CRATER LAKE NATIONAL PARK--GEOLOGY SYNOPSIS

General Volcanology

Technically, a volcano is a vent or chimney connected to a reservoir of molten material, a magma chamber, within the earth's crust.

Ejected material usually accumulates around the opening, the vent, to build a cone, or "volcanic edifice."

As popularly used, the term volcano includes both the vent and accumulated materials.

Origin of Volcanoes - Basic considerations

1. Temperature of the earth's crust increases with depth. Rate of increase varies with locality and depth, varying from 86° to 122° F per mile. At great depths, the rate of increase diminishes.

2. Forty miles below the surface, the temperature is probably close to 2,200° F.

3. At 2,200° F., most materials liquify. Earthquakes, however, demonstrate the solidity of such material.

4. The material remains solid or semi-solid due to the tremendous pressure of overlying rock.

5. Magma usually collects at various levels within the crust, to displace and/or incorporate the surrounding rock, and form a reservoir, the feeding chamber. These pockets of molten material near the surface may be formed by:

   A. Reduction of pressure, typically occurring in volcanic mountain belts.

   B. Increase of temperature, usually caused by reduction of pressure and by radioactive breakdown of elements - such as uranium, thorium, and/or earth movements along faults in the crust.

   C. Combination of A and B.

6. Once magma forms near the crust surface, it tends to rise, or to be forced to the surface by self-contained gases.

7. A variety of eruptions may occur:

   A. Magma, under low pressure, may erupt from swarms of fissures, to spread as floods of basaltic lava (such as the Columbia Basalt Plateau).

   B. Less viscous lavas may build giant shield volcanoes, such as Kilauea in Hawaii.

   C. Magma, under high pressure may erupt explosively to form steep-sided volcanoes.

8. A volcano may eject various types of material. Variation in materials ejected occur because components separate in the magma chamber. As magma cools, the first minerals to crystalize are poor in silica and rich in iron, calcium, and magnesium. As cooling progresses, minerals richer in silica and potassium develop. Heavier crystals, rich in iron, magnesium and calcium sink toward the bottom of the reservoir and leave the lighter, silica-rich residual liquid on top.

   Eruptions may occur at any stage in the cooling process, and fissures may tap any level of the feeding chamber.

9. A major effect of crystallization within the magma chamber is an increase in concentration of gas within the remaining liquid. Ultimately, the gas pressure becomes too great for the reservoir roof to withstand. Gas then, becomes the driving force within a volcano.

   Initial eruptions or explosions, whether gas, magma, or a combination of the two, reduce the pressure, allowing more gas to separate from the liquid. In tnis manner, eruptions become self-sustaining.

The Product of Volcanoes

The principle gas, steam, is generally more than 95% of the total discharge, seldom less than 82%.

Carbon dioxide is the second most common gas.

Sulfurous gases such as sulfuric acid, H_2SO_4, create the characteristic odor of volcanoes. However, less is released than of H_2O and CO_2.

Gases released in minor amounts include hydrogen, ammonium chloride, and carbon monoxide.

Fragmented or pyroclastic products are named according to size, texture and composition of materials.

Fine-sized materials, smaller than peas, include dust and ash, which, when compacted to rock, form volcanic tuff.

Fragmental material between pea and walnut size is termed lapilli.

Material larger than walnut size is termed block. Blocks compacted to rock form volcanic breccia.

Volcanic bombs are almond shaped, with twisted "ropes" of lava and cooling cracks. These form as large blobs of molten or semi-solid lava solidify while falling through the air. Bombs compacted into rock with other large, round ejecta form agglomerates.

Highly visiculer, frothy, light colored ejecta, with low enough density to float on water, is termed pumice. Pumice is generally quite siliceous in composition.

Highly visiculer, frothy, dark colored ejecta, less siliceous than pumice, and more dense, is termed scoria.

The laymen's term, cinders, is used to include all fragmental material between ash and block in size.

Lava is the general term for all volcanic material above ground, whether liquid or solid.

Lava character is determined by checmical composition, gas content, magma temperature, and environment where extruded.

Lavas are classified according to composition and textual character, such as percentage and size of gas cavities, amount of crystallization, and selective size of crystals. Composition, the primary criteria for classification, determines most characteristics of the flows. Lavas poor in silica and rich in calcium, iron, and magnesium, the basalts, are more fluid than lavas with the reversed composition, the rhyolites and dacites. The basaltic lavas usually move greater distances and at greater speeds, to form thin layers, than the rhyolitic or dacitic lavas, which are pasty and sluggish. Basaltic lavas are generally 1,800° to 2,200° F. Siliceous lavas are generally 1,100° to 1,550° F.

Andesitic lavas are intermediate in composition and other characteristics.

Occasionally, rhyolitic and dacitic lavas cool to form volcanic glass, obsidian.

Surface flows of lava are usually termed Pahoehoe if appearing ropy or as cordlike corregations; Aa if appearing rough, clinkery or blocky.

Pillow lavas are formed whenever lava flows into water, and rapidly cools.

Forms of Volcanoes

Composite cones are formed of alternate layers of lava flows and fragmental material, from both effusive and violent eruptions. Examples - Mt. Shasta, Mt. Hood, Mt. Rainier and Mt. Mazama.

Shield cones are formed by copious outwellings of very fluid basalt. Their profile resembles a low dome or inverted saucer. Examples are Union Peak and Mt. Thielsen.

Cinder cones are formed by explosive eruptions of ash, lapilli, and bombs. Usually, they are symmetrical in shape, with rapid growth. Paricutin, for example, in Mexico, grew 1,200 feet in several years. Generally, cinder cones are less than 1,000 feet high. Examples include Red Cone.

Plug domes are formed as large, viscous masses of lava emerge rapidly and "enmass" from a vent, to form steep-sided, bulbous mounds. These may vary from tens to thousands of feet. Examples include Lassen Peak.

Caldera Vs. Crater (Hans Rick's classification)

1. All calderas are related to volcanic topography.
   Many craters are not related to volcanic topography.

2. Craters are inseparably related to conduits.
   Calderas are related to the roof of the reservoir.

3. ~~Craters are the eruption vents.~~
Calderas are never entirely ~~eruption vents~~.

4. Craters are the vents through which ejecta passes. They are positive, active volcanic forms.
Calderas are the result of change in state or volume within the underlying reservoirs. They are negative, passive forms.

5. Craters occur during the active, growing periods of volcanoes.
Calderas are marks of decandence and age, although caldera formation may be followed by renewal of activity.

Types of Eruptions

1. Hawaiian: Exemplified by basaltic shield volcanoes such as Kilauea. Extremely hot, fluid lavas pour from summit vents and also from fissures on the mountain flanks. Fragmental material is minimal.

2. Strombolian: Named after Stromboli, Italy. Rhythmic discharges occur at intervals of seconds or minutes, ejecting pasty, glowing clots of magma which cool to form bombs and lapilli. A few solid fragments are expelled. Lava outwellings are on a very small scale, usually more viscous than the Hawaiian types. A cinder cone is the characteristic form.

3. Vulcanian: Named for Vulcano, Italy. Explosive discharges of viscous magma are spaced by intervals of quiescence. Solid, angular fragments are ejected, together with pasty lumps of magma, bombs, and frothy pumice. The final phases are characterized by gas eruptions, which may continue hundreds of years after the last magma eruption. Huge cauliflower-like clouds of steam charged with fine ash are often formed. Flows are rare, and characteristic of siliceous magmas, those that do form cool to thick, stumpy tongues of obsidian.

4. Ultra-vulcanian: Only rock fragments are discharged. No lava. Normally, these low temperature steam blasts occur as the first outbreak of a new volcano, or as initial explosions of older volcanoes after periods of dormancy.

5. Pelean: Named for Mt. Pelee, West Indies. Following plug-dome formation, intense explosions of superheated steam blast great amounts of glowing ash and larger fragments, as glowing avalanches, over wide regions.

6. Fissure: Lavas escape from fissures, rather than from central vents. More copious flows produce no volcanoes, but rather large, level plateaus such as the Columbia River Basalts.

Summary

The nature of volcanic eruptions is determined primarily by gas pressure and viscosity of the magma, both of which are controlled by magma composition.

The lower the viscosity, the greater the tendency to outwell quietly (basic composition, basaltic). The lavas form low lying structures.

Increasing gas pressure is correlated with high viscosity, which increases the tendency toward explosive activity and formation of conical structures. Generally, these lavas are more acid in composition (rhyolitic, dacitic).

Lava viscosity decreases with high temperature and gas content.

Siliceous lavas are generally more viscous than basaltic lavas.

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Geology of Crater Lake National Park

Setting

Crater Lake National Park lies in the High Cascades, within the volcanic province of the Pacific Northwest, a part of the Pacific "ring of fire." This generally unstable portion of the earth's crust exhibits frequent earthquake and volcanic activity.

The High Cascades extend as an almost straight line of peaks from Mt. Baker in northern Washington, to Lassen Peak in northern California. This belt of mountains is 20 to 25 miles in width. The range is composed of Pliocene and younger volcanoes, and has a youthful topography.

West of the Park lie the lower, older and wider Western Cascades, composed of Eocene to upper Miocene basic volcanics. The topography is sub-mature to mature, with the original volcanic structures obscured by ice and stream erosion.

Further west, adjacent to the Pacific Ocean, lie the Coast Ranges, a Tertiary belt of faulted and folded volcanic sediments.

Southwest of the Park lie the older and quite complex Klamath-Siskiyou Mountains. Initial sediments were intruded by igneous rock, uplifted and metamorphosed during the Jurassic. The topography is very mature.

East of the Cascade Range lie the Columbia River Basalts, composed of many Miocene basalt layers. From 200,000 to 300,000 square miles of the Pacific Northwest are covered by these flood basalts. This plateau, up to 10,000 feet thick, is broken by steep scarps of tilted fault-block mountains, such as the Steens. Beneath the High Cascades, the lavas of the Columbia Basalt Plateau interfinger with lavas of the Western Cascades.

I. The Foundations of Mt. Mazama

Mt. Mazama developed in an irregular depression between older cones of olivine basalt and basaltic andesite during the Pleistocene and Recent epochs. In turn, these lavas lie upon folded volcanics formed during the lower Eocene to upper Miocene epochs. These volcanics have a thickness of many thousand feet.

A. Union Peak Volcano was built by long-continued outwellings of very fluid lavas, chiefly from a central vent, which formed a broad, low shield. Subsequent eruptions on the flanks formed several cinder cones, while exp... ..ons from the cen... vent formed a summit cone. Lastly, a viscous mass of lava rose in the central conduit, and congealed as a rigid plug. The volcano's quiescence probably coincided with Mt. Mazama's beginning development.

Near the period of Mt. Mazama's greatest height, a fissure opened far down the eastern slope of Union Peak, allowing several cinder cones, including Goose Nest, to develop. The recentness of these cones, and their arrangement along a line directed toward the center of Crater Lake, suggests a relationship with Mt. Mazama rather than with Union Peak.

During the Pleistocene epoch several glaciers developed around the base of Union Peak and scoured the peak into a matterhorn.

B. Other Pre-Mazama Lavas

During late Pliocene, before Mt. Mazama began to form, the northwest corner of tne Park was occupied by a group of volcanoes which grew by quiet effusions of very fluid, basic lavas. Pyroclastic explosions were almost completely absent. Many of these volcanoes are related to Desert Ridge. However, the cinder cones of Bald Crater, Desert Crater and Red Cone are related to Mazama activity.

Mt. Mazama rose in the depression between this northern group of volcanoes and Union Peak.

II. The Andesite Cone of Mt. Mazama

A. The oldest of the visible Mt. Mazama lavas seem to have issued from a vent near the Phantom Ship, the Phantom Vent. Its products are collectively termed the Phantom Cone. Correctly, this is the filling of a conduit, which measures 200 to 500 yards in diameter.

B. The beginning cone of Mazama grew principally by effusions of hypersthene andesite from summit vents. Later, this flow activity was supplemented by growth of parasitic cones and outpourings of dacite from lateral fissures.

C. Throughout its growth, the volcano was often sheathed in ice, as evidence by glacial striations, moraines and U-shaped valleys. Some of the final glaciers grew to more than ten miles in length and 1,000 feet in thickness.

D. The dips of the lavas indicate an eccentric position of the principle vents. The vents lay one-half to one mile south or southeast of the present center of Crater Lake. This conclusion is supplemented in part by the observation that the south rim is much higher than the north.

E. In general, the lavas of Mt. Mazama became more viscous as the activity progressed. Earlier flows averaged 20 to 30 feet in thickness, few reached 100 feet.

The thickest flows, essentially confined to the higher walls, were ejected at the close of the andesitic period.

1. The thickest andesites are those of the Palisades and Roundtop, which rest on deep glacial deposits. These flows did not issue from summit

vents, but from fissures far down the northern slopes. In places, these flows are 500 feet thick.

2. Palisade Point, resting on glacial moraines, also issued from a fissure on the lower slopes.

3. Other recent, thick, andesite flows form the topmost cliffs of Grotto Cove, the flows south of Wineglass, and the highest cliffs of the Watchman and Sentinel Point.

4. As parasitic or subterminal flows, nothing was added to the height of the mountain. Only the less viscous andesites from the central vents built the primary slopes. The fissure flows served only to widen, not heighten the volcano.

F. Although explosive eruptions continued intermittently throughout the growth of the main cone, they were minor. Explosions likely occurred at low temperatures, for the ejecta is composed primarily of angular blocks and ash. Scoria and bombs are conspicuously absent.

1. A cursory examination will lead to exaggeration of the amount of explosion debris, for the red and brown layers between the lava flows, although apparently of explosive origin, are actually the oxidized surfaces and bases of flows.

2. Layers of pyroclastic debris are most abundant and well defined on the south and southwest wall of the caldera. The cliffs below Sinnott Memorial, Garfield Peak, Eagle Crags and Dutton Cliff are the most impressive areas of activity.

G. Much of the beauty of the caldera wall is due to the delicate coloring of the rocks, notably at Garfield Peak, Eagle Crags and Hillman Peak. These rocks have been colored by solfataric action.

1. In contact with rising gases and solutions, lavas were reduced to soft, friable masses of brown "earth" composed chiefly of kaolin and opal, stained by iron oxide.

2. Elsewhere, lavas have been bleached to white opal, stippled with crystals of pyrite. Some flow faces are lined with specular hematite and sulfur. Others have assumed dull-green and brown tints, as ferro-magnesium compounds have been converted to chlorite and limonite.

Most of the Mazama andesites issued from vents near the summit. However, Mt. Mazama cannot be considered a single, symmetrical cone. The walls of the caldera reveal many angular unconformities which cannot be attributed to erosion, but rather to a shifting or simultaneous activity of several vents. Mt. Mazama then, is a complex of overlapping cones. Much symmetry and conformity of Mt. Mazama was also destroyed by glacial action and fissure flows.

H. After Mt. Mazama had grown to considerable height, its sides were split by radial fissures. These dikes were partly a result of the weight of lava within the central conduit, but were primarily a response to the general doming of the volcano by increased pressure of magma within the underlying reservoir. Sixteen fissures are exposed as dikes on the caldera wall. Other radial fissures developed in the outer flanks of the volcano, and served as feeders to many of the parasitic cinder cones and dacite domes. All dikes are andesite, with the exception of two dacite dikes under Llao Rock.

I. Mt. Scott, the large parasitic cone on the eastern flank of Mt. Mazama became extinct long before the last eruptions of Mt. Mazama. Much of its northwest side was eroded into a cirque, leaving little trace of a summit cinder cone. Remains of the vent lie approximately 1/3 mile west of the present summit, on the wall of the cirque.

J. The dacites of Mt. Mazama may be divided into three groups. The youngest dacites include the deposits of pumice erupted immediately prior to the collapse. An older group includes pumice deposits and viscous flows ejected from the "northern arc of vents". The oldest dacites include the dacite pumice interbedded with andesites within the caldera walls, together with the extensive dacite lava sheets and domes on the south and east slopes of the volcano. Pumice was the only dacite material ejected from Mazama's summit.

K. The first dacites erupted were likely, those forming Grayback Ridge and the southern end of Vidae Ridge. Later, these dacites were almost completely buried by the glaciers of Sun, Sand and Annie Creeks. These lavas predate the period of maximum glaciation. The lavas can be traced up the slopes to an elevation of 6,500 feet, only to disappear at Tututni and Maklaks Passes. These lavas, therefore, must have escaped, in part at least, from fissures in those areas. Much dacite also erupted from vents scattered along the length of the flows.

Several oval hills, numbers 5725, 6122 and 6077, which rise above the general level of both Vidae and Grayback Ridges, seem to represent domical protrusions of a pelean type. These may be the final products of the vents from which some of the dacite flows were erupted.

L. The main cone of Mt. Mazama had nearly reached full height when the principle center of activity moved from the summit region to the northern flank. When this occured, the glaciers were quite small, and few extended beyond the present rim.

This northward shift of vents was caused, possibly, by enlargement of the magma chamber in a northward direction, a result of internal assimilation of the cone, or most likely, as a consequence of ring fracture stopping. Whatever the cause, a semi-circular line of vents opened along the present north wall, approximately 5,000 feet below the original summit. These northern vents included:

Watchman Dike and flow - andesite; one of the earliest.
Hillman Cone - andesite; the highest point on the rim.
Sentinel Rock flow and vent - andesite.
Llao Rock - dacite; 1,200 feet thick flow in a glacial valley.
Grouse Hill dome and flow - dacite.
Cleetwood flow - "Diller backflow", an inclined dacite feeder vent.
Redcloud and Cloudcap - dacites; respectively a vent and dome.

M. Concurrently, and also subsequent to the northern are eruptions, a group of parasitic, basaltic cinder cones erupted on the lower mountain side. Some of these produced short flows of basaltic lava. This parastitic development is a sign of old age in volcanoes.

Within the park there are thirteen of these parasitic cones. Only the two small cones on the north side of Castle Creek have been modified by glacial action.

A few scoria cones had formed earlier, when glaciers were still extensive, yet the majority show no signs of extensive glaciation.

Outside the park there are eleven other cinder cones of approximately the same age, probably fed from the same magma chamber.

Bald Crater, 600 feet above pre-Mazama basalts, is composed of basaltic scoria with some flows of basalt. It is a composite cone.

Desert Cone, is composed of vesicular, red-crusted dark scoria and fine ash with short flows of lava near the summit.

Red Cone is the best preserved, largest, and probably youngest of the three northern cones. It was a producer of many volcanic bombs.

Forgotten Crater, rests on a ridge of lava that descends from Hillman Peak. It is composed of cinders, with rather large flows of lava on its western flank.

Crater Peak, 750 feet above Vidae Ridge, is composed of lapilli and bombs. Several dark scoriaceous flows of lava issued from its flanks. A crater 150 feet deep rests within the summit. This cone is also well preserved.

Diller Cone, Maklaks Crater, 600 feet above Grayback Ridge, is, with the exception of Wizard Island, the most symmetrical cone in the park. The summit is almost flat, with no crater.

Southeast Corner Cone is a small cone of red and black scoria. There is no trace of a crater.

Cavern Creek Cone, 150 feet high, is similar to Southeast Corner Cone. It is bisected by the Park Boundary.

Pumice Flat Cones rest upon Union Peak lavas, but are likely related to Mt. Mazama cones.

N. Timber Crater is composed of olivine basalt and basaltic andesite. The shield volcano is approximately five miles in diameter, and capped by two pyroclastic cones. The older cone, Hill 6889, is damaged and has no trace of a crater. The younger cone is complex and only slightly eroded. Oval in shape, it stretches a mile in a North-South direction, rising 600 feet above the lava shield. It contains three craters, which indicate a southern migration of vents during the concluding activity of Timber Crater.

Activity of Timber Crater ceased before that of Mt. Mazama. Probably contemporary with the parasitic cinder cones of Mazama, Timber Crater is not, however, a parasite itself.

O. Mt. Mazama's maximum height is an uncertainty. Yet, if the visible slopes and glacial stria of the mountain are projected upward with an ever increasing angle, using Mt. Shasta, Mt. Adams, and Mt. Rainier as guides, a height of 12,000 feet is determined. With a large crater, Mt. Mazama probably rose to 10,000 feet.

P. A long period of quiescence probably proceeded the culminating activity. By then, the glaciers had dwindled to small tongues, four to five miles long.

1. The first ejecta was composed principally of fine dacite pumice, with a low percentage of crystals, and few lithic fragments. The pumice was discharged to great heights, and carried to the east and northeast by the prevailing winds.

2. The vent was likely enlarged by this initial activity, and the pressure on the magma greatly reduced, for gases escaped from the solution with increasing speed. Frothy magma was expelled in great volumes, which, instead of being thrown high above the summit, rose only a short distance and fell back on the slopes of the mountain, to race down hill in a succession of glowing clouds of <u>nuees ardentes</u>.

   The rapid expansion of the gases in this mass of incendenscent dust and pumice gave tremendous mobility to the clouds. This, plus their own momentum, enabled the avalanches to race down the canyons at high speeds and spread over the encircling lowlands for distances of up to 35 miles. Large chunks of pumice were also carried along.

3. In the higher reaches of the southern canyons and the western slopes adjacent to the rim, the glowing deposits are completely absent. Either

   a. The speed of the flows near their source was too great to deposit, but rather eroded the surface, or,

   b. The upper canyons and slopes of Mt. Mazama were still mantled with snow and ice.

   The latter is more likely.

4. The first pumice flows are of dacite composition, containing only a small percentage of crystals, and are almost wholly white or buff colored.

   Subsequent flows are more basic, gray in color, extremely rich in crystals, and contain much fine lithic detritus. This succession of sharply defined material agrees with the concept of a magma chamber, first drained of its topmost acid froth, then its lower, more crystaline layers, all in a relatively short time. As the eruptions continued, the conduit walls were widened and subjected to caving, increasing the amount of lithic detritus.

5. Quite likely, the temperature of the glowing avalanches was high. Even thirty miles from the caldera, the flows carried large trees which were totally carbonized. Moreover, the flows retained their heat for a long period. Secondary fumaroles, caused by prolonged escape of hot gasses from the pumice, produced a brick-red layer of iron oxides near the top of the deposits, and gas fumaroles in Pinnacle Valley and elsewhere.

6. Enough gas remained in the magma chamber to cause a few dying explosions. There were no violent explosions, for the ejecta is quite fine and limite in distribution. The ejecta consists of dark-brown and reddish crystal-rich scoria and small fragments of old lava. This final "ash fall" is approximately .25 cubic miles in volume.

7. The volume of magma ejected during the culminating eruptions may be roughly classifed.

Material	Volume - Cubic miles	% Crystals	% Rock Fragme
Pumice fall	3.5	10-15	3-4
Glowing avalanches	6-8	20-25	15-20
Ash fall	.25	40	40

The total volume of material deposited is 9.75 to 11.75 cubic miles. Of this amount, 1.65 to 2.65 cubic miles consists of crystals; 1.10 to 1.84 cubic miles consists of old rock.

Eleven cubic miles of ejecta was deposited, including two cubic miles of crystals and 1.5 cubic miles of old rock fragments, leaving 7.5 cubic miles of frothy pumice and scoria.

Volume of liquid magma ejected	- maximum	3.0 cubic miles
Volume of crystals ejected	- approximately	2.0 cubic miles
Volume of lithic fragments	- approximately	1.5 cubic miles
Total	- approximately	6.5 cubic miles

Q. The area enclosed by the caldera rim is approximately 27 square miles. Its original depth is a matter of conjecture. Conceivably, the floor of Crater Lake subsided several hundred feet as the residual magma contracted during crystallization.

Assuming a 1500 to 3500 foot variation in the depth of the caldera, the volume of the original depression was approximately 12 cubic miles.

To this must be added the volume of the summit. Again using the approximation of 12,000 feet, the additional volume would be eight cubic miles, less the volume of the summit crater and glacial cirques on the mountain flanks.

Even if the summit had been lowered 200 feet by collapse during the northern arc activity, the volume would not have diminished more than a cubic mile.

Therefore, approximately 17 cubic miles of Mt. Mazama disappeared to form the present caldera.

For this, there are three possibilities:
1. Removal by explosion
2. Collapse
3. A combination of 1 and 2.

Explosion:

Only 1.5 cubic miles of lithic fragments are found among the ejecta.

Where exposed, the base of the pumice deposits rest directly on either old lava flows or on glacial moraines.

Erosion, since the formation of the caldera, has not removed much material. The glaciers were cut off from their supply, and therefore lost their erosive power. The streams have cut deep box canyons through the deposits of pumice, but otherwise, there has been little loss of material.

The deposits would have to be many hundreds of feet thicker for explosions to account for the 17 cubic miles of missing mountain top.

Collapse:

Pumice flows show that explosions did occur, so total collapse is ruled out.

Combination of collapse and explosion:

The total volume of liquid magma, crystals and lithic fragments ejected approximates 7 cubic miles. Since 17 cubic miles disappeared the conclusion is made that collapse of the peak into the chamber was caused by deep seated intrusions.

The basin holding Crater Lake was formed by both rapid expulsions of an enormous volume of material, and lateral intrusions within the chamber. The roof of the magma chamber, no longer supported from below, collapsed.