Volcano

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This article is about the geological feature. For other uses, see Volcano (disambiguation).

"Volcanic" redirects here. For other uses of "volcanic", see Volcanic (disambiguation).

Cleveland Volcano in the Aleutian Islandsof Alaska photographed from theInternational Space Station, May 2006.

Ash plumes reached a height of 19 km during the climactic explosive eruption atMount Pinatubo, Philippines in 1991.

A 2007 eruptive column at Mount Etnaproducing volcanic ash, pumice and lava bombs.

Ubinas Volcano

Mount Shasta

A **volcano** is an opening, or rupture, in the surface or crust of the Earth or a planetary mass object, which allows hot lava, volcanic ash and gases to escape from the magma chamber below the surface.

On Earth, volcanoes are generally found where tectonic plates are diverging or converging. A mid-oceanic ridge, for example the Mid-Atlantic Ridge, has examples of volcanoes caused by divergent tectonic plates pulling apart; the Pacific Ring of Fire has examples of volcanoes caused by convergent tectonic plates coming together. By contrast, volcanoes are not usually created where two tectonic plates slide past one another. Volcanoes can also form where there is stretching and thinning of the Earth's crust in the interiors of plates, e.g., in the East African Rift, the Wells Gray-Clearwater volcanic field and the Rio Grande Rift in North America. This type of volcanism falls under the umbrella of "Plate hypothesis" volcanism.[1] Volcanism away from plate boundaries has also been explained as mantle plumes. These so-called "hotspots", for example Hawaii, are postulated to arise from upwellingdiapirs with magma from the core–mantle boundary, 3,000 km deep in the Earth.

Erupting volcanoes can pose many hazards, not only in the immediate vicinity of the eruption. Volcanic ash can be a threat to aircraft, in particular those with jet engines where ash particles can be melted by the high operating temperature; the melted particles then adhere to the turbine blades and alter their shape, disrupting the operation of the turbine. Large eruptions can affect temperature as ash and droplets of sulfuric acid obscure the sun and cool the Earth's lower atmosphere or troposphere; however, they also absorb heat radiated up from the Earth, thereby warming the stratosphere. Historically, so-called volcanic winters have caused catastrophic famines.

Contents

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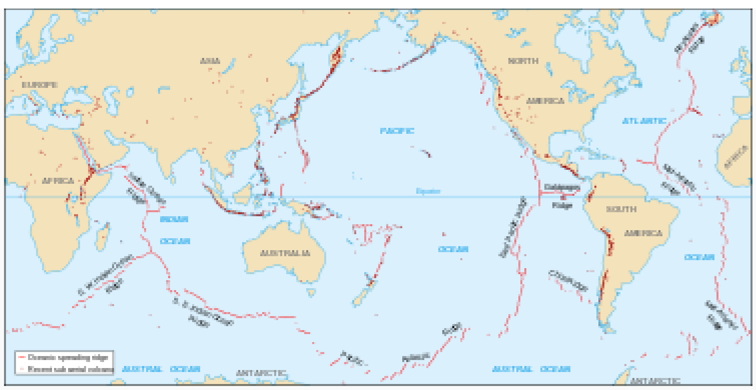
Etymology

The word *volcano* is derived from the name of Vulcano, a volcanic island in the Aeolian Islands of Italy whose name in turn originates from Vulcan, the name of a god of fire in Roman mythology.[2] The study of volcanoes is called volcanology, sometimes spelled *vulcanology*.

Plate tectonics



Map showing the divergent plate boundaries (OSR – Oceanic Spreading Ridges) and recent sub aerial volcanoes.

Main article: Plate tectonics

Divergent plate boundaries

Main article: Divergent boundary

At the mid-oceanic ridges, two tectonic plates diverge from one another. New oceanic crust is being formed by hot molten rock slowly cooling and solidifying. The crust is very thin at mid-oceanic ridges due to the pull of the tectonic plates. The release of pressure due to the thinning of the crust leads to adiabatic expansion, and the partial melting of the mantle causing volcanism and creating new oceanic crust. Most divergent plate boundaries are at the bottom of the oceans, therefore most volcanic activity is submarine, forming new seafloor. Black smokers or deep sea vents are an example of this kind of volcanic activity. Where the mid-oceanic ridge is above sea-level, volcanic islands are formed, for example, Iceland.

Convergent plate boundaries

Main article: Convergent boundary

Subduction zones are places where two plates, usually an oceanic plate and a continental plate, collide. In this case, the oceanic plate subducts, or submerges under the continental plate forming a deep ocean trench just offshore. In a process called flux melting, water released from the subducting plate lowers the melting temperature of the overlying mantle wedge, creating magma. This magma tends to be very viscous due to its high silica content, so often does not reach the surface and cools at depth. When it does reach the surface, a volcano is formed. Typical examples for this kind of volcano are Mount Etna and the volcanoes in the Pacific Ring of Fire.

"Hotspots"

Main article: Hotspot (geology)

"Hotspots" is the name given to volcanic provinces postulated to be formed by mantle plumes. These are postulated to comprise columns of hot material that rise from the core-mantle boundary. They are suggested to be hot, causing large-volume melting, and to be fixed in space. Because the tectonic plates move across them, each volcano becomes dormant after a while and a new volcano is then formed as the plate shifts over the postulated plume. The Hawaiian Islands have been suggested to have been formed in such a manner, as well as the Snake River Plain, with theYellowstone Caldera being the part of the North American plate currently above the hot spot. This theory is currently under criticism, however.[1]

Volcanic features

Lakagigar fissure vent in Iceland, source of the major world climate alteration of 1783–84.

[Skjaldbreiður](), a shield volcano whose name means "broad shield"

The most common perception of a volcano is of a conical mountain, spewing lava and poisonous gases from a crater at its summit. This describes just one of many types of volcano, and the features of volcanoes are much more complicated. The structure and behavior of volcanoes depends on a number of factors. Some volcanoes have rugged peaks formed by lava domes rather than a summit crater, whereas others present landscape features such as massive plateaus. Vents that issue volcanic material (lava, which is what magma is called once it has escaped to the surface, and ash) and gases (mainly steam and magmatic gases) can be located anywhere on the landform. Many of these vents give rise to smaller cones such as Puʻu ʻŌʻō on a flank of Hawaii's Kīlauea. Other types of volcano include cryovolcanoes (or ice volcanoes), particularly on some moons of Jupiter, Saturn and Neptune; and mud volcanoes, which are formations often not associated with known magmatic activity. Active mud volcanoes tend to involve temperatures much lower than those of igneous volcanoes, except when a mud volcano is actually a vent of an igneous volcano.

Fissure vents

Main article: Fissure vent

Volcanic **fissure vents** are flat, linear cracks through which lava emerges.

Shield volcanoes

Main article: Shield volcano

Shield volcanoes, so named for their broad, shield-like profiles, are formed by the eruption of low-viscosity lava that can flow a great distance from a vent. They generally do not explode catastrophically. Since low-viscosity magma is typically low in silica, shield volcanoes are more common in oceanic than continental settings. The Hawaiian volcanic chain is a series of shield cones, and they are common in Iceland, as well.

Lava domes

Main article: Lava dome

Lava domes are built by slow eruptions of highly viscous lavas. They are sometimes formed within the crater of a previous volcanic eruption (as inMount Saint Helens), but can also form independently, as in the case of [Lassen Peak](). Like stratovolcanoes, they can produce violent, explosive eruptions, but their lavas generally do not flow far from the originating vent.

Cryptodomes

Cryptodomes are formed when viscous lava forces its way up and causes a bulge. The 1980 eruption of Mount St. Helens was an example. Lava was under great pressure and forced a bulge in the mountain, which was unstable and slid down the north side.

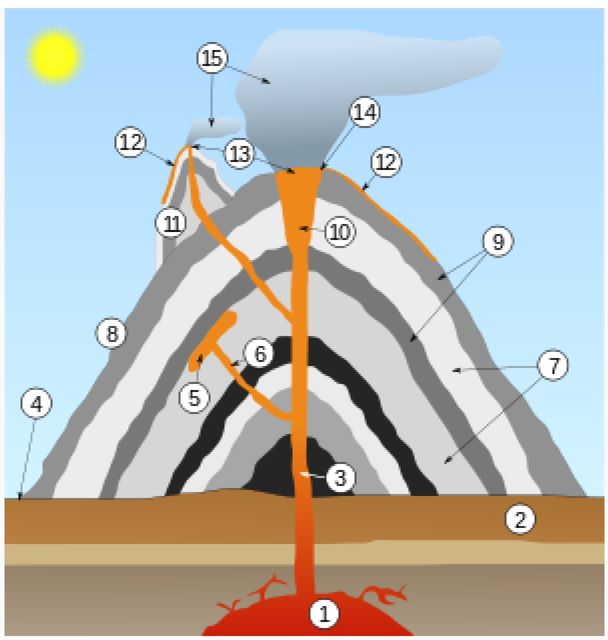
Volcanic cones (cinder cones)

Main articles: volcanic cone and Cinder cone

Volcanic cones or **cinder cones** result from eruptions of mostly small pieces of scoria and pyroclastics (both resemble cinders, hence the name of this volcano type) that build up around the vent. These can be relatively short-lived eruptions that produce a cone-shaped hill perhaps 30 to 400 meters high. Most cinder cones erupt only once. Cinder cones may form as flank vents on larger volcanoes, or occur on their own. Parícutin in Mexico and Sunset Crater in Arizona are examples of cinder cones. In New Mexico, Caja del Rio is a volcanic field of over 60 cinder cones.

Based on satellite images it was suggested that cinder cones might occur on other terrestrial bodies in the Solar system too; on the surface of Mars and the Moon.[3][4][5][6]

Stratovolcanoes (composite volcanoes)



Cross-section through a stratovolcano (vertical scale is exaggerated):

1. Large magma chamber
2. Bedrock
9. Layers of lava emitted by the volcano
10. Throat

3. Conduit (pipe)	11. Parasitic cone
4. Base	12. Lava flow
5. Sill	13. Vent
6. Dike	14. Crater
7. Layers of ash emitted by the volcano	15. Ash cloud
8. Flank	

Main article: Stratovolcano

Stratovolcanoes or **composite volcanoes** are tall conical mountains composed of lava flows and other ejecta in alternate layers, thestrata that give rise to the name. Stratovolcanoes are also known as composite volcanoes, created from several structures during different kinds of eruptions. Strato/composite volcanoes are made of cinders, ash and lava. Cinders and ash pile on top of each other, lava flows on top of the ash, where it cools and hardens, and then the process begins again. Classic examples include Mt. Fuji in Japan, Mayon Volcano in the Philippines, and Mount Vesuvius and Stromboli in Italy.

Throughout recorded history, ash produced by the explosive eruption of stratovolcanoes has posed the greatest hazard to civilizations as compared to other types of volcanoes. Shield volcanos have smaller pressure buildup from the underlying lava flow as compared to stratovolcanoes. Fissure vents and monogenetic volcanic fields (volcanic cones) have less powerful eruptions, as they are many times under extension. Stratovolcanoes have been a greater historical threat because they are steeper than shield volcanos, with slopes of 30–35° compared to slopes of generally 5–10°, and their loose tephra are material for dangerous lahars.[7]

Supervolcanoes

Main article: Supervolcano

See also: List of largest volcanic eruptions

A **supervolcano** is a large volcano that usually has a large caldera and can potentially produce devastation on an enormous, sometimes continental, scale. Such eruptions would be able to cause severe cooling of global temperatures for many years afterwards because of the huge volumes of sulfur and ash erupted. They are the most dangerous type of volcano. Examples include Yellowstone Caldera inYellowstone National Park and Valles Caldera in New Mexico (both western United States), Lake Taupo in New Zealand, Lake Toba inSumatra, Indonesia and Ngorogoro Crater in Tanzania, Krakatoa near Java and Sumatra, Indonesia. Supervolcanoes are hard to identify centuries later, given the enormous areas they cover. Large igneous provinces are also considered supervolcanoes because of the vast amount of basalt lava erupted, but are non-explosive.

Submarine volcanoes

Main article: Submarine volcano

Submarine volcanoes are common features on the ocean floor. Some are active and, in shallow water, disclose their presence by blasting steam and rocky debris high above the surface of the sea. Many others lie at such great depths that the tremendous weight of the water above them prevents the explosive release of steam and gases, although they can be detected by hydrophones and discoloration of water because of volcanic gases. Pumice rafts may also appear. Even large submarine eruptions may not disturb the ocean surface. Because of the rapid cooling effect of water as compared to air, and increased buoyancy, submarine volcanoes often form rather steep pillars over their volcanic vents as compared to above-surface volcanoes. They may become so large that they break the ocean surface as new islands. Pillow lava is a common eruptive product of submarine volcanoes.Hydrothermal vents are common near these volcanoes, and some support peculiar ecosystems based on dissolved minerals.

Subglacial volcanoes

Main article: Subglacial volcano

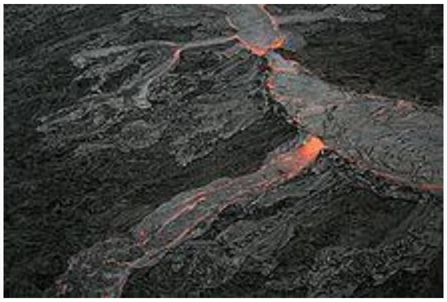
Subglacial volcanoes develop underneath icecaps. They are made up of flat lava which flows at the top of extensive pillow lavas and palagonite. When the icecap melts, the lavas on the top collapse, leaving a flat-topped mountain. These volcanoes are also called table mountains, tuyas or (uncommonly) mobergs. Very good examples of this type of volcano can be seen in Iceland, however, there are also tuyas in British Columbia. The origin of the term comes from Tuya Butte, which is one of the several tuyas in the area of the Tuya River and Tuya Range in northern British Columbia. Tuya Butte was the first such landform analyzed and so its name has entered the geological literature for this kind of volcanic formation. The Tuya Mountains Provincial Park was recently established to protect this unusual landscape, which lies north of Tuya Lake and south of the Jennings River near the boundary with the Yukon Territory.

Mud volcanoes

Main article: Mud volcano

Mud volcanoes or **mud domes** are formations created by geo-excreted liquids and gases, although there are several processes which may cause such activity. The largest structures are 10 kilometers in diameter and reach 700 meters high.

Erupted material



Pāhoehoe lava flow on Hawaii. The picture shows overflows of a main lava channel.

The Stromboli stratovolcano off the coast of Sicily has erupted continuously for thousands of years, giving rise to the termstrombolian eruption.

Lava composition

Another way of classifying volcanoes is by the *composition of material erupted* (lava), since this affects the shape of the volcano. Lava can be broadly classified into 4 different compositions (Cas & Wright, 1987):

- If the erupted magma contains a high percentage (>63%) of silica, the lava is called felsic.
  - Felsic lavas (dacites or rhyolites) tend to be highly viscous (not very fluid) and are erupted as domes or short, stubby flows. Viscous lavas tend to form stratovolcanoes or lava domes. Lassen Peak in California is an example of a volcano formed from felsic lava and is actually a large lava dome.
  - Because siliceous magmas are so viscous, they tend to trap volatiles (gases) that are present, which cause the magma to erupt catastrophically, eventually forming stratovolcanoes. Pyroclastic flows (ignimbrites) are highly hazardous products of such volcanoes, since they are composed of molten volcanic ash too heavy to go up into the atmosphere, so they hug the volcano's slopes and travel far from their vents during large eruptions. Temperatures as high as 1,200 °C are known to occur in pyroclastic flows, which will incinerate everything flammable in their path and thick layers of hot pyroclastic flow deposits can be laid down, often up to many meters thick. Alaska's Valley of Ten Thousand Smokes, formed by the eruption of Novarupta near Katmai in 1912, is an example of a thick pyroclastic flow or ignimbrite deposit. Volcanic ash that is light enough

to be erupted high into the Earth's atmosphere may travel many kilometres before it falls back to ground as a tuff.

- If the erupted magma contains 52–63% silica, the lava is of *intermediate* composition.
  - These "andesitic" volcanoes generally only occur above subduction zones (e.g. Mount Merapi in Indonesia).
  - Andesitic lava is typically formed at convergent boundary margins of tectonic plates, by several processes:
    - Hydration melting of peridotite and fractional crystallization

Sarychev Peak eruption, Matua Island, oblique satellite view

    - Melting of subducted slab containing sediments[citation needed]]]
    - Magma mixing between felsic rhyolitic and mafic basaltic magmas in an intermediate reservoir prior to emplacement or lava flow.
- If the erupted magma contains <52% and >45% silica, the lava is called mafic (because it contains higher percentages of magnesium (Mg) and iron (Fe)) or basaltic. These lavas are usually much less viscous than rhyolitic lavas, depending on their eruption temperature; they also tend to be hotter than felsic lavas. Mafic lavas occur in a wide range of settings:
  - At mid-ocean ridges, where two oceanic plates are pulling apart, basaltic lava erupts as pillows to fill the gap;
  - Shield volcanoes (e.g. the Hawaiian Islands, including Mauna Loa and Kilauea), on both oceanic and continental crust;

- As continental flood basalts.
- Some erupted magmas contain <=45% silica and produce ultramafic lava. Ultramafic flows, also known as komatiites, are very rare; indeed, very few have been erupted at the Earth's surface since the Proterozoic, when the planet's heat flow was higher. They are (or were) the hottest lavas, and probably more fluid than common mafic lavas.

Lava texture

Two types of lava are named according to the surface texture: ʻAʻa (pronounced [ˈʔaʔa]) and pāhoehoe ([paːˈho.eˈho.e]), both Hawaiian words. ʻAʻa is characterized by a rough, clinkery surface and is the typical texture of viscous lava flows. However, even basaltic or mafic flows can be erupted as ʻaʻa flows, particularly if the eruption rate is high and the slope is steep.

Pāhoehoe is characterized by its smooth and often ropey or wrinkly surface and is generally formed from more fluid lava flows. Usually, only mafic flows will erupt as pāhoehoe, since they often erupt at higher temperatures or have the proper chemical make-up to allow them to flow with greater fluidity.

Volcanic activity

Fresco with Mount Vesuviusbehind Bacchus andAgathodaimon, as seen inPompeii's House of the Centenary

Popular classification of volcanoes

A popular way of classifying magmatic volcanoes is by their frequency of eruption, with those that erupt regularly called **active**, those that have erupted in historical times but are now quiet called **dormant** or **inactive**, and those that have not erupted in historical times called **extinct**. However, these popular classifications—extinct in particular—are practically meaningless to scientists. They use classifications which refer to a particular volcano's formative and eruptive processes and resulting shapes, which was explained above.

Active

There is no consensus among volcanologists on how to define an "active" volcano. The lifespan of a volcano can vary from months to several million years, making such a distinction sometimes meaningless when compared to the lifespans of humans or even civilizations. For example, many of Earth's volcanoes have erupted dozens of times in the past few thousand years but are not currently showing signs of eruption. Given the long lifespan of such volcanoes, they are very active. By human lifespans, however, they are not.

Scientists usually consider a volcano to be *erupting* or *likely to erupt* if it is currently erupting, or showing signs of unrest such as unusual earthquake activity or significant new gas emissions. Most scientists consider a volcano *active* if it has erupted in the last 10,000 years (Holocene times) – the Smithsonian Global Volcanism Program uses this definition of *active*. There are about 1500 active volcanoes in the world – the majority along the Pacific Ring of Fire – and around 50 of these erupt each year.[8] An estimated 500 million people live near active volcanoes.[8]

Historical time (or recorded history) is another timeframe for *active*.[9][10] The *Catalogue of the Active Volcanoes of the World*, published by the International Association of Volcanology, uses this definition, by which there are more than 500 active volcanoes.[9] However, the span of recorded history differs from region to region. In China and theMediterranean, it reaches back nearly 3,000 years, but in the Pacific Northwest of the United States and Canada, it reaches back less than 300 years, and in Hawaii and New Zealand, only around 200 years.[9]

Kīlauea lava entering the sea.

As of 2013, the following are considered Earth's most active volcanoes:[11]

- Kīlauea, the famous Hawaiin volcano, has been in continuous, effusive eruption for thirty years, and has the longest-observed lava lake
- Mount Etna and nearby Stromboli, two Mediterranean volcanoes in "almost continuous eruption" since antiquity

- Mount Yasur, in Vanuatu, has been erupting "nearly continuously" for over 800 years

The longest currently ongoing (but not necessarily continuous) volcanic eruptive phases are:[12]

- Mount Yasur, 111 years
- Mount Etna, 109 years
- Stromboli, 108 years
- Santa María, 101 years
- Sangay, 94 years

Other very active volcanoes include:

- Mount Nyiragongo and its neighbor, Nyamuragira, are Africa's most active volcanoes

Nyiragongo's lava lake

- Piton de la Fournaise, in Réunion, erupts frequently enough to be a tourist attraction
- Erta Ale, in the Afar Triangle, has maintained a lava lake since at least 1906
- Mount Erebus, in Antarctica, has maintained a lava lake since at least 1972
- Mount Merapi
- Ol Doinyo Lengai
- Ambrym
- Arenal Volcano
- Pacaya
- Klyuchevskaya Sopka

- Sheveluch

Extinct

Fourpeaked volcano, Alaska, in September 2007, after being thought extinct for over 10,000 years.

Mount Rinjani eruption in 1994, inLombok, Indonesia

Extinct volcanoes are those that scientists consider unlikely to erupt again, because the volcano no longer has a magma supply. Examples of extinct volcanoes are many volcanoes on the Hawaiian – Emperor seamount chain in the Pacific Ocean, Hohentwiel, Shiprock and the Zuidwal volcano in theNetherlands. Edinburgh Castle in Scotland is famously located atop an extinct volcano. Otherwise, whether a volcano is truly extinct is often difficult to determine. Since "supervolcano" calderas can have eruptive lifespans sometimes measured in millions of years, a caldera that has not produced an eruption in tens of thousands of years is likely to be considered dormant instead of extinct. Some volcanologists refer to extinct volcanoes as inactive, though the term is now more commonly used for dormant volcanoes once thought to be extinct.

Dormant

It is difficult to distinguish an extinct volcano from a dormant (inactive) one. Volcanoes are often considered to be extinct if there are no written records of its activity. Nevertheless, volcanoes may remain dormant for a long period of time. For example, Yellowstone has a repose/recharge period of around 700,000 years, and Toba of around 380,000 years.[13] Vesuvius was described by Roman writers as having been covered with gardens and vineyards before its eruption of AD 79, which destroyed the towns of Herculaneum and Pompeii. Before its catastrophic eruption of 1991, Pinatubo was an inconspicuous volcano, unknown to most people in the surrounding areas. Two other examples are the long-dormant Soufrière Hills volcano on the island of Montserrat, thought to be extinct before activity resumed in 1995 and Fourpeaked Mountain in Alaska, which, before its September 2006 eruption, had not erupted since before 8000 BC and had long been thought to be extinct.

Technical classification of volcanoes

Volcanic-alert level

The three common popular classifications of volcanoes can be subjective and some volcanoes thought to have been extinct have erupted again. To help prevent people from falsely believing they are not at risk when living on or near a volcano, countries have adopted new classifications to describe the various levels and stages of volcanic activity.[14] Some alert systems use different numbers or colors to designate the different stages. Other systems use colors and words. Some systems use a combination of both.

Volcano warning schemes of the United States

The United States Geological Survey (USGS) has adopted a common system nationwide for characterizing the level of unrest and eruptive activity at volcanoes. The new volcano alert-level system classifies volcanoes now as being in a normal, advisory, watch or warning stage. Additionally, colors are used to denote the amount of ash produced. Details of the US system can be found atVolcano warning schemes of the United States.

Decade volcanoes

Koryaksky volcano towering overPetropavlovsk-Kamchatsky on Kamchatka Peninsula, Far Eastern Russia.

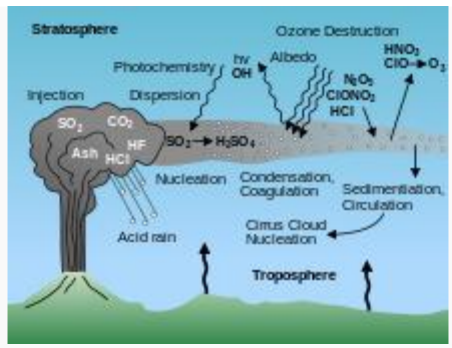
Main articles: Lists of volcanoes and Decade Volcanoes

The Decade Volcanoes are 16 volcanoes identified by the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) as being worthy of particular study in light of their history of large, destructive eruptions and proximity to populated areas. They are named Decade Volcanoes because the project was initiated as part of the United Nations-sponsored International Decade for Natural Disaster Reduction. The 16 current Decade Volcanoes are

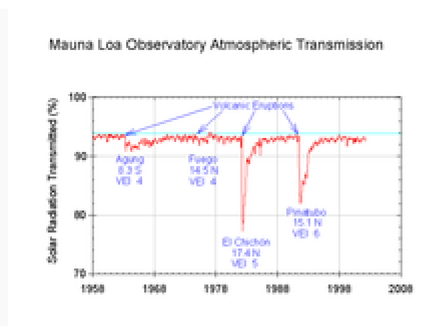
- Avachinsky-Koryaksky, Kamchatka, Russia
- Sakurajima, Kagoshima Prefecture, Japan

- Nevado de Colima, Jalisco and Colima, Mexico
- Mount Etna, Sicily, Italy
- Galeras, Nariño, Colombia
- Mauna Loa, Hawaii, USA
- Mount Merapi, Central Java, Indonesia
- Mount Nyiragongo, Democratic Republic of the Congo
- Mount Rainier, Washington, USA
- Santa Maria/Santiaguito, Guatemala
- Santorini, Cyclades, Greece
- Taal Volcano, Luzon, Philippines
- Teide, Canary Islands, Spain
- Ulawun, New Britain, Papua New Guinea
- Mount Unzen, Nagasaki Prefecture, Japan
- Vesuvius, Naples, Italy

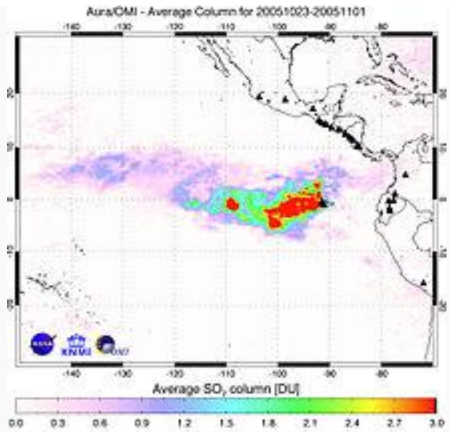
Effects of volcanoes



Schematic of volcano injection of aerosols and gases.



Solar radiation graph 1958–2008, showing how the radiation is reduced after major volcanic eruptions.



Sulfur dioxide concentration over the Sierra Negra Volcano, Galapagos Islands during an eruption in October 2005

There are many different types of volcanic eruptions and associated activity: phreatic eruptions (steam-generated eruptions), explosive eruption of high-silica lava (e.g., rhyolite), effusive eruption of low-silica lava (e.g., basalt), pyroclastic flows, lahars (debris flow) and carbon dioxide emission. All of these activities can pose a hazard to humans. Earthquakes, hot springs, fumaroles, mud pots and geysers often accompany volcanic activity.

The concentrations of different volcanic gases can vary considerably from one volcano to the next. Water vapor is typically the most abundant volcanic gas, followed by carbon dioxide and sulfur dioxide. Other principal volcanic gases include hydrogen sulfide, hydrogen chloride, and hydrogen fluoride. A large number of minor and trace gases are also found in volcanic emissions, for example hydrogen, carbon monoxide, halocarbons, organic compounds, and volatile metal chlorides.

Large, explosive volcanic eruptions inject water vapor (H_2O), carbon dioxide (CO_2), sulfur dioxide (SO_2), hydrogen chloride (HCl), hydrogen fluoride (HF) and ash (pulverized rock and pumice) into the stratosphere to heights of 16–32 kilometres (10–20 mi) above the Earth's surface. The most significant impacts from these injections come from the conversion of sulfur dioxide to sulfuric acid (H_2SO_4), which condenses rapidly in the stratosphere to form fine sulfate aerosols. The aerosols increase the Earth's albedo—its reflection of radiation from the Sun back into space – and thus cool the Earth's lower atmosphere or troposphere; however, they also absorb heat radiated up from the Earth, thereby warming the stratosphere. Several eruptions during the past century have caused a decline in the average temperature at the Earth's surface of up to half a degree (Fahrenheit scale) for periods of one to three years – sulfur dioxide from the eruption ofHuaynaputina probably caused the Russian famine of 1601–1603.[15]

One proposed volcanic winter happened c. 70,000 years ago following the supereruption of Lake Toba on Sumatra island in Indonesia.[16] According to the Toba catastrophe theory to which some anthropologists and archeologists subscribe, it had global consequences,[17] killing most humans then alive and creating a population bottleneck that affected the genetic inheritance of all humans today.[18] The 1815 eruption of Mount Tambora created global climate anomalies that became known as the "Year Without a Summer" because of the effect on North American and European weather.[19] Agricultural crops failed and livestock died in much of the Northern Hemisphere, resulting in one of the worst famines of the 19th century.[20] The freezing winter of 1740–41, which led to widespread famine in northern Europe, may also owe its origins to a volcanic eruption.[21]

It has been suggested that volcanic activity caused or contributed to the End-Ordovician, Permian-Triassic, Late Devonian mass extinctions, and possibly others. The massive eruptive event which formed the Siberian Traps, one of the largest known volcanic events of the last 500 million years ofEarth's geological history, continued for a million years and is considered to be the likely cause of the "Great Dying" about 250 million years ago,[22]which is estimated to have killed 90% of species existing at the time.[23]

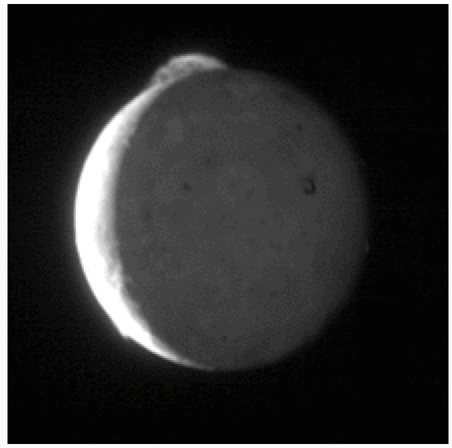
Ash plume rising from Eyjafjallajökull on April 17, 2010

The sulfate aerosols also promote complex chemical reactions on their surfaces that alter chlorine and nitrogen chemical species in the stratosphere. This effect, together with increased stratospheric chlorine levels from chlorofluorocarbon pollution, generates chlorine monoxide (ClO), which destroysozone (O_3). As the aerosols grow and coagulate, they settle down into the upper troposphere where they serve as nuclei for cirrus clouds and further modify the Earth's radiation balance. Most of the hydrogen chloride (HCl) and hydrogen fluoride (HF) are dissolved in water droplets in the eruption cloud and quickly fall to the ground as acid rain. The injected ash also falls rapidly from the stratosphere; most of it is removed within several days to a few weeks. Finally, explosive volcanic eruptions release the greenhouse gas carbon dioxide and thus provide a deep source of carbon for biogeochemical cycles.

Gas emissions from volcanoes are a natural contributor to acid rain. Volcanic activity releases about 130 to 230 teragrams (145 million to 255 millionshort tons) of carbon dioxide each year.[24] Volcanic eruptions may inject aerosols into the Earth's atmosphere. Large injections may cause visual effects such as unusually colorful sunsets and affect global climate mainly by cooling it. Volcanic eruptions also provide the benefit of adding nutrients tosoil through the weathering process of volcanic rocks. These fertile soils assist the growth of plants and various crops. Volcanic eruptions can also create new islands, as the magma cools and solidifies upon contact with the water.

Ash thrown into the air by eruptions can present a hazard to aircraft, especially jet aircraft where the particles can be melted by the high operating temperature; the melted particles then adhere to the turbine blades and alter their shape, disrupting the operation of the turbine. Dangerous encounters in 1982 after the eruption of Galunggung in Indonesia, and 1989 after the eruption of Mount Redoubt in Alaska raised awareness of this phenomenon. Nine Volcanic Ash Advisory Centers were established by the International Civil Aviation Organization to monitor ash clouds and advise pilots accordingly. The 2010 eruptions of Eyjafjallajökull caused major disruptions to air travel in Europe.

Volcanoes on other planetary bodies



The Tvashtar volcano erupts a plume 330 km (205 mi) above the surface ofJupiter's moon Io.

Olympus Mons (Latin, "Mount Olympus") is the tallest known mountain in our solar system, located on the planet Mars.

Main articles: Geology of the Moon, Volcanology of Mars, Volcanism on Io, and Volcanism on Venus

The Earth's Moon has no large volcanoes and no current volcanic activity, although recent evidence suggests it may still possess a partially molten core.[25] However, the Moon does have many volcanic features such as maria (the darker patches seen on the moon), rilles and domes.

The planet Venus has a surface that is 90% basalt, indicating that volcanism played a major role in shaping its surface. The planet may have had a major global resurfacing event about 500 million years ago,[26] from what scientists can tell from the density of impact craters on the surface. Lava flows are widespread and forms of volcanism not present on Earth occur as well. Changes in the planet's atmosphere and observations of lightning have been attributed to ongoing volcanic eruptions, although there is no confirmation of whether or not Venus is still volcanically active. However, radar sounding by the Magellan probe revealed evidence for comparatively recent volcanic activity at Venus's highest volcano Maat Mons, in the form of ash flows near the summit and on the northern flank.

There are several extinct volcanoes on Mars, four of which are vast shield volcanoes far bigger than any on Earth. They include Arsia Mons, Ascraeus Mons, Hecates Tholus, Olympus Mons, and Pavonis Mons. These volcanoes have been extinct for many millions of years,[27] but the European *Mars Express* spacecraft has found evidence that volcanic activity may have occurred on Mars in the recent past as well.[27]

Jupiter's moon Io is the most volcanically active object in the solar system because of tidal interaction with Jupiter. It is covered with volcanoes that erupt sulfur,sulfur dioxide and silicate rock, and as a result, Io is constantly being resurfaced. Its lavas are the hottest known anywhere in the solar system, with temperatures exceeding 1,800 K (1,500 °C). In February 2001, the largest recorded volcanic eruptions in the solar system occurred on Io.[28] Europa, the smallest of Jupiter's Galilean moons, also appears to have an active volcanic system, except that its volcanic activity is entirely in the form of water, which freezes into ice on the frigid surface. This process is known as cryovolcanism, and is apparently most common on the moons of the outer planets of the solar system.

In 1989 the Voyager 2 spacecraft observed cryovolcanoes (ice volcanoes) on Triton, a moon of Neptune, and in 2005 the Cassini–Huygens probe photographedfountains of frozen particles erupting from Enceladus, a moon of Saturn.[29] The ejecta may be composed of water, liquid nitrogen, dust, or methane compounds. Cassini–Huygens also found evidence of a methane-spewing cryovolcano on the Saturnian moon Titan, which is believed to be a significant source of the methane found in its atmosphere.[30] It is theorized that cryovolcanism may also be present on the Kuiper Belt Object Quaoar.

A 2010 study of the exoplanet COROT-7b, which was detected by transit in 2009, studied that tidal heating from the host star very close to the planet and neighboring planets could generate intense volcanic activity similar to Io.[31]

Traditional beliefs about volcanoes

Many ancient accounts ascribe volcanic eruptions to supernatural causes, such as the actions of gods or demigods. To the ancient Greeks, volcanoes' capricious power could only be explained as acts of the gods, while 16th/17th-century German astronomer Johannes Kepler believed they were ducts for the Earth's tears.[32] One early idea counter to this was proposed by JesuitAthanasius Kircher (1602–1680), who witnessed eruptions of Mount Etna and Stromboli, then visited the crater of Vesuvius and published his view of an Earth with a central fire connected to numerous others caused by the burning of sulfur, bitumen and coal.

Various explanations were proposed for volcano behavior before the modern understanding of the Earth's mantle structure as a semisolid material was developed. For decades after awareness that compression and radioactive materials may be heat sources, their contributions were specifically discounted. Volcanic action was often attributed to chemical reactions and a thin layer of molten rock near the surface.