elements present in concentrations below .001%

- - - - - - -

Radioactivity Nil

Mercury Nil

Thomas C. Matthews, Spectroscopist

From--J. T. HACK "VOLCANISM IN THE HOPI BUTTES, ARIZONA"

This period of sedimentation was accompanied by volcanic activity. Magma penetrated the earth's crust beneath the area in a complicated system of fissures. As the rising magma neared or reached the surface its extrusion was accompanied by violent explosions which produced numerous, funnel-shaped diatremes. The craters of the diatremes were partially filled soon after the explosions by the rising magma or by a basalt. Many of them had a crater rim at the surface and contained pools of water which allowed fine ash, gypsum, and other materials to collect. Eventually many of the craters which had not overflowed with lava or agglomerate were filled and buried by coarse sandy basaltic tuff, carried by aggrading steams.

Bulletin of the Geological Society of America
Volume 53. Number 2 February, 1942

Spec. on material from Looney Crater.

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PORTLAND 1

Date September 26, 1961

Field Laboratory Number ______ Name DOGAMI

General Laboratory Number P-26948 Address N. V. Peterson

Spectrographic Laboratory Number ______ City ______

QUALITATIVE SPECTROGRAPHIC ANALYSIS
(Quantities estimated to nearest power of ten)

Magnetite from above and west of reported crater

1. Elements present in concentrations over 10%

   Silicon, iron

2. Elements present in concentrations 10% to 1%

   Aluminum, magnesium, calcium, sodium

3. Elements present in concentrations 1% to 0.1%

   Manganese, titanium

4. Elements present in concentrations 0.1% to .01%

   Lead, chromium, vanadium

5. Elements present in concentrations .01% to .001%

   Copper, nickel

6. Elements present in concentrations below .001%

   - - - - - - -

Radioactivity Nil

Mercury Nil

T. C. Matthews

Thomas C. Matthews, Spectroscopist

Specs. from Looney Crater, or materials

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Date September 26, 1961

Field Laboratory Number ____________

Name DOGAMI

General Laboratory Number P-26947

Address N. V. Peterson

Spectrographic Laboratory Number ____________

City ____________

QUALITATIVE SPECTROGRAPHIC ANALYSIS
(Quantities estimated to nearest power of ten)

From hole dug 30' deep in loose slide formation.

1. Elements present in concentrations over 10%

   Silicon

2. Elements present in concentrations 10% to 1%

   Aluminum, iron, magnesium, sodium

3. Elements present in concentrations 1% to 0.1%

   Manganese, titanium

4. Elements present in concentrations 0.1% to .01%

   Calcium, copper

5. Elements present in concentrations .01% to .001%

   Chromium, vanadium

6. Elements present in concentrations below .001%

   Nickel

Radioactivity Nil

Mercury Nil

T. C. Matthews

Thomas C. Matthews, Spectroscopist

CHARACTERISTICS OF METEORITE CRATERS

1. Tend to be circular or moderately elliptical.
2. Bottom of the pit is always considerably lower than the general level of the surrounding terrain.
3. The pit is always surrounded by a prominent collar or uplifted rim covered with ejected rock fragments.
4. Strata in the rim dip radially away from vertical axis of crater.
5. No evidence of lava extrusion from the crater in any known examples.
6. Fragments of slaggy and vesicular glass derived from fusion of rock by meteorite impact. These may contain droplets of nickel-iron.
7. Presence of meteorite fragments on rim and surrounding area about crater.
8. Rock fragments of rim may show shattering and crushing.
9. Presence of "rock flour", pulverised rock consisting of sharp angular grains, in rim and pit.
10. Metallic spheroids present in soil about the crater and recoverable by magnetic methods. Spheroids contain nickel and cobalt.
11. Siliceous glass or crushed rock containing coesite (high pressure polymorph of quartz).

SOME CHARACTERISTICS OF DIATREMES

1. Their walls flare widely, indicating a funnel-shape and a narrowing downward.
2. Usually filled with basaltic tuff, or with lava and agglomerate.
3. Some contain gypsum, travertine, or silica. These minerals indicate circulating waters, possibly of hydrothermal origin.
4. Bedding of intruded rocks has not been disturbed.
5. Filling of many diatremes has subsided as shown by steep dips inward of the filling.
6. Many diatremes connect with dikes, or are with other diatremes aligned in long rows.

Diatremes are probably deeply dissected tuff ~~craters~~ cones or tuff rings. The narrow throats which are exposed by erosion containing material that has fallen back into the vents after the short-lived explosive phase.

State of Oregon
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1069 State Office Building
Portland 1, Oregon

May 9, 1961

TO: Norm Peterson

FROM: June Roberts

At the request of Ed Groh I am sending you, under separate cover, two additional aerial photographs of Hole-in-the-Ground.

June

jr