



A VOLCANO IS AN OPENING IN THE EARTH'S CRUST THROUGH WHICH LAVA, VOLCANIC ASH, AND GASES ESCAPE

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ABSTRACT

A volcano is commonly defined as a vent or fissure in the crust of a planetary-mass object, such as Earth, that allows hot lava, volcanic ash, and gases to escape from a magma chamber below the surface. A volcano is an opening in the Earth's crust that allows magma, ash and gasses to erupt from below the surface. It is made up of a magma chamber, a vent, a crater and a cone shaped mountain made of layers of ash and lava. Volcanoes are a specialized type of mountain built by the accumulation of erupted lava, ash, and rock around a central vent, often featuring a crater and the potential for active eruptions. Conversely, mountains are generally, larger, older landforms created by tectonic plate collisions, folding, or uplift that lack internal volcanic activity. Most of the estimated 2,000 deaths at Pompeii occurred on the second day of the eruption, when the top of Vesuvius collapsed and an avalanche of raging-hot volcanic material tore through the city. This fast-moving wall of hot rock and ash, known as pyroclastic flow, killed with both heat and sheer force. Volcanic eruptions are partly driven by pressure from dissolved gas, much as escaping gases force the cork out of a bottle of champagne.

KEYWORDS: volcano, lava, magma, ash, gas.

Preamble: Lava is a molten mixture of silicate minerals, gases, and crystals, primarily composed of silicon and oxygen (SiO₂), along with aluminium, iron, magnesium, calcium, sodium, and potassium. It erupts at temperatures of 800°C–1200°C, with composition determining viscosity and explosively, ranging from fluid, low-silica basalt to thick, high-silica rhyolite.

Key Components and Composition Silica Content (SiO₂): Determines viscosity and rock type. Higher silica makes lava more viscous (thick). **Major Elements:** Oxygen (46%), Silicon (27%), Aluminium (8%), Iron (5%), Calcium (3.6%), Sodium (2.8%), Potassium (2.6%), and Magnesium (2.1%). **Volcanic Gases:** Water

vapour, carbon dioxide, sulphur, chlorine, and fluorine.

Components: A mixture of liquid melt, suspended crystals (e.g., olivine, pyroxene, feldspar), and gas bubbles (vesicles).

Types of Lava Based on Composition **Basaltic (Mafic):** Low silica (45%-52%), high magnesium and iron. Very fluid, high-temperature, and non-explosive. **Andesitic (Intermediate):** Intermediate silica (52%-63%). **Dacite/Rhyolitic (Felsic):** High silica (>63%), sometimes (>70%), high viscosity, and typically explosive. **Carbonatite:** Rare, non-silicate, very low-temperature, and fluid.^[1-3]



Figure-1: Volcanic eruption.

Physical Properties

Viscosity: Controlled by silica content and temperature. Low-silica basalt flows easily, while high-silica rhyolite moves slowly.

Magma is a molten or semi-molten mixture of silicate minerals, dissolved gases H_2O , CO_2 and suspended crystals found beneath Earth's surface. Its composition is dominated by oxygen and silicon, along with aluminium, iron, calcium, sodium, potassium, and magnesium.

Key Aspects of Magma Composition

Principal Components: The main elements are oxygen, silicon, aluminium, iron, calcium, sodium, magnesium, and potassium, which make up >98% of the composition. **Viscosity Control:** Higher silica content increases polymerization, leading to higher viscosity (resistance to flow), which, along with gas content, dictates the explosiveness of eruptions. **Source Influence:** Magmas from the mantle are higher in Fe, Mg, and Ca (mafic), while those from melting crustal material are richer in Si, Al, Na, and K (felsic). **Magma, Melting, and Crystallization.** Magma collects in magma chambers in the crust at 160 kilometers (100 miles) beneath the surface of a volcano.

Texture: Solidifies into crystals and volcanic glass.

Surface Forms: Pahoehoe (smooth/ropy) or A'a (jagged/rough).

Key Differences between Volcanoes and Mountains

Formation Process: Volcanoes are formed by volcanic activity (magma reaching the surface), whereas mountains are typically formed by tectonic, geological uplift, or erosion.

Structure: Volcanoes usually have a conical shape with a crater, vent, or caldera at the top. Mountains often have irregular, jagged peaks, ridges, and slopes.

Composition: Volcanoes are built from igneous rock (lava and ash). Mountains are made of various rock types, including sedimentary and metamorphic rocks, created by immense pressure.

Activity: Volcanoes can be active, dormant, or extinct, meaning they can erupt and change rapidly. Mountains are generally inactive and change very slowly over geological time due to erosion.



Figure-2: Lava eruption from volcano.

Internal Structure: Volcanoes contain a magma chamber and conduits for magma transport, while mountains do not.

While all volcanoes are technically mountains, not all mountains are volcanoes. Mountains like the Himalayas were formed by the collision of plates, whereas volcanoes like Mt. Fuji were formed by eruptive material.^[4-6]

Scientists use the term magma for molten rock that is underground and lava for molten rock that breaks through the Earth's surface. Lava is molten rock ejected by volcanoes in the form of a liquid. Once it emerges on the Earth's surface, it flows and gradually cools down, consuming objects along its path. When lava erupts it is made up of a slush of crystals, liquid, and bubbles. The liquid "freezes" to form volcanic glass. Chemically lava is made of the elements silicon, oxygen, aluminium, iron, magnesium, calcium, sodium, potassium, phosphorus, and titanium (plus other elements in very small concentrations). Lava forms when magma erupts from a volcano. As pressure is released gases, dissolved in the magma, bubble out so the composition of lava changes. Lava is molten or partially molten rock (magma) that has been expelled from the interior of a terrestrial planet (such as Earth) or a moon onto its surface. Lava may be erupted at a volcano or through a fracture in the crust, on land or underwater, usually at temperatures from 800 to 1,200°C (1,470 to 2,190 °F). Lava may be erupted directly onto the land surface or onto the sea floor or it may be ejected into the atmosphere before falling back down. The solid volcanic rock resulting from subsequent cooling of the molten material is often also called lava. Magma is molten rock beneath the Earth's surface, the essential fuel for volcanoes, collecting in underground chambers and rising due to lower density and pressure, eventually erupting as lava (magma at the surface) along with gas and ash, forming volcanic structures. The key difference is location: magma is inside the Earth, while lava is magma that has erupted onto the surface, with gas escaping during the process.

Magma & Volcano Formation

Origin: Magma forms from melting crust or mantle rocks, often in tectonic settings like subduction zones or hotspots.

Movement: Being lighter, magma rises and gathers in large underground reservoirs called magma chambers.

Eruption Trigger: Dissolved gases in the magma build pressure. When pressure overcomes the surrounding rock, magma forces its way up through cracks (dikes/vents).

Volcano Structure: Over time, repeated eruptions build the cone-shaped volcano around the vent.

Lava forms from magma, which is molten rock beneath the Earth's surface that erupts onto the surface through volcanoes, fissures, or vents. This transformation from magma to lava happens when pressure decreases or temperatures rise sufficiently, causing rock to melt and form magma; then, when this magma reaches the surface, it becomes lava, often losing gases and changing composition as it erupts, flowing out at temperatures around 700°C to 1200°C (1292°F to 2192°F). Magma is formed deep within the Earth's crust and upper mantle through the melting of solid rock, driven by increased temperature, decreased pressure (decompression), or the addition of volatiles (flux melting). It most commonly occurs at tectonic plate boundaries—specifically subduction zones and rift zones—and hotspots, where geological conditions allow rock to partially melt.

Key Processes of Magma Formation

Decompression Melting: Occurs when hot mantle rock rises to shallower depths (lower pressure) without cooling, such as at mid-ocean ridges or mantle plumes, causing it to melt.

Flux Melting: Occurs at subduction zones where water and other volatile compounds are released from the sinking slab, lowering the melting point of the surrounding mantle rock.

Heat Transfer Melting: Occurs when hot magma from the mantle rises into the colder continental crust, melting the surrounding rock.

Where Magma Forms

Divergent Boundaries (Rift Zones): Plates move apart, allowing mantle material to rise and undergo decompression melting.

Convergent Boundaries (Subduction Zones): An oceanic plate sinks beneath another plate, releasing volatiles that cause flux melting in the mantle wedge.

Hotspots: Intense heat from deep within the mantle melts the crust above, regardless of plate boundaries. Magma is composed of molten rock, suspended crystals, and dissolved gases (water, carbon dioxide, sulfur), and is less dense than the surrounding solid rock, allowing it to rise through the crust.

The biggest volcano on Earth by mass and volume is Mauna Loa in Hawaii, the world's largest active volcano, but the most massive overall is the submerged Puhonu volcano (Gardner Pinnacles), while the tallest is also Mauna Loa when measured from its base on the seafloor.



Figure-3: Magma eruption from volcano.

Mauna Loa (Largest Active Volcano)

Location: Big Island, Hawaii.

Size: It's a shield volcano, meaning gentle slopes from numerous lava flows, covering half the Big Island and rising immensely from the seafloor, making it the largest active volcano by volume and mass.

Height: Over 17 km (10.5 miles) from its base on the ocean floor to its summit.

Puhonu (Most Massive Overall)

Location: Under the Pacific Ocean (Gardner Pinnacles).

Size: This extinct volcano is twice the volume of Mauna Loa, holding the title for the single most massive volcano on Earth.

Volcanoes erupt because magma (molten rock) from deep within the Earth rises due to buoyancy and pressure, carrying dissolved gases; when this magma nears the surface, pressure drops, gases expand like in a soda bottle, and force the magma out as lava, ash, and gas, often triggered by tectonic plate movements that create pathways for the magma to escape. Volcanoes erupt when molten rock called magma rises to the surface. Magma is formed when the earth's mantle melts. Melting may happen where tectonic plates are pulling apart or where one plate is pushed down under another. Magma is lighter than rock so rises towards the Earth's surface.^[7,8]

The Process

Magma Formation: Intense heat and pressure deep underground melt rock into magma.

Magma Rises: Because magma is less dense (lighter) than surrounding solid rock, it slowly rises and collects in underground chambers.

Volcanic eruptions

Table-1: Volcanic eruptions.

Human death toll	Volcano	VEI	Location	Year
71,000 to 250,100+	Mount Tambora	7	Indonesia	1815
36,000+	Krakatoa	6	Indonesia	1815
30,000	Mount Pelée	4	Martinique	1902
23,000	Nevado del Ruiz	3	Colombia	1985
20,000	Santorini	6	Greece	1600 BC
15,000 to 20,000	Mount Samalas	7	Indonesia	1257

Gas Buildup: Water vapor, carbon dioxide, and other gases are trapped in the magma under immense pressure.

Pressure Increases: As magma fills a chamber, pressure builds, and gases try to escape.

Eruption: When the pressure becomes too great, or new magma injects into the chamber, the magma forces its way through weak points in the Earth's crust (vents and fissures) and erupts as lava, ash, and gas.

What Makes Eruptions Explosive or Gentle?

Thick, Sticky Magma (High Silica): Gases get trapped, causing extreme pressure buildup, leading to violent, explosive eruptions (like stratovolcanoes).

Thin, Runny Magma (Low Silica): Gases escape easily, resulting in gentler, effusive eruptions with flowing lava (like shield volcanoes).

Where Volcanoes Form

Plate Boundaries: Most volcanoes occur where tectonic plates pull apart (like mid-ocean ridges) or collide (subduction zones).

Hotspots: Some volcanoes form far from plate boundaries over mantle plumes, like in Hawaii.

Volcanic eruptions can be highly explosive. Some volcanoes have undergone catastrophic eruptions, killing large numbers of humans or other life forms. This list documents volcanic eruptions by human death toll.

15,000	Mount Unzen	2	Japan	1792
13,000+ (estimated)	Mount Vesuvius	5	Italy	79 AD
10,000+	Laki and Grímsvötn	4	Iceland	1783
10,000	Kelud	5	Indonesia	1586
6,000	Santa María	6	Guatemala	1902
5,160	Kelud	4	Indonesia	1919
4,011	Mount Galunggung	5	Indonesia	1822
3,360	Mount Vesuvius	5	Italy	1631
3,000	Ritter Island	2	Papua New Guinea	1888
2,957	Mount Papandayan	3	Indonesia	1772
2,942	Mount Lamington	4	Papua New Guinea	1951
2,806	Mount Awu	3	Indonesia	1856
2,033	Oshima Oshima	4	Japan	1741
2,000	Tseax Cone	4	Canada	1700
19,00	El Chichón	5	Mexico	1982
1,700	Soufriere	4	St. Vincent	1902
1,584	Mount Agung	5	Indonesia	1963
1,532	Mount Awu	3	Indonesia	1892
1,500	Huaynaputina	6	Peru	1600
1,369	Mount Merapi	3	Indonesia	1930
1,335	Taal	3	Philippines	1911
1,300	Gamalama	3	Indonesia	1775
1,200	Mount Mayon	4	Philippines	1814
1,151	Mount Asama	4	Japan	1783
1,000	Nevado del Ruiz	3	Colombia	1845
847	Mount Pinatubo	6	Philippines	1991
700	Hokkaido	5	Japan	1640
600	Nevado del Ruiz	4	Colombia	1595
507	Tavurvur	4	Papua New Guinea	1937
500	Hibok-Hibok	3	Philippines	1951
477	Mount Bandai	4	Japan	1888
426	Anak Krakatoa	3	Indonesia	2018
416	Ruang	2	Indonesia	1871
400+	Kilauea	4	Hawaii	1790
350 to 400	Mount Mayon	4	Philippines	1897
353	Mount Merapi	4	Indonesia	2010
340	Cotopaxi	4	Ecuador	1877
326	Makian	4	Indonesia	1861
245	Nyiragongo	1	Democratic Republic of the Congo	2002
216	Mount Vesuvius	4	Italy	1906
190 to 2,900	Volcán de Fuego	3	Guatemala	2018
160+	Paluweh	3	Indonesia	1928
150	Tori-shima	3	Japan	1902
149	Dieng Volcano	1	Indonesia	1979
140	Mount Tokachi	3	Japan	1926
117	Dieng Volcano	2	Indonesia	1944
114	Dieng Volcano	1	Indonesia	1964
108 to 120	Mount Tarawera	5	New Zealand	1886
106	Dubbi	3	Eritrea	1861
100 to 1000	Cotopaxi	4	Ecuador	1768
100 to 1000	Cotopaxi	3	Ecuador	1742
87	Volcán Arenal	3	Costa Rica	1968
80	Mount Marapi	2	Indonesia	1979
79	Mount Mayon	2	Philippines	1993
70	Nyiragongo	1	Republic of the Congo	1977
70~	Kolumbo	4	Greece	1650
69	Semeru	4	Indonesia	2021
64	Mount Merapi	2	Indonesia	1994

63	Mount Ontake	3	Japan	2014
58	Sakurajima	4	Japan	1914
57	Mount St. Helens	5	United States	1980
56	Mount Etna	2	Italy	1843
56	La Soufrière	4	Saint Vincent	1812
50	Mount Usu	4	Japan	1822
43	Mount Unzen	1	Japan	1991
40	Dieng Volcano	2	Indonesia	1928
39	Taal	4	Philippines	2020
38	Dieng Volcano	2	Indonesia	1786
32	Mount Nyiragongo	1	Republic of the Congo	2021
32	Kelud	4	Indonesia	1990
31	Bayonnaise Rock	2	Japan	1952
31	Nabro Volcano	4	Eritrea	2011
30	Rinjani	3	Indonesia	1994
27	Mount Vesuvius	3	Italy	1944
25	Villarrica	2	Chile	1964
24	Monte Nuovo	3	Italy	1538
23	Villarrica	3	Chile	1948
23	Mount Marapi	2	Indonesia	2023
22	Whakaari	2	New Zealand	2019
19	Soufrière Hills	3	Montserrat	1997
19	Soufrière Hills	3	Montserrat	1997
18	Galunggung	4	Indonesia	1982
16	Sinabung	4	Indonesia	2014
15 to 30	Villarrica	2	Chile	1971
15	Raikoke	4	Russia	1778
10	Dieng Volcano	1	Indonesia	1939
10	Lewotobi	3	Indonesia	2024
10	Whakaari	10	New Zealand	1914
9	Galeras	2	Colombia	1993
9	Mount Etna	3	Italy	1979
8	Dieng Volcano	1	Indonesia	2017
8	Kuchinoerabujima	4	Japan	1933
7	Kelud	4	Indonesia	2014
7	Jabal al-Tair	3	Yemen	2007
6	Hunga Tonga	5	Tonga	2022
6	Karangetang	2	Indonesia	1992
5	Mount Tavurvur	4	Papua New Guinea	1994
5	Mount Hudson	3	Chile	1971
4	Gamalama	2	Indonesia	2011
4	Yakedake	1	Japan	1995
4	Stromboli	2	Italy	1930
3	Pacaya	3	Guatemala	2010
3	Kanlaon	2	Philippines	1996
3	Didicas	2	Philippines	1969
2	Santa Ana	3	El Salvador	2005
2	Mount Bromo	2	Indonesia	2004
1	Popocatepetl	2	Mexico	2022
1	Cumbre Vieja	3	Spain	2021
1	Stromboli	2	Italy	2019
1	Chaitén	4	Chile	2008
1	Raoul Island	1	New Zealand	2006
1	Eldfell	3	Iceland	1973

VEI=volcanic explosively index

Volcanic gases are released across a wide range of pressures, with deep-seated CO₂-rich gases resolving at

20–35+ megapascals (MPa) at depths of 10–40 km. As magma rises, decreasing pressure causes further

degassing, with final release occurring at surface atmospheric pressure during eruptions or from fumaroles. Initial Absolution (Deep): High pressures 20-

35MPa at depths of 10–40 km allow significant amounts of gas (especially CO₂) to be dissolved in the magma.^[9,10]

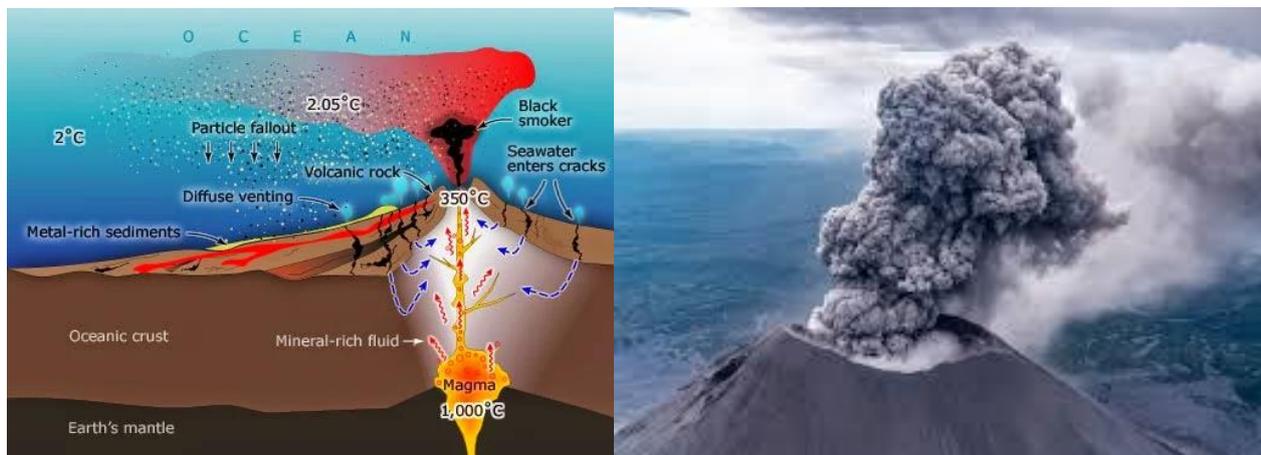


Figure-4: Mechanism of volcano.

Ascent and Expansion: As magma ascends to 3–4 km, lower surrounding pressure allows gas bubbles to grow, with pressure decreasing significantly. **Surface Release:** Gases are ultimately released into the atmosphere at 1 bar (approx. 0.1MPa). **Eruption Mechanism:** The build-up of gas pressure, often exceeding 10s of MPa, drives the volcanic eruption. High-pressure magma storage zones, often several kilometres down, contain dissolved gases that resolve as magma rises, with pressure dropping as it nears the surface.

CONCLUSION

A volcano is commonly defined as a vent or fissure in the crust of a planetary-mass object, such as Earth, that allows hot lava, volcanic ash, and gases to escape from a magma chamber below the surface. Volcanic eruptions occur when magma, gas, and ash explode from beneath Earth's surface through cracks or vents, often driven by pressure and high gas content. These events range from slow lava flows (effusive) to violent explosions, with roughly 40-50 volcanoes in "continuing eruption" status at any given time.

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